# STUDY ON TAXONOMY AND ECOLOGY OF THE LICHENS FAMILY TRYPETHELIACEAE IN THAILAND

KAJOHNSAK VONGSHEWARAT

A THESIS PRESENTED TO RAMKHAMHAENG UNIVERSITY
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE DEGREE OF MASTER OF SCIENCE
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# การศึกษาอนุกรมวิธานและนิเวศวิทยาของไลเคนวงศ์ทริพพิทิเลียซิอิในประเทศไทย

ขจรศักดิ์ วงศ์ชีวรัตน์

วิทยานิพนธ์เสนอต่อมหาวิทยาลัยรามคำแหง
เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญา
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| Thesis Title | Study on Taxonomy and Ecology of the Lichens Family Trypetheliaceae in Thailand | |
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| | Dr. Natsurang Homchantara | |

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# ABSTRACT

Thesis Title : Study on Taxonomy and Ecology of the Lichens Family Trypetheliaceae in Thailand

Student's Name : Mr. Kajohnsak Vongshewarat

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Major : Biology

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3. Dr. Natsurang Homchantara

The Trypetheliaceae is a large family, which occurs commonly in tropical areas. The objectives of this study are to explore taxonomy, ecology and distribution of the lichen family Trypetheliaceae in Thailand. The study was performed from collection of samples during 1994 to 1999. Corticolous lichens were collected from 63 species of host trees from 26 study areas distributed throughout the country from sea level to 2,250 meters altitude. Total collections comprised of 559 specimens. About 519 specimens were identified to species, the rest were unable to determine their taxa because they were lack of ascospores, which are used for identification to species level. The identification was confirmed at Australian National Botanic Garden,

Australia. They composed of 6 genera, 33 species, 1 variety and 4 unidentified species. This study found 22 new recorded species in Thailand. A new species, *Laurera meristosporoides* P. M. McCarthy & Vongshewarat sp. nov. was described. It was collected from the hill evergreen forest at 1200 meters above sea level from Phu Hin Rong Kla National Park, Phisanulok Province. The most widely distributed species are *Laurera benguelensis* and *Trypethelium eluteriae*. The highest biodiversity was recorded from Khao Yai National Park, where all 6 genera 22 species that occurred in Thailand were found. Very few samples were collected from Bangkok Metropolitan and other urban areas.

# บทคัดย่อ


ชื่อเรื่องวิทยานิพนธ์ : อนุกรมวิธานและนิเวศวิทยาของไลเคนวงศ์ทริพพิทิเลียซิอิ ในประเทศไทย

ชื่อผู้เขียน : นายขจรศักดิ์ วงศ์ชีวรัตน์

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3. ดร. ณัฐสุรางค์ หอมจันทร์

ไลเคนวงศ์ทริพพิทิเลียซิอิ เป็นไลเคนที่พบได้ทั่วไปในเขตร้อน การศึกษานี้มีวัตถุประสงค์เพื่อรวบรวม จัดจำแนกตามหลักอนุกรมวิธานพร้อมทั้งศึกษาการแพร่กระจายและนิเวศวิทยาของไลเคนวงศ์ทริพพิทิเลียซิอิในประเทศไทย โดยกระทำจากตัวอย่างที่เก็บระหว่างปี พ.ศ. 2537-2542 จำนวน 559 ตัวอย่าง จากพื้นที่ต่างๆ ในประเทศจำนวน 26 แห่ง บนพรรณพืชที่ไลเคนเจริญเติบโต 63 ชนิด ที่ความสูงตั้งแต่ระดับน้ำทะเลถึง 2,250 เมตร จากจากการวิเคราะห์ไลเคนตามหลักอนุกรมวิธานจนถึงปัจจุบันสามารถจำแนกชนิดได้ 519 ตัวอย่าง ส่วนที่เหลือไม่สามารถจำแนกชนิดได้เนื่องจากไม่พบ แอสโคสปอร์ (ascospore) ซึ่งเป็นส่วนสำคัญที่ใช้ในการจำแนกชนิด เมื่อนำตัวอย่างบางส่วนไปตรวจสอบจากแหล่งข้อมูลที่เชื่อถือได้ ณ Austalian National Botanic Garden ประเทศออสเตรเลีย พบไลเคนวงศ์ทริพพิทิเลียซิอิ 6 สกุล 33 ชนิด 1 สายพันธุ์ และไม่สามารถจำแนกถึงระดับชนิดได้ 4 ชนิด ในจำนวนนี้เป็นไลเคนที่พบครั้งแรกในประเทศไทย 22 ชนิด (new record) และพบไลเคนชนิดใหม่ (new species) 1 ชนิด คือ *Laurera meristosporoides* P. M. McCarthy & Vongshewarat sp. nov. ในป่าดิบเขา ที่

ความสูงจากระดับน้ำทะเล 1200 เมตร จากอุทยานแห่งชาติภูหินร่องกล้า จังหวัดพิษณุโลก ไลเคนวงศ์นี้มีการแพร่กระจายทั่วประเทศไทย โดย *Laurera benguelensis* และ *Trypethelium eluteriae* พบได้เกือบทุกระบบนิเวศ บริเวณที่ทีความหลากหลายมากที่สุด ได้แก่ อุทยานแห่งชาติเขาใหญ่ โดยพบ 6 สกุล 22 ชนิด ที่พบทั้งหมดในประเทศไทย บริเวณที่มีความหลากหลายชนิดน้อยได้แก่ กรุงเทพมหานคร และเขตชุมชนเมืองต่างๆ

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Kajohnsak Vongshewarat

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# CHAPTER 1

# INTRODUCTION

## General Introduction

The Trypetheliaceae is a family of the Pyrenulales, which consists of 5 families namely: Massariaceae, Phyllobatheliaceae, Pleurotremataceae, Pyrenulaceae and Trypetheliaceae (Hawksworth *et al.* 1995, 567). The Trypetheliaceae is a large family, which occurs commonly in tropical areas. It composes of thirteen genera, which are *Architrypethelium* Aptroot., *Astrothelium* Eschw., *Buscalionia* Sambo., *Campylothelium* Müll. Arg., *Exiliseptum* R. C. Harris., *Laurera* Reichenb., *Megalotremis* Aptroot., *Melanothecopsis* C. W. Dodge., *Ornatopyrenis* Aptroot.., *Polymeridium* (Müll. Arg.) R. C. Harris, *Pseudopyrenula* Müll. Arg, *Trypetheliosis* Asahina. and *Trypethelium* Sprengel. (Hawksworth 1995, 567). Almost 200 species belong to this family (Harris 1984, 56). It contains almost exclusively of tropical epiphytes attach on branches in rainforests, especially in the neotropics (Aptroot 1991, 118). They are characterized by corticolous thallus varying form well developed, with distinct to poorly developed cortex and medulla, which are distinguishable only by discoloration of the bark. This taxa contains *Trentrepohlia* as photobiont. Ascomata are solitary or aggregated, often with pseudostromatic tissue which may be mutilayer containing crystals and

various lichen products. The centrum is filled with gelatin. Pseudoparaphyses are branched or anastomoses. Ascus is generally cylindrical contains mostly 8 ascospores. Ascospores are transeversely septated to muriform, colorless and sometimes surrounded by gelatinous sheath. Lichen substances are lichexanthone and various products including anthraquinones such as parietin (Harris 1984, 56). Bioactivity of the lichen products as antibiotic and fungicide from the Trypetheliaceae were detected in many species. For example, extract from *Trypethelium eluteriae* efficiency inhibits growth of *Aspergillus* sp. or *Penicillium* sp. (Methey 1979, 917). The Trypetheliaceae is distributed abundantly in the tropical region such as Panama, Venezuela, India and Sri Lanka (Harris 1984, 56).

The Trypetheliaceae is poorly known in Thailand. This study provides information on biodiversity of this family in Thailand. During the past Vainio, a Danish lichenologist, reported three species of the Trypetheliaceae from Koh Chang Island (Vainio 1909b, 147-150); Paulson reported *Trypethelium eluteriae* as an only species from Koh Tao Island (Paulson 1930, 100). In 1991-1993, Wolseley and Aguirre-Hudson studied lichens as indicator of environmental change in the tropical forests of northern Thailand. They recorded 7 species and 4 variety of the Trypetheliaceae (Wolseley and Aguirre-Hudson 1991, 1997a, 1997b, 1997c). Intensive collections by local botanists during 1993-1995, collected 76 genus and 169 species of lichens from Queen Sirikit Botanic Garden, Chiang Mai Province, and 89 genus and 166 species from Na Heao National Park, Loei Province. Only 2 species of the Trypetheliaceae were reported from both studies (Mongkolsuk et al. 1996, 7-

12; 1997, 8-12). Subsequent collection of lichens from Khao Yai National Park found 6 species. (Boonpragob et al. 1998, 209-219). Presently, 5 genera 11 species of the Trypetheliaceae have been discovered in Thailand.

## Objectives

The aims of this study are listed as following:

1. To collect and preserve the lichens family Trypetheliaceae in Thailand.

2. To study the taxa belong to the family Trypetheliaceae in Thailand and to describe the genus and the species of the family Trypetheliaceae.

3. To organize database of the Trypetheliaceae in Thailand.

4. To study the distribution of the Trypetheliaceae in Thailand.

## Hypothesis

Hawksworth (1995) and Harris (1984 and 1995) reported that about 13 genera and 200 species are mumber of the Trypetheliaceae. Infrequent collections in Thailand during the part found 5 genera and 11 species of this family. Intensive collections from different forest ecosystems in Thailand in this study are expected to found more than 20 species.

# CHAPER 2

# REVIEW LETERATURE

## Historical Background

The first genus of lichen the family Trypetheliaceae was *Trypethelium*. Sprengel proposed this genus in 1804. It was characterized by having ascomata embedded in pseudostroma, and produced hyaline ascospores with transversely septate (Farr et al. 1979, quoted in Makhija and Patwardhan 1993, 183). Before 1819, Eric Acharius, the father of lichenologist, described 2 genera as *Astrothelium* and *Trypethelium*. They composed of 6 species, *Astrothelium papillosum* Ach. (*Trypethelium papillosum* Ach.), *A. variolosum* Ach. (*T. variolosum* Ach.), *Trypethelium anomalum* Ach, *T. eluteriae* Sprengel. (*T. conglobatum* Ach.), *T. mastoideum* Ach. (*Bathelium mastoideum* Ach.) and *T. ochroleucum* Ach (*T. porosum* Ach.) (Myrdal 1998).

Müller Argovensis separated the *Trypethelium* into 2 sections by using shape and septation of the ascospore. One of these is *Bathelium*, which ascospores compose of 4 locules and *Eutrypethelium* having fusiform ascospores consist of 10-16 locules. He also proposed 5 genera of Trypetheliaceae, which were: *Bathelium*, *Bottaria, Melanotheca*, *Tomasellia* and *Trypethelium* (Müller 1885, 239; 1888b, 391). In 1951, *Laurera* and *Trypethelopsis* was added to the Catalogus Lichenum Universalis. (Zahlbruckner 1951, 471-508). Thirty years later, Dodge studied lichen in

tropical Africa and gives a new genus *Riddle*, but this genus is discarded later (Dodge 1953, 286-297). About 36 species of *Laurera* were reported world wide in the Revision monographique de genre *Laurera* (Lichens, Trypetheliaceae) by Letrouit-Gulinou (Letrouit-Gulinou 1957, 207-264; 1958, 66-73). The major changes in the Trypetheliaceae were performed by Harris. He proposed 7 genera: *Astrothelium, Campylothelium, Cryptothelium, Exilliseptum, Pleurotrema, Polymeridium* and *Pseudopyrenula,* and separated 3 genera, *Botarria, Melanotheca* and *Tomasellia* out of this family. Harris's assumption based on hamathecium (pseudoparaphyses) and type of septation of ascospores (Harris 1975, 148-162, 180-189; 1984, 55-80). In 1991, Aptroot presented 3 new genera; *Architrypethelium*, *Megalotremis* and *Ornatopyrenis* (Aptroot 1991, 29). Thirteen genera were proposed to be members of Trypetheliaceae by Hawksworth, et al. (1995, 567). These are *Architrypethelium* Aptroot., *Astrothelium* Eschw., *Buscalionia* Sambo., *Campylothelium* Müll. Arg., *Exiliseptum* R. C. Harris., *Laurera* Reichenb., *Megalotremis* Aptroot., *Melanothecopsis* C. W. Dodge., *Ornatopyrenis* Aptroot., *Polymeridium* (Müll..Arg.) R. C. Harris., *Pseudopyrenula* Müll. Arg., *Trypetheliopsis* Asahina. and *Trypethelium* Sprengel. The two genera *Buscalionia* Sambo and *Trypetheliopsis* Asahina have not been assigned to the member of the Trypetheliaceae, whereas *Melanothecopsis* C. W. Dodge was included in the Pyrenulaceae (Aptroot 1991, 29; and Hawksworth 1995, 567). They regarded *Crytothelium* as a synonym of *Laurera.*

This study is based on the arrangement of Harris and Aptroot by using morphological and anatomical characteristics of ascus and ascospores (Harris

1975, 148-162, 180-189; 1984, 55-80) by regarding them as the evolution of phylogenetic information (Aptroot 1991, 29). (See the Table 1.)

Table 1 Mumber of Taxa of the Trypetheliaceae During 1885-1995 Propose by Six Authors.

| Müller (1885, 1888) | Zahlbruckner (1951) | Dodge (1953) | Harris (1975, 1984) | Aptroot (1991) | Hawksworth (1995) |
|---|---|---|---|---|---|
| *Bathelium* | *Bottaria* | *Bathelium* | *Astrothelium* | *Architrypethelium* | *Architrypethelium* |
| *Bottaria* | *Laurera* | *Bottaria* | *Campylothelium* | *Astrothelium* | *Astrothelium* |
| *Melanotreca* | *Melanotreca* | *Laurera* | *Crypetothelium* | *Campylothelium* | *Buscalionia* |
| *Tomassellia* | *Tomassellia* | *Melanotreca* | *Exilliseptum* | *Crypetothelium* | *Campylothelium* |
| *Trypethelium* | *Trypetheliopsis* | *Riddlea* | *Laurera* | *Exilliseptum* | *Exiliseptum* |
| | *Trypethelium* | *Tomassellia* | *Pleurotrema* | *Laurera* | *Laurera* |
| | | *Trypethelium* | *Polymeridium* | *Megalotremis* | *Megalotremis* |
| | | | *Pseodopyrenula* | *Ornatopyrenis* | *Melonothecopsis* |
| | | | *Trypethelium* | *Polymeridium* | *Ornatopyrenis* |
| | | | | *Pseodopyrenula* | *Polymeridoium* |
| | | | | *Trypethelium* | *Pseudopyrenula* |
| | | | | | *Trypetheliopsis* |
| | | | | | *Trypethelium.* |

This study accepted 10 genera out of 12 genera as proposed by Harris and Aptroot, because their classification consisted of detail description of genus characteristic. These genera are listed below:

*Architrypethelium* Aptroot. *Astrothelium* Eschw.

*Campylothelium* Müll. Arg. *Exilliseptum* R. C. Harris.

*Laurera* Riechemb. *Megalotremis* Aptroot.

*Ornatopyrenis* Aptroot. *Polymeridium* (Müll.Arg.) R. C.Harris.

*Pseudopyrenula* Müll.Arg. *Trypethelium* Sprengel.

The *Trypetheliaceae* may need future reassessment by incoporation genetic information, with studies in morphology, anatomy, ontogeny and molecular biology.

**Distribution of the Trypetheliaceae**

Investigation of the Trypetheliaceae were carried on extensively in various parts of the world. In North American continent, such as USA and Canada, found 6 genera and 34 species (Degelius 1940; Egan 1987; and Harris 1975, 1995), 1 genera and 3 species from Mexico (Zahlbruckner 1951). South American continent consisted of 2 genera and 11 species from Cuba (Zahlbruckner 1951), 3 genera and 4 species from Hawaii Island (Magnusson and Zahlbruckner 1944), 5 genera and 10 species from Venezuela (Feuere 2000), 7 genera and 108 species from Brazil (Harris 1984; Marcelli 2000), 1 genera and 1 species from Peru (Feuere 2000), 2 genera and 2 species from Chili (Feuere 2000). In African continent, 2 genera and 20 species were reported from Tropical Africa (Dodge 1953). In Asian continent, 3 genera and 11 species were collected from China (Jiang-chum 1991), 1 genera and 2 species from Japan (Okamoto 1995), 3 genera from Hong Kong (Thrower 1988), 5 genera and 81 species from India, Napal and Sri Lanka (Makhija and Patwardhan 1988, 1992, 1993; and Awasthi 1991), 2 genera and 4 species from Andaman Island (Makhija and Patwardhan 1988), 2 genera and 2 species from

the Philippine (Zahlbruckner 1951), 2 genera and 5 species from Indonesia (Borneo and Java) (Zahlbruckner 1951). Austalian continent and small Pacific island, were represented by 9 genera and 29 species from Australia (McCarthy 1993; and Filson 1996), 3 genera and 4 species from Tasmania (Wetmore 1963; and McCarthy 1995), 3 genera and 4 species from New Zealand (Malcolm and Galloway 1997), 8 genera and 22 species from Papua New Guinea and Irian Jaya (Streimann 1986; and Aptroot et al. 1997), 6 genera and 25 species from small Pacific Island (Elix and McCarthy 1998). This family is absent from European continent. Mumbers of genera and species of the Trypetheliaceae reported from various countries are shown in the Table 2.

**Studies of theTrypetheliaceae in Thailand**

The report of the Trypetheliaceae in Thailand was first recognized by the Danish lichenologist, Vainio, who collected specimens from Koh Chang Island, Trat Province. Among the examined lichens of 29 genera and 95 species, only 1 genus and 3 species belong to the Trypetheliaceae. They were *Pseudopyrenula* (subg. *Trypethelium*) *ochroleuca.*, *P.* (subg. *Heterothelium* sect. *Homalothecium*) *endoxanthoides.*, *P.* (subg. *Heterothelium* sect 3 *Hemithecium*) *diluta* var. *degenerans* (Vainio 1909b, 104-152). Paulson (1930, 99-101) published an only species, *Trypethelium eluteriae,* from Koh Tao Island, an island in the gulf of Siam, Surat Thanni Province in southern Thailand. Thirty one species of Warncke's collection from the north of Thailand were identified by Isao Yoshimura. These samples are preserved at

Table 2 Distribution of the Trypetheliaceae in Various Countries.

| Country | Number of genera | Number of species | Reference |
|---|---|---|---|
| **North American continent** | | | |
| USA, Canada | 6 | 34 | Degelius, 1940; Egan, 1987; Harris, 1975, 1995. |
| Mexico | 1 | 3 | Zahlbruckner, 1951 |
| **South American continent** | | | |
| Cuba | 2 | 11 | Zahlbruckner, 1951 |
| Hawaii Island | 3 | 4 | Magnusson & Zahlbruckner, 1944 |
| Venezuela | 5 | 10 | Feuere, 2000 |
| Brazil | 7 | 108 | Harris, 1984; Marcelli, 2000 |
| Peru | 1 | 1 | Feuere, 2000 |
| Chili | 2 | 2 | Feuere, 2000 |
| **European continent** | | | |
| Britain and Ireland | - | - | Puvis *et al.*, 1992 |
| Europe | - | - | Zahlbruckner, 1951 |
| **African continent (Tropical Africa)** | 2 | 20 | Dodge, 1953, 1964 |

Table 2 (continued)

| Country | Number of genera | Number of species | Reference |
|---|---|---|---|
| **Asian continent** | | | |
| China | 3 | 11 | Jiang-chum, 1991 |
| Japan | 1 | 2 | Okamoto, 1995 |
| Hong Kong | 3 | 2 | Thrower, 1988 |
| India, Napal and Sri Lanka | 5 | 81 | Awasthi, 1991; Makhija & Patwardhan, 1988, 1992, 1993; Upreti & Singh, 1987 |
| Andanan Island | 2 | 4 | Makhija & Patwardhan, 1988 |
| Philippine | 2 | 2 | Zahlbruckner, 1951 |
| Indonesia (Java and Borneo) | 2 | 6 | Zahlbruckner, 1951 |
| **Australian continent** | | | |
| Australia | 9 | 28 | McCarthy, 1995; Filson, 1996 |
| Tasmania | 3 | 5 | Wetmore, 1963; McCarthy, 1993 |
| New Zealand | 3 | 4 | Malcolm & Gallaway, 1997 |
| **Other region** | | | |
| Papua New Ginea and Irian Jaya | 8 | 22 | Streimann, 1986; McCarthy, 1995; Aptroot *et al.*, 1997 |
| Small Pacific Island | 6 | 25 | Elix & McCarthy, 1997 |

the department of Systematic Botany, University of Arrhus, Denmark and Kochi Gukuen College, Japan. None of the Trypetheliaceae was recorded (Yoshimura 1978, 35-40). Wolseley and Aquirre-Hudson reported 105 genera and 407 species collected mainly from northern and western Thailand. They comprised of 2 genera 7 species and 4 variety of the Trypetheliaceae (Wolseley and Aquirre-Hudson 1991, 1997a, 1997b, 1997c). Only *Trypethelium eluteriae* was reported in the peninsular Thailand (Ommatavivat 1994, 70).

Between 1993-1995, projects on Biodiversity of lichens at the Queen Sirikit botanic Garden, Mae Rim District, Chiang Mai Province and Phuteen Suansai Forest, Na Haeo District, Loei Province reported 76 genera, 169 species and 89 genera, 166 species respectively. Only 2 species belong to the Trypetheliaceae (Piboon Mongkolsuk et al. 1996, 22; 1997, 26). A preliminary study on biodiversity at Khao Yai National Park, Saraburi to Nakhonratchasrima found about 6 species of the Trypetheliaceae, which were *Laurera benguelensis*, *L. madreporiformis*, *L. meristospora*, *Polymeridium* spp., *Trypethelium tropicum* and *T.* cf *eluteriae*. (Kansri Boonpragob et al. 1998, 209-219).

# CHAPTER 3

# SURVEYS AND STUDIED AREAS

## Location and Topographic Characteristic of Thailand

Thailand is suited on the Indo-China Peninsula in the Southern part of Asia, between latitudes 5° 40′ and 20° 30′ N, longitudes 97° 20′ and 105° 45′ E (Figure 1). The country total area is 513,115 sq. km, of which about 230,000 sq. km is forested land. The North shares a borderline with Burma (Union of Myanmar) and Laos. The northeast and the eastern parts of Thailand adjoin Laos and Cambodia separated by the Mae Khong River. The whole western and southwestern parts of Thailand bound by Burma (Union of Myanmar), with the long Tanawsri mountain range acting as a huge natural boundary. The sourthern peninsular of Thailand is almost surrounded by ocean; only the southern most parts is bounded by Malaysia (Kansri Boonpragob 1999, III-3-4; Weerachai Nanakon 1993, 1-31).

The topography of Thailand composes of highland, plateaus, peneplains and depression. The principal mountain ranges the Daenlao-Phi Pannam in the North, the Tanaosri or the Tenasserim in the West run mostly along the North-Southeast directions. The plateau on northeastern lies above 120 - 220 m elevation. The Northwestern highland is being drained by the 4 tributaries, i.e. Ping, Wang, Yom and Nan, of the Chao Phraya River (850 km). The Chao Phraya River, the Thachin River and the others drain into the central plain.

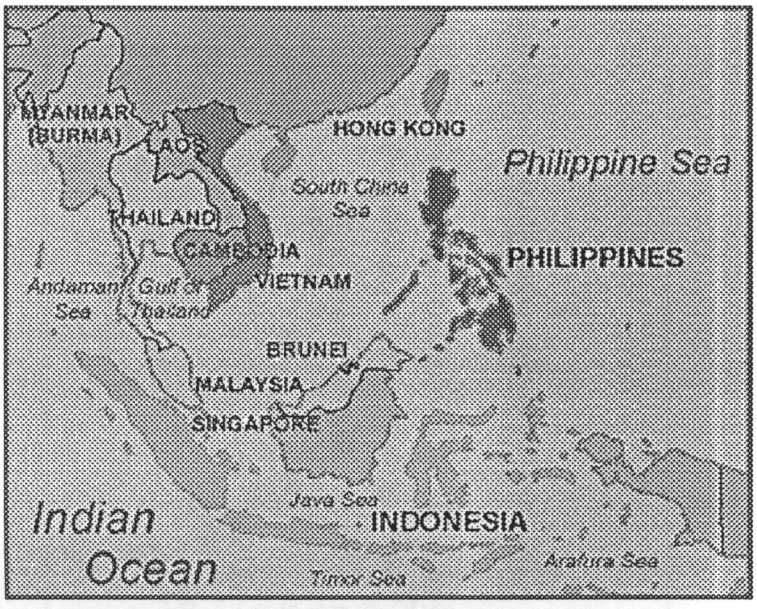



Figure 1 Map of Thailand and Neighboring Country in South East Asia

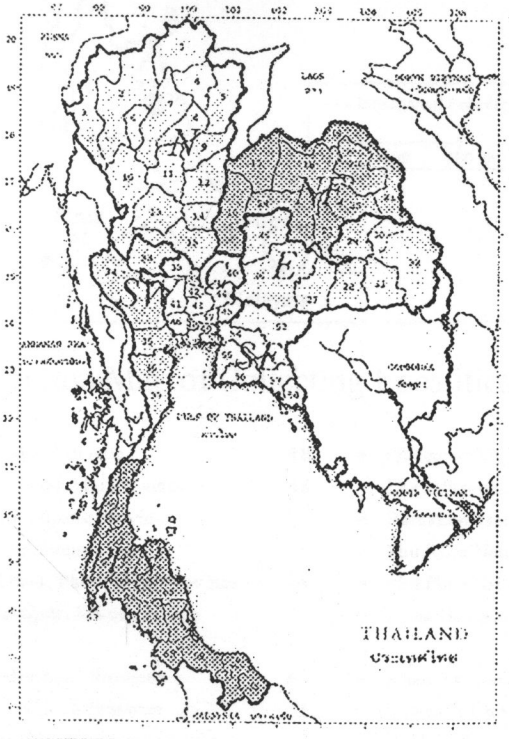



Figure 2 Vegetation Map of Thailand Showing the Seven Regions.
N = the north, NE = the northeast, E = the east, C = the central,
SW = the southwest, SE = the southwest and PEN = the peninsular.

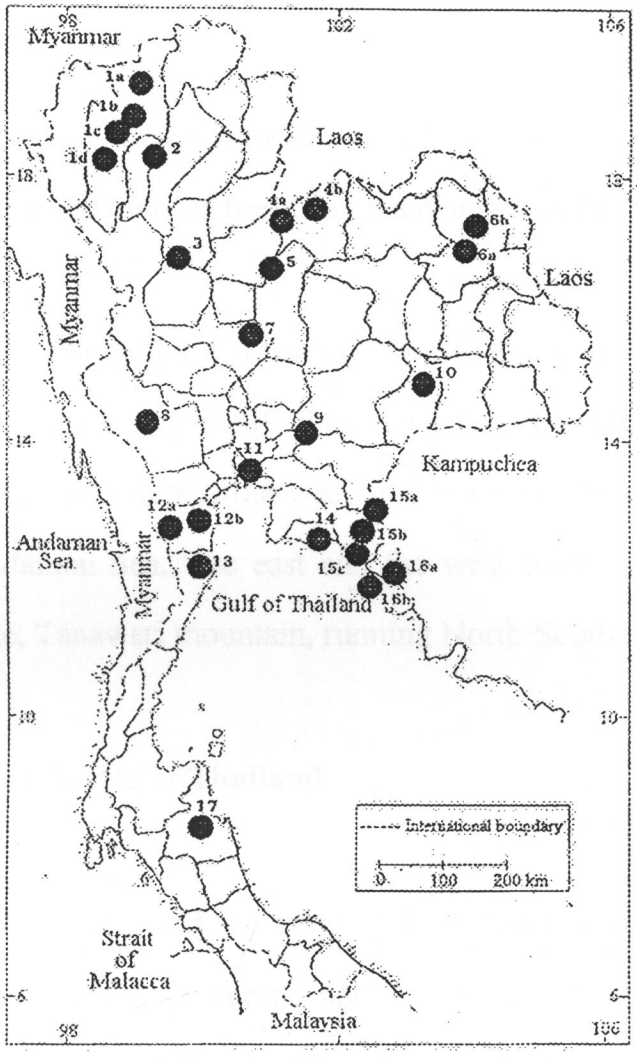



Figure 3 Distribution Map of Collecting Localities in Thailand

1a = Chiang Doa Resort, Chiang Mai Province
1b = Queen Sirikit Botanic Garden, Chiang Mai Province
1c = Suthaep-Pui National Park, Chiang Mai Province
1d = Doi Inthanon National Park, Chiang Mai Province
2 = Doi Khuntan National Park, Lumpang Province
3 = Ramkhamhaeng National Park, Sukhothai Province
4a = Na Haeo National Park, Loei Province
4b = Phu Ruea National Park, Loei Province
5 = Phu Hin Rong Kla National Park, Phitsanulok Province
6a = Phu Phan National Park, Sakon Nakhon Province
6b = Ratjabhat Sakhon Nakhon Institute, Sakon Nakhon Province
7 = Nong Bua School Forest, Nakhon Sawan Province
8 = Erawan National Park, Kanchanaburi Province
9 = Khao Yai National Park, Nakhon Ratchasima Province
10 = Khao Kadong Forest Park, Buri Ram Province
11 = Kasetsart University, Bangkok Province
12a = Khang Ka Chan National Park, Phetchaburi Province
12b = Banlad District, Phetchaburi Province
13 = Communication Station in Hua Hin District, Prachuap Khiri Khan Province
14 = Mangove Forest in Klaeng District, Rayong province
15a = Numtok Phliu National Park, Chanthaburi Province
15b = Kitchakut National Park, Chanthaburi Province
15c = Management Mangrove forest Unit in Klung, Chanthaburi Province
16a = Management Mangrove forest Unit, Trat Province
16b = Kao Chang Island National Park, Trat Province
17 = Khao Luang National Park, Nakhon Sri Thammarat Provinc

Besides the existing irrigation system, this plain is fertile and appropriate for agriculture.

The southeast area comprises of numerous small hill with NE-SW orientation, a continuation of the Kamphuchian mountain range, form narrow coastal plains.

The peninsular south is a narrow stip of land, part of Malay peninsular, the east coast is approximately 1930 km long bound to the gulf of Thailand in the South China sea, whereas the west cost is narrow beach of about 490 km along the Anadaman Sea. The east and the west coasts is seperated by high mountain range, Tanawsri mountain, running North-South.

**Characteristic Climate of Thailand.**

Climate in Thailand is under the influences of Asian monsoons originated from the Indian oceans and the northeast territory of the Asian continent. They are modified largely by regional topography especially the Himalayan ridges in the center of the continent (Weerachai Nanakhon 1990, 6). The country, therefore, consists of two climatic systems; the monsoon climate and the tropical rain forest climate. The monsoon climate is characterized by an extremely wet and an extremely dry season, whereas the tropical rain forest climate prevails with wet conditions throughout the year. The monsoon climate influences Continental Southeast Asia. The Southwest monsoon bring moisture laden air from Indian Ocean to both the continent and the southern peninsular. Heavy rains occur in rainy season from May to October. The Northeast

monsoon begins when the northern air mass brings cool dry air from the northern continent to Southeast Asia in cold season from November through February. However, as this air mass flow over South China sea, it pick up moisture, and bring rain to the southern peninsular, particularly the east coast. Therefore, three seasons are characterized in Thailand as mentioned below;

**Cold Season**: from mid-November to February. The weather is cool and dry. The coolest period is during December – January, by which temperature varies from 8-16 $^{\circ}$C. The northern and northeastern is the coolest areas. Minimal temperature varies from –2 to 1$^{\circ}$C or –1 to 4 $^{\circ}$C at Phu Luang Wildlife Sanctuary, Loei Province in northeastern Thailand.

**Summer Season**: from March to May. The weather is dry and hot. The hottest period has average temperature of 26-36 $^{\circ}$C. Temperature at the hottest area averages 35 to 45$^{\circ}$C were recorded at the Korat plateau, Nakhon Ratchasrima Province, in eastern Thailand.

**Rainy Season**: from June to October. The weather is humid with quite stable temperature between 17 and 25 $^{\circ}$C. The average precipitation exceed 1,500 to 2,000 mm is common, sometimes reach 4,000 mm per year. This occurs in the Southeastern and Southern Thailand, such as Kong Log District, Trat Province and Ranong Province.

Climate have major impact on species and vegetation types of the whole country. (Kansri Boonpragob 1999, Weerachai Nanakhon 1990, Somkit Pongpayant and Suparp Phupasert 1971, Tem Smitinand 1977).

**The Characteristic Forests of Thailand**

The Royal Forest Department broadly categories forests into seven floristic regions: north, northeast, east, central, southeast, southwest and south or peninsular regions (Tem Smitinand 1980; Figure 2). The vegetation types mentioned below consist of 3 major groups, which are the evergreen forest, the deciduous forest and forest or vegetation of other specific type (Weerachai Nanakhon 1993, 1-31). However, altitudinal gradient plays significant role in forest classification. The detail characteristic of forests are described as follow: (Somkit Pongpayant and Suparp Phupasert 1971, 13-30; Tem Smitinand 1977, 160-171; Weerachai Nanakhon 1993, 1-31).

**Mangrove Forest**. The mangrove is coastal tropical formations found along the border of the sea and lagoons. The forest grows along the estuaries of high salinity in muddy clay and occasionally cover by the seawater during high tide. The distribution of forest is very extensive along the west coast from Satun Province to Ranong Province, and along the sea coast on the Gulf of the Thailand from Samut Sakhon Province in the southwest to Trat Province in the southeast. The total area of mangrove forests is about 47,400 sq. km. (Sanit Aksornkoae 1998, 7). The dominant species of trees are *Avicennia offcinalis, Bruguiera* sp, *Rhizophora apiculata, R. mucronata* and *Xylocarpus* sp.

**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. It is under the influences tropical rain forest

climate, which experience high precipitation over 2,500 mm. The forest is multilayered strata with dense and a continuous crown canopy. The ground floor are well scattered by herbaceous species, so that it is easy to walk within the forest, although at the edges, where more light is available, impenetrable thickets of vegetation occur (Vickery 1984, 65). The vegetation cover composes of high diversity of trees species, such as *Adenanthera, Dipterocarpus, Ficus* and *Hopea spp* etc.

**Dry Evergreen Forest.** The forest is scattered throughout the country along the depression on the peneplain, along the valleys of long hill ranges of about 500 - 700 m. elevations, but rarely in the south. Precipitate is between 1,000 - 2,000 mm/year. 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.*

**Mixed Deciduous Forest.** The vegetation of this forest type is widely distributed throughout the country. A heavy mixture of deciduous tree species characterizes the forests. The dominant trees species are Dipteroccarp and Teak.

**Dry Dipterocarp Forest.** This forest covers about 30% of the total forested area of the country, mainly in northeastern and eastern region, at 150 – 700 m elevations. The typical forest is dry or extremely dry, annual rainfall average 800 - 1,500 mm/year. This type of forest is characterized by five major species of the dipterocarp: *Dipterocarpus intricatus, D. obtusifolius, D. tuberculatus, Shorea siamensis* and *S. obtusa*, with the presence of *S. roxburghii* in the north.

**Hill Evergreen Forest**. This type of forest occurs on high mountain ridges and slopes from 700 - 2,562 m elevations and scatters all over the country. The large percentage is in the northwestern highlands. The atmospheric humidity is extremely moist, with precipitation between 1,500 - 2,000 mm annually. 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.

**Studied Areas**

Categories of vegetation types in the studied areas follow Smitinand's classification (Tem Smitinand 1980, 9). The major topography and climate of Thailand consists of 7 floristic regions. The collections were performed on 26 sites throughout the country as shown in the Figure 2. The surveys were started from January 1998 to June 1999. Over 500 specimens were collected from the localities as described below.

The names of provinces and collecting localities are spelled in English after systematic spelling of Smitinand (Tem Smitinand 1980, 9).

**Northern (N)**

The Chiang Dao resort (1a in Fig. 3) is a private area located in Chiang Dao District, Chiang Mai Province. It situated in the mixed deciduous forest associated with *Tectona grandis* Linn at 600m elevation.

The Queen Sirikit Botanic Garden (1b in Fig. 3) situated between Mae Rim District and Mae Sa Sub-district, Chiang Mai Province. The main area is in the dry dipterocarp forest at 700-1,100 m elevation.

Sankuu and Doi Pui research station (1c in Fig. 3) located in Suthep-Pui National Park and forest near Phu Phing Ratchanivate Palace. Over 50 specimens were collected from two locations. Both areas are mainly covered by the hill evergreen forests comprise of oak-chestnut trees at 13,00-1,500 m elevation.

The Doi Inthanon National Park (1d in Fig. 3) located at Chum Tong District, Chiang Mai Province. It is the highest point in Thailand composes of various forest types e.g. dry dipterocarp forest at 300 - 400 m elevation, dry evergreen forest at 600 -700 m elevation and hill evergreen forest above 1,000 m elevation. The lichens *Trypetheliaceae* were mostly collected in the dry dipterocarp forests at 400 m elevation.

Doi Khuntan National Park (2 in Fig. 3) situated at $18^{\circ}$ $25'$ N $99^{\circ}$ $16'$ E at Lampang Province. This area is approximately 255 sq. km, spans between 325-1,373 m elevation straddles between the mountains separate Lamphun Province from Lampang Province. The survey was made in the dry dipterocarp forest at 600-700 m elevation near the Park's entrance and Yo 2 site, which is in the dry evergreen forest at 1,000-1,200 m elevation. About 30 specimens were collected in Kluk Litt's old Litchi garden of the latter site.

Ramkhamhaeng National Park (3 in Fig. 3) is located at 16° 53′ N 99° 42′ E at Sukhothai Province. The specimens were collected from the nature trail along the foot hill of the mountain, from headquarter to the top of the mountain. However, the specimens were found mostly on fallen log in front of the park.

The forest adjacent to Nongbua school in Nongbua District (7 in Fig. 3) is about 70 km from Nakhon Sawan province. Specimens were collected from the dry dipterocarp forest.

**Northeastern (NE)**

Na Heao National Park (17° 05′ N 101° 05′ E) and Phu Ruea National Park (17° 05′ N 101° 07′ E) are located in Loei Province. Both of the forests are borderline between Thailand and Laos. Na Heao National Park (4a in Fig. 3) is a pristine forest with high diversity of lichens. The specimens were collected along the trail from the village of Ban Bomoeng Noi to the top of Toko Song Mountain between 865-1,200 m elevation. The forest is the tropical rain forest at elevation 800-1,000 m with abundant species of *Cinnamon, Croton, Dipterocarpus, Eugenia* and *Terminalia* etc. The forest turns into the hill evergreen forest dominated by oak and chestnut trees at the summit where climate is rather dry and windy. The collections were carried on around Wat Pa Charoem Phakiat, Ban Bomoeng Noi District where the dry dipterocarp forest occupied the altitudes between 750-900 m elevation. The last collection was performed at the tropical rain forest, 200-450 m elevation, beside Hoeng River, the borderline between Thailand and Laos.

Phu Ruea National Park (4b in Fig. 3), is a plateau of about 1,350 m elevation, where the lowest temperature in Thailand was recorded. Agriculture and tourism disturbed most areas of the park. The specimens were collected along the nature trail of the park. The *Trypetheliaceae* were mainly found at Hin Sam Chan waterfall and Suan Hin Palee on the transition of the hill evergreen forest and the dry dipterocarp forest. This site is exposed to bright light.

Phu Hin Rong Kla National Park (5 in Fig. 3) is situated at 16° 59′ N 101° 01′ E on the mountain between Phetchabun and Phisanulok provinces at 1,400-18,00 m elevation. The foliose and the fruticose lichens are abundant. The forest at Lan Hin Tak, and Lan Hin Pum to Pha Chu Thong are similar to hill evergreen forest, but relatively dry condition. Oak (*Quercus* sp.) and chestnut (*Castanopsis* sp.) trees are presented 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.

Phu Phan National Park (6a in Fig. 3) is one of the highest mountain 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 areas as following: "To ket" is in the dry evergreen forest at 300-400 m elevation located on the border of Sakon Nakhon and Kalasin Provinces. The dominated tree species are *Dipterocarpus sp.*, the second area is in the dry dipterocarp forest at Pha Nang Moen and at the forest named "K.M. 25", and the last area was Huai Wiang Pri, where the mixed deciduous forest occurs at 200 m elevation. The specimens were collected on the trunk of *Peltophorum*

*pterocarpum* Back near the main road from the park to Sakon Nakhon Province. The lichens were collected on trunk of *Mangifera indica* Linn in the yard of the Ratjabhat Institute Sakon Nakhon at 16° 53′ N 104° 26′ E (6b in Fig. 3).

**Southwestern (SW)**

Erawan National Park (8 in Fig. 3) located at 14° 24′ N 99° 06′ E on the Northern Khao Salop, Kanchanaburi Province, cover on the area of about 550 sq. km. at 165-900 m elevation. The main topography consist of high limestone mountain ranges in the rain shadow of the northeast monsoon. The forest types are the mixed deciduous forest and the dry dipterocarp forest. They climate exposed to relatively extreme climate with temperatures are as high as 40°C in summer season and as low as 8 °C in the cold season. The area experiences low precipitation. The specimens were collected in the evergreen forest along the trail to Erawan waterfall and in the dry evergreen forest at Pa Lum Ton.

Kaeng Kra Chan National Park is situated at 12° 47′ N 99° 27′ E (12a in Fig. 3). This area is the largest national park of Thailand, located in Phetchaburi Province. It covers an area of 2,915 sq. km on the western part of Thailand, along the border of the Union of Myanmar. About eighty percent (80%) of forest belongs to the tropical rain forest, 20 % is the dry evergreen forest, the dry dipterocarp forest and grassland. The specimens were collected from the tropical rain forest at 700 m elevation in Ban Grang Camp, and form the hill evergreen forest at 900-1,000 m elevation at Pa Nern Thung. Banlad District situated 12° 30′

N 99° 56′ E (12b in Fig. 3) This area is about 6 kilometer from Moeng District, where the *Trypetheliaceae* are often occur on the trunk of *Mangifera indica* Linn and *Eloeocarpus hydrophilus* Kurz.

The Communication Station (13 in Fig. 3) located at 12°49′N 99° 21′ E in the Air-force army in Hua Hin District, Prachuap Khiri Khan Province. This reforestation areas is on a hill of approximately 50-100 m elevation. It is under the influenced of monsoon. The specimens were collected along the trails from the foothill to the summit.

**Central (C)**

At Kasetsart University' s main campus (11 in Fig. 3) in Bangkok, where air quality is probably worsen than the other sites. Crustose lichens were found and collected on trunks of *Peltophorum pterocarpum* Back and *Pterocarpus macrocarpus* Kurz grow along Chu Chat Kum Phu road in the campus. Lichen is not found in any other area in Bangkok.

**Eastern (E)**

KhaoYai National Park is situated at 14°11′-14°25′N 101°22′-101° 27′E (9 in Fig. 3). This area was established in 1962 as the first Thailand's national park. Its location is on the western edge of the Panom Dongrak mountain range in the northeastern Thailand. The park cover 2,168 sq. km within four provinces: Saraburi, Nakhon Ratchasima, Nakhon Nayok and

Prachinburi. About seventy-percent of the park is moist evergreen forests. The main collections were done within 5 forest types. The tropical rain forest along the Nong Phakchi trail to Kilometer 33, the trail from camping area at Pha Gluaymai to Heaw Suwat waterfall, and the forest beside a creek from Pha Tabeak waterfall at 500 - 800 m elevation. The park is dominated by the dry evergreen forests. The specimens were collected at Ban Chom View and Yaowachon Camp at 600 - 800 m elevations. The dry dipterocarp forest situated in the southeast of park, named "Khao Noi". The hill evergreen forest often occurs at the elevation above 1,000 m. The specimens were collected from the top of Khao Khieo near the Radar station of the air force Army at about 1,500 m elevation. The dominant host species are *Castanopsis* sp and *Quercus* sp, together with species of *Dacrydium alatum* and *Podocarpus.* The last collection was done in the reflorestation area from Nong Khing to the old golf field at 600-700 m elevation, where *Croton spp* is abundant.

Khao Kadong Forest Park (10 in Fig. 3) located at 14° 49′ N 103° 06′ E. This areas is about 6 kilometers east of Moeng district, Burirun Province. The area consists of two small vocanic hills (Khao Yai and Khao Kadong hill) of 12.5 sq. km. The dry dipterocarp forests occur at 300 m elevation. The climate is dry and hot almost throughout the year.

**Southeastern (SE)**

At Ban Klam, Klang District is situated at 12° 38′ N 102° 05′ E (14 in Fig. 3), Rayong Province. The specimens were collected form the mangrove

forest near the shrimp farm. The dominant host tree species are *Bruguiera*, *Rhizophora* and *Xylocarpus* are generally found.

Numtok Phliu National Park (15 a in Fig. 3) situated at 12° 29′ N 102° 12′ E in the west of Cardomon range on an area of 134.5 sq. km. at Chanthaburi Province. The tropical rain forest occupied this park at 10 – 50 m elevations. Specimens were collected around the head quarter office of Phliu waterfall. Collection is also performed from Ban Ang checkpoint station, located in the north of the park. It comprises of the exposed forest dominated by *Termenalia* sp along the small lake.

Exploration was made in Khao Kitchakut National Park (15b in Fig. 3) located 12° 30′ N 102° 11′ E on Khao Phra Bath, Ma Kham District, Chanthaburi Province. The park is mostly covered with the hill evergreen forest at 800-1,000 m elevations and mixed deciduous forest at 655-700 m elevations. The specimens were found mostly in the tropical rain forest at 80 – 100 m elevations between the blangalow and the headquarter. The second survey was done along the trail to Wat Phabath Pluang, which is approximate 10 kilometers away from the reservoir. The collection was made in the durian plantation in front of the Ratchamongala Institute of Technology, Chanthaburi Campus.

The Mangrove Forest Management, Khlung District situated at 12° 26′ N 102°13′E (15c in Fig. 3), Chanthaburi Province. This area is a pristine mangrove forest. The survey was done near the estuary of the Veru river. A few specimens were collected in the rubber plantation along the main road from Khlung to Trat Province.

The explorations were made in the Mangrove Forest Management (16a in Fig. 3) located at 12° 26′ N 102°07′E on Moeng District, Trat Province. Kao Chang Island National Park located at 12° 26′ N 102° 09′E (16b in Fig. 3), in the western part of Laem Loob District. The main park in the central Island is tropical rain forest. The specimens were collected in Tan Ma Yom waterfall east of the Island (200-300 m elevation).

**Peninsular (PEN)**

Collection was performed at Khao Luang National Park (17 in Fig. 3), approximately 570 sq. km in Nakhon Sri Thammarat Province, in the southern part of Thailand. It is the headwater of few main rivers of the peninsular e.g. Tapee river. Due to high rainfall through out the year, tropical rain forests are the main forest type. Forest of the southern park Numtok Karom, 70 m elevation, is deminated by the foliose lichens and the *Trypetheliaceae* was not found. A few specimens were collected from Nomtok Krung Ching, 30 m. elevation, located north of the park.

# CHAPTER 4

# MATERIALS AND METHODS

## Sampling Collection

The surveys started from January 1998 to June 1999 in various forest of Thailand, such as Mangrove forest, Tropical rain forests, Dry evergreen forests, Mix deciduous forests, Dry dipterocarp forests, Hill evergreen forests, Plantations and Urban areas (Figure 4). The specimens were collected from bark of sixty-three trees species (Table 3) by cutting the bark on which the lichens occupied. Promptly physiographic features of habitat, the grid reference, the altitude and species of host trees in each collection were recorded. This study also included the sample collections from Queen Sirikit Botanic Garden and Phuteen Suansai projects.

## Preparation of Specimens

The samples collected from the forests (Figure 5-6) were then transferred to Ramkhamhaeng University Laboratory for drying under ambient air for a week to inhibit growth of alien fungi (Figure 7). Specimens were kept in paper envelopes sized 15 x 10 cm., which label the details of the host, habitat, physiographic feature and other important information in front of the envelope. The samples were, then, assigned numbers sequently.


Figure 4 Study Sites Represent Different Habitats of Various Forest Types in Thailand.

A. Hill Evergreen forest (Phu Hin Rong Kla National Park)

B. Dry Dipterocarp forest (Doi Khuntan National Park)

C. Dry Evergreen forest (Phu Pan National Park)

D. Mix Deciduous forest (Phupan National Park)

E. Tropical Rain forest (Kaeng Kra Chan National Park)

F. Urbanized area

Table 3 Host Plants, which the Lichens Family Trypetheliaceae were collected in Thailand.

| Scientific Name | Family |
|---|---|
| *Adenanthera pavonina* Linn. | Mimosaceae |
| *Arthocarpus heterophyllus* Lamk. | Moraceae |
| *Annesles fragrans* Wall. | Theaceae |
| *Betula alnoides* Buch.-Ham. | Betulaceae |
| *Bruguiera cylindrica* Bl. | Rhizophoraceae |
| *Bombax anceps* Pierre. | Bombacaceae |
| *Buchanania florida* Schuaer. | Anacadiaceae |
| *Buchanania latifolia* Roxb. | Anacadiaceae |
| *Canarium subulatum* Guill | Burseraceae |
| *Cassia siamensis* | Caesalpiniaceae |
| *Catanopsis costata* | Fagaceae |
| *Catanopsis helfoliana* | Fagaceae |
| *Catanopsis sp.* | Fagaceae |
| *Citrus aurantifolia* Swing | Rutaceae |
| *Cleidion javanicum* Blume. | Euphorbiaceae |
| *Colona flagrocarpa* Craib. | Tiliaceae |
| *Cratoxylum formosum* Dyer. | Guttiferae |
| *Dalbergia* sp. | Papilionaceae |
| *Dillienia ovata* Wall. | Dillieniaceae |
| *Dipterocapus baudii* Korth. | Dipterocapaceae |
| *Dipterocapus tuberculatus* | Dipterocapaceae |
| *Dipterocarpus* sp. | Dipterocapaceae |
| *Diospyros* sp. | Ebenaceae |
| *Durio ziberthinus* Linn. | Bombacaceae |
| *Elateriospermum tapos* Bl. | Euphobiaceae |
| *Eloeocarpus hydrophilus* Kurz. | Elaeocarpaceae |
| *Entada pursaetha* DC. | Leguminosae |
| *Excoecaria agallacha* Linn. | Euphobiaceae |
| *Ficus* sp. | Moraceae |
| *Gmelina arborea* Roxb. | Verbenaceae |
| *Gynura procumbens* Merr. | Compositae |

Table 3 (continued)

| Scientific Name | Family |
|---|---|
| *Helicia* sp. | Proteaceae |
| *Hevea brasiliensis* Muell. Arg. | Euphorbiaceae |
| *Holigrana kurzii* King. | Anacadiaceae |
| *Lannea coromondelica* Merr. | Anacardiaceae |
| *Litchi chinensis* Sonn. | Sapindaceae |
| *Mammea siamensis* Kostern | Guttiferae |
| *Mangifera indica* Linn. | Anacadiaceae |
| *Memecylon gracinioides* Bl. | Memecylaceae |
| *Michelia champaca* Linn. | Magnoliaceae |
| *Millettia pendula* Benth. | Leguminosae |
| *Neolitsea* sp. | Luaraceae |
| *Olax scandens* Roxb. | Olacaceae |
| *Paramichelia baillonii* Hu. | Magnoliaceae |
| *Peltophorum pterocarpum* Black. | Caesalpinaceae |
| *Pinus kesiya* Royle ex Gordon | Pinaceae |
| *Pittosporum ferrugineum* Ait. | Pittosporaceae |
| *Prunus ceylanica* Miq. | Rosaceae |
| *Pterocarpus macrocarpus* Kurz. | Papilionaceae |
| *Quercus sp.* | Fagaceae |
| *Rhizophora mucronata* Poir. | Rhizophoraceae |
| *Schima wallichii* BL. | Theaceae |
| *Zezygium* sp. | Murtaceae |
| *Shorea obtusa* Wall | Dipterocarpaceae |
| *Shorea roxbergii* G. Don. | Dipterocarpaceae |
| *Shorea siamensis* Miq. | Dipterocarpaceae |
| *Smilax ovalifolia* Roxb. | Smilaxceae |
| *Sterculia pexa* Pierre. | Sterculiaceae |
| *Ternstroemia gymanthera* Bedd. | Theaceae |
| *Thespesia populnea* Soland ex Correa. | Malvaceae |
| *Wrightia pubescens* R.Br. | Aponaceae |
| *Xylia xylocarpa* Taub. | Minosaceae |
| *Xylocarpus moluccensis* | Meliaceae |

Figure 5 The Trypetheliaceae Lichens Grow on Bark in the Dry Dipterocarp Forest

Figure 6 *Laurera benguelensis* (Trypetheliaceae) Grows on Bark


Figure 7 Sample Preparation for Identification and Herbarium Preservation.

A. Drying under ambient air.

B. Placing sample on a paper card (3 x 5 inch), (about size of index card).

C. Enclosing sample in a brown envelope with label contains information of the specimen.

D. Assigned number to the sample sequently and record it in the collecting book.

## Determinations

The procedures for classification begin with observation on anatomy, morphology and chemical constituents of the thallus. Chemical characteristic was performed by using thin layer chromatography according to White and Jame (1985).

### Macroscopic Examination

Morphological observation included thalline features (surface, colour and density), pseudostromata structure (shapes, degree of emergence and ostiole) and ascomata characteristic (size, colour and number) were examined by using a hand-len at 10 x and the low-magnification stereo microscope (Olympus) at 10x to 40x.

### Microscopic Examination

Anatomical character, such as thallus and ascomata of all specimens were performed by freehand section, with a sharp razor -blade under stereo microscope (Olympus) at 10x to 20x. The tissue was mounted with water on a glass slide and examined under the light microscope. Measurement of the thalline layers (cortex, algal and medulla), hamathecial tissue of ascomata and the size of ascospore were, then, examined.

**Microchemical Test**

Spot test was the chemical examination used for detecting lichen substances in the thallus, ascomata, ascus or ascospore. The solutions included 10% solution of Potassium hydroxide solution (K), Sodium hypochorite solution (C) and a saturated solution of para-phenylenediaminne in ethanol (Pd). Lugal's Iodine solution (I) was utilized for detection of amyloid substances in ascomatal tissue and in ascospore.

**Chemical Examination**

Although the chemical products of lichens are primarily determined by spot test, but this method is not sufficient to identify the substances precisely. Thin layer chromatography (TLC) was used to confirm chemical compounds found from spot test, by comparison will known substances. TLC were performed according to standardize method of White & Jame (1985).

Merck silica gel 60 F-254 per-coated aluminum 20 x 20cm TLC sheets were equally cut in to 2 parts, mark a base line (with 2B pencil) 1.5 cm from the bottom edge. This is easily made by using a ruler of 0.8 cm intervals for 11 points on each plate, and then numbered with pencil. A terminating front line was marked at 11 cm above the base line.

Lichen substances from the thallus were extracted by crushing thallus fragments in a small test tubes, and add about 0.5 ml of acetone (about 4 drops) to dissolve lichen substances from the thallus. These solutions were evaporated

in a warm water-bath. By using a capillary tube for each sample, the acetone extract in each tube was transferred to a corresponding numbered point on TLC plates. One plate was used for a solvent system. The treated plates were placed into the solvent solution tanks and left until the solvent moved to the terminating front line.

Two tanks filled with standard solvent solution A and G. Solvent solution A is made of toluene-dioxan-acetic acid: 180-60-8 ml and solvent G consisted of toluene-ethyl acetate-formic: 139-83-8 ml. When the solvent reached the terminating front line, the plate were taken out of the tank and dried at room temperature. Both sheets were examined under daylight and ultra-violet lamps at short wavelength 254 nm and long wave length 365 nm (to detect pigments). Spot detection were marked with a soft pencil and any color characteristics noted. The plates were then sprayed with distilled water to identify for fatty acids. After drying, the plates were sprayed with 10% of sulfuric acid solution and then heating in an oven at 110 $^{o}$C for 10 minutes to allow development of spots of lichen substances. Characteristics of the spots are noted in daylight and under long wave ultra-violet at 365 nm. The lichen substances were identified by their characteristics, such as, Rf-class, and color in daylight and under ultra-violet light. In some cases spot test (C, K and Pd) were carried out on undeveloped plates to help confirm identification of substances. Identification was based on comparison with known lichens substances, which were also applied on the same plate (Homchantara 1999). *Hypotrachyna kingii* containing atranorin, norstictic acid and salacenic acid

was used as standard for routine identification of standard lichen substance in the Trypetheliaceae.

**Scanning Electron Microscopy (SEM)**

The thallus, ascomata structure were investigated for the characteristic of the fungal and algal components. The ascospores were determined by thin section of ascomata, by adding a drop of water, then placed it on cover slit, which was laid on stub (for Scanning Electron Microscopy). The stub was heated in an oven at 100 $^{o}$C for 3 hour. The thallus, ascomata and ascospore shape, size, ornamentation were investigate by using a Scanning Electron Microscope (Jeol JSM-35CF) at Central Laboratory and Greenhouse Complex of Khamphangsaen Campus, Kasetsart University in Nakhon Pratom Province.

**Drawing, measuring and photography**

The ascomatal structures were measured by Olympus stereo microscope equipped with alternating eyepiece of 10x to 40x. The measuring and drawing of the thallus and ascomatal sections and ascospore were made under the light microscope using a drawing tube (Olympus) at 100x, 200x for figures of thalline layer and ascomatal structure, and 400x for ascospores structure

The illustrations of each species of the Trypetheliaceae were taken by using Kodak Image 100, under the stereomicroscope (Nikon SMZ-10). The illustrations of the thallus and ascomata section, and ascospores in ascus were taken using Kodak Image 100, under the light microscope (Nikon Potiphot). Both illustrations were accomplished by using camera (Nikon FDX-35) at the Biological Department, Ramkhamhaeng University, Bangkok.

# CHAPTER 5

# MORPHOLOGICAL CHARACTER OF THE TRYPETHELIACEAE

## Structural Character

The generic determination of the Trypetheliaceae in this study relied on Harris's concept (Harris 1984). He divided the Trypetheliaceae into 10 genera by using the following charcters, poorly or well developed thalli, solitary or aggregated pyrenoascomata within or without pseudostromatic tissue, and transversed or muriform ascospores, as the basis for classification. This investigation catagorized the Trypetheliaceae into 6 genera, *Astrothelium, Campylothelium, Laurera, Polymeridium, Pseudopyrenula* and *Trypethelium,* as shows in the Table 4.

**Table 4. The Generic Characteristic of the Trypetheliaceae.**

| Genera | Ascomata within or without pseudostromatic tissue | Ascospore type | Development of thallus | Figure |
|---|---|---|---|---|
| *Astrothelium* | within pseudostromatic tissue | transversely septate | Well | Fig 8B |
| *Campylothelium* | without pseudostromatic tissue | muriform | Poor | Fig 10F, 17F |
| *Laurera* | within pseudostromatic tissue | muriform | Well | Fig 8A ,17B |
| *Polymeridium* | without pseudostromatic tissue | transversely septate | Poor | Fig 14C |
| *Pseudopyrenula* | without pseudostromatic tissue | transversely septate | Poor | Fig 9A, 14B, 15 |
| *Trypethelium* | within pseudostromatic tissue | transversely septate | Well | Fig 9B, 14E, 15 |

**Thallus**

According to Harris' assumption, the thalli of the Trypetheliaceae were characterized by degree of development. The poorly developed thallus mostly lack of or has ill-defined cortex, algae scattered throughout medulla hyphae and occasionally medulla hyphae penetrate in to periderm of the bark. (Figure 9A). The thallus color is white, such as *Campylothelium nitidum, Polymeridium albidum, P. albocinereum* and *P. catapastum*; whitish yellow such as, *Campylothelium superbum* or colorless, such as, *Polymeridium pleiomeroides* and *Pseudopyrenula diluta* var. *degenerance.*

Most species have the well developed thalli with distinct cortex, continuous algal layer and well-defind medulla over the periderm (Figure 9B). Surface of the thallus is smooth, continuous and rimose, for example, *Astrothelium cinamomeum, Laurera subsphaerioides, Trypethelium andananicum, T. concatervatum* and *T. microstomum.* A discontinuous thallus is found in *Laurera phaeomelodes.* The tuberculate thallus belongs to *Laurera tuberculosa.* Color of pruinose is also used for species determination, such as *Laurera benguelensis, Trypethelium albopruinosum* and *T. eluteriae.* These species prosses orange or yellow pruina, whereas *Trypethelium microstomum* and *T. ochroleucum* havs white pruina. Some specimens of the *Astrothelium cinnamomeum* have free living algae, which are different from photobiont, strive on surface of the thallus. Soredia and isidia are not presented in the Trypetheliaceae.

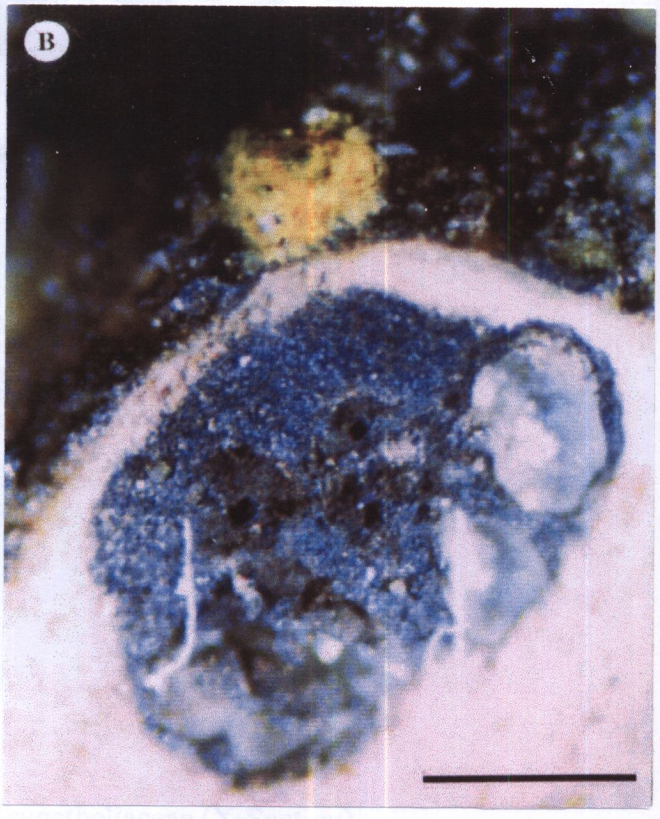




Figure 8 Ascoma Sections Show Two Characters of Ascoma Types. (Bar = 0.5 mm)

A. *Laurera benguelensis* (Müll. Arg.) Zahlbr. Simple ascoma on thallus (RU——10,021).

B. *Astrothelium cinnamomeum* (Eschw.) Müll. Arg. Compound ascomata immerse in thallus (RU——12,571).

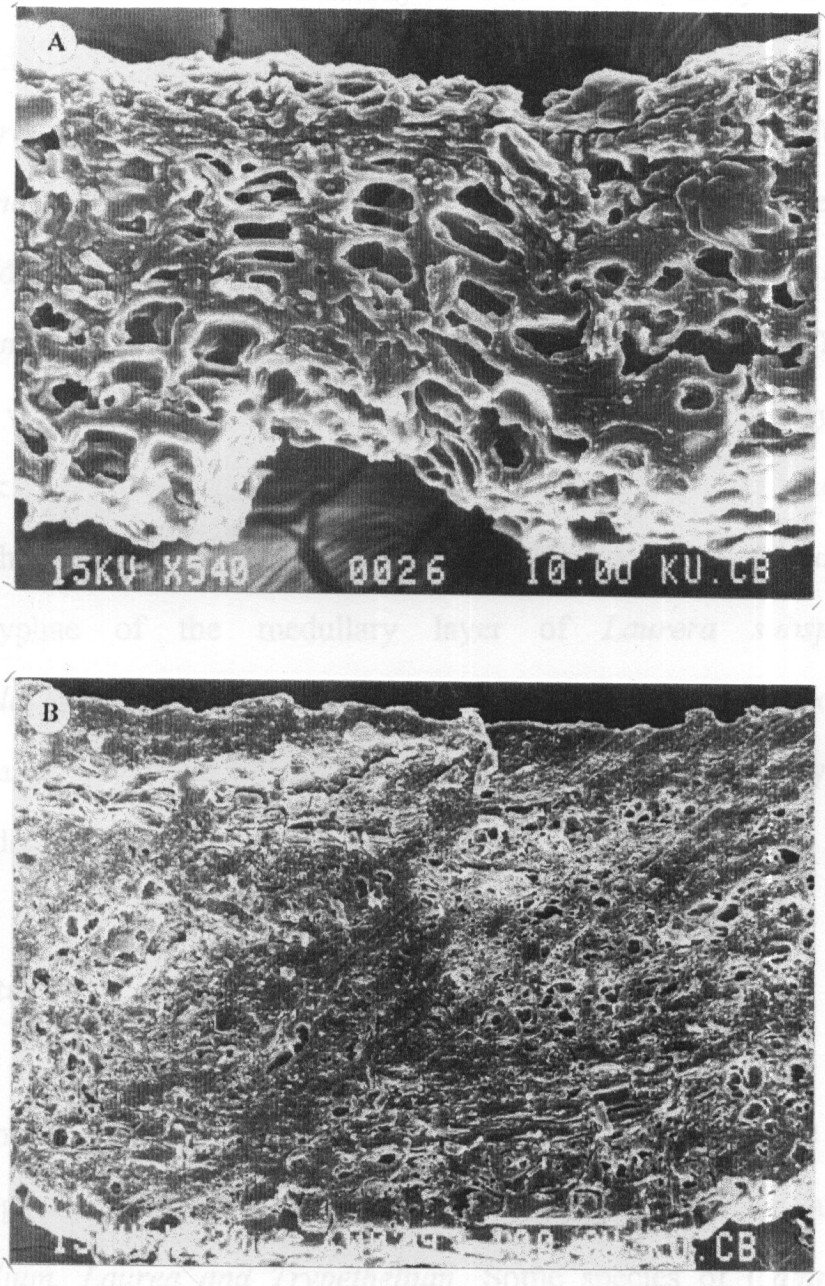



Figure 9 Thallus Structure of the Trypetheliaceae (X-Section).

A. *Pseudopyrenula diluta* var. *degenerans* Vainio. Poorly developed thallus with loose cortex.(Bar = 10 μm) (RU——5,875).

B. *Trypethelium albopruinosum* Makhija & Patw. Well developed thallus with three layers; cortex, algal layer and medulla. (Bar = 100 μm) (RU——6,685).

The species in Thailand mostly have smooth and shiny thalli with well developed and a thick cortex, 25-100 μm, for example *Laurera madreporiformis, L. megasperma, L. meristospora, Trypethelium albopruinosum, T. eluteriae* and *T. tropicum.* The well developed cortex is composed of distinct continuous algae on lower layer, such as *Laurera benguelensis, L. keralensis*, *Trypethelium microstomum* and *Trypethelium celatum,* whilst scattered algal layer is found in, *Trypethelium myriocarpum.* The thick thallus, 80-100 μm, belongs to *Trypethelium microstomum*, whereas the thin thallus, 10-25 μm, is found in *Trypethelium cinereo-rosellum.*

Hyphae of the medullary layer of *Laurera subsphaerioides*, *Trypethelium albopruinsum, T. cinereo-rosellum* and *T. myriocarpum* are occasionally mixed with colorless crystal inclusions, which may penetrated into periderm of the wood.

**Ascomata**

The ascomata, pyrenocarpous types, of the Trypetheliaceae are solitary or aggregated and often embedded in the pseudostromatic tissue, such as *Astrothelium, Laurea and Trypethelium.* Some species of *Campylothelium, Polymeridium* and *Pseudopyrenula* contain ascomata without the pseudostromatic tissue and have poorly developed thalli.

The pseudostromata with pseudostromatic tissue, is a distinguishable character of the Trypetheliaceae. It occurrs from vegetative hyphae of the stromatic tissue mix with the bark cells. In 1940, Johnson found that it is

different from a true stroma (Makhija and Patwardhan 1993, 186). In 1981, Eriksson called stroma as a primary structure and pseudostroma as a secondary structure comprising with simple or divided in to several chambers with a black ("carbonized") wall contain bark cells, and are colorless or color by pigment crystal (Harris 1984, 56; Makhija and Patwardhan 1993, 186).

The color, size, shape, and number of ascomata are important for species identification (Figure 10). *Campylothelium nitidum* (Figure 10F), *C. superbum, Polymeridium albidium, P. albocinereum, P. catapastum, P. pleiomeroides, P. quenqueseptatum* and *Pseudopyrenula diluta* var. *degenerance* are those compose of single spherical or subglobal ascoma without pseudostroma covering. Their sizes are between 0.3-0.75 mm diameter.

Single or aggregate ascomata, in pseudostroma, are important character for *Trypethelium nigroporum* (Figure 10A) and *T. eluteriae* (Figure 10C), *Laurera subsidcreta* (Figure 10B), *L. madreporiformis* (Figure 10D). Thallus covered by layers of pseudostroma are characteristic of *Laurera megasperma, L. meristospora* and *L. meristosporoides* (Figure 10E). Shapes of pseudostromata are mainly hemispherical in *Laurera madreporiformis*, global in *Trypethelium tropicum* and *T. nigroporum* or subglobose in *Laurera benguelensis*. The sizes range between 0.5 – 1.5 mm diameter.

Colors of pseudostroma in the Trypetheliaceae are varied, black in *Trypethelium nigroporum* and *T. tropicum,* whereas some species contain orange pigment (KOH + purple) in medulla of pseudostroma, such as *Laurera madreporiformis* and *L. tuberculosa.*

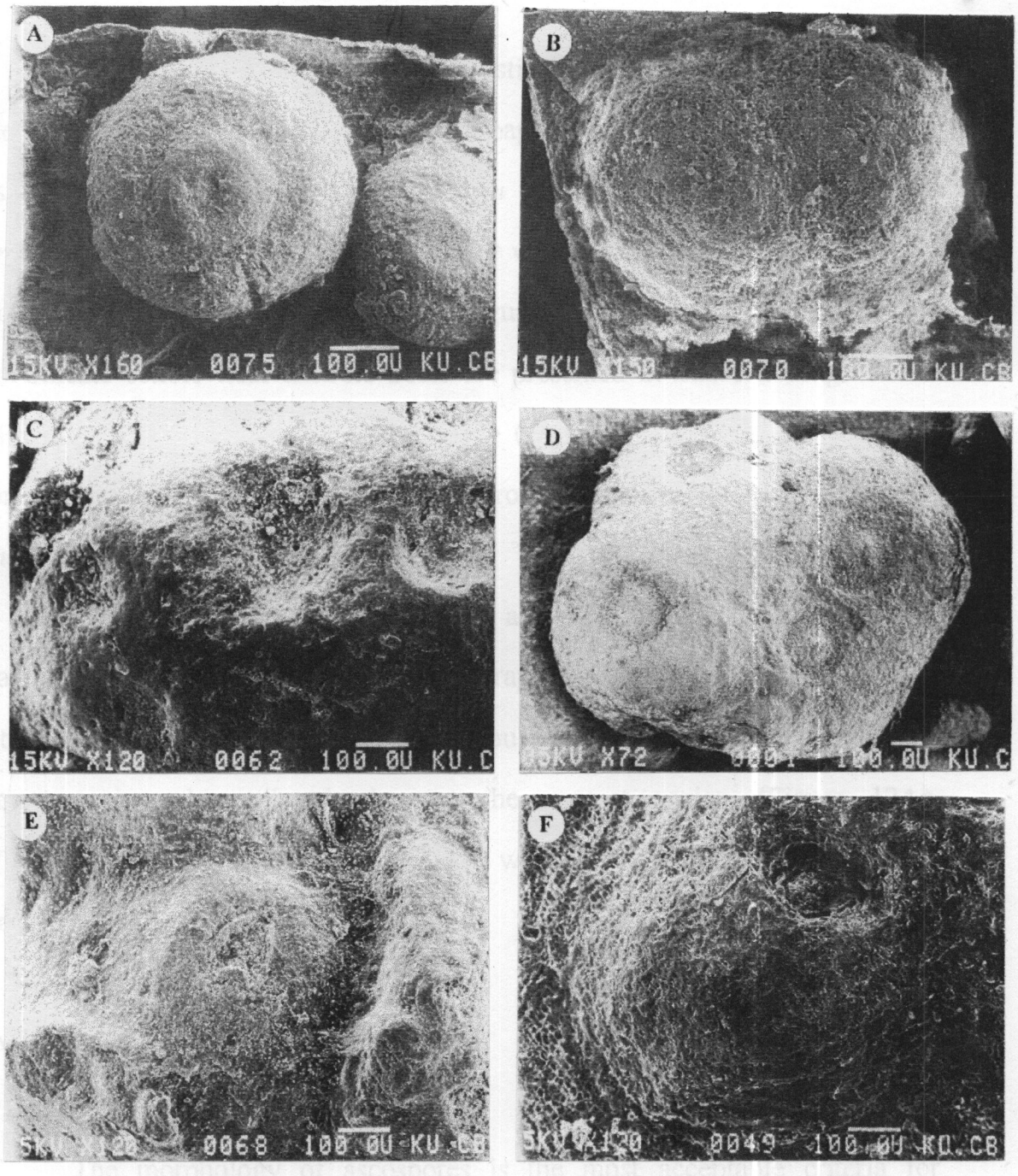



Figure 10 Types of Ascomata of the Trypetheliaceae on (Bar = 100 μm).

A. *Trypethelium nigrporum* Makhija & Patw. Single ascoma immersed in the pseudostromata.(RU——12,571).

B. *Laurera subdiscreta* (Nyl.) Zahlbr. Single ascoma immersed in the pseudostromata. (RU——4,898).

C. *Trypethelium eluteriae* Sprengel. Aggregated ascomata immersed in the pseudostromata. (RU——4,898).

D. *Laurera madreporiformis* (Eschw.) Riddle in Howe. Aggregated ascomata immersed in the pseudostromata. (RU——7,072).

E. *Laurera meristosporoides* P. M. McCarthy & Vongshewarat. Single ascomata immersed in the pseudostromata covered with thallus (RU——10,990).

F. *Campylothelium nitidum* Müll. Arg. Single ascoma with oblique ostiole (RU——5,287).

The types and orientation of ostioles are characters for species determination. The small nipple-shape of papillate ostiole on the pseudostroma is found in *Astrothelium cinnamomeum* (Figure 11A) and *Trypethelium tropicum* (Figure 11B). The sunken ostiole without protuding on the surface is found on *Campylothelium nitidum* (Figure 11C) and *C. superbum*. The umbilicate ostiole with encircle holes are presented in *Laurera benguelensis* (Figure 11D) and *Trypethelium eluteriae* (Figure 11E). The smooth ostiole presented at the same plane of pseudostroma surface is found in *Laurera subdiscreta* (Figure 11F).

Ascomata of the Trypetheliaceae are usually filled with hymenium layer, asci with ascospores and pseudoparaphyses. The pseudoparaphyses are sterile hyphae, with or without oil globules. They are simple cylinder or anastomosis, where the hyphae at the contact region (Figure 12A). *Trypethelium eluteriae* is the only species which found calcium oxalate crystal in the centrum of ascoma (Figure 12B).

**Ascospores**

The morphology of ascospores is the most acceptable criteria for identifying species in the Trypetheliaceae. The shape of ascus are usually hyaline clavate shape in *Laurera benguelensis* (Figure 13A), *L. meristosporoides* (Figure 13C), Polymeridium catapastum (Figure 13D) and *Trypethelium ochroleucum* (Figure 13F), or cylindrical shape in *Trypethelium tropicum* (Figure 13B), and *Polymeridium quinqueseptatum* (Figure 13E).

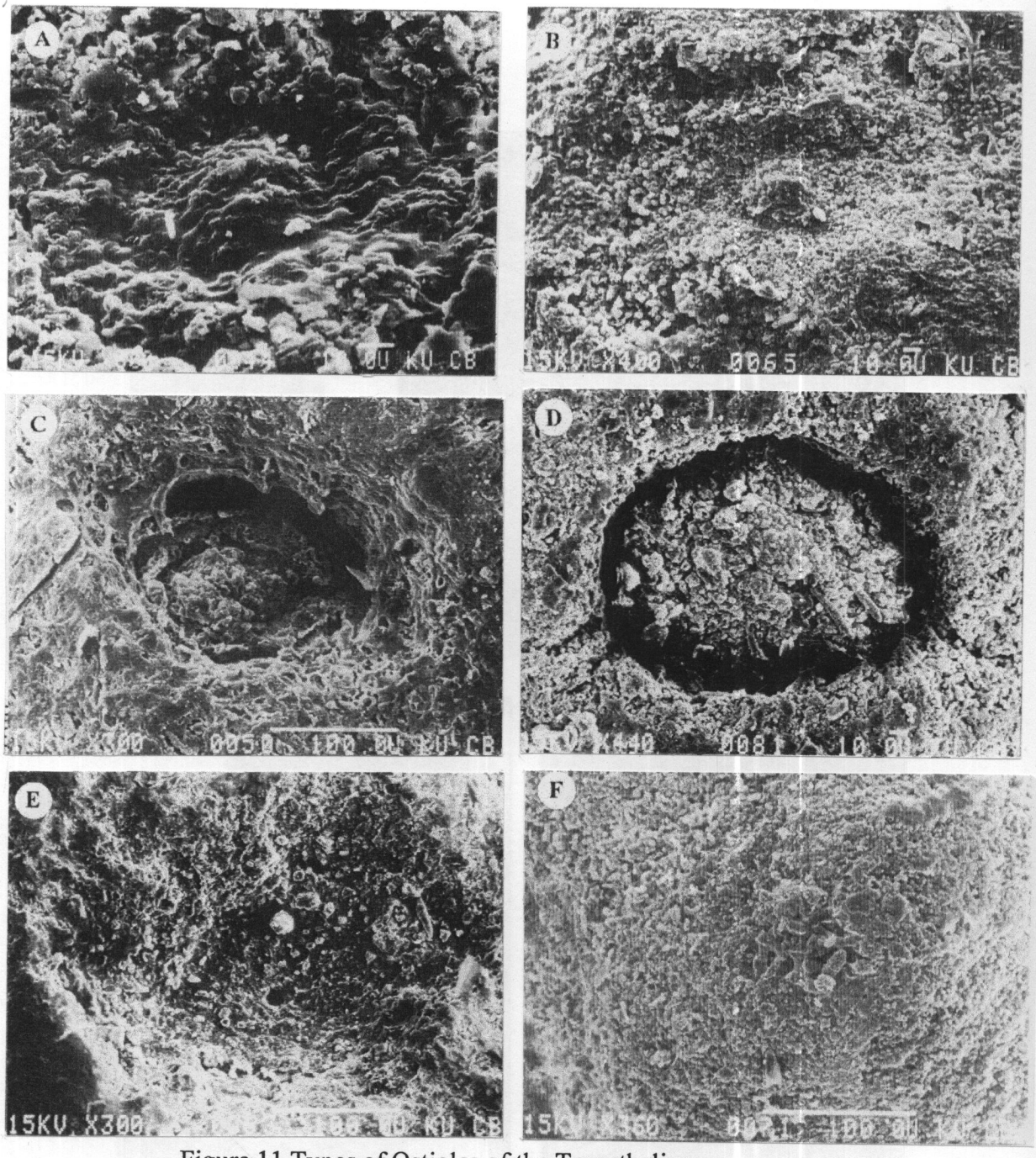



Figure 11 Types of Ostioles of the Trypetheliaceae.

A. *Astrothelium cinnamomeum* (Eschw.) Müll. Arg. Papillate ostiloe. (Bar = 10 μm) (RU——12,571).

B. *Trypethelium tropicum* (Ach). )Müll. Arg. Papillate ostiloe. (Bar = 10 μm) (RU——12,571).

C. *Campylothelium nitidum* Müll. Arg. Sucken oblique ostiole. (Bar = 100 μm) (RU——5,287).

D. *Laurera benguelensis* (Müll. Arg.) Zahlbr. Umbilicate ostiole. (Bar = 10 μm) (RU——10,021).

E. *Trypethelium eluteraia* Sprengel. Umbilicate ostiole, small hole. (Bar = 100 μm) (RU——4,898).

F. *Laurera subdiscreta* (Nyl.) Zahlbr. Smooth ostiole, ascospores remained on ostiole. (Bar = 10 μm) (RU——4,898).

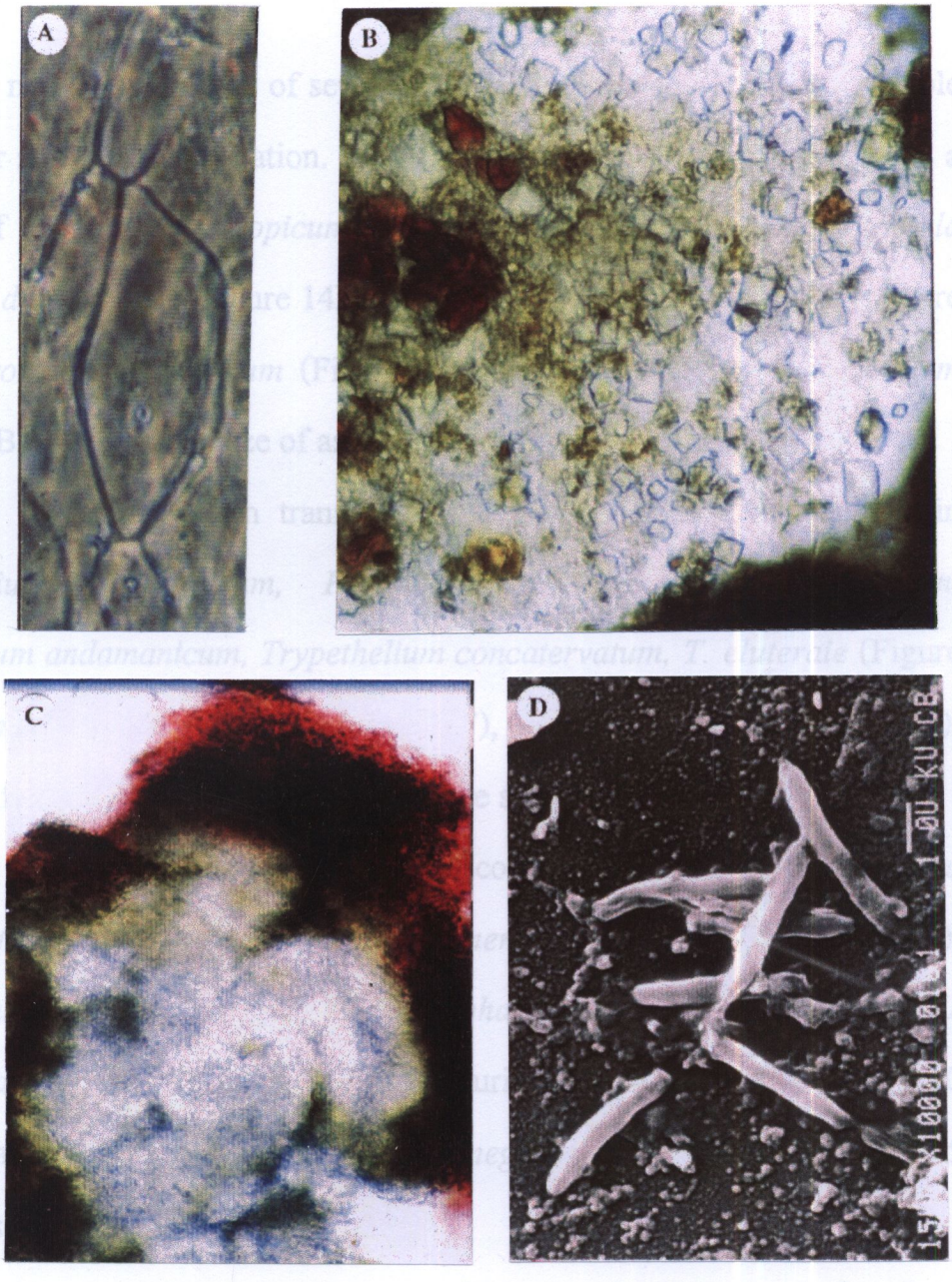



Figure 12 Some Character of the Trypetheliaceae

A. Pseudoparaphyses, anastomosis type, in centrum of *Laurera benguelensis* (Müll. Arg.) Zahlbr.

B. Crystal of ca-oxalate in centrum of *Trypethelium eluteriae* Sprengel.

C. x-section of pycnidia in *Laurera benguelensis* (Müll. Arg.) Zahlbr.

D. Conidia of *Laurera benguelensis* (Müll. Arg.) Zahlbr. (Bar = 1 μm).

Ascospores are in bitunicate clavate ascus (Figure 13A), with 2-8 ascospores per ascus.

The number and types of septation of ascospores are also indispensable account for species determination. The three transverse-septate ascospores is a charater of *Trypethelium tropicum* (Figure 14A and 15D), *Pseudopyrenula diluta* var. *degenerance* (Figure 14B and 15C), *Polymeridium albidum* (Figure 14C), *Astrothelium galbineum* (Figure 15A) and *Trypethelium ochroleucum* (Figure 15B). The normal size of ascospore are small (5-7 x 20-30 μm).

The ten to seventeen transverse-septate ascospores are presented in *Polymeridium albocinereum, P. pleiomeroides, P. quesqueseptatum, Trypethelium andamanicum, Trypethelium concatervatum, T. eluteraie* (Figure 14D), *T. microstomum* (Figure 14E and 15F), *T.* unidentified A (Figure 15E), *T.* unidentified C (Figure 14F). They are large sizes, 7-12 x 40-80 μm.

The vertical septation of muriform ascospores are presented in *Laurera madreporiformis* (Figure 16A), *L. meristosporoides* (Figure 16B), *Campylothelium nitidum* (Figure 17F), *L. phaeomelodes* (Figure 17D) and *L. subdiscreta* (Figure 17E). Most of the muriform ascospores have 10—20 longitudinal septations, however, *Laurera megasperma* (Figure 16 D) has 65 vertically septated.

The large muriformed ascospores of 11-50 x 50-180 μm, is found on *Campylothelium superbum, Laurera meristospora* (Figure 16C) and *L. subsphaerioides* (Figure 16E) and *L. benguelensis* (Figure 17B). The extra ascospores is presented in *Laurera megasperma* (Figure 17A) is 30-32 x 200-320 μm.

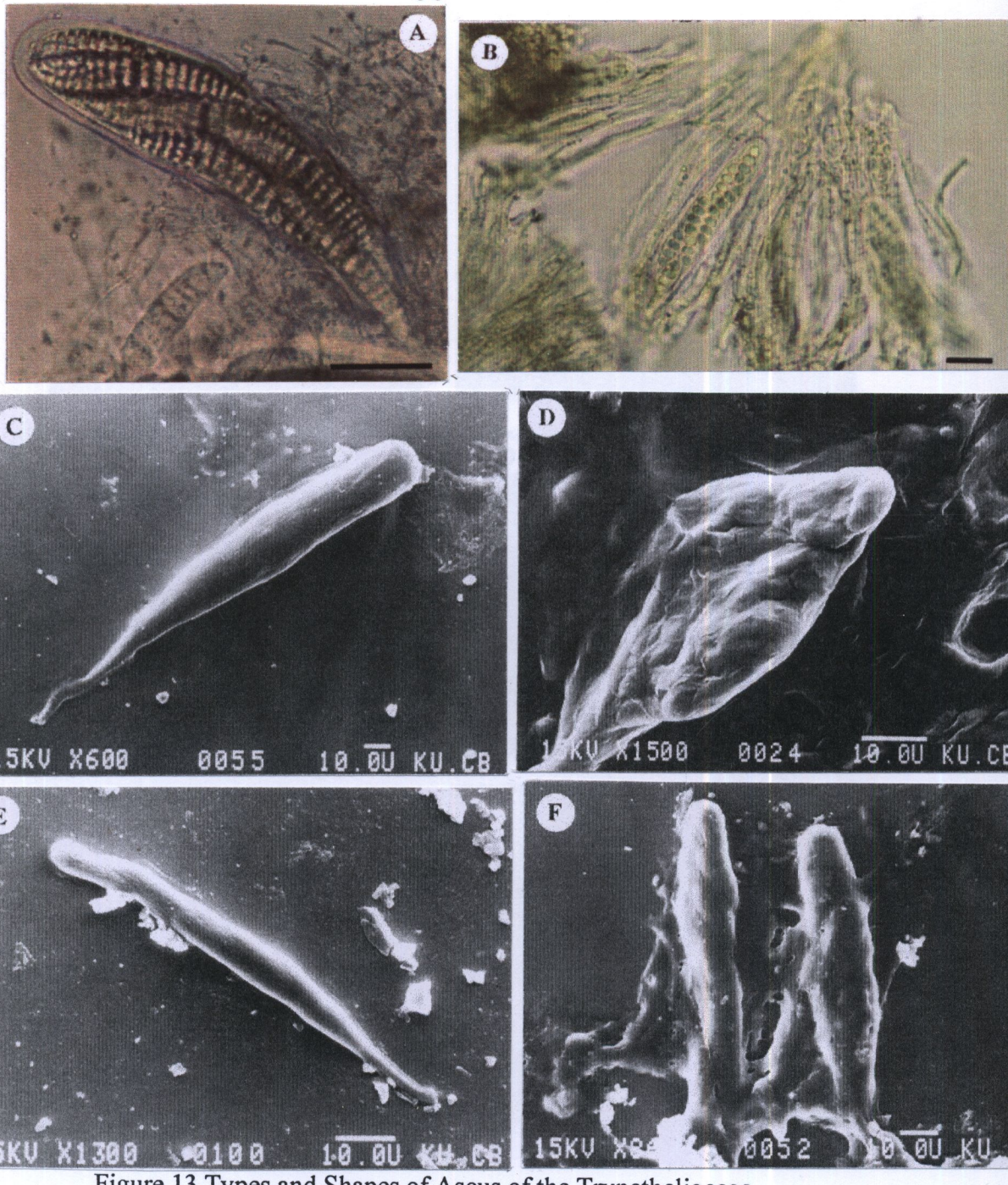



Figure 13 Types and Shapes of Ascus of the Trypetheliaceae

A. *Laurera benguelensis* (Müll. Arg.) Zahlbr. Clavate ascus: (Bar = 20 μm)(RU——10,021).

B. *Trypethelium tropicum* (Ach). )Müll. Arg. Cylindrical ascus : (Bar = 20 μm) (RU——12,571).

C. *Laurera meristosporoides* P. M. McCarthy & Vongshewarat. Clavate ascus : (Bar = 10 μm) (RU——10,990).

D. *Polymeridium catapastum* (Nyl.) R. C. Harris. Clavate ascus with gelatinized cover : (Bar = 10 μm) (RU——7,782).

E. *Polymeridium quinqueseptatum* (Nyl.) R. C. Harris. Cylindrical ascus : (Bar = 10 μm) (RU——12,576).

F. *Trypethelium ochroleucum* (Esch.) Nyl. Clavate ascus : (Bar = 10 μm) (RU——6,362).

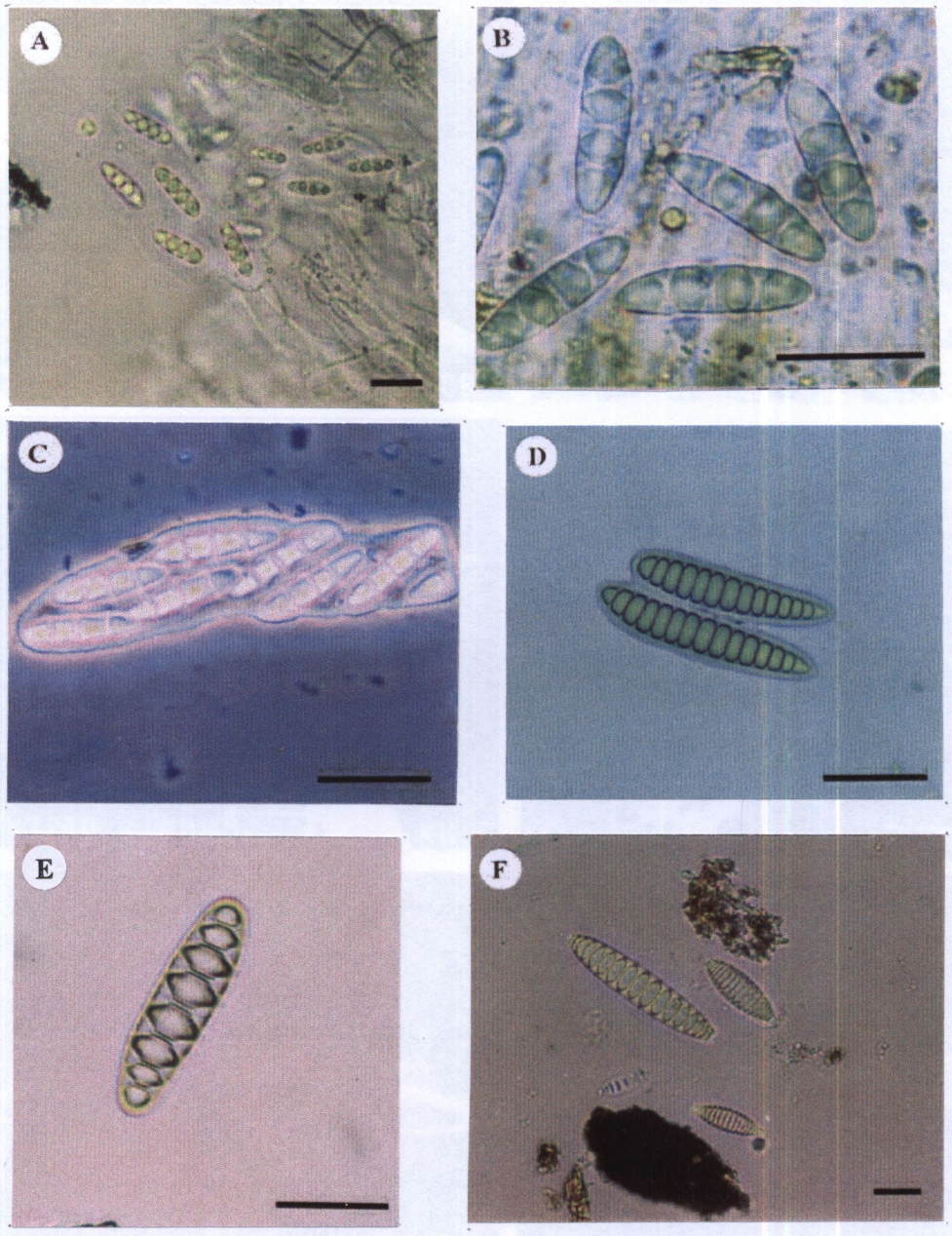



Figure 14 Types and Septations of Ascospore of the Trypetheliaceae.(Bar = 20 μm)

A. Colorless and transverse-septate ascospores of *Trypethelium tropicum* (Ach.) Müll. Arg :(RU——12,571).

B. Colorless and transverse-septate ascospores of *Pseudopyrenula diluta* var.*degenerans* Vainio:(RU——5,875).

C. Colorless and transverse-septate ascospores of *Polymeridium albidum* (Müll. Arg.) R. C. Harris: (RU——11,113).

D. Colorless and transverse-septate ascospores of *Trypethelium eluteriae* Sprengel: (RU——4,898).

E. Colorless and transverse-septate ascospores of *Trypethelium microstomum* Makhija & Patw.(RU——12,556).

F. Colorless and transverse-septate ascospores of *Trypethelium* unidentified C (RU——9,742).

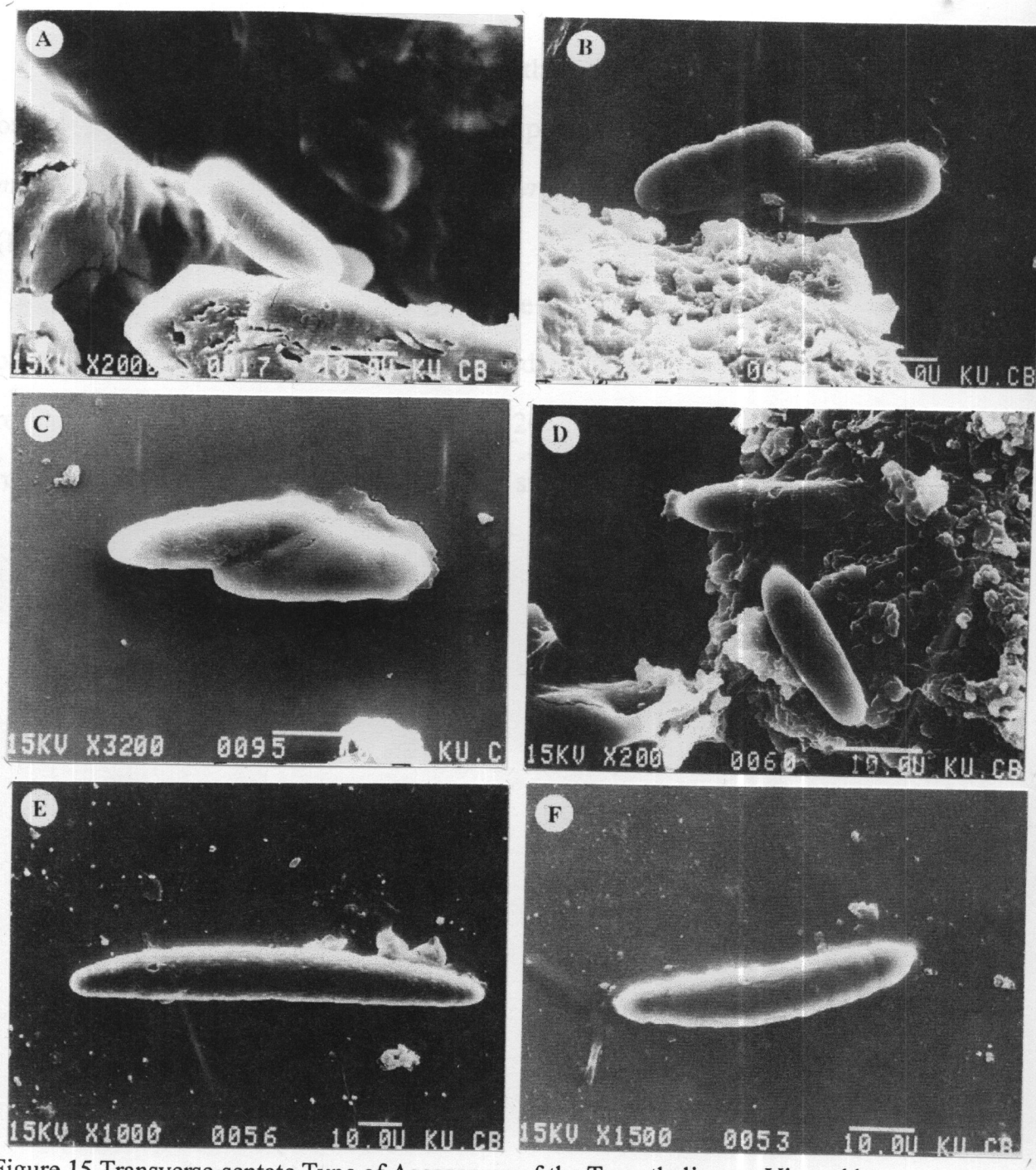



Figure 15 Transverse-septate Type of Ascospores of the Trypetheliaceae Viewed by SEM (Bar = 10 μm).

A. Colorless and transverse-septate ascospores of *Astrothelium galbineum* Krempelh: (RU——6,688).

B. Colorless and transverse-septate ascospores of *Trypethelium ochroleucum* (Esch.) Nyl: (RU——6,362).

C. Colorless and transverse-septate ascospores of *Pseudopyrenula diluta* var.*degenerans* Vainio: (RU——5,875).

D. Colorless and transverse-septate ascospores of *Trypethelium tropicum* (Ach.) Müll. Arg: (RU——12,571).

E. Colorless and transverse-septate ascospores of *Trypethelium* unidentified A: (RU——10,004).

F. Colorless and transverse-septate ascospores of *Trypethelium microstomum* Makhija & Patw: (RU——12,556).

Locule of ascospore cells in the Trypetheliaceae are angular, cylindrical or oval shaped. But sometimes hexagonal shape is found, such as *Trypethelium microstromum* (Figure 14E) and *Pseudopyrenula diluta* var. *degenerance* (Figure 14B).

Pycnidiospores are, rod shaped (Figure 12D), only found on the thallus of *Laurera benguelensis.* They are produced from the flask shaped asexual reproductive structure, pycnidium (Figure 12C), which immerse and open its round brown or black ostiole on their thallus surface.

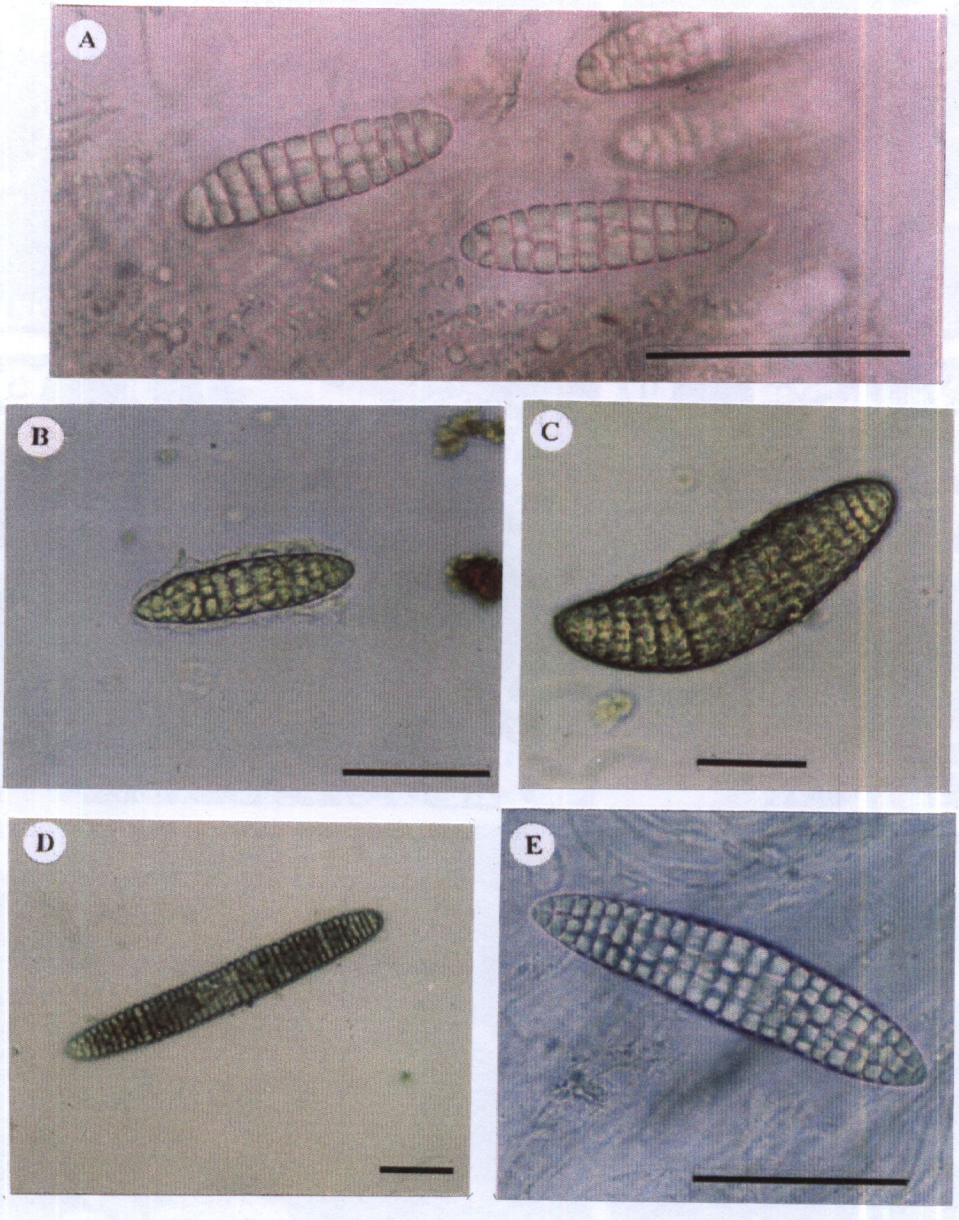



Figure 16 Muriform Type and Septation of Ascospores of the Trypetheliaceae (Bar = 50 μm).

A. Colorless and muriform ascospores of *Laurera madreporiformis* (Eschw.) Riddle in Howe: (RU——12,571).

B. Colorless and muriform ascospore of *Laurera meristosporoides* P. M. McCarthy & Vongshewarat: (RU——10,990).

C. Colorless and muriform ascospore of *Laurera meristospora* (Mont. Etv. Bosch) Zahlbr: (RU——6,174).

D. Colorless and muriform ascospore of *Laurera megasperma* (Mont.) Riddle: (RU——7,958).

E. Colorless and muriform ascospore of *Laurera subsphaerioides* Makhija & Patw: (RU——11,009).

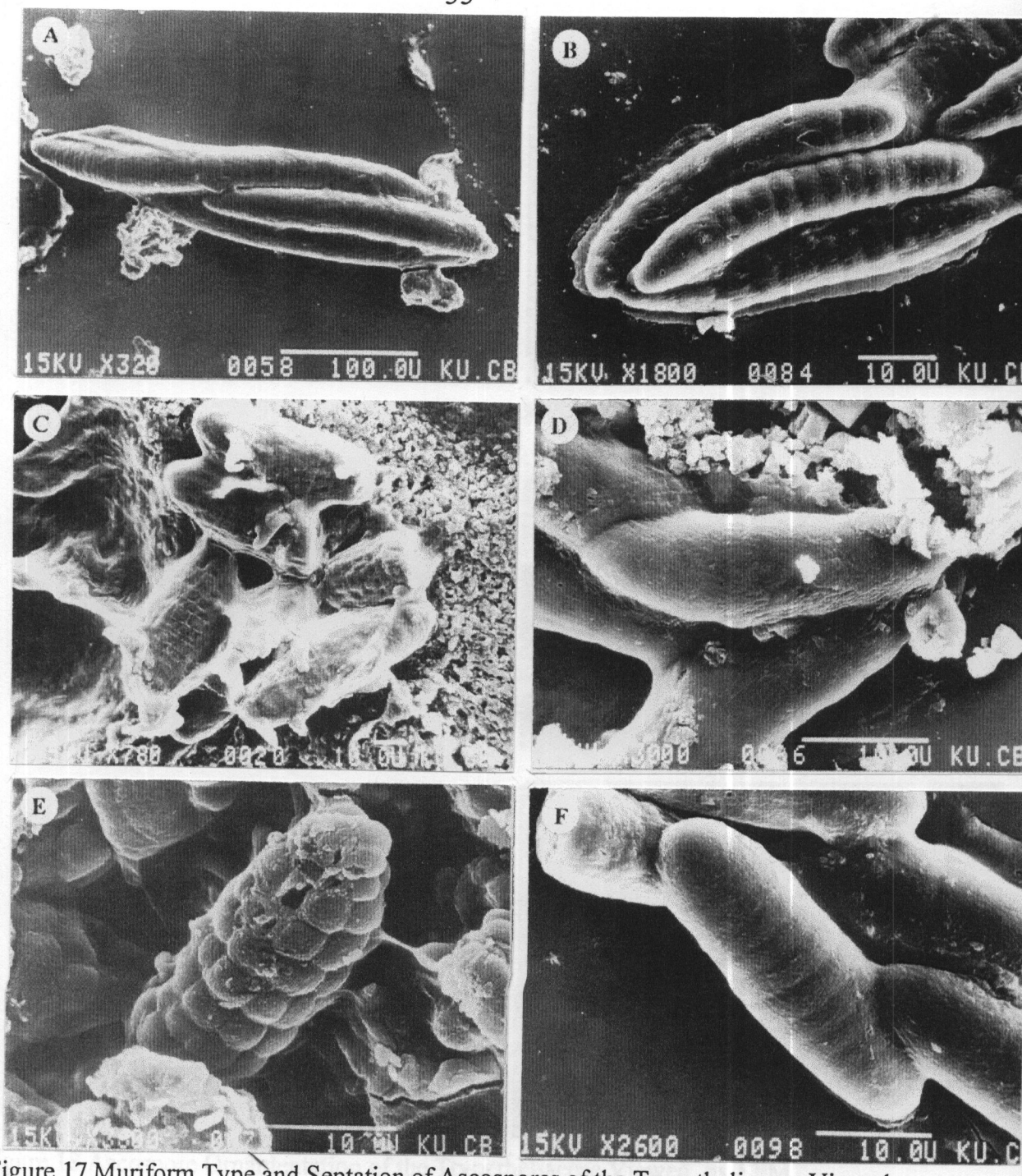



Figure 17 Muriform Type and Septation of Ascospores of the Trypetheliaceae Viewed by SEM.

A. Colorless and muriform ascospores of *Laurera megasperma* (Mont.) Riddle: (Bar = 100 µm) (RU——7,958).

B. Colorless and muriform ascospores of *Laurera benguelensis* (Müll. Arg.) Zahlbr: (Bar = 10 µm) (RU——10,021).

C. Colorless and muriform ascospores of *Laurera keralensis* Uperti & Singh: (Bar = 10 µm) (RU——6,976).

D. Colorless and muriform ascospores of *Laurera phaeomelodes* (Müll. Arg.) Zahlbr: (Bar = 10 µm) (RU——10,896).

E. Colorless and muriform ascospore of *Laurera subdiscreta* (Nyl.) Zahlbr: (Bar = 10 µm) (RU——4,898).

F. Colorless and muriform ascospores of *Campylothelium nitidum* Müll. Arg: (Bar = 10 µm) (RU——5,287).

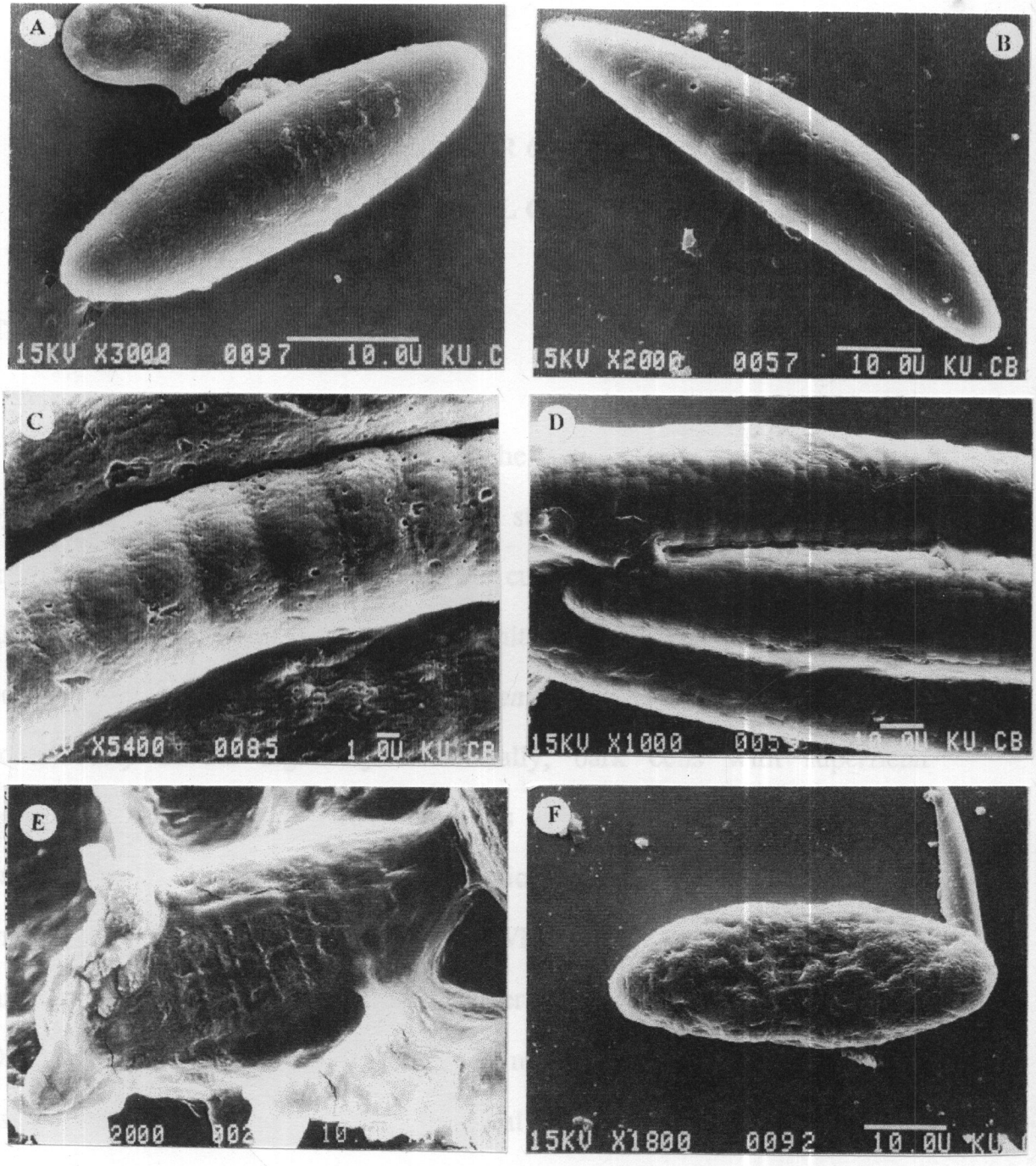



Figure 18 Ascospore Ornamentation of the Trypetheliaceae Viewed by SEM (Bar = 10 μm).

A. Transverse-septate and smooth ascospore of *Polymeridium catapastum* (Nyl.) R.C. Harris: (RU——7,782).

B. Transverse-septate and smooth ascospore of *Trypethelium* unidentified A: (RU——10,004).

C. Muriform and rough ascospores of *Laurera benguelensis* (Müll. Arg.) Zahlbr: (RU——10,021).

D. Muriform and rough ascospores of *Laurera megasperma* (Mont.) Riddle: (RU——7,958).

E. Muriform and rough ascospore of *Laurera keralensis* Uperti & Singh: (RU——6,976).

F. Muriform and rough ascospore of *Laurera tuberculosa* Makhija & Patw: (RU——11,085).

# CHAPTER 6

# TAXONOMIC AND ECOLOGICAL CHARACTERISTICS

## Taxonomic Characteristics

Species of the lichens family Trypetheliaceae are characterized not only by thallus, sexual reproductive structures, such as ascomata and ascospores morphology are also considered. The custose thallus can be smooth, tuberculate, verruculose or rough, with white, yellow or orange pruinose on poorly or well developed cortex. *Trentepohlia* is photobiont scatter continuously in the algal layer. Normally, bark cells with superficial gelatinized compacted hyphae as well as crystal of calcium oxalate are presented in medulla layer. The monocarpic or polycarpic ascomata may or may not be embedded in pseudostroma. While pseudostromata are globose, subglobose or hemisphaerical which immersed or raised above the thallus. Orange masses and crystal inclusion bodies may be found in the layer thalli of pseudostromata in some species. The apical or lateral ostioles of solitary or aggregated ascomata are brown or carbonized colors, with or without oil globules. The hymenium composes of the bitunicate clavate asci and branching or anastomosing pseudoparaphyses. The bitunicate ascus of some species are enclosed by gelatinous sheath and contain 1-8 transversely septated or muriform ascospores. Number and type of septations, transversely septate or longitudinal septate are of important for species identification.

## Ecological Characteristics

Among 13 genera and over 200 species of the Trypetheliaceae, most of them occur in the tropical epiphytes with high diversity in the rain forests, especially in the Neotropic. Few species occur in the temperate region e.g. *Trypethelium varian* (Aptroot 1991, 29). The Trypetheliaceae in Thailand distributes mostly on tree trunk and branch (Fig. 5-6) such as the moist habitat with low temperature of the hill evergreen forests (900-1500 m. elevation) comprised of 26 species and 2 variety. Forests with semidry habitats with high temperature contain less species diversity e.g. the dry dipterocarp forests (400-700 m. elevations) found 10 species. In stress condition of the mangrove forests, only one species *Trypethelium tropicum* was found.

*Laurera benguelensis* and *Trypethelium eluteriae* are common species. They are widely distributed throughout the country. *Trypethelium eluteriae* are found from Chaing Dao resort, Chaing Mai Province, the northern part, the rubber plantation in Nakonsrithammarat Province, the eastern part, and the peninsular south of Thailand as well as on the tree in Bangkok.

## Generic Classification

The *Trypethelium* was proposed as the first genera of the Trypetheliaceae by Sprengel in 1904 (Farr et al. 1979, quoted in Makhija and Patwardhan 1993, 183). Before 1819, Acharius introduced 2 genera as *Astrothelium* and *Trypethelium* (Myrdal 1998). Müller Argovensis (1887)

separated the family Trypetheliaceae based on color and septation of ascospores. These are *Bathelium* (colourless, muriform), *Tomasellia* and *Trypethelium* (colureless, trans-septate), *Bottaria* (brown, muriform), *Melanotheca* (brown, trans-septate). In addition, *Trypethelium* was separated into 2 groups, *Bathelium* (ascospores with 4 locules) and *Eutrypethelium* (ascospores fusiform with 10-16 locules). Zahlbruckner (1951) added *Laurera and Trypetheliopsis* in the *Catalogus Lichenum Universalis*. A new genera, *Riddle*, was added to this family (Dodge 1953), but later on was unaccepted and discarded from this family. The generic criteria was based on pseudoparaphyses, septation of ascospores and the evolution of phylogenetic information (Harris 1975 and 1984; and Aptroot 1991). Ten genera were accepted as *Architrypethelium, Astrothelium, Campylothelium, Exiliseptum, Laurera, Megalotremis, Ornatopyrenis, Polymeridium, Pseudopyrenula* and *Trypethelium* (Harris 1975 and 1984; and Aptroot 1991).

**Key to genera**

**1a.** Simple ascomata, naked or enclosed by pseudostromata.....2

**1b.** Compound ascomata with several cavities joined in a common ostiolar neck, solitary or aggregated.....***Astrothelium***

**2a.** Muriform ascospores.....3

**2b.** Transversely septated ascospores.....4

**3a.** Apical ostiole .....***Laurera***

**3b.** Lateral ostiole.....***Campylothelium***

**4a.** Thallus well developed, often with a distinct cortex; ascomata mostly aggregateed in pseudostromata or immersed in thallus .....***Trypethelium***

**4b.** Thallus poorly developed, cortex lacking; ascomata naked, never in pseudostromata..... .....5

**5a.** Ascospores wall thick.....***Pseudopyrenula***

**5b.** Ascospores wall thin .....***Polymeridium***

**List of Species**

A total of 38 species of consists of 33 species and 1 variety with 4 unidentified species from 519 collections of the *Trypetheliaceae* in Thailand are listed in alphabetic order under six genera: *Astrothelium, Campylothelium, Laurera, Polymeridium, Pseudopyrenula* and *Trypethelium*. The synonyms for same species derived from to Müller 1885, 1888 and 1891; Zahlbruckner 1951; Dodge 1953; Wetmore 1963; Harris 1975, 1984, 1989 and 1995; Tucker and Harris 1980; Streimann 1986; Egan 1987; Upreti and Singh 1987; Makhija and Patwardhan 1988 and 1993; Awasthi 1991; Jiang-chum 1991; Okamoto 1995; Filson 1996; Aptroot et al. 1997; Malcolm and Galloway 1997; Elix and McCarthy, 1998; Feuerer 1998; Marcelli 2000.

The descriptions compose of anatomical measurements of the thalline layers (cortex, algal and medulla), hamathecial tissue of ascomata and ascospores, made from free-hand section under the light microscope. The structures are best visualized in sections mount with potash solution (10%

KOH) or in 'wet water' (a drop of liquid detergent in 100 ml of distilled water). The illustrations for each species show the orientation of ascomata in thallus, ascospores in ascus, and ascospore, as well as the distribution map of collecting localities in Thailand.

## *Astrothelium*

### Description of the Genus

*Astrothelium* Eschw., Syst. Lich. 18. 1824.

**Thallus** crustose, greenish-yellow or buff, smooth to rough, shiny, UV+/-; cortex colorless, K+ yellow, continuous, 40-100 µm; algal layer continuous to scatted, 40-60 µm, Photobiont: *Trentepohlia*; medulla white, thin, 25-90 µm, with colorless crystalline inclusion; **pseudostromata** monocarpic or polycarpic, hemisperical or subglobose, yellow pigmented, K+ purple, containing 1(-4) ascomata, 0.6-1.0(-1.5) mm diam; ascomata apex plane to concave, 0.2-0.5 mm diam; pseudostroma wall carbonized; **ascomata** solitary or rarely aggregated, embedded in pseudostromata; ostioles brown or carbonized; centrum slightly oil globules; hymenium with branching and anastomosing pseudoparaphyses; **ascus** bitunicate, clavate to cylindrical, apex broad, convex ocular chamber, 8–ascospores; **ascospores** hyaline, elipsoid, trans-septate, 3-transversely septates, cell locule globose or hexagonal.

**Number of Species.** About 40 (Hawksworth 1995, 40).

**Habitat.** *Astrothelium* are widely distributed in the moist habitats with low temperature, such as the hill evergreen forest, at Phu Ruea National Park and in the dry evergreen forest in Khao Yai National Park. The distribution is relatively limited in the dry habitats with high temperature, such as the dry dipterocarp at Na Haoe National Park.

**Distribution.** USA, Maxico, Cuba, Trinidad, Tobago, French Guiana, Venezuela, Brazil (Bahia, Mato Grosso), Africa, India, Sri Lanka, Thailand, Philippine and Indonesia.

**Observation.** The general appearances are similar to *Laurera benguelensis*. Noticeable, by multi-ascomata embedded in pseudostromata, distinct ostiole and transversely septated ascospores. In Thailand, *Astrothelium* are presented three species as, *Astrothelium cinnamomeum, A. eustomum* and *A. galbineum.*

**Key to Species**

**1a.** Thallus UV+ orange-yellow; yellowish-orange pigmented pseudostromata, K+ purple, ascospores 3-transversely septates, 21-28 x 7-9 µm.....***A. galbineum***

**1b.** Thallus UV-.....2

**2a.** Pseudostromata raised, yellowish-orange pigmented pseusostromata, K+ purple; ascospores 3-transversely septates and 23-30 x 8-10 µm.. .....***A. cinnamomeum***

**2b.** Pseudostromata immersed in thallus; ascospores 5-transversely septates, 25-30 x 9-11µm.....***A. eustomum***

**1.** ***Astrothelium cinnamomeum*** **(Eschw.) Müll. Arg.,** *Flora* 68: 270 (1884). (Fig. 19).

*Astrothelium minus* Müll. Arg., Bot jahrb. Syst. 6: 382 (1885).

*Astrothelium minus* var. *nigratum* Müll. Arg., Bot jahrb. Syst. 6: 382 (1885).

*Pyrenastrum cinnamomeum* Eschw., in Mart., Icon. Pl. Crypt. 18, pl. 9, f.l. (1828).

**Thallus** citrine dull green, smooth to rough, continuous, often free living algal scattered, UV-; cortex colorless, K+ yellow, continuous, 80-100 µ m; algal layer 40-60 µm, presented in the medulla; medulla white, thin, with colorless crystalline inclusions, 20-40 µm; **pseudostromata** monocarpic, occasionally polycarpic, raised, bright yellow, K+ purple, UV+; containing 1-4 ascomata; **ascomata** solitary; ascomata apex plane to concave; ascomata wall carbonized; ostiole carbonized, distinctly protruding; centrum without oil globule; hymenium with branching and anastomosing pseudoparaphyses; **ascus** bitunicate, clavate, 90-100 x 12-15 µm, 8–ascospores; **ascospores** hyaline, elipsoid, trans-septate, 3–transversely septates, (20.0)21.5-22.5-23.5(25.0) x (6.25)7.5-8.0-8.5(8.9) µm, cell locule hexagonal.

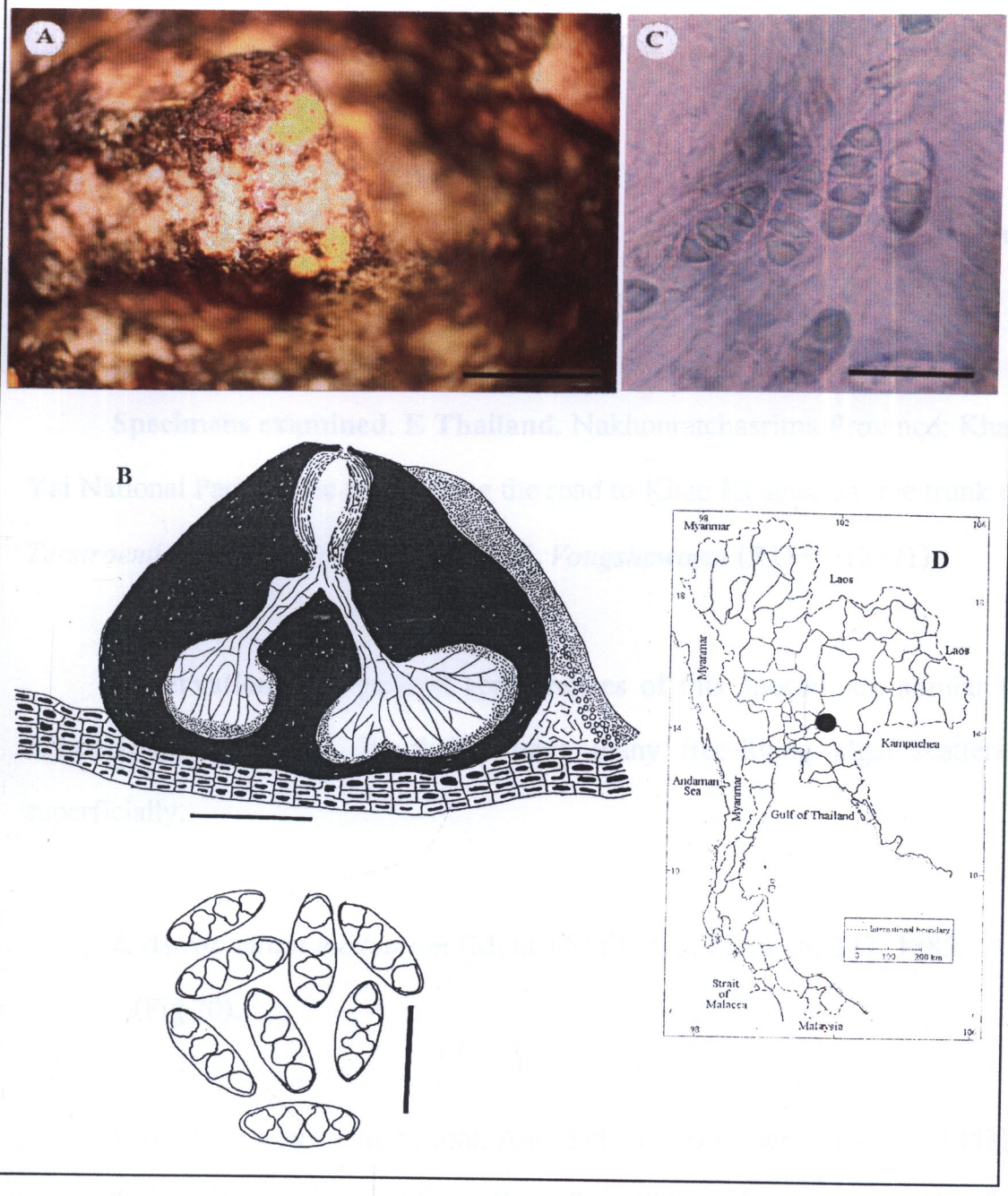



Figure 19 *Asthothelium cinnamomeun* (Eschw.) Müll. Arg. (RU——12571)

A. Pseudostromata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 500 μm) and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 20 μm).

D. Distribution in Thailand.

**Habitat.** On tree trunk of *Terstroemia gymanthera* in the moist situation with low temperature, such as in the hill evergreen forest at 1,400 m elevation of Khao Yai National Park.

**Distribution.** Southern USA, Mexico, Cuba, Trinidad and Tobago, French Guiana, Venezuela, Brazil, Thailand and Borneo.

**Specimens examined. E Thailand.** Nakhonratchasrima Province: Khao Yai National Park, in the forest along the road to Khao Khaew, on tree trunk of *Terstroemia gymanthera* Bedd., 1999, *K. Vongshewarat* (RU——12571).

**Observation**. The general apprearences of this species are similar to *Astrothelium galbineum.* Its thallus have many free-living algal scattered superficially.

**2. *Astrothelium eustomum*** (Mont.) Müll. Arg. Flora 68: 247. 1885. (Fig 20).

*Pyrenastrum eustomum* Mont. Ann. Sci. Nat. Bot. Ser. 2 19: 63. (1843).

*Trypethelium celatum* Stirton, Proc. Roy. Philos. Soc. Glasgow 13: 193. (1881).

**Thallus** citrine, smooth to rough, continuous, UV-; cortex colorless, K+ yellow, continuous, 50-80 µm; algal layer continuous, 40-60 µm, scattered in

the medulla; medulla white; **pseudostromata** monocarpic, sometimes with polycarpic, immersed in thallus, UV+, containing 1-2 ascomata, **ascomata** solitary, or aggregated; ascomata apex plane to concave; ascomata wall carbonized; ostiole carbonized, surrounding with white periostiole; centrum without oil globule; hymenium with branching and anastomosing pseudoparaphyses; **ascus** bitunicate, clavate, 8–ascospores; **ascospores** hyaline, elipsoid, trans-septate, 3—5–transversely septates, (20.0)21.5-22.5-23.5(25.0) x (6.25)7.5-8.0-8.5(8.9) µm, cell locule hexagonal.

**Habitat.** On tree trunk in the moist situation with low temperature as in the hill evergreen forest at 1,400 m elevation.

**Distribution.** Cuba, French Guiana, Columbia, Venezuela, Brazil, Bolivia, India, Sri Lanka and Thailand.

**Specimens examined. NE Thailand.** Loei Province: Phu Ruea National Park, along the trail to Hin Sam Chan waterfall, on unidentified tree, 1999, *K. Vongshewarat* (KV——38RU).

**Ooservations.** Species from Thailand have larger ascospores than the species from Brazil (25-30 x 9-11 µm; Harris 1984, 58). However the other characteristic fit into the category of *Astrothelium eustomum*.

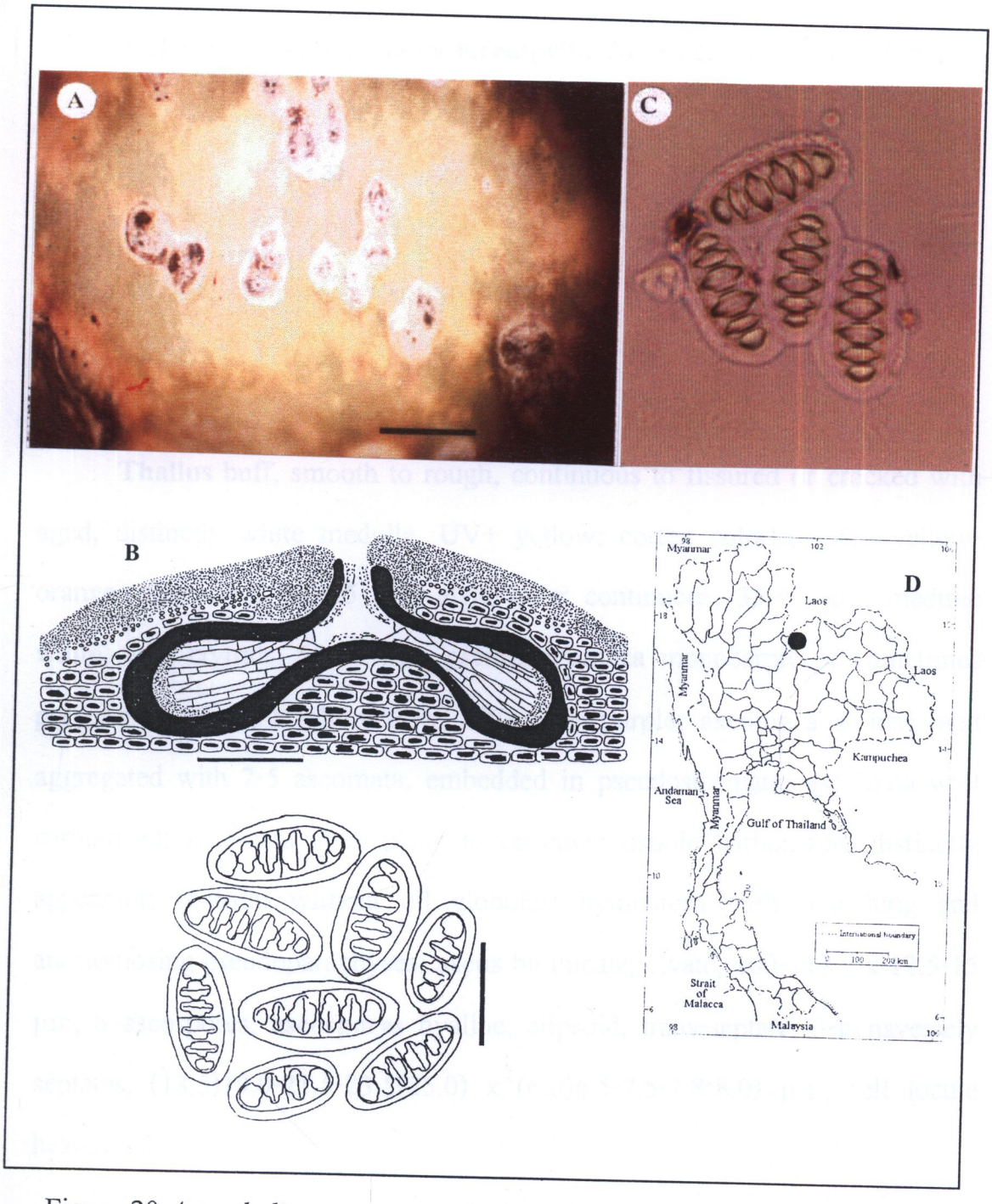



Figure 20 *Astrothelium eustomum* (Mont.) Müll. Arg. (KV——38RU)

A. Pseudostromata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 300 μm) and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 20 μm).

D. Distribution in Thailand.

**3. *Astrothelium galbineum* Krempelh.,** *Nuovo giorn. Bot Ital.* 7; 58, pl 1, f. 27. (1875). (Fig. 21).

*Astrothelium ochrothelizum* Müll. Arg., Bot. Jahrb. Syst. 6: 382. (1885).

*Astrothelium conicum* var. *pallidum* Müll. Arg., Bot. Jahrb. Syst. 6: 382. (1885).

**Thallus** buff, smooth to rough, continuous to fissured or cracked with aged, distinctly white medulla, UV+ yellow; cortex colorless, K+ yellow-orange, continuous, 40-55 µm; algal layer continuous, 35-45 µm; medulla white, with crytrals, 55-90 µm; **pseudostromata** monocarpic or sometimes polycarpic, raised, bright yellow, UV+, K+ purple; **ascomata** solitary and aggregated with 2-5 ascomata, embedded in pseudostromata; ascomata wall carbonized; ascomata apex plane to concave; ostiole carbonized, distinctly appearant; centrum without oil globules; hymenium with branching and anastomosing pseudoparaphyses; **ascus** bitunicate, clvate, 100-112.5 x 12.5-15 µm, 8–ascospores; **ascospores** hyaline, elipsoid, trans-septate, 3-transversely septates, (18.5)19.0-21.5-23.5(25.0) x (6.0)6.5-7.5-7.8(8.0) µm, cell locule hexagonal.

**Habitat.** On tree trunk in the moist habitat with moderate temperature, such as in the dry dipterocarp forest at Na Haeo National Park, in the hill evergreen forest at Phu Ruea National Park and the dry evergreen forest at Khao Yai National Park.

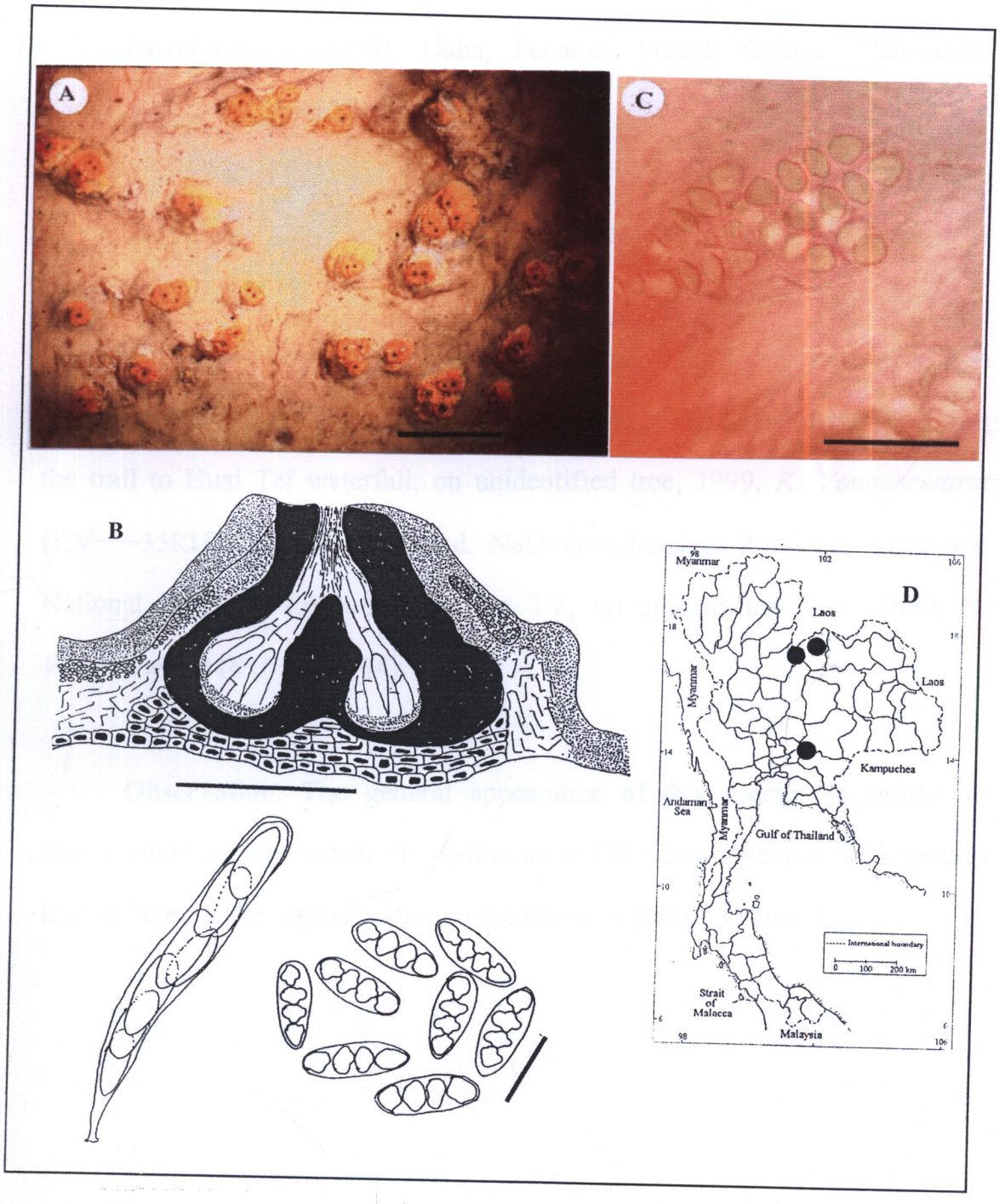



Figure 21 *Asthothelium galbineum* Krempelh (RU——6688)

A. Pseudostromata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 300 μm) and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 20 μm).

D. Distribution in Thailand.

**Distribution.** Florida, Cuba, Panama, French Guiana, Venezuela, Africa, India, Sri Lanka, Thailand and Borneo.

**Specimens examined. NE Thailand.** Loei Province: Na Haeo National Park, along the trail to Wat Charoem Phrakiat, on unidentified trees, 1995, *K. Vongshewarat* (RU——6688). Phu Ruea National Park, along the trail to Lan Hin Tak, on unidentified tree, 1999, *K. Vongshewarat* (KV——34RU), along the trail to Huai Tei waterfall, on unidentified tree, 1999, *K. Vongshewarat* (KV——35RU); ibid., **E Thailand.** Nakhonratchasrima Province: Khao Yai National Park, the forest nearby Ban TV, on unidentified tree , 1999, *K. Vongshewarat* (RU——14614).

**Observation.** The general appearance of this species is similar to *Astrothelium cinnamomeum.* Its thallus show UV+ bright yellow. This species is distributed at the high elevation in the northern part of Thailand.

*Campylothelium*

**Description of the Genus**

*Campylothelium* Müll. Arg., *Bibliotheca lichenologica* 40. (1991).

**Thallus** crustose, ecorticate, white, smooth to rough, UV-; cortex lacking or loosely organized, K-; algae scattered immerse thallus or closely cell bark, Photobiont *Trentepohlia*; medulla indistinct. **ascomata** solitary, rarely aggregated, 0.6-1.0 mm diam, embedded in thalline; ascomata wall carbonized; ostioles carbonozied, oblique or inclined canal leading to ostiole; centrum slightly oil globules or lacking; hymenium with branching and anastomosing pseudoparaphyses; **ascus** bitunicate, clavate, 2—8–ascospores; **ascospores** hyaline, elipsoid, with gelatinous sheath, muriform, I-.

**Number of species**. About 9 (Hawksworth 1995, 72).

**Habitat.** In Thailand, the *Campylothelium* mostly grow on tree trunk at high elevations in the north-easthern part of country, such as in the hill evergreen forest at Khao Yai National Park.

**Distribution.** Florida, Brazil, India, Thailand and Australia.

**Observation.** The oblique or inclined canal of ostiole of ascomata is the distinct characteristic. Therefore, the ostiole of ascomata, type of ascospores

were used for species determination.

**Key to species**

**1a.** Thallus whitish-yellow, UV+ yellow white; ascospores yellow or hyaline,126-158 x 46-53 µm.....***C. superbum***

**1b.** Thallus white, UV+ yellow bright; ascospores hyaline, 53-58 x 18-20 µm..... ***C. nitidum***

**1.** ***Campylothelium nitidum*** **Müll. Arg.,** *Bibliotheca lichenologica* 40. (1991). (Fig. 22).

**Thallus** crustose, ecorticate, white, smooth to rough, UV+ yellow white; cortex lacking or loosely organized, K-, algae scattered in the medullary and in the periderm, Photobiont *Trentepohlia*; medulla indistinct; **ascomata** solitary, carbonized, hemispherical or subglobose, 0.6-0.9 mm diam, raised, sometimes immersed in the thallus, ascomata wall carbonized; ostioles carbonized, oblique or inclined canal leading to ostiole; centrum slightly presented oil globules; hymenium with branching and anastomosing pseudoparaphyses; **ascus** bitunicate, clavate, 8–ascopores; **ascospores** hyaline, ellipsoid, with gelatinous sheath, muriform, 11—22–transversely septates, 1—5–vertically septates, (50)53.0-55.5-58.5(62.0) x (18.0)18.0-19.5-20.5(22.0) µ m.

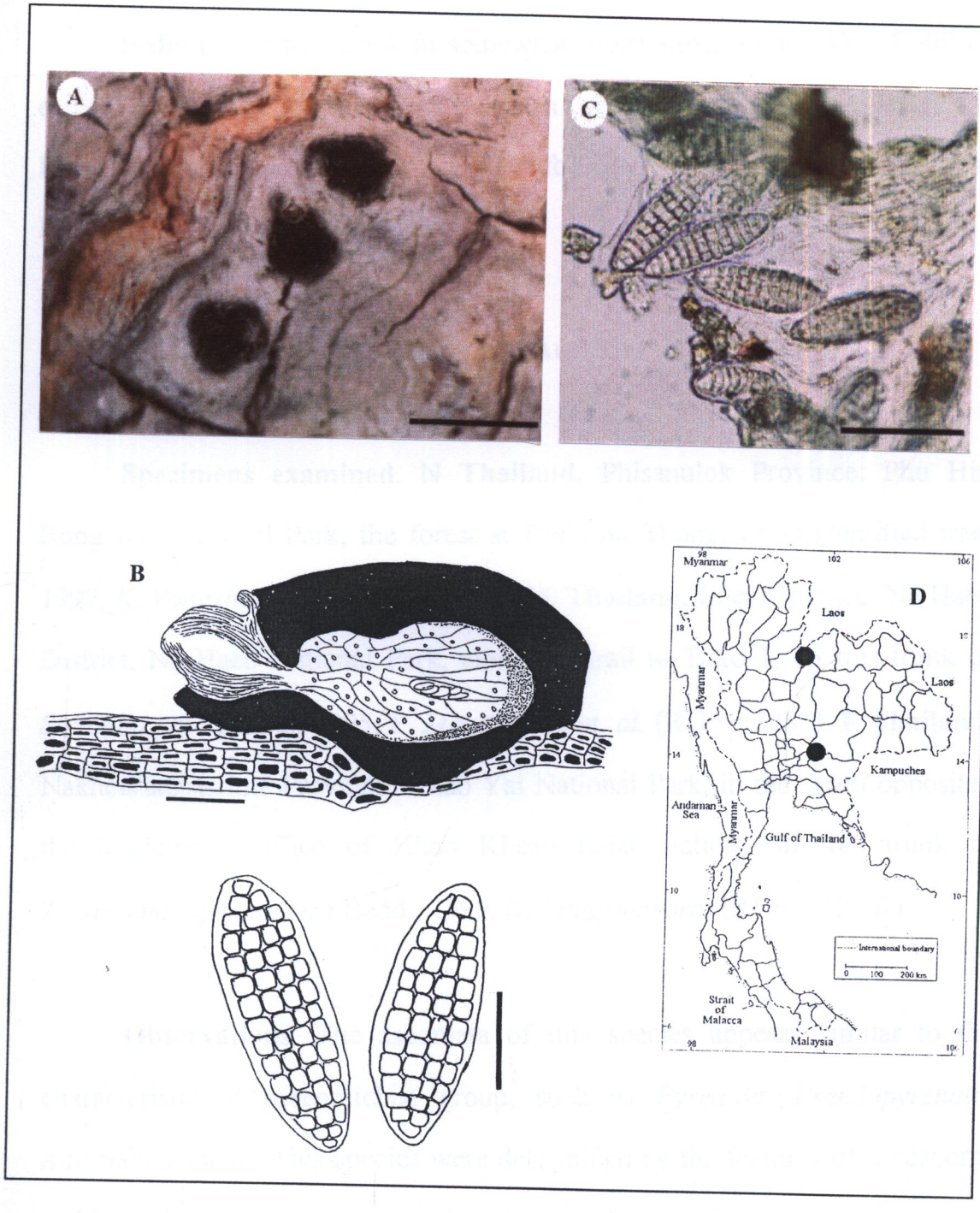



Figure 22 *Campylothelium nitidum* Müll. Arg. (RU——12562)

A. Ascomata on thallus (Bar = 1 mm).

B. L-section of ascoma (Bar = 300 μm) and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 50 μm).

D. Distribution in Thailand.

**Habitat.** On tree trunk in somewhat moist situation at 840 – 1,500 m elevations with moderate temperature, such as in the dry evergreen forest at Na Haeo National Park, in the hill evergreen forest at Phu Hin Rong Kla National Park and Khao Yai National Park.

**Distribution.** India, Thailand and Australia.

**Specimens examined. N Thailand.** Phisanulok Province: Phu Hin Rong Kla National Park, the forest at Pha Chu Thong, on unidentified tree, 1997, *K. Vongshewarat* (RU——9440). **NE Thailand.** Loei Province: Na Haeo District, Na Haeo National Park, along the trail to Toko 1, on tree trunk of *Sterculia pexa* Pierre., 1995, *P. Mongkolsuk et. al.* (RU——5287). **E Thailand.** Nakhonratchasrima Province: Khao Yai National Park, in the forest opposited the headquarter office of Khao Kheao radar station, on tree trunk of *Terstroemia gymanthera* Bedd., 1999, *K. Vongshewarat* (RU——12562).

**Observations.** The ascomata of this species appears similar to the characteristic of pyrenolichen group, such as *Pyrenula, Pseudopyrenula, Anthracothecium.* This species were determined by the features of ascospores and hamathecium.

**2. *Campylothelium superbum* (Fr.) Müll. Arg.,** *Bibliotheca lichenologica* 40. (1991). (Fig. 23).

**Thallus** crustose, whitish-yellow, smooth to rough, UV+ yellow bright; cortex colorless, K-, 50-55 μm; algae scattered in the medullary or in the periderm, Photobiont *Trentepohlia*; medulla indistinct; **ascomata** solitary, carbonized, hemispherical to subglobose, 0.6-1.0 mm diam, raised, sometimes immersed; ascomata wall carbonized; ostioles carbonized, oblique or inclined canal leading to ostiole, with some apical erect rim; centrum without oil globules; hymenium with branching and anastomosing pseudoparaphyses; **ascus** bitunicate, clavate, 4-ascospores; **ascospores** hyaline or pale yellow at mature, ellipsoid, with gelatinous sheath, muriform, 19—22–transversely septates, 1—6–vertically septates,(130)126.5-142.5-158.5(176.8) x (44.0) 45.74-48.6-53.0(54.0) μm.

**Habitat.** On tree trunk of *Michelia floribunda* in the moist situation with moderate temperature at dry evergreen forest at 900 m elevation.

**Distribution.** India and Thailand.

**Observations.** Morphology of the ascomata is similar to *Campylothelium nitidum*, but the latter produce smaller ascospores (50-62 x 18-22 μm) (Awasthi 1991, 90) and occasinally with ostiole apical.

**Specimens examined. NE Thailand.** Loei Province: Na Haeo National Park, along the trail from the village to Toko 1, on unidentified tree, 1995, *P. Mongkolsuk et. al.* (RU——4823).

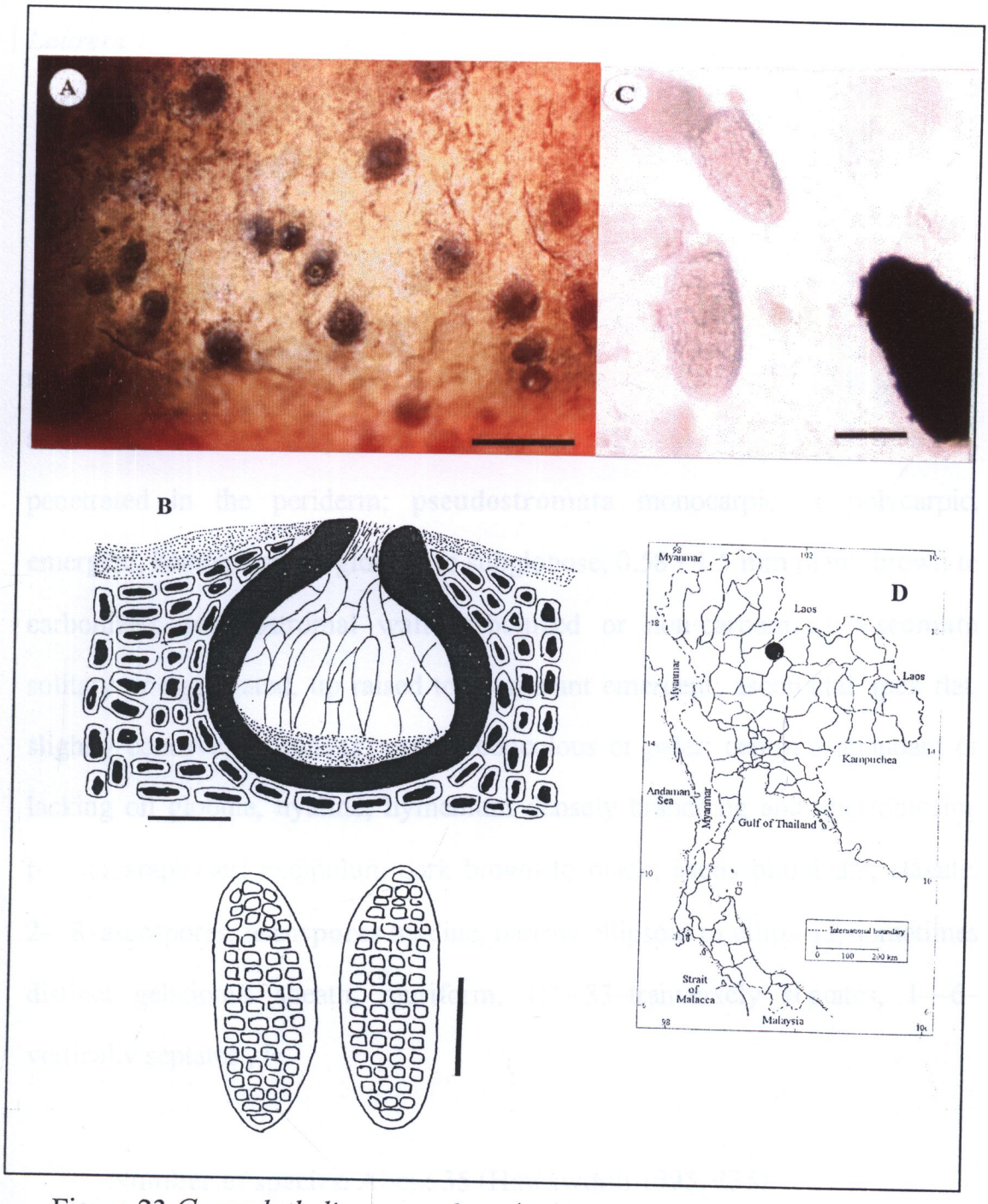



Figure 23 *Campylothelium superbum* (Fr.) Müll. Arg. (RU——4823)

A. Ascomata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 200 μm) and ascospores (Bar = 50 μm).

C. Ascospores (Bar = 50 μm).

D. Distribution in Thailand

*Laurera*

**Description of the genus**

*Laurera* Riechenb., *Rev. Bryol. Lichen.* 26: 207-264 (1957).

**Thallus** crustose, buff, pale yelow, pistachio green or green, smooth to rough, or shiny; cortex colorless or pale yellow; algal layer continuous or scattered in the medullary, Photobiont *Trentepohlia*; medulla white, indistinct, penetrated in the periderm; **pseudostromata** monocarpic or polycarpic, emergent, hemispherical, globose to subglobose, 0.58 - 1.5 mm diam, brown to carbonized, pseudostromal wall carbonized or non-carbonized; **ascomata** solitary or aggregated, up raised to prominant emergent; ascomatal apex flat, slightly concave, or convex; ostiole concolous or paler; centrum abundant or lacking oil globule, hyaline; hymenium densely branching and anastomosing pseudoparaphyses; excipulum dark brown to black; **ascus** bitunicate, clavate, 2—8–ascospores; **ascospores** hyaline, narrow ellipsoid to ellipsoid, sometimes distinct gelationus sheath, muriform, 15—33–tranversely septates, 1—6–vertically septates , I-.

**Number of species.** About 35 (Hawkworth 1995, 235).

**Habitat.** *Laurera* occur abundantly in the moist forests of the hill evergreen forests, the tropical rain forests and the dry evergreen forests and less abundantly in the dry habitat with high temperature.

**Distribution.** Cuba, Brazil, Nigeria, India, Sri Lanka, Thailand, Indonesia, and Australia.

**Observations.** *Laurera* has various type and form of pseudostromata. For example, superficial or immerse ascomata with, black, brown, yellow or orange color. The ascospores are mostly long (48-320 x 16-30 µm). This genera is commomly distributed in Thailand, for example, *Laurera benguelensis* and *L. madreporiformis*. This study described a new species, *Laurera meristosporoides* P. M. McCarthy & Vongshewarat which was collected from the hill evergreen forest at 1,200 m elevation in Phu Hin Rong Kla National Park, Phisanulok Province.

**Key to the species**

**1a** Carbonized pseudstromatal tissue .....2

**1b** Non-carbonized pseudotromatal tissue .....4

**2a** One carpic pseudostromatal .....***L. subdiscreta***

**2b** One to many carpic pseudostromatal.....3

**3a** Ascomatal centrum without oil globule, ascospores 46-50 µm.....

.....***L. phaeomelodes***

**3b** Ascomatal centrum with abundant oil globule, ascospores 60-80 µm

.....***L. keralensis***

**4a** Ascospores more than 80 µm .....5

**4b** Ascospores less than 80 µm .....8

**5a** 2—4 ascospores / ascus .....6

**5b** 8 ascospores / ascus.....7

**6a** 2 ascospores/ascus, their sizes 85-110 µm .....*L subsphaerioides*

**6b** 4ascospores/ascus, their sizes 200-300 µm.....*L. megasperma*

**7a** Ascospore sizes 70-90 µm.....*L. meristosporoides*

**7b** Ascospore sizes 140-200 µm .....*L. meristospora*

**8a** Ascomatal centrum without oil globule.....9

**8b** Ascomatal centrum abundant with oil globule.....*L. benguelensis*

**9a** Thallus tuberculate, leaf green to olivaceous green color.....

.....*L. tuberculosa*

**9b** Thallus rough to smooth, buff or straw color.....*L. madreporiformis*

**1.** ***Laurera benguelensis*** **(Müll. Arg.) Zahlbr.**, Catal. Lich. Univ. 1 : 503 (1922). (Fig. 24).

*Bathelium benguelensis* Müll.Arg., Flora 68: 256 (1885).

*Trypethelium madreporiforme* sensu Nyl., Flora 52: 73 (1869).

**Thallus** crustose, yellowish-green to buff, smooth to rough, cracked, sometimes orange or yellow prouinose, K+ purple; cortex colorless or suffer yellow, 50-70 µm; algal layer continuous, 30-40 µm; medulla white, with crystalline inclusions; **pseudostromata** luteous to lemom yellow, globose or ovate, 1.5-2.0 mm diam, with crystalline inclusions and pruinose; **ascomata** solitary or aggregated, embedded in pseudostromata, carbonized; ascomata apex concave, plane to convex; ostiole brown to carbonized, punctuate,

surrounding with periostiole; centrum fill with oil globule; excipulum dark brown to carbonized; hymenium with branching and anastomosing pseudoparaphyses; **ascus** bitunicate, clavate, 8–ascospores; **ascospores** hyaline, ellipsoid, distinct gelatinous sheath, muriform, 15—20– tranversely septates, 1—5–vertically septates, (52)55.5-63.0-71.0(80) x (16)15.9-17.9-19.8(22) μm.

**Habitat.** On tree trunks in the hill evergreen forests at 1,100-1,400 m elevations, in the dry dipterocarp forests at 300-400 m elevations, in the mixed deciduous forests at 200 m elevation, in the dry evergreen forests at 600-1,000 m elevations and occasinally found in the tropical rain forests at 10-50 m elevations.

**Distribution.** Sri Lanka, Andaman Island and Thailand.

**Specimens examined. N Thailand.** Chaingmai Province: Mae Rim District, The Queen Sirikit Botanic Garden, on tree trunk of *Castanopsis costata* Miq., 1994, *K. Boonpragob et. al.* (RU——737), on tree trunk of *Pittosporum fereugium* Al., 1994, *K. Boonpragob et. al.* (RU——1175); ibid., in the opposited forest of the garden, on tree trunk of *Schima wallichii* Korth. 1994, *K. Boonpragob et. al.* (RU——1164 & 1165); ibid., on tree trunk of *Pterocarpus macrocarpus* Kurz., 1994, *K. Boonpragob et. al.* (RU——2610 & 2611); ibid., on tree trunk of *Shorea roxbergii* G. Don., 1994, *K. Boonprogob et. al.* (RU——1719); ibid., on unidentified tree, 1994, *K. Boonprogob et. al.* (RU——1955, 1956, 2773 & 2774); ibid., on tree trunk of *Canarium*

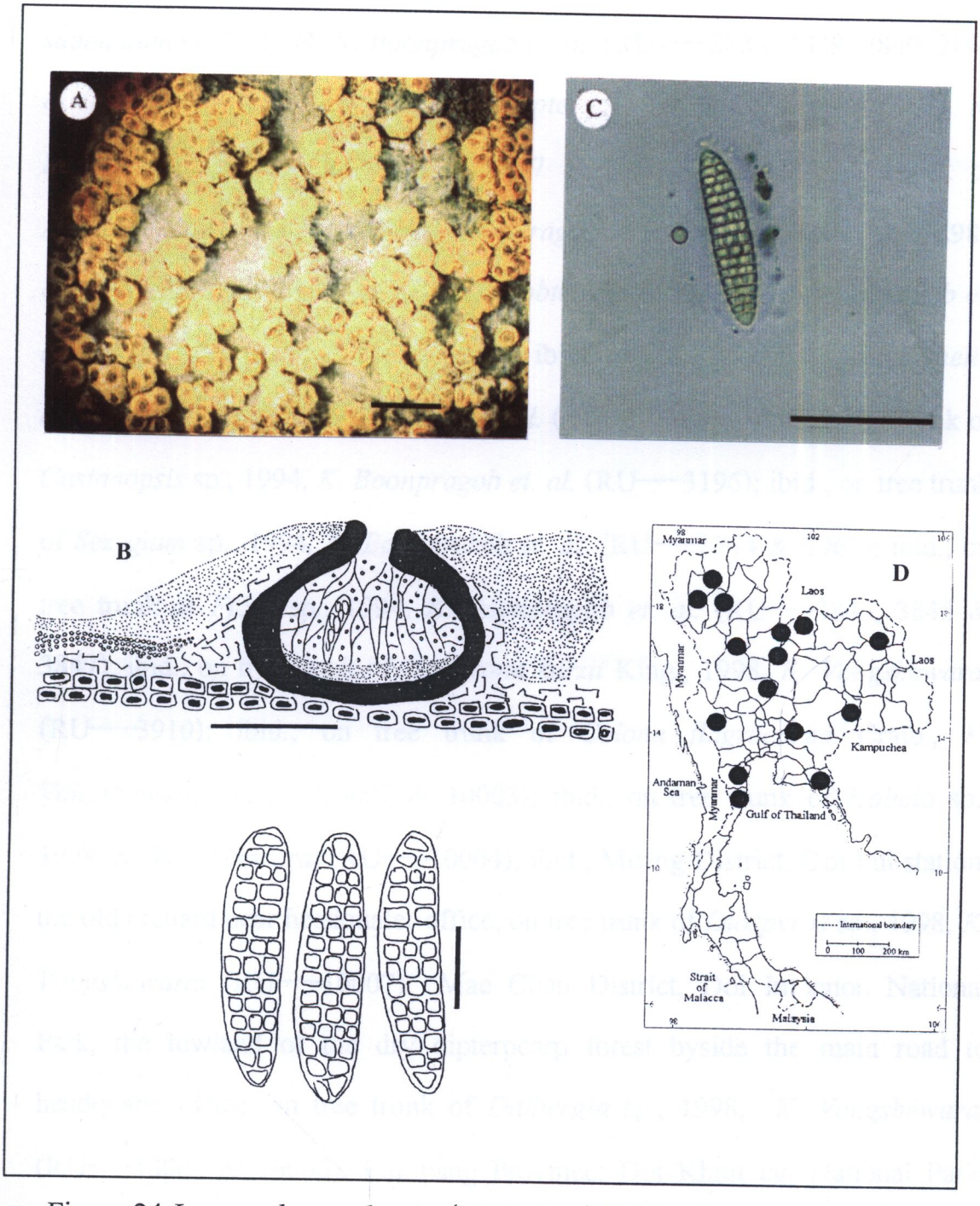



Figure 24 *Laurera benguelensis* (Müll. Arg.) Zahlbr. (RU——10021)

A. Pseudostromata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 300 μm) and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 50 μm).

D. Distribution in Thailand.

*subbuatum* Gull., 1994, *K. Boonpragob et. al.* (RU—— 2833, 2839, 2840, 2841 & 2842); ibid., on tree trunk of *Dipterocarpus tuberculatus.*, 1994, *K. Boonprobob et. al.* (RU——2896, 2897 & 2898); ibid., on tree trunk of *Anneslea fragans* Wall., 1994, *K. Boonpragob et. al.* (RU——2987, 2988, 2989 & 2990); ibid., on tree trunk of *Shorea obtusa* Wall., 1994, *K. Boonpragob et. al.* (RU——3033, 3034, 3035 & 3036); ibid., on tree trunk of *Paramichelia boiilonii* Hu., 1994, *K. Boonpragob et. al.* (RU——3076); ibid., on tree trunk of *Castanopsis* sp., 1994, *K. Boonpragob et. al.* (RU——3196); ibid., on tree trunk of *Sezygium* sp., 1994, *K. Boonprakob et. al.* (RU——3744 & 3961); ibid., on tree trunk of *Ficus* sp., 1994, *K. Boonpragob et. al.* (RU——3845, 3846 & 3847); ibid., on tree trunk of *Holigrana kurzii* King., 1998, *K. Vongshewarat* (RU——3910); ibid., on tree trunk of *Colona flagrocarpa* Craib., *K. Vongshewarat* (RU——10002 & 10003); ibid., on tree trunk of *Holicia* sp., 1998, *K. Vongshewarat* (RU——10004); ibid., Muang District, Doi Pui station, the old orchard near headquater office, on tree trunk of *Diospyros* sp., 1998, *K. Vongshewarat* (RU——10007). Mae Chan District, Doi Inthanon National Park, the lowland of the dry dipterocarp forest byside the main road to headquater office, on tree trunk of *Dalbergia* sp., 1998, *K. Vongshewarat* (RU——10005 & 10006). Lumpang Province: Doi Khun tan National Park, along the trail within the old orchard to forward Yo 2, 1998, *K. Vongshewarat* (RU——9972), on tree trunk of *Lichi chinensis* Sonn., 1998, *K. Vongshewarat* (RU—— 9973, 9974, 9975, 9976, 9977, 9978, 9979, 9980, 9981, 9982, 9983, 9984, 9985, 9986, 9987, 9989, 9990 & 9991); ibid., the dry dipterocarp forests

beside road to headquater office, on tree trunk of *Buchanania latifilia* Roxb., 1998, *K. Vongshewarat* (RU——9992, 9993, 9994, 9995, 9996, 9997 & 10046 ); ibid., on tree trunk of *Shorea siamensis* Miq., 1998, *K. Vongshewarat* (RU——10047 & 10048); ibid., Sukhothai Province: Kririmart District, Ramkhamhaeng National Park, the wood log at the entrance of headquater office, on tree trunk of *Sterculia pexa* Pierre., 1997, *K. Vongshewarat* (RU—— 9519). Phitsanulok Province: Phu Hin Rong Kla National Park, the forest at Lan Hin Tak, on unidentified tree, 1998, *K. Vongshewarat* (RU——10008, 10009, 10010 & 10011). Nakhon Sawan Province: Nong Bua District, the forest within the areas of Nong Bua School, on tree trunk of *Cleidion javanicum* Bl., 1998, *K. Vongshewarat* (RU——9964 & 9966), on tree trunk of *Dalbergia sp.*, 1998, *K. Vongshewarat* (RU——9968); ibid., on tree trunk of *Lannea coromondelica* Merr., 1998, *K. Vongshewarat* (RU——9970); ibid., on unidentified trees, 1998, *K. Vongshewarat* (RU——9969 & 9971); ibid., **NE Thailand**. Loei Province: Na Haeo District, Na Haeo National Park, Phuteen Suan Sai forest, along the trial from village to Toko 1, on tree trunk of *Adenanthera pavonina* Linn., 1995, *P. Mongkolsuk et. al.* (RU——4544, 4545, 4966, 4967, 4968, 4969, 4970, 4971, 4972, 4973, 4974, 4975, 4976 & 4977), on tree trunk of *Dipterocapus* sp., 1995, *P. Mongkolsuk et. al.* (RU——4595, 4596, 4598, 4599, 4601, 4602, 4603, 4604, 4914 & 5156); ibid., on tree trunk of *Dillienia ovata* Wall., 1995, *P. Mongkolsuk et. al.* (RU——5238 & 5239); ibid., on tree trunk of *Sterculia pexa* Piere., 1995, *P. Mongkolsuk et. al.* (RU—— 5355, 5356 & 5357); ibid., Sakon Nakhon Province: Phu Phan National Park, Huai Wian Pri forest, on trees beside the main road to city

center, on unidentified trees, 1997, *K. Vongshewarat* (RU——8921 & 8958)., on tree trunk of *Peltophorum pterocarpum* Back., 1997, *K. Vongshewarat* (RU——8921); ibid., on tree trunk of *Sterculia sp.*, 1997, *K. Vongshewarat* (RU——8932); ibid., the dry dipterocarp forests at Par Nang Mong, on tree trunk of *Xylia xylocarpa* Taub., 1998, *W. Khamthaim* (RU——10049, 10051, 10052 & 10053); ibid., forest at K.M 25, on tree trunk of *Xylia xylocarpa* Taub., 1998, *K. Vongshewarat* (RU——11054 & 11056); ibid., on unidentified tree, 1998, *W. Khamthaim* (RU——10050); ibid., Muang District, with plantation of in Ratjabhat Institute Sakon Nakhon, on tree trunk of *Mangifera indica* Linn., 1998, *W. Khamthaim* (RU——10054)., on tree trunk of *Arthocarpus heterophyllus* Lamk., 1998, *W. Khamthaim* (RU——10055); ibid., **E Thailand.** Nakhon Ratchasima Province: Khao Yai National Park, along the trail to old golf course, on tree trunk of *Mangifera indica* Linn., 1997, *K. Boonpragob et. al.* (RU——7957), on tree trunk of *Peltophorum pterocarpum* Back., 1997, *K. Boonpragob et. al.* (RU——8084); ibid., the forest in Khao Lu Chang, on unidentified tree, 1997, *K. Boonpragob et. al.* (RU——8283 & 8284); ibid., the forest in front of Khao Khaeo radar station, on tree trunk of *Schima walichii* Korth., 1997, *K. Vongshewarat* (RU——8442); ibid., along the trail of Pha Kluy Mai waterfall to Heo Suwat waterfall, on unidentified tree, 1997, *K. Vongshewarat* (RU——9071); ibid., the forest near Ban Chom View, on tree trunk of *Peltophorum pterocarpum* Back., 1999, *K. Vongshewarat* (RU——12511); ibid., Buri Rum Province: Khao Kadong Forest Park, on unidentified tree, 1998, *W. Khomthim* (RU——9998, 9999,

10000 & 10001), on tree trunk of *Sezygium sp.*, 1998, *K. Vongshewarat* (RU——10012 & 10013); ibid., on tree trunk of *Olax scandens* Roxb., 1998, *K. Vongshewarat* (RU——10014 & 10015); ibid., on tree trunk of *Buchanania latifolia* Roxb., 1998, *K. Vongshewarat* (RU——10016, 10020, 10021, 10022, 10023, 10024, 10025, 10026, 10027 & 10028); ibid., on tree trunk of *Pterocarpus macrocarpus* Kurz., 1998, *K. Vongshewarat* (RU——10030); ibid., on tree trunk of *Anesles fragrans* Wall., 1998, *K. Vongshewarat* (RU——10031); ibid., on unidentified trees, 1998, *K. Vongshewarat* (RU——10029, 10032, 10033, 10034, 10035, 10036, 10037, 10038, 10,039, 10040, 10041 & 10042). ibid., on tree trunk of *Cassia siamea* Britt., 1998, *K. Vongshewarat* (RU——10043, 10044 & 10045); ibid., **SW Thailand**. Kanchanaburi Province: Erawan Natinal Park, along the trail to Thalaen Tum Sao, on unidentified tree, 1997, *K. Vongshewarat* (RU——8611 & 8612). Phetchaburi Province: Ban lad District, Tum Lu sub-district, on tree trunk of *Eloeocarpus hygrophilus* Kurz., 1998, *K. Vongshewarat* (RU——10018 & 10019). Prachuap Khiri Khan Province: Hua Hin District, the forest near the Military Communication station, on tree trunk of *Mammea siamensis* Kosterm., on unidentified trees, 1998, *K. Vongshewarat* (RU——11095, 11096, 11097, 11098 & 11099). **SE Thailand**. Chanthaburi Province: Khao Kit Cha Kut National Park, the forest near headquater office, on unidentified tree, 1997, *K. Vongshewarat* (RU——8488).

**Observations**. The specimens from Thailand show numerous oil globule in the centrum, but its absent in the specimens from India (Awasthi,

1991). Generally, specimens collected from hot and dry habitat have orange thallus and pseudostromata, but those from the moist and shaded habitat have pale orange to yellow thallus and pseudostromata.

2. ***Laurera keralensis*** **Upreti & A. Singh.**, *Bull. Jard. Bot. Belg.* 57 : 374 (1987). (Fig. 25).

**Thallus** crustose, olivaceous to yellow-green, smooth to rough, shiny; hypothallus indistinct; cortex colorless, 40-80 µm, algal layer 40-60 µm, scattered in medulla; medulla indistinct, without crystal; **pseudostromata** brown to carbonized, subglobose, 0.3-0.7 mm diam, cracked at maturity; **ascomata** solitary to aggregated, embedded in pseudostromata, carbonized; ascomatal apex concave; ostiole carbonized; centrum abundant with oil globule; excipulum carbonized; hymenium with branching and anastomosing pseudoparaphyses; **ascus** bitunicate, clavate, 8–ascospores; **ascospores** hyaline, ellipsoidal, muriform, 15—22–transversely septates , 1—5–vertically septates, (64.0)65.8-71.7-77.6(80.0) x (20.0)20.3-22.1-23.9(24.0) µm.

**Habitat.** On tree trunks in the hill evergreen forests at 1300-1400 m elevations, on dipterocarp trees in the dry dipterocarp forests at 300-400 m elevations and the dry evergreen forests at 800-900 m elevations.

**Distribution.** India and Thailand.

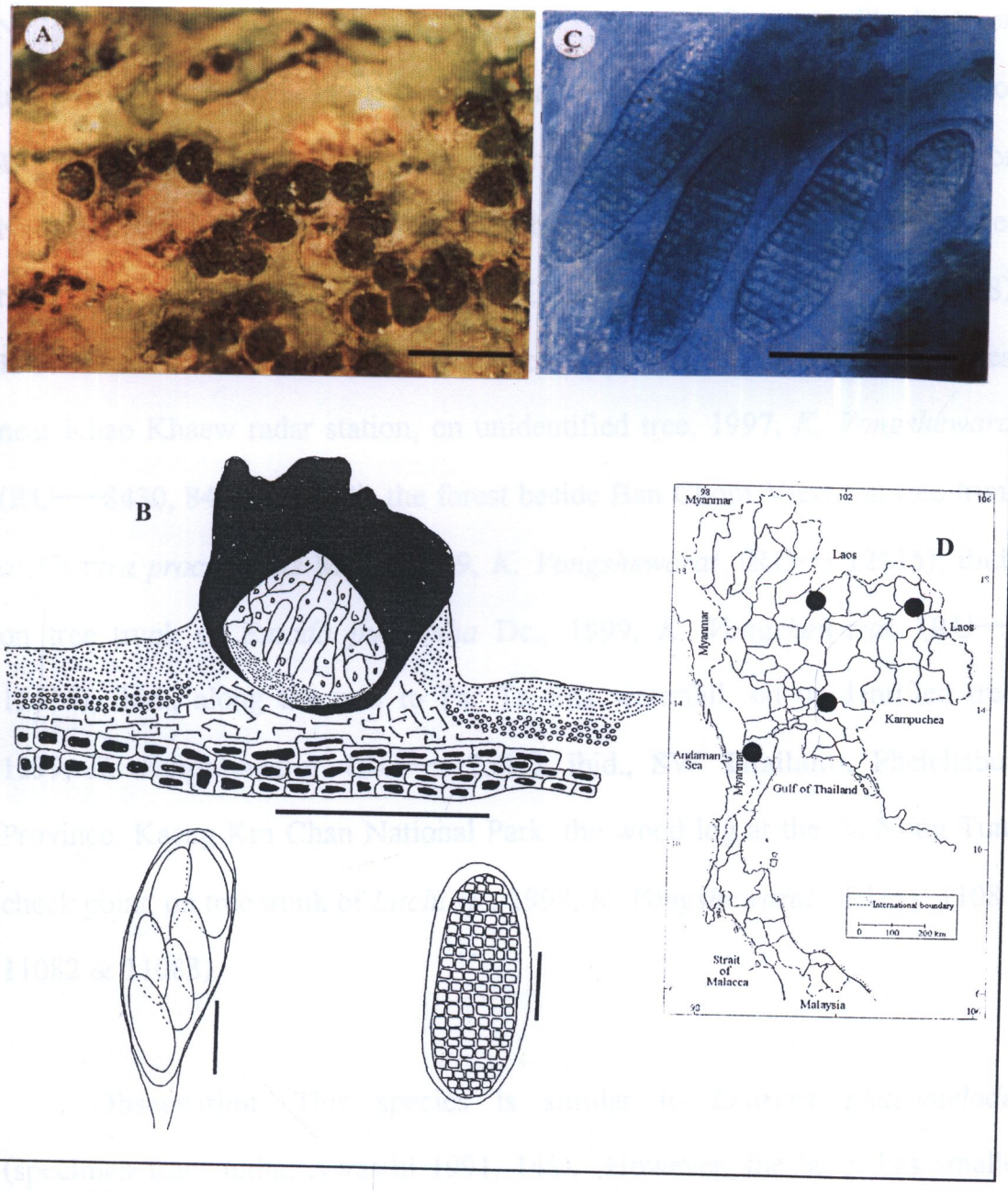



Figure 25 *Laurera keralensis* Upreti & A. Singh. (RU——6976)

A. Pseudostromata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 300 μm), ascus (Bar = 50 μm) and ascospores (Bar = 20 μm).

C. Ascospore (Bar = 50 μm).

D. Distribution in Thailand.

**Specimens Examined. NE Thailand.** Loei Province: Na Haeo District, Na Haeo National Park, the forest adjacent to Wat Charoem Phrakiat, on unidentified tree, 1995, *P. Mongkolsuk et. al.* (RU——6976), on tree trunk of *Memecylon sp.*, 1995, *P. Mongkolsuk* et al. (RU——7085); ibid., Sakon Nakhon Province: Muang District, Ratjabhat Institute Sakon Nakhon, on tree trunk of *Mangifera indica* Linn., 1998, *W. Khamthim* (RU——11047 & 11048). **E Thailand.** Nakhon Ratchasima Province: Khao Yai National Park, the forest near Khao Khaew radar station, on unidentified tree, 1997, *K. Vongshewarat* (RU——8430, 8435 & 8458), the forest beside Ban Chom View, on tree trunk of *Gynura procumbens* Merr., 1999, *K. Vongshewarat* (RU——12515); ibid., on tree trunk of *Entada pursactha* Dc., 1999, *K. Vongshewarat* (RU——12524); ibid., along the trail to Par Ta Bak waterfall, on unidentified tree, 1999, *K. Vongshewarat* (RU——12541); ibid., **SW Thailand.** Phetchaburi Province: Kaeng Kra Chan National Park, the wood log at the Pa Nong Tung check point, on tree trunk of *Litchi sp.*, 1998, *K. Vongshewarat* (RU——11081, 11082 & 11083).

**Observation.** This species is similar to *Laurera phaeomelodes* (specimen from India; Awasthi 1991, 148). However, the latter has smaller pseudostromata (0.4-0.6 mm diam) without cracked in mature thallus.

**3. *Laurera madreporiformis* (Eschw.) Riddle apud Howe**, Torreya 16: 50 (1916). (Fig. 26).

*Trypethelium madreporiformis* Eschw., Syst. Lich.: 24 (1824).

**Thallus** crustose, buff to pale yellow, smooth to rough; hypothallus indistinct; cortex colorless, 20-45 μm; algal layer continuous, 20-40 μm; medulla indistinct, lossely organized, penetrate in the periderm; **pseudostromata** brown to carbonized, 0.5-0.75 mm diam, hemispherical to globose, irregular, with orange medullary, K+ purple; **ascomata** solitary or aggregated, embedded in the pseudostromata, carbonized; ascomatal apex concave to plane; ostiole brown to carbonized, punctate, with surrounding white to yellow periostiole; centrum without oil globule; excipulum dark brown to carbonized; hymenium with branching and anastomosing pseudoparaphyses; **ascus** bitunicate, clavate, with short stalk, 8—ascospores; **ascospores** hyaline, ellipsoid, distinct gelatinous sheath, muriform, 9—12–tranversely septates, 1—4–vertically septates, (44.0)45.0-50.0-54.8(60.0) x (12.0)13.0-15.7-18.3(20.0) μm.

**Habitat.** On tree trunks in the hill evergreen forests at 1,100-1,500 m elevations, the dry dipterocarp forests at 600-800 m elevations, the mixed deciduous forests at 300 m elevation and the dry evergreen forests at 200-300 m elevations.

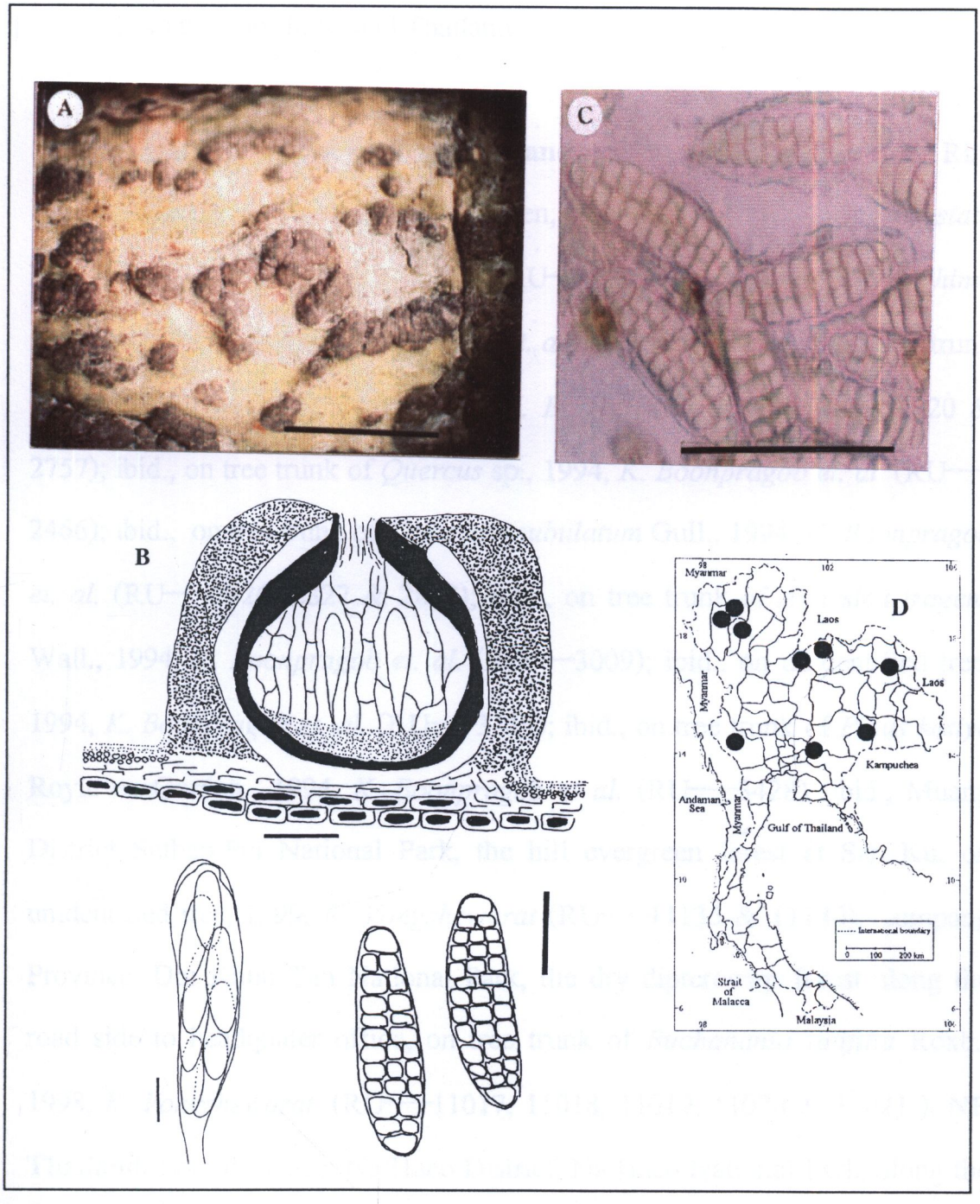



Figure 26 *Laurera madreporiformis* (Eschw.) Riddle in Howe. (RU——7072)

A. Pseudostromata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 300 μm), ascus and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 50 μm).

D. Distribution in Thailand.

**Distribution.** India and Thailand.

**Specimens examined. N Thailand.** Chaingmai Province: Mae Rim District, The Queen Sirikit Botanic Garden, on tree trunk of *Catanopsis costata* Miq., 1994, *K. Boonpragob et. al.* (RU——717), on tree trunk of *Schima wallichii* Korth., 1994, *K. Boonpragob et. al.* (RU——1663); ibid., on tree trunk of *Shorea roxberigii* G. Don., 1994, *K. Boonpragob et. al.* (RU——1720 & 2757); ibid., on tree trunk of *Quercus* sp., 1994, *K. Boonpragob et. al.* (RU——2466); ibid., on tree trunk of *Canarium subulatum* Gull., 1994, *K. Boonpragob et. al.* (RU——2826, 2827 & 2828); ibid., on tree trunk of *Anneslea fragens* Wall., 1994, *K. Boonpragob et. al.* (RU——3009); ibid., on unidentified tree, 1994, *K. Boonpragob et. al.* (RU——3119); ibid., on tree trunk of *Pinus kesiya* Royle ex Gordon., 1994, *K. Boonpragob et al.* (RU——3428); ibid., Muang District Suthep-Pui National Park, the hill evergreen forest at San Ku, on unidentified tree, 1999, *K. Vongshewarat* (RU——11135 & 11140). Lumpang Province: Doi Khun Tan National Park, the dry dipterocarp forest along the road side to headquater office, on tree trunk of *Buchanania latifilia* Roxb., 1998, *K. Vongshewarat* (RU——11017, 11018, 11019, 11020 & 11021 ). **NE Thailand.** Loei Province: Na Haeo District, Na Haeo National Park, along the trial to Heang Yar waterfall, on tree trunk of *Bombax ancep* Pierre., 1995, *P. Mongkolsuk et. al.* (RU——5865), on tree trunk of *Buchanania forida* Schuaer., 1995, *P. Mongkolsuk et. al.* (RU——5984); ibid., along the trial to Wat Charoem Phrakiat, on tree trunk of *Shorea obtusa* Wall., 1995, *P.*

*Mongkolsuk et. al.* (RU——7070, 7072, 7075, & 7076); ibid., on unidentified tree, 1995, *P. Mongkolsuk et. al.*(RU——7722); ibid., Sakon Nakhon Province: Phu Phan National Park, Huai Wian Pri forest, on trees along the main road to city center, on tree trunk of *Peltophorum pterocarpum* Back., 1997, *K. Vongshewarat* (RU——8942), the dry dipterocarp forest at Pha Nang Mong, on unidentified tree, 1998, *W. Khamthaim* (RU——11049); ibid., the forest at K.M 25, on tree trunk of *Xylia xylocarpa* Taub.,1998, *K. Vongshewarat* (RU——11056, 11057 & 11058); ibid., **E Thailand.** Nakhon Ratchasima Province: Khao Yai National Park, along the trial to Mo Sing, 1997, *K. Vongshewarat.* (RU——8994), along to the trial of nature study KM. 33 to Nong Pak Chee, on tree trunk of *Dipterocapus sp.*, 1999, *K. Vongshewarat* (RU——12507); ibid., the forest near Ban Chom View, on tree trunk of *Peltophorum pterocarpum* Back., 1999, *K. Vongshewarat* (RU——12509 & 12510); ibid., Buri Rum Province: Khao Kadong Forest Park, on unidentified tree, 1998, *W. Khamthim* (RU——11038). **SW Thailand.** Kanchanaburi Province: Erawan Natinal Park, on unidentified tree, 1997, *K. Vongshewarat* (RU——8571).

**Observations.** The distinct characteristic of this species is aggregated ascomata which immersed in dark pseudostromata and medulla of pseudostromata contain yellow-orange pigment (K+ purple). It commonly occurs in the dry dipterocarp forests, such as Doi Khuntan National Park and Khao Kadong Forest Park.

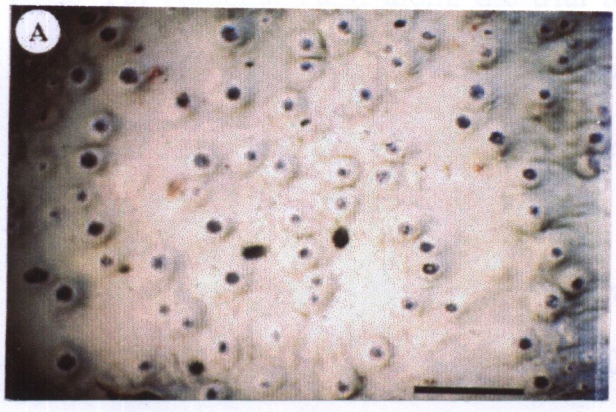
**4. *Laurera megasperma* (Mont.) Riddle.** *Bull. Torrey bot. Club.* 44: 323 (1917). (Fig. 27).

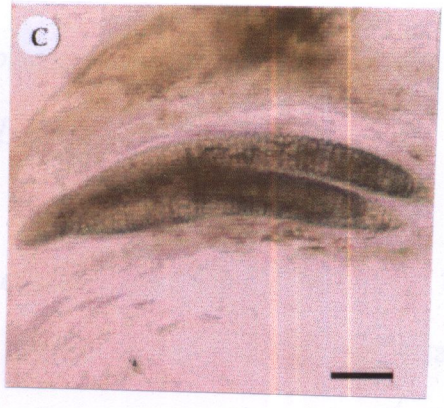
*Trypethelium megaspermum* Mont. *Ann. Sci. Nat. Bot., ser.* 2, 19: 68 (1843).

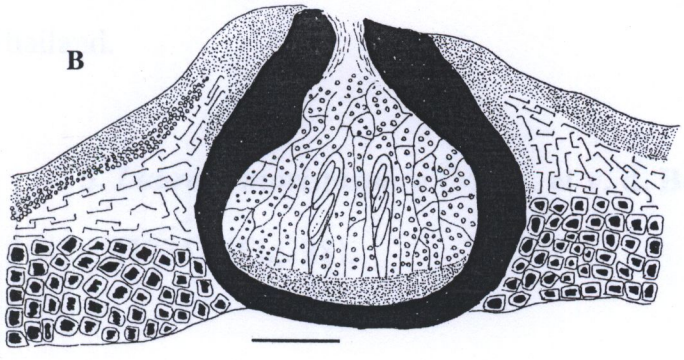
**Thallus** crustose, pale yellow, smooth or rough, sometimes white pruinose; cortex colorless, 28-60 μm; algal layer continuous, 10-20 μm; medulla white 20--30 μm, studded with crystrals; **pseudostromata** pale yellow, concolorous with the thallus, 0.5-1.5 mm diam; **ascomata** solitary or composed, embedded in pseudostromata, carbonized; ascomata apex plane to slightly convex; ostiole brown or carbonized, surroundding with white periostiole; centrum with abundant oil globules; excipulum dark brown to carbonized; hymenium with branching anastomosing pseudoparaphyses; **ascus** bitunicate, clavate, 4—6–ascospores; **ascospores** hyaline, elongate-cylindrical, muriform, 40—65–tranversely septates, 1—4–vertically septates, (180.0)234.0-279.6-325.1(320.0) x (30.0)29.9-30.9-31.9(32.0) μm.

**Habitat.** On tree trunk of *Mangifera indica* Linn in the dry evergreen forest at 800 m elevations.

**Distribution.** Brazil, India, Sri Lanka and Thailand.





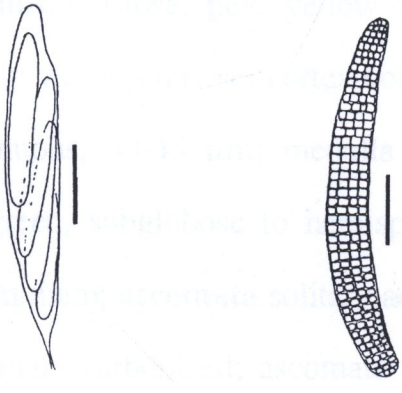


Figure 27 *Laurera megasperma* (Mont.) Riddle. (RU——7958)

A. Pseudostromata on thallus (Bar = 5 mm).

B. L-section of ascoma (Bar = 300 μm), ascus (Bar = 100 μm) and ascospores (Bar = 50 μm).

C. Ascospores (Bar = 50 μm).

D. Distribution in Thailand.

**Specimens examined. E Thailand.** Nakhon Ratchasima Province: Khao Yai National Park, along the trial to old golf course, on tree trunk of *Mangifera indica* Linn., 1997, *K. Boonpragob et. al.* (RU——7958), on unidentified tree, 1997, *K. Boonpragob et. al.* (RU——8140);ibid.

**Observations.** Similar to *Laurera meristospora.* The difference is this species have smaller ascospores (170-220 x 32-40 μm and 33-40 septated transversely; Letrouit-Gulinou; 1957, 235). This species less abundant in Thailand.

**5. *Laurera maristospora* (Mont. et v. d. Bosch) Zahlbr.** Catal. n. (1735). (Fig. 28).

**Thallus** crustose, pele yellow to yellowish-green, smooth to rough, osccasionally white pruinose; cortex colorless to pale yellow, 86-90 μm; algal layer continuous, 40-45 μm; medulla white 40--100 μm; **pseudostromata** yellowish-green, subglobose to hemispherical, concolorous with the thallus, 0.5-1.25 mm diam; **ascomata** solitary and sometimes aggregated, embedded in pseudostromata, carbonized; ascomata apex plane to slightly convex; ostiole brown to carbonized, surrounding with whitish periostiole; centrum with abundant oil globule; excipulum dark brown to carbonized; hymenium with branching and anastomosing pseudoparaphyses; **ascus** bitunicate, clavate, 4—8–ascospores; **ascospores** hyaline, ellipsoid-cylindrical, muriform, 19—25–

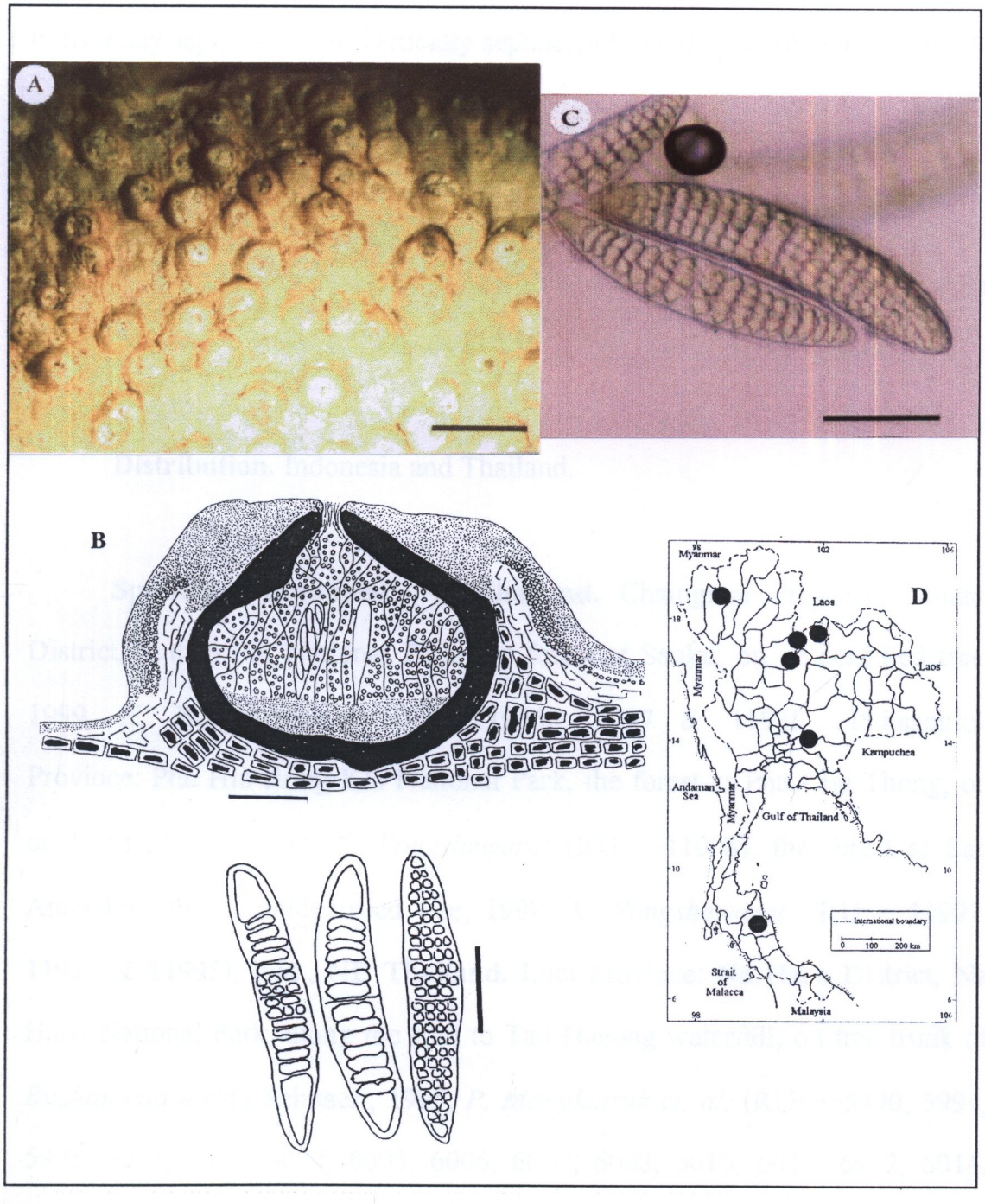



Figure 28 *Laurera meristospora* (Mont. Et v. Bosch) Zahlbr. (RU——6174)

A. Pseudostromata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 300 μm), ascus and ascospores (Bar = 50 μm).

C. Ascospores (Bar = 50 μm).

D. Distribution in Thailand.

tranversely septates, 1—4–vertically septates, (140.0)153.4-168.3-183.2(200.0) x (30.0)29.7-30.7-31.6(32.0) μm, angular or rounded cells locule.

**Habitat.** On trees trunk in the moist areas with low temperature, such as the hill evergreen forests at 1,100-1,500 m elevations, the dry evergreen forests at 500-900 m elevations and the tropical rain forests at 100 m elevation.

**Distribution.** Indonesia and Thailand.

**Specimens examined.** **N Thailand.** Chaingmai Province: Muang District, Suthep Pui National Park, the forest at Sanku, on unidentified tree, 1999, *K. Vongshewarat* (RU——11936, 11937 & 11938). Phitsanulok Province: Phu Hin Rong Kla National Park, the forest at Pha Chu Thong, on unidentified tree, 1998, *K. Vongshewarat* (RU——11008), the forest at Lan Anag Pasong, on unidentified tree, 1998, *K. Vongshewarat* (RU——11991, 11992 & 11995); ibid., **NE Thailand.** Loei Province: Na Haeo District, Na Haeo National Park, along the trial to Tad Haeong waterfall, on tree trunk of *Buchanania forida* Schuaer., 1995, *P. Mongkolsuk et. al.* (RU——5990, 5994, 5995, 5997, 6003, 6004, 6005, 6006, 6007, 6008, 6010, 6011, 6012, 6014, 6016, 6017, 6018, 6019, 6020, 6021, 6026, 6076, 6078, 6090, 6091, 6174, 6179, 6180, 6181, 6182, 6184, 6186, 6187 & 6193), the forest at Toko 1, on tree trunk of *Quercus sp.*, 1995, *P. Mongkolsuk et. al.* (RU——6960); ibid., the forest near Wat Charoem Phrakiat, on unidentified tree, 1995, *P. Mongkolsuk et. al.* (RU——6975); ibid., along the trial to Heang Yar waterfall, on

unidentified tree, 1995, *P. Mongkolsuk et. al.* (RU——7336); ibid., **E Thailand.** Nakhon Ratchasima Province: Khao Yai National Park, the forest at Mo Sing To, on unidentified tree, 1997, *K. Vongshewarat* (RU——8994), along the trial of Pha Kluy Mai waterfall to Heo Suwat waterfall, on unidentified tree, 1997, *K. Vongshewarat* (RU——9071); ibid., along the trial of nature study forest at KM. 33 to Nong Pak Chee, on tree trunk of *Dipterocapus sp.*, 1999, *K. Vongshewarat* (RU——12505); ibid., the forest at Khao Khaeo radar station, on unidentified tree, 1999, *K. Vongshewarat* (RU——12589 & 12590); ibid., the tree behind Youth camp, on tree trunk of *Citrus aurantifolia* Swing., 1999, *K. Vongshewarat* (RU——12536); ibid., along the trial to Pha Ta Bak waterfall, on unidentified tree, 1999, *K. Vongshewarat* (RU——12543); ibid., **PEN Thailand.** Nakhon Sri Thammarat Province: Khao Loung National Park, tree in the front of headquauter office, Krung Ching waterfall, on tree trunk of *Elateriospermum tapass* Bl., 1998, *K. Vongshewarat* (RU——9836).

**Observations.** The appearance is resemble to *Laurera megasperma,* deference is this species has smaller ascospores (175-300 x 25-48 μm, with 40-50–septated transversely; Awasthi 1991, 150). This species was commonly found at high altitude (700-1,500 m elevations) and moist habitat, such as in the hill evergreen forests, the dry evergreen forest. It rarely occurs in the dry dipterocarp forests and the tropical rain forest.

**6. *Laurera meristosporoides* P. M. McCarthy & Vongshewarat,** sp. nov. Mycotaxon 70: 228 (1999). (Fig. 29).

**Thallus** crustose, pale yellowish-green, continuous to sparsely rimose, smooth to rugose, glossy; cortex colorless, 30-60 μm; algal layer continuous, 20-30 μm, medulla white, immered in the periderm; **pseudostromata** pale yellow, concolorous with the thallus, semiconvex to convex, 0.6-1.2(-2) mm diam; **Ascomata** solitary, embedded in pseudostromata, carbonized; ascomatal apex concave to plane; ostiole gray to carbonized; centrum rather dense with oil globules; excipulum carbonized; hymenium with branching and anastomosing pseudoparaphyses; **ascus** bitunicate, clavate, apex with a broad, convex ocular chamber, with long stalk, 8—ascospores; **ascospores** hyaline, narrowly ellipsoid, with gelatinous sheath, muriform, (9-)11-15(-18)– transversely septates, (74.0)75.0-80.2-85.5(90.0) x (18.0)19.5-20.2-21.0(21.0) μm, angular or rounded cells locule.

**Habitat.** On tree trunk in the hill evergreen forest at 1,200 m elevation from Phu Hin Roung Kla National Park, Phisanulok Province.

**Distribution.** Thailand.

**Specimens examined. N Thailand.** Phitsanulok Province: Phu Hin Rong Kla National Park, the forest at Lan Anag Pasong, on tree trunk of *Quercus sp.* 1998, *K. Vongshewarat*, (RU——10988, 10989 & 10990).

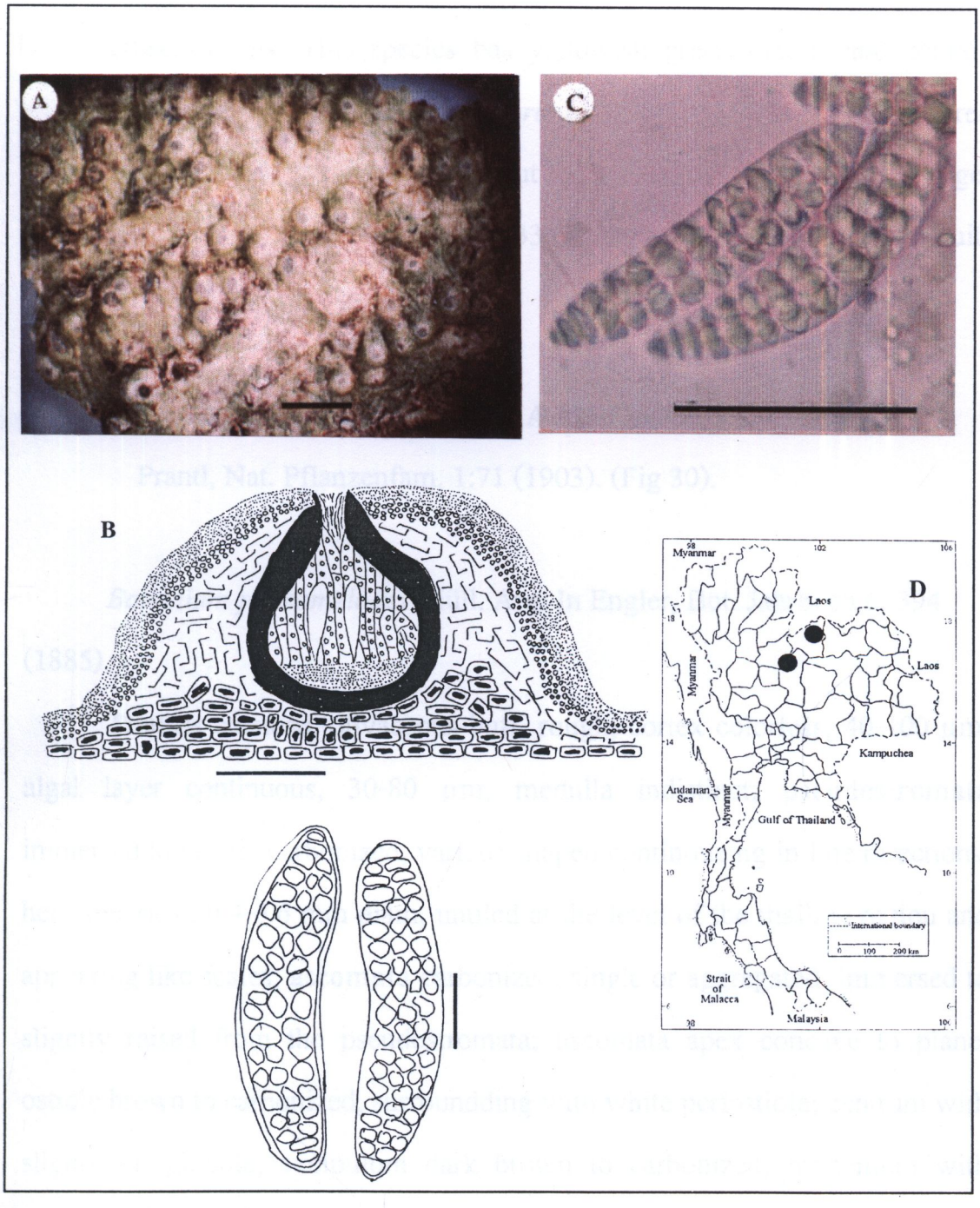



Figure 29 *Laurera meristosporoides* P. M. McCarthy & Vongshewarat.

(RU——10,990)

A. Pseudostromata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 300 μm)and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 50 μm).

D. Distribution in Thailand.

**Observations.** This species has yellowish green thallus and contain small monocarpic pseudostromata. *Laurera meristospora* can be compared with this species in many respects, but difference is having much longer ascospores 170-220 x 32-40 µm and 33-40–transversely septates (Letrouit-Gulinou 1957, 235).

**7. *Laurera phaeomelodes* (Müll. Arg.) Zalhbr.**, in A. Engler & K. Prantl, Nat. Pflanzenfam. 1:71 (1903). (Fig 30).

*Bathelium phaeomelodes* Müll. Arg. In Engler, Bot. Jahrbuch 6: 394 (1885).

**Thallus** crustose, olivaceous buff, rough; cortex colorless, 40-100 µm; algal layer continuous, 30-80 µm, medulla indistinct; **pseudostromata** immersed to raised, carbonized, various shaped continoueing in line directions, hemispherical, 0.4-0.6 mm diam, untiled at the level of the thalline region and appearing like scales; **ascomata** carbonized, single or aggregated, immersed to slightly raised from the pseudostromata; ascomata apex concave to plane; ostiole brown to carbonized, surroundding with white periostiole; centrum with slighty oil globule; excipulum dark brown to carbonized, hymenium with branching and anastomosing pseudoparaphyses; **ascus** bitunicate, clavate, 8—ascospores; **ascospores** hyaline, ellipsoid, distinct gelatinous sheath, muriform, 8—10-transversely septates, 1—3-vertically septates, (38.0)43.6-46.7-49.7 (50.0) x (12.0)12.1-13.5-14.8(16.0) µm.

**Habitat.** On tree trunk of *Quercus sp.* in the hill evergreen forests at 1,200 m elevation.

**Distribution.** Cuba, Nigeria, Andaman Island and Thailand.

**Specimens examined. N Thailand.** Phitsanulok Province: Phu Hin Rong Kla National Park, the forest at Lan Anag Pasong, on tree trunk of *Quercus sp.*, 1998, *K. Vongshewarat* (RU——10986 & 10987).

**Observations.** The distinct characteristic of this species is having connected dark ascomata, parallel with thalline surface and contains the smallest ascospores (38-50 x 12-16 μm) among the *Laurera* occurred in Thailand.

**8. *Laurera subdiscreta* (Nyl.) Zahlbr.,** Catal. Lich. Univ. 1 : 506 (1922). (Fig. 31).

*Trypethelium subdiscretum* Nyl., Flora 52: 73 (1869).

**Thallus** crustose, olivaceous to greenish-green, rather rough, dull; cortex colorless, 40-60 μm; algal layer continuous, 37-45 μm; medulla indistinct, penetrate in the periderm; **pseudostromata** solitary, hemispherical to subglobose, carbonized, 0.5-1.0 mm diam; **ascomata** solitary, embedded in pseudostromata, carbonized; ascomatal apex concave to plane; ostiole

carbonized, punctate; centrum slightly oil globule; excipulum carbonized; hymenium with branching and anastomosesing pseudoparaphyses; **ascus** bitunicate, clavate, 8–ascospores; **ascospores** hyaline, cylindrical to elongate-ellipsoidal, muriform, 9—13-tranversely septates, 1—3-vertically septates, (48.0)51.5-62.2-73.7(78.0) x (15.0)14.9-16.3-17.7(20.0) μm.

**Habitat.** On trees trunk in the hill evergreen forests at 1,000 m elevation, in the dry evergreen forests at 900 m elevation, in the dry dipterocarop forests and in the mixed deciduous forests at 300-400 m elevations.

**Distribution.** India and Thailand.

**Specimens examined. NE Thailand.** Loei Province: Na Haeo District, Na Haeo National Park, along the trial from village to Toko 1, on unidentified trees, 1995, *P. Mongkolsuk et. al.* (RU——4898, 4899, 4900, 4903, 4904, 4905, 4908 & 4909), on tree trunk of *Dillienia ovata* Wall., 1995, *P. Mongkolsuk et. al.* (RU——5219 & 5221); ibid., Sakon Nakhon Province: Phupan Natioal Park, Huai Wian Pri forest, on tree beside the main road to city center, on unidentified tree, 1997, *K. Vongshewarat* (RU——8917), on tree trunk of *Peltophorum pterocarpum* Back., 1997, *K. Vongshewarat* (RU——8944); ibid., the forest at To Ket Unit, on unidentified tree, 1997, *K. Vongshewarat* (RU——8895); ibid., the forest at Pha Nang Mon forest, on unidentified tree, 1998, *W. Khomthim* (RU——11,051, 11,052 & 11,053); ibid., the forest at

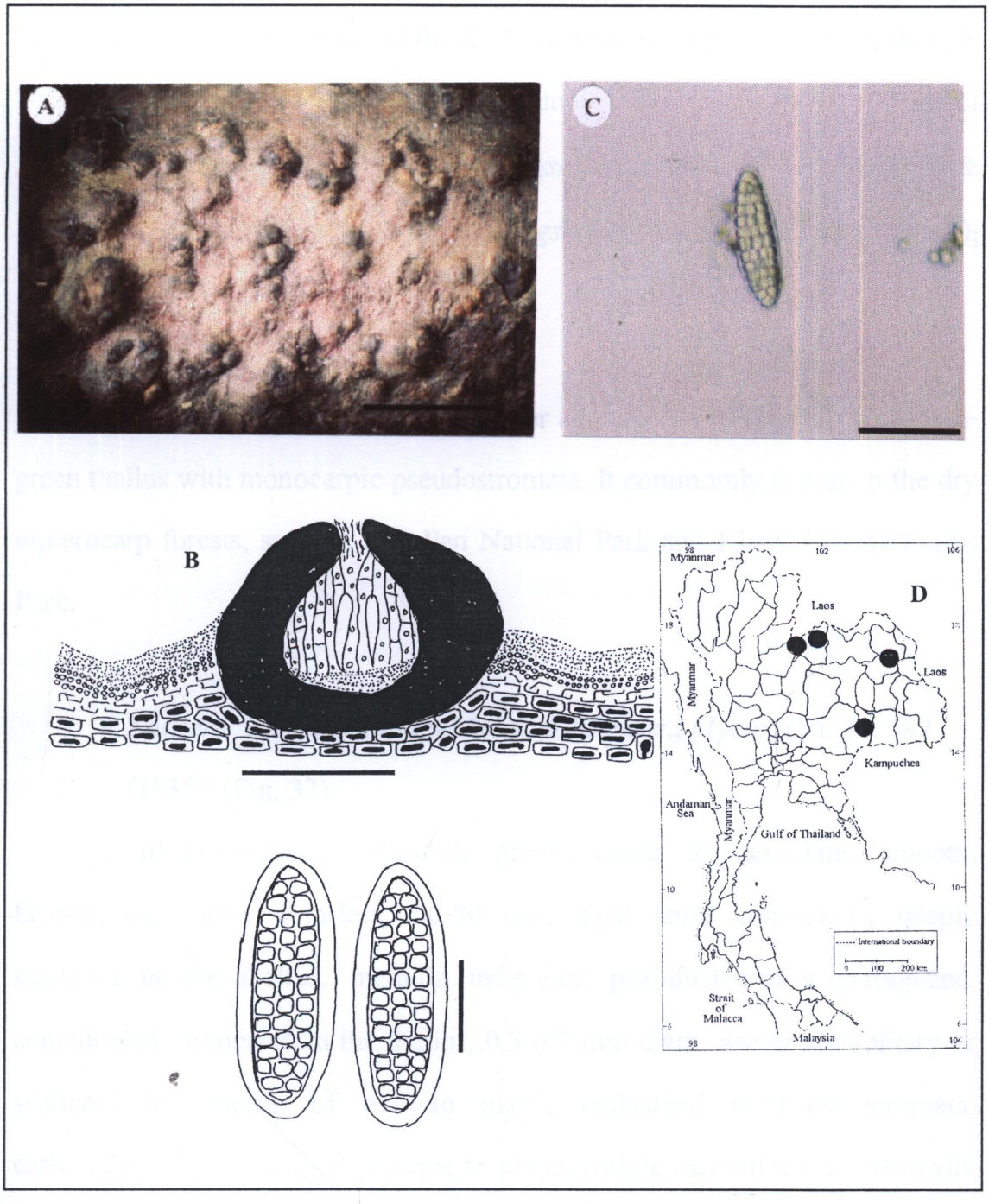



Figure 31 *Laurera subdiscreta* (Nyl.) Zahlbr. (RU——4898)

A. Pseudostromata on thallus (Bar = 5 mm).

B. L-section of ascoma (Bar = 300 μm)and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 50 μm).

D. Distribution in Thailand.

KM. 25, on unidentified tree, 1998, *K. Vongshewarat* (RU—— 11062); ibid., **E Thailand**. Buri Ram Province: Khao Kadong Forest Park, on tree trunk of *Buchanania latifolia* Roxb., 1998, *K. Vongshewarat* (RU—— 11039, 11040 & 11041), on unidentified tree, 1998, *K. Vongshewarat* (RU——11042 & 11043); ibid.

**Observations.** The distinct character of *Laurera subdiscreta* is grayish-green thallus with monocarpic pseudostromata. It commomly occurs in the dry dipterocarp forests, such as Phu Pan National Park and Khao Kadong Forest Park.

**9. *Laurera subsphaerioides* Makhija & Patw.,** *Mycotaxon*. 31: 582 (1988). (Fig. 32).

**Thallus** crustose, yellowish green, crack to aereolate, smooth, farinaceous; cortex colorless, 60-70 μm, algal layer continuous, deeply scattered in the thallus, medulla indistinct; **pseudostromata** carbonized, concolorous, immersed in the thallus, 0.3-0.7 mm diam; **ascomata** solitary or scattered in-grouping of two to many, embedded in pseudostromata, carbonized; ascomata apex concave to plane; ostiole carbonized, occasionally crack; centrum without oil globule; excipulum carbonized; hymenium with branching and anastomosing pseudoparaphyses; **ascus** clavate, 1—4–ascospores, easy broken when section; **ascospores** hyaline, ellipsoidal, muriform, 22—28-tranversely septates, 1—5-vertically septates, (82.0)85.2-93.8-102.4(115.0) x (20.0)20.5-22.7-24.8(28.0) μm.

**Habitat.** On tree trunk in the hill evergreen forests at 1,200 m elevation.

**Distribution.** India and Thailand.

**Specimens examined. N Thailand.** Phitsanulok Province: Phu Hin Rong Kla National Park, the forest at Lan Anag Pasong, on unidentified tree, 1998, *K. Vongshewarat* (RU——11009).

**Observations.** The distinct characteristic of this species is having the yellow and deeply cracked thallus with distinct carbonized ostiole, ascomata mostly immersed in the peridium.

**10. *Laurera tuberculosa* Makhija & Patw.,** *Mycotaxon*. 31: 584-583 (1988). (Fig. 33).

**Thallus** crustose, olivaceous or pistachio green, distinctly dense tuberculoid; cortex colorless 30-100 μm, algal layer continuous, 30-40 μm; medulla white, stuff with crystalline inclusion; **pseudostromata** solitary, brown to carbonized, spherical, 0.62-0.75 mm diam, constricted at base, with pseudostromata medulla orange, K+ purple; **ascomata** solitary, rarely 2-3 carpic, embedded in the pseudostromata, carbonized; ascomata apex concave to plane; ostiole carbonized, pustule; centrum without oil globule; excipulum dark brown to carbonized; hymenium with branching and anastomosing

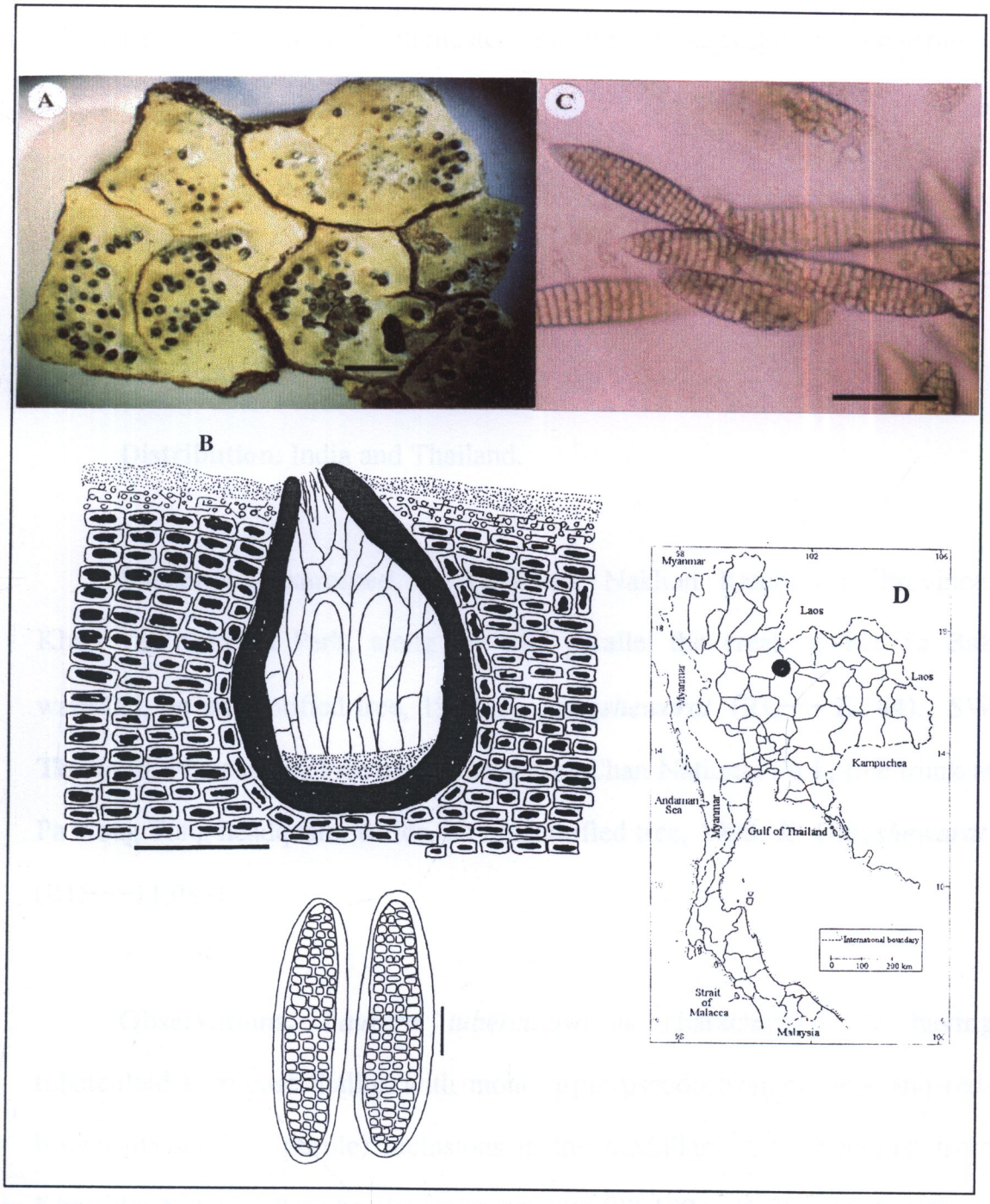



Figure 32 *Laurera subsphaerioides* Makhija & Patw. (RU——11009)

A. Pseudostromata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 300 μm)and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 50 μm).

D. Distribution in Thailand.

pseudoparaphyses; **ascus** bitunicate, clavate, 4—ascospores; **ascospores** hyaline, ellipsoidal, muriform, 15—20–tranversely septates, 1—8– vertically septates, (82.0)85.2-93.8-102.4(115.0) x (20.0)20.5-22.7-24.8(28.0) μm.

**Habitat.** On tree trunk in the tropical rain forests at 500-900 m elevations.

**Distribution.** India and Thailand.

**Specimens examined. E Thailand.** Nakhon Ratchasima Province: Khao Yai National Park, along the trial parallel the creak to Par Ta Bak waterfall, on unidentified tree, 1997, *K. Vongshewarat* (RU——12544). **SW Thailand.** Phetchaburi Province: Kaeng Kra Chan National Park, tree trunk at Pa Nong Tung headquater office, on unidentified tree, 1998, *K. Vongshewarat* (RU——11,085).

**Observations.** *Laurera tuberculosa* is characterized by having tuberculoid verrucose thallus with monocarpic pseudostromata with and red-brown masses (K+ purple) inclusions in the medullary. The specimen from Khao Yai National Park has larger ascospores (90-100 x 36-38 μm) than those (60-66 x 10-12 μm) from Kaeng Kra Chan National Park.

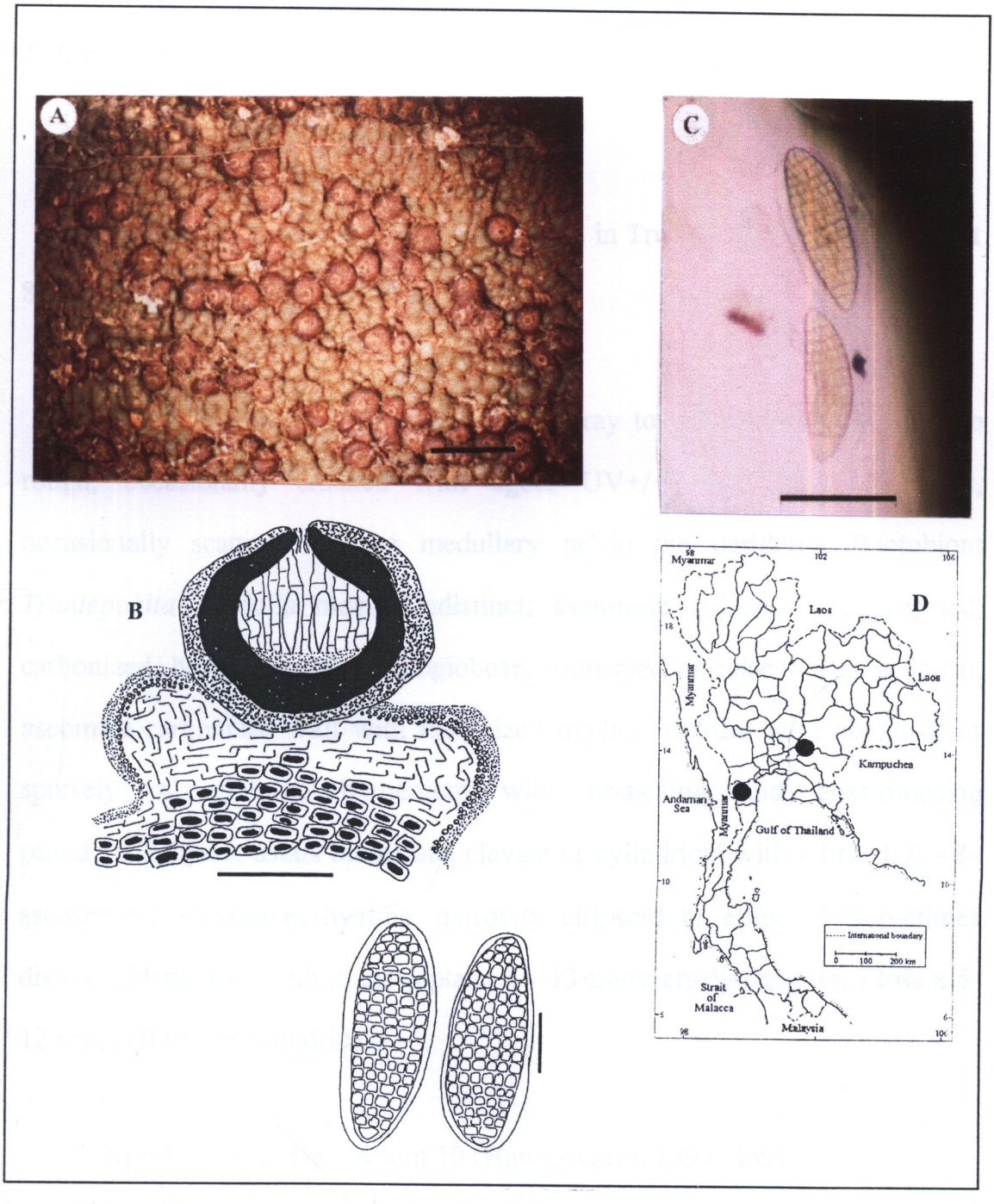



Figure 33 *Laurera tuberculosa* Makhija & Patw. (RU——11085)

A. Pseudostromata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 300 μm)and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 50 μm).

D. Distribution in Thailand.

***Polymeridium***

**Description of the genus**

*Polymeridium* (Müll. Arg.) R. C. Harris in Trucker & Harris, Bryologist 83: 12. 1980.

**Thallus** crustose, ecorticate, whitish-gray to greenish-gray, smooth to rough, occasionally cracked with aged, UV+/-; algal layer indistinct, occasionally scattered in the medullary or in the periderm, Photobiont *Trentepohlia*; medulla mostly indistinct; **ascomata** solitary or aggregated, carbonized, hemispherical or subglobose, immersed or raised; ostiole apical, ascomata carbonized wall with melanized hyphe; centrum with abundant or sparsely oil globule; hymenium with branching and anastomosing pseudoparaphyses; **ascus** bitunicate, clavate or cylindrical with a broad, 4—8–ascospores; **ascospores** hyaline, narrowly ellipsoid to ellipsoid, sometimes distinct gelatinous sheath, trans-septate, 4—13-transversely septates, 22-62 x 5-12 μm, cell locule cylindrical.

**Number of species**. About 19 (Hawksworth, 1995, 369)

**Habitat.** *Polymeridium* distribute on tree trunk at low altitude (0-10 meter above sea level) in the mangrove forests and also in high altitude (1,000 meter elevations or more) at the hill evergreen forests.

**Distribution.** USA, Cuba, Jamaica, Puerto Rico, Cayman Island, Columbia, Venezuela, Mozambique, Brazil, Angola, Dominican Rebublic, Hong Kong, Thailand, Malaysia, Philippines and Australia.

**Observation.** The general characters of *Polymeridium* are similar to *Pseudopyrenula.* However, the shape of cell locules are cylindrical in *Polymeridium* whist hexagonal shape in *Pseudopyrenula.* This genus is rarely found in Thailand.

**Key to the species**

**1a** 3-septated transversely ascospores.. .....**2**

**1b** 6—13-septated transversely ascospores.....**3**

**2a** Ascospore sizes 30-(34)-37 x 7.5-(8.5)-10 µm .....***P. catapastum***

**2b** Ascospores sizes 22-(24)-26 x 5-(6.6)-7.5 µm .....***P. albidum***

**3a** Thallus greenish gray, ascospore sizes (6-)8-10(-11)-celled, 27-(30)-32.5 x 5-(5.1)-6 µm.....***P. albocinereum***

**3b** Thallus olivaceous or whitish brown.....**4**

**4a** Thallus whitish-yellow, ascospore sizes (5-)6-8(-9)-celled, 22-(23.5)-26 x 5-(5.2)-6 µm .....***P. quinqueseptatum***

**4b** Thallus whitish brown, ascospore sizes (9-)11-celled, 50-(54.5)-62.5 x 10-(11)-12 µm .....***P. pleiomeroides***

**1. *Polymeridium albidum* (Müll. Arg.) R. C. Harris,** *Bol. Mus. Para. Emi lio Goeldi, sér. bot*, 7(2), 1991. (Fig. 34).

*Arthopyrenia albida* Müll. Arg., Flora 67: 664. 1884.

*Arthopyrenia siamensis* Vainio, Ann. Soc. Zool. Bot. Fenn. Vanamo 1 (3): 55. 1921.

*Arthopyrenia obvelata* Vainio, Ann Acad. Sci Fenn. Ser. A 19(15): 11. (1923)

**Thallus** crustose, greenish-green, rather rough, fissured with aged, UV+ yellow; cortex lacking; algal layer sparsely scattered in the periderm, photobiont *Trentepohlia*; medulla indistinct; **ascomata** solitary, occasionally aggregated, carbonized, hemispherical to subglobose, 0.45-0.65 mm diam, mostly raised up; ascomata wall entire, carbonized; ascomatal apex concave to plane, 0.1-0.25 mm diam, surrounding with white periostiole; ostiole apical; centrum without oil globule; hymenium with branching and anastomosing pseudoparaphyses; **ascus** bitunicate, cylindrical, 75-90 x 15-20 µm, 8-ascospores; **ascospores** hyaline, elongate-ellipsoidal, trans-septate, 3-transversely septates, (22)22.8-24.1-25.4(26) x (5)5.1-6.0-7.0(7.5) µm., cell locule cylindrical.

**Habitat.** On tree trunk in various forests, such as *Rhizophora mucronata* in the mangrove forest, *Ternstroemia gymanthera* in the hill evergreen forest and unknown tree species in the dry evergreen forest.

**Distribution.** USA, Brazil, Mozambique, Thailand, Malaysia and Australia.

**Specimens examined. N Thailand.** Phitsanulok Province; Phu Hin Rong Kla National Park, the forest at Samnak Am Nat Rat, on unidentified tree, 1997, *K. Vongshewarat* (RU——9347). **E Thailand.** Nakhon Ratchasima Province: Khao Yai National Park, the forest at Khao Khaeo radar station, on tree trunk of *Terstroemia gymanthera* Bedd., 1999, *K. Vongshewarat* (RU——12561). **SE Thailand.** Trad Province: Mangrove Management Unit, in the mangrove forest adjacent to headquarter office, on tree trunk of *Rhizophora mucronata* Poir., 1999, *K. Vongshewarat* (RU——11133).

**Observations.** The utraviolet delection on thallus of *Polymeridium albidum*. Show both positives yellow (UV+) and negative (UV-). For example, The specimens from Brazil have UV+, whitish the specimen from USA, Mozambique, Malaysia and Australia have UV-. The specimens from Thailand show UV+ yellow on thallus similar to Brazil's specimens (Harris; 1993, 624).

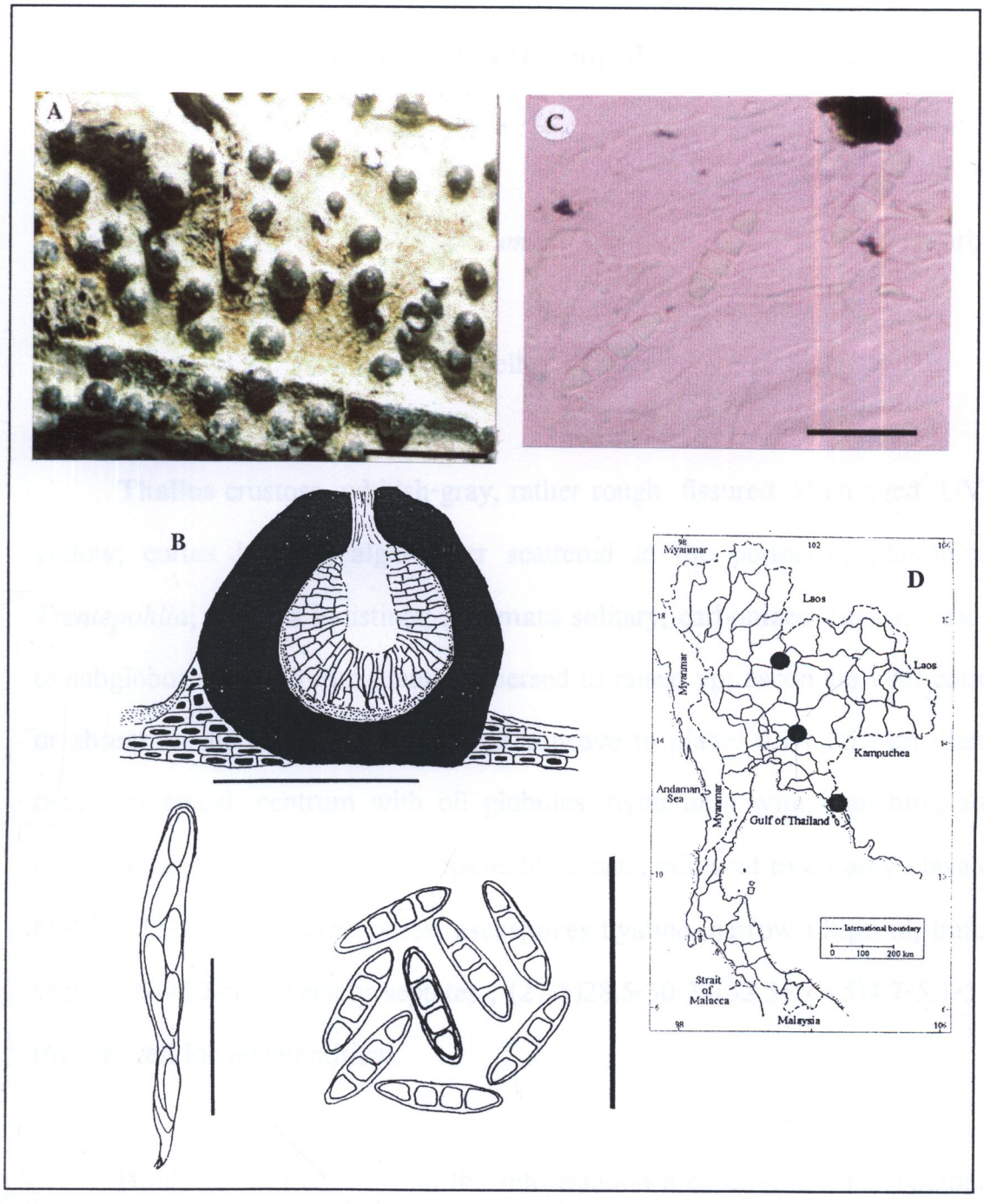



Figure 34 *Polymeridium albidum* (Müll. Arg.) R. C. Harris. (RU——11133)

A. Ascomata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 300 μm), ascus and ascospores (Bar = 50 μm).

C. Ascospores (Bar = 50 μm).

D. Distribution in Thailand.

**2. *Polymeridium albocinereum* (Krempelh.) R. C. Harris.**, Bol. *Mus. Para. Emi lio Goeldi, sér. bot*, 7(2), 1991. (Fig. 35).

*Arthopyrenia* (sect. *Polymeridium*) *pleiomerella* Müll. Arg., Bot. Jahrb. Syst. 6: 406. 1885.

*Verrucaria albocinerea* Krempelh., Flora 59: 524. 1876.

**Thallus** crustose, whitish-gray, rather rough, fissured when aged, UV+ yellow; cortex lacking; algal layer scattered in the periderm, photobiont *Trentepohlia*; medulla indistinct; **ascomata** solitary, carbonized, hemispherical to subglobose, 0.4-0.5 mm diam, immersed to raised up; ascomata wall entire or absent on the base; ascomatal apex concave to plane, 0.1-0.25 mm diam; ostiole at apical; centrum with oil globules, hymenium with branching and anastomosing pseudoparaphyses; **ascus** bitunicate, ellipsoid to broadly clavate, 65-75 x 12-18 µm, 8-ascospores; **ascospores** hyaline, narrow ellipsoid, trans-septate, 6—10–transversely septates , (27.5)28.5-30-32(32.5) x (5)4.7-5.1-5.5 (6) µm, cell locule cylindrical.

**Habitat.** On tree trunk in the reforestation area at Khao Yai National Park at 600 elevation.

**Distribution.** USA, Mexico, Puerto Rico, Brazil, Tanzania and Thailand.

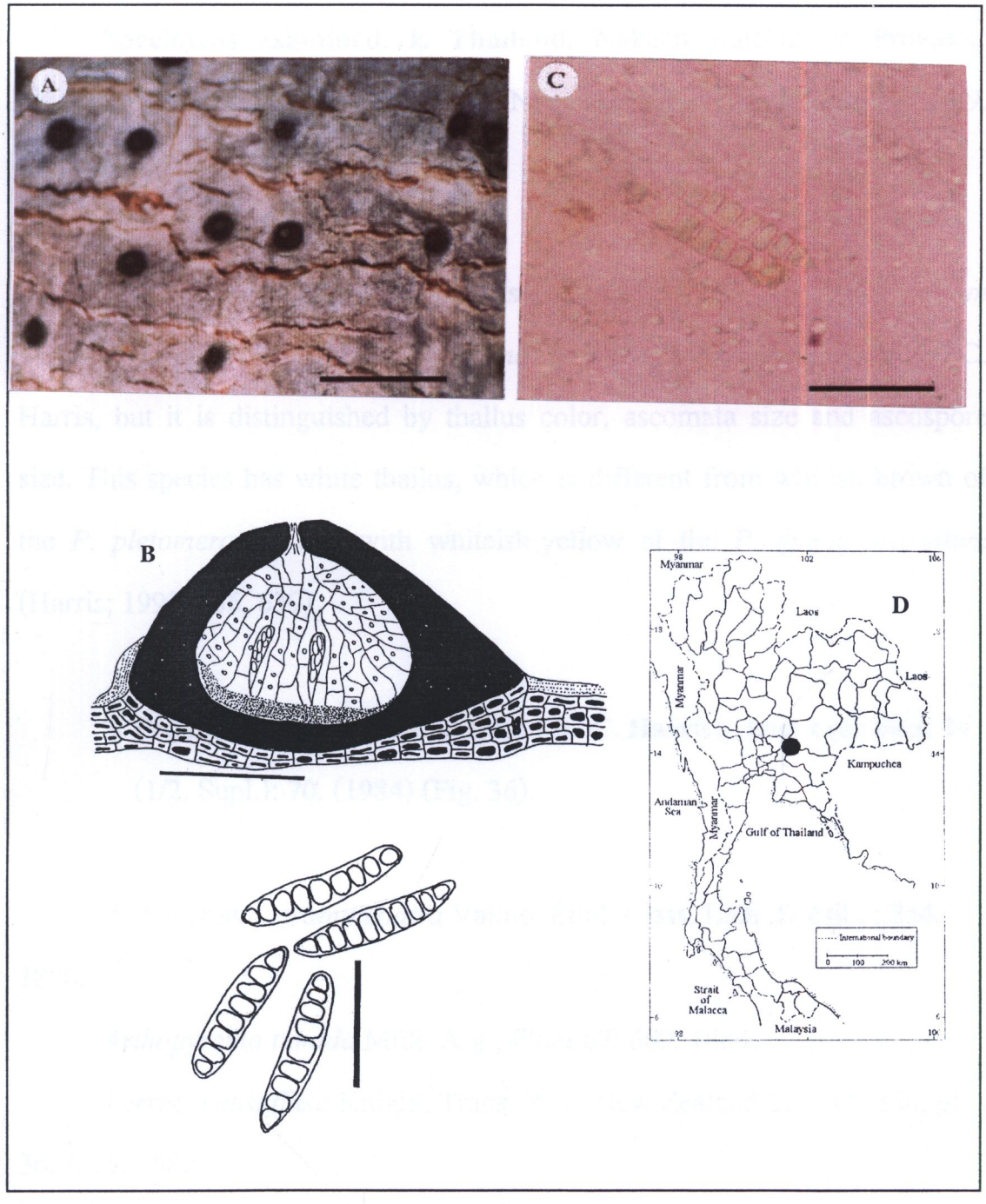



Figure 35 *Polymeridium albocinereum* (Krempelh.) R. C. Harris.

(RU——12535).

A. Ascomata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 300 μm) and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 20 μm).

D. Distribution in Thailand.

**Specimens examined. E Thailand.** Nakhon Ratchasima Province: Khao Yai National Park, in the forest at Nong King, on unidentified tree, 1999, *K. Vongshewarat* (RU——12535).

**Observations.** This species is closely related to *Polymeridium quenqueseptatum* (Nyl.) R. C. Harris *and P. pleiomeroides* (Müll. Arg.) R. C. Harris, but it is distinguished by thallus color, ascomata size and ascospore size. This species has white thallus, which is different from whitish brown of the *P. pleiomeroides* and with whiteish-yellow of the *P. quenqueseptatum* (Harris; 1993, 636, 639).

**3. *Polymeridium catapastum* (Nyl.) R. C. Harris.**, *Acta amazonica* 14 (1/2, Supl.): 70. (1984) (Fig. 36).

*Arthopyrenia stramineoatra* Vainio, Étud. Class. Lich .Brésil 2: 234. 1890.

*Arthopyrenia tumida* Müll. Arg., Flora 67: 669. 1884.

*Verrucaria suffusa* Knight, Trans. Proc. New Zealand Inst. 15: 356, pl. 36, f. 12. 1882.

*Verrucaria subvirescens Leighton,* Trans, Linn. Soc. London 25: 488, pl. 56, f. 25. 1866.

*Verrucaria catapastum* Nyl., Acta Soc. Sci.fenn. 7: 488. (1863).

**Thallus** crustose, olivaceous, rather rough, UV+ yellow; cortex lacking; algal layer scattered in the periderm, photobiont *Trentepohlia*; medulla indistinct; **ascomata** solitary, or in-group, subglobose, 0.3-0.5 mm diam, immersed to raised; ascomatal wall entire or lacking at the base; ascomatal apex concave to plane, 0.1 – 0.2 mm diam, ostiole usually apical; centrum filled with oil globule, hymenium with branching and anastomosing pseudoparaphyses; **ascus** bitunicate, clavate, 120-130 x 15-20 µm, 8-ascospored; **ascospores** hyaline, biseriate to somewhat irregularly arranged, ellipsoid, trans-septate, 3-transversely septates, (30)31.5-34.5-37.5(38) x (7.5) 7.5-8.5-9.5(10) µm, cell locule cylindrical.

**Habitat.** On tree trunk in the hill evergreen forest at 800-1500 m elevation.

**Distribution.** USA, Columbia, Brazil, Venezuela, Cayman Island, Thailand, Malaysia and Papua New Guinea.

**Specimens examined. NE Thailand**. Loei Province: Na Haeo National Park, on unidentified tree, 1996, *P. Mongkolsuk et. al.* (RU——7782). Phu Ruea National Park, on unidentified tree, 1999, *K. Vongshewarat* (KV——3RU). **E Thailand**. Nakhon Ratchasima Province: Khao Yai National Park, in the forest at Khao Khaeo radar station, on tree trunk of *Terstroemia gymanthera* Bedd., 1999, *K. Vongshewarat* (KV——39RU).

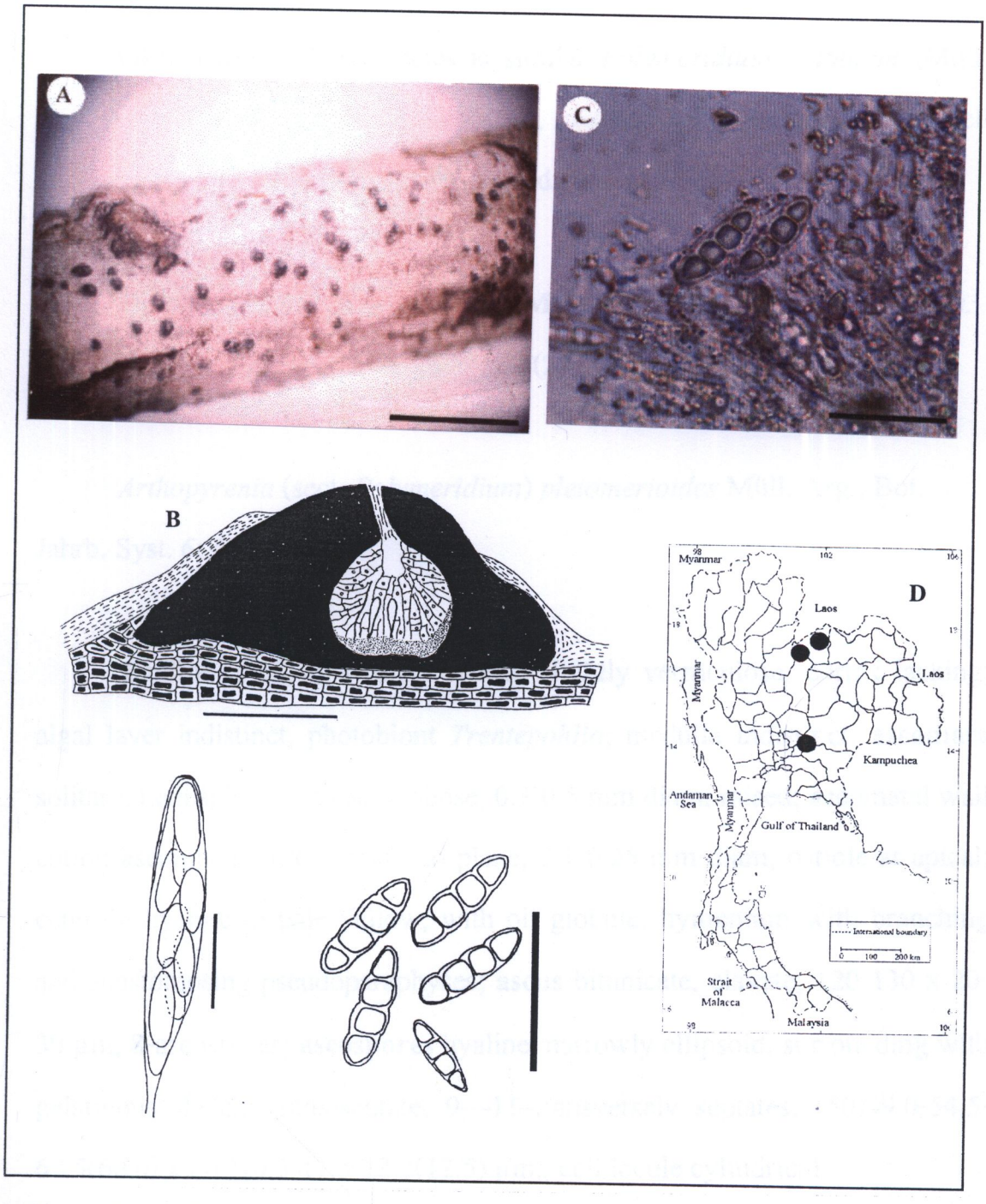



Figure 36 *Polymeridium catapastum* (Nyl.) R. C. Harris. (RU——7782)

A. Ascomata on thallus (Bar = 5 mm).

B. L-section of ascoma (Bar = 500 μm), ascus and ascospores (Bar = 50 μm).

C. Ascospores (Bar = 10 μm).

D. Distribution in Thailand.

**Observations.** This species is similar *Polymeridium albidum* (Müll. Arg.) R. C. Harris in number of septation, sized of ascomata and shape of cell lucules. However their thallus have much different color.

**4. *Polymeridium pleiomerioides* (Müll. Arg.) R. C. Harris**, *Bol. Mus. Para. Emi lio Goeldi, sér. bot*, 7(2), 1991. (Fig. 37).

*Arthopyrenia* (sect. *Polymeridium*) *pleiomerioides* Müll. Arg., Bot. Jahrb. Syst. 6: 407. 1885.

**Thallus** crustose, whitish brown, slightly verruculose, cortex lacking; algal layer indistinct, photobiont *Trentepohlia*; medulla indistinct; **ascomata** solitary, hemispherical to subglobose, 0.3-0.5 mm diam, raised; ascomatal wall entire; ascomatal apex concave to plane, 0.1-0.25 mm diam, ostiole at apical; centrum hyaline to pale yellow, with oil globule; hymenium with branching and anastomosing pseudoparaphyses; **ascus** bitunicate, clavate, 120-130 x 20-30 µm, 8-ascospores; **ascospores** hyaline, narrowly ellipsoid, surrounding with gelatinous sheath, trans-septate, 9—11–transversely septates, (50)49.0-54.5-62.5(60.0) x (10)10.3-11.3-12.2(12.5) µm., cell locule cylindrical.

**Habitat.** On tree trunk of *Durio ziberthinus* at 10 m elevations.

**Distribution.** Brazil and Thailand.

**Specimens examined. SE Thailand** Chanthaburi: Makham District, in the old Durian orchard at Ratchamongkol Chanthaburi Institute, on tree trunk of *Durio ziberthinus*., 1997, *K. Vongshewarat* (RU——8536).

**Observations.** This species is comparable with *Polymeridium albocinerum* (Krempelh.) R. C. Harris and *P. quenqueseptatum* (Nyl.) R. C. Harris. However, it can be distinguished in having whitish brown thallus. *Polymeridium albocinerum* has whitish-gray with small ascospores (24-40 x 5.5-8.5 μm, with 8—10–transversely septates; Harris, 1993, 623) and *P. quenqueseptatum* has whitish buff and smaller ascospores (18-27 x 4-7 μm, with 6—8–transversely septates; Harris, 1993, 623).

**5. *Polymeridium quenqueseptatum* (Nyl.) R. C. Harris** in Tucker & Harris, Bryologist 83: 12. 1980. (Fig 38).

*Pseudopyrenula* (sect. *Heterothelium*) *polyphragmia* Vainio, Bol. Soc. Brot. sér. 2, 6: 178. 1930.

*Arthopyrenia* (sect. *Polymeridium*) *compartula* Müll. Arg., bot. Jahrb. Syst. 6: 406. 1885.

*Verrucaria pustulosa* Stirton, Proc. Roy. Phiols. Soc. Glasgow 13: 191. 1881.

*Verrucaria quenqueseptata* Nyl., Expos. Syn. Pyrenocarp. 58. 1858.

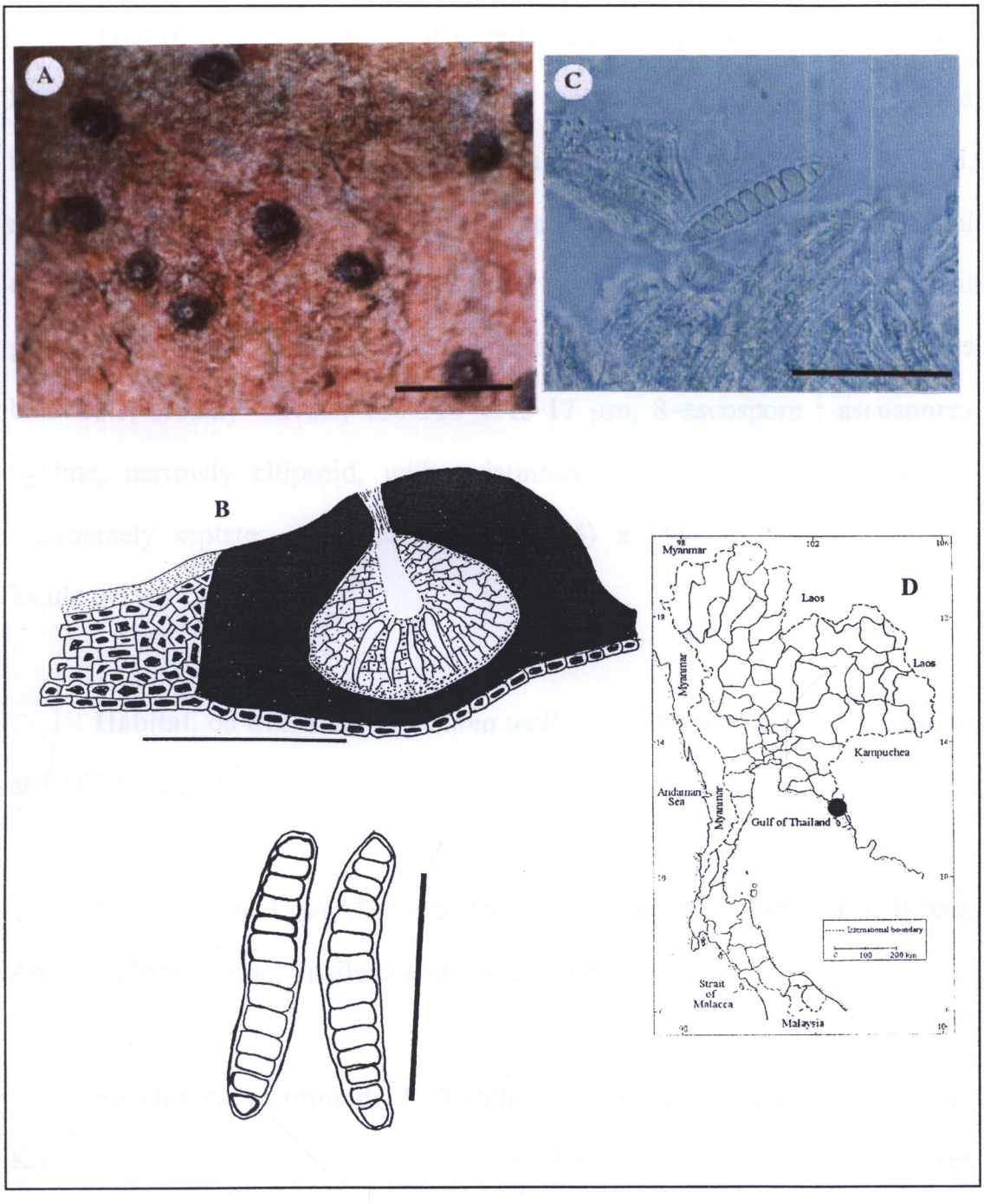



Figure 37 *Polymeridium pleiomeroides* (Müll. Arg.) R. C. Harris

(RU——8536)

A. Ascomata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 300 μm) and ascospores (Bar = 50 μm).

C. Ascospores (Bar = 50 μm).

D. Distribution in Thailand.

**Thallus** crustose, gray, whitish buff, rather rough; UV+ yellow, cortex lacking; sometimes algal layer indistinct, photobiont *Trentepohlia*; medulla indistinct; **ascomata** solitary, hemispherical to subglobose, 0.4-0.6 mm diam, raised or rarely immered; ascomatal wall entire, or lacking at base; ascomatal apex concave to plane, 0.1-0.2 mm diam; ostiole at apical; centrum with oil globule; hymenium with branching and anastomosing pseudoparaphyses; **ascus** bitunicate, broadly clavate, 100-110 x 15-17 µm, 8–ascospores; **ascospores** hyaline, narrowly ellipsoid, with gelatinous sheath, trans-septate, 8—10–transversely septates, (22)22.2-23.5-25.0(27.5) x (5)4.7-5.2-5.6(6) µm.,cell locule cylindrical.

**Habitat.** on tree trunk of *Schima wallichii* and *Terstroemia gymanthera* at 1,500 m. elevations.

**Distribution.** USA, Jamaica, Dominican Republic, Venezuela, Brazil, Angola, Mozambique, Thailand and Hong Kong.

**Specimens examined. E Thailand.** Nakhon Ratchasima Province: Khao Yai National Park, in the forest at Khao Khaew Radar station, on tree trunk of *Terstroemia gymanthera* Bedd., 1999, *K. Vongshewarat* (RU—— 12535, 12558, 12560 & 12573), on tree trunk of *Schima wallichii* Korth., 1999, *K. Vongshewarat* (RU——12576 & 12581); ibid., on unidentified tree, 1999, *K. Vongshewarat* (RU——12582 & 12568); ibid.

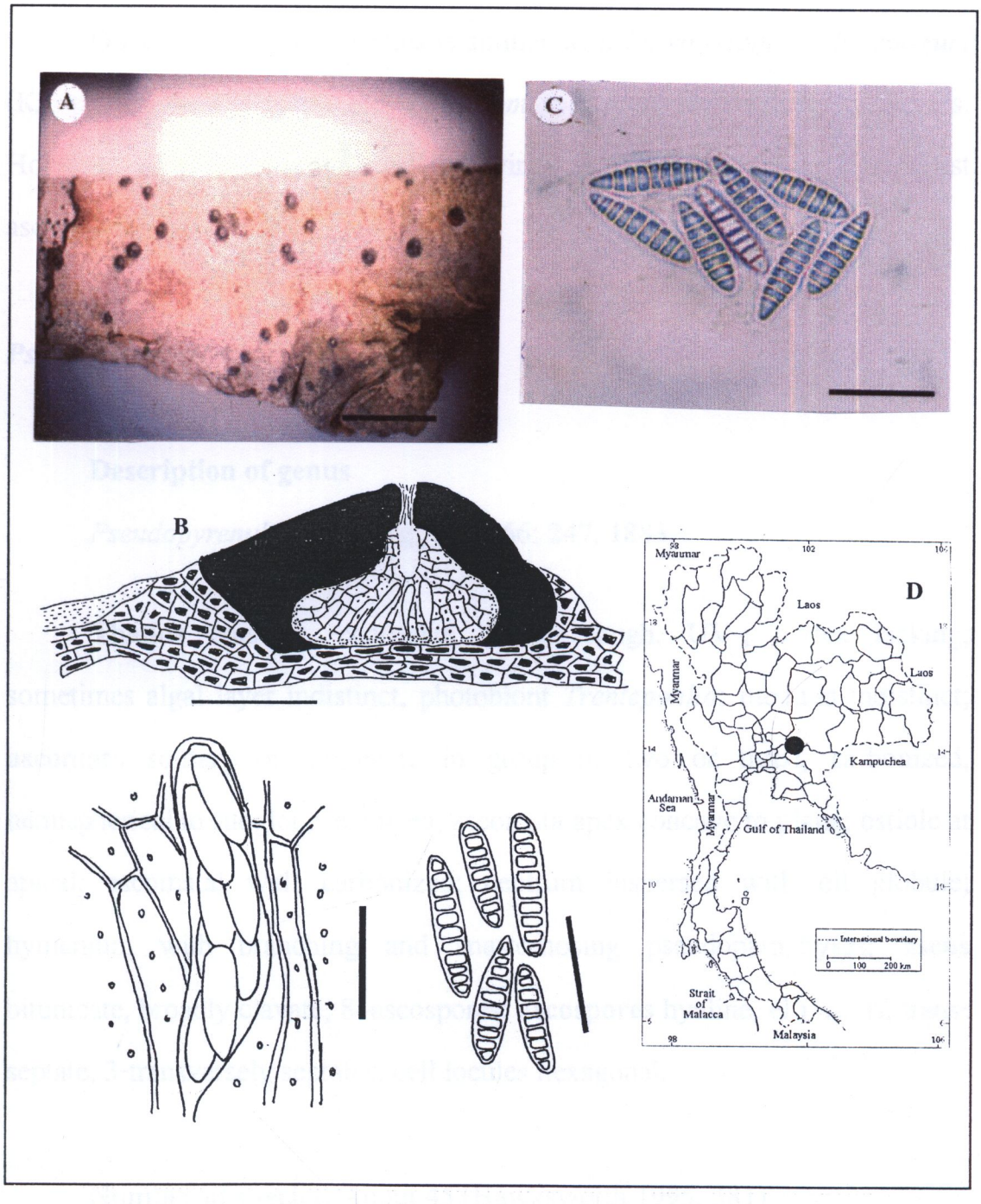



Figure 38 *Polymeridium quinqueseptatum* (Nyl.) R. C. Harris.

(RU——12576)

A. Ascomata on thallus (Bar = 5 mm).

B. L-section of ascoma (Bar = 200 μm), ascus and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 20 μm).

D. Distribution in Thailand.

**Observations.** This species is similar with *Polymeridium albocinerum* (Krempelh.) R. C. Harris and *P. pleiomeroides* (Müll. Arg) R. C. Harris. However, it can be distinguished in having whitish buff thallus and smallest ascospores.

***Pseudopyrenula***

**Description of genus**

*Pseudopyrenula* Müll. Arg., flora 66: 247. 1883.

**Thallus** crustose, ecorticate, white, rough, UV-; cortex lacking; sometimes algal layer indistinct, photobiont *Trentepohlia*; medulla indistinct; **ascomata** solitary or aggregate in group of two or three, carbonized, hemispherical to subglobose, raised; ascomata apex concave to plane; ostiole at apical; ascomatal wall carbonized; centrum inspersed with oil globule; hymenium with branching and anastomosing pseudoparaphyses; **ascus** bitunicate, broadly clavate, 8–ascospores; **ascospores** hyaline, ellipsoids, trans-septate, 3-transversely septates, cell locules hexagonal.

**Number of species.** About 45 (Hawksworth 1995, 381).

**Habitat.** This genus commonly occurs in the tropical regions. Most species are epiphytic lichens or saxicolous lichens.

**Distribution.** USA, Cuba, Cayman Island, Hispaniola, Jamaica, Puerto Rico, Stt. Eustatius, Nevis, Dominica, Trinidad, Guatemala, Honduras, Costa Rica, Columbia, Venezuela, French Guiana, Guyana, Brazil, Ecuador, Bolivia, Cameroon, Sierra Leone, Zaire, India, Thailand, Sarawak, Malaysia, Hong Kong, Philippine Islands and Hawaiian Island.

**Observations.** *Pseudopyrenula* is presented by only one species in Thailand. It generally occurs in the forest at about 100-1,500 m elevations, such as in the hill evergreen forests, in the dry evergreen forests, in the dry dipterocarp forests. Its distinct characteristics are trans-septate with 3-transversely septates and cell locules are hexagonal.

***Pseudopyrenula diluta* var. *degenerans* Vainio.** (Fig. 39).

**Thallus** crustose, white buff, rough, fissure with aged, UV-; cortex lacking; algal layer mostly indistinct, medulla indistinct; **ascomata** solitary or aggregated in-group, carbonized, highly variable, applanate, or hemispherical to subglobose, 0.3-0.7 mm diam, raised or rarely immered; ostiole at apical; centrum with hyaline and yellow oil globule; hymenium with branching and anastomosing pseudoparaphyses; **ascus** bitunicate, broadly clavate, 55-70 x 15-18 µm, 8–ascospores; **ascospores** colorless, ellipsoid, trans-septate, 3-transversely septates, (25)24.7-25.5-26.3(27) x (5)4.7-5.1-5.4(6) µm., cell locules hexagonal.

**Habitat.** On trunk of various trees species, such as *Bombax ancep*, *Neolithea sp.*, *Peltophorum pterocarpum*, *Prunus ceylanica*, *Sterculia pexa* and *Terstroemia gymanthera* at 100-1,500 m elevations. It occurs in the hill evergreen forests, the dry evergreen forests, the dry dipterocarp forests and the reforestation areas.

**Distribution.** USA, Cuba, Cayman Island, Hispaniola, Jamaica, Puerto Rico, Stt. Eustatius, Nevis, Dominica, Trinidad, Guatemala, Honduras, Costa Rica, Columbia, Venezuela, French Guiana, Guyana, Brazil, Ecuador, Bolivia, Cameroon, Sierra Leone, Zaire, India, Thailand, Malaysia, Sarawak, Hong Kong, Philippine Islands and Hawaiian Island.

**Specimens examined. N Thailand.** Phitsanulok Province; Phu Hin Rong Kla National Park, in the forest at Lan Anag Pasong, on unidentified tree, 1998, *K. Vongshewarat* (RU——11729). **NE Thailand.** Loei Province; Na Haeo District, Na Haeo National Park, along the trail to Tad Haeang waterfall, on tree trunk of *Sterculia pexa* Pierre., 1995, *P. Mongkolsuk et.al.* (RU——5307), on tree trunk of *Bombax ancep* Pierre., 1995, *P. Mongkolsuk et.al.* (RU——5875); ibid., on tree trunk of *Neolithea sp.*, 1995, *P. Mongkolsuk et.al.* (RU——6337); ibid., **E Thailand.** Nakhon Ratchasima Province: Khao Yai National Park, along the trail to old golf field, on tree trunk of *Peltophorum pterocarpum* Back., 1997, *K. Boonpragob et. al.* (RU——8089), in the reforestation at Nong King, on tree trunk of *Prunus ceylanica* Miq., 1999, *K. Vongshewarat* (RU——12527); ibid., along the trail to Pha Ta Bak waterfall, on

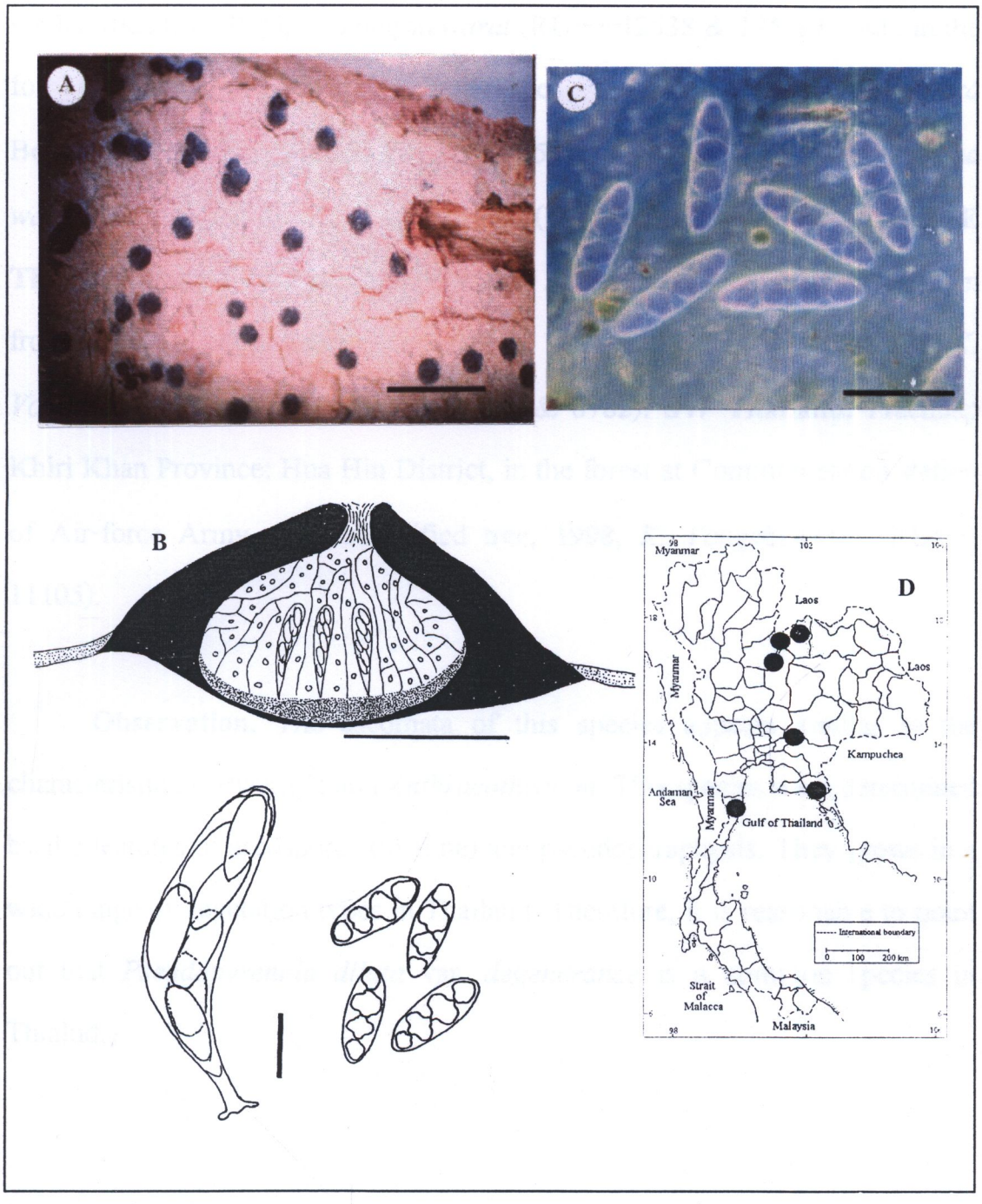



Figure 39 *Pseudopyrenula diluta* var. *degenerans* Vainio. (RU——5875)

A. Ascomata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 500 μm), ascus and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 20 μm).

D. Distribution in Thailand.

unidentified tree, 1999, *K. Vongshewarat* (RU——12538 & 12539); ibid., in the forest at Khao Khaeo radar station, on tree trunk of *Terstroemia gymanthera* Bedd., 1999, *K. Vongshewarat* (RU——12564); ibid., on tree trunk of *Schima wallichii* Korth., 1999, *K. Vongshewarat* (RU——12578 & 12584); ibid., **SE Thailand**. Chanthaburi Province: Numtok Phluie National Park, the forest in front of Ban Ang headquarter office, on unidentified trees, 1991, *K. Vongshewarat* (RU——8560, 8766, 8768 & 8782). **SW Thailand.** Prachuap Khiri Khan Province: Hua Hin District, in the forest at Communication station of Air-force Army, on unidentified tree, 1998, *K. Vongshewarat* (RU——11105).

**Observation.** The ascomata of this species appears similar to the characteristic of *Pyrenula* and *Anthracothecium.* This species were determined by the features of ascospores (hyaline) and pseudoparaphysis. They grows in a wide range of vegetation types in Thailand. Therefore, it is reasonable to point out that *Pseudopyrenula diluta* var. *degenerance* is a common species in Thialnd.

*Trypethelium*

**Description of the genus**

*Trypethelium* Sprengel, Aneleitung Kenntn 3: 350 (1804).

**Thallus** crustose, olivaceous gray to brownish-yellow, smooth to rough, continuous, rimose to verrucose, sometimes with orange or white pruina on the surface; cortex colorless or sometimes pale yellow; algal layer discontinuous to continuous, scattered in the medullary, few superficial or deeply immersed in the periderm, photobiont *Trentepohlia*; medulla white, with crytalline inclusions; **pseudostromata** mono-or polycarpic, sometiomes numerous, grayish-gray to reddish brown to carbonized, ovate to hemispherical, pseudostromata wall carbonized or non-carbonized; **ascomata** solitary or aggregated embedded in pseudostromata; ostiole brown to carbonized, punctate or pustule, sometimes concolous with thallus; centrum inspersed with occasional to very abundant oil globules; excipulum dark brown to carbonized; hymenium with branching and anastomosing pseudoparaphyses; **ascus** bitunicate, clavate, 8-ascospores; **ascospores** hyaline, trans-septate, 3-many-transversely septates, ellipsoid to fusiform, cell locule usually lentiform to subglobose, I-.

**Number of species.** About 100 (Hawksworth 1995, 468).

**Habitat.** *Trypethelium* is widely distributed in Thailand such as in the hill evergreen forests, in the dry dipterocarp forests, in the dry evergreen forests, in the tropical rain forests and urban area. It is important to note that, some species are able to survive in Bangkok metropolitan area.

**Distribution.** Brazil, Florida, Cuba, Mexico, Africa, China, Japan, India, Thailand, Indonisia and Philippines.

**Observations.** *Trypethelium* exhibits a great variation is external morphology. The thallus is smooth or rough, continuous or rimnose and verrucose. The color may be orange (*T. eluteriae*) or whtie pruinose (*T. ochroleucum*). This genera can be found in every forest types as well as in the campus of Kasetsart Universuty, in Bangkok, where *T. eluteriae* was collected. However, the hill evergreen forest seems to be favorite place for the *Trypethelium*.

**Key to the species**

**1a** Thallus UV+, bright yellow to orange.....**2**

**1b** Thallus UV-.....**12**

**2a** 3-transvesely septated ascospores.....**3**

**2b** More than 3-transvesely septated ascospores.....**6**

**3a** Centrum abundant with oil globule.....**4**

**3b** Centrum without oil globule..... .....**5**

**4a** Thallus yellow-white, UV+orange, with orange pruina.....

.....*T. albopruinosum*

**4b** Thallus yellow-green, UV+bright yellow, sometimes with white pruina .....*T. ochroleucum*

**5a** Thallus yellow, UV+bright yellow, angular locules in ascospores.... .....*T. myriocarpum*

**5b** Thallus pale yellow, UV+bright yellow, cylindrical locules in ascospsores.....*T. celatum*

**6a** Centrum abundant with oil globule.....7

**6b** Centrum without oil globule..... *T. unidentified A*

**7a** Ascospores with hexagonal locules.....8

**7b** Ascospores with cylindrical locules.....10

**8a** Ascomata not immersed, ascospores 3-tranvesely septates..... .....*T. unidentified B*

**8b** Ascomata immersed in thallus.....9

**9a** Thallus white, UV+bright yellow, pseudostromata semi-immersed in the thallus, 0.5-0.6 mm.....*T. microtomum*

**9b** Thallus yellow, UV+orange, pseudostromata flattened, forming network on the thallus, 0.2-0.3 mm.....*T. cinereo-rosellum*

**10a** Ascomata immersed in the thallus.....*T. concatervatum*

**10b** Ascomata not immersed in the thallus..... 11

**11a** Thallus yellow-white, pseudostromata rounded, monocarpic..... .....*T. luteum*

**11b** Thallus yellow, brownish-green, pseudostromata aggregated.....

.....*T. eluteriae*

**12a** Ascospores 3-tranversely septates .....13

**12b** Ascospores more than 3-tranversely septates .....16

**13a** Pseudostromata distinctly protuding on thallus.....14

**13b** Pseudostromata immersed in thallus.....15

**14a** Thallus green, ostiole punctate, surrounded by a black periostiole region, ascopsores 5—6-septated.....*T. nigroporum*

**14a** Thallus green, ostiole not surrounded, ascospores 3 spetated.....

.....*T. tropicum*

**15a.** Thallus greenish yellow, ascomata covered by thallus and a white periostiole region .....*T. ochroleucum* **var.** *subdissocians*

**15b** Thallus yellow-brown, ascomata black.....*T. unidentified C*

**16a** Thallus yellow, smooth, cracked, and ostiole smooth.....

.....*T. andamanicum*

**16b** Thallus green, rough, and ostiole punctate..... *T. unidentified D*

**1.** ***Trypethelium albopruinosum*** **Makhija & Patw.,** *J. Hattori Bot. Lab.* 73: 193 (1993). (Fig. 40).

**Thallus** crustose, olivaceous-gray, UV+ bright yellow, rough, reddish orange pruina on the surface, K+ purple; cortex sulphur yellow, K+ yellow, 50-90 µm; algal layer discontinuous, 20-30 µm; medulla white, 100-120 µm; **pseudostromata** linear or irregularly arranged, 1—8–carpic, 0.3-0.5 mm diam,

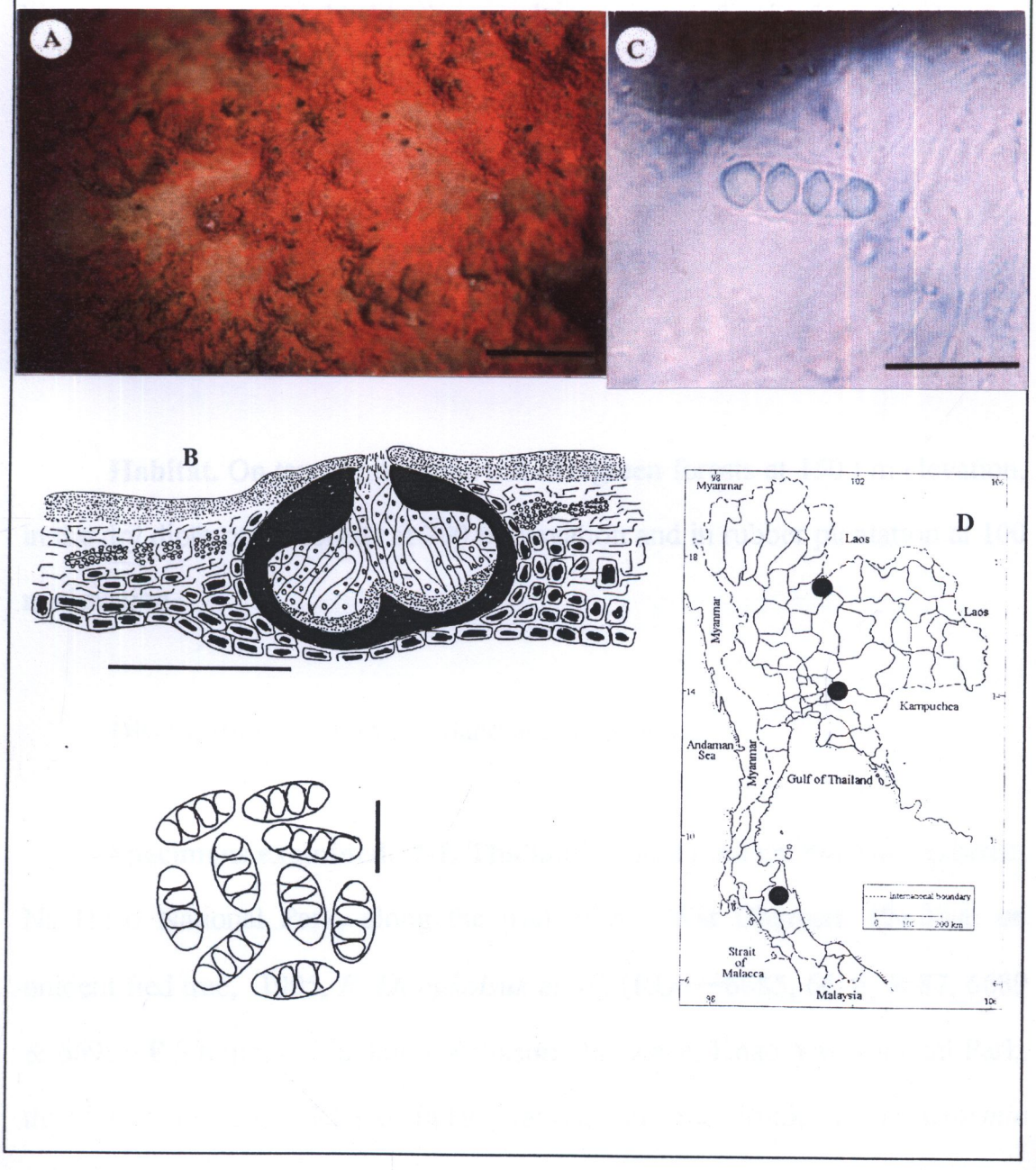



Figure 40 *Trypethelium albopruinosum* Makhija & Patw. (RU——6685)

A. Pseudostromata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 200 μm) and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 20 μm).

D. Distribution in Thailand.

immersed to raised, covered by a thick pruina; **ascomata** solitary or aggregated into two or more, embedded in the pseudostromata, carbonized; ascomata apex concave to plane, brown to carbonized; centrum with oil globule; excipulum carbonized; hymenium with branched and anastomosing pseudoparaphyses; **ascus** easily broken when section, 8–ascospores; **ascospores** hyaline, ellipsoidal, trans-septate, 3-transversly septates, (20)20.7-22.5-24.3(25) x (7) 7.3-7.8-8.4(9.0) µm, cell locule subglobose to hexagonal.

**Habitat.** On tree trunk in the hill evergreen forests at 1500 m elevation, in the dry dipterocarp forests at 700 m elevation and in rubber plantation at 100 m elevation.

**Distribution.** Andaman Island and Thailand.

**Specimens examined. NE Thailand.** Loei Province: Na Haeo District, Na Haeo National Park, along the trial within Wat Charoem Phrakiat, on unidentified tree, 1995, *P. Mongkolsuk et. al.* (RU——6685, 6686, 6687, 6689 & 6690). **E Thailand.** Nakhon Ratchasima Province: Khao Yai National Park, the forest in Khao Khaeo radar station, on tree trunk of *Terstroemia gymanthera* Bedd., 1999, *K. Vongshewarat* (KV——37RU). **PEN Thailand.** Nakhon Sri Thummarat Province: the rubber plantation near headquater of Krung Ching waterfall, on tree trunk of *Hevea brasiliensis* Müll. Arg., 1998, *K. Vongshewarat* (RU——9877).

**Observations.** The reddish-brown pruina on the surface of thallus is a distinctive feature of this species. Even though the speciemens from Thailand have larger ascospores (20-25 x 5-8 μm) than those from India (13-20 x 6-8 μ m) (Makhija & Patw; 1993, 193), but other characters can be recognized as *Trypethelium alburruinosum.*

**2. *Trypethelium andamanicum* Makhija & Patw.,** *J. Hattori Bot. Lab.* 73: 193 (1993). (Fig 41).

**Thallus** crustose, yellowish-green, continuous or fissured with aged, UV-, smooth dull; cortex colorless, K-, 50-60 μm; algal layer discontinuous, 20-30 μm, medulla indistinct; **pseudostromata** monocarpic, sometimes with polycarpic, hemispherical or subglobose, 0.5-0.7 mm diam, immersed to raised, concolorous with the thallus; **ascomata** solitary, embedded in the pseudostromata, carbonized, immersed in the thallus and the periderm cells, with pruinose superficial; ascomata apex plane, carbonized; ostiole brown, punctate, surrounding with carbonized periostiole; centrum sparsely oil globule; excipulum carbonized; hymenium with branching and anastomosing pseudoparaphyses; **ascus** easily broken when section, 8-ascospores; **ascospores** hyaline, ellipsoid, trans-septate, 5—13-transversely septates, (26.5)27.1-30.5-34.0(34.8) x (5.1)5.3-6.0-6.8(6.8) μm., cell locule cylindrical.

**Habitat.** On tree trunk in the tropical rain forest at 200 m elevation.

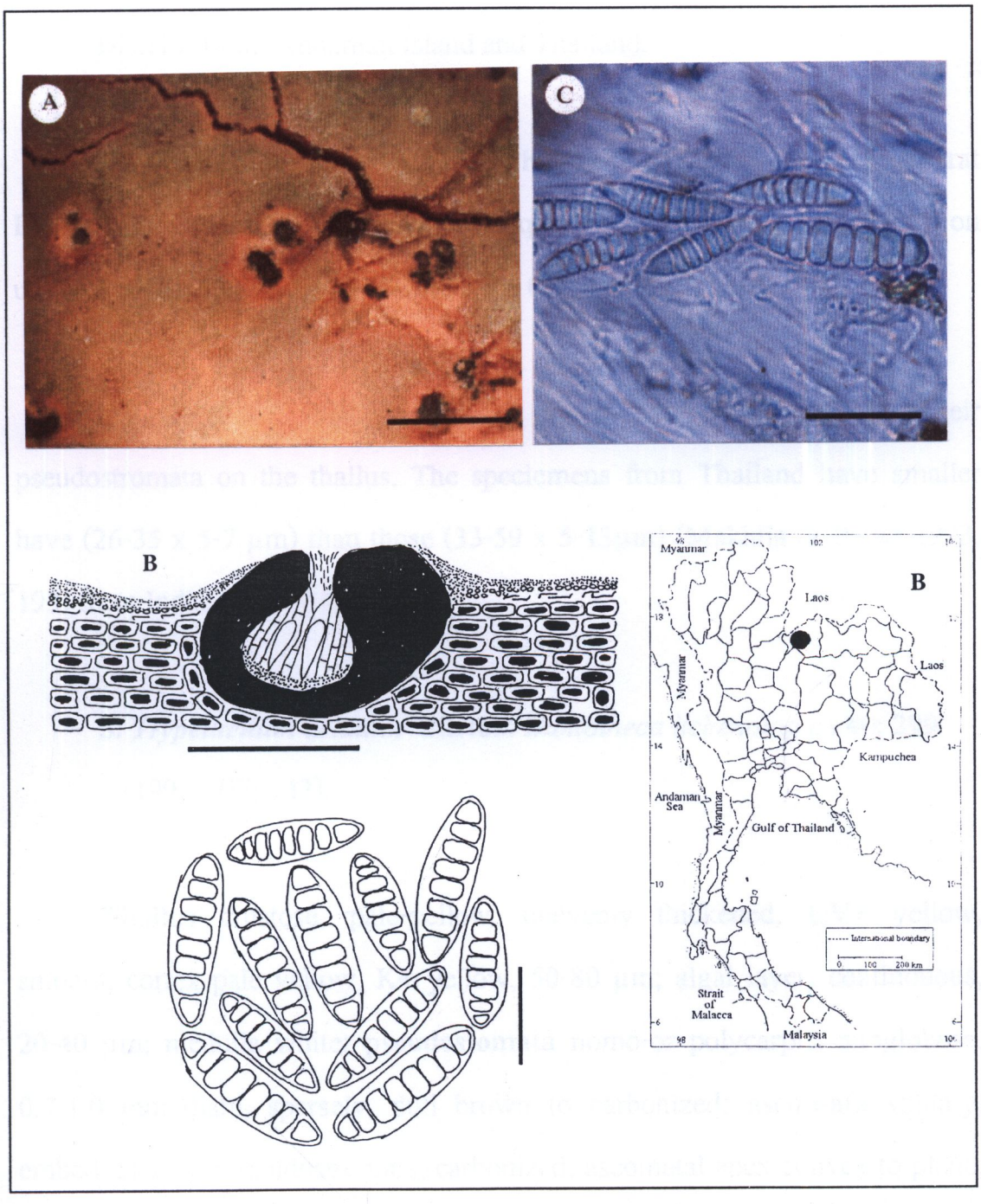



Figure 41 *Trypethelium andamanicum* Makhija & Patw. (RU——9743)

A. Pseudostromata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 300 μm) and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 20 μm).

D. Distribution in Thailand.

**Distribution.** Andaman Island and Thailand.

**Specimens examined. PEN Thailand.** Nakhon Sri Thummarat Province: the forest adjacent to headquater Krung Ching waterfall, on unidentified tree, 1998, *K. Vongshewarat* (RU——9943).

**Observations.** *Trypethelium andamanicum* possesses their pseudostromata on the thallus. The speciemens from Thailand have smaller have (26-35 x 5-7 μm) than those (33-59 x 5-13μm) (Makhija & Patw; 1993, 193) from India.

**3. *Trypethelium celatum* Stirton.** *Bibliotheca lichenologica* 40; 299 (1991). (Fig. 42).

**Thallus** crustose, pale-yellow, unevenly thickened, UV+ yellow, smooth; cortex pale yellow, K+ yellow, 50-80 μm; algal layer, continouous, 20-40 μm; medulla white; **pseudostomata** nomo-or polycarpic, subglobose, 0.7-1.0 mm diam, sparsely, dull brown to carbonized; **ascomata** solitary, embedded in the pseudostromata, carbonized; ascomatal apex convex to plane; ostiole brown to carbonized; centrum filled with oil globule; excipulum carbonized; hymenium with anastomosing pseudoparaphyses; **ascus** bitunicate, broadly clavate, 8-ascospores; **ascospores** hyaline, ellipsoidal, slightly gelatinous sheath, trans-septate, 3-transversely septates, (23.2)24.0-26.5-29.0 (30.7) x (5.8)6.2-6.7-7.2(7.4) μm, cell locule cylindrical.

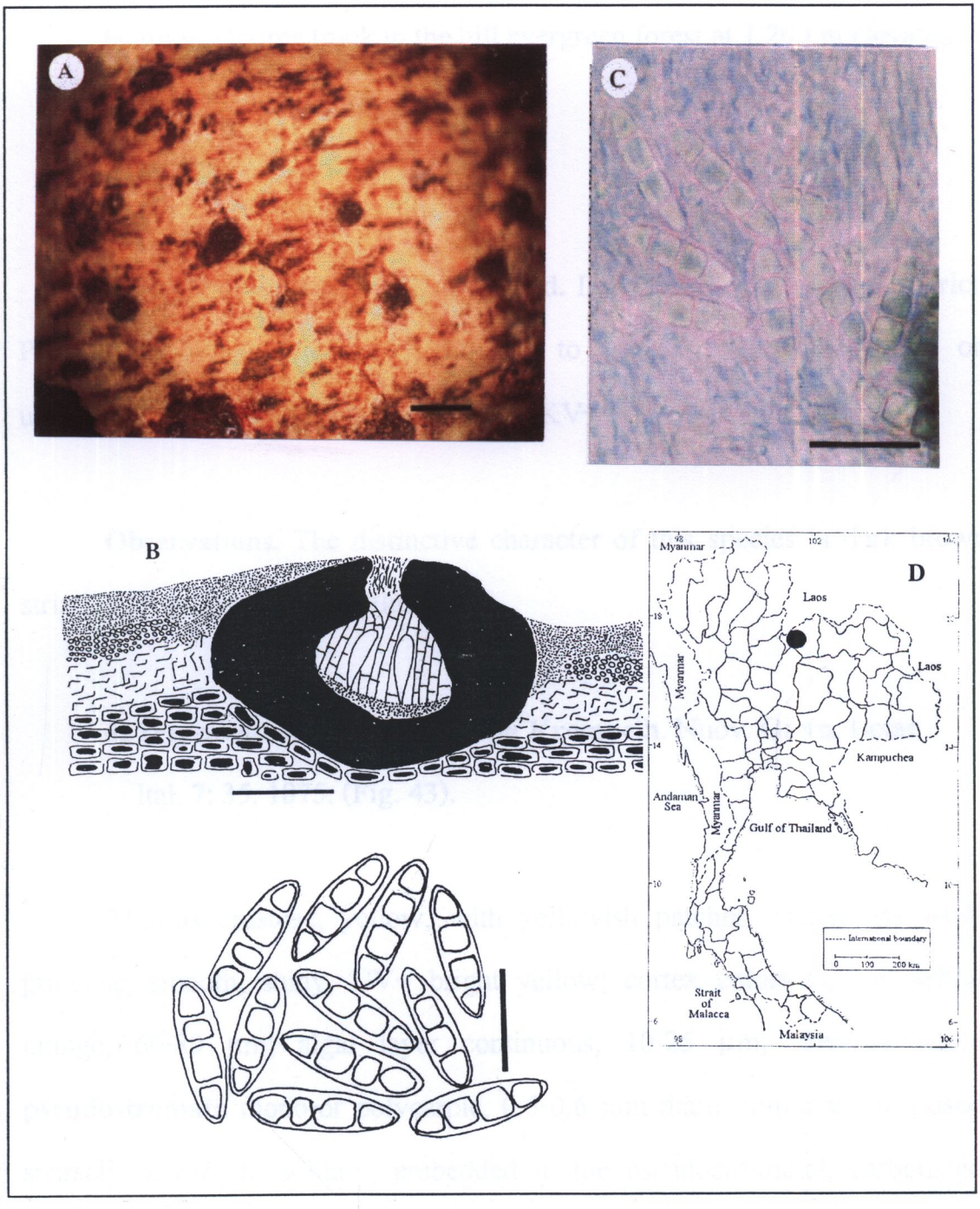



Figure 42 *Trypethelium celatum* Stirton. (KV——20RU)

A. Pseudostromata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 300 μm) and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 20 μm).

D. Distribution in Thailand.

**Habitat.** On tree trunk in the hill evergreen forest at 1,200 m elevation.

**Distribution.** India and Thailand.

**Specimens examined. NE Thailand.** Loei Province: Phu Rua District, Phu Rua National Park, along the trial to Hin Sam Chan waterfall, on unidentified tree, 1999, *K. vongshewarat* (KV——20RU).

**Observations.** The distinctive character of this species is dark brown striation on surface of the thallus.

**4. *Trypethelium cinereo-rosellum* Krempelh.** Nuov. Giorn. Botan. Ital. 7: 35, 1875. (Fig. 43).

**Thallus** crustose, yellow, with yellowish patches, sometimes white pruinose, smooth, shiny, UV+ bright yellow; cortex colorless, K+ yellow orange, 60-80 μm; algal layer continuous, 10-25 μm; medulla white; **pseudostromata** mono-or polycarpic, 0.5-0.6 mm diam, immersed to raised, sparsely; **ascomata** solitary, embedded in the pseudostromatal, carbonized; ascomatal apex concave to plane; ostiole carbonized, punctate, surrounded by white periostiole; centrum filled with abundant oil globule; excipulum carbonized; hymenium with branching and anastomosing pseudoparaphyses; **ascus** easily broken when sections, 8–ascospores; **ascospores** hyaline,

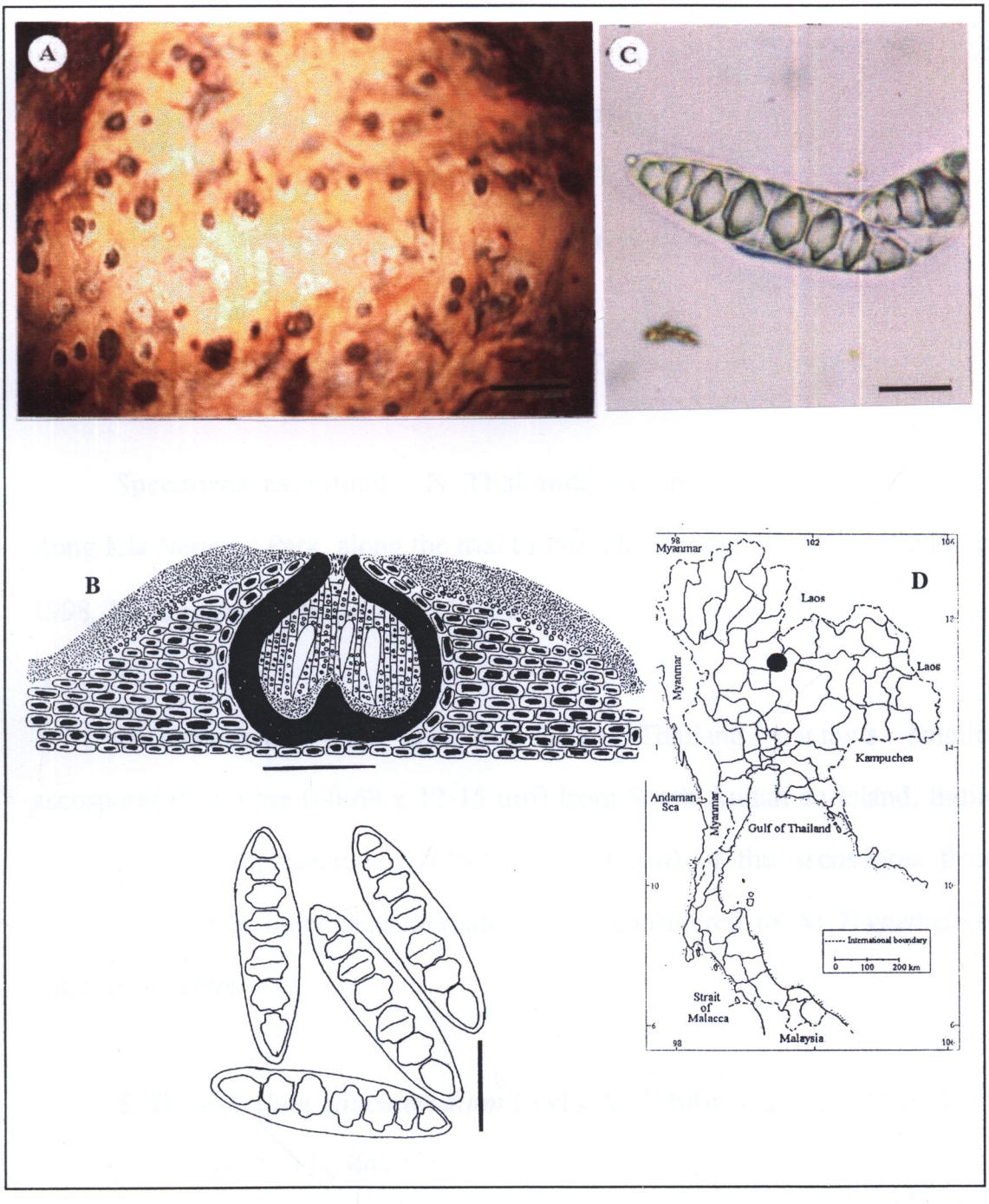



Figure 43 *Trypethelium cinereo-rosellum* Krempelh. (RU——11727)

A. Pseudostromata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 300 μm) and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 20 μm).

D. Distribution in Thailand.

ellipsoidal, trans-septate, 5—6-transversely septates, (53.0)53.9-56.1-58.3 (60.0) x (12.0)12.1-12.8-13.6(14.0) μm., cell locule rhomboid.

**Habitat.** On tree trunk in the hill evergreen forest at 1,200 m elevetion.

**Distribution.** South Andaman Island, Thailand and Malaysia.

**Specimens examined.** **N Thailand.** Phisanulok Province: Phu Hin Rong Kla National Park, along the trial to Pha Chu Thong, on unidentified tree, 1998, *K. Vongshewarat* (RU——11727).

**Observations.** This specimen from Thailand contains smaller ascospores than those (60-68 x 12-15 μm) from South Andaman Island, India. The latters are represented by (36-52 x 7-13 μm) of the ascospores from Borneo. However other characteristic can be considered to be *Trypethelium cinereo-rosellum.*

5. ***Trypethelium concatervatum*** **(Nyl.) A. Zahlbr.** *Cat Lich. Univ.* 1: 489, 1992. (Fig. 44).

*Verrucaria concatervatum* Nyl., *Bot. Journ. Linn. Soc. London* 20: 68. 1883.

**Thallus** crustoses, yellowish-green, smooth, shiny, UV+ yellow; cortex colorless, K-, 40-80 μm, algal layer thin, 20-50 μm; medulla indistinct; **pseudostromata** polycarpic, 0.3-0.37 mm diam, paler than the thallus color, slight raised, irregular; **ascomata** solitary or aggregated, embedded in the pseudostromata, subglobose; surroundding with yellow pigmented (K+ red); ascomatal apex convex to plane, surrounding with white network; ostiole brown, pustule minute; centrum with abundant oil globule; excipulum dark brown to carbonized; hymenium with anastomosing pseudoparaphyses; **ascus** bitunicate, cylindrical-clavate, 8–ascospores; **ascospores** hyaline, narrow ellipsoid, trans-septate, 12—14–transversely septates, (40.0)(48.0) x (6.0)6.3-6.9-7.6(8.0) μm., cell locule ellipsoid.

**Habitat.** On tree trunk in the dry evergreen forest at 600 m elevation.

**Distribution.** Japan, India and Thailand

**Specimens examined. SW Thailand.** Phetchaburi Province: Kaeng Ka Chan National Park, the forest at KM. 27 (main road to Pa Nong Tung headquater), on unidentified tree, 1998, *K. Vongshewarat* (RU——11089).

**Observations.** This species have distinct yellow strip (K+ red) surrounding ascomata. The pseudstromata are connected in white networks with pustule of brown ostiole.

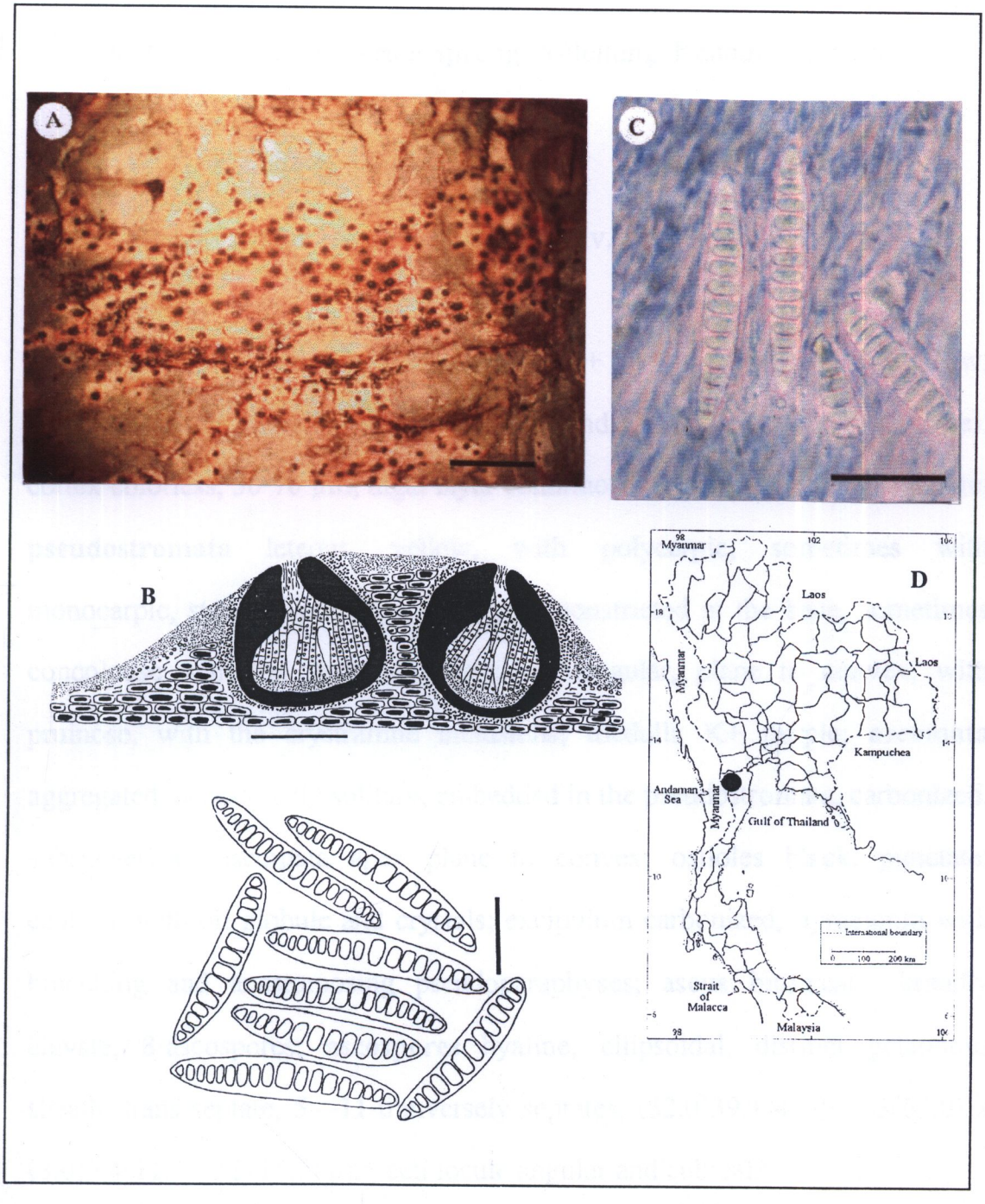



Figure 44 *Trypethelium concatervatum* (Nyl.) A. Zahlbr. (RU——11,089)

A. Pseudostromata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 300 μm) and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 20 μm).

D. Distribution in Thailand.

6. ***Trypethelium eluteriae*** **Spreng.** Anleitung. Kenntn. Gewache 3: 351, 1804. (Fig. 45).

*Trypethelium sprengelii Ach.,* Lich. Univ. 30, pl. 4, f-8., 1810.

**Thallus** crustose, olivaceous-gray, K+ yellow, UV+ bright yellow, rough, dull, continuous, sometimes orange and yellow pruinose (K+ purple); cortex colorless, 30-70 µm; algal layer continuous, 30-100 µm; medulla white; **pseudostromata** leteous, yellow, with polycarpic, sometimes with monocarpic, strougly protuding emergent, constricted at the base, sometimes concolouse with the thallus, rounded to irregular, plane to convex, with pruinose, with the crystralline inclusions; medulla K+ purple; **ascomata** aggregated, occasionally solitary, embedded in the pseudostromata, carbonized, subsphaerical; ascomata apex plane to convex; ostioles black, punctate; centrum with oil globule and crystals; excipulum carbonized, hymenium with branching and anastomosing pseudoparaphyses; a**scus** bitunicate, broadly clavate, 8-ascospores; **ascospores** hyaline, ellipsoidal, distinct gelatinous sheath, trans-septate, 5—11-tranversely septates, (32.0)39.1-46.2-53.3(62.0) x (8.0)9.4-11.2-12.9(15.0) µm, cell locule angular and cubical.

**Habitat.** *Trypethelium eluteriae* occurs commonly on tree trunk in throughout Thailand at 10-1,400 m elevations, such as in the hill evergreen forests (1,200-1,400 m elevations), in the dry dipterocarp forests (300-600 m elevations), in the dry evergreen forests (600-1,000 m elevations), and in the

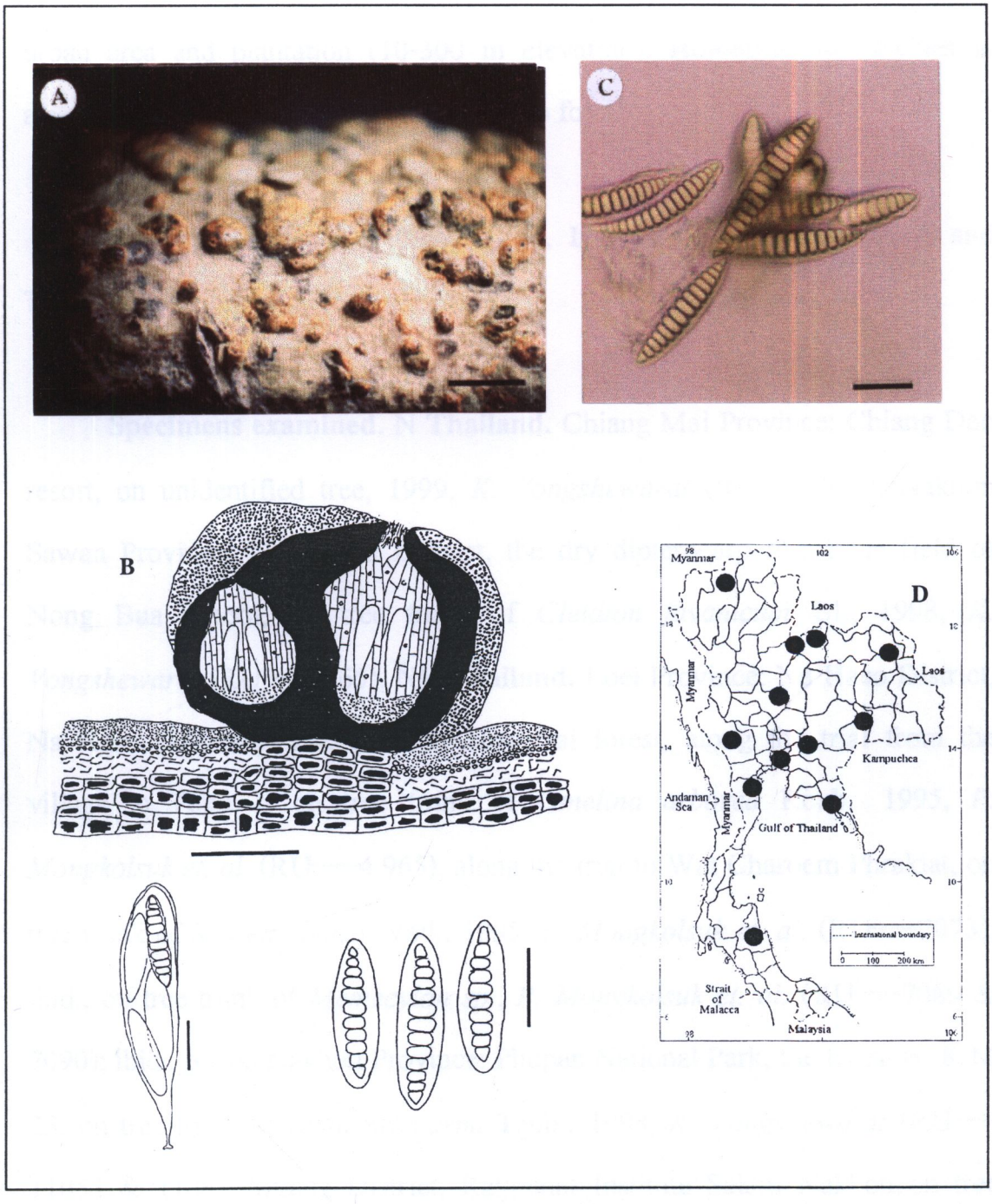



Figure 45 *Trypethelium eluteriae* Spreng. (RU——8087)

A. Pseudostromata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 300 μm) and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 20 μm).

D. Distribution in Thailand.

urban area and plantation (10-300 m elevation). However, this species is abundant in dry habitat (the dry dipterocarp forest).

**Distribution.** Brazil, China, Cuba, Indonesia, India, Philippines and Thailand.

**Specimens examined. N Thailand.** Chiang Mai Province: Chiang Dao resort, on unidentified tree, 1999, *K. Vongshewarat* (RU——9965). Nakhon Sawan Province: Nong Bua District, the dry dipterocarp forest the field of Nong Bua school, on tree trunk of *Cleidion javanicum* Bl., 1998, *K. Vongshewarat* (RU——9965). **NE Thailand.** Loei Province: Na Haeo District, Na Haeo National Park, Phuteen Suan Sai forest, along the trial from the village to Toko 1, on tree trunk of *Gmelina arborea* Roxb., 1995, *P. Mongkolsuk et. al.* (RU——4,965), along the trial to Wat Charoem Phrakiat, on tree trunk of *Shorea obtusa* Wall., 1995, *P. Mongkolsuk et. al.* (RU——7073); ibid., on tree trunk of *Memecylon sp.*, *P. Mongkolsuk et. al.* (RU——7089 & 7090); ibid., Sakon Nakhon Province: Phupan National Park, the forest at K.M 25, on tree trunk of *Xylia xylocarpa* Taub., 1998, *K. Vongshewarat* (RU——11054 & 1106), Muang District, Ratjabhat Institute Sakon Nakhon, on tree trunk of *Mangifera indica* Linn., 1998, *W. Khamthim* (RU——10054). **E Thailand.** Nakhon Ratchasima Province: Khao Yai National Park, along the trial to old golf field, on tree trunk of *Wrigtia pubescens* R.Br., 1997, *K. Boonpragob et al.* (RU——8021), on tree trunk of *Ficus sp.*, 1997, *K. Boonpragob et. al.* (RU——8061); ibid., on tree trunk of *Peltophorum*

*pterocarpum* Back., 1997, *K. Boonpragob et. al.* (RU——8087, 8088 & 8090); ibid., along trial to Khao Lu Chang, 1997, *K. Boonpragob et. al.* (RU——8116 & 8175); ibid., the forest in front of Khao Khaeo radar station, on unidentified tree, 1997, *K. Boonpragob et. al.* (RU——8457); ibid., along the trial of Pha Kluy Mai waterfall to Heo Suwat waterfall, on tree trunk of *Peltophorum pterocarpum* Back., 1997, *K. Vongshewarat* (RU——9071); ibid., along the trial of nature study KM. 33 to Nong Pak Chee, on tree trunk of *Dipterocapus sp.*, 1999, *K. Vongshewarat* (RU——12506); ibid., the forest at Nong King, on unidentified tree, 1999, *K. Vongshewarat* (RU——12532); ibid., along the trial to Khao Khaeo, on unidentified tree, 1999, *K. Vongshewarat* (RU——12550); ibid., on tree trunk of *Cratoxylon formosum* Dyer., 1999, *K. Vongshewarat* (RU——12553); ibid., Buri Ram Province: Khao Kadong Forest Park, on tree trunk of *Buchanania latifolia* Roxb., 1998, *K. Vongshewarat* (RU——11044, 11045 & 11046). **SW Thailand.** Kanchanaburi Province: Erawan National Park, along the trial to Pa Lum, on unidentified tree, 1997, *K. Vongshewarat* (RU——8068). Phetchaburi Province: Ban lad District, Tum lu sub-district, on tree trunk of *Millettia pendula* Benth., 1998, *K. Vongshewarat* (RU——11022, 11023 & 11024), on tree trunk of *Eloeocarpus hygrophilus* Kurz., 1998, *K. Vongshewarat* (RU——11026, 11027 & 11028); ibid., **C Thailand.** Bangkok Province: the campus of Kasetsart university, tree beside Chu Chat Kom Phu road, on tree trunk of *Peltophorum pterocarpum* Back., 1998, *K. Vongshewarat* (RU——11015), on tree trunk of *Pterocarpum macrocarpus* Kurz., 1998, *K. Vongshewarat* (RU——11016); ibid., **SE Thailand.**

Chanthaburi Province: Klung District, the rubber plantation adjacent to road from Klung to Trat, on tree trunk of *Hevea brasiliensis* Müll. Arg., 1998, *K. Vongshewarat* (RU——11115). **PEN Thailand.** Nakhon Si Thammarat Province: Khao Loung National Park, the rubber plantation trees near Krung Ching headquater, on tree trunk of *Hevea brasiliensis* Muell. Arg., 1998, *K. Vongshewarat* (RU——9875, 9876, 9877 & 9879).

**Observations.** Morphology of *Trypethelium eluteriae* most closely resembles *Laurera benguelensis*. However, the distinct characteristic of this species is aggregated ascomata which immersed in yellow pseudostromata and transeptate ascospores. Color of the thallus and pseudostromal pigments are vary. It is the only species collected from Bangkok metropolitan area, where air quality is polluted. The specimens from urban area generally found crystalline inclusion in the centrum of ascomata.

**7. *Trypethelium luteum* Tayl.** *Bot Lond. Journ.* 6: 157 (1847). (Fig. 46).

**Thallus** crustose, greenish-gray, UV+ bright yellow, smooth, shiny; cortex colorless, K+ yellow, 20-100 μm; algal layer dense, continuous, 40-60 μm; medulla indistinct; **pseudostromata** monocarpic, subglobose, 0.3-0.5 mm, linear or irregularly arranged, with mostly 1—to 4 carpic or more (-12)-carpic, immersed to raised, with reddish brown at base attached with thallus region; **ascomata** solitary, embedded in the pseudostromata, carbonized, ascomata

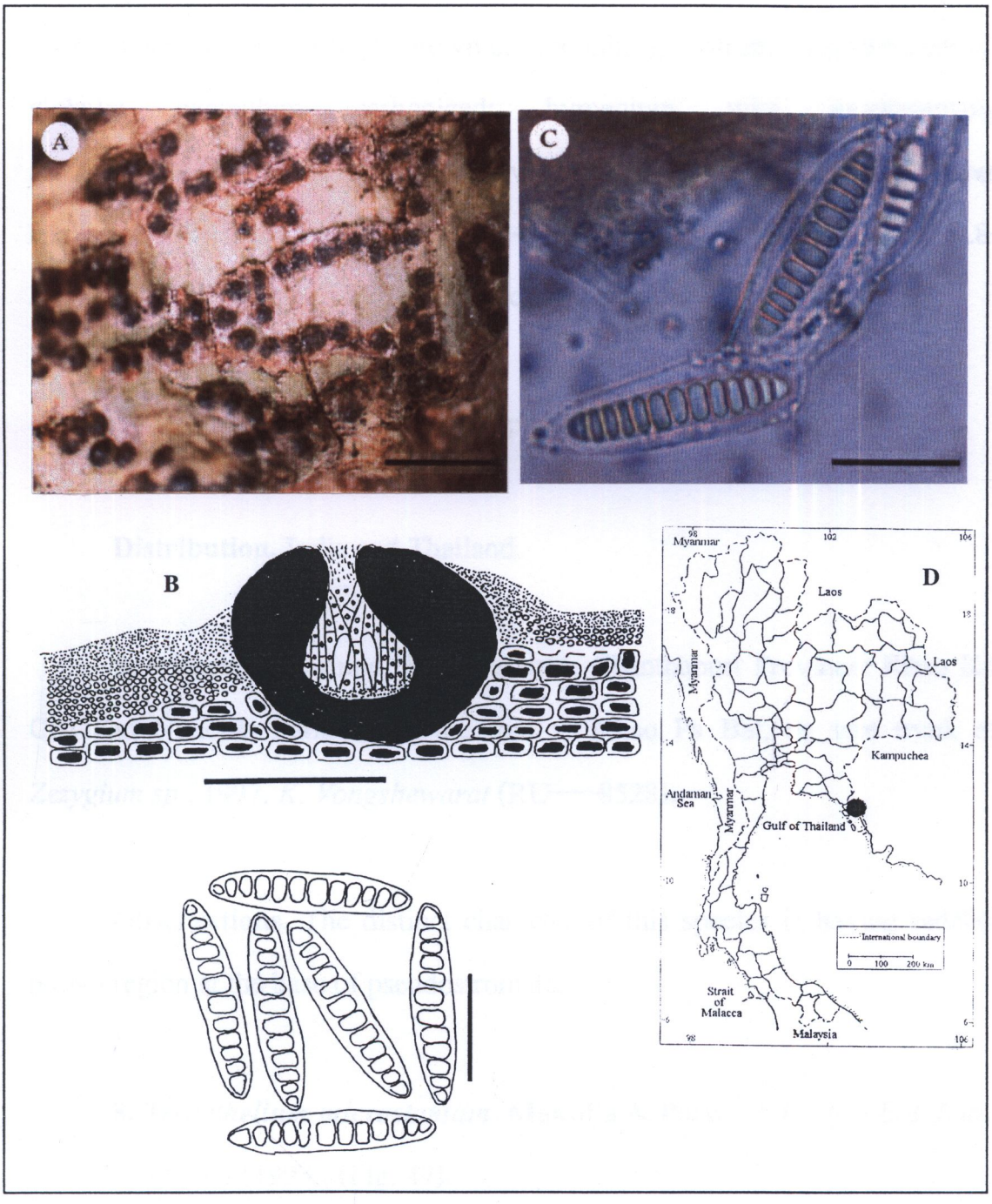



Figure 46 *Trypethelium luteum*Tayl. (RU——8528)

A. Pseudostromata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 300 μm) and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 20 μm).

D. Distribution in Thailand.

apex convex to plane; ostioles brown or carbonized; centrum with abundant oil globule; excipulum carbonized; hymenium with anastomosing pseudoparaphyses; **ascus** easily broken when section, 8-ascospores; **ascospores** hyaline, ellipsoid, trans-septate, 7—12-transversely septates, (24.9)25.4-31.8-38.1(37.5) x (5.8)5.8-6.5-7.3(7.4) µm., cell locule cylindrical.

**Habitat.** On tree trunk in the tropical rain forest at 500 m elevation.

**Distribution.** India and Thailand.

**Specimens examined. SE Thailand.** Chanthaburi Province: Khao Kit Cha Kut National Park, along the trial to Khao Pa Bat, on tree trunk of *Zezygium sp.*, 1997, *K. Vongshewarat* (RU——8528).

**Observations.** The distinct character of this species is having reddish brown region at the base of pseudostromata.

**8. *Trypethelium microstomum* Makhija & Patw.**, *J. Hattori Bot. Lab.* 73: 201 (1993). (Fig. 47).

**Thallus** crustose, buff to olivaceous buff, UV+ bright yellow, rather rough, dull, continuous; cortex colorless, K+ yellow, 30-70 µm; algal layer continuous, 20-30 µm; medulla white, 30-50 µm; **pseudostromata** polycarpic, 0.5-0.6 mm diam, concolorous with the thallus, fattened, dispersed in the

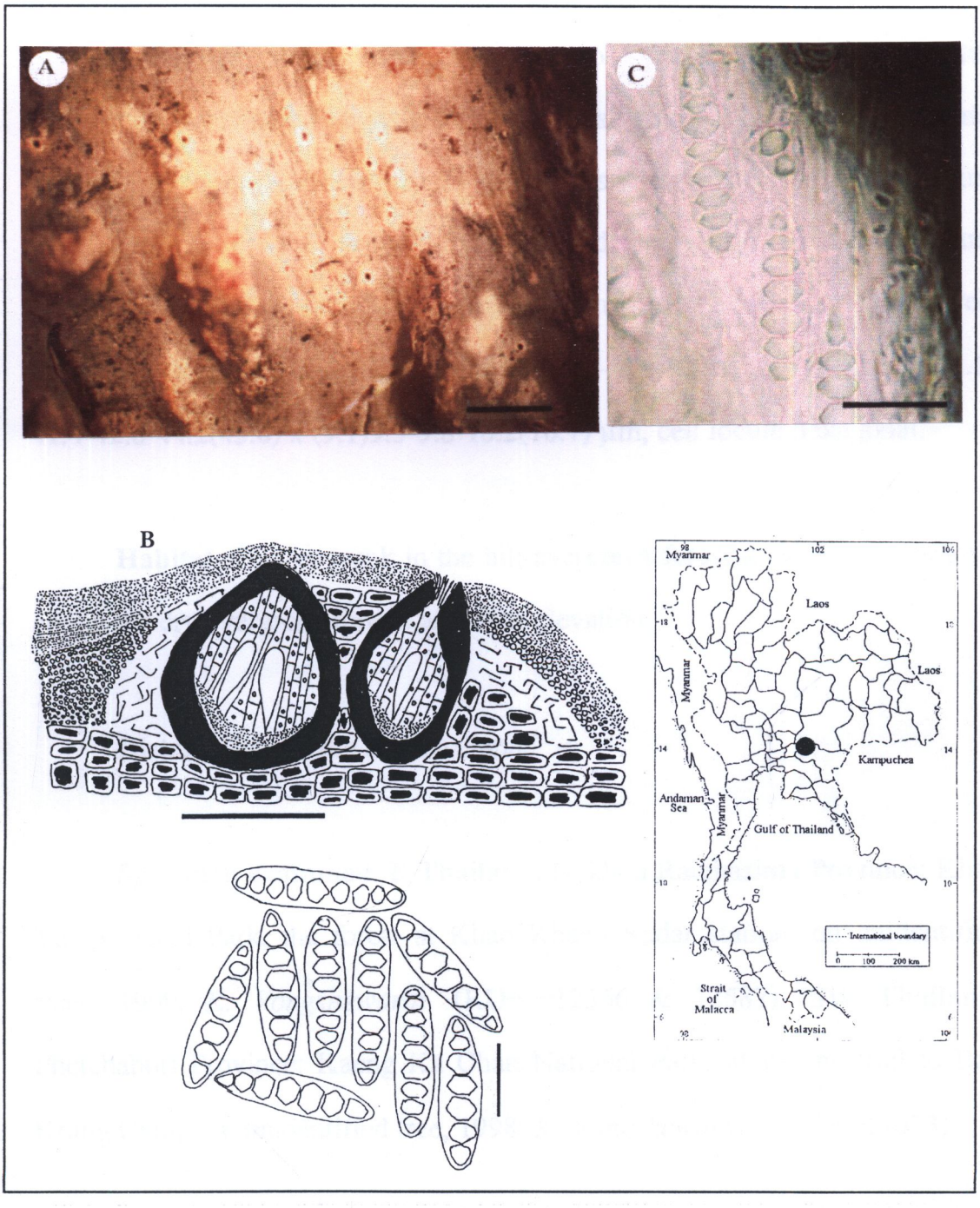



Figure 47 *Trypethelium microstomum* Makhija & Patw. (RU——12,566)

A. Pseudostromata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 300 μm) and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 20 μm).

D. Distribution in Thailand.

thallus, irregularly spread; **ascomata** solitary or aggregated of two, embedded in the pseudostromata; ascomata carbonized; ascomatal apex concave to plane, enclosed by white network on the thallus; ostioles brown, minute; centrum with slightly oil globule; excipulum carbonized; hymenium with branched and anastomosing pseudoparaphyses; **ascus** bitunicate, clavate, 8-ascospores; **ascospores** hyaline, ellipsoid, trans-septate, 7—9-transversely septates, (41.5) 41.4-42.8-44.2(45.6) x (9.1)9.3-9.8-10.2(10.7) μm, cell locule hexagonal.

**Habitat.** On tree trunk in the hill evergreen forest at 1,500 m elevation and in the dry evergreen forests at 200 m elevation.

**Distribution.** India and Thailand.

**Specimen examined. E Thailand.** Nakhon Ratchasima Province: Khao Yai National Park, the forest at Khao Khaeo Radar station, on unidentified trees, 1999, *K. Vongshewarat* (RU——12566 & 12587). **SW Thailand.** Phetchaburi Province: Kaeng Ka Chan National Park, along the trial to Ban Krang Camp, on unidentified tree, 1998, *K. Vongshewarat* (RU——11073).

**Observations.** This species has UV+ thallus and a thin pseudostromata dispered in the thallus and tiny ostiole. However, This species is closely related to *Trypethelium cinereo-rosellum* in having ascospores with more than 3-transvesely septates and hexagonal cell locule, but their external characteristic are different.

**9. *Trypethelium myriocarpum* (Fée) Müll. Arg.** *Biibliotheca lichenologica* 40.300. (1991). (Fig. 48).

**Thallus** custose, straw, smooth, UV+ bright yellow, dull, continuous; cortex colorless, K+ yellow, 40-80 µm; algal layer discontinuous, not many, 30-45 µm; medulla indistinct; **pseudostromata** monocarpic, subglobose, 0.3-0.5 mm diam, concolorous with the thallus, flush to slight raised; **ascomata** mostly solitary, embedded in the pseudostromata, cabonized; ascomatal apex concave to plane, ostiole punctate, surrounded by carbonized wall, disc-like periostiole region; centrum without oil globule. Excipulum carbonized; hymenium with anastomosing pseudoparaphyses; **ascus** easily broken when sections, 8-ascospores; **ascospores** hyaline, ovate, trans-septate, 3-transversely septates, (20.0)20.5-22.5-24.6(25.7) x (6.6)7.3-7.9-8.5(8.3) µm, cell locule angular.

**Habitat.** On tree trunk in the hill evergreen forest at 1,200 m elevation.

**Distribution.** India and Thailand

**Specimens examined. N Thailand.** Phitsanulok Province: Phu Hin Rong Kla National Park, the forest at Lan Anag Pasong, on unidentified tree, 1998, *K. Vongshewarat.* (RU——11729).

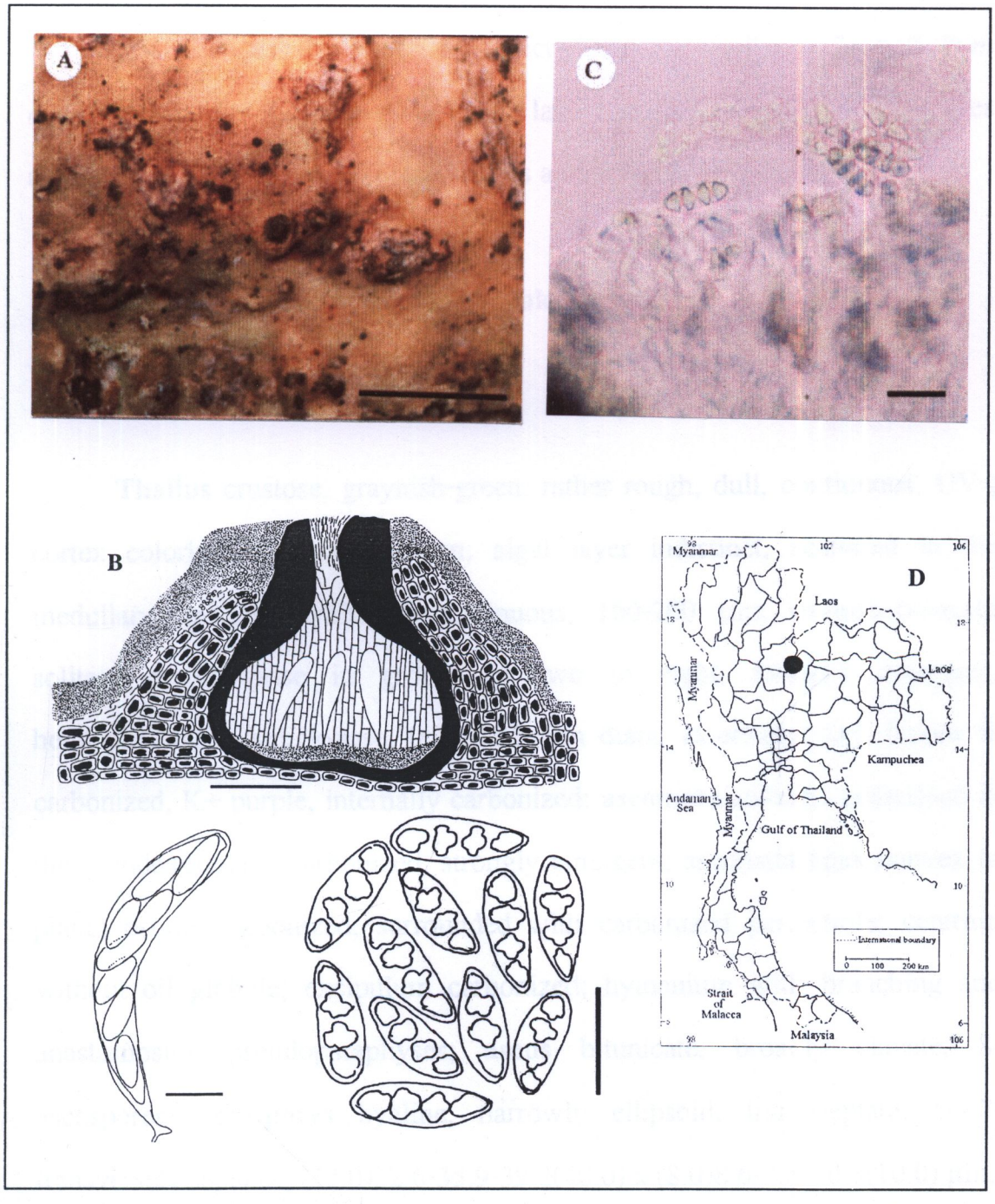



Figure 48 *Trypethelium myriocarpum* Fee. Müll. Arg. (RU——11729)

A. Pseudostromata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 200 μm) and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 20 μm).

D. Distribution in Thailand.

**Observations.** The external characteristics are similar to *Trypethelium andamanicum*, but the ascospores of the later have 5—13–septated ascospores and cylindrical cell locule. This species is a new record in Thailand.

**10. *Trypethelium nigroporum* Makhija & Patw.,** *J. Hattori Bot. Lab.* 73: 202 (1993). (Fig. 49).

**Thallus** crustose, graynish-green, rather rough, dull, continuous, UV-; cortex colorless, K-, 60-120 μm; algal layer indistinct, scattered in the medullary; medulla white, discontinuous, 100-200 μm; **pseudostromata** solitaty or comprise in groups of two to eight, strongly emergent, hemispherical to subglobose, 0.25-0.37 mm diam, externally dark brown to carbonized, K+ purple, internally carbonized; **ascomata** solitary, embedded in the pseudostromata, carbonized, strongly emergent; ascomata apex convex to plane; ostiole carbonized, surrounded with carbonized periostiole; centrum without oil globule; excipulum carbonized; hymenium with branching and anastomosing pseudoparaphyses; **ascus** bitunicate, broadly clavate, 8-ascospores; **ascospores** hyaline, narrowly ellipsoid, trans-septate, 5—7-transversely septates, (32.0)32.6-35.9-39.2(40.0) x (8.0)8.6-9.5-10.3(10.0) μm., cell locule cubical.

**Habitat.** On tree trunks in the dry evergreen forests at 300 m elevation, in the dry dipterocarp forests at 600 m elevation and in the mixed deciduous forests at 300-400 m elevations.

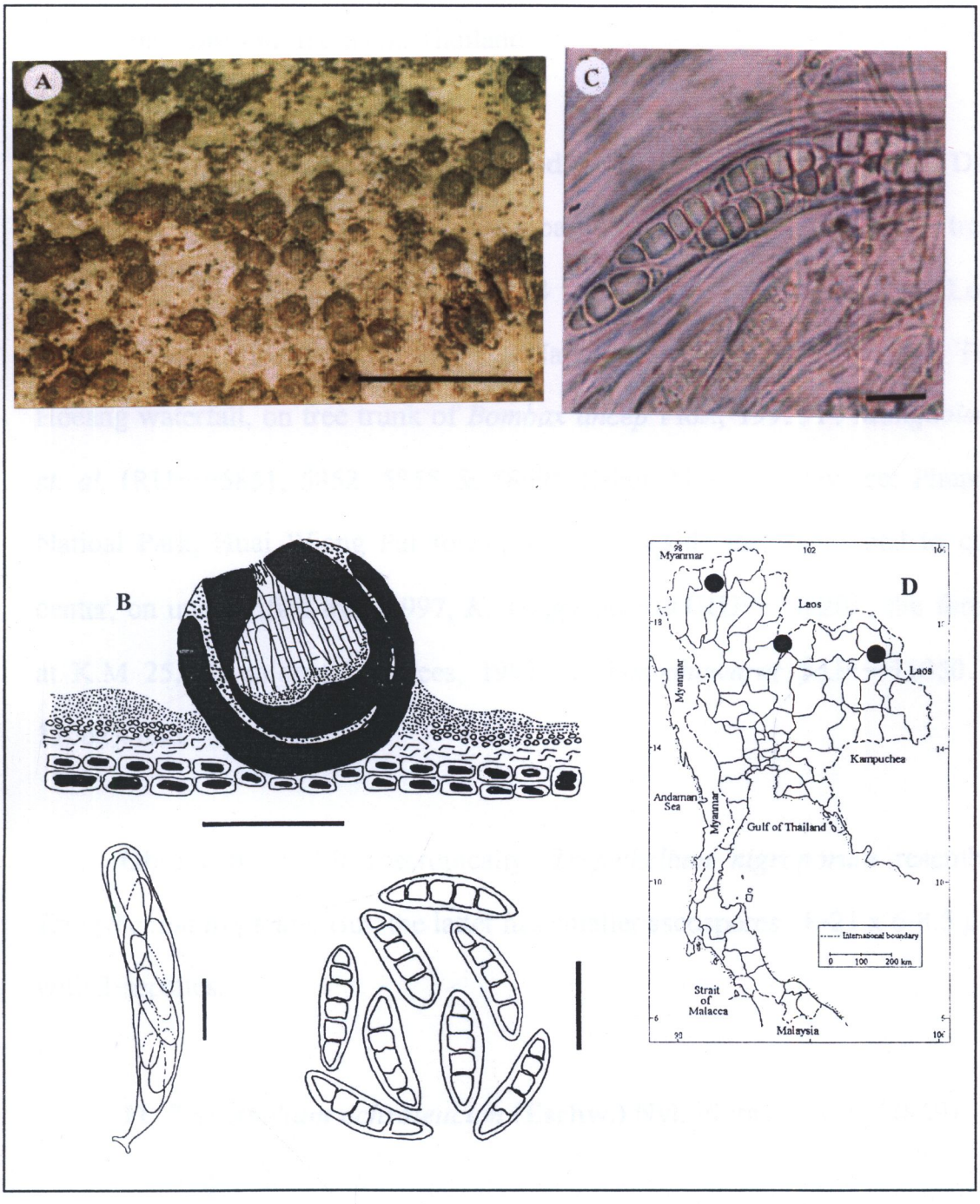



Figure 49 *Trypethelium nigroporum* Makhija & Patw. (RU——11050)

A. Pseudostromata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 300 μm) and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 20 μm).

D. Distribution in Thailand.

**Distribution.** India and Thailand.

**Specimens examined. N Thailand.** Chiangmai Province: Chaing Dao District, Chaing Dao resort, the forets back of resort, on unidentified tree, 1999, *K. Vongshewarat* (RU——11144 & 11145). **NE Thailand.** Loei Province: Na Haeo District, Na Haeo National Park, along the trial to Tad Hoeang waterfall, on tree trunk of *Bombax ancep* Pior., 1995, *P. Mongkolsuk et. al.* (RU——5851, 5852, 5855 & 5869). Sakon Nakhon Province: Phupan Natioal Park, Huai Wiang Pai forest, on trees beside the main road to city center, on unidentified tree, 1997, *K. Vongshewarat* (RU——8920)., the forest at K.M 25, on unidentified trees, 1998, *K. Vongshewarat* (RU——11050 & 11061). ibid.

**Observations.** Macroscropically, *Trypethelium nigroporum* resemble *Trypethelium tropicum.* But, the latter has smaller ascospores 18-21 x 6-8.5 μm with 3-septates.

**11. *Trypethelium ochroleucum* (Eschw.) Nyl.** Flora 52: 126, (1869). (Fig. 50).

*Verrucaria ochroleucum* Eschw., Mart. Icon. Plant. Crytog. 16, pl. fig. 3-4, 1828.

*Trypethelium pallescens* Fée, Ann. Sci. Nat. 23: 440, pl. 13 f. 3A-C, 1831.

**Thallus** crustose, whitish and greenish gray, UV+ bright yellow, smooth, dull, continuous, mostly white pruina; cortex colorless, K-, 50-150 μ m; algal layer scattered, 10-20 μm; medulla white indistinct; **pseudostromata** concolorous or paler than the thallus polycarpic, immersed to raised, 0.4-0.5 mm, forming a network on the thallus; **ascomata** solitary, or aggregated into two, embedded in the pseudostromata, carbonized, sometimes with hyaline crystal inclusion; ascomatal apex convex to plane; ostiole carbonized; centrum with abandant oil globule; excipulum carbonized; hymenium with anastomosing pseudoparaphyses; **ascus** bitunicate, broadly clavate, 8–ascospores; **ascospores** hyaline, ellipsoidal, trans-septate, 3-transversely septates, (23.2)23.2-24.1-24.9(25.0) x (7.8)8.1-8.6-9.0(9.1) μm., cell locule hexagonal.

**Habitat.** On tree trunk in the hill evergreen forests at 1,100-1,200 m elevations, in the dry evergreen forests at 800 m elevation and in the reforestation at 300-400 m elevations.

**Distribution.** Brazil, Cuba, Mexico Africa, China, India, Thailand, Indonisia and Philippines.

**Specimens examined.** **N Thailand.** Phitsanulok Province: Phu Hin Rong Kla National Park, the forest at Lan Anag Pasong, on unidentified tree, 1998, *K. Vongshewarat* (RU——10994). **NE Thailand.** Loei Province: Na Haeo District, Na Haeo National Park, along the trial to from village Toko 1,

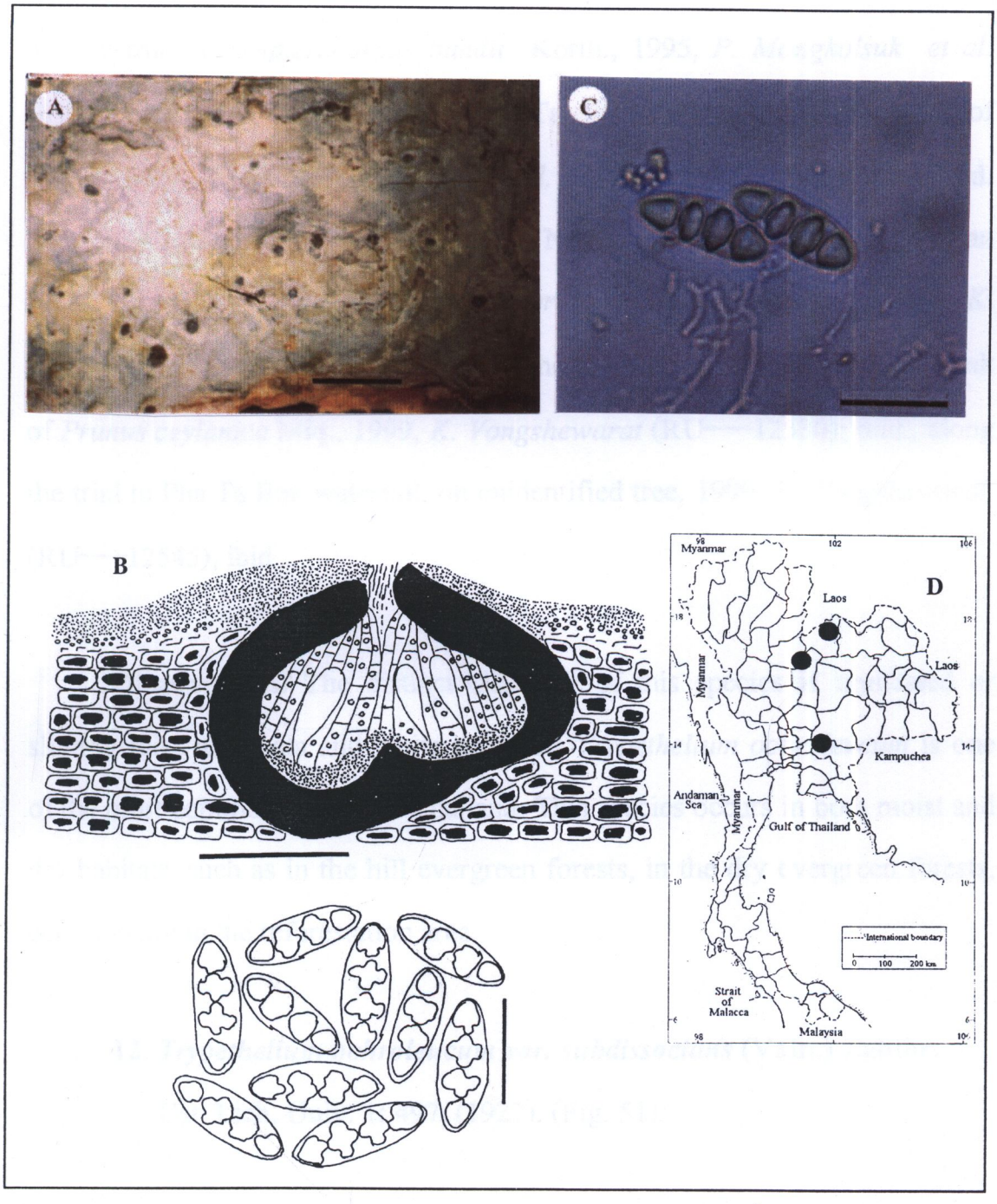



Figure 50 *Trypethelium ochroleucum* (Eschw.) Nyl. (RU——10994)

A. Pseudostromata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 300 μm) and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 20 μm).

D. Distribution in Thailand.

on tree trunk of *Dipterocarpus bandii* Korth., 1995, *P. Mongkolsuk et al.* (RU——5071 & 5072 ), alond the trial to Tad Heang waterfall, on tree trunk of *Neolithea sp.*, 1995, *P. Mongkolsuk et al.* (RU——6,362); ibid., **E Thailand.** Nakhon Ratchasima Province: Khao Yai National Park, the trees beside Ban Chom View, on tree trunk of *Peltophorum pterocarpum* Back., 1999, *K. Vongshewarat* (RU——12513 & 12514), the forest at Nong King, on tree trunk of *Prunus ceylanica* Miq., 1999, *K. Vongshewarat* (RU——12530); ibid., along the trial to Pha Ta Bak waterfall, on unidentified tree, 1999, *K. Vongshewarat* (RU——12545); ibid.

**Observations.** The distinct character of this species is immersed or slightly raise ascomata and white pruinose. *Trypethelium ochroleucum* is one of the most common species in Thailand. This species occurs in both moist and dry habitats, such as in the hill evergreen forests, in the dry evergreen forests, occasionally in the reforestation area.

**12. *Trypethelium ochroleucum var. subdissocians* (Vain.) Zahlbr.**

Cat. Lich. Univ. 1: 497, (1922). (Fig. 51).

*Pseudopyrenula ochroleuca* var. *subdissocians* Vain., Bot. Tidsskrift 29: 147, 1909

*Trypethelium pallescens* var. *subdissocians* Nyl. Flora 47: 618, 1864.

**Thallus** crustose, greenish-gray, UV-, smooth, shiny, continuous; cortex colorless, K+ yellow, 30-60 μm., algal layer discontinous, 20-40 μm, medulla indistincte; **pseudostromatal** monocarpic, rarely polycarpic, concolorous with the thallus; **ascomata** solitary or aggregated into two, embedded in the pseudostromata, carbonized, entire or partially divided or determinate, flush to emergent, sometimes with colorless crystalline inclusions; ascomatal apex concave to plane, surrounding with white periostiole, ostiole carbinized, punctate; centrum without oil globule; excipulum dark brown to carbonized; hymenium with branching and anastomosing pseudoparaphyses; **ascus** easily broken when sections, 8–ascospores; **ascospores** hyaline, ellipsoid, trans-septate, 3-transversely septates, (20.0)20.0-22.7-25.5(27.3) x (7.4)7.4-8.1-8.7 (9.1) μm, cell locule hexagonal.

**Habitat.** On trees trunk in the hill evergreen forests at 1,100-1,200 m elevations, in the dry evergreen forests at 800 m elevation, in the urban and in the plantation at 10-50 m elevations.

**Distribution.** Rio Megdalana, Andaman Islands and Thailand.

**Specimen examined**. N **Thailand**. Lumpang Province: Doi Khuntan National Park, the old orchard, along the trial Yo 2, on tree trunk of *Lichi chinensis* Sonn., 1998, *K. Vongshewarat* (KV——36 RU). **NE Thailand.** Loei Province: Na Haeo District, Na Haeo National Park, in the trial from village to Toko 1, on tree trunk of *Dipterocarpus bandii* Korth., 1995, *P. Mongkolsuk et.*

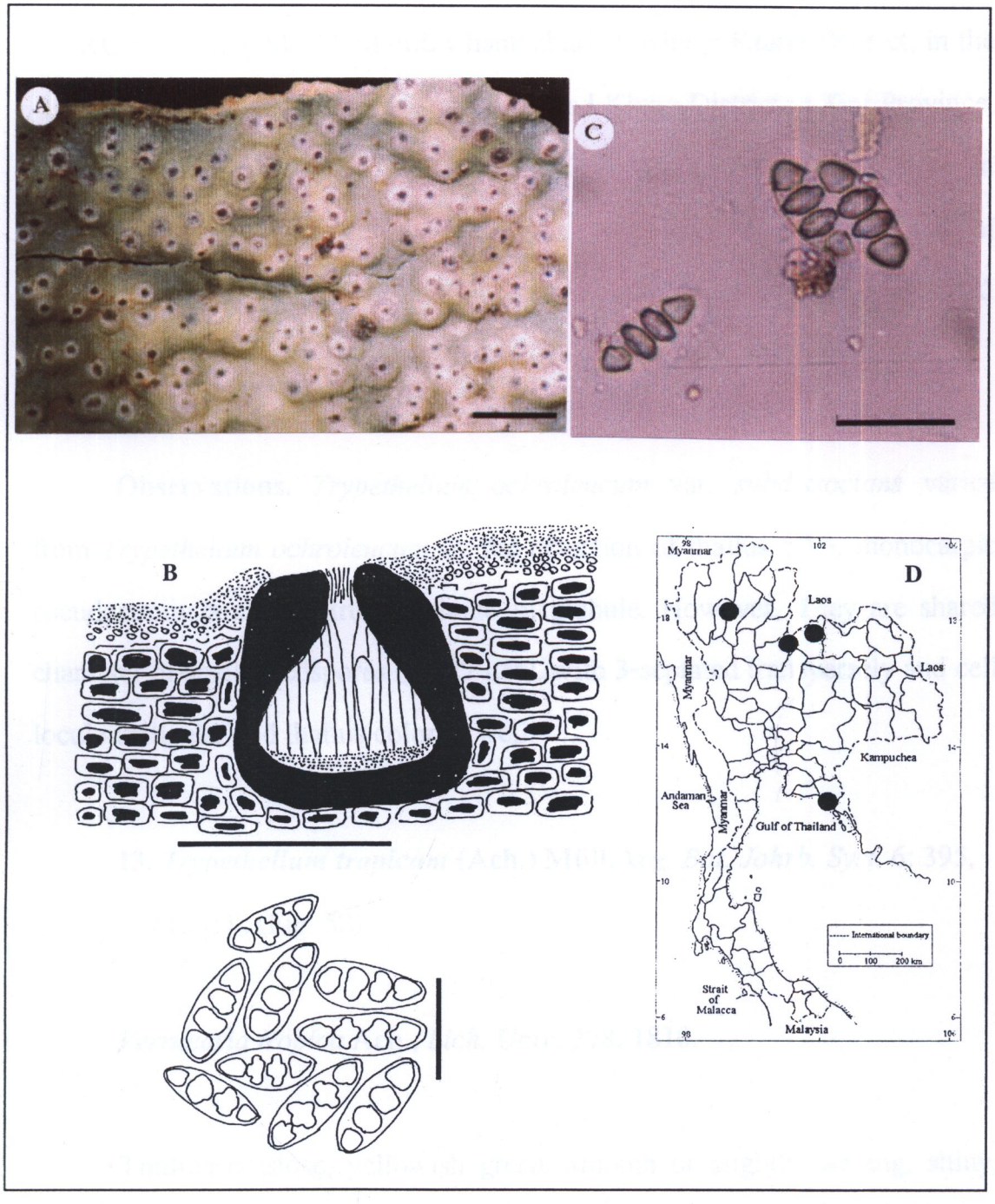



Figure 51 *Trypethelium ochroleucum* var. *subdissocians* (Vain.) Zahlbr.

(RU——11114)

A. Pseudostromata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 300 μm) and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 20 μm).

D. Distribution in Thailand.

*al.* (RU——5138 ). **SE Thailand.** Chanthaburi Province: Klung District, in the plantation of the rubber trees beside main road Klung District to Trat Province, on tree trunk of *Hevea brasiliensis* Müll. Arg., 1998, *K. Vongshewarat* (RU——11114), Mangrove management Unit, tree standing infront of headquater office, on tree trunk of *Michelia champaca* Linn., 1998, *K. Vongshewarat* (RU——11117).

**Observations.** *Trypethelium ochroleucum* var. *subdissocians* varied from *Trypethelium ochroleucum* by the detection of thallus UV-, monocarpic pseudostromata and centrum without oil globule. However, They are shared character of small ascospores (20-27 μm), with 3-septated transversely and cell locule lenticular and thallus color as well.

**13. *Trypethelium tropicum* (Ach.) Müll.Arg.** *Bot. Johrb. Syst.* 6: 395, (1885) . (Fig. 52).

*Verrucaria tropica* Ach., *Lich. Univ.* 278, 1810.

**Thallus** crustose, yellowish green, smooth or slightly waving, shiny, continuous, UV-; cortex colorless to pale yellow, 42-50 μm; algal layer continuous, distinct, 40-50 μm; medulla white; **pseudostromata** monocarpic, less polycarpic, subglobose or hemispherical, 0.4-0.6 mm diam, irregularly spread, carbonized, the thalline layers ended at pseudostroma; **ascomata** solitary, or comprising in groups of two or three, strongly emergent, embedded

in the pseudostromata, carbinized, entire, exposed at the top; ostiole black, punctate; surrounding with carbonized periostiole; centrum without oil globule; excipulum dark brown to carbonized; hymenium with braching and anastomosing pseudoparaphyses; **ascus** bitunicate, clavate, 8–ascospores; **ascospores** hyaline, narrowly ellipsoid, trans-septate, 3- transversely septates, (19.0)19.5-20.9-22.3(23.0) x (6.0)6.3-7.3-8.2(8.5) µm, cell locule subglobose.

**Habitat.** This species were widely distributed in various areas, such as mony in the mangroove forests at 0 m elevation, in the dry evergreen forests at 700-800 m elevations, in the hill evergreen forests at 1,100 – 1,500 m elevations and less in the dry dipterocarp forest at 600 m elevation.

**Distribution.** Brazil, Cuba, Florida, China, India, Thailand, Malaysia, Singapore, Indonesia and Australia.

**Specimens examined. N Thailand.** Chiang Mai Province: Chaing Dao District, Chaing Dao resort, on unidentified tree, 1999, *K. Vongshewarat* (RU——11146). Phitsanulok Province: Phu Hin Rong Kla National Park, 1 on unidentified tree, 1997, *K. Vongshewarat* (RU——9501). **NE Thailand.** Loei Province: Na Haeo District, Na Haeo National Park, along the trial from village to Toko 1, on tree trunk of *Catanopsis helfoliana.*, 1995, *P. Mongkolsuk et. al.* (RU——4445), on tree trunk of *Dipterocarpus bandii* Korth., 1995, *P. Mongkolsuk et. al.* (RU——5071, 5072 & 5138); ibid., along the trial to Wat Charoem Phrakiat, on tree trunk of *Shorea obtusa* Wall., 1995, *P. Mongkolsuk*

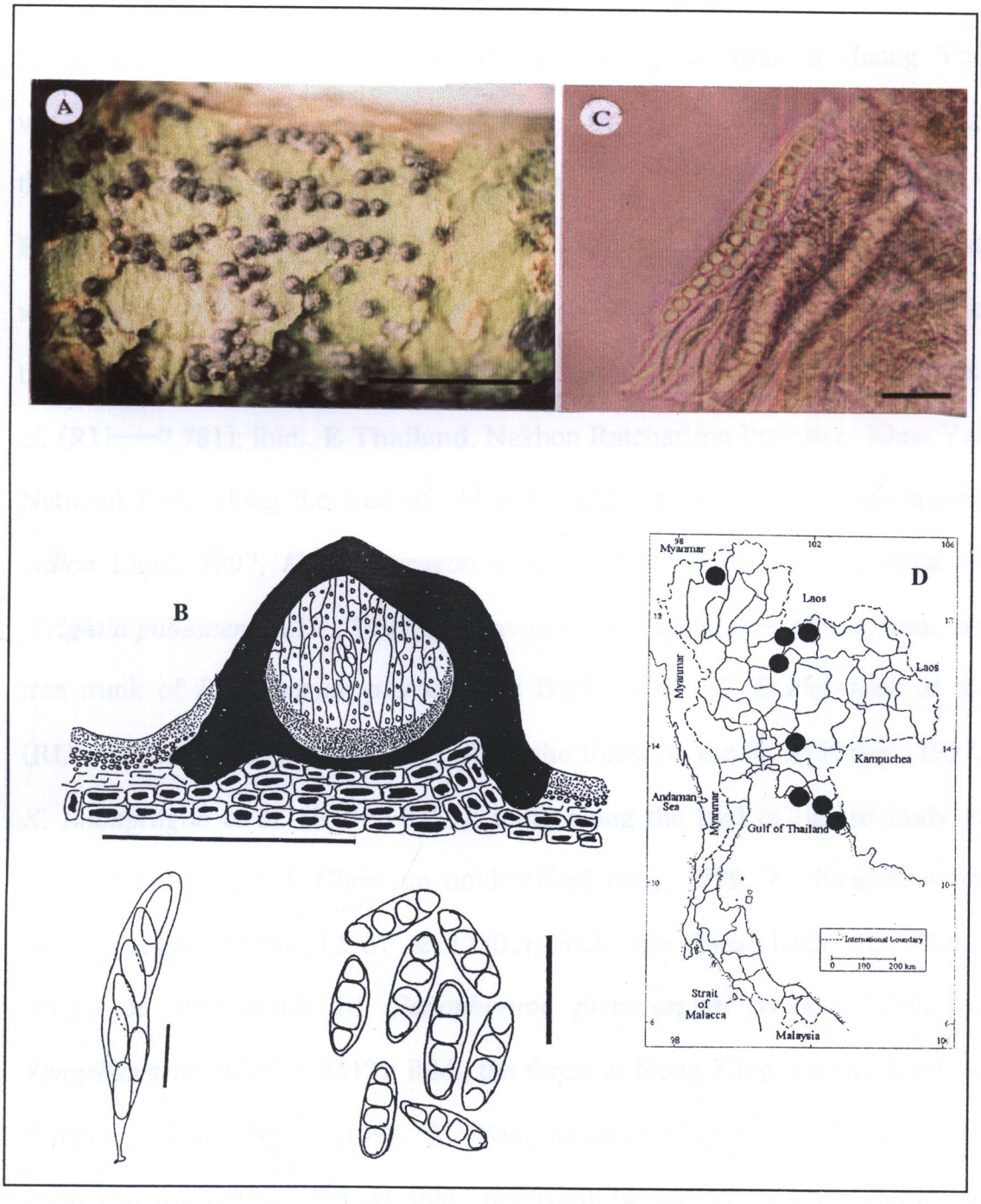



Figure 52 *Trypethelium tropicum* (Ach.) Müll. Arg. (RU——12537)

A. Pseudostromata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 300 μm) and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 20 μm).

D. Distribution in Thailand.

*et. al.* (RU——7071, 7074 & 7077); ibid., along the trial to Heang Yar waterfall, on unidentified tree, 1995, *P. Mongkolsuk et. al.* (RU——7342); ibid., the forest near Lo Ko Hok sub-district, on tree trunk of *Betula anoides* Buch.-Ham., 1995, *P. Mongkolsuk et. al.* (RU——7172); ibid., on tree trunk of *Schima wallichii* Korth., 1995, *P. Mongkolsuk et. al.* (RU——7172); ibid., along the trial to Wat Charoem Phrakiat, on unidentified tree, 1996, *P. Mongkolsuk et. al.* (RU——7,781); ibid., **E Thailand**. Nakhon Ratchasima Province: Khao Yai National Park, along the trial of old golf field, on tree trunk of *Mangifera indica* Linn., 1997, *K. Boonpragob et al.* (RU——7956), on tree trunk of *Wrightia pubescens* R.Br., 1997, *K. Boonpragob et al.* (RU——8014); ibid., on tree trunk of *Peltophorum pterocarpum* Back., 1997, *K. Boonpragob et al.* (RU——8085, 8090, 8091 & 8097); ibid., the forest on the Khao Khaeo, 1997, *K. Boonpragob et al.* (RU——8439); ibid., along the trial of nature study at KM. 33 to Nong Pak Chee, on unidentified tree, 1999, *K. Vongshewarat* (RU——12499, 12500, 12501 & 12502); ibid., the forest back Ban Chom View, on tree trunk of *Peltophorum pterocarpum* Back., 1999, *K. Vongshewarat* (RU——12512); ibid., the forest at Nong King, on tree trunk of *Prunus ceylanica* Miq., 1999, *K. Vongshewarat* (RU——12528); ibid., *K. Vongshewarat* (RU——12533); ibid., tree trunk behind Yowvachon Camp, on tree trunk of *Citrus aurantifolia* Swing., 1999, *K. Vongshewarat* (RU——12537); ibid., the on the Khao Khaeo radar station, on tree trunk of *Schima wallichii* Korth., 1999, *K. Vongshewarat* (RU——12574); ibid., *K. Vongshewarat* (RU——12588); ibid., on tree trunk of *Terstroemia gymanthera*

Bedd., 1999, *K. Vongshewarat* (RU——12565); ibid., **SE Thailand.** Rayong Province: Klang District, in the mangrove forest infront of shrimp farm at Klam sub-district, on unidentified tree, 1998, *K. Vongshewarat* (RU——11031), on tree trunk of *Bruguiera cylindrica* Bl., 1998, *K. Vongshewarat* (RU——11032); ibid., on tree trunk of *Xylocarpus moluccensis*, 1998, *K. Vongshewarat* (RU——11892); ibid., Chanthaburi Province: Klung District, Kleng Huk sub-district, in the old mangrove forest infront of old shrimp farm, on unidentified tree, 1998, *K. Vongshewarat* (RU——11112), on tree trunk of *Thespesia populnea* ex Correa., 1998, *K. Vongshewarat* (RU——11113); ibid., in the mangrove forest infront of the Mangrove management Unit, on tree trunk of *Rhizophora mucronata* Poir., 1998, *K. Vongshewarat* (RU——11114); ibid., tree trunk infront of headquater office of the Mangrove management Unit, on tree trunk of *Michelia champaca* Linn., 1998, *K. Vongshewarat* (RU——11115); ibid., Trat Province: Muang District, in the mangrove forest infront of the Mangrove management Unit, on tree trunk of *Excoecaria agallcha* Linn., 1998, *K. Vongshewarat* (RU——11129), on tree trunk of *Rhizophora mucronata* Poir., 1998, *K. Vongshewarat* (RU——11130); ibid., Mo Ko Chang National Park, along the trail to Tran Ma Yom waterfall, on unidentified tree, 1995, *K. Vongshewarat* (RU——7376).

**Observations.** The black ascomata and is distinctive feature of this species. *Trypethelium tropicum* is very common and easily distinguishable species amongst the tropical species. In Thailand, this species was often found

in the mangrove forest, in the hill evergreen forests, and in the tropical rain forests.

**14. *Trypethelium Unidentified* A** (Fig. 53).

**Thallus** crustose, olivaceous yellow, smooth, shiny, continouous, UV+ yellow orange; cortex colorless, K+ orange, 80-120 μm; algal layer continouos, 40-50 μm, medulla white; **pseudostromata** yellow, monocarpic, raised up and constricted at the base, distinctly rounded to elongate, reddish-orange in KOH solution (K+ red); **ascomata** solitary, embedded in the pseudostromata, ascomata apex cocave; ostioles carbonized, punctate to small red papillate, surrounded brown periostiole; centrum with oil globule; excipulum carbonized; hymenium with branching and anastomosing pseudoparaphyses; **ascus** easily broken when sections; **ascospores** hyaline, ellipsoid, trans-septate, 13—15-transversely septates, (58.1) 56.8-67.9-79.0(100.0) x (10.9)11.5-12.5-13.6 (15.0) μm. cells locule cubical.

**Habitat.** On tree trunk in the hill evergreen forest at 1,100-1,200 m elevations and on tree of *Helicia sp* in the dry dipterocarp forest at 700 m elevation.

**Distribution.** Thailand.

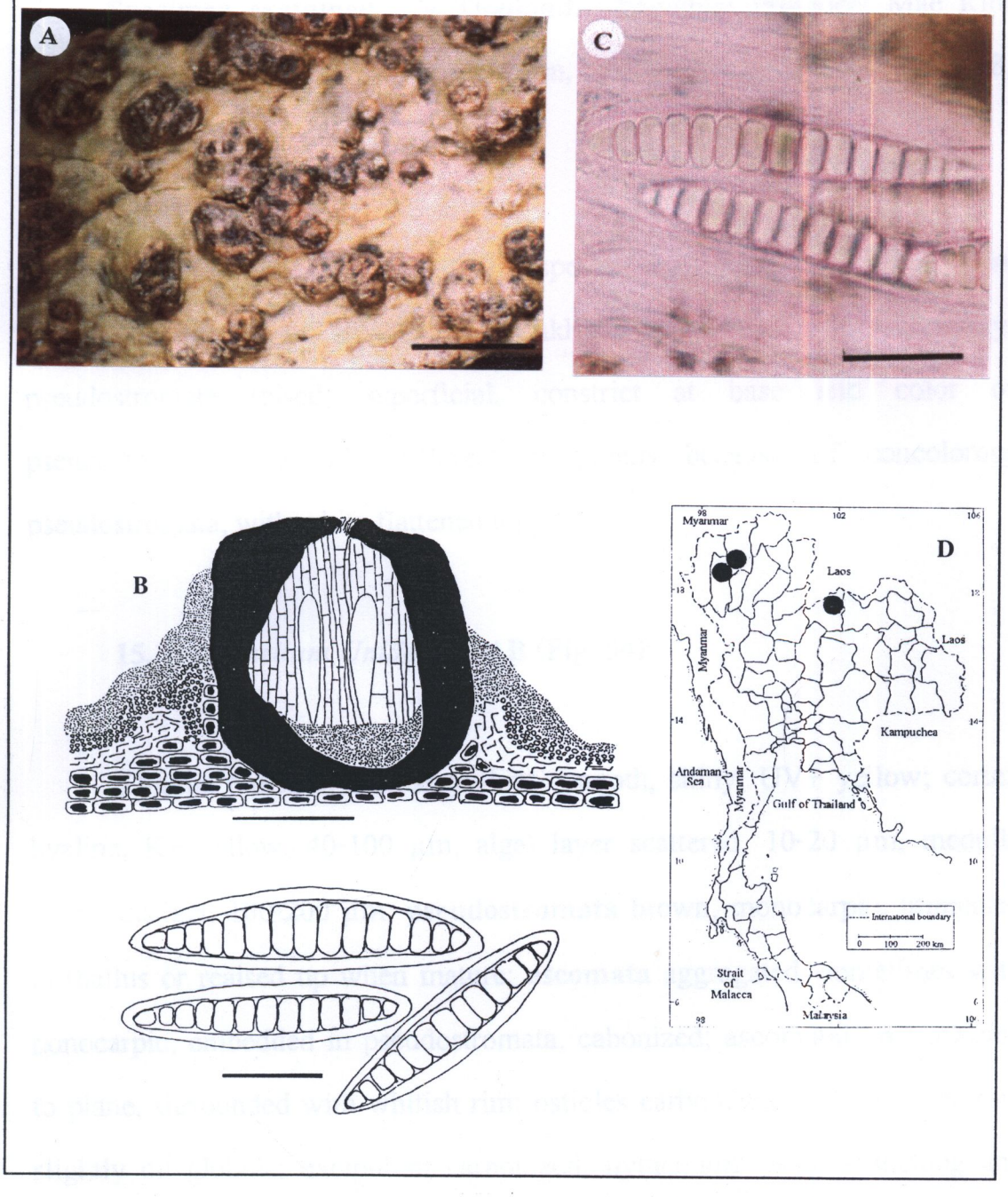



Figure 53 *Trypethelium* Unidentified A.(RU——10004)

A. Pseudostromata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 300 μm) and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 20 μm).

D. Distribution in Thailand.

**Specimen examined. N Thailand.** Chaingmai Province: Mae Rim District, The Queen Sirikit Botanic Gargen, on tree trunk of *Helicia sp*, 1998, *K. Vongshewarat* (RU——10004).

**Observations.** Externally, this species is similar to *Trypethelium rubocintum* (specimen from India; Makhija & Patw, 1993). Noticeably, pseudostromata raised, superficial, constrict at base and color of pseudostromata. But it's different specimens because of concolorous pseudostromata, with white flattened tops.

**15. *Trypethelium Unidentified* B** (Fig. 54).

**Thallus** crustose, whitish-yellow, smooth, shiny, UV+ yellow; cortex hyaline, K+ yellow, 40-100 µm, algal layer scattered, 10-20 µm, medulla white, distinct, 100-200 µm; **pseudostromata** brown, monocarpic, immersed in thallus or reaised up when mature; **ascomata** aggragated, sometimes with nonocarpic, embedded in pseudostromata, cabonized; ascomatal apex convex to plane, surrounded with whitish rim; ostioles carbonized, punctate; centrum slightly oil globule; excipulum carbonized; hymenium with branching and anastomosing pseudoparaphyses; **ascus** easily broken when sections; **ascospores** hyaline, ellipsoid, trans-septate, 5-transversely septates, (33.0)33.9-36.8-39.7(40.0) x (8.0)8.6-9.3-10.0(10.0) µm., cell locule quadrangular or hexagonal.

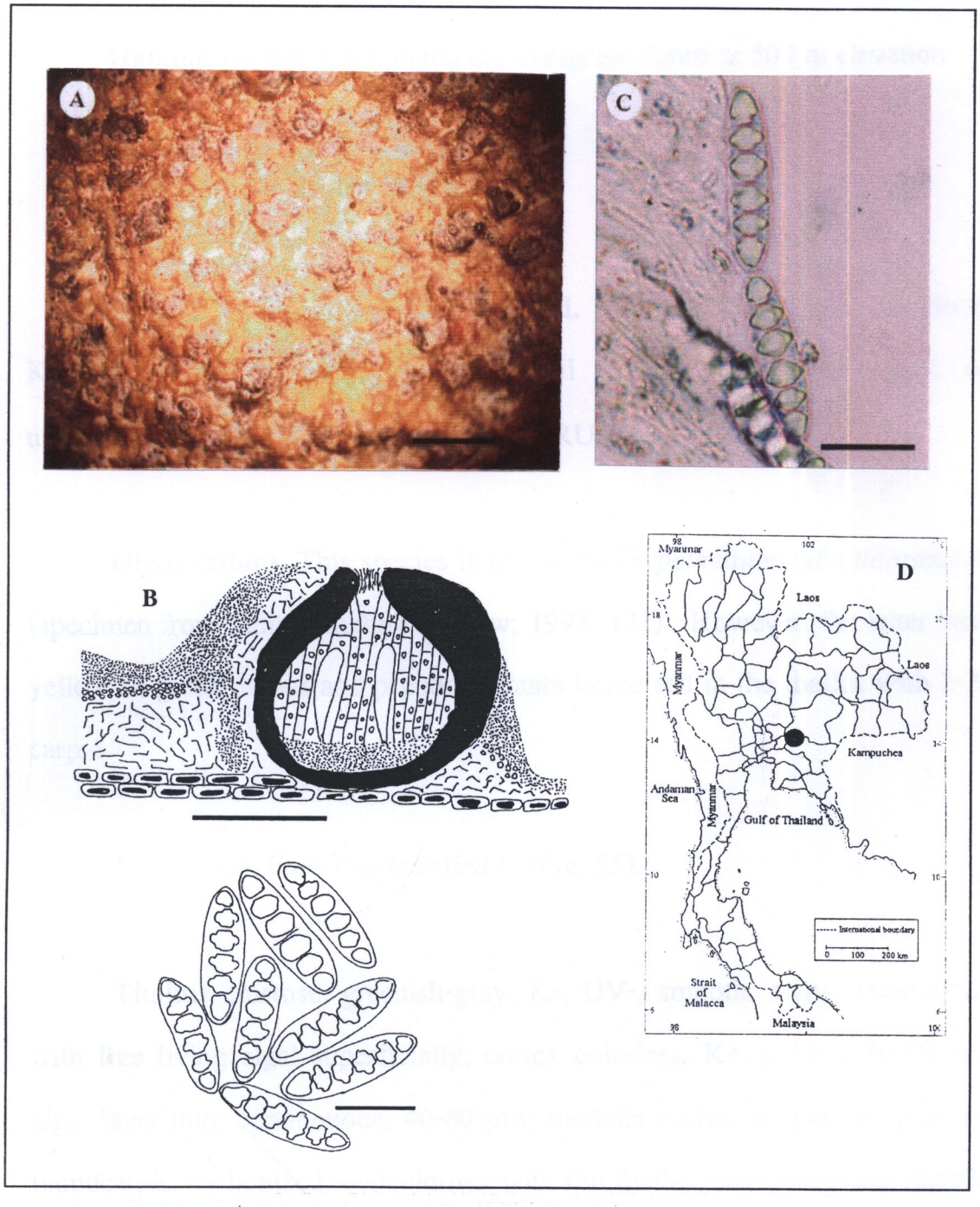



Figure 54 *Trypethelium* Unidentified B. (RU——12545)

A. Pseudostromata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 300 μm) and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 20 μm).

D. Distribution in Thailand.

**Habitat.** On tree trunk in the dry evergreen forest at 500 m elevation.

**Distribution.** Thailand

**Specimens examined. E Thailand.** Nakhon Ratchasima Province: Khao Yai National Park, along the trial to Pha Ta Bak waterfall, on unidentified tree, 1999, *K. Vongshewarat* (RU——12545).

**Observations.** This species is related to *Trypethelium subnitidiusculum* (specimen from India; Makhija & Patw; 1993, 191). However, the latter have yellowish-green thallus and pseudostromata immersed in the thallus with 2-20 carpic.

**16. *Trypethelium Unidentified* C** (Fig. 55).

**Thallus** crustose, greenish-gray, K-, UV-, smooth, shiny, continuous, with free living algal superficially; cortex colorless, K+ yellow, 40-50 μm; algal layer thin, continouous, 40-60 μm; medulla indistinct; **pseudostromata** monocarpic, carbonized, concolorous with the thallus, immersed and raisedat maturity; **ascomata** solitary or groups of two, embedded in the pseudostromata, carbonized; ascomata apex convex to plane; ostioles carbonized, punctate; centrum without oil globule; excipulum carbonized; hymenium with branching and anastomosing pseudoparaphyses; **ascus** bitunicate, clavate, 8–ascospores; **ascospores** hyaline, ellipsoid, trans-septate,

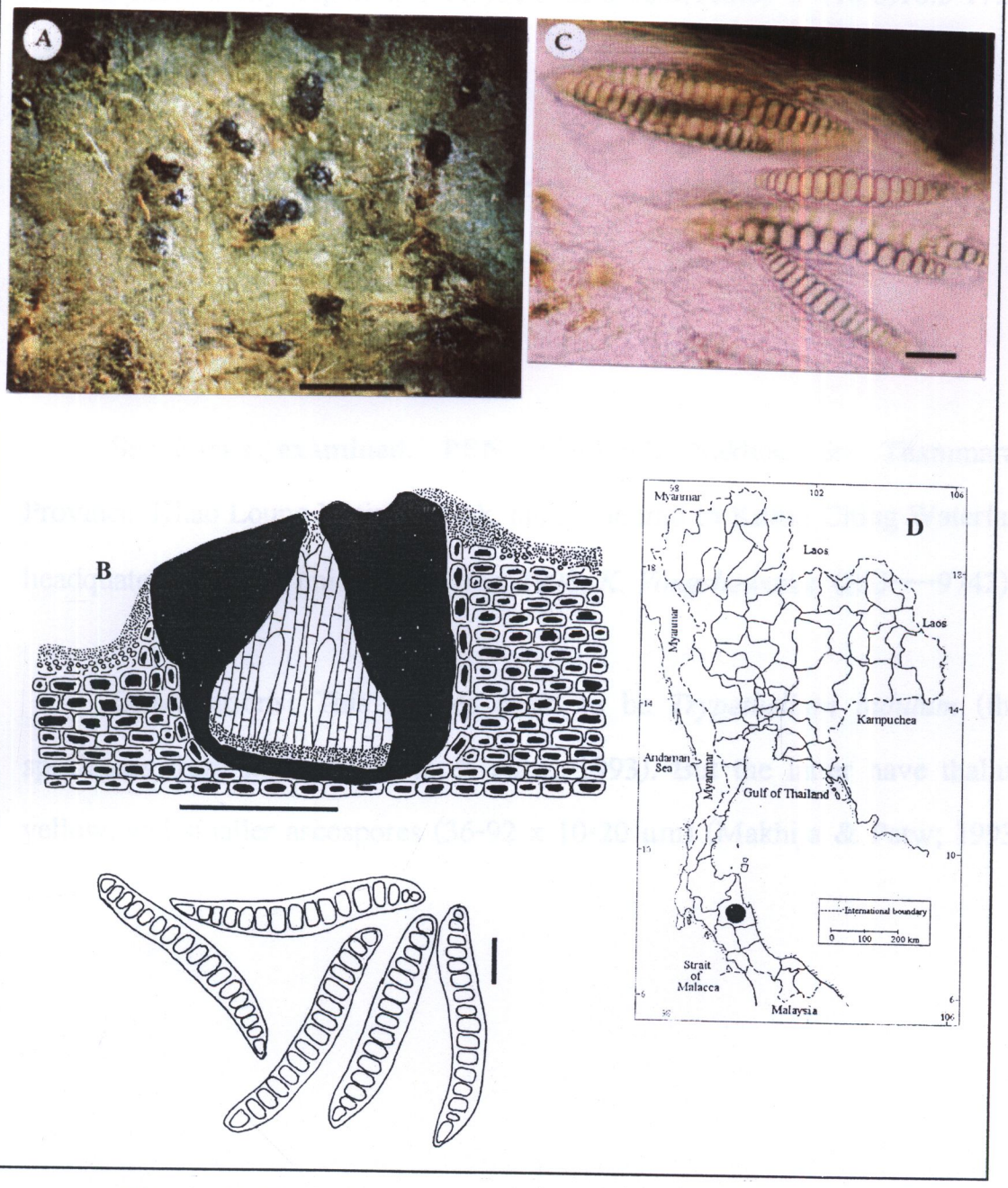



Figure 55 *Trypethelium* Unidentified C.(RU——9742)

A. Pseudostromata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 300 μm) and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 20 μm).

D. Distribution in Thailand.

13—16-transversely septates, (76.0)80.0-88.0-96.0(110.0) x (16.0)16.5-17.5-18.4(19.0) µm., cell locule cylindrical.

**Habitat.** On tree trunk in the tropical rain forest at 100 m elevation.

**Distribution.** Thailand

**Specimens examined. PEN Thailand.** Nakhon Sri Thammarat Province: Khao Loung National Park, along the trail to Krung Ching Waterfall headquater office, on unidentified tree, 1998, *K. Vongshewarat.* (RU——9742).

**Observations:** This species seem to be *Trypethelium indutum* (the specimens from India; Makhija & Patw, 1993). But the latter have thallus yellow, and smaller ascospores (36-92 x 10-20 µm) (Makhija & Patw; 1993, 191).

**17. *Trypethelium Unidentified* D** (Fig. 56).

**Thallus** crustose, brownish buff, slightly rough, dull, continuous, UV+ yellow; cortex colorless, K+ yellow 60-100 μm, algal layer dense, continuous, 60-70 μm; medulla indistinct; **pseudostromata** carbonized, immersed, or reaised up; **ascomata** solitary or aggregated into two, embedded in the pseudostromata, cabonized; ascomata apex convex to plane; ostioles carbonized, punctate; periostiolar region black, plane as disc-like; centrum with slightly oil globule; excipulum carbonized; hymenium with branching and anastomosing pseudoparaphyses; **ascus** bitunicate, clavate, 80-90 x 14-16 μm, 8–ascospores; **ascospores** hyaline, ellipsoid, trans-septate, 3-transversely septates, (33.0)33.9-36.8-39.7(40.0) x (8.0)8.6-9.3-10.0(10.0) μm., cell locule hexagonal.

**Habitat.** On tree trunk in the hill evergreen forest at 1,500 m elevation.

**Distribution.** Thailand

**Specimens examined. E Thailand.** Nakhon Ratchasima Province: Khao Yai National Park, in the forest in front of Khao Khaeo radar station headquater office, on tree trunk of *Terstroemia gymanthera* Bedd., 1999, *K. Vongshewarat* (RU——12567, 12568, 12569 & 12570).

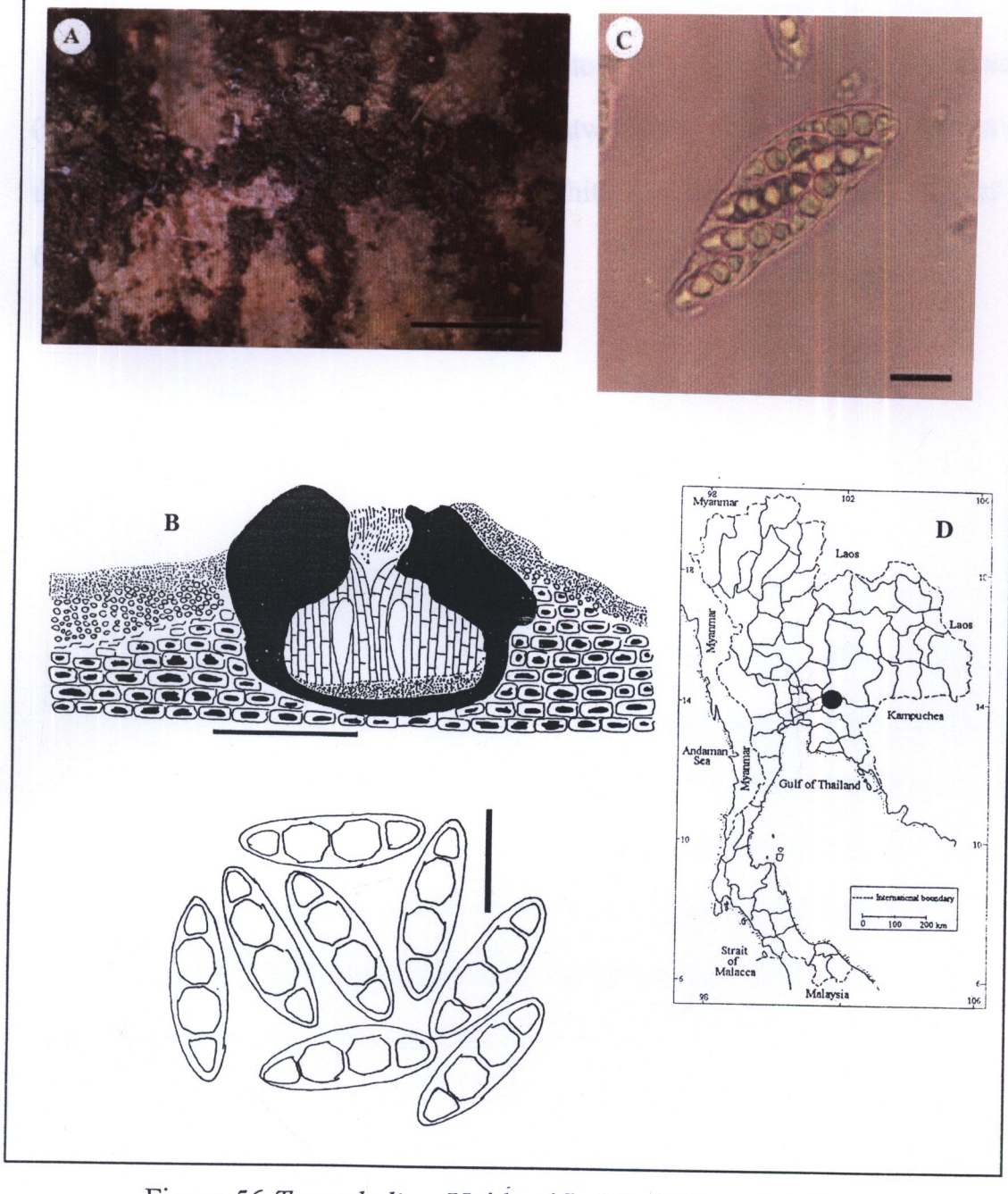



Figure 56 *Trypethelium* Unidentified D.(RU——9743)

A. Pseudostromata on thallus (Bar = 2 mm).

B. L-section of ascoma (Bar = 300 μm) and ascospores (Bar = 20 μm).

C. Ascospores (Bar = 20 μm).

D. Distribution in Thailand.

**Observations.** This species seem to be *Trypethelium albopruinosum* (the specimens from India; Makhija & Patw; 1993, 192). But the latter have thallus yellowish-white, pseudostromata white and smaller ascospores (13-20 x 6-8 μm) (Makhija & Patw; 1993, 192).

# CHAPTER 7

# CONCLUSION AND DISCUSSION

## Taxonomical Conclusion

The taxonomic and ecological study of the lichen family Trypetheliaceae in Thailand in this study was performed from 519 specimens collected from 63 tree species in 26 sites throughout the country. The taxa comprised of 6 genera, the 33 described species, and 1 variety with 4 unidentified species. Twenty two species were new recorded for Thailand. They consisted of 3 species of *Astrothelium*, 2 species of *Campylothelium*, 2 species of *Laurera* , 3 species of *Polymeridium*, 10 species of *Trypethelium* and 1 variety of *Trypethelium*. One new species, *Laurera meristosporoides* P. M. McCarthy & Vongshewarat was collected from the hill evergreen forest ($16^{\circ}59'$ N $101^{\circ}06'$ E) on 1,200 m elevation at Phu Hin Rong Kla National Park in the province of Phisanulok.

Thirty seven species and one variety found in this study, 45% belong to *Trypethelium*, 26% to *Laurera*, 13% to *Polymeridium*, 8% to *Astrothelium*, 5% *Campylothelium* and 3% to *Pseudopyrenula* as show in Figure 57.

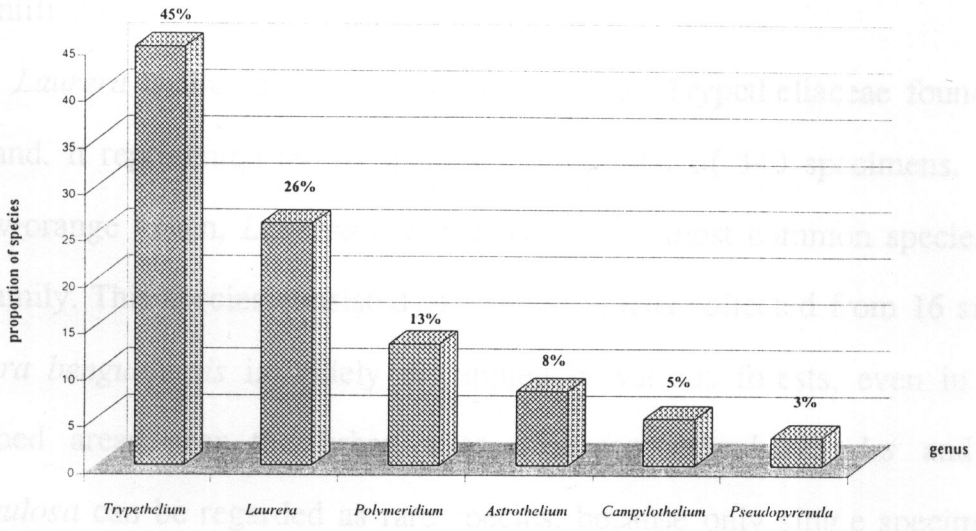



Figure 57 The Proportion of thirty eight Species of the Family Trypetheliaceae found in Thailand.

*Trypethelium* shares the hightest species number of 45 %, with the lesser contributions of *Laurera* 26%, *Polymeridium* 13 %, *Astrothelium* 8 %, *Campylothelium* 5 % and *Pseudopyrenula* 3 %.

The *Trypethelium* consist of 17 species from 138 specimens. It composes of 13 species, 1 variety and 4 unidentified species. The common species, *Trypethelium tropicum* and *T. eluteriae* consisted of 46 and 41 specimens respectively. The second common species are *Trypethelium ochroleucum* (12 specimens), *T. nigroporum* (9 specimens), *T. albopruinosum* (7 specimens) and *T. ochroleucum* var. *subdissocians* (6 specimens).

There are eleven species which were represent by only one sample from single collection. These are *Trypethelium andamanicum*, *T. cinereo_rosellum*, *T. concatervatum*, *T. celatum*, *T. luteum*, *T. microstomum*,

*T. myriocarpum*, *T.* unidentified A, *T.* unidentified B, *T.* unidentified C and *T.* unidentified D.

*Laurera* is the second largest genus of the Trypetheliaceae found in Thailand. It represented by 10 species from a total of 340 specimens. The yellow-orange lichen, *Laurera benguelensis* is the most common species in this family. This species consisted of 188 specimens collected from 16 sites. *Laurera benguelensis* is widely distributed in various forests, even in the disturbed areas near the urban sites. *Laurera subsphaerioides* and *L. tuberculosa* can be regarded as rare species, because only single specimens could be collected. *Laurera meristospora* and *L. madreporiformis* are the second common species, which represented by 57 and 42 specimen respectively. In addition, the contribution of *Laurera subdiscreta* was 29, *L. keralensis* 13, *L. meristosporoides* 4, *L. megasperma* 2 and *L. phaeomelodes* 2 of the total samples collected.

*Polymeridium* consisted of 5 species from 15 specimens. *Polymeridium albidum* and *P. catapastum* are relatively common species because they were found from 3 different sites, comparing with *Polymeridium quenqueseptatum*, which consisted of 7 specimens collected only from Khao Yai National Park. This species may be endemic to KhaoYai National Park. *Polymeridium albocinereum* and *P. pleiomerioides* were rather rare, because each was collected only once.

*Astrothelium* comprised of 3 species from 6 specimens. *Astrothelium galbineum* was represented by 4 collections. *Astrothelium cinnamomeum* and *A. eustomum* were relative rare because they were collect once apiece.

*Campylothelium* is a small genus of the Trypetheliaceae in Thailand. It represented by only 2 species of 4 specimens. *Campylothelium nitidum* consisted of 3 speciemens only, and *Campylothelium superbum* was represented by one collection from Phu Hin Rong Kla National Park.

*Pseudopyrenula diluta* var. *degenerance* are commonly distributed in various forests, the evergreen forests, the dry evergreen forests, the tropical rain forests and the reforestation. This species comprised of 17 specimens collected from these forests.

**Taxonomical Discussion**

The common genera of the Trypetheliaceae in Thailand are *Trypethelium* and *Laurera*. The genus *Trypethelium* was represented by 17 species of 138 specimens, whereas the *Laurera* comprised of 10 species from 340 specimens. The distinct characteristic of both genera are well developed thallus, and the ascospores with distinct gelatinous sheath, such as *Laurera benguelensis, L. madreporiformis, L. subdiscreta, Trypethelium eluteriae* and *T. tropicum*. However, the differences lie on ascospore type, by which the *Trypethelium* produced trans-septate ascospore, whereas *Laurera* produced muriform ascospore.

The rare genus, *Polymeridium, Astrothelium, Campylothelium* and *Pseudopyrenula* consisted of few specimens collected in the primary forests, such as Na Haeo, Phu Rua and Khao Yai National Park. Single species of

*Polymeridium* can survive in the mangrove forests, which was *Polymeridium albidum*.

Seven species of the Trypetheliaceae which are commonly found in Thailand consisted of *Laurera benguelensis, L. meristospora, L. madreporiformis, Polymeridium albidum, P. catapastum, Trypethelium eluteriae* and *T. tropicum*. They contributed 18 % of the total number of 38 species. Nineteen species are less common, they comprised of *Astrothelium cinnamomeum, A. eustomum, Campythelium nitidum, C. superbum, Laurera subsphaeriodes, L. tuberculosa P. albocinereum, P. pleiomerioides, T. andamanicum, T. cinereo_rosellum, T. concatervatum, T. celatum, T. luteum, T. microstomum,T. myriocarpum, T.* unidentified A, *T.* unidentified B, *T.* unidentified C and *T.* unidentified D. The proportion of uncommon species could be changed in the future, when surveys are performed in the other parts of the country.

The lichen family Trypetheliaceae is generally recognized as essential tropical lichens. The number of species occurred in the tropical countries were out number those found in the temperate zone. For example 108 species was found from Brazil, 81 from India subcontinent, Nepal and Sri Lanka, 26 from Florida, 25 from small Pacific Island, 22 from Papua New Ginea and Irain Jaya, 10 from Venezuela and 20 from tropical Africa. Although some countries in the tropic have few species, such as 6 from Indonesia, 4 from Hawaii Island. This is because these countries have not performed intensive study of this family.

Thailand shares number of species with the other countries as follow: 21 species shared with India subcontinent, Nepal and Sri Lanka, 14 with Brazil, 9 with Florida, 6 with Venezuela, 5 with small Pacific Island, 4 with Papua New Ginea and Irain Jaya, 2 with tropical Africa, 1 with Indonesia and 1 with Hawaii Island.

The India subcontinent, Nepal and Sri Lanka share the highest common species with Thailand (Table 5). The India subcontinent is located in the tropical region, where climate and vegetation are relatively similar. In addition to their close proximity to Thailand. Therefore, Thailand shares have highest common on species with these countries.

The temperate region, such as Australia, North America, Hong Kong and China found only a few species of the Trypetheliaceae (Table 5). However, species that can survive in the low temperature, such as *Laurera robusta* from Tasmania (McCarthy and Kantivilas 1993) can not be found in Thailand. More importantly, there is no report of the Trypetheliaceae in Britain and other European countries which are in the temperate region (Table 5). These countries have already preformed intensive studies of their lichens.

**Chemical Conclusion and Discussion**

*Laurera* and *Trypethelium* are large genus, which possess great morphological similarity, such as *Laurera benguelensis*, *Trypethelium eluteriae*. However, chemical constituents of this family have been neglected.

Table 5 The Number of Species of the Trypetheliaceae from other Countries and Number of Common Species Thailand Shares with the others.

| Country | Number of species | Shared species | Proportion of share with Thailand | Reference |
|---|---|---|---|---|
| **North American continent** | | | | |
| USA, Canada | 34 | 10 | 26 % | Degelius, 1940; Egan, 1987 |
| Florida | 26 | 9 | 24 % | Harris, 1975, 1995. |
| **South American continent** | | | | |
| Cuba | 11 | 1 | 3 % | Zahlbruckner, 1951 |
| Hawaii Island | 4 | 1 | 3 % | Magnusson & Zahlbruckner, 1944 |
| Venezuela | 10 | 6 | 16 % | Feuere, 2000 |
| Brazil | 108 | 14 | 37 % | Harris, 1984; Marcelli, 2000 |
| Chili | 2 | 1 | 3 % | Feuere, 2000 |
| **European continent** | | | | |
| Britain and Ireland | - | - | - | Puvis *et al.*, 1992 |
| Europe | - | - | - | Zahlbruckner, 1951 |
| **African continent (Tropical Africa)** | 20 | 2 | 6 % | Dodge, 1953, 1964 |

Table 5 (continued)

| Country | Number of species | Shared species | Proportion of share with Thailand | Reference |
|---|---|---|---|---|
| **Asian continent** | | | | |
| China | 11 | 1 | 3 % | Jiang-chum, 1991 |
| Hong Kong | 2 | 1 | 3 % | Thrower, 1988 |
| India, Napal and Sri Lanka | 81 | 21 | 55 % | Awasthi, 1991; Makhija & Patwardhan, 1988, 1992, 1993; Upreti & Singh, 1987 |
| Thailand | 38 | 38 | 100 % | - |
| Indonesia (Java and Borneo) | 6 | 1 | 3 % | Zahlbruckner, 1951 |
| **Australian continent** | | | | |
| Australia | 28 | 10 | 26 % | McCarthy, 1995; Filson, 1996 |
| Tasmania | 5 | 1 | 3 % | Wetmore, 1963; McCarthy, 1993 |
| New Zealand | 4 | 1 | 3 % | Malcolm & Gallaway, 1997 |
| **Other region** | | | | |
| Papua New Ginea and Irian Jaya | 22 | 4 | 10 % | Streimann, 1986; McCarthy, 1995; Aptroot *et al.*, 1997 |
| The Small Pacific Island | 25 | 5 | 13 % | Elix & McCarthy, 1997 |

The determination of their taxa basically lie on morphology and anatomy of the ascomata and the ascospores. This study try to distinguish morphological dissimilarity base on chemical constituents by performing chemical analysis of nine species. The results of the analysis revealed that lichexanthone and parietin were the main constituents in that three most widely distributed species, *Laurera benguelensis*, *Trypethelium eluteriae* and *T. tropicum*. The other 6 species contain less chemical compounds, or absent of any substance (Table 6).

Table 6 Lichen Substances in Some Species of the Trypetheliaceae.

| Species | Lichen substance |
|---|---|
| *L. benguelensis* | Lichexanthone, parietin, secalonic acid, eumitrin, emodin |
| *T. eluteriae* | Lichexanthone, parietin, secalonic acid, emodin, unknown lichen substance |
| *T. tropicum* | Lichexanthone, parietin, unidentified lichen substance |
| *L.. keralensis* | parietin, secalonic acid |
| *L. meristospora* | emodin, panarin, echinocarpic, psoromic acid |
| *L. megasperma* | unidentified lichen substance |
| *L. meristosporoides* | unidentified lichen substance |
| *L. phaemelodes* | unidentified lichen substance |
| *L. subdiscreta* | no lichen substance |

Morphological character of the first two species, *Laurera benguelensis* and *Trypethelium eluteriae* are almost indistinguishable. However, chemical analysis reveal that they contained two major compound, which were the

same, and only one different component. Lichexanthone and parietin, may play significant roles in protecting these species in adverse habitats. *Trypethelium tropicum* which has morphology diverse from the former two species consisted of different unidentified lichen substances. The other 6 species can be distinguished by their chemistry at different confidence, based on the limitation of this analysis.

Further studies on chemical substances would enhance taxa determination of this family.

**Ecological Conclusion**

Although ecological sampling methods, such as quadrate, were not employed in this study, but species abundance of each genus can be observed from different ecosystems. The 38 species of the *Trypetheliaceae* in Thailand composes of 27 species occurred in the hill evergreen forests, 10 species in the dry dipterocarp forests, 4 species in the mixed deciduous forests, 18 species in the dry evergreen forests, 10 species in the tropical rain forests, 5 species in the reforestation areas, 4 species in the plantations and urban area and 2 species in the mangrove forests (Figure 58). Therefore, The diversity of Trypetheliaceae are highest in the hill evergreen forests and the dry evergreen forests, whereas the mangrove forest has the lowest diversity of this family.

Of the total 38 species found in each ecosystem, *Trypethelium* contributes 27% in the hill evergreen forests, 14% in the dry dipterocarp forest, 3% in the mixed deciduous forests, 19% in the dry evergreen forests,

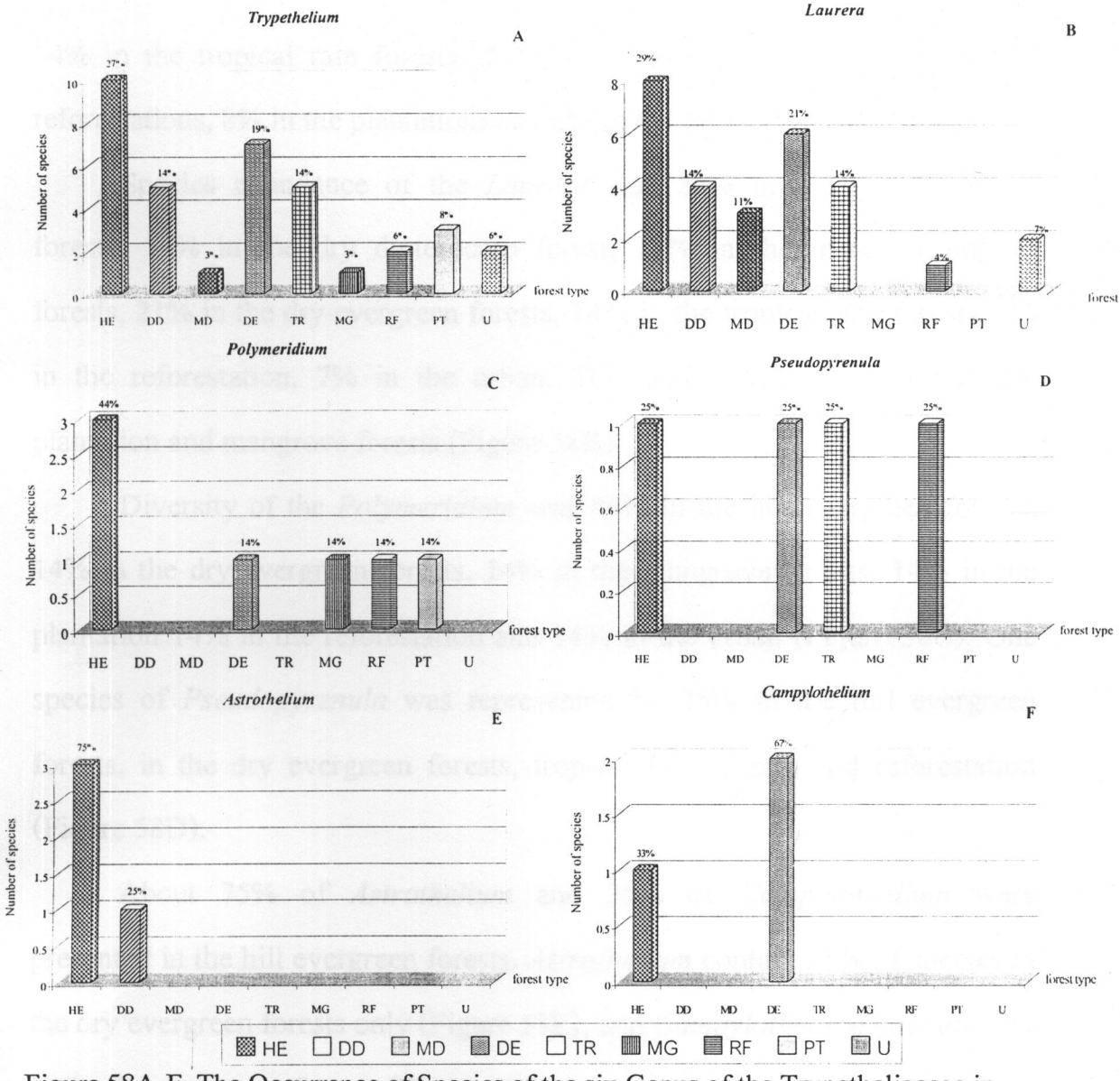



Figure 58A-F The Occurrence of Species of the six Genus of the Trypetheliaceae in Various Forests of Thailand.

A. *Trypethelium* represented the highest species number of 27% in the hill evergreen forest, with the lesser contributions in other forest. B. *Laurera* represented highest species number of 29% in the hill evergreen forest, with the lesser contributions in other forest, without appearence in the mangrove forest and plantation. C. The highest species number, 44%, of *Polymeridium* was found in the hill evergreen forest, with the lesser contributions of 14% in the dry evergreen forest, the mangrove forest, reforestation and plantation. D. *Pseudopyrenula* represented of 25% in the hill evergreen forest, the dry evergreen forest, the tropical rain forest and the reforestation. E. *Astrothelium* contributed 75% of species number in the hill evergreen forest and 25% in the dry dipterocarp forest. F. *Campylothelium* shared 67% of species number in the dry evergreen forest and 33% in the hill evergreen forest.

14% in the tropical rain forests, 3 % in the mangrove forests, 6% in the reforestations, 8% in the plantations and 6% in the urban (Figure 58A).

Species abundance of the *Laurera* was 29% in the hill evergreen forests, 14% in the dry dipterocarp forest, 11% in the mixed deciduous forests, 21% in the dry evergreen forests, 14% in the tropical rain forests, 4% in the reforestation, 7% in the urban. This genus was not found in the plantation and mangrove forests (Figure 58B).

Diversity of the *Polymeridium* was 44% in the hill evergreen forests, 14% in the dry evergreen forests, 14% in the mangrove forests, 14% in the plantation 14% in the reforestation and 14% in the urban (Figure 58C). One species of *Pseudopyrenula* was represented by 25% in the hill evergreen forests, in the dry evergreen forests, tropical rain forests and reforestation (Figure 58D).

About 75% of *Astrothelium* and 35% of *Campylothelium* were presented in the hill evergreen forests. *Astrothelium* contain 25% of species in the dry evergreen forests only (Figure 58E), and *Campylothelium* contain 67% in the dry evergreen forests (Figure 58F).

From 26 total studied sites, collections were done in 14 National Park, 1 Forest Park and 11 other areas. Twenty two species of 6 genus were found in Khao Yai National Park. Whilst other National Parks have a few genus. Obviously, Khao Yai National Park has the highest diversity of the lichen family Trypetheliaceae (Figure 59). Because this park have diverse habitats, which intensive collections were performed. Other areas contributed only one species of the Trypetheliaceae, such as Doi Inthanon National Park,

Ramkhamhaeng National Park, Kasetsart University, Num Tok Phlui National Park, Mu Koh Chang National Park and the mangrove forest in the provinces of Rayong, Chanthaburi and Trad. Only one their collection was performed in each site.

Altitude plays significant role in the abundance of species. Number of species increased for 1-2 species at every level of 300 meter higher in elevation. The maximum number of 19 species was attained at 1,000 –1,200 m elevations. It is important to note that the *Trypethelium* and *Laurera* distributed in every elevation ranges (Figure 60).

The Trypetheliaceae was found on about 63 species of host trees. The trunk of *Ternstroemia gymnanthera* was the most favorite host of this lichens. This host species only grows in the hill evergreen forests, at about 1,400 m elevations in Khao Yai National Park. Nine species of the Trypetheliaceae were found on *Ternstroemia gymnanthera* (Figure 61). Seven species was found on the trunk of *Peltophorum pterocarpum* and six species on the trunk of *Schima wallichii*. These two host species were found in the dry evergreen forests and the mixed deciduous forests. The rest of the host trees support only one species of the Trypetheliaceae, such as *Adenanthera pavinina* Linn, *Betula alnoides* Buch.-Ham, *Bruguiera cylindrica* Bl., *Durio ziberthinus* Linn, *Eloecarpus hydrophilus* Kurz, *Gynura procumbens* Merr and *Pottosporum ferrugineum* Ait. *et. al.*

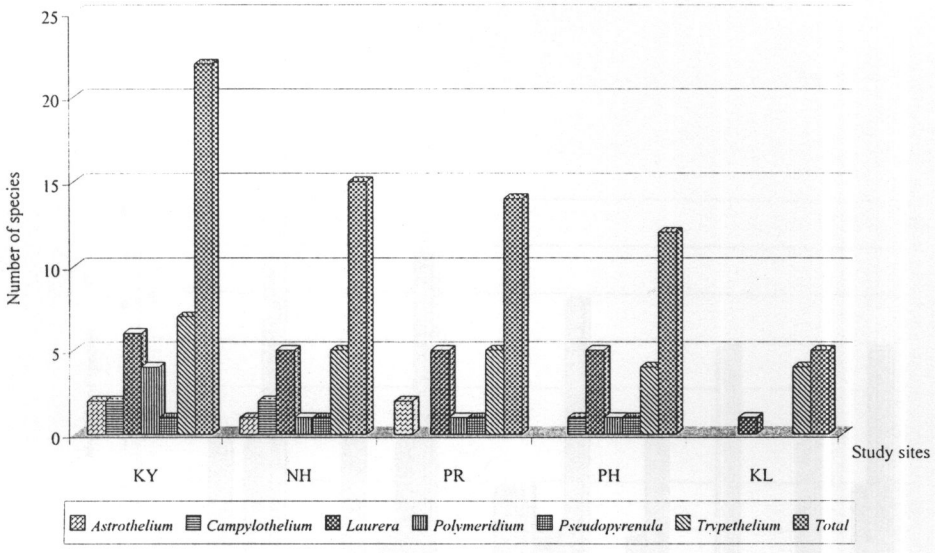



Figure 59 The Occurrence of the Trypetheliaceae in the same National Parks of Thailand.

The highest species number of 22 was found at in Khao Yai National Park, 15 species in Na Haeo National Park, 14 species in Phu Ruea National Park, 12 species in Phu hin Rong Kla National Park and 5 species in Khao Loung National Park. (KY = Khao Yai National Park, NH = Na Haeo National Park, PR = Phu Ruea National Park, PH = Phu hin Rong Kla National Park and KL = Khao Loung National Park)

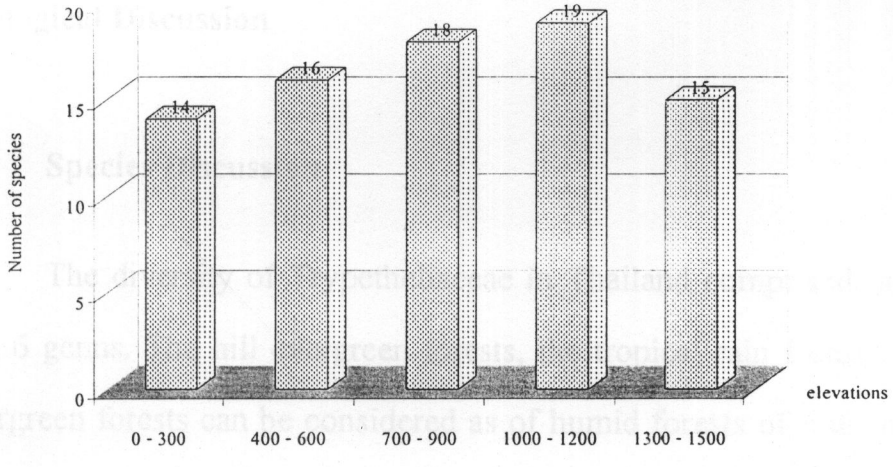



Figure 60 Number of species of the Trypetheliaceae found in deferent elevations.

About 1-2 species increased at every 300 meter higher in elevations and maximum at 1,000 – 1,200 meter altitude.

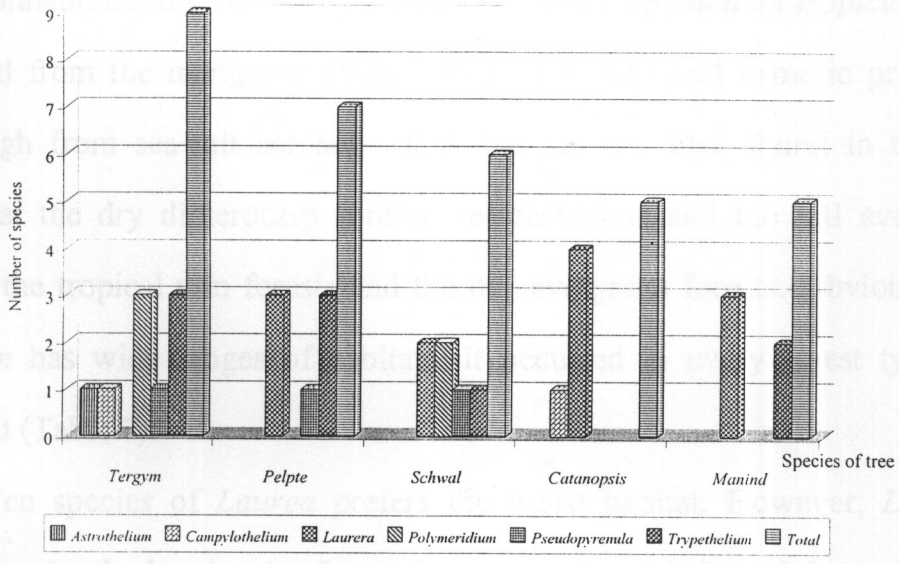



Figure 61 The Occurrence of the Trypetheliaceae in the five Tree Species.

The highest number of species, 9 species, found on *Ternstroemia gymnanthera*, 7 species on *Peltophorum pterocarpum*, 6 species on *Schima Wallichii*, 5 species on *Castanopsis* sp and 5 species on *Mangifera indica*. (Tergym = *Ternstroemia gymnanthera* Bedd., Pelpte = *Peltophorum pterocarpum* Back., Schwal = *Schima Wallichii* Korth., Castanopsis = *Castanopsis* sp., Manind = *Mangifera indica* Linn).

## Ecological Discussion

### Species Discussion

The diversity of Trypetheliaceae in Thailand comprised of 38 species and 6 genus. The hill evergreen forests, the tropical rain forests and the dry evergreen forests can be considered as of humid forests of low and moderate temperature, whereas dry and high temperature are characteristics of the mixed deciduous forests, the dry dipterocarp forests, urban, plantation and reforestation. The common species, *Trypethelium*, are mostly distributed in

the hill evergreen forest. Sixteen species colonized the moist habitat, seven species inhabit the dry habitat. Only one species, *Trypethelium tropicum*, was collected from the mangrove forest, where humidity and osmotic pressures were high from sea-salt aerosol. This species was also found in the dry habitat at the dry dipterocarp forests, reforestations and the hill evergreen forests, the tropical rain forests and the dry evergreen forests. Obviously, *T. tropicum* has wide ranges of habitats. It occurred in every forest types in Thailand (Table 7).

Ten species of *Laurea* prefers the moist habitat. However, *Laurera benguelensis, L. keralensis, L. madreporiformis* and *L. subdiscreta* were common in the dry habitat. They produced the muriform ascospores with length between 50-60 μm. In the dry evergreen forests at Khao Yai National Park, *Laurera tuberculosa* produced larger muriform ascospores (90-100 x 36-38 μm) than those (60-66 x 10-12 μm) found at Kaeng Kra Chang Nation Park, where atmospheric moisture is lower than Khao Yai National Park. Therefore, the size of the ascospores were affected by the environment.

It should be noted that *Laurera benguelensis, L. keralensis, L. madreporiformis, Trypethelium eluteriae* and *T. tropicum* can survive in both of the tropical forest and the dry dipterocarp forests. These areas exhibit different environmental, but these five species were able to adapt and colonize in these forests. *Laurera benguelensis* and *Trypethelium eluteriae* are widely distributed throughout the countries, whereas the other three species occurs sporadically (Table 7).

Table 7 Distribution of the Lichen Family Trypetheliaceae in Various Types of Forests.

| Environment | Humid and low temperature | | | Dry and high temperature | | | | | High humid osmotic pressure |
|---|---|---|---|---|---|---|---|---|---|
| | Low tem | Moderate tem. | | Natural | | Man-made | | | |
| Ecosystem / Genus | Hill evergreen forest | Tropical rain forest | Dry evergreen forest | Mixed deciduous forest | Dry dipterocarp forest | Urban | Planta-tion | Re-forestation | Mangrove forest |
| *Astrothelium cinnamomeum* | + | - | - | - | - | - | - | - | - |
| *A.galbineum* | + | - | - | - | + | - | - | - | - |
| *A.eustomum* | + | - | - | - | - | - | - | - | - |
| *Campylothelium nitidum* | + | - | + | - | + | - | - | - | - |
| *C. superbrum* | - | - | + | - | - | - | - | - | - |
| *Laurera benguelensis* | + | + | + | + | + | + | - | + | - |
| *L. keralensis* | + | + | + | - | + | + | - | - | - |
| *L. madreporiformis* | + | + | + | + | + | - | - | - | - |
| *L. megasperma* | - | - | + | - | - | - | - | - | - |
| *L. meristospora* | + | + | + | - | - | - | - | - | - |
| *L. meristosporoides* | + | - | - | - | - | - | - | - | - |
| *L. phaeomelodes* | + | - | - | - | - | - | - | - | - |
| *L. subsphaerioides* | + | - | - | - | - | - | - | - | - |
| *L. subdiscreta* | + | - | - | + | + | - | - | - | - |
| *L. tuberculosa* | - | - | + | - | - | - | - | - | - |
| *Polymeridium albidum* | + | - | - | - | - | - | - | - | + |
| *P. albocinereum* | - | - | - | - | - | - | - | + | - |

Table 7 (continued)

| Environment | Humid and low temperature | | | Dry and high temperature | | | | | High humid osmotic pressure |
|---|---|---|---|---|---|---|---|---|---|
| | Low tem | Moderate tem. | | Natural | | Man-made | | | |
| Ecosystem / Genus | Hill evergreen forest | Tropical rain forest | Dry evergreen forest | Mixed deciduous forest | Dry dipterocarp forest | Urban | Planta-tion | Re-forestation | Mangrove forest |
| *P. catapastum* | + | - | + | - | - | - | - | - | - |
| *P. pleiomeroides* | - | - | - | - | - | - | + | - | - |
| *P.quenqueseptatum* | + | - | - | - | - | - | - | - | - |
| *Pseudopyrenula diluta var. degenerans* | + | + | + | - | - | - | - | + | - |
| *Trypethelium albopruinosum* | + | - | - | - | + | - | + | - | - |
| *T. andamanicum* | - | + | - | - | - | - | - | - | - |
| *T. cinereo-rosellum* | + | - | - | - | - | - | - | - | - |
| *T. celatum* | + | - | - | - | - | - | - | - | - |
| *T. concatervatum* | - | - | + | - | - | - | - | - | - |
| *T. eluteriae* | + | + | + | - | + | + | + | - | - |
| *T. luteum* | - | + | - | - | - | - | - | - | - |
| *T. microstomum* | + | - | + | - | - | - | - | - | - |
| *T. myriocarpum* | + | - | - | - | - | - | - | - | - |
| *T. nigroporum* | - | - | + | + | + | - | - | - | - |
| *T. ochroleucum* | + | - | + | - | - | - | - | + | - |

Table 7 (continued)

| Environment | Humid and low temperature | | | Dry and high temperature | | | | | High humid osmotic pressure |
|---|---|---|---|---|---|---|---|---|---|
| | Low tem | Moderate tem. | | Natural | | Man-made | | | |
| Ecosystem / Genus | Hill evergreen forest | Tropical rain forest | Dry evergreen forest | Mixed deciduous forest | Dry dipterocarp forest | Urban | Planta-tion | Re-forestation | Mangrove forest |
| *T. ochroleucum var. subdissocian* | + | - | + | - | - | + | + | - | - |
| *T. tropicum* | + | + | + | - | + | - | - | + | + |
| *T.* unidentified A | + | - | - | - | + | - | - | - | - |
| *T.* unidentified B | - | - | + | - | - | - | - | - | - |
| *T.* unidentified C | + | - | - | - | - | - | - | - | - |
| *T.* unidentified D | - | + | - | - | - | - | - | - | - |
| Total (species) | 27 | 10 | 18 | 4 | 11 | 4 | 4 | 5 | 2 |

The ecorticate lichen, *Polymeridium* was found in the humid of low and moderate temperature of the hill evergreen forests and the dry evergreen forests. *Polymeridium albidum* occurs only in the mangrove forests. The only species of *Pseudopyrenula* occur mostly in the humid and low temperature as well as in reforestation.

All species of *Astrothelium* favor condition in the hill evergreen forests. *Astrothelium galbimeum* was found in the dry dipterocarp forest, and the sites of exposing light in the hill evergreen forests (Table 7). *Campylothelium* occurred in the dry evergreen forests, nevertheless *C. nitidum* colonized the hill evergreen and the dry dipterocarp forests. Therefore, it is rather difficult to justify the preference of this genus.

**Characteristics of Forests**

The hill evergreen forests provide favorable condition for the Trypetheliaceae. The main characteristics of this forest are humid, low temperature and high elevations (1,000-1,500 m elevations) that compose of mixture of shade and large canopy gap, which exposed to strong wind. Twenty two species were found with well developed thallus and five species with ecorticate thallus. The well-developed thallus was able to adapt and colonize in this environment. Climate of the hill evergreen forests in Thailand are fluctuated, therefore both humid and dry species can be found.

The dry evergreen forests and the hill evergreen forests are uncommon. The dry evergreen forest has moderate temperature, situated on lower altitude

(700-1,000 m elevations). Nevertheless, eleven species and one variety are commonly share in these habitats. These are *Campylothelium nitidum, Laurera benguelensis, L. keralensis, L. madreporiformis, L. meristospora, Polymeridium catapastum, Pseudopyrenula diluta* var. *degenerans, Trypethelium eluteriae, T. microstomum, T. ochroleucum, T. ochroleucum* var. *subdissocian* and *T. tropicum*. The dry evergreen forests and the hill evergreen forest provided moist and shaded habitats, with less fluctuation, which may be favorable for growth of this species.

The wet and shaded habitat of the tropical rain forests are optimal conditions for plant growth throughout the year. Normally, species which mostly occur in the humid tropical are those require high humid environment (Saxen 1963, quoted in Kappen 1973, 365). Nevertheless, their distribution is limited by low light environment under the canopy of the tropical rain forest. Number of species of the Trypetheliaceae observed at this ecosystem is lesser than the two previously mentioned ecosystems. This survey found ten species, with six common species shared with the hill evergreen forest and the dry evergreen forest. These six species are *Laurera benguelensis, L. keralensis, L. madreporiformis, L. meristospora, Pseudopyrenula diluta* var. *degenerans, Trypethelium eluteriae,* and *T. tropicum.* In addition, the height of canopy was a major limitation for collection of the specimens. Samplings at the canopy level are required in the future for further conclusion.

The dry and high temperature habitats in this study are represented by two forests, the mixed deciduous forests and the dry dipterocarp forests, in addition to three disturbed areas, reforestation, plantation and urban. The

mixed deciduous forests and the dry dipterocarp forests are similar. This is probably due to climate between the two sites, which are characterized by severe drought during six month of dry monsoon and extreme wet during six month of heavy rain during the wet monsoon. These areas are frequently disturbed by fire. Trees in these forest have thick corticate bark that resist to fire, such as teak (*Tectona grandis*), taeng (*Shorea obtusa*) or rang (*S. siamensis*). There is still a great diversity of corticolous lichen on *S. obtusa* (Wolseley and Aguirre-Hudson 1997c, 357). The difference between the two sites lies only on soil characteristic that is independent from growth of the corticolous lichens.

The lichen flora of the dry habitat are represented by those found in the dry dipterocarp forests. Four of these species (*Laurera benguelensis, L. medreporiformis, L. subdiscreta* and *Trypethelium tropicum*) are commonly found in the mixed deciduous forests. However, collection in the mixed deciduous forests were not as intensive as the dry dipterocarp forest. Consequently, lesser number of taxa was found. A species of poorly developed thallus was collected in the dry dipterocarp and was absent from the mixed deciduous forests. The cause of this is still unknow.

Few species was found in the disturbed areas, reforestation, plantation and urban, however *Astrothelium* and *Campylothelium* species were not presented. Air quality in Bangkok is more polluted than the forests mentioned earlier. Lichens are sensitive to air pollution and easily disappear from the urban areas (Richardson 1991, 30). Nevertheless, a few species have been recognized as in habitors of the polluted cities in Europe and North America

e.g. *Buellia punctata, Lecanora conizoides, L. dispersa* (Richardson 1991, 40). The presence of *Trypethelium eluteriae* in Bangkok metropolitan area is noteworthy. *T. eluteriae* has never been reported from other urban area. More importantly, the *T. eluteriae* is also found in the other ecosystems except the mangrove forest. Laboratory examination revealed that this species contains crystals of calcium oxalate at the centrum, above the ascomata. This substance or other lichen products, that may present, probably play a significant role in protecting the lichens from adverse effects of the unfavorable condition. Thus, this species is able to distribute abundantly.

The mangrove forest has high humid as well as high osmotic pressure from sea-salt aerosol. The vegetation is under water stress in this condition. The lichens, *Trypethelium tropicum* and *Polymeridium albidum* which survived in this environment should possess lichen substances or having unique physiological performance that enable them to survive under high osmotic pressure from sea-salt aerosol of the maritime influences. Tolerance of these lichens in mangrove forests require further investigation.

The altitude affects diversities of the lichens. In the tropical mountain of Venezuela, the occurrence of the lichens is strongly limited at around 4,500 m elevations and mostly reduce vitality beyond 4,750 m elevation (Varreschi 1956; Hertel 1971, quoted in Kappen 1973, 361). Collections in this investigation were performed at the highest altitude of 1,500 m. Diversity of the Trypetheliaceae in Thailand increase for 1-2 species in each level of 300 meter higher elevations. This is consistent with their occurrence reported in Venezuela (Varreschi, 1956; Hertel 1971, quoted in Kappen 1973, 361).

The Khao Yai National Park houses the highest diversity of the Trypetheliaceae in Thailand (Figure 59). This is probably due to diverse topography and habitats of the park. In addition, intensive explorations have been performed in this area. Ramkhamhaeng National Park, Kasetsart University, Mu Koh Chang National Park and in the mangrove forest at the provinces of Rayong and Chanthaburi and Trad were the areas that have been disturbed heavily by human activities. Most of the Trypetheliaceae could not survive under this harsh environment. Therefore, only a few species were collected.

**Substatrum Effect**

The most favorit host species of the Trypetheliaceae was *Ternstroemia gymnanthera.* This tree species was found in the hill evergreen forests at Khao Yai National Park. *Peltophorum pterocarpum, Schima wallichii* and *Castanopsis sp* were the second most favorit hosts of the Trypetheliaceae. *Pseudopyrenula diluta* var. *degenerance*, the ecorticate species, and *Trypethelium tropicum*, the species with well developed thallus, were often found on trunk of *Ternstroemia gymnanthera*, *Peltophorum pterocarpum* and *Schima wallichii.* The lichens produced absolutely deferent characteristic of thallus. *Trypethelium eluteraie* were often found on *Peltophorum pterocarpum* and *Pterocarpus macrocarpus* which grow in the metropolitan areas. Other host trees supported a few species of the Trypetheliaceae. Texture of bark was relatively important for survival of the lichens (Brodo, 1973). The

Trypetheliaceae species are mostly growth on trees with smooth bark. Tress with rough bark were rarely found these lichens. In addition, thick bark with high moisture content and possibly high nutrient, such as barks of *Peltophorum pterocarpum,* are often found the Trypetheliaceae. The acidity of bark may influence germination of the Trypetheliaceae. This point requires the further investigation.

The *Trypethelium* and *Laurera* occur throughout Thailand. The bright yellow lichens, *Laurera benguelensis,* and *Trypethelium eluteriae* were found in almost every forest type. They dominated in the dry dipterocarp forests. These species produced lichexanthone, parietin and various pigments, which may protect their thallus from ultraviolet irradiation, and bright light. The importance of secondary metabolites in protecting the photobiont from the harmful effects of high light intensity and ultraviolet irradiation are well-documented (Rundell 1978, quoted in Wolseley 1997). In addition, lichen products may be function as antibiotics and fungicides that protect the lichen thallus from invasion by foreign lichens or propagules of other species (Lawray 1986; Elix 1996, quoted in Wolseley 1997). However, other substances may be important to survival in different environment of various ecosystems.

**Other Effect**

Thailand is under the influence of monsoon climate, but topography plays important roles in determination of forest characteristics. The forest

types in Thailand are very difficult to delimit absolutely due to continuous changes in topography. Many forest areas are the mixtures of two or more sub types of forests. The mixed deciduous forests are always occupied small areas under other forest types. In addition, moist microhabitat in the hill evergreen forest which favor growth of also mosses and epiphyte support high diversity of the Trypetheliaceae.

Future studies to enhance understanding of the Trypetheliaceae in Thailand are recommended in these areas. Firstly, intensive exploration in the eastern and the southern peninsular. Seconly, analysis and synthesis of the chemical constituents for taxonomic criteria and economic benefit. Lastly, employ biomolecular and phylogenetic to determine taxa.

## REFERENCES


Ahmadjian, V., and M. E. Hale. 1973. **The lichens**. New York: Academic.

Aptroot, A. 1991. A Monograph of the Pyrenulaceae (Excluding Anthracothecium and Pyrenula and the Requienellaceae, with Notes on the Pleomassariaceae, the Trypetheliaceae and Mycomicrothelia (Lichenized and Non-lichenized Ascomycetes)). **Biliotheca Lichenologica** 44: 1-153.

_____, P. Diederich, E. Serusiaux, and H. J. M. Sipman. 1997. Lichens and lichenicolous fungi from New Guinea. **Biliotheca Lichenologica** 64: 1-220.

Awasthi, D. D. 1991. A key to the Microlichen of India, Napal and Sri Lanka. **Biliotheca Lichenologica** 40: 1-360.

Brodo, I. M. 1973. Substrate ecology. In **The lichens,** ed. V. Ahmadjian, 410-441. New York: Academic Press.

Degelius, G. 1940. Contributions to the lichen flora of North America. I. Lichen from Maine. **Arkiv för Botanik** 30A. No1.

Dodge, C. W. 1953. Some lichens of Tropical Africa. **Annals of the Missouri Botanical Garden** 40: 286-297.

_____.1964. Some lichens of Tropical Africa. IV. Dermatocaceae to Pertusariaceae. **Nova Hedwigia** 12: 19-29.

Egan, R. S. 1987. A fifth checklist of the lichen-forming, Lichenicolous and allied fungi of the continental United States and Canada. **The Bryologist** 90, 2: 77-173.

Elix, J. A., and P. M. McCarthy. 1998. Catalogue of the lichens of the smaller Pacific Island. **Biliotheca Lichenologica** 70: 1-361.

Feuerer, T. 1998. **Checklist of Venezuelian lichens** [Online]. Available URL: http:// rrz.uni-humburg.de/biologie/ialb/herbar/venez_f2.ht.

_____. 1999. **Checklist of Bolivian lichens** [Online]. Available URL: http:// rrz.uni-humburg.de/biologie/ialb/herbar/boliv_f2.ht.

_____. 2000. **Checklist of Chilean lichens** [Online]. Available URL: http://rrz.uni-humburg.de/biologie/ialb/herbar/chile_f2.ht.

_____. 2000. **Checklist of Ecuadorian lichens.** [Online]. Available URL: http:// rrz.uni-humburg.de/biologie/ialb/herbar/ecuad_f2.ht.

_____. 2000. **Checklist of Paraguayian lichens.** [Online]. Available URL: http://rrz.uni-humburg.de/biologie/ialb/herbar/parag_f2.ht.

_____. 2000. **Checklist of Peruvian lichens.** [Online]. Available URL: http:// rrz.uni-humburg.de/biologie/ialb/herbar/peru_f2.ht.

Filson, R. B. 1996. **Checklist of Austalian lichens and allied fungi. Flora of Australia supplementary series 7.** Canberra: Australian Biological resources Study.

Hale, M. E. 1983. **The Biology of lichens.** London: Edward Arnold.

Harris, R. C. 1975. A taxonomy revision of the genus *Arthopyrenia* Massal. s. lat. (Ascomycetes) in North America. Doctoral thesis, Michigan State University, East Lansing.

Harris, R. C. 1984. The family Trypetheliaceae (Loculoascomycetes: lichenized Melanommatales) in Amazonian Brazil. **Acta amazon., Manus.** 14, 1/2: 55-80.

_____. 1989. A sketch of the family *Pyrenulaceae* (*Melanomatales*) in eastern North America. **Memoirs of the New York Botanical Garden** 49: 74-107.

_____. 1991. A reversion of *Polymeridium* (Müll. Arg.) R. C. Harris (Trypetheliaceae). **Boleti do Museu Paraense Emilio Goedi, Botanica** 7: 619-644.

_____. 1995. Including The 10c Tour of the Pyrenolichens. **More Florida Lichens.** Bronx: The New York Botanical Garden.

_____. 1998. A preliminary revision of *Pseudopyrenula* Müll. Arg. (Lichenized Ascomycetes, Trypetheliaceae) with a redisposition of the names previously assigned to the genus. **Lichenographia Thomsaniana.** North America: Lichenology in Honor of John W. Thomson.

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.

Homchatara, N. 1999. The taxonomic and ecological aspects of the Thelotremataceae in Southeast Asia. Doctoral thesis, Liverpool John Moores University.

Jiang-chum, W. 1991. **An Enumeration of Lichens in China.** Beijing: International Academic Publishers.

Kansri Boonpragob. 1999. **Thailand's country study on Climate Change 1990**. Bangkok: Thailand Environment Institute.

_____, 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.

Kappen, L. 1973. Response to extreme environments. **The Lichens.** (ed. By V. Ahmadjian). pp. 310-380. New York: Academic Press.

Letrouit-Galinou, M. A. 1957. Revision monographique de genre *Laurera* (Lichens, Trypetheliaceae). **Revue Bryol. Lichen** 26: 207-264.

_____. 1958. Revision monographique de genre Laurera (Lichens, Trypetheliaceae). Supplement I. **Revue Bryol. Lichen** 27: 66-73.

Magnusson, A. H., and A. Zahlbruckner. 1944. Hawaiian lichens. **Arkiv for Botanik** 31 A, 10: 45-55.

Makhija, U., and P. G. Patwardhan. 1988a. The lichen genus *Laurera* (family *Trypetheliaceae*) in India. **Mycotaxon** 31: 565-590.

_____. 1988b. Material for a lichens flora of the Andaman Islands. IV. Pyrenocarpous lichens. **Mycotaxon** 31, 2: 467-481.

_____. 1992. Nomenclatural notes on some species of *Trypethelium*. **Int. J. Mycol. Lichenol.** 5, 3: 237-251.

_____. 1993. A contribution to our knowledge of the lichen genus *Trypehtelium* (family Trypetheliaceae). **Journal of the Hattori Botanical Laboratory** 73: 183-219.

Malcolm, W. M., and D. J. Galloway. 1997. **New Zealand Lichens Checklist, Key and Glossary.** Wellingtion: Museum of New Zealand Te Papa Tongarewa.

Marcelli, M. P. 2000. **Checklist of Brazilian lichens.** [Online]. Available URL: http:// rrz.uni-humburg.de/biologie/ialb/herbar/brazi_f2.ht.

Mathey, A. 1979. Contribution à l' étude de la famille des Trypétheliacées (lichens pyrénomycétes). **Nova Hedwigia** 31: 917-935.

Mc Carthy, P. M. 1993. New records of pyrenocapous lichens from Australia. **Muelleria** 8, 1: 31-36.

_____. 1995. *Laurera papilosa* (Trypetheliaceae), A remarkable new lichen from Papua New Guinea. **The Lichenologist** 27, 4: 310-314.

_____., and G. Kantvilas. 1993. *Laurera robuta* (Trypetheliaceae), A new alpine lichen from Tasmania. **The Lichenologist** 25, 1: 51-55.

Müller, A. 1884. Revisio Lichenum Eschweilerianorum. **Flora** 35: 1-17.

_____. 1885. Pyrenocarpeae Cubenses. **Botanische Jahrbücher.**

_____. 1888a. Lichenes Paraguayenses. **Revue Mycologigue du 1$^{er}$** 38: 1-32.

_____. 1888b. Pyrenocarpeæ Feeanæ. **Mémoires de la Societété de Physique et d Histoire Naturelle de Genève** 30, 3: 3-45.

_____. 1891a. Lichenes Bellendenici. **Hedwigia** 1: 47-56.

_____. 1891b. Lichenes Brisbanenses. **Nuovo Giornale Botanico Italiano** 23, 3: 385-404.

Müller, A. 1891c. Lichenes Tonkinenes. **Hedwigia** 4: 181-189.

_____. 1892. Lichenes Manipurenses. **Linnean Society's Journal-Botany** 29: 217-231.

Myrdal, M. 1998. **Erick Acharius, the father of lichenology.** [Online]. Available URL: http:// linnaeus,nrm.se/botany/kbo/ach/ welcome.html.en.

Nash, T. H., III, 1996. **Lichen biology.** Cambridge: Cambridge University Press.

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.

Ommatavivat, F. 1994. Chemotaxonomy and chemistry of lichens in Southern Thailand. Final report of Faculty of Science, Prince of Songkla University.

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.

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.

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: The British Lichen Society.

Richardson, R. D. S. 1991. Pollution monitoring with lichens. **Naturalist's Handbooks,** 19. London: Richmond.

Roger, R. W. 1992. Key to Australian lichen genera in flora of Australia. Vol.54, **Lichens introduction Lecanorales 1.** Canberra: An A PGS.

Tem Smitinand. 1977. **Vegetation and Ground Cover of Thailand.** Kasetsart University. Technical Paper, no. 1: 160-171. Bangkok: n.p.

_____. 1980. **Thai Plant Names (Botanical names-Vernacular names).** Bangkok: Royal Forest Department.

Thrower, S. L. 1988. **Hong Kong Lichens.** Hong Kong: The urban Council Hong Kong.

Tucker, S. C., and R. C. Harris. 1980. New and noteworthy Pyrenocarpous lichens from Louisiana and Florida. **Bryologist** 83, 1: 1-20.

Sanit Aksornkoae. 1998. **Mangrove..Ecology and management.** Bangkok: Kasetsart University Press.

Somkit Pongpayant, and Suparp Phupaasert. 1971. **Edible and Poisonous Plants in Thai Forest.** Bangkok: Science Social of Thailand.

Singh, A. 1982. Observations on some Pyrenocarpous lichen1. **Nova Hedwigia** 36: 237-239.

Streimann, H. 1986. Cataloque of lichens of Papua New Guinea and Irain Jaya. **Biliotheca Lichenologica** 22: 1-145.

Upreti, D. K., and A. Singh. 1987. Lichen genus *Laurera* from the Indian subcontinent. **Bulletin de Jardin Botanique National de Belgique** 57: 367-383.

Vainio, E. A. 1909. Lichen. **Botanik Tidsskrift** 29: 104-152.

Vickery, M. L. 1984. Tropical vegetation. **Ecology of Tropical Plants.** Canada: John Wiley & Son.

Weerachai Nanakorn.1993. **A preliminary study on the forest vegetation of Thailand.** Bangkok: Botanical Garden.

Wetmore, C. M. 1963. Catalogue of the lichens of Tasmania. **Revue Bryol. Lichen** 32: 229-230.

Wolseley, P. A. 1997. Response of epiphytic lichens to fire in tropical forest of Thailand. ***Biliotheca Lichenologica** 68: 165-176.*

_____, 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.

Wolseley, P. A., and B. Aguirre-Hudson. 1997a. **Lichens of tropical forest in Thailand. a field key to characteristic epiphytic species in North Thailand.** London: Botanic Department, Natural History Meuseum.

_____. 1997b. The ecology and distribution of lichens in tropical deciduous and evergreen forests in Thailand. **Journal of Biogeography** 24: 327-343.

_____. 1997c. Fire in tropical dry forests: corticolous lichens as indicators of recent ecological change in Thailand. **Journal of Biogeography** 24: 345-362.

Wolseley, P. A., Moncrieff, C., 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.

Zahlbruckner, A., 1951. **Catalogus Lichenum Universalis** 1: 471-508.

_____ .1951. **Catalogus Lichenum Universalis** 10: 99-103.

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Kajohnsak Vongshewarat, Piboon Mongkolsuk, and Kansri Boonpragob. 1997. Some Pyreno Crustose Lichen in Thailand. In **Proceedings of the 23th congress on science and technology of Thailand**, 402-403. Bangkok: Pinyo Press.

_____. 1998. Study on Taxonomy and Ecology of the Lichen Family Trypetheliaceae in Thailand. In **Research Reports on Biodiversity in Thailand of Proceeding Congress BRT 2,** 148. Bangkok: Work Press Printing.

_____. 1998. Study of the lichens family Trypetheliaceae at Khao Ka Dong Forest Park, Buri Ram Province. In **Proceedings of the 24th congress on Science and technology of Thailand,** 442-443. Bangkok: Pinyo Press.

_____. 1999. Study on Taxonomy and Ecology of the Lichen Family

*Trypetheliaceae* in Thailand. **Research Reports on Biodiversity in Thailand of Proceeding Congress BRT 3.** 119-123. Bangkok: Work Press Printing

Kajohnsak Vongshewarat, McCarthy, P.M., Piboon Mongkolsuk and Kansri Boonpragob.1999. Additions to the Lichen Flora of Thailand. **Mycotaxon.** 70: 227-236.