SYSTEMATIC STUDY OF THE LICHENS FAMILY PARMELIACEAE IN THAILAND

THITIPORN POOPRANG

THESIS PRESENTED TO RAMKHAMHAENG UNIVERSITY
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF MASTER OF SCIENCE
(BIOLOGY)
2001

M 15.

19 ก.ค. 2545

โครงการพัฒนาองค์ความรู้และศึกษานโยบายการจัดการทรัพยากรชีวภาพในประเทศไทย
c/o ศูนย์พันธุวิศวกรรมและเทคโนโลยีชีวภาพแห่งชาติ
อาคารสำนักงานพัฒนาวิทยาศาสตร์และเทคโนโลยีแห่งชาติ
73/1 ถนนพระรามที่ 6 เขตราชเทวี
กรุงเทพฯ 10400

SYSTEMATIC STUDY OF THE LICHENS FAMILY PARMELIACEAE IN THAILAND

THITIPORN POOPRANG

A THESIS PRESENTED TO RAMKHAMHAENG UNIVERSITY
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF MASTER OF SCIENCE
(BIOLOGY)
2001

ISBN 974-09-0060-7

การศึกษาทางอนุกรมวิธานของไลเคนวงศ์พาร์มีเลียซิอิในประเทศไทย

ฐิติพร ภู่ปราง

วิทยานิพนธ์เสนอต่อมหาวิทยาลัยรามคำแหง
เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญา
วิทยาศาสตรมหาบัณฑิต (ชีววิทยา)
ปีการศึกษา 2544

ISBN 974-09-0060-7

Thesis Title	Systematic Study of the Lichens Family Parmeliaceae in Thailand	
Student's Name	Miss Thitiporn Pooprang	
	Department of Biology, Faculty of Science	
Advisory Committee	Asst. Prof. Dr. Kansri Boonpragob	Chairperson
	Assoc. Prof. Piboon Mongkolsuk	

Ramkhamhaeng University approved this thesis as a partial fulfillment of the requirements for the degree of Master of Science (Biology)

..... Dean of Graduate School

(Assoc. Prof. Dr. Suraphol Rajbhandaraks)

Examination Committee

..... Chairperson

(Asst. Prof. Dr. Kansri Boonpragob)

..... Member

(Assoc. Prof. Piboon Mongkolsuk)

..... Member

(Asst. Prof. Dr. Natsurang Homchantara)

ABSTRACT

Thesis Title : Systematic Study of the Lichens Family Parmeliaceae in Thailand

Student's Name : Miss Thitiporn Pooprang

Degree Sought : Master of Science

Major : Biology

Academic Year : 2001

Advisory Committee :

1. Asst. Prof. Dr. Kansri Boonpragob Chairperson
2. Assoc. Prof. Piboon Mongkolsuk

The Parmeliaceae is the largest family of macrolichens occurs worldwide. The objectives of this study are to explore taxonomy and distribution of this family in Thailand. Sampling collections were performed during 1994 to 1999. A total of 1,521 specimens were collected on tree trunks, twigs, and canopies from 55 host plants, as well as rocks, and soil. Collecting localities consisted of eight forest types and two plantations from various parts of Thailand. Taxonomic identification was based on morphological, anatomical and chemical characters. They comprised of 14 genera and 75 species. Laminal apothecia and pycnidia are important characters used to identify the parmelioid lichens. By using spot test and TLC these specimens composed of 64 lichen substances. The identification was confirmed at Australian National University, Canberra, Australia.

They consisted of fourteen genera and seventy-five species. These are *Bulbothrix* (8 species), *Canomaculina subtinctoria*, *Canoparmelia* (2 species), *Everniastrum* (3 species), *Hypotrachyna* (15 species), *Myelochroa* (2 species), *Parmelinella* (2 species), *Parmelinopsis* (4 species), *Parmeliopsis ambigua*, *Parmotrema* (28 species), *Relicina* (3 species), *Relicinopsis* (3 species), *Rimelia reticulata*, and *Xanthoparmelia* (2 species).

Five species of three genera were described as new to Thailand. These are *Everniastrum scabridum, Hypotrachyna chlorobarbatica, Hypotrachyna ramkhamhaengiana, Parmotrema rubromarginatum,* and *Parmotrema thailandicum. Parmelinella chozoubae* was a new taxa raise from *Parmelina chozoubae.* Twenty-nine species were new records to Thailand. These are *Bulbothrix* (4 species), *Canomaculina subtinctoria, Hypotrachyna* (6 species), *Parmelinella chozoubae, Parmelinopsis* (3 species), *Parmeliopsis ambigua, Parmotrema* (10 species), *Relicinopsis malaccensis,* and *Xanthoparmelia* (2 species).

The richest biodiversity of the parmelioid lichens are found in the Lower montane forests, the Mixed deciduous forests and on rock outcrops in the Dry dipterocarp forests respectively. The most widely distributed species is *Parmotrema tinctorum.* It occurs in six forest types except the Mangrove forest. Whist, twenty-two species are restricted to the Lower montane forests. *Everniastrum, Hypotrachyna, Myelochroa, Parmelinopsis,* and *Parmeliopsis* only inhabit the high altitude above 1,000 meter. *Parmotrema* and *Hypotrachyna* are the most common species in the tropic.

บทคัดย่อ

ชื่อเรื่องวิทยานิพนธ์ : การศึกษาทางอนุกรมวิธานของไลเคนวงศ์พาร์มีเลียซิอิ ในประเทศไทย

ชื่อผู้เขียน : นางสาวฐิติพร ภู่ปราง

ชื่อปริญญา : วิทยาศาสตรมหาบัณฑิต

สาขาวิชา : ชีววิทยา

ปีการศึกษา : 2544

คณะกรรมการที่ปรึกษาวิทยานิพนธ์ :

1. ผู้ช่วยศาสตราจารย์ ดร. กัณฑรีย์ บุญประกอบ ประธานกรรมการ
2. รองศาสตราจารย์ พิบูลย์ มงคลสุข

ไลเคนวงศ์พาร์มีเลียซิอิเป็นไลเคนขนาดใหญ่ที่มีจำนวนชนิดมากที่สุดในโลก การศึกษาครั้งนี้เป็นการศึกษาอนุกรมวิธานและการแพร่กระจายของไลเคนวงศ์นี้ในประเทศไทย จากการรวบรวมตัวอย่างไลเคนบนพรรณพืช 55 ชนิด รวมทั้งบนหินและดิน จากพื้นที่ต่างๆของประเทศไทย ได้ตัวอย่างไลเคน 1,521 ตัวอย่าง เมื่อนำมาวิเคราะห์ตามหลักอนุกรมวิธานโดยใช้ลักษณะสัณฐานวิทยา กายวิภาควิทยาและการตรวจสอบสารธรรมชาติของไลเคน (Lichen substances) ด้วยการทำสปอตเทส (Spot test) และ Thin Layer Chromatography (TLC) พบสารธรรมชาติ 64 ชนิด จากการเทียบตัวอย่างและการยืนยันจากผู้เชี่ยวชาญ ณ Australian National University ประเทศออสเตรเลีย สามารถจำแนกไลเคนได้ 14 สกุล 75 ชนิด โดยจัดเป็นกลุ่มพาร์มีลิออยด์ (Parmeloid lichens) ตามลักษณะแอโพธีเซีย และพิคนิเดียที่เกิดบนแผ่นแทลลัส

ไลเคนที่พบประกอบด้วย *Bulbothrix* (8 ชนิด), *Canomaculina* (1 ชนิด), *Canoparmelia* (2 ชนิด), *Everniastrum* (3 ชนิด), *Hypotrachyna* (15 ชนิด), *Myelochroa* (2 ชนิด), *Parmelinella* (2 ชนิด), *Parmelinopsis* (4 ชนิด), *Parmeliopsis* (1 ชนิด), *Parmotrema* (28 ชนิด), *Relicïna* (3 ชนิด), *Relicinopsis* (3 ชนิด), *Rimelia* (1 ชนิด) และ

Xanthoparmelia (2 ชนิด) นอกจากนี้ยังค้นพบชนิดใหม่ (new species) 5 ชนิด คือ *Parmotrema thailandicum, Hypotrachyna ramkhamheangiana, Everniastrum scabridum, Hypotrachyna chlorobarbatica* และ *Parmotrema rubromarginatum* และพบครั้งแรก (new records) ในประเทศไทย 29 ชนิด คือ *Bulbothrix* (4 ชนิด), *Canomaculina subtinctoria, Hypotrachyna* (6 ชนิด), *Parmelinella chozoubae, Parmelinopsis* (3 ชนิด), *Parmeliopsis ambigua, Parmotrema* (10 ชนิด), *Relicinopsis malaccensis,* และ*Xanthoparmelia* (2 ชนิด). ได้รับการเปลี่ยนชื่อใหม่ 1 ชนิด คือ *Parmelinella chozoubae*

ไลเคนกลุ่มนี้มีความหลากหลายสกุลและชนิดมากที่สุดในป่าดิบเขา ป่าเบญจพรรณ บนหินในป่าเต็งรัง ตามลำดับ ชนิดที่พบแพร่กระจายมากที่สุดคือ *Parmotrema tinctorum* ซึ่งพบในทุกระบบนิเวศยกเว้นป่าชายเลน ในขณะที่มี 22 ชนิดพบเฉพาะในป่าดิบเขา โดย *Everniastrum, Hypotrachyna, Myelochroa, Parmelinopsis,* และ *Parmeliopsis* พบได้ที่ระดับความสูงมากกว่า 1,000 เมตรขึ้นไป สกุลที่มีการแพร่กระจายได้ดีในเขตร้อนชื้นคือ *Parmotrema* และ *Hypotrachyna*

ACKNOWLEDGEMENTS

I would like to express my deeply gratitude to Asst. Prof. Dr. Kansri Boonpragob, Assoc. Prof. Piboon Mongkolsuk, and Asst. Prof. Dr. Natsurang Homchantara for their valuable guidance and intensive supervision throughout my study. I am extremely grateful to Mr. Ek Sangvichien for introducing the information sources throughout the study. They kindness and helpfulness will always be remembered.

I would also like to express my sincere gratitude to Professor John A. Elix from Australian National University, Australia and Dr. Patrick McCarthy from Australian Biological Resources Study (ABRS), who advice, support training, and help in specimens confirmation as well as preparation for publication. Special thanks extend to Simone Louwhoff for her assistance and providing information and Judith Wardlaw for her help on HPLC. I am indebted to Professor Dr. Ming-Jou Lai for his valuable consultation on identification and offered helpful comment for preparing the manuscript.

It is my pleasure to thank a number of colleagues at the excellent organization team, Lichen Research Unit, for their assistance in fieldwork and laboratory. I am grateful to Department of Biology, Faculty of Science, Ramkhamhaeng University for using some instruments and facilities in the laboratory. I am very grateful to my friend, Mr. Santi Wattana and Miss Sirinan Madnote, for moral support and help.

Finally, I would like to express my deepest gratitude to my parents for their support and encouragement during my study. I extend my sincere

gratitude to my brothers, Mr. Kittipan and Mr. Watthana Pooprang for their help and advice in photographic techniques. This work was supported by the TRF/BIOTEC special program for Biodiversity Research and Training grant BRT 541004 as well as Australian Biological Resources Study, which supported my training in Australia.

Thitiporn Pooprang

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

µm	=	micrometer
cm	=	centimeter
diam.	=	diameter
E	=	east
et al.	=	*et alii*; and others
i.e.	=	*id est* (that is)
ibid.	=	ibidem
L.S.	=	longitudinal section
mm	=	millimeter
N	=	north
NE	=	north-east
RAMK	=	Ramkhamhaeng University Lichen Herbarium, Bangkok
RU	=	Ramkhamhaeng University
S	=	south
SE	=	south-east
SEM	=	Scanning Electron Microscopy
sp. nov.	=	species nova (new species)
sp./spp.	=	species (singular/plural)
SW	=	south-west
tlc	=	thin layer chromatography
UV	=	ultraviolet

CHAPTER 1

INTRODUCTION

The Lichen Family Parmeliaceae

The lichen family Parmeliaceae belongs to order Lecanorales of the Class Ascomycetes, Sub-division Ascomycotina consisting of 85 genera and 2,319 species (Hawksworth *et al.* 1995). This family is characterized by development of the foliose growth form. Thallus are made up from the algae and fungi lying in stratified layers. Rhizines usually present on the lower surface. Upper cortex is gray to green or yellow-green to yellow. The exciple, which support apothecia, is lecanorine type that contains algae. Bitunicate ascus fills with eight, simple and hyaline ascospores. Phycobionts are green algae usually *Trebouxia* (Elix 1994, 1). *Parmelia* is the first and the largest genus of this family, which was subsequently separated into more than 30 genera by various authors (DePriest 1999, 446). Parmelioid lichens, a term proposed by Kärnefelt *et al.* (Kärnefelt and Thell 1992), include genera segregated from *Parmelia* by having laminal apothecia and pycnidia disposition. This group is also the largest and the most important member of this family in Thailand.

Lichens in this family have been exploited in herbal medicines such as *Cetraria islandica*, which was used against coughing. Lichen extracts are resources of essential fixative for fragrances in perfumes industry such as

Evernia prunastri and *Pseudevernia furfuracea*. Several *Parmotrema* species are harvested for food and flavor. *Parmotrema tinctorum* and *Parmelia omphalodes* have been utilized for red, brown or purple for dyeing wool and silk (Richardson 1988; Elix 1996b).

The Parmeliaceous lichens are widely distributed on rock, soil, bark and other substrates. They are found in various ecosystems from tundra, temperate, desert and tropic (Elix 1993, 367). *Xanthoparmelia*, the largest genus is widely distributed in the Southern Hemisphere and Australia, where these two locations are the main areas of its speciation. *Parmotrema* and *Hypotrachyna* are widely distributed in the tropical regions (Elix 1994, 1). Recently Poinar *et al.,* described the only two new fossils species from Dominican amber, as *Parmelia ambra* and *P. isidiiveteris*, dating from 15-20 million years to 30-45 million years (Poinar *et al.* 2000).

The tropical lichens are poorly known, especially in Thailand. During 1899-1994, lichens from Thailand had been collected and deposited in herbariums outside the country (Kansri Boonpragob *et al.* 1998). Most of these specimens were collected from northern Thailand. This study focuses on taxonomy and distribution of the parmelioid genera and species in the family Parmeliaceae in Thailand. The outcomes of this study would enhance knowledge for sustainable utilization and conservation of biodiversity resources in this country.

Objectives

The aims of the present study include:

1. Identifications and descriptions of the parmelioid genera and species of the lichen family Parmeliaceae in Thailand.
2. Extensive collections of specimens to be kept in the herbarium.
3. Preparation of keys to the genera and species in Thailand and record them in database.
4. Investigation of the distribution of parmelioid lichens in Thailand.

Hypothesis

The family Parmeliaceae consists of 64 genera and more than 1,000 species (Elix 1993). But Hawksworth *et al.* (1995) included 85 genera and 2,319 species. Investigations engaged so far in Thailand have discovered more than 20 genera and 100 species. In the present study it is expected to find new species and new records because intensive survey and new collecting localities are planned.

CHAPTER 2

LITERATURE REVIEW

Historical Background

Taxonomy

Linnaeus described the first two species, currently belong to the Parmeliaceae under the name, *Lichen olivaceus* and *L. stygius* in 1753. Later, in 1762 Hudson described two more species, *Lichen perforatus* Jacq. and *L. perlatus* Huds, which are presently accepted within the genus *Parmotrema* (Hale 1965, 195).

Acharius, who is recognized as Father of Lichenology, described a total of 114 species in five genera, which are currently members of the Parmeliaceae in "*Synopsis Methodica Lichenum*" (Acharius 1814, 195-303). These species are characterized by lecanorine apothecia. They consist of *Cetraria* (11 species), *Cornicularia* (8 species), *Evernia* (3 species), *Parmelia* (80 species), and *Usnea* (12 species).

The family Parmeliaceae was proposed by Zenker in 1827 (Eriksson and Hawksworth 1998). However, the largest genus, *Parmelia,* which was proposed by Acharius in 1803, included mostly foliose species (Hale 1987, 1). This genus was later segregated into several new genera by many lichenologists. Massalongo divided the genus *Parmelia* into *Menegazzia* in

1854 and *Parmotrema* in 1860. Nylander separated *Hypogymnia* and *Parmeliopsis* from it in 1869. Vainio splited the genus *Parmelia* subgenus *Euparmelia* into three sections, namely, *Amphigymnia*, *Hypotrachyna*, and *Xanthoparmelia* in 1890. Lynge established *Pseudoparmelia* in 1914. Zahlbruckner revised 10 genera of the family Parmeliaceae in 1962. These were *Anzia, Candelaria, Cetraria, Heterodea, Megalopsora, Nephromopsis, Parmelia, Parmeliopsis, Physcidia,* and *Pseudoparmelia.* Five of these genera with more than 30 species are presently accepted as members of this family (DePrist 1999, 441-443; Hale 1965, 196; 1984, 18; 1987, 1).

After Zahlbruckner period, there was improvement on techniques in lichen systematic study. Hale and Kurokawa segregated *Parmelia* subgenus *Parmelia* into five sections and four subsections. These are: section 1 *Parmelia* with subsection *Parmelia* and subsection *Simplices*, section 2 *Irregulares*, section 3 *Imbricaria* with subsection *Bicornute* and subsection *Imbricaria*, section 4 *Cyclocheila*, and section 5 *Hypotrachyna* (DePriest 1999, 447-451; Hale and Kurokawa 1964, 121-191; Hale 1984, 18; Lai and Qian 1993, 31-32). Hale proposed the genus *Parmelia* Ach. to be consisted of three subgenera: *Parmelia*, *Amphigymnia*, and *Xanthoparmelia* (Hale 1965, 195).

Mason Hale introduced new taxonomic criteria of the Parmeliaceae by using chemical characters and scanning electron microscopy (SEM) of cortical ultrastructures (Hale 1973). He proposed to use ultrastructural characters of the cortex as important criteria for classification. Based on those criteria, he divided the *Parmelia* subgenus *Amphigymnia* into 106 species

(Hale 1965, 193-358). This subgenus was changed to generic rank, *i.e.* *Parmotrema* Mass. with 124 species in 1974 (Hale 1974a, 334-339; Louwhoff and Elix 1999, 10). The *Parmelia* section *Xanthoparmelia* was first described by Vainio in 1890 (Hale 1974c, 489-490). In 1964 Hale changed it into subgenus *Xanthoparmelia*, and later on in 1974 he proposed it as a genus (Hale 1974c, 489-490; Nash *et al.* 1995, 10). Subsequently, some species of the genus *Xanthoparmelia* were described as new genera, these were *Arctoparmelia* (Hale 1986a, 251), *Flavoparmelia* (Hale 1986b, 603), *Karoowia* (Hale 1989b, 177), *Namakwa* (Hale 1988, 169), *Psiloparmelia* (Hale 1989a, 41; Elix and Nash 1992, 377), and *Xanthomaculina* (Hale 1985, 255).

The genus *Hypotrachyna* was described as a new genus, consisted of about 110 species, by Hale in 1974. This genus derived from the subgenus *Parmelia* section *Hypotrachyna* (Hale 1974b, 340-342; Hale and Kurokawa 1964). The genera *Bulbothrix* and *Relicina* arised from member of subgenus *Parmelia* section *Imbricaria* subsection *Bicornutae* (Hale and Kurokawa 1964; Hale 1974c, 479-481). The genus *Parmelina* originated from subsection *Imbricaria.* Elix and Hale splited this genus into *Canomaculina*, *Myelochroa*, *Parmelinella*, *Parmelinopsis*, and *Parmotremopsis* in 1987 (Elix and Hale 1987, 233-244).

The old genus *Pseudoparmelia*, which had been described by Lynge in 1914, was combined with the genus *Parmelia* subgenus *Parmelia* section *Cyclocheila* by Hale in 1974 (Hale 1974d, 188-191). Elix *et al.* separated

Pseudoparmelia into new genera *Canoparmelia*, *Paraparmelia*, and *Relicinopsis* in 1986 (Elix *et al.* 1986, 271-282).

Hale presented 44 genera of the family Parmeliaceae in 1990 (DePrist 1999, 443), while Elix included 64 genera and more 1,000 species based on morphological and anatomical characters as well as chemical constituents (Elix 1993, 359). Hawksworth *et al.* reported that the family Parmeliaceae consists of 85 genera with 31 synonyms and 2,319 species (Hawksworth *et al.* 1995, 332). He described this family as follow:

Thallus foliose of fruticose, corticates on both surfaces, usually with rhizoids, often brightly pigmented; ascomata apothecial, sessile, occasionally immersed or stalked, sometimes marginal, with a well-developed margin; interascal tissue of sparingly branched paraphyses, sometimes pigmented, the apices sometimes swollen; asci with a well-developed I+ apical cap with a more weakly I+ plug; ascospores varied, usually small, hyaline, and aseptate, without sheath. Pycnidia are frequently presented. Lichenized with green algae, cosmopolitan.

Morphologically five major groups of genera are recognized within the Parmeliaceae, namely the alectorioid lichens, the cetrarioid lichens, the hypogymnioid lichens, the parmelioid lichens, and the usneoid lichens. The alectorioid lichens are bread-like or truly fruticose, pendulous; consist of *Bryocaulon*, *Bryoria*, and *Pseudephebe*. The hypogymnioid lichens are usually characterized by hollow thalli with pseudocyphellae; the genera include *Hypogymnia*, *Cavernularia*, *Menegazzia*, and *Pseudevernia*.

The cetrarioid and parmelioid lichens are identical in morphological characters, but the differences are positions of apothecia and pycnidia (Krog 1982, 307-310; Karnefelt and Thell 1992, 181-204). Thalli of the cetrarioid genera are either strap-shaped, subfruticose or ascending foliose, which possess mainly marginal apothecia and pycnidia. It consists of 138 species in 23 genera: *Ahtiana*, *Allocetraria*, *Arctocetraria*, *Asahinea*, *Cetraria*, *Cetrariella*, *Cetrelia*, *Cetreliopsis*, *Coelopogon*, *Cornicularia*, *Dactylina*, *Esslingeriana*, *Flavocetraria*, *Karnefeltia*, *Masonhalea*, *Nephromopsis*, *Nimisia*, *Parmelaria*, *Platismatia*, *Tuckermannopsis*, *Tuckneraria*, *Vulpicida*, and *Bryocaulon*. The last genus was recently included in the list in 2000 (Randlane *et al.* 1997, 109-110; Randlane and Saag 2000). The Usneoids lichens are characterized by isodiametric fruticose thalli with basal holdfast. The thalli have prosoplectenchymatous supporting tissue bound by algal layer. It composes of *Usnea* and *Neuropogon*. However, Elix proposed criteria to segregate the Usneoid lichens into family Usneaceae. This family is known as having radial thallus structure, often with medullary chords. Beard-like thallus of the Usneaceae is lack of rhizines, but holdfast and lateral or terminal apothecia are normally presented (Elix 1993, 359; 1994, 1).

The parmelioid lichens are recognized by typical foliose growth form, possessing laminal apothecia and pycnidia. The lobes expand in horizontal plane, without erected growth. Hale and DePriest published a list of parmelioid genera gathered from Hale's previous publications. It shows numerous segregate genera of the genus *Parmelia* Ach.. The Parmelioid lichens are recognized to consist of approximately 1,300-1,500 species in 37

genera (Hale and DePriest 1999, 462-544): *Allantoparmelia*, *Almbornia*, *Arctoparmelia*, *Bulborhizina*, *Bulbothrix*, *Canomaculina*, *Canoparmelia*, *Cetrariastrum*, *Concamerella*, *Everniastrum*, *Flavoparmelia*, *Flavopunctelia*, *Hypotrachyna*, *Karoowia*, *Melanelia*, *Myelochroa*, *Namakwa*, *Neofuscelia*, *Omphalora*, *Paraparmelia*, *Parmelia*, *Parmelina*, *Parmelinella*, *Parmelinopsis*, *Parmeliopsis*, *Parmotrema*, *Parmotremopsis*, *Placoparmelia*, *Pleurosticta*, *Pseudoparmelia*, *Psiloparmelia*, *Punctelia*, *Relicina*, *Relicinopsis*, *Rimelia*, *Xanthomaculina*, and *Xanthoparmelia*.

The taxonomic treatment of this study is based on Hale and Elix classification scheme (Elix 1993, 1994; Hale and DePriest 1999). Elix used chemical characteristic as the major criteria for taxonomic identification of this family.

Chemistry

The secondary metabolites of lichens, often referred to as " lichen substances" or "lichen acids", have been studied intensively in Lichenology. They are routinely used in lichen systematics, more than chemical substances of other groups of organisms (Galun and Shomer-Ilan 1988, 3).

Approximately 700 substances have known structures. Methods for isolation and identification of lichen substances comprise of physical and spectroscopy methods, microcrystallization, thin layer chromatography, high performance liquid chromatography, gas liquid chromatography and derivatization (Huneck and Yoshimura 1996, 11).

In 1860s, Nylander carried out preliminary studies showing that chemical tests had considerable potential in Lichen taxonomy. First, he found iodine solution (I) to be a useful aid and later discovered that bleaching powder (Calcium hypochlorite, $Ca(OCl)_3$) also served as a useful taxonomic tool. Shortly after ward he also found that Potassium hydroxide (KOH) was equally valuable. Nylander surveyed systematic reagent tests on various genera (Elix 1992, 23).

The first extensive chemical investigation was conducted by Zopf. His publication on *Die Flechtenstoffe* in 1907s contained descriptions over 150 lichen compounds (Elix 1992, 23; 1999, 103; Huneck and Yoshimura 1996, 1). The final structural elucidation of many common lichen metabolites was due to the meticulous work of Asahina and coworkers in Japan during the 1930s. Asahina developed an additional spot test reagent as *para*-phenylenediamine (P or Pd) and more importantly, a microcrystallisation technique for definitive recognition of individual lichen acids on a routine basis. The development of microchemical detection methods has been far more important (Elix 1992, 23; 1999, 103).

During 1950s the Swedish chemist Wachtmeister introduced paper chromatography to identify lichen acids and their hydrolysis products (Elix 1992, 24), which beyond detectable capacity of microcrystallization techniques. Experimental problems, poor spot resolution, low sensitivity and long analysis time were subsequently overcome by the development of thin layer chromatography (TLC), which is now the most widely used method for identifying lichen products. This technique improves speed and precision to

recognize lichen substances by relatively simple and inexpensive means. Standard methods developed by Culberson and co-workers (Culberson 1970), and recently, high-performance liquid chromatography (HPLC) have been more widely used as efficient analytical tools for separation and identification of lichen substances (Feige *et al.* 1993; Elix 1996b).

These techniques play important role in the classification of lichens at generic and intrageneric levels. Lichens produce large numbers of secondary metabolites in the form of aliphatic acids, *para*- and *meta*- depsides, depsidones, usnic acids, xanthones, terpenes and terpenoids etc., through two main biosynthetic routes as shikimic acid pathway and the acetate malonate pathway (Elix 1996).

Historical Account of the Parmeliaceae in Thailand

Previous studies of the Parmeliaceae in Thailand by foreign and Thai botanists reported 25 genera and 100 species as shows in Appendix 1. The first report consisted of three genera and seven species. They were collected by Vainio, a Finnish lichenologist, from Koh Chang Island, Trat Province (Vainio 1909, 104-152). In 1921, Vainio published 2 genera and 14 species from Doi Suthep-Pui National Park, Chiang Mai Province. Four of them were new species: *Parmelia siamensis* Vain. [= *Parmotrema nilgherrense* (Nyl.) Hale], *Parmelia rahengensis* Vain. [= *Relicinopsis rahengensis* (Vain.) Elix and Verdon], *Parmelia osseoalba* Vain. [= *Hypotrachyna osseoalba* (Vain.) Y.S. Park and Hale] and *Parmelia coilocarpa* Vain. (Vainio 1921, 33 - 41).

Paulson reported 2 parmelioid species from Koh Tao (Paulson 1930, 99-101). In 1962, Sato published 8 species, 2 genera collected from Doi Inthanon and Doi Suthep–Pui National Park (Sato 1962, 1-4).

Hale described 6 new species of *Parmelia* from Southeast Asia. One of them was *Parmelia explanata* Hale [= *Parmotrema explanatum* (Hale) Hale] collected from Phu Kradung, Loei Province (Hale 1965, 199-200).

Three years later, Hale described a new species *Parmelia kingii* Hale [= *Hypotrachyna kingii* (Hale) Hale] collected from Khao Yai National Park, Nakhon Nayok Province (Hale 1968, 324-325).

Aguirre-Hudson and Wolseley collected samples from tropical forests of northern Thailand. They reported 15 genera with 24 species of the Parmeliaceae that can be used as bio-indicators of forest health (Wolseley 1997; Wolseley and Aguirre-Hudson 1995, 303-335; 1997a; 1997b; Wolseley *et. al.* 1994). However, there are 20 genera and 79 species in the checklist of lichen in Thailand, which was distributed by them (manuscript). Feeya Amatawiwat studied chemotaxonomy and chemistry of lichens in southern Thailand. She found fourty-four species (Feeya Amatawiwat 1994).

In 1993-1995 lichen research unit at Ramkhamhaeng explored biodiversity of lichens at Queen Sirikit Botanic Garden, Chiang Mai Province and Phuteen-Sounsai forest, Naheao National Park, Loei Province. Both projects collected more than 1,700 specimens of the Parmeliaceae. They are deposited at Ramkhamhaeng University herbarium (Piboon Mongkolsuk *et. al.* 1994; 1995). Some of these specimens are also included in this study. During a workshop on lichens at Khao Yai National Park in 1997 conducted

by Ramkhamhaeng University's lichen research unit, 14 species, 6 genera of the Parmeliaceae were reported as new additions to lichens of Thailand (Kansri Boonpragob *et. al.* 1998).

Distribution and Ecology of the Parmeliaceous Lichens

The Parmeliaceous lichens grow on a broad range of substrata in almost every natural environment (Roger 1992, 30). Investigations were carried on extensively in various parts of the world. This family has many cosmopolitan genera, including *Flavoparmelia, Flavopunctelia, Hypotrachyna, Imshaugia, Melanelia, Myelochroa, Neofuscelia, Parmelia, Parmelina, Parmelinopsis, Parmotrema, Platismatia, Punctelia, Rhizoplaca, Rimelia,* and *Xanthoparmelia* (Elix 1993, 367). An endemic element is often present in the lichen flora of a particular geographical region and may consist of genera of very limited distribution, for examples, *Ahtiana* and *Esslingeriana* in western North America, *Cetrariopsis* in eastern Asia, *Almbornia* in southern Africa (Galloway 1996, 200). *Cetrelia* has a center of origin in eastern Asia, *Platismatia* in north Pacific, and *Relicina* in tropical southeastern Asia (Elix 1993, 365). The paleotropical includes most of Africa, the Arabian Peninsula, most of the Indian subcontinent and the Malaysian archipelago, and the islands of the Pacific Ocean. Lichens of these areas are represented by genera of the Parmeliaceae such as *Bulbothrix, Canomaculina, Canoparmelia, Cetraiastrum, and Pseudoparmelia* (Elix 1993, 367). The

genus *Parmotrema* varies greatly in the tropical regions, where over 300 species are known (Louwhoff and Elix 1999, 24).

Table 1 Distribution of the Parmeliaceae in the World

Continents and Countries	Genera	Species	References
North America			
Adak Island, Alaska	8	19	Talbot et al. 1997
USA and Canada	41	293	Esslinger 1997
South America			
Venezuela	20	279	Feuerer 2000b
Ecuador and Galapagos Island	8	26	Feuerer 2001b
Peru	7	42	Feuerer 2001d
Bolivia	19	69	Feuerer 1999
Chile	8	62	Feuerer 2000a
Guianas	9	47	Sipman 1997
Brazil	21	299	Marcelli 2001
Uruguay	13	57	Osorio 2000
Argentina	36	272	Calvelo and Liberatore 2001
Europe			
Sweden and Norway	23	94	Santesson 1993
Great Britain and Ireland	13	52	Purvis et al. 1996
Germany	15	89	Wirth 2001
Italy	16	62	Nimis 1999
Ukraine	34	117	Kondratyuk et al. 1996
Turkey	15	38	John 1996
Africa			
Guinea	5	7	Thell 2001d
Sierra Leone	2	3	Thell 2001h
Ivory Coast	8	12	Thell 2001j
Tunisia	4	19	Seaward 1996
Cameroon	3	3	Thell 2001b
Angola	10	22	Thell 2001a

Table 1 (continued)

Continents and Countries	Genera	Species	References
Namibia	8	41	Feuerer 2001e
Zaire	8	25	Thell 2001m
Ethiopia	13	67	Thell 2001c
Somalia	4	4	Thell 2001i
Uganda	18	131	Thell 2001l
Kenya	31	197	Thell 2001e
Rwanda	4	12	Thell 2001g
Tanzania	21	139	Thell 2001k
Zambia	2	4	Thell 2001n
Zimbabwe	7	23	Thell 2001o
Mozambique	4	7	Thell 2001f
Lesotho	4	36	Feuerer 2001a
South Africa	28	375	Feuerer 2001f
Madagascar	10	42	Feuerer 2001c
Temperate Asia			
China	26	150	Lai and Qian 1993
Hong Kong	8	15	Thrower 1988
South Korea	15	53	Park 1990
Taiwan	30	137	Lai 2000
Japan	14	54	Okamoto 1995
Tropical Asia			
India and Nepal	16	182	Awasthi 1988
Thailand	26	142	in this study and Appendix1
Papua New Guinea and Irian Jaya	13	77	Streimann 1986
Australasia and small Pacific Islands			
Australia	33	395	Elix 1994
New Zealand	26	127	Malcom and Galloway 1997
The smaller Pacific Islands	23	130	Elix and McCarthy 1998

CHAPTER 3

METHODOLOGY

Study Areas

Thailand is located in the center of mainland South East Asia between latitudes 5° $37'$N to 20° $27'$N and longitudes 97° $22'$E to 105° $37'$E. It is bound by the Andaman Sea on the west, Myanmar on the west and northwest, Laos on the east and northeast, Cambodia on the east, and Malaysia and the Gulf of Thailand on the south (Figure 1).
(http://lib.utexas.edu/libs/PCL/Map_collection/cia99/Thailand_sm99)

The Climate and the Forest Vegetation of Thailand

The Climate of Thailand

Thailand is under the influence of monsoon climate characterized by alternate wet and dry seasons influence by the southwest monsoon and the northeast monsoon. It is divided into three seasons as follows (www.tmd.motc.go.th/eng/thclim.htm.).

Rainy or southwest monsoon season lasts from mid-May to mid-October. The southwest monsoon prevails over Thailand and abundant rain occurs all over the country. The wettest period of the year is August to

Figure 1 Map of Thailand

Source: http://lib.utexas.edu/libs/PCL/Map_collection/cia99/Thailand_sm99

September in the continental part. The exception is found in the peninsular of Southern Thailand, where the east coasts receive abundant rain until the end of the year from the northeast monsoon and November is the wettest month.

Cold season is under the influences of northeast monsoon. It spans from mid-October to mid-February. This is the mild period of the year with relatively cool-dry in December and January in the inland part of the country, but large amount of rain falls in the east coasts of Southern peninsular, especially during October to November.

Summer or pre-monsoon season lasts from mid-February to mid-May. This is the transitional period from the northeast to the southwest monsoons. The weather becomes warmer, in most part of the country. April is the hottest month.

The Forest Vegetation of Thailand

The forest vegetation of Thailand is one of the most complex types. The Royal Forest Department broadly categories forests into seven floristic regions: north (N), northeast (NE), east (E), central (C), southeast (SE), southwest (SW) and south (S) or peninsular regions (Tem Smitinand 1980). The Thai forests are divided into 3 major groups, which are the evergreen forest, the deciduous forest and forest or vegetation of other specific type (Figure 2). The detail characters of forests are described as follow: (Tem Smitinand 1977, 160-171; Weerachai Nanakhon 1993, 1-31).

1. Evergreen Forest

1.1 Lower Montane Forest or Hill Evergreen Forest This type of forest occurs on high mountain ridges and slopes from 700-2,562 m elevations. It scatters all over the country. Rainfall is heavy with annual precipitation ranges from approximately 1,500–2,000 mm. The tree trunks are generally covered with lichens, mosses and leafy fern. The dominant trees belong to family Fagaceae, such as *Castanopsis, Lithocarpus* and *Quercus*, with the presence Magnoliaceae, Ericaceae (*Rhododendron* sp.), *Betula alnoides, Catimbium, Daphne, Schima wallichii* and etc.

1.2 Tropical Rain Forest This forest type occupies slopes and ridges of the lowland at altitudes below 1,000 m. It occurs in the Southeast and Southern Peninsular of Thailand. The forest has multilayered strata with dense and a continuous crown canopy. Mean annual rainfall is more than 2,000 mm. The vegetation cover composes of high diversity of trees species, such as *Adenanthera, Dipterocarpus, Ficus* and *Hopea* sp. etc.

1.3 Dry Evergreen Forest The forest is scattered throughout the country along the valleys of long hill on the elevations range about 500-700 m, but rarely found in the south. The annual precipitation is between 1,000–2,000 mm. The forest is similar, but lesser complicate than that of the tropical rain forest. The dominant trees species are *Anisoptera costata, Dipterocarpus alatus* and *Hopea odorata.*

1.4 Pine Forest *Pinus kesiya* and *P. murkusii* are the only two species of pine occur in Thailand. *P. kesiya* generally occupies the areas at high altitudes between 700–1,300 m, whereas *P. murkusii* prefers lower elevation mainly at 400–800 m. This forest is found in the north and northestern regions such as Doi Suthep at 1,000–1,300 m, Doi Inthanon at 800–1400 m, Doi Khuntan at 1,000–1,350 m, Phu Rua at 1,000–1,300 m, Phu Kradueng at 1,200 m, Phu Luang at 1,000–1,800 m and etc.

1.5 Mangrove Forest The mangrove forest occupies coastal plain along the border of the land and the sea in the tropic. Forests are extensively found along the west coast from Satun Province to Ranong Province, along the coasts, on the Gulf of the Thailand from Samut Sakhon Province in the southwest to Trat Province in the southeast. The dominant species of trees are *Avicennia offcinalis, Rhizophora apiculata, R. mucronata* and *Xylocarpus* sp.

2. Deciduous Forest

2.1 Dry Dipterocarp Forest This forest covers mainly in northeastern and eastern region, at 150–700 m elevations. The typical forest is dry or extremely dry, with frequent fires. Annual rainfalls average 800-1,500 mm/year. This type of forest is characterized by five major species, *Dipterocarpus intricatus, D. obtusifolius, D. tuberculatus, Shorea siamensis, S. obtusa*, and *S. roxburghii.*

2.2 Mixed Deciduous Forest The vegetation of this forest type is widely distributed throughout the country. The annual rainfall is about 1,000-1,500 mm. Mixture of deciduous tree species characterizes the forests. The dominant trees are dipterocarp and teak. This forest is found in northern Thailand.

3. Specific Types

3.1 Secondary Forest The secondary growth is the effect of human encroachment as well as effective fire control in the National Park. This forest is in the low elevation at 400–1,000 m and generally found on both sides of roads.

3.2 Rubber Plantation and Plum Orchard Rubber plantation, *Hevea braziliensis,* in the South of Thailand at 0-100 m elevation replaces the tropical rain forest. The plum orchard, *Diospyros* sp., is planted in Doi Pui Research Station, Doi Suthep-Pui National Park at 1,400 m elevation.

Figure 2 Forest Types of Thailand

Note: 1. Lower montane forest or Hill evergreen forest (Phu Hin Rong Kla National Park)

2. Tropical rain forest (Khao Luang National Park)

3. Dry evergreen forest (NaHaeo National Park)

4. Pine forest (Doi Khuntan National Park)

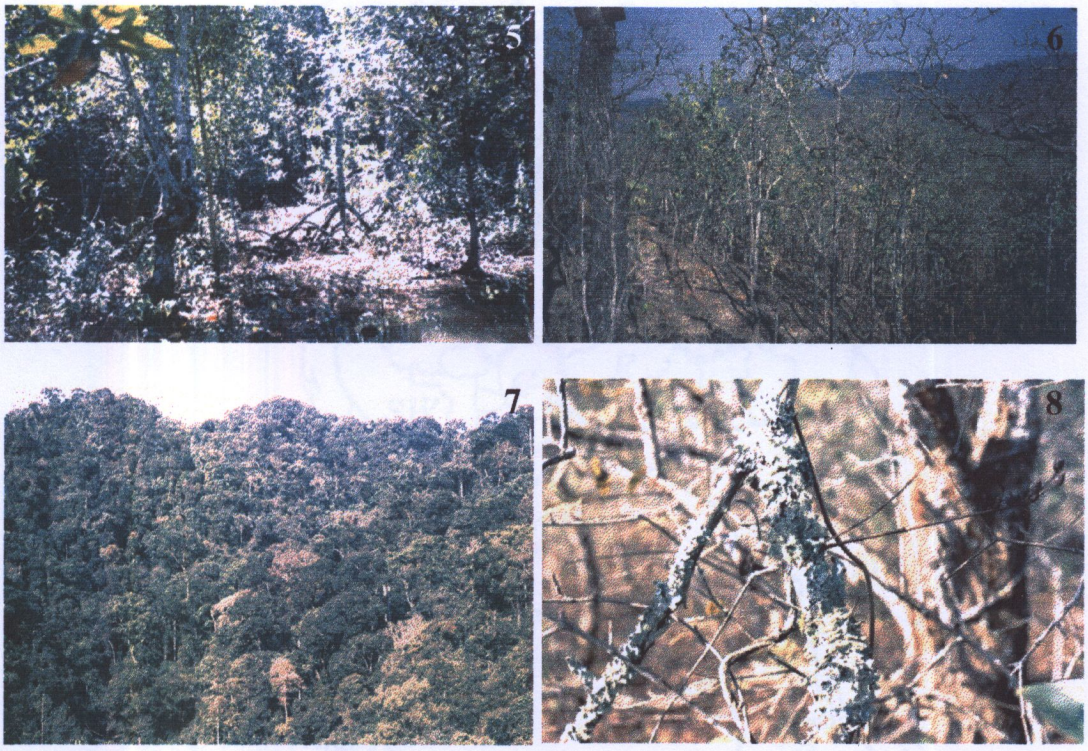


Figure 2 Forest Types of Thailand (continued)

Note: 5. Mangrove Forest (Trat Province)

6. Dry dipterocarp forest (Khuntan National Park)

7. Mixed deciduous forest (Queen Sirikit Botanic Garden)

8. Secondary forest (Khao Yai National Park)

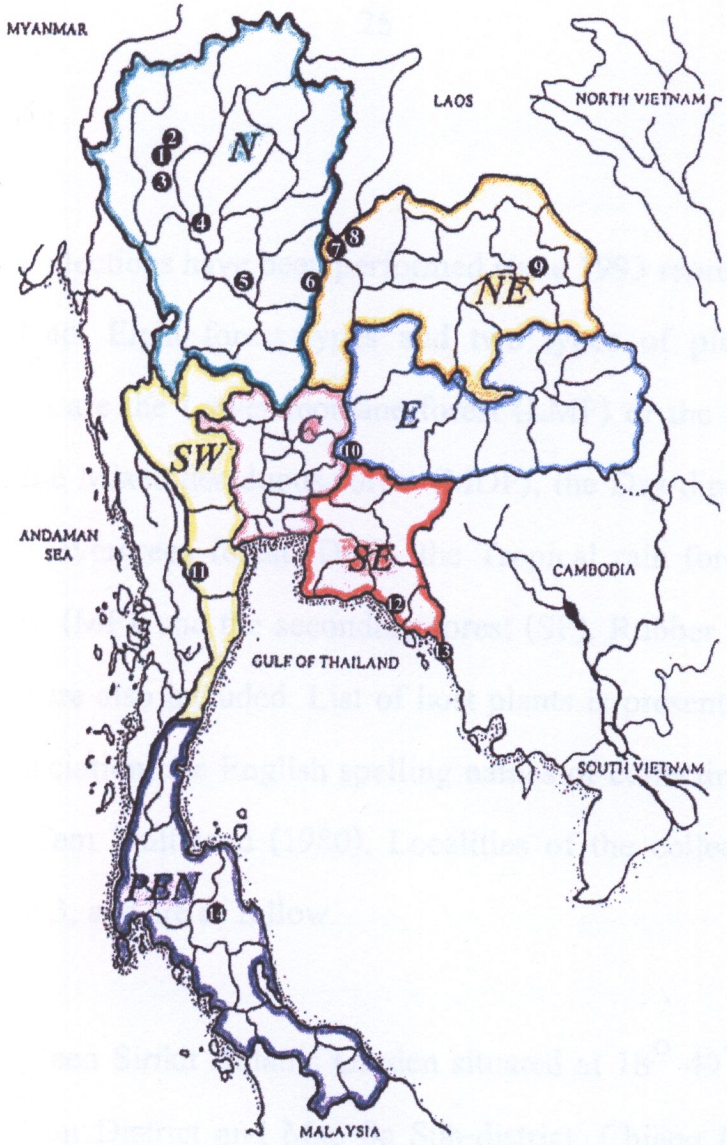


Figure 3 Collecting Localities of the Parmeliaceae in Thailand

Note: 1 = Queen Sirikit Botanic Garden, Chiang Mai Province; 2 = Doi Suthep-Pui National Park, Chiang Mai Province; 3 = Doi Inthanon National Park, Chiang Mai Province; 4 = Khuntan National Park, Lampang Province; 5 = Ramkhamhaeng National Park, Sukhothai Province; 6 = Phu Hin Rong Kla National Park, Phitsanulok Province; 7 = Na Haeo National Park, Loei Province; 8 = Phuraeu National Park, Loei Province; 9 = Phupan National Park, Sakon Nakhon Province; 10 = Khao Yai National Park, Nakhon Ratchasima Province; 11 = Kaeng Krachan National Park, Phetchaburi Province; 12 = Mangrove forest, Chantaburi Province; 13 = Mangrove forest, Trat Province; 14 = Khao Luang National Park, Nakhon Srithammarrat Province.

Collecting Sites

Lichen collections have been performed since 1993 represented various parts of Thailand. Eight forest types and two types of plantations were sampling. These are the Lower montane forest (LMF) or the Hill evergreen forest (HEF), the Mixed deciduous forest (MDF), the Dry dipterocarp forest (DDF), the Dry evergreen forest (DEF), the Tropical rain forest (TRF), the Mangrove forest (MF), and the secondary forest (SF). Rubber plantation and plum orchard were also included. List of host plants is presented in Table 3. For Thai pronunciation, the English spelling names of collecting sites follow the system of Tem Smitinand (1980). Localities of the collecting sites are shown in Figure 3, and are as follow.

1. The Queen Sirikit Botanic Garden situated at 18° 49′ N 98° 59′E between Mae Rim District and Mae Sa Sub-district, Chiang Mai Province. The main area is in Dry dipterocarp forest and the Mixed deciduous forest at 700-1,100 m elevation.

2. Doi Suthep-Pui National Park is located at 18° 48′ N 98° 58′ E Chiang Mai Province. The survey was made at Sankuu and Plum orchard in Doi Pui research station. These areas are mainly covered by the Lower montane forests comprise of oak-chestnut trees and the pine forest at 1,300-1,600 m elevation.

3. Doi Inthanon National Park located at 18° 45′ N 98° 48′ E Chom Tong District, Chiang Mai Province. It is the highest point in Thailand at 2,565 m compose of lower montane forest above 1,000 m elevation. Trees above 1,800 m is covered with lichens and wild orchids. The Parmeliaceae were mostly collected in the lower montane forest at above 2,000 m elevation.

4. Doi Khuntan National Park is situated at 18° 40′ N 99° 20′ E and administratively is included in three districts, which are Mae Tah District of Lamphun Province, Muang District and Hangchat District of Lampang Province. The area of the park is 255 km^2. The elevation is 325-1,363 m. The survey was made in the Dry dipterocarp forest at 600-700 m elevation near the Park's entrance and Yaw 2 site, which is in the Dry evergreen forest at 800 - 1,000m elevation, including the Pine forest at above 1,000 m elevation.

5. Ramkhamhaeng National Park is located at 16° 53′ N 99° 42′ E Sukhothai Province. The specimens were collected from the nature trail along the foothill of the mountain, from park's headquarter to the top of the mountain in the Dry evergreen forest. However, the specimens were found mostly on fallen log in front of the park.

6. Phu Hin Rong Kla National Park is situated at 16° 59′ N 101° 01′ E on the mountain between Phetchabun and Phitsanulok Provinces at 1,400-16,00 m elevations. The foliose and the fruticose lichens are abundant on rock outcrops. The forest at Lan Hin Tak, and Lan Hin Pum to Pha Chu Thong are

similar to the Hill evergreen forest, but relatively dry condition. Oak (*Quercus* sp.) and chestnut (*Castanopsis* sp.) trees are covered with epiphyte on the branches. The Samnak Amnat Rat and Lan Anak Prasong at the elevation about 1,200-1,400 m are rather shade and moist under the dipterocarp trees.

7. Na Heao National Park is situated at17° 05′N 101° 05′E Loei Province. This National Park is a pristine forest with high diversity of lichens. The specimens were collected along the trail from the village of Ban Hauy Num Phak to the top of Toko 2 Mountain between 865-1,200 m elevation. The forest turns into the Lower montane forest dominated by oak and chestnut trees at the summit where climate is rather dry and windy. The collections were carried on around Wat Chaloem Phrakiat, Ban Bomuaeng Noi District where the Dry dipterocarp forest occupies the altitudes between 750-900 m elevations. The last collection was performed at the Tropical rain forest, 200-450 m elevations, beside Huaeng River, the borderline between Thailand and Laos.

8. Phu Ruea National Park is located at 17° 05′ N 101° 07′ E Loei Province. Most areas are strange rock formations. Natural rock gardens are covered with orchids and rhododendrons, and sweeping vines over sandstone landscape. The plateau, rising to a maximum elevation of 1,365 m. The vegetation has been highly degraded by regular fires and chopping of trees, but this disturbance has created an open pine forest and savannah-like areas.

Particularly interesting are the communities of plants, moss, and lichen growing on rocks.

9. Phu Phan National Park is one of the highest mountains in the northeastern part of Thailand, situated at 16° 53′ N 104° 25′ E between Sakon Nakhon and Kalasin Provinces. The specimens were collected from the Dry evergreen forest at 300-400 m elevations located on the border of Sakon Nakhon and Kalasin Provinces. The second collecting area is in the Dry dipterocarp forest in Pha Nang Moen, and in the K.M. 25. The last area was Huai Wian Pri, where the Mixed deciduous forest occurs at 200 m elevation.

10. KhaoYai National Park is situated at 14°11′-14°25′N 101°22′-101°27′E. Its location is on the western edge of the Panom Dongrak mountain range in the northeastern Thailand. The park cover 2,168 km^2 situated in four provinces: Saraburi, Nakhon Ratchasima, Nakhon Nayok and Prachinburi. The main collections were done within 2 forest types. The specimens were collected from the secondary forests at Ban Chom Wiu to Nong Khing and the Old Golf Course at 600-800 m elevations. The lower montane forest occurs at the elevation above 1,000 m of Khao Khiao near the Radar station of the air force Army was also included.

11. Kaeng Kra Chan National Park is situated at 12° 47′ N 99° 27′ E. This area is the largest national park of Thailand, located in Phetchaburi Province. It covers an area of 2,915 km^2 on the western part of Thailand, along

the border of the Union of Myanmar. About eighty percent of the forest belongs to the Tropical rain forest, whereas twenty percent consist of the Lower montane forest, the Dry evergreen forest, the Dry dipterocarp forest and grassland. The specimens were collected from the Lower montane forest at 900-1,000 m elevation at Pa Noen Thung.

12. The Mangrove Forest Management Unit, Khlung District situated at 12° 26′ N 102°13′E Chanthaburi Province. This area is a pristine mangrove forest. The survey was done near the estuary of the Weru river.

13. The Mangrove Forest Management Unit located at 12° 26′ N 102° 07′E on Muang District, Trat Province. The specimens collected from the old forest dominated by *Rhizoflora apiculata*.

14. Khao Luang National Park situated at 8° 25′ N 99°58′E, approximately 570 km^2 in Nakhon Sri Thammarat Province, in the southern part of Thailand. Tropical rain forest is the main forest type. Foliose lichens were collected from Numtok Karom, at 70 m elevation, and rubber plantation in this National Park. The trunk of *Hevea braziliensis* is covered by various foliose lichen.

Table 2 Host Plants of the Parmeliaceae Collected in this Study

Scientific names of Hosts	Family of Hosts
Adenanthera pavonina Linn.	F. Mimosaceae
Adina cordifolia Benth and Hook.f	F. Rubiaceae
Afzelia xylocarpa Roxb.	F. Caesalpiniaceae
Anneslea fragrans Wall.	F. Theaceae
Artocarpus lakoocha Roxb.	F. Moraceae
Betula alnoides Buch-Ham	F. Betulaceae
Bombax anceps Pierre	F. Bombacacaea
Bombax ceiba Linn.	F. Bombacacaea
Bouea microphylla Merr.	F. Anacardiaceae
Canarium subulatum Gillaumin	F. Buraceae
Castanopsis costata A.DC.	F. Fagaceae
Castanopsis diversifolia King	F. Fagaceae
Castanopsis ferox Spach	F. Fagaceae
Croton tigium Linn.	F. Euphorbiaceae
Dalbergia oliveri Gamble ex Prain	F. Papilionaceae
Dillenia ovata Wall.	F. Dilleniaceae
Dillenia parviflora Griff.	F. Dilleniaceae
Diospyros kaki Linn.	F. Ebenaceae
Dipterocarpus intricatus Dyer	F. Dipterocarpaceae
Dipterocarpus obtusifolius Teysm. Ex Miq.	F. Dipterocarpaceae
Dipterocarpus tuberculatus Roxb.	F. Dipterocarpaceae
Elaeocarpus grandiflorus J.E.Smith	F. Eleocarpaceae
Engellhardtia spicata Blume	F. Juglandaceae
Garuga pinnata Roxb.	F. Burseraceae
Hevea brasiliensis Mull. Arg.	F. Euphorbiaceae
Holigrana kurzii King	F. Anacardiaceae
Litsea glutinosa C.B. Robinson	F. Lauraceae
Mangifera indica Linn.	F. Anacardiaceae
Melia azedarach Linn.	F. Meliaceae
Memoxylon sp.	F. Memocylaceae

Table 2 (continued)

Scientific names of Hosts	Family of Hosts
Oroxylum indicum (L.) Kurz	F. Bignoniaceae
Paramichelia baillonii (Pierre) Hu	F. Magnoliaceae
Parashorea stellata Kurz.	F. Dipterocarpaceae
Peltophorum pterocarpum Backer ex K. Heyne	F. Caesalpiniaceae
Pinus kesiya Royle ex Gordon	F. Pinaceae
Pittosporum ferrugineum Ait.	F. Pittosporaceae
Protium serratum Engl.	F. Buraceae
Pterocarpus macrocarpus Kurz	F. Papilionaceae
Quercus mespilifolioides A. Camus	F. Fagaceae
Rhizophora apiculata BL.	F. Rhizophoraceae
Schima wallichii Choisy	F. Theaceae
Shorea obtusa Wall.	F. Dipterocarpaceae
Shorea roxburghii G. Don	F. Dipterocarpaceae
Shorea siamensis Miq.	F. Dipterocarpaceae
Spondias sp.	F. Anacardiaceae
Sterculia pexa Pierre	F. Sterculiaceae
Stereopermum neuranthum Kurz	F. Bignoniaceae
Styrax benzoides Craib.	F. Styraceae
Syzygium claviflorum (Roxb.) A. M. Cowan and Cowan	F. Guttiferae
*Tectona grandis*Linn.	F. Verbenaceae

Materials and Data Collections

This study is based on specimens collected during extensive survey on several parts of Thailand from 1998 to 1999. It also included specimens preserved in the herbarium at Ramkhamhaeng University. They consisted of approximately 1,500 specimens collected by staffs of the Lichen Research Unit, Ramkhamhaeng University during 1993 to 1995 from Queen Sirikit Botanic Garden, Chiang Mai Province and Nahaeo National Park, Loei Province.

Preparation of Herbarium Specimens

Foliose lichens grow on trees, dead woods, rocks, soil and other substrates were collected by pocket knife or hammer and chisel. Occasionally the thalli were sprayed with water to make them soft for easily removal from substrates. The samples should include the margins of the thallus and fruiting body, if presented. In some cases, samples on rocks are difficult to collect. It is scrape off with a cutter or sharp knife. The collected samples were bound by tissue papers and enclosed in paper envelopes, where information of the collection is primarily noted. The specimens were then keep in cloth bag to prevent from damage during transportation. They were air-dried before examination and for storage in herbarium. Lichens are not pack in plastic bags as they are quickly discolor and become mouldy.

During identification process, the dry specimens were kept in standard size pockets, 21 x 29 cm, made from brown paper. Index cards 7.5 x 12.5 cm were inserted in envelopes, under the samples, for labeling numbers and biological information of specimen. Information of specimens included scientific name family, date of collection, collector, collecting locality, altitude, substrate or host, determinator and the date as well as other important information.

Morphological and Anatomical Observations

Macroscopic Examination

The morphology of the thallus including lobe size, rhizines, cilia, vegetative propagules, reproductive structure, color and surface texture were examined by using a hand magnification of 10x or 20x and low magnification stereomicroscope (Olympus, SZ) from 14x to 80x.

Microscopic Examination

The anatomical characters of thallus including reproductive structure, apothecium and pycnidium were free-hand sectioned with the aid of razor blade. Investigation of the fine structures was performed under light microscope (Olympus, CH) from 40–1,000 magnifications.

Scanning Electron Microscope Examination

The characters of pored epicortex and non- pored epicortex on upper surface were studied by Scanning Electron Microscope (SEM, Jeol JSM-35CF) at Central Laboratory and Greenhouse Complex of Khamphangsaen Campus, Kasetsart University in Nakhon Pratom Province.

Illustrations (Drawings and Photographs)

Macroscopic and microscopic characters of every taxon were illustrated by using a drawing tube (Olympus) and Olympus stereomicroscope equipped with eyepiece of 4x to 40x. Measuring of thallus and reproductive structure were made under the light microscope. Photographs of the thallus under the stereomicroscope were taken by using Nikon, SMZ-10. Detail characters of reproductive structure under the light microscope (Nikon, Optiphot) were recorded by using Nikon (FDX-35) at the Department of Biology, Ramkhamhaeng University.

Spot Test

Spot tests for color reactions of lichen substances were carried out on thallus. The reagents were applied with a haemalytic capillaries. For tests of the medulla a small area of the overlying cortex were removed with a razor

blade. The color test for lichen substances are usually carried out with the following reagent according to Elix (1994, 2-3):

1. A 10% aqueous solution of potassium hydroxide (K).
2. Commercial bleach solution (Sodium hypochorite) (C).
3. A saturated solution of *para*-phenylenediamine in 95% ethanol (P or Pd).
4. K reagent immediately followed by C reagent (KC).

Thin Layer Chromatography (TLC)

Lichen substances of the Parmeliaceae were identified by thin layer chromatography method according to the standard method of White and James (1985) and Elix and Ernst-Russell (1993). A thallus fragments were placed in small test tubes and added four drops of acetone to extract lichen substances from the thallus. These extraction were evaporated in a warm water-bath to get concentrated solutions. These solutions are then spotted on the tlc-plate using a capillary tube for each sample. Merck silica gel 60 F-254 per-coated aluminum 20 x 20 cm tlc-plate for each solvent system was used. A 2B pencil was used to mark base line and front line, 1.5 cm from the bottom edge and 11 cm above the base line respectively. Nineteen points were made on each notches at 1 cm intervals.

The control lichen used for routine identification of lichen substances in the parmelioid was *Hypotrachyna kingii*, containing atranorin, norstictic acid and salazinic acid base on R*f* class 7, 4 and 2 respectively.

Two standard solvent systems, A and G were used, for routine examinations. The basic solvent systems were prepared according to White and James (1985) as follow.

A = Toluene (180 ml): dioxan (60 ml): acetic acid (8 ml) (T.D.A.)

G = Toluene (139 ml): ethylacetate (83 ml): formic acid (8 ml)

The treated tlc-plates were placed into the solvent tanks and left the solvent moved to the terminating front line. The plates were then, taken out of the tank and dried at room temperature. Pigments were observed and marked under daylight. Spot detection and color note were marked under ultra violet light at 254 nm. Fatty acid can be detected by spraying distilled water on the solvent G plate, and then dried the plate. The lichen substances were developed after spraying with 10% sulphuric acid solution and heat the plate in an oven or on a hot plate at 110 °C for about 10 to 15 minutes. After heating, the spots were marked under ultraviolet light at 365 nm for checking characteristic of the spots. Identification of lichen substances was determined from R*f* class, color spot in daylight and under ultraviolet fluorescence both before and after heating. In some cases comparison with spot tests were needed to confirm the identification.

CHAPTER 4

MORPHOLOGICAL, ANATOMICAL, AND CHEMICAL CHARACTERS OF THE PARMELIOID LICHENS

Fundamental criteria for identification of the Parmeliaceae rely on thallus characters rather than the ascomata. The parmelioid lichens, which possess laminal apothecia and pycnidia, were determined based on Hale and Elix (Hale 1965; Hale and Kurokawa 1964; Elix 1993; 1994). The characters that have been used for segregating genera and species are as follows.

Structure of thallus includes lobes configuration, (the pored) epicortex, tissue of upper and lower cortex, thallus color, thallus ornamentation, and vegetative propagules. Reproductive structure comprises sexual and asexual reproduction. Ascomata apothecium is a reproductive structure fills with bitunicate ascus and ascospores, which are hyaline, simple, ellipsoid to reniform, and containing eight ascospores per ascus. Conidiomata pycnidium is a structure for asexual reproduction. It produces conidia or pycnidiospores on conidiophores. However, this character require further study. Photobiont of this family is *Trebouxia*, a coccoid, unicellular green algae. Chemical substances in the cortex and medulla were also used. Cortical substances were atranorin, chloroatranorin, lichexanthone, and usnic acid. Sixty medullary substances mainly consist of orcinal depsides, orcinal depsidones, β-orcinal depsides, and β-orcinal depsidones.

Structural and Thallus Characters

Epicortex on surface of thallus, is important for identification of the Parmeliaceae. Foliose thallus of this family is typically composed of few stratified layers called heteromerous (Figure 4). The upper and lower cortical layers provide both protection and structural support. The algal layer is generally found below the upper cortex in a distinct zone. The medullary layer is loosely interwoven hyphae situated between the upper and lower cortex (Hale 1979; 1981; Hawksworth and Hill 1984).

Thallus is divided into numerous branches called lobe, which shows various degrees of branching (irregular to dichotomously branched). Generally, lobe arranges in radial or overlap. Lobe width is one of the taxonomic characters (Hale 1979). Parmelioid lichens with narrow lobes are those with lobe width less than 3 mm, flat to convex, irregular to dichotomously branched, linear with incised to truncate apex. These lichens are identified as *Bulbothrix queenslandica*, *Everniastrum* (3 species), *Parmeliopsis ambigua*, *Relicina* (3 species), *Relicinopsis* (3 species), *Xanthoparmelia* (2 species). Broad lobes with widths range from 3 to more than 20 mm, flat to subascending, crowed, irregular branched, sublinear to elongate with rounded or rotund apex are those, for example, identified as *Bulbothrix* (7 species), *Canomaculina subtinctoria*, *Canoparmelia* (2 species), *Hypotrachyna* (15 species), *Myelochroa*, *Parmelinella*, *Parmelinopsis* (4 species), *Parmotrema* (28 species), and *Rimelia reticulata*. Margins of lobes

may vary from entire, crenate or dentate. In some species, margins have line of dark brown to black rim, for example, *Parmelinopsis microlobulata.*

Epicortex

The epicortex of parmelioid lichens is recognized as a thin polysaccharide sheet at 0.6—1 μm thick. It covers the upper cortex and some part may be free from the cortex. It is a unique character belongs to some genera of the Parmeliaceae. The epicortex is characterized into non-pored epicortex and pored epicortex (Hale 1973; 1981; Lawrey 1984, 13). Genera with non-pored epicortex produce pseudocyphellae, such as *Melanelia*, *Parmelia*, *Punctelia*, etc, which are not found in this study.

The pored epicortex is distinguished by numerous, more or less, regular perforations. The pores are not penetrated into the medulla. The maximum size and density of pores vary by ages of specimens. The normal diameters range between 15—40 μm, with 100—400 pores per mm^{-2} respectively (Hale 1981). In this study, the pored epicortex have diameters between 5—50 μm, and separated into three sizes by using 540 magnification. The small size, up to 5 μm, was observed in *Hypotrachyna*, *Parmelinopsis*, *Relicina* (Figure 5A) and *Xanthoparmelia* (Figure 5B). The medium size, approximate 10 μm, represented by *Bulbothrix* (Figure 5C), *Canomaculina*, *Canoparmelia* (Figure 5D), *Parmeliopsis*, *Parmotrema*, and *Rimelia.* The large size, up to 50 μm, was found in *Everniastrum*, *Myelochroa* (Figure 5E), *Parmelinella*, and *Relicinopsis* (Figure 5F). It is noteworthy that species with pseudocyphellae

never form pored epicortex, and consequently species with a pored epicortex never form pseudocyphellae (Hale 1973; Elix 1993; Lai 2001).

The Upper and Lower Cortex

Cortex is the outermost layer of the thallus. It consists of upper cortex and lower cortex, which attached to the substrate. The cortex layer aids in gas exchange. Hale recognized three basic types of cortical tissue: paraplectenchyma, prosoplectenchyma, and palisade plectenchyma (Hale 1976; Lawrey 1984).

Paraplectenchymatous tissue is a pack of hyphae oriented randomly. It appears as short cell in both transverse and longitudinal sections. Prosoplectenchymatous tissue is formed by parallel-elongated hyphae with conglutinated cell walls and longer than paraplectenchyma cell in longitudinal section, but look similar in transverse section. The prosoplectenchymatous tissue is not formed in the cortex but formed in rhizines and cilia of most parmelioid species. Lastly, palisade plectenchymatous tissue composes of short hyphae oriented vertically similar to palisade cells in the leaf tissue of flowering plants.

The upper cortex is well-developed plectenchymatous tissue of about 3—7 rows. This layer is formed by hyphae of the medulla growing from the inner part of the thallus in right angles to the surface (Lawrey 1984). This layer has a protective function. It prevents excessive water loss of the algae. It may have physiological role in reducing intensity of sunlight reaching the

algae (Rundel 1978; Hale 1981, 2). Amongst seventy-five parmelioid species (Table 3), paraplectenchyma of the upper cortex (Figure 4A and 4B) is formed in 2 genus 4 species. Whereas, the palisade plectenchyma of upper cortex (Figure 4C and 4D) represented by 12 genus 71 species. The lower cortex of all species is paraplctenchymatous tissue.

Table 3 Types of Cortical Tissue in the Parmelioid Species

Types of tissue	Species
Paraplectenchyma	*Everniastrum nepalense, E. cirrhatum, E. scabridum,* *Rimelia reticulata*
Palisade plectenchyma	*Bulbothrix goebelii, B. hypochraea, B. isidiza, B. meizospora, B. queenslandica, B.sensibilis, B. setschwanensis, B. tabacina,* *Canomaculina subtinctoria,* *Canoparmelia ecaperata, C.owariensis,* *Hypotrachyna adducta, H. adjuncta, H. chlorobarbatica, H. coorgiana, H. costaricensis, H. crenata, H. ducalis, H. exsecta, H. immaculata, H. kingii, H. mason-halei, H. osseoalba, H. physcioides, H. ramkhamhaengiana, H. scytodes,* *Myelochroa siamea, M. xantholepis,* *Parmelinella chozoubae, P. wallichiana,* *Parmelinopsis expallida, P. horrescens, P. microlobulata, P. minarum,* *Parmeliopsis ambigua,* *Parmotrema abessinicum, P. amaniense, P. corniculans, P. cristiferum, P. dilatatum, P. elacinulatum, P. explanatum, P. eunetum, P. gardneri, P. hababianum, P. incrassatum, P. maclayanum, P. mellissii, P. merrillii, P. overeemii P. planatilobatum, P. poolii, P. praesorediosum,P.pseudocrinitum, P. pseudonilgherrense, P. rampoddense, P. rubromarginatum, P. saccatilobum, P. sancti-angelii, P. subarnoldii, P. sulphuratum, P. thailandicum, P. tinctorum,* *Relicina abstrusa, R. subabstrusa, R. sublimbata,* *Relicinopsis intertexta, R. malaccensis, R. rahengensis,* *Xanthoparmelia congensis, and X. moegeotina*

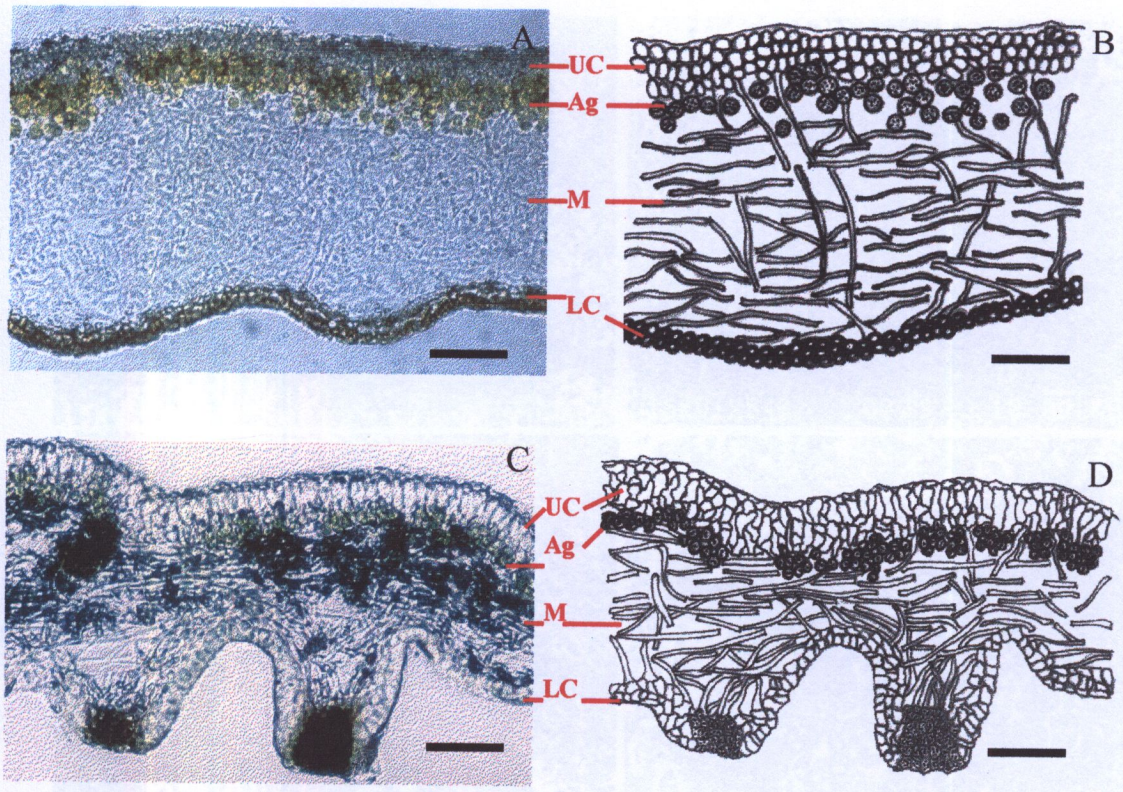


Figure 4 Cross Section of Heteromerous Thallus

Note: A. X-section of thallus shows paraplectenchymatous tissue in upper cortex [RU—— 955 (RAMK), scale = 50 μm].

B. Illustration of x-section thallus with paraplectenchymatous tissue (scale = 36 μm).

C. X-section of thallus shows palisade plectenchymatous tissue in upper cortex [RU——6965 (RAMK), scale = 50 μm].

D. Illustration of x-section thallus with palisade plectenchymatous tissue (scale = 50 μm).

[UC = Upper cortex; Ag = Algal layer; M = Medulla; LC = Lower cortex].

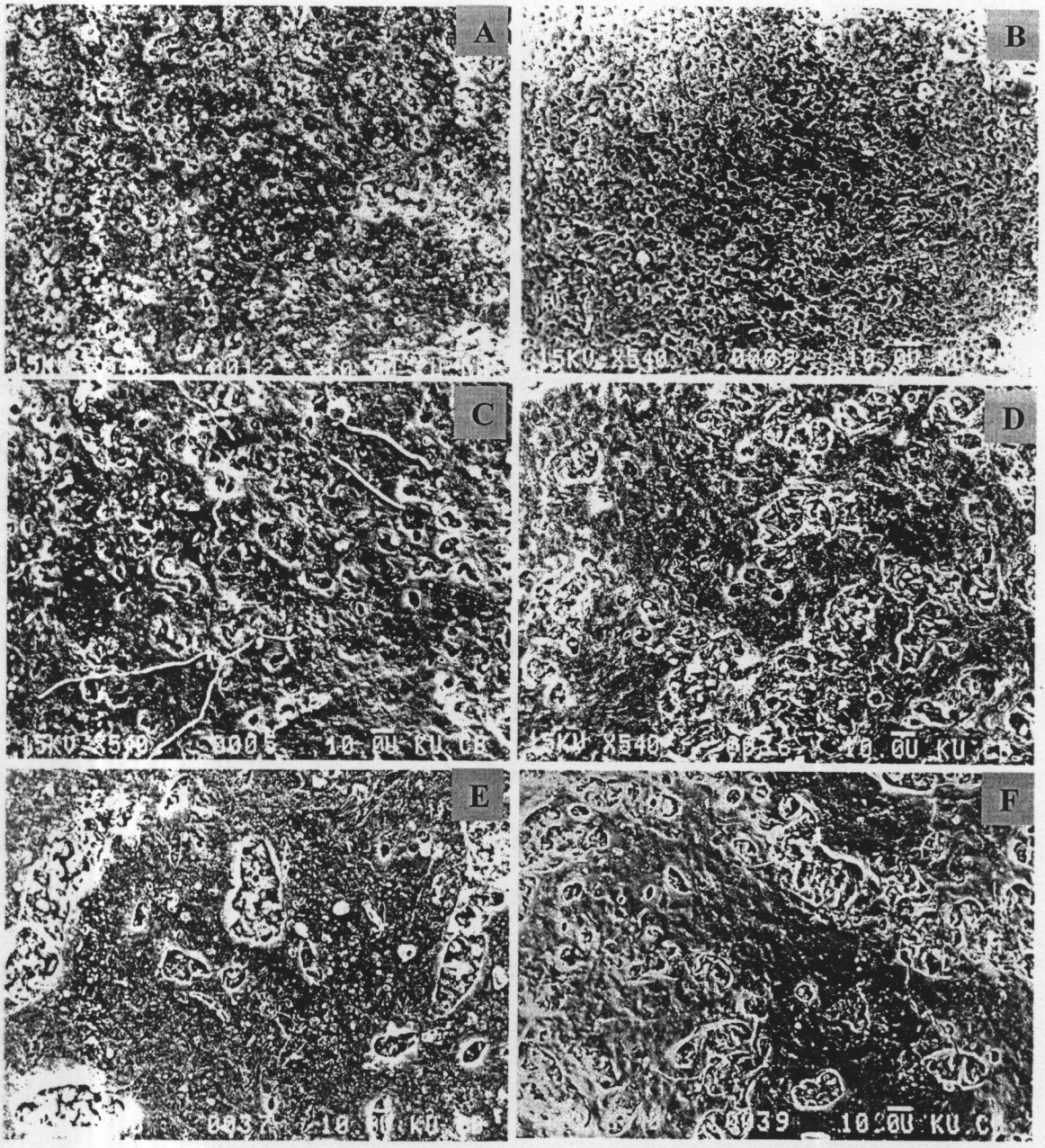


Figure 5 The Pored Epicortex of Some Parmelioid Genera by SEM, Magnification 540 x

Note: A. Small sized epicortex of *Relicina* [RU—6590 (RAMK), scale = 10 μm].

B. Small sized epicortex of *Xanthoparmelia* [RU—10331 (RAMK), scale = 10 μm].

C. Medium sized epicortex of *Bulbothrix* [RU—10154 (RAMK), scale = 10 μm].

D. Medium sized epicortex of *Canoparmelia* [RU—10327 (RAMK), scale = 10 μm].

E. Large sized epicortex of *Myelochroa* [RU—4261 (RAMK), scale = 10 μm].

F. Large sized epicortex of *Relicinopsis* [RU—6965 (RAMK), scale = 10 μm].

Thallus Color

Colors of thallus in the parmelioid lichens are mostly pale gray to greenish gray and yellowish green. The different tensity of green in some thallus is due to compacting of green algae under the cortical layer. The thallus with patches of pale green is found in *Canomaculina subtinctoria*, *Canoparmelia ecaperata*, *Relicinopsis intertexta*, etc.

Based on chemical constituent, color of thallus belongs to two groups. The first group shows pale gray to greenish gray upper surface owing to absence of pigment or presence of colorless lichen substances: atranorin, chloroatranorin, and lichexanthone. This group occurs in *Bulbothrix* (8 species), *Canomaculina* (1 species), *Canoparmelia* (1 species), *Everniastrum* (3 species), *Hypotrachyna* (15 species), *Myelochroa* (2 species), *Parmelinella* (2 species), *Parmelinopsis* (4 species), *Parmotrema* (28 species), and *Rimelia* (1 species). The second group contains usnic acid, which makes the upper surface appears yellowish green, for example, *Parmeliopsis* (1 species), *Relicina* (3 species), *Relicinopsis* (3 species), and *Xanthoparmelia* (2 species). Besides age of thallus, environmental factors also affect color of thallus. The mature thallus shows paler green than the younger one. The environment has no effect on the thallus color.

The color of lower surface is usually ivory, pale brown to black. The melanin pigment in the lower cortex resulted in dark brown and black appearance. The accumulation of melanin pigment in the lower cortex might affects shade of color in some species, such as *Bulbothrix tabacina*,

Everniastrum cirrhatum, E. nepalense, E. scabridum, Hypotrachyna coorgiana, H. ducalis, H. kingii, H. osseoalba, H. scytodes, Parmelinella chozoubae, P. wallichiana, and *Rimelia reticulata,* etc. Thallus color is one feature that requires generic determination. For example, the thallus of *Canoparmelia* and *Parmotrema* are black at the center and pale brown at the marginal zone, which were obviously seen without rhizines (Figure 22B and 57B).

The medulla is mostly white, with pale yellow in some species, for example, *Myelochroa siamea* (Figure 45A), *M. xantholepis, Parmotrema sulphuratum* (Figure 83A). The medulla layer of *Parmotrema dilatatum* containing usnic acid generally shows bright yellow in sunny habitats. However, some specimens collected from shade habitats show yellow layer in the upper part of medulla and pale yellow to white in most part of the lower medulla. Furthermore, *Parmotrema rubromarginatum* has red marginal lobes to the base of cilia. The red color is probably anthraquinone substances (K+ purple).

Thallus Ornamentation

The ornamentation of parmelioid lichens in Thailand have three kinds: cilia, rhizines, and maculae. Cilia are hair-like outgrowth from the margin of thallus. Rhizines developed from the lower cortex for attaching to the substrate. Macula is a small pale blotch on the upper surface of thallus. It's often caused by a lack of green algae cells (Hale 1979; Filson 1992).

Cilia

The presence and form of cilia are important character to distinguish the generic and species levels. Cilia of the parmelioid lichens in Thailand compose of two types; simple cilia and bulbate cilia (Figure 6A and 6B). The simple cilia are presented in *Canomaculina, Myelochroa, Parmelinella, Parmelinopsis, Parmotrema,* and *Rimelia.* In addition, some species have branches cilia, for example, *Parmotrema hababianum* and *Rimelia reticulata.* Whilst, bulbate cilia are found on *Bulbothrix* and *Relicina.* In addition, *Bulbothrix goebelii* and *Relicina sublimbata* have bulbate cilia at the base and branched at the apex. However, branching of cilia is not the main character for identification.

Position of cilia mainly occurs along the margins of lobes. A few species produced cilia along the margin of lobules such as in *Myelochroa xantholepis* (Figure 45B). Cilia produces from isidia are called 'ciliate isidia'. This is found in *Parmelinopsis horrescens* (Figure 53B). In some case, cilia are produced from apothecia such as *Parmotrema elacinulatum* (Figure 63B). *Parmelinella chozoubae* and *P. wallichiana* are characterized by cilia in axils of lobes.

Rhizines

Rhizine has root-like structure composes of thread of hyphae functioning for attachment to the substrate. Different types of rhizines may be

valuable for generic and species identification. Branching of rhizine has been recognized as a consistent generic character (Hale and Kurokawa 1964), as follows: squarrosely branched rhizines of *Rimelia* (Figure 6C), dichotomously branched of *Hypotrachyna* and *Parmelinopsis* (Figure 6D), and dimorphous rhizines (short and long rhizines) of *Canomaculina subtinctoria* (Figure 6E) are particularly distinctive. Rhizines of *Bulbothrix*, *Canoparmelia*, *Everniastrum*, and *Parmotrema* are simple (Figure 6C). One species, *Rimelia reticulata,* has both simple and squarrose rhizines in their thallus.

Maculae

Maculae are recognized submacroscopically as pale spots or areas cause by discontinuities of the green algae layer below the upper cortex. This feature resulted in spot or marble appearances of the thallus. Three types of maculae are observed in this study, spotted maculae of *Relicinopsis* species (Figure 6F), effigurate maculae of *Canomaculina subtinctoria* (Figure 6G), and reticulate maculae of *Rimelia reticulata* (Figure 6H).

Vegetative Propagules

Vegetative propagules of thallus are used to determine species level. Only four types were studied as follow: isidia and soredia are common structure, lobules and pustule originate from isidia and soredia (Jahns 1973; Hale 1979; filson 1992).

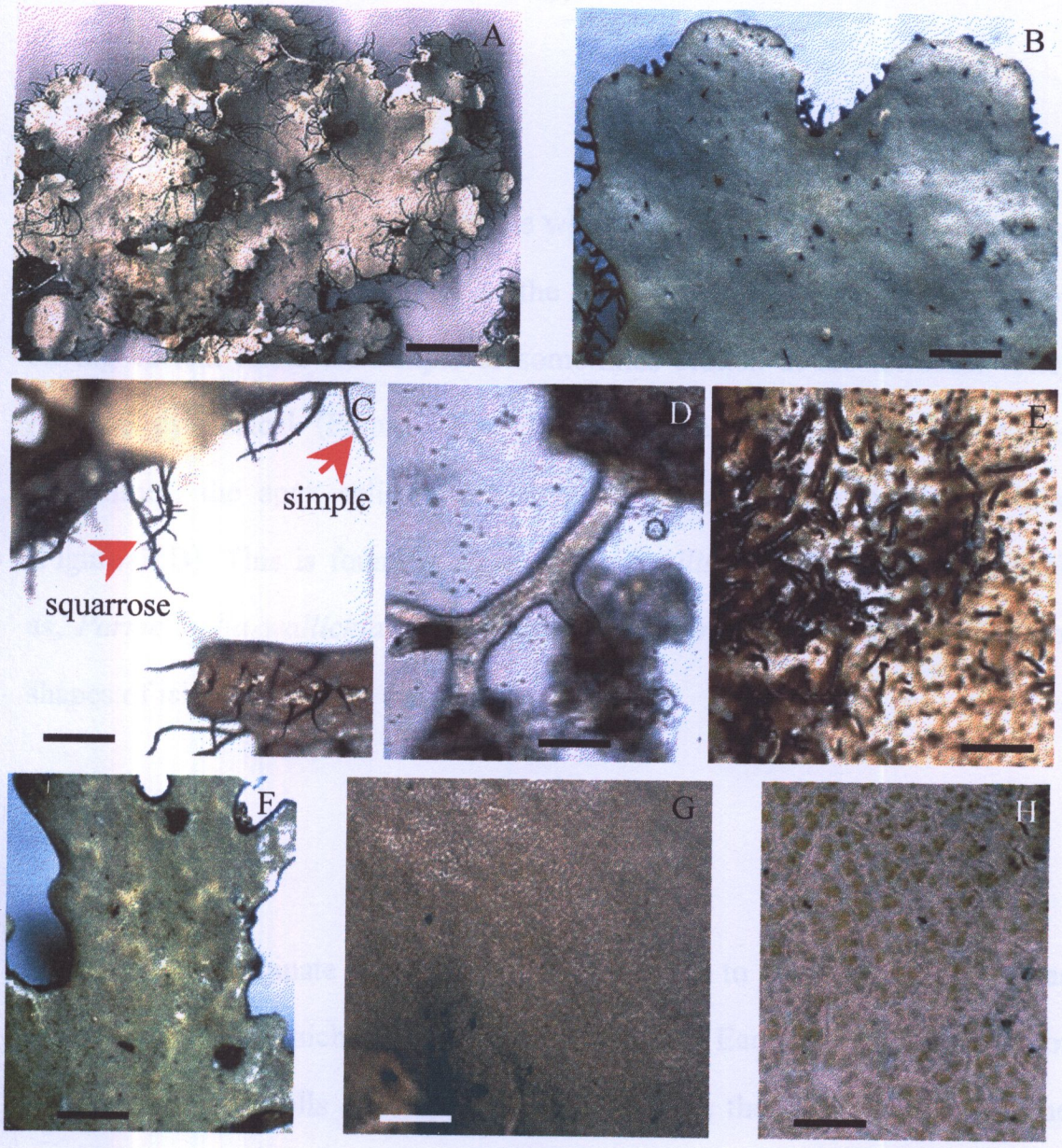


Figure 6 Thallus Ornamentation

Note: A. Simple cilia [RU——7952 (RAMK), scale = 1 cm]; B. Bulbate cilia [RU——10154 (RAMK), scale = 0.8 mm]; C. Simple and squarrose rhizines [RU——10247 (RAMK), scale = 0.25 cm]; D. Dichotomously branched rhizine [RU——7990 (RAMK), scale = 0.12 cm]; E. Dimorphic rhizines [RU——4651 (RAMK), scale = 0.22 cm]; F. Spotted maculae [RU——6773 (RAMK), scale = 1 mm]; G. Effigurate maculae [RU——4651 (RAMK), scale = 1 mm]; H. Reticulate maculae [RU——10247 (RAMK), scale = 0.5 mm].

Isidia

Isidia erect and scatter over the whole surface of the thallus or confine to the margins at the older parts of the thallus. Isidia differ from soredia by having cortex. Isidia are simple or sometimes branch at the terminal. They may be cylindrical (Figure 7A), globose, flattened, or coralloid shapes. Sometimes, the apex splits and becomes soredia called 'sorediate isidia' (Figure 70B). This is found in *Parmotrema mellissii*. Some specimens such as, *Parmelinella wallichiana*, *Parmotrema tinctorum*, etc. produce different shapes of isidia.

Soredia

Soredia originate in the medulla and erupt to the surface appear as clump of powder, which can be easily wiped away. Each soredium consists of a few photobiont cells envelope by fungal hyphae that never corticate. The diameters of grain range from 25–100 μm, appear as floury or granular. Soralia originate by rupture of upper cortex and then replaced by a powdery or granular mass of soredia (Figure 7B and 7C). The solaria are divided into several types based on shape and position (Jahns 1973, 46-47). These are, for examples, laminal soralia of *Parmeliopsis ambigua* (Figure 56B), the marginal soralia of *Parmotrema cristiferum* (Figure 61B), the terminal soralia of *Rimelia reticulata* (Figure 94B), and the capitate soralia of *Hypotracyna immaculata* (Figure 38B).

Lobule

Lobule is distinctly small foliose, flattened, and dorsiventral growths on the upper cortex (Figure 7D). This vegetative structure disperses similar to soredia and isidia. This structure is called 'lobulae or lobules' by Hale, but Poelt called 'phyllidia' (Poelt 1973, 107). *Myelochroa xantholepis* has compact and imbricate lobules on the upper surface (Figure 47B). *Parmelinopsis microlobulata* has distinct lobules called 'isidioid lobules' (Figure 54B), which formed globose isidia when young and become flatten at maturity. The lobes of *Parmotrema planatilobatum* produced more imbricate laciniate-lobules on the upper surface and along the margins (Figure 73B).

Pustule

This structure is developed from isidia or soredia (Esslinger 1977; Hale and Kurokawa 1964). Pustulate isidia is actually the isidia, which develop to be blister-like but its apex does not open (Figure 7E). The example species are *Canoparmelia owariensis* and *Hypotrachyna adjuncta*. Pustulate soredia are different from the pustulate isidia. Pustulate soredia originate from swelling of thallus, then open, tear off and split irregularly. After splitting of thallus, the cortex is exposed and then margins become soredia (Figure 7F). The granular soredia with exposing medulla and lower surface are one feature of the pustule soredia that found in *Hypotrachyna exsecta*, *H. kingii*, etc.

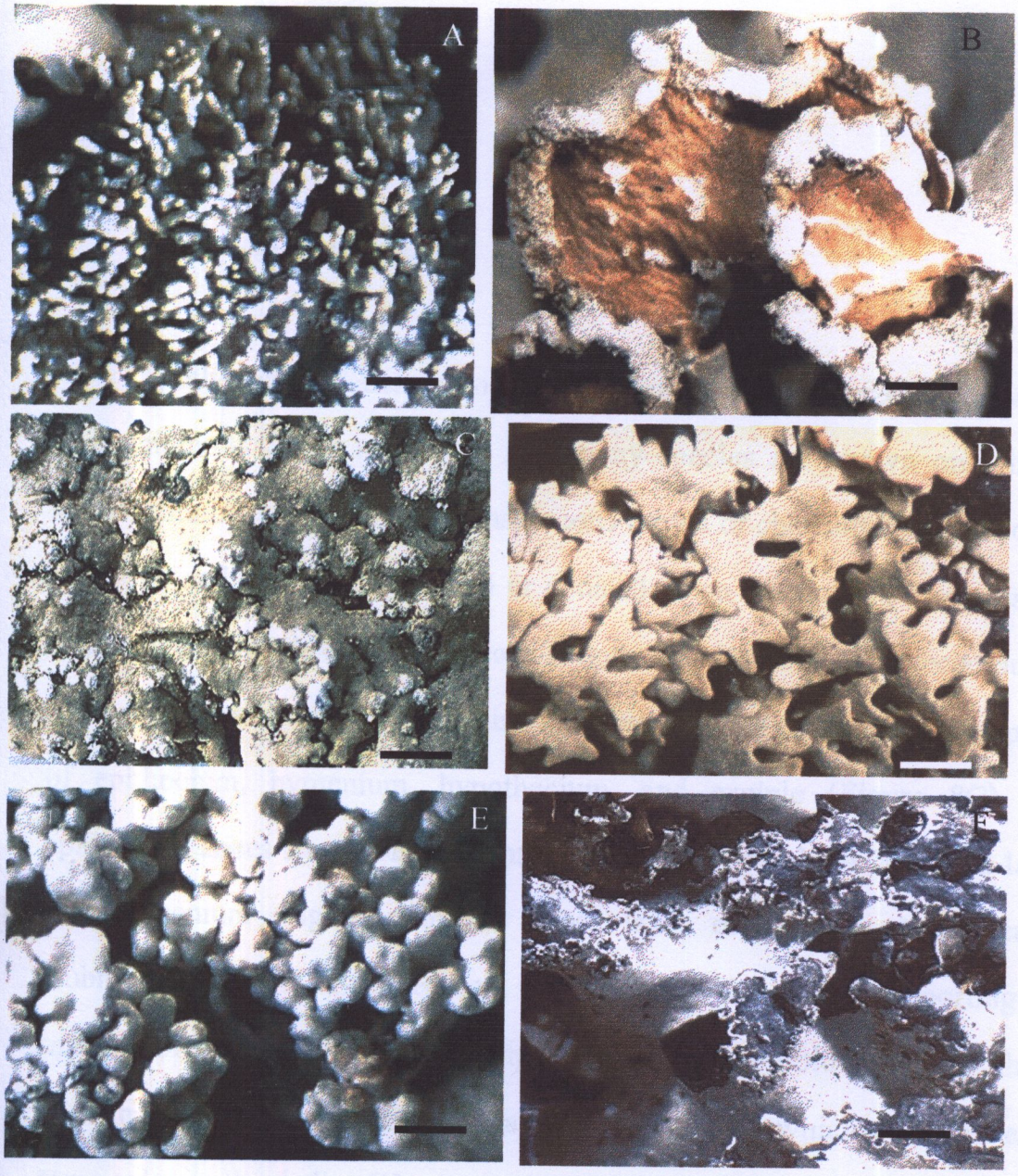


Figure 7 Vegetative Propagules

Note: A. Simple and cylindrical isidia [RU——10327 (RAMK), scale = 0.07 cm].

B. Marginal soralia [RU——994 (RAMK), scale = 0.4 cm].

C. Laminal soralia [RU——10328 (RAMK), scale = 0.23 cm].

D. Imbricate lobules [RU——4205 (RAMK), scale = 0.1 cm].

E. Pustulate isidia [RU——9441 (RAMK), scale = 0.01 cm].

F. Pustulate soredia [RU——10234 (RAMK), scale = 0.3 cm].

Reproductive Structure

Apothecial characters

Apothecium of the parmelioid lichens is characterized by laminal apothecium. It seems to be rare and many species are known only in the sterile state. Apothecia are the conspicuous brown or chestnut brown disc-like structure, and sessile (Figure 8A) or pedicellate on the thallus. The presence or absence of apothecial perforations (Figure 8B) is useful for speciation, for example, *Parmotrema eunetum* and *P. tinctorum*. An apothecium comprises of epithecium, hymenium, hypothecium, and exciple (Figure 8C). The epithecium arises from non-pigmented paraphyses tips above the ascal layer. The hymenium originates in the dense layer of colorless tissue called 'subhymenium' or 'hypothecium'. The exciple, the tissue supporting the margins of the disc, is thalline exciple containing photobiont. The apothecia with thalline exciple is called 'lecanorine apothecia', which often have the same color as the thallus (Hawksworth and Hill 1984, 30-31). The paraphyses in hymenium are simple, branched, and anastomosed (Figure 9A and 9B).

Asci and Ascospores

In this study, the shape of ascus is clavate and ascal wall is bitunicate. An ascus contains eight ascospores (Figure 9A and 9B). The ascospores are hyaline, simple, ellipsoidal (Figure 9C), which present by the genus

Bulbothrix, *Canoparmelia*, *Hypotrachyna*, *Parmotrema*, *Relicina*, *Relicinopsis*, *Rimelia*, and *Xanthoparmelia*. The reniform (bean shaped), occurs in the genus *Everniastrum* (Figure 9D). The length ranges between 5 to 30 micrometer. Hale and Elix divided the length of ascospores into four classes (Hale 1987; Elix 1993; 1994)). The smallest size is less than 10 μm long, such as *Relicinopsis* and *Xanthoparmelia*. The small size is about 10-15 μm long, for example, *Bulbothrix* and *Hypotrachyna*. The medium size is 15-20 μm long, such as *Bulbothrix meizospora*, *Parmelinella*, and *Rimelia reticulata*. The largest size is over 20 μm long, which was found in all species of *Everniastrum*, and most species of *Parmotrema*.

Pycnidial Characters

The lichens family Parmeliaceae often produce asexual reproductive spores in the conidiomata which are generally called 'pycnidia'. Its shape is small globose or flask-like. Pycnidia on the thallus have been considered as laminal pycnidia. Type of pycnidia is catagorized into *Umbilicaria*-type or *Parmelia*-type by Hawksworth (1988) and Elix (1993). This investigation, the pycnidial conidiomata shows brown to black, visible ostioles, immersed or emergent either on the upper surface (Figure 10A and 10B), on the isidia (Figure 17B), or on the apothecium. Some species of *Bulbothrix* and *Relicina* produce pycnidia on the exciple of apothecium that called 'coronate apothecia' (Figure 87C).

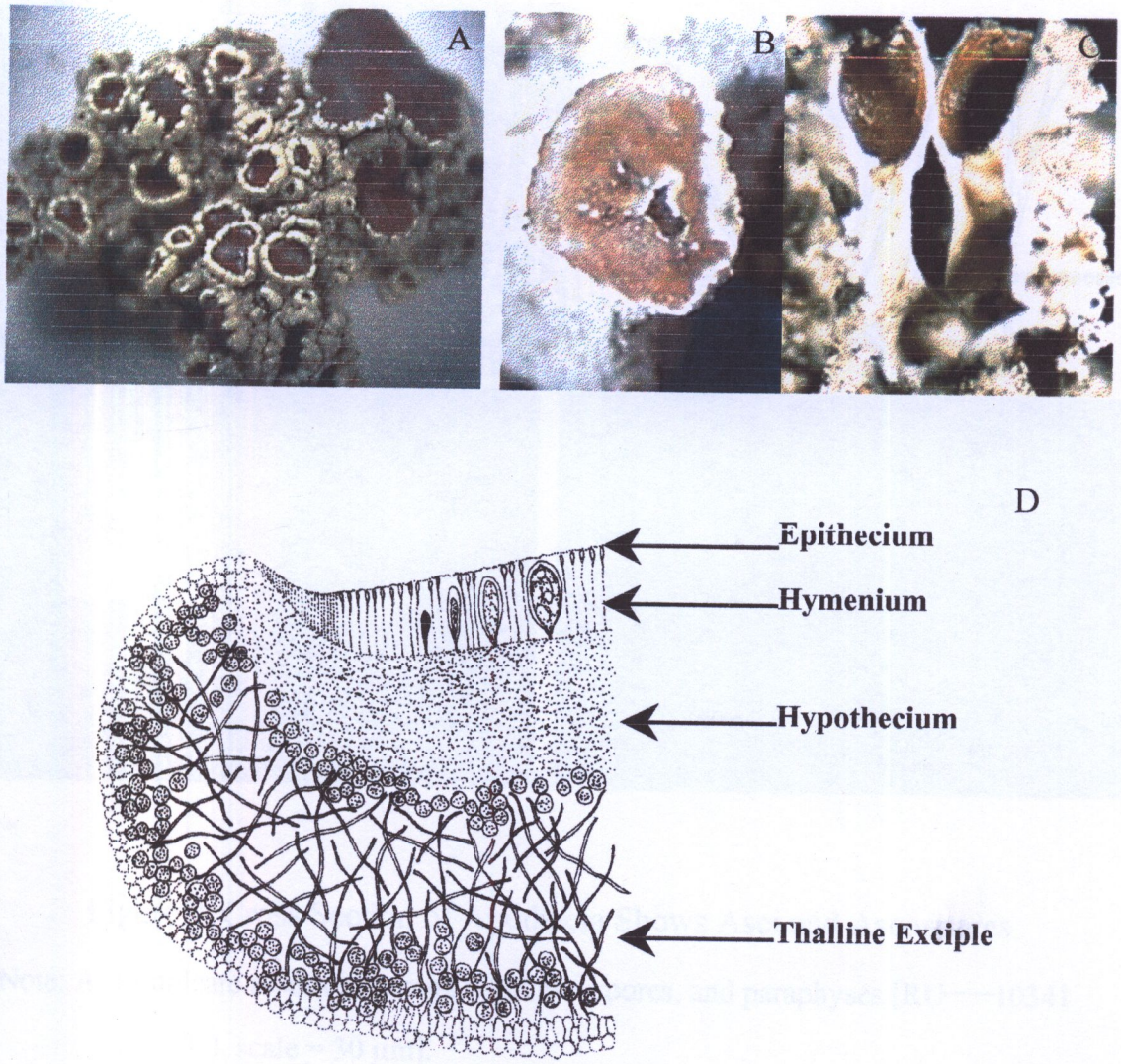


Figure 8 Apothecia Characters

Note: A. Sessile apothecia [RU——6965 (RAMK), scale = 0.16 cm].

B. Close up of perforate apothecia with hole at the center [RU——7329 (RAMK), scale = 0.16 cm].

C. L-section of perforate apothecia [RU——7329 (RAMK), scale = 0.16 cm].

D. Illustration of lecanorine apothecia shows thalline exciple (scale = 50 μm).

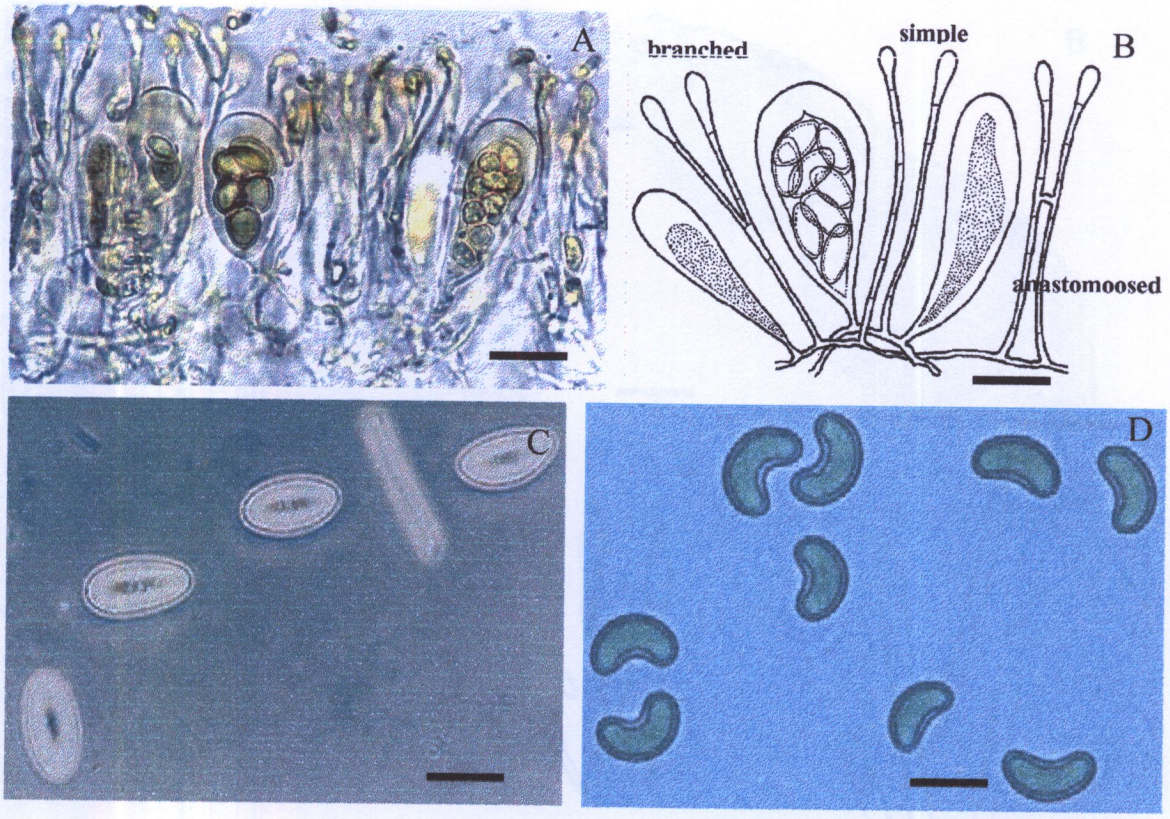


Figure 9 Cross Section of Apothecia Shows Asci and Ascospores

Note: A. Bitunicate ascus containing eight ascospores, and paraphyses [RU——10341 (RAMK), scale = 30 μm].

B. Illustrated ascus and paraphyses (scale = 20 μm).

C. Ellipsoidal ascospores [RU——3288 (RAMK), scale = 20 μm].

D. Reniform ascospores (bean shaped) [RU——10242 (RAMK), scale = 20 μm].

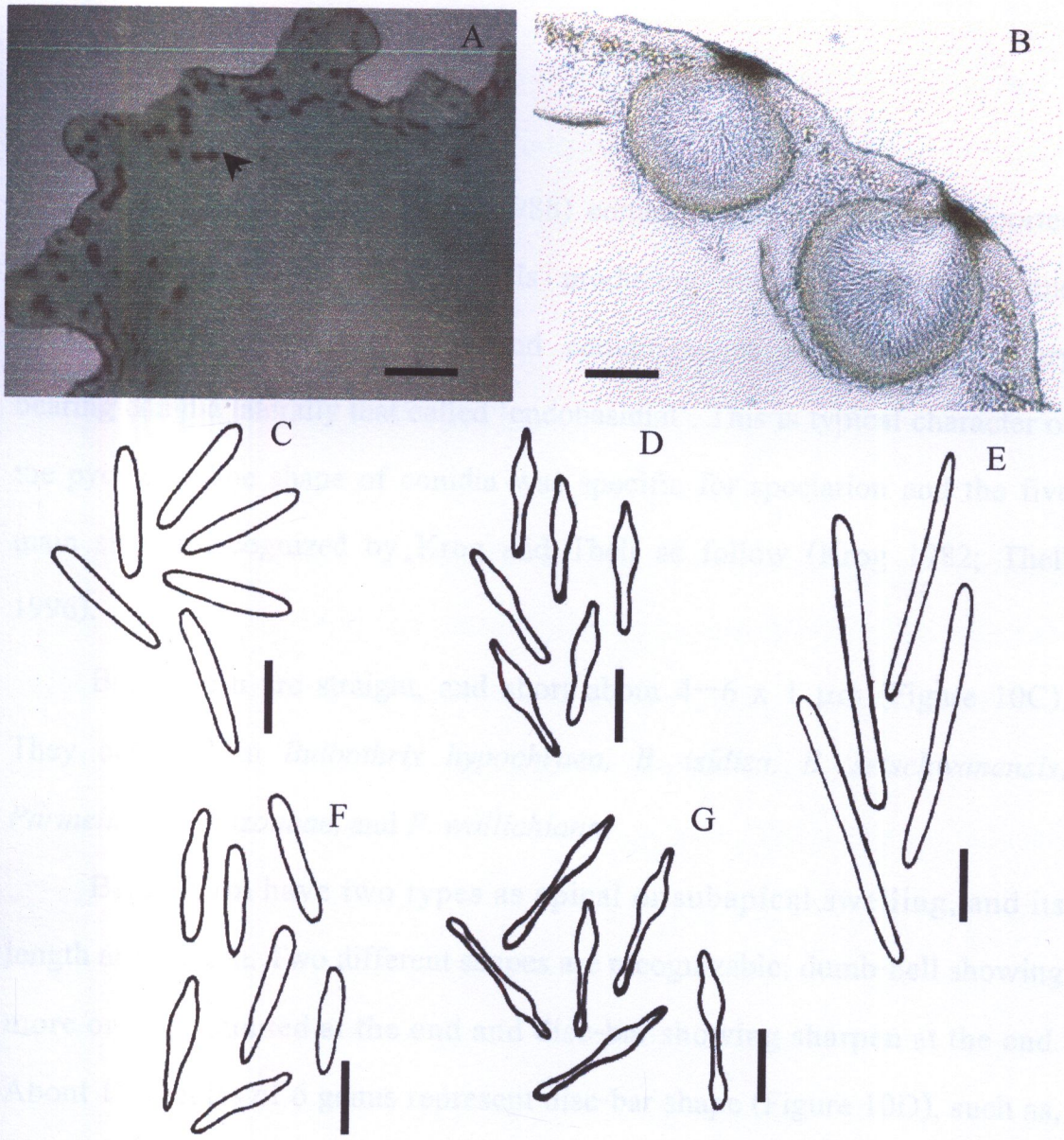


Figure 10 Pycnidia and Conidia Characters

Note: A. Pycnidia immerse in the upper cortex (arrow) [RU—10322 (RAMK), scale = 0.17 cm].

B. Cross section of pycnidia containing conidia [RU—10237 (RAMK), scale = 100 μm].

C. Bacilliform conidia (scale = 4 μm); D. Bifusiform conidia (scale = 5 μm);

E. Filiform conidia (scale = 5 μm); F. Fusiform conidia (scale = 6 μm);

G. Sublageniform conidia (scale = 3 μm).

Conidiophores and Conidia

According to Hawksworth (1988) conidiophores are fertile supported hyphae for the conidiogenous cells producing conidia. The shape and branching of the conidiophores and conidiogenous cells are intercalary bearing conidia laterally that called 'endobasidial'. This is typical character of the pycnidia. The shape of conidia was specific for speciation and the five main shapes recognized by Krog and Thell as follow (Krog 1982; Thell 1996).

Bacilliform are straight, and short about 4—6 x 1 μm (Figure 10C). They occurred in *Bulbothrix hypochraea, B. isidiza, B. setschwanensis, Parmelinella chozoubae,* and *P. wallichiana.*

Bifusiform have two types as apical or subapical swelling, and its length are 5-7 μm. Two different shapes are recognizable: dumb-bell showing more or less rounded at the end and disc-bar showing sharpen at the end. About 18 species of 6 genus represent disc-bar shape (Figure 10D), such as, *Bulbothrix isidiza, Canoparmelia owariensis, Everniastrum cirrhatum, Hypotrachyna adducta, H. kingii,* and *Relicina abstrusa.*

Filiform is straight and long approximately 8—20 μm (Figure 10E). It presents in 2 genus and 5 species: *Parmotrema corniculans, P. eunetum, P. pseudonilgherrense, P. tinctorum,* and *Rimelia reticulata.*

Fusiform is short, 4-6 μm long, and spindle-shaped (Figure 10F). *Relicinopsis intertexta, R. malaccensis,* and *R. rahengensis* present fusiform conidia naturally.

Sublageniform are bottle-like and swollen near one end (Figure 10G). The sublageniform conidia represented by twelve species of the *Parmotrema*.

Photobionts

According to Elix (1993) photobiont of the Parmeliaceae is unicellular algae, *Trebouxia* belonging to family Chlorophyceae of order Microthammales. Algal layer situated between the upper cortex and medullar layer (Figure 4A and 4C). The photobiont cells possess about 7 % of the total thallus volume. They obtain optimal sunlight for photosynthesis. The cortex protects the photobiont cells from drying and excessive light while the loosely woven medulla facilitates gas exchange (Admadjian 1993). The algal layers of most species have continuous or discontinuous arrangement. For example, *Canomaculina subtinctoria*, *Relicinopsis intertexta*, and *Rimelia reticulata* have the latter type. The arrangement of algal cells in thallus cause different colors of the surface. Ahmadjian reported the green algae in *Parmeliopsis ambigua* and *Parmotrema tinctorum* are *Trebouxia irregularis* and *T. usneae* respectively (Ahmadjian 1993, 32). The identification to species of algal partner requires further study.

Chemical Characters

Lichen chemistry is used extensively in systematic purpose of the Parmeliaceae. Sixty-four lichen substances have been detected in the

parmelioid species in this study (Table 4, Appendix 2, and Figure 11). These products usually present in the upper cortex and medulla. The cortical and the medullary substances are used to categorize these lichens into genera and species (Elix 1993).

Cortical Chemistry

The four cortical substances are atranorin, chloroatranorin (β-orcinal depsides), usnic acid, and lichexanthone (xanthones) (Elix 1993, 363). Atranorin and chloroatranorin are commonly found in the upper cortex. They were detected on chromatograms of sixty-five species in nine genera of the parmelioid lichens. These substances appear gray-green on upper cortex and show yellow color in the contact with potassium hydroxide solution. Atranorin and chloroatranorin do not show spot on tlc-plate. Only high performance liquid chromatography (HPLC) is able to detect the presence of the latter substance. These substances are found in *Canomaculina subtinctoria, Rimelia reticulata, Parmotrema* (28 species), *Hypotrachyna* (14 species), *Bulbothrix* (8 species), *Parmelinopsis* (4 species), *Everniastrum* (3 species), *Canoparmelia* (2 species), *Myelochroa* (2 species), and *Parmelinella* (2 species) show in Appendix 2.

The third cortical substance, usnic acid, presents in nine species of four genera. The yellowish green color at class 6-7 is considered as usnic acid on tlc-plate and show negative reaction with potassium hydroxide solution. Usnic

acid naturally presents in the upper cortex of *Parmeliopsis ambigua*, *Relicina* (3), *Relicinopsis* (3), and *Xanthoparmelia* (2).

Lichexanthone is a colorless cortical substance, detected by the brilliant yellow-orange color under longwave ultraviolet light. *Hypotrachyna osseoalba* contains this substance in the upper cortex, whilst the other species of *Hypotrachyna* contain atranorin.

Medullary Chemistry

Most chemicals are detected in the medulla layer. They are very useful for final determination to species level. Sixty lichen substances can be divided into seven main groups by many lichenologists and chemists. These groups consist of aliphatic acid, aromatic compounds, dibenzofurans, anthraquinones, ergochrome, tetronic acid and xanthone. They were listed in the Table 4 and Appendix 2 (Culberson and Culberson 1970; Elix 1993; 1996; Elix and Ernst-Russell 1993; Elix *et al.* 1986; Esslinger 1977; Feige *et al.* 1993; Louwhoff and Elix 1999).

Twenty-nine substances mainly found in the parmelioid lichens are orcinal depsidones and β-orcinal depsidones groups. Two of β-orcinal depsidones, salazinic acid (represent in 17 species) and protocetraric acid (represent in 16 species), are common in parmelioid species in Thailand. Alectoronic acid was only found in eight species of *Parmotrema*. It shows bright white to bluish white fluoresces of the medulla in longwave ultraviolet light.

Orcinal depsides and β-orcinal depsides consist of twenty substances in the medulla of *Hypotrachyna* (6 species), *Parmotema explanatum*, *Relicinopsis rahengensis*, etc. (Table 4 and Appendix 2). Aliphatic acids are colorless fatty acid and on tlc-plate appears as white spot after spray by distill water. Praesorediosic acid is a fatty acid specific to *Parmotrema praesorediosum*.

The other substances, for example, skyrin, vulpinic acid, secalonic acid, appear in medulla and sometimes in the upper cortex or other structures. Antraquinones show purple to red color with potassium hydroxide solution. Vulpinic acid and secalonic acid present as yellow pigment in the medulla.

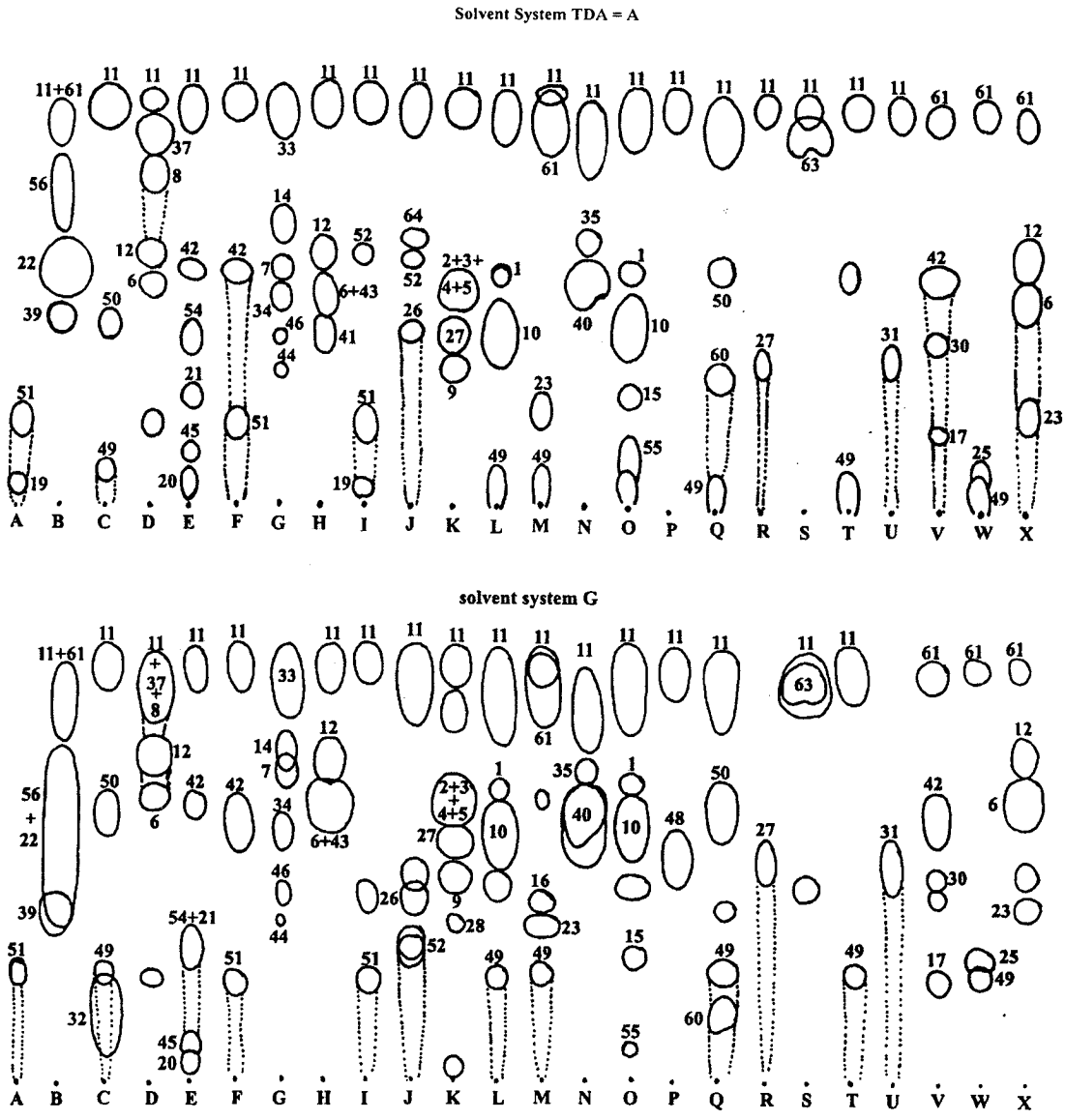


Figure 11 Lichen Substances on Tlc-plate Developed in Solvent System A and G

Note: A = *Bulbothrix isidiza*, B = *Canoparmelia ecaperata*, C = *Everniastrum scabridum*, D = *Hypotrachyna chlorobarbatica*, E = *H. crenata*, F = *H. kingii*, G = *H. osseoalba*, H = *H. physcioides*, I = *H. ramkhamhaengiana*, J = *Myelochroa siamea*, K = *Parmelinopsis horrescens*, L = *Parmotrema amaniense*, M = *P. dilatatum*, *N* = *P. hababianum*, O = *P. poolii*, P = *P. praesorediosum*, Q = *P. rubromarginatum*, R = *P. sancti-angelii*, S = *P. sulphuratum*, T = *P. thailandicum*, U = *P. tinctorum*, V = *Relicina abstrusa*, W = *Relicina sublimbata, and* X = *Relicinopsis rahengensis*; Number 1-64 of spots according to Appendix 2.

Table 4 Major and Minor Substances Found in the Parmelioid Lichens in Thailand.

Main metabolic group	Lichen substances	
	Major substances	**Minor substances**
1. Aliphatic acid	lichesterinic acid, praesorediosic acid, protolichesterinic acid	-
2. Aromatic compounds		
2.1 Orcinal depsides	divaricatic acid, gyrophoric aicd, hiasic acid, lecanoric acid	2,4,5-tri-*O*-methylhiasic acid, 2,4-di-*O*-methylgyrophoric acid, 3-methoxy-2,4-di-*O*-methylgyrophoric acid, 4,5-di-*O*-methylhiasic acid, 5-*O*-methylhiasic acid, nordivaricatic acid, subdivaricatica acid, umbillicaric acid
2.2 Orcinal depsidones	α-collatolic acid, alectoronic acid, colensoic acid, lividic acid, loxodin, norlobaridone, physodic acid	4-*O*-demethylphysodic acid, conalectoronic acid, oxyphysodic acid, subalectoronic acid
2.3 β-Orcinal benzyl esters	echinocarpic acid	conechinocarpic acid, hirtifructic acid
2.4 β-Orcinal depsides	4-*O*-demethylbarbatic acid, atranorin, barbatic acid	5-chloro-4-*O*-demethylbarbatic acid, chloroatranorin, methyl-5-chloro-4-*O*-demethylbarbatate, norobtusatic acid, obtusatic acid

Table 4 (continued)

Main metabolic group	Lichen substances	
	Major substances	**Minor substances**
2.5 β-Orcinal depsidones	fumarprotocatraric acid, galbinic acid, norstictic acid, protocetraric acid, salazinic acid, stictic acid	connorstictic acid, conprotocetraric acid, consalazinic acid, constictic acid, cryptostictic acid, hyposalazinic acid, menegazziaic acid, methyl virensate, peristictic acid, subvirensic acid, succinprotocetraric acid, virensic acid
3. Dibenzofurans	usnic acid	-
4. Anthraquinones	pigmentosin A, skyrin, unknown red pigmented, zeorin	-
5. Ergochromes	secalonic acid A	eumitrin
6. Tetronic acid	vulpinic acid	-
7. Xanthones	lichexanthone	-

CHAPTER 5

TAXONOMIC TREATMENT

The Parmelioid lichens belong to family Parmeliaceae, which classified based on morphological, anatomical and chemical characters. The typical characters are foliose growth form, possesing laminal apothecia and pycnidia. This group consists of 37 genera and 1,300–1,500 species (Hale and DePriest 1999) from 85 genera and 2,319 species of this family (Hawksworth *et al.* 1995). In this study the parmelioid lichens were determined to 14 genera and 75 species from approximately 1,500 specimens. A dichotomous key to the genera is given by using characters of thallus structure, reproductive structure, and chemistry as the basis for classification. Taxonomic character of each genus, habitat, distribution, and a dichotomous key to the species are included. Within genera the species are listed alphabetically. The species includes basionym and is followed by description based on the material cited.

The parmelioid genera in this study comprise *Bulbothrix* (8 species), *Canomaculina* (1 species), *Canoparmelia* (2 species), *Everniastrum* (3 species), *Hypotrachyna* (15 species), *Myelochroa* (2 species), *Parmelinella* (2 species), *Parmelinopsis* (4 species), *Parmeliopsis* (1 species), *Parmotrema* (28 species), *Relicina* (3 species), *Relicinopsis* (3 species), *Rimelia* (1 species), and *Xanthoparmelia* (2 species).

Key to genera of the Parmelioid Lichens in Thailand

1a Upper cortex yellowish green; K-, UV-; containing usnic acid..... 2

1b Upper cortex whitish gray to grayish green or yellowish gray; K+ yellow or UV+ bright yellow; containing atranorin, or lichexanthone..... 5

2a Lobes with marginal bulbate cilia..... *Relicina*

2b Lobes without cilia..... 3

3a Thallus occur on rock; lobes narrow less than 2 mm wide..*Xanthoparmelia*

3b Thallus occur on bark or rock; lobes more than 2 mm wide..... 4

4a Thallus with isidia or without isidia; spotted maculae present on upper surface.....*Relicinopsis*

4b Thallus with soredia, without isidia; maculae absent on upper surface .....*Parmeliopsis ambigua*

5a Lobes canaliculate, narrow and dichotomously branched.... *Everniastrum*

5b Lobes flat, broad and irregular branched..... 6

6a Lobes with marginal cilia..... 7

6b Lobes without marginal cilia.....13

7a Lobes with bulbate cilia..... *Bulbothrix*

7b Lobes with simple to branched cilia.....8

8a Cilia mainly in lobe axils..... *Parmelinella*

8b Cilia evenly dispersed..... 9

9a Lower surface with dichotomously branched rhizines..... *Parmelinopsis*

9b Lower surface with simple or squarrose or dimorphic rhizines.....10

10a Upper surface with effigurate or reticulate maculae.....11

10b Upper surface emaculate or with faintly maculae..... 12

11a Upper surface with effigurate maculae and with isidia; lower surface pale brown with dimorphic rhizines..... *Canomaculina subtinctoria*

11b Upper surface with reticulate maculae; lower surface black with simple to squarrose rhizines.....*Rimelia reticulata*

12a Medulla yellow; containing secalonic acid A; lobes less than 5 mm wide ..... *Myelochroa*

12b Medulla sulpher yellow or white throughout; lacking secalonic acid A; lobes more than 8-10 mm wide..... *Parmotrema*

13a Lower surface with dichotomously branched rhizines..... *Hypotrachyna*

13b Lower surface with simple rhizines.....14

14a Lobes 3-5 mm wide; lower surface with a narrow naked marginal zone, less than 1-2 mm wide..... *Canoparmelia*

14b Lobes broad, more than 8 mm wide; lower surface with a broad naked marginal zone, more than 5 mm wide.....*Parmotrema*

Genus *Bulbothrix*

Bulbothrix **Hale**, *Phytologia* 28: 480, 1974

Figure 12

Thallus foliose, adnate to tightly adnate; lobes contiguous, rarely imbricate, sublinear to subirregular, narrow to moderately broad, 0.1-5 mm wide; margins entire, crenate to serrate, apices incise to truncate; cilia bulbate at base; upper surface gray, smooth to wrinkled, faintly maculate or emaculate, with or without isidia and lobules, lacking soredia; upper cortex a palisade plectenchymatous with pored epicortex, 10-25 μm thick; cell walls containing isolichenan; medulla loosely packed, white, 20-130 μm thick; lower surface pale brown to black, 12-25 μm thick; rhizines simple, sometimes dichotomously branched; **apothecia** rare to common, laminal, sessile to subpedicellate; disc flat to concave, pale to dark brown; coronate or ecoronate; thalline exciple entire to crenate; ascospores hyaline, simple, ellipsoid, 8 per ascus, 6-15 x 4-8 μm; **pycnidia** common, immersed in thallus or in the margin of the thalline exciple; conidia bifusiform, rarely bacilliform, 5-9 x 1 μm.

Habitat: *Bulbothrix* is common in the lower montane forests, the dry dipterocarp forests and the secondary forests in Thailand. This genus occurs on barks and rocks.

Distribution: North and South America (United States, Mexico, Guatemala, Honduras, Costa Rica, Panama, Cuba, Jamaica, Colombia, Venezuela, Peru, Ecuador, Guyana, Brazil, Uruguay, Paraguay, Chile, Argentina); Africa (Sierra, Ivory Coast, Guinea, Cameroon, Uganda, Kenya, Zaire, Zambia, Malawi, Angola, Rhodesia, Tanzania, Mozambique, Union of South Africa, Madagascar, Mauritius); Asia (Pakistan, Nepal, India, Thailand, Malaysia, Indonesia, Philippines, Papua New Guinea, Taiwan, China, Japan, Hawaii, Pacific Area); Australia and New Zealand.

Observation: *Bulbothrix* is characterized by bulbate cilia at the margin and gray upper surface containing atranorin (K+ yellow). This genus differs from *Relicina,* which has yellow-green upper surface and contains usnic acid (K-). Eight species are found in this study. *B. isidiza* is the most common species.

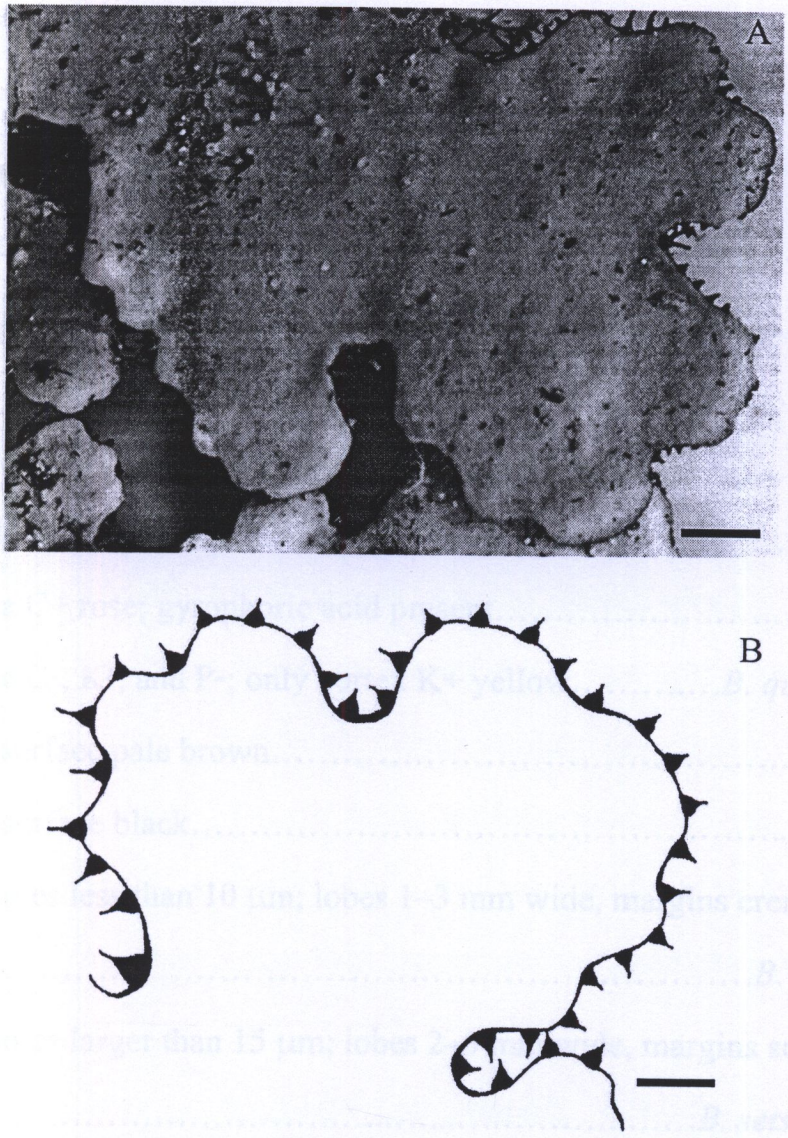


Figure 12 Genus *Bulbothrix* Hale

Note: A. Lobes show bulbate cilia along the margins of the thallus [RU——10154 (RAMK), scale = 0.5 mm].

B. Illustration of bulbate cilia (scale = 0.4 mm).

Key to the species of *Bulbothrix*

1a Thallus isidiate.....2

1b Thallus lacking isidia.....5

2a Lower surface pale brown; medulla K+ yellow turning red.....*B. isidiza*

2b Lower surface black.....3

3a Medulla K+ yellow turning red; salazinic acid present.....*B. tabacina*

3b Medulla K- 4

4a Medulla C+ rose; gyrophoric acid present.....*B. goebelii*

4b Medulla C-, K-, and P-; only cortex K+ yellow.....*B. queenslandica*

5a Lower surface pale brown.....6

5b Lower surface black.....7

6a Ascospores less than 10 μm; lobes 1–3 mm wide, margins crenate

.....*B. hypochraea*

6b Ascospores larger than 15 μm; lobes 2–5 mm wide, margins serrate

.....*B. setschwanensis*

7a Ascospores less than 10 μm; lobes distinct rounded axils

.....*B. sensibilis*

7b Ascospores larger than 15 μm; lobes undistinct rounded axils

.....*B. meizospora*

Description of the species of *Bulbothrix*

1. *Bulbothrix goebelii* (Zenker) Hale, *Smithsonian Contr. Bot.* 32: 14, 1976

Basionym: *Parmelia goebelii* Zenker, *Pharm. Waarenk.* 1: 134, 1827

Figure 13

Thallus foliose, closely adnate; lobes sublinear to irregularly branched, 0.5–1.5 mm wide; margin crenate, apices incised; bulbate cilia simple to dichotomously branched, short; isidia laminal, erect, globose to cylindrical, less than 1 mm high; upper surface gray-green, plane, rarely cracks, faintly maculate, 20 μm thick; medulla white, 45 μm thick; lower surface dark brown to black, 15 μm thick; rhizines black, simple to dichotomously branched, 1 mm long; **apothecia** and **pycnidia** not seen.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing gyrophoric acid (K-, C+ rose, KC+ red, and P-).

Habitat: On tree trunk in the mixed deciduous forests and the lower montane forests at 700-1,400 m elevations.

Distribution: America, Africa, India, Thailand, Taiwan, and tropical region of Asia.

Specimens examined: N Thailand. Chiang Mai Province: Queen Sirikit Botanic Garden, on trunk of *Peltophorum pterocarpum*, 1994, *K. Boonpragob et al.*, RU——160, 307 & 308 (RAMK). ibid., on trunk of *Bombax ceiba*, 1994, *K. Boonpragob et al.*, RU——635 & 2322 (RAMK). ibid., on trunk of *Schima wallichii*, 1994, *K. Boonpragob et al.*, RU——1646 (RAMK). ibid., on trunk of *Melia azedarach*, 1994, *K. Boonpragob et al.*, RU——2281 (RAMK). ibid., on trunk of *Dillienia* sp., 1994, *K. Boonpragob et al.*, RU——2554 (RAMK). **E Thailand.** Nakhon Ratchasima Province: Khao Yai National Park, Khao Kiaeo, on trunk of *Mangifera indica*, 1997, *T. Pooprang*, RU——7990 (RAMK). ibid., on trunk of unidentified tree, 1997, *T. Pooprang*, RU——8146 (RAMK).

Observation: *Bulbothrix goebelii* is characterized by simple to dichotomously branched of bulbate cilia and rhizines, C+ rose which containing gyrophoric acid.

2. *Bulbothrix hypochraea* (Vain.) Hale, *Phytologia* 28: 480, 1974

Basionym: *Parmelia hypochraea* Vainio, *Cat. Welw. Pl.* 2(2): 400, 1901

Figure 14

Thallus foliose, adnate to loosely adnate; lobes subirregular to sublinear, margin crenate, apices tuncate, 1-3 mm wide; short bulbate cilia, up to 0.5 mm long; without isidia; upper surface gray-green, plane, smooth,

faintly to distinctly maculate, 25 μm thick; medulla white, 130 μm thick; lower surface pale brown, 15 μm thick; rhizines simple, sparse, pale brown to dark brown, up to 1 mm long; **apothecia** rare to common, sessile to subpedicellate, up to 5 mm diameter, ecoronate, disc brown, thalline exciple entire, ascospores hyaline, simple, ellipsoid, 7.5-10 x 5 μm; **pycnidia** sparse, laminal, immersed, conidia bacilliform 5-6 x 1 μm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing salazinic aicd, and consalazinic acid (K+ yellow turning red, C-, KC-, and P+ orange).

Habitat: On trees in open habitats at 700-1,000 m elevations.

Distribution: Brazil, Africa, and Thailand.

Specimens examined: N Thailand. Chiang Mai Province: Queen Sirikit Botanic Garden, on trunk of *Pittosporum ferrugineum*, 1994, *K. Boonpragob et al.*, RU——1142 (RAMK). ibid., on trunk of *Protium serratum*, 1994, *K. Boonpragob et al.*, RU——3472, 3473 & 3474 (RAMK). ibid., on trunk of *Adina cordifolia*, 1994, *K. Boonpragob et al.*, RU——3529 (RAMK). ibid., on *Holigrana kurzii*, 1995, *K. Boonpragob et al.*, RU——3954 & 3980 (RAMK). **SE Thailand.** Chantaburi Province: Khao Kitchagud National Park, in the tropical rain forest, on trunk of *Diopyros sp.*, 1997, *N. Homchantara et al.*, RU——8513 (RAMK).

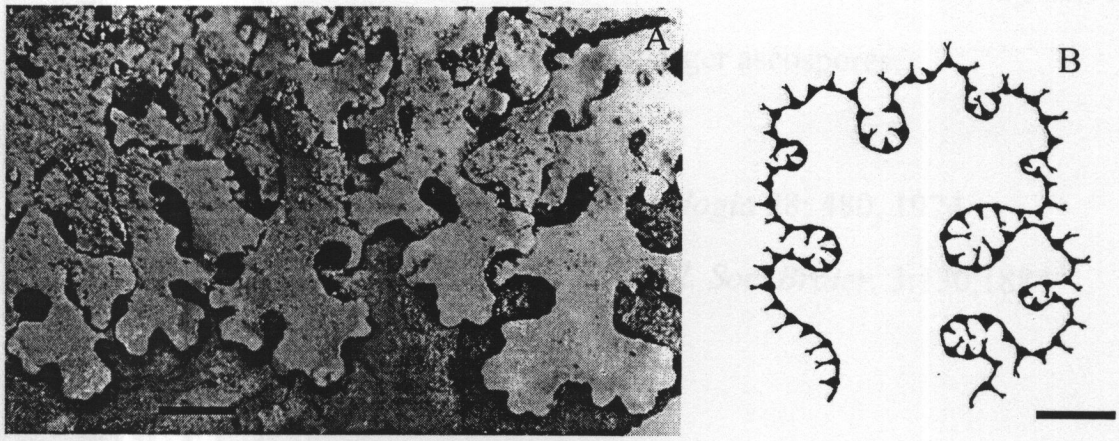


Figure 13 *Bulbothrix goebelii* (Zenker) Hale

Note: A. Thallus gray-green with isidia [RU——7990 (RAMK), scale = 0.5 mm].

B. Illustration of apical branches of bulbate cilia (scale = 0.3 mm).

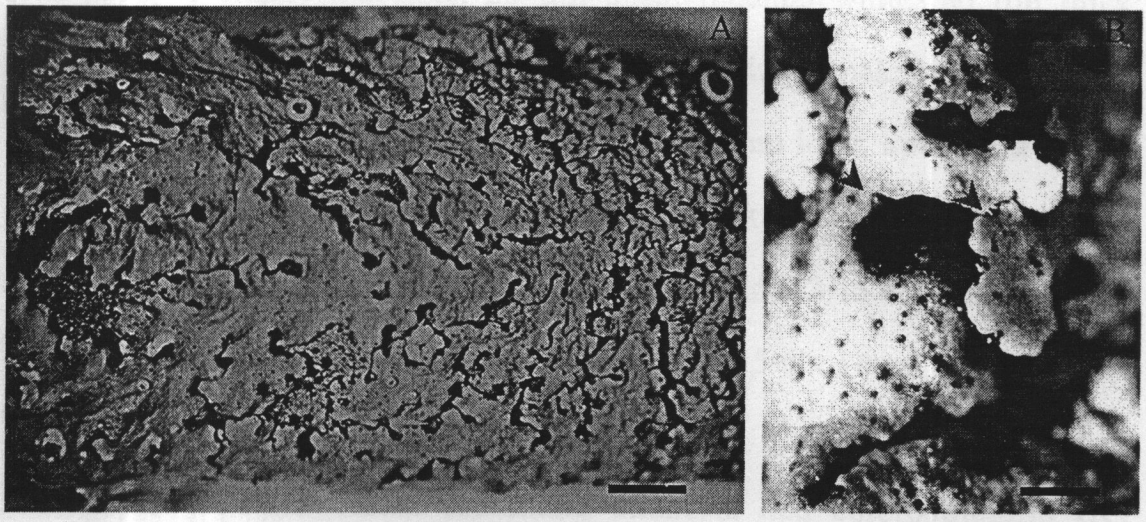


Figure 14 *Bulbothrix hypochraea* (Vain.) Hale

Note: A. Thallus gray green without isidia [RU——3474 (RAMK), scale = 2 mm].

B. Lobes show sparse pycnidia and short bulbate cilia (arrow) [RU——3474 (RAMK), scale = 1 mm].

Observation: This species resembles *B. setschwanensis* by having pale brown lower surface, but the latter has larger ascospores.

3. *Bulbothrix isidiza* (Nyl.) Hale, *Phytologia* 28: 480, 1974

Basionym: *Parmelia isidiza* Nyl., *Bull. Soc. Broter.* 3:130,1884

Figure 15

Thallus foliose, closely to loosely adnate; lobes irregularly sinuate, 1-5 mm wide; margins crenate to serrate, apices subrotund to truncate; bulbate cilia, sparse at the margins, 0.5-1 mm long; isidia laminal, cylindrical, simple to coralloid branched, up to 0.5 mm high; upper surface gray-green, smooth, emaculate to faintly maculate, 20 µm thick; medulla white, 80 µm thick; lower surface ivory to pale brown, 20 µm thick; rhizines pale brown to black, simple to rarely branched, sparse to dense, 1-1.5 mm long; **apothecia** rare, if present sessile, 2-6 mm wide; ecoronate, disc dark brown, concave; thalline exciple smooth; ascospores hyaline, simple, ellipsoid, 12-15 x 8 µm; **pycnidia** common, conidia bacilliform to weakly bifusiform, 5-6 x 1 µm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing salazinic acid and consalazinic acid (K+ yellow turning red, C-, KC-, and P+ orange).

Habitat: Abundant on trees and rocks, usually in the lower montane forests, the dry dipterocarp forests and the mixed deciduous forests.

Distribution: Pantropical: Central and South America, Africa, India, Thailand, West Malaysia, Indonesia, Papua New Guinea, Japan, and Hawaii.

Specimens examined: N Thailand. Chiang Mai Province: Queen Sirikit Botanic Garden, on trunk of *Peltophorum pterocarpum*, 1994, *K. Boonpragob et al.*, RU——28, 29, 106, 239 & 316 (RAMK). ibid., on trunk of *Litsea glutinosa*, 1994, *K. Boonpragob et al.*, RU——389 (RAMK). ibid., on trunk of *Bombax ceiba*, 1994, *K. Boonpragob et al.*, RU——632 & 634 (RAMK). ibid., on trunk of *Castanopsis costata*, 1994, *K. Boonpragob et al.*, RU——721 (RAMK). ibid., on trunk of *Dillenia* sp., 1994, *K. Boonpragob et al.*, RU——816, 818, 819, 820, 825, 826, 827, 2556, 2557, 2558, 2561, 2562 & 2567 (RAMK). ibid., on trunk of *Quercus mespilifolioides*, 1994, *K. Boonpragob et al.*, RU——1412, 1413, 1414 & 1415 (RAMK). ibid., on trunk of *Schima wallichii*, 1994, *K. Boonpragob et al.*, RU——1644, 1645, 1647, 1649, 1650, 1651, 1652 & 1653 (RAMK). ibid., on trunk of *Shorea roxburghii*, 1994, *K. Boonpragob et al.*, RU——1728 (RAMK). ibid., on trunk of *Shorea obtusa*, 1994, *K. Boonpragob et al.*, RU——1870, 1871, 1872, 1874, 1875, 3031 & 3046 (RAMK). ibid., on trunk of *Melia azedarach*, 1994, *K. Boonpragob et al.*, RU——2282 (RAMK). ibid., on trunk of *Quercus* sp., 1994, *K. Boonpragob et al.*, RU——2500 (RAMK). ibid., on trunk of *Pterocarpus macrocarpus*, 1994, *K. Boonpragob et al.*, RU——2602, 2605, 2606 & 2607 (RAMK). ibid., on trunk of *Sezygium claviflora*, 1994, *K. Boonpragob et al.*, RU——2683 & 2684 (RAMK). ibid., on trunk of

Dipterocarpus tuberculatus, 1994, *K. Boonpragob et al,* RU——2883 & 2884 (RAMK). ibid., on trunk of *Paramichelia baillonii*, 1994, *K. Boonpragob et al,* RU——3077 & 3083 (RAMK). ibid., on trunk of *Castanopsis* sp., 1994, *K. Boonpragob et al,* RU——3183 (RAMK). ibid., on trunk of *Pinus kesiya*, 1994, *K. Boonpragob et al,* RU——3410 (RAMK). ibid., on trunk of *Styrax benzoides*, 1994, *K. Boonpragob et al,* RU——3509, 3514 & 3515 (RAMK). ibid., on trunk of *Stereospermum neuranthum*, 1994, *K. Boonpragob et al.*, RU——3588 & 3786 (RAMK). ibid., on trunk of *Ficus* sp., 1995, *K. Boonpragob et al,* RU——3867 (RAMK). ibid., on trunk of *Holigrana kurzii*, 1995, *K. Boonpragob et al,* RU——3914, 3949, 3957 & 3987 (RAMK). ibid., on trunk of *Sezygium* sp., 1995, *K. Boonpragob et al.*, RU——3970, 4002, 4003 & 4009 (RAMK). ibid., in the dry dipterocarp forest, on trunk of unidentified trees, 1998, *T. Pooprang*, RU——10205 & 10209 (RAMK). Doi Suthep–Pui National Park, at Doi Pui Research Station, in the lower montane forest, on trunk of unidentified trees, 1998, *T. Pooprang*, RU——10269, 10270 & 10271 (RAMK). Lampang Province: Khuntan National Park, along a trial to Yaw 1, in the dry dipterocarp forest, on rock, 1998, *T. Pooprang*, RU——10325 (RAMK). ibid., a trail from Yaw 2 to the Pine forest, on unidentified tree, 1998, *T. Pooprang*, RU——10335 (RAMK). ibid., on rock, 1998, *T. Pooprang*, RU——10336 (RAMK). Phitsanulok Province: Phu Hin Rong Kla National Park, Lan Anekprasong, in the lower montane forest, on trunk of *Betula alnoides*, 1997, *N. Homchantara et al.*, RU——9367 & 9368 (RAMK). ibid., Lan Hin Taek, in the lower montane forest, on trunk of *Pinus kesiya*,

1998, *T. Pooprang*, RU——10056 (RAMK). ibid., on trunk of unidentified tree, 1998, *T. Pooprang*, RU——10060 (RAMK). ibid., on rock, 1998, *T. Pooprang*, RU——10072 (RAMK). ibid., Lan Anek Prasong, in the lower montane forest, on trunk of unidentified tree, 1998, *T. Pooprang*, RU——10086 (RAMK). ibid., Phachuthong, in the lower montane forest, on trunk of unidentified tree, 1998, *T. Pooprang*, RU——10098 (RAMK). ibid., Rong Rian Kan Mueang Thahan, in the lower montane forest, on trunk of unidentified trees, 1998, *T. Pooprang*, RU——10117 & 10118 (RAMK). ibid., on the old tractor, 1998, *T. Pooprang*, RU——10149, 10150, 10152, 10153 & 10154 (RAMK). ibid., Kung Hun Num, on rock, 1998, *T. Pooprang*, RU——10158 & 10159 (RAMK). Ibid., Lum Lob Phai, in the lower montane forest, on trunk of *Quercus* sp., 1998, *T. Pooprang*, RU——10175 (RAMK). ibid., The lodging Area, at the Pine Plantation, on trunk of *Pinus kesiya*, 1998, *T. Pooprang*, RU——10196, 10198 & 10199 (RAMK). Sukhothai Province: Ramkhamhaeng National Park, in the evergreen forest, on trunk of unidentified trees, 1997, *N. Homchantara et al.*, RU——9713 & 9715 (RAMK). **NE Thailand.** Loei Province: Nahaeo National Park, a trail to Toko 1, in the lower montane forest, on rock, 1995, *T. Pooprang*, RU——4167, 4173, 4233, 4234, 4236, 4239, 4240 & 4264 (RAMK). ibid., on trunk of *Dillenia parviflora*, 1995, *T. Pooprang*, RU——4275 (RAMK). ibid., on trunk of *Castanopsis helfoliana*, 1995, *T. Pooprang*, RU——4459 (RAMK). ibid., on trunk of *Adenanthera pavonina*, 1995, *T. Pooprang*, RU——5004 (RAMK). ibid., on trunk of *Croton* sp., 1995, *T. Pooprang*, RU——6809 (RAMK). ibid.,

on trunk of *Shorea obtusa*, 1995, *T. Pooprang*, RU——7066 (RAMK). ibid., on trunk of unidentified trees, 1995, *T. Pooprang*, RU——6593, 6876, 6877, 6880, 7331 & 7713 (RAMK). Sakhon Nakon Province: Phupan National Park, Nuai To Ket, in the dry evergreen forest, on trunk of unidentified trees, 1997, *T. Pooprang*, RU——8855 & 8873 (RAMK). **E Thailand.** Nakhon Ratchasima Province: Khao Yai National Park, Khao Khieo, in the lower montane forest, on trunk of unidentified trees, 1997, *T. Pooprang*, RU——8356, 8373, 8376 & 9131 (RAMK). **SW Thailand.** Phetchaburi Province: Kaeng Krachan National Park, Phanoenthung camp, in the lower montane forest, on trunk of unidentified trees, 1998, *T. Pooprang*, RU——11165, 11171, 11172 & 11174 (RAMK).

Observation: *Bulbothrix isidiza* is one of the most common species in Thailand. It is closely related to *B. tabacina* by presence of salazinic acid in the medulla, but the latter has black lower surface and somewhat thinner, more fragile thallus.

4. *Bulbothrix meizospora* (Nyl.) Hale, *Phytologia* 28: 480, 1974

Basionym: *Parmelia tiliacea* var. *meizospora* Nyl., *Syn. Lich.* 383, 1860

Figure 16

Thallus foliose, closely adnate; lobes irregularly branched to sublinear-elongate, up to 2 mm wide; margin crenate, apices subrotund; cilia

bulbate, short, simple, black, up to 0.5 mm long; isidia and soredia absent; upper surface gray to green, plane, smooth to wrinkled, faintly maculate, 20 μ m thick; medulla white, 100 μm thick; lower surface black, shiny, 25 μm thick; rhizines simple, dark brown to black, up to 1.5 mm long; **apothecia** mostly young if present, ecoronate, disc brown, thalline exciple entire; ascospores hyaline, simple, ellipsoid, 17.5-20 x 7.5 μm; **pycnidia** laminal, immerse, conidia weakly bifusiform 4-6 x 1 μm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing salazinic acid and consalazinic acid (K+ yellow turning red, C-, KC-, and P+ orange).

Habitat: On trunks of trees in open habitats in the dry dipterocarp forests and the mixed deciduous forests.

Distribution: Africa, Pakistan, Nepal, India, and Thailand.

Specimens examined: N Thailand. Chiang Mai Province: Queen Sirikit Botanic Garden, in the mixed deciduous forest, on trunk of *Bombax ceiba*, 1994, *K. Boonpragob et al.*, RU——626, 627, 629, 631 & 633 (RAMK). ibid., on trunk of *Peltophorum pterocarpum*, 1994, *K. Boonpragob et al.*, RU——752 (RAMK). ibid., on trunk of *Schima wallichii*, 1994, *K. Boonpragob et al.*, RU——1648 (RAMK). ibid., on trunk of *Shorea roxburghii*, 1994, *K. Boonpragob et al.*, RU——1780 & 2767 (RAMK). ibid.,

on trunk of unidentified tree, 1994, *K. Boonpragob et al.*, RU——1981 (RAMK). ibid., on trunk of *Pterocarpus macrocarpus*, 1994, *K. Boonpragob et al.*, RU——2600, 2601, 2603 & 2609 (RAMK). ibid., on trunk of *Artocarpus lakoocha*, 1994, *K. Boonpragob et al.*, RU——2810 & 2811 (RAMK). ibid., on trunk of *Dipterocarpus tuberculatus*, 1994, *K. Boonpragob et al.*, RU——2901 (RAMK). ibid., on trunk of *Sezygium* sp., 1994, *K. Boonpragob et al.*, RU——2917 (RAMK). ibid., on trunk of *Protium serratum*, 1994, *K. Boonpragob et al.*, RU——3469, 3476 & 3478 (RAMK). ibid., on trunk of *Holigrana kurzii*, 1995, *K. Boonpragob et al.*, RU——3958 (RAMK). ibid., on trunk of unidentified tree, 1998, *T. Pooprang*, RU——10208 (RAMK). **NE Thailand.** Loei Province: Phuruea National Park, in Pine forest, on trunk of unidentified tree, 1996, *T. Pooprang*, RU——7863 (RAMK).

Observation: This species is characterized by thallus is absence of soredia and isidia, with black lower surface. It resembles *Bulbothrix sensibilis*, by having black lower surface, but smaller ascospores of the latter.

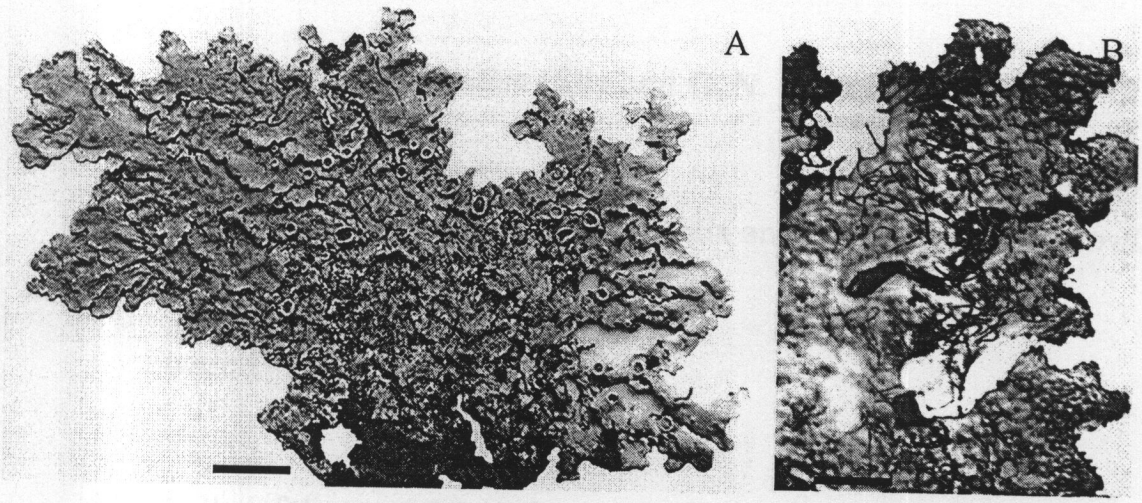


Figure 15 *Bulbothrix isidiza* (Nyl.) Hale

Note: A. Thallus gray-green with isidia [RU—10154 (RAMK), scale = 1 cm].

B. Pale brown lower surface with black rhizines [RU—10154 (RAMK), scale = 2 mm].

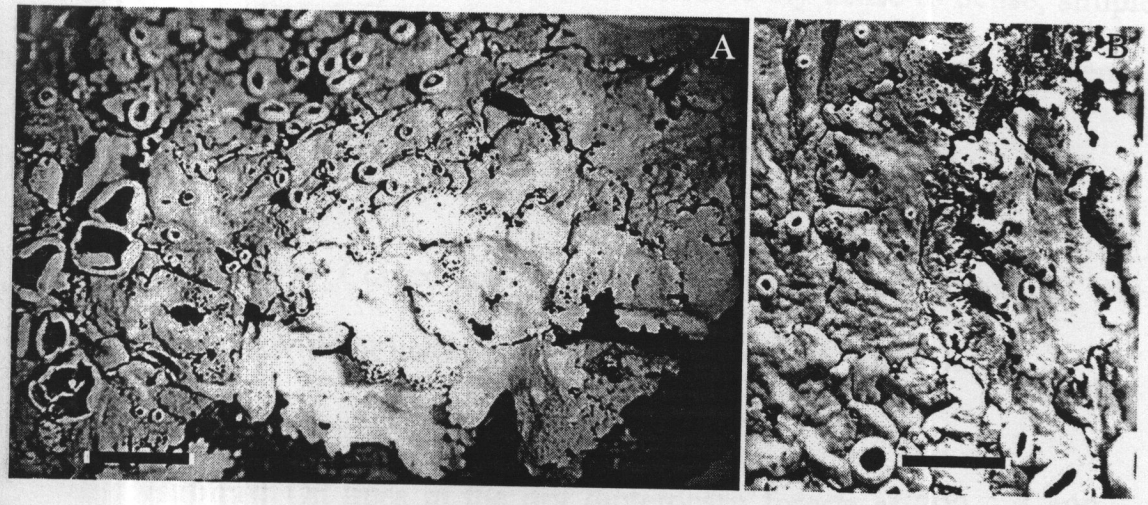


Figure 16 *Bulbothrix meizospora* (Nyl.) Hale

Note: A. Thallus gray-green without isidia [RU—2901 (RAMK), scale = 0.5 cm].

B. Smooth to wrinkle upper surface with young apothecia [RU—2901 (RAMK), scale = 0.5 mm].

5. *Bulbothrix queenslandica* (Elix and G. N. Stevens) Elix, *Mycotaxon* 47: 126, 1993

Basionym: *Parmelia queenslandica* Elix and G. N. Stevens, *Austral. J. Bot.* 27: 873, 1979

Figure 17

Thallus foliose, tightly adnate; lobes linear to sublinear, narrow, subdichotomously branched, very small, 0.1-0.5 mm wide; apices incise; bulbate cilia dense, simple to branched, slender, up to 0.3 mm long; isidia dense, simple to branched, numerous pycnidia, less than 0.3 mm high; upper surface gray, flat, shiny, emaculate, 10 µm thick; medulla white, 20 µm thick; lower surface black, 12 µm thick; rhizines moderately dense to dense, simple to rarely branched, black; **apothecia** not seen; **pycnidia** sparse to dense, immerse, laminal and on isidia, conidia bifusiform 5-6 x 1 µm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla without lichen substances (K-, C-, KC-, and P-).

Habitat: On trees in the dry dipterocarp forests at 200 – 1,400 m elevations.

Distribution: Thailand and Australia.

Specimens examined: N Thailand. Lampang Province: Khuntan National Park, a trail to Yaw 2, on trunk of unidentified tree, 1998, *T. Pooprang*, RU——10326 (RAMK). Phitsanulok Province: Phu Hin Rong Kla National Park, Lan Hin Taek, on trunk of unidentified tree, 1998, *T. Pooprang*, RU——10070 (RAMK). **NE Thailand.** Loei Province: Nahaeo National Park, Wat Bo Mueang Noi, in the dry dipterocarp forest, on dead wood, 1995, *T. Pooprang*, RU——6981, 6982 & 6983 (RAMK). Sakon Nakhon Province: Phupan National Park, at the edge of the dry evergreen forest, on trunk of unidentified tree, 1997, *T. Pooprang*, RU——8837 & 8838 (RAMK). ibid., Pha Nang Moen, in the dry dipterocarp forest, on trunk of unidentified tree, 1998, *W. Khamtim*, RU——10339 (RAMK).

Observation: This species is characterized by very small lobes and tiny individual, pycnidia on isidia, and negative chemical test of the medulla. The closely related species, *Bulbothrix pigmentacea*, has red pigment in the lower medulla (Hale 1976).

6. *Bulbothrix sensibilis* (Stein. and Zahlbr.) Hale, *Phytologia* 28: 480, 1974

Basionym: *Parmelia sensibilis* Zahlbr., *Symb. Sin.* 3: 184, 1930

Figure 18

Thallus foliose, adnate to tightly adnate; lobes irregularly branched, rarely imbricate, rounded axils, 2 mm wide, margin crenate, apices truncate;

bulbate cilia sparse, simple, short, 0.2 mm long; isidia and soredia absent; upper surface gray green, smooth to rugose, shiny, faintly to moderately maculae, 25 μm thick; medulla white, 70 μm thick; lower surface black, 15 μm thick; rhizines moderately dense, black, simple, up to 2 mm long; **apothecia** moderately dense, sessile to subpedicellate, ecoronate, disc brown, thalline exciple smooth, ascospores hyaline, simple, ellipsoid, 7.5-10 x 5-8 μm; **pycnidia** sparse, immerse, laminal, conidia bifusiform, 5-6 x 1 μm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing salazinic acid and consalazinic acid (K+ yellow turning red, C-, KC-, and P+ orange).

Habitat: On trunks of trees in the evergreen forests and the deciduous forests at 200 – 900 m elevations.

Distribution: Venezuela, Africa, and Thailand.

Specimens examined: N Thailand. Chiang Mai Province: Queen Sirikit Botanic Garden, in the mixed deciduous forest, on trunk of *Litsea glutinosa*, 1994, *K. Boonpragob et al.*, RU——496 (RAMK). ibid., on trunk of *Peltophorum pterocarpum*, 1994, *K. Boonpragob et al.*, RU——748 (RAMK). ibid., on trunk of unidentified trees, 1994, *K. Boonpragob et al.*, RU——2798, 2800 and 3471 (RAMK). **NE Thailand.** Loei Province:

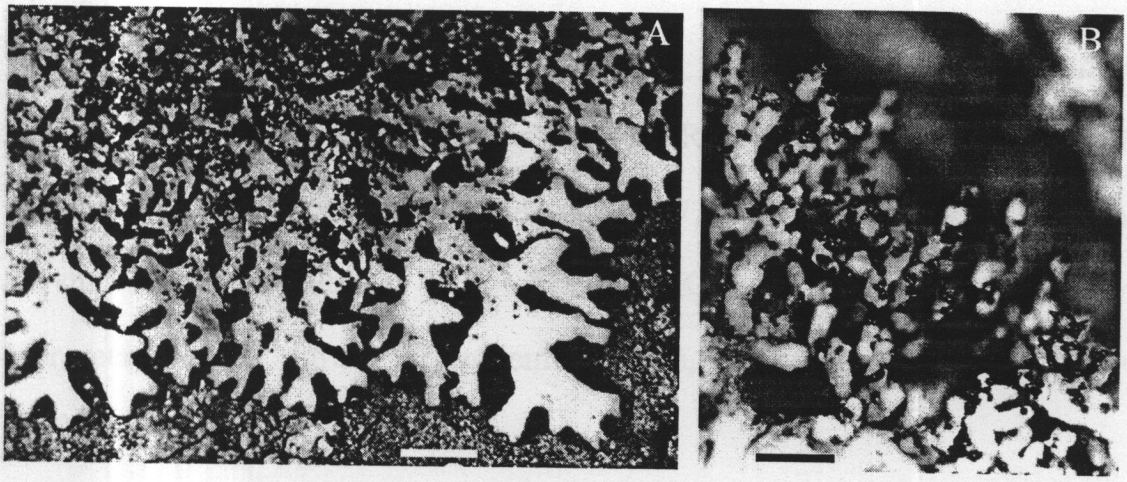


Figure 17 *Bulbothrix queenslandica* (Elix and G. N. Steven) Elix

Note: A. Thallus gray with numerous isidia [RU——6982 (RAMK), scale = 0.1 mm].

B. Cylindrical isidia with pycnidia [RU——6982 (RAMK), scale = 0.5 mm].

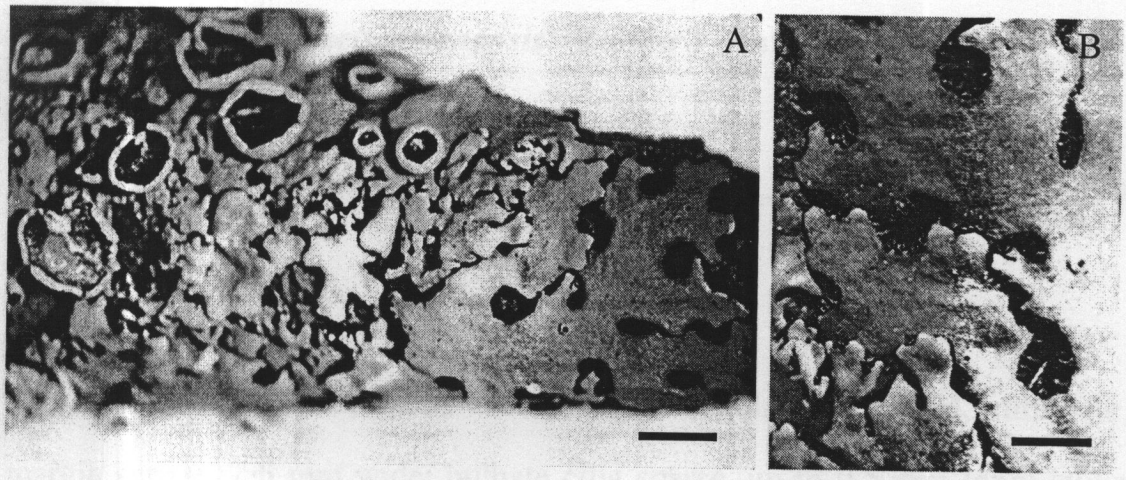


Figure 18 *Bulbothrix sensibilis* (Stein. and Zahlbr.) Hale

Note: A. Thallus gray-green without isidia [RU——7790 (RAMK), scale = 2 mm].

B. Deeply sinuate lobes with slender bulbate cilia [RU——7790 (RAMK), scale = 1 mm].

Nahaeo National Park, in the dry evergreen forest, on trunk of *Bombax anceps*, 1995, *T. Pooprang*, RU——5945 (RAMK). ibid., on trunk of unidentified trees, 1996, *T. Pooprang*, RU——7790 (RAMK). Sakon Nakhon Province: Phupan National Park, Nuai To Khet, at the rim of the dry evergreen forest, on trunk of unidentified tree, 1997, *T. Pooprang*, RU——8840 (RAMK).

Observation: *Bulbothrix sensibilis* is characterized by black lower surface, absent of isidia and soredia, and ascospores are smaller (less than 10 μm) than *B. meizospora* (more than 15 μm).

7. ***Bulbothrix setschwanensis* (Zahlbr.) Hale**, *Phytologia* 28: 480, 1974

Basionym: *Parmelia setschwanensis* Zahlbr., *Symb. Sin.* 3: 184, 1930

Figure 19

Thallus foliose, tightly adnate, lobes irregularly branched, imbricate, margin serrate, 2-5 mm wide; bulbate cilia sparse, up to 0.5 mm long; isidia and soredia absent; upper surface gray, smooth to rugose, sometimes wrinkled on the older lobes, 20 μm thick; medulla white, 80-120 μm thick; lower surface pale brown, 15 μm thick; rhizines moderately dense, simple, brown, up to 1 mm long; **apothecia** rare, if present mostly ascus deformed, disc dark brown, ecoronate, thalline exciple smooth, ascospores rare, hyaline, simple,

ellipsoid, 15-17.5 x 7.5-8 μm; **pycnidia** sparse, immerse, laminal, conidia baciliform, 6-7 x 1 μm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing salazinic acid and consalazinic acid (K+ yellow turning red, C- KC-, and P+ orange).

Habitat: On trees in open habitats at 700 m elevation in the mixed deciduous forests.

Distribution: India, Nepal, China, and Thailand.

Specimens examined: N Thailand. Chiang Mai Province: Queen Sirikit Botanic Garden, on trunk of *Canarium suburatum*, 1994, *K. Boonpragob et al.*, RU——2237 (RAMK). ibid., on trunk of *Bombax ceiba*, 1994, *K. Boonpragob et al.*, RU——2324, 2325 & 2326 (RAMK).

Observation: This species is closely resemble to *Bulbothrix hypochraea* by having pale brown lower surface, but ascospores of the former species are larger.

8. ***Bulbothrix tabacina*** **(Mont. and Bosch) Hale**, *Phytologia* 28: 481, 1974

Basionym: *Parmelia tabacina* Mont. and Bosch, *Sylloge Gen. Spec. Crypto.* 327, 1856

Figure 20

Thallus foliose, adnate to tightly adnate; lobes subirregular to sublinear, 1.5-3 mm wide; margins with moderately dense bulbate cilia, simple, short, 0.5-0.7 mm long; isidia sparse, cylindrical, simple to branched, less than 0.5 mm high; upper surface plane, faintly maculate, 25 μm thick; medulla white, 80 μm thick; lower surface black and dark brown at the margin, 15 μm thick; rhizines black, simple, sparse, up to 1 mm long; **apothecia** and **pycnidia** not seen.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing salazinic acid, and consalazinic acid (K+ yellow turning red, C-, KC-, and P+ orange).

Habitat: On rocks and trunks of trees in the dry dipterocarp forests, the dry evergreen forests, and the lower montane forests at 200 – 1,200 m elevation.

Distribution: Central and South America, Africa, India, Nepal, Thailand, Malaysia, Indonesia, Philippines, Papua New Guinea, and Taiwan.

Specimens examined: N Thailand. Chiang Mai Province: Queen Sirikit Botanic Garden, in the mixed deciduous forest, on trunk of *Peltophorum pteroarpum*, 1994, *K. Boonpragob et al.*, RU——30, 95, 96, 97, 99, 101, 103, 107, 108, 109, 110, 112, 113, 228, 311, 312, 745, 746, 747, 749, 750, 751 & 754 (RAMK). ibid., on trunk of *Dillenia* sp., 1994, *K. Boonpragob et al.*, RU——833 (RAMK). ibid., on trunk of *Dipterocarpus obtusifolius*, 1994, *K. Boonpragob et al.*, RU——1110 & 1861 (RAMK). ibid., on trunk of *Pittosporum ferrugineum*, 1994, *K. Boonpragob et al.*, RU——1200 (RAMK). ibid., on trunk of *Quercus mespilifolioides*, 1994, *K. Boonpragob et al.*, RU——1418 & 1419 (RAMK). ibid., on trunk of unidentified trees, 1994, *K. Boonpragob et al.*, RU——1982, 1983, 2799 & 2801 (RAMK). ibid., on trunk of *Quercus* sp., 1994, *K. Boonpragob et al.*, RU——2500 (RAMK). ibid., on trunk of *Pterocarpus macrocarpus*, 1994, *K. Boonpragob et al.*, RU——2608 (RAMK). ibid., on trunk of *Canarium subulatum*, 1994, *K. Boonpragob et al.*, RU——2846 & 2848 (RAMK). ibid., on trunk of *Dipteroarpus tuberculatus*, 1994, *K. Boonpragob et al.*, RU——2878 & 2882 (RAMK). ibid., on trunk of *Tectona grandis*, 1994, *K. Boonpragob et al.*, RU——2966 (RAMK). ibid., on trunk of *Shorea obtusa*, 1994, *K. Boonpragob et al.*, RU——3032, 3034 & 3035 (RAMK). ibid., on trunk of *Styrax benzoides*, 1994, *K. Boonpragob et al.*, RU——3511 (RAMK). ibid., in the dry dipterocarp forest, on trunk of *Shorea obtusa*, 1995, *K. Boonpragob et al.*, RU——3719 (RAMK). ibid., on trunk of *Sezygium* sp., 1995, *K. Boonpragob et al.*, RU——3756 & 4006 (RAMK). ibid., on trunk of

Holigrana kurzii, 1995, *K. Boonpragob et al.*, RU——3943, 3944, 3946 & 3953 (RAMK). ibid., on trunk of unidentified tree, 1998, *T. Pooprang*, RU——10203 (RAMK). Phitsanulok Province: Phu Hin Rong Kla National Park, Lum Lob Phai, on trunk of *Quercus* sp., 1998, *T. Pooprang*, RU——10176 (RAMK). **NE Thailand.** Loei Province: Nahaeo National Park, a trail to To Ko 1, in the lower montane forest, on rock, 1995, *T. Pooprang*, RU——4237 & 4264 (RAMK). ibid., on trunk of *Sterculia pexa*, 1995, *T. Pooprang*, RU——5406 (RAMK). ibid., on trunk of *Schima wallichii*, 1995, *T. Pooprang*, RU——5543 (RAMK). ibid., on trunk of *Bombax anceps*, 1995, *T. Pooprang*, RU——5939, 5942, 5943, 5946, 5948 & 5949 (RAMK). Sakon Nakhon Province: Phupan National Park, Nuai To Khet, at the rim of the dry evergreen forest, on trunk of unidentified trees, 1997, *T. Pooprang*, RU——8836, 8856 & 8857 (RAMK). E Thailand. Nakhon Ratchasima Province: Khao Yai National Park, in the dry evergreen forest, on trunk of unidentified tree, 1997, *T. Pooprang*, RU——8143 (RAMK).

Observation: This species is characterized by presence of isidia and black lower surface. It resembles *Bulbothrix isidiza*, which has pale brown lower surface.

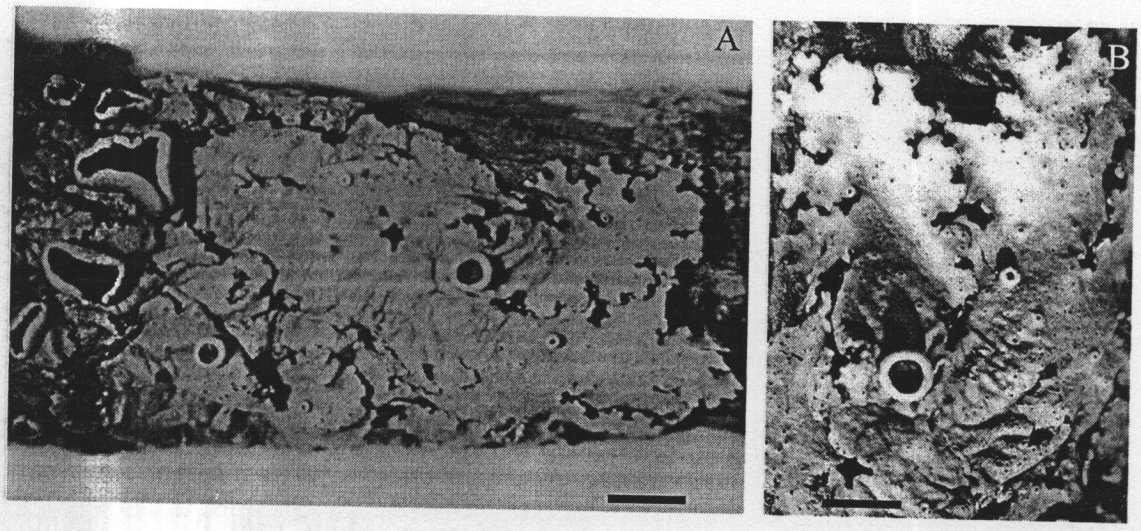


Figure 19 *Bulbothrix setschwanensis* (Zahlbr.) Hale

Note: A. Thallus gray-green without isidia [RU——2237 (RAMK), scale = 2 mm].

B. Lobes show serrate margins and sparse pycnidia [RU——2237 (RAMK), scale = 1 mm].

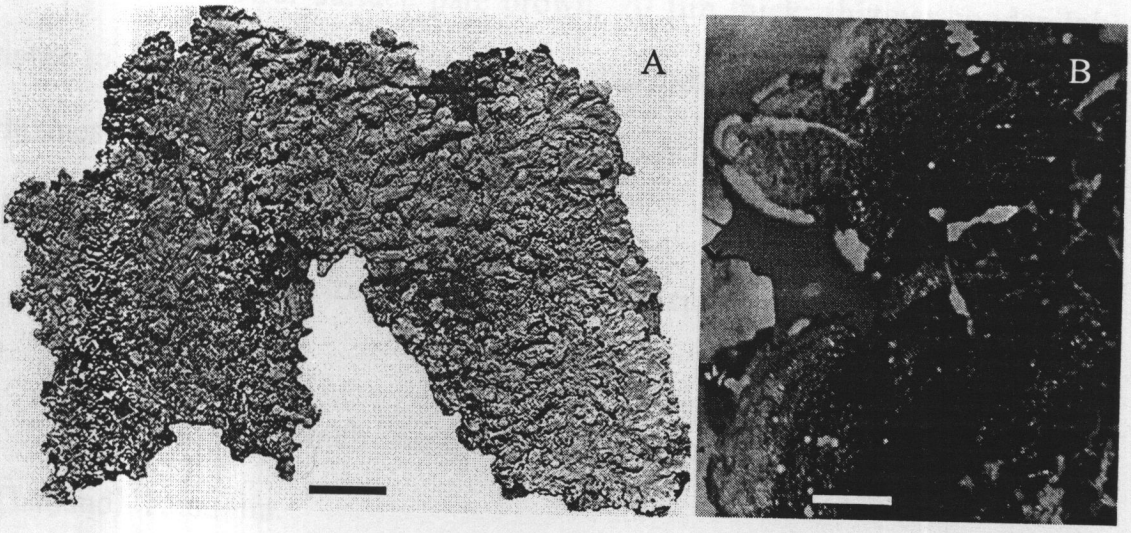


Figure 20 *Bulbothrix tabacina* (Mont. and Bosch) Hale

Note: A. Thallus gray with isidia [RU——10176 (RAMK), scale = 1 cm].

B. Black center and brown margin of lower surface [RU——311 (RAMK), scale = 1 mm].

Genus *Canomaculina*

***Canomaculina* Elix and Hale**, *Mycotaxon* 29: 239, 1987

Figure 21

Thallus foliose, loosely adnate to adnate; lobes flat, sublinear to elongate, 5-10 mm wide, margins entire to crenate, apices subrotund to rotund; cilia scattered moderately to dense, tapered, simple to furcate, short; upper surface pale to grey-green, effigurate maculae, with or without soredia and isidia; upper cortex palisade plectenchymatous with a pored epicortex, 25-30 μm thick; cell walls containing *Cetraria*-type lichenan; medulla white, 120 μm thick; lower surface pale brown, 20 μm thick; rhizines moderately dense to dense, black, simple, dimorphic rhizines which have short and long rhizines; **apothecia** and **pycnidia** not seen.

Habitat: On tree trunk in Northeast Thailand.

Distribution: South America, Africa, Subtropical to tropical Asia (Thailand), Australia.

Observation: *Canomaculina* is characterized by tapered cilia, effigurate-maculae on upper surface, and dimorphic rhizines. This genus closely related to *Parmotrema*, the differences lie on broader lobes, simple

cilia and rhizines, and lacking effigurate maculae on the upper surface. Only one species, *Canomaculina subtinctoria* was determined.

Description of the species of *Canomaculina*

***Canomaculina subtinctoria* (Zahlbr.) Elix**, *Mycotaxon* 65: 477, 1997

Basionym: *Parmelia subtinctoria* Zahlbr., *Symb. Sin.* 3: 193, 1930

Figure 21

Thallus foliose, loosely adnate; lobes sublinear to elongate, 5-10 mm wide, margins crenate, apices rotund; cilia simple to furcate, tapered, up to 2 mm long; upper surface gray-green, smooth to rugose at the thallus center, irregularly cracked, distinctly effigurate maculae, 25-30 μm thick; isidiate dense, cylindrical, simple to branched, with a few lobules; medulla white, 120 μm thick; lower surface pale brown, 20 μm thick; dimorphic rhizines, short rhizines dense, simple, up to 0.2 mm long, long sparse rhizines, coarse, simple to furcate, 1-2 mm long; **apothecia** and **pycnidia** not seen.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow) and medulla containing norlobaridone, salazinic acid, and consalazinic acid (K+ yellow turning dark red, C-, KC+ red, and P+ orange).

Habitat: On tree trunk in the dry evergreen forest at 900 m elevation.

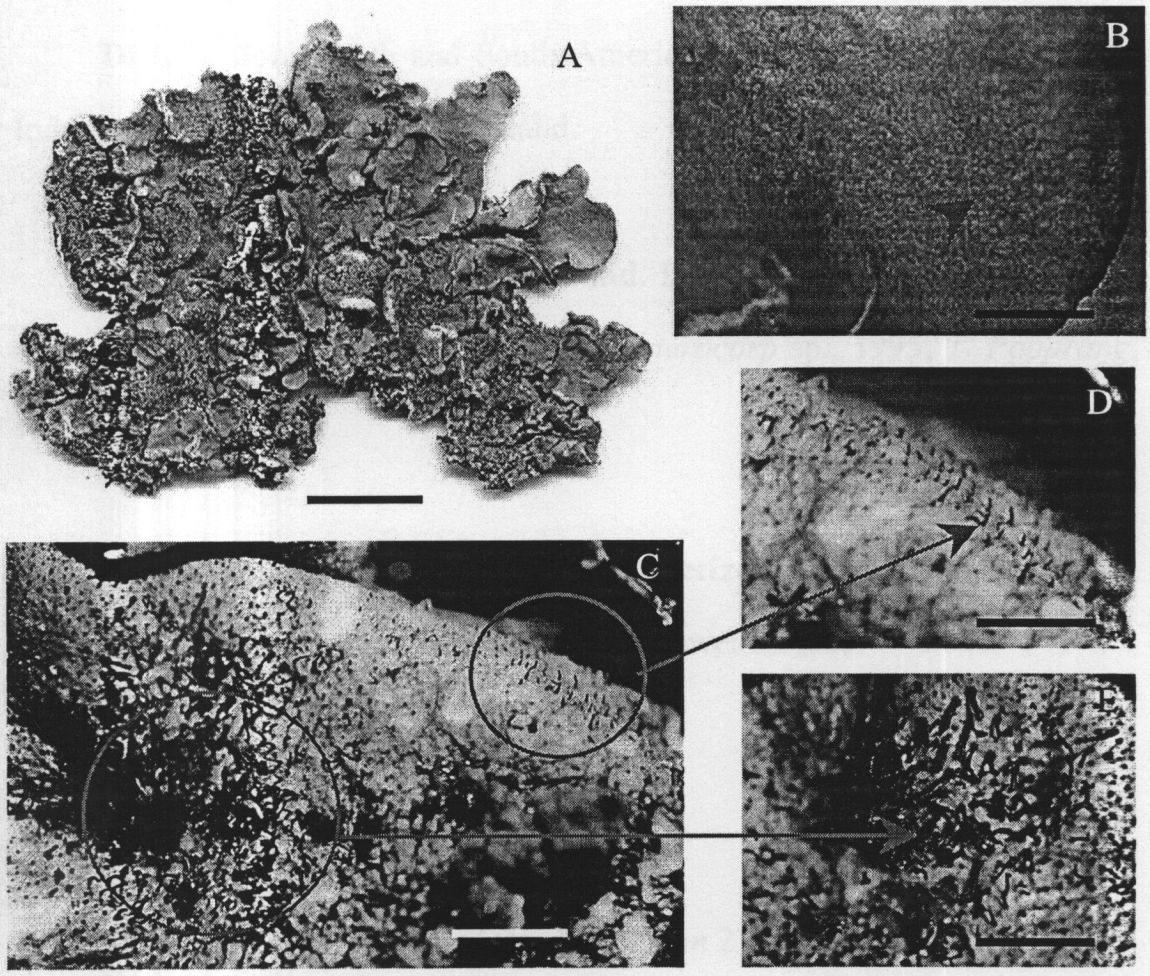


Figure 21 *Canomaculina subtinctoria* (Zahlbr.) Elix

Note: A. Thallus gray-green with isidia [RU——4651 (RAMK), scale = 1 cm].

B. Effigurate maculae on upper surface (arrow) [RU——4651 (RAMK), scale = 1.5 mm].

C. Dimorphic rhizines under lower surface [RU——4651 (RAMK), scale = 3.3 mm].

D. Short rhizines (arrow) [RU——4651 (RAMK), scale = 1.5 mm].

E. Long rhizines (arrow) [RU——4651 (RAMK), scale = 1.5 mm].

Distribution: North and South America, Africa, India, Thailand, and Indonesia, Australia, and New Zealand.

Specimen examined: NE Thailand. Loei Province: Nahaeo National Park, along trial to Toko 1, on trunk of *Dipterocarp* sp., 1995, *T. Pooprang*, RU——4651 (RAMK).

Observation: This species is characterized by effigurate maculae, isidia, and dimorphic rhizines on pale brown lower surface.

Genus *Canoparmelia*

***Canoparmelia* Elix and Hale**, *Mycotaxon* 27: 277, 1986

Figure 22

Thallus foliose, adnate to tightly adnate; lobes sublinear to subirregular, eciliate, apices subrotund to rotund, 0.5-8 mm wide; upper surface ashy gray to gray-green or yellow-green, with or without maculae, isidia, soredia; upper cortex palisade plectenchymatous with a pored epicortex, 15 μm thick; cell walls containing isolichenan; medulla loosely packed, white or partly pale yellow, 50-80 μm thick; lower surface black and pale brown with a narrow naked marginal zone, 15-20 μm thick; rhizines simple, black; **apothecia** laminal, sessile or subpedicellate; disc brown;

ascospores hyaline, simple, ellipsoidal; **pycnidia** immersed to emergent, laminal, conidia bifusiform, 4-5 x 1 μm.

Habitat: On tree trunks and on rocks in expose sunny habitats in the dry dipterocarp forests.

Distribution: Tropical, subtropical, and temperate of North and South America, Africa, and Asia (Thailand).

Observation: This genus resembles *Parmotrema* but its lobe is smaller. The marginal zone of *Canoparmelia* is narrow (less than 1 mm) and without cilia.

Key to the species of *Canoparmelia*

1a Thallus yellow green to gray green; medulla pale yellow with numerous isidia, cylindrical, simple to branched.....*C. ecaperata*

1b Thallus ashy gray with pustulate isidia, occurring on the rock.....

.....*C. owariensis*

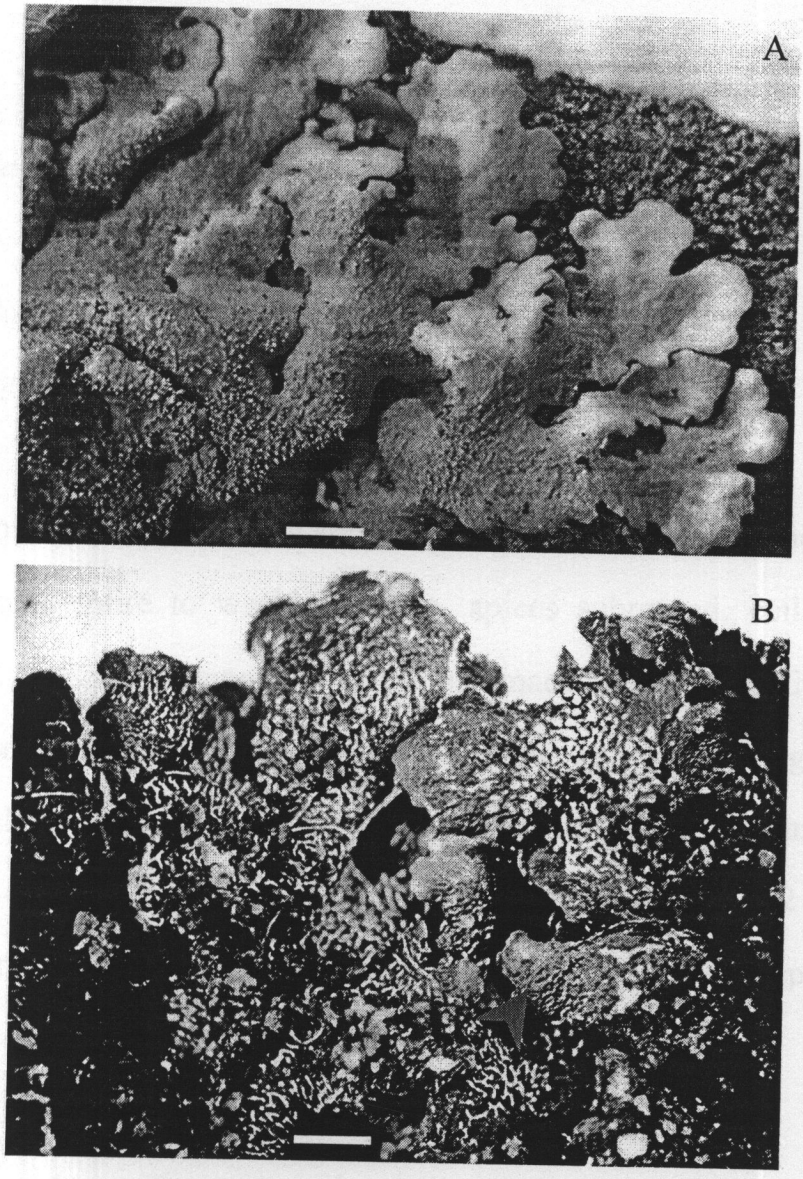


Figure 22 Genus *Canoparmelia* Elix and Hale

Note: A. Lobes rather sublinear, apices subrotund without cilia [RU——10327 (RAMK), scale = 0.15 cm].

B. Lower surface without rhizine at narrow brown marginal zone (arrow) [RU——10074 (RAMK), scale = 0.1 cm].

Description of the species of *Canoparmelia*

1. *Canoparmelia ecaperata* (Müll. Arg.) Hale, *Mycotaxon* 27: 278, 1986

Basionym: *Parmelia ecaperata* Müll. Arg. *Flora, Jena* 74: 378, 1891

Figure 23

Thallus foliose, closely adnate; lobes irregularly to sublinear,1-4 mm wide; margins entire to weakly crenate, apices subrotund, eciliate; upper surface yellow-green, smooth to crenate, emaculate, 15 µm thick; isidia laminal, dense, cylindrical to coralloid branched, up to 2 mm high; medulla white to pale yellow, 80 µm thick; lower surface black, 20 µm thick; simple to sparsely rhizines, with brown black naked marginal zone, 1-2 mm wide; **apothecia** rare, sessile, isidia on margin of thalline exciple; ascospores rarely and mostly deformed; **pycnidia** not seen.

Chemistry: Cortex containing atranorin, chloroatranorin and usnic acid (K+ yellow) and medulla containing divaricatic acid group (K-, C-, KC+ pale brown or pale orange, and P-).

Habitat: On tree trunks in the dry dipterocarp forests and mostly occur on rocks at 1,000 m elevation in the lower montane forests at Phu Hin Rong Kla National Park.

Distribution: Western and Southern Africa, India, and Thailand.

Specimens examined: N Thailand. Chiang Mai Province: The Queen Sirikit Botanic Garden, on trunk of *Dillenia* sp., 1994, *K. Boonpragob et al.*, RU——841, 842, 843, 845, 847, 848, 849, 850, 851, 852, 853, 854, 855, 857, 858, 859, 860, 861, 862, 863, 864, 865, 866, 2564, 2565, 2566, 2577, 2593 & 2594 (RAMK). ibid., on trunk of *Shorea roxburghii*, 1994, *K. Boonpragob et al.*, RU——907, 908, 909, 910, 911, 912, 913, 914, 937, 956, 1723, 1724, 1728, 2749, 2750, 2751, 2752, 2753 & 2754 (RAMK). ibid., on trunk of *Dipterocarpus intricatus*, 1994, *K. Boonpragob et al.*, RU——977, 981, 982 & 983 (RAMK). ibid., on trunk of *Castanopsis diversifolia*, 1994, *K. Boonpragob et al.*, RU——1028 (RAMK). ibid., on trunk of *Pterocarpus* sp., 1994, *K. Boonpragob et al.*, RU——1048 (RAMK). ibid., on trunk of *Shorea obtusa*, 1994, *K. Boonpragob et al.*, RU——1057, 1061, 1065, 1066, 1067, 1366, 1367, 1368, 1369, 1869, 1911 & 3037 (RAMK). ibid., on trunk of *Pittosporum ferrugineum*, 1994, *K. Boonpragob et al.*, RU——1139, 1202 & 1203 (RAMK). ibid., on trunk of *Dipterocarpus obtusifolius*, 1994, *K. Boonpragob et al.*, RU——1328, 1330, 1331, 1614, 1616, 1617, 1618, 1619, 1788, 1789, 1790, 1792 & 1793 (RAMK). ibid., on the trunk of unidentified tree, 1994, *K. Boonpragob et al.*, RU——1526 (RAMK). ibid., on trunk of *Schima wallichii*, 1994, *K. Boonpragob et al.*, RU——1667 (RAMK). ibid., on trunk of *Melia azedarach*, 1994, *K. Boonpragob et al.*, RU——2189, 2190, 2191, 2192, 2194, 2195, 2196, 2197 & 2284 (RAMK). ibid., on trunk of

Canarium subulatum, 1994, *K. Boonpragob et al.*, RU——2231, 2232, 2233, 2234, 2235 & 2847 (RAMK). ibid., on trunk of *Bombax ceiba*, 1994, *K. Boonpragob et al.*, RU——2288, 2289, 2290, 2291, 2292 & 2323 (RAMK). ibid., on trunk of *Quercus* sp., 1994, *K. Boonpragob et al.*, RU——2642, 2643 & 2644 (RAMK). ibid., on trunk of *Anneslea fragrans*, 1994, *K. Boonpragob et al.*, RU——2948, 3001 & 3003 (RAMK). ibid., on trunk of *Tectona grandis*, 1994, *K. Boonpragob et al.*, RU——2968 & 2969 (RAMK). ibid., on trunk of *Castanopsis ferox*, 1994, *K. Boonpragob et al.*, RU——3020 (RAMK). ibid., on trunk of *Betula alnoides*, 1994, *K. Boonpragob et al.*, RU——3201, 3202, 3203 & 3204 (RAMK). ibid., on trunk of *Adina cordifolia*, 1994, *K. Boonpragob et al.*, RU——3277 (RAMK). ibid., on trunk of *Pinus kesiya*, 1994, *K. Boonpragob et al.*, RU——3399, 3400 & 3441 (RAMK). ibid., on trunk of *Protium serratum*, 1994, *K. Boonpragob et al.*, RU——3446, 3465, 3466 & 3467 (RAMK). ibid., on trunk of *Styrax benzoides*, 1994, *K. Boonpragob et al.*, RU——3489, 3510, 3512 (RAMK). ibid., on trunk of *Dipterocarpus obtusifolius*, 1995, *K. Boonpragob et al.*, RU——3644, 3645, 3646, 3649–3659, 3681, 3682, 3683, 3685 & 3689 (RAMK). ibid., on runk of unidentified trees, 1995, *K. Boonpragob et al.*, RU——3663, 3664, 3665 & 3668 (RAMK). ibid., on trunk of *Holigrana kurzii*, 1995, *K. Boonpragob et al.*, RU——3818, 3936, 3937, 3938, 3939, 3940, 3941, 3942 & 3956 (RAMK). ibid., on trunk of *Ficus* sp., 1995, *K. Boonpragob et al.*, RU——3965 (RAMK). ibid., on trunk of *Sezygium* sp., 1995, *K. Boonpragob et al.*, RU——3968, 3971, 3999, 4000 & 4001 (RAMK). ibid., on trunk of unidentified trees,

1998, *T. Pooprang*, RU——10212, 10219, 10220, 10221 & 10222 (RAMK). Doi Suthep–Pui National Park, Sanku, in the lower montane forest, on unidentified trees, 1995, *K. Boonpragob et al.*, RU——4074, 4075, 4076, 4077 & 4124 (RAMK). ibid., Doi Pui Research Station, on trunk of *Pinus kesiya*, 1998, *T. Pooprang*, RU——10255, 10262, 10264 & 10265 (RAMK). ibid., on dead wood, 1998, *T. Pooprang*, RU——10272 & 10273 (RAMK). ibid., on the trunks of unidentified trees, 1998, *T. Pooprang*, RU——10276, 10284, 10285, 10286, 10287 & 10288 (RAMK). ibid., on twig of *Diospyros* sp., 1998, *T. Pooprang*, RU——10312 (RAMK). Lampang Province: Khuntan National Park, along the trial from Yo 2, on trunk of unidentified tree in the Pine forest, 1998, *T. Pooprang*, RU——10327, 10328 & 10332 (RAMK). Phitsanulok Province: Phu Hin Rong Kla National Park, Lan Hin Taek, on rocks, 1998, *T. Pooprang*, RU——10081 (RAMK). ibid., Pha Chuthong, on rocks, 1998, *T. Pooprang*, RU——10095 & 10096(RAMK). ibid., on unidentified tree, 1998, *T. Pooprang*, RU——10101 (RAMK). ibid., on trunk of *Quercus* sp., 1998, *T. Pooprang*, RU——10103 & 10105 (RAMK). ibid., Lan Hin Pum, on rocks, 1998, *T. Pooprang*, RU——10109 & 10112(RAMK). ibid., Rong Riean Kan Mueang Thahan, on unidentified trees, 1998, *T. Pooprang*, RU——10122, 10123 & 10130(RAMK). **NE Thaiand**. Loei Province: Na Haeo National Park, along the trail to Toko 1, in the lower montane forest, on trunk of *Castanopsis helfoliana*, 1995, *T. Pooprang*, RU——4461 (RAMK).

Observation: The prominant characteristic of this species is yellow-green thallus and containing usnic acid and atranorin in the cortex.

2. ***Canoparmelia owariensis*** **(Asahina) Elix,** *Mycotaxon* 47: 127, 1993

Basionym: *Parmelia owariensis* Asahina, *J. Jap. Bot.* 28: 135, 1953

Figure 24

Thallus foliose, especially saxicolous, tightly adnate; lobes moderately imbricate, sublinear to subirregular, up to 3 mm wide, margins entire, darkening rim, apices truncate to rotund; upper surface ashy grey, flat, smooth or becoming rugulose, 15 μm thick; pustulate isidia, cylindrical to irregularly inflated, rarely brusting apically, up to 1 mm high; medulla white, 50 μm thick; lower surface black, brown at the naked marginal zone, 15-20 μ m thick; rhizines, simple sparsely, black; **apothecia** sessile, 1-2 mm wide; disc concave, dark brown; thalline exciple with pustulate isidia; ascospores hyaline, simple, ellipsoidal, 9-10 x 4-5 μm; **pycnidia** immerse, laminal, conidia bifusiform, 5-6 x 1 μm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing divaricatic acid, and nordivaricatic acid (K-, C-, KC-, and P-); pigmented lower medulla, K+ purple to violet of eupectin.

Habitat: Only occur on rock in the exposed area of the lower montane forest at 1,000 m elevation.

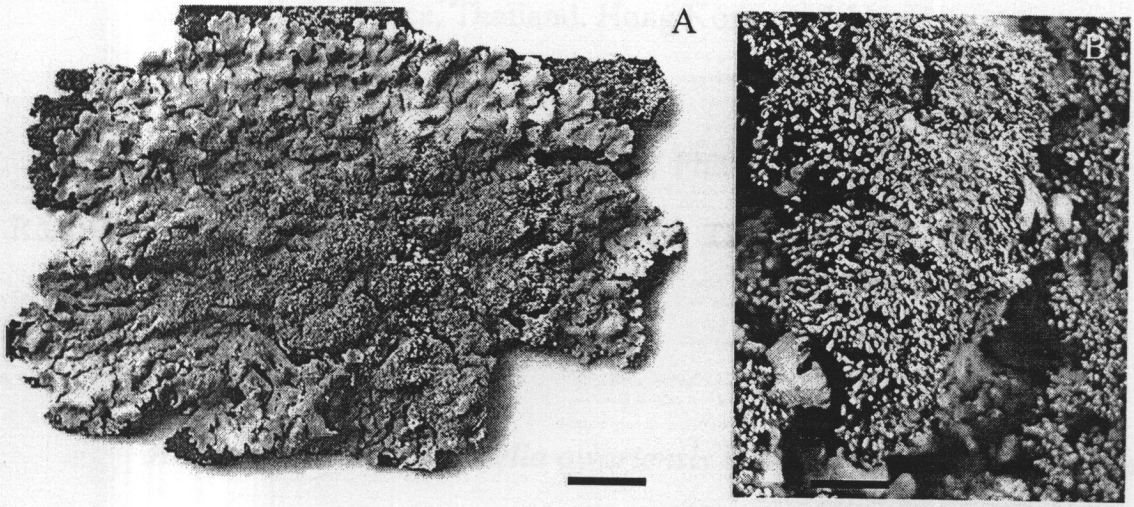


Figure 23 *Canoparmelia ecaperata* (Müll. Arg.) Hale

Note: A. Thallus yellow-green with isidia [RU——10327 (RAMK), scale = 1 cm].

B. Cylindrical to coralloid isidia [RU——847 (RAMK), scale = 1.5 mm].

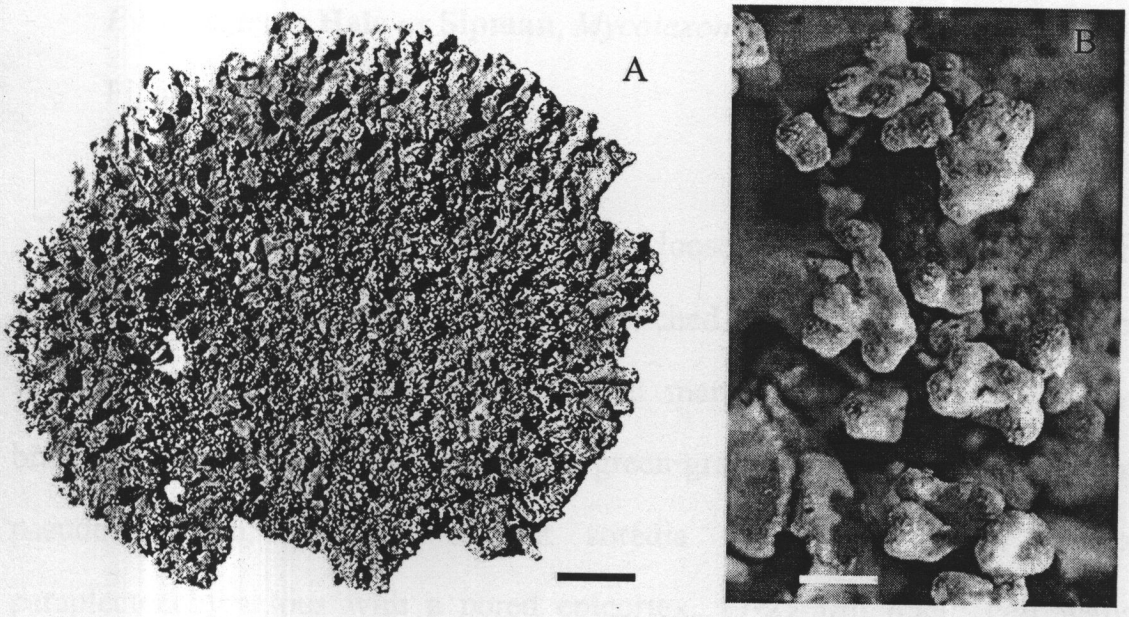


Figure 24 *Canoparmelia owariensis* (Asahina) Elix

Note: A. Thallus white-gray with pustulate isidia [RU——10074 (RAMK), scale = 1 cm].

B. Pustulate isidia [RU——10074 (RAMK), scale = 1 mm].

Distribution: Africa, Thailand, Hong Kong, and Japan.

Specimen examined: N Thailand. Phitsanulok Province: Phu Hin Rong Kla National Park, the trial in Lan Hin Taek, on rock, *T. Pooprang*, RU——10074 (RAMK).

Observation: *Canoparmelia owariensis* is distinguished by pustulate isidia, the simple isidia belongs to *C. ecaperata*.

Genus *Everniastrum*

***Everniastrum* Hale *ex* Sipman**, *Mycotaxon* 26: 237, 1986

Figure 25

Thallus foliose to subfruticose, loosely adnate; lobes linear, subdichotomously to dichotomously branched, canaliculate to involute, narrow, 0.5-4 mm wide; with or without marginal cilia, cilia simple or branched, black; upper surface gray to green-gray, faintly maculae, without pseudocyphellae, with or without soredia and isidia; upper cortex paraplectenchymatous with a pored epicortex, 17-25 μm thick; cell walls containing isolichenan, medulla white, 80-100 μm thick; lower surface black to brown near the margins, 12-20 μm thick; rhizines simple to dichotomously branched, rarely squarrose, black or brown-black; **apothecia** laminal; disc brown, pedicellate; thalline exciple entire to wrinkled; ascospores hyaline,

simple, ellipsoid to reniform (bean-shaped), 12.5-25 x 7-10 μm; **pycnidia** laminal, immersed, conidia bifusiform 4-7 x 1 μm.

Habitat: On tree trunks, twigs and on soils. Only occur in the lower montane forests at Northern Thailand.

Distribution: Pantropical, Central and South America, Asia, and Australia.

Observation: *Everniastrum* is characterized by foliose to subfruticose growth form, linear elongate, dichotomously branched and canaliculate lobes with marginal cilia.

Key to the species of *Everniastrum*

1a Thallus lacking isidia or soredia; medulla K+ red, salazinic acid present.....2

1b Thallus lacking isidia or soredia; Pd+ orange-red, protocetraric acid present.....*E. scabridum*

2a Rhizines rare, mostly marginal; without fatty acid.....*E. cirrhatum*

2b Rhizines dense, mostly laminal; with fatty acid.....*E. nepalense*

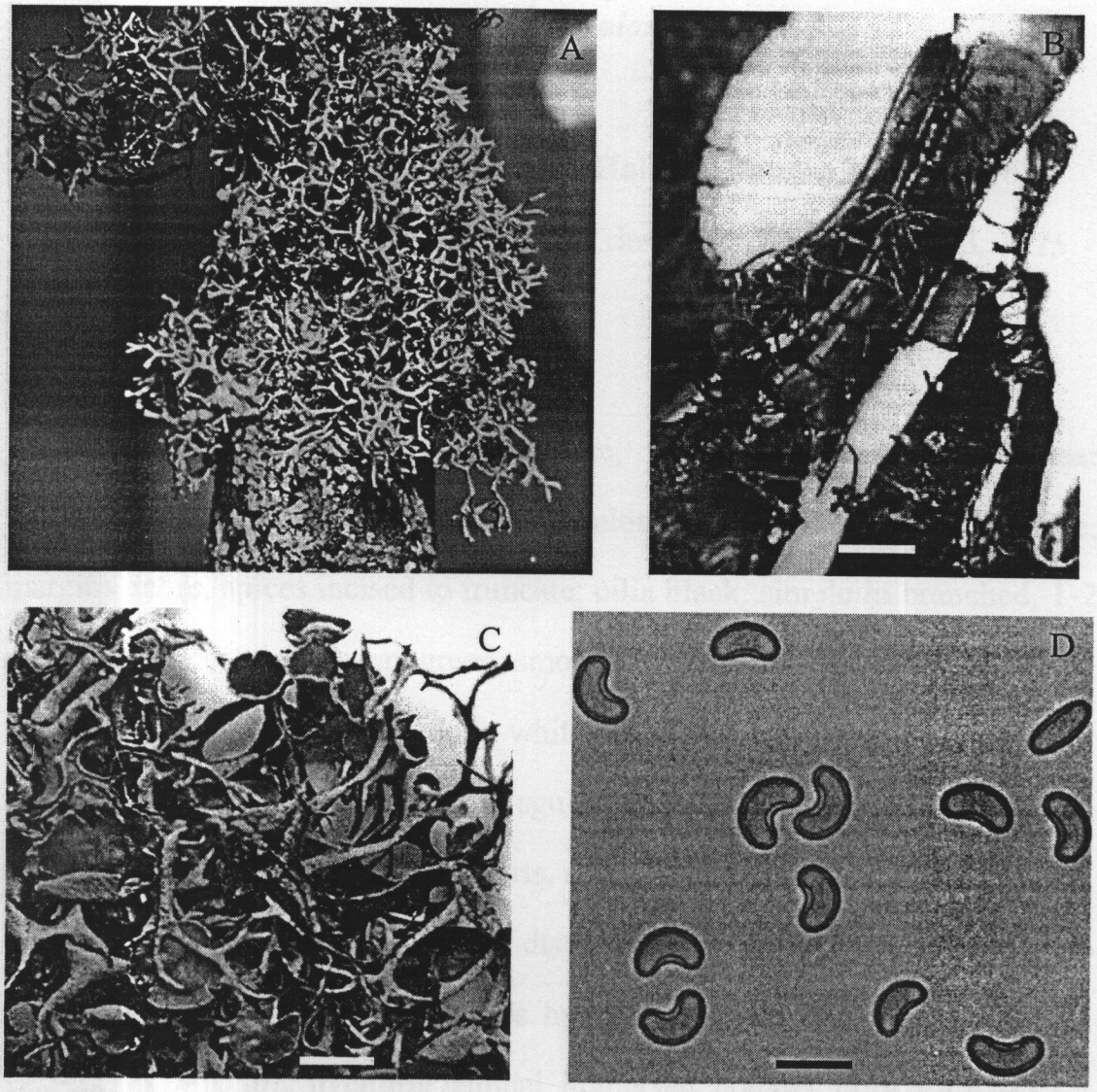


Figure 25 Genus *Everniastrum* Hale *ex* Sipman

Note: A. Thallus growing on tree trunk.

B. Canaliculate lobes with rhizines on lower surface [RU——10242 (RAMK), scale = 2 mm].

C. Lobes with laminal disc-like apothecia [RU——10242 (RAMK), scale = 0.5 cm].

D. Hyaline, simple, reniform (bean-shaped) ascospores [RU——3433 (RAMK), scale = 20 μm].

Descriptions of the species of *Everniastrum*

1. ***Everniastrum cirrhatum* (Fries) Hale**, *Mycotaxon* 3: 347, 1976

Basionym: *Parmelia cirrhata* E. Fries, *Syst. Orb. Veg.* 1: 283, 1825

Figure 26

Thallus foliose to subfruticose, loosely adnate; lobes linear dichotomously branched, suberect to pendulous, canaliculate, 0.5-2 mm wide; margins entire, apices incised to truncate; cilia black, simple to branched, 1-2 mm wide; upper surface gray green, smooth, convex, emaculate, 25 μm thick; without isidia and soredia; medulla white, 100 μm thick; lower surface black and brown at the margins, with irregular transversely ridge, 18 μm thick; rhizines sparse to rare in the older parts, mostly marginal, black, 0.5 mm long; **apothecia** laminal, subpedicellate, disc brown, thalline exciple entire to wrinkled, 5-12 mm wide; ascospores hyaline, simple, ellipsoid to reniform, 12.5-22.5 x 7-10 μm; **pycnidia** laminal, immersed, conidia, bifusiform 4-5 x 1 μm.

Chemistry: Cortex containing atranorin, chloroatranorin (K+ yellow) and medulla containing salazinic acid and consalazinic acid (K+ yellow turning red, C-, KC-, and P+ orange).

Habitat: On trees in the lower montane forests and on mosses and soils in moist areas at 1,000-2,500 m above sea levels in Northern Thailand.

Distribution: Pantropical, Central and South America, India, Thailand, Taiwan, Korea, and Japan.

Specimens examined: N Thailand. Chiang Mai Province: The Queen Sirikit Botanic Garden, on twig and trunk of *Castanopsis ferox*, 1994, *K. Boonpragob et al.*, RU——3243, 3244 & 3245 (RAMK). ibid., on trunk of *Pinus kesiya*, 1994, *K. Boonpragob et al.*, RU——3370, 3376, 3378, 3381 & 3416 (RAMK). Doi Suthep-Pui National Park, Sunkuu, on trunk of unidentified tree, 1995, *K. Boonpragob et al.*, RU——4117 (RAMK). Doi Inthanon National Park, on soil, 1998, *T. Pooprang*, RU——10242, 10243, 10244, 10245, 10246, 10247, 10248, 10250, 10251, 10252 & 10253 (RAMK).

Observation: This species is distinguished by rarely to sparsely rhizines along the margins.

2. ***Everniastrum nepalense* (Taylor) Hale**, *Mycotaxon* 3: 348, 1976

Basionym: *Parmelia nepalensis* Taylor, *London Journal Bot.* 6: 172, 1847

Figure 27

Thallus foliose to subfruticose, loosely adnate, lobes linear dichotomously branched, suberect to pendulous, canaliculate, 1.5-2 mm wide; margins entire; cilia black, simple to branched, 1 mm wide; upper surface gray-green, smooth, convex, emaculate, 17.5-20 μm thick; without isidia and

soredia; medulla white, 80 μm thick; lower surface black, brown at the margins, 12.5-15 μm thick; rhizines moderately dense, mostly laminal, simple to branched, black, 0.5 mm long; **apothecia** laminal, sessile to subpedicellate, disc brown, thalline exciple smooth to wrinkled, 3-5 mm wide; ascospores hyaline, simple, ellipsoid to reniform, 15-22.5 x 7-10 μm; **pycnidia** laminal to subterminal, immersed, conidia, bifusiform 4-5 x1 μm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow) and medulla containing salazinic acid and protolichesterinic acid (fatty acid) (K+ yellow turning red, C-, KC-, and P+ orange).

Habitat: Occurring on trees and soils with *Everniastrum cirrhatum.*

Distribution: Southern China, India, Thailand, Taiwan, Korea, and Japan.

Specimens examined: N Thailand. Chiang Mai Province: The Queen Sirikit Botanic Garden, on trunk of *Quercus mespilifolioides*, 1994, *K. Boonpragob et al.*, RU——2941 (RAMK). ibid., on trunk of unidentified tree, 1994, *K. Boonpragob et al.*, RU——3095, 3130, 3131 & 3132 (RAMK). ibid., on trunk of *Castanopsis* sp., 1994, *K. Boonpragob et al.*, RU——3140, 3141, 3142 & 3143 (RAMK). ibid., on trunk of *Stereospermum neuranthum*, 1994, *K. Boonpragob et al.*, RU——3229 (RAMK). ibid., on trunk and twig

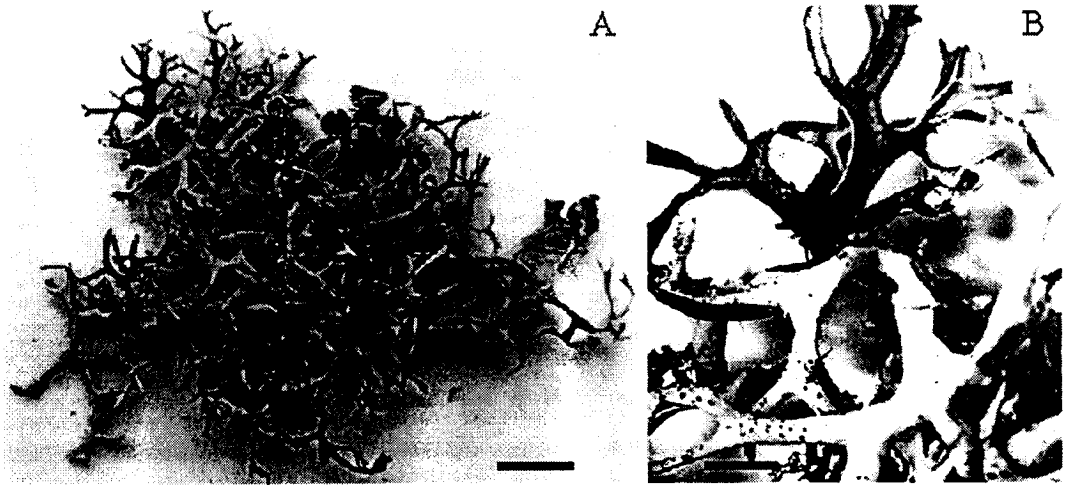


Figure 26 *Everniastrum cirrhatum* (Fries) Hale

Note: A. Canaliculate and dichotomously branched lobes [RU——10242 (RAMK), scale = 1 cm].

B. Lower surface with sparsely rhizines mostly along the margins [RU——10242 (RAMK), scale = 0.33 cm].

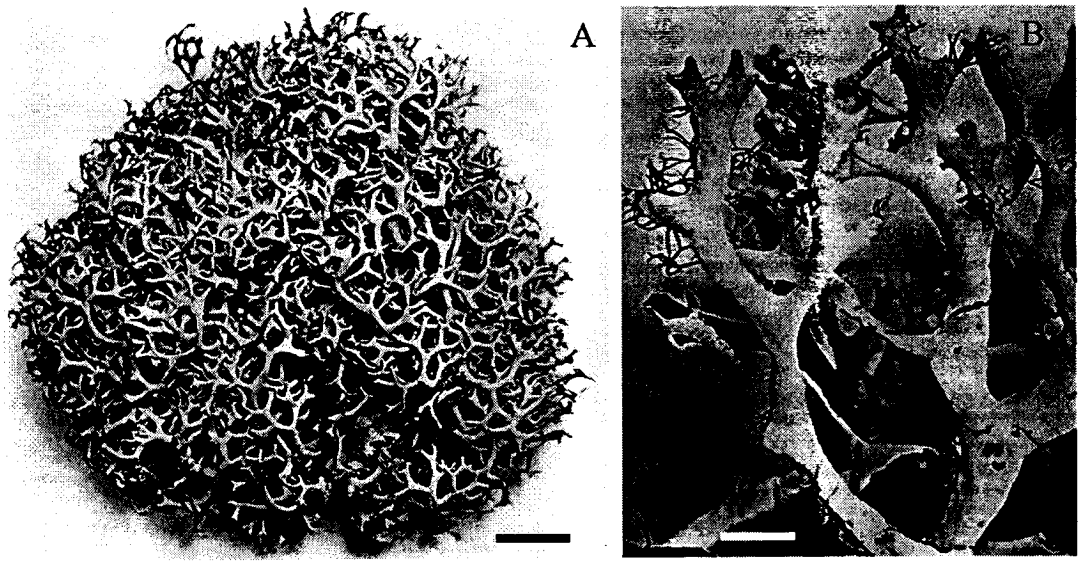


Figure 27 *Everniastrum nepalense* (Taylor) Hale

Note: A. Canaliculate and short dichotomously branched lobes [RU——3366 (RAMK), scale = 1 cm].

B. Lobes with dense rhizines on lower surface [RU——3366 (RAMK), scale = 0.33 cm].

of *Castanopsis ferox*, 1994, *K. Boonpragob et al.*, RU——3246, 3247 & 3248 (RAMK). ibid., on trunk of *Adina cordifolia*, 1994, *K. Boonpragob et al.*, RU——3278 (RAMK). ibid., on trunk and twig of *Pinus kesiya*, 1994, *K. Boonpragob et al.*, RU——3303, 3304, 3305, 3306, 3307, 3315, 3318, 3319, 3320, 3321, 3322, 3323, 3324, 3325, 3326, 3327, 3336, 3343, 3359, 3360, 3361, 3362, 3363, 3364, 3365, 3366, 3367, 3368, 3369, 3371, 3372, 3373, 3374, 3377, 3379, 3380 & 3382 (RAMK). Doi Inthanon National Park, on soil, 1998, *T. Pooprang*, RU——10249 (RAMK). Doi Suthep-Pui National Park, on trunk of *Pinus kesiya*, 1998, *T. Pooprang*, RU——10254 (RAMK).

Observation: *Everniastrum nepalense* is characterized by moderately dense, mostly laminal rhizines.

3. ***Everniastrum scabridum*** Elix and Pooprang, sp. nov., *Mycotaxon* 71: 111, 1999

Figure 28

Thallus foliose, loosely adnate; lobes linear-elongate to subirregular, dichotomously to subdichotomously branched, involute, 1-2 mm wide, margin entire, apices incised to truncate; without isidia and soredia; eciliate; upper surface pale gray or darkening with age, flat to weakly convex, shiny and smooth at the margins, distinctly maculae, 20 μm thick; medulla white, 80 μm thick; lower surface ivory to pale brown along broad marginal zone, black, rugulose, 20 μm thick; rhizines very sparse, if present mainly laminal,

sparsely branched, black; **apothecia** pedicellate, imperforate, 2-7 mm wide; disc concave to undulate-distorted, dark brown to olive-brown; thalline exciple maculate, rugose and ridged, becoming undulate; ascospores hyaline, simple, ellipsoid to reniform, 20-25 x 8-10 μm; **pycnidia** common, immersed, laminal, conidia weakly bifusiform, 5-7 x 1 μm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow) and medulla containing protocetraric acid, protolichesterinic acid, lichesterinic acid, virensic acid, and conprotocetraric acid (K-, C-, KC-, and P+ orange-red).

Habitat: At present this new species has been known from several localities in lower montane forest at 1,300-2000 m elevation at Chiang Mai Province, northern Thailand.

Distribution: Thailand.

Specimens examined: N Thailand. Chiang Mai Province: The Queen Sirikit Botanic Garden, on trunk of *Pinus kesiya*, 1995, *K. Boonpragob et al.*, RU——3306.1, 3433 & 3438 (RAMK). Doi Suthep-Pui National Park, Doi Pui Research Unit, on twig of *Diospyros* sp., 1998, *T. Pooprang*, RU—— 10291, 10305, 10306, 10307 & 10308 (RAMK).

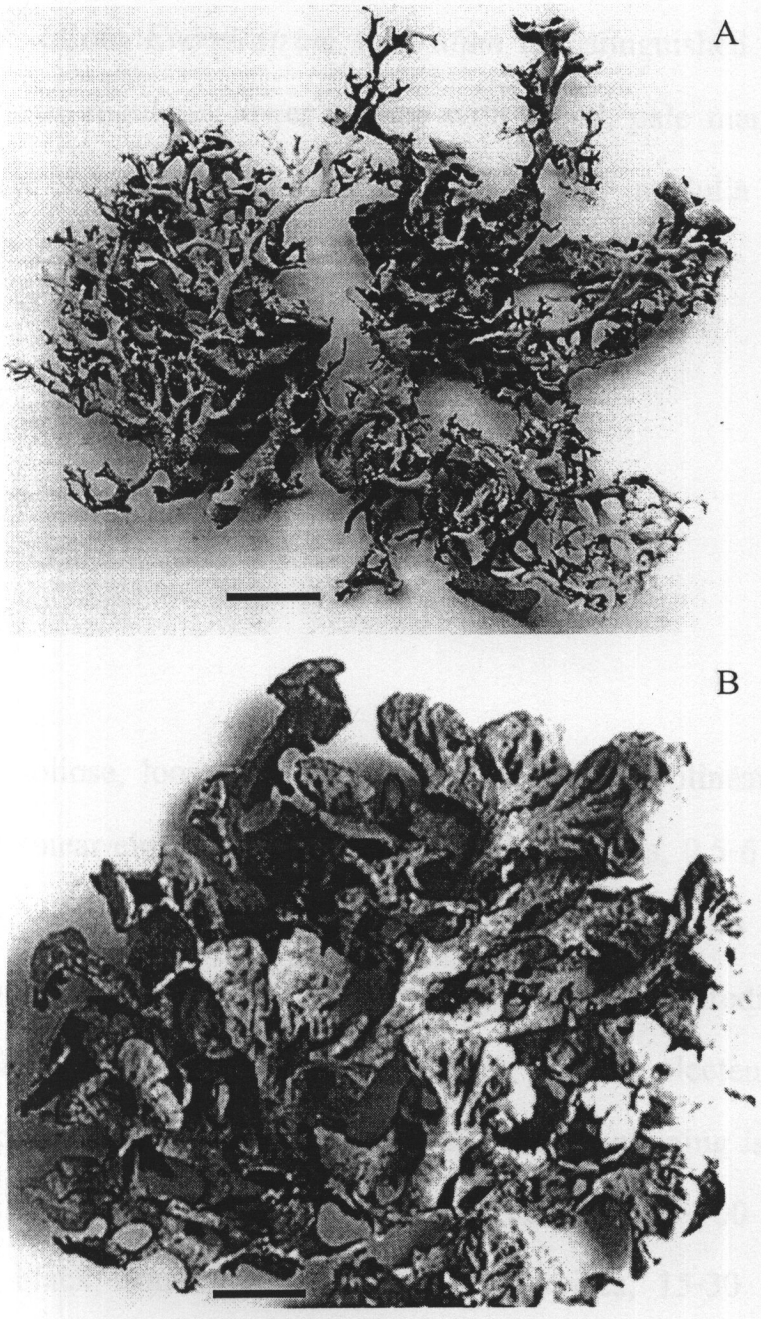


Figure 28 *Everniastrum scabridum* Elix and Pooprang

Note: A. Irregular to subdichotomously branched lobes [RU——10308 (RAMK), scale = 0.72 cm].

B. Apothecia wrinkled and ridged with thalline exciple [RU——3433 (RAMK), scale = 0.36 cm].

Observation: *Everniastrum scabridum* is distinguished by eciliate, sparsely rhizinate, rugulose, lower surface with broad, pale marginal zone. The spores are larger than the other species and medulla containing protocetraric acid.

Genus *Hypotrachyna*

***Hypotrachyna* (Vain.) Hale,** *Phytologia* 28:340, 1974

Figure 29

Thallus foliose, loosely to tightly adnate; lobes sublinear or rarely subirregular or linear-elongate, with rounded axils of lobes, 0.5-6 mm wide; margins entire; eciliate; apices subtruncate, incised, sometimes subrotund; upper surface whitish to ashy gray, with or wihtout maculae, soredia, pustules and isidia; without pseudocyphellae; upper cortex palisade plectenchymatous and with pored epicortex, 10-25 μm thick; cell walls containing isolichenan; medulla white or occasionally partly yellow or orange, 80-100 μm thick; lower surface black, sometimes brown at lobe apices, 15-30 μm thick; rhizines dichotomously branched, rarely squarrosely branched or simple, black, protruding beyond the margins; **apothecia** rare to common, laminal, sessile to subpedicellate, 1-10 mm wide; disc imperforate; thalline exciple entire sometimes with isidia; ascospores hyaline, simple, ellipsoidal, 8 per ascus, 6-16 x 3-10 μm; **pycnidia** rare to common, immersed, laminal; conidia bifusiform, 5-8 x 1 μm.

Habitat: On trunks and canopies of trees, on rocks, and sometimes on mosses. Mostly occur at 1,000 m above sea level in the lower montane forests.

Distribution: Cosmopolitan, temperate, and tropic.

Observation: *Hypotrachyna* is distinguished by dichotomously branched rhizines, rounded axils of lobes, and eciliate. Frequently occur in the lower montane forests at elevation above 1,000 m.

Key to the species of *Hypotrachyna*

1a Thallus without isidia and soredia 2

1b Thallus with isidia, soredia or pustules.....8

2a Medulla KC+ pale orange; with barbatic acid group.....3

2b Medulla KC-; without barbatic acid.....6

3a Medulla with obtusatic acid and echinocarpic.....4

3b Medulla without obtusatic acid and echinocarpic.....5

4a Obtusatic acid present.....*H. physcioides*

4b Echinocarpic present.....*H. scytodes*

5a Only barbatic acid present.....*H. ducalis*

5b 5-chloro-4-O-demethylbarbatate present.....*H. chlorobarbatica*

6a Medulla K+ red.....7

6b Medulla K-, and P+ orange to red of protocetraric acid.....*H. adducta*

7a Medulla with norstictic acid and salazinic acid.....*H. mason-halei*

7b Medulla with only salazinic acid.....*H. coorgiana*

8a Thallus with isidia.....9

8b Thallus with soredia or pustules.....11

9a Medulla K-; containing fatty acid.....*H. costaricensis*

9b Medulla K+ red or yellow turning red.....10

10a Norstictic acid and stictic acid groups present.....*H. crenata*

10b Salazinic acid present.....*H. ramkhamhaengiana*

11a Thallus with capitate soredia.....*H. immaculata*

11b Thallus with pustulate soredia.....12

12a Cortex UV+ yellow, lichexanthone present.....*H. osseoalba*

12b Cortex UV-, lichexanthone absent.....13

13a Medulla K+ red; norstictic acid and salazinic acid present.....*H. kingii*

13b Medulla K-, KC+ orange.....14

14a Echinocarpic present.....*H. adjuncta*

14b Echinocarpic absent.....*H. exsecta*

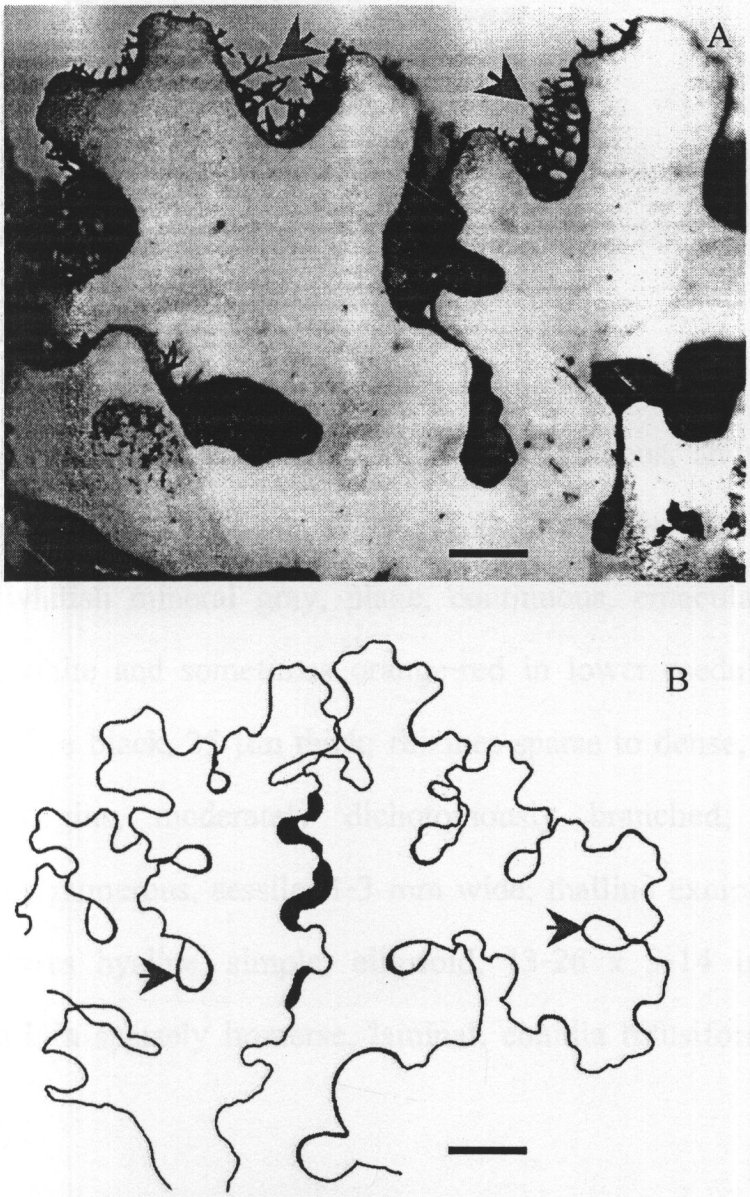


Figure 29 Genus *Hypotrachyna* (Vain.) Hale

Note: A. Dichotomously branched rhizines (arrow) [RU——11173 (RAMK), scale = 0.75 mm].

B. Illustration of rounded axils of lobes (arrow) (scale = 2 mm).

Description of the species of *Hypotrachyna*

1. ***Hypotrachyna adducta* (Nyl.) Hale**, *Phytologia* 28: 340, 1974

Basionym: *Parmelia adducta* Nyl., *Flora* 68: 610, 1885

Figure 30

Thallus foliose, adnate, lobes subirregular sinuous, short, 2-3 mm wide; margin entire; apices subrotund to incise; without soredia and isidia; upper surface whitish mineral gray, plane, continuous, emaculate, 25 μm thick; medulla white and sometimes orange-red in lower medulla, 80 μm thick; lower surface black, 25 μm thick; rhizines sparse to dense, protruding beyond the margins, moderately dichotomously branched; **apothecia** common, usually numerous, sessile, 1-3 mm wide; thalline exciple entire to crenate; ascospores hyaline, simple, ellipsoid, 13-26 x 9-14 μm, mostly deformed; **pycnidia** sparsely immerse, laminal, conidia bifusiform, 4-5 x 1 μm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing protocetraric acid (K-, C-, KC-, and P+ orange turning red), and skyrin pigmented (K+ purple in the lower medulla).

Habitat: On trees trunk above 1,000 m elevation in the lower montane forests and the moist areas.

Distribution: India, Nepal, Thailand, Malaysia, Papua New Guinea, Philippines, Taiwan, and Japan.

Specimens examined: N Thailand. Chiang Mai Province: Doi Inthanon National Park, opposite Kiu Mae Pan, on unidentified tree, 1998, *T. Pooprang*, RU——10231, 10232, 10233, 10240 & 10241 (RAMK), Doi Suthep-Pui National Park, Doi Pui Research Station, on trunk of *Pinus kesiya*, 1998, *T. Pooprang*, RU——10260 (RAMK). **E Thailand.** Nakhon Ratchasima Province: Khao Yai National Park, Khao Khiao, Pha Trom Chai, on truks of unidentified tree, 1999, *T. Pooprang,* RU——TP001, TP002, TP003 & TP004 (RAMK).

Observation: The morphology resembles *Hypotrachyna masonhalei*, which has numerous apothecia, norstictic acid, and salazinic acid, but *H. adducta* has protocetraric acid.

2. ***Hypotrachyna adjuncta* (Hale) Hale**, *Phytologia* 28: 340, 1974

Basionym: *Parmelia adjuncta* Hale, *Phytol.* 22: 434, 1971

Figure 31

Thallus foliose, loosely adnate to adnate; lobes contiguous, sublinear to elongate, 2-4 mm wide; margin entire; upper surface pale gray, plane, shiny, emaculate, 25 μm thick, pustulate isidia; medulla white,100 μm thick; lower surface black, 30 μm thick; rhizines dense, richly dichotomously

branched; **apothecia** present but the collected specimens mostly have young ascus and ascospores; thalline exciple entire; **pycnidia** not seen.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing barbatic acid, 4-*0*-demethylbarbatic acid, and ± echinocarpic (K-, C-, KC+ orange to red, and P-).

Habitat: On trunks of trees and rocks at altitude over 1,000 m in the moist forests.

Distribution: India, Thailand, Malaysia, Philippines, Taiwan, and Japan.

Specimens examined: N Thailand. Chiang Mai Province: Queen Sirikit Botanic Garden, on trunk of *Ficus* sp., 1995, *T. Pooprang*, RU——3832 (RAMK). ibid., Doi Inthanon National Park, along trail opposite Kiu Mae Pan, on unidentified tree, 1998, *T. Pooprang*, RU——10238 (RAMK). Phitsanulok Province: Phu Hin Rong Kla National Park, Phu Chu Thong, on unidentified tree, 1997, *N. Homchantara*, RU——9441 (RAMK). ibid., Rong Rian Kaan Mueang Thahaan, on unidentified tree, 1998, *T. Pooprang,* RU——10120, 10132 & 10161 (RAMK). **NE Thailand.** Loei Province: Na Haeo National Park, a trial to Toko1, on unidentified trees, 1995, *T. Pooprang*, RU——6801, 6802, 6803 & 6878 (RAMK).

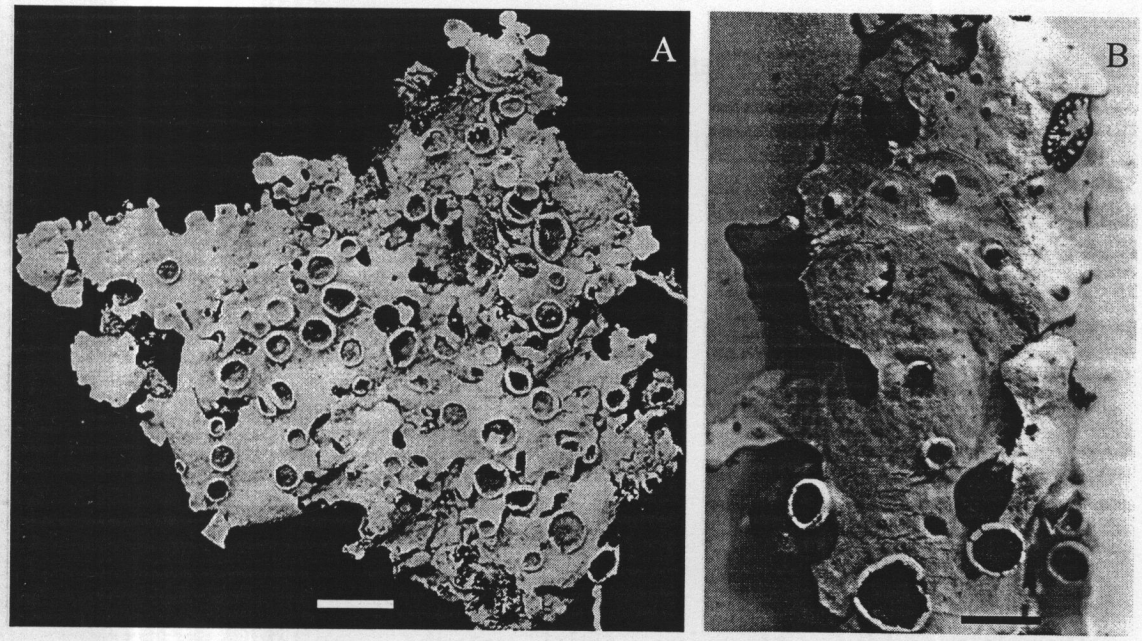


Figure 30 *Hypotrachyna adducta* (Nyl.) Hale

Note: A. Thallus with numerous apothecia [RU——TP001 (RAMK), scale = 0.5 cm].

B. Lobes with rouded axils and dichotomously branched rhizines [RU——10231 (RAMK), scale = 3 mm].

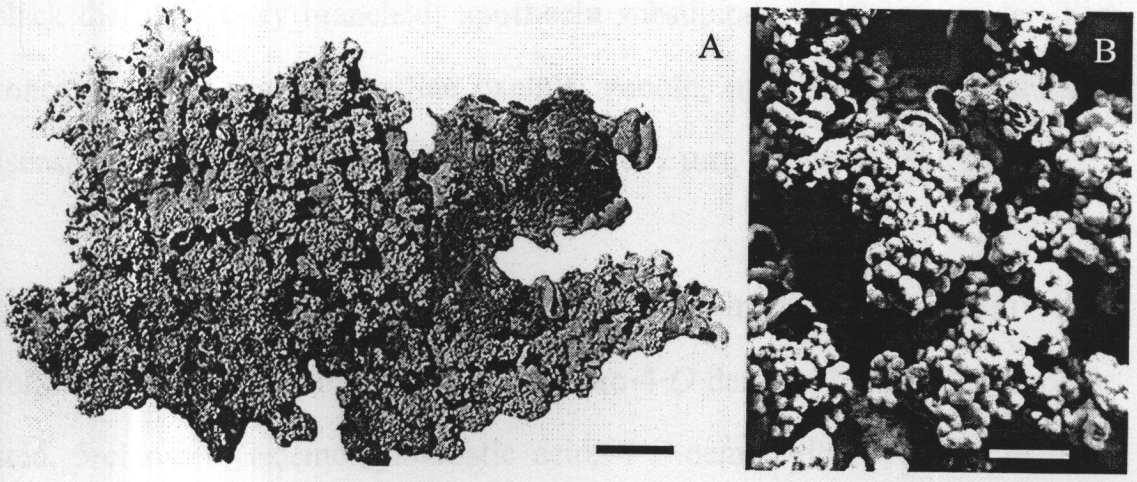


Figure 31 *Hypotrachyna adjuncta* (Hale) Hale

Note: A. Thallus with numerous pustules [RU——9441 (RAMK), scale = 1 cm].

B. Pustulate isidia [RU——9441 (RAMK), scale = 1 mm].

Observation: *Hypotrachyna adjuncta* is similar to *H. exsecta* by having sorediate pustules and barbatic acid complex, whereas the former contains echinocarpic.

3. *Hypotrachyna chlorobarbatica* Elix & Pooprang, sp. nov., *Mycotaxon* 71: 113, 1999

Figure 32

Thallus foliose, adnate; lobes imbricate, sublinear-elongate, subdichotomously to irregularly branched, 1-2 mm wide, eciliate; margin entire; apices subrotund; lacking pustules, soredia and isidia; upper surface pale gray to gray, flat, shiny, smooth to rugulose, emaculate, 15 μm thick; medulla white, 100 μm thick; lower surface dull, black, 20 μm thick; rhizines black dichotomously branched; **apothecia** substipitate, 4-10 mm wide; disc concave to flat, brown; thalline exciple smooth, margin narrow, undulate; ascospores hyaline, simple, ellipsoid, 8-11 x 5-7 μm; **pycnidia** not seen.

Chemistry: Cortex containing atranorin, chloroatranorin (K+ yellow); medulla containing methyl-5-chloro-4-*O*-demethylbarbatate, barbatic acid, 5-chloro-4-*O*-demethylbarbatic acid, 4-*O*-demethylbarbatic acid, and unknowns (trace) (K-, C+ orange, KC+ orange, and P-).

Habitat: On trunk of unidentified tree in the moist area of the lower montane forest at 1,400 m above sea level.

Distribution: Thailand

Specimen examined: E Thailand. Nakhon Ratchasima Province: Khao Yai National Park, Khao Khieo, a trail to Pha Dieo Daai, moist areas in the lower montane forests, on trunk of unidentified tree, 1997, *T. Pooprang*, RU—9708 (RAMK).

Observation: The overall morphology of this new species resembles *Hypotrachyna physcioides*. Both are characterized by adnate thalli, narrow sublinear elongate lobes with a black lower surface and the presence of medullary barbatic and 4-*O*-demethylbarbatic. However, *H. physcioides* is clearly distinguished by the maculate upper surface of the lobes and the common lobulate-laciniae, whereas *H. chlorobarbatica* lacks these morphological features and contains additional methyl 5-chloro-4-*O*-demethylbarbatate and 5-chloro-4-*O*-demethylbarbatic acid.

4. ***Hypotrachyna coorgiana*** **Patwardhan and Prabhu**, *The Bryologist* 80: 348, 1977

Figure 33

Thallus foliose, adnate, lobes subirregular to sublinear, 3-5 mm wide; margin entire; apices subrotund; without pustules, soredia and isidia; upper surface whitish mineral gray, plane to involute, smooth, emaculate, 25 µm thick; medulla white and sometimes with orange-red spot in lower

medulla, 80 μm thick; lower surface black, 25 μm thick; rhizines sparse to dense, protruding beyond the margins, moderately simple to dichotomously branched; **apothecia** present, sessile, 1-3 mm wide; thalline exciple entire to crenate; ascospores mostly deformed or immature; **pycnidia** numerous, immerse, conidia bifusiform, 4-5 x 1 μm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing salazinic and consalazinic acid (K+ red, C-, KC-, and P+ orange).

Habitat: On trees and rocks in the exposed sunny habitats.

Distribution: India, and Thailand.

Specimens examined: N Thailand. Phitsanulok Province: Phu Hin Rong Kla National Park, Lan Hin Taek, on rock, 1998, *T. Pooprang*, RU—— 10083 (RAMK). **E Thailand.** Nakhon Ratchasima Province: Khao Yai National Park, Khao Kieo, on trunk of unidentified tree, 1997, *T. Pooprang*, RU——9710 (RAMK).

Observation: The morphology and chemistry resemble *Parmelinella chozoubae,* but the difference lie on *Hypotrachyna coorgiana* has dichotomously branched rhizines and eciliate.

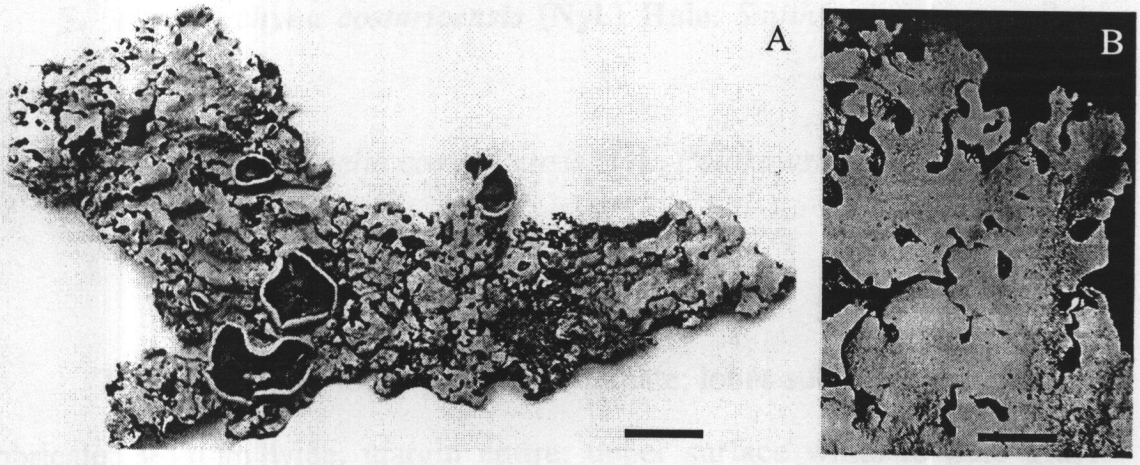


Figure 32 *Hypotrachyna chlorobarbatica* Elix and Pooprang

Note: A. Thallus gray with imperforate apothecia [RU—9708 (RAMK), scale = 1.2 cm].

B. Imbricated lobes with rounded axils [RU—9708 (RAMK), scale = 0.33 cm].

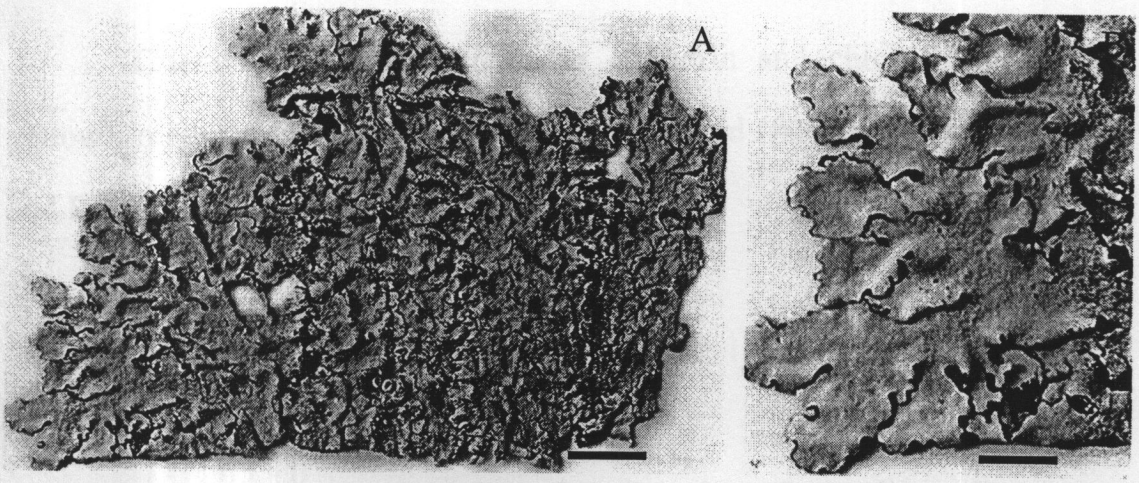


Figure 33 *Hypotrachyna coorgiana* Patw. and Prabhu

Note: A. Thallus lacking isidia and soredia [RU—10083 (RAMK), scale = 1.2 cm].

B. Lobes sublinear with small rounded axils [RU—10083 (RAMK), scale = 1 cm].

5. *Hypotrachyna costaricensis* (Nyl.) Hale, *Smithsonian Contr. Bot.* 25: 29, 1975

Basionym: *Parmelia costaricensis* Nyl., *Polakowsky* 225, 1877

Figure 34

Thallus foliose, loosely adnate to adnate; lobes sublinear to irregular, imbricate, 3-5 mm wide; margin entire; upper surface white to pale gray, plane, smooth to wrinkled, faintly maculate, 15 μm thick, isidia numerous, mostly laminal, cylindrical, simple to branched, up to 1 mm high; medulla white, 60 μm thick; lower surface black, 20 μm thick; rhizines dense, obviously visible along the margins, dichotomously branched, up to 2 mm long; **apothecia** and **pycnidia** not seen.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing protolichesterinic acid (fatty acid) (K-, C-, KC-, and P-).

Habitat: On trees in open habitats above 1,000 m elevetion.

Distribution: Central America (Mexico, Costa Rica, Dominican Republic); South America (Venezuela and Bolivia); Africa (Ethiopia, Kenya, Tanzania); Asia (India, Indonesia, Thailand, Philippines, and Papua New Guinea); and Australia.

Specimens examined: N Thailand. Phitsanulok province: Phu Hin Rong Kla National Park, Lan Hin Pum, on trunk of tree, 1998, *T. Pooprang*, RU——10127 (RAMK). **SW Thailand.** Kaeng Krachaan National Park, Phanoenthong camp, on trunk of unidentified tree, 1998, *T. Pooprang*, RU——11177 (RAMK).

Observation: *Hypotrachyna costaricensis* is characterized by dense isidia and presence of fatty acid.

6. ***Hypotrachyna crenata* (Kurokawa) Hale**, *Phytologia* 28: 34, 1974

Basionym: *Parmelia crenata* Kurokawa, *Contr. U. S. Nat. Herb.* 36: 168,1964

Figure 35

Thallus foliose, loosely adnate to adnate; lobes sublinear to irregular, imbricate, up to 5 mm wide; margin entire to distinctly crenate and black rimmed, apices subrotund; upper surface whitish gray, plane, smooth to wrinkled, faintly maculate, 15 μm thick, isidia mostly laminal, cylindrical, simple to branched; medulla white, 80 μm thick; lower surface black, 20 μm thick; rhizines dense, dichotomously branched, up to 2 mm long; **apothecia** present, laminal, disc brown; thalline exciple with numerous isidia; ascospores hyaline, simple, ellipsoid, 10-15 x 9 μm; **pycnidia** not seen.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containig norstictic acid, stictic acid, and constictic acid (K+ red, C-, KC+ red, and P+ orange).

Habitat: On trees and rocks in exposed habitats in the moist forests.

Distribution: India, Thailand, Philippines, Papua New Guinea, Taiwan, and Japan.

Specimens examined: N Thailand. Chiang Mai Province: Queen Sirikit Botanic Garden, on trunk of *Pinus kesiya*, 1994, *K. Boonpragob et al.*, RU——3397, 3398, 3402 & 3409 (RAMK). Phitsanulok Province: Phu Hin Rong Kla National Park, Phachuthong, on rock, 1997, *N. Homchantara et.al.*, RU——9480 (RAMK). ibid., Kang Han Nam near Rong Rian Kan Mueang Thahan, on rock, 1998, *T. Pooprang*, RU——10077, 10092, 10094, 10097, 10128, 10157, 10164 & 10277 (RAMK).

Observation: *Hypotrachyna crenata* is distinguished by having numerous isidia and containing stictic acid complex. The external feature resembles *H. costaricensis*, which has isidia and fatty acid.

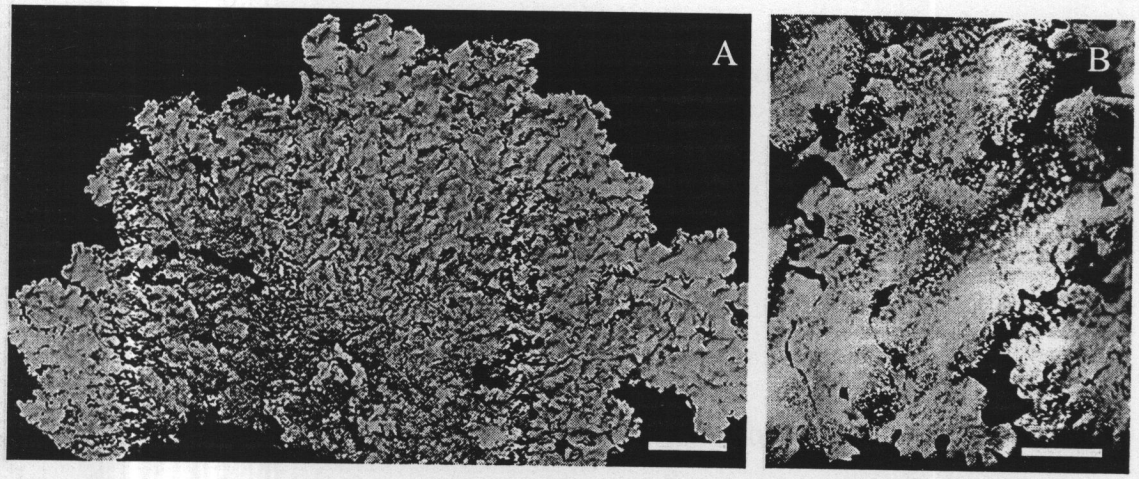


Figure 34 *Hypotrachyna costaricensis* (Nyl.) Hale

Note: A. Thallus with numerous isidia [RU——11177 (RAMK), scale = 1.5 cm].

B. Dense cylindrical isidia cover on upper surface [RU——11177 (RAMK), scale = 0.2 cm].

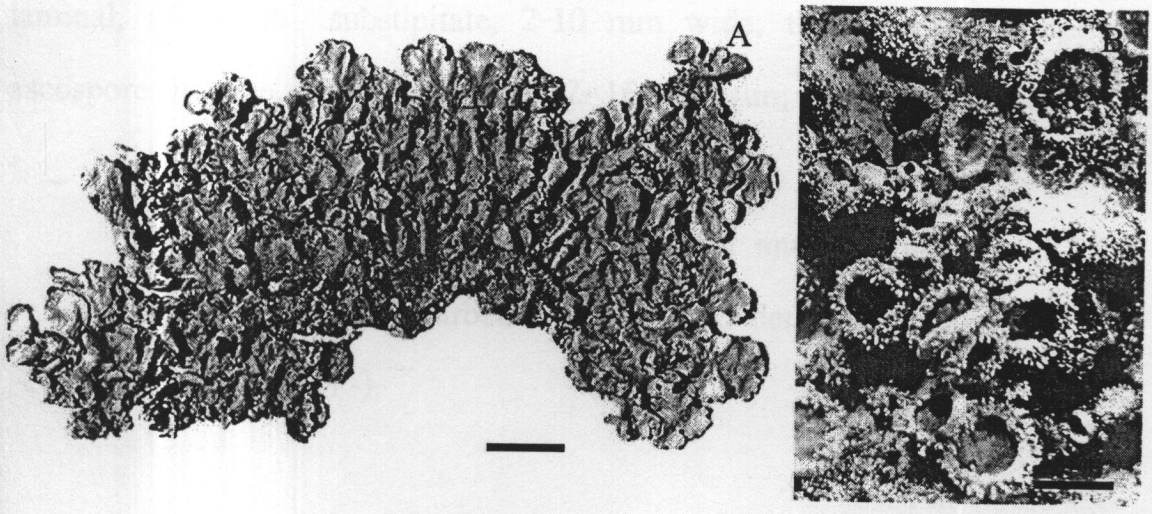


Figure 35 *Hypotrachyna crenata* (Kurokawa) Hale

Note: A. Thallus with crenate margins and isidia [RU——10277 (RAMK), scale = 1 cm].

B. Apothecia with isidia on the thalline exciple [RU——10277 (RAMK), scale = 3 mm].

7. ***Hypotrachyna ducalis*** **(Jatta) Hale,** *Smithsonian Contr. Bot.* 25:33, 1975.

Basionym: *Parmelia ducalis* Jatta

Figure 36

Thallus foliose, loosely adnate to adnate; lobes sublinear, long and a little branched often much longer than lobe width, 2-6 mm wide; margin entire, apices subrotund to truncate; without isidia and soredia; upper surface ashy white to gray plane to convex, dull and sometimes distinctly white-maculate, 20 μm thick; medulla white, 100 μm thick; lower surface black, 25 μm thick, rhizines dense, dichotomously branched; **apothecia** rare if present laminal, adnate to substipitate, 2-10 mm wide; thalline exciple entire; ascospores hyaline, simple, ellipsoid, 12- 16 x 6-9 μm; **pycnidia** not seen.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing barbatic acid, and 4-*O*-demethylbarbatic acid (K-, C-, KC+ orange, and P-).

Habitat: Occur on trees with *Hypotrachyna physcioides* and *H. scytodes* in the lower montane forests at high elevation above 1,000 m.

Distribution: India, and Thailand.

Specimens examined: N Thailand. Chiang Mai province: Doi Suthep-Pui National Park, Doi Pha Klong, on trunk of unidentified tree, 1994, *K. Boonpragob et al.*, RU——3123 (RAMK). ibid., San Kuu, a trial in the lower montane forest, 1995, *K. Boonpragob et al.*, RU——4018, 4022, 4025, 4026 & 4083 (RAMK). ibid., Queens Sirikit Botanic garden, on trunk of *Castanopsis diversifolia*, 1994, *K. Boonpragob et al.*, RU——1024 (RAMK). ibid., on trunk of *Pittosporum ferrugineum*, 1994, *K. Boonpragob et al.*, RU——1199 (RAMK). ibid., on trunk of *Dillenia* sp., 1994, *K. Boonpragob et al.*, RU——1499 (RAMK). ibid., on trunk of *Pinus kesiya*, 1994 *K. Boonpragob et al.*, RU——3408 & 3434 (RAMK). ibid., on trunk of *Holigrana kurii*, 1995, *K. Boonpragob et al.*, RU——3831 (RAMK).

Observation: *Hypotrachyna ducalis* resembles *H. physcioides* and *H. scytodes*, all lack of isidia and soredia and presence of barbatic acid group. This species often has lobes length longer than lobes width.

8. *Hypotrachyna exsecta* (Taylor) Hale, *Phytologia* 28: 341, 1974.

Basionym: *Parmelia exsecta* Taylor, *London Jour. Bot.* 6: 166, 1847.

Figure

Thallus foliose, loosely adnate to adnate; lobes crowded, sublinear, discrete to imbricate, subascending, 2-3 mm wide; margin entire to dentate with rounded axils of lobes; pustules becoming granular sorediate and eroding, exposed black lower surface; upper surface white gray, smooth to

rugous, flat to convex, emaculate, 30 μm thick; medulla white, 100 μm thick; lower surface black, 20 μm thick; rhizines rather dense, dichotomously branched, usually protruding to the margins, up to 1 mm long; **apothecia** and **pycnidia** not seen.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing barbatic acid, 4-O-demethylbarbatic acid, obtusatic acid, and norobtusatic acid (K-, C-, KC+ orange, and P-).

Habitat: On trunks of trees at elevations above 1,000 m in the lower montane forests.

Distribution: Tropical and subtropical region of Southeastern Asia and Eastern Asia (India, Thailand, and Taiwan), South Pacific (Papua New Guinea), and Australia.

Specimens examined: N Thailand. Chiang Mai Province: Doi Inthanon National Park, along trail opposite Kiu Mae Pan, On branches of unidentified tree, 1998, *T. Pooprang*, RU——10234, 10235, 10236, 10238 & 10239 (RAMK).

Observation: *Hypotrachyna exsecta* resembles *H. adjuncta,* but the former has pustules becoming sorediate and exposing black lower surface.

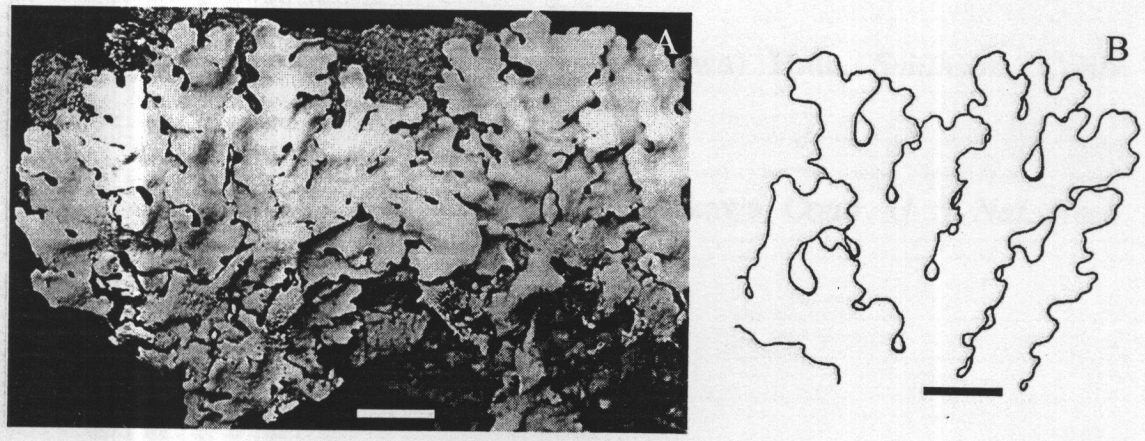


Figure 36 *Hypotrachyna ducalis* (Jatta) Hale

Note: A. Thallus lacking isidia and soredia [RU——3408 (RAMK), scale = 1 cm].

B. Illustration of long lobes with short branches (scale = 2 mm).

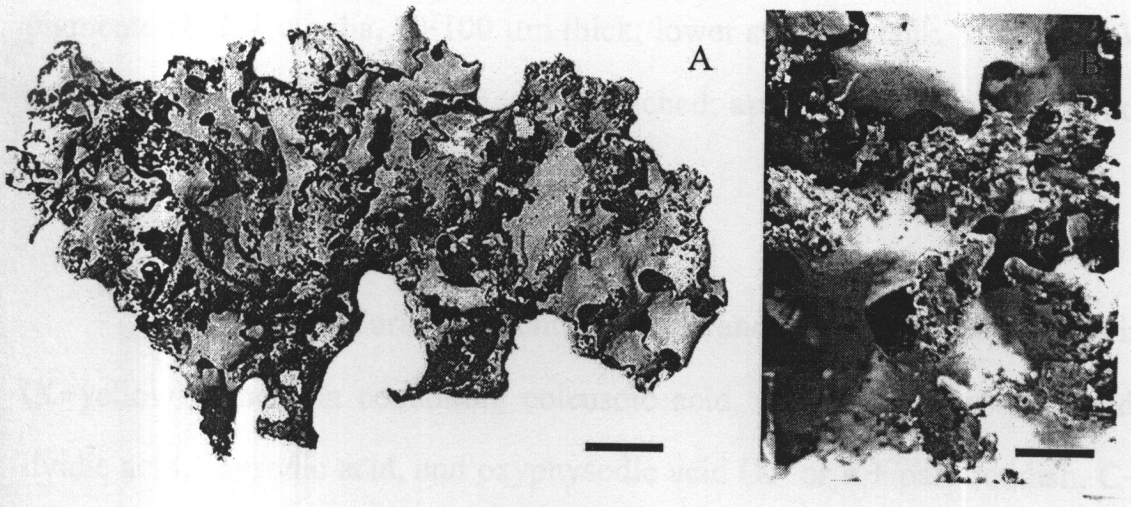


Figure 37 *Hypotrachyna exsecta* (Taylor) Hale

Note: A. Thallus convex with pustulate soredia [RU——10234 (RAMK), scale = 1.4 cm].

B. Pustules becoming granulate soredia which open and exposing black lower surface [RU——10234 (RAMK), scale = 0.5 cm].

9. *Hypotrachuna immaculata* (Kurokawa) Hale, *Smithson. Contr. Bot.*, 25: 41, 1975

Basionym: *Parmelia immaculata* Kurokawa, *Contr. U. S. Nat. Herb.* 36: 178, 1964

Figure 38

Thallus foliose, loosely adnate to adnate; lobes sublinear, subdichotomously branched, 1.5-3 mm wide; margins entire with axils sinuous, apices incised; soralia subterminal to terminal, distinctly capitate, often turn to finely pustular at old age; upper surface whitish gray, plane, smooth, shiny, 10 μm thick; medulla white often yellow to ochraceous pigmented below soralia, 80-100 μm thick; lower surface black, 10 μm thick; rhizines black, densely dichotomously branched; **apothecia** and **pycnidia** not seen.

Chemistry: Cortex containing atranorin and chloroatranorin (K+yellow); medulla containing colensoic acid, 4-*O*-methylphysodic acid, lividic acid, physodic acid, and oxyphysodic acid (K- or K+ pale reddish, C-, KC+ rose, and P-).

Habitat: On rocks in exposed sunny habitats in the lower montane forest.

Distribution: Australia, temperate-tropical of South America and Africa.

Specimens examined: N Thailand. Phitsanulok Province: Phu Hin Rong Kla National Park, Lan Hin Taek, on rock, 1998, *T. Pooprang*, RU—— 10066, 10071 & 10133 (RAMK).

Observation: This species is distinguished by the capitate soralia and the upper cortex absent lichexanthone (UV-).

10. *Hypotrachyna kingii* (Hale) Hale, *Phytologia* 28 : 34, 1974

Basionym: *Parmelia kingii* Hale, *Journ. Jap. Bot.* 43: 324, 1968

Figure 39

Thallus foliose, loosely adnate to adnate; lobes sublinear to subirregular, subimbricate, subascending, 2-3 mm wide; margin entire to deeply dentate with sinuous, apices subrotund; pustules becoming granular sorediate and eroding, exposed black lower surface; upper surface whitish gray, smooth to rugous, plane to involute, flaking, emaculate, 10 μm thick; medulla white, 100 μm thick; lower surface black, 20 μm thick; rhizines dense, dichotomously branched, usually protruding beyond the margins, up to 1 mm long; **apothecia** present, disc brown, thalline exciple entire to undulate; ascospores hyaline, simple, ellipsoid, 9-11 x 6-7 μm; **pycnidia** emergent on upper surface, laminal, conidia bifusiform 5-6 x 1 μm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing norstictic acid, and salazinic acid (K+ red, C-, KC-, and P+ orange).

Habitat: On trunks or branches of trees in the lower montane forests at 1,000 m elevation.

Distribution: Thailand, Indonesia, and Taiwan.

Specimens examined: E Thailand. Nakhon Ratchasima Province: Khao Yai National Park, Pha Trom Chai, Khao Khiao, on trunk of unidentified tree, 1999, *T. Pooprang,* RU——8362, 8371 & 8378 (RAMK). **SW Thailand.** Phetchaburi Province: Kaeng Krachan National Park, Pha Noen Thung camp, on trunk of unidentified trees, 1998, *T. Pooprang*, RU——11151, 11159, 11162, 11182 & 11186 (RAMK).

Observation: *Hypotrachyna kingii* is distinguished by pustulate soredia, which sometime erode at the center expose medulla and black lower surface. This is similar to *H. exsecta*, but the former has norstictic acid and salazinic acid whereas the latter contain barbatic acid group and obtusatic acid.

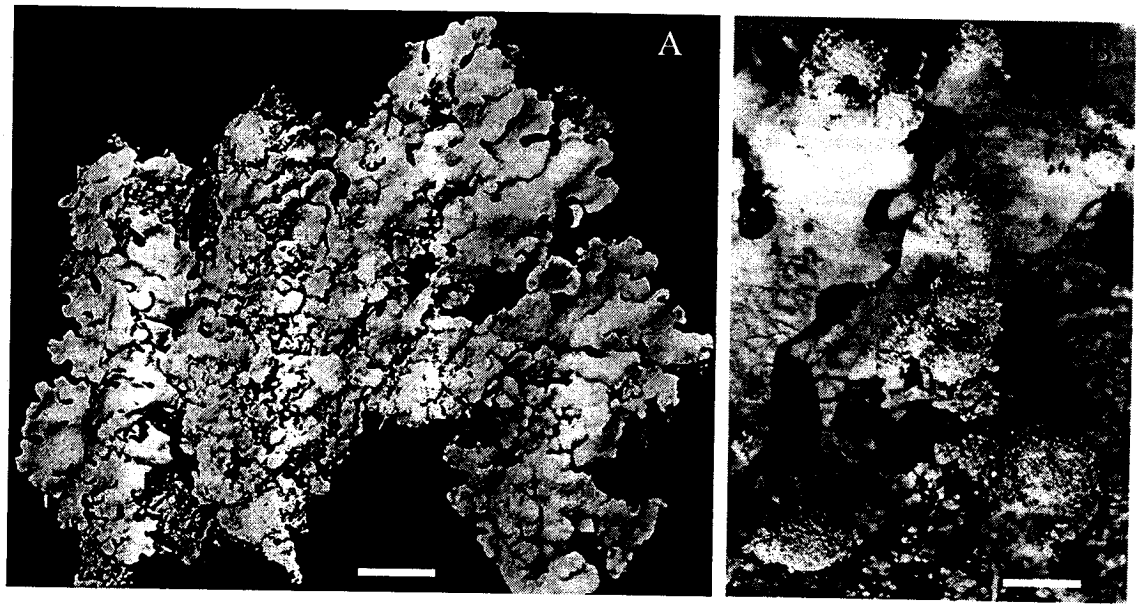


Figure 38 *Hypotrachyna immaculata* (Kurokawa) Hale

Note: A. Thallus with capitate soralia [RU—10071 (RAMK), scale = 1.5 cm].

B. Capitate soralia [RU—10071 (RAMK), scale = 0.5 cm].

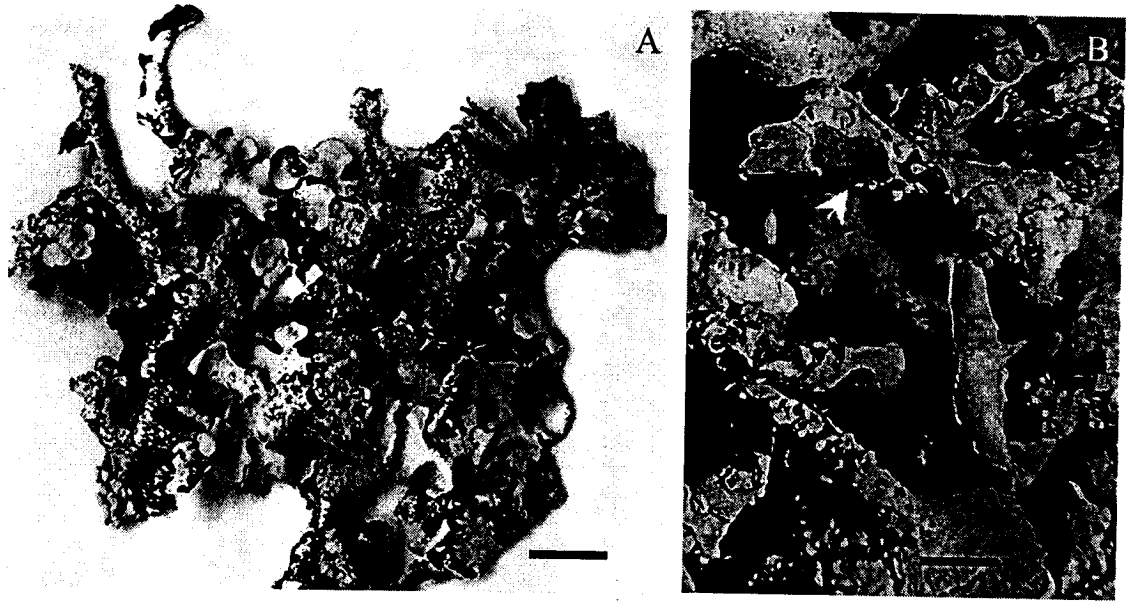


Figure 39 *Hypotrachyna kingii* (Hale) Hale

Note: A. Thallus plane to involute with pustulate soredia [RU—8378 (RAMK), scale = 1 cm].

B. Pustulate soredia (arrow) exposing medulla and black lower surface [RU—8378 (RAMK), scale = 0.5 cm].

11. *Hypotracyna mason-halei* Patwardhan and Prabhu,

The Bryologist 80: 348, 1977

Figure 40

Thallus foliose, closely adnate, lobes sublinear, sinuous, short, 1-2 mm wide; margin entire with dark rimmed; apices subrotund to incise; without soredia and isidia; upper surface whitish gray, plane, shiny, emaculate, 20 μm thick, medulla white, 80 μm thick; lower surface black, 20 μm thick; rhizines sparse to dense, protruding beyond the margins, dichotomously branched; **apothecia** numerous, sessile, 1-3 mm wide; thalline exciple entire to crenate; ascospores hyaline, simple, ellipsoid, 13-26 x 9-14 μ m; **pycnidia** sparsely immerse, conidia bifusiform, 5-6 x 1 μm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing norstictic acid, and salazinic acid (K+ red, C-, KC+red, and P+ orange).

Habitat : On branches of *Diospyros sp.* in the orchard at 1,400 m.

Distribution: India, and Thailand.

Specimens examined: N Thailand. Chiang Mai Province: Doi Suthep-Pui National Park, Doi Pui Research Station, in *Diospyros* sp. Orchards, 1998, *T. Pooprang*, RU——10293 (RAMK).

Observation: *Hypotrachyna mason-halei* resembles *H. adducta*, but the latter contain protocetraric acid. This species is characterized by numerous apothecia and containing both norstictic acid and salazininc acid.

12. *Hypotrachyna osseoalba* (Vain.) Y. S. Park and Hale, *Taxon* 38: 88, 1989.

Basionym: *Parmelia osseoalba* Vain., *Ann. Soc. Zool. Bot. Fenn. Vanamo* 1: 39, 1921

Figure 41

Thallus foliose, loosely adnate to adnate; lobes sublinear to subdichotomously branched, subimbricate, 1-3 mm wide; margins entire; apices incised; pustules breaking open apically and sometimes becoming coarse sorediate; upper surface white-gray, flat to weakly convex, shiny, emaculate to faintly maculate, smooth to cracked, 15 μm thick; medulla mostly white and partly pale yellow patch below soralia (K+ purple), 50-75 μm thick; lower surface black, 15 μm thick; rhizines dense, dichotomously branched protruding beyond the margins; **apothecia** rare, if present sessile to subpedicellate, disc brown; thalline exciple smooth or with pustulate; ascopsores hyaline, simple, ellipsoid, 7-11 x 5-8 μm; **pycnidia** immersed laminal, conidia bifusiform 4-6 x 1 μm.

Chemistry: Cortex containing lichexanthone (K-, UV+ yellow); medulla containing colensoic acid, 4-*O*-methylphysidic acid, lividic acid, physodic acid and oxyphysodic acid (K+ red, C-, KC+ pale red, and P-).

Habitat: Occur on trees and rock in exposed to sun habitats in the lower montane forests at altitude above1,000 m.

Distribution: Cosmopolitan, temperate and tropical (Thailand).

Specimens examined: N Thailand. Chiang Mai Province: Queen Sirikit Botanic Garden, on trunk of unidentified tree, 1994, *K. Boonpragob et al.*, RU——3109 (RAMK). ibid., on trunk of *Castanopsis* sp., 1994, *K. Boonpragob et al.*, RU——3175, RAMK). ibid., on trunk of *Stereospermum neuranthum*, 1994, *K. Boonpragob et al.*, RU——3241 & 3242 (RAMK). ibid., on trunk of Pinus kesiya, 1994, *K. Boonpragob et al.*, RU——3405 (RAMK). Doi Suthep-Pui National Park, Doi Pui Research Station, on trunk of *Pinus kesiya*, 1998, *T. Pooprang,* RU——10261 & 10279 (RAMK). Phitsanulok Province: Phu Hin Rong Kla National Park, Sumnak Amnaadrad, on trunk of *Quercus* sp., 1997, *N. Homchantara et al.*, RU——9451.1 (RAMK). ibid., Lan Anekprasong, on trunk of unidentified tree, 1998, *T. Pooprang,* RU——10089 (RAMK). ibid., Phachuthong, on trunk of unidentified tree, 1998, *T. Pooprang,* RU——10100 (RAMK). ibid., on trunk of *Quercus* sp., 1998, *T. Pooprang,* RU——10104 (RAMK). ibid., Lan Hin Pum, on trunk of

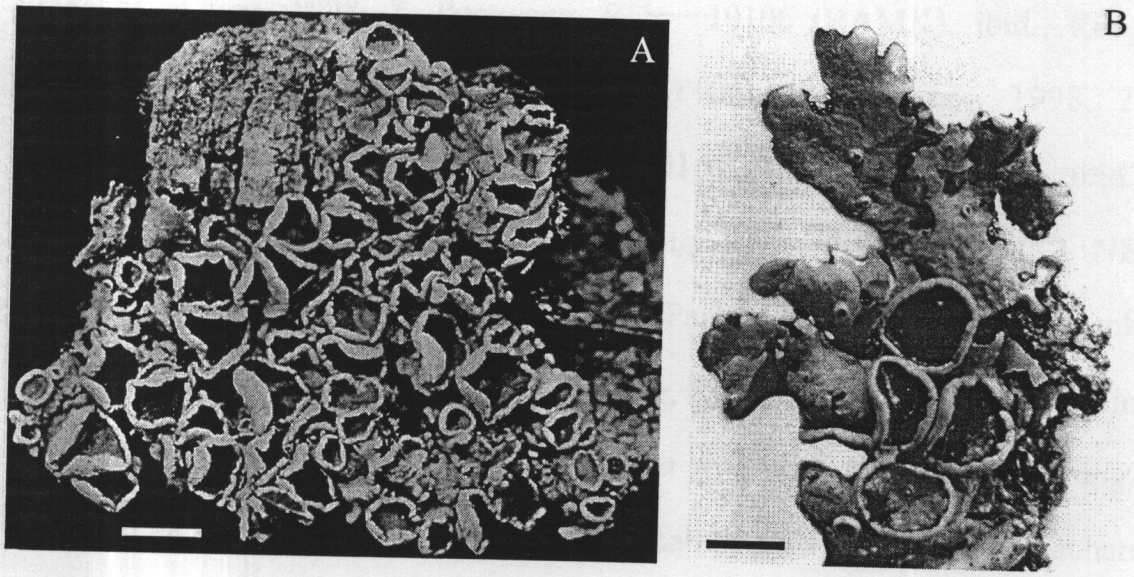


Figure 40 *Hypotrachyna mason-halei* Patw. and Prabhu

Note: A. Thallus with numerous apothecia [RU——10293 (RAMK), scale = 0.5 cm].

B. Lobes linear with subrotund apices [RU——10293 (RAMK), scale = 2 mm].

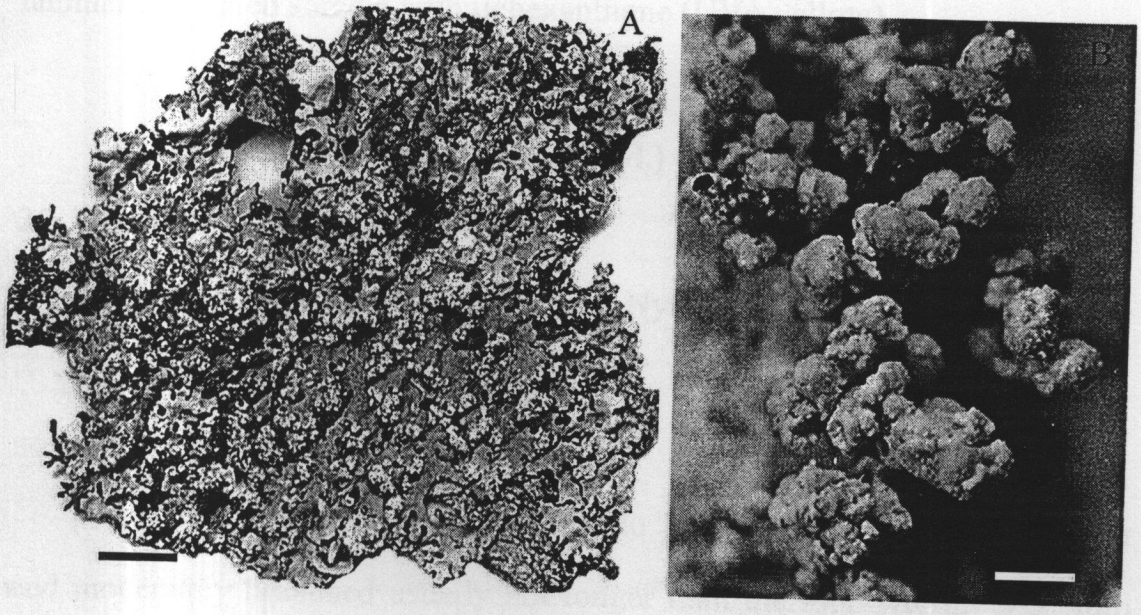


Figure 41 *Hypotrachyna osseoalba* (Vain.) Park and Hale

Note: A. Thallus with pustulate soredia [RU——9451.1 (RAMK), scale = 1.2 cm].

B. Pustulate soredia [RU——9451.1 (RAMK), scale = 1.5 mm].

unidentified tree, 1998, *T. Pooprang,* RU——10106 (RAMK). ibid., Rong Rian Kaan Mueang Thahaan, on trunk of unidentified trees, 1998, *T. Pooprang,* RU——10119, 10139, 10140, 10141 & 10142 (RAMK). ibid., Kang Han Nam, on rock, 1998, *T. Pooprang,* RU——10169 (RAMK). **NE Thailand.** Loei Province: Na Haeo National Park, a trail to Toko 1, on trunk of *Castanopsis helforiana*, 1995, *T. Pooprang,* RU——4425 (RAMK). ibid., in the dry evergreen forest, on trunk of *Schima wallichii*, 1996, *T. Pooprang,* RU——7666 (RAMK). **SW Thailand.** Phetchaburi province: Kaeng Krachan National Park, Pha Noen Thung camp, on trunk of unidentified tree, 1998, *T. Pooprang,* RU——11173 (RAMK).

Observation: *Hypotrachyna osseoalba* is characterized by the laminal pustulated soredia with lichexanthone (UV+ yellow).

13. *Hypotrachyna physcioides* (Nyl.) Hale, *Smithsonian Contr. Bot.* 25: 54, 1975

Basionym: *Parmelia physcioides* Nyl., 1860

Figure 42

Thallus foliose, loosely adnate to adnate; lobes sublinear, shorter and moderately branched usually not longer than the lobe width, 3-5 mm wide; margins entire, apices subrotund to truncate; without isidia and soredia; upper surface whitish to gray, plane to convex, faintly maculae, 20 μm thick; medulla white, 80-100 μm thick; lower surface black, 30 μm thick; rhizines

dense, dichotomously branched, black; **apothecia** adnate to substipitate, 2-10 mm wide, disc brown; thalline exciple entire; ascospores hyaline, simple, ellipsoid, 12- 16 x 5-7 μm; **pycnidia** immerse, laminal, conidia bifusiform 4-6 x 1 μm.

Chemistry: Cortex containing atrnorin and chloroatranorin (K+ yellow); medulla containing barbatic acid, 4-*O*-demethylbarbatic acid, obtusatic acid, and norobtusatic acid (K-, C-, KC+ orange, and P-).

Habitat: On trees in open habitats at above 1,000 m elevation.

Distribution: Central America, South America, and Southeast Asia (India, and Thailand).

Specimens examined: N Thailand. Chiang Mai Province: Queen Sirikit Botanic Garden, on trunk of unidentified tree, 1994, *K. Boonpragob et al.*, RU——3123 (RAMK). ibid., on trunk of *Pinus kesiya*, 1994, *K. Boonpragob et al.*, RU——3434 (RAMK). Doi Suthep-Pui National Park, San Kuu, in the lower montane forest, on trunk of unidentified trees, 1995, *K. Boonpragob et al.*, RU——4017, 4019, 4020, 4021, 4025 & 4085 (RAMK). **NE Thailand.** Loei Province: Na Haeo National Park, a trail to Toko1, in the lower montane forest, on trunk of unidentified tree, 1995, *T. Pooprang*, RU——6860 (RAMK).

Observation: *Hypotrachyna physcioides* commonly occured in the northern part of Thailand. It is characterized by short lobes, containing obtusatic acid and barbatic acid group.

14. *Hypotrachyna ramkhamhaengiana* Elix and Pooprang, sp. nov., *Mycotaxon* 71: 115, 1999

Figure 43

Thallus foliose, closely adnate; lobes not imbricate, sublinear, subdichotomously to irregularly branched, 1.5-5 mm wide, eciliate; isidia moderate to dense, cylindrical, simple or rarely branched; upper surface pale gray to gray, flat, shiny and smooth, becoming strongly white-maculate, 15 μ m thick; medulla white and yellow in part, 80 μm thick; lower surface black, 15 μm thick; rhizines moderately dense to dense, simple or sparsely dichotomously branched, black; **apothecia** and **pycnidia** not seen.

Chemistry: Cortex containing atranorin and chloroatranorin (K+yellow); medulla containing salazinic acid, pigmentosin A, consalazinic acid, and secalonic acid A (K+ yellow then dark red, C-, and P+ orange-red).

Habitat: On trunk of tree in the mixed deciduous forest at altitude 300 m elevation.

Distribution: Thailand.

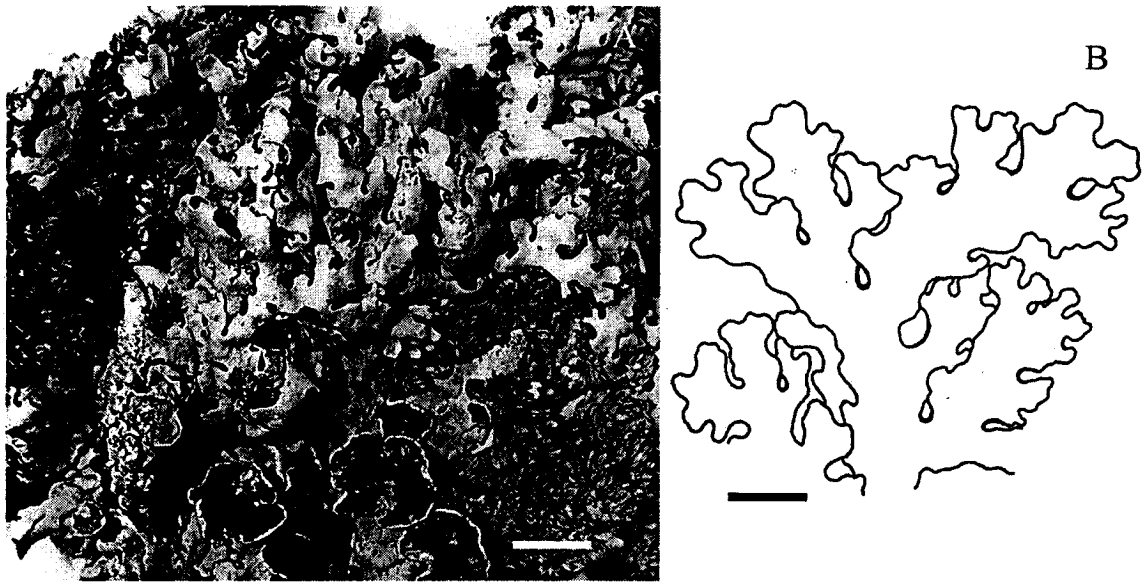


Figure 42 *Hypotrachyna physcioides* (Nyl.) Hale

Note: A. Thallus lacking isidia and soredia [RU——4025 (RAMK), scale = 1.2 cm].

B. Illustration of rather short lobes and moderately branched (scale = 2 mm).

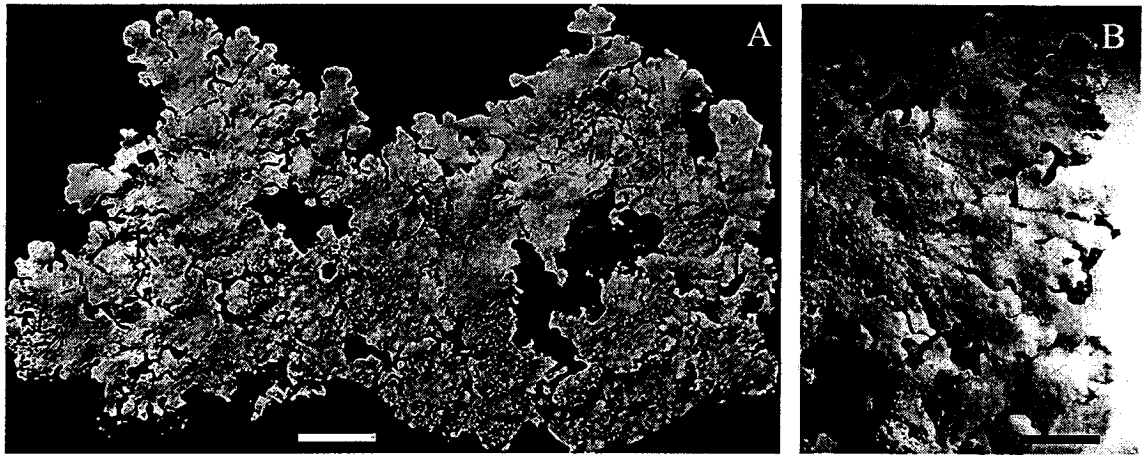


Figure 43 *Hypotrachyna ramkhamhaengiana* Elix and Pooprang

Note: A. Thallus irregularly branched with small rounded axils of lobes [RU——8928 (RAMK), scale = 0.8 cm].

B. Lobes with isidia [RU——8928 (RAMK), scale = 0.8 cm].

Specimen examined: NE Thailand. Sakon Nakhon Province: Phu Pan National Park, at the rim of the mixed deciduous forest, on trunk of *Dillenia* sp., 1997, *T. Pooprang,* RU——8928 (RAMK).

Observation: This species is characterized by the simple, cylindrical isidia, medulla partly pigmented yellow, mostly simple and sparsely branched rhizines and the presence of salazinic acid. The overall morphology resembles *Hypotrachyna crenata*, on both having sublinear lobes and cylindrical isidia.

15. *Hypotrachyna scytodes* (Kurokawa) Hale, *Phytologia* 28: 245, 1974.

Basionym: *Parmelia scytodes* Kurokawa, *Contr. U. S. Nat. Herb.* 36: 185, 1964

Figure 44

Thallus foliose, loosely adnate to closely adnate; lobes linear to subirregular, 1.5-2 mm wide; margins entire with rounded axils, apices subrotund to truncate; without isidia and soredia; upper surface gray, plane, emaculate to faintly maculae, 25 µm thick; medulla white, 100 µm thick; lower surface balck, 30 µm thick; rhizines densely dichotomously branched; **apothecia** adnate to substipitate, 0.3-12 mm wide; disc brown; thalline exciple entire; ascospores hyaline, simple, ellipsoid, 12-15 x 7-10 µm; **pycnidia** immersed, laminal, conidia bifusiform, 5-6 x 1 µm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing barbatic acid, 4-*O*-demethylbarbatic acid, echinocarpic (K-, C-, KC + orange, and P-).

Habitat: On trunk of trees in the lower montane forests at altitude above 1,000 m.

Distribution: India, Thailand, Sabah, and Indonesia.

Specimens examined: N Thailand. Chiang Mai Province: Queen Sirikit Botanic Garden, on trunk of unidentified tree, 1994, *K. Boonpragob et al.*, RU——3113 (RAMK). ibid., on trunk of *Pinus kesiya*, 1994, *K. Boonpragob et al.*, RU——3432 (RAMK). **NE Thailand.** Loei Province: Na Haeo National Park, a trial to Toko1, on branched of *Croton* sp., 1995, *T. Pooprang*, RU——6804, 6805, 6806, 6807 (RAMK). ibid., at Toko1, on trunk of unidentified trees, 1995, *T. Pooprang*, RU——6875, 6952 & 6955 (RAMK).

Observation: *Hypotrachyna scytodes*, *H. ducalis* and *H. physcioides* are similar on absences of isidia, soredia and presence of barbatic acid, but *H. scytodes* contains echinocarpic.

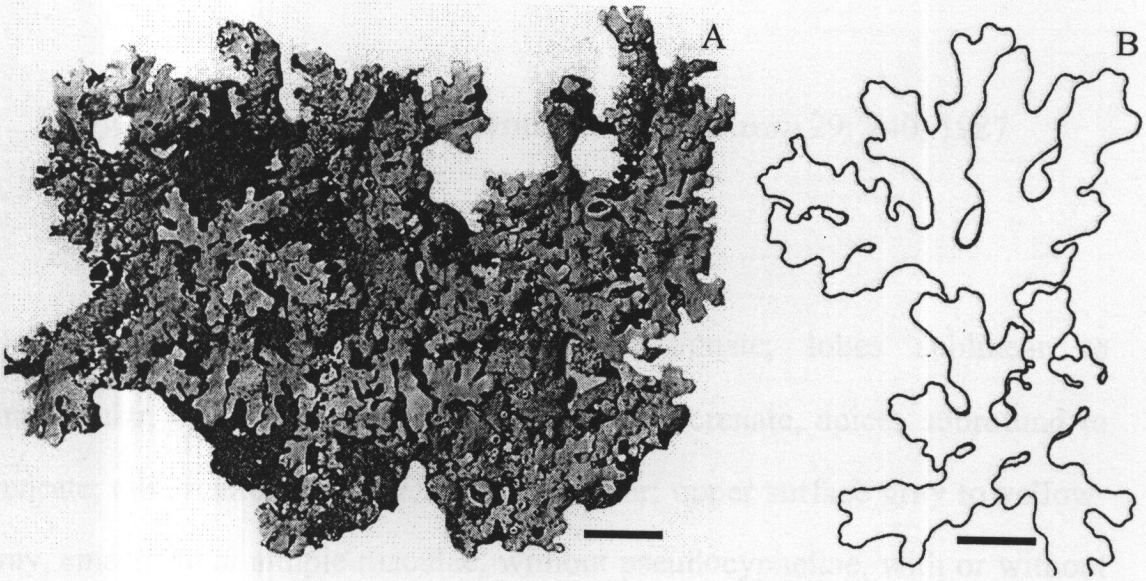


Figure 44 *Hypotrachyna scytodes* (Kurokawa) Hale

Note: A. Thallus lacking isidia and soredia [RU——6807 (RAMK), scale = 1.2 cm].

B. Illustration of linear, rather long lobes (scale = 2 mm.).

Genus *Myelochroa*

***Myelochroa* (Asahina) Elix and Hale**, *Mycotaxon* 29: 240, 1987

Figure 45

Thallus foliose, loosely adnate to adnate; lobes sublinear to subirregular, 0.5-3 mm wide; margins entire to crenate, apices subrotund to truncate; cilia scattered sparse, simple, slender; upper surface gray to yellow-gray, emaculate or simple maculae, without pseudocyphellae, with or without soredia and isidia; upper cortex palisade plectenchymatous, with a pored epicortex, 10-20 μm thick; cell walls containing isolichenan; medulla pale yellow to deep yellow containing secalonic acid A, 50-150 μm thick; lower surface black, 10-20 μm thick; rhizines moderate to dense, occur from the centers to the margins, simple or rarely furcate or squarrose, up to 1-2 mm long; **apothecia** and **pycnidia** not seen.

Habitat: On tree trunks or on rocks in Northern and Northeastern Thailand.

Distribution: North America, Northeastern Asia, East Asia, and Australia.

Observation: The distinct characteristic of *Myelochroa* is having cilia along the margins with yellow medulla.

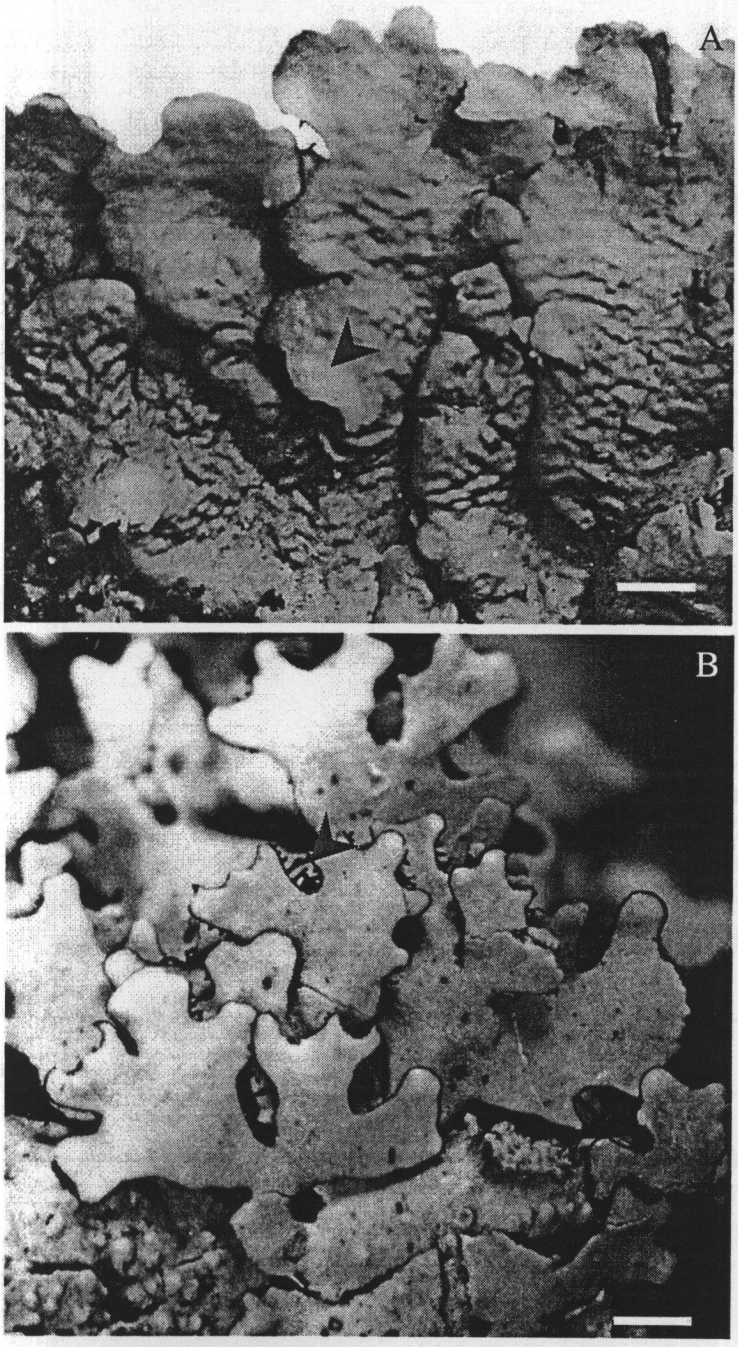


Figure 45 Genus *Myelochroa* (Asahina) Elix and Hale

Note: A. Yellow medulla (arrow) [RU—4261 (RAMK), scale = 1 mm].

B. Cilia along the margins (arrow) [RU—4205 (RAMK), scale = 0.5 mm].

Key to the species of *Myelochroa*

1a Thallus non-isidiate and esorediate, deep yellow medulla .....*M. siamea*

1b Thallus with lobules numerous, pale yellow medulla.....*M. xantholepis*

Description of the species of *Myelochroa*

1. *Myelochroa siamea* Kurokawa, *Journal of Japanese Botany* 73: 12-14, 1998.

Figure 46

Thallus foliose, adnate; lobes sublinear to elongate, 1.5-3 mm wide, margin entire to crenate, apices subrotund; cilia sparse at the axil of lobes, black, simple, 0.1-0.7 mm long; without isidia and soredia; upper surface gray to yellow-gray, wrinkled to rugose at center of thallus, 15-20 μm thick; medulla deep yellow, 100-150 μm thick; lower surface black, 15-20 μm thick, densely rhizines, black, simple to furcate, up to 1 mm long; **apothecia** and **pycnidia** not seen.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow) and medulla containing zeorin, galbinic acid, secalonic acid A, salazinic acid, and eumitrin (K+ red, C-, KC-, P-, and K+ purple in lower medulla).

Habitat: On rock in the evergreen forest at about 1,000 m elevation.

Distribution: Northeastern Thailand

Specimens examined: NE Thailand. Loei Province: Nahaeo National Park, on rock at Toko 1, 1995, *P. Mongkolsuk et al.*, RU——4235, 4261 (RAMK).

Observation: The specimen from Chiang Mai Province, Thailand, was firstly described as *Myelochroa siamea* by Kurokawa in 1998. This species is characterized by a deep yellow medulla and more wrinkled at the center.

2. *Myelochroa xantholepis* (Mont. and Bosch) Elix and Hale, *Mycotaxon* 29: 241, 1987

Basionym: *Parmelia xantholepis* Mont. and Bosch, *F. Junghuhn, Plantae Junghuhnianae* 428, 1855

Figure 47

Thallus foliose, adnate; lobes elongate to sublinear, 0.5-2 mm wide; margins entire or crenate, apices subrotund to truncate; lobules dense, imbricate, subascending on the upper surface; upper surface gray to pale yellow gray, plane, easily fragile, 10-15 μm thick; medulla pale yellow to lemon yellow, 50-70 μm thick; lower surface black, 10 μm thick; densely

rhizines, black, simple to furcate, 1-2 mm long; **apothecia** and **pycnidia** not seen.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla zeorin and secalonic acid A (K+ yellow, C-, KC+ yellow, and P±yellow).

Habitat: On tree trunks and on rocks in the exposed areas of the lower montane forests at 900-1,300 m elevations.

Distribution: India, Nepal, Thailand, Indonesia, Philippines, and Taiwan

Specimens examined: N Thailand. Chiang Mai Province: Doi Suthep-Pui National Park, Doi Pui Research Station, on the trunk of unidentified tree, 1998, *T. Pooprang*, RU——10275 (RAMK). Ibid., Sunkuu, on the trunk of unidentified tree, 1999, *K. Vongshewarat*, RU——TP005 (RAMK). Phitsanulok Province: Phu Hin Rong Kla National Park, Lan Hin Pum, on the tree trunk of *Quercus* sp., 1997, *N. Homchantara et al.*, RU——9434 (RAMK), Rong Rean Kan Mueang Thahan site, on the tree trunk of unidentified tree, 1998, *T. Pooprang*, RU——10135 & 10136 (RAMK). **NE Thailand.** Loei Province, Toko 1, on rock, 1995, *Mongkolsuk et al.*, RU——4178, 4179, 4191, 4192, 4193, 4194, 4195, 4196, 4198, 4200, 4201, 4202,

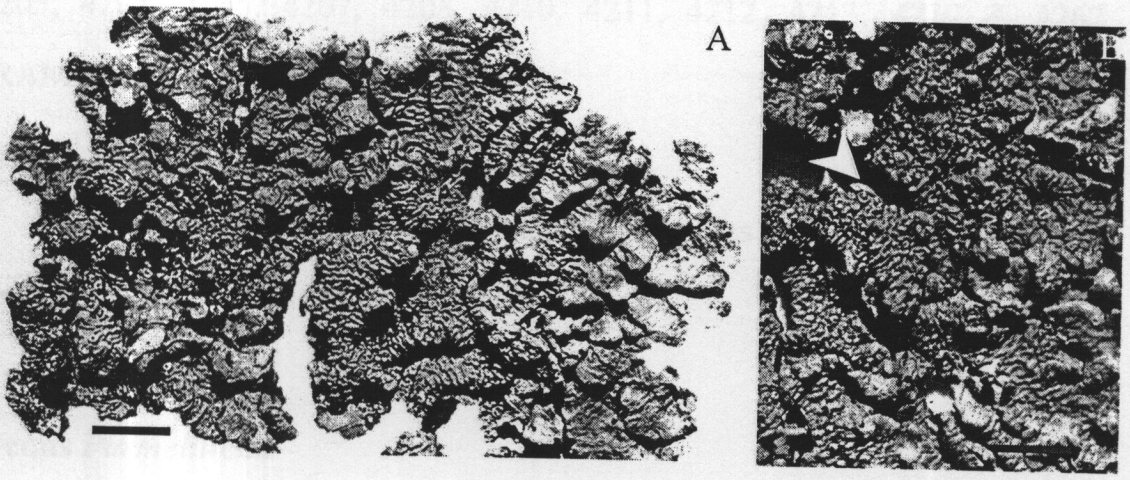


Figure 46 *Myelochroa siamea* Kurokawa

Note: A. Thallus gray with yellow medulla [RU—4261 (RAMK), scale = 0.6 cm].

B. Upper surface strongly wrinkled (arrow) [RU—4261 (RAMK), scale = 0.2 cm].

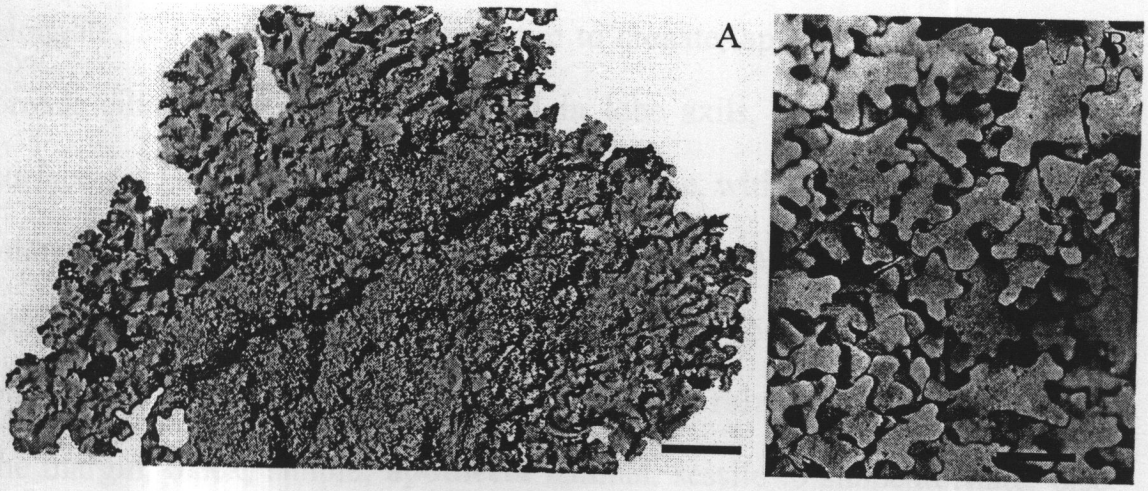


Figure 47 *Myelochroa xantholepis* (Mont. and Bosch) Elix and Hale

Note: A. Thallus gray-green with numerous lobules [RU—4205 (RAMK), scale = 1.3 cm].

B. Densely imbricate lobules with cilia [RU—4205 (RAMK), scale = 0.1 cm].

4203, 4204, 4205, 4207, 4208, 4210, 4211, 4212, 4213, 4232 & 4262 (RAMK)).

Observation: Thallus with numerous lobules and yellow medulla are the distinct characteristics of this species.

Genus *Parmelinella*

***Parmelinella* Elix and Hale,** *Mycotaxon* 29: 242, 1987

Figure 48

Thallus foliose, loosely adnate to adnate; lobes subirregular to elongate, 3-12 mm wide, margin entire to crenate, apical rotund to truncate, broad; cilia sparse, mostly restricted in lobe axils, simple, slender; upper surface gray, emaculate, without pseudocyphellae, with or without soredia and isidia; upper cortex palisade plectenchymatous with a pored epicortex, 15-20 µm; cell walls contain isolichenan; medulla white, 65-120 µm; lower surface black, with brown naked marginal zone, 15 µm; rhizines protruding beyond the margin, black, simple; **apothecia** laminal, sessile to subpedicellate, disc imperforate, brown; ascospores hyaline, simple, ellipsoidal, 14-18 x 8-10 µm; **pycnidia** laminal, immersed; conidia bacilliform, 5-9 x 1 µm.

Habitat: On tree trunks and on rocks in the dry dipterocarp forests and the lower montane forests.

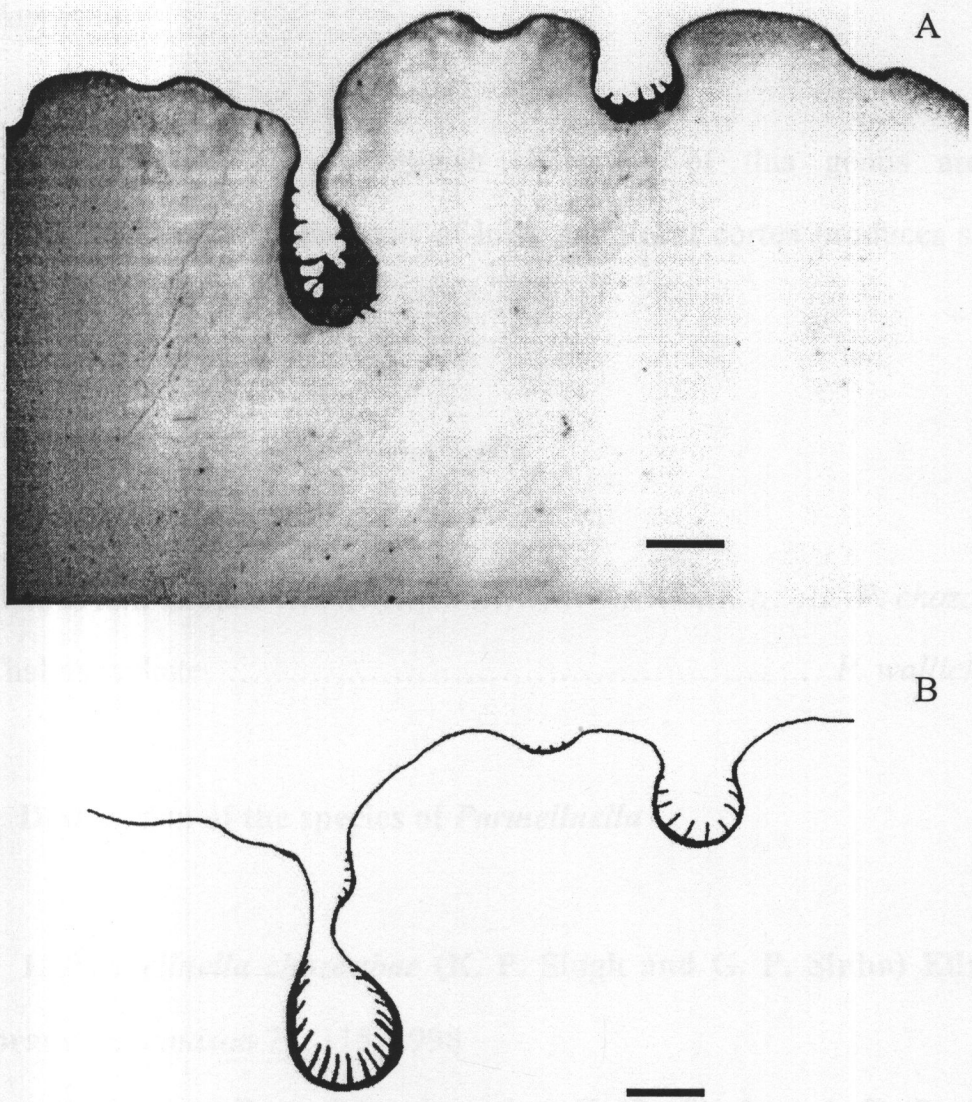


Figure 48 Genus *Parmelinella* Elix and Hale

Note: A. Cilia in lobe axils [RU—6859 (RAMK), scale = 0.2 cm].

B. Illustration of cilia in lobe axils (scale = 0.2 cm).

Distribution: Africa, Southern Asia and particularly India, Thailand, and Australia.

Observation: The distinguish characters of this genus are the occurrence of cilia along the axils of lobe, and lower cortex produces simple rhizines.

Key to the species of *Parmelinella*

1a Thallus non-isidiate .....*P. chozoubae*

1b Thallus isidiate.....*P. wallichiana*

Description of the species of *Parmelinella*

1. *Parmelinella chozoubae* (K. P. Singh and G. P. Sinha) Elix and Pooprang, *Mycotaxon* 71: 115, 1998

Basionym: *Parmelina chozoubae* K. P. Singh and G. P. Sinha, *Nordic J. Bot.*, 13: 463, 1993

Figure 49

Thallus foliose, closely to loosely adnate; lobes sublinear, subimbricate to subirregularly branched, 3-5 mm wide, margin crenate, apices truncate to rotund; cilia small in lobes axils, 0.5 mm long; isidia lacking; upper surface gray, shiny to dull, smooth to rugose, emaculate, flat to convex,

15 μm thick; medulla white, 65 μm thick; lower surface black, 15 μm thick, rhizines simple to weakly furcate, black, 0.5-1 mm long; **apothecia** laminal, subpedicellate, disc brown, concave; thalline exciple smooth, ascospores hyaline, simple, ellipsoid, 9-17 x 5-9 μm; **pycnidia** laminal, immerse, conidia bacilliform, 8 x 1 μm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow) and medulla containing salazinic acid and consalazinic acid (K+ red, C-, KC+ red, and P+ yellow).

Habitat: On tree trunks and on rock in moist areas of the evergreen forests at 1,000 - 1,400 m elevation.

Distribution: India, and Thailand.

Specimens examined: N Thailand. Chiang Mai Province: The Queen Sirikit Botanic Garden, on tree trunk of *Pinus kesiya*, 1994, *K. Boonpragob et al.*, RU——3412 (RAMK). Phitsanulok Province: Phu Hin Rong Kla National Park, Lan Hin Pum, in lower montane forest, on rock, 1997, *N. Homchantara*, RU——9480 (RAMK). **NE Thailand.** Loei Province: Nahaeo National Park, a trail to ToKo 1, in the dry evergreen forest, on trunk of unidentified tree, 1995, *T. Pooprang*, RU——6882 (RAMK). **E Thailand.** Nakhon Ratchasima Province: Khao Yai National Park, Khao Khiao, in the

lower montane forest, on trunk of unidentified tree, 1997, *T. Pooprang*, RU——9707 (RAMK).

Observation: This species is characterized by containing salazinic acid and simple to weakly furcate rhizines. Morphologically it closely resembles *Parmelinella wallichiana,* but the latter has isidia on the upper surface of thallus.

2. *Parmelinella wallichiana* (Taylor) Elix and Hale, *Mycotaxon* 29: 242, 1987

Basionym: *Parmelia wallichiana* Taylor, *London J. Bot.* 6: 176, 1847

Figure 50

Thallus foliose, loosely adnate to adnate; lobes irregularly branched, 3-8 (10) mm wide; margins entire to crenate, apices rotund to truncate; cilia mostly in axils of lobe and sparsely on the margin, simple, black, up to 2 mm long; upper surface gray-green, shiny, smooth to rarely cracked, 20 μm thick; isidiate sparse, isidia cylindrical, simple to branched, up to 0.5 mm high; medulla white, 90 μm thick; lower surface black and brown at the marginal zone, 15 μm thick; rhizines dense, black, simple, up to 2 mm long; **apothecia** rare, laminal, sessile to substipitate, disc 1-8 mm wide, ascospores hyaline, simple, ellipsoid, 12.5-18 x 6-10 μm; **pycnidia** laminal, immersed, conidia bacilliform, 6-8 x 1 μm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow) and medulla containing salazinic acid and consalazinic acid (K+ red, C-, KC-, and P+ orange).

Habitat: On tree trunks and rocks at every type of forests in Thailand generally.

Distribution: Africa, India, SE Asia (Thailand), Taiwan, and Japan.

Specimens examined: N Thailand. Chiang Mai Province: The Queen Sirikit Botanic Garden, on trunk of *Dillenia* sp., 1994, *K. Boonpragob et al.*, RU——830 & 837 (RAMK). ibid., on trunk of *Castanopsis diversifolia*, 1994, *K. Boonpragob et al.*, RU——1027 (RAMK). ibid., on trunk of *Pittosporum ferruginum*, 1994, *K. Boonpragob et al.*, RU——1190 (RAMK). ibid., on trunk of *Dipterocarpus obtusifolius*, 1994, *K. Boonpragob et al.*, RU——1641 & 1643 (RAMK). ibid., on trunk of *Bombax ceiba*, 1994, *K. Boonpragob et al.*, RU——2293 (RAMK). ibid., on trunk of *Pinus kesiya*, 1994, *K. Boonpragob et al.*, RU——3340, 3341, 3442 & 3444 (RAMK). ibid., on trunk of unidentified tree, 1994, *K. Boonpragob et al.*, RU——3589 & 3593 (RAMK). Doi Suthep-Pui National Park, Sunkuu, on trunk of unidentified tree, 1995, *K. Boonpragob et al.*, RU——4030, 4078, 4079 & 4080 (RAMK). ibid., Doi Pui Research Unit, on trunk of *Pinus kesiya*, 1998, *T. Pooprang*, RU——10256, 10259, 10266 & 10267 (RAMK). ibid., on trunk of unidentified

tree, 1998, *T. Pooprang*, RU——10289 & 10290 (RAMK). ibid., on twig of *Diospyros* sp., 1998, *T. Pooprang*, RU——10297 & 10301 (RAMK). Lampang Province: Khuntan National Park, the trail to Yaw 2, on trunk of unidentified tree, 1998, *T. Pooprang*, RU——10329 (RAMK). Phitsanulok Province: Phu Hin Rong Kla National Park, Lan Anek Prasong, on rock, 1998, *T. Pooprang*, RU——10084 & 10085 (RAMK). ibid., on trunk of unidentified tree, 1998, *T. Pooprang*, RU——10091 & 10099 (RAMK). ibid., Pha Chuu Thong, on rock, 1998, *T. Pooprang*, RU——10102 (RAMK). ibid., Lan Hin Pum, on rock, 1998, *T. Pooprang*, RU——10113 & 10114 (RAMK). ibid., Rong Rian Kan Mueang Thahan, on trunk of unidentified tree, 1998, *T. Pooprang*, RU——10116 (RAMK). ibid., on the old tractor, 1998, *T. Pooprang*, RU——10155 & 10168 (RAMK). ibid., on trunk of *Pinus kesiya*, 1998, *T. Pooprang*, RU——10200 (RAMK). **NE Thailand.** Loei Province: Nahaeo National Park, the trail to To Ko 1, on rock, 1995, *T. Pooprang*, RU——4165, 4168 & 4263 (RAMK). ibid., on trunk of *Dillenia* sp., 1995, *T. Pooprang*, RU——4272 (RAMK). ibid., on trunk of *Castanopsis helforiana*, 1995, *T. Pooprang*, RU——4459, 4460 & 4467 (RAMK). ibid., On trunk of *Adenanthera pavonina*, 1995, *T. Pooprang*, RU——4509, 5002 & 5006 (RAMK). ibid., on twig of *Garuga pinnata*, 1995, *T. Pooprang*, RU——4743, 4748, 4749, 4750 & 4757 (RAMK). ibid., on trunk of *Schima wallichii*, 1995, *T. Pooprang*, RU——5537 & 5542 (RAMK). ibid., on trunk of *Croton* sp., 1995, *T. Pooprang*, RU——6798, 6799 & 6800 (RAMK). ibid., on trunk of unidentified tree, 1995, *T. Pooprang*, RU——4927, 6858, 6859,

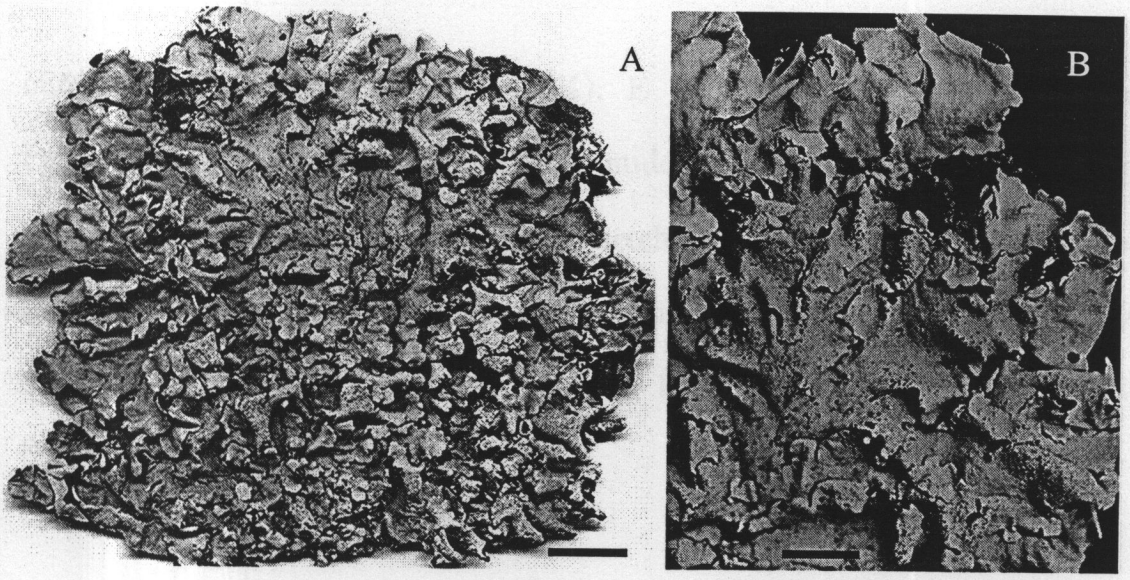


Figure 49 *Parmelinella chozoubae* (Singh and Sinha) Elix and Pooprang

Note: A. Thallus gray-green with imbricate lobes [RU—9480 (RAMK), scale = 1.5 cm].

B. Lobes without isidia [RU—9480 (RAMK), scale = 0.33 cm].

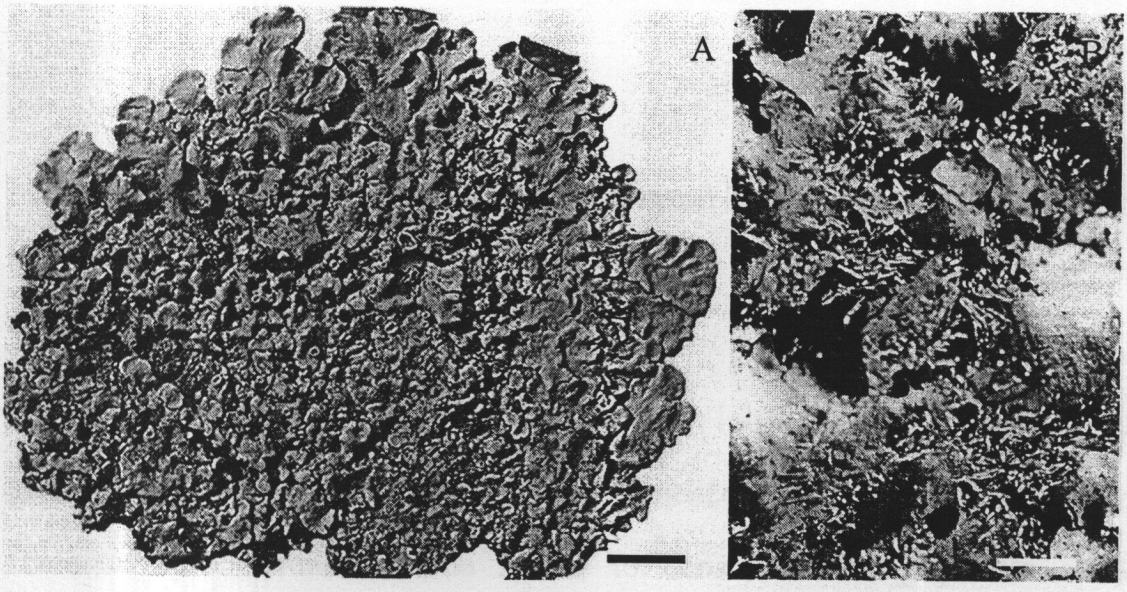


Figure 50 *Parmelinella wallichiana* (Taylor) Elix and Hale

Note: A. Thallus gray-green with isidia and rotund apices [RU—6859 (RAMK), scale = 1.2 cm].

B. Dense and long isidia cover upper surface [RU—10329 (RAMK), scale = 0.5 cm].

6861, 6863, 6864 & 6865 (RAMK). **E Thailand.** Nakhon Ratchasima Province: Khao Yai National Park, on unidentified tree, 1997, *T. Pooprang*, RU——8107 (RAMK). **SW Thailand.** Phetchaburi Province: Pha Noen Thung Camp, in the lower montane forest, on trunk of unidentified trees, 1998, *T. Pooprang*, RU——11161, 11163, 11167, 11168, 11169, 11179 & 11184 (RAMK).

Observation: *Parmelinella wallichiana* is distinguished by presence of cilia in lobe axils, isidia, and containing salazinic acid. This species has large morphological variation.

Genus *Parmelinopsis*

***Parmelinopsis* Elix and Hale**, *Mycotaxon* 29: 242, 1987

Figure 51

Thallus foliose, loosely to tightly adnate; lobes flat, linear to sublinear-elongate, dichotomously to irregularly branched, 0.5-5 mm wide; margins crenate, apices truncate; cilia sparse to dense, black, simple to rarely branched, slender; upper surface gray to gray-green, emaculate, with or without soredia, pustules and isidia; upper cortex palisade plectenchymatous, with a pored epicortex, 10-15 μm thick; cell walls containing isolichenan; medulla white or partly yellow, 60-80 μm thick; lower surface ivory to pale

brown or black, 10-20 μm thick; rhizines sparse to dense, simple or furcate to squarrose or dichotomously branched; **apothecia** and **pycnidia** not seen.

Habitat: On tree trunks or on rocks in pantemperate and subtropical.

Distribution: Cosmopolitan such as America, Southern Africa, Asia, and Australia.

Observation: The characteristics of *Parmelinopsis* is closely related to *Hypotrachyna* and *Parmelina* in many respects. But, *Hypotrachyna* is lack of the cilia.

Key to the species of *Parmelinopsis*

1a Lower surface pale brown, with fatty acid or KC-.....2

1b Lower surface black, with gyrophoric acid or KC+ rose or red 3

2a Thallus isidiate, isidia simple, cylindrical to coralloid.....*P. expallida*

2b Thallus lobulate, numerous lobules.....*P. microlobulata*

3a Thallus isidiate, isidia simple, cylindrical; C+ rose.....*P. minarum*

3b Thallus cilia on isidia, isidia simple with black tip; C-.....*P. horrescens*

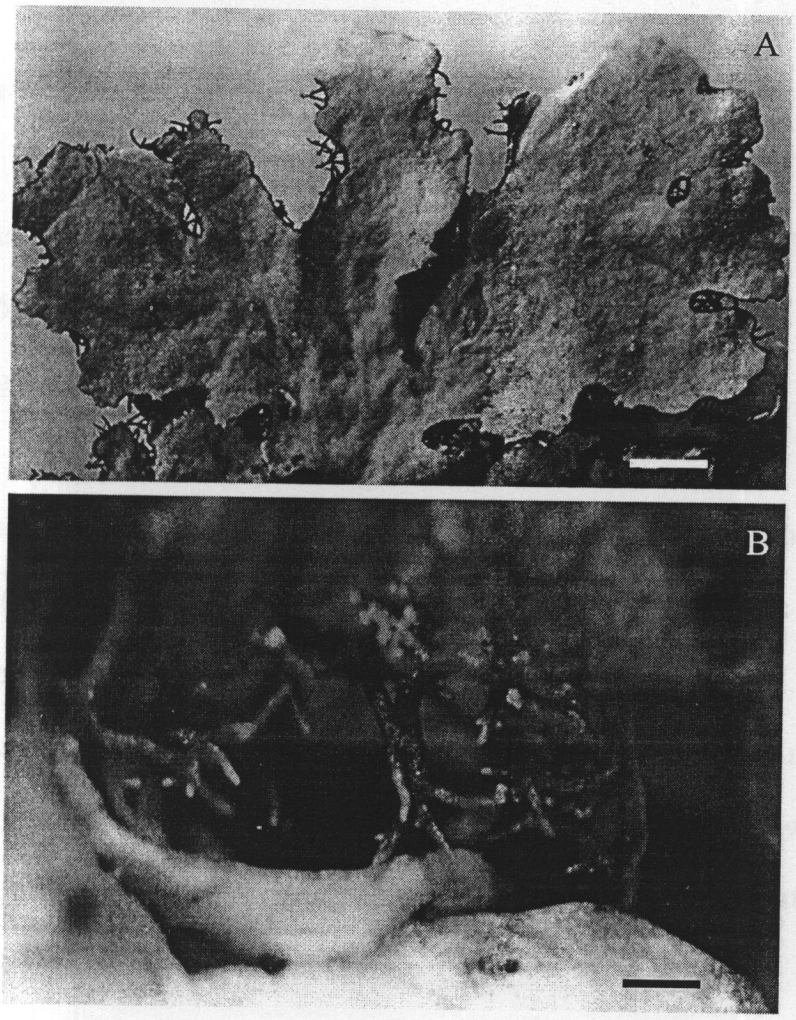


Figure 51 Genus *Parmelinopsis* Elix and Hale

Note: A. Cilia along the margins [RU——10257 (RAMK), scale = 1 mm].

B. Dichotomously branched rhizines [RU——10257 (RAMK), scale = 0.5 mm].

Description of the species of *Parmelinopsis*

1. *Parmelinopsis expallida* (Kurokawa) Elix and Hale, *Mycotaxon* 29: 242, 1987

Basionym: *Parmelia expallida* Kurokawa, *Bull. Nat. Sc. Mus., Tokyo* 11:191, 1968

Figure 51

Thallus foliose, loosely adnate to adnate; lobes sublinear, lateral lobes imbricate, 2-4 mm wide; margins entire to crenate, apices subrotund; isidia dense, simple or becoming coralloid-branched, cylindrical, 0.3-1 mm high; cilia sparse at the margin, simple, 0.5 mm long; upper surface gray, plane, emaculate, 15 μm thick; medulla white, 80 μm thick; lower surface pale brown, 20 μm thick; rhizines sparse, simple or rarely furcate, 0.5 mm long; **apothecia** and **pycnidia** not seen.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing protolichesterinic acid (K-, C-, KC-, and P-).

Habitat: On tree trunks in the lower montane forest above 900m elevation.

Distribution: India, Thailand, Taiwan, and Japan.

Specimens examined: N Thailand. Phitsanulok Province: Phu Hin Rong Kla National Park, Roeng Rian Kan Mueang Thahan, on trunk of unidentified tree, 1998, *T. Pooprang*, RU——10121 (RAMK). **E Thailand.** Nakhon Ratchasima Province: Khao Yai National Park, Khao Kiaeo, on trunk of unidentified tree, 1997, *T. Pooprang*, RU——8363 (RAMK). **SW Thailand.** Phetchaburi Province: Kaeng Krachan National Park, along the trial to Num Tok Totip, Pha Noen Thung Camp, on trunk of unidentified tree, 1998, *T. Pooprang*, RU——11158, 11176 & 11181 (RAMK).

Observation: Externally, *Hypotrachyna crenata* and *Parmelinella wallichiana* look similar to this species. But, the rhizines of *Hypotrachyna* is dichotomously branching, whereas *Parmelinella* has cilia in the axils of lobes and simple rhizines. *Parmelinopsis expallida* is characterized by pale brown lower srface and presence of fatty acid.

2. *Parmelinopsis horrescens* (Taylor) Elix and Hale, *Mycotaxon* 29: 242, 1987

Basionym: *Parmelia horrescens* Taylor, *Flora Hibern* 144, 1836

Figure 52

Thallus foliose, closely adnate to adnate, lobes irregular to dichotomously branched, sublinear, contiguous to imbricate, 0.5-2 mm wide; margins crenate; cilia evenly dispersed, black, simple, 0.3-0.8 mm long; isidia dense, cylindrical often branched, apically spinulate or short-ciliate; upper

surface whitish to gray to green, 15 μm thick, shiny, emaculate; medulla white, 80 μm thick; lower surface black, 10 μm thick; rhizines black, simple to dichotomously branched; **apothecia** and **pycnidia** not seen.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow) and medulla containing gyrophoric acid and 4, 5-di-0-methylhiascic acid (complex) (K-, C+ rose, KC+ rose or red, and P-).

Habitat: On tree trunk at exposed area of the lower montane forest above 1,000 m elevation.

Distribution: North America, Central America, South America, Europe, Africa, Asia (Thailand, Indonesia, Philippines, Taiwan, and Japan), Australia, and New Zealand.

Specimens examined: N Thailand. Phitsanulok Province: Phu Hin Rong Kla National Park, along the trail to Lan Hin Tak, on trunk of unidentified tree, 1998, *T. Pooprang*, RU——10057 & 11167 (RAMK).

Observation: This species closely resembles *Parmelinopsis minarum,* but *P. horrescens* has cilia, and reacts colorless with the calcium hypochlorite solution (C-).

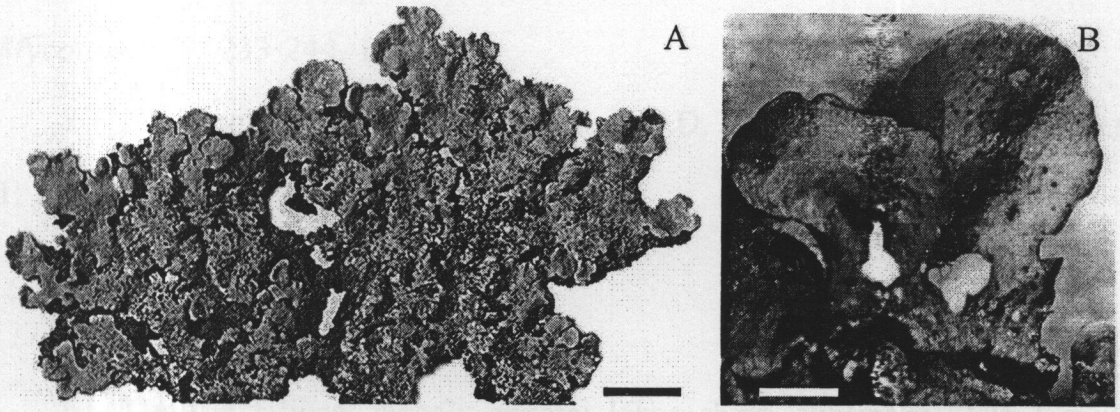


Figure 52 *Parmelinopsis expallida* (Kurokawa) Elix and Hale

Note: A. Thallus green with isidia [RU—— 10121 (RAMK), scale = 1.5 cm].

B. Lower surface pale brown [RU——10121 (RAMK), scale = 0.25 cm].

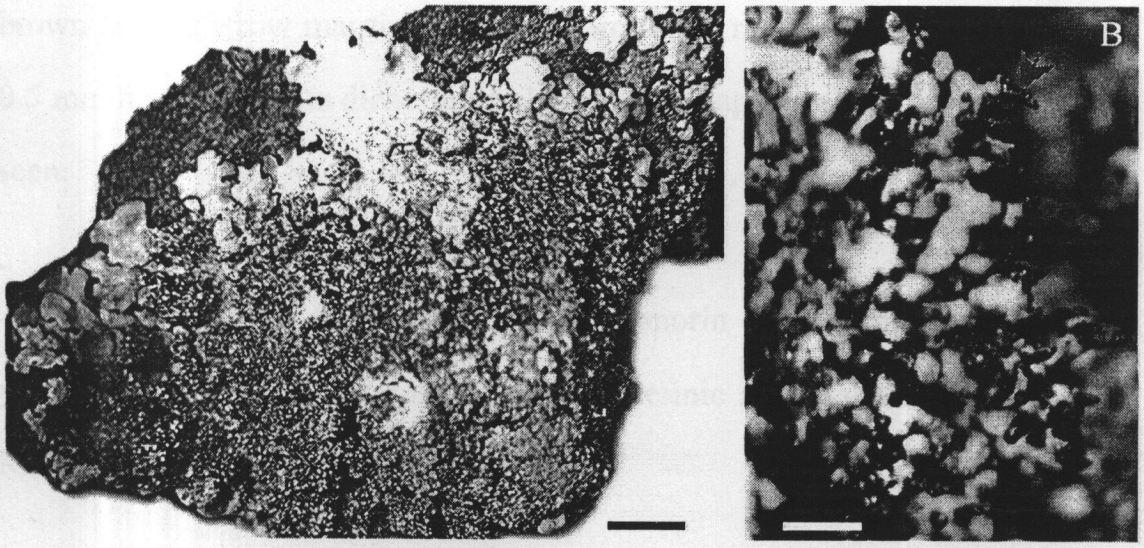


Figure 53 *Parmelinopsis horrescens* (Taylor) Elix and Hale

Note: A. Thallus gray-green with dense isidia [RU——10067 (RAMK), scale = 0.53 cm].

B. Cilia on isidia (arrow) [RU——10067 (RAMK), scale = 0.12 cm].

3. *Parmelinopsis microlobulata* (D.D. Awas.) Elix and Hale, *Mycotaxon* 29: 233-244, 1987

Basionym: *Parmelia microlobulata* D.D. Awas., *Biological Memoirs* 1: 182, 1977

Figure 53

Thallus foliose, closely adnate; lobes short, sublinear, 0.25-1 mm wide; dark brown rim, apices incised to subrotund; sparsely cilia; upper surface pale gray to ashy gray, smooth, isidioid lobules dense, isidia initially rounded, cylindrical and ultimately flattened, dorsiventral lobules with brown rim, 10 μm thick; medulla white, 60 μm thick; lower surface black, dark brown at the narrow marginal zone, 15 μm thick; rhizines sparse, black, 0.2-0.5 mm long, simple to dichotomously branched; **apothecia** and **pycnidia** not seen.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow) and medulla containing protolichesterinic acid (fatty acids) (K-, C-, KC-, and P-).

Habitat: On tree trunks and on rocks in the shade areas of the lower montane forests at 200-1,400 m elevations.

Distribution: India and Thailand.

Specimens examined: N Thailand. Chiang Mai Province: Doi Suthep-Pui National Park, Doi Pui Research Station, on bark of *Diospyros* sp., 1998, *T. Pooprang*, RU——10321 (RAMK). Phitsanilok Province: Phu Hin Rong Kla National Park, along the trail to Pha Chu Thong, on rock, 1998, *T. Pooprang*, RU——10093 (RAMK). ibid., along the trail to Lan Hin Pum, on rock, 1998, *T. Pooprang*, RU——10111 (RAMK). ibid., along a trial to Rong Rian Kan Mueang Thahan, on trunk of unidentified tree, 1998, *T. Pooprang*, RU——10134, 10136, 10137 & 10138 (RAMK). **SW Thailand.** Phetchaburi Province: Kang Krachan National Park, along a trial to Pha Noen Thung Camp, 1997, *T. Pooprang*, RU——11156, 11178 & 11185 (RAMK). **S Thailand.** Nakhon Srithammarat Province: Khao Luang National Park, along the trail to Num Tok Karom, on the trunk of unidentified tree, 1997, *T. Pooprang*, RU——9897 (RAMK).

Observation: The prominent character of this genus is the presence of numerous isidioid lobules and protolichesterinic acid in the medulla.

4. *Parmelinopsis minarum* (Vain.) Elix and Hale, *Mycotaxon* 29: 243, 1987

Basionym: *Parmelia minarum* Vainio, *Acta Soc. Faun.-Flor Fenn.*, 7: 48, 1890

Figure 54

Thallus foliose, adnate; lobes sublinear-elongate, 1-3 mm wide; margins entire to crenate, cilia sparse, black, simple, up to 0.7 mm long, isidia dense, cylindrical often branched, less than 0.5 mm high; upper surface green-gray, shiny, emaculate, plane to convex, 10 μm thick; medulla white, 60 μm thick; lower surface black, 15 μm thick; rhizines dense, black, simple to sparsely branched; **apothecia** and **pycnidia** not seen.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow) and medulla containing gyrophoric acid, 5-*O*-methylhiascic acid, 4-5-di-*O*-methylhiascic acid, and trace of lecanoric acid (K-, C+ rose or red, KC+ red, and P-)

Habitat: On tree trunks and on rocks in exposed areas of the lower montane forests.

Distribution: Pantemperate and montane pantropical; North America, Central America, South America, Europe, Africa, Asia (India, Sri Lanka, Thailand, Malaysia, Indonesia, Philippines, Taiwan, and Japan).

Specimens examined: N Thailand. Chiang Mai Province: Doi Suthep-Pui National Park, Doi Pui Research Station, on bark of *Pinus kesiya*, 1998, *T. Pooprang,* RU——10257 (RAMK). Phitsanulok Province: Phu Hin Rong Kla National Park, Kung Hun Num, on rock, 1998, *T. Pooprang*, RU——10170 & 10171 (RAMK). **SW Thailand.** Phetchaburi Province:

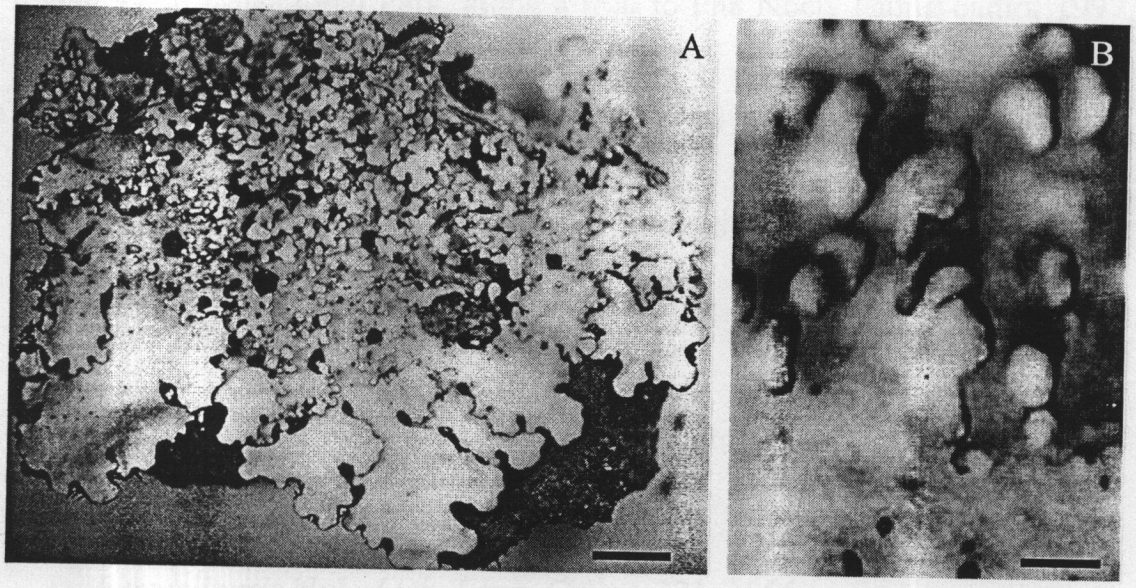


Figure 54 *Parmelinopsis microlobulata* (D.D. Awas.) Elix and Hale

Note: A. Thallus white-green with numerous lobules [RU——10093 (RAMK), scale = 0.2 cm].

B. Isidioid lobulate [RU——10093 (RAMK), scale = 0.04 cm].

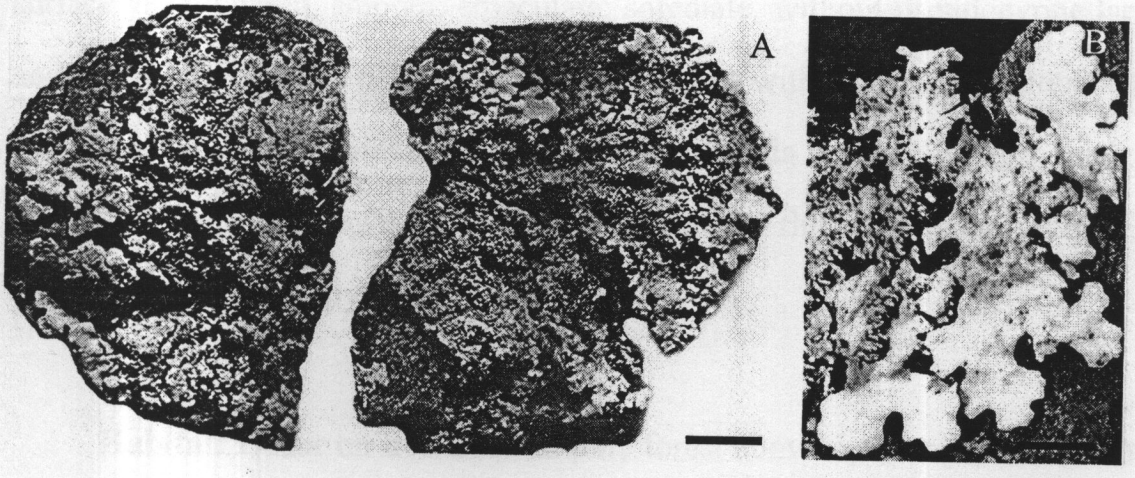


Figure 55 *Parmelinopsis minarum* (Vain.) Elix and Hale

Note: A. Thallus gray-green with isidia [RU——10257 (RAMK), scale = 1.7 cm].

B. Lobes with globular to cylindrical isidia [RU——10257 (RAMK), scale = 1.7 cm].

Kaeng Krachan National Park, along a trial to Pha Noen Thung camp, 1997, *T. Pooprang*, RU——11175 (RAMK).

Observation: Apparently, this species resembles *Parmelinopsis horrescens* but the latter has ciliate isidia.

Genus *Parmeliopsis*

Parmeliopsis **Nyl.**, *Lich. Lapp. Orient.* 121, 1866

Figure 56

Thallus foliose, closely adnate; lobes contiguous, sublinear, narrow, 0.5-1.5 mm. wide; margins entire, apices subrotund to incised, eciliate; upper surface yellow green, smooth, emaculate; sorediate, without pseudocyphellae and isidia; upper cortex palisade plectenchymatous with a pored epicortex, 10 μm thick; cell walls containing isolichenan; medulla white, 120 μm thick; lower surface pale brown to black, 15 μm thick; rhizines sparse, simple, black; **apothecia** and **pycnidia** not seen.

Habitat: Occur on tree trunk in pine forest above 1,000 m elevation in northern Thailand.

Distribution: Center in North America, other boreal and temperate regions of the Northern Hemisphere, montane regions of the Southern

Hemisphere, and Asia (Thailand).

Observation: This genus closely resembles *Relicinopsis* in having small yellow-green thallus. The difference is the thallus of *Parmeliopsis* has soredia. Only one species, *Parmeliopsis ambigua*, was found at Khuntan National Park.

Description of the species

***Parmeliopsis ambigua* (Wulfen) Nyl.,** *Lich. Lapp. Orient.* 121, 1866

Basionym: *Lichen ambigua* Wulfen, *Collect. Bot. Spectantia (Vienna)* 4: 239, 1790

Figure 56

Thallus foliose, closely adnate; lobes contiguous or separate at apices, sublinear-elongate, subdichotomously branched, 0.5-1.5 mm wide; upper surface yellowish green, flat, rough becoming rugose, 10 μm thick; densely laminal sorediate, punctiform soralia, powdery soredia; medulla white, 120 μm thick; lower surface pale brown at the margins and black at the center, 15 μm thick; rhizines simple or sparsely branched, black; **apothecia** and **pycnidia** not seen.

Chemistry: Cortex containing usinc acid (K-, UV-) and medulla containing divaricatic acid and subdivaricatic acid (K-, C-, KC+ rose, and P-).

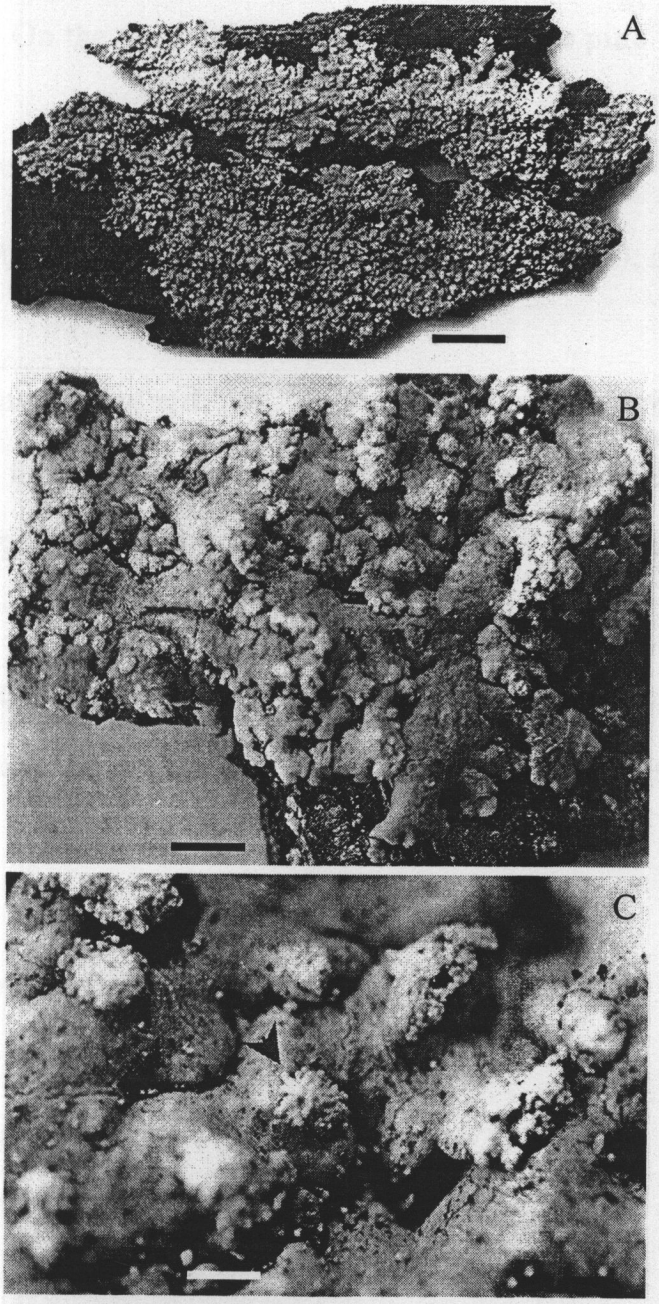


Figure 56 *Parmeliopsis ambigua* (Wulf.) Nyl.

Note: A. Thallus yellow-green closely attached to the substrate [RU—— 10328 (RAMK), scale = 1 cm].

B. Lobes show laminal soralia [RU—— 10328 (RAMK), scale = 2.5 mm].

C. Powderly soredia in laminal punctiform soralia (arrow) [RU—— 10328 (RAMK), scale = 1 mm].

Habitat: On the trunk of unidentified tree in the pine forest at 1,000 m elevation.

Distribution: Northern Hemisphere, Asia (Thailand), and Australia.

Specimens examined: N Thailand. Lampang Province: Khuntan National Park, the pine forest on the trunk of unidentified tree, 1998, *T. Pooprang* and *S. Wattana*, RU——10328 (RAMK).

Observation: The distinguished characteristic of *Parmeliopsis ambigua* is having yellow-green thallus with punctiform soralia. It is rarely found in Thailand.

Genus *Parmotrema*

***Parmotrema* Massal.,** *Phytologia* 28: 334-339, 1974

Figure 57

Thallus foliose, loosely adnate to adnate, coriaceous or membranaceous; lobes broad, irregular, sublinear to elongate, plane to ascending, 5-30 mm wide; margins entire, crenate, serrate or undulate, apices rotund; with or without cilia, cilia simple or branched; upper surface white, gray to gray-green, yellowish gray or pale green, flat to convolute, shiny or dull, smooth to rugose or wrinkled, with or without maculae, soredia and

isidia, without pseudocyphellae; upper cortex palisade plectenchymatous with pored epicortex; cell walls containing *Cetraria*-type lichenan, 10-30 μm thick; medulla mostly white, yellow pigmented or pigmented near the lower cortex, 80-250 μm thick; lower surface black at the center and commonly with brown or white mottled, broad margins without rhizines (more than 5 mm wide), 10-30 μm thick; rhizines brown or black, simple or rarely branched, slender or coarse at the center or grouped subapically, usually rather sparsely; **apothecia** laminal to submarginal, sessile to commonly pedicellate; disc perforate or imperforate; thalline exciple smooth to rugose or ridge, sometimes maculate or with isidia or soredia; ascospores hyaline, simple, ellipsoid, 8 per ascus, large and thick-walled, 8-37 x 5-18 μm; **pycnidia** laminal, immersed to emergent, conidia sublageniform, filiform, or bacilliform.

Habitat: Common on trunks, twigs or upper branches at the canopies of trees from the mangrove forests to the lower montane forests at 0–2,500 m elevations. Occur on rocks at sunny habitats.

Distribution: North and South America, Europe, Africa, Asia, Australia, New Zealand, and the Pacific islands.

Observation: *Parmotrema* is characterized by large thalli with broad lobes, and naked margins. Lower surface is erhizinated, black to brown at marginal zone of about 5 mm. This genus is very common in Thailand, with 28 species reported. There are 2 new species described in this study.

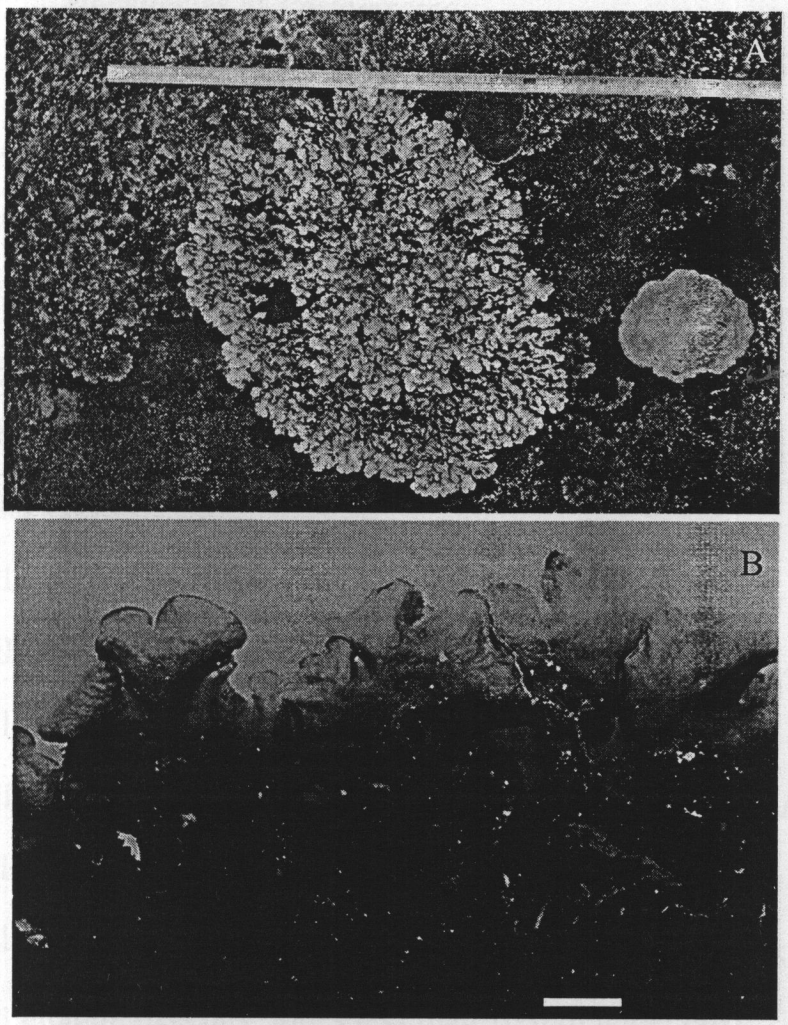


Figure 57 Genus *Parmotrema* Massal.

Note: A. Thallus morphology.

B. Lower surface showing black central area with a broad brown erhizinated marginal zone. Lobes are broader than 0.5 cm [RU—— 8148 (RAMK), scale = 1 cm].

Key to the species of *Parmotrema*

1a Thallus lacking isidia, soredia, or lobules.....2

1b Thallus isidiate, sorediate, or lobulate.....12

2a Lobes with cilia along the margins.....3

2b Lobes without cilia.....8

3a Medulla C+ red; gyrophoric acid present, apothecia perforate...*P. eunetum*

3b Medulla C-.....4

4a Medulla P+ orange to red; protocatraric acid present.....5

4b Medulla P-; protocatraric acid absent.....6

5a Medulla containing fatty acid.....*P. elacinulatum*

5b Medulla containing alectoronic acid.....*P. amaniense*

6a Medulla containing norlobaridone and loxodin.....*P. abessinicum*

6b Medulla containing alectoronic acid.....7

7a Thallus membranaceous; lobes less than 10 mm wide; cilia conspicuous.....*P. corniculans*

7b Thallus coriaceous; lobes more than 15 mm wide; cilia rare.....*P. maclayanum*

8a Medulla containing barbatic acid (KC+ pale orange).....*P. explanatum*

8b Medulla not containing barbatic acid.....9

9a Medulla P-; containing alectoronic acid and UV + white....*P. maclayanum*

9b Medulla P+ orange to red; containing protocetraric acid.....10

10a Lobes ascending with lobulate laciniae.....11

10b Lobes plan without lobulate laciniae.....*P. overeemii*

11a Lobulate laciniae mainly laminal.....*P. thailandicum*

11b Lobulate laciniae mainly marginal; growing on twig.....*P. merrillii*

12a Thallus isidiate, lobulate.....13

12b Thallus sorediate.....19

13a Lobes with cilia.....14

13b Lobes without cilia.....17

14a Medulla sulpher yellow; cylindrical to coralloid isidia.....*P. sulphuratum*

14b Medulla white.....15

15a Isidia cylindrical to coralloid or becoming sorediate.....16

15b Isidia flattened becoming lobules, gyrophoric acid present.....
.....*P. planatilobatum*

16a Isidia cylindrical to coralloid; gyrophoric acid present...*P. pseudocrinitum*

16b Isidia becoming sorediate; alectoronic acid present.....*P. mellissii*

17a Medulla C+ red, P-; lecanoric acid present.....*P. tinctorum*

17b Medulla C-, P+ orange to red; protocetraric acid present.....18

18a Isidia granule to thick and long cylindrical, scattered.....*P. incrassatum*

18b Isidia thin and small cylindrical, cover throughout thallus.....
.....*P. saccatilobum*

19a Lobes with cilia.....20

19b Lobes without cilia.....25

20a Medulla UV+ white; containing alectoronic acid.....21

20b Medulla UV-.....22

21a Skyrin present (pink pigmented).....*P. rampoddense*

21b Skyrin absent.....*P. poolii*

22a Medulla P-; protocetraric acid absent.....23

22b Medulla P+; protocetraric aicd present.....24

23a Medulla C+ red; gyrophoric acid present, with marginal soralia.....

.....*P. sancti-angelii*

23b Medulla C-, KC+ pale red; norlobaridone present, with laminal and marginal soralia.....*P. hababianum*

24a Red pigment present (K+ purple) at cilia and margin of lower surface.....

.....*P. rubromarginatum*

24b Red pigment absent.....*P. subarnoldii*

25a Medulla C+ red; sometimes cilia present in damaged lobes.....

.....*P. cristiferum*

25b Medulla C-.....26

26a Medulla P+; protocetraric acid present.....27

26b Medulla P-; protocetraric acid absent.....28

27a Medulla pale yellow; usnic acid and echinocarpic acid present.....

.....*P. dilatatum*

27b Medulla white; Echinocarpic acid absent.....*P. gardneri*

28a Medulla UV -; fatty acid present.....*P. praesorediosum*

28b Medulla UV+ white; alectoronic acid present.....*P. pseudonilgherrense*

Description of the species of *Parmotrema*

1. *Parmotrema abessinicum* (Krempelh.) Hale, *Phytologia* 28: 334, 1974

Basionym: *Parmelia abessinica* Kremplh., *Linnaea* 41: 140, 1877

Figure 58

Thallus foliose, loosely adnate, lobes broad, subirregular to elongate, 8-10 mm wide; margins crenate, subascending; apices rotund; cilia simple, sparse at the crenate margins, up to 2 mm long; upper surface gray, smooth to rarely wrinkled, faintly maculae, 20 μm thick; without isidia and soredia; medulla white, 100 μm thick; lower surface black at the center and brown mottled at the margin, 1 cm wide, 25 μm thick; rhizines simple, black; **apothecia** not seen; **pycnidia** sparse, immersed, laminal to submarginal, conidia sublageniform, 5-6 x 1 μm.

Chemistry: Cortex containing atranorin, chloroatranorin (K+ yellow); medulla containing norlobaridone and loxodin (K-, C-, KC+ purple to pale red, and P-).

Habitat: On trunk of tree in the mixed deciduous forest at elevation over 1,000 m.

Distribution: Africa, India, and Thailand.

Specimens examined: N Thailand. Chiang Mai Province: Queen Sirikit Botanic Garden, in the mixed deciduous forest, on trunk of unidentified tree, 1994, *K. Boonpragob et al.*, RU——1993 (RAMK).

Observation: *Parmotrema abessinicum* is characterized by presence of cilia, without isidia and soredia, and containing norlobaridone and loxodin (KC+ purple to pale red). This species resembles *P. hababianum*, which has soredia.

2. *Parmotrema amaniense* (Steiner and Zahlbr.) Krog and Swinscow, *Lichenologist* 15: 129, 1983

Basionym: *Parmelia amaniensis* Steiner and Zahlbr., *Bot. Jb.* 60: 526, 1926

Figure 59

Thallus foliose, loosely adnate, coriaceous; lobes broad, sublinear to elongate, 8-12 mm wide; margins distinct crenate to undulate; apices subrotund; cilia dense, simple, up to 5 mm long; upper surface gray, emaculate, smooth to wrinkled, 25-30 μm thick; without isidia and soredia; medulla white, 120 μm thick; lower surface black at the center and narrow brown to white mottled at the margin, 30 μm thick; rhizines simple, scattered sparse; **apothecia** submarginal on swollen stipitated and twist of convoluted lobes, disc imperforate, dark brown, up to 1 cm wide; thalline exciple distinct wrinkled to ridged, deeply dentate to serrate with cilia at the margins;

ascospores hyaline, simple, ellipsoid, 25-30 x 15-18 μm; **pycnidia** immerse, sparse, conidia sublageniform, 5-8 x 1 μm.

Chemistry: Cortex containing atranorin, chloroatranorin (K+ yellow); medulla containing alectoronic acid, α-collatolic acid, protocetraric acid, and ±methylvirensate (K-, C-, KC+ orange, and P+ orange to red).

Habitat: On trunks of trees in the lower montane forests at elevations above 1,000 m.

Distribution: Western and Southern Africa, and Thailand.

Specimens examined: N Thailand. Chiang Mai Province: Doi Suthep-Pui National Park, Doi PhaKlong, in the lower montane forest, on trunk of unidentified tree, 1994, *K. Boonpragob et al.*, RU——10337 (RAMK). **NE Thaiand.** Loei Province: Nahaeo National Park, along a trail to Num Tok Taad Hueang, on twig from canopy branch of unidentified tree, 1995, *T. Pooprang*, RU——6452 (RAMK).

Observation: *Parmotrema amaniense* is distinguished by prominent wrinkled to ridged, with deeply dentate to serrate of thalline exciple, and having cilia. Apothecia are swollen and twist stipitate. This species contains both alectoronic aicd and protocetraric acid.

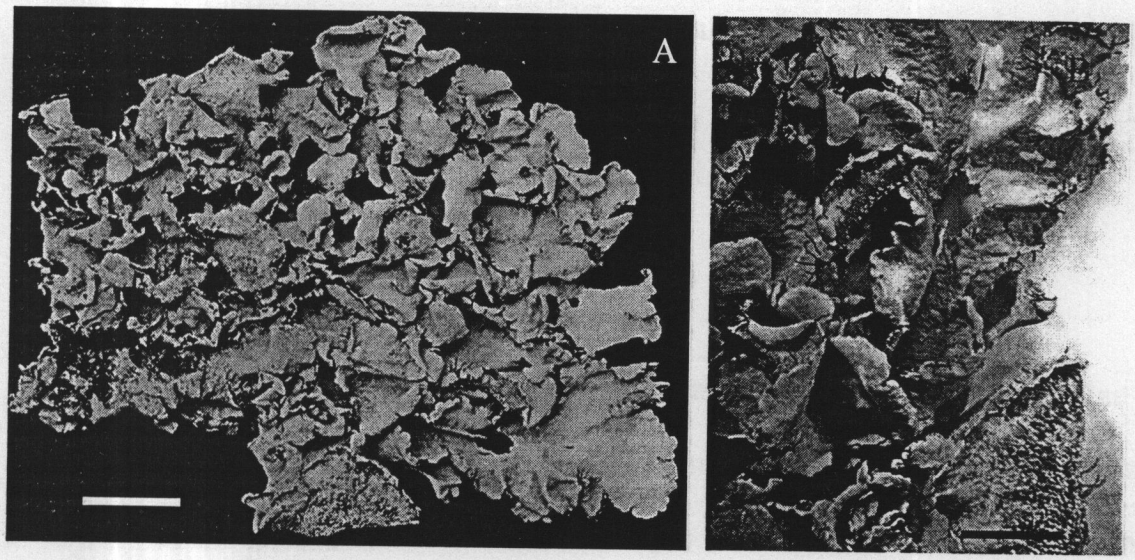


Figure 58 *Parmotrema abessinicum* (Krempelh.) Hale

Note: A. Thallus gray-green with crowded lobes [RU——1993 (RAMK), scale = 1 cm].

B. Crenate margins with cilia [RU——1993 (RAMK), scale = 0.6 cm].

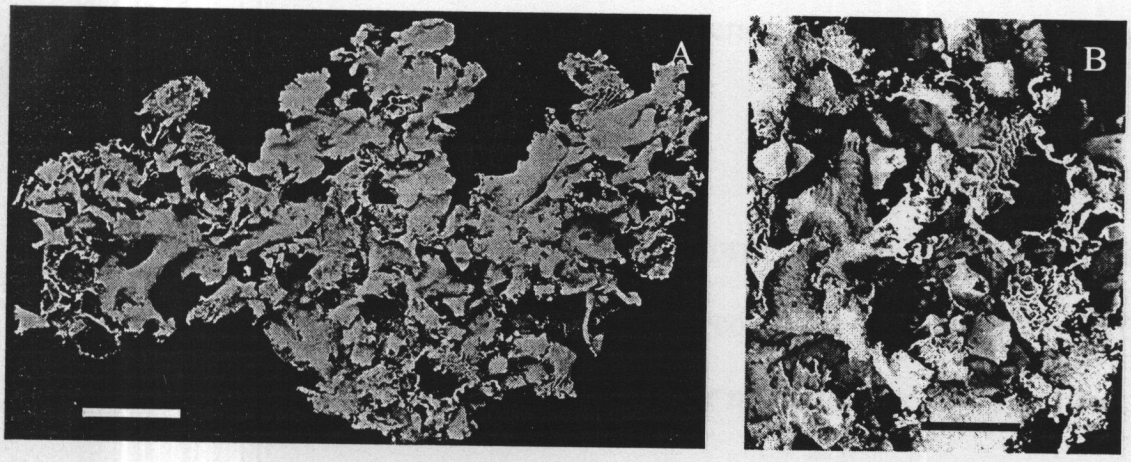


Figure 59 *Parmotrema amaniense* (Steiner and Zahlbr.) Krog and Swinscow

Note: A. Thallus gray-green with convoluted lobes and apothecia [RU——10337 (RAMK), scale = 1.3 cm].

B. Strongly wrinkled to ridged on thalline exciple of apothecia [RU——10337 (RAMK), scale = 0.7 cm].

3. *Parmotrema corniculans* (Nyl.) Hale, *Contr. U.S. Natl. Herb.* 36: 283, 1965

Basionym: *Parmelia corniculans* Nyl., *Flora* 68: 607, 1885

Figure 60

Thallus foliose, loosely adnate, membranaceous; lobes irregular to elongate, rounded, imbricate, 8-10 mm wide; margins entire to crenate-dentate to weakly laciniae, apices rotund; cilia simple to branched, dense, up to 2 mm long; without isidia and soredia; upper surface gray-green, faintly maculae to effigurate maculae, smooth to rarely cracked, 15 μm thick; medulla white, 80 μm thick; lower surface black at the center and brown at the margin, 15 μm thick; rhizines black, simple to branched, sparse; **apothecia** not seen; **pycnidia** numerous, mostly submarginal, immerse; conidia filiform, 8-10 x 1 μm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing alectoronic, α-collatolic acid (K-, C-, KC+ orange, and P-), and skyrin (K+ purple at lower medulla near lower cortex).

Habitat: Occur on tree in moist habitat at elevation above 2,000 m.

Distribution: Thailand, Laos, Indonesia, Philippines, and Papua New Guinea.

Specimens examined: N Thailand. Chiang Mai Province: Doi Inthanon National Park, opposite Kiu Mae Pan, on trunk of unidentified tree, *T. Pooprang,* RU——10237 (RAMK).

Observation: *Parmotrema corniculans* is characterized by crenate-dentate to laciniate lobes, with cilia, and contains alectoronic acid and α-collatolic acid. The related species is *P. eunetum*, which has morphologically identical lobes but differs in chemistry. The latter has gyrophoric acid.

4. *Parmotrema cristiferum* (Taylor) Hale, *Phytologia* 28: 335, 1974

Basionym: *Parmelia cristifera* Taylor, *London Journ. Bot.* 6: 165, 1847

Figure 61

Thallus foliose, loosely adnate, membranaceous to coriaceous; lobes irregular to subirregular, broad, round, flat to subascending at margins, 5-15 mm wide; margins entire to weakly crenate; mostly main lobes without cilia, sometimes sparsely ciliated at lobes axils or damaged margins, less than 1 mm long; soralia marginal and linear along ascending lobes, soredia granular; upper surface gray-green, smooth to rarely cracked, emaculate to weakly maculate or black spots, 25 μm thick; medulla white, 80-100 μm thick; lower surface black, always brown near the margins, 25 μm thick; rhizines black, sparse, simple; **apothecia** rarely present, laminal, sessile, up to 10 mm wide; disc brown, concave; thalline exciple smooth to wrinkled, sometimes with

soredia; ascospores hyaline, simple, ellipsoid, 24-30 x 13-15 μm; **pycnidia** and conidia not seen.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing salazinic acid and consalazinic acid (K+ dark red, C-, KC-, and P+ orange).

Habitat: Occur on trees, which widely distributed in every type of forests at 0-2,000 m elevations.

Distribution: North to South America, Africa, Asia (India, Burma, Thailand, Malaysia, Indonesia, Philippines, and Papua New Guinea), the Pacific Island, Australia, and New Zealand.

Specimens examined: N Thailand. Chiang Mai Province: Queen Sirikit Botanic Garden, in the mixed deciduous forest, on trunk of *Peltophorum pterocarpum*, 1994, *K. Boonpragob et al.*, RU——24 (RAMK). Phitsanulok Province: Phu Hin Rong Kla National Park, Lum Lob Phai, on trunk of *Quercus* sp., 1998, *T. Pooprang*, RU——10177 (RAMK). **NE Thailand.** Loei Province: NaHeao National Park, a trail to Nam Tok Taad Hueang, on branches of *Dalbergia oliveri*, 1995, *T. Pooprang*, RU——6200 (RAMK). ibid., on branches of *Spondias* sp., 1995, *T. Pooprang*, RU——6207 & 6209 (RAMK). ibid., along a trail follow Mae Nam Hueang, on trunk of *Neolitsea* sp., 1995, *T. Pooprang*, RU——6290 (RAMK). **SE Thailand.**

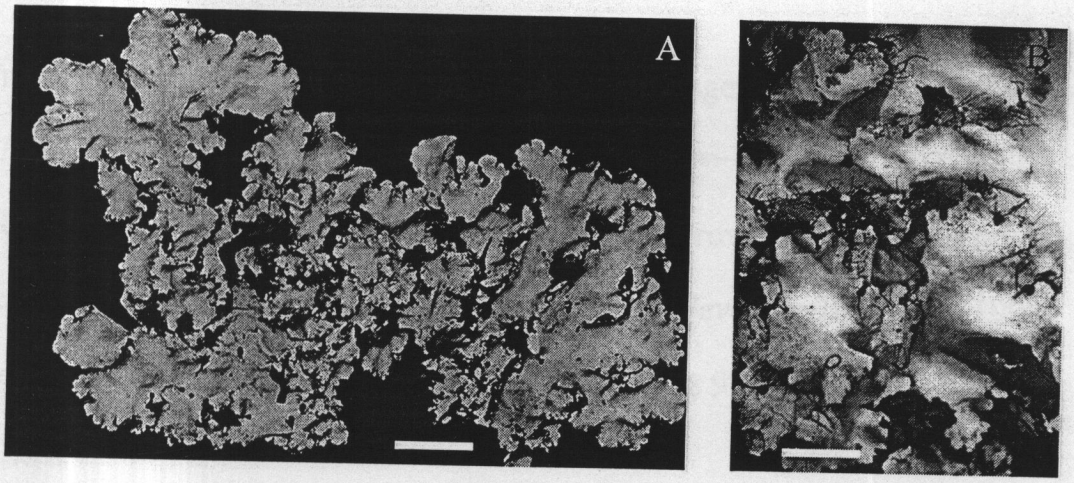


Figure 60 *Parmotrema corniculans* (Nyl.) Hale

Note: A. Thallus gray-green with cilia [RU——10237 (RAMK), scale = 1.3 cm].

B. Cilia at deeply crenate margins [RU——10237 (RAMK), scale = 0.5 cm].

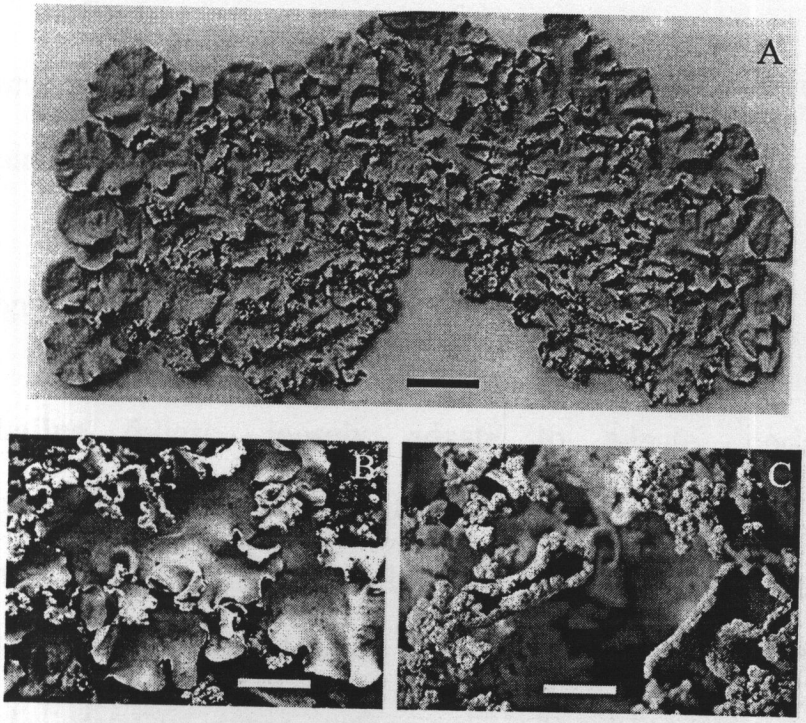


Figure 61 *Parmotrema cristiferum* (Taylor) Hale

Note: A. Thallus gray-green with soredia [RU——9851 (RAMK), scale = 1.2 cm].

B. Powdery soredia become marginal soralia [RU——9855 (RAMK), scale = 0.5 cm].

C. Soralia produced on thalline exciple [RU——6290 (RAMK), scale = 0.35 cm].

Trat Province: in The mangrove forest management unit, on twig of *Rhizophora apiculata*, 1998, *T. Pooprang*, RU——11191, 11193 & 11196 (RAMK). **S Thailand.** Nakhon Srithammarat Province: Rubber Plantation near Khao Luang National Park, on trunk of *Hevea braziliensis*, 1998, *T. Pooprang*, RU——9851, 9854, 9855, 9856, 9857 & 9859 (RAMK).

Observation: *Parmotrema cristiferum* is characterized by having soredia and salazinic acid. The related species is *P. dilatatum* has soredia and protocetraric acid.

5. *Parmotrema dilatatum* (Vainio) Hale, *Phytologia* 28: 335, 1974

Basionym: *Parmelia dilatata* Vainio, *Acta. Soc. Faun. Fl. Fenn.* 7(7): 33, 1890

Figure 62

Thallus foliose, loosely adnate to adnate, coriaceous to membranaceous; lobes irregular to sublinear, rounded, up to 10 mm wide; margins entire to crenate and weakly laciniate, apices rotund; eciliate; soralia marginal, linear on peripheral lobes and subcapitate on ascending lateral lobes, soredia granular; upper surface pale yellowish gray to gray-green, emaculate, smooth to cracked centrally and rarely wrinkled, 30 μm thick; medulla white to pale yellow, 80-100 μm thick; lower surface black and brown at the marginal zone, 30 μm thick; rhizines black, scattered, simple; **apothecia** and **pycnidia** not seen.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing protocetraric acid, echinocarpic, yellow pigments, and usnic acid (K+ yellow, C-, KC- sometimes + yellow, and P+ orange to red).

Habitat: Occurs on trees and rocks in open sunny habitats in the mangrove forests, the dry dipterocarp forests and the lower montane forests at 0-1,200 m elevations.

Distribution: North America, Central America, South America, Africa, Asia (India, Thailand, Singapore, Taiwan, Philippines, and Papua New Guinea), and Australia.

Specimens examined: N Thailand. Phitsanulok Province: Phu Hin Rong Kla National Park, in the lower montane forest, on rock, 1998, *T. Pooprang*, RU——10193 (RAMK). **NE Thailand.** Loei Province: Nahaeo National Park, in the dry dipterocarp forest, on trunk of *Shorea obtusa*, 1995, *T. Pooprang*, RU——7064 (RAMK). **SE Thailand.** Trat Province: The mangrove forest, on branches of *Rhizoflora apiculata*, 1998, *T. Pooprang*, RU——11199 (RAMK).

Observation: *Parmotrema dilatatum* closely resembles *P. cristiferum*, but the former has protocetraric acid (P+ red), and pale yellow medulla containing usnic acid under irregular cracked upper surface.

6. ***Parmotrema elacinulatum*** **(Kurokawa) Streimann**, *Bibl. Lichenol.* 22: 94, 1986

Basionym: *Parmelia elacinulata* Kurokawa, *Studies Crypt. Papua New Guinea* 132, 1979

Figure 63

Thallus foliose, loosely adnate, coriaceous; lobes sublinear to subirregular, flat, round, 5-10 mm wide; margins entire to crenate, apices rotund; cilia black, dense at the margin sparse near margins of upper surface, simple, up to 2 mm long; without isidia and soredia; upper surface gray, smooth to rugose, emaculate, 20 μm thick; medulla white, 120 μm thick; lower surface black, brown near the margins, 25 μm thick; rhizines sparse, black, simple; **apothecia** present, subpedicellate, submarginal, up to 5 mm wide; disc brown; thalline exciple weakly wrinkled, margins entire to dentate, sometimes with red pigmented cilia; ascospores hyaline, simple, ellipsoid, 20-25 x 13-15 μm; **pycnidia** common, immersed, conidia not seen, sometimes deformed.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing protocetraric acid, lichesterinic acid, and protolichesterinic acid (K- or K+ pale yellow, C-, KC-, and P+ orange-red), and unkown pigment K+ purple at some cilia and near lower surface.

Habitat: Occur on tree above 1,400 m in the lower montane forest.

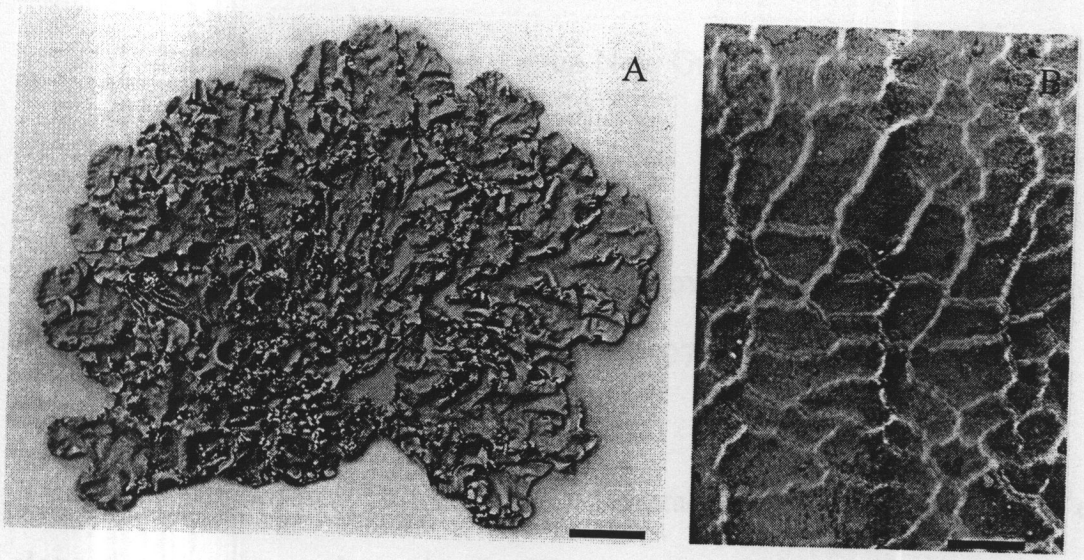


Figure 62 *Parmotrema dilatatum* (Vain.) Hale

Note: A. Thallus yellow-gray with soredia become marginal soralia [RU——10193 (RAMK), scale = 1.5 cm].

B. Irregular cracked on upper surface exposing pale yellow medulla [RU——10193 (RAMK), scale = 0.6 mm].

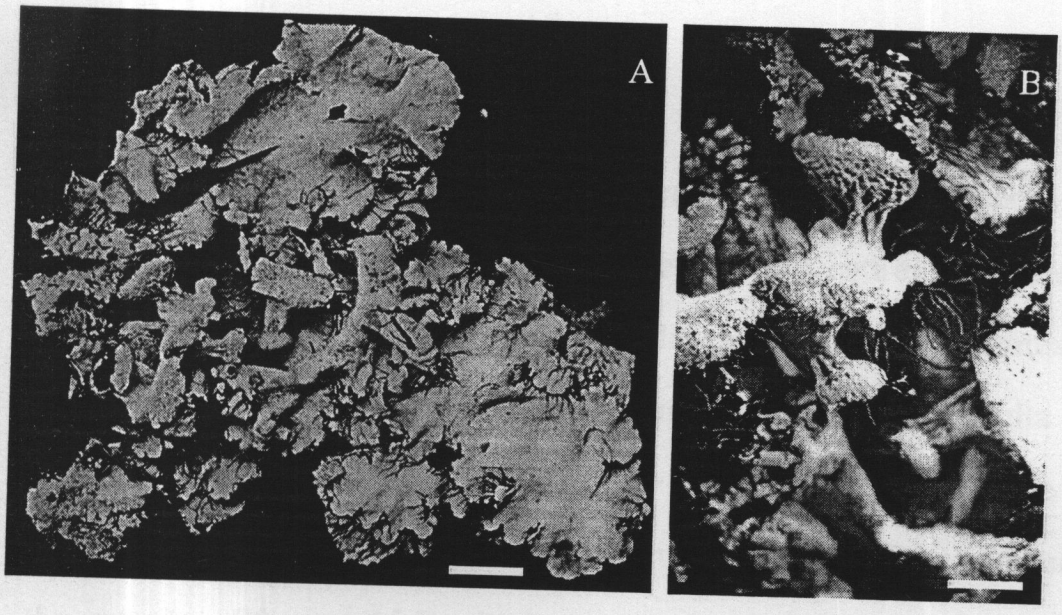


Figure 63 *Parmotrema elacinulatum* (Kurokawa) Streimann

Note: A. Thallus gray-green with long cilia [RU——9711 (RAMK), scale = 0.8 cm].

B. Apothecia with cilia, swollen and wrinkled stipitate [RU——9711 (RAMK), scale = 0.4 cm].

Distribution: Thailand, Papua New Guinea, and Australia

Specimens examined: E Thailand. Nakhon Ratchasima Province: Khao Yai National Park, Khao Kieao, in the lower montane forest, on trunk of unidentified tree, 1997, *T. Pooprang*, RU——9711 (RAMK).

Observation: This species is characterized by conspicuous cilia along the margins and on the thalline exciples with swollen pedicels, and containing protocetraric acid and fatty acids.

7. ***Parmotrema eunetum* (Stirton) Hale**, *Phytologia* 28: 336, 1974

Basionym: *Parmelia euneta* Stirton, *Scott Nat.* 4: 298, 1877

Figure 64

Thallus foliose, loosely adnate, membranaceous to coriaceous; lobes broad, irregular to elongate, 8-10 mm wide; margins entire to crenate, cilia simple, black, up to 1 mm long; without isidia and soredia; upper cortex gray-green, 15 μm thick, faintly maculate, cracked in older parts; medulla white, occasionally with pale yellow patches (K+ purple of skyrin near the lower cortex), 80 μm thick; lower surface black with brown to white mottled near the margins, 20 μm thick; rhizines simple, sparse to dense; **apothecia** submarginal, swollen stipitate; disc perforate, brown, up to 1 cm in diameter; thalline exciple smooth to rugose; margin crenate to dentate; ascospores 20-30 x 12-17 μm; **pycnidia** sparse, immersed, conidia filiform, 12-15 x 1 μm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing gyrophoric acid, and lecanoric acid (K-, C+ red, KC+ red, and P-).

Habitat: On trunks of trees in the mixed deciduous forests and the lower montane forests in northern Thailand.

Distribution: Africa (Ethiopia, Kenya, Tanzania, Uganda, Sierra Leone, Angola, and Congo), and Asia (Sri Lanka, and Thailand).

Specimens examined: N Thailand. Chiang Mai Province: Queen Sirikit Botanic Garden, in the mixed deciduous forest, on trunk of *Dillenia* sp., 1994, *K. Boonpragob et al.*, RU——762, 766, 772, 775, 784, 786, 790, 793 & 800 (RAMK). ibid., on trunk of *Castanopsis diversifolia*, 1994, *K. Boonpragob et al.*, RU——1035 (RAMK). ibid., on trunk of *Dipterocarpous obtusifolius*, 1994, *K. Boonpragob et al.*, RU——1099, 1101, 1104 & 1123 (RAMK). ibid., on trunk of *Shorea obtusa*, 1994, *K. Boonpragob et al.*, RU——1326 (RAMK). ibid., on trunk of *Castanopsis cordifolia*, 1994, *K. Boonpragob et al.*, RU——3288 (RAMK). ibid., on trunk of *Shorea obtusa*, 1995, *K. Boonpragob et al.*, RU——3714 (RAMK). Doi Suthep-Pui National Park, Doi Pui Research Station, in Plum orchard, on twig of *Diospyros* sp., 1998, *T. Pooprang*, RU——10295 (RAMK).

Observation: *Parmotrema eunetum* is distinguished by ciliated margins, perforate apothecia, and contains gyrophoric acid.

8. *Parmotrema explanatum* (Hale) Hale, *Phytologia* 28: 337, 1974

Basionym: *Parmelia explanata* Hale, *Journ. Jap. Bot.* 40: 199, 1964

Figure 65

Thallus foliose, loosely adnate, coriaceous; lobes broad, irregular to elongate, 8-10 mm wide; margins entire, apices rotund; eciliate; without isidia and soredia; upper surface pale yellow gray to gray green, smooth to weakly rugose, plane, emaculate, 20 μm thick; medulla white, 150 μm thick; lower surface black and brown near the margin, 20 μm thick; rhizines sparse, simple, black; **apothecia** abundant, sessile to subpedicellate, disc imperforate, brown; thalline exciple entire to crenate, smooth to cracked, up to 8 mm wide; ascospores hyaline, simple, ellipsoid, 17-25 x 7-10 μm; **pycnidia** laminal to submarginal, immerse, conidia sublageniform, 5-6 x 1 μm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing barbatic acid (K-, C-, KC+ pale orange, and P-).

Habitat: On trunk of tree in secondary forest at about 600 m elevation.

Distribution: Thailand.

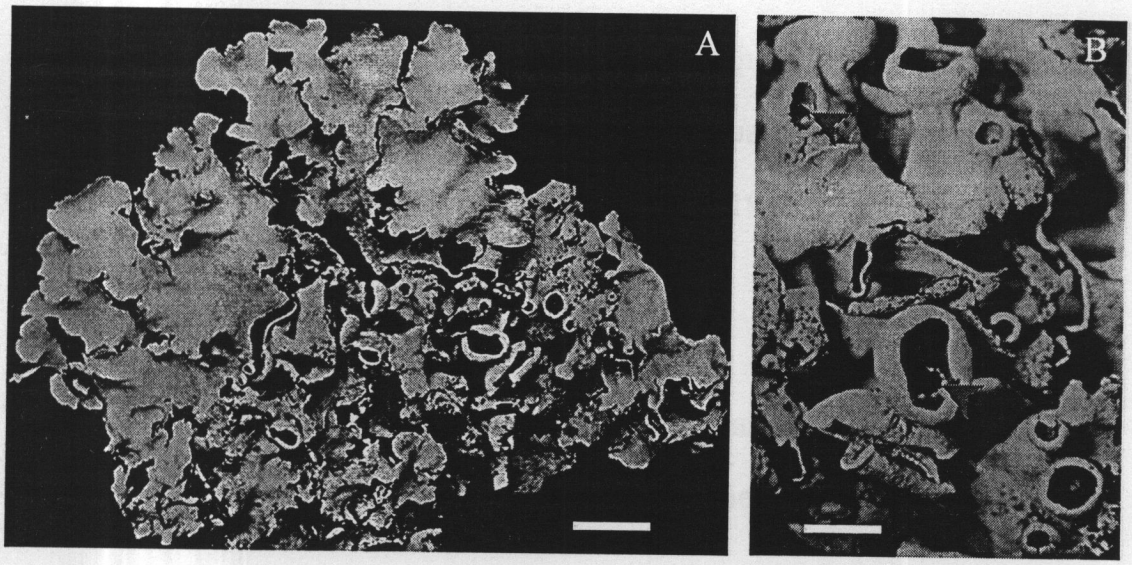


Figure 64 *Parmotrema eunetum* (Stirt.) Hale

Note: A. Thallus gray-green with cilia [RU——3288 (RAMK), scale = 1.2 cm].

B. Perforate apothecia (arrow) [RU——3288 (RAMK), scale = 0.33 cm].

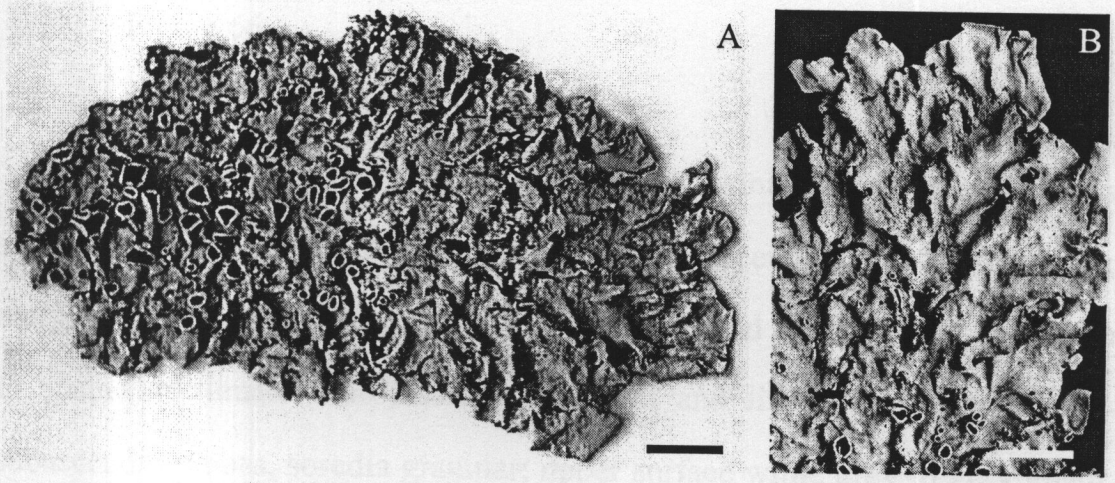


Figure 65 *Parmotrema explanatum* (Hale) Hale

Note: A. Thallus gray-green with many apothecia [RU——TP014 (RAMK), scale = 1.4 cm].

B. Smooth to weakly rugose on upper surface [RU——TP014 (RAMK), scale = 0.8 cm].

Specimens examined: E Thailand. Nakhon Ratchasima Province: Khao Yai National Park, along a trail from Pratamnak to the old Golf Course, the secondary forest, on trunk of unidentified tree, 1999, *T. Pooprang*, RU—TP016 (RAMK).

Observation: *Parmotrema explanatum* has identical lobes with *P. overeemii* but differs in chemistry. The former species has barbatic acid.

9. *Parmotrema gardneri* (C.W. Dodge) Sérus., *The Bryologist* 87: 5, 1984

Basionym: *Parmelia gardneri* C.W. Dodge, *Ann. Mo. Bot. Gdn.* 46: 179, 1959

Figure 66

Thallus foliose, loosely adnate to adnate, coriaceous; lobes subirregular to elongate, rounded, imbricate, subascending, 10-15 mm wide; margins entire, crenate to sublaciniate, apices rotund with sinuous; cilia rare to sparse at sinuate lobes; soralia marginal and linear or subcapitate on subascending lobes, soredia granular; upper surface white gray to gray-green, plane to subascending, 30 μm thick; medulla white, 70-100 μm thick; lower surface black to brown near the margins, white to pale brown under soralia, 25 μm thick; rhizines sparse, simple, black; **apothecia** rare, laminal, sessile, disc imperforate, dark brown; thalline exciple thick with soredia; ascospores

hyaline, simple, ellipsoid, 20-27 x 10-15 μm; **pycnidia** sparse, immerse, laminal, conidia sublageniform 4-5 x 1 μm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing protocetraric acid (K-, C-, KC-, and P+ orange to red).

Habitat: On trunks of trees in the dry dipterocarp forests, the lower montane forests and the secondary forests from the North to the East of Thailand.

Distribution: South America, Africa, Thailand, Papua New Guinea, and Australia.

Specimens examined: N Thailand. Chiang Mai Province: Queen Sirikit Botanic Garden, in the mixed deciduous forest, on trunk of *Pittosporum ferrugenum*, 1994, *K. Boonpragob et al.*, RU——1133 (RAMK). ibid., on trunk of *Dipterocarpus obtusifolias*, 1994, *K. Boonpragob et al.*, RU——1932 (RAMK). ibid., on trunk of *Shorea obtusa*, 1994, *K. Boonpragob et al.*, RU——1898 (RAMK). **NE Thailand.** Loei Province: Nahaeo National Park, along a trail to ToKo 1, in the lower montane, on rock, 1995, *T. Pooprang*, RU——4159 (RAMK). ibid., Wat Bo Muaeng Noi, in the dry dipterocarp forest, on trunk of *Shorea obtusa*, 1995, *T. Pooprang*, RU——7055 (RAMK). **E Thailand.** Nakhon Ratchasima Province: Khao Yai

National Park, in the secondary forest, 1997, *T. Pooprang*, RU——8080 (RAMK).

Observation: *Parmotrema gardneri* is characterized by marginal soralia and containing protocetraric acid, but it differs from *P. dilatatum*, which has usnic acid.

10. *Parmotrema hababianum* (Gyelnik) Hale, *Phytologia* 28: 338, 1974

Basionym: *Parmelia hababiana* Gyelnik, *Spec, Regni veg.* 29: 288, 1931

Figure 67

Thallus foliose, loosely adnate to adnate, coriaceous; lobes irregular to elongate, 6-10 mm wide; margins crenate, subascending to revolute, apices subrotund; cilia sparse to dense, simple to branched; soralia along the lobes margins and punctiform at the submargins, soredia powdery to granule; upper surface gray-green to green, smooth to rugose, faintly maculae, 15-20 μm thick; medulla white, 120 μm thick; lower surface black to brown with ridge near marginal zone, 20 μm thick; rhizines black, simple, scattered; **apothecia** and **pycnidia** not seen.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing norlobaridone and loxodin (K-, C-, KC+ purple to pale red, and P-).

Habitat: On trunks and twigs of trees in the lower montane forests, the mixed deciduous forests, and the dry dipterocarp forests at 700-1400 m elevations in northern Thailand.

Distribution: North and South America, Africa, and Asia (India and Thailand).

Specimens examined: N Thailand. Chiang Mai Province: Queen Sirikit Botanic Garden, in the mixed deciduous forest, on trunk of *Castanopsis diversifolia*, 1994, *K. Boonpragob et al.*, RU——1041 (RAMK). ibid., on trunk of *Shorea obtusa*, 1994, *K. Boonpragob et al.*, RU——1346 & 2718 (RAMK). ibid., on trunk of *Melia azedarach*, 1994, *K. Boonpragob et al.*, RU——2112, 2253, 2255 & 2256 (RAMK). ibid., on trunk of *Bombax ceiba*, 1994, *K. Boonpragob et al.*, RU——2314 & 2316 (RAMK). ibid., on trunk of *Stereospermum neuranthum*, 1994, *K. Boonpragob et al.*, RU——2406 (RAMK). ibid., on trunk of *Dipterocarpus tuberculatus*, 1994, *K. Boonpragob et al.*, RU——2869, 2871 & 2909 (RAMK). ibid., on trunk of *Sezygium* sp., 1994, *K. Boonpragob et al.*, RU——2915 (RAMK). ibid., on trunk of *Tectona grandis*, 1994, *K. Boonpragob et al.*, RU——2956 (RAMK).

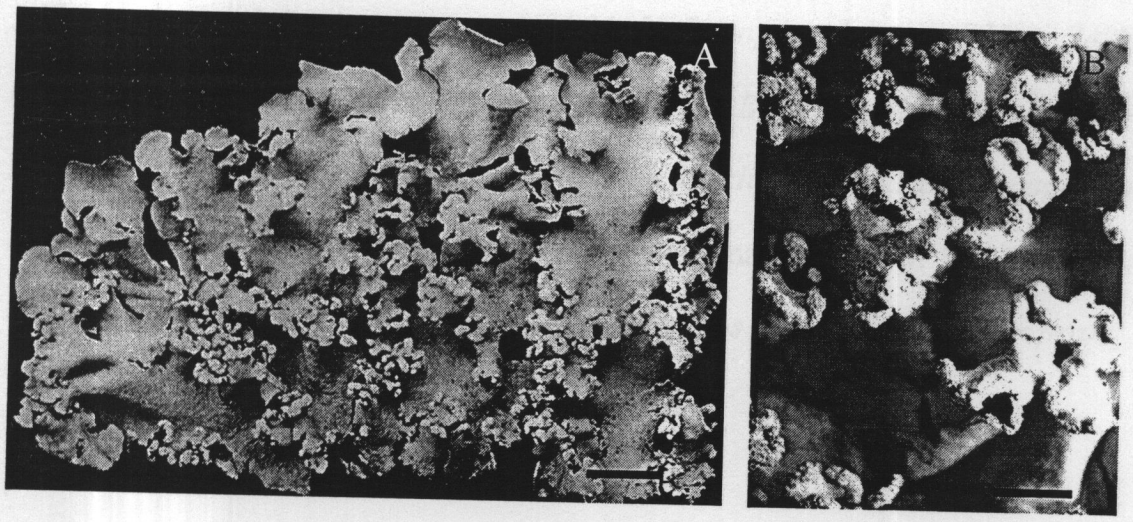


Figure 66 *Parmotrema gardneri* (Dodge) Serus

Note: A. Thallus gray-green with marginal soredia [RU—4159 (RAMK), scale = 1 cm].

B. Powdery soredia developed into marginal soralia along the edges of central lobes [RU—4159 (RAMK), scale = 0.45 cm].

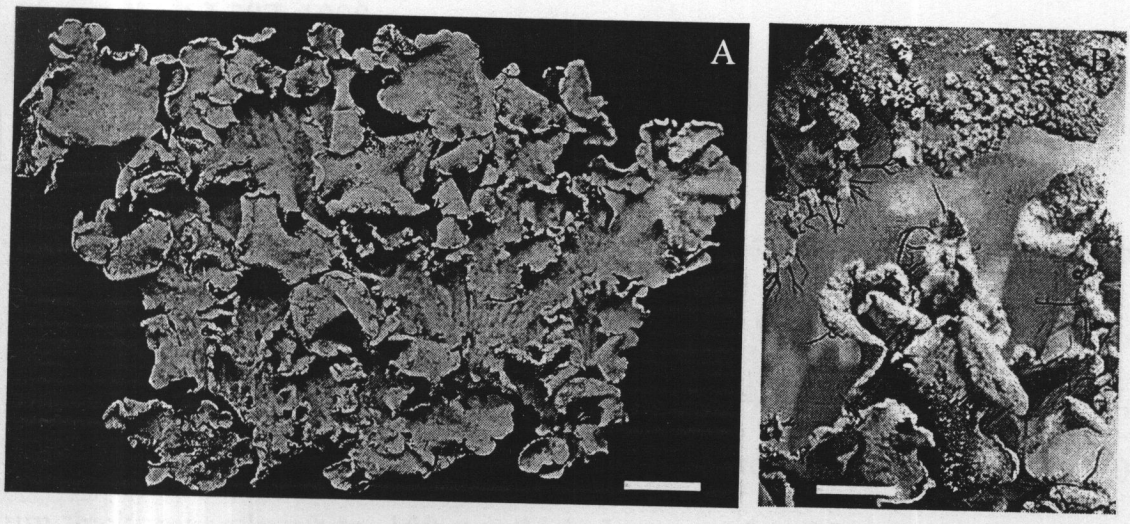


Figure 67 *Parmotrema hababianum* (Gyeln.) Hale

Note: A. Thallus yellow-gray with soredia and cilia [RAMK—10299, scale = 1 cm].

B. Laminal and marginal soralia; simple to branched cilia along the margins [RU—10300 (RAMK), scale = 0.4 cm].

ibid., on trunk of *Protium serratum,* 1994, *K. Boonpragob et al.*, RU——3480 (RAMK). ibid., on trunk of *Ficus* sp., 1995, *K. Boonpragob et al.*, RU——3889 (RAMK). ibid., on trunk of *Holigrana kurzii*, 1995, *K. Boonpragob et al.*, RU——3892 (RAMK). Doi Suthep-Pui National Park, Doi Pui Research Station, in Plab Orchard, on twig of *Diospyros* sp., 1998, *T. Pooprang*, RU——10299, 10300, 10314 & 10315 (RAMK).

Observation: *Parmotrema hababianum* is characterized by marginal soralia, simple to branched cilia, white to mottled brown near the margins of lower surface.

11. *Parmotrema incrassatum* Hale ex DePriest and B.W. Hale, *Mycotaxon* 67:207, 1998

Figure 68

Thallus foliose, loosely adnate, coriaceous; lobes broad, irregular to elongate, flat to revolute, 10 mm wide; margins entire to weakly crenate, apices subrotund; without cilia; isidia very thick, granular to cylindrical, simple to irregular branched; upper surface gray green, smooth to rugose, 20 µm thick; medulla white, 150 µm thick; lower surface black and brown near the margin, 20 µm thick; rhizines black, sparse, simple; **apothecia** laminal, disc imperforate, dark brown, up to 5 mm wide; thalline exciple entire; ascospores deformed; **pycnidia** laminal and submarginal, immersed; conidia bifusiform, 4-6 x 1 µm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing protocetraric acid and virensic acid (K-, C-, KC+ pale red, and P+ orange to red).

Habitat: On trunk of tree in the mixed deciduous forest about 700 elevation in Northern Thailand.

Distribution: Thailand and Hong Kong.

Specimens examined: N Thailand. Chiang Mai Province: Queen Sirikit Botanic Garden, in the mixed deciduous forest, on trunk of unidentified tree, 1998, *T. Pooprang*, RU——10210 (RAMK).

Observation: *Parmotrema incrassatum* is distinguished by very thick, glanular to cylindrical isidia and containing protocetraric acid, which is similar to *P. saccatilobum*. However, the former has virensic acid (KC+ pale red) in the medulla, whereas the latter lacking this substance (KC-).

12. *Parmotrema maclayanum* (Müll. Arg.) Hale, *Phytologia* 28: 337, 1974

Basionym: *Parmelia maclayana* Müll. Arg., *Flora* 74: 376, 1891

Figure 69

Thallus foliose, loosely adnate to adnate, coriaceous; lobes broad, irregular to elongate, rounded, 8-20 (25) mm wide; margins entire to crenate, plane to ascending, apices rotund; with or without cilia, cilia simple 0.5-2 mm long; without isidia and soredia; upper surface gray, smooth to rugose, weakly to strongly wrinkled, plane to convex, emaculate, 20-30 μm thick; medulla white, 100-200 μm thick; lower surface black and brown near the margin, 20-25 μm thick; rhizines black, simple, sparse; **apothecia** laminal, sessile to swollen pedicellate, disc imperforate, brown; thalline exciple entire to crenate, smooth to cracked, up to 20 mm wide; ascospores hyaline, simple, ellipsoid, 12-16 x 8-10 μm; **pycnidia** laminal to submarginal, immerse, conidia sublageniform, 5-7 x 1 μm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing alectoronic acid (K-, C-, KC+ purple, and P+ red) and under UV positive (UV+ white).

Habitat: On trunks and twigs of trees grow above 1,000 m elevation in the dry dipterocarp forests and the mixed deciduous forests in northern Thailand, mostly on rocks at the sun exposured habitats in the lower montane forests.

Distribution: South America (Brazil), Africa, Madagascar, Thailand, Papua New Guinea, and New Caledonia.

Specimens examined: N Thailand. Chiang Mai Province: Queen Sirikit Botanic Garden, in the mixed deciduous forest, on trunk of *Dillenia* sp., 1994, *K. Boonpragob et al.*, RU——801, 2580, 2581, 2583, 2584, 2585, 2586, 2587, 2588 & 2590 (RAMK). ibid., on trunk of *Shorea roxburghii*, 1994, *K. Boonpragob et al.*, RU——945, 946, 948, 950, 951, 954, 955, 957, 959, 1729, 1734, 1735, 1736, 1738, 1740, 1741, 1742, 1743, 1744, 1745, 1746, 1747, 1748, 1749, 1750, 1751, 1752, 1753, 1757, 1758, 1772, 1773, 1774, 1775, 276 & 2765 (RAMK). ibid., on trunk of *Dipterocarpus intricatus*, 1994, *K. Boonpragob et al.*, RU——985, 987, 988, 991, 992, 996, 997, 999, 1000, 1001, 1002, 1003, 1004, 1005 & 1006 (RAMK). ibid., on trunk of *Castanopsis diversifolia*, 1994, *K. Boonpragob et al.*, RU——1029, 1031, 1032, 1036, 1037, 1038 & 1040 (RAMK). ibid., on trunk of *Pterocarpus* sp., 1994, *K. Boonpragob et al.*, RU——1042, 1043 & 1044 (RAMK). ibid., on trunk of *Shorea obtusa*, 1994, *K. Boonpragob et al.*, RU——1094, 1334, 1338, 1343, 1344, 1912, 2721 & 2732 (RAMK). ibid., on trunk of *Dipterocarpus obtusifolius*, 1994, *K. Boonpragob et al.*, RU——1106, 1110, 1113, 1114, 1115, 1116, 1117, 1118, 1822 & 1863 (RAMK). ibid., on trunk of *Pittosporum ferrugineum*, 1994, *K. Boonpragob et al.*, RU——1126, 1127, 1129, 1130, 1131, 1186, 1189, 1191, 1192 & 1193 (RAMK). ibid., on trunk of *Quercus mespilifolioides*, 1994, *K. Boonpragob et al.*, RU——1440, 1441, 1442, 1443, 1444, 1445, 1449, 1454 & 1455 (RAMK). ibid., on trunk of unidentified tree, 1994, *K. Boonpragob et al.*, RU——1516, 1519 & 1520 (RAMK). ibid., on trunk of *Pterocarpus macrocarpus*, 1994, *K. Boonpragob*

et al., RU——1539 (RAMK). ibid., on trunk of *Schima wallichii*, 1994, *K. Boonpragob et al.*, RU——1687 (RAMK). ibid., on trunk of *Melia azedarach*, 1994, *K. Boonpragob et al.*, RU——2103, 2104, 2260, 2261 & 2265 (RAMK). ibid., on trunk of *Bombax ceiba*, 1994, *K. Boonpragob et al.*, RU——2340, 2341, 2343, 2345 & 2376 (RAMK). ibid., on trunk of *Quercus* sp., 1994, *K. Boonpragob et al.*, RU——2645 (RAMK). ibid., on trunk of *Sezygium* sp., 1994, *K. Boonpragob et al.*, RU——2910, 2911, 2912, 2913 & 2918 (RAMK). ibid., on trunk of *Anneslea fragrans*, 1994, *K. Boonpragob et al.*, RU——2950, 2991, 2992, 2993, 2996, 2998 & 3000 (RAMK). ibid., on trunk of *Paramichelia baillonii*, 1994, *K. Boonpragob et al.*, RU——3082 (RAMK). ibid., on trunk of Pinus kesiya, 1994, *K. Boonpragob et al.*, RU——3426 (RAMK). ibid., on trunk of *Protium serratum*, 1994, *K. Boonpragob et al.*, RU——3468, 3470 & 3477 (RAMK). ibid., on trunk of *Dipterocarpus obtusifolius*, 1995, *K. Boonpragob et al.*, RU——3647 (RAMK). ibid., on trunk of *Sezygium* sp., 1995, *K. Boonpragob et al.*, RU——3737 (RAMK). ibid., on trunk of unidentified tree, 1998, *T. Pooprang*, RU——10213 (RAMK). Doi Suthep-Pui National Park, Doi Pui Research Station, in plub orchard, on twig of *Diospyros* sp., 1998, *T. Pooprang*, RU——10296 (RAMK). Phitsanulok Province: Phu Hin Rong Kla National Park, Lan Hin Pum, on rock, 1997, *N. Homchantara et al.*, RU——9677 (RAMK). ibid., on rock, 1998, *T. Pooprang*, RU——10108 (RAMK).

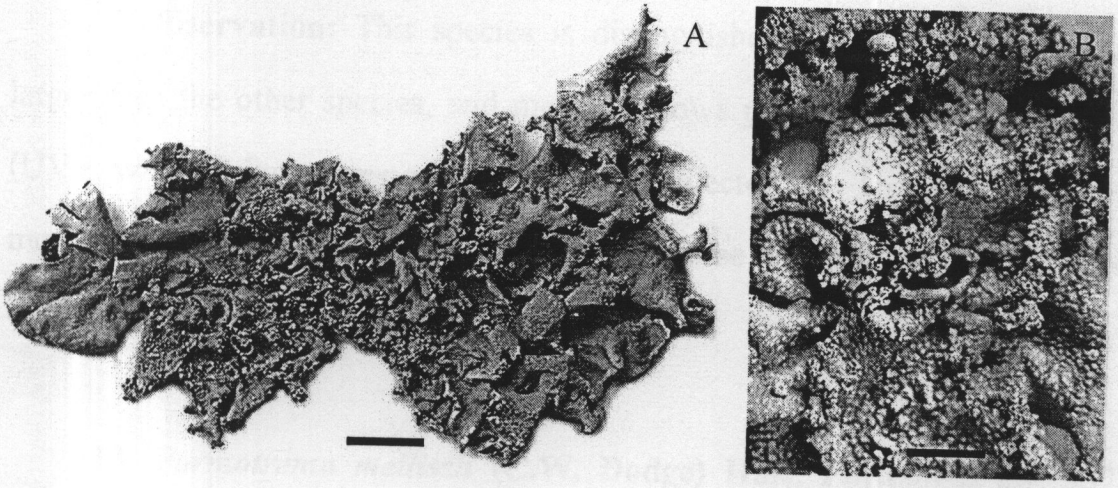


Figure 68 *Parmotrema incrassatum* Hale *ex* DePriest and B. W. Hale

Note: A. Thallus gray-green with isidia [RU—10210 (RAMK), scale = 1.2 cm].

B. Granular to thick cylindrical isidia [RU—10210 (RAMK), scale = 0.45 cm].

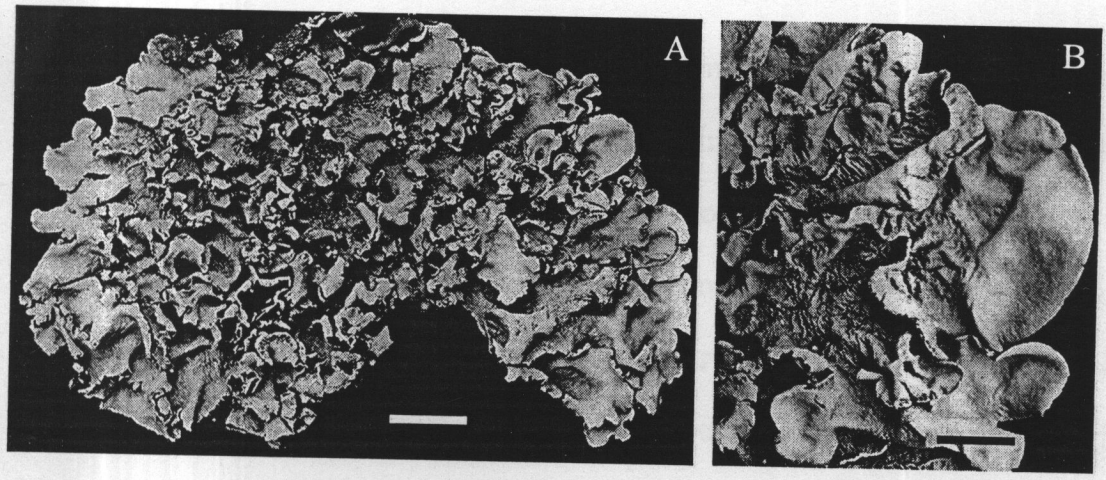


Figure 69 *Parmotrema maclayanum* (Müll. Arg.) Hale

Note: A. Thallus gray with broad rounded lobes [RU—950 (RAMK), scale = 1.3 cm].

B. Strongly wrinkled of upper surface [RU—1044 (RAMK), scale = 1 cm].

Observation: This species is distinguished by lobes rounded and larger than the other species, and medulla shows positive reaction with UV (UV+ white). *Parmotrema maclayanum*, collected in Thailand has two morphological variation of thallus, one with sparse cilia and another without cilia.

13. *Parmotrema mellissii* (C.W. Dodge) Hale, *Phytologia* 28: 337, 1974

Basionym: *Parmelia mellissii* C.W. Dodge, *Ann. Missouri Bot. Gard.* 46: 134, 1959

Figure 70

Thallus foliose, loosely adnate, membranaceous; lobes elongate, rounded, imbricate, 5-8 (10) mm wide; margins crenate-dentate to weakly laciniae, ascending, apices rotund; cilia simple to branched, slender, dense, up to 1-3 mm long; isidia mainly marginal, becoming sorediate; upper surface gray-green, faintly maculae, smooth to weakly rugose, 15 μm thick; medulla white, 80 μm thick; lower surface black at the center and white at the margin, 20 μm thick; rhizines black, simple, sparse; **apothecia** and **pycnidia** not seen.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing alectoronic, α-collatolic acid (K-, C-, KC+ orange, and P-), and skyrin (K+ purple at lower medulla near lower cortex).

Habitat: Occur on trees in moist habitats at elevation above 1,000 m in the lower montane forests.

Distribution: North, Central, and South America, East Africa, India, Thailand, Papua New Guinea, Japan, and Australia.

Specimens examined: N Thailand. Chiang Mai Province: Doi Suthep-Pui National Park, in the lower montane forest, on twig of *Diospyros* sp., 1998, *T. Pooprang*, RU——10294 (RAMK). Phitsanulok Province: Phu Hin Rong Kla National Park, in the lower montane forest, on trunk of unidentified tree, *T. Pooprang*, RU——10129 (RAMK).

Observation: *Parmotrema mellissii* is characterized by having cilia, marginal isidia becoming soredia, and presence of alectoronic acid and α-collatolic acid.

14. *Parmotrema merrillii* (Vainio) Hale, *Contr. U. S. Natl. Herb.* 36: 298, 1965

Basionym: *Parmelia merrillii* Vainio, *Phil. Journ. Sci.* 4: 658, 1909

Figure 71

Thallus foliose, loosely adnate, membranaceous; lobes broad, irregular to elongate, 8-10 mm wide; margins crenate to laciniate, apices rotund; eciliate; isidia and soredia lacking, with laciniate lobules; upper

surface gray green, smooth to weakly rugose, plane to convolute, emaculate, 15 μm thick; medulla white, 80 μm thick; lower surface black and brown near the margin, 20 μm thick; rhizines sparse, simple, black; **apothecia** moderate to dense, sessile to subpedicellate, disc imperforate, brown; thalline exciple entire, up to 1 mm wide; ascospores hyaline, simple, ellipsoid, 22-25 x 7-10 μm; **pycnidia** laminal to submarginal, immerse, conidia sublageniform, 5-6 x 1 μm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing protocetraric acid and virensic acid (K-, C-, KC-, and P+ orange to red).

Habitat: On twigs of trees in secondary forests at 600 m elevation.

Distribution: South America, Thailand, Indonesia, Philippines, Papua New Guinea, and Taiwan.

Specimens examined: N Thailand. Lampang Province: Khuntan National Park, in the dry dipterocarp forest, along the road to National Park entrance, on trunk of unidentified tree, 1998, *T. Pooprang*, RU——10322 (RAMK). **NE Thailand**. Loei Province: Nahaeo National Park, Wat Bo Mueang Noi, in the mixed deciduous forest, on twigs of unidentified trees, 1995, *T. Pooprang*, RU——6713, 6714, 6716, 6718, 6719, 6721, 6723, 6724, 6725, 6726, 6728, 6729, 6730, 6731 & 6732 (RAMK). ibid., on branched of

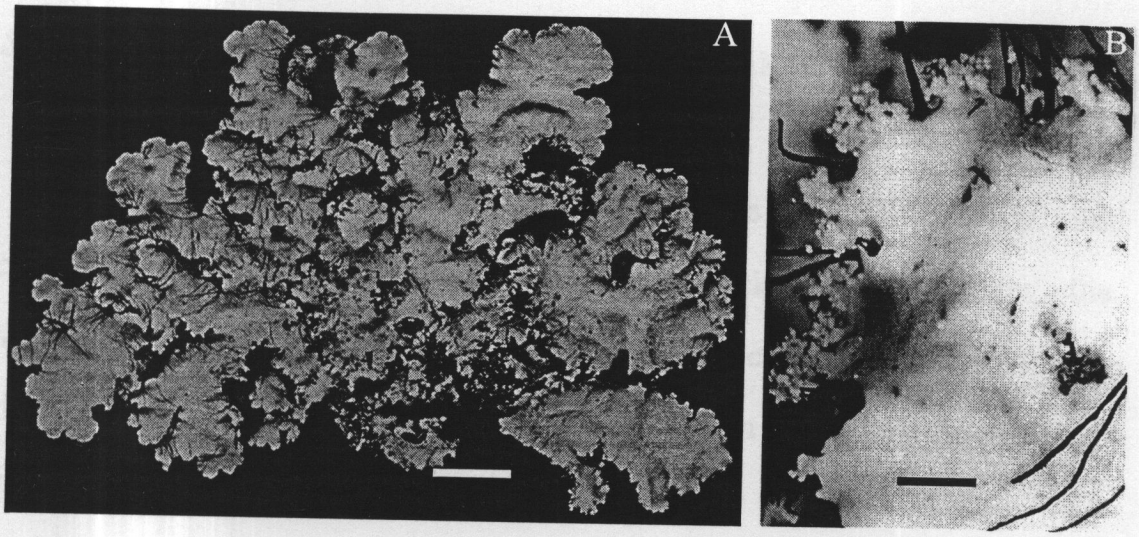


Figure 70 *Parmotrema mellissii* (Dodge) Hale

Note: A. Thallus white-green with cilia and sorediate isidia [RU——10129 (RAMK), scale = 0.6 cm].

B. Isidia becoming sorediate [RU——10129 (RAMK), scale = 0.6 mm].

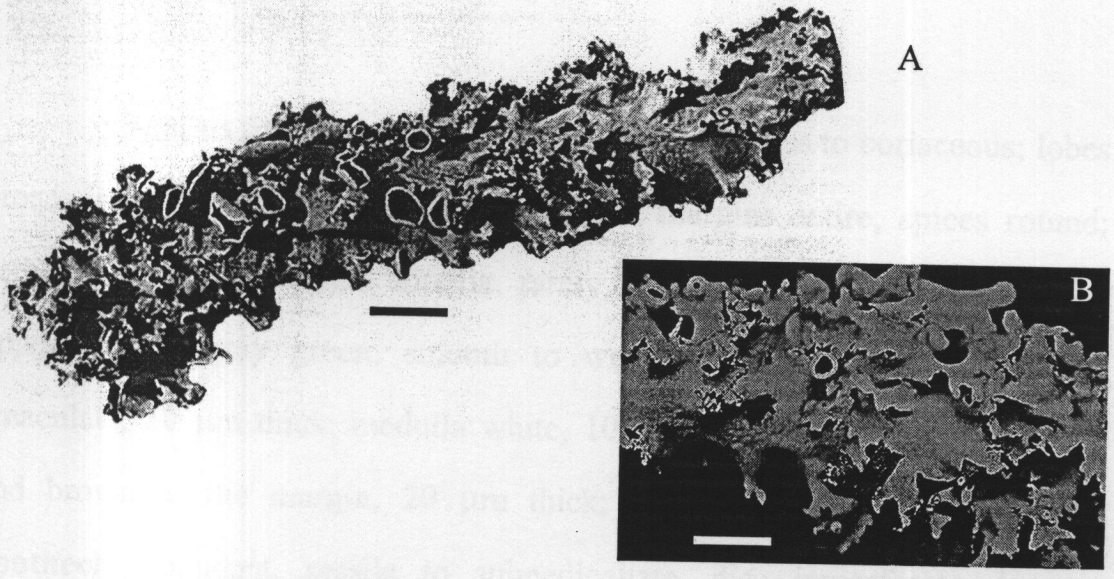


Figure 71 *Parmotrema merrillii* (Vain.) Hale

Note: A. Thallus gray-green with laciniate lobules [RU——6729 (RAMK), scale = 1 cm].

B. Laciniate lobules [RU——10322 (RAMK), scale = 1 cm].

Shorea obtusa, 1995, *T. Pooprang*, RU——7057 (RAMK).

Observation: *Parmotrema merrillii* is morphologically and chemically identical with *P. overeemii* by thallus lacking isidia, soredia, cilia, as well as containing protocetraric acid. But, this species has larger ascopsores than the latter. They commonly occurs on twigs in secondary forests or in sunny habitats.

15. *Parmotrema overeemii* (Zahlbr.) Elix, *Australasian Lichenology* 43: 23, 1998

Basionym: *Parmelia overeemii* Zahlbr., *Ann. Crypt. Exot.* 1: 204, 1928

Figure 72

Thallus foliose, loosely adnate, membranaceous to coriaceous; lobes broad, irregular to elongate, 8-10 mm wide; margins entire, apices rotund; eciliate; without isidia and soredia, rarely lobules at the central of thallus; upper surface gray green, smooth to weakly rugose, plane to convex, emaculate, 30 μm thick; medulla white, 100 μm thick; lower surface black and brown at the margin, 20 μm thick; rhizines sparse, simple, black; **apothecia** abundant, sessile to subpedicellate, disc imperforate, brown; thalline exciple entire to crenate, up to 8 mm wide; ascospores hyaline, simple, ellipsoid, 17-20 x 7-10 μm; **pycnidia** laminal to submarginal, immerse, conidia sublageniform, 5-6 x 1 μm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing protocetraric acid and virensic acid (K-, C-, KC-, and P+ orange to red).

Habitat: On trunks of trees in the dry dipterocarp forests, the mixed deciduous forests, and the lower montane forests.

Distribution: East Africa, Thailand, Indonesia, Papua New Guinea, and Australia.

Specimens examined: N Thailand. Chiang Mai Province: Queen Sirikit Botanic Garden, in the mixed deciduous forest, on trunk of *Pterocarpus macrocarpus*, 1994, *K. Boonpragob et al.*, RU——1540 (RAMK). ibid., on trunk of unidentified tree, 1994, *K. Boonpragob et al.*, RU——2009 & 2781 (RAMK). ibid., on trunk of *Bombax ancep*, 1994, *K. Boonpragob et al.*, RU——2342 (RAMK). ibid., on trunk of *Anneslea fragrans*, *K. Boonpragob et al.*, RU——2972 & 2994 (RAMK). ibid., in the dry dipterocarp forest, on trunk of unidentified tree, *T. Pooprang*, RU——10214 & 10215 (RAMK). **NE Thailand.** Loei Province: Nahaeo National Park, in the mixed deciduous forest, on trunk of *Spondias* sp., 1995, *T. Pooprang*, RU——6210 (RAMK). Sakol Nakhon Province: Phupan National Park, in the dry dipterocarp forest, on trunk of unidentified tree, 1997, *T. Pooprang*, RU——10341 (RAMK). **E Thailand**. Nakhon Ratchasima Province: Khao Yai National Park, in the

secondary forest, on branches of *Mangifera indica*, 1997, *T. Pooprang*, RU——7946 & 7948 (RAMK).

Observation: *Parmotrema overeemii* is separated from *P. merrillii* by having smaller ascospores than the latter species.

16. *Parmotrema planatilobatum* (Hale) Hale, *Phytologia* 28: 338, 1974

Basionym: *Parmelia planatilobata* Hale, *Journ. Jap. Bot.* 40: 200, 1964

Figure 73

Thallus foliose, loosely adnate, membranaceous; lobes broad, elongate, 10 mm wide; margins entire to crenate, ascending, apices subrotund; cilia dense, short, simple, occasionally on lobules near the margins; isidia flattened becoming lobulate isidia to laciniate lobules; upper surface gray green, smooth to rugous, 15 μm thick; medulla white, 80 μm thick; lower surface black and brown near the margin, 20 μm thick; rhizines black, sparse, simple; **apothecia** and **pycnidia** not seen.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing gyrophoric acid and lecanoric acid in trace (K-, C+ red, KC+ red, and P-).

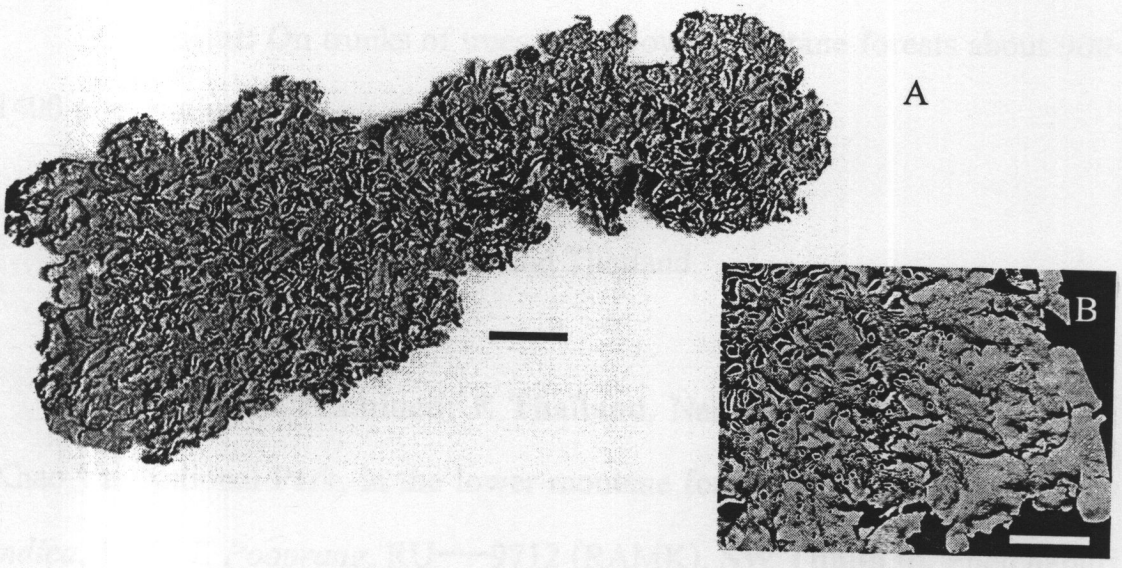


Figure 72 *Parmotrema overeemii* (Zahlbr.) Elix

Note: A. Thallus with numerous apothecia [RU——10341 (RAMK), scale = 1.6 cm].

B. Imbricate lobes with weakly wrinkle upper surface [RU——10341 (RAMK), scale = 0.8 cm].

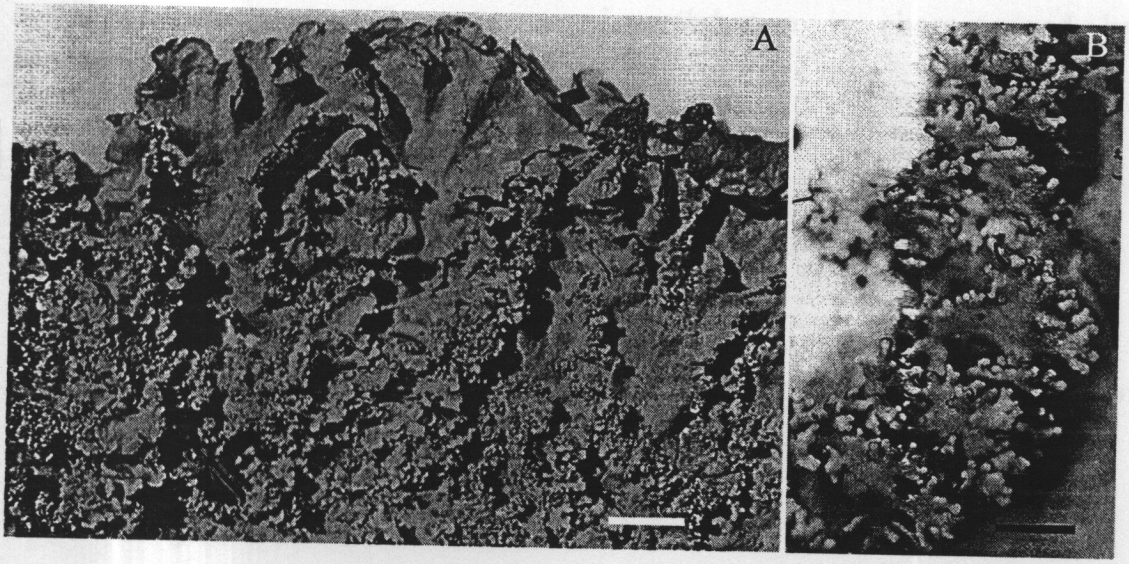


Figure 73 *Parmotrema planatilobatum* (Hale) Hale

Note: A. Thallus green with cilia and dense lobulate isidia [RU——9712 (RAMK), scale = 1.2 cm].

B. Laciniate lobules [RU——9712 (RAMK), scale = 0.5 cm].

Habitat: On trunks of trees in the lower montane forests about 900-1400 m elevations.

Distribution: East Africa and Thailand.

Specimens examined: E Thailand. Nakhon Ratchasima Province: Khao Yai National Park, in the lower montane forest, on trunk of *Mangifera indica*, 1997, *T. Pooprang*, RU——9712 (RAMK). **SW Thailand.** Phetchaburi Province: Kaeng Krachan National Park, Pha Noen Thung camp, in the lower montane forest, on trunk of unidentified trees, 1998, *T. Pooprang*, RU——11157, 11183, 11187 (RAMK).

Observation: *Parmotrema planatilobatum* is characterized by having cilia, flatten isidia becoming lobulate isidia.

17. *Parmotrema poolii* (C.W. Dodge) Krog and Swinscow, *Lichenologist* 15:130, 1983

Basionym: *Parmelia poolii* C.W. Dodge, *Ann. Mo. Bot. Gdn* 46: 146, 1959

Figure 74

Thallus foliose, loosely adnate to adnate, coriaceous; lobes irregular to elongate, rounded, 6-10 mm wide; margins entire to crenate, subascending, apices rotund; cilia sparse to dense, simple; soralia along the lobes margins,

linear to subcapitate, soredia powdery to granule; upper surface gray green to green, smooth to rugose, sometimes wrinkled centrally, faintly maculae, 20 μm thick; medulla white, 80 μm thick; lower surface black, white to pale brown mottle near the margins, 20 μm thick; rhizines black, simple, scattered; **apothecia** not seen; **pycnidia** immerse, laminal to submarginal, conidia sublageniform, 5-7 x 1 μm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing alectoronic acid and α-collatolic acid (K-, C-, KC+ purple to pale red, and P-) and UV + white.

Habitat: On trunks of trees in the mixed deciduous forests, the dry dipterocarp forests, and the secondary forests at 600-1200 m elevations.

Distribution: Africa, and Asia (Thailand) and Australia.

Specimens examined: N Thailand. Chiang Mai Province: Queen Sirikit Botanic Garden, in the mixed deciduous forest, on trunk of *Dipterocarpus obtusifolias*, 1994, *K. Boonpragob et al.*, RU——1105, 1823, 1824 & 1837 (RAMK). ibid., on trunk of *Anneslea fragrans*, 1994, *K. Boonpragob et al.*, RU——2976 (RAMK). **NE Thailand.** Loei Province: Nahaeo National Park, Wat Bo Muaeng Noi, in the dry dipterocarp forest, on trunk of *Shorea obtusa*, 1995, *T. Pooprang*, RU——7062 (RAMK). **E Thailand.** Nakhon Ratchasima Province: Khao Yai National Park, in the

secondary forest, on trunk of unidentified tree, 1997, *T. Pooprang*, RU—— 8447 (RAMK).

Observations: *Parmotrema poolii* is mainly characterized by marginal soralia and containing alectoronic acid (UV+ white) in medulla. This species closely resembles *P. rampoddense*, which has skyrin (pink pigment) in the medulla.

18. *Parmotrema praesorediosum* (Nyl.) Hale, *Phytologia* 28: 338, 1974

Basionym: *Parmelia praesorediosa* Nyl., *Sert. Lich. Trop. Labuan Singapore* 18, 1891

Figure 75

Thallus foliose, loosely adnate, membranaceous to coriaceous; lobes irregular to elangate, rounded, flat, 5-10 mm wide; margins entire to crenate; without cilia; soralia marginal and laminal, soredia granular; upper surface gray-green, smooth to weakly wrinkled, emaculate, 10 μm thick; medulla white, 80 μm thick; lower surface black and white to mottled brown near the margins, 15 μm thick; rhizines black, sparse, simple; **apothecia** and **pycnidia** not seen.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing praesorediosic acid (K-, C-, KC-, and P-).

Habitat: On trunks of trees in the mixed deciduous forests, the dry evergreen forests at 500-1000 m elevations in the northern and northeastern Thailand.

Distribution: North to South America, Africa, Tropical Asia (India, Thailand, Indonesia, and Papua New Guinea), the Pacific Island, Australia, and New Zealand.

Specimens examined: N Thailand. Chiang Mai Province: Queen Sirikit Botanic Garden, in the mixed deciduous forest, on trunk of *Shorea roxburghii*, 1994, *K. Boonpragob et al.*, RU——1777 (RAMK). ibid., on trunk of *Dipterocarpus obtusifolius*, 1994, *K. Boonpragob et al.*, RU——1826 (RAMK). ibid., on trunk of unidentified tree, 1994, *K. Bonpragob et al.*, RU——2010 & 2011 (RAMK). ibid., on trunk of *Canarium subulatum*, 1994, *K. Boonpragob et al.*, RU——2852 & 2853 (RAMK). **NE Thailand.** Loei Province: NaHaeo National Park, a trail to ToKo1, in the dry evergreen forest, on branches of *Adenanthera pavonina*, 1995, *T. Pooprang*, RU——5002 (RAMK). ibid., Namtok Taad Hueang, on rock, 1995, *T. Pooprang*, RU——5591, 5593, 5594 & 5595 (RAMK). ibid., Wat Bo Mueang Noi, on branches of *Shorea obtusa*, 1995, *T. Pooprang*, RU——7060 (RAMK). **E Thailand.** Nakhon Ratchasima, Khao Yai National Park, along a trail follow the old Golf Course road, on trunk of *Peltophorum pterocarpum*, 1997, *T. Pooprang*, RU——8093 (RAMK). **SW Thailand.** Phetchaburi Province:

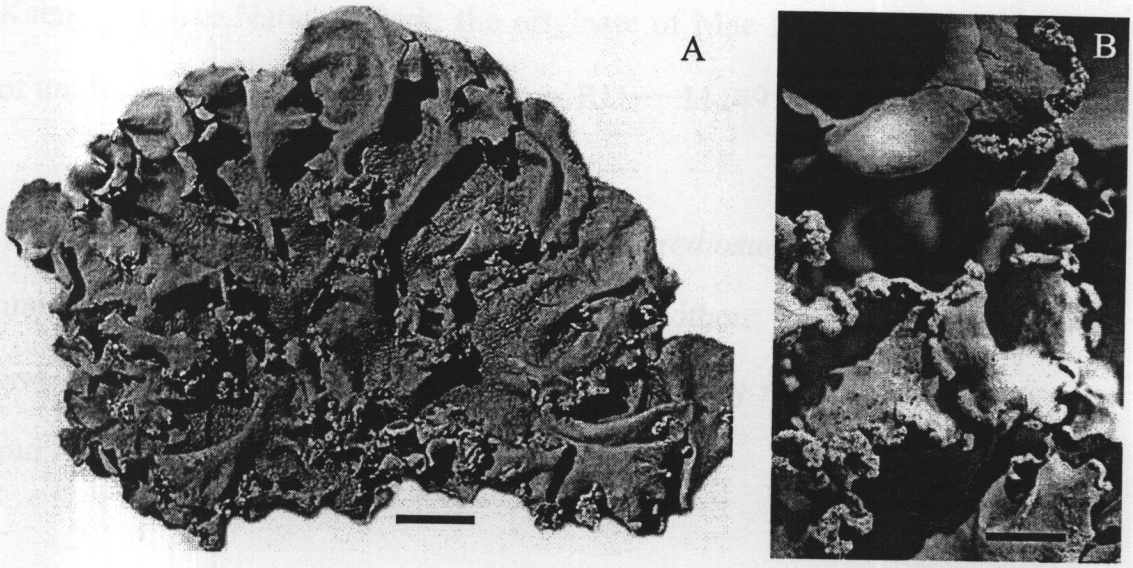


Figure 74 *Parmotrema poolii* (Dodge) Krog and Swinscow

Note: A. Thallus with soredia and cilia at the matgins [RU—2976 (RAMK), scale = 1 cm].

B. Granular soredia becoming marginal soralia [RU—1837 (RAMK), scale = 0.2 cm].

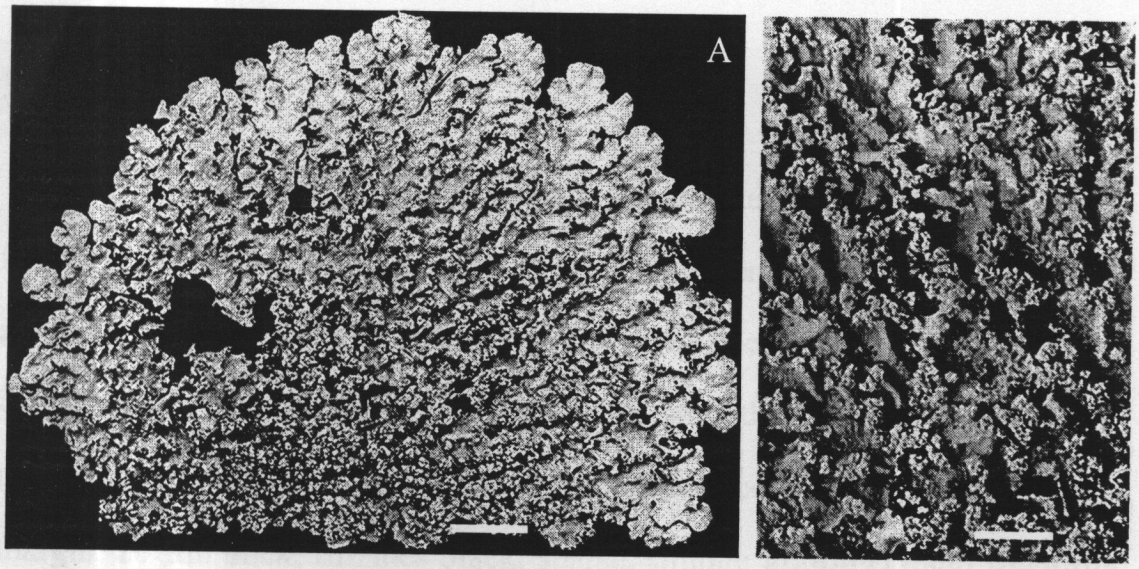


Figure 75 *Parmotrema praesorediosum* (Nyl.) Hale

Note: A. Thallus with numerous soredia [RU—5593 (RAMK), scale = 1.2 cm].

B. Granular soredia becoming laminal and marginal soralia [RU—5593 (RAMK), scale = 0.4 cm].

Kaeng Krachan National Park, the originate of Mae Nam Pranburi, on trunk of unidentified tree, 1998, *T. Pooprang*, RU——11149 (RAMK).

Observation: *Parmotrema praesorediosum* is distinguished by numerous marginal and laminal sorolia, without cilia and presence of praesorediosic acid (fatty acid). This species closely resembles *P. cristiferum* and *P. dilatatum,* but differs in chemistry.

19. *Parmotrema pseudocrinitum* (des Abb.) Hale, *Phytologia* 28: 338, 1974

Basionym: *Parmelia pseudocrinita* des Abb., *Bull. Inst. Fr. Afr. Noire* 20: 19, 1958

Figure 76

Thallus foliose, loosely adnate, coriaceous; lobes broad, elongate, flat, imbricate, 10 mm wide; margins crenate to dentate, apices rotund; cilia moderate to dense, simple; isidia scattered, cylindrical to coralloid, simple to irregular branched; upper surface gray green, smooth to weakly rugose, 20 μ m thick; medulla white, 150 μm thick; lower surface black and brown at the margin, 20 μm thick; rhizines black, sparse, simple; **apothecia** and **pycnidia** not seen.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing gyrophoric acid (K-, C+ red, KC+ red, and P-).

Habitat: On trunks of trees in the mixed deciduous forest about 700 elevation in Northern and in the dry evergreen forests about 900 m elevation in Northeast Thailand.

Distribution: Africa, and Thailand.

Specimens examined: N Thailand. Chiang Mai Province: Queen Sirikit Botanic Garden, in the mixed deciduous forest, on trunk of *Dillenia* sp., 1994, *K. Boonpragob et al.,* RU——779, 785, 802 & 804 (RAMK). ibid., on trunk of unidentified trees, 1994, *K. Boonpragob et al.,* RU——1994, 1998, 2001, 2002, 2003 & 3110 (RAMK). ibid., on trunk of *Bombax ceiba*, 1994, *K. Boonpragob et al.,* RU——2371 (RAMK). ibid., on trunk of *Stereospermum neuranthum*, 1994, *K. Boonpragob et al.*, RU——2412, 2413, 2414, 2416, 2417, 2419, 2420 & 2421 (RAMK). ibid., on trunk of *Shorea obtusa*, 1994, *K. Boonpragob et al.*, RU——2733 & 2734 (RAMK). **NE Thailand.** Loei Province: Na Haeo National Park, a trail to Toko1, on trunk of *Sterculia pexa*, 1995, *T. Pooprang*, RU——5408 (RAMK).

Observation: *Parmotrema pseudocrinitum* is distinguished by moderately dense cylindrical to coralloid isidia and moderate to dense cilia. This species resembles *P. tinctorum* in having broad lobe with isidia but the latter is absent of cilia.

20. *Parmotrema pseudonilgherrense* (Asahina) Hale, *Mycotaxon* 5: 441, 1977

Basionym: *Parmelia pseudoilgherrensis* Asahina, *Journ. Jap. Bot*, 29: 370, 1954

Figure 77

Thallus foliose, loosely adnate, coriaceous; lobes irregular to subirregular, broad, rounded, flat to convolute, 8-12 mm wide; margins entire to weakly crenate; eciliate; soralia marginal and linear ascending lobes, soredia granular; upper surface gray-green, smooth to rarely cracked, faintly maculae, 15 μm thick; medulla white, 100 μm thick; lower surface black to pale brown at the marginal zone, 20 μm thick; rhizines black, sparse, simple; **apothecia** not seen; **pycnidia** immerse, sparse, conidia filiform, 8-10 x 1 μm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing alectoronic acid and subalectoronic acid (K-, C-, KC+ pale red, and P-).

Habitat: On trunk of tree in the mixed deciduous forest in Northern Thailand.

Distribution: Africa, Tropical Asia (India, Nepal, Thailand, and Korea).

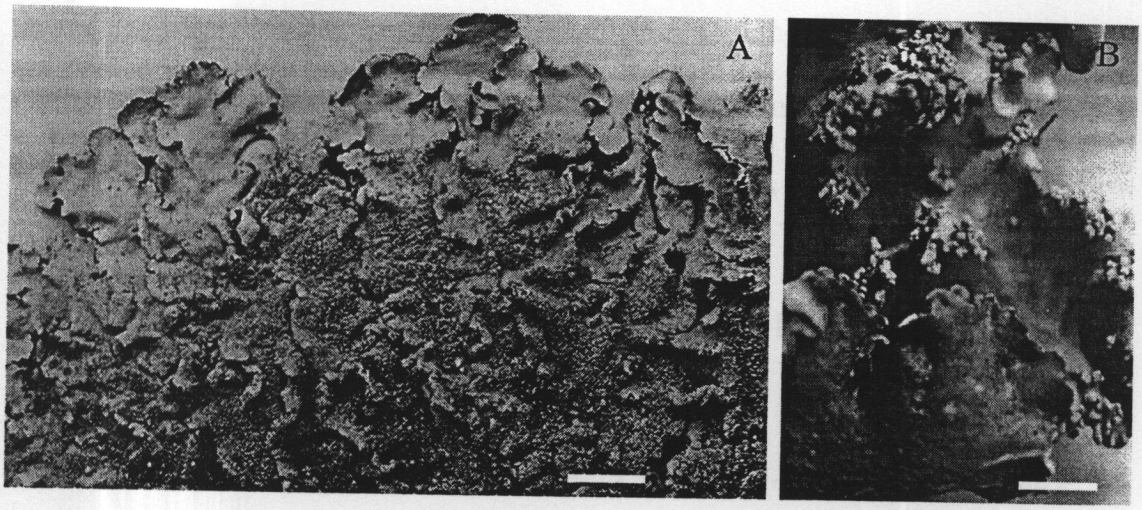


Figure 76 *Parmotrema pseudocrinitum* (des Abb.) Hale

Note: A. Thallus with moderately dense isidia and short cilia [RU——802 (RAMK), scale = 1 cm].

B. Simple to coralloid isidia on upper surface [RU——3110 (RAMK), scale = 0.4 cm)].

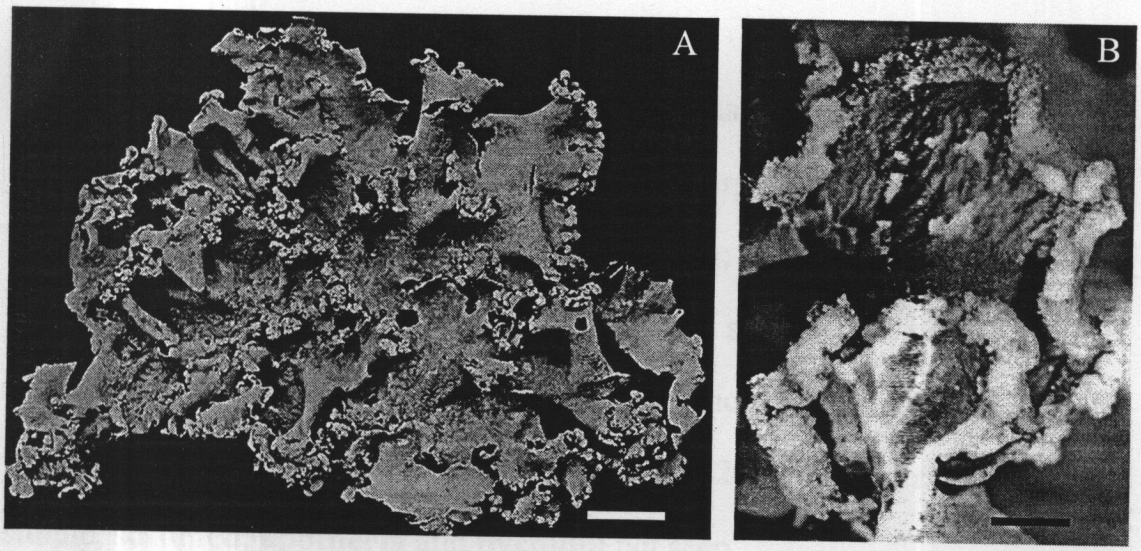


Figure 77 *Parmotrema pseudonilgherrense* (Asahina) Hale

Note: A. Thallus with soredia [RU——994 (RAMK), scale = 1cm].

B. Granular soredia on marginal soralia and brown margin of lower surface [RU——994 (RAMK), scale = 0.4 cm].

Specimens examined: N Thailand. Chiang Mai Province: Queen Sirikit Botanic Garden, in the mixed deciduous forest, on trunk of *Dipterocarpus intricatus*, 1994, *K. Boonpragob et al.*, RU——994 (RAMK).

Observation: This species is characterized by marginal soralia, line ascending on revolute lobes and maculate on upper surface, main lobes are absent of cilia, if present mainly on damaged margins.

21. *Parmotrema rampoddense* (Nyl.) Hale, *Phytologia* 28: 338, 1974

Basionym: *Parmelia rampoddense* Nyl., *Acta. Soc. Sci. Fenn.* 26, 10: 7, 1900

Figure 78

Thallus foliose, loosely adnate to adnate, membranaceous; lobes irregular to elongate, rounded, 8-12 mm wide; margins crenate, apices rotund; cilia dense, simple to branched, 2-3 mm long; soralia marginal, soredia powdery; upper surface gray-green to green, smooth to rugose, faintly maculae, 20 μm thick; medulla white, 120 μm thick; lower surface black and white to pale brown mottle at the marginal zone, 20 μm thick; rhizines black, simple, scattered; **apothecia** and **pycnidia** not seen.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing alectoronic acid and α-collatolic acid(K-, C-, KC+ purple to pale red, and P-), and with skyrin (pink pigment).

Habitat: On trunk of tree in the lower montane forest at 1100 m elevation in northern Thailand.

Distribution: North and South America, Africa, and Asia (India, Sri Lnuka, and Thailand).

Specimens examined: N Thailand. Phitsanulok Province: Phu Hin Rong Kla National Park, Lum Lob Phai, on trunk of *Quercus* sp., 1998, *T. Pooprang*, RU——10178 (RAMK).

Observation: This species closely resembles *Parmotrema poolii*, but the former species has skyrin.

22. *Parmotrema rubromarginatum* Elix and Pooprang, sp. nov., *Mycotaxon* 71: 115-117, 1999

Figure 79

Thallus foliose, loosely adnate, membranaceous; lobes irregular to elongate, rounded, crowed, 8-12 mm wide; margins entire to crenate, ascending, apices rotund; cilia moderate to dense, simple to branched, slender, containing red pigment, 3-6 mm long; soralia marginal, linear, narrow, soredia powdery to granule; upper surface gray-green to green, smooth to rugose, faintly maculae, 15-20 μm thick; medulla white, 120 μm thick; lower surface black, with a broad, brown and in part red-pimented, erhizinate marginal

zone, 20 μm thick; rhizines black, simple, scattered; **apothecia** not seen; **pycnidia** scattered, immersed, submarginal, conidia sublageniform, 7-8 x 1 μm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing protocatraric acid, protolichesterinic acid (K-, C-, KC+ yellow then brown, and P+ orange to red) and unknown red pigment (K+ purple).

Habitat: On trunks of trees in the dry dipterocarp forests and the secondary forests at 600-800 m elevations in Northeast to East Thailand.

Distribution: Thailand.

Specimens examined: NE Thailand. Loei Province: Nahaeo Natioanl Park, Wat Bo Muaeng Noi, in the dry dipterocarp forest, on branched of *Shorea obtusa*, 1995, *T. Pooprang*, RU——7011, 7058, 7061, 7063 (RAMK). **E Thailand.** Nakhon Ratchasima Province: Khao Yai National Park, in the secondary forest, on trunk of *Sezygium* sp., 1997, *T. Pooprang*, RU——8079 (RAMK).

Observation: *Parmotrema rubromarginatum* closely resembles *P. subarnoldii*, both species are distinguished by marginal soralia, cilia, and contain protocatraric acid. However, *P. rubromarginatum* can be clearly

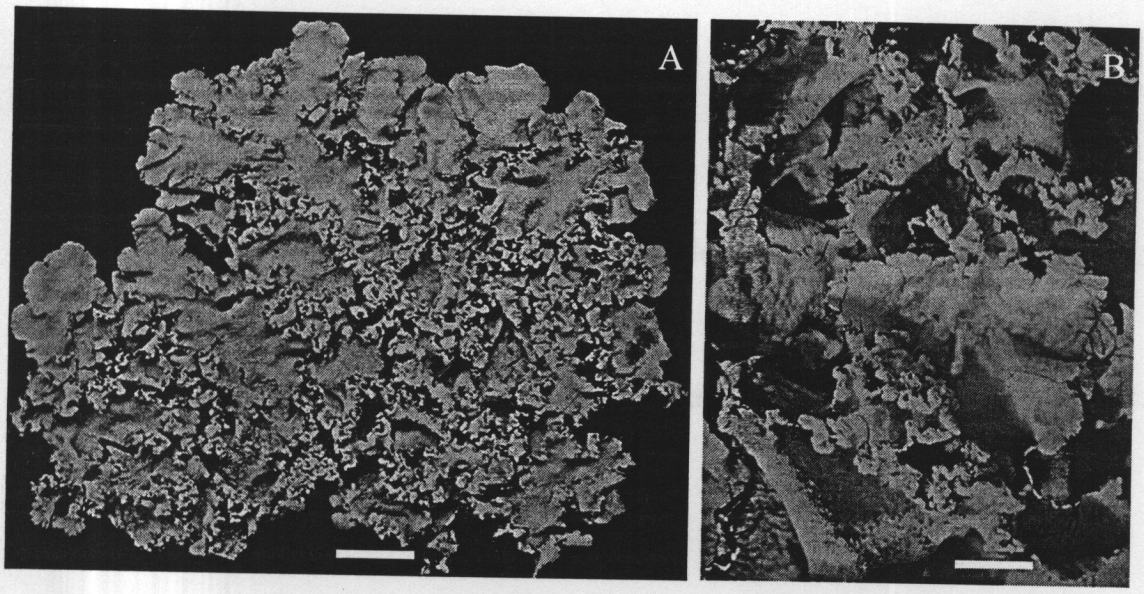


Figure 78 *Parmotrema rampoddense* (Nyl.) Hale

Note: A. Thallus with soredia and long cilia at the margins [RU——10178 (RAMK), scale = 1 cm].

B. Marginal soralia [RU——10178 (RAMK), scale = 0.4 cm].

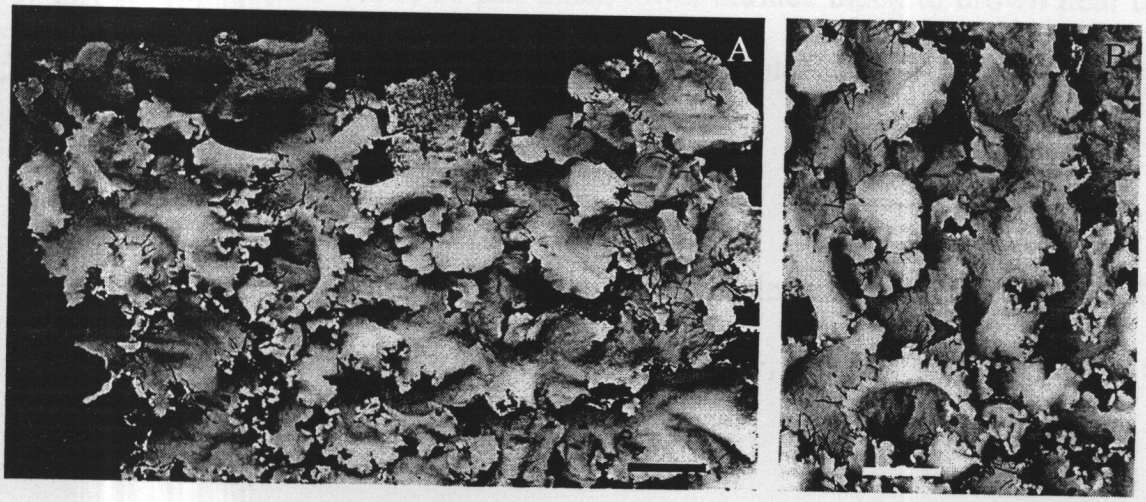


Figure 79 *Parmotrema rubromarginatum* Elix and Pooprang

Note: A. Thallus with soredia and cilia [RU——8079 (RAMK), scale = 1 cm].

B. Red pigment at the margins of lobes (arrow) [RU——8079 (RAMK), scale = 0.8 cm].

separated by red pigmentation (K+ purple) near the margins of the lower surface and on cilia.

23. *Parmotrema saccatilobum* (Taylor) Hale, *Phytologia* 28: 339, 1974

Basionym: *Parmelia saccatiloba* Taylor, *London Journ. Bot.* 6: 174, 1847

Figure 80

Thallus foliose, loosely adnate, coriaceous; lobes broad, irregular to elongate, flat to revolute, 5-10 mm wide; margins entire to weakly crenate, apices subrotund; without cilia; isidia dense, short, granular to cylindrical, simple to irregular branched; upper surface gray green, smooth to rugous, 15 µm thick; medulla white, 80 µm thick; lower surface black to brown near the margin, 20 µm thick; rhizines black, sparse, simple; **apothecia** and **pycnidia** not seen.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing protocetraric acid (K-, C-, KC-, and P+ orange to red).

Habitat: On trunks of trees in the mangrove forests at sea level in Southeast of Thailand.

Distribution: South America, India, Thailand, Singapore, Taiwan, Australia and the Pacific Island.

Specimens examined: SE Thailand. Chantaburi Province: in the mangrove forests, on branches of *Rhizophora apiculata*, 1998, *T. Pooprang*, RU——11189 (RAMK). Trad Province: in the mangrove forests, on trunks of *Rhizophora apiculata*, 1998, *T. Pooprang*, RU——11194 & 11195 (RAMK).

Observation: *Parmotrema saccatilobum* is distinguished by shorter, glanular to cylindrical isidia, and has protocetraric acid (P+ orange red). These characters are similar to *P. incrassatum*, but medulla of the former species reacts KC-, whereas the latter react KC+. These two species are distinguished from *P. tinctorum*, on having C- medulla and smaller lobes

24. *Parmotrema sancti-angelii* (Lynge) Hale, *Phytologia* 28: 339, 1974

Basionym: *Parmelia sancti-angelii* Lynge, *Ark. Bot.* 13 (13): 35, 1914

Figure 81

Thallus foliose, loosely adnate to adnate, membranaceous to coriaceous; lobes irregular to elongate, rounded, crowed, 5-10 mm wide; margins entire to deeply crenate, ascending, apices rotund; cilia dense, simple to branched; soralia marginal, linear, narrow, soredia granular; upper surface

gray green to green, smooth to rugose, faintly maculae, 20-30 μm thick; medulla white, 150-200 μm thick; lower surface black and white to pale brown mottle at the margins, 20-30 μm thick; rhizines black, simple, scattered; **apothecia** not seen; **pycnidia** scattered, immersed, conidia sublageniform, 4-6 x 1 μm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing gyrophoric acid and lecanoric acid (K-, C+ red, KC+ pale red, and P-).

Habitat: On trunks of trees and on rocks in the lower montane forests, the mixed deciduous forests, and the dry dipterocarp forests at 600-1400 m elevations.

Distribution: Central and South America, Africa, and Asia (India China, Thailand, Laos, Indonesia, Papua New Guinea, and Australia).

Specimens examined: N Thailand. Chiang Mai Province: Queen Sirikit Botanic Garden, in the mixed deciduous forest, on trunk of *Dillenia* sp., 1994, *K. Boonpragob et al.*, RU——777 & 782 (RAMK). ibid., on trunk of *Shorea obtusa*, 1994, *K. Boonpragob et al.*, RU——1897 (RAMK). ibid., on trunk of *Canarium suburatum*, 1994, *K. Boonpragob et al.*, RU——2845 (RAMK). ibid., on trunk of *Castanopsis* sp., 1994, *K. Boonpragob et al.*, RU——3290 (RAMK). ibid., on trunk of *Pinus kesiya*, 1994, *K. Boonpragob*

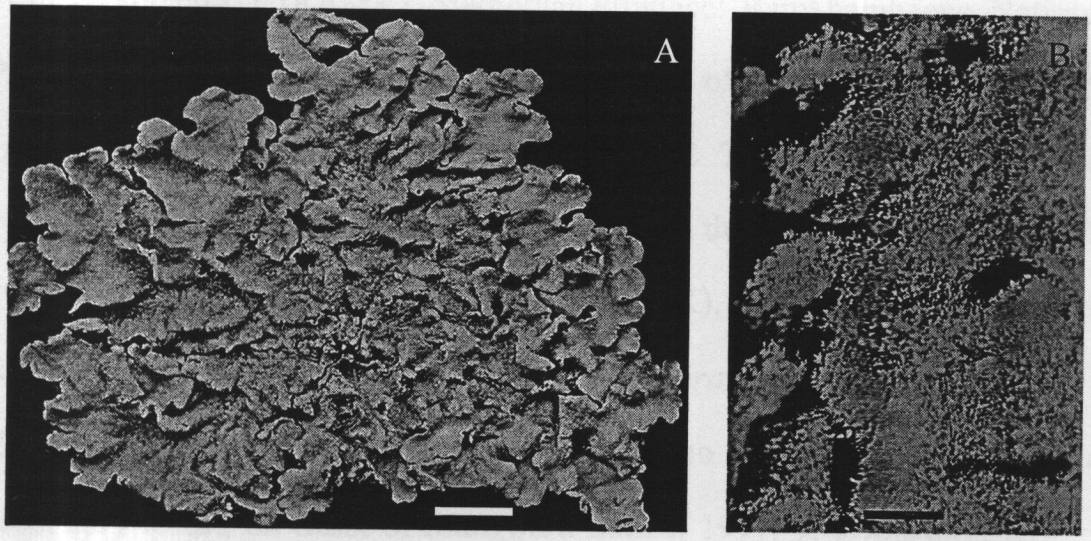


Figure 80 *Parmotrema saccatilobum* (Taylor) Hale

Note: A. Thallus with lobes less than 1cm and scattered isidia [RU——11195 (RAMK), scale = 0.6 cm].

B. Cylindrical isidia [RU——11189 (RAMK), scale = 0.4 cm].

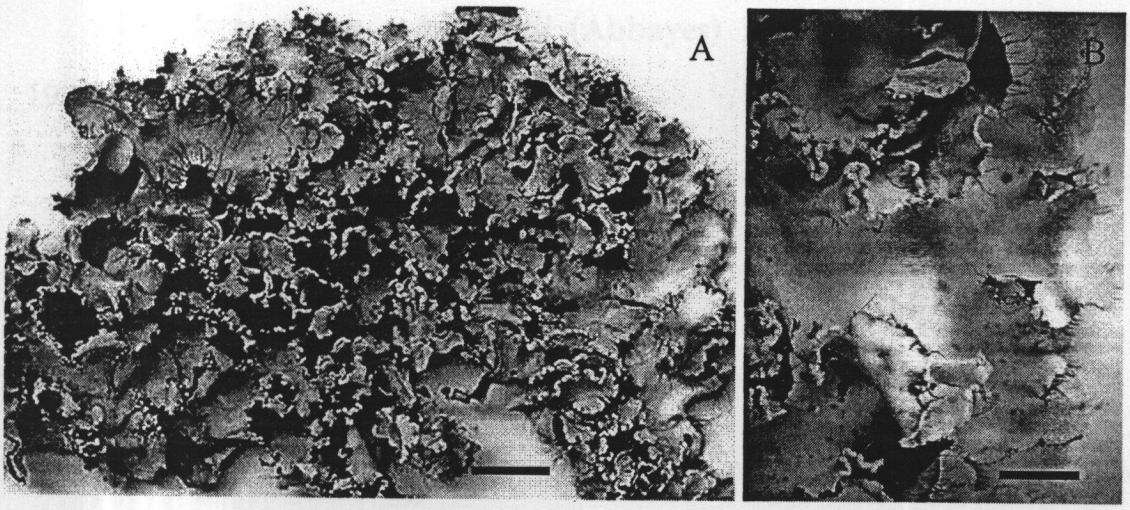


Figure 81 *Parmotrema sancti-angelii* (Lynge) Hale

Note: A. Thallus with soredia and dense cilia [RU——7952 (RAMK), scale = 1 cm].

B. Soralia along the margins and long cilia [RU——9350 (RAMK), scale = 0.5 cm].

et al., RU——3411 (RAMK). Sukhothai Province: Ramkhamhaeng National Park, in the dry evergreen forest, on trunk of *Quercus* sp., 1997, *N. Homchatara et al.*, RU——9350 (RAMK). **NE Thailand.** Loei Province: Nahaeo National Park, along a trail to ToKo 1, in the lower montane, on rock, 1995, *T. Pooprang*, RU——4161 & 4258 (RAMK). ibid., in the dry evergreen forest, on trunk of *Dillenia ovata*, 1995, *T. Pooprang*, RU——5172 (RAMK). **E Thailand.** Nakhon Ratchasima Province: Khao Yai National Park, in the secondary forest, on trunk of *Mangifera indica*, 1997, *T. Pooprang*, RU——7952 (RAMK).

Observation: *Parmotrema sancti-angelii* is characterized by linear, narrow marginal soralia, cilia, and contains gyrophoric acid (KC+ pale red).

25. *Parmotrema subarnoldii* (Abbayes) Hale, *Phytologia* 28: 339, 1974

Basionym: *Parmelia subarnoldii* des Abb., *Mem. Inst. Sci. Madagascar, ser, B*, 10: 113, 1961

Figure 82

Thallus foliose, loosely adnate to adnate, membranaceous to coriaceous; lobes irregular, rounded, crowed, 8-15 mm wide; margins crenate, ascending, apices rotund; cilia sparse to dense, simple to branched, 2-3 mm long; soralia marginal, linear, ascending lobes, soredia powdery; upper surface gray green to green, smooth to rugose, faintly maculae, 20 μm thick;

medulla white, 120 μm thick; lower surface black and white to pale brown mottle at the marginal zone, and black at marginal lobes under soralia, 30 μm thick; rhizines black, simple, scattered; **apothecia** and **pycnidia** not seen.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing protocetraric acid and protolichesterinic acid (K-, C-, KC+ red brown, and P+ red).

Habitat: On trunks and twigs of trees in the dry dipterocarp forests and the secondary forests at 500-800 m elevations.

Distribution: Central and South America, Africa, and Asia (India, Thailand, Indonesia, and Papua New Guinea), and Australia.

Specimens examined: NE Thailand. Loei Province: Nahaeo National Park, Wat Bo Muaeng Noi, in the dry dipterocarp forest, on trunk of Shorea obtusa, 1995, T. Pooprang, RU——7056 (RAMK). **E Thailand.** Nakhon Ratchsima Province: Khao Yai National Park, in the secondary forest, on trunk of *Mangifera indica*, 1997, *T. Pooprang*, RU——7952 (RAMK).

Observation: *Parmotrema subarnoldii* closely resembles *P. rubromarginatum* in having marginal soralia, cilia, and presence of protocetraric acid. But, this species is absent of red pigment.

26. *Parmotrema sulphuratum* (Nees and Flot.) Hale, *Phytologia* 28: 339, 1974

Basionym: *Parmelia sulphurata* Nees and flot., *Linnaea* 9: 501, 1835

Figure 83

Thallus foliose, loosely adnate, membranaceous; lobes broad, irregular to elongate, rounded, 8-10 mm wide; margins entire to crenate, apices rotund; cilia dense, simple; isidia cylindrical to coralloid, simple to irregular branched; upper surface yellow-gray to gray green, smooth to rugose, easily fragile, 10 μm thick; medulla deep yellow or sulpher yellow, 100 μm thick; lower surface black to brown near the margin, 20 μm thick; rhizines black, sparse, simple; **apothecia** and **pycnidia** not seen.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing vulpinic acid (K+ purple to red, C-, KC-, and P-).

Habitat: On trunks of trees in the mixed deciduous forests about 700 m elevation in Northeastern Thailand and in rubber plantation in the South.

Distribution: Central and South America, Africa, Thailand, Indonesia, Papua New Guinea and Australia.

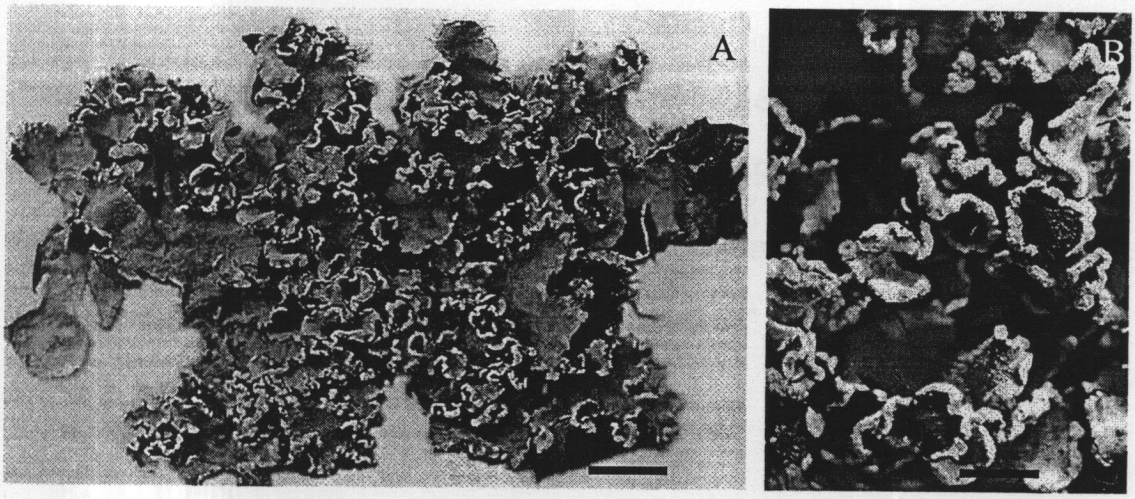


Figure 82 *Parmotrema subarnoldii* (Abbayes) Hale

Note: A. Thallus with soredia and cilia [RU——7056 (RAMK), scale = 1.4 cm].

B. Lower surface with black margins and marginal soralia [RU——7056 (RAMK), scale = 0.5 cm].

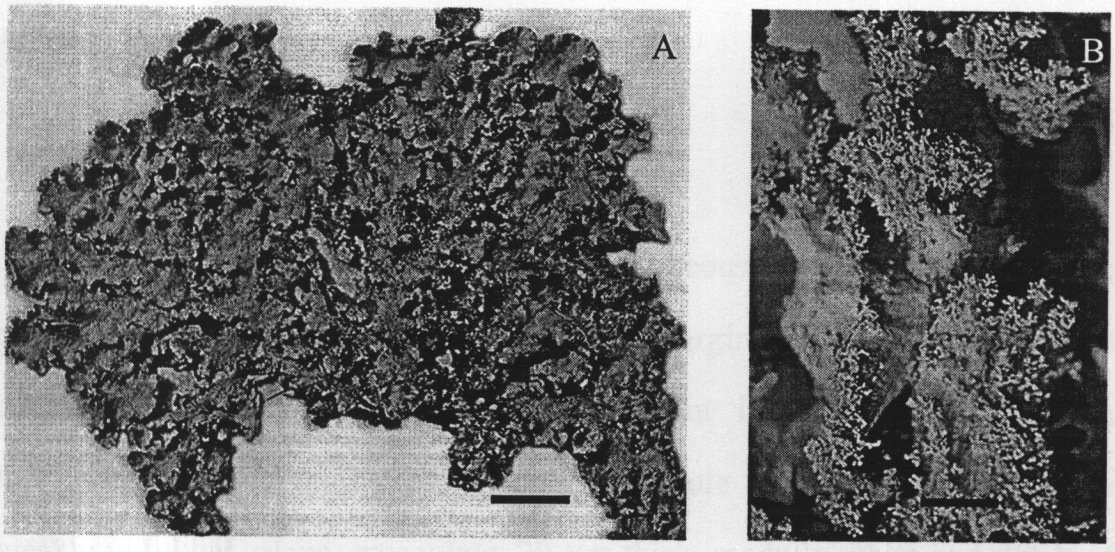


Figure 83 *Parmotrema sulphuratum* (Nees and Flot.) Hale

Note: A. Thallus with yellow medulla, isidia and cilia [RU——9852 (RAMK), scale = 1.2 cm].

B. Cylindrical to coralloid isidia [RU——9852 (RAMK), scale = 0.4 cm].

Specimens examined: NE Thailand. Loei Province: Nahaeo National Park, Wat Bo Muaeng Noi, in the dry dipterocarp forest, on trunk of unidentified tree, 1995, *T. Pooprang*, RU—6739 (RAMK). **S Thailand.** Nakhon Srithammarat Province: Khao Luang National Park, in tropical rain forest, on trunk of *Hevea braziliensis*, 1998, *T. Pooprang*, RU—9852 (RAMK).

Observation: *Parmotrema sulphuratum* is characterized by crack of fragile upper surface shows deep yellow or sulphur yellow of the medulla, cylindrical to coralloid isidia, and presence of cilia at the margins.

27. *Parmotrema thailandicum* Elix and Pooprang, sp. nov., *Mycotaxon* 71: 117, 1999

Figure 84

Thallus foliose, loosely adnate, coriaceous; lobes broad, irregular to elongate, ascending, rounded, 5-10 mm wide; margins entire to crenate, apices rotund to irregularly incised; eciliate; without isidia and soredia, with lobulate-laciniate at the center; upper surface pale to gray green, smooth to weakly wrinkled, plane, emaculate, 20 μm thick; medulla white and patch of yellow-orange pigmented near the lower cortex, 100 μm thick; lower surface black and brown at the margin, 20 μm thick; rhizines scattered, simple, black; **apothecia** rare, sessile to subpedicellate, disc imperforate, concave, brown; thalline exciple entire to dentate, up to 3 mm wide; ascospores hyaline,

28. *Parmotrema tinctorum* (Despr. ex Nyl.) Hale, *Phytologia* 28: 339, 1974

Basionym: *Parmelia tinctorum* Nyl., Flora, *Jena* 55: 547, 1872

Figure 85

Thallus foliose, loosely adnate, membranaceous to coriaceous; lobes broad, irregular to elongate, rounded, flat to ascending, 10-25 mm wide; margins entire to crenate, apices rotund; without cilia; isidia conspicuous, granular to cylindrical, simple to irregular branched; upper surface gray to gray green, smooth to rugous, 20-30 μm thick; medulla white, 150 μm thick; lower surface black to brown near the margin, 20-30 μm thick; rhizines black, sparse, simple; **apothecia** laminal, disc perforate, brown, up to 10 mm wide; thalline exciple entire or with isidia; ascospores hyaline, simple, ellipsoid, 12-15 x 8-10 μm; **pycnidia** laminal and submarginal, immersed; conidia filiform, 8-10 x 1 μm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow); medulla containing lacanoric aicd (K-, C+ red, KC+ red, and P-).

Habitat: On trunks of trees and on rocks in every type of forests in various parts of Thailand.

Distribution: Cosmopolitan species: North, Central and South America, Africa, Asia (India, Nepal, China, Thailand, Indonesia, Papua New

Guinea, Taiwan, Hong Kong, and Japan), Australia, New Zealand, and the Pacific Island.

Specimens examined: N Thailand. Chiang Mai Province: Queen Sirikit Botanic Garden, in the mixed deciduous forest, on trunk of *Peltophorum pterocarpum*, 1994, *K. Boonpragob et al.*, RU——86, 87, 88, 89, 114, 134, 163, 164, 233, 313, 314 & 743 (RAMK). ibid., on trunk of *Litsea glutinosa*, 1994, *K. Boonpragob et al.*, RU——425, 426, 427, 428, 429, 505, 522, 524, 525, 526, 528, 531, 532, 535, 536, 537, 538, 539, 540, 544, 545, 546, 552, 553, 564, 598, 605, 606 & 608 (RAMK). ibid., on trunk of *Bombax ceiba*, 1994, *K. Boonpragob et al.*, RU——610, 616, 619, 620, 621, 2293, 2294, 2295, 2296, 2297, 2298, 2299, 2300, 2301, 2302, 2303 & 2304 (RAMK). ibid., on trunk of *Castanopsis costata*, 1994, *K. Boonpragob et al.*, RU——724, 1575 & 1576 (RAMK). ibid., on trunk of *Dillenia* sp., 1994, *K. Boonpragob et al.*, RU——780, 791, 803, 805, 806 & 807 (RAMK). ibid., on trunk of *Shorea roxburghii*, 1994, *K. Boonpragob et al.*, RU——916, 917, 918, 936, 940, 941, 942, 943, 944, 947, 1729, 1732, 1737, 1766, 1767, 1768, 1769, 1770, 1778, 2739 & 2740 (RAMK). ibid., on trunk of *Dipterocarpus intricatus*, 1994, *K. Boonpragob et al.*, RU——986, 989, 990, 995 & 998 (RAMK). ibid., on trunk of *Dipterocarpus obtusifolius*, 1994, *K. Boonpragob et al.*, RU——1103, 1111, 1119, 1120, 1121, 1122, 1624, 1628, 1629, 1632, 1633, 1635, 1636, 1637, 1638, 1840, 1841, 1842, 1843, 1844, 1845, 1846, 1847, 1848, 1850, 1851, 1852, 1853, 1854, 1855 & 1856 (RAMK). ibid., on trunk of *Pittosporum ferrugineum*, 1994, *K. Boonpragob et al.*, RU——1138,

1185 (RAMK). ibid., on trunk of *Shorea obtusa*, 1994, *K. Boonpragob et al.*, RU——1339, 1340, 1342, 1345, 1354, 1886, 1901, 1902, 1903, 1904, 1905, 1906, 1907, 1908, 1909, 1910, 2735, 2736, 2737, 2738 & 3047 (RAMK). ibid., on trunk of unidentified tree, 1994, *K. Boonpragob et al.*, RU——1525, 1527, 1529, 1530, 1531, 1532, 1533, 1534, 1535, 1987, 1996, 1999, 2000, 2780, 3088, 3089, 3090, 3091, 3112, 3126, 3129 & 3590 (RAMK). ibid., on trunk of *Schima wallichii*, 1994, *K. Boonpragob et al.*, RU——1679, 1680, 1682, 1683, 1684, 1685, 1686, 1687, 1688, 1690 (RAMK). ibid., on trunk of *Melia azedarach*, 1994, *K. Boonpragob et al.*, RU——2025, 2106, 2107, 2108, 2109 & 2259 (RAMK). ibid., on trunk of *Stereospermum neuranthum*, 1994, *K. Boonpragob et al.*, RU——2410, 2411, 2414, 2415 & 2422 (RAMK). ibid., on trunk of *Quercus* sp., 1994, *K. Boonpragob et al.*, RU——2495, 2496, 2497, 2498, 2499 & 2649 (RAMK). ibid., on trunk of *Dillenia* sp.,1994, *K. Boonpragob et al.*, RU——2568 (RAMK). ibid., on trunk of *Pterocarpus macrocarpus*, 1994, *K. Boonpragob et al.*, RU——2620 & 2621 (RAMK). ibid., on trunk of *Canarium subulatum*, 1994, *K. Boonpragob et al.*, RU——2822, 2823 & 2824 (RAMK). ibid., on trunk of *Engellhardtia spicata*, 1994, *K. Boonpragob et al.*, RU——2866 (RAMK). ibid., on trunk of *Dipterocarpus tuberculatus*, 1994, *K. Boonpragob et al.*, RU——2881 (RAMK). ibid., on trunk of *Tectona grandis*, 1994, *K. Boonpragob et al.*, RU——2951, 2952, 2953, 2954 & 2955 (RAMK). ibid., on trunk of *Anneslea fragrans*, 1994, *K. Boonpragob et al.*, RU——3002 (RAMK). ibid., on trunk of *Castanopsis ferox*, 1994, *K. Boonpragob et al.*, RU——3026 & 3028 (RAMK). ibid., on

trunk of *Paramichelia baillonii*, 1994, *K. Boonpragob et al.*, RU——3080 & 3081 (RAMK). ibid., on trunk of *Castanopsis* sp., 1994, *K. Boonpragob et al.*, RU——3153, 3176 (RAMK). ibid., on trunk of *Adina cordifolia*, 1994, *K. Boonpragob et al.*, RU——3279 (RAMK). ibid., on trunk of *Pinus kesiya*, 1994, *K. Boonpragob et al.*, RU——3414, 3440 & 3443 (RAMK). ibid., on trunk of *Styrax benzoides*, 1994, *K. Boonpragob et al.*, RU——3500 & 3508 (RAMK). ibid., in the dry dipterocarp forest, on trunk of *Dipterocarpus obtusifolius*, 1995, *K. Boonpragob et al.*, RU——3677, 3678, 3679 & 3687 (RAMK). ibid., on trunk of *Sezygium* sp., 1995, *K. Boonpragob et al.*, RU——3736, 3754, 3755, 4016 & 4082 (RAMK). ibid., on trunk of *Stereospermum neurathum,* 1995, *K. Boonpragob et al.*, RU——3783 (RAMK). ibid., on trunk of *Holigrana kurzii*, 1995, *K. Boonpragob et al.*, RU——3820 & 3833 (RAMK). Doi Sutep-Pui National Park, Doi Pui Research Unit, in Plab orchard, on twig of *Diospyros* sp., 1998, *T. Pooprang*, RU——10217 & 10313 (RAMK). Phitsanulok Province: Phu Hin Rong Kla National Park, Lum Lob Phai, in the lower montane forest, on rock, 1998, *T. Pooprang,* RU——10194 & 10195 (RAMK). **NE Thailand.** Loei Province: Nahaeo National Park, along a trail to ToKo 1 in the lower montane forest, on rock, 1995, *T. Pooprang*, RU——4148, 4149, 4150, 4152, 4153, 4154, 4155, 4156, 4157, 4158, 4163, 4164, 4249, 4250, 4251, 4252, 4253, 4254, 4255, 4256,4257v 4259 (RAMK). ibid., on trunk of *Dillenia parviflora*, 1995, *T. Pooprang*, RU——4270, 4271 &4278 (RAMK). ibid., on trunk of *Castanopsis helfoliana*, 1995, *T. Pooprang*, RU——4419, 4421, 4422 & 4466 (RAMK). ibid., on trunk

of *Garuga pinnata*, 1995, *T. Pooprang*, RU——4745, 4746, 4751, 4752 & 4753 (RAMK). ibid., on trunk of *Adenanthera pavonina*, 1995, *T. Pooprang*, RU——5005, 5007 & 5008 (RAMK). ibid., on trunk of *Dillenina ovata*, 1995, *T. Pooprang*, RU——5170 & 5171 (RAMK). ibid., on trunk of *Sterculia pexa*, 1995, *T. Pooprang*, RU——5407 (RAMK). ibid., on trunk of *Schima wallichii*, 1995, *T. Pooprang*, RU——5775 & 7287 (RAMK). ibid., a trail to Numtok Tad Huaeng, on trunk of *Dalbergia oliveri*, 1995, *T. Pooprang*, RU——6197, 6198, 6199, 6201, 6202, 6203, 6204, 6205 & 6208 (RAMK). ibid., on trunk of *Neolithsea* sp. 1995, *T. Pooprang*, RU——6291, 6292, 6293, 6294, 6295 & 6297 (RAMK). ibid., on trunk of unidentified tree, 1995, *T. Pooprang*, RU——6607, 6608, 7329 (RAMK). ibid., on rock, 1995, *T. Pooprang*, RU——7179 (RAMK). Sakol Nakhon Province: Phupan National Park, Nuai To Khat, in the dry evergreen forest, on trunk of unidentified tree, 1997, *T. Pooprang*, RU——8841 (RAMK). **E Thailand.** Nakhon Ratchasima Province: Khao Yai National Park, a trail to old Golf Course, in the secondary forest, on trunk of *Mangifera indica*, 1997, *T. Pooprang*, RU——7947, 7949v 7950 (RAMK). ibid., on trunk of *Sezygium* sp., 1995, *T. Pooprang*, RU——8077, 8078, 8092, 8147, 8152, 8156 & 8242 (RAMK). Khao Kieao, in the lower montane forest, on trunk of unidentified tree, 1997, *T. Pooprang*, RU——8339 (RAMK). **W Thailand.** Kanchanaburi Province: Erawan National Park, in the mixed deciduous forest, on trunk of *Bamboo*, 1997, *N. Homchantara et al.*, RU——8639 (RAMK).

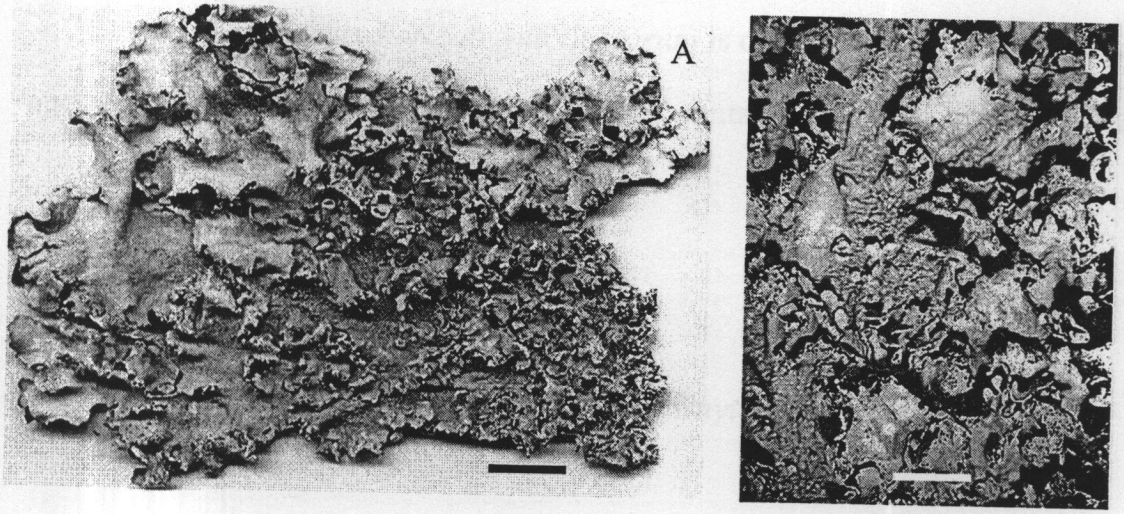


Figure 84 *Parmotrema thailandicum* Elix and Pooprang

Note: A. Thallus with lobules at the center [RU——10073 (RAMK), scale = 1 cm].

B. Lobules on upper surface [RU——10073 (RAMK), scale = 0.4 cm].

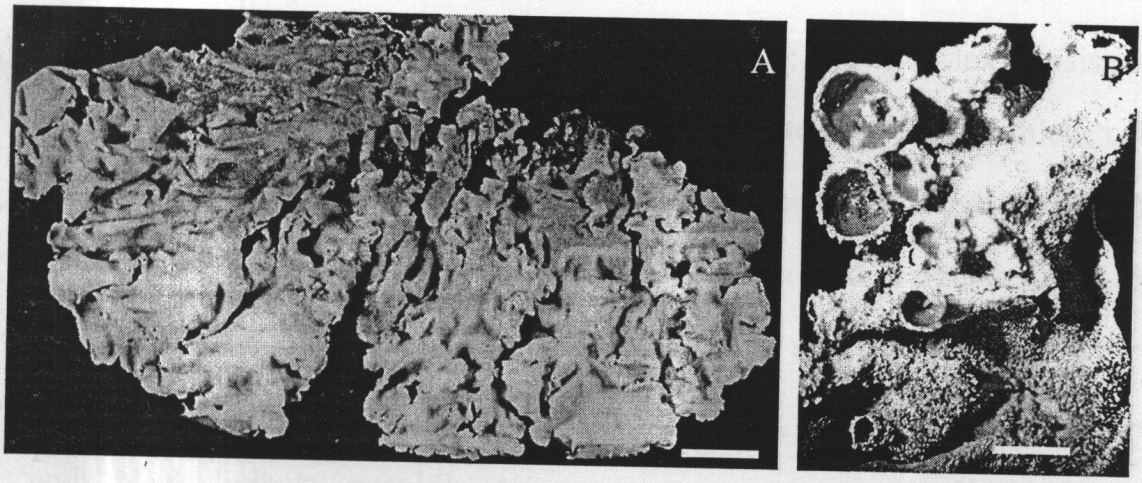


Figure 85 *Parmotrema tinctorum* (Despr. *ex* Nyl.) Hale

Note: A. Thallus with lobes broader than 1 cm and isidia [RU——4150 (RAMK], scale = 1.5 cm).

B. Perforate apothecia and isidia on upper surface [RU——7329 (RAMK), scale = 0.5 cm].

Observation: *Parmotrema tinctorum* is distinguished by broad lobes and numerous cylindrical isidia. This species contains lecanoric acid (C+ red).

Genus *Relicina*

***Relicina* (Hale and Kurokawa) Hale**, *Phytologia* 28: 484, 1974

Figure 86

Thallus foliose, adnate to tightly adnate; lobes contiguous to separate, sublinear to linear-elongate, subdichotomously to dichotomously branched, narrow, 0.3-3.0 mm wide, ciliate, cilia bulbate; upper surface pale green to yellowish green, smooth or rarely rugulose in the thallus center, without pseudocyphellae and soredia, with or without isidia; upper cortex consisting of a palisade plectenchymatous with a pored epicortex, 20-25 μm thick; cell walls containing isolichenan; medulla compact to loosely packed, white, 80-100 μm thick; lower surface pale tan to black, 25 μm thick; rhizines simple or sparsely branched; **apothecia** laminal, sesile to short stipitate; disc concave or becoming flat, imperforate, pale brown to red brown; thalline exciple coronate with black bulbate pycnidia or ecoronate; ascospores hyaline, simple, ellipsoid, 3-12 x 2-6 μm; **pycnidia** laminal and immersed to slightly emergent in thallus, or present in erect bulbate around the inner margin of the apothecial rim; conidia usually bifusiform, rarely bacilliform (cylindrical), 5-10 x 1 μm.

Habitat: *Relicina* species occupy the canopy branches, on trunks of rainforest trees, and on rocks at low to mid-elevation in open habitats.

Distribution: Africa, Southeastern Asia, and Australia.

Observation: *Relicina* is characterized by bulbate cilia, yellow-green upper cortex, which contains usnic acid. The related genus *Bulbothrix* differs in having a gray upper cortex, which contains atranorin.

Key to the species of *Relicina*

1a Thallus isidiate; K+ yellow turning red
(norstictic acid present).....*R. abstrusa*

1b Thallus non-isidiate.....2

2a Medulla K+ yellow turning red (norstictic acid present).....*R. subastrusa*

2b Medulla K+ brown, P+ orange-red
(protocetraric acid present).....*R. sublimbata*

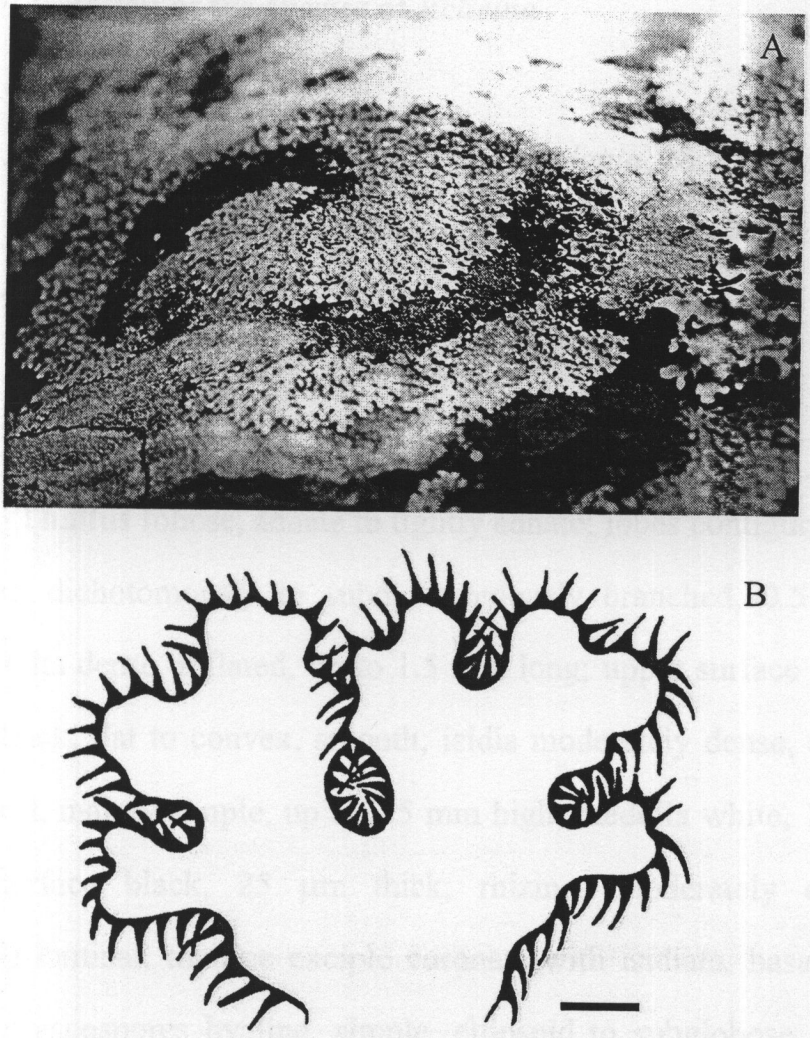


Figure 86 Genus *Relicina* (Hale and Kurokawa) Hale

Note: A. Thallus growing on rock [RU——6590 (RAMK)].

B. Bulbate cilia at the margin of lobe (scale = 1 mm).

Description of the species of *Relicina*

1. *Relicina abstrusa* (Vain.) Hale, *Phytologia*, 28: 484, 1974

Basionym: *Parmelia abstrusa* Vain., *Acta Soc. Fauna Fl. Fenn.* 7: 64, 1890

Figure

Thallus foliose, adnate to tightly adnate; lobes contiguous, imbricate, sublinear, dichotomously to subdichotomously branched, 0.5-2 mm wide; bulbate cilia dense, inflated, up to 1.5 mm long; upper surface yellow-green, 25 μm thick, flat to convex, smooth; isidia moderately dense, subglobose to cylindrical, mainly simple, up to 0.5 mm high; medulla white, 140 μm thick; lower surface black, 25 μm thick; rhizines moderately dense, black; apothecia laminal, thalline exciple coronate with isidiate, basally retrousely rhizinate; ascospores hyaline, simple, ellipsoid to subglobose, 5-6 x 4 μm; pycnidia laminal, immerse, conidia bifusiform, 5-6 x 1 μm.

Chemistry: Cortex containing usnic acid (K-) and medulla containing norstictic acid, connorstictic acid, hyposalazinic acid (K+ yellow turning red, C-, KC+ red, and P+ deep orange).

Habitat: This species occurs on trunks and canopy branches of trees in the tropical rain forests, the lower montane forests and on rocks near waterfalls.

Distribution: Central America, South America, Kenya, India, Thailand, Indonesia, Papua New Guinea, Taiwan, Japan, and Australia.

Specimens examined: NE Thailand. Loei Province: Nahaeo National Park, Wat Bo Mueang Noi, on trunk of unidentified tree, 1995, *T. Pooprang*, RU——6589 & 6594 (RAMK). ibid., on rock near Hueang River, 1995, *T. Pooprang*, RU——6639, 6643, 6645, 6656 & 6657 (RAMK). **E Thailand.** Nakhon Ratchasima Province: Num Tok Pha Klaiw Mai, on rock, 1997, *T. Pooprang*, RU——9082 (RAMK). ibid., on trunk of unidentified tree, 1997, *T. Pooprang*, RU——9701 & 9702.1 (RAMK). **SW Thailand.** Phetchaburi Province: Kang Krachan National Park, along a trial to Pha Noen Thung Camp, 1998, *T. Pooprang*, RU——11152, 11156, 11178 & 11185 (RAMK). **S Thailand.** Nakhon Srithammarat Province: Khao Luang National Park, on unidentified tree at Num Tok Karom, 1998, *T. Pooprang*, RU——9899, 9900, 9901, 9902, 9903, 9912, 9913, 9914, 9915 & 9916 (RAMK).

Observation: *Relicina abstrusa* is distinguished by the cylindrical isidia, black lower surface and norstictic acid.

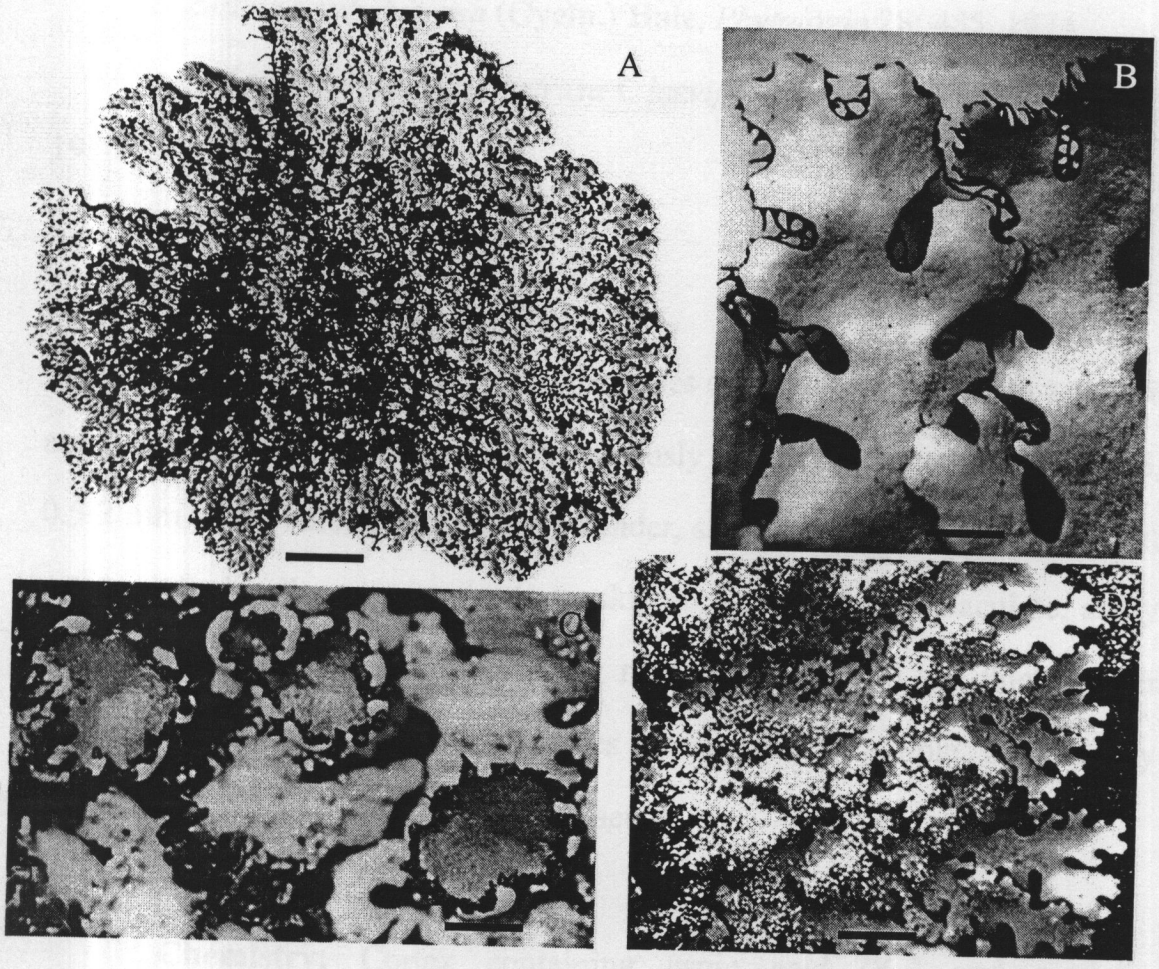


Figure 87 *Relicina abstrusa* (Vain.) Hale

Note: A. Thallus with linear and subdichotomously branched lobes [RU——9912 (RAMK), scale = 1 cm].

B. Lobes with slender simple bulbate cilia [RU——9912 (RAMK), scale = 1 mm].

C. Apothecia with coronate thalline exciple [RU——9912 (RAMK), scale = 1 mm].

D. Cylindrical isidia on upper surface [RU——9912 (RAMK), scale = 4 mm].

2. *Relicina subabstrusa* (Gyeln.) Hale, *Phytologia* 28: 485, 1974

Basionym: *Parmelia abstrusa* f. *laevigata* Lynge, *Arkiv Bot.* 13: 147, 1914

Figure 88

Thallus foliose, tightly adnate; lobes contiguous centrally to separate at the periphery, not imbricate, dichotomously to subdichotomously branched, 0.5-2 mm wide; bulbate cilia dense, slender, strongly inflated, to 1 mm long; upper surface yellow-green, flat to weakly convex, smooth, emaculate, shiny at apices, 25 µm thick; without isidia; medulla white, 100 µm thick, lower surface black, 25 µm thick; rhizines dense, black, simple or sparsely branched; **apothecia** and **pycnidia** not seen.

Chemistry: Cortex containing usnic acid (K-) and medulla containing norstictic acid, connorstictic acid, and hyposalazinic acid (K+ yellow turning red, C-, KC+ red, and P+ deep orange).

Habitat: On barks and on rocks in sun exposure habitats near moist areas.

Distribution: Brazil, Paraguay, Guyana, Thailand, Malaysia, Indonesia, Philippines, Taiwan, and Australia.

Specimens examined: E Thailand. Nakhon Ratchsima Province: Khao Yai National Park, Num Tok Pha Klaiw Mai, on trunk of unidentified tree, 1997, *T. Pooprang*, RU——9702.2 & 9703 (RAMK). **SW Thailand.** Phetchaburi Province: Kaeng Krachan National Park, along a trial to Num Tok Totip, Pha Noen Thung Camp, on twig of unidentified tree, 1998, *T. Pooprang*, RU——11153 (RAMK).

Observation: This species closely relates to *Relicina abstrusa* on external morphology and chemistry, but *R. subabstrusa* is distinguished by non-isidiate thallus.

3. *Relicina sublimbata* (Nyl.) Hale, *Phytologia* 28: 485, 1974

Basionym: *Parmelia sublimbata* Nyl., *Flora* 68: 615, 1885

Figure 89

Thallus foliose, adnate; lobes contiguous, imbricate, sublinear to subdichotomously branched, 1.5-2 mm wide; bulbate cilia moderately dense, slender, simple to branhed, up to 1 mm long; upper surface yellow-green, convex, smooth to rugose, emaculate, 20 μm thick; without isidia; medulla wihte, 80 μm thick; lower surface black, 25 μm thick; densely rhizinate, rhizines simple to sparsely branched, black, up to 1.5 mm long; **apothecia** common, 1-2 mm wide, sessile, disc pale brown to chestnut brown, thalline exciple ecoronate; ascopores hyaline, simple, ellipsoid to subglobose, 5-6 x 4-5 μm; **pycnidia** immersed, laminal, conidia bifusiform, 4-6 x 1 μm.

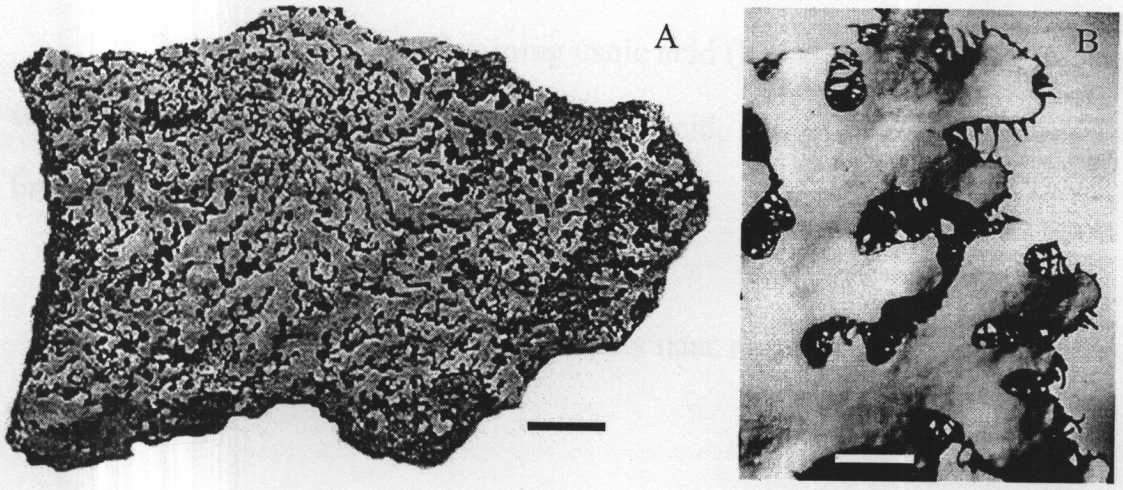


Figure 88 *Relicina subabstrusa* (Gyeln.) Hale

Note: A. Thallus yellow-green lacking isidia [RU——9702 (RAMK), scale = 0.4 cm].

B. Lobes with dense long simple bulbate cilia [RU——11153 (RAMK), scale = 1.2 mm].

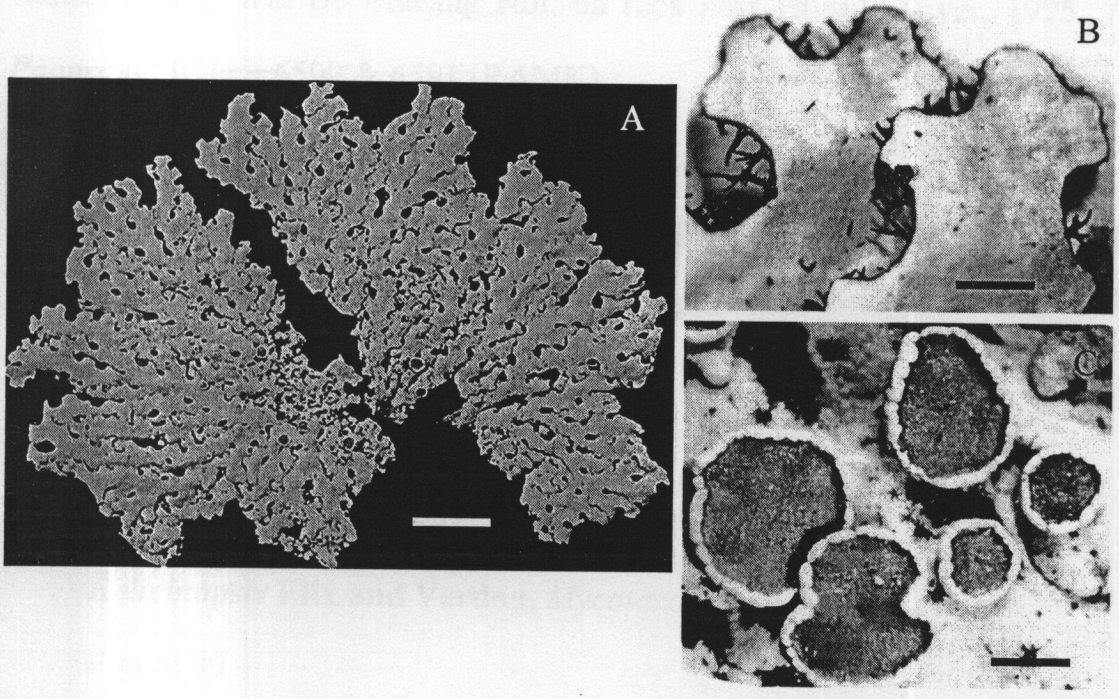


Figure 89 *Relicina sublimbata* (Nyl.) Hale

Note: A. Thallus yellow-green with imbricate lobes [RU——6590 (RAMK), scale = 1 cm].

B. Lobes with simple to branched bulbate cilia [RU——6591 (RAMK), scale = 1 mm].

C. Apothecia with ecoronate thalline exciple [RU——6591 (RAMK), scale = 1 mm].

Chemistry: Cortex containing usnic acid (K-) and medulla containing fumarprotocetraric acid, succinprotocetraric acid, and protocetraric acid (K+ brown, C-, KC-, and P+ orange to red).

Habitat: On rocks in open habitats near moist areas at about 500 m elevation.

Distribution: Myanma, and Thailand.

Specimens examined: NE Thailand. Loei Province: Nahaeo National Park, Wat Bo Mueang Noi, on rock near Hueang River, 1995, *T. Pooprang*, RU——6590 & 6591 (RAMK).

Observation: This species is distinguished in slender, simple to branched bulbate cilia and presence of protocetraric acid group.

Genus *Relicinopsis*

***Relicinopsis* Elix and Verdon**, *Mycotaxon* 27: 281, 1986

Figure 90

Thallus foliose, adnate to tightly adnate; lobes contiguous at center and separate at periphery, sublinear to linear-elongate, dichotomously to subirregularly branched, up to 2 mm wide; margins entire to crenate, apices

incised to subrotund; eciliate; upper surface yellow-green, smooth, faintly maculae to spotted maculae, convex; lacking pseudocyphellae and soredia; with or without isidia; upper cortex palisade plectenchymatous with a pored epicortex, 25-30 μm thick; cell walls containing isolichenan; medulla white, 80-100 μm thick; lower surface ivory to brown, 25 μm thick; rhizines extending to lobe margins, pale brown, sparse to dense, simple to branched, agglutinate; **apothecia** laminal, sessile; disc flat to concave, red-brown or cinnamon-brown, thalline exciple entire to crenate, ascospores hyaline, simple, ellipsoid, 4-7 x 3-5 μm; **pycnidia** laminal, immersed to emerged, conidia fusiform, 5-7 x 1 μm.

Habitat: On trees trunk, canopy branches and on rocks in expose sunny habitat.

Distribution: Africa, India, Thailand, Malaysia, Indonesia, Philippines, Papua New Guinea, and Australia.

Observation: *Relicinopsis* is distinguished by yellow-green turncate lobes, pale brown lower surface, and densely rhizines to the margins.

Key to the species of *Relicinopsis*

1a Thallus isidiate.....2

1b Thallus non-isidiate; medulla P+orange (protocetraric acid)....*R. intertexta*

2a Medulla P+ orange-red, containing protocetraric acid.....*R. malaccensis*

2b Medulla P-, containing barbatic acid.....*R. rahengensis*

Description of the species of *Relicinopsis*

1. ***Relicinopsis intertexta* (Mont. and Bosch) Elix and Verdon,** *Mycotaxon* 27: 281, 1986

Basionym: *Parmelia intertexta* Mont and Bosch, *Sylloge Gen. Spec. Cryptog.* 327, 1856

Figure 91

Thallus foliose, tightly adnate; lobes contiguous to imbricate, sublinear-elongate, dichotomously to subdichotomously branched, 1-2 mm wide, margin entire to subcrenate, apices incise; eciliate; upper surface convex, faintly maculae to white spotted maculae, smooth to cracked, lacking isidia, 30 μm thick; medulla white, 100 μm thick; lower surface pale brown, 25 μm thick; rhizines moderately dense, pale brown, simple to densely branched; **apothecia** common, up to 2 mm wide, disc flat to concave, brown, thalline exciple smooth to crenate, ascospores 5-7.5 x 3-5 μm; **pycnidia** common, laminal, immersed, conidia fusiform, 5-7 x 1 μm.

Chemistry: Cortex containing usnic acid (K-) and medulla containing protocetraric acid, protolichsterinic acid, and with or without atranorin (K- or K+ brown, C-, KC-, and P+ red).

Habitat: On canopy branches of trees, and on rocks in expose sunny places.

Distribution: Andaman Island, Thailand, Malaysia, Indonesia, Philippines, Papua New Guinea, and Australia.

Specimens examined: NE Thailand. Loei Province: Nahaeo National Park, Wat Bo Mueang Noi, on rock, 1995, *T. Pooprang*, RU—6646, 6773, & 7004 (RAMK). ibid., on twig of *Shorea obtusa*, 1995, *T. Pooprang*, RU—6652, 6658, 6661, 6965, 7049 & 7053 (RAMK). ibid., on trunk of unidentified tree, 1995, *T. Pooprang*, RU—6734, 6966, 6967, 7366 (RAMK). **E Thailand.** Nakhon Ratchasima Province: Khao Yai National Park, on trunk of unidentified tree, 1998, *T. Pooprang*, RU—TP015 (RAMK).

Observation: *Relicinopsis intertexta* is easily recognized by lacking isidia, numerous apothecia, and with protocetraric acid and fatty acid (protolisterinic acid).

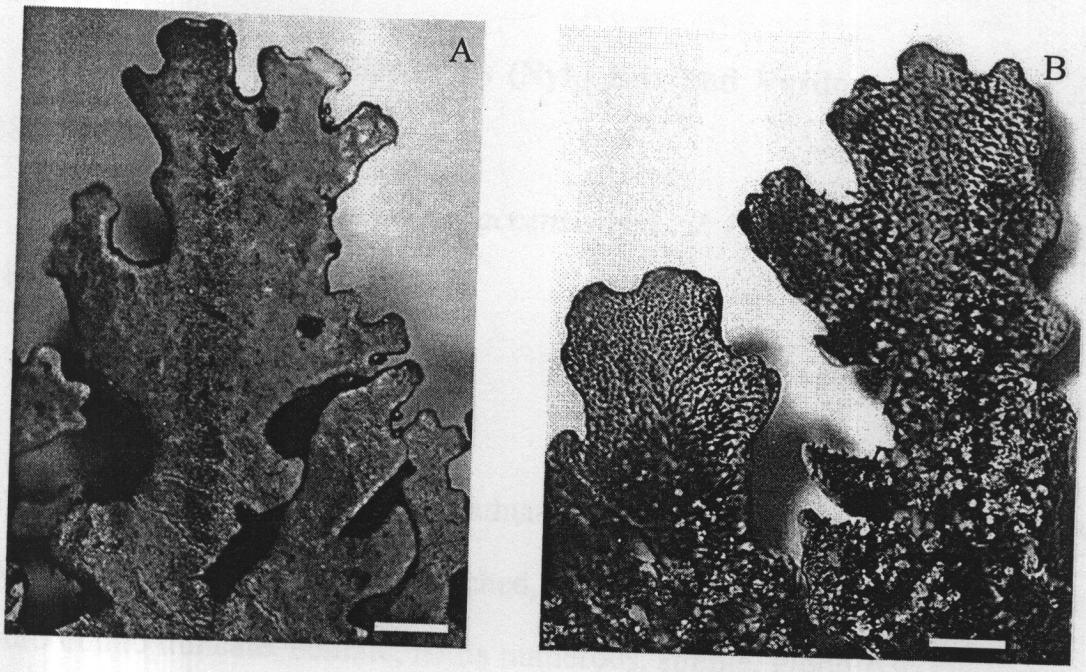


Figure 90 Genus *Relicinopsis* Elix and Verdon

Note: A. White marking of simple maculae on upper surface [RU—6773 (RAMK), scale =1 mm].

B. Rhizines on lower surface without extending beyond the margin of lobes [RU—6660 (RAMK), scale =1 mm].

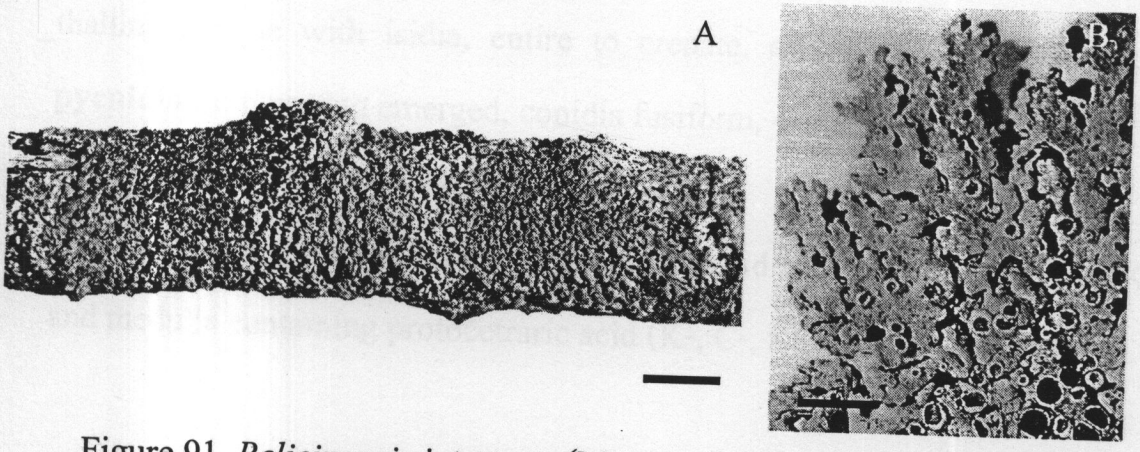


Figure 91 *Relicinopsis intertexta* (Mont. and Bosch) Elix and Verdon

Note: A. Thallus yellow-green with numerous apothecia [RAMK—6965, scale = 1.2 cm].

B. Lobes without isidia [RAMK—6773, scale = 6 mm].

2. *Relicinopsis malaccensis* (Nyl.) Elix and Verdon, *Mycotaxon* 27: 282, 1986

Basionym: *Parmelia malaccensis* Nyl., *J. Linn. Soc. London* 20: 52, 1883

Figure 92

Thallus foliose, tightly adnate; lobes contiguous to subimbricate, sublinear, subdichotomously branched, 1-2 mm wide; margins entire, apices subrotund to truncate, eciliate; isidia numerous, simple, globose to cylindrical, up to 0.1-0.5 mm high; upper surface yellow-green, flat to convex, shiny, white spotted maculae at lobe apices, smooth to transversely cracked, 25 μm thick; medulla white, 100 μm thick; lower surface pale brown to black, 25 μm thick; rhizines dense, simple to sparsely branched, pale to dark brown; **apothecia** rare, up to 2 mm wide; disc flat to concave, cinnamon-brown, thalline exciple with isidia, entire to crenate, ascospores 5-7 x 4-6 μm; **pycnidia** immersed to emerged, conidia fusiform, 4-6 x 1 μm.

Chemistry: Cortex containing usnic acid and trace of atranorin (K-) and medulla containing protocetraric acid (K-, C-, KC-, and P+ orange-red).

Habitat: On trees trunk and on rocks in open sunny habitats.

Distribution: Africa, Southern India, Sri Lanka, Thailand, West Malaysia, Sabah, Sarawak, Indonesia, Philippines, and Papua New Guinea.

Specimens examined: N Thailand. Chaing Mai Province: The Queen Sirikit Botanic Garden, on trunk of *Dipterocarpus obtusifolius*, 1994, *K. Boonpragob et al.*, RU——1615 (RAMK). Phitsanulok Province: Phu Hin Rong Kla National Park, Lan Hin Taek, on rock, 1998, *T. Pooprang*, RU——10079, 10080 & 10165 (RAMK). **NE Thailand.** Loei Province: Nahaeo National Park, Wat Bo Mueang Noi, on rock, 1995, *T. Pooprang*, RU——6649, 6655, 6774 & 6775 (RAMK). ibid., on twig and trunk of unidentified tree, 1995, *T. Pooprang*, RU——7001, 7009, 7010 & 7052 (RAMK). Sakon Nakhon Province: Phupan National Park, Pha Nang Moen, on trunk of unidentified tree, 1997, *T. Pooprang*, RU——8987 (RAMK). **SE Thailand**. Trat Province: Mangrove forest Management Unit, on trunk of *Rhizophora apiculata* Bl., 1998, *T. Pooprang*, RU——11192 (RAMK). **SW Thailand.** Phetchaburi Province: Kaeng Kra Chan National Park, Pha Noen Thung Camp, on twig of unidentified tree, 1998, *T. Pooprang*, RU——11155 (RAMK). **S Thailand.** Nakhon Srithammarat Province: Khao Luang National Park, Rubber Plantation, on trunk of *Hevea brasiliensis* Müll. Arg., 1998, *T. Pooprang*, RU——9849 (RAMK).

Observation: *Relicinopsis malaccensis* is characterized by isidiated lobes with subrotund to truncate apices, and presence of protocatraric acid (P+ orange to red).

3. *Relicinopsis rahengensis* (Vain.) Elix and Verdon, *Mycotaxon* 27: 282, 1986

Basionym: *Parmelia rahengensis* Vain., *Ann. Soc. Zool.- Bot. Fenn. Vanamo*. 1: 39, 1921

Figure 93

Thallus foliose, tightly adnate; lobes contiguous to imbricate, linear to sublinear-elongate, subdichotomously branched, up to 2 mm wide; margin entire, apices incise to truncate; eciliate; upper surface flat to convex, smooth to rich wrinkled, faintly maculae to white spotted maculae, 30 μm thick; isidia sparse to dense, simple to branched, cylindrical, up to 0.2 mm high; medulla white, 80 μm thick; lower surface pale brown to brown, 25 μm thick; rhizines dense, simple to sparsely branched, pale brown, up to 1 mm long; **apothecia** rare, if present up to 3 mm wide, disc flat to concave, red-brown to cinnamon brown; thalline exciple with sparsely isidia, entire to crenate, ascospores 5-7 x 3-5 μm; **pycnidia** immerse to emerge, laminal and isidia, conidia fusiform, 4-5 x 1 μm.

Chemistry: Cortex containing usnic acid (K-), and medulla containing barbatic acid, 4-*O*-demethylbarbatic acid, with or without echinocarpic (K-, C-, KC+ yellow to pale orange, and P-).

Habitat: On tree trunks and on rocks in open habitats in the dry dipterocarp forests, canopy branches in evergreen forests, and sun habitats in

mangrove forests.

Distribution: Thailand and Australia.

Specimens examined: N Thailand. Chiang Mai Province: The Queen Sirikit Botanic Garden, on trunk of *Dillenia* sp., 1994, *K. Boonpragob et al.*, RU——2592 (RAMK). ibid., on trunk of *Dipterocarpus obtusifolius*, 1995, *K. Boobpragob et al.*, RU——3657, 3658, 3680, 3684 (RAMK). ibid., on trunk of unidentified tree, 1995, *K. Boonpragob et al.*, RU——3666, 3667 & 3675 (RAMK). ibid., on trunk of *Sezygium* sp., 1995, *K. Boonpragob et al.*, RU——3758, 3764 & 4007 (RAMK). ibid., on trunk of *Holigrana kurzii*, 1995, *K. Boonpragob et al.*, RU——3826, 3827 & 3959 (RAMK). ibid., on trunk of *Ficus* sp., 1995, *K. Boonpragob et al.*, RU——3866 (RAMK). Lampang Province: Khuntan National Park, the trail to Yo Song, on rock, 1998, *T. Pooprang*, RU——10330 (RAMK). ibid., the dry dipterocarp forest along the trail to the entrance, on trunk of unidentified tree, 1998, *T. Pooprang*, RU——10323 (RAMK). Phitsanulok Province: Phu Hin Rong Kla National Park, Lan Hin Taek, on trunk of unidentified tree, 1998, *T. Pooprang*, RU——10062, 10063, 10064 & 10065 (RAMK). ibid., on rock, 1998, *T. Pooprang*, RU——10078 (RAMK). ibid., Kung Hun Num, on rock, 1998, *T. Pooprang*, RU——10166 (RAMK). **NE Thailand.** Loei Province: Nahaeo National Park, the trail to To Ko 1, on rock, 1995, *T. Pooprang*,

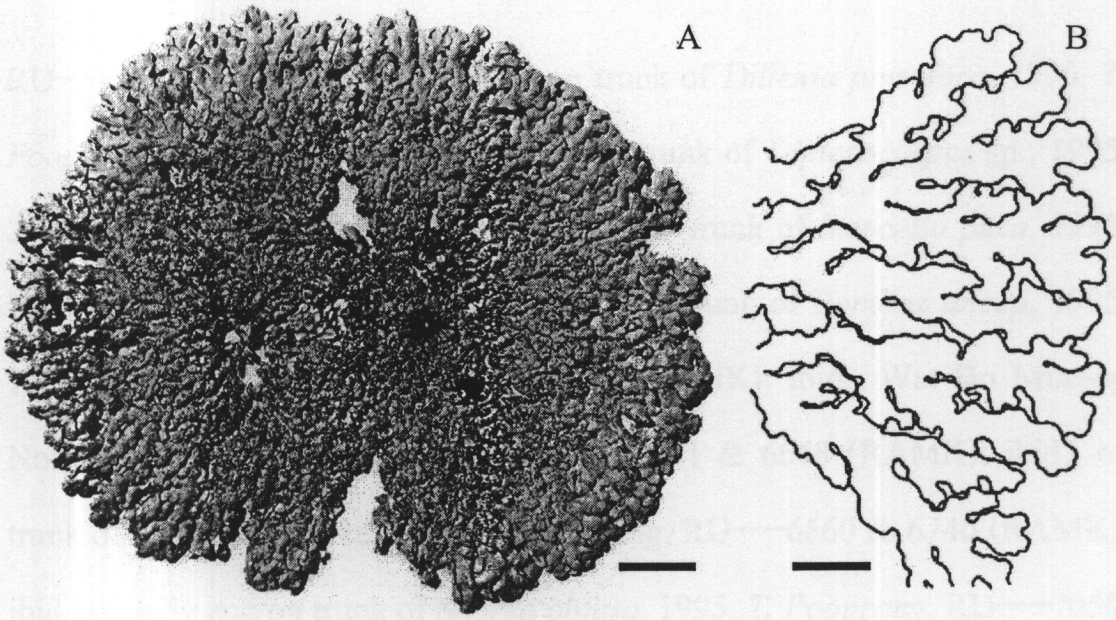


Figure 92 *Relicinopsis malaccensis* (Nyl.) Elix and Verdon

Note: A. Thallus yellow-green with isidia [RU—6655 (RAMK), scale = 1.2 cm].

B. Illustration of subimbricate lobes with subrotund to truncate apices (scale = 4 mm).

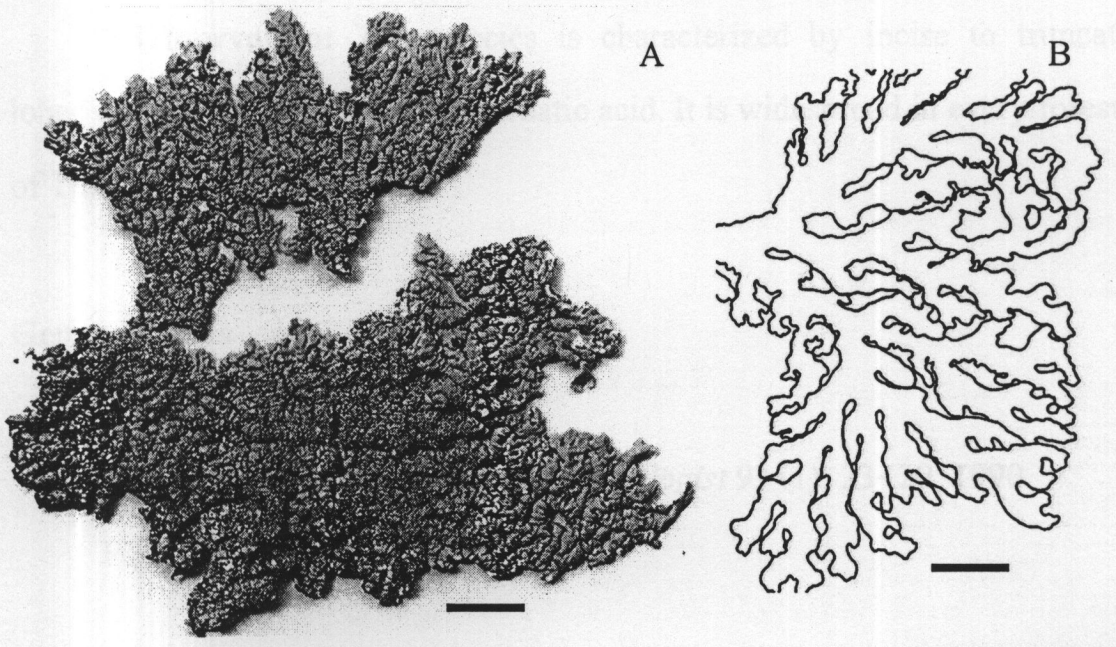


Figure 93 *Relicinopsis rahengensis* (Vain.) Elix and Verdon

Note: A. Thallus yellow-green with numerous isidia [RU—6660 (RAMK), scale = 1.2 cm].

B. Illustration of irregular lobes with incise apices (scale = 4 mm).

RU——4176 & 4229 (RAMK). ibid., on trunk of *Dillenia parvifora*, 1995, *T. Pooprang*, RU——4277 (RAMK). ibid., on trunk of *Dipterocarpus* sp., 1995, *T. Pooprang*, RU——4652 (RAMK). ibid., on trunk of *Sterculia pexa*, 1995, *T. Pooprang*, RU——5405 (RAMK). ibid., on trunk of *Bombax ancep*, 1995, *T. Pooprang*, RU——5937, 5941 & 5944 (RAMK). ibid., Wat Bo Mueang Noi, on rock, 1995, *T. Pooprang,* RU——6641 & 6648 (RAMK). ibid., on trunk of unidentified tree, 1995, *T. Pooprang*, RU——6660 & 6740 (RAMK). ibid., on twig and on trunk of *Shorea obtusa*, 1995, *T. Pooprang*, RU——7050, 7051 & 7054 (RAMK). Ibid., on trunk of *Memexylon* sp., 1995, *T. Pooprang*, RU——7081 (RAMK).

Observation: This species is characterized by incise to truncate lobes with isidia, and producing barbatic acid. It is widespread in every forests of Thailand.

Genus *Rimelia*

***Rimelia* Hale and Fletcher**, *The Bryologist* 93 (1): 23- 29, 1990

Figure 94

Thallus foliose, loosely adnate to adnate; lobes plane, 3-10 mm wide, often marginal entire to crenate and laciniae form, apices subrotund; cilia black, 3-5 mm long; soredia powdery to granular, soralia laminal or

submarginal, and terminal at the laciniate lobes; upper surface reticulate maculae; upper cortex palisade plectenchymatous with pored epicortex, gray-green, 25 μm thick; medulla white, 100 μm thick; lower surface black and brown at the margins, sometimes white at the marginal zone, glossy, 20 μm thick; rhizines simple to irregularly squarrosely branched at maturity; **apothecia** substipitate, laminal to submarginal, disc brown, thalline exciple smooth to wrinkled and with maculae; ascospores hyaline, simple, ellipsoid, 13-18 x 8-11 μm; **pycnidia** immersed, laminal; conidia cylindrical or filiform, 9-16 μm.

Habitat: Occur on trees or rocks in sun habitats.

Distribution: Cosmopolitan, temperate and tropical region.

Observation: *Rimelia* is distinguished from *Parmotrema* by white reticulate-maculae. *Rimelia* has simple to squarrose rhizines and cilia. Only one species has been found in Thailand.

Description of the species of *Rimelia*

***Rimelia reticulata* (Taylor) Hale and Fletcher,** *The Bryologist* 93: 28, 1990

Basionym: *Parmelia reticulata* Taylor, *Fl. Hiber.* 148, 1836

Figure 94

Thallus foliose, loosely adnate to adnate; lobes imbricate or subascending at margins, subirregular to sublinear-elongate, 5-15 mm wide; margins entire to deeply crenate, apices rotund to laciniae; cilia sparse to dense, simple, 0.2-3 mm long; soredia granular, soralia linear to subcapitate, commonly on short marginal laciniate, sometimes submarginal; upper surface pale gray to gray–green, dull to shiny, 25 μm thick; reticulate maculae throughout lobes; medulla white, 100 μm thick; lower surface black and brown at the margins, 20 μm thick; rhizines dense, black, simple or squarrose, slender, to 2 mm long, erhizinate marginal zone 1-3 mm wide on the marginal lobes; **apothecia** rare, submarginal to laminal, subpedicellate, 2-8 mm wide; disc imperforate, concave, dark brown; thalline exciple entire to wrinkled with sorediate and reticulate maculae; ascospores hyaline, simple, ellipsoid, 13-18 x 8-11 μm; **pycnidia** rare, immersed, laminal; conidia filiform, 12-16 x 1 μm.

Chemistry: Cortex containing atranorin and chloroatranorin (K+ yellow) and medulla containing salazinic acid and consalazinic acid (K+ yellow turning red, C-, KC-, and P+ orange-red).

Habitat: On trunks, twigs of trees and on rocks in the every forests.

Distribution: Pantemperate, subtropic, tropic.

Specimens examined: N Thailand. Chiang Mai Province: Queen Sirikit Botanic Garden, on trunk of *Dillenia* sp., 1994, *K. Boonpragob et. al.*, RU——817 (RAMK). ibid., on unidentified tree, 1995, *K. Boonpragob et. al.*, RU——3104, 3114 & 3115 (RAMK). ibid., on trunk of *Castanopsis* sp., 1995, *K. Boonpragob et. al.*, RU——3154, 3174, 3180, 3269, 3291 & 3292 (RAMK). ibid., on trunk of *Pinus kesiya*, 1995, *K. Boonpragob et al.*, RU——3338, 3339, 3383, 3384, 3385, 3386, 3387, 3388, 3389, 3390, 3391, 3392, 3393, 3394, 3395, 3396, 3417 & 3418 (RAMK). **NE Thailand.** Loei Province: Naheao National Park, on rock along a trial to To Ko 1, 1995, *T. Pooprang*, RU——4165 & 4263 (RAMK). ibid., on trunk of *Dillenia pavifora,* 1995, *T. Pooprang*, RU——4276 (RAMK). ibid., on twig of *Garuga pinnata*, 1995, *T. Pooprang*, RU——4754 (RAMK). ibid., on trunk of *Schima wallichii*, 1995, *T. Pooprang*, RU——5540 (RAMK). ibid., on trunk of *Croton* sp., 1995, *T. Pooprang*, RU——6862 (RAMK). ibid., Lao Ko Hok, on rock, 1995, *T. Pooprang*, RU——7181 (RAMK). ibid., on trunk of unidentified tree, 1995, *T. Pooprang*, RU——7332 (RAMK).

Observation: *Rimelia reticulata* is distinguished by soredia on terminal of laciniate lobes with cilia and reticulate maculae.

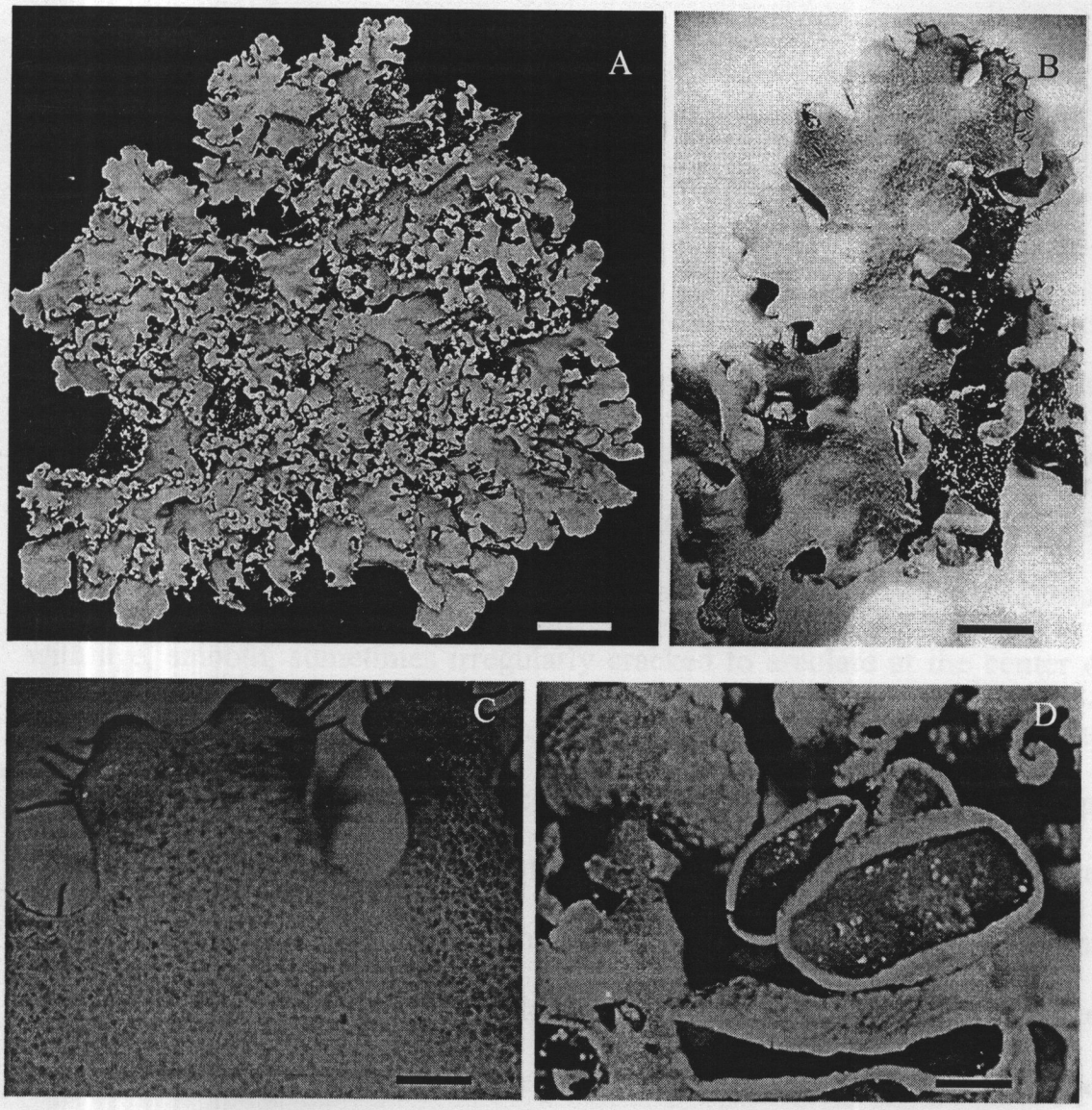


Figure 94 *Rimelia reticulata* (Taylor) Hale

Note: A. Thallus gray with soredia and cilia [RU——10247 (RAMK), scale = 1 cm].

B. Soralia at the terminal of laciniate lobes [RU——10247 (RAMK), scale =0.3 cm].

C. Reticulate maculae on lobes and simple cilia [RU——817 (RAMK), scale = 0.2 cm].

D. Apothecia shows thalline exciple with reticulate maculae [RU——10292 (RAMK), scale = 0.5 cm].

Genus *Xanthoparmelia*

***Xanthoparmelia* (Vain.) Hale**, *Phytologia* 28: 485, 1974

Figure 95

Thallus foliose to subcrustose, very tightly adnate; lobes linear, irregular to dichotomously branched, separate to imbricate, 0.1-2 mm wide; margins entire, apices incise to rotund, eciliate, with or without isidia and without soredia; upper surface pale yellow to green-yellow, often darkening with age, smooth, sometimes irregularly cracked to areolate at the center of thallus, without pseudocyphellae; upper cortex palisade plectenchymatous with pored epicortex, 10 μm thick; cell walls containing *Xanthoparmelia*-type lichenan; medulla loosely packed, white or pigmented, 45-85 μm thick; lower surface brown-black, 10-15 μm thick; rhizines sparsely or rarely absent, simple; **apothecia** laminal, sessile to subpedicellate, disc imperforate, concave, chestnut brown, thalline exciple; ascospores hyaline, simple, ellipsoidal to subglobose, 5-10x5-7 μm; **pycnidia** laminal, immersed, conidia bifusiform.

Habitat: On rocks in expose sunny habitats, mostly occurs in the dry dipterocarp forests.

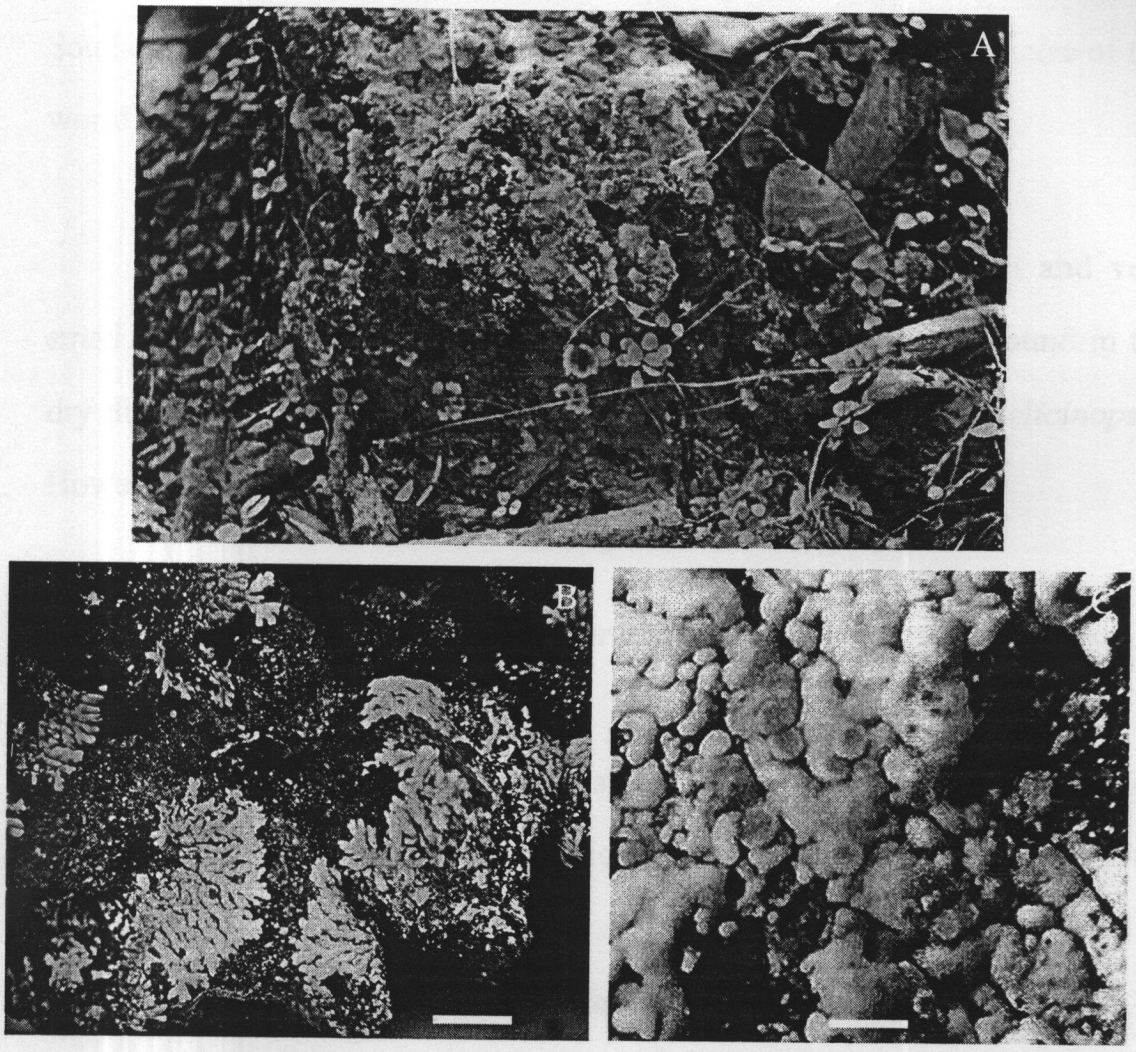


Figure 95 Genus *Xanthoparmelia* (Vain.) Hale

Note: A. Habitat of *Xanthoparmelia* which only occurs on rocks.

B. Thallus tightly adnated on rock [RU——10340 (RAMK), scale = 4 mm].

C. Disc-like apothecia on laminal lobes [RU——10331 (RAMK), scale = 0.7 mm].

Distribution: cosmopolitan such as temperate region, tropical region, Southern Africa, Asia, Australia, even in the hot and semi-arid climates of the world.

Observation: This genus is characterized by yellow-green and very small lobes and often occurring on rock. Only two species were found in the dry dipterocarp forests of Thailand. The apperence is similar to *Relicinopsis*. However, these genera have a different chemical constituent.

Key to the species of *Xanthoparmelia*

1a Lobes scattered, sparsely globose isidia.....*X. congensis*

1b Lobes contiguous, densely cylindrical and black tip isidia...*X. mougeotina*

Description of the species of *Xanthoparmelia*

1. *Xanthoparmelia congensis* (Stein.) Hale, *Phytologia* 28: 486, 1974

Basionym: *Parmelia congensis* Stein., *Schles. Ges. Vartel. Cult.* 66: 140, 1889

Figure 96

Thallus foliose to subcrustose, very tightly adnate; lobes moderately discrete, scattered like radial performing, narrow, linear, irregularly to subdichotomously branched, 0.1- 0.5 mm wide; margins entire, apices

markedly incised; upper surface green-yellow, smooth, continuous to irregularly cracked at the center of thallus, becoming areolate, 10 μm thick; isidia sparse, globose, simple, less than 0.2 mm high; medulla white, 45-60 μ m thick; lower surface black, somtime scatter with dark brown zone, 10 μm thick; rhizines sparse, black, simple, up to 0.5 mm long; **apothecia** and **pycnidia** not seen.

Chemistry: Cortex containing usnic acid (K-) and medulla containing stictic acid, constictic acid, norstictic acid, cryptostictic acid and menegazziaic acid (K+ yellow turning red, C-, KC-, and P+ orange).

Habitat: Mostly on rocks in the dry dipterocarp forests at 200-700 m elevations.

Distribution: North and South America, Africa (Zaire, Uganda, South Africa), Asia (India, Thailand), and Australia.

Specimens examined: N Thailand. Lampang Province: Khuntan National Park, on roadside to the entrance of the National Park, on rock, 1998, *T. Pooprang*, RU——10324 (RAMK). **NE Thailand.** Sakon Nakhon Province: Phupan National Park, Pha Nang Moen, on rock in the dry dipterocarp forest, 1997, *T. Pooprang*, RU——10340 (RAMK).

Observation: This species is characterized by globose isidia and radial-like forming thallus.

2. *Xanthoparmelia mougeotina* (Nyl.) D. J. Galloway, *New Zealand J. Bot.* 18: 538, 1981

Basionym: *Parmelia mougeotina* Nyl., *Lich. Nov. Zel.* 27, 1888

Figure 97

Thallus foliose to subcrustose, very tightly adnate; lobes subdichotomously branched, moderately contiguous to imbricate, rosette-like forming, narrow, linear to elongate, 0.1-1 mm wide, margins entire, apices incised; upper surface pale yellow-green, yellow-brown to black at the center, flat to slightly concave, shiny at lobe apices, smooth to irregularly cracked at thallus center, 10 μm thick; isidia dense, subglobose to cylindrical, simple, fragile to robust, black tip apices, more than 0.2 to 0.5 mm high; medulla white, 60-85 μm thick; lower surface flat, wholly black or partly dark brown, shiny, 15 μm thick; rhizines sparse, simple, black, up to 0.5 mm long; **apothecia** sessile, laminal, up to 1 mm wide; disc concave, dark brown; thalline exciple entire, smooth; ascospores hyaline, simple, ellipsoid to subglobose, 5-10 x 3.5-7 μm; **pycnidia** not seen.

Chemistry: Cortex containing usnic acid (K-) and medulla stictic acid, constictic acid, norstictic acid, cryptostictic acid and menegazziaic acid (K+ yellow, C-, KC-, and P+ orange).

Habitat: On rock in the exposed area of the dry diptrocarp forest at 900 m elevation.

Distribution: India, Thailand, Hong Kong, Australia, and New Zealand.

Specimens examined: N Thailand. Lampang Province: Khuntan National Park, the trial to Yaw 2, on rock, 1998, *T. Pooprang*, RU——10331 (RAMK).

Observation: *Xanthoparmelia mougeotina* differs from *X. congensis* in the presence of cylindrical and black tip isidia of the former species, while *X. congensis* has globose isidia.

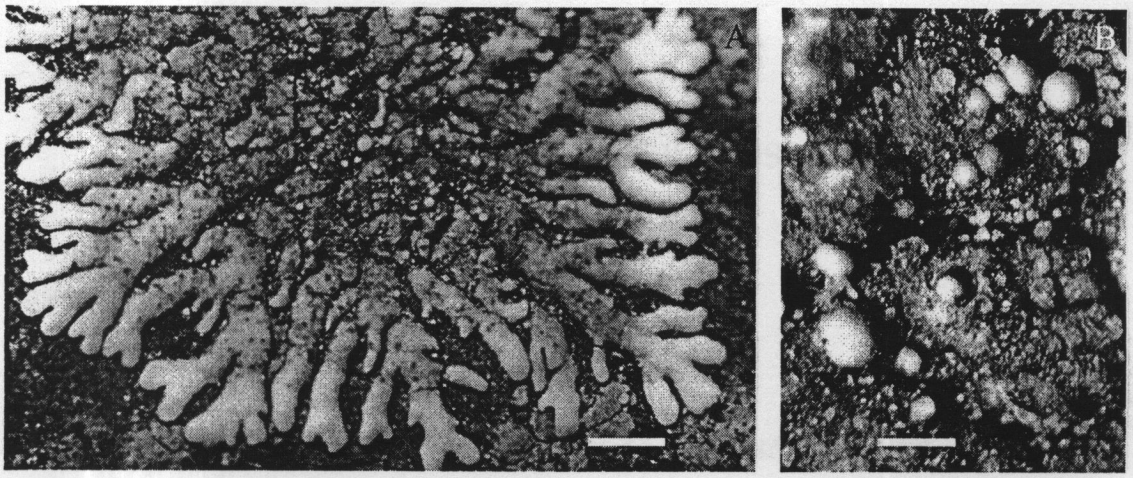


Figure 96 *Xanthoparmelia congensis* (Stein.) Hale

Note: A. Thallus yellow-green with radial orientation of discrete lobes [RU——10324 (RAMK), scale = 0.1 cm[.

B. Globular isidia [RU——10324 (RAMK), scale = 0.2 mm].

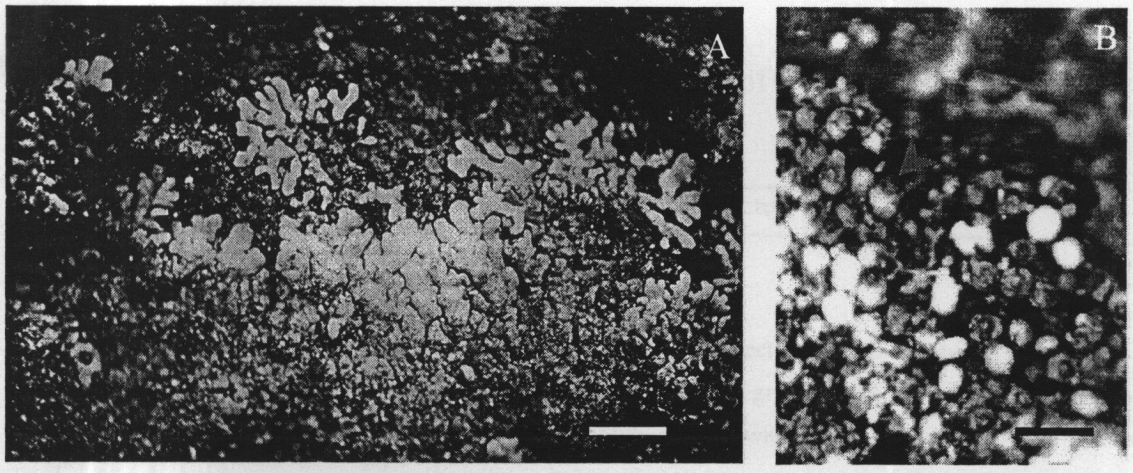


Figure 97 *Xanthoparmelia mougeotina* (Nyl.) Galloway

Note: A. Thallus yellow-green with irregular orientation of contiguous lobes [RU——10331 (RAMK), scale = 0.1 cm].

B. Cylindrical isidia with black tip (arrow) [RU——10331 (RAMK), scale = 0.2 mm].

CHAPTER 6

CONCLUSIONS AND DISCUSSION

Taxonomic Conclusions

This study includes 1,521 specimens of the parmelioid lichens belong to the family Parmeliaceae. They were determined into fourteen genera and seventy-five species. Globally, this group consists of thirty-seven genera and approximately 1,300-1,500 species (DePriest 1999). Taxonomic features of the parmelioid lichens used for determining into genera are presented in Table 5 (Elix 1993; 1994).

Table 5 Morphological and Anatomical Characters of the Parmelioid Lichens

Structures	Characters
— Epicortex	Pored or nonpored epicortex
— Cell-wall polysaccharides	Lichenan or isolichenan
— Upper and lower cortex	Paraplectenchymatous or palisade plectenchymatous tissue
— Color of upper cortex	Yellow-green, green-gray, or yellow-gray
— Color of lower cortex	White to ivory, pale brown, dark brown or black
— Cilia	Simple, bulbate, branched or absent
— Rhizines	Simple, dichotomously branched, dimorphous, or squarrose
— Maculae	Reticulate, effigurate, spotted or absent
— Lobes	Linear, sublinear, elongate or dichotomous
— Vegetative propagules	Isidia, soredia, lobules, and pustules
— Apothecial	Sessile, substipitate, stipitate, perforate, imperforate or absent
— Ascus and Ascospore	Bitunicate ascus and hyaline, simple, ellipsoid or reniform ascospores
— Pycnidial and conidia	Position of pycnidia and conidia shape

At present, techniques on chemistry have been improved lichen secondary metabolic products plays important roles in species identification. As consequences, many new species under the family Parmeliaceae were established by Hale and Elix. *Parmelia* is a large and widespread genus. It was segregates into *Hypotrachyna*, *Parmotrema*, and *Xanthoparmelia* by Hale, Kurokawa, Elix and other lichenologists by using secondary metabolites as well as morphology as the main characters for separation (Sipman and Aptroot 2001).

Five species in three genera were described as new to Thailand. These are *Everniastrum scabridum, Hypotrachyna chlorobarbatica, Hypotrachyna ramkhamhaengiana, Parmotrema rubromarginatum,* and *Parmotrema thailandicum. Parmelinella chozoubae* was renamed replacing *Parmelina chozoubae.* Twenty-nine species were new records in Thailand (Pooprang *et al.* 1999). These are *Bulbothrix hypochraea, B. meizospora, B. queenslandica, B. sensibilis, Canomaculina subtinctoria, Hypotrachyna adducta, H. adjuncta, H. coorgiana, H. immaculata, H. physcioides, H. masonhalei, Parmelinella chozoubae, Parmelinopsis horrescens, P. microlobulata, P. minarum, Parmeliopsis ambigua, Parmotrema abessinicum, P. corniculans, P. elaninulatum, P. hababianum, P. incrassatum, P. overeemii, P. planatilobatum, P. psuedonilgherrense, P. subarnoldii, P. sulphuratum, Relicinopsis malaccensis, Xanthoparmelia congensis,* and *X. mougeotina.*

Generic conclusions of fourteen genera in this study are summarized below.

Bulbothrix composes of eight species from about 43 species (Hale and DePriest 1999; Kurokawa and Lai 2001). The most common species is *B. isidiza*. Six genera contain salazinic acid in the medulla. Only one species, *B. goebelii* contains gyrophoric acid, whilst *B. queenslandica* possesses only atranorin and chloroatranorin. This genus is widely distributed in several habitats and ecosystems.

Canomaculina subtinctoria contains salazinic acid, consalazinic acid and norlobaridone in the medulla. Only one sample of this species was collected from bark in the Dry evergreen forest in northeastern Thailand. This genus consists of 22 species worldwide (Hale and DePriest 1999).

Canoparmelia is recognized by narrow eciliate lobes, about 39 species have been described worldwide (Hale and DePriest 1999). Two species were recognized in this study. *C. ecaperata* contains atranorin and usnic acid in the upper cortex, whilst *C. owariensis* contains only atranorin in the cortex and only occur on rock. The medulla of both species contains divaricatic acid group.

Everniastrum comprises of about 31 species worldwide. This study found three species. A new species, *E. scabridum* is described from Doi Suthep-Pui National Park, Chiang Mai Province. It contains protocetraric acid, protolichesterinic acid and lichesterinic acid (Pooprang *et al.* 1999). Two common species are *E. cirrhatum* and *E. nepalense*. Both species contain salazinic acid in the medulla, the difference lies on position of rhizines. Two species are commonly found on soil and bark.

Hypotrachyna consists of fifteen species. They are identified based on twenty-eight lichen substances found in the medulla of this genus. *H. osseoalba* is the only species that contain lichexanthone in the upper cortex. It is the most widely distributed species. Other species contain atranorin in the cortex. Barbatic acid and 4-*O*-demethylbarbatic acid are common medullary lichen substances, which are presented in six species. Most importantly, two new species, *H. chlorobarbatica* and *H. ramkhamhaengiana* are described. They were collected from Khao Yai National Park, Nakhon ratchasima and Phupan National Park, Sakon nakhon respectively (Pooprang *et al.* 1999). This genus is distributed in the Lower montane forest at altitudes above 900 meter. The new species, *H. ramkhamhaengiana,* only occurs in the Dry evergreen forest at the altitude about 300 meter. *Hypotrachyna* represents by about 138 species in the world.

Myelochroa consists of two species, which are *M. siamea* and *M. xantholepis*. The upper cortex appears grayish yellow from the pigment of secalonic acid A, which is deposited in the medulla. Other medullary substances in this genus are eumitrin, galbinic acid and zeorin. They occur on bark and rock at the lower montane forest. This genus represents by 22 species worldwide.

Parmelinella consists of two species, which are *P. chozoubae* and *P. wallichiana.* The two species are similar on the presence of salazinic acid and consalazinic acid in the medulla. The difference depends on the presence of isidia on the upper cortex of *P. wallichiana.* This species is widely distributed in every forest types. There are 4 species of this genus in the world. *P.*

chozoubae was recently renamed by Elix and Pooprang to replace the formally known *Parmelina chozoubae* (Singh and Sinha 1993; Pooprang *et al.* 1999), which is characterized by presence of simple cilia in axils of lobes.

Parmelinopsis composes of four species. The two common species are *P. microlobulata* and *P. expallida*. They contain protolichesterinic acid and lichesterinic acid (fatty acid) in the medulla. *P. horrescens* and *P. minarum* possess similar medullary substances such as gyrophoric acid and hiascic acid derivatives. The morphology of both species are similar, the difference lies on the presence or absence of cilia on isidia. This genus is common in the lower montane forest. The genus is represented by 23 species worldwide.

Parmeliopsis in this study contains only one species from 3 species globally, *P. ambigua,* is a rare species. It possesses divaricatic acid and subdivaricatic acid. Only one sample was collected from Doi Khuntan National Park, Lampang.

Parmotrema is a large genus comprises of twenty-eight species, whilst more than 224 species have been known worldwide (Hale and DePriest 1999). They contain two cortical substances and twenty-two medullary substances. This genus is common inhabitor of the canopy. They are found on all kinds of substrates, on wide ranges of elevations and forest types. The most common species is *P. tinctorum*, which possesses lecanoric acid. The rare species, *P. sulphuratum* contains vulpinic acid and yellow pigment in the medulla. Two new species are described, *P. rubromarginatum* and *P. thailandicum* from Khao Yai National Park, Nakhon ratchasima and Phu Hin Rong Kla National Park, Phitsanulok respectively (Pooprang *et al.* 1999). The major lichen

substances are protocetreric acid, which is presented in 11 species, and alectoronic acid occurs in 8 species. Barbatic acid is the rare medullary substance, which found in only one species, *P. explanatum*. Hale (1965) considered morphological characters for distinguishing species of the *Parmotrema*. These include the presence or absence of vegetative propagules, cilia, maculae, and color of the cortex. Krog and Swinscow (1981) emphasized the significance of spore and conidial characters among taxa of the *Parmotrema*, but downplayed the importance of some morphological features and chemical variation.

Relicina consists of three species. Global reports consist of about 47 species. *R. abstrusa* and *R. subabstrusa* are closely related on their chemistry which contain norstictic acid, connorstictic acid and hyposalazinic acid. The difference between them is the presence of isidia on *R. abstrusa*. *R. sublimbata* possesses succinprotocetraric acid, fumarprotocetraric acid and protocetraric acid. This genus occurs in the Tropical rain forests, the Dry dipterocarp forests and on rock outcrops.

Relicinopsis composes of three out of five species in the world. The two common species are *R. rahengensis* and *R. malaccensis*. Both of them have isidia, but *R. rahengensis* contains barbatic acid, 4-o-demethylbarbatic acid and echinocorpic, whereas *R. malaccensis* has protocetraric acid. *R. intertexta* is different from two species on the absence of isidia and the presence of protocetraric acid and protolichesterinic acid. This genus is commonly found in the Dry dipterocarp forests and on rock outcrops.

Rimelia consists of only one species, *R. reticulata*. This species has soredia on terminal laciniate lobes and cilia, as well as containing salazinic acid. There are about 16 species reports in the world.

Xanthoparmelia is the largest genus of the family Parmeliaceae, comprises of more than 473 species worldwide. There are two saxicolous species *X. congensis* and *X. mougeotina*. Both species contain norstictic acid, stictic acid, cryptostictic acid and menegazziaic acid. The difference is based on characters of the isidia. Both species occur on rocks in the Dry dipterocarp forest.

Lichen substances are important for identification lichens into species level. Sixty-four substances were found in this study according to Table 4 and Appendix 2.

Physiography and biodiversity of Thailand are diverse. Intensive study during two years of this project is unable to discover complete taxa of the Parmeliaceae. However, this type of study has never performed by the indigenous botanists. It may be regarded as another milestone of achievement in lichen taxonomy. Extensive surveys throughout the country need to be carried on.

Taxonomic Discussion

Genus Concept

In general, genus concept relies on morphology rather than chemical characters. Many genus have been segregated on the basis of differences in ascomata characters, including ascus, ascospores, and paraphyses. But thallus features of the Parmeliaceae are accounted for more than the ascomata due to growth from of these lichens is normally presence in the sterile state. Category of a genus comprises of combined characters. It is inappropriate to initiate a new genus base on single character. Therefore, Hale, Elix and the other lichenologists separated new genera of the parmelioid lichens, by combining chemical characters, fine structures of the cortex and morphological characters (Elix 1993; 1994; DePriest 1999; Hale 1973; 1981; 1984; Hale and DePriest 1999). Approximately 50% of total species in this study were collected with apothecia whereas about half of the specimens were in sterile state. Therefore, concepts of Hale and Elix were used in this study. Altogether the specimens comprise of seventy-five species in fourteen genera.

Species Concept

According to some lichenologists a species should always be recognized on the basis of morphological characters (Almborn 1965). Other lichenologists rule out that two morphologically identical taxa comprising

different secondary chemistries might reasonably be treated as different species (Thell 1996). Brodo provided an excellent discussion on the different possible interpretations of chemical variation in lichen taxonomy (Brodo 1986). Although it is often somewhat impractical to recognize identical morphologically as the same taxa, the final decision should, in principal, depends on how many separating features are presented and if they correlate with other characters (Thell 1996). With advance of equipments and techniques, taxonomic views have continuously changed since Linnaeus' proposed his system of binomial nomenclature. All lichenologists, who are as the lichens they study, hold no universal view (Thell 1996).

Thallus ornamentation and vegetative propagules as well as the medullary substances are important characters useful for characterizing taxa. Species that usually lack apothecia are frequently produced pycnidia and vegetative diaspores. Vainio's classification, used by almost all lichenologists, is based on color of the thallus (presence or absence of usnic acid), a character which is considered to be of secondary importance. Presence or absences of isidia, soredia as well as other morphological and chemical characters are also considered. Maculae, cilia, and perforate apothecia all show a high degree of association. Spore size is less important to identify species in the parmelioid lichens (Hale 1965).

Pycnidia occur in forty-two species of the total observation. Four genera were absent of pycnidia on the upper cortex. These are *Canomaculina, Myelochroa, Parmelinopsis, and Parmeliopsis*. Bifusiform conidia were found in eighteen species of six genera, for example, seven species of *Hypotrachyna*,

three species of *Everniastrum* etc. Sublageniform conidia usually occur in twelve species of *Parmotrema*. Whilst, filiform conidia appear in *Rimelia reticulata* and four species of *Parmotrema,* for example, *Parmotrema corniculans, P. eunetum, P. pseudonilgherrense,* and *P. tinctorum.* Louwhoff and Elix indicated the relationship between filiform conidia and perforate apothecia among few species (Louwhoff and Elix 1999, 19). This evidence was observed in *Parmotrema eunetum* and *P. tinctorum*, whereas the other two species were found in sterile state rather than fertile state. In the other cases, cooccurrence of sublageniform conidia and imperforate apothecia are observed among some species of the *Parmotrema.*

Figure 98 show that thirty-five species produced both apothecia and pycnidia, twenty-six species absent of these characters, seven species only produced apothecia, and seven species only produced pycnidia. It is important to note that species, which are absent of apothecia and pycnidia often produce vegetative propagules. Apothecia including ascus and ascospores may be disregarded due to most macrolichen are in sterile state in nature. Although 50% of total species have apothecia, but most specimens collected in this study were in sterile state. Therefore asexual reproduction and vegetative propagules as well as lichen substances were used for identification into taxa. Pycnidia and conidia characters could be emphasized in future study for increasing potential technique for determination.

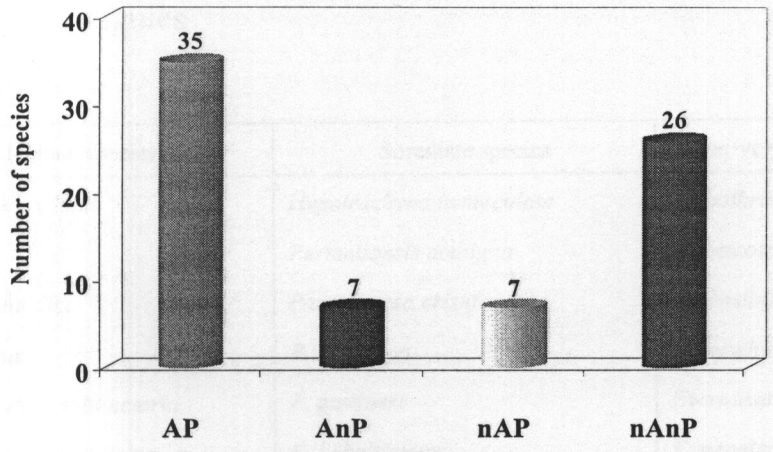


Figure 98 Comparing Number of Species that Produce Apothecia and Pycnidia

Note: AP = Apothecia and Pycnidia present; AnP = Apothecia present and pycnidia absent; nAP = Apothecia absent and pycnidia present; nAnP = Apothecia and pycnidia absent

Some of structures serve as vegetative diaspores for dispersal of the lichens and may have special physiological functions. Reproduction by soredia and isidia are an adaptation of the symbiotic role. As these diaspores disperse both partners of the symbiosis together, grow into new lichen thalli (Jahns 1973). It is possible that the isidia serve to increase the surface area and presumably the assimilative capacity of the thallus. From investigation, lichens that produce isidia or soredia are unlikely to produce ascomata. Forty-six species, about 60% of a total species produced vegetative propagules. Table 6 shows that 24 species has isidia. Soredia are presented in 14 species. Whilst twenty-nine species, about 40 % of the total species, do not produced vegetative propagules. Species produced pustules and lobules consist of 8 species, which were not included in Table 6.

Table 6 Parmelioid Species with Isidia, Soredia, and without Non-Vegetative Propagules

Isidiate species	Sorediate species	Non-vegetative propagules species
Bulbothrix goebelii	*Hypotrachyna immaculata*	*Bulbothrix hypochraea*
B. isidiza	*Parmeliopsis ambigua*	*B. meizospora*
B. queenslandica	*Parmotrema cristiferum*	*B. sensibilis*
B. tabacina	*P. dilatatum*	*B. setschwanensis*
Canomaculina subtinctoria	*P. gardneri*	*Everniastrum cirrhatum*
Canoparmelia ecaperata	*P. hababianum*	*E. nepalense*
Hypotrachyna costaricensis	*P. poolii*	*E. scabridum*
H. crenata	*P. praesorediosum*	*Hypotrachyna adducta*
H. ramkhamhaengiana	*P. pseudonilgherrense*	*H. chlorobarbatica*
Parmelinella wallichiana	*P. rampoddense*	*H. coorgiana*
Parmelinopsis expallida	*P. rubromarginatum*	*H. ducalis*
P. horrescens	*P. sancti-angelii*	*H. masonhalei*
P. minarum	*P. subarnoldii*	*H. physcioides*
Parmotrema incrassatum	*Rimelia reticulata*	*H. scytodes*
P. mellissii		*Myelochroa siamea*
P. pseudocrinitum		*Parmelinella chozoubae*
P. saccatilobum		*Parmotrema abessinicum*
P. sulphuratum		*P. amaniense*
P. tinctorum		*P. corniculans*
Relicina abstrusa		*P. elacinulatum*
Relicinopsis malaccensis		*P. eunetum*
R. rahengensis		*P. explanatum*
Xanthoparmelia congensis		*P. maclayanum*
X. mougeotina		*P. merrillii*
		P. overeemii
		P. thailandicum
		Relicina subabstrusa
		R. sublimbata
		Relicinopsis intertexta

Parmotrema, the largest genus in this study, has twenty-eight species. They can be easily grouped into three forms as follow: Sorediate group consists of eleven species, non-vegetative propagules group has ten species, and isidiate groups are presented by six species. Only one species, *P. planatilobatum*, produce lobules and cilia.

Some genus has specific characters for identification to species. For example, the texture of *Parmotrema* can be coriaceous (thick and leathery) or membranaceous (thin and papery). This feature is never used as a primary character because it varies by the environment. However, it may be used in combination with other characters. For example, *Parmotrema tinctorum* may has thin, membanaceous thalli in shade habitat, but the same species in a drier, sunny habitat and extreme environment may produce smaller and thicker coriaceous thalli (Louwhoff and Elix 1999). *Parmotrema* is often mistake with *Rimelia* and *Canomaculina* on general morphology. However, the former is absent of distinct maculae on the upper surface.

Chemical Discussion

Lichen substances are secondary metabolic products, which play significant roles as antibiotic, alleopathic substances, anti-herbivore compounds as well as light screening pigments (Rundal 1978). Sixty-four lichen substances were found in fourteen genera and seventy-five species. Each genus produces lichen substances that have been used for determination to species as presented in Table 7 to Table 17.

Table 7 Lichen Substances Occur among Species of the Genus *Bulbothrix*

Bulbothrix	atranorin	chloroatranorin	gyrophoric acid	salazinic acid
B. goebelii	+	+	+	
B. hypochraea	+	+		+
B. isidiza	+	+		+
B. meizospora	+	+		+
B. queenslandica	+	+		
B. sensibilis	+	+		+
B. setschwanensis	+	+		+
B. tabacina	+	+		+

Table 8 Lichen Substances Occur among Species of the Genus *Canoparmelia*

Canoparmelia	atranorin	chloroatranorin	divaricatic acid	nordivaricatic acid	subdivaricatic acid	usnic acid
C. ecaperata	+	+	+	+	+	+
C. owariensis	+	+	+		+	

Table 9 Lichen Substances Occur among Species of the Genus *Everniastrum*

Everniastrum	atranorin	chloroatranorin	conprotocetraric acid	lichesterinic acid	protocetraric acid	protolichesterinic acid	salazinic acid	virensic acid
E. cirrhatum	+	+					+	
E. nepalense	+	+					+	
E. scabridum	+	+	+	+	+	+		+

Table 10 Lichen Substances Occur among Species of the Genus *Hypotrachyna*

Hypotrachyna	atranorin	barbatic acid	chloroatranorin	5-chloro-4-o-demethylbarbatic acid	coechinocarpic acid	colensoic acid	consalazinic acid	constictic acid	4-o-demethylbarbatic acid	4-o-demethylphysodic acid	echinocarpic acid	hirtifructic acid	lichexanthone	lividic acid	menegazziaic acid	methyl-5-chloro-4-o-demethylbarbatate	4-o-methylphysodic acid	norobtusatic acid	norstictic acid	obtusatic acid	oxyphysodic acid	physodic acid	pigmentosin A	protocetraric acid	protolichesterinic acid	salazinic acid	secalonic acid	stictic acid
H. adducta	+		+																									
H. adjuncta	+	+	+		+				+		+																	
H. chlorobarbatica	+	+	+	+					+							+												
H. coorgiana	+	+	+				+																					
H. costaricensis	+	+	+																									
H. crenata	+	+	+					+							+				+									
H. exsecta	+	+	+						+																			
H. immaculata	+	+	+			+				+				+			+											
H. kingii	+	+	+																									
H. masonhalei	+	+	+															+	+									
H. osseoalba						+				+			+	+			+				+	+						
H. physcioides	+	+	+						+			+								+								
H. ramkhamhaengiana	+		+				+																+					
H. scytodes	+	+	+						+		+	+												+		+		+

In some case, for example, *Hypotrachyna chlorobarbatica, H. ducalis, H. physcioides,* and *H. scytodes*, are tentatively called the *H. physcioides* group (Kurokawa 1986). They have identical morphology by possessing non-vegetative propagules and contain barbatic acid as a major substance in the medulla. Each species differs in having different associate substances, as shown in Table10. Consequently, it is difficult to identify these species by only morphological characters. It is necessary to detect these substances by using TLC or HPLC methods. Only one species, *H. osseoalba*, produces lichexanthone in the upper cortex, which can detect by using fluorescent in longwave ultraviolet light. This substance appears brilliant yellow on the upper cortex.

Table 11 Lichen Substances Occur among Species of the Genus *Myelochroa*

Myelochroa	atranorin	chloroatranorin	eumitrin	galbinic acid	pulvinic acid	secalonic acid A	zeorin
M. siamea	+	+	+	+		+	+
M. xantholepis	+	+			+	+	

Table 12 Lichen Substances Occur among Species of the Genus *Parmelinella*

Parmelinella	atranorin	chloroatranorin	consalazinic acid	salazinic acid	secalonic acid A
P. chozoubae	+	+	+	+	
P. wallichiana	+	+	+	+	+

Table 13 Lichen substances Occur among Species of the Genus *Parmelinopsis*

Parmelinopsis	alectoronic acid	atranorin	chloroatranorin	4,5-di-o-methylhiascic acid	2,4-di-o- methylhiascic methylgyrophoric acid	gyrophoric acid	hiascic acid	lecanoric acid	lichesterinic acid	5-o-methylhiascic acid	3-methoxy-2,4-di-o-methylgyrophoric acid	protolichesterinic acid	2,4,5-tri-o-methylhiascic acid	umbilicaric acid
P. expallida	+	+	+									+		
P. horrescens	+	+	+	+	+	+	+			+	+		+	+
P. microlobulata	+	+	+						+			+		
P. minarum	+	+	+			+	+	±		+	+		+	+

Parmelinopsis horrescens and *P. minarum* have chemically identical by the presence of gyrophoric acid and derivative compounds, including hiascic acid and derivative compounds. These substances show on tlc-plate or can be identified by HPLC method, but they cannot detedct by simple spot test. In this case, spots on tlc-plate are mixtures of two or three substances, which appear together on the similar R_f class (as shown in Appendix 2).

The genus *Parmotrema* has protocetraric acid as the major substance. It consisted of eleven species. Their medulla react P+ yellow, orange to red. Alectoronic acid was found in eight species, which mainly appeared together with α-collatolic acid. Both substances fluorescent under UV light by giving white-blue at the medulla.

Table 14 Lichen Substances Occur among Species of the Genus *Parmotrema*

Parmotrema	*P. abessinicum*	*P. amaniense*	*P. corniculans*	*P. cristiferum*	*P. dilatatum*	*P. elacinatulum*	*P. eunetum*	*P. explanatum*	*P. gardneri*	*P. hababianum*	*P. incrassatum*	*P. maclayanum*	*P. mellissii*	*P. merrillii*	*P. overeemii*	*P. planatilobatum*	*P. poolii*	*P. praesorediosum*	*P. pseudocrinitum*	*P. pseudonilgherrense*	*P. rampoddense*	*P. rubromarginatum*	*P. saccatilobum*	*P. sancti-angelii*	*P. subarnoldii*	*P. sulphuratum*	*P. thailandicum*	*P. tinctorum*
alectoronic acid		+	+									+	+				+			+	+							
atranorin	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
barbatic acid								+				+	+				+											
chloroatranorin	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
α-collatolic acid		+	+										+															
conalectoronic acid												+					+											
echinocarpic					+																							
gyrophoric acid							+									+			+									
lecanoric acid							+									+			+									
lichesterinic acid						+																						
loxodin	+									+																		
methylvirensate		+																										
norlobaridone	+									+																		
praesorediosic acid																	+											
protocetraric acid		+			+	+			+		+			+	+						+		+				
protolichesterinic acid						+								+	+						+		+			+	
red pigment																					+							
salazinic acid				+																								
skyrin														+														
subalectoronic acid																				+								
usnic acid					+								+				+			+								
virensic acid											+			+	+													
vulpinic acid																										+		

Table 15 Lichen Substances Occur among Species of the Genus *Relicina*

Relicina	connorstictic acid	fumarprotocetraric acid	hyposalazinic acid	norstictic acid	protocetraric acid	succinprotocetraric acid	usnic acid
R. abstrusa	+		+	+			+
R. subabstrusa	+		+	+			+
R. sublimbata		+			+	+	+

Table 16 Lichen Substances Occur among Species of the Genus *Relicinopsis*

Relicinopsis	atranorin	barbatic acid	4-o-demethylbarbatic	echinocarpic acid	protocetraric acid	protolichesterinic acid	usnic acid
R. intertexta	±				+	+	+
R. malaccensis					+		+
R. rahengensis		+	+	+			+

Table 17 Lichen Substances Occur among Species of the Genus *Xanthoparmelia*

Xanthoparmelia	constictic acid	menegazziaic acid	norstictic acid	stictic acid	usnic acid
X. congensis	+	+	+	+	+
X. mougeotina	+	+	+	+	+

Among the *Xanthoparmelia*, stictic acid is the major substance that usually presents together with minor substances, which are derivative of stictic acid such as constictic acid, menegazziaic acid, etc.

Three genera in this study have only one member species. These are *Canomaculina subtinctoria, Parmeliopsis ambigua,* and *Rimelia reticulata. Parmeliopsis ambigua* can be characterized by presence of soredia and the yellowish green upper surface, which contains usnic acid and divaricatic acid. *C. subtinctoria* and *R. reticulata* are similar in the presence of maculae on the upper cortex. This character is also presented by *Parmotrema*. Although they also have identical morphology, but they can be segregated by chemical characters.

Distribution and Ecological Discussion

The parmelioid lichens distribute throughout various elevation gradients, substrate, climate, as well as other environmental conditions. They inhabit bark, rock and soil, which are refered as corticolous, saxicolous, and terricolous. Corticolous species were found on bark of trunks, twigs or branches of fifty host plants. It also includes fallen branches of unidentified trees on the forest floor. This group was generally found in the Lower montane forest, but they were occasionally presented in the Mangrove forest. The second group is saxicolous, which often found in the Lower montane forest, and the Dry dipterocarp forest. Terricolous among the parmelioid lichens are *Everniastrum cirrhatum* and *E. napalense*.

Intensive survey in eight types of forests and two plantations found a total of 75 species in 14 genera as shown in Table 18 and Figure 99. Distributions of some genera are specific. *Everniastrum*, *Hypotrachyna* and *Parmelinopsis*, were mostly collected from the Lower montane forest at altitude above 1,000 meters in the north and the northeast of Thailand. *Everniastrum* occurs in the Lower montane forest above 1,000 meters elevations in the north of Thailand. At Doi Inthanon National Park, *Everniastrum* inhabits on soil and abundant on bark and twig of *Rhododendron* sp.. Four species of *Parmelinopsis* occurred on rock and tree trunks in the Lower montane forest.

Of the fifty-one species occurred in the Lower montane forest, twenty-two species are restricted to this forest. The Dry evergreen forest houses only ten species of the parmelioid lichens. This may be due to incomplete collection in this type of forest because samples from upper branches or canopies were inaccessible. On the other hand, crustose lichens seem to be common inhabitors in this forest more than macrolichens. *Parmeliopsis ambigua* is a rare species. Only one sample was collected from the Pine forest in Doi Khuntan National Park, Lampang Province.

The Mixed deciduous forest has the second highest diversity of thirty-four species. Most specimens were collected at the Queen Sirikit Botanic Garden, Chiang Mai Province. The garden comprises of this kind of forest with the Dry dipterocarp forest is the main forest type.

Table 18 Species Composition of the Parmelioid Lichens in Various Forests in Thailand

	Parmelioid lichens	Forest types									
		LMF	DEF	PF	MDF	DDF	TRF	MF	SF	PO	RP
1	*Bulbothrix goebelii*	+			+						
2	*B. hypochraea*	+			+		+				
3	*B. isidiza*	+	+	+	+	+				+	
4	*B. meizospora*			+	+	+					
5	*B. queenslandica*					+					
6	*B. sensibilis*		+		+						
7	*B. setschwanensis*				+						
8	*B. tabacina*	+	+		+	+			+		
9	*Canomaculina subtinctoria*		+								
10	*Canoparmelia ecaperata*	+		+	+	+				+	
11	*C. owariensis*	+									
12	*Everniastrum cirrhatum*	+									
13	*E. nepalense*	+		+							
14	*E. scabridum*	+								+	
15	*Hypotrachyna adducta*	+									
16	*H. adjuncta*	+			+						
17	*H. chlorobarbatica*	+									
18	*H. coorgiana*	+									
19	*H. costaricensis*	+									
20	*H. crenata*	+			+						
21	*H. ducalis*	+			+						
22	*H. exsecta*	+									
23	*H. immaculata*	+									
24	*H. kingii*	+									
25	*H. mason-halei*	+								+	
26	*H. osseoalba*	+			+						
27	*H. physcioides*	+			+						
28	*H. ramkhamhaengiana*				+						
29	*H. scytodes*	+			+						
30	*Myelochroa siamea*	+									
31	*M. xantholepis*	+									
32	*Parmelinella chozoubae*	+	+		+						
33	*P. wallichiana*	+	+		+	+					
34	*Parmelinopsis expallida*	+									
35	*P. horrescens*	+									
36	*P. microlobulata*	+					+			+	
37	*P. minarum*	+									
38	*Parmeliopsis ambigua*			+							
39	*Parmotrema abessinicum*				+						
40	*P. amaniense*	+									
41	*P. corniculans*	+									
42	*P. cristiferum*	+			+		+	+			+
43	*P. dilatatum*	+				+		+			
44	*P. elacinulatum*	+									
45	*P. eunetum*	+			+					+	
46	*P. explanatum*								+		

Table 18 (continued)

Parmelioid lichens	Forest types									
	LMF	DEF	PF	MDF	DDF	TRF	MF	SF	PO	RP
1. *P. gardneri*	+			+	+		+	+		
2. *P. hababianum*	+			+					+	
3. *P. incrassatum*				+						
4. *P. maclayanum*	+			+					+	
5. *P. mellissii*	+								+	
6. *P. merrillii*					+					
7. *P. overeemii*				+	+			+		
8. *P. planatilobatum*	+									
9. *P. poolii*				+	+			+		
10. *P. praesorediosum*		+		+	+	+		+		
11. *P. pseudocrinitum*		+		+						
12. *P. pseudonigherrense*				+						
13. *P. rampoddense*	+									
14. *P. rubromarginatum*					+			+		
15. *P. saccatilobum*							+			
16. *P. sancti-angelii*	+	+		+				+		
17. *P. subarnoldii*					+			+		
18. *P. sulphuratum*					+	+				
19. *P. thailandicum*	+									
20. *P. tinctorum*	+	+		+	+	+		+	+	+
21. *Relicina abstrusa*	+				+	+				
22. *R. subabstrusa*	+					+				
23. *R. sublimbata*					+					
24. *Relicinopsis intertexta*					+			+		
25. *R. malaccensis*	+			+	+	+	+			+
26. *R. rahengensis*	+			+	+					
27. *Rimelia reticulata*	+			+					+	
28. *Xanthoparmelia congensis*					+					
29. *X. mougeotina*					+					
Total number of species	51	10	5	34	23	9	5	11	11	3

Two species are specific to this forest; *Bulbothrix setschwanensis* and *Parmotrema abessinicum*. Twenty-three species were found in the Dry dipterocarp forest. The only two species of *Xanthoparmelia* found in this study were collected from the Dry dipterocarp forest. In addition, all species of *Relicinopsis* only collected from rocks and barks in this forest.

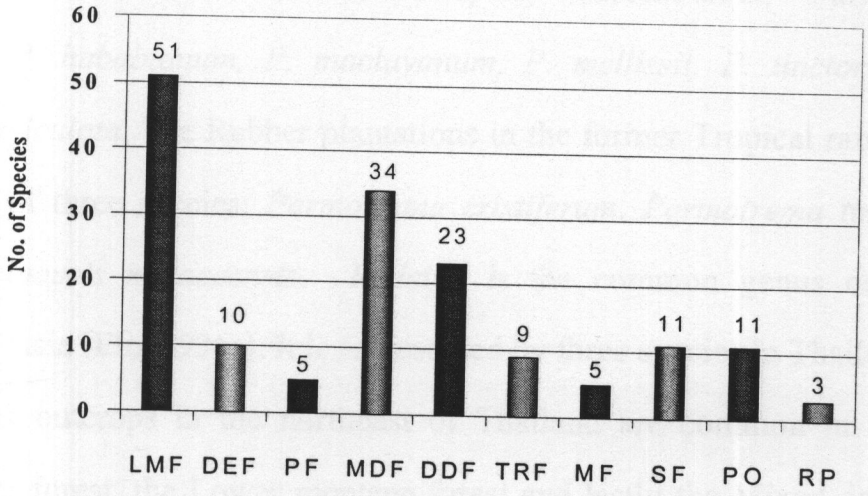


Figure 99 Diversity of the Parmelioid Species in Various Forest Types

Note: LMF = The Lower montane forest; DEF = The Dry evergreen forest; PF = The Pine forest; MDF = The Mixed deciduous forest; DDF = The Dry dipterocarp forest; TRF = The Tropical rain forest; MF = The Mangrove forest; SF = The secondary forest; PO = The Plub Orchard; RP = The Rubber plantation.

Nine species occurred in the Tropical rain forest. It is important to note that mostly specimens were collected in exposed sunny habitats and close to streams or waterfalls such as *Relicina abstrusa* and *R. subabstrusa*. The Mangrove forests comprise of five species of two genera; *Parmotrema cristiferum, P. dilatatum, P. gardneri, P. saccatilobum,* and *Relicinopsis malaccensis*. The Secondary forests are characterized by extreme environment, caused by exposure to intense sunlight. Eleven species were found. *Parmotrema* is the dominant genus in this forest.

Plub orchard in the Lower montane forest found eleven species; *Bulbothrix isidiza, Canoparmelia ecaperata, Everniastrum scabridum,*

Hypotrachyna mason-halei, Parmelinopsis microlobulata, Parmotrema eunetum, P. hababianum, P. maclayanum, P. mellissii, P. tinctorum, and *Rimelia reticulata.* The Rubber plantations in the former Tropical rain forests consisted of three species; *Parmotrema cristiferum*, *Parmotrema tinctorum*, and *Relicinopsis malaccensis*. *Relicina* is the common genus occurs in Southeast Asia (Elix 1996a). It is represented by three species in Thailand.

Rock outcrops in the northeast of Thailand are common in the Dry dipterocarp forest, the Lower montane forest and lastly the Mixed deciduous forest. Saxicolous species collected are *Canoparmelia owariensis*, *Xanthoparmelia congensis*, and *Xanthoparmelia mougeotina*. The parmelioid lichens in Thailand that commonly occupy on rocks are, for example; *Bulbothrix*, *Canoparmelia, Hypotrachyna, Parmelinella, Parmotrema, Relicinopsis,* and *Rimelia.*

Parmotrema is the largest genus of this family in Thailand, consists of 28 species. Of which 24 lichen substances were found. It is widespread in all substrates, elevations and forests. This genus was mostly found in the canopy of deciduous tree more than on trunks near the ground (Wolseley 1997). *Parmotrema tinctorum* is the most common weedy species. It is distinguished by broad lobe, cylindrical isidia and contains lecanoric acid, which medulla reacts C+ red. *Parmotrema saccatilobum* is restricted to the mangrove forest. This species has isidia and very similar externally to *P. tinctorum,* but it contains protocetraric acid in the medulla. The second common species, *Parmotrema gardneri* and *Parmotrema praesorediosum* have similar

structures but different chemistry. They contain protocetraric acid and praesorediosic acid respectively.

Hypotrachyna consists of fifteen species. Most species occur in the Lower montane forest, except *H. ramkhamhaengiana*, which was collected from the Mixed deciduous forest at the boundary between this forest and the Dry dipterocarp forest at about 300 m elevation.

The ten most widely distributed species are *Bulbothrix isidiza, B. tabacina, Canoparmelia ecaperata, Parmelinella wallichiana, Parmotrema cristiferum, P. gardneri, P. praesorediosm, P. sancti-angelii, P. tinctorum,* and *Relicinopsis malaccensis*. All of them flourish best in the Lower montane forests and the Mixed deciduous forests as well as on rock outcrops in the Dry dipterocarp forests in the north and the northeast of Thailand. These habitats have relatively high light intensities in certain season of the year, and most of these species possess atranorin, chloroatranorin and other substances, which are light screening substances. However, the lichen products of these groups are not much different from the others. Six of them possess isidia, and four species of *Parmotrema* produce soredia, which are the minute vegetative propagules.

The most widely distributed species of this family commonly contain atranorin and chloroatranorin. These two substances are also found in the other species. These species possess two or three other substances. These substances have unknown function in environmental point of view. However, these species possess isidia and soredia, which are minute vegetative

propagules and can be easily carried away by wind, rainwash and insect. Thus, these ten species are able to distribute abundantly.

In addition, *Relicinopsis malaccensis* that flourish in the Dry dipterocarp forest and on rock outcrops, which expose to bright light contain usnic acid. Usnic acid provides protective function against high light intensities reaching the algal layer in the upper cortex (Rundel 1978). It is reasonable to believe that the other sixty-four substances found in this study are associated with different environmental stress from various habitats where these lichens occupy. Although the function of these lichen substances are not well understood. Nevertheless, these products have promising prospect in biotechnology.

The parmelioid lichens in this study shares number of species with the other continents and countries, as shows in Table 19. Distribution maps of the parmelioid lichens in this study are based on investigation of individual species as shown in Appendix 3. These small maps present information where the parmelioid lichen are known to occur in Thailand.

Table 19 Number of Species of the Parmelioid lichens Found in Various Countries and Numbers of Species Share with Thailand

Continents and Countries	Number of Species		References
	Found	Shared with Thailand	
North America			
Adak Island, Alaska	19	-	Talbot *et al.* 1997
USA and Canada	293	17	Esslinger 1997
South America			
Venezuela	279	29	Feuerer 2000b
Ecuador and Galapagos Island	26	6	Feuerer 2001b
Peru	42	5	Feuerer 2001d
Bolivia	69	3	Feuerer 1999
Chile	62	12	Feuerer 2000a
Guianas	47	14	Sipman 1997
Brazil	299	29	Marcelli 2001
Uruguay	57	8	Osorio 2000
Argentina	272	11	Calvelo and Liberatore 2001
Europe			
Ukraine	117	1	Kondratyuk *et al.* 1996
Turkey	38	1	John 1996
Sweden and Norway	94	1	Santesson 1993
Great Britain and Ireland	52	4	Purvis *et al.* 1996
Germany	89	8	Wirth 2001
Italy	62	3	Nimis 1999
Africa			
Guinea	7	4	Thell 2001d
Sierra Leone	3	2	Thell 2001h
Ivory Coast	12	5	Thell 2001k
Tunisia	19	-	Seaward 1996
Cameroon	3	1	Thell 2001b
Angola	22	6	Thell 2001a
Namibia	41	-	Feuerer 2001e

Table 19 (continued)

Continents and Countries	Number of Species		References
	Found	Shared with Thailand	
Zaire	25	7	Thell 2001n
Ethiopia	67	18	Thell 2001c
Somalia	4	1	Thell 2001l
Uganda	131	24	Thell 2001m
Kenya	197	35	Thell 2001e
Rwanda	12	2	Thell 2001g
Tanzania	139	28	Thell 2001l
Zambia	4	1	Thell 2001o
Zimbabwe	23	3	Thell 2001p
Mozambique	7	1	Thell 2001f
Lesotho	36	-	Feuerer 2001a
South Africa	375	18	Feuerer 2001f
Madagascar	42	17	Feuerer 2001c
Temperate Asia			
China	150	-	Lai and Qian 1993
Hong Kong	15	9	Thrower 1988
South Korea	53	9	Park 1990
Taiwan	137	32	Lai 2000
Japan	54	6	Okamoto 1995
Tropical Asia			
India and Nepal	182	30	Awasthi 1988
Thailand	142	142	in this study and Appendix1
Papua New Guinea and Irian Jaya	77	20	Streimann 1986
Australasia and small Pacific Islands			
Australia	395	37	Elix 1994
New Zealand	127	10	Malcom and Galloway 1997
The smaller Pacific Islands	130	18	Elix and McCarthy 1998

APPENDIX 1

Historical Accounts of the Parmeliaceous Lichens Found in Thailand

Table 20 Historical Accounts of the Parmeliaceous Lichens Found in Thailand, with Original Published Names and Presently Accepted Name

Presently accepted names	Published nomenclature	Collecting localities	Reference
Bulbothrix goebelii (Zenker)Hale	*Bulbothrix subdissecta* (Nyl.) Hale	S, KC, DS, DI, UT	Feeya Amatawiwat, 1994
	Bulbothrix goebelii (Zenker)Hale		Hale, 1976
Bulbothrix isidiza (Nyl.) Hale	*Bulbothrix isidiza* (Nyl.) Hale	DS, DI, UT, S	Feeya Amatawiwat, 1994
Bulbothrix laevigatula (Nyl.) Hale	*Parmelia hookeri* Tayl.	DS	Vainio, 1921
Bulbothrix meizospora (Nyl.) Hale	*Bulbothrix meizospora* (Nyl.)Hale	KY	Kansri Boonpragob *et al.*, 1998
Bulbothrix pigmentacea (Hale) Hale	*Bulbothrix pigmentacea* (Hale) Hale	DI, DS, UT	Aguirre-Hudson & Wolseley, unpublished
Bulbothrix setschwanensis (Zahlbr.) Hale	*Bulbothrix setschwanensis* (Zahlbr.) Hale	DI, LP, UT	Aguirre-Hudson & Wolseley, unpublished
Bulbothrix subinflata (Hale) Hale	*Bulbothrix subinflata* (Hale) Hale	LP, UT	Aguirre-Hudson & Wolseley, unpublished
Bulbothrix tabacina (Mont & Bosch) Hale	*Bulbothrix tabacian* (Mont. & Bosch) Hale	DI, UT	Aguirre-Hudson & Wolseley, unpublished
	Parmelia meizosporoides C.W. Dodge	DI, DS	Sato, 1962
Canomaculina subtinctoria (Zahlbr.) Elix	*Parmelia subtinctoric* Zahlbr.	S	Feeya Amatawiwat, 1994

Table 20 (continued)

Presently accepted names	Published nomenclature	Collecting locality	Reference
Canoparmelia adspersa (Vain.) Elix & Hale	*Parmelia adspersa* Vain.	KC, LN	Vainio, 1909; Hale, 1965
	Pseudoparmelia adspersa (Vain.) Hale	-	Hale, 1976
Canoparmelia ecaperata (Mull. Arg.) Elix & Hale	*Parmelia ecaperata*Mull. Arg.	-	Hale, 1976
	Parmelia malaccensis Nyl.*var.laeteflavens* Vain.	DS	Vainio, 1921
	Canoparmelia ecaperata (Mull. Arg) Elix & Hale	KY	Kansri Boonpragob *et al.*, 1998
Canoparmelia owariensis (Asah.) Elix	*Parmelia owariensis* Asahina	-	Hale, 1976
Canoparmelia salacinifera (Hale) Elix & Hale	*Parmelia salacinifera* Hale	-	Hale, 1976
Canoparmelia texana (Tuck.) Elix & Hale	*Parmelia texana* Tuck.	-	Hale, 1976
Cetraria collata (Nyl.) W.L. Culb. & C. F. Culb.	*Cetraria collata f.isidiata* Asahina	DI, DS	Sato, 1962
Cetrariopsis wallichiana (Yaylor) Kurok.	*Cetrariopsis wallichiana* (Yaylor) Kurok.	DS	Vainio, 1921
Cetrelia braunsiana (Mull. Arg.) W.L. Culb.& C.F. Culb.	*Cetrelia braunsiana* (Mull. Arg.) W.L. Culb.& C.F. Culb.	S	Feeya Amatawiwat, 1994
Evernia mesomorpha Nyl. *fesorediosa* Mull Arg	*Evernia mesomorpha* Nyl. *fesorediosa* Mull Arg	S	Feeya Amatawiwat, 1994
Everniastrum americanum (Mey & Flot) Hale ex Sipman	*Parmelia americana* Meyen & Flot.	DI, DS	Vainio, 1921; Sato, 1962
Everniastrum arsenei (Hale & M. Wirth) Hale ex Sipman	*Everniastrum arsenei* (Hale & M. Wirth) Hale ex Sipman	DS	Aguirre-Hudson & Wolseley, unpublished
Everniastrum cirrhatum (Fr.) Hale ex Sipman	*Cetraliastrum cirrhatum* (Fr.) W.L. Culb & C.F. Culb.	S, DS	Feeya Amatawiwat, 1994
	Parmelia vermicularis Vain.		Vainio, 1921

Table 20 (continued)

Presently accepted names	Published nomenclature	Collecting locality	Reference
Everniastrum nepalense (Taylor) Hale ex Sipman	*Cetrariastrum nepalense* (Taylor) W.L. Culb. & C. F. Culb.	S, DS	Feeya Amatawiwat, 1994
	Everniastrum nepalense (Taylor) W.L. Culb. & C. F. Culb.		Aguirre-Hudson & Wolseley, unpublished
Everniastrum sorocheilum (Vain.) Hale & Sipman	*Everniastrum sorocheila* Vainio	DI, DS	Aguirre-Hudson & Wolseley, unpublished
	Parmelia sorocheila Vain.		Sato, 1962
Everniastrum vexans (Zahlbr.) Hale ex Sipman	*Everniastrum vexans* (Zahlbr.) Hale ex Sipman	DS	Aguirre-Hudson & Wolseley, unpublished
Flavoparmelia haysomii (Dodge) Hale	*Flavoparmelia haysomii* (Dodge) Hale	S	Feeya Amatawiwat, 1994
Flavoparmelia rutidota (Hook & Taylor) Hale	*Flavoparmelia rutidota* (Hook & Taylor) Hale	S	Feeya Amatawiwat, 1994
Flavopunctelia soredica (Nyl.) Hale	*Parmelia ulophyllodes* (Vain.) Savierz.	S	Feeya Amatawiwat, 1994
Hypogymnia subphysodes (Krempelh.)	*Parmelia subphysodes* Krempelh.	DS	Vainio, 1921
Hypotrachyna adducta (Nyl.) Hale	*Parmelia addenta* Wain.	KC	Vainio, 1909
Hypotrachyna bahiana (Nyl.) Hale	*Parmelia bahiana* Nyl.	DS	Vainio, 1921
Hypotrachyna ducalis (Jatta)Hale	*Hypotrachyna ducalis* (Jatta)Hale	S, KY	Feeya Amatawiwat, 1994; Kansri Boonpragob *et al.*,1998
Hypotrachyna exsecta (Taylor) Hale	*Parmelia exsecta* Taylor	DI, DS	Sato, 1962

Table 20 (continued)

Presently accepted names	Published nomenclature	Collecting locality	Reference
Hypotrachyna imbricatula (Zahlbr.) Hale	*Parmelia imbricatula* Zahlbruckner	DS	Aguirre-Hudson & Wolseley, unpublished
Hypotrachyna infirma (Kurok.) Hale	*Parmelia infirma* Kurokawa	-	Aguirre-Hudson & Wolseley, unpublished
Hypotrachyna kingii (Hale) Hale	*Parmelia kingii* Hale	KY	Hale, 1968
Hypotrachyna massartii (Hue.) Hale	*Parmelia bostrychodes* Zahlbr.	S	Feeya Amatawiwat, 1994
Hypotrachyna orientalis (Hale)Hale	*Hypotrachyna orientalis* (Hale)Hale	KY	Kansri Boonpragob *et al.*, 1998
Hypotrachyna osseoalba (Vain.) Y.S. Park & Hale	*Hypotrachyna osseoalba* (Vain.) Y.S. Park & Hale *Parmelia osseoalba* Vain.	S, DS, KY	Feeya Amatawiwat, 1994; Vainio, 1921
Hypotrachyna pseudosinuosa (Asah.) Hale	*Hypotrachyna pseudosinuosa* (Asah.) Hale	S	Feeya Amatawiwat, 1994
Myelochroa perisidians (Nyl.) Elix & Hale	*Parmelina perisidians* Nyl.	PK	Hale, 1976
Myelochroa siamea Kurok.	*Myelochroa siamea* Kurok.	CM	Kurokawa, 1998
Myelochroa xantholepis (Mont & Bosch) Elix & Hale	*Myelochroa xantholepis* (Mont & Bosch) Elix & Hale	CM, PK	Hale, 1976
Nephromopsis pallescens (Schaer.) Park	*Cetraria wallichiana* (Taylor) Kurokawa	DS	Vainio, 1921
Paraparmelia lithophiloides (Kurok.) Elix & J. Johnst.	*Paraparmelia lithophiloides* (Kurok.) Elix & J. Johnst.	S	Feeya Amatawiwat, 1994
Parmelia fertilis Mull. Arg.	*Parmelia subdivaricata* Asah.	S	Feeya Amatawiwat, 1994

Table 20 (continued)

Presently accepted names	Published nomenclature	Collecting locality	Reference
Parmelia pseudolaevior Asah.	*Parmelia pseudolaevior* Asah.	S	Feeya Amatawiwat, 1994
Parmelia pseudoshinanoana Asah.	*Parmelia pseudoshinanoana* Asah.	S	Feeya Amatawiwat, 1994
Parmelia pseudotenuirima Gyel.	*Parmelia pseudotenuirima* Gyel.	S	Feeya Amatawiwat, 1994
Parmelia shinanoana Zahlbr.	*Parmelia shinanoana* Zahlbr.	S	Feeya Amatawiwat, 1994
Parmelia signifera Nyl.	*Parmelia signifera* Nyl.	S	Feeya Amatawiwat, 1994
Parmelia submutata Hue.	*Parmelia submutata* Hue.	S	Feeya Amatawiwat, 1994
Parmelina incertae sedis sensu Hale	*Parmelia coilocarpa* Stirton	DS	Vainio, 1921
Parmelina usambarensis Stein et. Zahlbr.	*Parmelia usambarensis* Stein et. Zahlbr.	S	Feeya Amatawiwat, 1994
	Parmelina usambarensis Stein. et Zahlbr.	PK	Hale, 1976
Parmelinella wallichiana (Taylor) Elix & Hale	*Parmelia wallichiana* Tayl.	S	Feeya Amatawiwat, 1994
	Parmelinella wallichiana (Taylor) Elix & Hale	PK	Hale, 1976
Parmelinopsis expallida (Kurokawa) Hale	*Parmelinopsis expallida* (Kurokawa) Hale	PK	Hale, 1976
Parmotrema amaniense (Steiner & Zahlbr.) Krog & Swinscow	*Parmotrema amaniense* (Steiner & Zahlbr.) Krog & Swinscow	-	Aguirre-Hudson & Wolseley, unpublished
Parmotrema andinum (Mull. Arg.) Hale	*Parmelia andinum* (Mull. Arg.) Hale	DS	Hale, 1965
Parmotrema bangii (Vain.) Hale	*Parmelia bangii* Vain.	S	Feeya Amatawiwat, 1994

Table 20 (continued)

Presently accepted names	Published nomenclature	Collecting locality	Reference
Parmotrema breviciliatum (Hale) Hale	*Parmelia breviciliata* Hale	KC	Hale, 1965
	Parmelia breviciliata Hale	PK	Aguirre-Hudson & Wolseley, unpublished
Parmotrema chinense (Osbeck) Hale	*Parmelia perlata* Ach.	KC	Vainio, 1909
	Parmotrema chinense (Osbeck) Hale	KY, S	Feeya Amatawiwat, 1994; Kansri Boonpragob *et al.*, 1998
Parmotrema crinitum (Ach.) M. Choisy	*Parmelia crinita* Ach.	S	Feeya Amatawiwat, 1994
Parmotrema cristiferum (Tayl.)Hale	*Parmotrema cristiferum* (Tayl.)Hale	Ud, DC	Hale, 1965
Parmotrema dilatatum (Vain.)Hale	*Parmotrema dilatatum* (Vain.)Hale	KY	Kansri Boonpragob *et al.*, 1998
Parmotrema explanatum (Hale) Hale	*Parmelia explanata* Hale	PK	Hale, 1965
Parmotrema gardneri (C.W. Dodge) Serus	*Parmotrema gardneri*	-	Aguirre-Hudson & Wolseley, unpublished
	Parmelia latissima var.cristifera (Taylor) Hue	KC	Vainio, 1909
Parmotrema nilgherrense (Nyl.) Hale	*Parmotrema nilgherrense*	DS	Aguirre-Hudson & Wolseley, unpublished
	Parmelia nilgherrensis Nyl.		Vainio, 1921, Hale, 1965
	Parmelia siamensis Vain.		

Table 20 (continued)

Presently accepted names	Published nomenclature	Collecting locality	Reference
Parmotrema pancheri (Hue.) Hale	*Parmelia pancheri* Hue.	DS	Hale, 1965
Parmotrema permutata (Stirt.) Hale	*Parmelia permutata* Stirt.	KK	Hale, 1965
Parmotrema platyphyllinum (Vain.) Elix	*Parmelia platyphyllina* Vain.	KC	Vainio, 1909
Parmotrema praesorediosum (Nyl.) Hale	*Parmotrema praesorediosum* (Nyl.) Hale	S	Feeya Amatawiwat, 1994
Parmotrema procerum (J.Steiner & Zahlbr.) Hale	*Parmotrema procera* (J.Steiner & Zahlbr.) Hale	KY	Kasri Boonpragob *et al.*,
	Parmelia procera J. Steiner & Zahlbr.	-	1998
			Hale, 1965
Parmotrema pseudocrinitum (Des Abb.) Hale	*Parmelia pseudocrinita* Des Abb.	PK	Aguirre-Hudson &
			Wolseley, unpublished
Parmotrema rampoddense (Nyl.) Hale	*Parmelia rampoddensis* Nyl.	S	Feeya Amatawiwat, 1994;
	Parmotrema rampoddense (Nyl.) Hale	PK	Aguirre-Hudson &
			Wolseley, unpublished
Parmotrema sancti-angelii (Lynge.) Hale	*Parmotrema sancti-angelii* (Lynge.) Hale	S	Feeya Amatawiwat, 1994
Parmotrema stuppeum (Taylor) Hale	*Parmelia claudelii* Harm.	KC	Vainio, 1909
Parmotrema subarnoldii (Des. Abb) Hale	*Parmelia subarnoldii* Des.Abb.	S	Feeya Amatawiwat, 1994
Parmotrema tinctorum (Despr. ex Nyl.) Hale	*Parmelia coralloidea* (Mey&Flot) Vain.	KT, DI, DS, DC	Vainio, 1921; Paulson,
	Parmotrema tinctorum (Despr. ex Nyl.) Hale		1930; Sato, 1962; Hale,
			1965

Table 20 (continued)

Presently accepted names	Published nomenclature	Collecting locality	Reference
Parmotrema ultralucens (Krog) Hale	*Parmelia ultralucens* Krog.	S	Feeya Amatawiwat, 1994
Parmotrema zollingeri (Hepp.) Hale	*Parmelia zollingeri* Hepp.	PNK	Hale, 1965
Platismatia erosa W.L. Culb. & C.F. Culb.	*Platismatia erosa* W.L. Culb. & C.F. Culb.	-	Aguirre-Hudson & Wolseley, unpublished
Relicina abstrusa (Vain.) Hale	*Relicina abstrusa* (Vain.)Hale	KY	Kansri Boonpragob *et al.*, 1998
Relicina subabstrusa (Gyeln.)Hale	*Relicina subabstrusa* (Gyeln.)Hale	KY	Kansri Boonpragob *et al.*, 1998
Relicina sublanea Kurokawa	*Relicina sublanea* Kurokawa	S	Feeya Amatawiwat, 1994
Relicina sublimbata (Nyl.) Hale	*Relicina sublimbata* (Nyl.) Hale	PK	Hale, 1975
Relicinopsis rahengensis (Vain.) Elix & Verdon	*Parmelia rahengensis* Vain.	DS	Vainio, 1921; Hale, 1976
	Relicinopsis rahengensis (Vainio) Elix & Verdon	Ud, S	Feeya Amatawiwat, 1994
Rimelia cetrata (Ach.) Hale & Fletcher	*Parmelia cetrata* Ach.	DI, DS	Vainio, 1921; Sato, 1962
Rimelia reticulata (Taylor) Hale & Fletcher	*Rimelia reticulata* (Taylor) Hale & Fletcher	-	Aguirre-Hudson & Wolseley, unpublished
Vulpicida juniperinus (L.) Mattsson & Lai	*Cetrelia japonica* (Zahlbr) W.Culb.& C.Culb.	KY	Kansri Boonpragob *et al.*, 1998
Xanthoparmelia amplexula (Stirt.) Elix & J.Johnst.	*Xanthoparmelia amplexula* (Stirt.) Elix & J.Johnst.	S	Feeya Amatawiwat, 1994

Table 20 (continued)

Presently accepted names	Published nomenclature	Collecting locality	Reference
Xanthoparmelia austroliensis (Cromb.) Hale	*Parmelia australiensis* Cromb.	KT	Paulson, 1930
Xanthoparmelia autralasica D.J. Galloway	*Xanthoparmelia autralasica* D.J. Galloway	S	Feeya Amatawiwat, 1994
Xanthoparmelia cheeli (Gyeln.) Hale	*Xanthoparmelia cheeli* (Gyeln.) Hale	S	Feeya Amatawiwat, 1994
Xanthoparmelia ecoronata Nyl.	*Xanthoparmelia ecoronata* Nyl.	KC	Vainio, 1909
Xanthoparmelia filarzkyana (Gyeln.) Hale	*Xanthoparmelia filarzkyana* (Gyeln.) Hale	S	Feeya Amatawiwat, 1994
Xanthoparmelia flavescentireagens (Gyeln.)D.J. Galloway	*Xanthoparmelia flavescentireagens* (Gyeln.)D.J. Galloway	S	Feeya Amatawiwat, 1994
Xanthoparmelia hypoprotocetrarica (Kurok. & Elix) Hale	*Xanthoparmelia hypoprotocetrarica* (Kurok. & Elix) Hale	S	Feeya Amatawiwat, 1994
Xanthoparmelia subdistorta (Kurok.) Hale	*Parmelia subdistorta* Kurok.	S	Feeya Amatawiwat, 1994
Xanthoparmelia substrigosa (Hale) Hale	*Xanthoparmelia substrigosa* (Hale) Hale	S	Feeya Amatawiwat, 1994
Xanthoparmelia versicolor (Mull. Arg.) Hale	*Parmelia versicolor* Mull. Arg.	S	Feeya Amatawiwat, 1994
Xanthparmelia rubrireagens (Gyeln.) Hale	*Xanthparmelia rubrireagens* (Gyeln.) Hale	S	Feeya Amatawiwat, 1994

Note: CM = Chiang Mai; DC = Doi Chiang Dao; DI = Doi Inthanon; DS = Doi Suthep-Pui; KC = Koh Chang; KK = Khao Krading; KT = Koh Tao; KY = Khao Yai; LN = Lam Ngob; LP = Lampang; N = North of Thailand; PK = Phu Kradueng; PNK = Pha Nok Kao; S = Southern Thailand; Ud = Udon Thani; UT = Uthai Thani.

APPENDIX 2

Lichen Substances in the Parmelioid Lichens in Thailand

Lichen Substances in the Parmelioid Lichens in Thailand

Sixty-four lichen substances were found in this study. These substances belong to seven metabolic groups according to Table 4. Each substance shows characters of spots as shown in Figure 11. Alphabetically lists these substances including their characteristics according to methods described by White and James (1985) and Elix *et al.* (1993).

Abbreviations and symbols used in this list are as follow:

* = Substance presents in trace amount which cannot detect by spot test and TLC method. It requires HPLC for identification.

\+ = Substance frequently presents in mixed-spot with other substances on tlc-plate.

X = Substance cannot detect by spot test, but shows on tlc-plate.

g+ = Minor substance presents in complex with major substances. It is unable to detect on tlc-plate. HPLC method is necessary for substance identification.

b halo = black halo

Bl = black

Br = brown

Bu = Blue

c = colorless

G = green

Gr = gray

Or = orange

p = pale

Pk = Pink

R = red

Rs = Rose

Wh = white

Wh-bu = White-blue

Y= yellow

YG = yellow-green

Table 21 Characteristics of Lichen Substances Found in the Parmelioid Lichens Detect by Spot Test and TLC

Lichen Substances	Spot Test				Thin layer chromatography					Parmelioid species
	K	C	KC	P	Solvent system A	Solvent system G	Color	UV before heat	UV after heat	
1. α-collatolic acid	-	-	+ Or/ R	-	4	5	*p* Y	+ Wh-bu	+ Bu	*Parmotrema amaniense*, *P. corniculans*, *P. mellissii*, and *P. rampoddense*
2. 2,4,5-tri-o-methylhiascic acid note: *; +3+34+5	-	+ Rs	+ Rs	-	4-5	4-5	Y-Or	-	+ G	*Parmelinopsis horrescens*, and *P. minarum*
3. 2,4-di-o-methylgyrophoric acid note: *; +2+4+5	-	+ Rs	+ Rs	-	4-5	4-5	Y-Or	-	+ G	*Parmelinopsis horrescens*
4. 3-methoxy-2,4-di-o-methylgyrophoric acid note: *; +2+3+5	-	+ Rs	+ Rs	-	4-5	4-5	Y-Or	-	+ G	*Parmelinopsis horrescens*, and *P. minarum*
5. 4,5-di-O-methylhiasic acid note: *; +2+3+4	-	+ Rs	+ Rs	-	4-5	4-5	Y-Or	-	+ G	*Parmelinopsis horrescens*
6. 4-o-demethylbarbatic acid	-	-	+ *p* Or	-	3-4	4	Y-Or	+ Wh-bu	+ Br	*Hypotrachyna adjuncta*, *H. chlorobarbatica*, *H. ducalis*, *H. exsecta*, *H. physciodes*, *H. scytodes*, and *Relicinopsis rahengensis*
7. 4-o-methylphysodic acid	x	x	x	x	4	5	*p* Y	-	-	*Hypotrachyna immaculata*, and *H. osseoalba*
8. 5-chloro-4-o-demethylbarbatic acid note: *	-	-	+ Or	-	5-6	6-7	*p* Y	+ Wh	+ Br	*Hypotracyna chlorobarbatica*
9. 5-o-methylhiascic acid	x	x	x	x	3-4	4	Y	-	-	*Parmelinopsis horrescens*, and *P. minarum*

Table 21 (continued)

Lichen Substances	Spot Test				Thin layer chromatography					Parmelioid species
	K	C	KC	P	Solvent system A	Solvent system G	Color	UV before heat	UV after heat	
10. alectoronic acid	-	-	+ *p* Or-R	-	3	3-4	*p* Pk-Or	+ Wh	+ Bu or Wh-bu	*Parmotrema amaniense,P. corniculans, P. maclayanum, P. mellissii, P. poolii, P. pseudonilgherrense, P. rampoddense,* and *P. thailandicum*
11. atranorin	+ Y	-	-	+ Y	7	7	Y to Or	-	Or to Br	*Bulbothrix goebelii, B. hypochraea, B. isidiza, B. meizospora, B. queenslandica, B.sensibilis, B. setschwanensis, B. tabacina, Canomaculina subtinctoria, Canoparmelia ecaperata, C.owariensis, Everniastrum nepalense, E. cirrhatum, E. scabridum, Hypotrachyna adducta, H. adjuncta, H. chlorobarbatica, H. coorgiana, H. costaricensis, H. crenata, H. ducalis, H. exsecta, H. immaculata, H. kingii, H. mason-halei, H. osseoalba, H. physcioides, H. ramkhamhaengiana, H. scytodes, Myelochroa siamea, M. xantholepis, Parmelinella chozoubae, P. wallichiana, Parmelinopsis expallida, P. horrescens, P. microlobulata, P. minarum, Parmotrema abessinicum, P. amaniense, P. corniculans, P. cristiferum, P. dilatatum, P. elacinulatum, P. explanatum, P. eunetum, P. gardneri, P. hababianum, P. incrassatum, P. maclayanum, P. mellissii, P. merrillii, P. overeemii P. planatilobatum, P. poolii, P. praesorediosum,P.pseudocrinitum, P. pseudonigherrense, P. rampoddense, P. rubromarginatum, P. saccatilobum, P. sancti-angelii, P. subarnoldii, P. sulphuratum, P. thailandicum, P. tinctorum,* and *Rimelia reticulata*

Table 21 (continued)

Lichen Substances	Spot Test				Thin layer chromatography					Parmelioid species
	K	C	KC	P	Solvent system A	Solvent system G	Color	UV before heat	UV after heat	
12. barbatic acid	-	-	+*p* Pk	-	4-5	5	Y	+ Wh-bu	+Br	*Hypotrachyna adjuncta, H. chlorobarbatica, H. ducalis, H. exsecta, H. physcioides, H. scytodes, Parmotrema explanatum,* and *Relicinopsis rahengensis*
13. chloroatranorin	+ Y	-	-	+ Y	7	7	Y to Or	-	Or to Br	*Bulbothrix goebelii, B. hypochraea, B. isidiza, B. meizospora, B. queenslandica, B.sensibilis, B. setschwanensis, B. tabacina, Canomaculina subtinctoria, Canoparmelia ecaperata, C.owariensis, Everniastrum nepalense, E. cirrhatum, E. scabridum, Hypotrachyna adducta, H. adjuncta, H. chlorobarbatica, H. coorgiana, H. costaricensis, H. crenata, H. ducalis, H. exsecta, H. immaculata, H. kingii, H. mason-halei, H. osseoalba, H. physcioides, H. ramkhamhaengiana, H. scytodes, Myelochroa siamea, M. xantholepis, Parmelinella chozoubae, P. wallichiana, Parmelinopsis expallida, P. horrescens, P. microlobulata, P. minarum, Parmotrema abessinicum, P. amaniense, P. corniculans, P. cristiferum, P. dilatatum, P. elacinulatum, P. explanatum, P. eunetum, P. gardneri, P. hababianum, P. incrassatum, P. maclayanum, P. mellissii, P. merrillii, P. overeemii P. planatilobatum, P. poolii, P. praesorediosum,P.pseudocrinitum, P. pseudonigherrense, P. rampoddense, P. rubromarginatum, P. saccatilobum, P. sancti-angelii, P. subarnoldii, P. sulphuratum, P. thailandicum, P. tinctorum,* and *Rimelia reticulata*
14. colensoic acid	x	x	x	x	5	5-6	*p* Or	+ Pk	-	*Hypotrachyna immaculata,* and *H. osseoalba*

Table 21 (continued)

Lichen Substances	Spot Test				Thin layer chromatography					Parmelioid species
	K	C	KC	P	Solvent system A	Solvent system G	Color	UV before heat	UV after heat	
15. conalectoronic acid	x	x	x	x	2	2	Br-Gr	+ Wh	+ Wh	*Parmotrema maclayanum*, and *p. poolii*
16. conechinocarpic acid	*	*	*	*	*	*	*	*	*	*Hypotrachyna adjuncta*, and *H. scytodes*
17. connorstictic acid	x	x	x	x	2	2	Rs-Or	-	-	*Relicina abstrusa*, and *R. subabstrusa*
18. conprotocetraric acid	*	*	*	*	*	*	*	*	*	*Everniastrum scabridum*
19. consalazinic acid	x	x	x	x	1	1	Or to Br	-	+ dull Or	*Bulbothrix hypochraea, B. isidiza, B. meizospora, B. snsibilis, B. setchwanensis, B. tabacina, Canomaculina subtinctoria, Everniastrum cirrhatum, E. nepalense, Parmelinella chozoubae, P. wallichiana, Hypotrachyna coorgiana, H. kingii, H. masonhalei, H. ramkhamhaengiana, Parmotrema cristiferum*, and *Rimelia reticulata*
20. constictic acid	x	x	x	x	1-2	1	Or	-	-	*Hypotrachyna crenata, Xanthoparmelia congensis*, and *X. mougeotina*
21. cryptostictic acid note: g+ 54 + 36	x	x	x	x	2-3	2	Rs-R	-	-	*Hypotrachyna crenata, Xanthoparmelia congensis*, and *X. mougeotina*
22. divaricatic acid	-	-	-	-	4	4-5	Y	Gr	+Bl	*Canoparmelia ecaperata, C. owariensis*, and *Parmeliopsis ambigua*
23. echinocarpic	x	x	x	x	2	2-3	Or	+or	or	*Hypotrachyna adjuncta*, and *H scytodes*
24. eumitrin	*	*	*	*	*	*	*	*	*	*Myelochroa siamea*
25. fumarprotocetraric acid	-	-	-	+ r	1-2	2-3	Gr	-	-	*Relicina sublimbata*
26. galbinic acid	-	-	-	-	3	3	Or-Y	-	Br	*Myelochroa siamea*
27. gyrophoric acid	-	+ r	+r	-	3	3	Y	-	G/ b halo	*Bulbothrix goebelii, Parmelinopsis horrescens, P. minarum, Parmotrema eunetum, P. planatilobatum, P. pseudocrinitum, and P. sancti-angelii*
28. hiascic acid	*	*	*	*	*	*	*	*	*	*Parmelinopsis horrescens*

Table 21 (continued)

Lichen Substances	Spot Test				Thin layer chromatography					Parmelioid species
	K	C	KC	P	Solvent system A	Solvent system G	Color	UV before heat	UV after heat	
29. hirtifructic acid	*	*	*	*	*	*	*	*	*	*Hypotrachyna scytodes*
30. hyposalazinic acid	x	x	x	x	3	3	R-Or	-	Or	*Relicina abtrusa*, and *R. subabstrusa*
31. lecanoric acid	-	+ R	+R	-	3	3	YG	-	G/b halo	*Parmotrema tinctorum*
32. lichesterinic acid	-	-	-	-	4	4	Gr	-	-	*Everniastrum scabridum*, and *Parmotrema elacinulatum*
33. lichexanthone	-	-	-	-	6-7	6-7	p-Y	+ Or	+ G	*Hypotrachyna osseoalba*
34. lividic acid note: g+14+7+46+44	x	x	x	x	3-4	4	Br	-	+ G	*Hypotrachyna immaculata*, and *H. osseoalba*
35. loxodin			+ Or	-	4-5	4-5	*P* Y	-	-	*Parmotrema abessinicum*, and *P. hababianum*
36. menegazziaic acid note: X, g+54	-	-	-	-	2-3	2-3	Gr	-	-	*Xanthoparmelia congensis*, and *X. mougeotina*
37. methyl-5-chloro-4-o-demethylbarbatate	-	-	*+p Or*	-	6-7	6-7	Y	+ Bu	+Br	*Hypotrachyna chlorobarbatica*
38. methylvirensate	*	*	*	*	*	*	*	*	*	*Parmotrema amaniense*
39. nordivaricatic acid	x	x	x	x	3-4	2-3	*p* Y	-	-	*Canoparmelia ecaperata*,
40. norlobaridone					4	4	*p* Or			*Canomaculina subtinctoria*, *Parmotrema abessinicum*, and *P. hababianum*
41. norobtusatic acid note: with or without 43	*	*	*	*	*	*	*	*	*	*Hypotrachyna physcioides*
42. norstictic acid	+ Y-R	-	+ R	+ Or	4	4	Y	-	-	*Hypotrachyna crenata*, *H. kingii*, *H. masonhalei*, *Relicina adstrusa*, *R. subabstrusa*, *Xanthoparmelia congensis*, and *X. mougeotina*
43. obtusatic acid note: *	x	x	x	x	3-4	4	Y	-	+ Or	*Hypotrachyna physcioides*

Table 21 (continued)

Lichen Substances	Spot Test				Thin layer chromatography					Parmelioid species
	K	C	KC	P	Solvent system A	Solvent system G	Color	UV before heat	UV after heat	
44. oxyphysodic acid note: *; g+ 34	x	x	x	x	2-3	2-3	*p* Gr	-	-	*Hypotrachyna immaculata,* and *H. osseoalba*
45. peristictic acid note: g+54	x	x	x	x	1-2	1	Br	-	-	*Hypotrachyna crenata*
46. physodic acid	-	-	+*p* Or	-	3	3	*P* Br	-	+ Bu	*Hypotrachyna immaculata,* and *H. osseoalba*
47. pigmentosin A	*	*	*	*	*	*	*	*	*	*Hypotrachyna ramkhamhaengiana*
48. praesorediosic acid note: fatty acid	-	-	-	-	3-4	3-4	*c*	-	-	*Parmotrema praesorediosum*
49. protocetraric acid	-	-	-	+ R	1-2	2	Gr	-	-	*Everniastrum scabridum, Hypotrachyna adducta, Parmotrema ameniense, P. dilatatum, P. elacinulatum, P. gardneri, P. incrassatum, P. merrillii, P. overeemii, P. rubromarginatum, P. saccatilobum, P. subarnoldii, P. thailandicum, Relicina sublimbata, Relicinopsis intertexta,* and *R. malaccensis*
50. protolichesterinic acid note: fatty acid	-	-	-	-	3-4	4	*p* Gr	-	-	*Everniastrum scabridum, Hypotrachyna costaricensis Parmelinopsis expallida, P. microlobulata, Parmotrama elacinulatum,* and *P. rubromarginatum*
51. salazinic acid	+ Y –R	-	+Y	-	2	2	Or	-	Or	*Bulbothrix hypochraea, B. isidiza, B. meizospora, B. snsibilis, B. setchwanensis, B. tabacina, Canomaculina subtinctoria, Everniastrum cirrhatum, E. nepalense, Parmelinella chozoubae, P. wallichiana, Hypotrachyna coorgiana, H. kingii, H. masonhalei, H. ramkhamhaengiana, Parmotrema cristiferum,* and *Rimelia reticulata*

Table 21 (continued)

Lichen Substances	Spot Test				Thin layer chromatography					Parmelioid species
	K	C	KC	P	Solvent system A	Solvent system G	Color	UV before heat	UV after heat	
52. secalonic acid A note: yellow pigment	x	x	x	x	4	2	Y	-	-	*Myelochroa siamea, M. xantholepis, Hypotrahyna ramkhamhaengiana,* and *Parmelinella wallichiana*
53. skyrin note: pink pigment	+ Pk -R	-	-	-	4-5	4	Pk-Gr	+Or	-	*Parmotrema mellissii, P. rampoddense,* and *P. thailandicum*
54. stictic acid	+ R	-	+R	+Y	3	2-3	Deep Or	-	Or	*Hypotrachyna crenata, Xanthoparmelia congensis,* and *X. mougeotina*
55. subalectoronic acid note: *	x	x	x	x	1-2	1	*p* Br	-	-	*Parmotrema poolii,* and *P. pseudonilgherrense*
56. subdivaricatic acid	x	x	x	x	5-6	5-6	*p* Gr	-	-	
57. subvirensic acid	*	*	*	*	*	*	*	*	*	*Canoparmelia ecaperata,* and *C. owariensis*
58. succinprotocetraric acid note: +25+59	-	-	-	+R	1-2	2	Gr	-	-	*Parmotrema thailandicum* *Relicina sublimbata*
59. umbillicaric acid	*	*	*	*	*	*	*	*	*	
60. unknown red pigment	+ *p* Pk	-	-	-	2-3	1-2	*p* R	-	+ Or	*Parmelinopsis horrescens,* and *P. minarum* *Parmotrema rubromarginatum*
61. usnic acid	-	-	+Y	-	6	6-7	*p* YG - Gr	-	-	*Canoparmelia ecaperata, Parmeliopsis ambigua, Parmotrema dilatatum, Relicina abstrusa, R. subabstrusa, R. sublimbata, Relicinopsis intertexta, R. malaccensis, R. rahengensis, Xanthoparmelia congensis,* and *X. mougeotina*
62. virensic acid	-	-	-	+ R	3-4	3-4	Gr	-	+ Or	*Everniastrum scabridum, Parmotrema incrassatum, P. merrillii, P. overeemii,* and *P. thailandicum*
63. vulpinic acid	-	-	-	-	6-7	6-7	Lemon Y	+ Pk	+Pk	*Parmotrema sulphuratum*

Table 21 (continued)

Lichen Substances	Spot Test				Thin layer chromatography					Parmelioid species
	K	C	KC	P	Solvent system A	Solvent system G	Color	UV before heat	UV after heat	
64. zeorin note: present near lower medulla	+*p* Pk	-	-	-	5	4	violet	-	+Pk	*Myelochroa siamea*

Note: Numbers after the names of substances in the first column refer to occurrence with other substances, which have designated member in the same column.

APPENDIX 3

Distribution Maps of the Parmelioid Species of Thailand

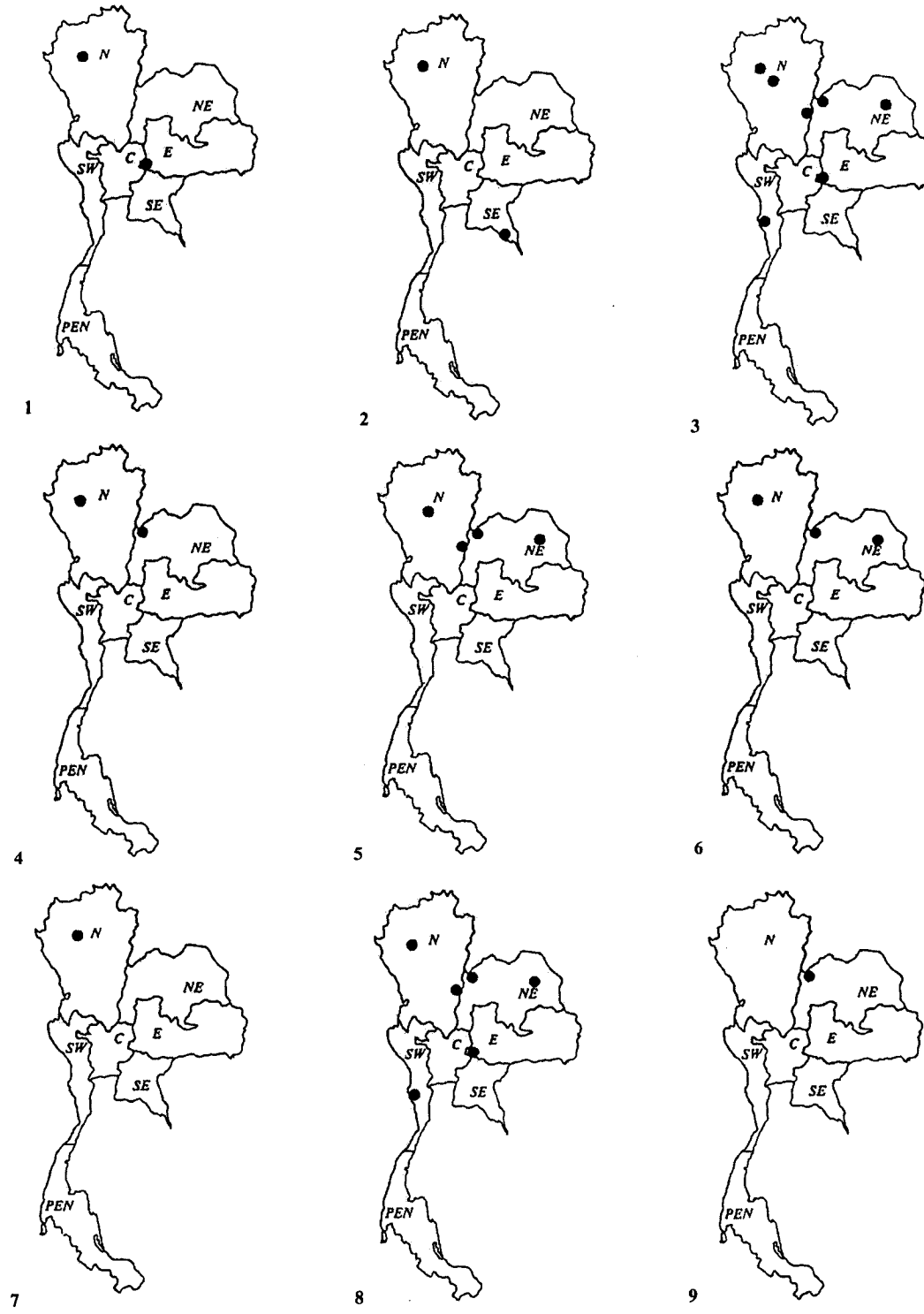


Figure 100 Distribution Maps of the Parmelioid Species in Thailand

Note: 1. *Bulbothrix goebelii* 2. *B. hypochraea* 3. *B. isidiza* 4. *B. meizospora* 5. *B. queenslandica* 6. *B. sensibilis* 7. *B. setschwanensis* 8. *B. tabacina* 9. *Canomaculina subtinctoria*

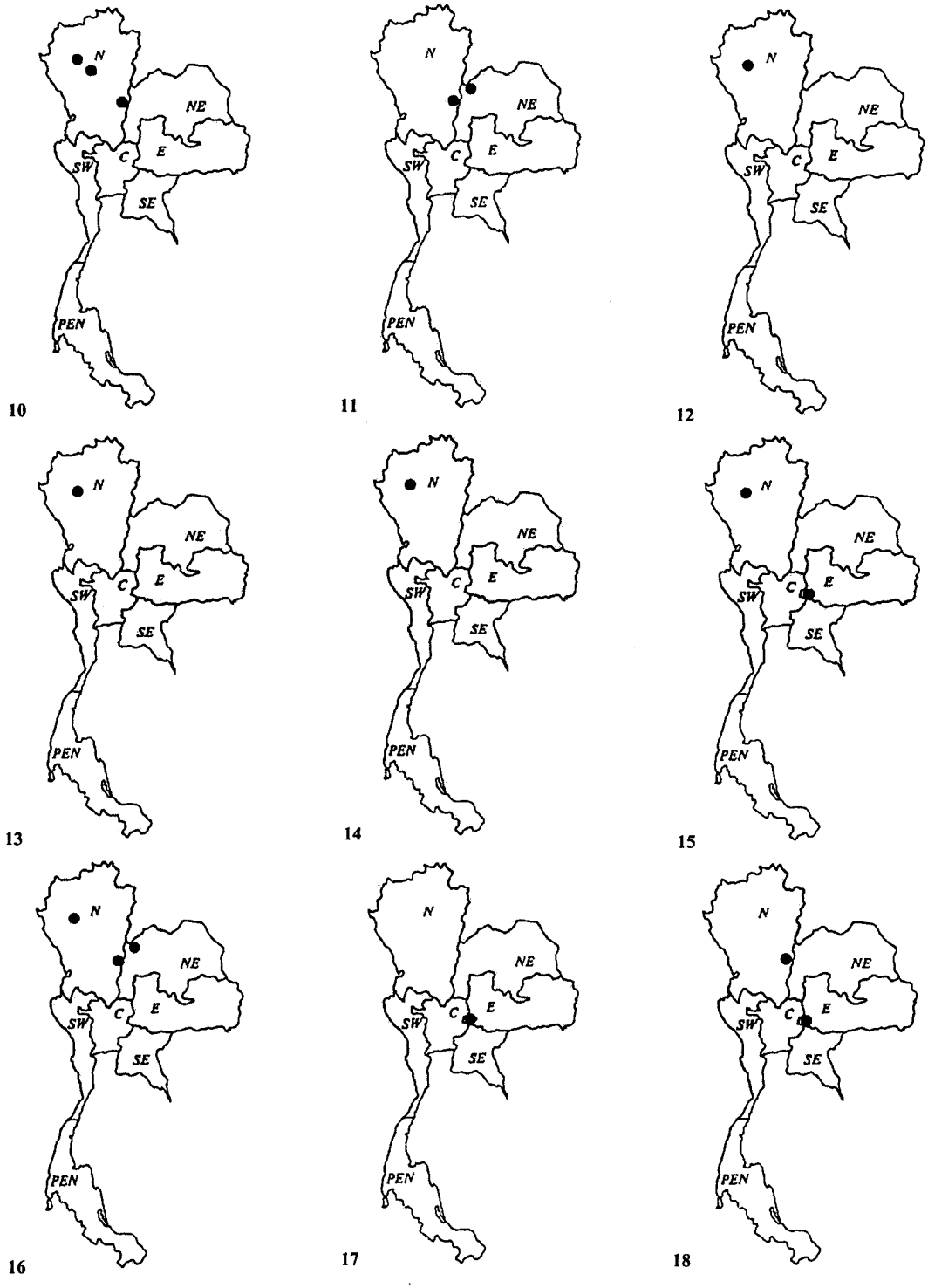


Figure 101 Distribution Maps of the Parmelioid Species in Thailand (continued)

Note: 10. *Canoparmelia ecaperata* 11. *C. owariensis* 12. *Everniastrum cirrhatum* 13. *E. nepalense* 14. *E. scabridum* 15. *Hypotrachyna adducta* 16. *H. adjuncta* 17. *H. chlorobarbatica* 18. *H. coorgiana*

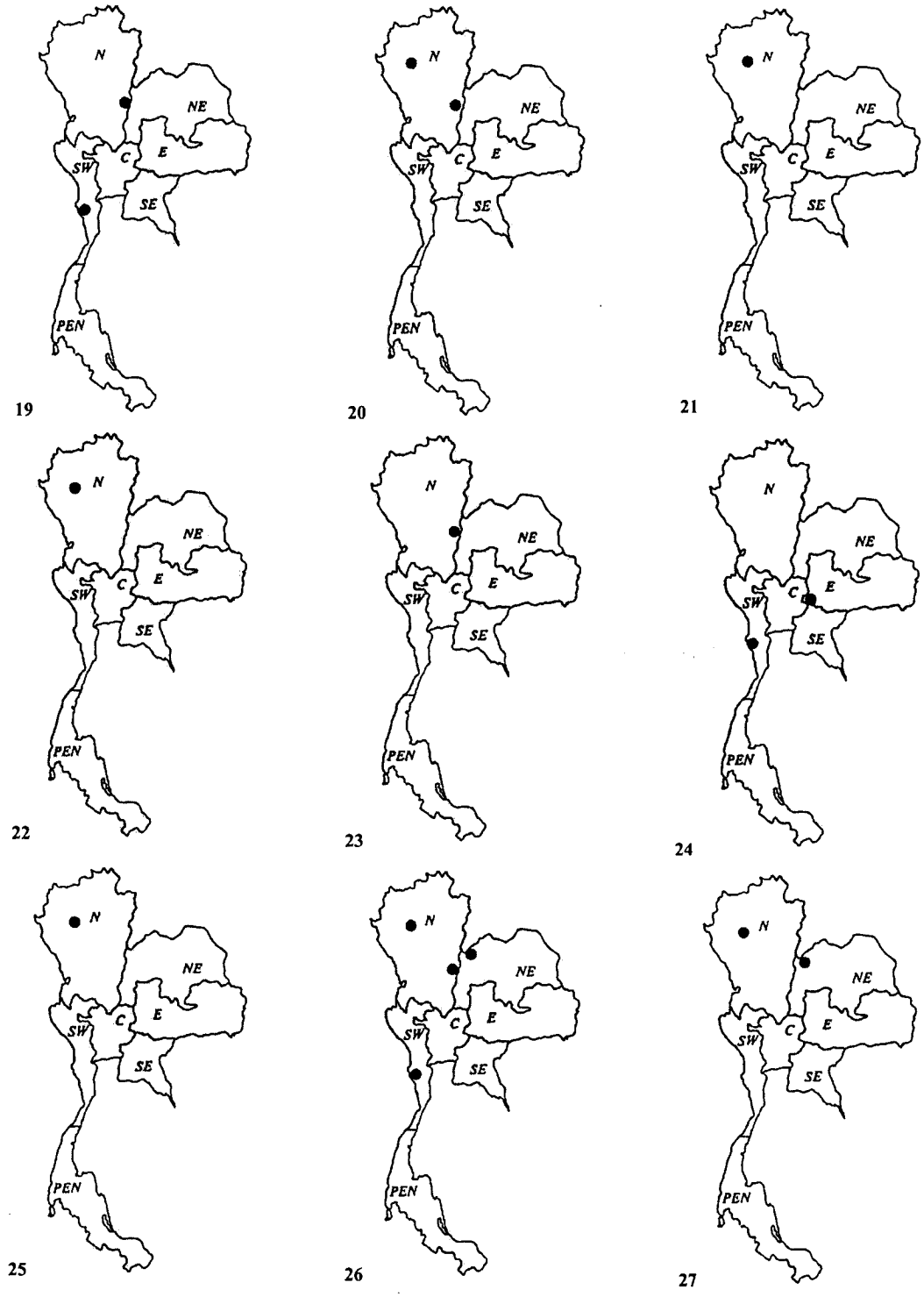


Figure 102 Distribution Maps of the Parmelioid Species in Thailand (continued)

Note: 19. *Hypotrachyna costaricensis* 20. *H. crenata* 21. *H. ducalis* 22. *H. exsecta* 23. *H. immaculata* 24. *H. kingii* 25. *H. mason-halei* 26. *H. osseoalba* 27. *H. physcioides*

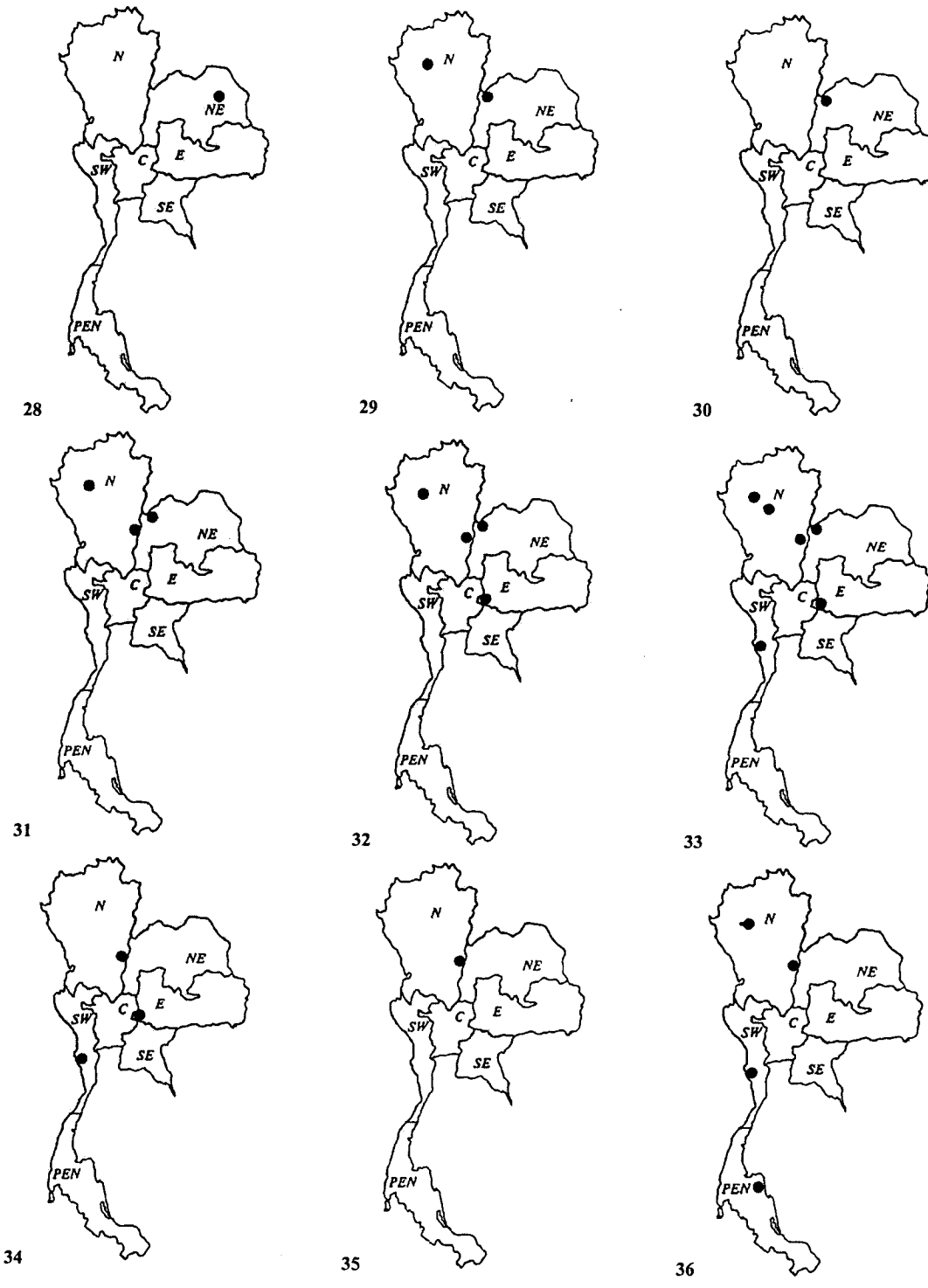


Figure 103 Distribution Maps of the Parmelioid Species in Thailand (continued)

Note: 28. *Hypotrachyna ramkhamhaengiana* 29. *H. scytodes* 30. *Myelochroa siamea* 31. *M. xantholepis* 32. *Parmelinella chozoubae* 33. *P. wallichiana* 34. *Parmelinopsis expallida* 35. *P. horrescens* 36. *P. microlobulata*

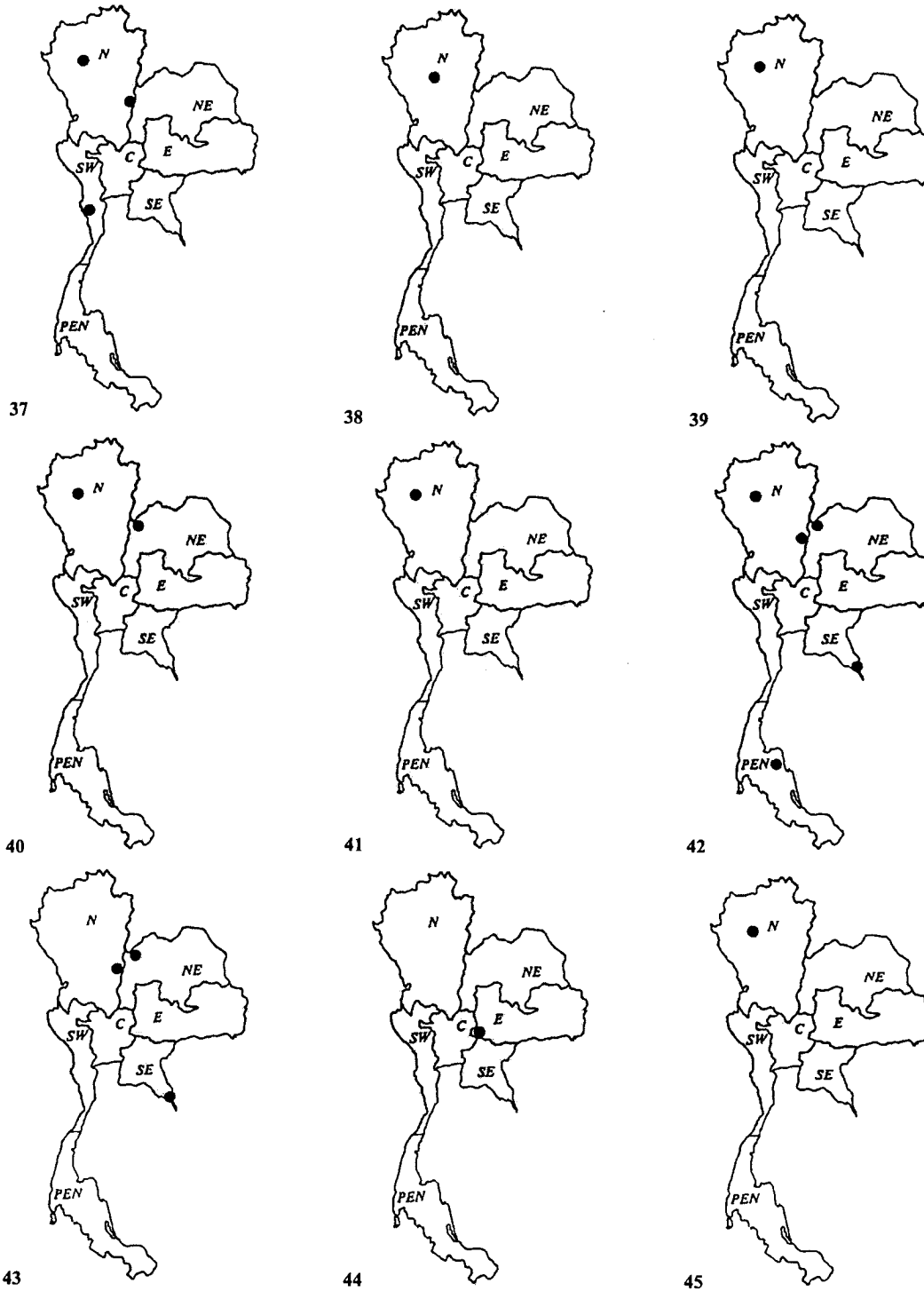


Figure 104 Distribution Maps of the Parmelioid Species in Thailand (continued)

Note: 37. *Parmelinopsis minarum* 38. *Parmeliopsis ambigua* 39. *Parmotrema abissinicum* 40. *P. amaniense* 41. *P. corniculans* 42. *P. cristiferum* 43. *P. dilatatum* 44. *P. elacinulatum* 45. *P. eunetum*

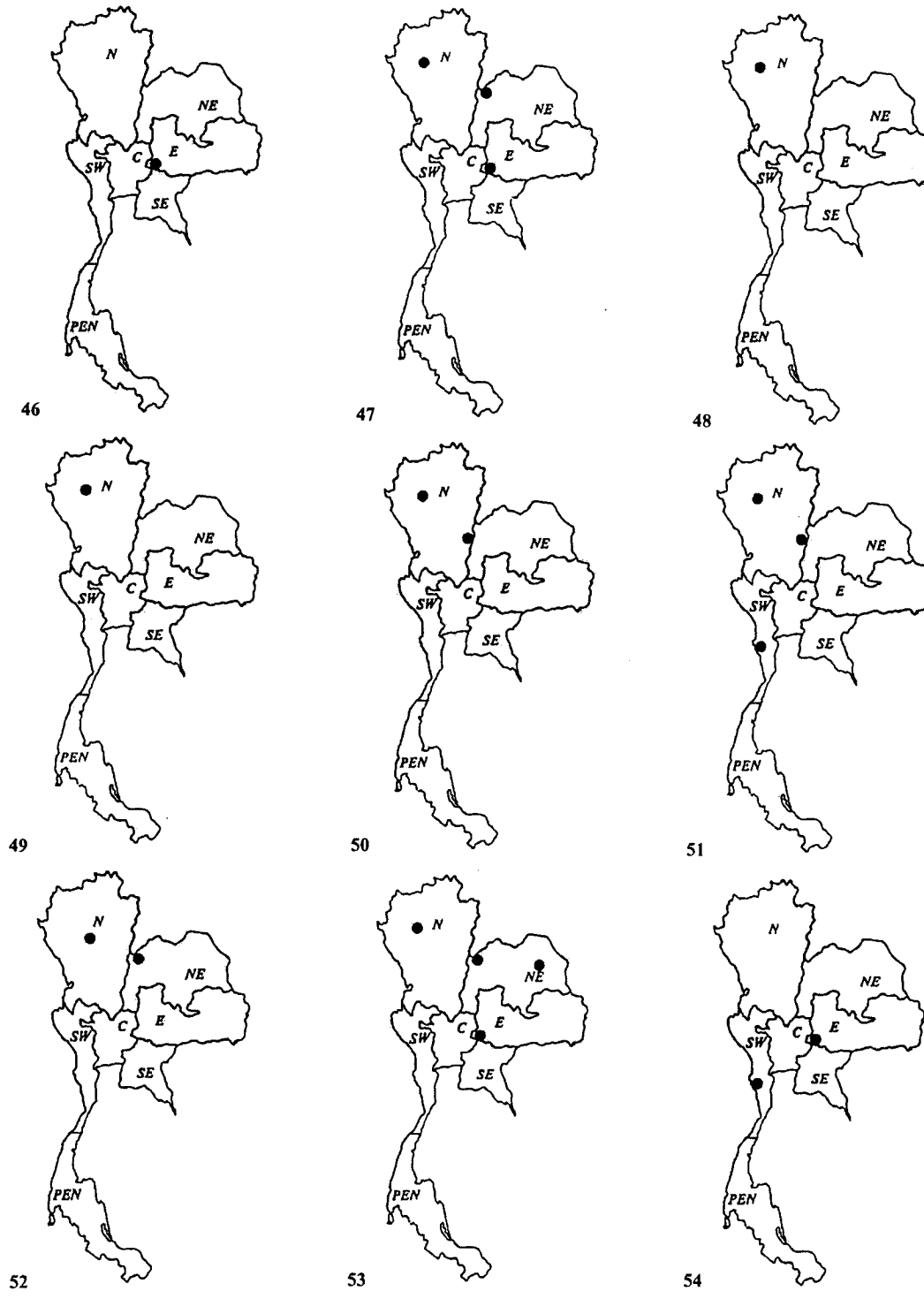


Figure 105 Distribution Maps of the Parmelioid Species in Thailand (continued)

Note: 46. *Parmotrema explanatum* 47. *P. gardneri* 48. *P.hababianum* 49. *P. incrassatum* 50. *P. maclayanum* 51. *P. mellissii* 52. *P. merrillii* 53. *P. overeemii* 54. *P. planatilobatum*

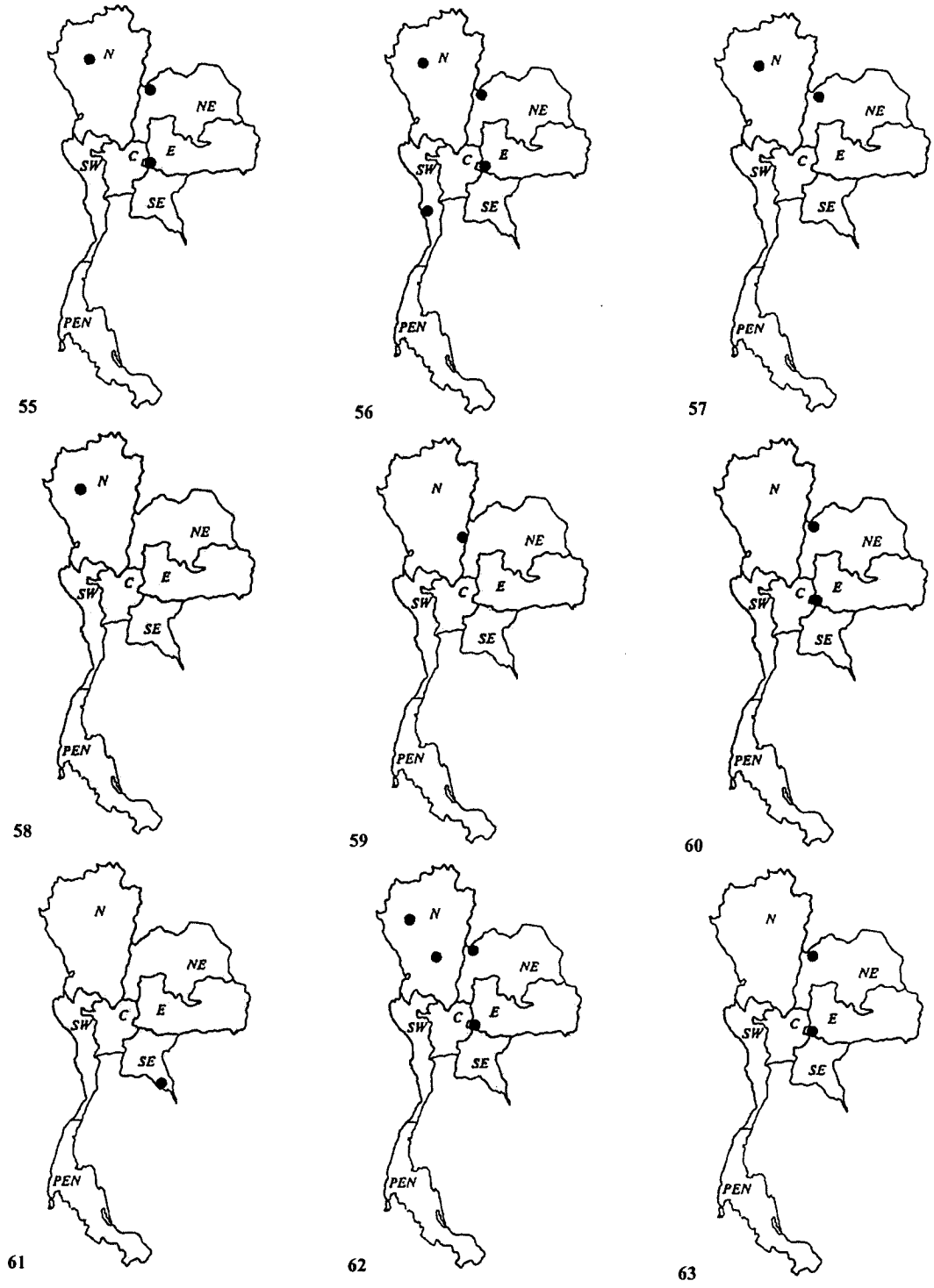


Figure 106 Distribution Maps of the Parmelioid Species in Thailand (continued)

Note: 55. *Parmotrema poolii* 56. *P. praesorediosum* 57. *P. pseudocrinitum* 58. *P. pseudonilgherrense* 59. *P. rampoddense* 60. *P. rubromarginatum* 61. *P. saccatilobum* 62. *P. sancti-angelii* 63. *subarnoldii*

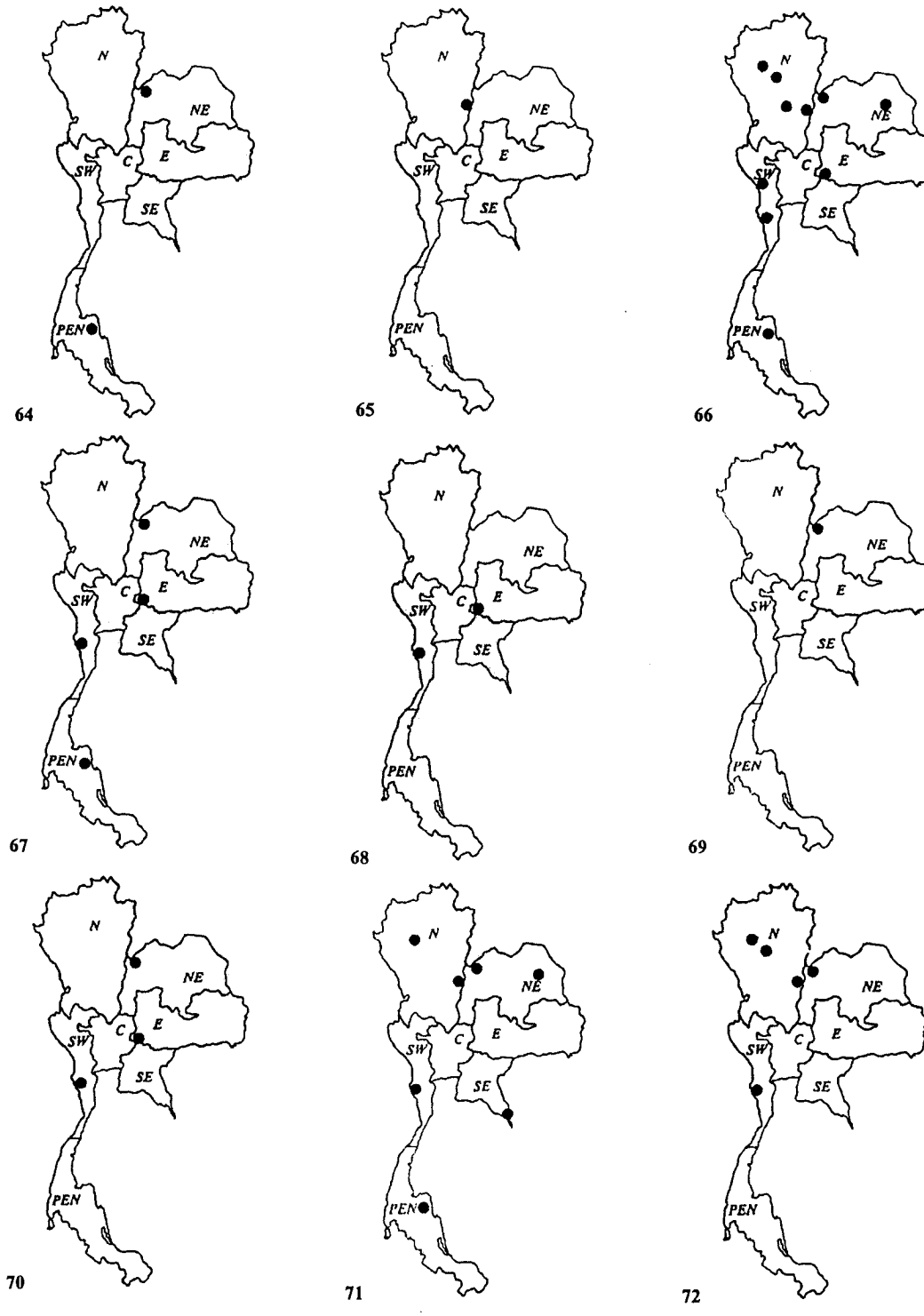
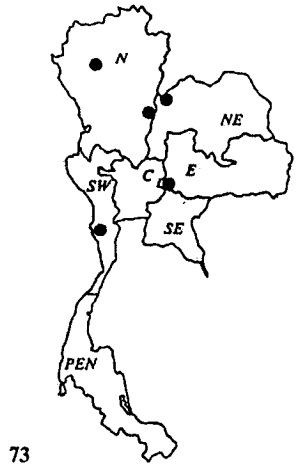
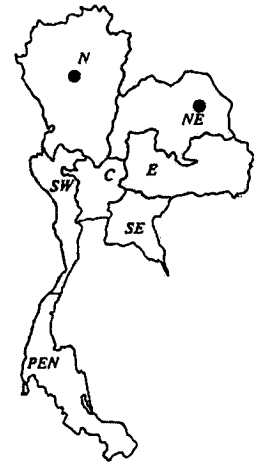


Figure 107 Distribution Maps of the Parmelioid Species in Thailand (continued)

Note: 64. *Parmotrema sulphuratum* 65. *P. thailandicum* 66. *P. tinctorum* 67. *Relicina abstrusa* 68. *R. subabstrusa* 69. *R. sublimbata* 70. *Relicinopsis intertexta* 71. *R. malaccensis* 72. *R. rahengensis*



73



74

75

Figure 108 Distribution Maps of the Parmelioid Species in Thailand (continued)

Note: 73. *Rimelia reticulata* 74. *Xanthoparmalia congensis* 75. *X. mougeotina*

REFERENCES

Acharius, E. 1814. **Synopsis Methodica Lichenum.** Svanborg et Soc, Lund. Reprint 1978. England: Richmond Publishing.

Ahmadjian, V. 1993. **The lichen symbiosis**. New York: John Wiley and son.

Almborn, O. 1965. The species concept in lichen taxonomy. **Botaniska notiser** 118: 454-457.

Awasthi, D. D. 1988. A key to the macrolichens of India and Nepal. **The Journal of the Hattori Botanical Laboratory** 65 (December): 207-302.

Brodo, I. M. 1986. Interpreting chemical variation in lichens for systematic purposes. **The Bryologist** 89, 2 (Summer): 132-138.

Brodo, I. M., S. D. Sharnoff, and S. Sharnoff. 2001. **Lichens of North America**. New heaven and London: Yale University.

Calvelo, S., and S. Liberatore. 2001. **Checklist of Argentinian lichens.** [Online]. Available URL: http://www.rrz.uni-humburg.de/biologie/ialb/herbar/argen_f2.ht.

Culberson, W. L. 1970. Chemosystematics and Ecology of Lichen-Forming Fungi. **Annual Review of Ecology and Systematics** 1: 153-170.

Culberson, W. L., and C. F. Culberson. 1970. A Phylogenetic View of Chemical Evolution in the Lichens. **The Bryologist** 73, 1 (Spring): 1-31.

DePriest, P. T. 1999. Development of Mason E. Hale's List of Epithets in the Parmelioid Genera (Lichen-forming Ascomycotina): A Bibliographic Review. **The Bryologist** 102, 3 (Fall): 442-461.

Elix, J. A. 1992. Lichen Chemistry. **Flora of Australia** 54: 23-29.

_____. 1993. Progress in the generic delimitation of *Parmelia* sensu lato lichens (Ascomycotina: Parmeliaceae) and a synopsis key to the Parmeliaceae. **The Bryologist** 96, 3 (Fall): 359-383.

_____. 1994. Parmeliaceae. **Flora of Australia** 55: 1.

_____. 1996a. A revision of the lichen genus *Relicina*. **Bibliotheca Lichenologica** 62: 1-150.

_____. 1996b. Biochemistry and secondary metabolites. In **Lichen Biology**, ed. T.H. Nash III, 154-180. Cambridge: Cambridge University Press.

_____. 1999. Detection and identification of secondary lichen substances: Contributions by the Uppsala School of Lichen Chemistry. **Acta Univ. Ups. Sysb. Bot. Ups.** 32, 2: 103-121.

Elix, J. A., and K. D. Ernst-Russell. 1993. **A catalogue of standardized thin layer chromatographic data and biosynthetic relationships for lichen substances.** 2d ed. Canberra: Department of Chemistry, The Faculties, Australian National University.

Elix, J. A., and M. E. Hale., Jr. 1987. *Canomaculina*, *Myelochroa*, *Parmelinella*, *Parmelinopsis*, and *Parmotremopsis*, five new genera in the Parmeliaceae (Lichenized Ascomycotina). **Mycotaxon** 29 (July-September): 233-244.

Elix, J. A., and P. M. McCarthy. 1998. Catalogue of the lichens of the smaller Pacific Island. **Bibliotheca Lichenologica** 70: 1-361.

Elix, J. A., and T. H. Nash III. 1992. A synopsis of the lichen genus *Psiloparmelia* (Ascomycotina, Parmeliaceae). **The Bryologist** 95, 4 (Winter): 377-391.

Elix, J. A., J. Johnston, and D. Verdon. 1986a. *Canoparmelia*, *Paraparmelia*, and *Relicinopsis*. Three new genera in the Parmeliaceae (Lichenized Ascomycotina). **Mycotaxon** 27 (October-December): 271-282.

Elix, J. A., J. Johnston, and P. A. Armstrong. 1986b. A revision of the lichen genus *Xanthoparmelia* in Australasia. **Bulletin of the British Museum (Natural History). Botany series.** 15, 3 (December): 163-362.

Eriksson, O. E., and D. L. Hawksworth. 1998. Outline of the ascomycetes 1998. **Systema Ascomycetum** 16: 83-296.

Esslinger, T. L. 1977. A chemosystematic revision of the brown *Parmeliae*. **The Journal of the Hattori Botanical Laboratory** 42 (May): 1-211.

_____. 1997. **A cumulative checklist for the lichen-forming, lichenicolous and allied fungi of the continental United States and Canada. North Dakota State University.** [Online]. Available URL: http://www.ndsu.nodak.edu/instruct/esslinger/chcklst/ chcklst7.htm.

Feeya Ammatavivat. 1994. **Chemotaxonomy and chemistry of lichens in Southern Thailand**. Final report of Faculty of Science. Songkla: Prince of Songkla University.

Feige, G.B., H.T. Lumbsch, S. Huneck, and J.A. Elix. 1993. Identification of lichen substances by a standardized high-performance liquid chromatographic method. **Journal of Chromatography** 646: 417-427.

Feuerer, T. 1999. **Checklist of lichens and lichenicolous fungi of Bolivia** [Online]. Available URL: http://www.rrz.uni-humburg.de/biologie/ialb/herbar/boliv_f2.htm.

_____. 2000a. **Checklist of Chilean lichens** [Online]. Available URL: http://www.rrz.uni-humburg.de/biologie/ialb/herbar/chile_f2.htm.

_____ . 2000b. **Checklist of Venezuelan lichens and lichenicolous fungi** [Online]. Available URL: http://www.rrz.uni/humburg.de/biologie/ialb/herbar/venez_f2.htm.

_____ . 2001a. (July). **Checklist of lichens and lichenicolous fungi from Lesotho.** Version 1. [Online]. Available URL: http://www.uni-humburg.de/biologie/ialb/herbar/lesot_12.htm.

_____ . 2001b. **Checklist of lichens and lichenicolous fungi of Ecuador.** [Online]. Available URL: http://www.rrz.uni-humburg.de/biologie/ialb/herbar/ecuad_f2.htm.

_____ . 2001c. (February). **Checklist of lichens and lichenicolous fungi of Madagascar.** Version 2. [Online]. Available URL: http://www.uni-humburg.de/biologie/ialb/herbar/madag_12.htm.

_____ . 2001d. **Checklist of lichens and lichenicolous fungi of Peru.** [Online]. Available URL: http://www.rrz.uni-humburg.de/biologie/ialb/herbar/peru_f2.ht.

_____. 2001e. (July). **Checklist of lichens and lichenicolous fungi of Namibia.** Version 1. [Online]. Available URL: http://www.uni-humburg.de/biologie/ialb/herbar/namib_12.htm.

_____. 2001f. (July). **Checklist of South African lichens and lichenicolous fungi.** Version 1. [Online]. Available URL: http://www.uni-humburg.de/biologie/ialb/herbar/souaf_12.htm.

Filson, R. B. 1992. Structure of lichens. **Flora of Australia** 54: 11-19.

Galloway, D. J. 1996. Lichen biogeography. In **Lichen Biology**, ed. T.H. Nash III, 199-216. Cambridge: Cambridge University Press.

Galun, M., and A. Shomar-Ilan. 1988. Secondary metabolic products. In **The handbook of lichenology III,** ed. Galun, 3-8. Florida: CRC Press.

Hale, B. W., and P. T. DePriest. 1999. Mason E. Hale's list of epithets in the Parmelioid genera. **The Bryologist** 102, 3 (Fall): 462-544.

Hale, M. E., Jr. 1965a. A monograph of *Parmelia* subgenus *Amphigymnia*. **Contributions from the United States National Herbarium** 36, 5:193-358.

_____. 1965b. Six new species of *Parmeliae* from Southeast Asia. **Journal of Japanese Botany** 40, 7 (July): 198-207.

_____. 1968. New *Parmeliae* from Southeast Asia. **Journal of Japanese Botany** 43,10-11 (November): 323-328.

_____. 1973. Fine structure of the cortex in the lichen family Parmeliaceae viewed with the scanning-electron microscope. **Smithsonian Contributions to Botany** 10: 1-92.

_____ . 1974a. New combinations in the lichen genus *Pamotrema* Massalongo. **Phytologia** 28, 4: 334-339.

_____ . 1974b. Delimitation of the lichen genus *Hypotrachyna* (Vainio) Hale. **Phytologia** 28, 4: 340-342.

_____ . 1974c. *Bulbothrix, Parmelina, Relicina,* and *Xanthoparmelia*, four new genera in the Parmeliaceae. **Phytologia** 28, 5: 479-490.

_____ . 1974d. New combinations in the lichen genus *Pseudoparmelia* Lynge. **Phytologia** 29, 3: 188-191.

_____ . 1975a. A revision of the lichen genus *Hypotrachyna* (Parmeliaceae) in tropical America. **Smithsonian contributions to Botany** 25: 1-73.

_____ . 1975b. A monograph of the lichen genus *Relicina* (Parmeliaceae). **Smithsonian Contributions to Botany 26**:1-32.

_____ . 1976a. Synopsis of a new lichen genus, *Everniastrum* Hale. **Mycotaxon** 3, 3 (April-June): 345-353.

_____ . 1976b. A monograph of the lichen genus *Pseudoparmelia* Lynge (Parmeliaceae). **Smithsonian Contributions to Botany** 31: 1-62.

_____ . 1976c. A monograph of the lichen genus *Bulbothrix* Hale (Parmeliaceae). **Smithsonian Contributions to Botany** 32: 1-29.

_____ . 1976d. A monograph of the lichen genus *Parmelina* Hale (Parmeliaceae). **Smithsonian Contributions to Botany** 33; 1-60.

_____ . 1979. **How to know the lichens.** 2d ed. Dubuque, Iowa: Wm. C. Brown.

_____. 1981. Pseudocyphellae and pored epicortex in the Parmeliaceae: Their delimitation and evolutionary significance. **Lichenologist** 13, 1 (February): 1-10.

_____. 1984. A historical review of the genus concept in lichenology. Beiheft zur **Nova Hedwigia** 79: 11-23.

_____. 1985. *Xanthomaculina* Hale, a new genus in the Parmeliaceae (Ascomycotina). **Lichenologist** 17, 3 (October): 255-265.

_____. 1986a. *Arctoparmelia*, a new genus in the Parmeliaceae (Ascomycotina). **Mycotaxon** 25 (April-June): 251-254.

_____. 1986b. *Flavoparmelia*, a new genus in the Parmeliaceae (Ascomycotina). **Mycotaxon** 25 (October-December): 603-605.

_____. 1987. A monograph of the lichen genus *Parmelia* Acharius sensu stricto (Ascomycotina: Parmeliaceae). **Smithsonian Contributions to Botany** 66: 1-55.

_____. 1988. *Namakwa*, a new lichen genus in the Parmeliaceae (Ascomycotina). **Mycotaxon** 32 (April-June): 169-174.

_____. 1989a. A new lichen genus *Psiloparmelia* Hale (Ascomycotina: Parmeliaceae), **Mycotaxon** 35 (January-March): 41-44.

_____. 1989b. *Karoowia* Hale, a new lichen genus in the Parmeliaceae (Ascomycotina). **Mycotaxon** 35 (January-March): 177-198.

Hale, M. E., and A. Fletcher. 1990. *Rimelia* Hale & Fletcher, a new lichen genus (Ascomycotina: Parmeliaceae). **The Bryologist** 93, 1 (Spring): 23-29.

Hale, M. E., and S. Kurokawa. 1964. Studies on *Parmelia* subgenus *Parmelia*. **Contributions from the United States National Herbarium** 36:121-191.

Hawksworth, D. L. 1988. Coniodiomata, conidiogenesis, and conidia. In **The handbook of lichenology I,** ed. Galun, 181-186. Florida: CRC Press.

Hawksworth, D. L., and D. J. Hill. 1984. **The lichen–forming fungi (Tertiary level biology)**. Glasgow and London: Blackie.

Hawksworth, D. L., P. M. Krik, B. C. Sutton, and D. N. Pegler. 1995. **Ainsworth & Bisby's dictionary of the fungi**. 8 th ed. Wallingford, UK: CAB International.

Huneck, S., and I. Yoshimura. 1996. **Identification of lichen substances**. Berlin: Springer-Verlag.

Jahns, H. M. 1973. Anatomy, morphology, and development. In **The lichen**, eds. Ahmadjian and Hale, 3-57. New York: Academic.

John, V. 1996. Preliminary catalogue of lichenized and lichenicolous fungi of Mediterranean Turkey. **Bocconea** 6: 173-216.

Kansri Boonpragob, Natsurang Homchantara, B. J. Coppins, P. M. McCarthy, and P. A. Wolseley. 1998. An introduction to the lichen flora of Khao Yai National Park, Thailand. **Botanical Journal of Scotland** 50: 209-219.

Kärnefelt, I., and A. Thell. 1992. The evaluation of characters in lichenized families, exemplified with the alectorioid and some parmelioid genera. **Plant Systematics and Evolution** 180: 181-204.

Kondratyak, S., I. Navrotskaya, A. Khodosovtsev, and O. Solonina. 1996. Checklist of Ukrainian lichens. **Bocconea** 6: 217-294.

Krog, H. 1982. Evolutionary trends in foliose and fruticose lichens of the Parmeliaceae. In proceedings of the symposia on Lichenology at the XIII International Botanical Congress, Sydney, Australia, Aug. 21-28, 1981. **The Journal of the Hattori Botanical Laboratory** 52 (May): 303-311.

Kurokawa, S. 1968. *Parmelia expallida*, a new lichen species from Eastern Asia. **Bulletin of the National Science Museum Tokyo** 11, 1 (May): 191-195.

_____. Chemical variation in the *Parmelia physcioides* group (Lichenes). **Journal of Japanese Botany** 61, 9 (September): 257-269.

_____. 1998. A new record and a new species in *Myelochroa* (Parmeliaceae). **Journal of Japanese Botany** 73, 1 (February): 12-14.

_____., and M. J. Lai. 2001. Parmelioid lichen genera and species in Taiwan. **Mycotaxon** 77 (January-March): 225-284.

Lai, M. J. 2001. Parmelioid lichen biodiversity and distributional ecology in Taiwan. **Fung. Sci.** 16, 3-4: 39-46.

Lai, M. J., and Z. Qian. 1993. Synopsis of classification of the Chinese Parmelioid lichens (Ascomycotina: Parmeliaceae). **Investigatio Et Studium Naturae** 13: 27-52.

Lawrey, J. D. 1984. **Biology of lichenized fungi.** New York, U.S.A.: Praeger publishers.

Louwhoff, S. H. J. J., and J. A. Elix. 1999. *Parmotrema* and allied lichen genera in Papua New Guinea. **Bibliotheca Lichenologica** 73: 1-152.

Malcolm, W. M., and D. J. Galloway. 1997. **New Zealand Lichens Checklist, Key and Glossary**. Wellington: Museum of New Zealand Te Papa Tongarewa.

Marcelli, M. P. 2001. (January) **Checklist of lichens and lichenicolous fungi of Brazil**. Version 1. [Online]. Available URL: http:// rrz.uni-humburg.de/biologie/ialb/herbar/brazi_f2.htm.

Myrdal, M. 1998. **Erick Acharius, the father of lichenology**. [Online]. Available URL: http:// linnaeus.nrm.se/botany/kbo/ach/welcome.htm.

Nash III, T. H., C. Gries, and J. A. Elix. 1995. A revision of the lichen genus *Xanthoparmelia* in South America. **Bibliotheca Lichenologica** 56: 1-158.

Nimis, P. L. 1999. **Lichen of Italy**. Univ. of Trieste, Dept. of Biology.

Okamoto, T. 1995. **Checklist of Japanese lichens recorded in floristic studies since 1980**. [Online]. Available URL: http:// is.kochi- u.ac.jp/ Bio/lichens/fljapan.html.

Osorio, H. 2000. **Checklist of Uruguayan lichens and lichenicolous fungi.** [Online]. Available URL: http:// rrz.uni- humburg.de/biologie/ialb/ herbar/urugu_f2.htm.

Park, Y. S. 1990. The Macrolichen flora of South Korea. **The Bryologist** 93, 2 (Summer): 105-160.

Patwardhan, P. G., and A. V. Prabhu. 1977. Three New Species of Parmeliaceae from India. **The Bryologist** 80, 2 (Summer): 348-350.

Paulson, R. 1930. Lichens from Kaw Toa, an island in the Gulf of Siam. **Journal of the Siam Society, Natural History Supplement** 8: 99-101.

Piboon Mongkolsuk, Kansri Boonpragob, and Natsurang Homchantara. 1996. **Collection and Identification of Lichens at Phuteen Suasai Forest, Nahaeo District, Loei Province.** Final report of biology Department, Ramkhamhaeng University presented to National Center of Genetic Engineering and Biotechnology. Bangkok: n.p.

Piboon Mongkolsuk, Kansri Boonpragob, and Natsurang Homchantara. 1997. **Biodiversity of Lichens at Queen Sirikit Botanic Garden, Mae Rim District, Chiangmai Province.** Final report of biology Department, Ramkhamhaeng University presented to Queen Sirikit Botanic Garden. Bangkok: n.p.

Poelt, J. 1973. Systematic evaluation of morphological characters. In **The Lichens**, eds. Ahmadjian and Hale, 91-116. New York: Academic.

Poinar, G. O. Jr., E. B. Peterson, and J. L. Platt. 2000. Fossil *Parmelia* in new world amber. **Lichenologist** 32, 3 (May): 263-269.

Pooprang, T., K. Boonpragob, and J. A. Elix. 1999. New species and new records in the lichen family Parmeliaceae (Ascomycotina) from Thailand. **Mycotaxon** 71 (April-June): 111-127.

Purvis, O. W., B. J. Coppins, D. L. Hawksworth, P. W. James, and D. M. Moore. 1992. **The lichen flora of Great Britain and Ireland.** London: Natural History Museum.

Randlane, T., A. Saag, and A. Thell. 1997. A second updated world list of Cetraioid lichens. **The Bryologist** 100, 1 (Spring): 109-122.

Randlane, T., and A. Saag. 2000. (August, 16). **Revision of the second updated world list of Cetraioid lichens.** [Online] Available URL: http://www.ut.ee/lichns/cetraria.html.

Richardson, D. H. S. 1988. Medicinal and other economic Aspects of Lichens. In **The handbook of lichenology III,** ed. Galun, 93-108. Florida: CRC Press.

Roger, R. W. 1992. Lichen ecology and biogeography. **Flora of Australia** 54: 30-40.

Rundel, P. W. 1978. The ecological role of secondary lichen substances. **Biochemical Systematics and Ecology** 6: 157-170.

Santesson, R. 1993. **The lichens and lichenicolous fungi of Sweden and Norway.** Lund: SBT-forlaget.

Sato, M. 1962. Lichens of Inthanon and Doi Suthep, northwestern Thailand. **Nature and Life in Southeast Asia** 2: 1-4.

Seaward, M. R. D. 1996. Checklist of Tunisian lichens. **Bocconea** 6: 115-148.

Singh, K. P., and G. P. Sinha. 1993. Two new species of *Parmelina* from India. **Nordic Journal of Botany** 13, 4: 463-466.

Sipman, H. J. M. 1986. Notes on the lichen genus *Everniastrum* (Parmeliaceae). **Mycotaxon** 26 (July-Septembe): 235-251.

_____ . 1997. **Checklist of the lichenized fungi of the Guianas.** [Online] Available URL: http://www.nmnh.si.edu/biodiversity/lichlist.htm.

Sipman, H. J. M., and A. Aptroot. 2001. Where are the missing lichens? **Mycol. Res.** 105, 12: 1433-1439.

Streimann, H. 1986. Catalogue of lichens of Papua New Guinea and Irain Jaya. **Bibliotheca Lichenologica** 22: 1-145.

Swinscow, T. D. V., and Krog, H. 1988. **Macrolichens of East Africa**. London: British Museum (Natural History).

Talbot, S. S., S. L. Talbot, J. W. Thomson, and W. B. Schofield. 1997. Lichens of Adak Island, Central Aleutian Islands, Alaska. **The Bryologist** 100, 2 (Summer): 241-250.

Tem Smitinand. 1977. **Vegetation and Ground Cover of Thailand**. Technical Paper, no. 1. Kasetsart University. Bangkok: n.p.

_____ . 1980. **Thai Plant Names (Botanical names-Vernacular names).** Bangkok: Royal Forest Department.

Thell, A. 1996. **Anatomy and taxonomy of cetrarioid lichens**. Doctoral dissertation, Lund University.

_____ . 2001a. (January). **Checklist of lichens and lichenicolous fungi of Angola.** Version 1. [Online]. Available URL: http://www.rrz.uni-humburg.de/biologie/ialb/herbar/angol_f2.htm.

_____ . 2001b. (May). **Checklist of lichens and lichenicolous fungi of Cameroon.** Version 1. [Online]. Available URL: http://www.rrz.uni-humburg.de/biologie/ialb/herbar/camer_f2.htm.

_____ . 2001c. (May). **Checklist of lichens and lichenicolous fungi of Ethiopia.** Version 2. [Online]. Available URL: http://www.uni-humburg.de/biologie/ialb/herbar/ethio_f2.htm.

_____. 2001d. (July). **Checklist of lichens and lichenicolous fungi of Guinea.** Version 1. [Online]. Available URL: http://www.uni-humburg.de/biologie/ialb/herbar/guinea_12.htm.

_____. 2001e. (May). **Checklist of lichens and lichenicolous fungi of Kenya.** Version 2. [Online]. Available URL: http://www.uni-humburg.de/biologie/ialb/herbar/kenya_f2.htm.

_____. 2001f. (July). **Checklist of lichens and lichenicolous fungi of Mozambique.** Version 1. [Online]. Available URL: http://www.uni-humburg.de/biologie/ialb/herbar/mozam_f2.htm.

_____. 2001g. (July). **Checklist of lichens and lichenicolous fungi of Rwanda.** Version 1. [Online]. Available URL: http://www.uni-humburg.de/biologie/ialb/herbar/rwand_12.htm.

_____. 2001h. (July). **Checklist of lichens and lichenicolous fungi of Sierra Leon.** Version 1. [Online]. Available URL: http://www.uni-humburg.de/biologie/ialb/herbar/sierr_12.htm.

_____. 2001i. (May). **Checklist of lichens and lichenicolous fungi of Somalia.** Version 1. [Online]. Available URL: http://www.uni-humburg.de/biologie/ialb/herbar/somal_f2.htm.

_____. 2001j. (July). **Checklist of lichens and lichenicolous fungi of the Ivory Coast.** Version 1. [Online]. Available URL: http://www.uni-humburg.de/biologie/ialb/herbar/coted_f2.htm.

_____. 2001k. (July). **Checklist of lichens and lichenicolous fungi of Tanzania.** Version 1. [Online]. Available URL: http://www.uni-humburg.de/biologie/ialb/herbar/tanza_12.htm.

_____ . 2001l. (May). **Checklist of lichens and lichenicolous fungi of Uganda.** Version 1. [Online]. Available URL: http://www.uni-humburg.de/biologie/ialb/herbar/ugand_12.htm.

_____ . 2001m. (July) **Checklist of lichens and lichenicolous fungi of Zaire.** Version 1. [Online]. Available URL: http://www.uni-humburg.de/biologie/ialb/herbar/zaire_12.htm.

_____ . 2001n. (July). **Checklist of lichens and lichenicolous fungi of Zambia.** Version 1. [Online]. Available URL: http://www.uni-humburg.de/biologie/ialb/herbar/zambi_12.htm.

_____ . 2001o. (July) **Checklist of lichens and lichenicolous fungi of Zimbabwe.** Version 1. [Online]. Available URL: http://www.uni-humburg.de/biologie/ialb/herbar/Zimba_12.htm.

Thrower, S. L. 1988. **Hong Kong Lichens**. Hong Kong: The urban Council.

Vainio, E. A. 1909. Lichen. **Botanik Tidsskrift** 29: 104-152.

_____ . 1921. Lichens in summo mente Doi Suthep (circ. 1675 m.s.m.) in Siam Boreali anno 1904 a D: re C.. Hosseo collecti. **Annales Botanici Societalis Zoologicae-Botanicae Fennicae Vanamo** 1, 3: 33-55.

Weerachai Nanakorn.1993. **A preliminary study on the forest vegetation of Thailand.** Bangkok: Botanical Garden.

White, F. J., and P. W. James. 1985. A new guide to microchemical technique for the identification of lichen substances. **Brithish Lichen Society Bulletin** 57: 1-41.

Wirth, V. 2001. **Checklist of lichens and lichenicolous fungi of Germany**. [Online]. Available URL: http://rrz.uni-humburg.de/biologie/ialb/herbar/germa_f2.htm.

Wolseley, P. A. 1997. Response of epiphytic lichens to fire in tropical forest of Thailand. **Bibliotheca Lichenologica** 68: 165-176.

Wolseley, P. A., and B. Aguirre-Hudson. 1991. Lichens as indicators of environmental change in the tropical forests of Thailand. **Global Ecology and Biogeopraphy Letters** 1: 170-175.

_____. 1995. Key to lichen genera in Thailand with special reference to epiphytic taxa, Part I: Macrolichens. **Natural History Bulletin of the Siam Society** 43: 303-335.

_____. 1997a. Fire in tropical dry forests: corticolous lichens as indicators of recent ecological change in Thailand. **Journal of Biogeography** 24: 345-362.

_____. 1997b. The ecology and distribution of lichens in tropical deciduous and evergreen forests in Thailand. **Journal of Biogeography** 24: 327-343.

Wolseley, P. A., C. Moncrieff, and B. Aguirre-Hudson. 1994. Lichens as indicators of environmental stability and change in the tropical forests of Northern Thailand. **Global Ecology and Biogeopraphy Letters** 4: 116-123.

Yoshimura, I. 1978. Some lichens of Thailand collected by the Danish botanists. **Bulletin of the Kochi Gakuen Junior College** 9: 35-40.

VITA

Miss Thitiporn Pooprang was born on March 7, 1971 in Chonburi Province. She finished her High School Education from Chonkunyanukul School in her birthplace in 1988. She gratuated with degree of Bachelor of Science from Department of Biology, Ramkhamhaeng University in 1995.

Thitiporn Pooprang, Kansri Boonpragob, and Piboon Mongkolsuk. 1997. Biodiversity of the lichen family Parmeliaceae. In **Proceedings of the 23th congress on science and technology of Thailand**, 400-401. Bangkok: Pinyo Press.

_____. 1998. Systematic Study of the lichens Family Parmeliaceae in Thailand. In **Abstracts: Research and Thesis, 2nd BRT Annual Conference**, 143. Bangkok: Work Press.

_____. 1998. Systematic Study of the lichens Family Parmeliaceae in Thailand. In **Programme and Abstracts, 24th congress on science and technology of Thailand**, 441-442. Bangkok: Pinyo Press.

_____. 1999. Systematic Study of the lichens Family Parmeliaceae in Thailand. In **Research Reports on Biodiversity in Thailand of Proceeding Congress BRT 3**, 119-123. Bangkok: Work Press.

_____. 2000. Systematic Study of the lichens Family Parmeliaceae in Thailand. In **Abstracts: Research and Thesis, 4th BRT Annual Conference** , 42. Bangkok: Work Press.