ความหลากหลายของเทอริโดไฟต์ตามแนวเกรเดียนต์ของพื้นที่ที่ถูกรบกวนบริเวณเหมืองแร่ในอำเภอทองผาภูมิ จังหวัดกาญจนบุรี

นางสาวอภิรดา สถาปัตยานนท์

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
สาขาวิชาพฤกษศาสตร์ ภาควิชาพฤกษศาสตร์
คณะวิทยาศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2546
ISBN 974-17-5009-9

PTERIDOPHYTE DIVERSITY ALONG A GRADIENT OF DISTURBANCE WITHIN MINES IN THONG PHA PHUM DISTRICT, KANCHANABURI PROVINCE

Miss Apirada Sathapattayanon

A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Science in Botany
Department of Botany
Faculty of Science
Chulalongkorn University
Academic Year 2003

ISBN 974-17-5009-9

Thesis Title	PTERIDOPHYTE DIVERSITY ALONG A GRADIENT OF DISTURBANCE WITHIN MINES IN THONG PHA PHUM DISTRICT, KANCHANABURI PROVINCE
By	Miss Apirada Sathapattayanon
Field of Study	Botany
Thesis Advisor	Associate Professor Thaweesakdi Boonkerd, Ph.D.

Accepted by the Faculty of Science, Chulalongkorn University in Partial Fulfillment of the Requirements for the Master's Degree

……Dean of Faculty of Science
(Professor Piamsak Menasveta, Ph.D.)

THESIS COMMITTEE

…….. Chairman
(Associate Professor Nantana Angkinand)

…….……. Thesis Advisor
(Associate Professor Thaweesakdi Boonkerd, Ph.D.)

…….. Member
(Associate Professor Chirayupin Chandraprasong)

…….. Member
(Tosak Seelanan, Ph.D.)

อภิรดา สถาปัตยานนท์: ความหลากหลายของเทอริโดไฟต์ตามแนวเกรเดียนต์ของพื้นที่ที่ถูกรบกวนบริเวณเหมืองแร่ ในอำเภอทองผาภูมิ จังหวัดกาญจนบุรี (PTERIDOPHYTE DIVERSITY ALONG A GRADIENT OF DISTURBANCE WITHIN MINES IN THONG PHA PHUM DISTRICT, KANCHANABURI PROVINCE) อาจารย์ที่ปรึกษา: รองศาสตราจารย์ ดร. ทวีศักดิ์ บุญเกิด 199 หน้า. ISBN 974-17-5009-9.

ได้ศึกษาความหลากหลายของเทอริโดไฟต์ ตามแนวเกรเดียนต์ของพื้นที่ที่ถูกรบกวนบริเวณเหมืองแร่ที่อำเภอทองผาภูมิ จังหวัดกาญจนบุรี ตั้งแต่เดือนกรกฎาคม พ.ศ. 2545 ถึง เดือนมีนาคม พ.ศ. 2546 โดยวางแปลงทดลองขนาด 5 ม. x 20 ม. จำนวน 12 แปลงในแต่ละพื้นที่ศึกษา ซึ่งได้แก่ พื้นที่เหมืองทิ้งร้าง พื้นที่เหมืองที่ยังคงสภาพธรรมชาติ และพื้นที่ป่าธรรมชาติ รวมทั้งสิ้น 36 แปลง ศึกษาความหลากหลายของเทอริโดไฟต์โดยนับจำนวนชนิดและจำนวนของแต่ละชนิดที่พบในแปลงทดลอง วิเคราะห์ค่า Species richness index ค่า Species diversity index ค่า Species evenness index และค่าความเหมือนของชนิด โดยใช้ Menhinick's index, Shannon-Weiner's index, Evenness index และ Jaccard's coefficient ตามลำดับ พบว่า Species richness index และ Species diversity index ของพื้นที่เหมืองทิ้งร้าง มีค่าต่ำกว่าบริเวณพื้นที่เหมืองที่ยังคงสภาพธรรมชาติ และพื้นที่ป่าธรรมชาติ แต่ Species evenness index มีค่าสูงกว่าพื้นที่อื่นๆ ค่าความเหมือนของชนิดมีค่าต่ำมากแสดงให้เห็นว่า แต่ละพื้นที่ศึกษามีเทอริโดไฟต์ต่างชนิดกัน ได้ศึกษาปัจจัยทางกายภาพ คือ ความเข้มแสง และอุณหภูมิใบของเทอริโดไฟต์ วิเคราะห์ความสัมพันธ์ระหว่างปัจจัยดังกล่าวกับค่า Species richness index ค่า Species diversity index และค่า Species evenness index พบว่าทั้งสองปัจจัยมีความสัมพันธ์เชิงลบต่อค่า Species richness index แต่มีความสัมพันธ์เชิงบวกกับค่า Species evenness index และไม่มีความสัมพันธ์กับค่า Species diversity index ในการศึกษาครั้งนี้เก็บตัวอย่างเทอริโดไฟต์ได้ 184 หมายเลข จำแนกเป็น 65 ชนิด 1 ชนิดย่อย 5 พันธุ์ ใน 40 สกุล จาก 20 วงศ์ ในจำนวนนี้เป็นพืชใกล้เคียงเฟิร์น 8 ชนิด 2 สกุล 2 วงศ์ การศึกษาครั้งนี้พบเทอริโดไฟต์ 3 ชนิด ได้แก่ *Cheilanthes tenuifolia* (Burm. f.) Sw., *Sphenomeris chinensis* (L.) Maxon var. *divaricata* (H. Christ) K.U. Kramer และ *Lycopodiella cernua* (L.) Pic. Serm. เฉพาะในพื้นที่เหมืองทิ้งร้างเท่านั้น โดยมีแนวโน้มว่าจะเป็นชนิดบ่งชี้ถึงสภาพพื้นที่ที่ถูกรบกวนได้ นอกจากนี้ *Lindsaea ensifolia* Sw. และ *Pteris biaurita* L. สามารถพบได้ในทุกพื้นที่ศึกษา โดยมักเจริญบนพื้นที่ลาดชันที่ค่อนข้างแห้งหรือบนพื้นราบที่เป็นดินทรายในบริเวณที่เปิดโล่ง ได้จัดทำรูปวิธานจำแนกชนิด คำบรรยายลักษณะอย่างละเอียด พร้อมทั้งข้อมูลทางนิเวศวิทยา การกระจายพันธุ์ ชื่อพื้นเมือง รูปวาดลายเส้น และภาพถ่ายของเทอริโดไฟต์บางชนิด

ภาควิชา.....พฤกษศาสตร์.....ลายมือชื่อนิสิต .....

สาขาวิชา.....พฤกษศาสตร์.....ลายมือชื่ออาจารย์ที่ปรึกษา.....

ปีการศึกษา 2546

4472487323: MAJOR BOTANY
KEY WORD: PTERIDOPHYTE / DIVERSITY / GRADIENT / DISTURBANCE / MINES / THONG PHA PHUM / KANCHANABURI

APIRADA SATHAPATTAYANON: PTERIDOPHYTE DIVERSITY ALONG A GRADIENT OF DISTURBANCE WITHIN MINES IN THONG PHA PHUM DISTRICT, KANCHANABURI PROVINCE. THESIS ADVISOR: ASSOC. PROF. THAWEESAKDI BOONKERD, Ph. D. 199 pp. ISBN 974-17-5009-9.

The diversity of pteridophyte in Thong Pha Phum District, Kanchanaburi Province was conducted along a gradient of disturbance within mines, from July 2002 to March 2003. Twelve plots of 5 x 20 meters have been established in each three study sites, i.e. abandoned mines, remnants of the forest in mine area and natural forests. Pteridophyte diversity was determined by counting the number of species and individuals in each plot. Species richness, species diversity and species evenness indices were estimated using Menhinick's, Shannon-Weiner's and evenness indices, respectively. Species similarity was investigated using Jaccard's coefficient. Other physical environments related to pteridophyte diversity were examined, including light intensity and leaf temperature. Species richness and species diversity of abandoned mines were lower than those of remnants of the forest in mine area and natural forests, while species evenness was the highest of all. Low Jaccard's coefficient was observed, indicating the difference of pteridophyte species between each sites. Light intensity and leaf temperature showed negative significant correlation with Menhinick's index, but was positively significantly correlated with evenness index. However, significant correlation between those physical factors and Shannon-Weiner's index was not found. One hundred and eighty-four specimens of pteridophytes were collected from the 36 sampling plots and identified to 65 species, 1 subspecies, 5 varieties, in 40 genera, from 20 families. Among these 8 species, 2 genera, 2 families are fern allies. It was found that *Cheilanthes tenuifolia* (Burm. f.) Sw., *Sphenomeris chinensis* (L.) Maxon var. *divaricata* (H. Christ) K.U. Kramer and *Lycopodiella cernua* (L.) Pic. Serm. were found only in abandoned mines and tend to be indicator species for disturbed areas. Two terrestrial ferns, namely *Lindsaea ensifolia* Sw. and *Pteris biaurita* L. were commonly found in all study sites. They can be found on rather dry slopes or sandy ground, usually in open areas, but rarely on rocks. Dichotomous keys to species, full description, together with ecological data, distribution and vernacular name of each species were prepared. In addition, photographs and line drawings of some species were also provided.

Department……Botany ……. Student's signature…….…….
Field of study…….Botany ……..Advisor's signature…….
Academic year 2003

ACKNOWLEDGEMENTS

I would like to express my deepest thank and appreciation to my thesis advisor, Associate Professor Dr. Thaweesakdi Boonkerd, for his encouragement and valuable advice throughout the period of study. Furthermore, the beautiful pteridophytes' pictures in this thesis were taken by him.

I wish to express my sincere thanks to the thesis committees, Associate Professor Nantana Angkinand, Associate Professor Chirayupin Chandraprasong, Dr. Tosak Seelanan for their valuable comments and suggestions.

I am grateful to Associate Professor Dr. Obchant Thaithong, Associate Professor Busban Na Songkla, Associate Professor Wiyada Thephuttee, Miss Rossarin Pollawatn, Mr. Boonsanong Chourykaew, Mrs. Parinyanut Darumas, Miss Suchada Wongpakam and all staff of the Professor Kasin Suvatabhandhu Herbarium (BCU) for their advices and helps.

My special thank is to Mr. Job Boonpanya who help me in everything he can and he also encourage me from the past to the present.

My appreciation is to Miss Paweena Triperm, Mr. Tanucha Boonjaras and Mr. Piroon Potiapiyanwisult, for their kindly advices, line drawing and helping hand.

Sincere thanks to all of my friends who help me during field collection: Miss Orawan Wannasri, Miss Paweena Jaikrasane, Mr. Sahanat Phetsri, Mr. Manit Kidyu, Miss Wilawan Rattanathirakul, Miss Somruetai Chaiyapo, Miss Oratai Neamsuvan, Miss Pankamon Sornsuwan, Miss Pichaya Pongtudsirikul, Miss Anchalee Petchuensakul, Mr. Yotsawate Sirichamorn, Mr. Pitha Ratanasinlapin, and Miss Wasinee Khwaiphan.

I also sincere thank to PTT Public Company Limited for helping me to get access to the study area, especially to Mr. Chaiwat Somboonsab and Mr. Naowarat Subtanawin.

Thanks to Department of Botany, Faculty of Science, Chulalongkorn University and the Plants of Thailand Research Unit for providing laboratory facilities for this thesis.

This work was largely supported by The TRF/BIOTEC Special Program for Biodiversity Research and Training grant BRT T_145037, and in partly the Graduated School, Chulalongkorn University.

Finally, I am extremely grateful to my parent and grandfather for their loves and rewardless supports.

CONTENTS

PAGES

LIST OF SCIENTIFIC NAMES

SPECIES PAGES

LIST OF SCIENTIFIC NAMES (CONTINUED)

SPECIES PAGES

LIST OF SCIENTIFIC NAMES (CONTINUED)

SPECIES PAGES

LIST OF TABLES

TABLE PAGES

LIST OF FIGURES

FIGURES PAGES

LIST OF FIGURES (CONTINUED)

FIGURES PAGES

LIST OF FIGURES (CONTINUED)

FIGURES PAGES

LIST OF FIGURES (CONTINUED)

FIGURES PAGES

LIST OF FIGURES (CONTINUED)

FIGURES PAGES

LIST OF FIGURES (CONTINUED)

FIGURES PAGES

CHAPTER 1

INTRODUCTION

Thailand situated in Indochinese peninsula which is part of south-east Asian region and covering an area of 513,115 km^2. The country lies between latitudes 5° 36'-20° 27' North and longitudes 97° 20'-105° 37' East. Thailand shares boundaries with the Lao People's Democratic Republic and the Union of Myanmar to the north, the Lao People's Democratic Republic to the east, Cambodia to the south-east, the Union of Myanmar to the west, and Malaysia to the south. Thailand has maximum dimensions of about 2,500 km north to south and 1,250 km, east to west, with a coastline of approximately 1,840 km on the Gulf of Thailand and 865 km along the Indian Ocean (Royal Institute, 2002). The country does not have unique floristic elements, but shares plant species composition with the neighboring countries. Thus, Thailand could be considered as a collective center of plant diversity from 3 major phytogeographical elements, i.e. Indo-Burmese, Indo-Chinese and Malesian (Suntisuk, 1989).

At present, about 25% of the country area is under forest cover which include forest plantations. It is estimated that there are about 13,200 species of vascular plants (Nanakorn, 1994) of which 671 are pteridophytes (Boonkerd and Pollawatn 2000). It seems likely that Thai flora is particular rich in comparison with some other countries in the world, even though many native species have disappeared in many habitats. Over the last five decades, forest areas have turned into dams, mines, agricultural and urban areas, all have led to a reduction in biodiversity. Unfortunately, the number of plant species previously occurred in the country before human disturbance remains unknown.

Botanical explorations of plant diversity in some specific sites in Thailand were mainly focused on flowering plants and usually excluded detailed study of pteridophytes, especially ecology and diversity of pteridophytes in disturbed and undisturbed areas. So far, these two topics have never been studied. Naturally, pteridophyte is a plant group which is rather sensitive to environmental changes, especially air and soil humidity. They do need to have water for their everyday life.

Anyhow, there are some pteridophyte species that can adapt and withstand dry and sunny habitats of disturbed areas (Boonkerd, 1998).

Thong Pha Phum District in Kanchaniburi Province is located in south-western Thailand which is a part of Thai western forest. Over the last six decades, this district was famous for its richness in mineral resources, such as tin and wolfram as well as a large stretch of fertile forest. There are many forest types in this area, i.e. tropical rain forest, dry evergreen forest, dry mixed deciduous forest and hill evergreen forest (Royal Forest Department, n.d.). By that time, there were some human activities, for example active logging and mining in the area, resulting in massive deforestation throughout. After the Second World War, there was a low demand for tin and wolfram, followed by a series of reductions in prices of these metals in the world market. Nowadays, Thong Pha Phum District have more than 20 abandoned mines left. From the aforementioned information, it is very interesting to investigate an impact of deforestation on plant diversity along a gradient of forest disturbance.

Aims of this Thesis

This study aimed to investigate diversity of plants along a gradient of forest disturbance, using pteridophytes as a representative. Species richness, species diversity together with similarity indices were explored and compared among three sites with different levels of disturbance, i.e. abandoned mine, remnant of the forest in mine areas and natural forest. The data collected will be on one hand useful for biodiversity conservation management and on the other hand may be a basis for further study.

CHAPTER 2

LITERATURE REVIEW

2.1 Biodiversity

Biological diversity or biodiversity refers to the variety of life forms such as the different plants, animals and microorganisms, the genes they hold, and the ecosystems they exist. This creature is the product of hundreds of millions of years of evolutionary history. Biodiversity is usually considered at three different levels: genetic diversity, species diversity and ecosystem or ecological diversity.

Species diversity refers to the variety of living species.

Genetic diversity refers to the variety of genetic information contained in all of the individual plants, animals and microorganisms. Genetic diversity occurs within and between populations of species as well as between species.

Ecosystem diversity relates to the variety of habitats, biotic communities, and ecological processes, as well as the tremendous diversity present within ecosystems in terms of habitat differences and the variety of ecological processes (Baimai, 1989).

This study will focus on species diversity or species abundance relationships in communities. It is composed of two distinct components (Ludwig and Reynolds, 1988).

Species richness is the number of species in community.

Species evenness refers to how the species abundances (e.g., the number of individuals, etc.) are distributed among the species. Evenness is greatest when species are equally abundant.

There are several indices that can be used to characterize species richness and evenness, i.e. species richness indices and species evenness indices, respectively. Moreover, there is an index that attempt to combine species richness and evenness into a single component, i.e. species diversity index (Ludwig and Reynolds, 1988).

Whittaker (1970) classified species diversity into the following 3 types.

Alpha diversity is the species diversity within a site, or local diversity.

Beta diversity is the change in species composition from site to site, or species turnover.

Gamma diversity is the species diversity of a landscape composed of many local habitats, or regional diversity.

2.2 Pteridophytes Ecology

Pteridophytes are sensitive to drought and full sunlight to some extent. They are normally found in moist locations with a continuous water supply, neither too hot nor too cold. Ferns and fern allies do need to have liquid water during their development from spore to gametophyte and mature sporophyte. But once growing in the soil, some ferns and fern allies are rather hardy. Different pteridophytes tolerate different climatic extremes. Some can survive prolonged drought in semi-desert conditions. Other species are adapted to survive under feet of snow, while others thrive in alkaline or contaminated soils.

Some pteridophytes are slow growing and therefore have low nutritional needs so that they survive as terrestrials in poor soils, on rocks or rock crevices as lithophytes, and on tree and shrubs as epiphytes. A number of species which are normally found growing wild as epiphytes may establish themselves on suitable rock surface. There are also climbing plants, which start life on the ground and then climb up trees, sometimes only a little way, sometimes to a great height. There are a few pteridophytes which live at least partly in water. They are called aquatic plants and can be found in brackish or fresh water (Boonkerd and Pollawatn, 2000).

Holttum (1954) classified pteridophytes into 7 groups according to their ecology, which may apply to Thai pteridophytes. Detail examples of Thai pteridophytes are from Boonkerd (1996)

2.2.1 Terrestrial sun-pteridophytes

There are some common pteridophytes grow naturally in fully exposed places where full sunlight directly reach a plant canopy. This habitat can be found on mountain ridges, in disturbed areas by logging, shifting cultivation, or road building, etc. Examples of pteridophytes usually found in this habitat are *Lycopodiella cernua* (L.) Pic. Serm, *Dicranopteris linearis* (Burm. f.) Underw. var. *linearis*, *Pteridium aquilinum* (L.) Kuhn, *Blechnum orientale* L., and *Pityrogramma calomelanos* (L.) Link.

2.2.2 Terrestrial shade-pteridophytes

There are a great number of terrestrial forest pteridophytes, which limit themselves on forest floor where they will be shielded from full sunlight by upper

shrubs or trees. They have different requirements for moist and light conditions. Some occur on dry slopes where soils are rather dry and exposure to partial sunlight. While some terrestrial species confine to humus rich or wet soils in shady places. Some ferns are dwelling near streams or streamlets where sunlight may penetrate to the stream bank. In general, shade-pteridophytes usually grow rather slow as compared with sun-pteridophytes. This may be due in part to the stable condition of the weak light and high humidity which means less loss of water, and less root activity. Members of such habitat include small, medium and large size pteridophytes. For example, *Huperzia serrata* (Thunb. ex Murray) Trevis., *Selaginella* spp., *Pteris biaurita* L., *Tectaria angulata* (Willd.) C. Chr., *Tectaria polymorpha* (Wall. ex Hook.) Copel., *Bolbitis heteroclita* (Presl) Ching ex C. Chr., *Diplazium* spp., *Angiopteris evecta* (G. Forst.) Hoffm., *Cyathea* spp., *Cibotium barometz* J. Sm.

2.2.3 Climbing pteridophytes

These pteridophytes start their life on the forest floor and then climb up trees or shrubs with their long slender rhizomes, such as *Stenochlaena palustris* (Burm. f.) Bedd., *Lomagramma grossoserata* Holttum, and *Teratophyllum ludens* (Fée) Holttum. They usually grow along stream banks or margin of the forests where they are exposed to sunlight over some hours in the morning or in the afternoon during daytime. Some climbing ferns may use their rachis of compound fronds twine on shrubs or trees, such as *Lygodium salicifolium* C. Presl and *Lygodium flexuosum* (L.) Sw.

2.2.4 Epiphytic pteridophytes

Epiphytes use their roots to establish on tree or shrub surfaces. Their water and minerals supply are directly from the air. They are living in two different light conditions.

2.2.4.1 Epiphytic pteridophytes of sheltered places

These epiphytes are usually found on the lower part of trees in the shady forest, usually nearby streams, or amid the cloud-belt of montain forest. Examples include members of the fern families, Hymennophyllaceae and the Grammitidaceae. Other examples are *Huperzia hamiltonii* (Spreng.) Trevis., *Huperzia squarrosa* (G. Forst.) Trevis., *Antrophyum callifolium* Blume, *Asplenium nidus* L., *Colysis pedunculata* (Hook. & Grev.) Ching, *Elaphoglossum* spp., *Vittaria flexuosa* Fée, *Pyrrosia penangiana* (Hook.) Holttum, *Microsorum punctatum* (L.) Copel., *Asplenium crinicaule* Hance, etc.

2.2.4.2 Epiphytic pteridophytes of exposed places

These epiphytes live on upper part of trees. They usually expose to sunlight and wind to some extent. Therefore, they need to adapt themselves to survive during the summer months by having more effective methods of absorbing and storing water. For example, some members of the genus *Pyrossia*, viz. *Pyrrosia adnascens* (Sw.) Ching, *Pyrossia stigmosa* (Sw.) Ching and *Pyrrosia lingua* (Thunb.) Farw. have dense overlapping scales on rhizomes and dense stellate hairs on lower surface of lamina to protect water loss. While *Pyrossia longifolia* (Burm. f.) C.V. Morton has succulent fronds to accumulate water. In contrast, the genus *Drynaria*, i.e. *Drynaria quercifolia* (L.) J. Sm., *Drynaria rigidula* (Sw.) Bedd. have nest leaves, which protect rhizome from direct sunlight and wind. This genus also has succulent rhizome to store water.

2.2.5 Lithophytic pteridophytes

Lithophytes or rock plants usually confine themselves on rocks. Some species thrive in rock crevices on the cliff in partial shade or full sunlight. While some rock ferns stick to muddy, humus-rich or mossy rocks. Most of them have no special adaptations to store water or to prevent excessive loss of water. Some epiphytes can be found on rocks, such as members of the genera *Asplenium*, *Davallia*, *Drynaria*. However, true rock-ferns are not found as epiphytes, such as members of the genus *Bolbitis*, i.e. *Bolbitis appendiculata* (Willd.) K. Iwats., *Bolbitis virens* (Wall. ex Hook. & Grev.) Schott. etc.

2.2.6 Aquatic pteridophytes

There are five main genera of true aquatic pteridophytes, namely *Azolla*, *Ceratopteris*, *Isoetes*, *Marsilea* and *Salvinia*. They have their life cycle mainly in or nearby water. *Azolla*, and *Salvinia* are floating plants commonly found throughout the country. While *Ceratopteris*, *Isoetes*, *Marsilea* are immersed plants usually have their fronds above the water surface and their roots fixed to muddy soil underneath. Anyhow, *Ceratopteris thalictroides* (L.) Brongn. can be found as a submersed plant in some stagnant waters. Some rheophytes confine themselves nearby streams or growing on rocks in the streams. They usually experience flood after heavy rains. They can survive a long period of flood with the submersion of their whole plants. Example of rheophytes are *Microsorum pteropus* (L.) Copel., *Osmunda angustifolia* Ching, *Trichomanes javanicum* Bl.

2.2.7 Mountain pteridophytes

Some pteridophytes grow only on mountainous areas. They may be epiphytes, such as *Huperzia* spp., *Elaphoglossum* spp., *Humata repens* (L. f.) J. Small ex Diels, or lithophytes, such as *Oleandra musifolia* (Blume) C. Presl, or terrestrial, such as *Lycopodium* spp., *Brainea insignis* (Hook.) J. Sm., *Pteridium aquilinum* (L.) Kuhn. On mountain ridges in southern Thailand, there occurs *Dipteris conjugata* Reinw. in exposed and moist place, while *Cheiropleuria bicuspis* (Blume) C. Presl is found in the shade.

2.3 Related Literatures

Hobbs (1988) reported results of her study on vascular plants species richness of urban forest patches and implications for urban landscape diversity. These vascular plants were found to be positively related to their size. There was no significant relationship between species richness and the distance of these patches to other patches. Mowing and trampling reduced species richness of patches, whereas planting increased richness. Landscape richness can be maintained at a relatively high level by leaving even small unmown forested patches within a more disturbed matrix.

Ferreira and Stohlgren (1999) studied the effect of flooding level on tree species richness, diversity, density, and composition in lake, river, and stream habitats in Jaú National Park, Brazil. It was found that forest areas near lake had significantly lower species richness of trees than riverine and streamside habitats. Species richness and diversity were strongly negatively correlated with the water level and duration of flooding. The drier (stream) habitat had more total species and more unique species of trees than the riverine and the lake habitats. Species composition overlap among habitats was high, almost one-third of the species were found in all three habitat types, and few species were unique to each habitat. They concluded that (i) duration of flooding has a strong impact on species richness, diversity and plant distribution patterns; (ii) most species are adapted to a wide range of habitats and flood duration; (iii) flood duration may decrease local diversity.

Anderson (2000) surveyed plants along Old Mine Road (coppermine area) during field trip for the Philadephia Botanical Club, in July 22. There were 32 pteridophytes species, such as *Dennstaedtia punctilobula* (Michx.) T. Moore, *Lycopodium clavatum* L., *Polystichum acrostichoides* (Michx.) Schott, *Pteridium aquilinum* (L.) Kuhn, etc.

In 2001, Kirkman et al. studied plant productivity and species richness across an environmental gradient in a fire-dependent ecosystem. They used a natural gradient to examine how plant species richness and plant community structure vary with standing crop biomass as a function of soil moisture and nitrogen mineralization rates in a frequently burned long leaf pine-wiregrass savanna. Highest ground cover biomass and highest species richness were found at the same position along the gradient. Relative differences in species richness among site types were independent of scale. Nitrogen availability was negatively correlated with species richness. Dominance of wiregrass was consistent across the gradient and not correlated with species richness.

In the same year, Avery (2001) determined an impact of fire retardant on exotic species, species richness, and species diversity in a coastal grassland in central California. He found that the fire retardant significantly increased ammonium and nitrate levels in the soil, and therefore provided essential nutrients for plants. The nutrient inputs resulted in increased growth of exotic annual grasses, but had no effect on exotic thistles.

Kamo et al (2002) reported the results of the study of understorey plant species in various plantations of single exotic or indigenous species in Sakaerat, northeastern Thailand. They concluded that more plant species grew within stands near a natural forest than within grasslands. These forests contribute to the acceleration of the secondary succession from grassland, which was achieved by recurrent fires before reforestation. In the natural regeneration of understorey tree species in planted forests, large tree species in the natural forest seem to be the major common seed source among the stands studie. The small leaf biomass in these planted forests generated enough shade to prevent the invasion of 2 fire-adapted competitive grasses and to provide a suitable light environment for seeding establishment at an early stage of forest development. These factors facilitated the establishment of other species within the plantation of single tree species. Faster-growing exotic species accumulated larger amounts of understorey biomass than indigenous species.

Bhattarai and Vetaas (2003) studied the variation in plant species richness of different life forms along a subtropical elevation gradient in the Himalayas, east Nepal. They reported that the richness of herbaceous species, including herbaceous climbers, was unrelated to any of the climate variables. Potential evapotranspiration (PET) was strongly negatively correlated with elevation, and the following

relationships were found between increasing PET and richness: (i) shrubs, trees and total species showed unimodal responses (ii) ferns decreased monotonically, and (iii) woody climbers increased monotonically. Richness of all woody groups increased monotonically with mean annual rainfall (MAR) and moisture index (MI). The water-energy dynamics model explained 63% of the variation in shrubs, 67% for trees and 70% for woody species combined.

Moreno-Peñaranda (n.d.) studied plant species diversity as indicator of restoration quality: the case of soils amended with sewage sludge in abandoned quarries and showed results that sewage sludge amendment has a clear effect on increasing plant cover and plant biomass in the first stages of secondary succession, although differences in plant cover have almost disappeared six years later. Plant species richness decreased in sewage-sludge-treated plots, while diversity and evenness indices were not related to treatment. Species composition, including exotic plants, was analyzed in terms of similarity, but a clear relation to treatment was not found.

Seefeldt and McCoy (2003) assessed plant diversity in the tall threetip sagebrush (*Artemisia tripartita* subsp. *tripartita*) steppe: influence of previous grazing management practices. The study site is contained within a long-term sheep grazing. There were a total of 84 species in the sampled areas with 69 in the spring-grazed area and 70 each in the fall-grazed and ungrazed areas. The vegetation within plots was equally rich in and even with similar numbers of abundant species. The spring-grazed plots had half as much plant cover as the fall-grazed and ungrazed plots and the spring-grazed plots had the largest proportion of plant cover composed of introduced (27%) and annual (34%) plants. The fall-grazed plots had the highest proportion of native perennial grasses (43%) and the lowest proportion of native annual forbs (1%). The ungrazed plots had the lowest proportion of introduced plants (4%) and highest proportion of native perennial forbs (66%).

Makgomol (1982) studied some ecological characters of pteridophytes in hill evergreen forest at Doi-Pui, Chiang Mai Province. Four different habitats were selected: (1) opened area (2) 10-years old area after shifting cultivation (3) area where only underground species were removed but still had some trees left and (4) natural forest area. It was found that the relative humidity, percent of soil organic matter, and light intensity were related to the different species, density, and growth of pteridophytes. Moreover, each different habitat has different pteridophyte species.

Thommathawan and Thommathawan (1983) studied and collected sun-pteridophytes on Phu Kradung National Park, Loei Province, which get highly sunbeam all day. They reported 19 species from 16 genera of pteridophytes, which were grown in exposed areas. These pteridophytes have the protective structures from sunburn, for example, waxy fronds, hairy and scalely rhizome. Pteridophytes' photographs were taken and dichotomous keys to genera and species were constructed.

Foosombut (1985) studied the relationship between pteridophytes and environmental factors of hill evergreen forest at Doi Suthep-Pui, Chiang Mai Province. She investigated numbers of species between 1,000-1,600 m altitudes. Three plots of 5x5 meters were established at every 100 m elevation. It was found that pteridophytes were different at different altitudes at each season.

Vannasri (2002) explored pteridophyte diversity in natural forest and along natural gas pipeline in Thong Pha Phum District, Kanchanaburi Province. It was concluded that species richness and species diversity in natural forests were signicantly higher than those along natural gas pipeline. Low or nil of Jaccard's coefficient was observed between these two habitats, indicated different species composition of pteridophytes. Margalef and Shannon diversity indices showed positive significantly correlated with %soil water content, but negatively significant correlation was observed with light intensity (%PAR). Canonical discriminant analysis was employed to reveal discrepancy of physical environmental factors between the disturbed and undisturbed areas. It was found that soil pH and light intensity (%PAR) were the most two important factors to discriminate these two habitats.

CHAPTER 3

STUDY SITE

3.1 Location and History

Thong Pha Phum District covers an area of 3,655.71 km.^{2} It is located on the north-western of Kanchanaburi Province and lies between latitudes 14° 15’ - 15° 00’ North and longitudes 98° 15’ - 99° 00’ East. It is bounded on the north by Sangkhla Buri District, Umphang District of Tak Province, and Ban Rai District of Uthaithanee Province, on the south by Sai Yok District, on the east by Si Sawat District, and the west by the Union of Myanmar (Figure 3.1) (Royal Institute, 2002).

The national border between Thailand and the Union of Myanmar is “Ta Nao Sri Range”. This mountain range is also called “the Tenasserim Hills Biogeographic Units”. It is the location of “Western Forest Complex”, the largest forest of Thailand, composed of several forest types, such as dry dipterocarp forest, mixed deciduous forest, dry evergreen forest, and hill evergreen forest. Its abundance of ecosystem makes Western Forest Complex have more than 2,500 species of plants, 153 species of Mammalia, 490 species of Aves, 89 species of Reptilia and at least 108 species of fish. It is the distribution center of plants and animals from several regions, therefore Ta Nao Sri Range is a fertile and complex land (Anonymous, 2004). But in the past, the abundant biodiversity in this area was disturbed by forestry concession, dam, natural gas pipeline, mine, etc. Some parts of Western Forest Complex are the disturbed areas at present.

Ta Nao Sri Range is the one of important mineral resources of Thailand, especially tin and wolfram, which synchronized within granite rock layer. It is about 20 kilometers of the mineral streak along Ta Nao Sri Range (Royal Institute, 2002). In 1938, Thai government issued mining concessions in Western Thong Pha Phum District (N. S. Consultant, 1989). Since then, more than 20 mines were active resulting in massive deforestation throughout the district. After the Second World War, there was a low demand for tin and wolfram, followed by a series of reductions in prices of these metals in the world market. Nowadays, Thong Pha Phum District have more than 20 abandoned mines left, covering an area of more than 60 km^2 (Tuleewan, 2000).

The abandoned mines were excavated to remove the land surface above mineral layer. The physical structure of soil became mixed up, the slopes fallen down, the humus and soil sludge were washed out by rainfall. The areas have only medium to large size of rocks, almost no soil (N. S. Consultant, 1989). However, there were steep slopes or valleys or streams. Those conditions are not suitable for mining.

At present some parts of the district are declared as Thong Pha Phum Natioinal Park to encourage the forest conservation and development, which is the part of "Western Forest Complex". The Western Forest Complex in Kanchanaburi Province consists of Thong Pha Phum Natioinal Park, Thung Yai Naresuan Wildlife Sanctuary, Sai Yok National Park, Khao Laem National Park, Lum Klong Ngu National Park, Khaoen Sri Nakalin National Park, Erawan National Park and Salak Phra Wildlife Sanctuary (Figure 3.2). Thong Pha Phum Natioinal Park is bounded by Thong Pha Phum and Si Sawat Districts, covers an areas of 1,120 km^2 (Royal Forest Department, n.d.), and includes all of tin and wolfram abandoned mines of Thong Pha Phum District.

3.2 Topography

In general, the western part of Thong Pha Phum District is the mountainous areas of Ta Nao Sri Range. The park ranges in elevation from 100-1,249 m at the summit of Chang Puak Mountain. Several mountains of Ta Nao Sri Range are the important water sources for the park, streams originating from this mountain flow into waterfalls and downward streams which flow together into Vajiralongkorn Dam and Kwae Noi River (Royal Forest Department, n.d.).

3.3 Edaphic structure

Soil Survey Division of Land Development Department reported the detailed reconnaissance soil survey of Kanchanaburi Province, the details included soil series of each district. It was found that, there were two soil series characteristics in Thong Pha Phum District. The main area of the district is the Slope Complex (SC), The rest is Chan Tuk Series (CT).

Slope Complex is a complex of soils developed from residuum and slope colluvium derived from sedimentary rocks (sandstone, shale) and related metamorphic rocks and some igneous rocks (mainly andesite) on hills and mountains. Slopes are steeper than 16-20%. The components of the Slope Complex are not

identified for reasons of inaccessibility and limited agricultural potential. Most of the soils of the Slope Complex are deep, well drained soils that have a moderate permeability, a moderate available water holding capacity and a rapid to very rapid runoff. They have dark grayish brown or grayish brown sandy loam, loam or clay loam surface overlying yellowish red to red clay subsoils with variable gravel contents. Moist consistence is friable to firm and structure is moderate to strong blocky. In general, soils of the Slope Complex have a low natural fertility. In the main surface soils have medium to slightly acid soil reaction (pH 5.5-6.5), whereas subsoils have very strongly acid soil reaction (pH 4.5-5.5). Main management problems are steep slopes and hence very severe susceptibility to erosion if the forest cover is cleared.

Chan Tuk Series is residual and colluvial and/or transported soils formed from granitic rock and occur on erosion or local washed surface. Relief is undulating, range of slope is 2-5%. Drainage is excessive, permeability is moderate to rapid and runoff is medium to rapid. Natural fertility is low; reaction is medium acidic to slightly acidic throughout the profile (Soil Survey Division, 1994).

3.4 Lithology

The lithology of these areas is illustrated by metamorphic rock, sedimentary rock and igneous rock. Metamorphic rock in Precambrian-Cambrian is represented mainly by gneiss, phyllite, schist and quartzite. Ordovician rock consists mainly of limestone, and interbedded by shale. Silurian-Devonian-Carboniferous rocks consist of sandstone, mudstone, shale and limestone. Permian rock composes of limestone with siliceous nodules, this rock unit usually occuring in Karst topography. Triassic rock is represented by conglomeratic limestone, conglomerate and unconsolidated sediments. Along stream, sediments consist of Ouaternary fluvial deposit. Igneous rock; granite can be found in several localities in these areas, that correlated with metamorphic rock and mineral resources such as arsenopyrite, barite, galena, magnetite, stibnite and iron. In addition, the mineral resources correlate with Ordovician limestone. (Kokjalearnsap et al, 1988)

3.5 Climate

The climate of Thong Pha Phum District is a tropical climate, with average high rainfall year round. Three distinct seasons are observed in this area, i.e., the summer season during February-April, the rainy season during May-October, and the winter season during November-January (Meteorological Department, 2003). The south-western Monsoon blows to Ta Nao Sri Range and brings continuous heavy rain through 6 months. The nearest station of the study sites is Pilok Mine Station, but it has only temperature data of 2002 and rainfalls from 1998-2003. It is marked out approximately by the geographical coordinates of latitude 14° 38′ north and longitude 98° 26′ east. The Thong Pha Phum Climatic Station in Kanchanaburi Province has the complete set of climatological data. It is marked out approximately by the geographical coordinates of latitude 15° 45′ north and longitude 98° 38′ east.

The climatological data from 1973-2003 (Figure 3.3) at Thong Pha Phum Station indicate an average annual relative humidity of 79.2%. The average maximum relative humidity is 93.2% and the average minimum relative humidity is 55.75%. The average annual temperature is 26.8 °C, while the average maximum temperature is 33.4°C in April and the average minimum temperature is 20.4 °C in December. The average monthly rainfall is 147.3 mm. The highest average monthly rainfall, of approximately 349.4 mm is observed in August. While, the lowest monthly rainfall of about 8.4 mm is found in December (Meteorological Department, 2003).

Temperature data of 2002, from Pilok mine Station (Figure 3.4) show the average temperature of about 22.7°C. The highest temperature is 33°C in April and the lowest temperature is 14°C in December. Mean monthly rainfall from 1998-2003 at Pilok mine Station (Figure 3.5) shows the average annual rainfall of 417 mm. The highest average monthly rainfall of approximately 1,251 mm was observed in August. The lowest monthly rainfall of about 12.68 mm is observed in December. The total annual rainfall is 5005 mm.

3.6 Vegetation

The vegetation of Thong Pha Phum National Park includes tropical rain forest, dry evergreen forest, dry mixed deciduous forest, and hill evergreen forest (Anonymous, 2004).

3.6.1 Tropical rain forest: characteristic tree species include *Dipterocarpus* spp., *Hopea* spp., etc.

3.6.2 Dry evergreen forest: characteristic tree species include *Toona ciliate* M. Roem., *Magnolia elegans* (Blume) H. Keng, etc.

3.6.3 Dry mixed deciduous forest: *Phyllocarpus septentrionalis* Donn. Sm., *Lagerstroemia* spp., *Dillenia* spp.,and *Afzelia xylocarpa* (Kurz) Craib are commonly found in this forest type.

3.6.4 Hill evergreen forest: characteristic tree species include Fagaceae, *Betula alnoides* Buch.-Ham. ex G. Don, *Manglietia garrettii* Craib, *Dracontomelon dao* (Blanco) Merr. ex Rolfe, *Styrax* spp., *Cinnamomum* spp.,and *Schima wallichii* (DC.) Korth.

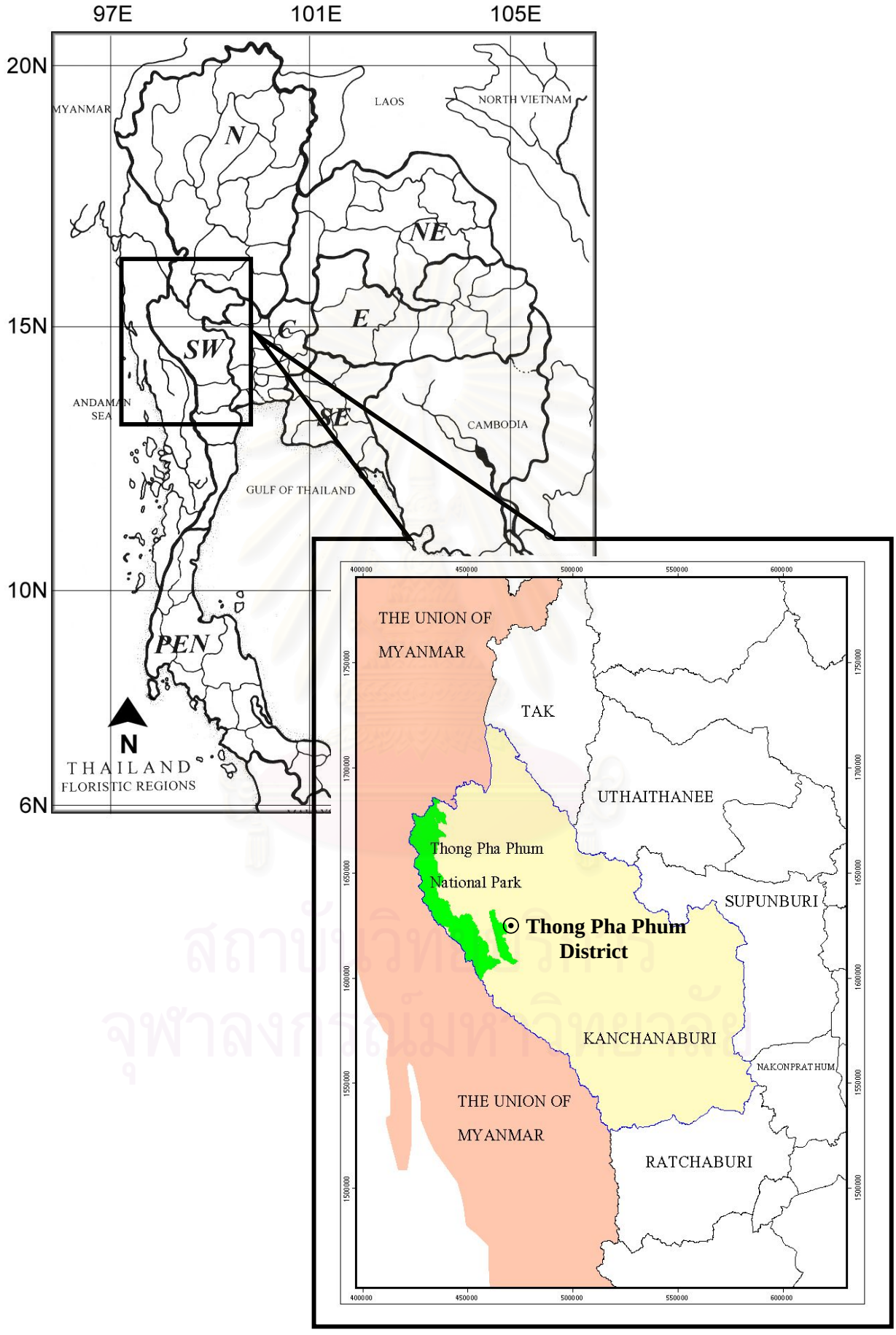


Figure 3.1 Locations of Thong Pha Phum District and Thong Pha Phum National Park.

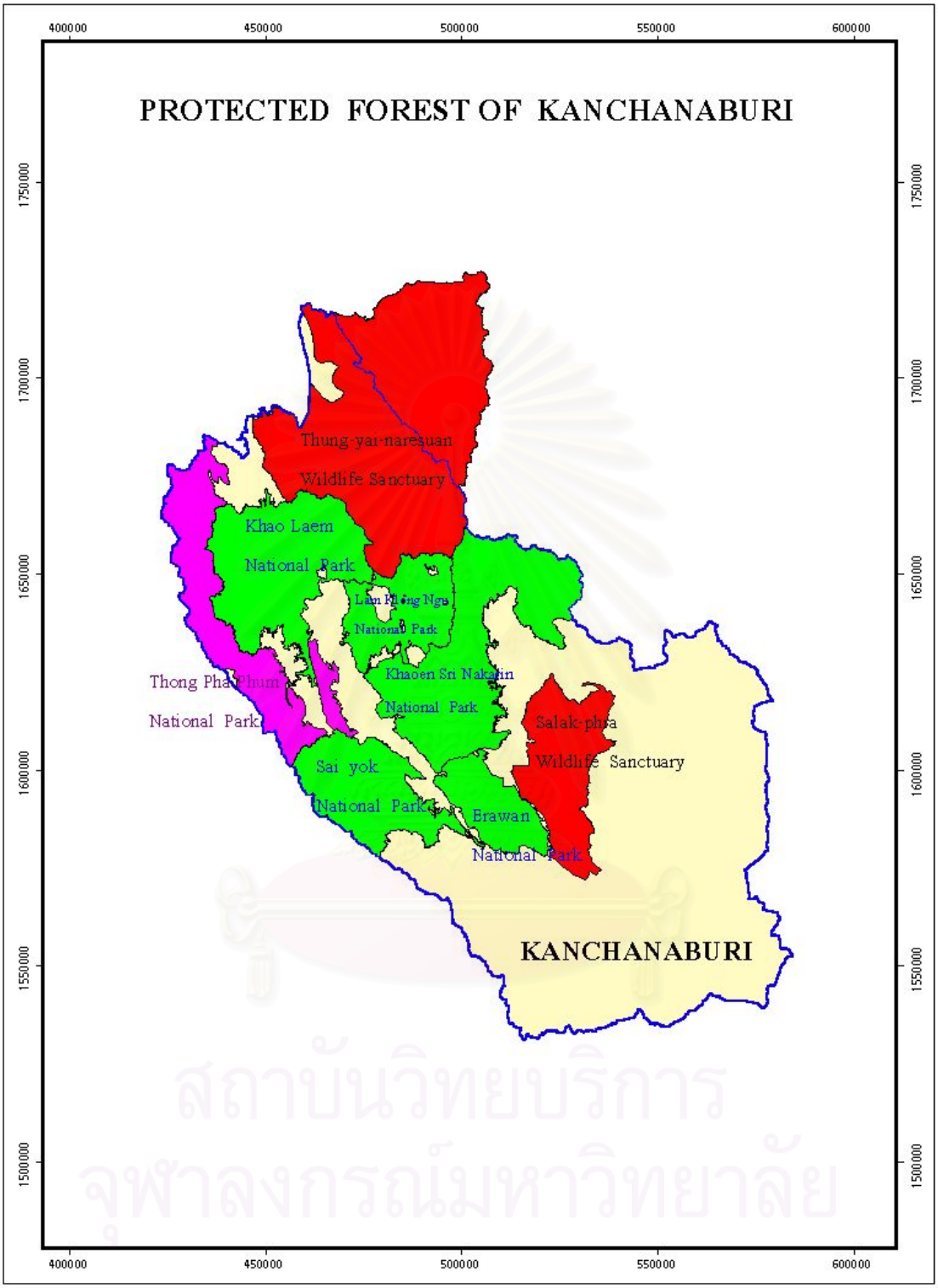


Figure 3.2 Thong Pha Phum National Park and adjacent protected areas.

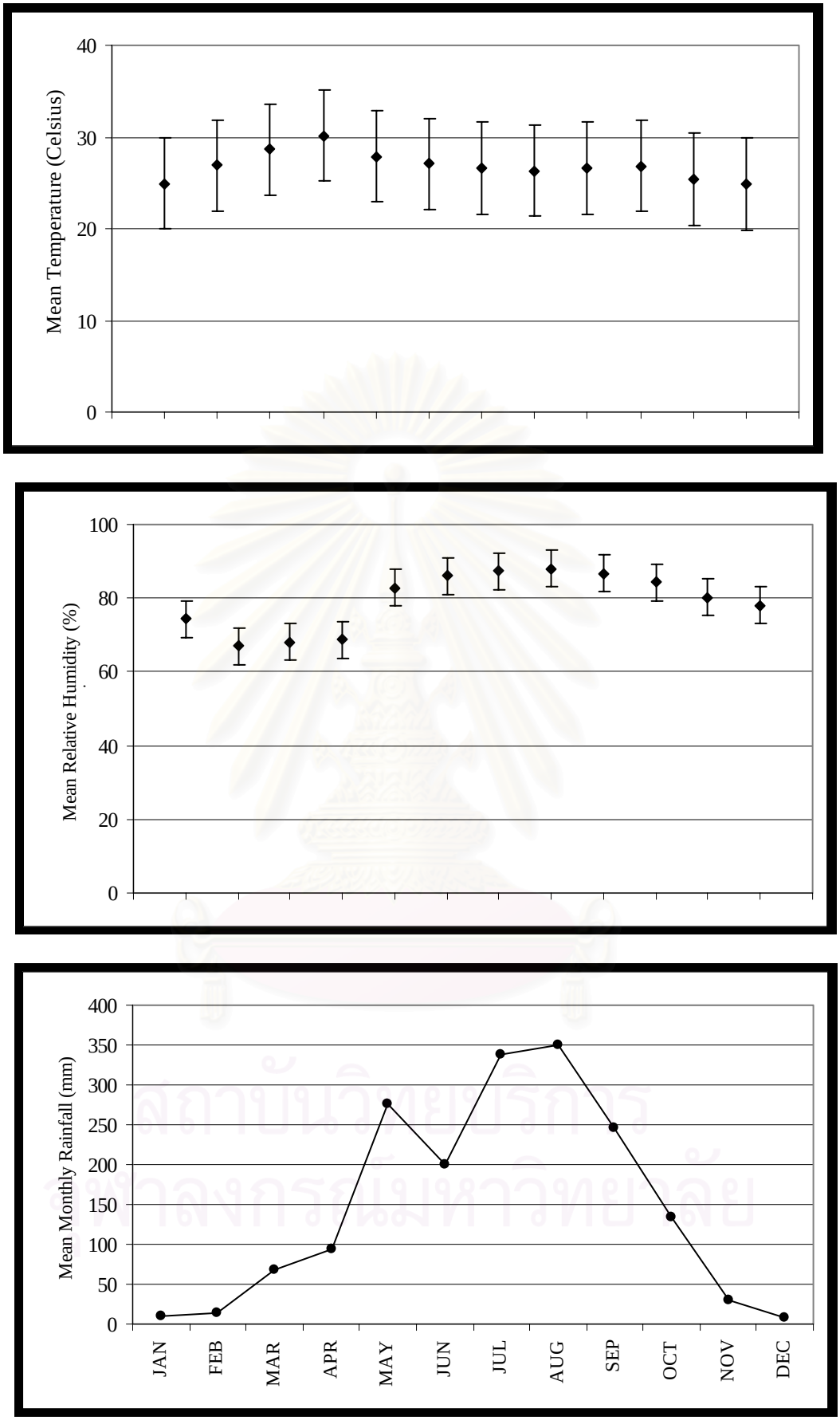


Figure 3.3 Climatological data during the period, 1973-2003, from Thong Pha Phum Station (Data from the Meteorological Department, Bangkok, Thailand).

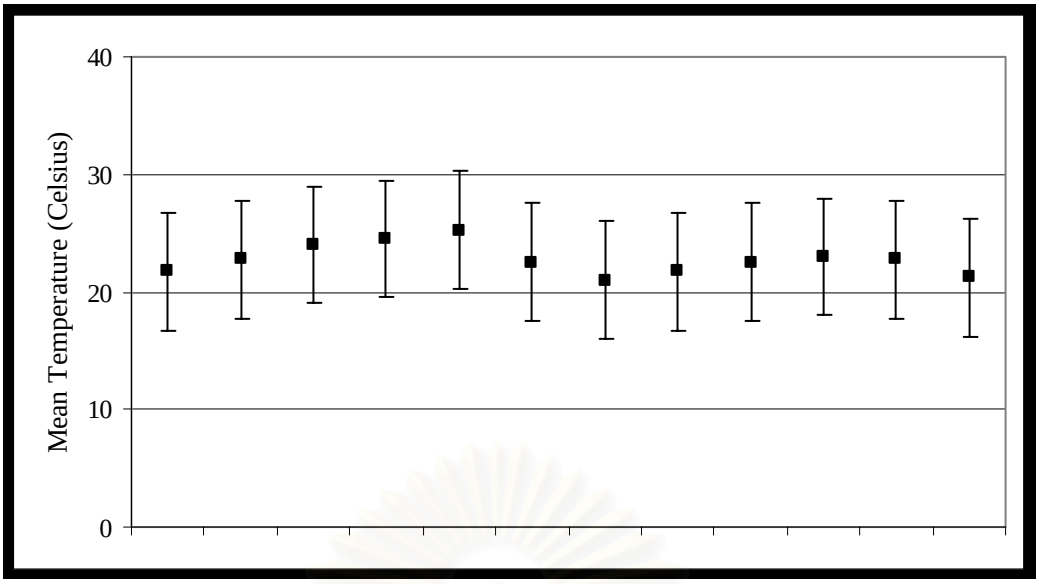


Figure 3.4 Mean temperature of 2002, from Pilok mine Station (Data from the Meteorological Department, Bangkok, Thailand).

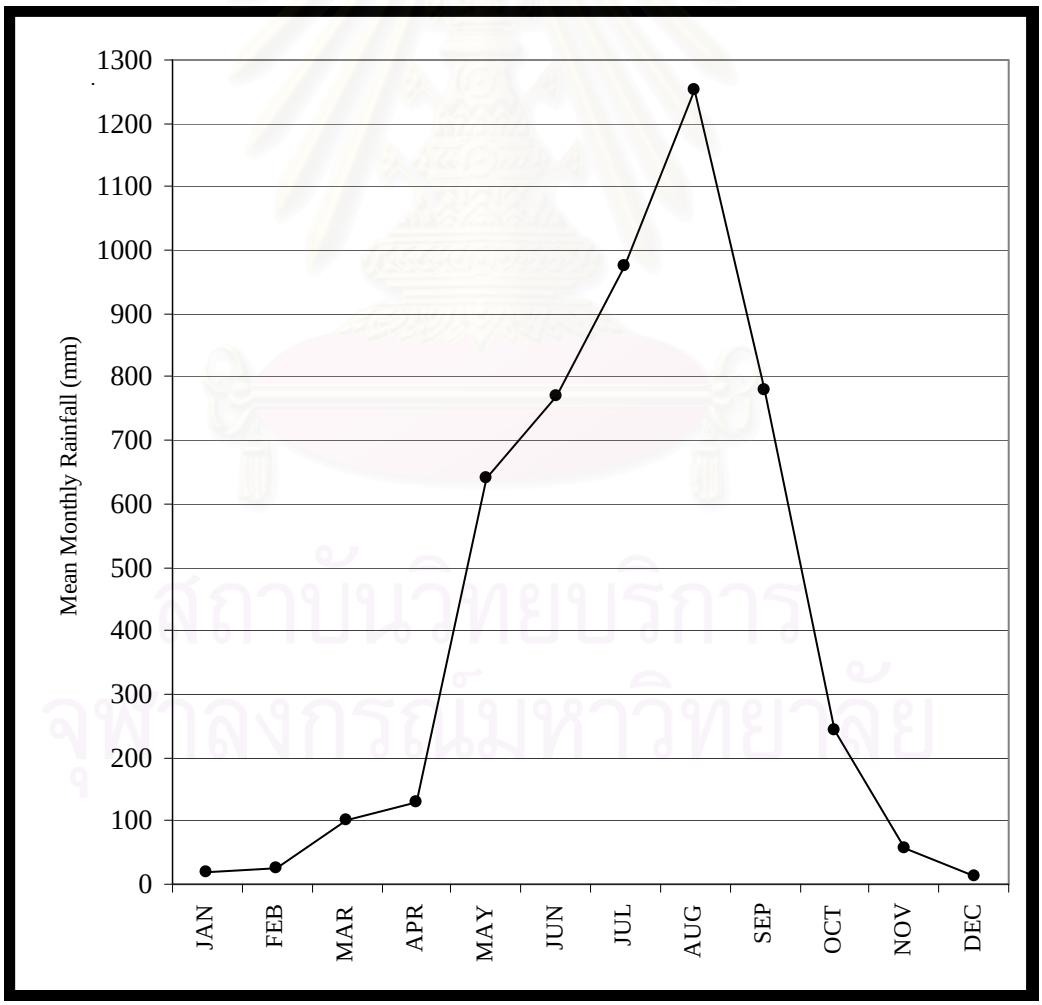


Figure 3.5 Mean monthly rainfall during the period, 1998-2003, from Pilok mine Station (Data from the Meteorological Department, Bangkok, Thailand).

Figure 3.6 Abandoned mine, plot 8.

Figure 3.7 Remnant of the forest in mine area, plot 2.

Figure 3.8 Natural forest, plot 7.

CHAPTER 4

MATERIALS AND METHODS

4.1 Materials

4.1.1 Specimen collecting equipments

- a plant press, 30 x 45 cm
- sheets of newspapers
- corrugated cardboard
- hand pruners
- spade
- quantum photometer, model: LI-189
- thermocouple, model: HI 9053
- plastic bags
- hand lens
- field note
- digital camera, model: CoolPix 995
- altimeter
- binocular
- The Global Positioning System (GPS) Equipment, Garmin model: Etrex/ Vista
- Collector's number card

4.1.2 Herbarium specimen preparing equipments

- deep freezer (-40 °C)
- hot air oven
- mounting paper, 30 x 42 cm
- species covers, 30 x 42 cm
- genus covers, 30 x 42 cm
- latex mixed with synthetic glue in ratio 1:1
- label pad, about 10.5 x 13.5 cm
- needle and thread
- sand bags

4.1.3 Identification equipments

- dissecting microscope
- dissecting needles
- forceps
- razor blades
- petri dishes
- microscopic slides and cover glasses
- related taxonomic literatures of pteridophytes
- voucher specimens in herbaria: Forest Herbarium (BKF) and Prof. Kasin Suvatabhandhu Herbarium (BCU).

4.2 Method

4.2.1 Literature review

- The related literature was searched from the libraries at the Prof. Kasin Suvathabhandhu Herbarium, Department of Botany, Chulalongkorn University (BCU) and from online CU-reference database via internet.
- The general data of this studied site such as location, area, boundary, topography, climate, vegetation, and transportation were studied from the park's folders, prior field trip was made.

4.2.2 Exploration and collection

- Field collection of pteridophyte was conducted at least every two month from July 2002 to July 2003 at Thong Phaphum District, Kanchanaburi Province.
- Simple random sampling method (Krebs, 1998) was employed; twelve plots of 5 x 20 meters were established at each three main study sites, i.e., abandoned mines, remnants of the forest in mine area and natural forests.
- The number of species and individuals in each plot was counted and the physical environment factors related to pteridophyte diversity were measured including light intensity and leaf temperature.

Measurements were made during 10.00-14.00 hours. Four measurements of Photosynthetically active radiation (PAR) and air temperature in full sun 1 m above the plots were measured using quantum photometer and thermocouple, respectively. Likewise, four measurements of PAR and leaf temperature at canopy of a dominant species within each plot were also measured. The mean values of these four data points were calculated, then an estimate of the percentage of full sunlight penetrating to pteridophyte's canopy and the ratios of leaf temperature and air temperature at 1 m above each plot were obtained.

- Three duplicates of pteridophyte specimens were collected and photographs of habit and habitats were taken.
- Ecological data as well as diagnostic characters of each species were noted.

4.2.3 Laboratory study

4.2.3.1 Pteridophytes diversity analysis

- Species richness index was estimated using Menhinick's index (Ludwig and Reynolds, 1988) defined as (equation 1):

$$R = \frac{S}{\sqrt{n}} \qquad (1)$$

R is species richness index.

S is number of pteridophyte's species in the plot.

n is number of all individual pteridophytes in the plot.

- Species diversity index was estimated using Shannon-Weiner's diversity index (Ludwig and Reynolds, 1988) from the defined as (equation 2):

$$H' = -\sum_{i=1}^{S^*} \{(pi\ [\ln(pi)]\} \qquad (2)$$

H' is species diversity index.

S is number of pteridophyte's species in the plot.

pi is equal to $\frac{ni}{n}$

ni is number of each pteridophyte's species in the plot.

- Species evenness index was estimated using Evenness Index 1 (Ludwig and Reynolds, 1988) from the defined as (equation 3):

$$E_1 = \frac{H'}{\ln(S)} \quad (3)$$

E_1 is evenness index 1.

H' is species diversity index.

S is number of pteridophyte's species in the plot.

- One-way analysis of variance (ANOVA) was used to test for differences between study sites for species richness index, species diversity index, species evenness index, percentage of full sunlight penetrating to pteridophyte's canopy and the ratio of leaf temperature and air temperature. Duncan Multiple Range Test (DMRT) was used to compare means where the F-test was significant.

4.2.3.2 Similarity coefficient analysis.

- Jaccard's coefficient was used to investigate similarity coefficient (Krebs, 1998) to compare species overlap between the study sites. It is derived from (equation 4).

$$Sj = \frac{a}{(a+b+c)} \quad (4)$$

Sj is Jaccard's similarity coefficient.

a is number of pteridophyte's species was found in both a and b sample group.

b is number of pteridophyte's species was found in only a, but don't found in b sample group.

c is number of pteridophyte's species was found in only b, but don't found in a sample group.

4.2.3.3 Relationships between the physical environment factors and pteridophyte diversity were analysed using Pearson's Correlation available in SPSS for Windows Program, version 9.0.

4.2.3.4 Taxonomic study

- Dried herbarium specimens were prepared as described in Boonkerd et al. (1987) and deposited at BCU.
- Plant specimens were identified using both keys and descriptions from taxonomic literatures, such as Flora, Manual, Monograph, Research papers, etc.
- Specimens of each species were proved for identity by comparison to the voucher herbarium specimens that were deposited at BCU and BKF.
- Author of scientific names and abbreviations used in this thesis are according to the author of plant names (Brummitt and Powell, 1992).
- Description and drawing illustration of some species were prepared and based on specimens collected from Thong Phaphum District, Kanchanaburi Province.
- Dichotomous keys to species based on their qualitative morphological characters were made.
- Classification of family and genera were according to Boonkerd and Pollawatn (2000).

CHAPTER 5

RESULTS

5.1 Study Sites

Twelve plots of 5x20 meters were established at each study site; i.e., abandoned mines, remnants of the forest in mine area and natural forests. The grid reference (UTM: the Universal Transverse Mercator) and altitude of each plots were listed in Table 5.1. They range in elevations from 425-1,032 m above sea level. The lowest plot was observed in abandoned mine at plot 6, while the highest plot was in the natural forest at plot 2.

5.2 Physical factors

5.2.1 Light intensity.

Light intensity at canopy of pteridophytes at each study site was statistically significant differences (Table 5.2). The highest mean light intensity was observed in abandoned mines, while the lowest mean light intensity was found in the remnants of the forest in mine area (Figure 5.1).

5.2.2 Leaf temperature

Ratios of leaf temperature and air temperature at 1 m above each plot were calculated. The mean values of these ratios at each study site were statistically significant differences (Table 5.2). The highest mean ratio of leaf temperature and air temperature was observed in abandoned mines, while the lowest mean ratio of leaf temperature and air temperature was found in the remnants of the forest in mine area (Figure 5.2).

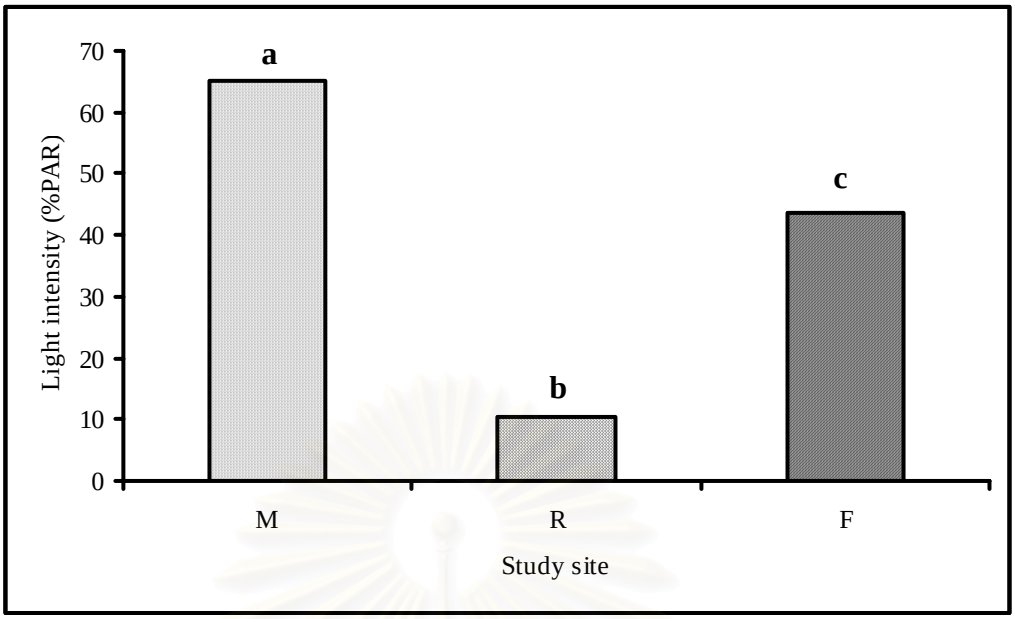
Table 5.1 Study sites of pteridophyte diversity.

Site/plot	Elevation (m)	Grid Reference (UTM)
Abandoned mine/ plot 1	810	47P 428280 1584092
2	881	47P 432144 1622394
3	741	47P 435600 1619100
4	732	47P 437147 1564370
5	840	47P 437537 1617996
6	425	47P 441400 1560026
7	927	47P 437939 1618274
8	890	47P 437956 1618274

Site/plot	Elevation (m)	Grid Reference (UTM)
9	906	47P 438118 1618243
10	917	47P 432799 1622202
11	877	47P 433098 1622381
12	737	47P 437132 1564294
Remnant of the forest in mine area / plot 1	866	47P 437093 1618645
2	826	47P 437300 1618835
3	889	47P 437706 1618656
5	916	47P 437652 1563506
6	517	47P 441500 1550180
7	881	47P 432320 1622462
8	800	47P 433703 1621252
9	788	47P 434281 1621305
10	667	47P 436008 1619901
11	850	47P 434351 1621276
12	900	47P 432721 1622328
Natural forest/ plot1	1004	47P 436005 1623549
2	1032	47P 435650 1624225
3	969	47P 4361221624068
4	956	47P 435924 1624431
5	960	47P 435719 1624504
6	1000	47P 435632 1624337
7	1030	47P 435605 1624288
8	970	47P 435916 1624140
9	950	47P 436083 1624471
10	960	47P 436195 1624547
11	974	47P 436365 1624611
12	965	47P 436436 1624263

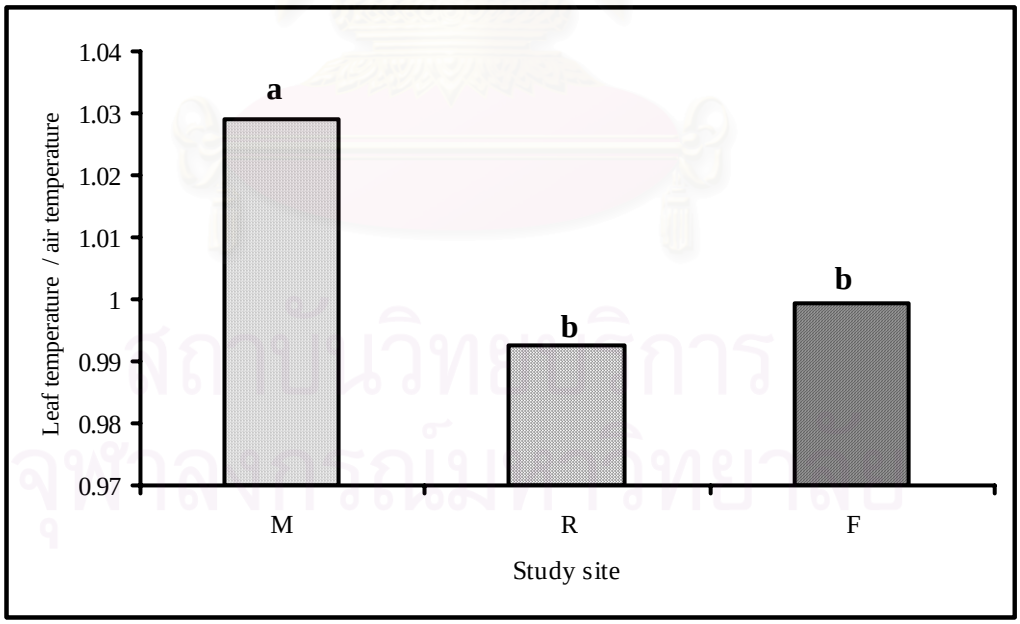
Table 5.2 ANOVA results of two physical factors.

Physical factors	Sum of square	df	Mean square	F	Sig.
Light intensity (%PAR)					
Between groups	18133.841	2	9066.921	39.878	0.000
Within groups	7503.033	33	227.365		
Total	25636.847	35			
Ratio of Leaf temperature and air temperature					
Between groups	91.105	2	45.552	23.657	0.000
Within groups	63.544	33	1.926		
Total	154.649	35			



M= Abandoned mines, R= Remnants of the forest in mine area, F= Natural forests

Figure 5.1 Means of light intensity at each study site. Significant differences among study sites are indicated by different letters.



M= Abandoned mines, R= Remnants of the forest in mine area, F= Natural forests

Figure 5.2 Mean ratios of leaf temperature and air temperature at each study site. Significant differences among study sites are indicated by different letters.

5. 3 Pteridophytes diversity

Diversity of pteridophytes was determined along a gradient of disturbance from abandoned mines, remnants of the forest in mine area to the natural forests.

5.3.1 Species richness

Species richness of each study site was assessed using Menhinick's index. There was statistically significant difference of species richness between study sites (Table 5.3). The lowest mean value of species richness was observed in abandoned mines while the highest mean value of species richness was observed in remnants of the forest in mine area. However, no statistically significant difference of species richness was found between remnants of the forest in mine area and the natural forest (Figure 5.3).

5.3.2 Species diversity

Species diversity of each study site was estimated using Shannon-Weiner's index. There was no statistically significant difference of species diversity between study sites (Table 5.3). The highest value was observed in remnants of the forest in mine area (Figure 5.4).

5.3.3 Species evenness

Species evenness of each study site was estimated using evenness index. There was no statistically significant difference of species diversity between study sites (Table 5.3). The highest and the lowest values were observed in the abandoned mines and the natural forests, respectively (Figure 5.5).

Table 5.3 ANOVA results of species richness index, species diversity index, and evenness index.

Pteridophytes diversity index	Sum of square	df	Mean square	F	Sig.
Species richness (Menhinick's index)					
Between groups	1.686	2	0.843	7.414	0.002
Within groups	3.751	33	0.114		
Total	5.437	35			
Species diversity (Shannon-Weiner's index)					
Between groups	4.986E-02	2	2.493E-02	0.261	0.772
Within groups	3.152	33	9.553E-02		
Total	3.202	35			
Species evenness (Evenness index)					
Between groups	8.298E-02	2	4.149E-02	3.219	0.053
Within groups	0.425	33	1.289E-02		
Total	0.508	35			

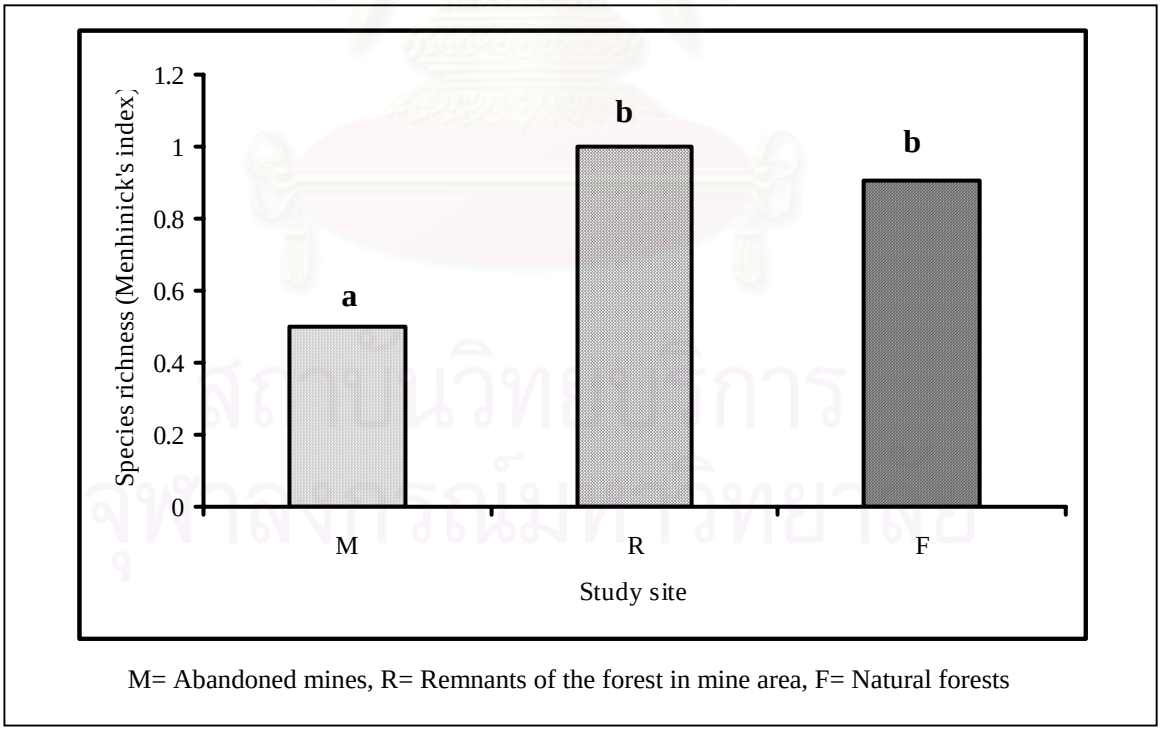
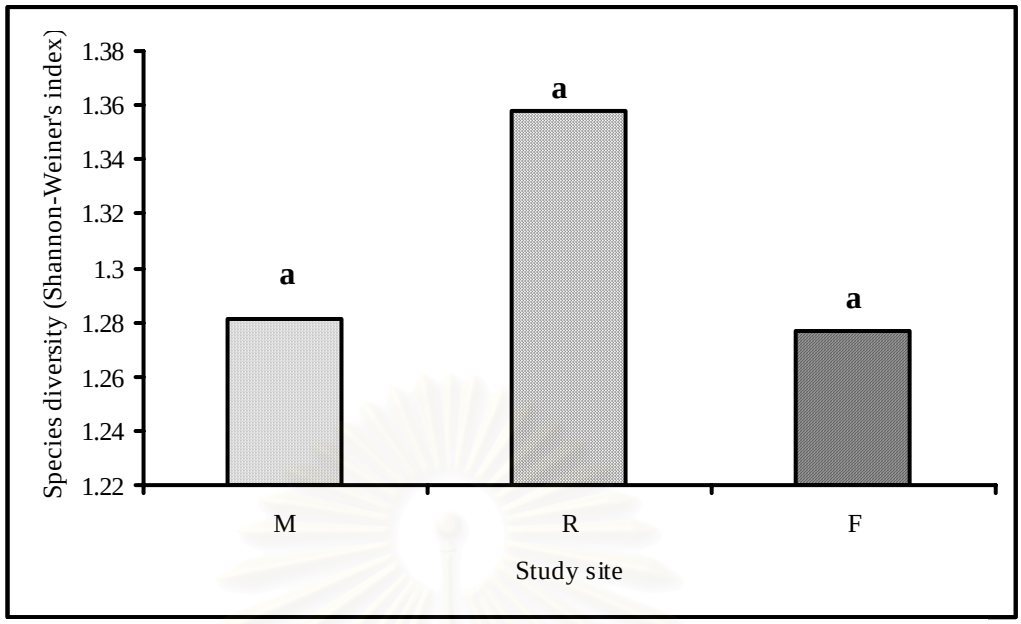
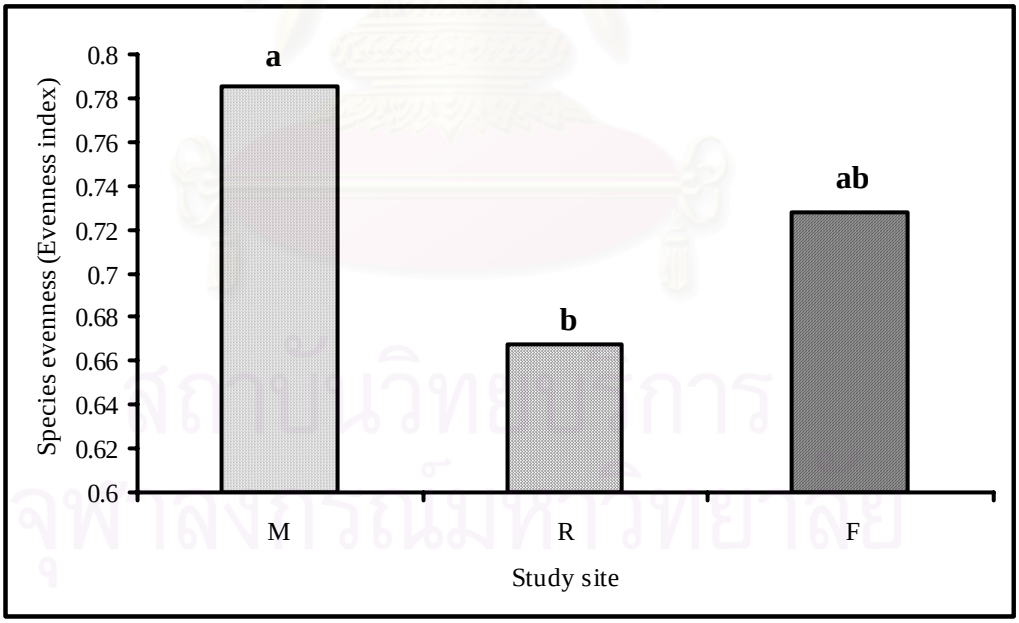


Figure 5.3 Means of species richness at each study site. Significant differences among study sites are indicated by different letters.



M= Abandoned mines, R= Remnants of the forest in mine area, F= Natural forests

Figure 5.4 Means of species diversity at each study site. Significant differences among study sites are indicated by different letters.



M= Abandoned mines, R= Remnants of the forest in mine area, F= Natural forests

Figure 5.5 Means of species evenness at each study site. Significant differences among study sites are indicated by different letters.

5.4 Similarity coefficient

Jaccard's coefficient was used to investigate similarity of species between study site. A list of ferns and fern allies occurred at each study site was showed in Table 5.4. It was found that a similarity coefficient between abandoned mines and remnants of the forest in mine area was 0.21. A similarity coefficient between abandoned mines and natural forest was 0.05, while a similarity coefficient between remnants of the forest in mine area and natural forest was 0.13 (Table 5.5).

Table 5.4 List of pteridophyte species found at each study site.
M= abandoned mines, R= remnants of the forest in mine area, F= natural forests.

TAXA	M	R	F
Fern Allies			
Lycopodiaceae			
-*Lycopodiella cernua* (L.) Pic. Serm	+	-	-
Selaginellaceae			
- *Selaginella biformis* A. Br. ex Kuhn	-	+	-
- *Selaginella helferi* Warb.	-	+	-
- *Selaginella inaequalifolia* (Hook. et Grev.) Spring	-	+	-
- *Selaginella lindhardii* Hieron.	+	-	-
- *Selaginella minutifolia* Spring	+	-	-
- *Selaginella siamensis* Hieron	-	-	+
- *Selaginella tenuifolia* Spring	+	+	-
Ferns			
Adiantaceae			
- *Cheilanthes tenuifolia* (Burm. f.) Sw.	+	-	-
- *Pityrogramma calomelanos* (L.) Link.	+	+	-
Aspleniaceae			
- *Asplenium apogamus* Murakami et Hatanaka	-	+	+
- *Asplenium perakense* B. Mathew et H. Christ	-	-	+
- *Asplenium yoshinagae* Makino	-	+	+
Blechnaceae			
- *Blechnum orientale* L.	+	+	-
- *Brainea insignis* (Hook.) J. Sm.	-	-	+
Cyatheaceae			
- *Cyathea borneensis* Copel.	-	+	-
- *Cyathea gigantea* (Wall. ex Hook.) Holttum	+	+	-
Davalliaceae			
- *Araiostegia imbricata* Ching	-	-	+
- *Humata repens* (L. f.) J. Small ex Diels	-	-	+

TAXA	M	R	F
Dennstaedtiaceae			
- *Histiopteris incisa* (Thunb.) J. Sm.	-	+	-
- *Hypolepis punctata* (Thunb.) Mett. ex Kuhn	-	+	-
- *Microlepia hookeriana* (Wall. ex Hook.) C. Presl	-	+	-
- *Microlepia speluncae* (L.) T. Moore	-	+	+
Dicksoniaceae			
- *Cibotium barometz* J. Sm.	-	+	-
Dryopteridaceae			
- *Dryopteris polita* Rosenst.	-	+	-
- *Heterogonium sagenioides* (Mett.) Holttum	-	+	-
- *Pteridrys australis* Ching	-	+	-
- *Pteridrys syrmatica* (Willd.) C. Chr. et Ching	-	+	-
- *Tectaria fuscipes* (Wall. ex Bedd.) C. Chr.	-	+	-
- *Tectaria impressa* (Fée) Holttum	-	-	+
- *Tectaria polymorpha* (Wall. ex Hook.) Copel.	-	+	+
- *Tectaria* sp.	-	+	-
Gleicheniaceae			
- *Dicranopteris linearis* (Burm. f.) Underw. var. *linearis*	+	+	-
Hymenophyllaceae			
- *Crepidomanes latealatum* (Bosch) Copel.	-	-	+
- *Hymenophyllum exsertum* Wall. ex Hook.	-	-	+
- *Hymenophyllum polyanthos* (Sw.) Sw.	-	-	+
Lindsaeaceae			
- *Lindsaea ensifolia* Sw.	+	+	+
- *Sphenomeris chinensis* (L.) Maxon var. *divaricata* (H. Christ) K.U. Kramer	+	-	-
- *Sphenomeris chinensis* (L.) Maxon var. *rheophila* K.U. Kramer	+	+	-
Lomariopsidaceae			
- *Bolbitis appendiculata* (Willd.) K. Iwats. subsp. *vivipara* (Hamilt. ex Hook.) Hennipman	-	+	+
- *Bolbitis heteroclita* (C. Presl) Ching	-	+	-
- *Bolbitis virens* (Wall. ex Hook. et Grev.) Schott var. *virens*	-	-	+
- *Elaphoglossum marginatum* (Wall. ex Fée) T. Moore	-	-	+
Marattiaceae			
- *Angiopteris evecta* (G. Forst.) Hoffm.	-	+	-
Polypodiaceae			
- *Aglaomorpha coronans* (Wall. ex Mett.) Copel.	-	+	+
- *Crypsinus oxylobus* (Wall. ex Kunze) Sledge	-	-	+
- *Crypsinus rhynchophyllus* (Hook.) Copel.	-	-	+
- *Goniophlebium subauriculatum* (Blume) C. Presl	-	-	+
- *Lepisorus scolopendrium* (Buch.-Ham. ex D. Don) Mehra & Bir	-	-	+

TAXA	M	R	F
Polypodiaceae (cont.)			
- *Leptochilus minor* Fée	-	+	-
- *Microsorum punctatum* (L.) Copel.	-	+	-
- *Pyrrosia albicans* (Blume) Ching	-	-	+
- *Pyrrosia lingua* (Thunb.) Farw. var. *heteractis* (Matt. ex Kuhn) Hovenkamp	-	-	+
Pteridaceae			
-*Pteris biaurita* L.	+	+	+
Schizaeaceae			
- *Lygodium microphyllum* (Cav.) R. Br.	+	+	-
- *Lygodium salicifolium* C. Presl	-	+	+
Thelypteridaceae			
- *Christella dentata* (Forssk.) Holttum	-	+	-
- *Christella parasitica* (L.) H. Lév.	+	+	-
- *Cyclosorus hirtisorus* (C. Chr.) Ching	-	-	+
- *Metathelypteris dayi* (Bedd.) Holttum	-	+	-
- *Metathelypteris singalanensis* (Baker) Ching var. *singalanensis*	-	+	-
- *Pronephrium nudatum* (Roxb.) Holttum	-	+	-
Woodsiaceae			
- *Diplazium donianum* (Mett.) Tardieu	-	+	-
- *Diplazium esculentum* (Retz.) Sw.	-	+	-
- *Diplazium simplicivenium* Holttum	-	+	-

Table 5.5 Jaccard's coefficient of each pair of study site.

Study site	abandoned mines	remnants of the forest in mine area	natural forests
abandoned mines	-	0.21	0.05
remnants of the forest in mine area	0.21	-	0.13
natural forests	0.05	0.13	-

5.5 Relationship between pteridophyte diversity and physical factors

Pearson's correlation was used to explore the relationship between pteridophyte diversity and physical factors. It was found that species richness (Menhinick's index) was negatively statistically significantly correlated to light intensity (%PAR) and ratio of leaf temperature and air temperature (Table 5.6, Figure 5.6, and Figure 5.8). No statistically significant correlation was observed between species diversity (Shannon-Weiner's index) and physical factors (Table 5.6). However, species evenness (Evenness index) was positively statistically significantly correlated to light intensity (%PAR) and ratio of leaf temperature and air temperature (Table 5.6, Figure 5.7, and Figure 5.9).

Table 5.6 Correlation between pteridophyte diversity and physical factors.

Pteridophytes diversity	Light intensity (%PAR)	leaf temperature/ air temperature
Species richness (Menhinick's index)	-0.434**	-0.460**
Species diversity (Shannon-Weiner's index)	-0.014	0.068
Species evenness (Evenness index)	0.351*	0.397*

*, ** indicated significant correlation at 95% and 99% confidence level, respectively

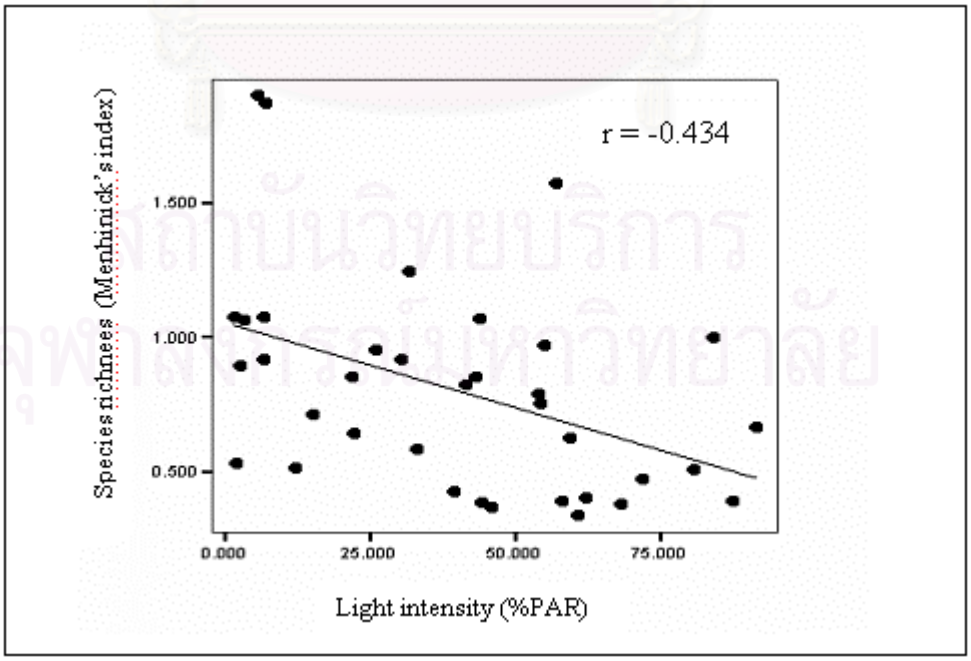


Figure 5.6 Relationship between light intensity and species richness.

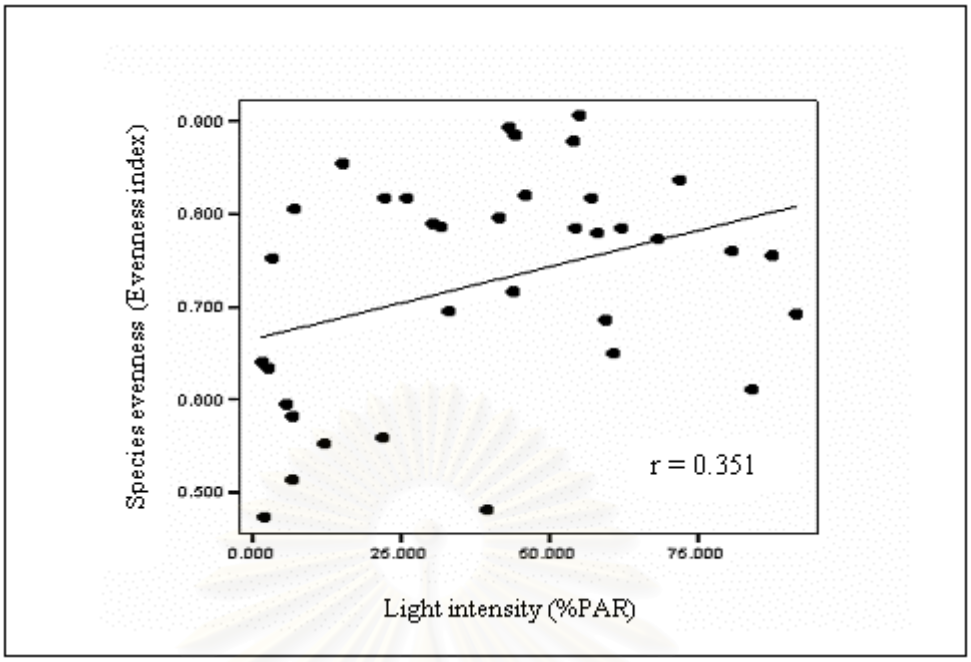


Figure 5.7 Relationship between light intensity and species evenness.

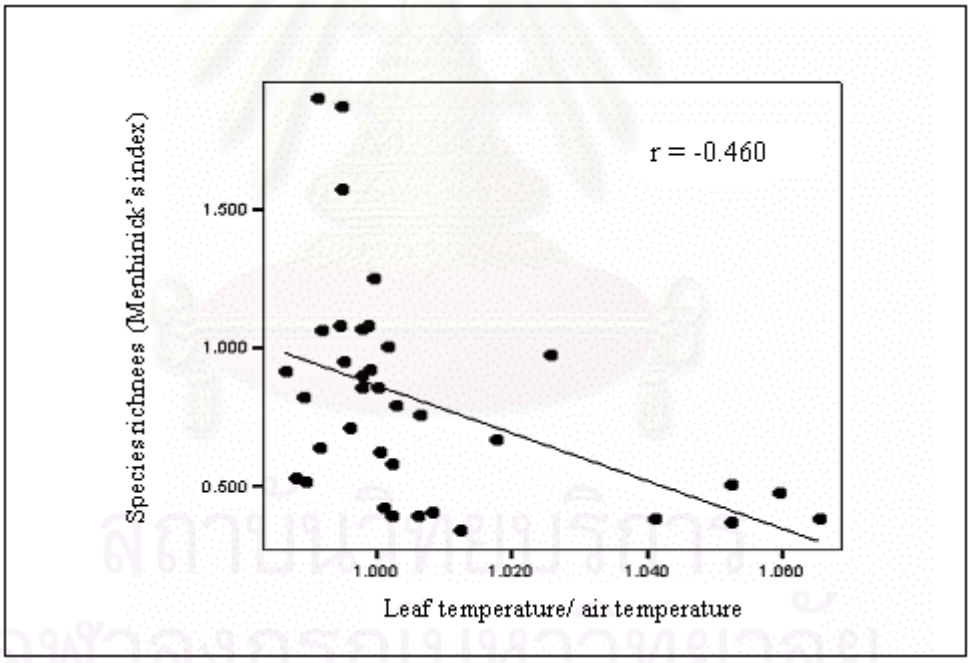


Figure 5.8 Relationship between ratio of leaf temperature and air temperature and species richness.

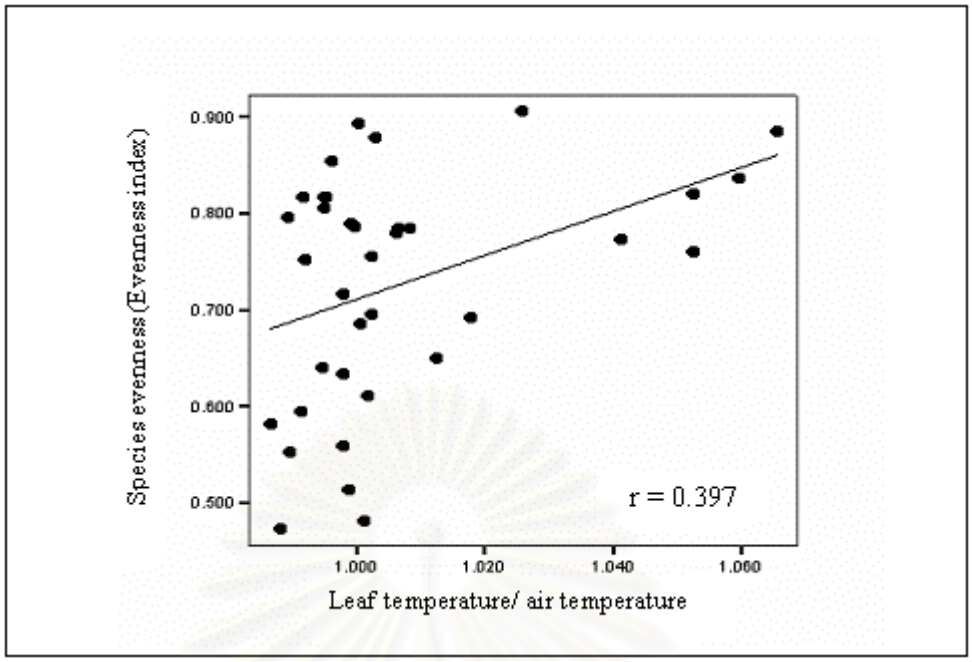


Figure 5.9 Relationship between ratio of leaf temperature and air temperature and species evenness.

5.6 Taxonomic diversity of pteridophytes

One hundred and eighty-four specimens of pteridophytes were collected from three study sites, i.e., abandoned mines, remnants of the forest in mine area, and natural forests nearby. These pteridophytes were classified into 20 families, 40 genera, 65 species, 1 subspecies and 5 varieties. Among these 18 families, 38 genera, 57 species, 1 subspecies and 5 varieties are ferns, while 2 families, 2 genera, 8 species are fern allies (Table 5.7). Fifteen species which was the lowest number were observed in the abandoned mines. While, 41 species of pteridophytes were found in the remnants of the forest in mine areas. In addition, 26 species of pteridophytes were found in the natural forests. The following are descriptions and keys to taxa of pteridophytes found in this study.

Table 5.7 Check list of pteridophytes at each study site.

Taxon	Habitat	Study Sites			Abundance
		M	R	F	
Fern Allies					
Lycopodiaceae					
-*Lycopodiella cernua*	T	1-11	-	-	+ + + + +
Selaginellaceae					
- *Selaginella biformis*	T	-	4,11	-	+ +
- *Selaginella helferi*	T	-	8,9	-	+ + +
- *Selaginella inaequalifolia*	T	-	11	-	+ +
- *Selaginella lindhardii*	T	4	-	-	+ + +
- *Selaginella minutifolia*	T	3	-	-	+ +
- *Selaginella siamensis*	T	-	-	10	+
- *Selaginella tenuifolia*	T	6,9	1,8	-	+ +
Ferns					
Adiantaceae					
- *Cheilanthes tenuifolia*	T	3,4,6,9	-	-	+ + + +
- *Pityrogramma calomelanos*	T	2,5,6	9	-	+ + + +
Aspleniaceae					
- *Asplenium apogamus*	T	-	2,12	-	+
- *Asplenium perakense*	E	-	-	2,6,7,8,9	+ + + +
- *Asplenium yoshinagae*	E	-	12	1	+ + + +
Blechnaceae					
- *Blechnum orientale*	T	1-12	1,2,4,5, 7,8,11	-	+ + + + +
- *Brainea insignis*	T	-	-	10,11	+
Cyatheaceae					
- *Cyathea borneensis*	T	-	2,4,8,10	-	+ +
- *Cyathea gigantea*	T	10	3,5,7, 8,9,11	-	+ + +
Davalliaceae					
- *Araiostegia imbricata*	E	-	-	1,6,7,8,12	+ +
- *Humata repens*	E	-	-	4,9,11	+ + + +
Dennstaedtiaceae					
- *Histiopteris incisa*	T	-	4	-	+
- *Hypolepis punctata*	T	-	9	-	+ +

Taxon	Habitat	Study Sites			Abundance
		M	R	F	
Dennstaedtiaceae (cont.)					
- *Microlepia hookeriana*	T	-	8	-	+
- *Microlepia speluncae*	T	-	1,5,12	5,6,9,12	+ +
Dicksoniaceae					
- *Cibotium barometz*	T	-	9	-	+
Dryopteridaceae					
- *Dryopteris polita*	T	-	8,11	-	+
- *Heterogonium sagenioides*	T	-	2,3,12	-	+
- *Pteridrys australis*	T	-	10	-	+
- *Pteridrys syrmatica*	T	-	6	-	+
- *Tectaria fuscipes*	T	-	6	-	+
- *Tectaria impressa*	T	-	-	6,7,9	+ +
- *Tectaria polymorpha*	T	-	6	2	+ +
- *Tectaria* sp.	T	-	2,10	-	+
Gleicheniaceae					
- *Dicranopteris linearis* var. *linearis*	T	1-12	7,8,11	-	+ + + + +
Hymenophyllaceae					
- *Crepidomanes latealatum*	E	-	-	6	+ +
- *Hymenophyllum exsertum*	E	-	-	7,8,11	+ + + +
- *Hymenophyllum polyanthos*	E	-	-	11	+ +
Lindsaeaceae					
- *Lindsaea ensifolia*	T	2	3,12	9,10,11	+ + +
- *Sphenomeris chinensis* var. *divaricata*	T	5	-	-	+
- *Sphenomeris chinensis* var. *rheophila*	T	1,2,4,5,7 8,9,10,11	5,8	-	+ + + +
Lomariopsidaceae					
- *Bolbitis appendiculata* subsp. *vivipara*	L	-	2,3,5 ,6,12	5,6	+ + + +
- *Bolbitis heteroclita*	T	-	6	-	+ +
- *Bolbitis virens* var. *virens*	T	-	-	6	+
- *Elaphoglossum marginatum*	E	-	-	1,2,4,7	+ + +
Marattiaceae					
- *Angiopteris evecta*	T	-	2,5,7, 8,10,12	-	+ + +

Taxon	Habitat	Study Sites			Abundance
		M	R	F	
Polypodiaceae					
- *Aglaomorpha coronans*	E	-	10	9	+
- *Crypsinus oxylobus*	E	-	-	1,3,4,6,7, 9,10,11,12	+ + +
- *Crypsinus rhynchophyllus*	E	-	-	1,6,7,10	+ +
- *Goniophlebium subauriculatum*	E	-	-	1,8	+ +
- *Lepisorus scolopendrium*	E	-	-	1,2,3,4,6,9	+ +
- *Leptochilus minor*	L	-	6	-	+ +
- *Microsorum punctatum*	E	-	5	-	+
- *Pyrrosia albicans*	E	-	-	9	+
- *Pyrrosia lingua* var. *heteractis*	E	-	-	4	+
Pteridaceae					
-*Pteris biaurita*	T	9	3,8	2,3,5,6	+ +
Schizaeaceae					
- *Lygodium microphyllum*	T	10	7,11	-	+ +
- *Lygodium salicifolium*	T	-	3	2	+
Thelypteridaceae					
- *Christella dentata*	T	-	2,6,11	-	+
- *Christella parasitica*	T	10	9	-	+
- *Cyclosorus hirtisorus*	T	-	-	2,6,11,12	+ + +
- *Metathelypteris dayi*	T	-	7	-	+
- *Metathelypteris singalanensis* var. *singalanensis*	T	-	4	-	+
- *Pronephrium nudatum*	T	-	1,5,7, 9,10,11	-	+ + + +
Woodsiaceae					
- *Diplazium donianum*	T	-	8,12	-	+ +
- *Diplazium esculentum*	T	-	9	-	+
- *Diplazium simplicivenium*	T	-	7,11	-	+ +

Habitat: T= Terrestrial, E= Epiphytic, L= Lithophytic.

Study Sites: M= Abandoned mines, R= Remnants of the forest in mine area,
F= Natural forests.

Abundance: + = Very rare + + = Rare + + + = Common
+ + + + = Very common + + + + + = Abundant

ORDER LYCOPODIALES

LYCOPODIACEAE

P. Beauv. ex Mirb., Hist. Nat. Veg. 4: 293. 1802; B. Øllg., The families and genera of vascular plants vol. I: 31. 1990.

Terrestrial or epiphytic, erect to pendulous herbs or climbers. Stems dichotomously branched, rarely with lateral branching. Leaves simple, with one simple vein, arranged in low alternating spirals or irregular whorls, or decussate, homophyllous or heterophyllous, isophyllous or anisophyllous. Sporophylls like the foliage leaves or modified, sometime specialized and aggregated into distinct strobili. Sporangia solitary, in the leaf axils or on the upper side of the sporophyll base.

LYCOPODIELLA

Holub, Preslia 36: 22. 1964; B. Øllg., The families and genera of vascular plants vol. I: 37. 1990.

Plants terrestrial, anisotomously branched, with horizontal, creeping, or arching-looping indeterminate shoots rooting at short to long intervals along the underside, and dorsally arising, determinate, erect, simple or profusely tree-like branched aerial shoots, or with irregularly, truly laterally branched. Subterranean stems. Stem steles radial, sometime with highly dissected xylem. Leaves isophyllous to anisophyllous. Strobili pendent and sessile, or erect and terminating simple (rarely forked), dorsally arising branches. Sporophylls subpeltate, with a thin basal decurrent wing, or with coalescent basal membranes which almost enclose the sporangia, with a mucilage cavity in the base and sometime along the vein. Sporangia reniform to subglobose. One species was known in Thailand and it was also found in Thong Pha Phum District.

Lycopodiella cernua (L.) Pic. Serm., Webbia 23(1): 166. 1968; W. P. de Winter, Plant resources of Southeast Asia No. 15(2): 121. 2003.— *Lycopodium cernuum* L., Sp. Pl. 2: 1103. 1753; Alston in Fl. Gén. I.-C. 7(2): 548. 1951; Tagawa et K. Iwats., Fl. Thail. 3(1): 12. 1979.

Stems of two kinds, creeping and erect; creeping main stem with indefinite length, rooting at long intervals; main erect stems to more than 60 cm tall, bearing many branches densely covered with leaves (not so dense on lower portion), 3-4 mm diam.; lateral branches 1.32 mm diam., densely covered with leaves, usually about 10.7 cm long, copiously branching. **Leaves** linear, pointed at apex, 3 mm long, up to 0.23 mm broad, entire, patent and recurved in upper portion; texture thick but soft, yellowish green. **Strobili** solitary or two at each apex of branches, pendulous, 3.65 mm long, about 2.36 mm diam.; sporophylls ovoid, acuminate at apex, with minute projections at margin. (Figure 5.10, 5.37, 5.38)

T h a i l a n d .— NORTHERN: Chiang Rai, Chiang Mai, Lampang, Phitsanulok, Tak; NORTH-EASTERN: Loei; CENTRAL: Nakhon Nayok; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Chumphon, Surat Thani, Satun, Nakhon Si Thammarat, Trang, Songkhla, Narathiwat, Yala.

D i s t r i b u t i o n .— Tropics and subtropics throughout the world (type from India).

E c o l o g y .— Terrestrial on open dry mountain slopes or ground in abandoned mines, at 400-900 m alt.

V e r n a c u l a r .— Khut khon (Northern); Yak an phiang, Yaeng yae (North-eastern); Slap, Dok hin (South-eastern); Rang kai, Ruai kai, Sam roi yot (Peninsular).

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 035; O. Vannasri 11; T. Boonkerd 210 [BCU]; C. Phengklai et al 13347, K. Larsenet al 1665, C. F. Beusekom et al 4491 [BKF].

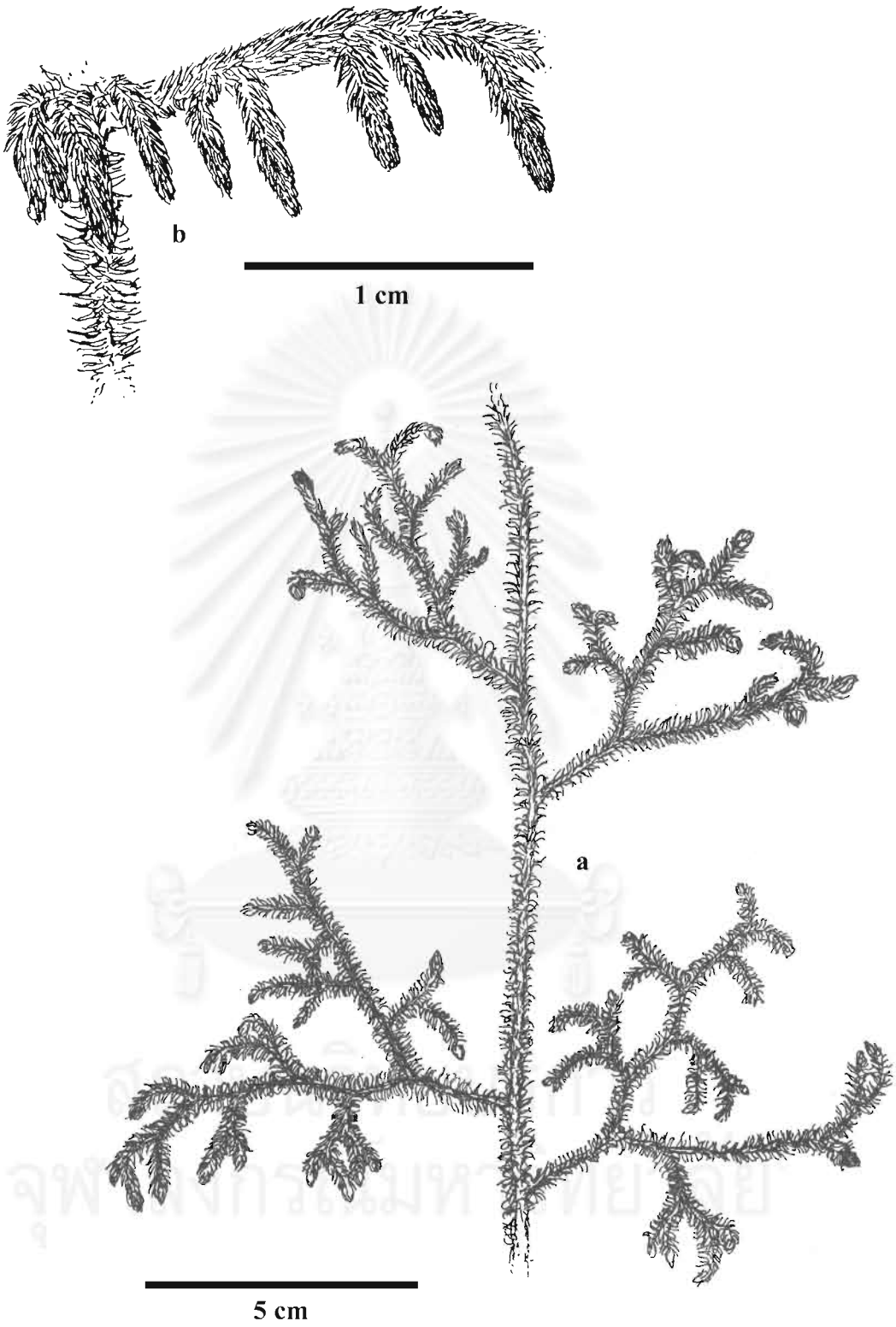


Figure 5.10 ***Lycopodiella cernua*** **(L.) Pic. Serm.** a. Main erect stem and branches. -- b. Fertile branches. (A. Sathapattayanon 035)

ORDER SELAGINELLALES

SELAGINELLACEAE

Willk., Anleit. Stud. Bot. 2: 163. 1854; Tagawa et K. Iwats., Fl. Thail. 3(1): 14. 1979.

Stems elongate, scandent or climbling, bearing leaves and rhizophores, branching dichotomously or pinnately, usually of foliar appearance. Rhizophores geotropic, dichotomously branching, bearing roots in the earth. Leaves microphyllous, monomorphic and spirally arranged, or as in all Thai species dimorphic arranged in four rows, the ventral two patent or ascending, larger, the dorsal two smaller, adpressed to stems, directed distally. Sporophylls uniform and arranged spirally forming cylindrical spike, uniform and arranged in four rows forming squarroid spikes, or dimorphic and arranged in four rows, the dorsal and ventral rows unequal; heterosporous, with tetrahedral spores.

SELAGINELLA

P. Beauv., Mag. Enc. 4: 478. 1804; Tagawa et K. Iwats., Fl. Thail. 3(1): 14. 1979.

Selaginellaceae is a monogeneric family. For generic characters see family Selaginellaceae's description. There were 29 species in Thailand and 7 species among them were found in Thong Pha Phum District.

Key to the species

1. Sporophylls of spikes uniform
   2. Branches pubescent **1. *S. biformis***
   2. Branches glabrous
      3. Stems scandent, or growing indefinitely; dorsal leaves not white-margined
         4. Stems scandent; dorsal leaves much smaller than the ventral ones; sporophylls strongly acuminate **2. *S. helferi***
         4. Stems growing indefinitely; ventral leaves ciliate; dorsal leaves nearly as large as the ventral leaves **6. *S. siamensis***
      3. Stems not scandent nor growing indefinitely; ventral leaves entire; lateral branches bipinnate **3. *S. inaequalifolia***

1. Sporophylls of spikes dimorphic
    5. Dorsal sporophylls acuminate at apex
        6. Sporophylls ciliate; branches tripinnate **5. *S. minutifolia***
        6. Sporophylls dentate; branches bipinnate **4. *S. lindhardii***
    5. Dorsal sporophylls round to obtuse at apex **7. *S. tenuifolia***

1. ***Selaginella biformis*** A. Braun ex Kuhn, Forsch. Gaz. 4. Bot. 6: 17, 19. 1889; Alston in Fl. Gén. I.-C. 7(2): 570. 1951; Tagawa et K. Iwats., Fl. Thail. 3(1): 17. f. 2: 6-8. 1979.

Stems erect or decumbent, rooting only at base for the erect plants, plants about 30 cm tall; main stems about 2.4 mm diam. near base, sparsely leaves, pubescent on lower surface or glabrescent in lower portion; lateral branches bipinnate to tripinnate, densely pubescent below; ultimate branches about 3 mm in breadth. **Leaves** on basal portion of erect stem unifrom, sparse and not imbricate; ventral leaves ascending, oblong-subdeltoid, gradually narrowing and falcate towards acute apex, cordate at base, 2.69 mm long, 1.56 mm broad, edges dentate or ciliate near base, texture herbaceous to softly papyraceous, green; dorsal leaves asymmetrically oblong, mucronate at apex, dentate or ciliate at margin. **Spikes** about 1 mm diam. Sporophylls unifrom, ovate-subtriangular with long mucronate apex, about 9.6 mm long, 1.6 mm broad. (Figure 5.11, 5.39)

T h a i l a n d .— NORTHERN: Chiang Rai, Chiang Mai, Nan, Phrae, Phitsanulok, Tak; NORTH-EASTERN: Phetchabun, Loei; EASTERN: Nakhon Ratchasima; CENTRAL: Nakhon Nayok; SOUTH-WESTERN : Kanchanaburi.

D i s t r i b u t i o n .— Assam, Myanmar, S. China, Indochina and Malesia throughout (type from the Philippines).

E c o l o g y .— Terrestrial on humus rich ground in light shade or margin of remnants of the forest in mine area, at 800-900 m alt.

V e r n a c u l a r .— Foen phaeng (North-eastern).

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 131, 133; T. Boonkerd 25 [BCU]; K. Iwatsuki 31479, G. Murata et al 49564, Winit 1044, T. Smitinand 2661 [BKF].

2. ***Selaginella helferi*** Warb., Monsunia 1: 107, 121. 1900; Alston in Fl. Gén. I.-C. 7(2): 582. 1951; Tagawa et K. Iwats., Fl. Thail. 3(1): 18. f. 2: 9-12. 1979.— *Selaginella willdenowii* auct. non (Desv.) Baker: C. Chr., Contr. U.S. Natn. Herb. 26: 335. 1931.

Stems scandent, sometime forming bushes of more than 2 m in height, 1-3 mm or rarely to more than 5 mm diam., very sparsely leaves; branches to more than 70 cm long, tripinnate, glabrous; leaves borne sparsely on the main branches but densely on the lateral branches. **Ventral leaves** patent, oblong, more or less falcate, acuminate at apex, round to subtruncate at sessile base, usually bearing small auricles forming pale hooks at acroscopic base, 2.5-4 mm long, up to 1.5 mm broad, distinctly margined with cartilaginous membrane, entire, glabrous; dorsal leaves adpressed, falcate, acuminate at apex, 0.7-2.3 mm long. **Spikes** solitary at apex of lateral branchlets, about 2 mm diam.; sporophylls ovate-lanceolate, about 3.5 mm long, 1.5-2 mm broad, acuminate at apex. (Figure 5.40, 5.41)

T h a i l a n d .— NORTHERN: Chiang Rai, Chiang Mai, Nan, Phitsanulok, Tak; NORTH-EASTERN: Loei; CENTRAL: Saraburi; SOUTH-EASTERN: Chon Buri; SOUTH-WESTERN: Kanchanaburi.

D i s t r i b u t i o n .— Assam, Myanmar (type), S. China, and Indochina.

E c o l o g y .— Climbing up bushes, grow on humus rich ground along stream in light shade in remnants of the forest in mine area, at 800 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 132, 135; P. Ratchata 57; R. Chaveerach 25; T. Boonkerd 26 [BCU]; J. F. Maxwell 94-1299, K. Larsen et al 1449, A. S. Barfod et al 45227 [BKF].

3. ***Selaginella inaequalifolia*** (Hook. et Grev.) Spring, Bull. Acad. Roy. Sci. Brux. 10: 145. 1843; Tagawa et K. Iwats., Fl. Thail. 3(1): 20. 1979.— *Lycopodium inaequalifolium* Hook. et Grev. in Hook., Bot. Misc. 2: 391. 1831.

Plants about 27 cm tall. **Stems** erect, commonly 2-3 mm diam. near base; lateral branches bipinnate, narrowly oblong, about 15 cm long, 4-7 cm wide, bearing 15-30 pairs of branches below distinct terminal ones; pinnae of lateral branches usually more than 1 cm apart, ascending, forming angles of about 45° to axes, linear-

lanceolate, up to 2.5 cm long, 5 mm wide; main stems dark in upper portion. **Ventral leaves** narrowly oblong, falcate, aciculate at apex, margined with narrow cartilaginous membrane, entire, about 3 mm long, up to 1 mm broad, ascending, forming angles of about 60° to axes; dorsal leaves adpressed to 1.5 mm long, acuminate at apex. **Spikes** more than 3 cm long, up to 1.3 mm diam.; sporophylls oblong-subtriangular, long-acuminate at apex, about 1.4 mm long, 0.8 mm broad.

T h a i l a n d .—NORTHERN: Tak; SOUTH-WESTERN: Kanchanaburi.

D i s t r i b u t i o n .— Madras (type), Assam and Myanmar.

E c o l o g y .— Terrestrial on slope in light shade in remnant of the forest in mine area, at 800 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 107; T. Boonkerd 321, 1198, 1478 [BCU]; S. Chongko 95 [BKF].

4. ***Selaginella lindhardii*** Hieron., Bull. Herb. Boiss. 2. 5: 723. 1905; Alston in Fl. Gén. I.-C. 7(2): 592. 1951; Tagawa et K. Iwats., Fl. Thail. 3(1): 29. 1979.

Plants small, up to 10 cm long. **Main stems** to 0.7 mm diam., bearing the branches nearly to the base, bearing leaves about 2.2 mm apart; main branches bipinnate; ultimate branches to 2.5 mm wide. **Ventral leaves** oblong, slightly narrowing towards, moderately acute at apex, unequally round at base, about 2 mm long, those on the main branches 1 mm broad, patent or ascending, edges dentate, texture thin, yellow-green; dorsal leaves elliptic with long tails at apex, narrowly round at base, dentate. **Spikes** about 2.7 mm broad; sporophylls dimorphic, oblong-subtriangular with round base and long acuminate apex, dentate. (Figure 5.42)

T h a i l a n d .— NORTHERN: Tak; CENTRAL: Bangkok; SOUTH-WESTERN: Ratchaburi, Kanchanaburi.

D i s t r i b u t i o n .— Endemic.

E c o l o g y .— Terrestrial on shady stony slope or ground in abandoned mine, at 730 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 089; P. Ratchata 21, 26 [BCU].

5. ***Selaginella minutifolia*** Spring, Mém. Acad. Roy. Belg. 24: 239. 1850; Alston in Fl. Gén. I.-C. 7(2): 591. 1951; Tagawa et K. Iwats., Fl. Thail. 3(1): 28. 1979.

Small plants of less than 10 cm long. **Main Stems** up to 0.75 mm diam. bearing leaves about 3 mm apart; main branches simple to bipinnate; ultimate branches 1.75 mm wide. **Ventral leaves** patent to ascending, oblong, round to moderately acute at apex, unequally round at base, those on the branches about 2.3 mm long, 0.8 mm broad, edges distinctly white-margined, dentate, texture thinly herbaceous, yellowish green; dorsal leaves elliptic with long-acuminnate apex with acumen 0.3 mm in length, cuneate at base, denticulate and white-margined. **Spikes** about 1.4 mm broad; sporophylls dimorphic, dentate, white-margined. (Figure 5.43)

T h a i l a n d .— NORTHERN: Chiang Mai, Phitsanulok; SOUTH-WESTERN: Kanchanaburi; PENINSULAR Ranong, Trang.

D i s t r i b u t i o n .— Myanmar (type), Malesia, and Indochina (Cambodia and cochinchina).

E c o l o g y .— Terrestrial on dry open stony slope or ground in abandoned mine, at 740 m alt.

V e r n a c u l a r .— Kut yi (Northern).

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 090; O. Thaithong 25, 40; P. Ratchata 231 [BCU]; M. Tagawa et al 11805, E. Hennipman 3207, G. Murata 38580 [BKF].

6. ***Selaginella siamensis*** Hieron., Bot. Tidsskr. 24: 113. 1901; Alston in Fl. Gén. I.-C. 7(2): 560. f. 65, 6-10. 1951; Tagawa et K. Iwats., Fl. Thail. 3(1): 18. 1979.— *Selaginella reptans* Ridl., J. Str. Br. Roy. As. Soc. 80: 155. 1919.— *Selaginella ridleyana* Kümm., Magyar Bot. Lapok 26: 100. 1938.

Stems long, growing indefinitely, climbing up bushes or procumbent, irregularly rooting to form new plants at apex, 1.9 mm diam., rather closely bearing brownish monomorphic leaves, glabrous; rhizophores stout, to more than 0.5 mm diam.; lateral branches tripinnate, ovate to oblong subtriangular in outline; ultimate branches 2-2.5 mm wide. **Ventral leaves** ascending, ovate-oblong, acute to mucronate with long aristae at apex, cordate at base, up to 3 mm long, 1.5 mm broad; edges

ciliate throughout with white setae of about 0.1 mm in length, texture softly papyraceous, green or sometimes reddish; dorsal leaves nearly the same as or smaller than ventral ones in size, asymmetrically oblong to suborbicular with long pale tails at apex, ciliate at margin. **Spikes** usually 5-8 mm long, about 1.2 mm diam.; sporophylls uniform, ovate-subtriangular with long tails. (Figure 5.44)

T h a i l a n d .— NORTHERN: Chiang Rai, Chiang Mai, Lampang, Phitsanulok; NORTH-EASTERN: Loei; CENTRAL: Nakhon Nayok; SOUTH-EASTERN: Trat; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Satun.

D i s t r i b u t i o n .— Indochina and Malesia.

E c o l o g y .— Terrestrial on rather dry ground in light shade or in open areas in natural forest, at 960 m alt.

V e r n a c u l a r .— Phak nok yung (North-eastern).

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 061, 210, 260, 322; K. Sridith 34; O. Thaithong 1153 [BCU]; M. Tagawa et al 1522; T. Shimizu et al 9037, E. Hennipman 3575 [BKF].

7. ***Selaginella tenuifolia*** Spring, Mém. Acad. Roy. Sci. Belg. 24: 253. 1850; Alston in Fl. Gén. I.-C. 7(2): 592. 1951; Tagawa et K. Iwats., Fl. Thail. 3(1): 29. 1979.

Plants small, up to 10 cm long. **Main stems** slender, with leaves 3.8 mm apart, bearing branches in the middle to upper portions; lateral branches a few times forked; ultimate branches up to 5 mm wide. **Ventral leaves** patent, oblong to subdeltoid, moderately acute at apex, unequally at base, about 2.3 mm long, those on main branches 1.4 mm broad, edges dentate, narrowly cartilaginous, texture thin; dorsal leaves elliptic with long-acuminate apex and cuneate base, subentire. **Spikes** about 3 mm wide; dorsal sporophylls elliptic, round at apex, similar to ventral trophophylls but smaller; ventral sporophylls subdeltoid with round base and long-acuminate apex, denticulate.

T h a i l a n d .—NORTHERN: Chiang Rai, Chiang Mai, Lamphun, Phrae; SOUTH-WESTERN: Kanchanaburi.

D i s t r i b u t i o n .— N. India (type) to Myanmar and Laos.

E c o l o g y .— Terrestrial on dry stony open slopes in abandoned mines and in remnants of the forest in mine area, at 400-900 m alt.

V e r n a c u l a r .— Rang kai (Peninsular).

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 036, 052; O. Thaithong 555; T. Boonkerd 1477 [BCU]; G. Murata et al 14970, K. Larsen et al 40848, K. Iwatsuki et al 3428 [BKF].

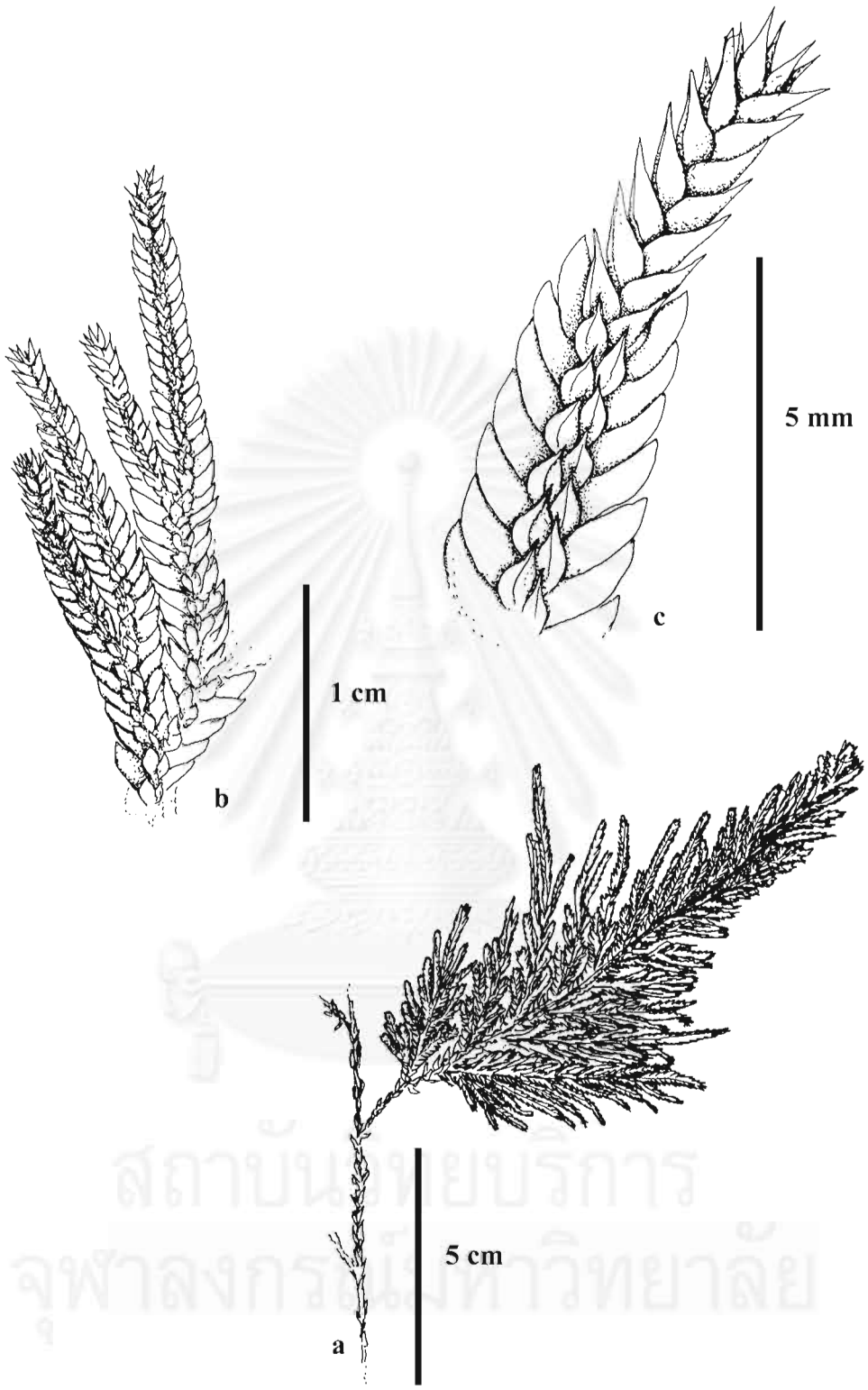


Figure 5.11 ***Selaginella biformis*** **A. Braun ex Kuhn** a. A lateral branch. -- b. Ventral and dorsal leaves. -- c. A strobilus. (A. Sathapattayanon 133)

ORDER MARATTIALES

MARATTIACEAE

Bercht. et J. Presl, Prir. Rostlin 272. 1820; Devol, Fl. Taiwan Vol. 1. 2nd ed.: 73. 1980.

Terrestrial ferns. Stem short, globose and erect. Rhizome fleshy, dorsiventral, creeping to suberect. Fronds pinnately compound, often very large, circinate when young, base of stipes with 2 large leathery persistent stipules; pulvinus at or near base of stipes and pulvini at bases of rachillae. Eusporangia closely arranged, elongate or circular sori, or synangia.

ANGIOPTERIS

Hoffm., Comm. Soc. Reg. Gott. 12: 29. 1796; Tagawa et K. Iwats., Fl. Thail. 3(1): 41. 1979.

Rhizome short, massive, bearing several large fronds in a tufts. Stipes fleshy, green, swollen at base, with scattered whitish streaks at both sides. Fronds bipinnate; pinnae and pinnules swollen at base; veins all free. Sori with two close rows of sporangia; sporangia dehiscing along slits on the side facing the veins. One species was known in Thailand and it was also found in Thong Pha Phum District.

Angiopteris evecta (G. Forst.) Hoffm., Comm. Soc. Reg. Gott. 12: 29. t. 5. 1796; Bedd., Handb.: 460. f. 285. 1883; Holttum, Rev. Fl. Malaya 2: 44. f. 3. 1955; Tagawa et K. Iwats., Fl. Thail. 3(1): 41. 1979.— *Polypodium evectum* G. Forst., Fl. Ins. Austr. Prod.: 81. 1786.— *Angiopteris crassipes* Wall. ex C. Presl, Suppl. Tent. Pterid.: 23. 1845; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 20. 1939.— *Angiopteris helferiana* C. Presl, Suppl. Tent. Pterid.: 22. 1845.— *Angiopteris* sp.; C. Chr., Contr. U.S. Natn. Herb. 26: 329. 1931.

Rhizome short, massive, bearing several large fronds in a tuft. **Stipes** fleshy, green, swollen at base, with scattered whitish streaks at both sides, more than 120 cm or much longer. **Fronds** bipinnate, pinnae and pinnules swollen at base, various in size, about 220 cm long, 180 cm wide; rachis green, fleshy, glabrous; pinnae up to 112.5 cm or more long, bearing pinnules 3 cm apart; pinnules about 16.5 by 1.5 cm,

oblong-lanceolate, acuminate at apex, each with short swollen fleshy stalk, base unequal, the basiscopic sides usually rounded and approaching the rachis a little nearer than the more cuneate acroscopic side, edges parallel for most of their length, with small blunt tooth to each vein-ending, texture subcoriaceous, green, pale below, glabrous, veins all free, simple or forked. **Sori** with two close rows of sporangia; sporangia dehiscing along slits on the side facing the veins, about 1 mm from edges. (Figure 5.45, 5.46)

T h a i l a n d .— This species is common throughout Thailand usually in shade and moist area.

D i s t r i b u t i o n .— Malesia and Indonesia.

E c o l o g y .— Terrestrial along stream in remnants of the forest in mine area, at 600-900 m alt.

V e r n a c u l a r .— Wan kip ma, Wan kip raet (Central); Kip ma lom, Kip raet (Northern); Duku (Malay/Peninsular).

U s e s .— Rhizome used in local medicine.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 106; P. Ratchata 31; S. Arkakraisri 10; T. Boonkerd 1252 [BCU]; C. Phengklai 1040, E. Smith 1466, B. Hansen & T. Smitinand 11965 [BKF].

ORDER HYMENOPHYLLALES

HYMENOPHYLLACEAE

Link, Handbuch 3: 36. 1883; Holttum, Rev. Fl. Malaya 2: 72. 1955.

Rhizome usually slender and long creeping with distant fronds, young parts covered with hairs, sometime rootless. Fronds variable in shape and size, texture membranous except along veins. Sori terminal on the ultimate one-veined lobes, or marginal at vein-ending on leaflets with many veins; receptacle columnar, more or less elongate, the apical part of the indusium more or less dilated, often more or less deeply divided into two lips.

Key to the genera

1. Involucres tubular; receptacle long extruded or included; rhizome with dense dark brownish hairs; false veinlets present **1. *Crepidomanes***
1. Involucres bilabiate; receptacle included; rhizome nearly glabrous or sparsely with brownish hairs; false veinlets absent **2. *Hymenophyllum***

1. CREPIDOMANES

C. Presl, Epim.: 258. 1849; Tagawa et K. Iwats., Fl. Thail. 3(1): 87. 1979.—*Microtrichomanes* Copel., Phil. J. Sci. 67: 35. 1938; Tagawa et K. Iwats., Fl. Thail. 3(1): 79. 1979.—*Gonocormus* van den Bosch, Hymen. Jav.: 7. 1861; Tagawa et K. Iwats., Fl. Thail. 3(1): 80. 1979.—*Trichomanes* L., Sp. Pl.: 1907; Tagawa et K. Iwats., Fl. Thail. 3(1): 82. 1979.—*Pleuromanes* C. Presl, Epim.: 258. 1849; Tagawa et K. Iwats., Fl. Thail.3(1): 85. 1979, p.p.—*Reediella* Pich.-Ser., Webbia 24: 718. 1970; Tagawa et K. Iwats., Fl. Thail. 3(1): 86. 1979, p.p.—*Microgonium* C. Presl, Hymen.: 19. pl. 6. 1843; Tagawa et K. Iwats., Fl. Thail. 3(1): 93. 1979, p.p.

Rhizome long-creeping, filiform, hairy. Fronds tiny digitate to medium size pinnately compound, the ultimate segments or lobes entire at margin; false veinlets present or absent; involucres tubular, obconic to campanulate, winged, with bilabiate mouth; receptacles extruded or included. Fifteen species were known in Thailand and 1 species among them was found in Thong Pha Phum District.

Crepidomanes latealatum (Bosch) Copel., Phil. J. Sci. 67: 60. 1938; Tagawa et K. Iwats., Fl. Thail. 3(1): 89. 1979.— *Didymoglossum latealatum* van den Bosch, Ned. Kruid. Arch. 5: 138. 1863.— *Trichomanes latealatum* (van den Bosch) H. Christ, Verh Nat. Ges. Basel 11: 424. 1896; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 64. 1939; Holttum, Rev. Fl. Malaya 2: 101. 1955.— *Trichomanes bipunctatum* var. *latealatum* (van den Bosch) C. B. Clarke, Tr. L. Soc. II. Bot. 1: 49.1880.— *Trichomanes plicatum* (van den Bosch) Bedd., Ferns Br. Ind.: t. 285. 1868; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 65. 1939.— *Trichomanes bipunctatum* var. *plicatum.* (van den Bosch) Bedd., Handb.: 42. 1883.— *Didymoglossum plicatum* van den Bosch, Ned. Kruid. Arch. 5: 139. 1863.

Rhizome about 0.4 mm diam., covered with dark brownish hairs. **Stipes** about 5 mm long, winged along almost to the base, bearing short hairs. **Fronds** variable in shape and size, ovate to oblong, round to acute at apex, tripinnatifid, usually 2.5 cm long, 1.6 cm wide; pinnae 5-8 pairs, the larger ones 9.8 mm long, 5.5 cm wide, shortly stalked or sessile in the upper ones; pinnules oblong to subdeltoid, with about 10 segments; ultimate segments linear-lanceolate, at a narrow angle to each other, acute at apex, entire and flat at margin; submarginal false veinlets absent, the other striae numerous, oblique. **Sori** on the apices of short axillary lobes; involucres tubular, 1-2 mm long, winged, the mouth bilabilate, the lips round to acute, as wide as long. (Figure 5.12, 5.47)

T h a i l a n d .— NORTHERN: Chiang Rai, Chiang Mai, Mae Hong Son, Tak, Phitsanulok; NORTH-EASTERN: Loei; CENTRAL: Nakhon Nayok; SOUTH EASTERN: Chanthaburi; SOUTH-WESTERN: Kanchanaburi, Prachuap Khiri Khan; PENINSULAR: Nakhon Si Thammarat, Trang.

D i s t r i b u t i o n .— Widely known in N. India (type), S. China and in S.E. Asia.

E c o l o g y .— Epiphytes on moist mossy tree trunks in natural forest, at 1000 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 294 [BCU]; K. Iwatsuki, H. Koyama, M. Hutoh & A. Chintayungkun 14593, T. Shimizu et al 27661, M. Tagawa, K. Iwatsuki & N. Fukuoka 1490 [BKF].

2. HYMENOPHYLLUM

Sm., Mém. Acad. Turin. 5. 418. 1793; Tagawa et K. Iwats., Fl. Thail. 3(1): 74. 1979.—*Hymenophyllum* subgen. *Mecodium* Copel., Phil. J. Sci. 64: 93. 1937.—*Mecodium* (Copel.) Copel., Phil. J. Sci. 67: 17. 1938.—*Meringium* C. Presl, Hymen.: 116. pl. 83B. 1843.

Rhizome filamentous, in general not distinctly different from stipe and rachis, Fronds small, flabellate or pinnate; false veinlets absent. Invulocres elongate, mouth dilated, entire; receptacles extruded or included. There were 13 species in Thailand and 2 species among them were found in Thong Pha Phum District.

Key to the species

1. Stipe, rachis, and pinna-rachis persistently hairy; involucres bilabiate **1. *H. exsertum***

1. All axes glabrous**;** involucres subdeltoid or rarely reniform **2. *H. polyanthos***

1. ***Hymenophyllum exsertum*** Wall. ex Hook., Sp. Fil. 1: 109, pl. 38A, 1844; Tagawa et K. Iwats., Fl. Thail. 3(4): 611. 1989.— *Hymenophyllum exertum* Wall. ex Hook., Sp. Fil. 1: 109. pl. 38A. 1844.— *Mecodium exsertum* (Wall. ex Hook.) Copel.; Tagawa et K. Iwats., Fl. Thail. 3(1): 73. 1979.

Rhizome wiry, hairy throughout, laxly branched, about 0.4 mm diam. **Stipes** remote, hairy on the abaxial sides, about 7 mm long, sometimes winged on the upper part. **Fronds** very variable in shape and size, oblong-ovate or oblong or oblong-lanceolate, round to acute at apex, tripinnatisect, 2.4 cm long, 1.9 cm wide; rachis like the upper part of stipes, hairy throughout; more densely on abaxial sides, winged throughout by flat wings, wings of the upper part broader, up to 0.9 mm on both sides; pinnae many, more than twelve in pairs on lower fronds, oblong to oblong-lanceolate, slightly falcate, round to moderately acute at apex, up to 7.22 mm wide; pinnules with a few to several segments, in larger ones pinnately decompound; ultimate segments up to 1.5 mm long, 1 mm broad, entire and flat; hairs on every axes, rather sparse on upper axes, brown, up to 2 mm long. **Sori** usually on upper sides of pinnae, dispersing from near rachis outward, the base constricted; involucres bilabiate; lips subtriangular,

moderately acute, entire and flat, up to 2 mm long, 1 mm broad; receptacles clavate, cell walls rather thick, coarsely pitted. (Figure 5.13, 5.48)

T h a i l a n d .— NORTHERN: Chiang Rai, Mae Hong Son, Chiang Mai, Lamphun, Phitsanulok; NORTH-EASTERN: Loei; CENTRAL: Nakhon Nayok; SOUTH-EASTERN: Chanthaburi, Trat; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Ranong, Nakhon Si Thammrat, Trang.

D i s t r i b u t i o n .— N. India (type from Nepal), S. China, Upper Myanmar, Indochina, south to Malesia.

E c o l o g y .— Epiphyte on moist mossy tree trunks in natural forests, about 1000 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 263, 298, 304; T. Boonkerd 93; P. Ratchata 186 [BCU]; K. Iwatsuki & N. Fukuoka 7497, E. Hennipman 3941, K. Larsen et al 32055 [BKF].

2. ***Hymenophyllum polyanthos*** (Sw.) Sw., Schrad. J. Bot. 1800 (2): 102. 1801; Tagawa et K. Iwats., Fl. Thail. 3(4): 611. 1989.— *Tricomanes polyanthus* Sw., Prod. Fl. Ind. Occ.: 137. 1788.— *Hymenophyllum polyanthus* (Sw.) Sw., Schrad. J. Bot. 1800(2): 102. 1801.—*Mecodium polyanthos* (Sw.) Copel.; Tagawa et K. Iwats., Fl. Thail. 3(1): 70. 1979.

Rhizome slender, less than 0.37 mm diam., with hairy rootlets. **Stipes** 4.5 mm long, wingless except the uppermost part, sparsely hairy especially in the younger parts, the rootlets densely hairy, the hairs brown, up to 1 mm long. **Fronds** very variable in size and form, lanceolate, oblong-lanceolate, oblong or subdeltoid, acute to acuminate at apex, 3.6 cm long, l.7 cm wide, usually tripinnatifid, light green, herbaceous; rachis winged throughout, wings very narrow, entire, flat; pinnae less than l0 pairs, the largest one in the middle of the frond, reducing in size upward and downward, the larger ones oblong-subdeltoid or oblong-lanceolate, somewhat falcate; ultimate segments linear or narrowly lanceolate, round to obtuse at apex, the margin entire and flat, usually about 0.8 mm broad. **Sori** scattered usually on the upper parts of fronds; involucres subdeltoid or rarely reniform, about 1 mm in length, usually longer than the breadth, deeply divided; lips round or moderately acute, entire or slightly crenate; receptacles clavate, included, cell walls thin, straight. (Figure 5.49)

T h a i l a n d .— NORTHERN: Chiang Mai; NORTH-EASTERN: Loei; CENTRAL: Nakhon Nayok; SOUTH-EASTERN: Chanthaburi, Trat; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Chumphon, Surat Thani, Nakhon Si Thammarat.

D i s t r i b u t i o n .— Tropics or subtropics throughout the world (type from Jamaica), north to central Japan.

E c o l o g y .— Epiphyte on moist mossy tree trunks in natural forest, at 1000 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 277, 329; P. Ratchata 302; T. Boonkerd 1052 [BCU]; M. Tagawa & K. Iwatsuki 1040, K. Iwatsuki 6493, E. Hennipman 3659A [BKF].

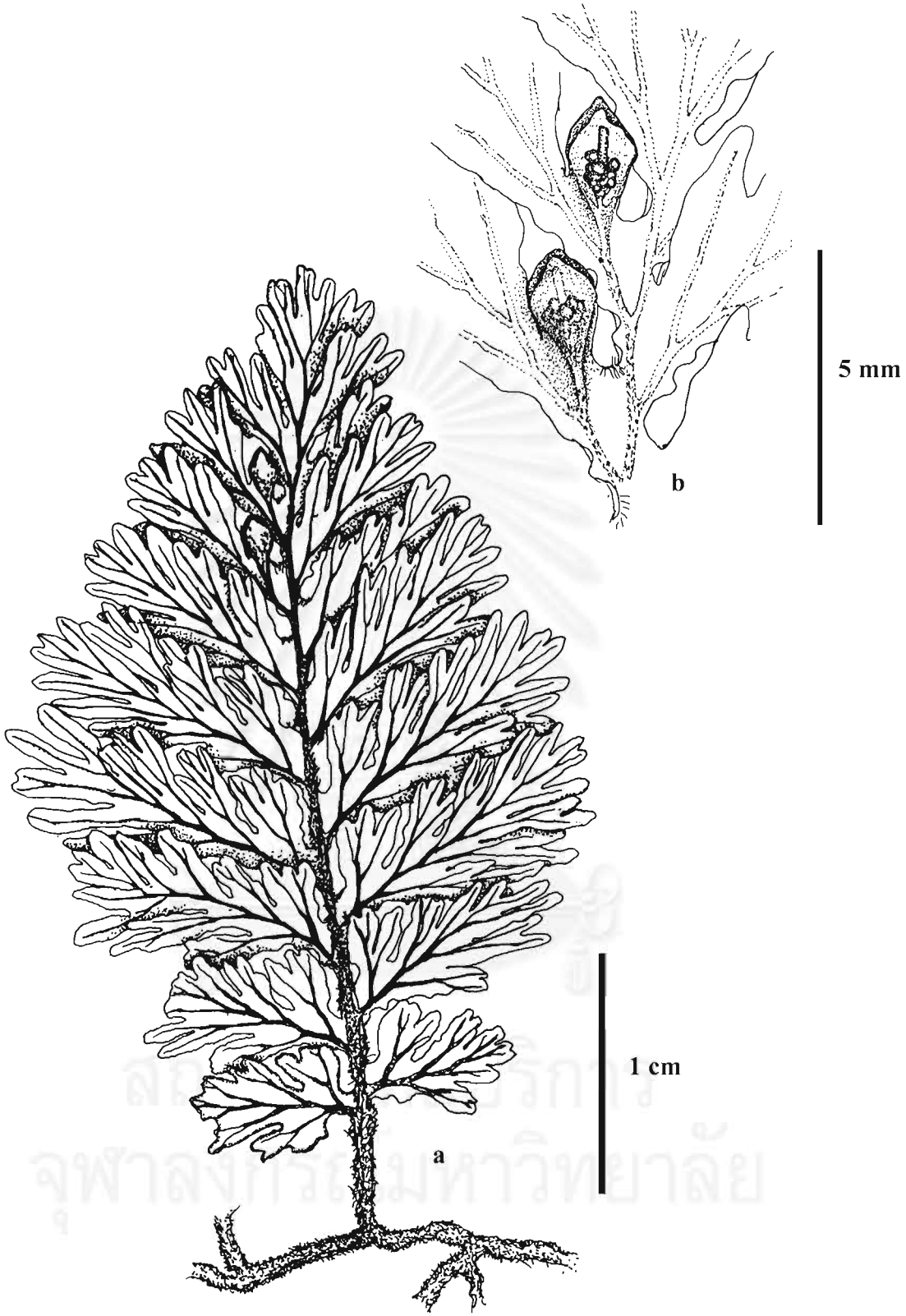


Figure 5.12 ***Crepidomanes latealatum*** **(Bosch) Copel.** a. Habit. -- b. Sori. (A. Sathapattayanon 294)

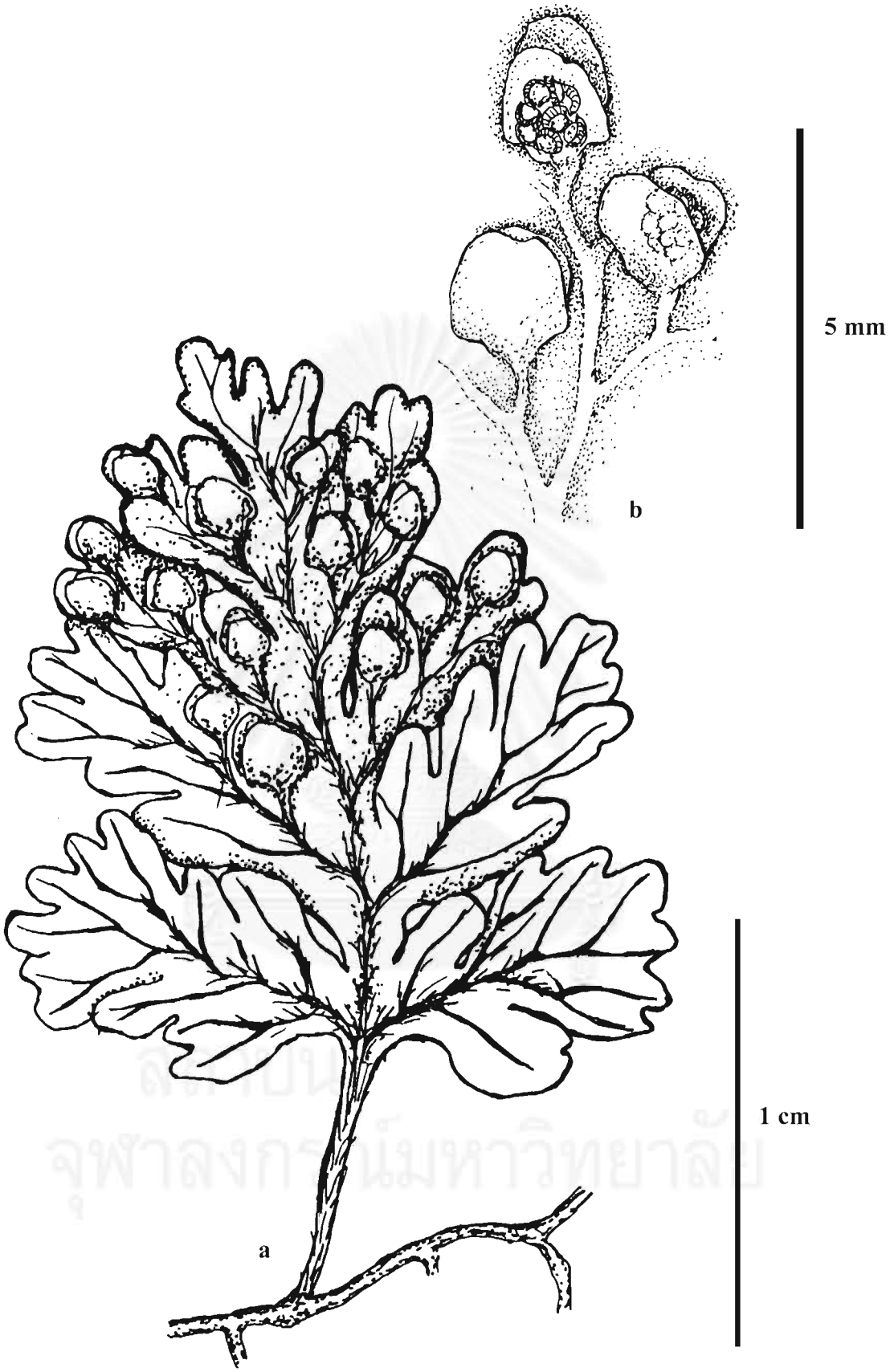


Figure 5.13 ***Hymenophyllum exsertum*** **Wall. ex Hook.** a. Habit.-- b. Sori. (A. Sathapattayanon 298)

ORDER GLEICHENIALES

GLEICHENIACEAE

(J. Presl) C. Presl, Reliq. Haenk. 1: 70. 1825; Holttum, Rev. Fl. Malaya 2: 61. 1955.— *Gleichenieae* trib. J. Presl, Wšobecný Rostlinopsis 2: 1777. 1846.

Rhizome long-creeping, the apical part covered with stiff hairs or with scales. Fronds usually long, scrambling or climbing; main rachis bearing opposite pairs of lateral branches, the apical bud protected by hairs or scales and often also by stipule-like leaflets; leaflets lobed almost to the costa; veins forked, all free. Sori on veins, terminal or not, sporangia few, rather large, without indusium.

DICRANOPTERIS

Bernh., Neues J. Bot. 1(2): 38. 1805.; Devol, Fl. Taiwan Vol. 1. 2nd ed.: 89. 1980.

Rhizome creeping, covered with deciduous, multicellular hairs of various types: straight, irregularly branched, stellate. Ultimate branches deeply pinnatifid. Dormant bud covered by stiff hairs and usually by small stipule-like lobed bracts. Reflexed accessory leafy branches (similar to ultimate branches) usually borne at base of forks. Vein more than once forked. Sori without paraphyses; sporangia 8-15; spores monolete or trilete. Four species and 2 varieties were known in Thailand, 1 species and 1 variety among them was found in Thong Pha Phum District.

Dicranopteris linearis (Burm. f.) Underw. var. ***linearis***, Bull. Torrey Bot. Club 34(5): 250. 1907; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 49. 1939; Holttum in Fl. Mal. II. 1: 33. f. 12, 14 f-i: 1959; Holttum, Rev. Fl. Malaya 2: 68. f. 16. 1955; Bedd., Handb.: 4. f. 1. 1969; Tagawa et K. Iwats., Fl. Thail. 3(1): 55. 1979; Devol, Fl. Taiwan Vol. 1. 2nd ed.: 90. 1980.— *Polypodium linearis* Burm. f., Fl. Ind.: 235. t. 67. f. 2. 1768.— *Gleichenia linearis* (Burm. f.) C. B. Clarke, Tr. L. Soc. II, Bot, 1: 428. 1880; Bedd., Handb.: 4. f. 1. 1883; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 49. 1939; Holttum, Rev. Fl. Malaya 2: 68. f. 16. 1955.

Rhizome widely creeping, hairy. **Primary rachis-branches** usual1y twice or thrice forked, the two branches at each fork nearly equal; ultimate branches 15-30 cm

long; 4-7 cm wide; stipular leaflets and rigid shining hairs with cell of attachment present at base of fork; ultimate segments linear, entire, round at apex, up to 4 mm broad; texture firm, lower surface slightly glaucous, glabrescent, veins more or less prominent on lower surface and some persistent, much-branched rusty hairs on costules. **Sori** in a single row at each side of costules. (Figure 5.14, 5.50, 5.51)

T h a i l a n d .— NORTHERN: Chiang Rai, Chiang Mai, Lampang, Lamphun; NORTH-EASTERN: Loei; SOUTH-EASTERN: Prachinburi, Chanthaburi, Trat; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Ranong, Chumpon, Surat Thani, Nakhon Si Thammarat, Phuket, Trang, Yala.

D i s t r i b u t i o n .— Tropical and subtropical regions in the Old World (type from Ceylon), north to central Japan.

E c o l o g y .— Terrestrial on dry open stony ground in clearings, usually at edge of forest in abandoned mines and at margin of some remnants of the forest in mine area, about 400-900 m alt.

V e r n a c u l a r .— Kiku kachoei (Karen/Northern); Kut pit, Kut muk (Northern); Kut taem, Chon lek, Chon (Peninsular); Kuekae, Ruesae (Malay/Peninsular).

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 020, 130; T. Boonkerd 1180, 1469 [BCU]; K. Iwatsuki, H. Koyama, N. Fukuoka & A. Nalompoon 9400, K. Larsen et al 373, C. Phengklai et al 11340 [BKF].

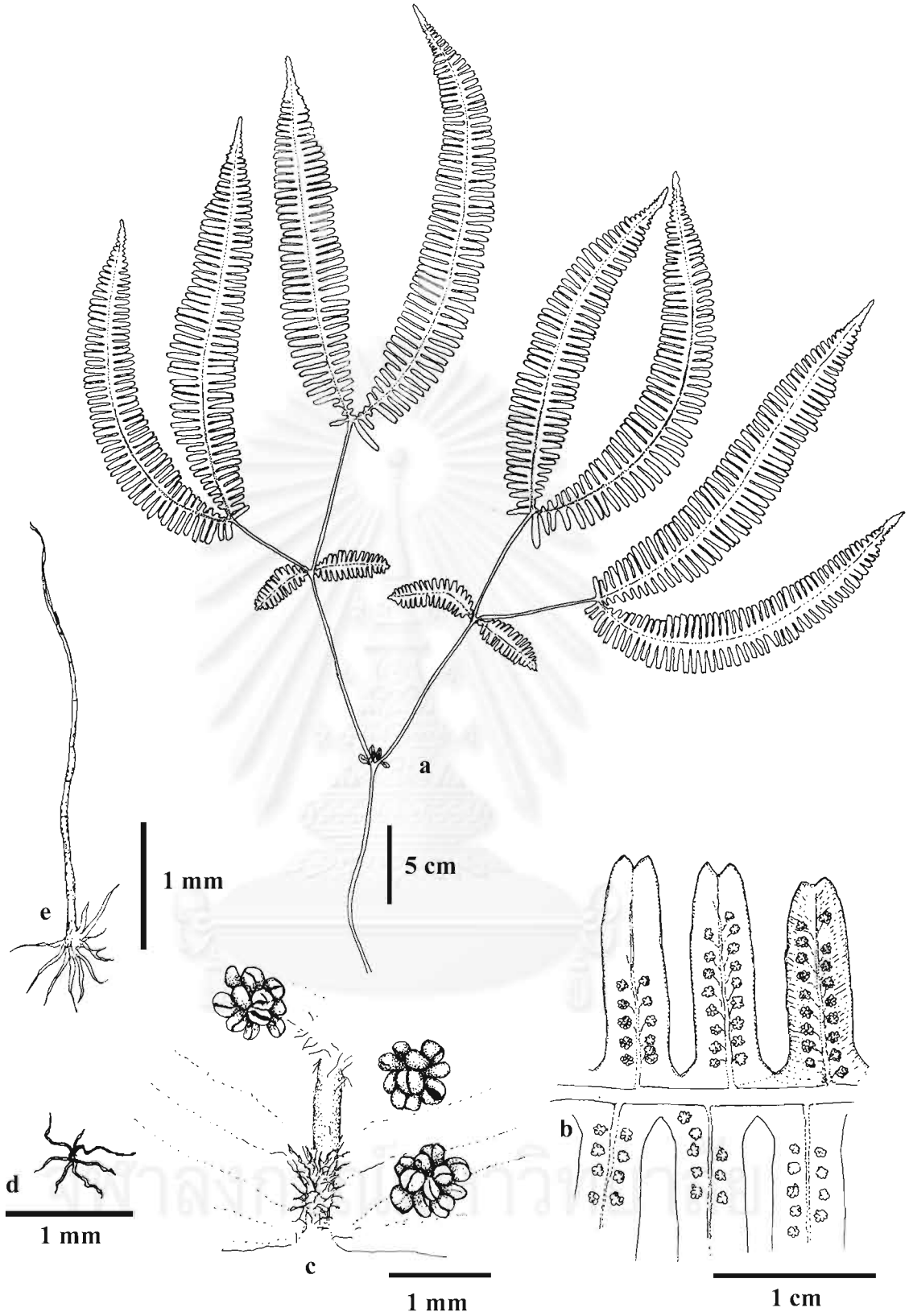


Figure 5.14 ***Dicranopteris linearis*** **(Burm. f.) Underw. var.** ***linearis*** a. Apical part of frond. -- b. Venation and Sori. -- c. Sori. -- d. Hair from lower surface of costules. -- e. Hair from base of primary rachis-branch. (A. Sathapattayanon 137)

ORDER SCHIZAEALES

SCHIZAEACEAE

Kaulf., Wesen Farrenkr. 119. 1827; Holttum in Fl. Mal. II. 1: 37. 1959.

Rhizome usually short-creeping with closely-placed fronds, less often wide-creeping or somewhat erect, the young parts covered with thick septate hairs, structure dorsiventral or radial, vascular strands protostele (medullated in *Schizaea*). Fronds of very varied structure, their branching showing varying gradations from dichotomous to pinnate; vein usually free; sporangia borne on specialized segments of the fronds (sorophores). Sorophores at the ends of veins of fertile leaflets, or in small pinnate groups at the apex of fronds or of its branches, or confined to special branches of the fronds. Sporangia arising marginally but becoming superficial due to subsegment extra-marginal growths, large, borne on massive stalks or sessile, with an almost apical annulus of a single row of elongate thickened cells, dehiscing on a line from annulus to base.

LYGODIUM

Sw., Schrad. J. Bot. 1800(2): 106. 1801; Tagawa et K. Iwats., Fl. Thail. 3(1): 59. 1979.

Rhizome creeping, hairy but whithout scale; leaves monostichous, twining, of indefinite growth. Fronds usually a few meters long; primary rachis-branches short, the apex dormant and covered with hairs, each bearing a pair of secondary branches; secondary rachis-branches bearing leaflets in a pinnate arrangement, or dichotomously branching bearing digitately lobed leaflet; sterile leaflet entire, toothed or lobed; vein free, or reticulate in some foreign species; fertile leaflets fringed along their edges with short narrow lobes, each lobe bearing two rows of sporangia, each attached to a short vein and covered by small indusium. Seven species were known in Thailand and 2 species among them were found in Thong Pha Phum District.

Key to the species

1. Primary rachis-branches distinct; rhizome wide creeping **1. *L. microphyllum***
1. Primary rachis-branches indistinct; rhizome short creeping **2. *L. salicifolium***

1. ***Lygodium microphyllum*** (Cav.) R. Br., Prod.: 162. 1810; Bedd., Handb.: 455. f. 282. 1883; Holttum in Fl. Mal. II. 1: 47. f. 5 e-f, 6,7. 1959; Tagawa et K. Iwats., Fl. Thail. 3(1): 60. 1979.— *Ugenia microphylla* Cav., Ic. Descr. Pl. 6: 76. t. 595. 1801.— *Lygodium scandens* Sw., Schrad. J. Bot. 1800(2): 106. 1801; Tardieu et C. Chr., in Fl. Gén. I.-C. 7(2): 41. 1939; Holttum, Rev. Fl. Malaya 2: 58. f. 12. 1955; Seidenf., Nat. Hist. null. Siam Soc. 19: 85.1958.

Rhizome widely creeping, irregularly branching, 2-3 mm diam., densely covered with blackish brown hairs. **Fronds** climbing, sometimes to several metres: stipes about 10 cm long, dark stramineous, glabrescent, very narrowly winged in the upper part; rachis like the upper part of stipes, stramineous, glabrescent; narrowly winged throughout; pinnae numerous, 2.67 cm apart; primary rachis-branches, 5 mm or so long, the apex densely covered with brown hairs, dormant but occasionally protruding to some extent; secondary rachis-branches 9 cm long, glabrescent, narrowly winged; leaflets several in pairs on secondary rachis-branches, with distinct stalk 2.5 mm, deltoid to oblong-subdeltoid, gradually narrowing towards moderately acute apex, subtruncate or broadly cuneate at more or less auricled base, entire at margin, glabrescent, 1.5-3 cm long, about 1 cm broad. **Sporangia-bearing lobes** narrow, protruding at margin of segments, 3-7 mm long, about 1 mm broad; indusia serrate at margin, glabrous. (Figure 5.52)

T h a i l a n d .— NORTHERN: Chiang Mai, Lampang; NORTH-EASTERN: Loei; CENTRAL: Nakhon Nayok; SOUTH-EASTERN: Chanthaburi, Trat; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Surat Thani, Songkhla, Yala.

D i s t r i b u t i o n .— Tropics of the Old World (type from Luzon), from Africa to Melanesia and Australia, north to the Ryukyus and south to New South Wales.

E c o l o g y .— Terrestrial fern climbing on bushes or on branches of trees, usually on dry slopes in open areas. Growing in abandoned mine and in remnants of the forest in mine area, about 700-800 m alt.

V e r n a c u l a r .— Kachot nu (South-eastern); Liphao yung (Peninsular).

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 364, T. Boonkerd 681, 735, 1561 [BCU]; C. Phengklai et al 13594, E. Hennipman 3647, Winit 146 [BKF].

2. ***Lygodium salicifolium*** C. Presl, Suppl. Tent. Pterid.: 102. 1845; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 41. 1939; Holttum in Fl. Mal. II. 1: 51. f. 6. 10, 13 a-b. 1959; Seidenf., Nat. Hist. Bull. Siam Soc. 19: 85. 1958; Tagawa et K. Iwats., Fl. Thail. 3(1): 64. 1979.— *Lygodium flexuosum* auct. non (L.) Sw.: H. Christ, Bot. Tidsskr. 24: 112. 1901; Holttum, Rev. Fl. Malaya 2: 57. 1955, p.p.— *Lygodium circinatum* auct. non (Burm. f.) Sw.: H. Christ, Bot. Tidsskr. 24: 112. 1901; Seidenf., Nat. Hist. Bull. Siam Soc. 19: 85. 1958.

Rhizome shortly creeping, densely covered with blackish brown hairs. **Fronds** very large, climbing, to several metres tall; stipes stramineous, minutely pubescent, very narrowly winged or with a distinct line at both sides; rachis like the upper part of stipes, 1.29 mm diam.; primary rachis-branches very short, up to 4 mm long, the apex dormant, covered with brown hairs; secondary rachis-branches pinnate, with about 4 pairs of leaflets and a terminal usually deeply lobed one; tertiary leaflets oblong-lanceolate, moderately acute at apex, cordate, subhastate or in extreme form 5-lobed at base, minutely dentate at margin, typically 10 cm long, 2.0 cm broad; stalks of leaflets distinct but wanting in smaller leaflets, up to 8.99 mm long, with a distinct junction at base of laminae; herbaceous to soft papyraceous, fresh green, almost glabrous on both surfaces except the hairy margin; every axis higher than the secondary rachis-branches with narrow but distinct wings, pubescent throughout, somewhat swollen at every junction. **Sporangia-bearing lobes** protruding at margin of tertiary leaflets, 2.17 mm long, about 0.97 mm broad; indusia glabrous. (Figure 5.53, 5.54)

T h a i l a n d .— NORTHERN: Chiang Rai, Chiang Mai, Phrae; NORTH-EASTERN: Loei; EASTERN: Nakhon Ratchasima; CENTRAL: Nakhon Nayok; SOUTH-EASTERN: Chanthaburi, Chon Buri, Trat; SOUTH-WESTERN: Kanchanaburi, Prachuap Khiri Khan; PENINSULAR: Surat Thani, Phangnga, Nakhon Si Thammarat, Trang, Phatthalung, Satun, Narathiwat, Yala.

D i s t r i b u t i o n .— Assam to Yunnan, Indochina, Hainan, Taiwan, throughout Malesia (type from Singapore), southeast to New Guinea and Micronesia.

E c o l o g y .— Terrestrial fern climbing on bushes or on branches of trees, on dry slopes in open areas. Grow in remnant of the forest in mine area and natural forest, about 800-1000 m alt.

V e r n a c u l a r .— Kut khue, Saiphan phi, U taphao (Northern); Kachot, Kachot nu (South-eastern); Yan li phao, Yan yai phao (Peninsular); Libu (Malay/Peninsular),

U s e s .— Stems used in making handbags and hats.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 056, 245; T. Boonkerd 21, 54, 656 [BCU]; C. Phengklai et al 13400, M. Tagawa et al 1109, Winit 70 [BKF].

ORDER DICKSONIALES

DENNSTAEDTIACEAE

Lotsy, Vortr. Bot. Stammesgesch. 2: 655. 1909; Holttum, Rev. Fl. Malaya 2: 302. 1955.

Rhizome creeping, covered with hairs. Fronds medium to large and much divided; ultimate leaflets more or less unequal at base; veins all free; texture thin or firm, never fleshy or leathery. Sori terminal on veins and either (a) marginal and enclosed in a cup, or (b) near the margin and more or less protected by a small reflexed lobe of the margin, or (c) near the margin and protected by pouch-shaped indusium attached below and at side of the receptacle.

Key to the genera

1. Sori elongate along margin of lobes, protected by thin reflexed edge of lobes **1. *Histiopteris***

1. Sori round, solitary at apex of veinlet, indusiate or naked
   2. Sori lacking indusia or protected by thin reflexed margin of lobes **2. *Hypolepis***
   2. Sori indusiate; indusia cup-shaped at least in appearance **3. *Microlepia***

1. HISTIOPTERIS

(Ag.) J. Sm.., Hist. Fil,: 294. 1875; Tagawa et K. Iwats., Fl. Thail. 3(1): 126. 1979.— *Pteris* Sect. *Histiopteris* Ag., Rec. Pterid.: 79. 1839.

Rhizome long-creeping, solenostelic, covered with thick hairs. Stipes long, usually very dark purplish, polished. Rachis grooved on uppersurface. Fronds larger, growing indefinitely at apex, bipinnate to tripinnate, with opposite pinnae and pinnules; veins anastomosing, areoles without free included veinlets; herbaceous, usually glaucous beneath. Sori submarginal, linear, covered by the reflexed margin of lobes, without inner indusia. One species was known in Thailand and it was also found in Thong Pha Phum District.

Histiopteris incisa (Thunb.) J. Sm., Hist. Fil.: 295.1875; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 139. f. l7, 2-3, 1939; Holttum, Rev. Fl. Malaya 2: 391. f. 227. 1955; Tagawa et K. Iwats., Fl. Thail. 3(1): 127. 1979.— *Pteris incisa* Thunb., Prod. Fl. Cap.: 171. 1800.— *Lithobrochia incisa* (Thunb.) C. Presl, Tent. Pterid.: 149. 1836.; Bedd., Handb.: 120. f. 62. 1883.

Rhizome long-creeping, covered with dark hairs. **Stipes** long, up to 74 cm or more in length, dark purplish, shining. **Fronds** bipinnate to quadripinnatifid, up to 108 cm or more in length, climbing with well spaced opposite pinnae and pinnules; rachis, costae and costules grooved on upper surface, a pair of reduced stipule-like pinnules usually present at base of each pinnae; pinnae up to 40 cm long, 15 cm wide; pinnules up to 10.5 cm long, 3.1 cm wide; veins copiously anastomosing, rather distinct below. **Sori** continuous at edge of lobes, linear, submarginal, covered by the reflexed edge of lobes. (Figure 5.55)

T h a i l a n d .— NORTH-EASTERN: Phetchabun, Loei; CENTRAL: Nakhon Nayok; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Ranong, Krabi, Nakhon Si Thammarat.

D i s t r i b u t i o n .— Pantropic.

E c o l o g y .— Terrestrial on rather dry exposed slopes in remnant of the forest in mine area, at 889 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 058; S. Arkakraisri 45; T. Boonkerd 1097 [BCU]; E. Hennipman 3642, M. Tagawa, K. Iwatsuki & N. Fukuoka 4789, T. Smitinand & Abbe 6339 [BKF].

2. HYPOLEPIS

Bernh., Schrad. Neues J. 1: 34. 1806; Tagawa et K. Iwats., Fl. Thail. 3(1): 124. 1979.

Rhizome long-creeping, solenostelic, hairy. Stipes usually covered with hairs. Fronds pinnately compound, usually herbaceous or papyraceous, hairy or glabrous, the apex sometimes growing to indefinite length; veins always free. Sori round, terminal on veinlets, usually near the margin of lobes, lacking indusia or protected by thin reflexed margin of lobes. Only 1 species was recorded from Thailand and it was also found in Thong Pha Phum District.

Hypolepis punctata (Thunb.) Mett. ex Kuhn, Fil. Afr.: 120. 1868; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 101. f. 11. 1-2. 1939; Holttum, Rev. Fl. Malaya 2: 318. 1955; Tagawa et K. Iwats., Fl. Thail. 3(1): 124. 1979.— *Polypodiilm punctatum* Thunb., Fl. Jap: 337. 1784.

Rhizome long-creeping, blackish, densely hairy at apex, glabrous on the older part, 3-4 mm diam. **Stipes** stramineous with dark brown base, puberulous, 37 cm long. **Fronds** oblong, acute at apex, widest at base, tripinnate-quadripinnatifid, 46 cm long, up to 41.4 cm wide; rachis like the upper part of stipes, stramineous, grooved on upper surface, hairy, the hairs multicellular, coarse, the bases remaining as minute prickles; lower lateral pinnae subopposite, oblong-subtriangular, acute at apex, 21 cm long, up to 14 cm wide, upper pinnae gradually reducing in size; larger pinnules oblong-subtriangular, acuminate at apex, stalked and subtruncate at base, up to 7 cm long, 2 cm wide; costules grooved, hairy throughout; secondary pinnules oblong, round at apex, truncate and sessile at base, up to 1.2 cm long, 0.4 cm wide, lobed to 2/3 way towards costules; ultimate lobed round, oblique, dentate at margin, veins pinnate, hairy but indistinct on both surfaces, papyraceous, green above. **Sori** terminal on veinlets, near the margin of lobes, naked. (Figure 5.15, 5.56, 5.57)

T h a i l a n d .— NORTHERN: Chiang Mai; NORTH-EASTERN: Phetchabun, Loei; SOUTH-WESTERN: Kanchanaburi.

D i s t r i b u t i o n .— Tropics of the Old World generally, northwards to Japan (type) and Korea, and southwards to New Zealand.

E c o l o g y .— Terrestrial on marshy ground or on wet sandy slopes in half shade in remnant of the forest in mine area, at 788 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 134; P. Ratchata 126; T. Boonkerd 45 [BCU]; M. Tagawa, K. Iwatsuki & N. Fukuoka 589, E. Smith 1084, R. Pooma 628 [BKF].

3. MICROLEPIA

C. Presl, Tent. Pterid.: 124. 1836; Tagawa et K. Iwats., Fl. Thail. 3(1): 112. 1979.

Rhizome creeping, solenostelic, covered with short hairs. Stipes rather close, hairy. Fronds pinnate to pinnately decompound, the ultimate pinnules usually

obliquely incised in most cases hairy; axes grooved, grooves decurrent to those of the next order, veins all free. Sori terminal on veins, usually close to margin of lobes; indusia attached by sides and base, rather thin, thus half cup-shaped, often hairy. Twelve species were known in Thailand and there were 2 species in Thong Pha Phum District.

Key to the species

1. Fronds simply pinnate; sori terminal on veinlets, at margin of pinnae

1. *M. hookeriana*

1. Fronds tripinnate or more compound; sori a little within the margin of lobes

2. *M. speluncae*

1. ***Microlepia hookeriana*** (Wall. ex Hook.) C. Presl, Epim.: 95. 1849; Bedd., Handb.: 62. f. 32. 1883; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 93. 1939; Tagawa et K. Iwats., Fl. Thail. 3(1): 113. f. 7: 1-2. 1979; Shieh, Fl. Taiwan Vol. 1. 2nd ed.: 248. 1980.—*Davallia hookeriana* Wall. ex Hook., Sp, Fil. 1: 172. t. 47 B. 1846.—*Scyphularia hookeriana* (Wall. ex Hook.) J. Sm., Hist. Fil.: 261. 1875.

Rhizome long-creeping, densely covered with setose bright brown hairs about 1.82 mm long, 3.23 mm diam. **Stipes** 1.7 cm apart, erect, 16 cm long, stramineous or darker, densely covered with hairs like those on rhizome but shorter, more or less grooved on the upper surface. **Fronds** pinnate, gradually narrowing towards acuminate apex, narrowly oblong, up to 47 cm long, 9 cm wide; rachis like the upper parts of stipes, distinctly grooved on the upper surface and densely hairs throughout; lateral pinnae usually more than 25 pairs, close except for a few ones which are somewhat shorter, remote and deflexed, all sessile, linear, slightly falcate, gradually narrowing towards acute apex, serrate at margin, broadly cuneate posteriorly and auricled anteriorly at base, the largest 5.2 cm long, 11 cm broad; terminal pinnae distinct, gradually narrowing upwards, up to 5.5 cm long; herbaceous, deep green, veins once forked, hairy on veins beneath and on both surfaces of costa. **Sori** terminal on veinlets, at margin of pinna; indusia cup-shaped, less than 1 mm broad, 0.5 mm long, glabrous.

T h a i l a n d .—NORTHERN: Chiang Rai; NORTH-EASTERN: Loei; EASTERN: Nakhon Ratchasima; CENTRAL: Nakhon Nayok; SOUTH-EASTERN: Chanthaburi; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Phangnga, Nakhon Si Thammarat.

D i s t r i b u t i o n .— E. Himalaya (type) and Upper Myanmar to S. China, Tonkin, Taiwan and Ryukyus, southwards to Borneo, Sumatra and Java.

E c o l o g y .— Terrestrial on rather dry ground in shade along streams in remnant of the forest in mine area, at 800 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 139; S. Arkakraisri 105; T. Boonkerd 1112 [BCU]; E. Hennipman 3832, K. Iwatuki & N. Fukuoka 3693, T. Smitinand 5910 [BKF].

2. ***Microlepia speluncae*** (L.) Moore, Ind. Fil.: 93. 1857; Bedd.,Handb.: 67.1883; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 99. 1939; Holttum, Rev. Fl. Malaya 2: 314. 1955; Tagawa et K. Iwats., Fl. Thail. 3(1): 118. 1979.— *Polypodium speluncae* L., Sp. Pl.: 1093. 1753.— *Microlepia hancei* Prantl, Arb. Bot. Gart. Breslau 1: 35. 1892.— *Microlepia speluncae* var. *hancet* (Prantl) C. Chr. et Tardieu, Not..Syst. 6: 9. 1937; in Fl. Gén. I.-C. 7(2): 100. 1939; Holttum, Rev. Fl. Malaya 2: 315. f. 182. 1955.— *Microlepia pilosula* C. Presl ex Prantl, Arb. Bot. Gart. Breslau 1: 36. 1892; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 97. 1939.— *Microlepia piaspeluncae* var. *pubescens* (Hook.) Sledge, Kew Bull. 11: 525. 1956.— *Microlepia speluncae* var. *villosissima* C. Chr., Gard. Bull. Straits Settlem. 4: 399. 1929; Holttum, Rev. Fl. Malaya 2: 315. 1955.

Rhizome wide-creeping, almost naked in the older part, deep brown, more than 7 mm diam. **Stipes** stramineous or brownish, pubescent or glabrescent, 54 cm long. **Fronds** large, tripinnate to quadripinnatifid, up to 112.2 cm long, 57 cm wide; rachis stramineous to brownish, grooved on upper surface, more or less hairy; larger pinnae oblong-subtriangular, broadly cuneate at base, broadest at lower second or third pinna, gradually narrowing towards caudately acuminate apex, with more than 28 pinnules, about 24.5 cm long, 8.3 cm wide; costa grooved on upper surface, more or less hairy, upper pinnae gradually reducing in size; larger pinnules oblong-subtriangular or oblong-lanceolate, gradually narrowing towards apex, unequally cuneate at base, up to 5.5 cm long, 1.7 cm wide, distinctly stalked, apical secondary

pinnules (segments) a little protruding; segments lobed to pinnatisect, oblong to subquadrangular, round to acute at apex, unequally cuneate at sessile base, typically 1.37 cm long, 5.96 mm wide; ultimate lobes round or spathulate, round to acute at apex, entire or undulate at margin of larger ones; softly papyraceous to papyraceous, deep green above, green below, variously hairy on axes or on laminar surfaces; veins pinnate, veinlets once or twice forked, indistinct on both surfaces, variously hairy. **Sori** a little within the margin of lobes, small; indusia cup-shaped, hairy. (Figure 5.58, 5.59)

T h a i l a n d .— NORTHERN: Chiang Rai, Chiang Mai, Mae Hong Son, Lampang, Tak; NORTH-EASTERN: Phetchabun, Loei; CENTRAL: Nakhon Nayok; SOUTH-EASTERN: Chon Buri, Chanthaburi; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Chumphon, Surat Thani, Phuket, Nakhon Si Thammarat, Trat, Satun, Narathiwat, Yala.

D i s t r i b u t i o n .— Pantropics according to the current delimitation of the species.

E c o l o g y .— Terrestrial on moderate, rather dry slopes in open areas or light shade. Growing in remnants of the forest in mine area and in natural forests, about 700-1000 m alt.

V e r n a c u l a r .— Kut phi, Kut yi, Hora phak kut (Central); Chon (South-western); Neraphusi (Peninsular).

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 096, 111, 140, 170, 206, 225, 286; T. Boonkerd 742, 1301, 1416 [BCU]; G. Murata et al 49573, E. Hennipman 3031, Kyoji Yoda 680 [BKF].

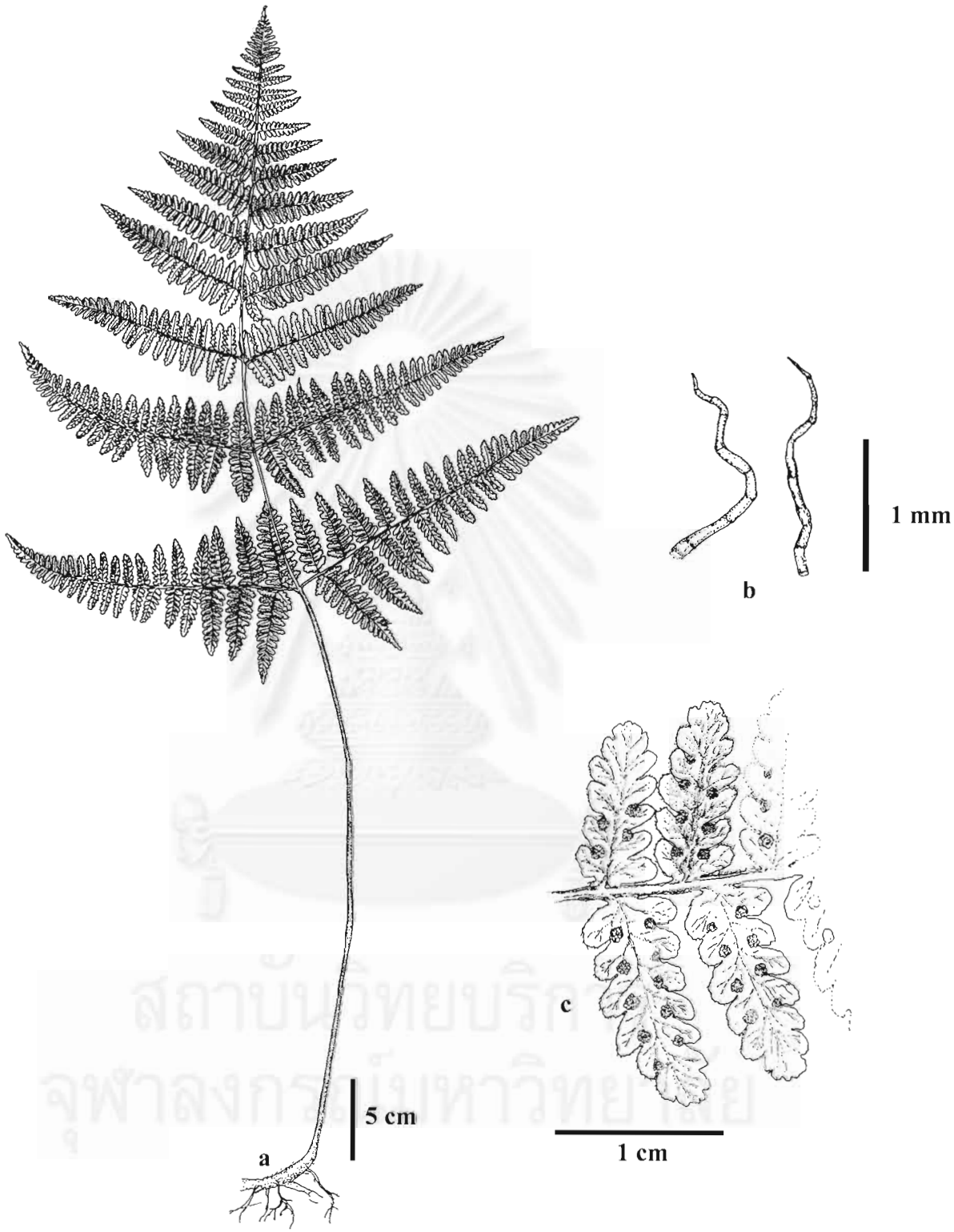


Figure 5.15 ***Hypolepis punctata*** **(Thunb.) Mett. ex Kuhn** a. Habit. -- b. Multicellular hairs. -- c. Sori. (A. Sathapattayanon 134)

DICKSONIACEAE

(C. Presl) Bower, Origin Land Fl. 591-595. 1908; Devol, Fl. Taiwan Vol. 1. 2nd ed.: 131. 1980.

Tree ferns with tall stout trunks or prostrate rhizomes, covered with a mass of hairs, Stipes not articulate to rhizome. Fronds large, tripinnatifid; veins free. Sori marginal or submarginal, terminal on veinlets; indusia 2 lobed, outer lobes a continuation of the leaf margin and bent at about right angles to leaf surface.

CIBOTIUM

Kaulf., Enum.: 229. 1824; Tagawa et K. Iwats., Fl. Thail. 3(1): 109. 1979.

Rhizome massive, densely covered with golden yellow long hairs. Stipes stout, not jointed to rhizome, densely hairy at base. Fronds very large, more than 3 m tall including stipes, pinnately decompound; ultimate segments acute at apex; veins forked, all free. Sori terminal on veins submarginal, protected by two indusia. There was only 1 species in Thailand and it was also found in Thong Pha Phum District.

Cibotium barometz J. Sm., Lond. J. Bot. 1: 437. 1842; Bedd., Handb.: 24. f. 8. 1833; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 78. f. 10, 6-7. 1939; Holttum, Rev. Fl. Malaya 2: 114. f. 45. 1955; Fl. Mal. II 1: 165. f. 33, a-c. 1963; Tagawa et K. Iwats., Fl. Thail. 3(1): 109. 1979.— *Polypodium barometz* L., Sp. Pl.: 1092. 1753.

Rhizome massive, prostrate, very densely covered with golden, yellow hairs. **Stipes** thick, sometimes attaining to 9.13 mm diam., more than 1.5 m long in larger ones, densely covered with shining, golden yellow, long (more than 4 cm long in some larger ones), slender or warty hairs at base, the hairs on upper parts not so dense, brown to darker, setose, gradually becoming shorter upwards. **Fronds** large, up to 2 m in length, more than 1 m in width, bipinnate; pinnae many, the largest ones up to 75 cm long, 25 cm wide, with numerous pinnules; pinnules deeply pinnatifid throughout, very shortly stalked or subsessile at posterior parts of pinnae, linear-lanceo1ate, gradually narrowing towards acuminate apex, broadly cuneate to subtruncate at base, 10-15 cm long, 1.5-2.5 cm wide; ultimate segments oblong, oblique to subfalcate, acute at apex, shallowly but distinctly dentate at margin,

glaucous in lower surface, 0.8-1.4 cm long, about 3 mm broad, with intervals of 4 mm between the adjacent costules; costae and costules covered with pale, entangled, flaccid, appressed hairs below; veins distinct, once (or twice in larger lobes) forked, sparsely hairy below. **Sori** terminal on usually unbranched lower veins, parallel to edge of lobes, protected by two indusia; outer indusia round, inner ones elongate at maturity, oblong. (Figure 5.60)

T h a i l a n d .— NORTHERN: Chiang Rai, Chiang Mai, Lampang, Phitsanulok; NORTH-EASTERN: Phetchabun, Loei; EASTERN: Nakhon Ratchasima; CENTRAL: Nakhon Nayok; SOUTH-EASTERN: Chanthaburi, Trat; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Yala.

D i s t r i b u t i o n .— Himalayas to S. China and Taiwan, south to W. Malesia, north to the Ryukyus.

E c o l o g y .— Terrestrial on open hill slopes and stream banks in remnant of the forest in mine area, at 737 m alt.

V e r n a c u l a r .— Kut phipa, Kut phan (Northern); Khon kai noi (North-eastern); Hatsadaeng (Eastern); La-ong faifa, Wan kai noi (Central); Kut sua, Pho si, Ninla phosi (Peninsular).

U s e s .— Locally used for medicine, especially silky hairs on buds used for fresh wound.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 365, T. Boonkerd 570, 1405 [BCU]; K. Iwatsuki, N. Fukuoka & A. Chintayungkun 9707, E. Hennipman 3927, G. Murata et al 17421 [BKF].

LINDSAEACEAE

Pic. Serm., Webbia 24(2): 707-708. 1970; Shieh, Fl. Taiwan Vol. 1.2nd ed.: 249. 1980.

Terrestrial or climbing. Rhizome creeping, clothed with narrow scales or with hairs. Fronds pinnately divided, sometimes very finely, in a few cases simple, not articulated to rhizome; veins free or anastomosing without included free veinlets. Sori marginal or nearly marginal, terminal on the veins simple or joined to form a fusion-sori (coensori) of varying lengths, indusium always present, attached on the basal sides of the sorus and opening toward the margin.

Key to the genera

1. Fronds pinnate to bipinnate; sori uniting the apices of many veins **1. *Lindsaea***
1. Fronds tripinnate to quadripinnate; pinnules usually short, or if long the sori uniting the end of a few veins **2. *Sphenomeris***

1. LINDSAEA

Dryand., Trans. L. Soc. 3: 39. 1797; Tagawa et K. Iwats., Fl. Thail. 3(2): 129. 1985.— *Isoloma* J. Sm., J. Bot. 3: 414. 1841.

Rhizome creeping, terrestrial or climbing, covered with hairs or scales, or with both. Fronds simply pinnate to bipinnate, usually with dimidiate pinnae or pinnules, veins free or anastomosing, herbaceous, glabrous. Sori usually marginal, terminal on veinlets, joining the apex of veins to form fusion-sori along the margin of lobes; indusia opening outwardly. Eighteen species were known in Thailand and only 1 species among them was found in Thong Pha Phum District.

Lindsaea ensifolia Sw., Schrad. J. Bot. 1800(2): 77. 1801; K.U. Kramer in Fl. Mal. II. 3: 211. 1971; Tagawa et K. Iwats., Fl. Thail. 3(2): 131. 1985.— *Schizoloma ensifolia* (Sw.) J. Sm., J. Bot. 3: 414. 1841; Bedd., Handb.: 80. f. 41. 1883; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 129. f. 15, 1-2. 1939; Holttum, Rev. Fl. Malaya 2: 346. f. 200. 1955; Seidenf., Nat. Hist. Bull. Siam Soc. 19: 86. 1958.— *Lindsaea griffithianum* Hook., Sp. Fil. 1: 219. t. 68 B. 1846.— *Schizoloma griffithianum* (Hook.) Fée, Gen.

Fil.: 108. 1852.— *Diplazium bantamense* auct. non Blume: H. Christ, Bot. Tiddsskr. 24: 108. 1901.

Rhizome creeping, 3-5 mm diam., bearing fronds close together or up to 2 cm apart, brown to darker, scaly at least apically; scales linear, up to 4.0 mm long, 1.02 mm broad, brown, slightly shining. **Stipes** stramineous or castaneous at least at base. **Fronds** simply pinnate, ovate to oblong-lanceolate in outline, lateral pinnae 3-7 pairs, linear-lanceolate, caudately acuminate at apex, cuneate, rounded or subtruncate at base, very shortly stalked, entire at margin, up to 27 cm long, 2.3 cm broad, rather variable, smaller ones about 5 mm broad; terminal pinnae like lateral ones, subcoriaceous; veins anastomosing forming 2-4 rows of areoles at each side of costa, distinct beneath. **Sori** continuous along margin; indusia firm, nearly reaching the edges. (Figure 5.61)

T h a i l a n d .— NORTHERN: Chiang Mai, Phitsanulok; NORTH-EASTERN: Loei, Nong Khai; EASTERN: Ubon Ratchathani; CENTRAL: Nakhon Nayok; SOUTH-EASTERN: Rayong, Chanthaburi, Trat; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Krabi, Ranong, Surat Thani, Phuket, Nakhon Si Thammarat, Trang, Satun, Yala.

D i s t r i b u t i o n .— Old World Tropics from W. Africa (type from Mauritus) to Australia and Polynesia, north to the Ryukyus.

E c o l o g y .— Terrestrial on rather dry slopes or on sandy ground, usually in open or half shade areas. In abandoned mine, remnants of the forest in mine area and in natural forests. Fairly common and locally abundant throughout Thailand at altitudes about 800-1000 m.

V e r n a c u l a r .— Hang nok kaling (Central).

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 039, 045, 087, 254, 266, 309, 320; T. Boonkerd 1243, 1261, 1309 [BCU]; J. F. Maxwell 00-2, T. Shimizu et al 10486, K. Larsen & T. Smitinand 9739 [BKF].

2. SPHENOMERIS

Maxon, J. Wash. Acad.. Sci. 3: 144. 1913, nom. cons.; Tagawa et K. Iwats., Fl. Thail. 3(2): 147. 1985.

Terrestrial ferns. Rhizome creeping, scaly with narrow shinning dark brown scales. Fronds bipinnate to quadripinnate; ultimate segments cuneiform, uninervate or with once or twice forked veinlets. Sori terminal on veinlets, uninervate or more often uniting two to three veinlets, close to margin; indusia attached by base, opening outwardly. One species and 2 varieties were recorded in Thailand. In this study, 1 species and 2 varieties were found. One of these is a new record variety to Thailand, that is variety *rheophila*.

Key to the species

1. Ultimate segments abruptly spathulately broadened at the sorus, slightly narrowed at round apex; indusium reach or nearly reach to the margin of soriferous apex **1. *S. chinensis* var. *divaricata***
1. Ultimate segments gradually broadened to the base; indusium not reach to the margin of soriferous apex **2. *S. chinensis* var. *rheophila***

1. ***Sphenomeris chinensis*** (L.) Maxon var. ***divaricata*** (H. Christ) K.U. Kramer, Blumea 15: 572. 1968; in Fl. Mal. II. 1: 183. f. 1. 1971; Tagawa et K. Iwats., Fl. Thail. 3(2): 148. 1985.—*Odontosoria chinensis* var. *divaritata* H. Christ, J. Bot. II. 2: 23. 1909.—*Stenoloma chusana* var. *tenuifolia* auct. non (Sw.) C. Chr.: Holttum, Rev. Fl. Malaya 2: 341. f. 198. 1955.

Rhizome short-creeping, 4 mm diam., bearing fronds close together, densely scaly; scales dark brown, up to 2 mm long, 2-3 cells broad at base, stiff. **Stipes** stramineous, brownish in lower part, scaly at base, grooved on abaxial surface of upper part, up to 40 cm long. **Fronds** oblong to narrower, up to 40 by 15 cm, acuminate at apex, tripinnate to quadripinnatifid; pinnae alternate, subtriangular, attenuately acuminate at apex, cuneate and stalked at base, suddenly spathulate-broadened at the sorus, slightly narrowed at the rounded apex, margin erose; veins usually one or two in each ultimate lobe, hardly visible. **Sori** not rarely two together

in a segment, mostly uninerval, if binerval mostly on two connivent vein-end; the soriferous apex usually dilated, uni- or binerved; indusia, 0.5 by 1 mm, attached at base and basal part of both sides, with distinctly convex base. (Figure 5.16 d, 5.62)

T h a i l a n d .— NORTH-EASTERN: Loei; SOUTH-EASTERN Chanthaburi; SOUTH-WESTERN: Kanchanaburi.

D i s t r i b u t i o n .— E. Himalayas, S.W. China, Myanmar, Indochina (type) and Malesia.

E c o l o g y .— Terrestrial on rather dry open sandy or stony ground in abandoned mine, at 840 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 062; Y. Yuyen 188 [BCU]; T. Smitinand & P. Suvanakoses 417, T. Smitinand 10140, M. Tagawa, K. Iwatsuki & N. Fukuoka 1273 [BKF].

2. ***Sphenomeris chinensis*** (L.) Maxon var. ***rheophila*** K.U. Kramer, Blumea 15: 573. 1968; in Fl. Mal. II. 1: 183. f. 2. 1971.

Rhizome short-creeping, 2-4 mm diam., bearing fronds close together, densely scaly; scales dark brown, up to 2 mm long, 2-3 cells broad at base, stiff. **Stipes** stramineous, brownish in lower part, scaly at base, grooved on abaxial surface of upper part, up to 27 cm long. **Fronds** oblong to narrower, elongate ovate, up to 30 by 20 cm, acuminate at apex, tripinnate or tripinnatifid; pinnae rigid, often with revolute margins, alternate, subtriangular, attenuately acuminate at apex, cuneate and stalked at base, gradually broadened to base, most of them monosporous and 4-5 times as long as wide, subcoriaceous; veins usually one or two in each ultimate lobe, hardly visible. **Sori** terminal on one, less often on two vein-end, close to apex of lobes; indusia 0.5 by 0.6 mm, attached at base and basal part of both sides, convex at base. (Figure 5.16 a-c, 5.63, 5.64)

T h a i l a n d .— SOUTH-WESTERN: Kanchanaburi.

D i s t r i b u t i o n .— Malesia: Pahang and Central Sumatra.

E c o l o g y .— Terrestrial on rather dry open sandy or stony ground in abandoned mines and in remnants of the forest in mine area, about 700-900 m alt.

S p e c i m e n e x a m i n e d .—A. Sathapattayanon 023, 033 [BCU].

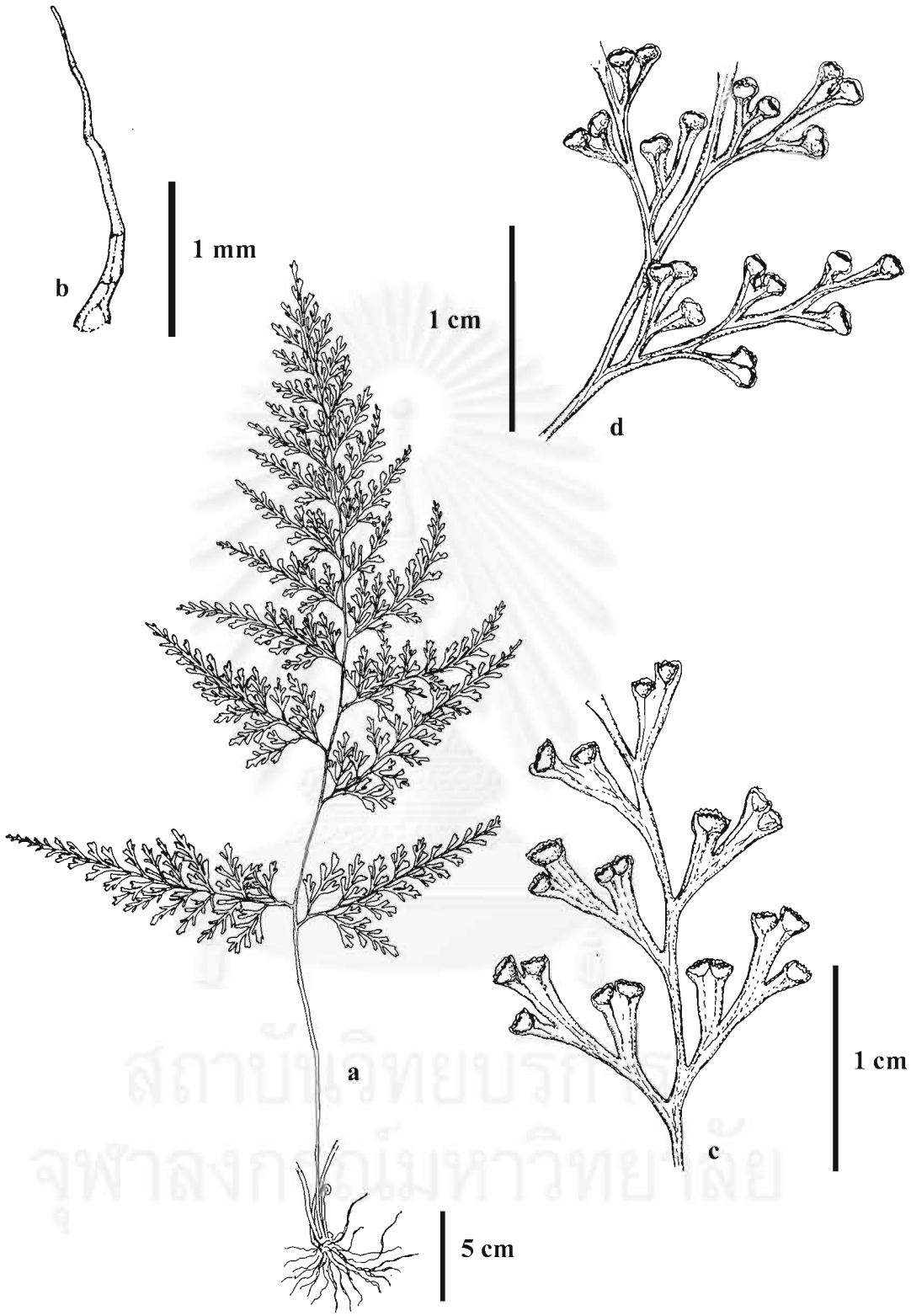


Figure 5.16 ***Sphenomeris chinensis*** **(L.) Maxon** a.-c. : **var.** ***rheophila*** **K.U. Kramer;** a. Habit. -- b. Rhizome scale. -- c. Sori and soriferous apex. -- d. : **var.** ***divaricata*** **(H. Christ) K.U. Kramer;** Sori and soriferous apex. (a. - c. : A. Sathapattayanon 062, d. : A. Sathapattayanon 023)

ORDER CYATHEALES

CYATHEACEAE

Kaulf., Wesen Farrenkr. 119. 1827; Holttum, Rev. Fl. Malaya 2: 115. 1955.

Terrestrial tree frens. Stems erect, forming a massive trunk in most species, when old cover with a mat of interlacing roots; apex of trunk and base of stipe more or less densely with scales. Stipes scaly at least nears the base. Fronds large, usually bipinnate and more or less deeply bipinnatifid; costules of pinnulate-lobes nearly at right angles to the costae; veins strictly pinnate, simple or forked. Sori one on the veins, the sporangia attached to a small raised receptacle, often mixed with hairs, without indusium or with a thin cup-shaped indusium which completely enclosed the sorus when young.

CYATHEA

Sm., Mém. Acad. Turin. 5. 416. 1793; Tagawa et K. Iwats., Fl. Thail. 3(1): 101. 1979.—*Gymnosphaera* Blume, En. Pl. Jav.: 242. 1828.—*Sphaeropteris* Bernh., Schrad. J. Bot. 1800(2): 122. 1801.—*Alsophila* R. Br., Prod.: 158. 1810.

Terrestrial tree ferns. Stem erect, tall, up to 10 m or more in height, scaly, bearing rosette of fronds at apex. Fronds usually larger, bearing both scales and hairs, pinnately compound, veins usually free. Sori round, dorsal on veinlets, on distinct receptacle; indusia distinct or wanting. Seven species were recorded in Thailand and 2 species among them were found in Thong Pha Phum District.

Key to the species

1. Sori with indusia; stipes with short spines throughout, scaly at base

1. *C. borneensis*

1. Sori without indusia; stipes covered throughout by copious spreading scales

2. *C. gigantea*

1. ***Cyathea borneensis*** Copel., Phil. J. Sci. 6: 135. 1911; Holttum, Fl. Mal. II. 1: 110. 1963; Tagawa et K. Iwats., Fl. Thail. 3(1): 103. 1979.—*Cyathea obtusata* Rosenst., Med. Rijksherb. 31: 1. 1971; Holttum, Rev. Fl. Malaya 2: 121. 1955.

Trunks to 2 m or more tall. **Stipes** about 40.6 cm long, with short spines throughout, scaly at base, dark purplish or brownish; scales linear, up to 2.06 cm long, 1.05 mm broad, dark brown, shining, edges ferrugineous, narrow, soon abraded; pneumathodes 1 cm or more in length, in a single row with short distance between each other. **Fronds** main rachis with short spines at base only, smooth or warty, pale brown; lower pinnae distant, more than 10 cm apart, reduced to 5 cm long or so, variable in form; longest pinnae about 48.2 cm long, 18.5 cm wide, caudately acuminate at apex; pinna-rachis brown or paler, purplish at basal portion, sparsely hairy with pale crisped hairs and bearing very sparse pale brown scales; pinnules more than 25 pairs, larger ones 2.5 cm apart, very shortly stalked, patent, straight or more or less falcate, lanceolate, gradually narrowing towards acuminate apex, truncate at base, about 9.5 cm long, 1.8 cm wide, lobed almost to costae, remaining decurrent lamina 0.2-1 mm broad; lobes oblique, falcate, round at apex, serrate at margin, about 0.81 cm long, 3.55 mm broad; costae sparsely scaly beneath with entire, acuminate, dark, usually flat scales; thinly papyraceous, veins forked, distinct on both surface. **Sori** close to costules; receptacles swollen; indusia thin, flat, on costular side of receptacles, usually under matured sori but visible. (Figure 5.65, 5.66)

T h a i l a n d .— EASTERN: Buri Ram; CENTRAL: Nakhon Nayok; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Chumphon, Surat Thani, Nakhon Si Thammarat, Satun.

D i s t r i b u t i o n .— Cambodia, Myanmar, Malesia, and Borneo (type).

E c o l o g y .— Terrestrial on rather dry ground near stream in light shade in remnants of the forest in mine area, about 600-900 m alt.

V e r n a c u l a r .— Maha sing dam (Northern); Kut ton, Maha sadam (Peninsular).

U s e s .— Fibrous trunk used for orchid media.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 049, 094, 105, 118,127, 146, 152, 164 [BCU], K. Iwatsuki & N. Fukuoka 7408, E. Hennipman 10878, J. F. Maxwell 97-188 [BKF].

2. ***Cyathea gigantea*** (Wall. ex Hook.) Holttum, Gard. Bull. S. S. 8: 318. 1935; Rev. Fl. Malaya 2: 128. f. 53. 1955; Fl. Mal. II 1: 124. 1963; Tagawa et K. Iwats., Fl. Thail. 3(1): 105. 1979.— *Alsophila gigantea* Wall. ex Hook., Sp. Fil. 1: 53. 1844.— *Alsophila glabra* auct. non. (Blume) Copel.: Bedd., Handb.: 14. 1883.

Trunks up to 2 m or more tall. **Stipes** up to 52 cm or more long, nearly black or deep castaneous, polished, densely covered with spreading scales; scales up to 5.91 mm long, 0.52 mm broad, dark brown to nearly black, shining, stiff, edges ferrugineous, rather broad, pale; pneumathodes small, in a single row, distinct. **Fronds** main rachis castaneous to nearly black, minutely scaly, smooth; pinnae up to 47 cm or more long, 18 cm wide, acuminate at apex; pinna-rachis hairy on upper surface, sparsely warty or scaly beneath, dark at base, paler towards apex; pinnules about 2.5 cm apart, patent or ascending, straight or slightly falcate lanceolate, caudate-acuminate at apex, cordate at base, very shortly stalked, up to 9.2 cm long, 1.66 cm wide, lobed to more than 1/3 way towards costae; round at apex, oblique, falcate, serrate at margin, up to 4.64 mm broad, with narrow sinus; texture thin, papyraceous, green, veins pinnate, veinlets simple, all free. **Sori** close to costules or medial, naked. (Figure 5.67)

T h a i l a n d .— NORTHERN: Chiang Rai, Chiang Mai, Tak; NORTH-EASTERN: Loei; SOUTH-EASTERN: Chanthaburi, Trat; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Ranong, Surat Thani, Phangnga, Nakhon Si Thammarat, Satun, Yala.

D i s t r i b u t i o n .— E. Himalaya (type), S. India, Ceylon, Myanmar, S. China, Indochina, Malesia, Sumatra and W. Indonesia.

E c o l o g y .— Terrestrial on mountain slopes or stream banks in abandoned mine and in remnants of the forest in mine area, about 800-900 m alt.

V e r n a c u l a r .— Maha sedam (South-eastern); Maha sadaeng (Peninsular); Kut ngong, Kut yong, Kut hang nok yung (Northern); Khasudo (Karen/Northern).

U s e s .— Fibrous trunk used for orchid media.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 025, 027, 040; P. Ratchata 71; T. Boonkerd 203 [BCU]; T. Shimizu et al 26596, K. Iwatsuki & N. Fukuoka 7182, E. Hennipman 3600 [BKF].

ORDER PTERIDALES

ADIANTACEAE

Newman, Hist. Brit. Fern 5. 1840; Shieh, Fl. Taiwan Vol. 1. 2nd ed.: 302. 1980.

Terrestrial ferns. Rhizome erect, oblique or creeping, solenostelic or dictyostelic, clothed with either hairs or narrow brownish scales. Fronds uniform or rarely subdimorphic, 1-4 pinnate or pedate, rarely simple, not articulate to rhizome; veins free or rarely anastomosing without included free veinlets. Sori superficial, linear, following the course of veins, exindusiate or close to the margin, borne along the apical part of fertile veins on the underside of the sharply reflexed discolored membranaceous or coriaceous leaf-margin, which protect the soil as a false indusia; sporangia with the vertical annulus, developing in mixed sequence; spores tetrahedral.

Key to the genera

1. Sori at the end of veins, protected by reflexed margin of lobes **1. *Cheilanthes***
1. Sori superficial, without indusia **2. *Pityrogramma***

1. CHEILANTHES

Sw., Syn. Fil.: 5, 126. 1806; Tagawa et K. Iwats., Fl. Thail. 3(2): 200. 1985.—*Aleuritopteris* Fée, Gen. Fil.: 153. pl. 12 B. f. 1-2. 1852.

Rhizome short, suberect to ascending, scaly. Stipes without articulation; axes grooved on adaxial surface, grooves decurrent. Fronds pinnately divided; veins all free. Sori at end of veinlets, in appearance often continuous along the margin of lobes, protected by reflexed margin of lobes. Seven species were known in Thailand and only 1 species among them was found in Thong Pha Phum District.

Cheilanthes tenuifolia (Burm. f.) Sw., Syn. Fil.: 129, 332. 1806; Bedd., Handb.: 92. 1883; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 173. 1940; Holttum, Rev. Fl. Malaya 2: 590. f. 347. 1955; Tagawa et K. Iwats., Fl. Thail. 3(2): 201. 1985. — *Trichomanes tenuifolium* Burm. f., Fl. Ind.: 237. 1768.

Rhizome short, ascending, covered with scales; scales light brown, very narrow, entire, 2.17 mm long. **Stipes** castaneous, polished, slightly swollen and densely scaly at base, sparsely and minutely scaly upwards, 19.5 cm long, grooved on adaxial surface. **Fronds** dimorphic; sterile fronds smaller, with stipe 8-12 cm in length, deltoid in outline. **Fertile fronds** tripinnate, or the larger quadripinnatifid, subdeltoid in outline, up to 9.8 by 9 cm; rachis and pinna-rachis scaly, grooved on upper surface; pinnae ten or more pairs, basal ones the largest, subtriangular, acute at apex; middle pinnae oblong-subtriangular; larger pinnules pinnatisect with a few pairs of lobes and a large terminal one, terminal lobes of pinnules like terminal pinnae and pinnules, oblong, round at apex, 10.98 by ca. 3.16 mm, entire; ultimate lobes round or oval, 5.11 mm long, up to 1.66 mm broad, papyraceous, green; veins all free, obscure. **Sporangia** confined to the end of veins but appearing continuous at margin of lobes, when young protected by reflexed margin of lobes, edges uneven, pellucid. (Figure 5.17, 5.68, 5.69)

T h a i l a n d .— NORTHERN: Chiang Mai, Mae Hong Son, Lampang, Lamphun, Phrae, Phitsanulok, Tak; CENTRAL: Nakhon Nayok; SOUTH-EASTERN: Chanthaburi, Trat; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Chumphon, Surat Thani, Songkhla, Phangnga, Satun, Trang, Yala.

D i s t r i b u t i o n .— Tropics of Asia and Oceania, from India and S. China through Malesia (type from India) to Polynesia, Australia and New Zealand.

E c o l o g y .— Terrestrial on dry open stony ground in abandoned mines, about 400-900 m alt.

V e r n a c u l a r .— Chon phi (Peninsular).

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 024, 032; T. Boonkerd 438, 1015, 1217 [BCU]; J. F. Maxwell 94-1035, M. Tagawa et al 2364, E. Smith 1502, K. Larsen et al 63886 [BKF].

2. PITYROGRAMMA

Link, Handb. Gew. 3: 19. 1833; Tagawa et K. Iwats., Fl. Thail. 3(2): 193. 1985.

Rhizome short, ascending, scaly; scales narrow, aciculate, brown. Stipes dark, polished. Fronds pinnately compound, herbaceous to papyraceous, the lower surface usually covered with waxy powder; veins all free. Sori along veins, without indusia, with no paraphyses; spores tetrahedral. One species was known in Thailand and it was also found in Thong Pha Phum District.

Pityrogramma calomelanos (L.) Link, Handb. Gew. 3: 20. 1833; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 189. f. 22, 3-4. 1940; Holttum, Rev. Fl. Malaya 2: 593. t. 348. 1955; Tagawa et K. Iwats., Fl. Thail. 3(2): 193. 1985. — *Acrostichum calomelanos* L., Sp. Pl.: 1072. 1753.— *Pellaea calomelanos* (L.) Link, Fil. Sp.: 61. 1841; Bedd.; Handb.: 104. 1883.

Rhizome short, erect, bearing a tuft of fronds, covered with scales; scales bright brown, narrow, 4.01 mm long, thin, entire. **Stipes** up to 36.5 cm long, dark purple, polished, scaly on lower part, glabrous upwards, covered with white powder in young stage. **Fronds** oblong, with acuminate apex, bipinnate-tripinnatifid, 35.5 by 30 cm; rachis grooved on upper surface; lateral pinnae gradually smaller upwards; lower ones stalked, linear-subtriangular, acuminate to long-tailed at apex, up to 15 by 4.4 cm; pinna-rachis slender, grooved; grooves decurrent to those on rachis; pinnules oblong to oblong-lanceolate, cuneate at base, acute to acuminate at apex, lobed or pinnatisect in larger ones, up to 1.5 by 1 cm; lobes oblanceolate to spatulate, acute and dentate at apical portion, herbaceous, light green, glabrous but coated with white waxy powder; veins free, pinnate in larger ones, to several times forked. **Sporangia** placed along veins throughout the lower surface, without any protection. (Figure 5.70, 5.71)

T h a i l a n d .— NORTHERN: Chiang Mai, Mae Hong Son, Tak; SOUTH-EASTERN: Trat; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Nakhon Si Thammarat, Narathiwat, Yala, Phangnga, Trang , Satun.

D i s t r i b u t i o n .— Pantropics (type from America); this may have been spread to the paleotropics by man.

E c o l o g y .— Terrestrial on exposed to half shaded ground in abandoned mines and in remnant of the forest in mine area, about 400-900 m alt.

V e r n a c u l a r .— Foen ngoen, Foen thong (General).

U s e s .— Often cultivated as an ornamental.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 019; T. Boonkerd 476, 1024, 1214 [BCU]; J. F. Maxwell 86-524, K. Larsen et al 30938, C. Phengklai et al 12978 [BKF].

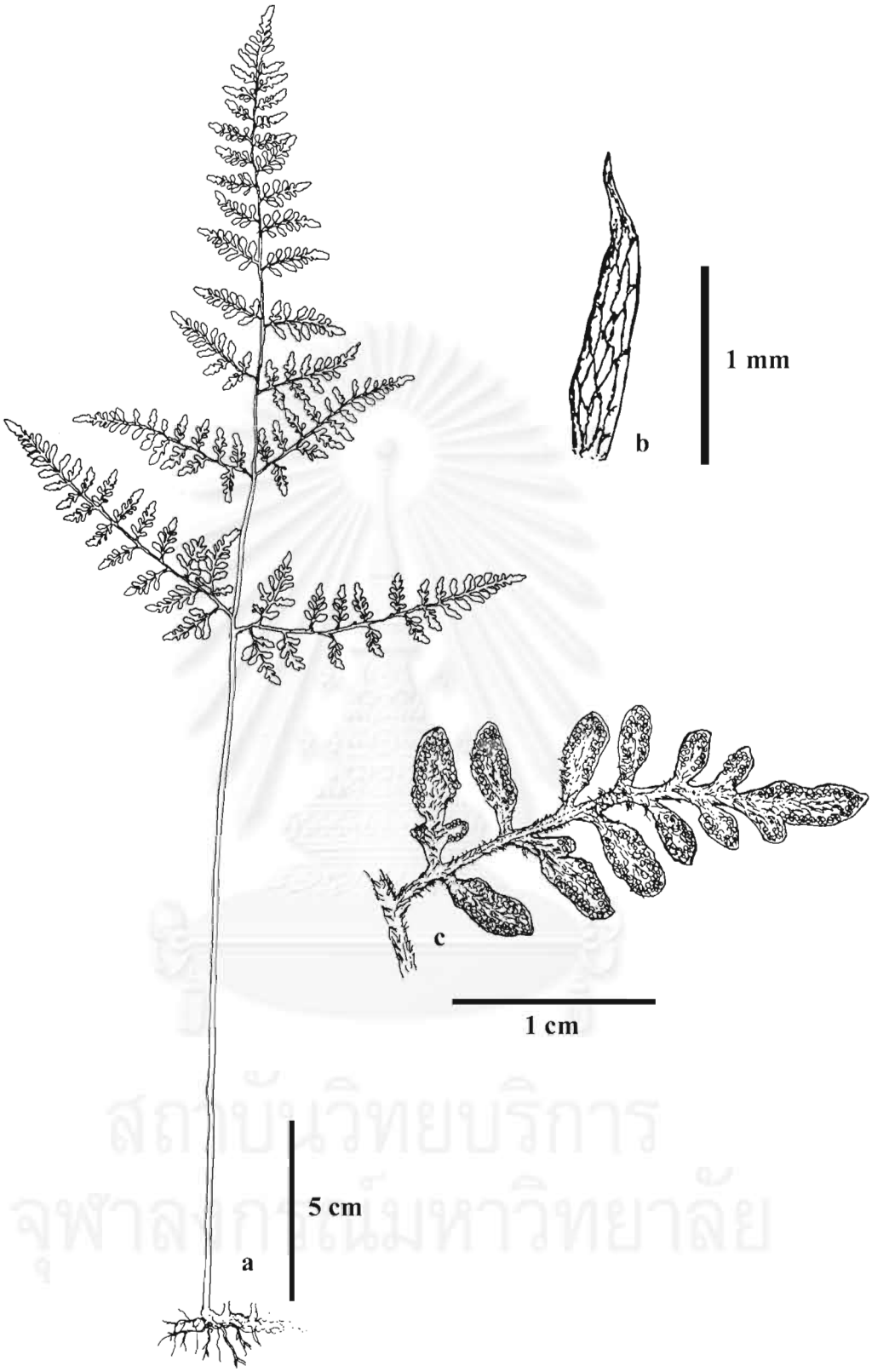


Figure 5.17 ***Cheilanthes tenuifolia*** **(Burm. f.) Sw.** a. Habit. -- b. Rhizome scale. -- c. Sori. (A. Sathapattayanon 024)

PTERIDACEAE

E.D.M. Kirchn., Schul-Bot. 109. 1831; Shieh, Fl. Taiwan Vol. 1. 2nd ed.: 281. 1980.

Terrestrial ferns. Rhizome erect or creeping, clothed with scales. Fronds unifrom or subdimorphic, 1-3 pinnate or variously divided, not articulate to rhizome; veins free or anastomousing without included free veinlets. Sori round or oblong, borne on distal ends or on the apical parts of veins, or forming continous coenosori borne on the vascular commissure connecting the vein-ends, without true indusium, but protected by the modified and sharply reflexed leaf-margin and opening introrsely.

PTERIS

L., Sp. Pl.: 1073. 1753; Tagawa et K. Iwats., Fl. Thail. 3(2): 231. 1985.

Rhizome usually short, erect or creeping, scaly; scales usually small, concolorous or bicoloured with pale ferrugineous edges. Stipes, rachis and costa distinctly grooved on upper surface, the edges distinct, usually spinose on costa, the grooves decurrent into those in the next order. Fronds in most cases bipinnatisect in opposite pairs, or in some cases simple, pinnate, tripartite, each basal pinna or branch with a pinnatisect or bipinnate branch; pinnatisect pinnae or pinnules usually bearing terminal lobes like the lateral ones or longer; veins pinnate in plan, in some species with costal and costular areoles, the others free except for the soral commissure, basal branch sometimes arising directly from costa. Sori continuous along margin of ultimate segments, indusiate; indusia formed by reflexed margin of lobes, usually transparent, glabrous.Twenty-nine species were known in Thailand and only 1 species among them was found in Thong Pha Phum District.

Pteris biaurita L., Sp. Pl.: 1076. 1753; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 159. 1940; Holttum, Rev. Fl. Malaya 2: 407. f. 237. 1955; Tagawa et K. Iwats., Fl. Thail. 3(2): 237. 1985.— *Campteria biaurita* (L.) Hook., Gen. Fil.: t. 65 A. 1841; Bedd., Handb.: 116. 1883.— *Pteris quadriaurita* var. *grevilleana* H. Christ, Bot. Tidsskr. 24: 106. 1901, p.p. excl. type.— *Pteris repandula* Link, Fil. Sp.: 56. 1841.

Rhizome short, erect, bearing a few fronds in a tuft, densely scaly at apex; scales up to 3.63 by 0.6 mm, nearly black margined by pale ferrugineous edges with toothed margin. **Stipes** up to 44.5 cm long, dark brown and scaly at apex. **Fronds** deeply bipinnatifid, up to 41 cm or more in length, 37 cm wide; pinnae opposite or nearly so, up to 12 pairs, straight, ascending, linear-lanceolate, broadly cuneate at base, gradually narrowing towards acuminate apex, up to 17.5 by 3.2 cm, deeply lobed to 5/6 way towards costa, basal pinnae bearing a long basiscopic pinnule just like lateral ones; ultimate segments oblong, falcate, rounded or moderately acute at apex, with rounded sinus, up to 6.81 mm broad, firm, green, glabrous; basal veinlets uniting with those of opposite groups forming arches close to costa, bearing a few branches on posterior side, the other veinlets forked, all free. **Sori** marginal, usually continuous along segments except at bottom of sinus and at apex; indusia thin, pale. (Figure 5.72)

T h a i l a n d .— NORTHERN: Chiang Rai, Chiang Mai, Lamphun, Phetchabun, Tak; NORTH-EASTERN: Loei; CENTRAL: Nakhon Nayok; SOUTH-EASTERN: Chon Buri, Chanthaburi, Trat; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Surat Thani, Nakhon Si Thammarat, Phangnga, Trang.

D i s t r i b u t i o n .— Pantropic (type from tropical America).

E c o l o g y .— Terrestrial on mountain slopes or moist ground in light shade. Growing in abandoned mine, remnant of the forest in mine area and in natural forests, about 800-1000 m alt.

V e r n a c u l a r .— Kut hang khang (Northern); Phak kut khan khang phaya nak (South-western).

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 251, 267; T. Boonkerd 62, 592, 641 [BCU]; C. Phengklai et al 13594, E. Hennipman 3647, Winit 146 [BKF].

ORDER BLECHNALES

ASPLENIACEAE

Newman, Hist. Brit. Ferns 6. 1840; Devol and Kuo, Fl. Taiwan Vol. 1. 2nd ed.: 476. 1980.

Terrestrial, lithophytic or epiphytic. Rhizome creeping or erect; scales usually clathrate, narrowly lanceolate, dark brown to black. Fronds simple, pinnate to decompound. Stipes not articulate to rhizome, with two vascular strands at base of stipes; venation free and forking. Sori linear, borne on side of a veinlet; indusia linear, narrow.

ASPLENIUM

L., Sp. Pl.: 1078. 1753; Tagawa et K. Iwats., Fl. Thail. 3(2): 261. 1985.

Rhizome short, erect or long-creeping; scales clathrate, glabrous. Fronds simple to pinnately compound; veins free, of uniting at apex to form submarginal veins. Sori elongate along veins, superficial, with indusia of the same shape; spores bilateral, with perispore. There were 35 species in Thailand and 3 species among them were found in Thong Pha Phum District.

Key to the species

1. Terrestrial; rhizome long-creeping **1. *A. apogamus***
1. Epiphyte; rhizome short to suberect
   2. Stipes and rachis nearly black, polished or paler; scales bearing a few projections near base **2. *A. perakense***
   2. Stipes and rachis dark green to brownish, not polished; scales entire, narrow, subulate **3. *A. yoshinagae***

1. ***Asplenium apogamus*** Murakami et Hatanaka, J. Fac. Sci. U. Tokyo III. 14: 193. f. 6. 1988; Tagawa et K. Iwats., Fl. Thail. 3(4): 620. 1985.— *Asplenium unilaterale* Lamk., Enc. 3: 305. 1786; Bedd., Handb.: 152. 1883; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 224. 1940; Holttum, Rev. Fl. Malaya 2 : 438. 1955; Tagawa et K. Iwats., Fl. Thail. 3(2): 277. 1985**.**

Rhizome long-creeping, 4.45 mm diam., bearing many roots on ventral and two rows of fronds on dorsal surfaces, scaly; scales gradually narrow from base towards hair-pointed apex, up to 4 by 0.5 mm, dark brown to nigrescent, clathrate. **Stipes** close or up to 0.5 cm apart, castaneous to purplish, polished scaly near the base, 14.5 cm long. **Fronds** pinnate, lanceolate, broadest at basal 1/5-1/8 portion, almost parallel or slightly narrowing upwards and then rather suddenly narrowing to caudate apex, 10-34.5 cm long, about 5.7 cm (sometimes up to 9 cm) wide; rachis terete throughout; pinnae usually 20-30 pairs, roundly quadrangular, posterior half of lower portion dimidiate, truncate and slightly auricled at acroscopic base, rounded at apex, lobed to 1/5 way at upper and anterior half of lower margin, lobes rounded, oblique, moderately acute to rounded at apex, commonly 20 by 6 mm, sometimes up to 4 by 1 cm, a few lowest pairs shortly stalked, slightly smaller, more or less reflexed, thin, herbaceous, light green; veins visible. **Sori** 4.83 mm long; indusia herbaceous, pale, opening towards anterior side. (Figure 5.73, 5.74)

T h a i l a n d .— NORTHERN: Chiang Rai, Chiang Mai, Lampang, Tak; CENTRAL: Nakhon Nayok; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Chumphon, Ranong, Trang, Pattani, Yala.

D i s t r i b u t i o n .— Widely distributed throughout the Old World tropics (type from Comoros), north to central Japan.

E c o l o g y .— Terrestrial on wet sandy slopes or on moist muddy rocks along streams in remnants of the forest in mine area, about 900 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 099, 150, 171, 230; P. Ratchata 58; T. Boonkerd 507, 555 [BCU]; K. Iwatsuki 10911, C. F. Beusekom 261, T. Smitinand S.N. [BKF].

2. ***Asplenium perakense*** B. Mathew et H. Christ, J. L. Soc. Bot. 39: 214. 1909; Holttum, Rev. Fl. Malaya 2: 429. f. 248. 1955; Tagawa et K. Iwats., Fl. Thail. 3(2): 286. 1985**.**

Rhizome short, suberect, bearing a tuft of fronds, densely scaly; scales gradually narrowing from base towards hair-pointed apex, entire, or with a few long projections near base, up to 2.09 by 0.33 mm at base, brown. **Stipe**s polished black to dark brownish-purple, scaly throughout, 6 cm long. **Fronds** narrowly oblong, acute at apex, a little reduced downwards, up to 18 by 5.5 cm; rachis like the upper part of stipes, scaly with narrow scales; pinnae 15-20 pairs, stalked, middle ones the largest, ascending, narrowly subtriangular, caudately cuminate at apex, auricled at acroscopic and cuneate at basiscopic bases, lobes oblong or quadrangular, oblique, dentate at apex, usually 6.7 mm wide; softly chartaceous to chartaceous, veins visible. **Sori** long, crescent-shaped, 1-4 for each lobe; indusia herbaceous. (Figure 5.18, 5.75)

T h a i l a n d .— SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Nakhon Si Thammarat.

D i s t r i b u t i o n .— Malesia (type).

E c o l o g y .— Epiphyte on mossy tree-trunks in natural forests, about 1000 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 193, 217, 268, 271, 315; T. Boonkerd 39; P. Ratchata 180; Y. Yuyen 189 [BCU]; G. Murata et al 49618, M. Tagawa et al 4785, E. Hennipman 3381 [BKF].

3. ***Asplenium yoshinagae*** Makino, Phan. Pterid. Jap. Ic. III. 1: pl. 64. 1900; Tagawa et K. Iwats., Fl. Thail. 3(2): 285. 1985.— *Asplenium planicaule* Wall. ex Mett., Abhandl. Senckenb. Naturf. Ges. 3: 201. 1859; Tardieu et C. Chr. in Fl Gén. I.-C. 7(2):231. 1940.— *Asplenium indicum* Sledge, Bul. Brit. Mus. (Nat. Hist.) Bot. 3: 264. 1965.

Rhizome short, erect, scaly; scales dark brown to nearly black, narrow, subulate, entire, up to 6.21 by 0.68 mm. **Stipes** usually up to 13.5 cm long, dark green to brownish, not polished, coarsely scaly. **Fronds** narrowly lanceolate, commonly about 24 by 7.5 cm, sometimes up to 40 by 8 cm, acute to acuminate at apex, pinnate;

rachis like the upper part of stipes, rarely gemmiferous; pinnae 12-25 pairs, stalked, dimidiate, rhomboid, acute at apex, broadly cuneate and auricled at acroscopic bases, narrowly cuneate and entire at basiscopic bases, margin irregularly lobed with dentate margin, 19.92 mm by 5.65 mm, chartaceous, deep green, brownish in dried specimens. **Sori** elongate many near the casta. (Figure 5.19, 5.76, 5.77)

T h a i l a n d .— NORTHERN: Chiang Rai, Chiang Mai, Lamphun, Tak; NORTH-EASTERN: Phetchabun, Loei, Khon Kaen; SOUTH-WESTERN: Kanchanaburi; CENTRAL: Saraburi; PENINSULAR: Surat Thani.

D i s t r i b u t i o n .— Ceylon, N. and S. India, Myanmar, S. China, Indochina, Taiwan, Philippines, north to Japan (type).

E c o l o g y .— Epiphyte on mossy tree-trunks in remnant of the forest in mine area and in natural forest, about 900-1000 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 065, 125, 196, 218, 240; O. Vannasri 41; P. Ratchata 175; Y. Yuyen 38 [BCU]; C. Phengklai et al 7372, M. Tagawa et al 9994, T. Smitinand & Anderson 7285 [BKF].

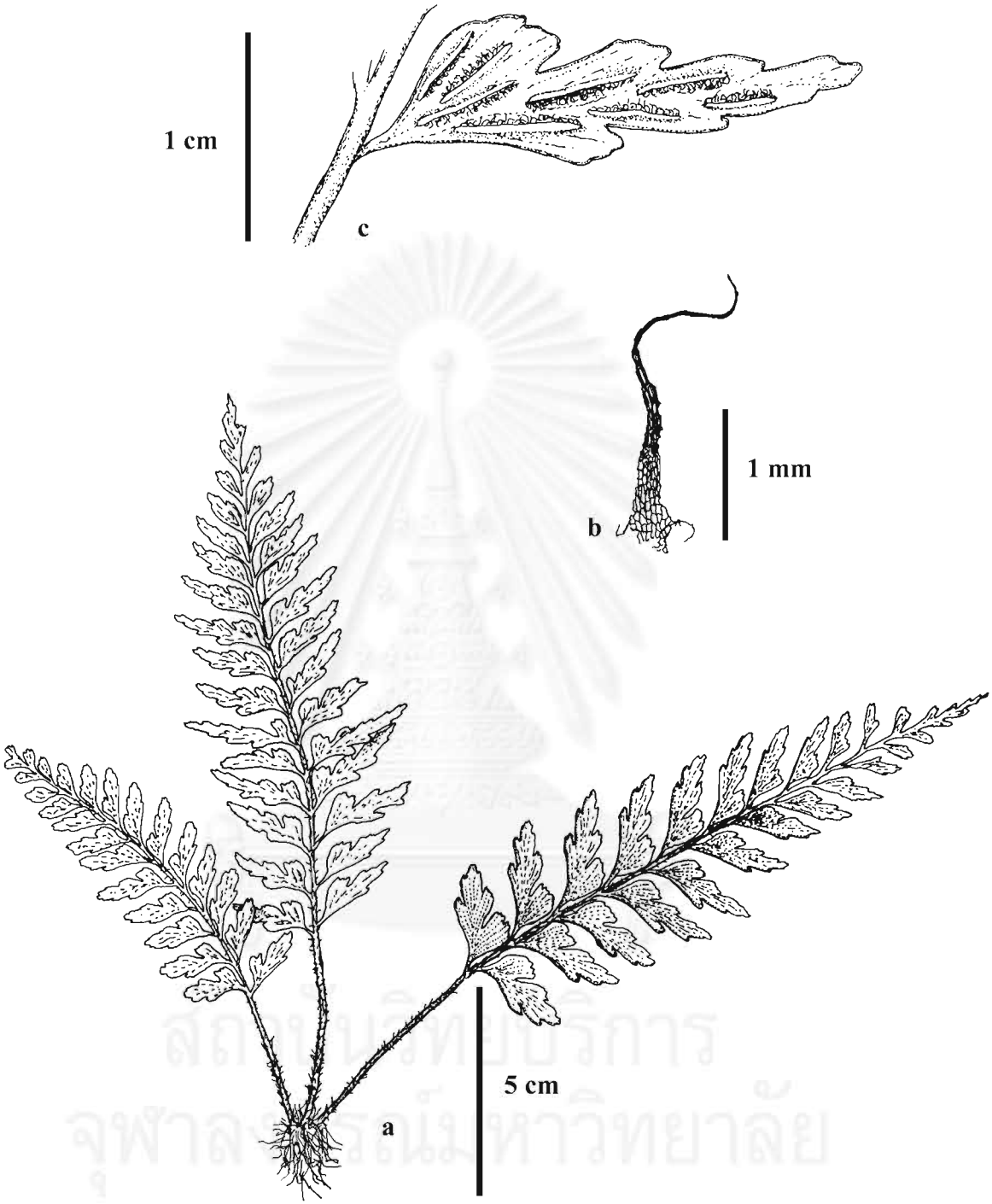


Figure 5.18 ***Asplenium perakense*** **B. Mathew et H. Christ** a. Habit. -- b. Rhizome scale with long projection near base. -- c. Sori. (A. Sathapattayanon 217)

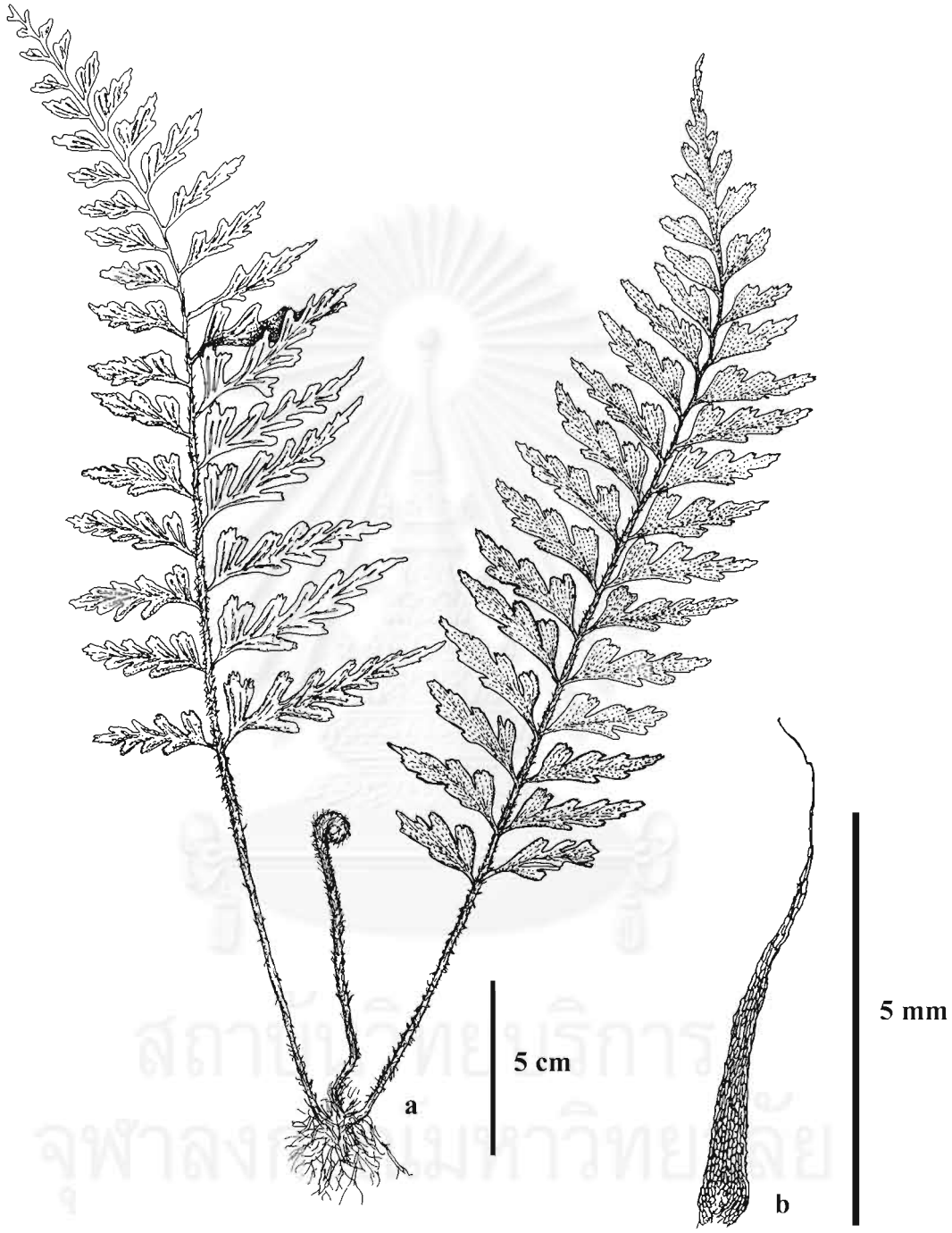


Figure 5.19 ***Asplenium yoshinagae*** **Makino** a. Habit. -- b. Rhizome scale. (A. Sathapattayanon 218)

BLECHNACEAE

(C. Presl) Copel., Ann. Cryptog. Phytopathol. 5: 155. 1947; Devol, Fl. Taiwan Vol. 1. 2nd ed.: 149. 1980.

Rhizome creeping, erect, stout or scandent. Fronds monomorphic or dimorphic, usually pinnate or pinnatifid, rarely bipinnate. Stipes scaly at base, not articulate to rhizome. Venation usually free, or with a costa row of areoles. Sori costal, discrete or in a coenosori; usually with an indusium opening towards costa, rarely exindusiate.

Key to the genera

1. Sori indusiate; rhizome not forming trunk **1. *Blechnum***
1. Sori exindusiate; rhizome forming trunk up to 1 m in height **2. *Brainea***

1. BLECHNUM

L., Sp. Pl.: 1077. 1753; Tagawa et K. Iwats., Fl. Thail. 3(3): 297. 1988.

Rhizome stout, erect, bearing fronds in a tuft, scaly; scales narrow, entire, usually margined with pale cartilaginous edges. Fronds pinnate with apical pinna, usually not thin, glabrous; lateral pinnae usually entire, narrow, fertile ones contracted or not; costal grooves not confluent with groove of rachis; veins free, usually once or a few times forked. Sori linear, parallel and close to costa, sometimes forming costal areoles of veins (soral veins); indusia attached on the side away from costa and opening inwards. Three species were known in Thailand and 1 species among them was found in Thong Pha Phum District.

Blechnum orientale L., Sp. Pl.: 1077. 1753; Bedd., Handb.: 132. f. 66. 1883; Tardieu et C. Chr. in Fl. Gén; I.-C. 7(2): 207. f. 26, 1-2. 1940; Holttum, Rev. Fl, Malaya 2: 446. f. 262. 1955; Seidenf., Nat. Hist. Bull. Siam Soc. 19: 87. 1958; Devol, Fl. Taiwan Vol. 1. 2nd ed.: 151. 1980; Tagawa et K. Iwats., Fl. Thail. 3(3): 298. 1988.

Rhizome thick, ascending or suberect, densely covered with scales; scales linear, gradually narrowing towards apex, 2 cm or more long, up to 2 mm broad,

tailed at apex, dark brown with pale cartilaginous edges which sometimes becoming uneven. **Stipes** stout, stramineous, or sometimes purplish when young, up to 20 cm long, densely scaly at base, bearing small auricles (reduced pinnae) throughout. **Lateral pinnae** many in number, close, 2-3 cm apart from each other, ascending, linear, gradually narrowing towards long-tailed apex, round or subtruncate at sessile base, or decurrent at posterior base and adnate in the upper ones, entire, 14 by 0.7 cm; veins simple or forked usually near costa, distinct on both surfaces, very close, up to 3.6 mm apart; coriaceous, green, glabrous throughout. **Sori** narrow, long-continuous along costa; indusia narrow, usually broken before maturity. (Figure 5.20, 5.78, 5.79)

T h a i l a n d .— NORTHERN: Chiang Rai, Chiang Mai, Tak; NORTH-EASTERN: Loei, Nong Khai, Udon Thani; EASTERN: Chaiyaphum; CENTRAL: Nakhon Nayok; SOUTH-EASTERN: Chanthaburi, Trat; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Chumphon, Ranong, Surat Thani, Nakhon Si Thammarat, Phangnga, Trang, Satun, Narathiwat, Yala.

D i s t r i b u t i o n .— Tropics of Asia, Australia and the Pacific, India to Polynesia, north to southern edge of Japan (Yakushima).

E c o l o g y .— Terrestrial on exposed to half shaded ground in abandoned mines, and in remnants of the forest in mine area, about 400-900 m alt.

V e r n a c u l a r .— Kut khang fan (Northern); Kut doi (Central); Mahasadam (South-eastern).

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 018; O. Vannasri 20; T. Boonkerd 331; Y. Yuyen 22 [BCU]; C. Phengklai et al 13592, M. Tagawa et al 4678, K. Larsen et al 32874 [BKF].

2. BRAINEA

J. Sm., Cat. Kew Ferns: 5. 1856; Tagawa et K. Iwats., Fl. Thail. 3(3): 302. 1988.

Rhizome erect, arborescent, scaly. Fronds not articulated, simply pinnate, dimorphic; pinnae many, close, toothed at margin; veins close, once or twice forking, forming a series of narrow costal areoles. Sori covering the whole undersurface of narrow fertile pinnae, without indusia. *Brainea* is a monotypic genus with the habit of a tree-fern and a crown of dimorphic fronds and it was found in Thong Pha Phum District.

Brainea insignis (Hook.) J. Sm., Cat. Kew Ferns: 5. 1856; Bedd., Handb.: 395. f. 230. 1883; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 207. f. 25, 3-4. 1940; Holttum, Rev. Fl. Malaya 2: 450. 1955; Tagawa et K. Iwats., Fl. Thail. 3(3): 302. 1988.— *Bowringia insignis* Hook., J. Bot. 5: 237. t. 2. 1853.

Rhizome erect, forming a trunk of more than 50 cm in height, the apex densely covered with scales; scales narrow with orbicular basal portion about 2 mm diam., up to 30 by 0.5-0.8 mm, entire, glabrous, brown with dark brown central strand. **Stipes** 18 cm long, thick, stramineous, densely scaly at base. **Fronds** simply pinnate, with numerous pinnae, dimorphic; sterile lamina 99 by 36 cm, oblong-lanceolate with acute apex; lateral pinnae close, straight, slightly ascending, linear, gradually narrowing towards the finely acute apex, sessile, decurrent at base in uppermost ones, broadly cuneate to deeply cordate towards base, the margin sharply serrate, up to 18 by 1.17 cm; veins close; papyraceous, green to paler; fertile fronds narrower; lateral pinnae up to 10 by 0.5 cm. (Figure 5.80, 5.81)

T h a i l a n d .— NORTHERN: Chiang Rai, Chiang Mai, Lamphun, Lampang, Phrae, Tak; NORTH-EASTERN: Loei; SOUTH-EASTERN: Trat; SOUTH-WESTERN: Kanchanaburi.

D i s t r i b u t i o n .— Himalayas, S. China (type from Hongkong), Myanmar, Indochina, Malesia and N. Sumatra.

E c o l o g y .— Terrestrial on rather dry slopes in natural forests, at about 1000 m alt.

V e r n a c u l a r .— Kut doi (Northern).

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 318, 324; P. Ratchata 62; T. Boonkerd 1030, 1103 [BCU]; J. F. Maxwell 98-632, Pai 135, C. Phengklai et al 10878 [BKF].

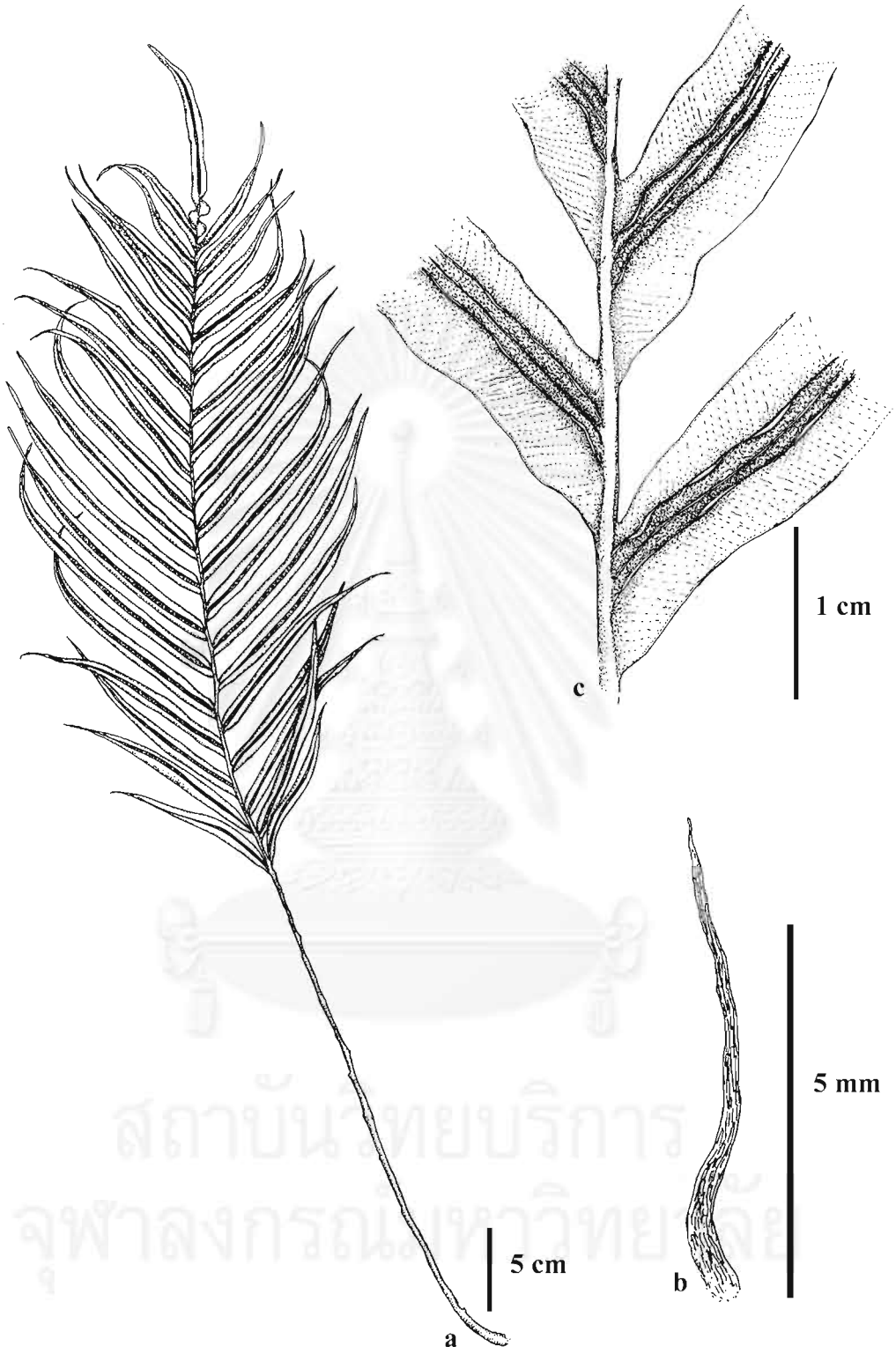


Figure 5.20 *Blechnum orientale* L. a. Frond. -- b. Rhizome scale. -- c. Sori. (A. Sathapattayanon 018)

LOMARIOPSIDACEAE

Alston, Taxon 5: 25. 1956; Devol and Kuo, Fl. Taiwan Vol. 1. 2nd ed.: 347. 1980.

Rhizome creeping, or scandent, stipes distant or tufted; scales brown, ovate of lanceolate, peltately attached near bases. Stipes with one or two grooves on upper sides. Fronds dimorphic, simple or pinnate; veins free, simple or once forked, or anastomosing and forming areolae without included veinlets, or free excurrent veinlets, fertile fronds usually with longer stipes and narrower fronds. Sporangia acrostichoid.

Key to the genera

1. Fronds pinnate to decompound; stipes usually not jointed to rhizome **1. *Bolbitis***
1. Fronds simple, epiphytic; stipes usually jointed to rhizome **2. *Elaphoglossum***

1. BOLBITIS

Schott, Gen. Fil.: ad.t. 14. 1834; Tagawa et K. Iwats., Fl. Thail. 3(3): 310. 1988.— *Egenolfia* Schott, Gen. Fil.: ad t. 16. 1834.— *Campium* C. Presl, Tent. Pterid.: 238. pl. X. 22-23. 1836.

Rhizome creeping, dorsiventral, bearing two rows of usually close fronds on dorsal surface and numerous roots on ventral surface, scaly; scales usually concolorous, hardly clathrate, glabrous. Fronds dimorphic, usually not jointed to rhizome, simple to bipinnatifid, often viviparous near apex. Sporangia dispersed on the whole undersurface, or rarely restricted to marginal portion, of fertile pinnae or fronds (acrostichoid). There were 12 species in Thiland and 3 species among them were found in Thong Pha Phum District.

Key to the species

1. Veins all free; base of lateral pinnae unequal, with auricles at anterior base

1. B. *appendiculata* subsp. *vivipara*

1. Veins anastomosing
   2. No included free veinlets in areoles; fronds simple or imparipinnate with one or two pairs of lateral pinnae, apex of fronds particularly elongate, with bud
      2. *B. heteroclita*
   2. Many included and excurrent free veinlets in areoles; fronds pinnate, oblong-ovate to oblong, fertile pinnae linear to oblong-lanceolate
      3. *B. virens* var. *virens*

1. ***Bolbitis appendiculata*** (Willd.) K. Iwats. subsp. ***vivipara*** (Hamilt. ex Hook.) Hennipman, Acta Phytotax. Geobot. 18: 48. 1959; Hennipman, in Fl. Mal. II. 1: 322. f. 26b, 27 d-f. 1978; Tagawa et K. Iwats., Fl. Thail. 3(3): 316. 1988.— *Acrostichum appendiculatum* Willd., Sp. Pl. 5: 114. 1810.—*Polybotrya appendiculata* (Willd.) J. Sm., J. Bot. 4: 150. 1841; Bedd., Handb.: 424. f. 255. 1883.— *Egenolfia appendiculata* (Wind.) J. Sm., Ferns Br. For.: 111. 1866; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 426. 1941; Holttum, Rev. Fl. Malaya 2: 459. f. 270. 1955; Seidenf., Nat. Hist. Bull. Siam Soc. 19: 87. 1958.— *Polybotrya helferiana* Kunze, Farnkr. 2: 35. 1849.— *Polybotrya appendiculata* var. *helferiana* (Kunze) H. Christ, Bot. Tidsskr. 24: 109. 1901.— *Egenolfia helferiana* (Kunze) C. Chr., Contr. U.S. Nat. Herb. 26: 292. 1931.— *Polybotrya appendiculata* var. *marginata* (Blume) C. Chr., Bot. Tidsskr. 32: 343. 1916.— *Polybotrya marginata* Blume, En. Pl. Jav.: 100. 1828, nom. superf.— *Egenolfia appendiculata* var. *moniliformis* Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 427. 1941.— *Acrostichum* sp. Hosseus, Beih. Bot. Centr. 28(2): 363. 1911.

Rhizome creeping; scales light brown or greyish, linear, up to 4.77 by 0.66 mm. **Sterile fronds**: stipe stramineous, sparsely scaly, 12 cm long; fronds lanceolate, acuminate at apex, 17.5 by 7.8 cm; rachis scaly beneath, winged at least on upper part, sometimes viviparous near apex; pinna 15 pairs, basal ones slightly shorter than the next above, middle ones the largest, patent or ascending, stalked, oblong to longer or gradually narrowing from base to apex, rounded to acute at apex, more or less auricled at acroscopic and dimidiate at basiscopic bases, margin shallowly lobed, 4 by 1.3 cm, the apical pinna variable in shape and size, usually narrowly subtriangular; veins pinnate, all free; lobes shallow, round, with a distinct tooth at each sinus; papyraceous, deep green, dark when dried. **Fertile fronds** taller: pinnae ± moniliform,

index 10-15, 4-6 cm long, with a narrow strip of fronds along costa, stipes up to 16.7 cm long; sporangia dispersed on the lower surface of pinna or lobes. (Figure 5.21, 5.82, 5.83)

T h a i l a n d .— NORTHERN: Chiang Mai, Lampang; NORTH-EASTERN: Phetchabun, Loei, Sakhon Nakhon; EASTERN: Nakhon Ratchasima, Chaiyaphum; SOUTH-EASTERN: Chanthaburi, Trat; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Chumphon, Phangnga, Phuket, Nakhon Si Thammarat, Trang, Songkhla, Satun.

D i s t r i b u t i o n .— S. China, India to S.E. Asia generally, throughout Malesia, northwards to Taiwan and the Ryukyus (type from India).

E c o l o g y .— Lithophyte on moist muddy rocks in light shade in remnants of the forest in mine area and in natural forests, about 500-1000 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 103, 114, 284, 293; T. Boonkerd 28, 52, 1360 [BCU]; P. Suvanakoses 769, T. Shimizu et al 27670, T. Smitinand 4114, C. F. Beusekom et al 163 [BKF].

2. ***Bolbitis heteroclita*** (C. Presl) Ching, Ind. Fil. Suppl. III.: 48. 1934; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 434. 1941; Holttum, Rev. Fl. Malaya 2: 462. f. 271. 1954; Hennipm., in Fl. Mal. II. 1: 325. f. 25d, 31a-g. 1978; Tagawa et K. Iwats., Fl. Thail. 3(3): 320. 1988.— *Acrostichum heteroclitum* C. Presl, Rel. Haenk. I: 15. pl. 2. f. 2. 1825.— *Leptochilus heteroclitus* (C. Presl) C. Chr., Ind. Fil.: 385. 1906.

Rhizome long-creeping, scaly; scales nearly black with narrow brown ferrugineous margin, linear, up to 7 by 1 mm. **Sterile fronds***:* stipes 16.5 cm long, stramineous; fronds simple or imparipinnate with one or two pairs of lateral pinnae; lateral pinnae oblong, cuneate and shortly stalked at base, caudate at apex, 4-7 cm apart, 10.5 by 3 cm, almost entire or irregularly shallowly waved, terminal pinna oblong, or often very long-tailed, up to 15-20 cm long excluding the tail, 5 cm broad; tails narrow, linear, 50-80 mm long,; rachis narrowly winged, glabrescent; costa naked, sometimes viviparous; veins distinct on both surfaces, finely reticulated, without included free veinlets; herbaceous or softly papyraceous, glabrous, deep green, blackish when dry. **Fertile fronds** not seen in Thailand, those of the Philippines plants: stipes nearly the same as or larger than those of sterile ones; lateral

pinnae up to 4 pairs, oblong, about 5 by 2.7 cm, apical pinna a little larger than lateral ones, veins reticulate; sporangia spread over the whole undersurface of pinnae. (Figure 5.84)

T h a i l a n d .— NORTHERN: Chiang Rai, Chiang Mai, Lampang, Phitsanulok; CENTRAL: Nakhon Nayok; SOUTH-EASTERN: Chon Buri, Chanthaburi, Trat; SOUTH-WESTERN: Kanchanaburi, Prachuap Khiri Khan; PENINSULAR : Nakhon Si Thammarat, Trang.

D i s t r i b u t i o n .— N. India, Upper Myanmar, S. and S.W. China, Taiwan, Ryukyu, Indochina, throughout Malesia (type from Luzon) to New Guinea.

E c o l o g y .— Terrestrial on wet ground near streams in undisturbed mine areas, at 900 m alt.

V e r n a c u l a r .— Kut pao, Kut hang nok kaling (Northern).

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 042, 172; P. Ratchata 144; T. Boonkerd 444, 1329 [BCU]; Garrett 223, K. Iwatsuki et al 10915, M. Tagawa & T. Yamada 211 [BKF].

3. ***Bobitis virens*** (Wall. ex Hook. et Grev.) Schott var. ***virens***, Gen. Fil.: ad t. 14. 1834; Holttum, Rev. Fl. Malaya 2: 468. f. 275. 1955; Hennipm., Blumea 18: 149. 1970; Tagawa et K. Iwats., Fl. Thail. 3(3): 314. 1988.— *Acrostichum virens* Wall. ex Hook. et Grev., Ic. Fil. II: pl. 231. 1831.— *Campium virens* (Hook. et Grev.) C. Presl, Tent. Pterid.: 239. 1836.— *Bolbitis costata* auct. non (C. Presl) Ching: Holttum, Dansk Bot. Ark. 20: 30. 1961.

Rhizome creeping, thick, densely scaly; scales thin but firm, dark brown, up to 6 by 7.43 mm. **Sterile fronds***:* stipes 22 cm long, densely scaly throughout, scales on upper portion light brown, ferrugineous, appressed, irregular in shape; fronds oblong-ovate to oblong, 27 by about 33 cm; lateral pinnae 5-7 pairs, stalked, straight, ascending or patent in lower ones, oblong to oblong-lanceolate, caudate at apex, narrowly cuneate or unequally rounded at base, up to 21 by 3.6 cm, toothed at margin, more or less waved; costa minutely scaly beneath, veins slightly raised on undersurface, reticulate with a few included veinlets in each areole; subcoriaceous, glabrous, green both in living and dried condition, terminal pinna like lateral ones or slightly larger, viviparous near apex. **Fertile fronds** nearly as high as the sterile ones: stipes up to 31 cm long; fronds up to 17 by 13 cm; pinnae 3 pairs, linear, acuminate at

apex, stalked, up to 9 cm by 2 mm; sporangia dispersed on the whole undersurface of pinnae. (Figure 5.22)

T h a i l a n d .— NORTHERN: Chiang Mai, Lamphun, Phrae, Tak; NORTH-EASTERN: Loei; SOUTH-EASTERN: Chanthaburi; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Surat Thani.

D i s t r i b u t i o n .— Yunnan, Chittagong, and Myanmar (type).

E c o l o g y .— Terrestrial on mountain slopes in natural forest, at 960 m alt.

V e r n a c u l a r .— Kut ngong (North-eastern).

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 159, 285; T. Boonkerd 412, 1537, 1567 [BCU]; Soerensen et al 2914, E. Hennipman 3159, M. Tagawa, K. Iwatsuki & N. Fukuoka 372 [BKF].

2. ELAPHOGLOSSUM

Schott ex Sm., Gen. Fil.: ad t. 14. 1834; Tagawa et K. Iwats., Fl. Thail. 3(3): 303. 1988.

Rhizome creeping, bearing two rows of fronds on dorsal surface, scaly. Frond close together or remote in *E. angulatum,* simple, entire, usually coriaceous, dimorphic. Stipe swollen at base (phyllopodium), jointed to rhizome; veins simple or forked, parallel or anastomosing in some species. Sporangia covering the whole lower surface of fertile fronds (acrostichoid). In Thialand 8 species were known and 1 species among them was found in Thong Pha Phum District.

Elaphoglossum marginatum (Wall. ex Fée) T. Moore, Ind. Fil.: 8, 11. 1857; 361. 1862; Tagawa et K. Iwats., Fl. Thail. 3(3): 308. 1988.— *Acrostichum marginatum* Wall. ex Fée, Hist. Acrost.: 31. 1845.— *Elaphoglossum conforme* auct. non (Sw.) Schott; Bedd., Handb.: 416. f. 247. 1883, p.p.; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 541. 1941.— *Elaphoglossum* sp. Holttum, Dansk Bot. Ark. 20: 29. 1961.

Rhizome very short, bearing very close fronds; scales brown or darker, linear, up to 6.4 by 1.24 mm, with irregular projections at margin. **Sterile fronds***:* stipes up to 2 cm long, stramineous, narrowly winged, densely scaly at base with scales like

those on rhizome, sparsely clad with narrower scales above; fronds oblong-lanceolate, up to 14.6 by 1.8 cm, gradually narrowing towards acute apex, the base narrowly round or attenuate, decurrent to wings of stipe, marginal cartilaginous membrane up to 1 mm wide, usually involute; midribs raised on both surfaces, sparsely scaly underneath, veins forked, parallel, hardly visible; coriaceous, green, minutely scaly on both surfaces. **Fertile fronds***:* stipes up to 5 cm long, thicker than sterile ones of the same plant; fronds about 14.3 by 1.4 cm. (Figure 5.23, 5.85, 5.86)

T h a i l a n d .— NORTHERN: Chiang Mai, Lampang, Phitsanulok; NORTH-EASTERN: Loei; SOUTH-WESTERN: Kanchanaburi; CENTRAL: Nakhon Nayok.

D i s t r i b u t i o n .— N. India (type), Yunnan, Indochina and Taiwan.

E c o l o g y .— Epiphyte on mossy tree-trunks in natural forests, about 900-1000 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 216, 244, 278, 303, 320, 336 [BCU]; M. Tagawa, K. Iwatsuki & N. Fukuoka 1288, M. Tagawa et al 8591, K. Larsen et al 45927 [BKF].

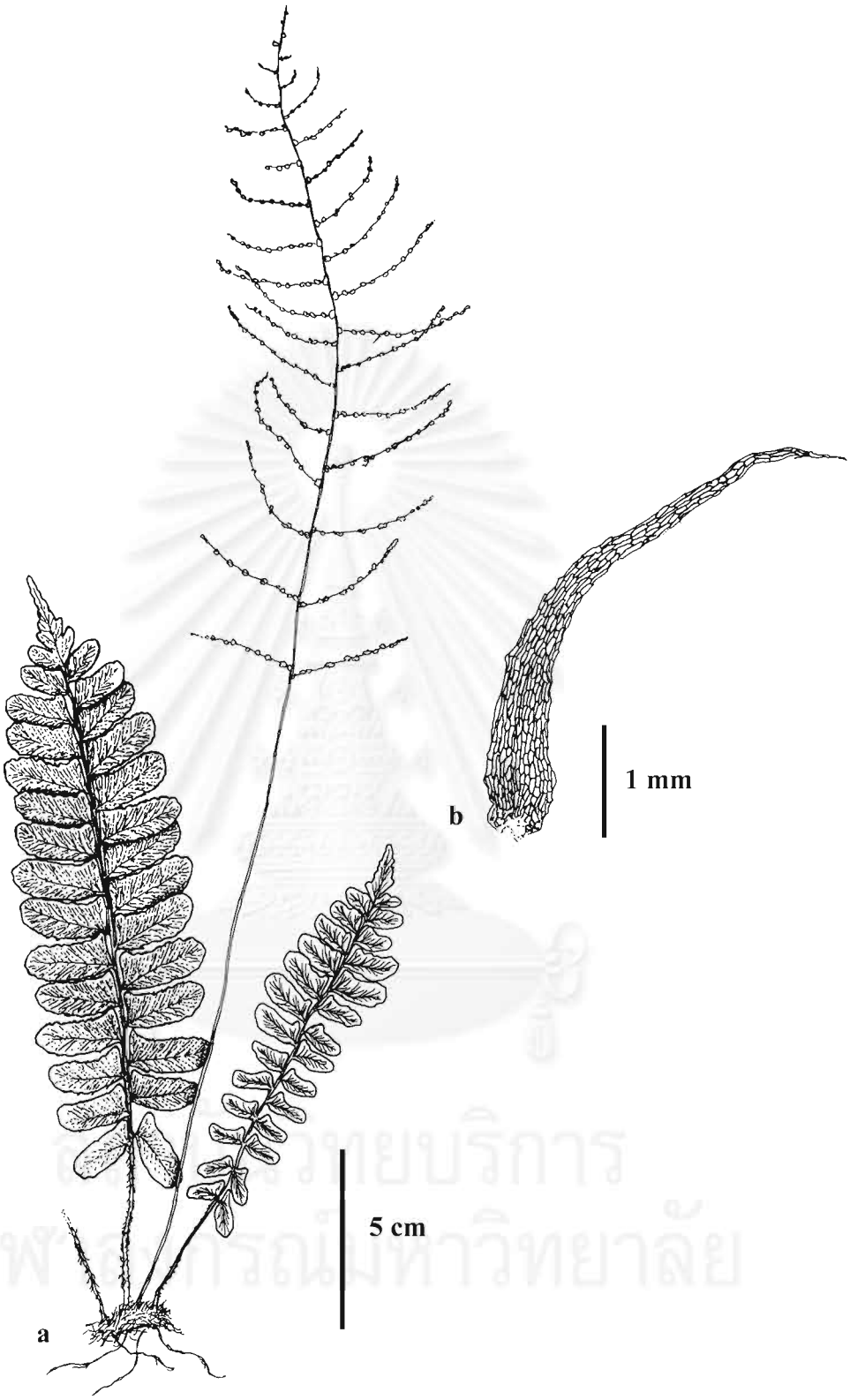


Figure 5.21 ***Bolbitis appendiculata*** **(Willd.) K. Iwats. subsp.** ***vivipara*** **(Hamilt. ex Hook.) Hennipman** a. Habit and dimorphic fronds. -- b. Rhizome scale. (A. Sathapattayanon 103)

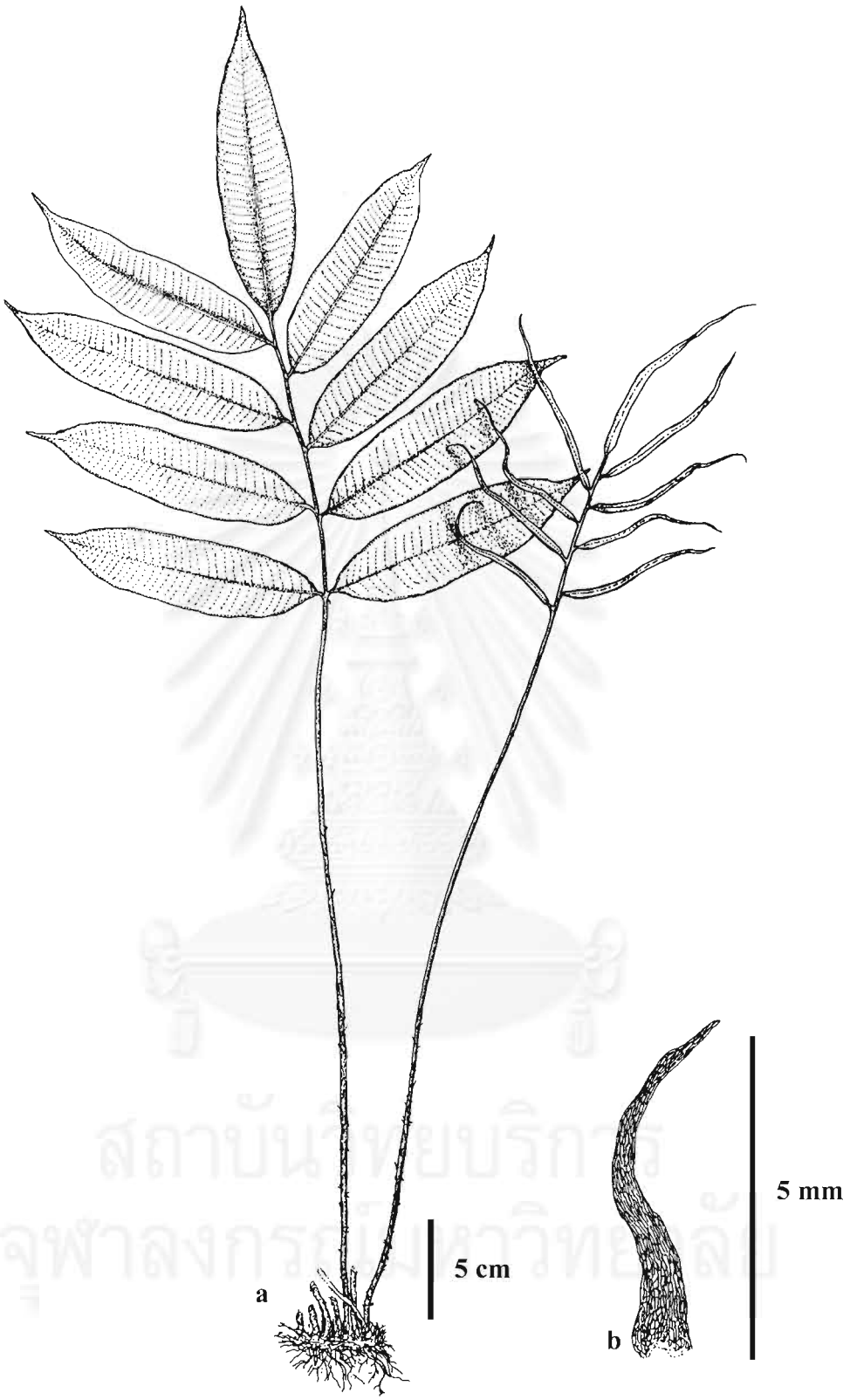


Figure 5.22 *Bolbitis virens* (Wall. ex Hook. et Grev.) Schott var. *virens* a. Habit. -- b. Rhizome scale. (A. Sathapattayanon 159)

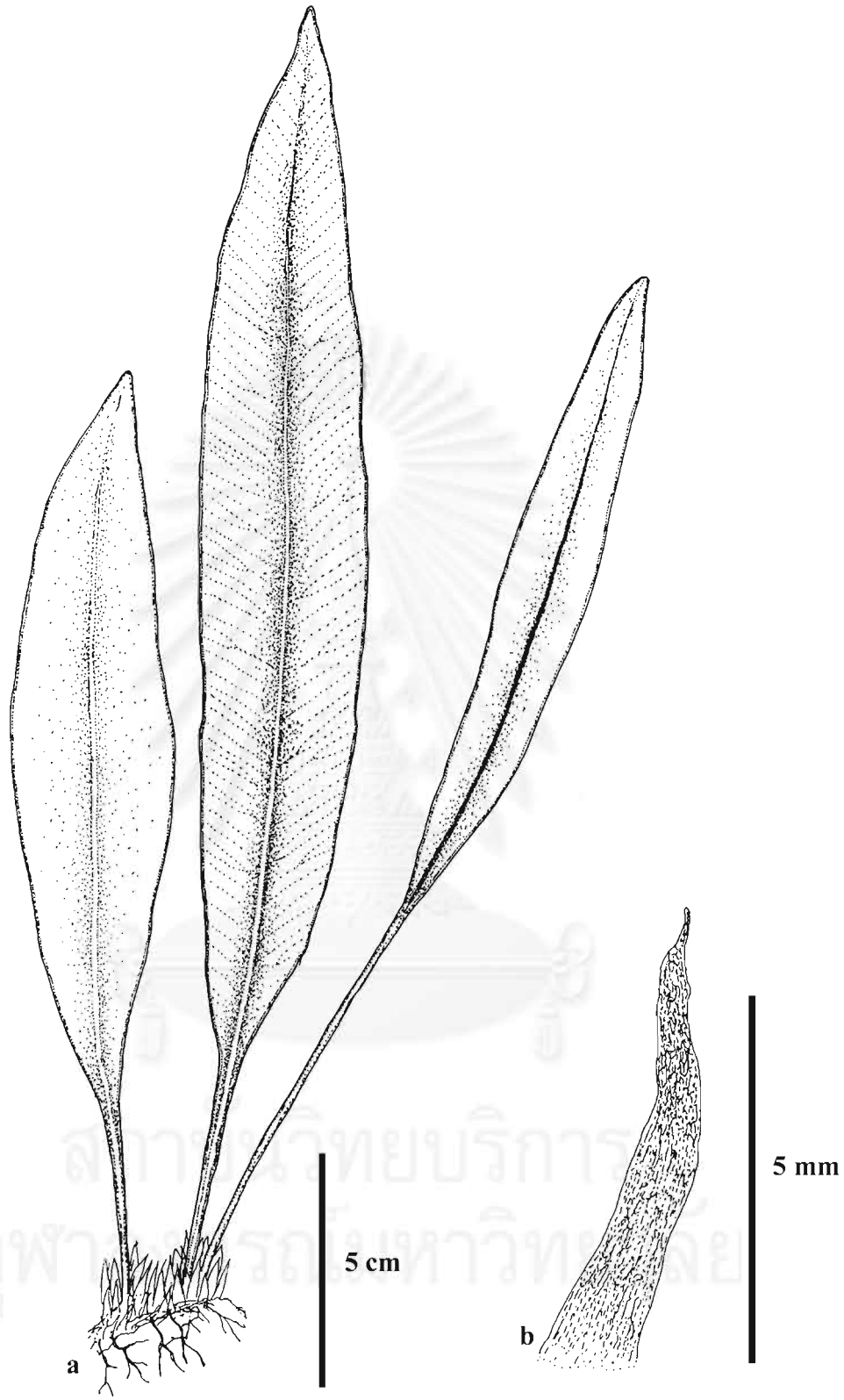


Figure 5.23 *Elaphoglossum marginatum* (Wall. ex Fée) T. Moore a. Habit. -- b. Rhizome scale. (A. Sathapattayanon 216)

WOODSIACEAE

(Hook.) Herter, Revista Sudamer. Bot. 9: 14. 1949.— *Athyriaceae* Alston, Taxon 5: 25. 1956; Devol and Kuo, Fl. Taiwan Vol. 1.2nd ed.: 441. 1980.

Rhizome usually short and stout, sometimes creeping and slender; scales thin, light brown to dark brown, lanceolate or ovate. Fronds usually thin, pinnate to decompound, rarely simple; veins usually free, goniopteroid or forming areolae, usually glabrous; rachis groove generally open to receive rachilla grooves but not in all genera. Sori elongate or round to oblong, usually present, round-reniform or horse-shoe-shaped or naked.

DIPLAZIUM

Sw., Schrad. J. Bot. 1800(2): 61. 1801; Tagawa et K. Iwats., Fl. Thail. 3(3): 449. 1988.— *Callipteris* Bory in Belanger, Voy. 1: 282. 1804.— *Athyrium* Roth, Röm. Mag. 2(1): 105. 1799, p.p.

Rhizome creeping to erect, scaly; rhizome-scales entire or toothed; rachis grooved, the grooves distinct, open. Fronds simple to pinnately compound; veins pinnate, or reticulate to form rather regular quadrangular areoles at each side of veinlets (seemingly goniopteroid venation); usually glabrous or minutely scaly on axes. Sori elongate along veins; indusia crescentic, often adjacent to the next ones, opening in opposite direction. Twenty-nine species were known in Thailand and 3 species among them were found in Thong Pha Phum District.

Key to the species

1. Fronds pinnate; rhizome creeping **1. *D. donianum***
1. Fronds bipinnate or more compound; rhizome erect
   2. Veins anastomosing **3. *D. simplicivenium***
   2. Veins all free **2. *D. esculentum***

1. ***Diplazium donianum*** (Mett.) Tardieu, Aspl. Tonkin: 58. t. 5. 1932; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 249. 1940; Tagawa et K. Iwats., Fl. Thail. 3(3): 455. 1988.— *Asplenium donianum* Mett., Fil. Lechl.: 177. 1859.— *Athyrium bantamense* auct. non (Blume) Milde: Bedd., Handb.: 177. f. 86. 1883.

Rhizome short-creeping, 3-4 mm diam., blackish, bearing a few fronds at apex; scaly on younger part, scales narrow, 13 by 1.2 mm, concolorous, dark brown, minutely toothed at margin. **Stipes** up to 44.2 cm long, brownish, darker in lower portion, grooved on adaxial surface. **Fronds** imparipinnate, oblong in outline, 22 by about 38 cm; rachis grooved on upper surface, minutely hairy, never gemmiferous; lateral pinnae 1-4 pairs, upper ones smaller, ascending, stalks distinct, more than 5 mm long, oblong, caudate at apex, cuneate at base, subentire or serrate at posterior portion, up to 19 by 5.5 cm; coriaceous, surface glabrescent; costa raised below, grooved with minute hairs on upper surface; veins several times forked, all free. **Sori** elongate along the whole length of veinlets, usually on both sides of veins; indusia thin, brown. (Figure 5.24, 5.87, 5.88)

T h a i l a n d .— NORTHERN: Chiang Mai, Tak, Phitsanulok; NORTH-EASTERN: Loei; CENTRAL: Nakhon Nayok; SOUTH-EASTERN: Trat; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Nakhon Si Thammarat.

D i s t r i b u t i o n .— N. India (type) to S. China and Taiwan, north to S. Japan, south to Indochina.

E c o l o g y .— Terrestrial on wet slopes in light shade in remnants of the forest in mine area, about 800-900 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 041, 182; Y. Yuyen 43 [BCU]; M. Tagawa et al 5269, Winit 1121, C. Niyomdham & P. Pundjaa 4646 [BKF].

2. ***Diplazium esculentum*** (Retz.) Sw., Schrad. J. Bot. 180l(2): 312. 1803; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 269. 1940; Tagawa et K. Iwats., Fl. Thail. 3(3): 466. 1988.— *Hemionitis esculenta* Retz., Obs. Bot.: 38. 1791.— *Anisogonium esculentum* (Retz.) C. Presl, Tent. Pterid.: 116. 1836; Bedd., Handb.: 192. f. 94. 1883.— *Athyrium esculentum* (Retz.) Copel., Phil. J. Sci. Bot. 3: 295. 1908; Holttum, Rev. Fl. Malaya 2: 562. f. 333. 1955.

Rhizome erect, sometimes more than 1 m in height; scales up to 10 by 1.2 mm, dark brown, black-margined, toothed. **Stipes** about 118 cm long. **Fronds** variable in size, often more than 1 m long, bipinnate; lower 1 or 2 pinnae often reduced, larger pinnae up to 35 by 16 cm, rather suddenly narrowing towards acute apex; larger pinnules subsessile or shortly stalked, subcordate or auricled at base, narrowing towards acuminate apex, up to 8 by 1.6 cm, lobed to 1/4 way to costule; lobes rounded at apex, serrate, papyraceous; veins pinnate, veinlets up to 10 pairs, uniting with the, opposite ones forming excurrent veinlets (seemingly goniopteroid venation). **Sori** on nearly the whole length of veinlets, often uniting with opposite ones. (Figure 5.89)

T h a i l a n d .— NORTHERN: Chiang Rai, Chiang Mai, Mae Hong Son, Lampang, Tak; EASTERN: Chaiyaphum; CENTRAL: Nakhon Nayok, Saraburi, Bangkok; SOUTH-EASTERN: Chon Buri; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Surat Thani, Satun, Narathiwat.

D i s t r i b u t i o n .— Tropics of Asia, north to central China and S. Japan, east to S. Pacific Islands.

E c o l o g y .— Terrestrial on moist ground along rivers in open places in remnant of the forest in mine area, at 790 m alt.

V e r n a c u l a r .— Hatsadam (Peninsular); Kut kin (Northern).

U s e s .— Young fronds locally consumed as vegetable.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 366, P. Ratchata 202, 208; T. Boonkerd 17 [BCU]; R. Geesink et al 7115, J. F. Maxwell 88-1281, K. Larsen et al 32875 [BKF].

3. ***Diplazium simplicivenium*** Holttum, Gard. Bull. S. S. 11: 100. 1940; Tagawa et K. Iwats., Fl. Thail. 3(3): 464. 1988.— *Athyrium simplicivenium* (Holttum) Holttum, Rev. Fl. Malaya 2: 573. f. 340. 1954.

Rhizome massive, erect, bearing a tuft of gigantic fronds; scales about 20 by 2 mm, brown, black-margined, toothed. **Stipes** up to 53 cm long, about 3.34 mm diam. near base. **Fronds** about 48 by 40 cm, bipinnate; lower pinnae about 21 by 9.3 cm, narrowly oblong with acute apex; larger pinnules shortly stalked or subsessile, narrowly oblong-subtriangular, gradually narrowing towards a long acuminate apex, broadly cuneate to subtruncate or subcordate at base, usually shallowly lobed, up to 12 by 2.5 cm; lobes supquadrangular, obtuse at apex; subentire, 4.76 mm in breadth; softly papyraceous, green veins pinnate with 4-6 pairs of simple veinlets; veinlets hardly reaching the margin of lobes, basal anterior ones stopping far below the sinus. **Sori** about 8 mm long. (Figure 5.90)

T h a i l a n d .— SOUTH-WESTERN: Kanchanaburi, Uthai Thani; PENINSULAR: Surat Thani, Nakhon Si Thammarat, Phangnga, Trang, Satun, Yala.

D i s t r i b u t i o n .— Malesia (type) and probably also in Borneo.

E c o l o g y .— Terrestrial on moist mountain slopes in remnants of the forest in mine area, about 800-900 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 122, 199; P. Ratchata 286, 345; T. Boonkerd 535 [BCU]; T. Smitinand 6053, M. Tagawa & I. Yamada 202, Winit 1211 [BKF].

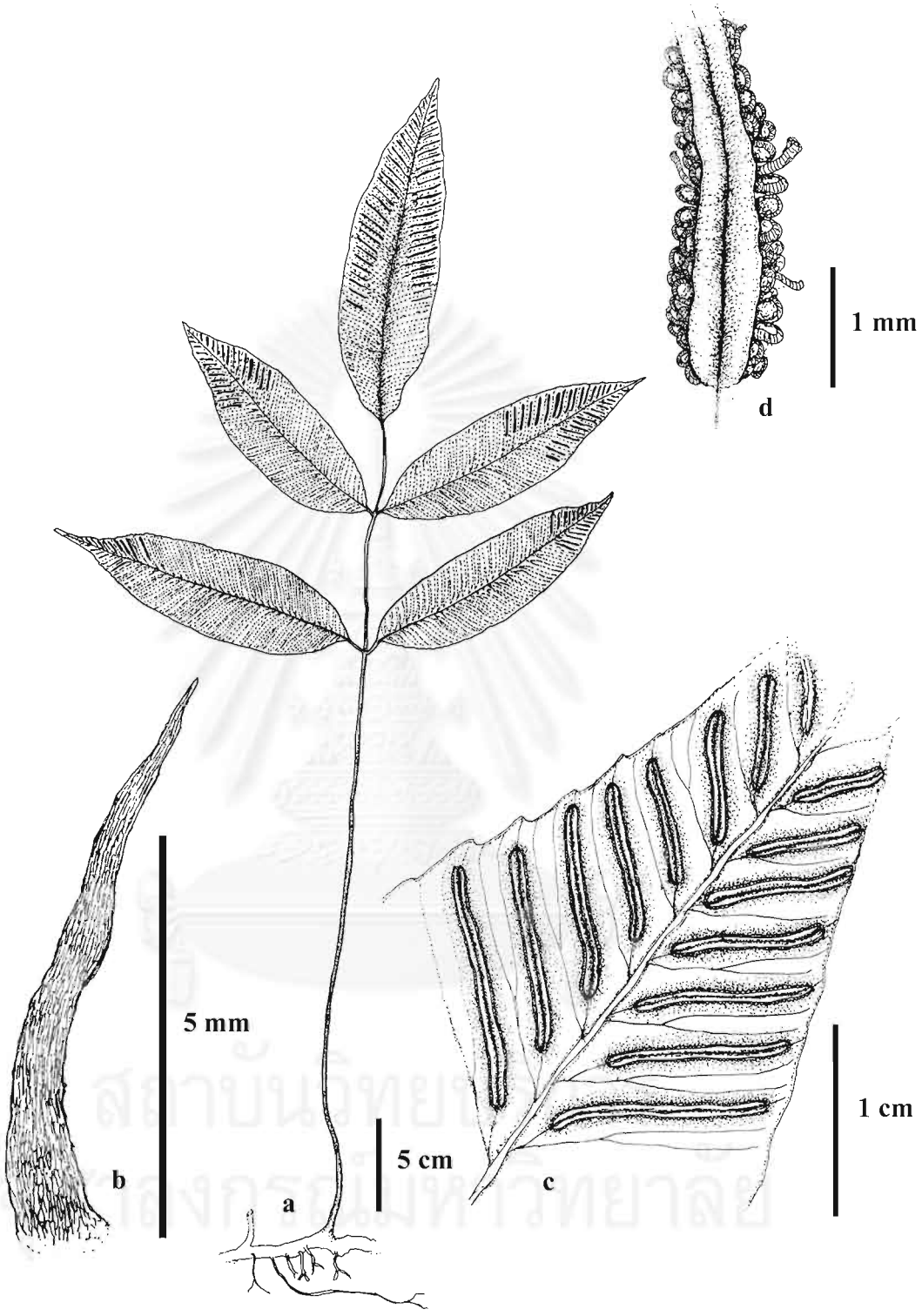


Figure 5.24 ***Diplazium donianum*** **(Mett.) Tardieu** a. Habit. -- b. Rhizome scale. -- c. Sori and venation. -- d. Indusiate sorus. (A. Sathapattayanon 041)

DRYOPTERIDACEAE

Herter, Revista Sudamer. Bot. 9: 15. 1949; Devol and Kuo, Fl. Taiwan Vol. 1. 2nd ed.: 359. 1980.

Medium-sized terrestrial ferns. Rhizome usually short erect or creeping. Stipes with a ring of several vascular bundles, usually tufted, scaly at least at base; scales opaque and quite diverse in size, shape, texture and color; venation free; rachis deeply grooved on upper side and usually open to receive rachillae grooves. Sori round, dorsal or terminal on veins; indusia round or round-reniform, paltate and centrally attached or attached by a deep sinus, rarely absent.

Key to the genera

1. Costa grooved; fronds bearing no articulated hairs; veins free **1. *Dryopteris***
1. Costa raised on upper surface and often hairy; fronds usually bearing articulated hairs; veins free or anastomosing
   2. Veins all free; basal posterior veins of a vein-group running from costules **3. *Pteridrys***
   2. Veins anastomosing or free; basal posterior veins of a vein-group running from costa; sinus-teeth between lobes of pinna or pinnules absent
      4. Basal pinna lobed with short basal posterior lobes or pinnules **2. *Heterogonium***
      4. Basal pinna unlobed, or when lobed the basal basiscopic lobes or pinnules longest **4. *Tectaria***

1. DRYOPTERIS

Adans., Fam. Pl. 2: 20, 551. 1763; Tagawa et K. Iwats., Fl. Thail. 3(3): 345. 1988.

Rhizome short, ascending to erect, stout, scaly; scales in most cases broad and entire, non-clathrate. Stipes usually in a tuft at apex of rhizome, scaly. Fronds mostly broad at base, pinnate to decompound, basal anterior pinnules interior to basal posterior ones or catadromic in sequence of frond-architecture; usually papyraceous or firm, typically glabrous; veins all free. Sori dorsal on veinlets, round with punctate

receptacles; indusia round-reniform, attached at the inner end of sinus, or rarely wanting. Thirteen species were known in Thailand and only 1 species among them was found in Thong Pha Phum District.

Dryopteris polita Rosenst., in Fedde, Rep. Sp. Nov. 13: 218. 1914; Holttum, Rev. Fl. Malaya 2: 492. 1955; Devol and Kuo, Fl. Taiwan Vol. 1. 2nd ed.: 378. 1980; Tagawa et K. Iwats., Fl. Thail. 3(3): 353. f. 32. 9-11. 1988.— *Dryopteris chapensis* auct. non C. Chr. et Ching: Holttum, Dansk Bot. Ark. 20: 30.1961, p.p.

Rhizome short, ascending or suberect, scales light brown, entire, up to 13.69 by 1.15 mm. **Stipes** stramineous, scaly at base with the scales similar to those on rhizome, more sparsely scaly upwards with smaller ones, up to 16.5 cm long. **Fronds** oblong with acuminate apex, bipinnate, up to 19.5 by 19 cm; 5 or 6 lower lateral pinnae nearly equal in size or slightly smaller upwards, with stalks of 1.5 cm long, narrowly subtriangular with acuminate apex, unequally broadly cuneate at base, 9.5 by 2.5 cm; upper pinnae rather suddenly shortened, very shortly stalked, sessile or adnate at base, oblong-subdeltoid with acute apex, shallowly lobed at margin; pinnules oblong-subdeltoid, rounded at apex, round or cuneate at base or acroscopically auricled in larger ones, up to 1.5 by 0.5 cm, serrate at margin; papyraceous, not very thick or harsh, deep green. **Sori** dorsal on veinlets, medial or just beyond midway from midrib to margin of pinnule, in one row, exindusiate. (Figure 5.25)

T h a i l a n d .— NORTHERN: Chiang Mai, Tak; NORTH-EASTERN: Loei; CENTRAL: Nakhon Nayok; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Nakhon Si Thammarat, Ranong.

D i s t r i b u t i o n .— Indochina, W. Malaysia, Sumatra, Borneo, Taiwan (type), and northwards to southern edge of Japan.

E c o l o g y .— Terrestrial on shade slopes in remnants of the forest in mine area, about 800 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 123 [BCU]; E. Hennipman 3095, Kyoji Yoda 465, T. Shimizu et al 26763 [BKF].

2. HETEROGONIUM

C. Presl, Epim.: 142. 1851; Tagawa et K. Iwats., Fl. Thail. 3(3): 360. 1988.— *Ctenitopsis* Ching, Bull. Fan Mem. Inst. Biol. 8: 304. 1938, p.p.

Rhizome short, erect, with dark castaneous scales. Stipes usually fuscous, hairy, with articulate hairs, scaly at base. Fronds catadromous in plan (the basal anterior pinnules interior to the basal posterior one), monomorphic to subdimorphic, pinnate to bipinnatifid, herbaceous, hairy at margin, on axes and on upper surfaces; basal pinnae similar to the next above in size and form; veins free or anastomosing, basal basiscopic veins sometimes springing directly from costa. Sori dorsal on veins, round or elongate, with reniform indusia or naked. There were 5 species in Thailand and 1 speices among them was found in Thong Pha Phum District.

Heterogonium sagenioides (Mett.) Holttum, Sarawak Mus. J. 5: 161. 1941; Rev. Fl. Malaya 2: 520. f. 306. 1955, p.p., Tagawa et K. Iwats., Fl. Thail. 3(3): 362. 1988.— *Aspidium sagenioides* Mett., Abh. Senckenb. Naturf. Ges. 2: 397. 1858.— *Ctenitopsis sagenioides* (Mett.) Ching, Bull. Fan Mem. Inst. Biol. 8: 312. 1938, p.p.— *Ctenitopsis obscura* auct. non Fée: C. Chr. ex Tardieu et C. Chr., Notul. Syst. 7: 87. 1938, excl. basion.; in Fl. Gén. I.-C. 7(2): 349. 1941.

Rhizome short, ascending or suberect; scales oblong, gradually narrowing towards tailed apex, dark brown, stiff, paler and somewhat ferrugineous at margin, hairy, up to 3 by 1 mm. **Stipes** deep purple, polished, 14.5 cm long, minutely pubescent throughout. **Fronds** bipinnatifid, oblong-lanceolate, acuminate at apex, up to 31.8 by 21 cm; lateral pinnae less than 10 pairs, sessile, lanceolate, caudate at apex, truncate at base, deeply lobed nearly to costa; basal pinna 11.5 by up to 5 cm; middle pinnae up to 10.3 by 2.8 cm, upper ones gradually becoming smaller, adnate at base, forming indistinct apical portion; pinnules oblong to oblong-subdeltoid, rounded to acute at apex, entire or crenulate in larger ones, herbaceous, deep green, hairy on both surfaces, costules and veins hairy, veinlets forked; hairs on upper surface of sterile pinna dense, one kinds, multiseptate, 5-8 celled, 0.8-1.5 mm in length. **Sori** dorsal on veinlets, medial, round indusiate; indusia small, fugacious, densely hairy. (Figure 5.26, 5.91)

T h a i l a n d .— EASTERN: Chaiyaphum; SOUTH-WESTERN: Kanchanaburi.

D i s t r i b u t i o n .— Hainan, Indonesia to W. Malesia (type from Java).

E c o l o g y .— Terrestrial on wet shade slopes in remnants of the forest in mine area, about 800-900 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 124, 129 [BCU], K. Larsen et al 30821 [BKF].

3. PTERIDRYS

(C. Chr.) C. Chr. et Ching, Bull. Fan Mem. Inst. Biol. 5: 125. 1935; Tagawa et K. Iwats., Fl. Thail. 3(3): 388. 1988.— *Lastrea* § *Pteridrys* C. Chr., Gard. Bull. S.S. 7: 243. 1934.

Rhizome short, ascending or erect, scaly; scales narrow, concolorous brown to darker, usually entire. Stipes scaly or glabrescent. Fronds oblong in outline, bipinnatifid with distinct, pinnatisect apical pinnae; lateral pinnae narrowly elliptic, basal basiscopic pinnules not distinctly larger; chartaceous, dark green or deep glass-green above and paler beneath, glabrous; rachis grooved, hairy below with septate multicellular hairs; venation campteroid, i.e. basiscopic branch of anterior basal vein meeting at sinus with that of posterior basal vein of next segment but never actually uniting, basal veins sometimes springing directly from costa; a prominent deltoid tooth at each sinus between adjacent pinnules. Sori round, dorsal or terminal on short acroscopic branch of veins, one row at each side of costule; indusia round-reniform. Three species were recorded from Thailand and 2 species among them were found in Thong Pha Phum District.

Key to the species

1. Pinnae sessile **1. *P. australis***

1. Pinnae distinctly stalked, petioles of lower pinna about 1 cm long **2. *P. syrmatica***

1. ***Pteridrys australis*** Ching, Bull. Fan Mem. Inst. Biol. 5: 142. pl. 15, 16, 19(12-13). 1934; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 306. 1941; Holttum, Rev. Fl. Malaya 2: 532. f. 313. 1955; Tagawa et K. Iwats., Fl. Thail. 3(3): 390. 1988.

Rhizome short-creeping, rather thick, scaly near apex; scales lanceolate, tailed at apex, up to 12 by 1.3 mm, dark-brown, stiff. **Stipes** stramineous or darker, scaly at base, glabrescent above, 75 cm long. **Fronds** oblong, hardly or a little narrowing at base, pinnate with very deeply lobed pinnae; up to 106.5 by 44 cm; rachis like the upper part of stipes, hairy throughout; pinnae 20 or more pairs, lanceolate, caudate at apex, broadly cuneate to subtruncate at base, sessile or very shortly stalked, deeply lobed to 3/4 way towards costa, up to 22 by 3.2 cm; costa and costule raised on both surfaces, hairy beneath; segments oblong to oblong-lanceolate, oblique to falcate, moderately acute at apex, serrate at margin; veins once or twice forked, the basal ones springing from the base of costule; the basal acroscopic branches soriferous, stopped at various positions between costule and margin, glabrous. **Sori** round, a row in medial position at each side of costule; indusia reniform, hairy. (Figure 5.27, 5.92)

T h a i l a n d .— NORTHERN: Chiang Mai, Lampang; SOUTH-EASTERN: Chanthaburi; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Nakhon Si Thammarat, Ranong, Phangnga, Yala.

D i s t r i b u t i o n .— S. China (type from Kwangtung), Myanmar, N. Vietnam and W. Malesia.

E c o l o g y .— Terrestrial on wet slopes along steam in remnant of the forest in mine area, at 660 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 117; T. Boonkerd 447, 454, 1479 [BCU]; T. Shimizu 9764, J. F. Maxwell 95-502, K. Larsen et al 30900, M. Tagawa, K. Iwatsuki & N. Fukuoka 5305 [BKF].

2. ***Pteridrys syrmatica*** (Willd.) C. Chr. et Ching, Bull. Fan Mem. Inst. Biol. 5: 131. pl. 11, 17. 1934; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 302. 1941; Holttum, Rev. Fl. Malaya 2: 530. f. 311, 312. 1955; Tagawa et K. Iwats., Fl. Thail. 3(3): 388. 1988.— *Aspidium syrmaticum* Willd., Sp. Pl. 5: 237. 1810.— *Lastrea syrmatica* (Willd.) Moore, Ind. Fil.: 105. 1858; Bedd., Handb.: 243. f. 124. 1883.

Rhizome short, creeping or ascending; scales lanceolate, rounded or cordate at base, tailed at apex, up to 8 by 1.2 mm, dark brown, rather thick hairy at margin. **Stipes** up to 49 cm long, stramineous to pale castaneous, scaly at base, glabrescent above. **Fronds** oblong to oblong-lanceolate, pinnate with deeply lobed pinnae, 61 by 36 cm; rachis glabrescent, pale stramineous to deep brown; lateral pinnae 5-12 pairs, ascending, petioles of basal pinnae 1.3 cm long, lanceolate, subtruncate to broadly cuneate at base, up to 19 by 4.5 cm, deeply lobed to 4/5 way towards costule; lobes oblong, oblique, rounded at apex, serrate at margin, up to 25.84 by 8.01 mm; papyraceous, deep green, glabrous; costules pale, glabrous, raised on both surfaces; veins pinnate, the basal basiscopic veinlets springing directly from costa, veinlets forked, acroscopic branches stopped at midway, basiscopic branches running into the projections at margin, and a branch in to sinus-teeth. **Sori** apical or subapical at acroscopic branches of veinlets, thus medial, round; indusia reniform, glabrous. (Figure 5.93)

T h a i l a n d .— NORTHERN: Chiang Mai; SOUTH-WESTERN: Kanchanaburi, Prachuap Khiri Khan; PENINSULAR: Surat Thani, Phangnga, Nakhon Si Thammarat, Trang, Satun, Yala.

D i s t r i b u t i o n .— Sri Lanka, Cochinchina and Malesia, east to Celebes and the Philippines.

E c o l o g y .— Terrestrial on humus-rich ground along steam in remnant of the forest in mine area, at 520 m alt.

V e r n a c u l a r .— Kut kham, Di ngu wa (Northern); Neraphusi thet (Central).

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 108; T. Boonkerd 1419; Y. Yuyen 11 [BCU]; T. Shimizu 7893, E. Hennipman 3743, K. Larsen et al 31055 [BKF].

4. TECTARIA

Cav., Anales Hist. Nat. 1: 115. 1799; Tagawa et K. Iwats., Fl. Thai. 3(3): 364. 1988. — *Ctenitopsis* Ching, Bull. Fan Mem. Inst. Biol. 8: 304. 1938.

Rhizome usually thick, short, erect to short-creeping, scaly at apex. Stipes stramineous to ebeneous. Fronds simple to amply divided, usually broad or pentagonal in outline; all axes hairy with articulated multicellular hairs; veins free to variously anastomosing with or without included veinlets. Sori terminal on included free veins, dorsal on veins or compital on connected veins, usually round, indusiate or exindusiate, or sometimes elongate; indusia if present round-reniform. There were 25 species in Thiland. Three species among them and one of unidentify species were found in Thong Pha Phum District.

Key to the species

1. Veins all free in fertile fronds, anastomosing only in sterile fronds **1. *T. fuscipes***
1. Veins copiously anastomosing to form areoles outside the costal and costular ones
   2. Sori terminal on included free veinlets
      3. Pinnae of fertile fronds much contracted as compared with those of sterile fronds **2. *T. impressa***
      3. Pinnae of fertile fronds not or little contracted **4. *T.* sp.**
   2. Sori on anastomosing veins **3. *T. polymorpha***

1. ***Tectaria fuscipes*** (Wall. ex Bedd.) C. Chr., Contr. U.S. Nat. Herb. 26: 290. 1931; Tagawa et K. Iwats., Fl. Thail. 3(3): 365. 1988.— *Aspidium fuscipes* Wall. ex Bedd., Ferns Br. Ind. Suppl.: 15. t. 366. 1876.— *Lastrea fuscipes* (Wall. ex Bedd.) Moore ex Bedd., Handb.: 243. 1883.— *Ctenitopsis fuscipes* (Wall. ex Bedd.) C. Chr. et Tardieu, Notul. Syst. 7: 87. 1938; in Fl. Gén. I.-C. 7(2): 354. 1941.— *Pleocnemia membranifolia* auct. non C. Presl: Bedd., Handb.: 225. f. 115. 1883.— *Sagenia membranifolia* auct. non (C. Presl) H. Christ: Hosseus, Beih.. Bot. Centr. 28(2): 366. 1911.

Rhizome short, suberect to ascending; scales stiff, nearly black, about 10 by 1.8 mm, entire. **Fronds** dimorphic. **Sterile fronds***:* stipes 10-20 cm long, scaly on lower part, pubescent throughout, stramineous to darker; fronds bipinnatifid, oblong

to oblong-lanceolate, acuminate at apex, broadest at base, up to 50 by 25 cm; basal pinnae asymmetrically oblong-subdeltoid, ca. 15 by 10 cm, caudate-acuminate at apex, lobed to 4/5 way towards costa, bearing large basal basiscopic pinnules; middle lateral pinnae lanceolate, broadest at base, up to 13 by 4 cm; upper pinnae adnate at base and decurrent to the next to form indistinct apical portion; lobes oblong-subdeltoid, oblique, round at apex, entire, 7-9 mm broad; herbaceous, deep green, hairy on upper surface; costa pubescent, a row of costal areoles present. **Fertile fronds** taller: stipes up to 16.2 cm long; fronds narrower, middle pinnae up to 3.6 cm wide, lobed to 4/5 way towards costa; veins all free. **Sori** dorsal on veinlets, round, rather irregularly dispersed on lower surface of pinna, about 1.18 mm diam.; indusia small, persistent. (Figure 5.28, 5.94, 5.95)

T h a i l a n d .—NORTHERN: Chiang Rai, Chiang Mai, Lampang, Phitsanulok, Tak; NORTH-EASTERN: Loei, Nakhon Sawan; SOUTH-EASTERN: Chon Buri, Chanthaburi; SOUTH-WESTERN: Kanchanaburi.

D i s t r i b u t i o n .—Sikkim (type) to S. China, east to Taiwan.

E c o l o g y .—Terrestrial on humus-rich ground in remnant of the forest in mine area, at 520 m alt.

S p e c i m e n e x a m i n e d .—A. Sathapattayanon 104; P. Ratchata 64, 145 [BCU]; G. Murata et al 49552, C. Phengklai et al 3905, Winit 904 [BKF].

2. ***Tectaria impressa*** (Fée) Holttum, Kew Bull. 43: 483. 1988.— *Phlebigonium impessum* Fée, Gen. Fil.: 314. 1852; Tagawa et K. Iwats., Fl. Thail. 3(4): 621. 1989.— *Aspidium variolosum* Wall. ex Hook., Sp. Fil. 4: 51. 1862; Bedd,. Handb.: 216. f. 111. 1883.— *Nephrodium variolosum* (Wall. ex Hook.) Hook. et Bak., Syn. Fil.: 298. 1867.— *Sagenia membranifolia* auct. non Christ: Hoss., Beih. Bot. Centr. 28(2): 366. 1911.— *Tectaria variolosa* (Wall. ex Hook.) C. Chr., Contr. U.S. Nat. Herb. 26: 289. 1931; Tardieu et C. Chr. in in Fl. Gén. I.-C. 7(2): 412. 1941; Holttum, Rev. Fl. Malaya 2: 506. f. 298. 1955; Tagawa et K. Iwats., Fl. Thail. 3(3): 368. 1988.

Rhizome short, creeping, ascending or erect, 4.04 mm diam.; scales linear, hairy at margin, rather stiff, bicoloured by nearly black central portion with brown ferrugineous edges or concolorous brown, up to 5.57 by 0.76 mm. **Stipes** pale brown to castaneous, 15 cm in sterile and up to 26.5 cm in fertile fronds, densely pubescent

on adaxial surface, glabrous beneath. **Fronds** ovate-subdeltoid or pentagonal, up to 15 by 12.2 cm, tripinnatifid at base; lateral pinnae 2-4 pairs, the basal pinna much the largest, stalked, asymmetrically subtriangular, acute at apex, with one or two basal basiscopic pinnules; upper pinnae shortly stalked, deeply lobed or with a free sessile basal basiscopic pinnule; apical pinna subdeltoid, cuneate and a little decurrent at base, deeply lobed to pinnatifid; herbaceous, green, glabrous on fronds surface; rachis and pinna-rachis with dense articulated hairs above, glabrous beneath; veins forming copious anastomoses with included veinlets. **Sori** terminal on free included veinlets, round, usually in a single row at each side of midrib, more or less raised on upper surface; indusia up to 1 mm diam., persistent, glabrous. (Figure 5.96, 5.97)

T h a i l a n d .— All over the country.

D i s t r i b u t i o n .— N. India (type), S.W. China, Indochina, Taiwan, W. Malesia to Java.

E c o l o g y .— Terrestrial on rather dry mountain slopes in natural forests, about 900-1000 m alt, fairly common throughout Thailand.

V e r n a c u l a r .— Kut kwang, Kut kieo, Kut sang, Kut hok, Kut horn kha (Northern); Chon pa (Peninsular).

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 058, 253, 288, 299, 310; P. Ratchata 112, 205; T. Boonkerd 1307 [BCU]; C. Phengklai 13001, T. Shimizu 10578, M. Tagawa 9244 [BKF].

3. ***Tectaria polymorpha*** (Wall. ex Hook.) Copel., Phil. J. Sci. 2C : 413. 1907; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 417. 1941, p.p.; Tagawa et K.Iwats., Fl. Thail. 3(3): 378. 1988.— *Aspidium polymorphum* Wall. ex Hook., Sp. Fil. 4: 54. 1862; Bedd., Handb.: 218. 1883.

Rhizome short, ascending to suberect; scales linear-subtriangular, about 10 by 2 mm, brown, stiff, margined with pale thinner edges about 0.3 mm broad. **Stipes** stramineous to brown, densely pubescent on adaxial surface, glabrescent beneath, 55.5 cm long. **Fronds** imparipinnate, ovate-oblong, 34 by 56 cm; rachis densely pubescent on upper surface, glabrescent beneath; lateral pinnae oblong-lanceolate, caudate at apex, cuneate to round at base, shortly stalked or sessile, broadest at 1/3 way from apex; usually about 19 by 5.3 cm, or up to 28 by 7 cm, subentire, or rarely

coarsely dentate, or each basal pinna sometimes with single large basiscopic lobe, terminal pinna a little larger, broadest at 2/3 way from apex; up to 17 by 6 cm, papyraceous, green, glabrous; costa and main veins distinctly raised beneath, shortly pubescent, veins copiously anastomosing, main areoles distinct including two rows of smaller areoles with free included veinlets, all veinlets raised beneath, glabrous. **Sori** on anastomosing veins, irregularly scattered on lower surface of pinnae, round, about 1 mm diam.; indusia small, fugacious, pubescent. (Figure 5.98, 5.99)

T h a i l a n d .— NORTHERN: Chiang Rai, Chiang Mai, Tak, Phitsanulok, Nakhon Sawan; NORTH-EASTERN: Loei; CENTRAL: Nakhon Nayok, Saraburi; SOUTH-EASTERN: Chanthaburi; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Chumphon, Surat Thani, Nakhon Si Thammarat, Trang, Yala.

D i s t r i b u t i o n .— E. Himalaya (type) to S. China and Taiwan, south to Sri Lanka and W. Malesia.

E c o l o g y .— Terrestrial on mountain slopes usually in dry places in remnant of the forest in mine area and in natural forest, about 500-1000 m alt.

V e r n a c u l a r .— Kut kaeo, Kut taem, Kut kaid, Kut hua lek (Northern); Kut hok (Shan/Northern); Seng-khia-du (Karen/Northern).

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 185, 226; P. Ratchata 15, 295; Y. Yuyen 31 [BCU]; J. F. Maxwell 93-883, C. Phengklai 12592, T. Smitinand & Th. S. et al 507 [BKF].

4. ***Tectaria* sp.**

Rhizome erect, scaly; scales linear-subtriangular, 20 mm long, 2 mm wide at base, entire, dark brown. **Stipes** 70 cm long, dark brown to castaneous, bearing many very narrow scales throughout. **Fronds** deltoid-pentagonal, 70 cm long and wide, free pinnae 2 pairs, basal pinna the largest, 45 cm long, stalk, with 1 pair of free pinnules, the rest lobed 10 mm from the costa; basal basiscopic pinnule 27 by 8 cm, widest at base, deeply lobed with costules 1.5 cm apart, lobes falcate, acute; acroscopic pinnule 16 by 5 cm, shallowly lobed; veins distinct on lower surface, forming broad costal and costular areoles, also other areoles below sinuses, costular areoles not forming in distal parts of lobes of fertile; lower surface sparsely hairy on costae and costules; upper surface of costae and costules densely covered with short thick hairs, small

groups of similar hairs present at sinuses. **Sori** round, terminal on short free included veinlets, indusiate, single row at each side of midrib in basal and terminal pinnae, irregular row in middle pinnae; indusia medium, 1 mm diam., persistent. (Figure 5.29, 5.100, 5.101)

T h a i l a n d .— SOUTH-WESTERN: Kanchanaburi.

E c o l o g y .— Terrestrial on rather dry slopes in remnants of the forest in mine area, about 900 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 101, 119 [BCU]

R e m a r k .— This species is closed to *Tectaria griffithii* (Baker) C. Chr. but different in the detail of fronds; basiscopic pinnule widest at middle, costal and costular areoles narrow, lower surface with some narrow scales, and the detail of sori; indusium large, in a single row at each side of midrib of all pinnae, in *T. griffithii*.

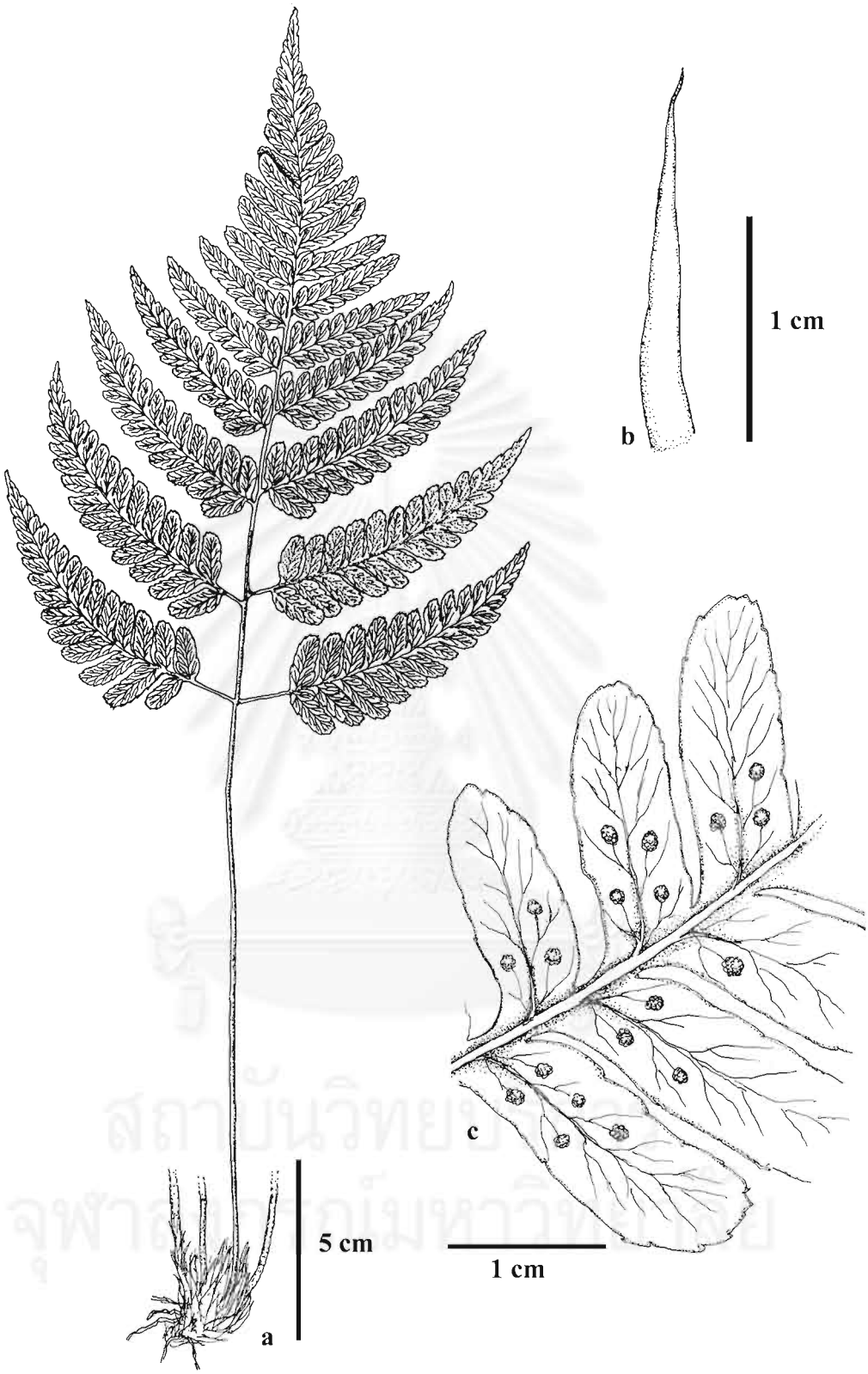


Figure 5.25 *Dryopteris polita* Rosenst. a. Habit. -- b. Rhizome scale. -- c. Sori and venation. (A. Sathapattayanon 123)

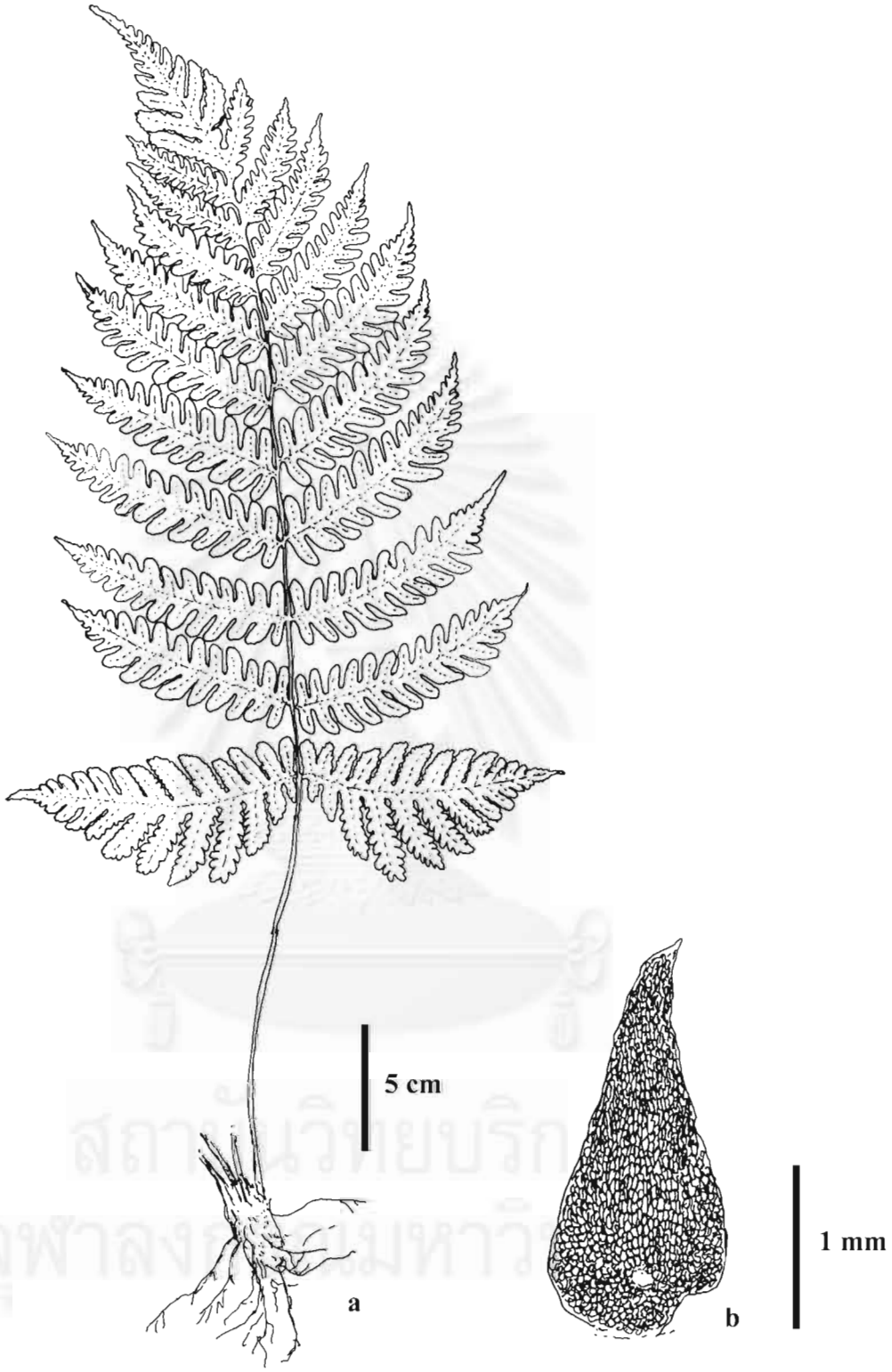


Figure 5.26 *Heterogonium sagenioides* (Mett.) Holttum a. Habit. -- b. Rhizome scale. (A. Sathapattayanon 100)

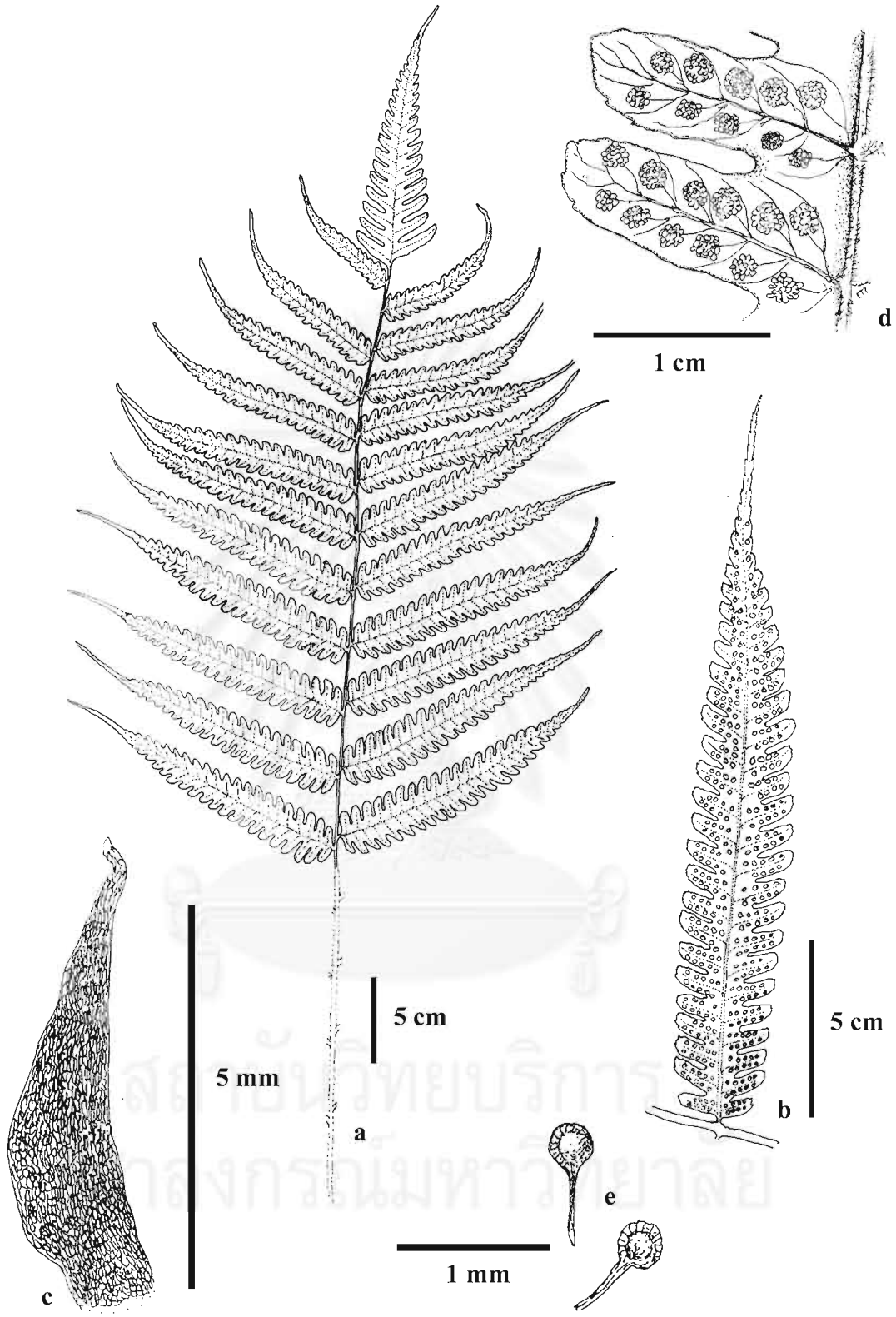


Figure 5.27 ***Pteridrys australis*** **Ching** a. Part of frond. -- b. pinnae. -- c. Rhizome scale. -- d. Sori and venation. -- e. sporangia. (A. Sathapattayanon 154)

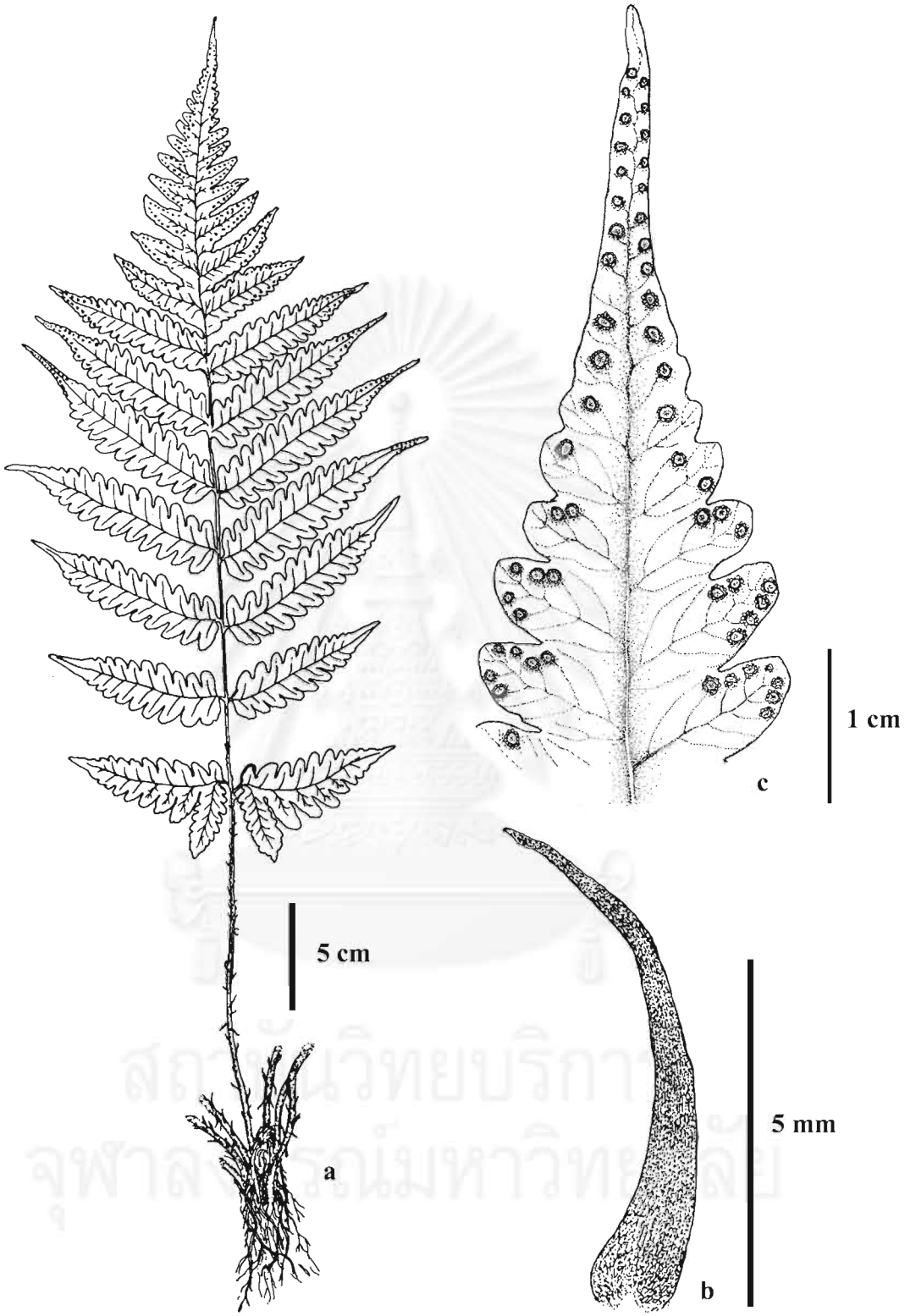


Figure 5.28 *Tectaria fuscipes* (Wall. ex Bedd.) C. Chr. a. Habit. -- b. Rhizome scale. -- c. Sori and free veins. (T. Boonkerd & R. Pollawatn 344)

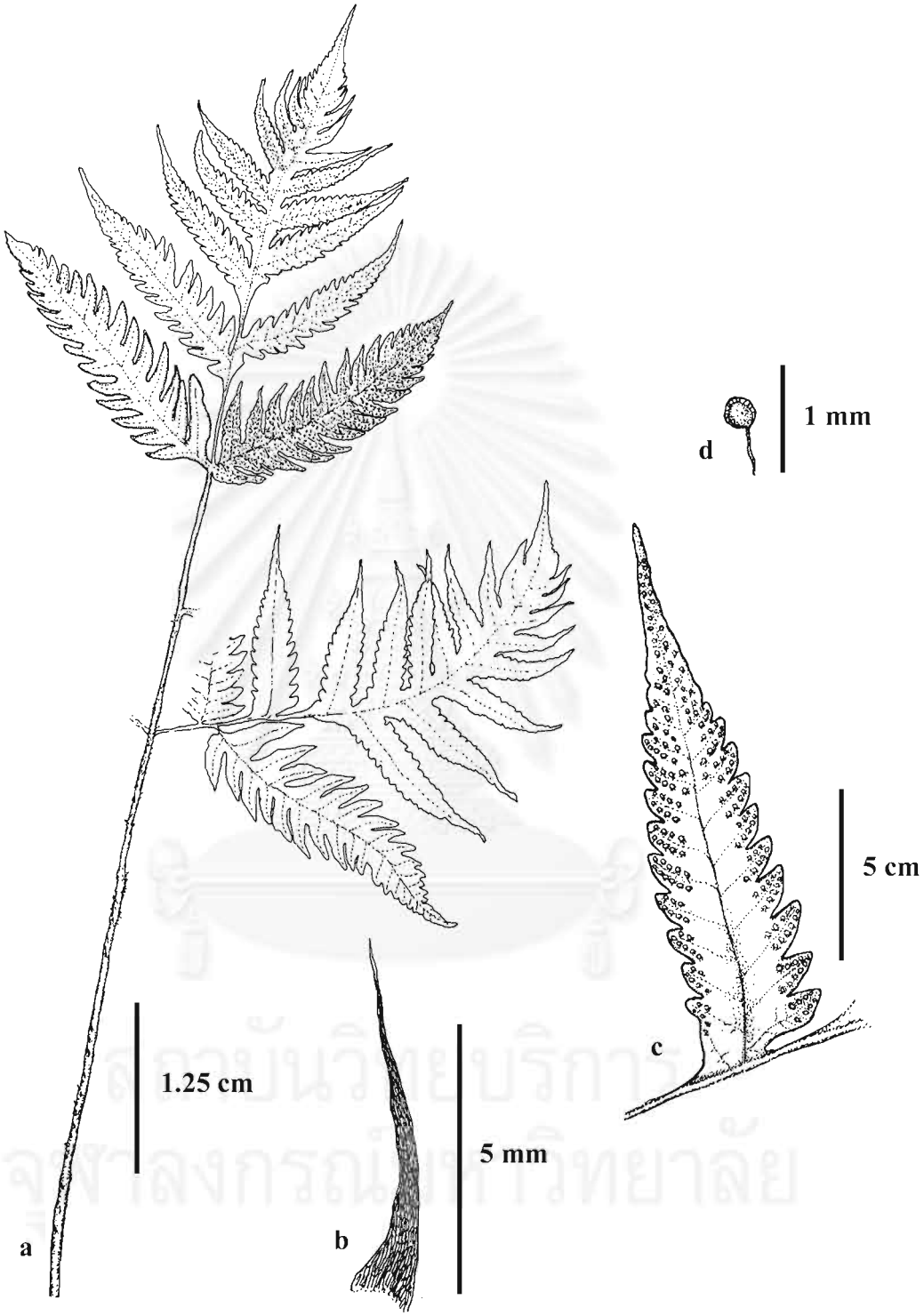


Figure 5.29 *Tectaria* sp. a. Habit. -- b. Rhizome scale. -- c. Sori. -- d. Sporangium. (A. Sathapattayanon 101)

THELYPTERIDACEAE

Ching ex Pic. Serm., Webbia 24: 709. 1970; Holttum in Fl. Mal. II. 1: 331. 1981; Kuo, Fl. Taiwan Vol. 1.2nd ed.: 401. 1980.

Rhizome erect, short-creeping or long-creeping; scales usually thin, not peltate. Stipes not articulated to stem, containing two vascular bundles at base and uniting into a U-shaped bundle in the upper part. Fronds usually pinnate with crenate or lobed pinnae, upper surfaces of costae grooved or not, if grooved, not open to admit grove of rachis; lowest pinnae without enlarged basiscopic basal pinnules; hairs normally unicellular; veins free in deeply lobed pinnae, or basal veins in adjacent lobes anastomosing to form an excurrent vein, which may be joined by other veins, terminating at the base of a sinus-membrane. Sori borne on abaxial surface of veins, indusiate or not; indusia renifrom, glabrous or bearing hairs and/or glands.

Key to the genera

1. Veins anastomosing, veinlets reaching the very margin of lobes
   2. Pinnae variously lobed, with callous membrane at sinus between lobes
      3. Sporangia glabrous **1. *Christella***
      3. Sporangia setiferous **2. *Cyclosorus***
   2. Pinnae subentire, callous membrane absent at sinus between crenae **4. *Pronephrium***
1. Veins all free, veinlets not reaching the very margin of lobes **3. *Metathelypteris***

1. CHRISTELLA

H. Lév., Fl. Kouy-Tchéou. 472. 1915; Holttum in Fl. Mal. II. 1: 550. f. 20. 1981; Kuo, Fl. Taiwan Vol. 1. 2nd ed.: 402. 1980.—*Thelypteris* Schmidel, Icon. Pl., ed. Keller 3, 45-48. 1763; Tagawa et K. Iwats., Fl. Thail. 3(3): 393. 1988.—*Nephrodium* Schott, Gen. Fil. t. 10. 1834.—*Thelypteris* subg. *Cyclosoriopsis* K. Iwats, Mem. Coll. Sci. Univ. Kyoto B, 31. 28. 1964.

Rhizome erect, suberect or creeping; scales almost always narrow with many superficial hairs. Fronds bipinnatifid with lobed pinnae, sinus membrane present; lower pinnae never or only gradually shortened, but not abruptly shortened; upper

surface of costae grooved. Venation goniopteroid. Sporangium with a single cylindric unicellular hair on stalk. Twelve species were recorded from Thailand and there are 2 species among them were found in Thong Pha Phum District.

Key to the species

1. The second basal pair of veinlets running to the callous membrane; lower pinnae gradually reduced at least 3 pairs **1. *C. dentata***
1. At least one of the second basal veinlets uniting with excurrent veinlets below callous membrane; lower pinnae gradually reduced up to 3 pairs **2. *C. parasitica***

1. ***Christella dentata*** (Forssk.) Holttum, J. S. African Bot. 40(2): 143. 1974; Kuo, Fl. Taiwan Vol. 1.2nd ed.: 404. 1980.—*Polypodium dentatum* Forssk. Fl. Aegypt.-Arab. 185. 1775.—*Thelypteris dentata* (Forssk.) St. John, Amer. Fern J. 26: 44. 1966; Tagawa et K. Iwats., Fl. Thail. 3(3): 427. 1988.—*Cyclosorus dentatus* (Forssk.) Ching, Bull. Fan Mem. Inst. Biol. 8: 206. 1938.—*Christella dentata* (Forssk.) Brownsey et Jermy, Brit. Fern Gaz. 10: 338. 1973; in Fl. Mal. II. 1: 557. f. 1 p, 20a. 1981.—*Cyclosorus subpubescens* auct. non (Blume) Ching; Holttum, Rev. Fl. Malaya 2: 273. f. 157. 1955.

Rhizome short, erect, ascending, or shortly creeping, with a tuft of fronds; scales narrow, about 8 by 1.5 mm, pale brown, hairy. **Stipes** about 70.5 cm long, bearing reduced pinnae on upper portion, scaly at base, hairy throughout. **Fronds** narrowly oblong, acute at apex, gradually narrowing downwards, up to 72.5 by 42 cm; lateral pinnae about 20 pairs, patent to ascending, sessile, linear-lanceolate, more or less auricled at base, gradually narrowing towards long-acuminate apex, up to 23.5 by 2 cm, lobed 1/3 to 2/3 way costa; lower pinnae gradually becoming smaller downwards but rarely reduced to mere auricles; segments oblong-subdeltoid, oblique, rounded at apex, entire; herbaceous to softly papyraceous, yellow-green to green, densely pubescent on both surfaces; basal veinlets and basal second anterior ones uniting below callous-membrane. **Sori** medial, round; indusia large, densely hairy. (Figure 5.102, 5.103)

T h a i l a n d .— NORTHERN: Chiang Rai, Chiang Mai, Mae Hong Son, Lamphun, Lampang, Phrae, Tak, Phitsanulok; NORTH-EASTERN: Phetchabun, Loei, Khon Kaen; CENTRAL: Nakhon Nayok, Saraburi, Bangkok; SOUTH-EASTERN: Prachin Buri, Chanthaburi, Trat; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Surat Thani, Nakhon Si Thammarat, Phangnga, Trang, Satun.

D i s t r i b u t i o n .— Pantropic (type from Arabia).

E c o l o g y .— Terrestrial on rather dry ground slopes in remnants of the forest in mine area, about 500-800 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 228, 258; T. Boonkerd 669, 687, 704 [BCU]; T. Shimizu 8700, Winit 990, C. Niyomdham et al 1477, Michio Matsuoka 184 [BKF].

2. ***Christella parasitica*** (L.) H. Lév., Fl. Kouy-Tchéou: 475. 1915; Holttum in Fl. Mal. II. 1: 559. f. 20 f. 1981.— *Polypodium parasiticum* L., Sp. Pl. 2: 1090. 1753.— *Dryopteris parasitica* (L.) O. Ktze., Rev. Gen. Pl. 2: 811. 1891.— *Aspidium parasiticum* (L.) H. Christ, Bot. Tidsskr. 24: 109. 1901.— *Nephrodium amboinense* auct. non Pr.: Hosseus, Beih. Bot. Centr. 28(2): 365. 1911.— *Cyclosorus parasiticus* (L.) Farw., Amer. Midl. Nat. 12: 259. 1929; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 381. 1941; Holttum, Rev. Fl. Malaya 2: 281. f. 162. 1955.— *Thelypteris parasitica* (L.) Fosberg, Occ. Pap. B.P. Bishop Mus. 23: 30. 1962; Tagawa et K. Iwats., Fl. Thail. 3(3): 424. 1988.

Rhizome creeping, about 8 mm diam.; scales narrow, up to 12 by 1 mm, dark brown, hairy. **Stipes** about 33 cm long, scaly at base, hairy throughout. **Fronds** oblong-lanceolate, acute at apex, about 67 by 24 cm; basal pinnae deflexed, lower pinnae patent or ascending, linear-lanceolate, sessile at acroscopic base, about 10.5 by 1.4 cm, lobed more than half-way toward costa; segment oblong, oblique, rounded at apex, entire; thinly papyraceous, yellow-green to green, hairy on under surface; basal pairs of veins anastomosing, the other veinlets running to margin of lobes, glandular; glands sessile, rod-shaped, orange to red. **Sori** supramedial, usually not on lobes, i.e. on one or two basal veinlets; indusia persistent, hairy. (Figure 5.104, 5.105)

T h a i l a n d .— NORTHERN : Ching Rai, Chiang Mai, Lampang, Tak, Phitsanulok; EASTERN: Chaiyaphum; NORTH-EASTERN: Loei; SOUTH-

EASTERN: Chon Buri, Trat; SOUTH-WESTERN : Kanchanaburi; PENINSULAR: Surat Thani, Nakhon Si Thammarat, Phangnga, Trang, Satun.

D i s t r i b u t i o n .— Tropics and subtropics in Asia (type from S. China), north to S. Japan and south to New Zealand.

E c o l o g y .— Terrestrial on rather dry slopes in open places in abandoned mine and remnant of the forest in mine area, about 700-800 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 157; P. Ratchata 280; T. Boonkerd 290, 291 [BCU]; K. Iwatsuki et al 152, C. Phengklai et al 11243, J. F. Maxwell 88-967 [BKF].

2. CYCLOSORUS

Link, Hort. Reg. Bot. Berol. 2: 128. 1833; Holttum, Blumea 19: 27. 1971.; in Fl. Mal. II. 1: 385. 1981.

Rhizome long-creeping. Fronds bipinnatifid, basal pinnae not reduced; thin flat scales present on lower surface of costae; spherical glandular cells present on lower surface of veins and at ends of hairs on stalks of sporangia, not on body of sporangia. Sori indusiate; spores with densely and irregularly spinulose. Three species were known in Thailand and 1 species was found in Thong Pha Phum District.

Cyclosorus hirtisorus (C. Chr.) Ching, Bull. Fan Mem. Inst. Biol. 8: 221. 1938.— *Dryopteris hirtisora* C. Chr., Contr. U.S. Nat. Herb. 26: 277, 330. 1931.— *Cyclosorus validus* auct. non (H. Christ) Tardieu: Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 398. 1941, p.p.— *Cyclosorus acuminatus* auct. non (Houtt.) Nakai ex H. Ito: Holttum, Dansk Bot. Ark. 20: 22. 1961.— *Thelypteris hirtisora* (C. Chr.) K. Iwats., J. Jap. Bot. 38: 314. 1963; Tagawa et K. Iwats., Fl. Thail. 3(3): 418. f. 43. 1-2. 1988.

Rhizome long-creeping, about 5.38 mm diam.; scales up to 4.92 by 1.63 mm, brown, hairy. **Stipes** 31 cm long, scaly at base, hirsute throughout. **Fronds** oblong or subrectangular with a long terminal pinna, up to 51 by 34.4 cm; lower pinnae hardly reduced, or lower one or two pairs slightly reduced and deflexed, larger pinnae patent to slightly ascending, about 12 pairs, nearly straightly, shortly stalked, linear, gradually narrowing to long-acuminate apex, round to broadly cuneate at base, up to 18 by 1.6 cm, lobed more than 1/3 way towards costa; segments subdeltoid, oblique,

acute at apex; softly papyraceous, hirsute on surface, more than 2 pairs of lower veinlets truly anastomosing below callous-sinus. **Sori** medial, round; indusia rather small, hairy, persistent but usually under sporangia in matured sori; sporangia setose. (Figure 5.30, 5.106, 5.107)

T h a i l a n d .— NORTHERN: Ching Rai, Chiang Mai, Tak; NORTH-EASTERN: Phetchabun, Loei; SOUTH-WESTERN: Kanchanaburi.

D i s t r i b u t i o n .— S.W. China, Upper Myanmar (type) and Indochina.

E c o l o g y .— Terrestrial on rather dry slopes in light shade in natural forests, about 900-1000 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 257, 327, 330; O. Vannasri 73; P. Ratchata 124; Y. Yuyen 203 [BCU]; T. Shimizu et al 23673, H. Koyama 40129, S. Mitsuta et al 50378 [BKF].

3. METATHELYPTERIS

(H. Ito) Ching, Acta Phytotax. Sinica 8: 304. 1963; Holttum, Blumea 19: 26. 1971; in Fl. Mal. II. 1: 350. 1981.— *Thelypteris* sect. *Metathelypteris* H. Ito in Nakai et Honda, Nov. Fl. Jap. no. 4: 137. 1939.

Rhizome short, erect or decumbent with tufted fronds. Stipes green when living, scaly at base only, scales less than 10 mm long, narrow with a few short acicular hairs. Fronds simply pinnate (in *M. flaccida* almost bipinnate) with deeply lobed pinnae, basal pinnae not or little reduced; veins free, often forked, with thickened ends not reaching margin; upper surface of costae prominent, not grooved; acicular and/or capitate hairs, not spherical glands, present on lower surfaces; scales on lower surface of costae, if present, uniseriate, about as in *Pseudophegopteris*. Sori indusiate, indusia thin; sporangia sometimes with a hair of several cells on the stalk, no hairs nor glands on body; spores with irregular ridges variously united. Two species were recorded in Thailand. In this study, there is a new record species in Thailand, that is *Metathelypteris dayi*.

Key to the species

1. Lower surfaces of costae and costules bearing sparse acicular hairs; stipes up to 45 cm long **1. *M. dayi***
1. Lower surfaces of costae and costules bearing copious capitate hairs; stipes up to 60 cm long **2. *M. singalanensis* var. *singalanensis***

1. ***Metathelypteris dayi*** (Bedd.) Holttum in Nayar et Kaur, Comp. to Bedd. 205. 1974; in Fl. Mal. II. 1: 352. f. 3d. 1981.— *Asplanium dayi* Bedd, J. Bot. 26: 4 1888.— *Lastrea dayi* (Bedd.) Bedd, Handb. Suppl. 54. 1892.— *Dryopteris dayi* (Bedd.) C. Chr, Ind. Fil. 260. 1905.— *Thelypteris singlanensis sensu* Holttum, Rev. Fl. Malaya 2: 243. f. 138. 1955, p.p.— *Thelypteris dayi* (Bedd.) Nayar et Kaur, Comp. to Bedd. 59. 1974.

Rhizome short, erect; plants fertile form a small size. **Stipes** up to 31 cm long; basal scales narrow, 5-7 mm long, not widened at base. **Fronds** up to 42 cm long, pinnate-pinnatifid, at least lower ones opposite, lobed to 1.5 mm from costa; pinnae sessile, linear-lanceolate, falcate, caudate-acuminate at apex, up to 8.5 by 1.5 mm; lower surface of rachis and base of costae glabrous, distally on costae and costules sparse acicular hairs 0.2 mm long; pinnules oblong, up to 9.23 by 2.69 mm, entire, round to acute at apex; papyraceous; veins pinnate, up to 10 pairs, veinlets simple or forked basiscopic branches sometimes forked again. **Sori** on terminal of veinlets; indusia thin. (Figure 5.31, 5.108)

T h a i l a n d .— SOUTH-WESTERN: Kanchanaburi.

D i s t r i b u t i o n .— Tonkin, Malesia.

E c o l o g y .— Terrestrial on wet mountain slopes near stream bank in light shade in remnant of the forest in mine area, at 880 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 198, 235 [BCU]

2. ***Metathelypteris singalanensis*** (Baker) Ching var. ***singalanensis***, Acta Phytotax. Sinica 8: 306. 1963; Holttum in Fl. Mal. II. 1: 352. f. 3, g. 1981.— *Nephrodium singalanense* Baker, J. Bot. 18: 212. 1880.— *Lastrea singalanense* (Baker) Bedd., Handb. Suppl.: 54. 1892.— *Dryopteris singalanense* (Baker) C. Chr., Ind. Fil. 293. 1905.— *Thelypteris singalanense* (Baker) Ching, Bull. Fan Mem. Inst Biol. 6: 334. 1936; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 365. 1941; Holttum, Rev. Fl. Malaya 2: 243. f. 138. 1955; Tagawa et K. Iwats., Fl. Thail. 3(3): 399. 1988.

Rhizome short, erect; scales very sparse, linear, up to 8 by 0.2 mm, dark brown. **Stipes** stramineous, up to 61 cm long, scaly and hairy at base when young, glabrescent upwards. **Fronds** about 65 by 31 cm, pinnate-bipinnatifid; pinnae sessile, linear-lanceolate, caudate-acuminate at apex, up to 20 by 3 mm; lower surface of rachis, costae, costules and veins bearing copious very short capitate hairs, some capitate hairs also on surface between veins; pinnules narrowly oblong, patent to falcate, up to 15.25 by 4.93 mm, entire, rounded to moderately acute at apex; softly papyraceous to papyraceous, green; veins pinnate, veinlets simple, forked, or triforked, glabrous. **Sori** dorsal on veinlets, in a medial row between costules and margin of pinnules; indusia thin, glabrous. (Figure 5.109)

T h a i l a n d .— NORTHERN: Phitsanulok; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Nakhon Si Thammarat.

D i s t r i b u t i o n .— Vietnam, Malesia, Sumatra (type), Borneo and W. Java.

E c o l o g y .— Terrestrial on wet mountain slopes in light shade in remnant of the forest in mine area, at 890 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 097 [BCU], M. Tagawa, K. Iwatski & N. Fukuoka 2019, E. Smith 903, H. Koyama et al 33231 [BKF].

4. PRONEPHRIUM

C. Presl, Epim. Bot. 258. 1851; Holttum, Blumea 19: 34. 1971; in Fl. Mal. II. 1: 507. f. 14-16. 1981; Kuo, Fl. Taiwan Vol. 1. 2nd ed.: 429. 1980.— *Thelypteris* Schmidel, Icon. Pl., ed. Keller 3, 45-48. 1763; Tagawa et K. Iwats., Fl. Thail. 3(3): 393. 1988.— *Haplodictyum* C. Presl, l. c. 50; Ching, Sunyatsenia 5: 251. 1940.— *Abacopteris* Fée, Gen. Fil. 309. 1852; Holttum, Rev. Fl. Malaya 2: 285. 1955.— *Dimorphopteris* Tagawa et K. Iwats., Acta Phytotax. Geobot. 19: 8. 1961.

Rhizome creeping or suberect. Fronds simple or simply pinnate with free apical pinnae; basal pinnae not reduced but often narrowed at base on basiscopic side, pinnae entire or nearly so; venation goniopteroid, veinlets almost all anastomosing. Sori indusiate or exindusiate, sporangia often bearing short setae, less often spherical glands or both glands and setae. There were 10 species in Thailand and only 1 species among them was found in Thong Pha Phum District.

Pronephium nudatum (Roxb.) Holttum, Blumea 20: 111. 1972.— *Polypodium nudatum* Roxb., Calc. J. Nat. Hist. 4: 491. 1844.— *Polypodium multilineatum* Wall. ex Hook., Sp. Fil. 5: 11. 1863.— *Nephrodium moulmeinense* Bedd., Ferns Br. Ind. Suppl.: 18. 1876; Handb. 275. f. 141. 1883.—*Nephrodium multilineatum* (Wall. ex Hook.) Bedd., Handb. Suppl.: 80. 1892.— *Dryopteris moulmeinense* (Bedd.) C. Chr., Ind. Fil.: 278. 1905.— *Abacopteris multilineata* (Wall. ex Hook.) Ching, Bull. Fan Mem. Inst. Biol. 8: 253. 1938; Holttum, Rev. Fl. Malaya 2: 297. 1955.— *Cyclosorus multilineatus* (Wall. ex Hook.) Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 358. 1941.— *Thelypteris multilineata* (Wall. ex Hook.) Morton, Amer. Fern J. 49: 113. 1959.— *Dryopteris urophyllum* auct. non (Mett.) C. Chr.: Bonap., Not. Pterid. 14: 49. 1923.— *Nephorodium urophyllum* auct. non (Mett.) Keys.: Smith, E. J. Siam Soc. Nat. Hist. Suppl. 8: 5. 1929.— *Thelypteris nudata* (Roxb.) Morton, Contr. U.S. Nat. Herb. 38: 352. 1974; Tagawa et K. Iwats., Fl. Thail. 3(3): 411. f. 41. 1, 42. 2-3. 1988.

Rhizome creeping, about 5 mm diam., scales caducous, dark brown, hairy. **Stipes** about 106 cm long, scaly at base. **Fronds** oblong, up to 68 by 56 cm; lateral pinnae lanceolate, sessile, ascending, gradually narrowing towards long-acuminate apex, rounded to narrowly cuneate at base, subentire or crenate, up to 26 by 5.7 cm; terminal pinna like lateral ones, rounded to subtruncate at base; marginal lobes acute

at apex, with cartilaginous margin; chartaceous, green, verrucose on lower surface; venation meniscioid. **Sori** rather close to excurrent veinlets or medial in two rows between costules; indusia setose. (Figure 5.110, 5.111)

T h a i l a n d .— NOTHERN: Chiang Rai, Chiang Mai, Mae Hong Son, Lampang, Tak, Nan, Phitsanulok, Phrae; CENTRAL: Nakhon Nayok; SOUTH-EASTERN: Chanthaburi, Trat; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Surat Thani, Nakhon Si Thammarat, Phangnga, Yala.

D i s t r i b u t i o n .— Himalaya (type), Myanmar, China and N. Vietnam.

E c o l o g y .— Terrestrial on rather dry ground near stream in light shade in remnants of the forest in mine area, about 600-900 m alt.

V e r n a c u l a r .— Kut daeng (South-eastern).

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 043, 102, 113, 116; P.Ratchata 20; T. Boonkerd 502, 743, 762 [BCU]; J. F. Maxwell 97-417, K. Iwatsuki et al 7320, Winit 996 [BKF].

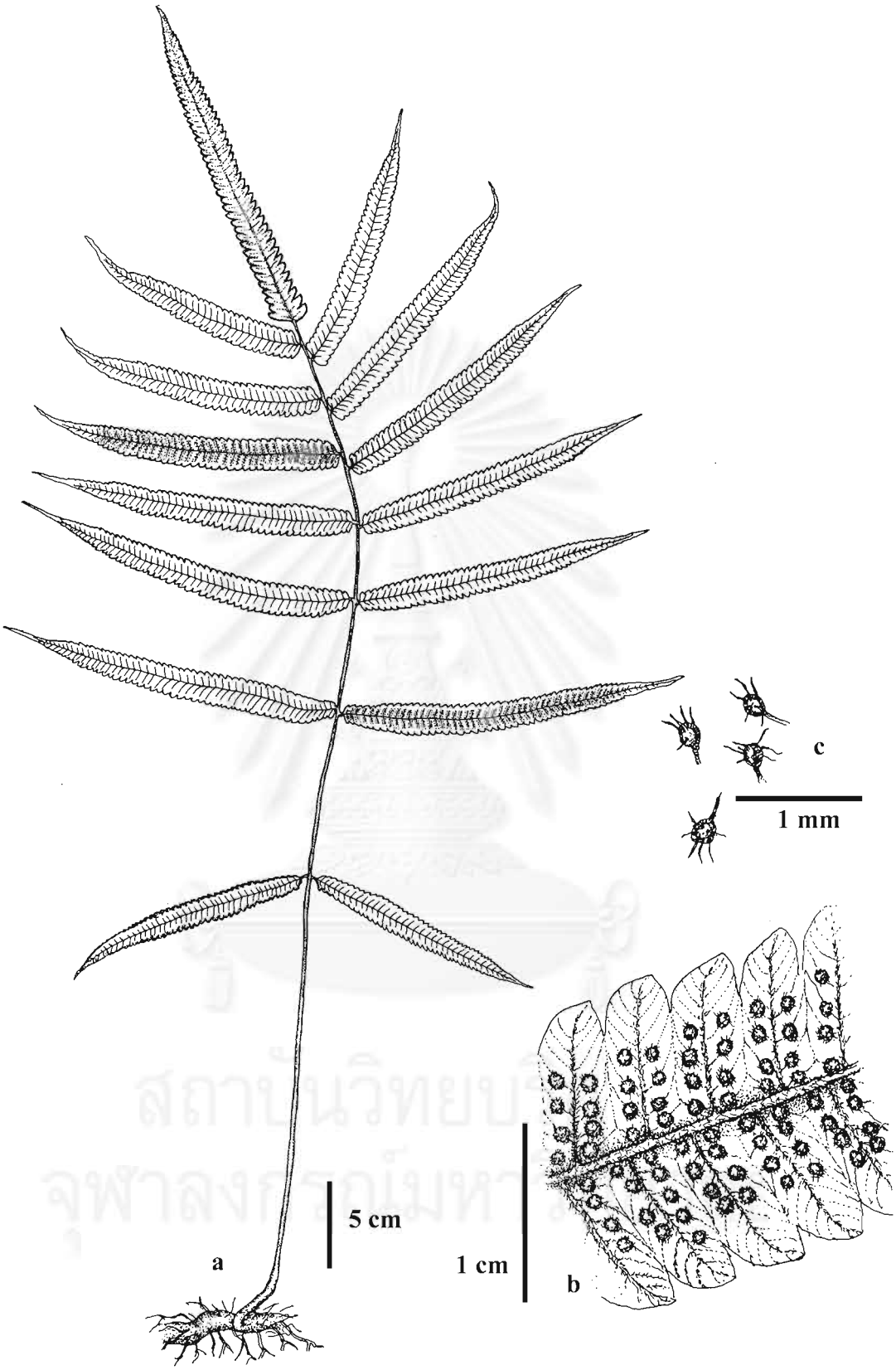


Figure 5.30 *Cyclosorus hirtisorus* (C. Chr.) Ching a. Habit. -- b. Sori and venation. -- c. Sporangia. (A. Sathapattayanon 327)

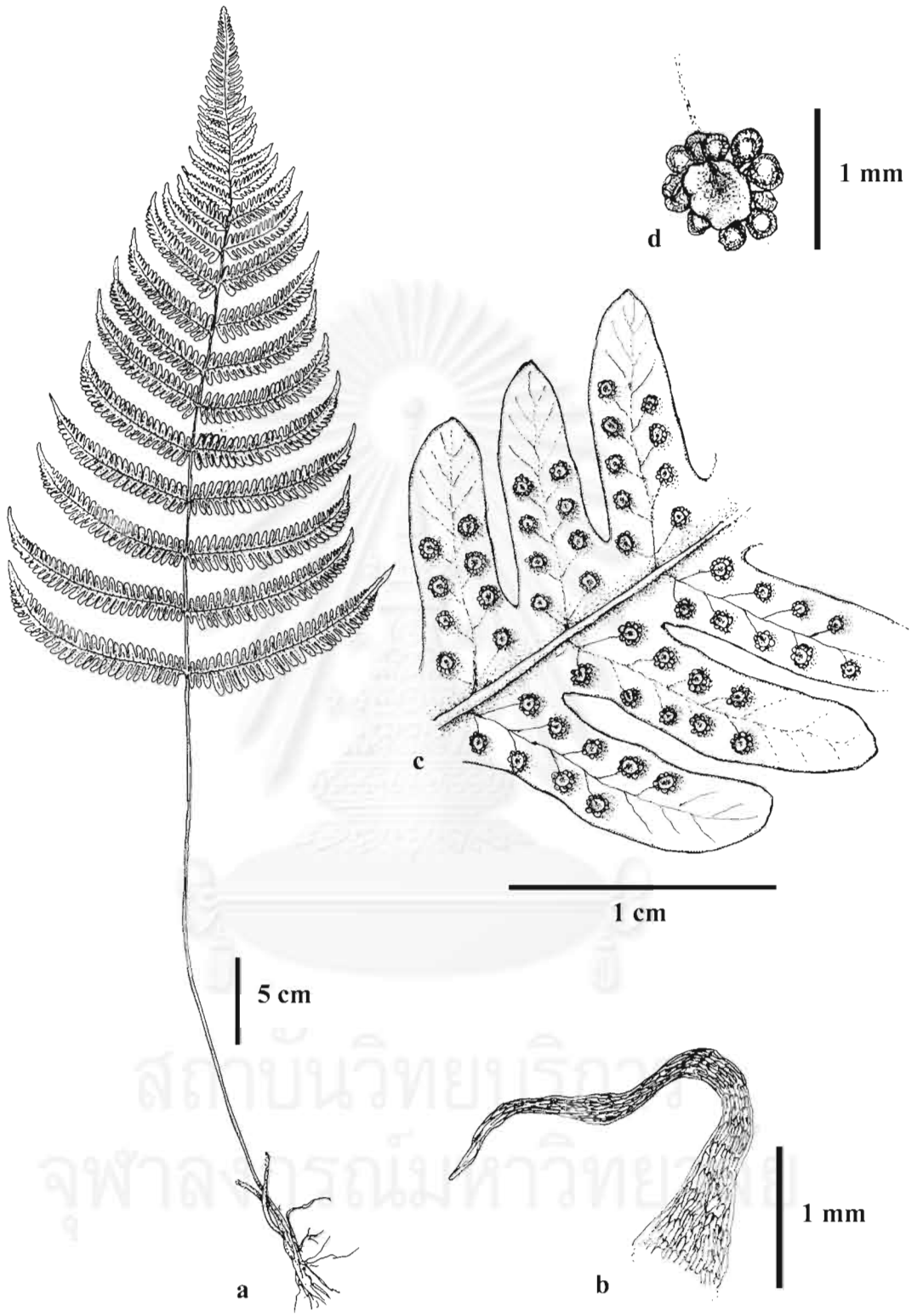


Figure 5.31 ***Metathelypteris dayi*** **(Bedd.) Holttum** a. Habit. -- b. Rhizome scale. -- c. Sori. -- d. Indusiate sorus. (A. Sathapattayanon 198)

ORDER DAVALLIALES

DAVALLIACEAE

Mett. ex A.B. Frank, Syn. Pflanzenk. ed. 2. 3: 1453, 1474. 1877; Devol and Yang, Fl. Taiwan. Vol. 1. 2nd ed.: 270. 1980.

Mostly epiphytes with long creeping scaly rhizomes. Stipes articulate to rhizome. Fronds uaually broadly deltoid and often finely dissected, but sometimes simple, venation free. Sori submarginal, terminal on veinlets; indusia tubular, scale-like, or linear and continuous, opening towards margin.

Key to the genera

1. Rhizome scaly, bearing no hair; fronds coriaceous **1. *Araiostegia***
1. Rhizome scaly as well as hairy; fronds herbaceous **2. *Humata***

1. ARAIOSTEGIA

Copel., Phil. J. Sci. 34: 240. 1927; Tagawa et K. Iwats., Fl. Thail. 3(2): 150. 1985.—*Gymnogrammitis* Griff., Ic. Pl. As. 2: pl. 129. f. 1. 1849; Tardieu et C.Chr. in Fl. Gén. I.-C. 7(2): 117. 1939.

Rhizome long creeping, scales throughout; scales attached basally, concolorously brown, broad, moderately acute to acuminate, not aciculate. Stipes articulated to rhizome; rachis groove decurrent to those of costae and costules. Fronds pinnately decompound, usually finely dissected, thin, glabrous. Sori round, terminal on short branch or vein, of dorsal in appearance by extreme shortening of branch, usually at base of forked lobes, placed at sinus of forked veins; indusia small, usually nearly round, attached only by base, or wanting. Five species were known in Thailand and 1 species among them was found in Thong Pha Phum District.

Araiostegia imbricata Ching, Fl. Reip. Pop. Sin. 2: 291, 377. 1959; Tagawa et K. Iwats., Fl. Thail. 3(2): 152. f. 11.3. 1985.

Rhizome creeping, about 4.89 mm diam., densely scaly throughout; scales oblong, moderately acute at both ends, about 4 by 2 mm, entire, pale brown, darker in age. **Stipes** on scaly phyllopode (stipe base remaining as a scar after leaf-shedding) about 0.7 cm high, light green to stramineous, very sparsely scaly 10.5 cm long. **Fronds** oblong-subdeltoid, acute to acuminate at apex, quadripinnate, 31 by 26 cm; lateral pinnae more than 10 pairs, alternate, basal ones the largest, asymmetrically oblong-subtriangular, caudately acuminate at apex, truncate at base, about 13 by 5.5 cm; pinnules patent or broadly placed on costae, oblong-subdeltoid, acute to moderately and unequally acute at apex, unequally cuneate at base; ultimate segments with a few lobes; lobes entire, acute at apex, about 0.9 mm broad; herbaceous to softly papyraceous. **Sori** one for each ultimate segment, rather large, up to 0.72 mm diam.; indusia very small, up to 0.5 mm long, completely hidden under sori at maturity. (Figure 5.112, 5.113)

T h a i l a n d .— NORTHERN: Lamphun; SOUTH-WESTERN: Kanchanaburi.

D i s t r i b u t i o n .— S. Yunnan (type).

E c o l o g y .— Epiphyte on mossy tree-trunks in natural forests, about 900-1000 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 213, 236, 269, 297 [BCU]; J. F. Maxwell 97-1259, C. Phengklai et al 7364, E. Hennipman 3600 [BKF].

2. HUMATA

Cav., Descr. Pl.: 272. 1802; Tagawa et K. Iwats., Fl. Thail. 3(2): 164. 1985.

Rhizome long-creeping, densely scaly with peltate scales, bearing stipes remotely. Stipes articulated to rhizome, grooved above. Fronds simple to tripinnatifid, coriaceous, glabrous. Sori round, terminal on veinlets, marginal; indusia attached only

by base, or rarely by the sides a little above the base as well. Five species were known in Thailand and 1 species among them was found in Thong Pha Phum District.

Humata repens (L. f.) J. Small ex Diels in Pflanzenfam. 1(4): 209. 1899; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 111. f. 13, 1. 1939; Holttum, Rev. Fl. Malaya 2: 371. f. 216.1955; Seidenf., Nat. Hist. Bull. Siam Soc. 19: 86. 1958; Devol and Yang, Fl. Taiwan Vol. 1. 2nd ed.: 276. 1980; Tagawa et K. Iwats., Fl. Thail. 3(2): 166. 1985.— *Adiantum repens* L. f., Suppl.: 446. 1781.—*Davallia repens* (L. f.) Kuhn, Fil. Deck.: 27. 1867.— *Humata pinnatifida* Bedd., Handb. Suppl.: 12. 1892.

Rhizome long-creeping, about 2.04 mm diam., glabrous, densely scaly throughout; scales acuminate at basal edges, long-acuminate at apex, up to 7 by 1.2 mm, brown. **Stipes** stramineous, terete, up to 6 cm long, sparsely scaly. **Fronds** oblong-subdeltoid or roundly pentagonous, 5.2 by 4 cm; basal pinna the largest, oblong-subdeltoid, pinnatifid to pinnate; upper pinnae shallowly lobed or entire, sessile or adnate; basal pinnules of basal pinnae lobed in larger ones, coriaceous, glabrous. **Sori** marginal, small; indusia nearly semicircular, entire and free except for the base to 1 mm broad. (Figure 5.114, 5.115)

T h a i l a n d .— NORTHERN: Mae Hong Son, Chiang Rai, Chiang Mai, Lampang, Lamphun, Phitsanulok; NORTH-EASTERN: Loei; CENTRAL: Nakhon Nayok; SOUTH-EASTERN: Chanthaburi, Trat; SOUTH-WESTERN: Kanchanaburi, Prachuap Khiri Khan; PENINSULAR: Surat Thani, Nakhon Si Thammarat, Phangnga, Trang, Yala.

D i s t r i b u t i o n .— Widely distributed in the tropics of the Old World: Madagascar and Seychelles, Mascarene Islands, Himalayas to S. Japan (type), S.E. Asia generally, through Malesia to Polynesia and Australia.

E c o l o g y .— Epiphyte on mossy tree trunks in natural forests, about 900-1000 m alt.

V e r n a c u l a r .— Kut hom bai yoi (Northern); Rut thong (North-eastern); Nakkharat tua mia (South-eastern).

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 220, 262, 312, 337; T. Boonkerd 131, 1081, 1407 [BCU]; C. Phengklai et al 13576, J. F. Maxwell 95-626, K. Larsen et al 26 [BKF].

ORDER POLYPODIALES

POLYPODIACEAE

Bercht. et J. Presl, Přir. Rostlin 272. 1820; Devol and Kuo, Fl. Taiwan Vol. 1. 2nd ed.: 165. 1980.

Usually epiphytes, growing on tree trunks, or moss-covered rocks, some terrestrial. Rhizome usually creeping; scales peltate, often clathrate. Fronds often simple, pinnatifid, pinnate or rarely digitately lobed. Stipes usually articulate to rhizome; veins anastomosing with included veinlets. Sori usually round, oval or linear, and in some genera acrostichoid, exindusiate, paraphyses often present.

Key to the genera

1. Fronds simple
   2. Fronds covered when young with stellate hairs **7. *Pyrrosia***
   2. Fronds not having stellate hairs
      3. Fronds bearing peltate scales on surface or in sori **4. *Lepisorus***
      3. Fronds not bearing any peltate scales
         4. Fronds dimorphic; sporangia acrostichoid **5. *Leptochilus***
         4. Fronds monomorphic; never acrostichoid having distinct sori
            5. At least the middle part of scales clathrate **6. *Microsorum***
            5. Scales not clathrate throughout **2. *Crypsinus***
1. Fronds pinnate or pinnately lobed
   6. Fronds very large, sessile, basal portion like nest leaves **1. *Aglaomorpha***
   6. Fronds with stipes, basal portion nothing particular
      7. Veins free **3. *Goniophlebium***
      7. Veins reticulate **2. *Crypsinus***

1. AGLAOMORPHA

Schott, Gen. Fil.: ad pl. 20. 1834; Tagawa et K. Iwats., Fl. Thail. 3(4): 550. 1989.

Rhizome creeping, thick, scaly. Fronds in one from, partially dimorphic; upper part like foliage leaves, pinnatifid, lower part like nest-leaves, very broad at base. Sori small, round or variously spreading and united. Only 1 species was known in Thailand and it was also found in Thong Pha Phum District.

Aglaomorpha coronans (Wall. ex Mett.) Copel.**,** Univ. Calif. Publ. Bot. 16: 117. 1929; Tagawa et K. Iwats., Fl. Thail. 3(4): 551. f. 55. 4-5. 1989.— *Polypodium coronans* Wall. ex Mett., Abh. Senck. Naturf. Ges. 2: 121. t. 3. f. 40-41. 1857.— *Drynaria coronans* (Wall. ex Mett.) J. Sm., J. Bot. 4: 61. 1841; Bedd., Handb.: 338. 1969.— *Pseudodrynaria coronans* (Wall. ex Mett.) Ching, Sunyatsenia 5: 262. 1940. — *Polypodium conjugatum* Baker, Syn. Fin.: 366. 1868.— *Drynaria conjugata* (Baker) Bedd., Ferns Brit. India correct. 1870.— *Aglaomorpha heraclea* (Kunze) Copel. *sensu* Holttum, Dansk Bot. Ark. 20: 21. 1961.

A large epiphyte. **Rhizome** creeping, thick, usually more than 1.5 cm diam., densely scaly throughout; scales brown, linear, 12 by more than 1 mm, sharply toothed at margin. **Fronds** sessile, usually more than 1.62 m long, about 42 cm wide, lobed almost to rachis; lobes continuing with wings less than 0.71 cm broad; the base of fronds broadly rounded to cordate, up to 6 cm broad, subentire or shallowly lobed, brown, like the nest-leaves of *Drynaria*; lobes of the upper part of fronds ascending, usually more than 24 pairs, linear-subtriangular, attenuately acuminate at apex, entire at margin, up to 24 by about 3.2 cm, every lobes falling at the abscission along rachis; veins raised on both surfaces, venation drynarioid, or with complicately reticulate, main areoles quadrangular, smaller areoles with free included veilets; coriaceous, green, glabrous. **Sori** one, or very rarely two, row(s) between main veins, more or less elongate, or sometimes uniting longitudinally, but rarely continuous beyond cross veins.

T h a i l a n d .— NORTHERN: Chiang Rai, Chiang Mai, Lampang, Phrae, Tak, Phitsanulok; EASTERN: Chaiyaphum; NORTH-EASTERN: Loei; SOUTH-

EASTERN: Prachin Buri, Chanthaburi; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Surat Thani, Nakhon Si Thammarat, Trang, Phangnga.

D i s t r i b u t i o n .— Himalaya to S. China, Indochina, Taiwan and northwards to the Ryukyus.

E c o l o g y .— Epiphyte on rather dry tree-trunks in open places in remnant of the forest in mine area and in natural forest, about 600-1000 m alt.

V e r n a c u l a r .— Bai kut om (Northern).

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 121, 126, 311; P. Ratchata 85; T. Boonkerd 615; Y. Yuyen 54 [BCU]; G. Murata et al 51613, E. Hennipman 3471, J. F. Maxwell 95-1209 [BKF].

2. CRYPSINUS

C. Presl, Epim. Bot.: 123. 1849; Tagawa et K. Iwats., Fl. Thail. 3(4): 553. 1989.

Rhizome long-creeping, scaly; scales gradually narrowing from peltate base to hairy apex, not or hardly clathrate. Stipes jointed to rhizome. Fronds simple, lobed or rarely pinnate, coriaceous or leatherly, glabrous, edges of lobes cartilagineous, more or less thickened; veins copiously anastomosing, areoles irregular, with included free veinlets. Sori round, one between adjacent main veins, in a single row at each side of costa, or scattered on the under surface of fronds, sometimes sunk in deep cavities; paraphyses only in some species, simple. Among 10 species were known in Thailand, 2 species were found in Thong Pha Phum District.

Key to the species

1. Fronds deeply lobed, monomorphic **1. *C. oxylobus***
1. Fronds simple, entire, moderately dimorphic **2. *C. rhynchophyllus***

1. ***Crypsinus oxylobus*** (Wall. ex Kunze) Sledge, Bull. Brit. Mus. (Nat. Hist.) Bot. 2: 145. 1960; Tagawa et K. Iwats., Fl. Thail. 3(4): 559. f. 56. 6. 1989.— *Polypodium oxylobum* Wall. ex Kunze, Linnaea 24: 255. 1851.— *Phymatodes oxyloba* (Wall. ex Kunze) C. Presl ex Ching, Contr. Inst. Bot. Nat. Acad. Peiping 2: 67. 1933.— *Pleopeltis hastata* (Thunb.) Bedd., Handb.: 362. f. 205. 1883.— *Pleopeltis trifida* (D. Don) Bedd., Handb.: 96. 1892.— *Crypsinus taeniatus* var. *palmatus* (Blume) C.Chr, *sensu* Holttum, Dansk Bot. Ark. 23: 231. 1965.

Rhizome long-creeping, about 1.77 mm diam., densely scaly throughout; scales gradually narrowing from round peltate base to long-tailed apex, about 2.12 by 0.93 mm, brown in broader basal portion, paler in narrow tails, toothed at margin. **Stipes** stramineous or brown, jointed to rhizome at low scaly phyllopodes, glabrous upwards, 3.5 cm long. **Fronds** lobed, with 3-8 pairs of lateral lobes and terminal one, up to 10.2 by 13 cm; rachis brown beneath, paler on upper surface, winged with lobes 4.56 mm in breadth; lateral lobes usually longest at base, becoming smaller upwards, ascending, sometimes bending downwards, linear to oblong-subdeltoid, acute to acuminate at apex, up to 10 by 1 cm, entire, terminal lobes longer; midrib raised on both surfaces, main veins distinct, ascending, more or less zigzag, the other veins obscure, reticulate, forming irregular areoles with included veinlets; papyraceous, deep green to paler, paler on lower surface, glabrous. **Sori** between adjacent main veins, in a single row along both side of midrib, subcostular or medial, round, 0.39 mm diam., hardly raised on upper surface. (Figure 5.32, 5.116, 5.117)

T h a i l a n d .— NORTHERN: Chiang Rai, Chiang Mai, Lamphun, Phitsanulok; NORTH-EASTERN: Loei; SOUTH-EASTERN: Prachin Buri; SOUTH-WESTERN: Ratchaburi.

D i s t r i b u t i o n .— N. India (type), Upper Myanmar, S.W. China (Yunnan and Szechuwan) and Indochina.

E c o l o g y .— Epiphyte on mossy tree-trunks in natural forests, about 900-1000 m alt.

V e r n a c u l a r .— Kut hom (Northern).

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 192, 205, 279, 290, 301, 321, 325; P. Ratchata 300; T. Boonkerd 1413; Y. Yuyen 151 [BCU]; K. Iwatsuki et al 9405, T. Shimizu et al 18569, Winit 1176 [BKF].

2. ***Crypsinus rhynchophyllus*** (Hook.) Copel., Gen. Fil.: 206. 1947; Tagawa et K. Iwats., Fl. Thail. 3(4): 556. f. 56. 3. 1989.— *Polypodium rhynchophyllum* Hook., Ic. Pl.: t. 954. 1854.— *Pleopeltis rhynchophylla* (Hook.) Moore, Ind.: ixxviii. 1857; Bedd., Handb.: 353. f. 198. 1969.— *Phymatodes rhynchophylla* (Hook.) Ching, Contr. Inst. Bot. Nat. Acad. Peiping 2: 69. 1933.

Rhizome long-creeping, about 1.78 mm diam., densely scaly throughout; scales ovate with long tails up to 2.88 by 0.7 mm, membraneous, entire at margin, light brown. **Fronds** in two forms. **Smaller sterile fronds** on the short stipes of 1.4 cm in length, oval or ovate-oblong, round to moderately acute at both the base and apex, 6.1 by 1.1 cm. **Larger soriferous fronds**: stipes 2.24 cm long, scaly at base, glabrescent upwards; laminae lanceolate, cuneate at base, broadest at 1/5-1/4 way from the base, narrowing at the soriferous portion of upper 1/4-1/2 part, acute to round at apex, 9 by 0.96 cm, the soriferous portion less than 6.17 mm in breadth; main lateral veins obscure at 4.02 mm inside the margin, other veinlets hardly visible, anastomosing to form irregular areoles with included free veinlets; coriaceous, green, paler beneath, glabrous. **Sori** between adjacent main veins, a single row at each side of midrib, half-way or a little closer to midrib, round, up to 3.2 mm diam. (Figure 5.33, 5.118)

T h a i l a n d .— NORTHERN: Chiang Mai, Phitsanulok; NORTH-EASTERN: Loei; SOUTH-EASTERN: Chanthaburi; SOUTH-WESTERN: Kanchanaburi.

D i s t r i b u t i o n .— N. India (type), Myanmar, S.W. China and Indochina, also in the Philippines.

E c o l o g y .— Epiphyte on mossy tree-trunks in natural forests, about 900-1000 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 206, 238, 280, 296; T. Boonkerd 46 [BCU]; K. Larsen et al 34418, T. Smitnand S. N., T. Shimizu et al 11611, M. Tagawa, K. Iwatsuki & N. Fukuoka 2662 [BKF].

3. GONIOPHLEBIUM

C. Presl, Tent. Pterid.: 185, pl. 7, f.13-14. 1836; Devol and Kuo, Fl. Taiwan Vol. 1. 2nd ed.: 178. 1980. — *Polypodium* L., Sp. Pl. 2: 1082. 1753; Tagawa et K. Iwats., Fl. Thail. 3(4): 568. 1989.

Rhizome long creeping; scales clathrate, dark brown to black, iridescent, peltate, lanceolate, hair tipped. Stipes wingless, distant, articulate to podophylla. Fronds pinnate, pinnae linear or lanceolate, patent, articulate to rachis; venation reticulate, with 1-2 rows of areolae along costa, veins near margin free; included veinlet straight, not forked. Sori round, borne in a single row on either side of costa, at the end of the single included veinlet. Nine species were known in Thailand, and 1 species was found in Thong Pha Phum District.

Goniophlebium subauriculatum (Blume) C. Presl, Tent. Pterid.: 186. 1836, Bedd., Handb.: 323. f. 173. 1883; Rödl- Linder, Blumea 34: 400. 1990; Hovenkamp et Rödl-Linder, Fl. Mal. Ser. II. 3: 58. 1998.— *Polypodium subauriculatum* Blume, En. Pl. Jav.: 133. 1828; Tardieu et C.Chr. in Fl. Gén. I.-C. 7(2): 538. 1941; Holttum, Rev. Fl. Malaya 2: 207. f. 108. 1955; Tagawa et K. Iwats., Fl. Thail. 3(4): 573. 1989.

Rhizome long-creeping, about 2.74 mm diam., distinctly glaucous, densely scaly; scales linear, about 3.28 by 0.84 mm, brown clathrate, toothed at margin. **Stipes** stramineous or brown, 10 cm long, densely scaly at base, minutely scaly upwards or glabrescent. **Fronds** imparipinnate, lanceolate, 35.5 by 26 cm; rachis pale brown, minutely scaly throughout; lateral pinnae 25-35 pairs, a few basal pairs usually a little shorter than the next above, deflexed or patent, middle ones the largest, subopposite, sessile, linear, subcordate or subtruncate roundly auricled on both sides at base, gradually narrowing from base to long attenuate apex, serrate at margin, patent or slightly ascending, straight or a little falcate, up to 26 cm by 1.38 cm, upper pinnae gradually becoming smaller; terminal pinna not so large, 14.5 cm long, irregularly lobed at basal portion; veins anastomosing to form 1-3 rows of areoles at each side of costa, more or less visible; herbaceous to subcoriaceous, deep green, glabrous. **Sori** terminal on simple included veinlets in costal areoles, in one row at each side of costa, costular, more than 1.63 mm diam., distinctly immersed and raised on the upper surface. (Figure 5.34, 5,119)

T h a i l a n d .— NORTHERN: Chiang Rai, Chiang Mai, Mae Hong Son, Lampang, Tak; NORTH-EASTERN: Phetchabun, Loei; SOUTH-EASTERN: Prachin Buri, Chanthaburi; SOUTH-WESTERN: Kanchanaburi.

D i s t r i b u t i o n .— N.E. India, S.W. China, Laos, Vietnam, Malesia throughout (type from Java) to Australia (Queensland), also in the Tenasserim.

E c o l o g y .— Epiphyte on mossy tree-trunks in light shade in natural forests, about 1000 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 214, 274; T. Boonkerd 1230; Y. Yuyen 66 [BCU]; K. Iwatsuki & N. Fukuoka 3440, T. Shimizu et al 8954, E. Hennipman 3363 [BKF].

4. LEPISORUS

(J. Sm.) Ching, Bull. Fan Mem. Inst. Biol. 4: 47. 1933; Tagawa et K. Iwats., Fl. Thail. 3(4): 507. 1989.— *Drynaria* et *Lepisorus* J. Sm., Bot. Mag. 72. Comp. 13. 1846.— *Pleopeltis* Humb. et Bonpl. ex Willd., Sp. Pl. 5: 211. 1810; Copel., Gen. Fil.: 183. 1947, p.p.

Rhizome creeping, bearing fronds closely, scaly; scales peltate, more or less clathrate. Stipes articulate to rhizome, sometimes indistinct from laminae, scaly at least at base. Fronds simple, entire, usually leatherly, bearing peltate scales or glabrescent; veins usually invisible, copiously anastomosing with included free veinlets in areoles. Sori usually at junction of veins, round or rarely elongate, in some species fusing to form linear submarginal lines, superficial or sunk in cavities, exindusiate but covered when young with umbrella-shaped peltate paraphyses. There were 11 species in Thailand and 1 species among them was found in Thong Pha Phum District.

Lepisorus scolopendrium (Buch.-Ham. ex D. Don) Mehra & Bir, Res. Bull. Panjab Univ. Sci. 15: 168. 1964; Tagawa et K. Iwats., Fl. Thail. 3(4): 511. f. 51. 6. 1989.— *Polypodium scolopendrium* Buch.-Ham. ex D. Don, Prodr. Fl. Nepal.: 1. 1825.— *Lepisorus excavatus* var. *scolopendrium* (Buch.-Ham. ex D. Don) Ching, Bull. Fan Mem. Inst. Biol. 4: 69. 1933; Tardieu et C. Chr. in Fl. Gén. I.-C. 7(2): 456. 1941.— *Pleopeltis scolopendrium* (Buch.-Ham. ex D. Don) Alston et Bonner, Candollea 15: 207. 1956.— *Polypodium excavatum* Bory ex Willd., Sp. 5: 158. 1810.

Rhizome creeping, bearing a few fronds closely, dark brown on surface, scaly; scales dense, thin, gradually narrowing towards acuminate apex, up to 7 by 2 mm, concolorously light brown, clathrate, rather irregular at paler margin. **Stipes** short, indistinct, usually up to 3.57 mm long. **Fronds** variable in size and form, linear-lanceolate, often broadest at 1/3 part from base, up to 22.1 by 1.8 cm, gradually narrowing towards both ends, entire but variously waved at margin; midrib raised on both surfaces; papyraceous to herbaceous, light green; veins, copiously anastomosing with branched included veinlets. **Sori** round to oblong, large, one between adjacent main veins, medial, up to 2.19 mm broad, sometimes obliquely elongate up to 1 cm or more long, never fused to the next ones, the receptacles raised with hollows on upper surface. (Figure 5.35, 5.120, 5.121)

T h a i l a n d .— NORTHERN: Chiang Rai, Chiang Mai, Lamphun, Phitsanulok; NORTH-EASTERN: Loei; SOUTH-EASTERN: Chanthaburi; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Surat Thani.

D i s t r i b u t i o n .— Himalayas (type) and Tibet, S.W. China, Upper Myanmar and Indochina.

E c o l o g y .— Epiphyte on branches of mossy trees in light shade in natural forests, about 900-1000 m alt.

V e r n a c u l a r .— Kut chak khep (Northern).

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 203, 209, 248, 251, 270, 292; P. Ratchata 254; T. Boonkerd 1038, 1079 [BCU]; K. Bunchuai 1493, E. Smith 1184, Winit 1201 [BKF].

5. LEPTOCHILUS

Kaulf., Enum.: 147. pl. 1. f. 10. 1824; Tagawa et K. Iwats., Fl. Thail. 3(4): 541. 1989.—*Paraleptochilus* Copel., Gen. Fil.: 198. 1947.

Terrestrial or on tree-trunks. Rhizome long-creeping, scaly; scales dark, peltate, more or less clathrate. Fronds biserrate, articulate to rhizome, distinctly dimorphic. Sterile fronds simple to laciniate, herbaceous to subcoriaceous, glabrous, with copiously reticulate venation, usually blackish when dried. Fertile fronds prominently contracted, linear. Sori covering the whole under surface of linear fertile laminae except on midrib and at margin, without peltate paraphyses. Three species were recorded from Thailand and only 1 species among them was found in Thong Pha Phum.

Leptochilus minor Fée, Mem. Foug. 2. Hist. Acrost. 87, pl. 25, f. 3. 1845; Noot., Blumea 42: 292. 1997; Hovenkamp in Fl. Mal. II. 3: 88. 1998; Boonkerd et Pollawatn, Nat. Hist. J. Chula. Univ. 2(1): 1-3. 2002.— *Gymnopteris normalis* J. Sm., J. Bot. (Hook.) 3: 403. 1841, nom. nud.— *Dendroglossa normalis* C. Presl, Epim. Bot. 149. nom. illeg. 1851.— *Acrostichum minus* Mett., Fil. Hort. Bot. Lips. 20. 1856.— *Gymnopteris minus* Hook., Sec. Cent. Ferns t. 78. 1861.— *Acrostichum lanceolatum* var. *normale* Hook., Sp. Fil. 5: 277 1864.— *Campium minus* Copel., Philipp. J. Sc. 37: 345, pl. 4, f. 1. 1928.— *Dendroglossa minor* Copel., Gen. Fil. 199. 1947.— *Colysis minor* M.G. Price, Kalikasan 3: 176. 1974.

Rhizome dorsiventrally flattened, 2.08 mm diam, short-creeping, densely roots scaly throughout; scales pseudopeltate, narrowly ovate or triangular, 1.5 by 0.22 mm, clathrate, margin denticulate, apex acute, central region glabrous or bearing multiseptate hairs. **Fronds** simple, strongly dimorphic. **Sterile fronds**: stipes absent; fronds narrowly elliptic to obovate, 12.7 cm long, 1.9 cm broad, entire or irregularly undulate at margin; midribs raised on both surfaces, the other veins visible on lower surface, hardly visible on upper surface. **Fertile fronds**: stipes 5.6 cm long; fronds narrowly ovate to linear, up to 5 cm long, 1.73 cm broad. ***Sori*** acrostichoid, covered the whole lower surface of fertile fronds. (Figure 5.122)

T h a i l a n d .— SOUTH-WESTERN: Kanchanaburi.

D i s t r i b u t i o n .— Continental Asia: India, Sri Lanka, Indochina. In *Malesia:* Sumatra, Borneo, Philippines, Sulawesi.

E c o l o g y .— Lithophyte on rocks along stream in remnant of the forest in mine area, at 520 m alt.

S p e c i m e n e x a m i n e d .—A. Sathapattayanon 367, T. Boonkerd 1480 [BCU].

6. MICROSORUM

Link, Hart. Berol. 2: 110. 1833.— *Microsorium* Link, Fil. Spec. 116: 135. 1841; Tagawa et K. Iwats., Fl. Thai. 3(4): 523. 1989.

Rhizome creeping, densely scaly in apical portion; scales peltate, usually thin, brown to darker, distinctly clathrate. Stipes articulate to rhizome, sometimes indistinct from the attenuate base of fronds. Fronds simple and entire, lobed, hastate, or pinnate, the margin of laminae or lobes not toothed; venation copiously anastomosing with free included veinlets in areoles. Sori round to oblong, usually small and scattered, rarely fused, without peltate paraphyses. There were 11 species in Thiland and only 1 species among them was found in Thong Pha Phum District.

Microsorum punctatum (L.) Copel., Univ. Calif. Publ. Bot. 16(2): 111. 1929; Bosman, A Monograph of the Fern Genus *Microsorum* (Polypodiaceae): 97. 1991.— *Microsorium punctatum* (L.) Copel.; Tardieu et C.Chr. in Fl. Gén. I.-C. 7(2): 483. 1941; Holttum, Rev. Fl. Malaya 2: 179. 1955; Seidenf., Nat. Hist. Bull. Siam Soc. 19: 86. 1958 ; Tagawa et K. Iwats., Fl. Thai. 3(4): 528. 1989.— *Acrostichum punctatum* L., Sp. Pl. ed. 2: 1524. 1763.— *Pleopeltis punctata* (L.) Bedd., Ferns Brit. Ind. Suppl.: 22. 1876; Handb.: 357. f. 201. 1883.— *Polypodium punctatum* (L.) Sw., Schrad. J. Bot. 1800(2): 21. 1801.

Rhizome creeping, 4.42 mm diam., dark or glaucous in surface, bearing fronds closely, scaly; scales narrowly oblong-subtriangular, gradually narrowing from ovate basal portion towards long-attenuate apex, concolorously dark grayish brown, clathrate, the surface wall of constituent cells not transparent, margin distinctly toothed, up to 8 by 1.5 mm. **Stipes** not distinct from laminae, scaly at base,

stramineous to greenish. **Fronds** narrowly oblong to lanceolate, gradually narrowing towards acute apex or moderately acute with not pointed apex, narrowing towards attenuate base and decurrent downwards to form wings of stipes sometimes nearly to the base, 2.85 cm long including stipes, 4.5 cm broad; midrib raised on both surfaces, other veins obscure, finely anastomosing to form copious areoles, subcoriaceous, the margin of fronds sometimes revoluted. **Sori** small, round, many, scattered on the whole under surface of fronds.

T h a i l a n d .— NORTHERN: Chiang Rai, Chiang Mai, Lampang, Tak, Phitsanulok; NORTH-EASTERN: Phetchabun, Loei; EASTERN: Chaiyaphum; SOUTH-EASTERN: Prachin Buri, Chon Buri, Nakhon Ratchasima, Chanthaburi, Trat; SOUTH-WESTERN: Kanchanaburi, Prachuap Khiri Khan; PENINSULAR: Ranong, Surat Thani, Phangnga, Phuket, Nakhon Si Thammarat, Trang, Yala.

D i s t r i b u t i o n .— Throughout the tropics of the Old World, W. Africa to Tahiti.

E c o l o g y .— Epiphyte on branches of small tree in light shade in remnant of the forest in mine area, at 920 m alt.

V e r n a c u l a r .— Kraprok hang sing (South-eastern); prue mai (South-western); Lin phi mai, Hang nok wa (Peninsular); Ai-ka bu-kong ka-waeng (Malay/Peninsular); Crested Fern.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 368, T. Boonkerd 124, 172, 1525 [BCU]; C. Phengklai et al 13401, E. Hennipman 3808, M. Tagawa & I. Yamada 140 [BKF].

7. PYRROSIA

Mirbe., Hist. Nat. Veg. 5: 91. 1803; Hovenkamp, Leid. Bot. Ser. 9: 139. 1986; Tagawa et K. Iwats., Fl. Thail. 3(4): 491. 1989.— *Niphobolus* Kaulf., Enum. Fil.: 124. 1824.

Rhizome long-creeping, usually slender, scaly; scales peltate, fringed with hairs or entire, not clathrate. Fronds simple to palmately lobed, entire, fleshy, rarely dimorphic; venation anastomosing, completely hidden; surfaces more or less entirely covered with stellate hairs, generally caducous on upper surface. Sori round, large, in a single row or more commonly in several close rows at each side of midribs,

sometime taking an appearance of the acrostichoid condition, naked, but protected when young by a dense matt of stellate hairs. Eighteen species were known in Thailand and there were 2 species in Thong Pha Phum District.

Key to the species

1. Fronds linear-lanceolate; upper surface of fronds lacking any hydathodes **1. *P. albicans***

1. Fronds oblong-lanceolate to oblong; upper surface of fronds with distinct hydathodes **2. *P. lingua* var. *heteractis***

1. ***Pyrrosia albicans*** (Blume) Ching, Bull. Chin. Bot. Soc. 1: 72. 1935; Hovenkamp, Leid. Bot. Ser. 9: 153. 1986.— *Niphobolus flocciger* Blume, En. Pl. Jav.: 107. 1828.— *Pyrrosia floccigera* (Blume) Ching, Bull. Chin. Bot. Soc. 1: 71. 1935; Holttum, Rev. Fl. Malaya 2: 147. 1955; Tagawa et K. Iwats., Fl. Thail. 3(4): 500. 1989.

Rhizome long-creeping, 1-2 mm diam., bearing fronds 1- 3 cm apart, densely scaly throughout; scales lanceolate, up to 3.23 mm long with tailed apex, 0.75 mm broad, dark brown to nearly black at central portion, the other part deep brown to paler, hairy at margin. **Stipes** 3 cm long, pale brown to darker, scaly at base, glabrescent. **Fronds** linear-lanceolate, up to 15 by 0.57 cm, very gradually narrowing towards both apex and bases; midrib distinctly raised beneath, veins hardly visible, anastomosing, upper surface glabrescent, lower surface densely covered with greyish to pale brown, stellate hairs with long arms or becoming glabrescent in older fronds, rigid coriaceous, fronds usually involute at margin. **Sori** round, distinct, covering the whole lower surface of the apical part of fronds, covered with hairs. (Figure 5.36, 5.123)

T h a i l a n d .— NORTHERN: Tak; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Nakhon Si Thammarat, Trang.

D i s t r i b u t i o n .— W. Malesia: Sumatra and Malaysia to the Philippines and Java (type).

E c o l o g y .— Epiphyte on tree-trunks in light shade in natural forest, at 950 m alt.

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 074, 224, 273, 316; T. Boonkerd 1208 [BCU]; E. Hennipman 3814, M. Tagawa, K. Iwatsuki & N. Fukuoka 5283 [BKF].

2. ***Pyrrosia lingua*** (Thunb.) Farw. var. ***heteractis*** Hovenkamp, Blumea 30: 208. 1984; Leid. Bot. Ser. 9: 206. 1986.—*Cyclophorus eberhardtii* H. Christ, J. Bot. France 21: 237, 270. 1908.—*Pyrrosia mannii* (Gies.) Ching et *Pyrrosia stigmosa* (Sw.) Ching *sensu* Holttum, Dansk Bot. Ark. 20: 19. 1961, p.p.—*Pyrrosia eberhardtii* (H. Christ) Ching, Bull. Chin. Bot. Soc. 1: 59. 1935; Tardieu et C.Chr. in Fl. Gén. I.-C. 7(2): 507. 1941; Tagawa et K. Iwats., Fl. Thail. 3(4): 505. 1989.

Rhizome long-creeping, 1.5 mm diam., bearing fronds 2.5 cm apart, scaly throughout; scales appressed or patent at least in the upper part especially in younger portions, narrowly subtriangular, gradually narrowing from broadest peltate portion towards attenuate apex, up to 7 by 1.2 mm, usually bi-coloured with nearly black basal portion and brown marginal portions, entire at margin, bearing long downy hairs at margin of apical portion. **Stipes** up to 3.2 cm long, scaly at base with those like rhizome-scales, densely hairy throughout, brown. **Fronds** oblong-lanceolate to oblong, acute to acuminate at apex, caudate or very shortly decurrent at base, 5.5 by 1.4 cm, sterile fronds usually lower and broader, midribs and main veins distinct, raised beneath, veins hardly visible, anastomosing, rigidly coriaceous, upper surface stellate hairy or glabrescent, with scattered hydathodes, the lower surface densely covered with dense mat of stellate hairs greyish in colour. **Sori** round, distinct, scattered on all the lower surface or in upper part of it, embedded in stellate hairs, not confluent. (Figure 5.124)

T h a i l a n d .— NORTHERN: Chiang Rai, Chiang Mai, Phitsanulok; NORTH-EASTERN: Loei; CENTRAL: Nakhon Nayok; SOUTH-EASTERN: Chanthaburi, Trat; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Nakhon Si Thammarat, Phangnga, Trang.

D i s t r i b u t i o n .— S. China (Hainan) and Vietnam (type).

E c o l o g y .— Epiphyte on tree-trunks in light shade in natural forest, at 970 m alt.

V e r n a c u l a r .— Lin kuram (Eastern).

S p e c i m e n e x a m i n e d .— A. Sathapattayanon 281, 306; T. Boonkerd 673, 1401 [BCU]; M. Tagawa et al 6826, T. Shimizu et al 11604, K. Larsen et al 30846 [BKF].

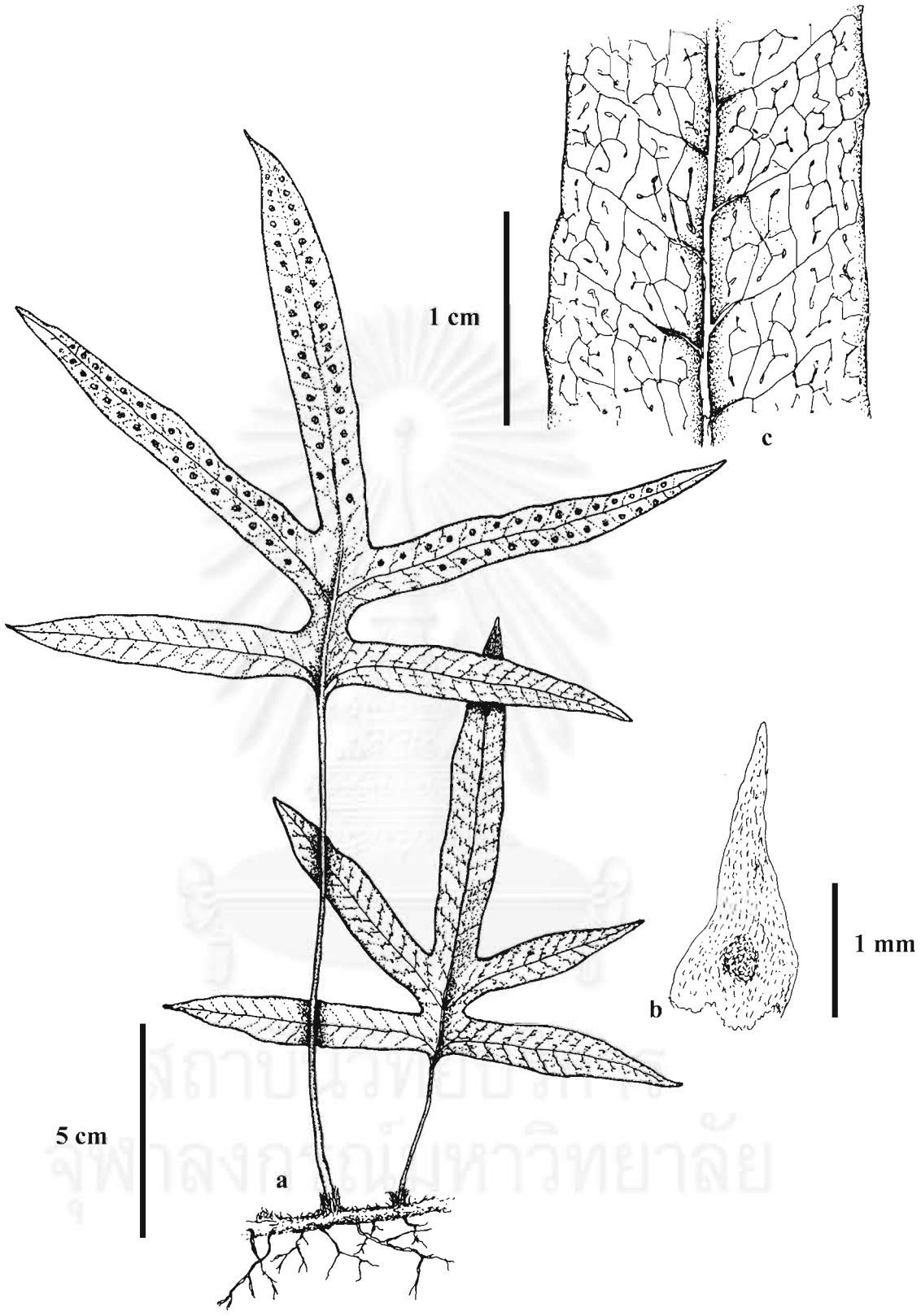


Figure 5.32 *Crypsinus oxylobus* (Wall. ex Kunze) Sledge a. Habit. -- b. Rhizome scale. -- c. Venation. (A. Sathapattayanon 205)

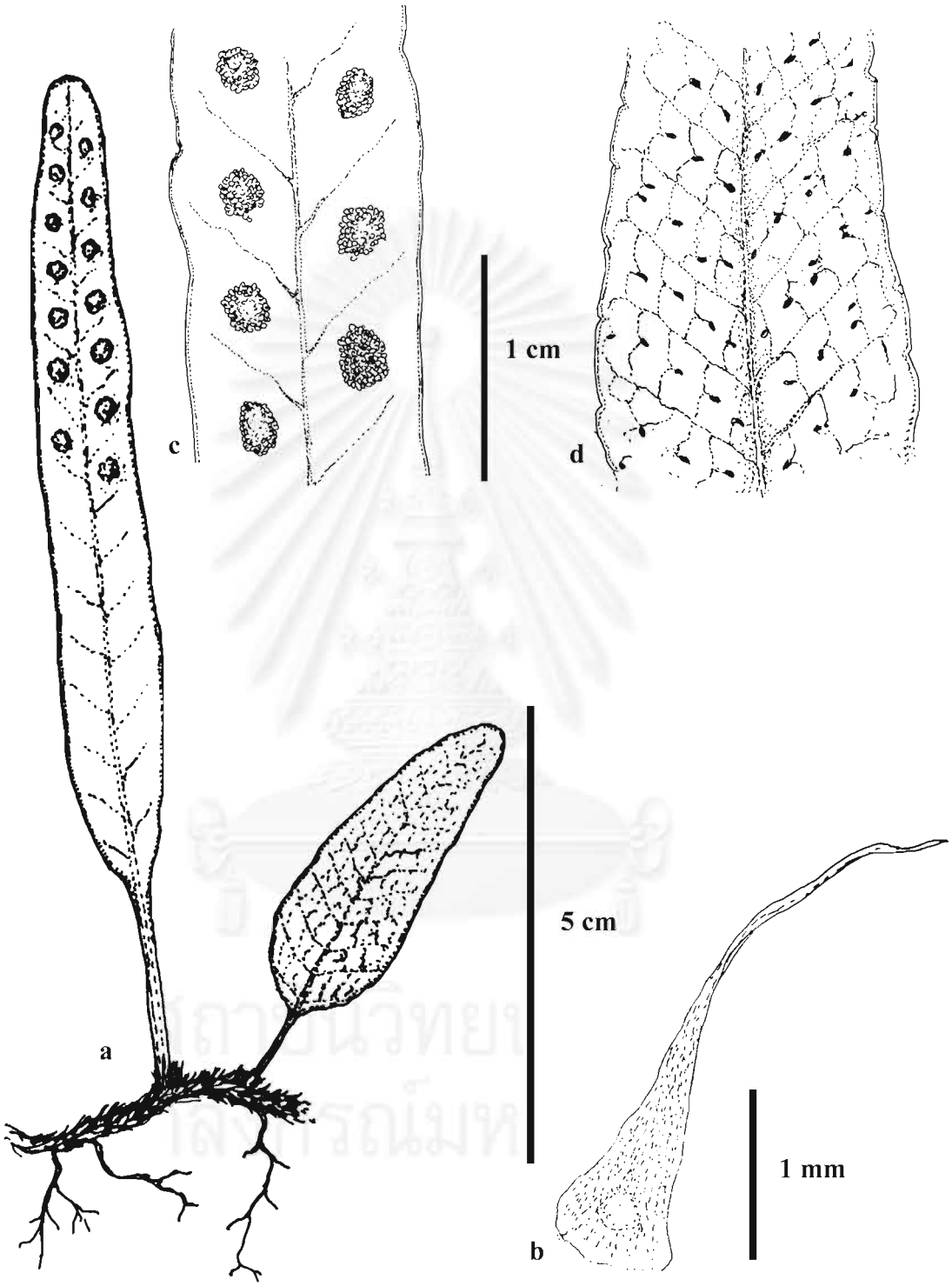


Figure 5.33 *Crypsinus rhynchophyllus* (Hook.) Copel. a. Habit. -- b. Rhizome scale. -- c. Sori. -- d. Venation. (A. Sathapattayanon 280)

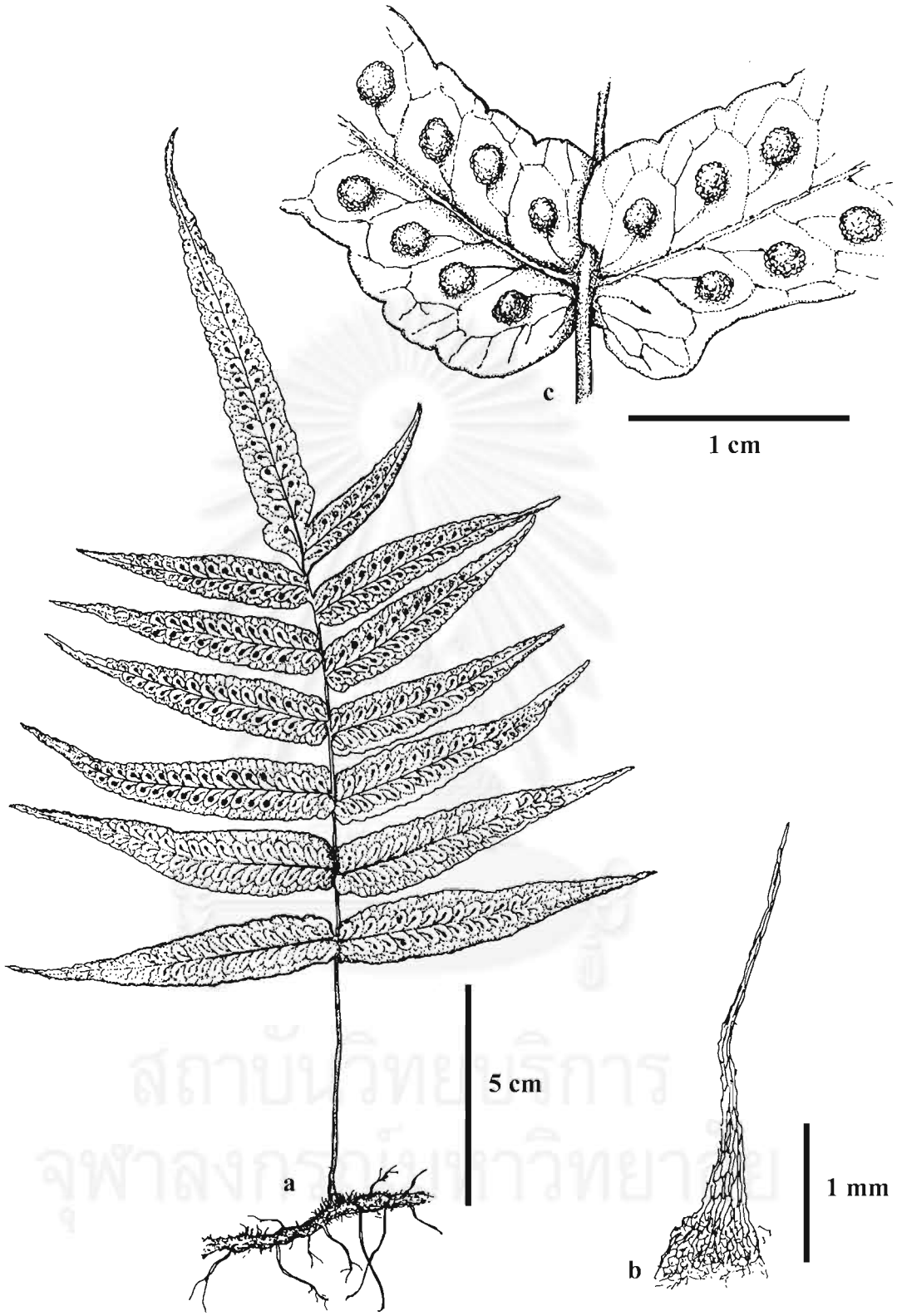


Figure 5.34 ***Goniophlebium subauriculatum*** **(Blume) C. Presl** a. Habit. -- b. Rhizome scale. -- c. Sori and base of pinnae. (A. Sathapattayanon 274)

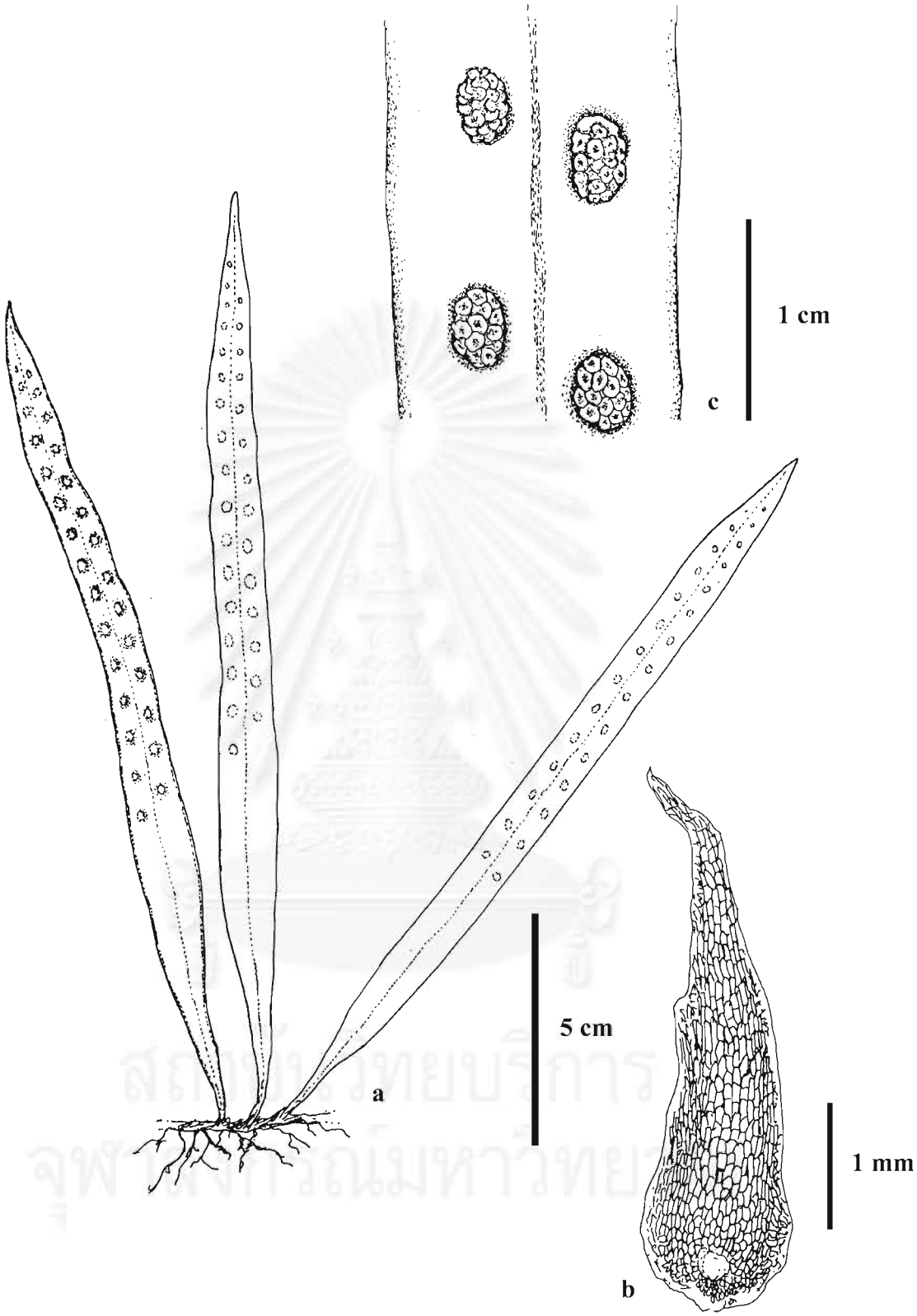


Figure 5.35 *Lepisorus scolopendrium* (Buch. - Ham. ex D. Don) Mehra & Bir
a. Habit. -- b. Rhizome scale. -- c. Sori. (A. Sathapattayanon 270)

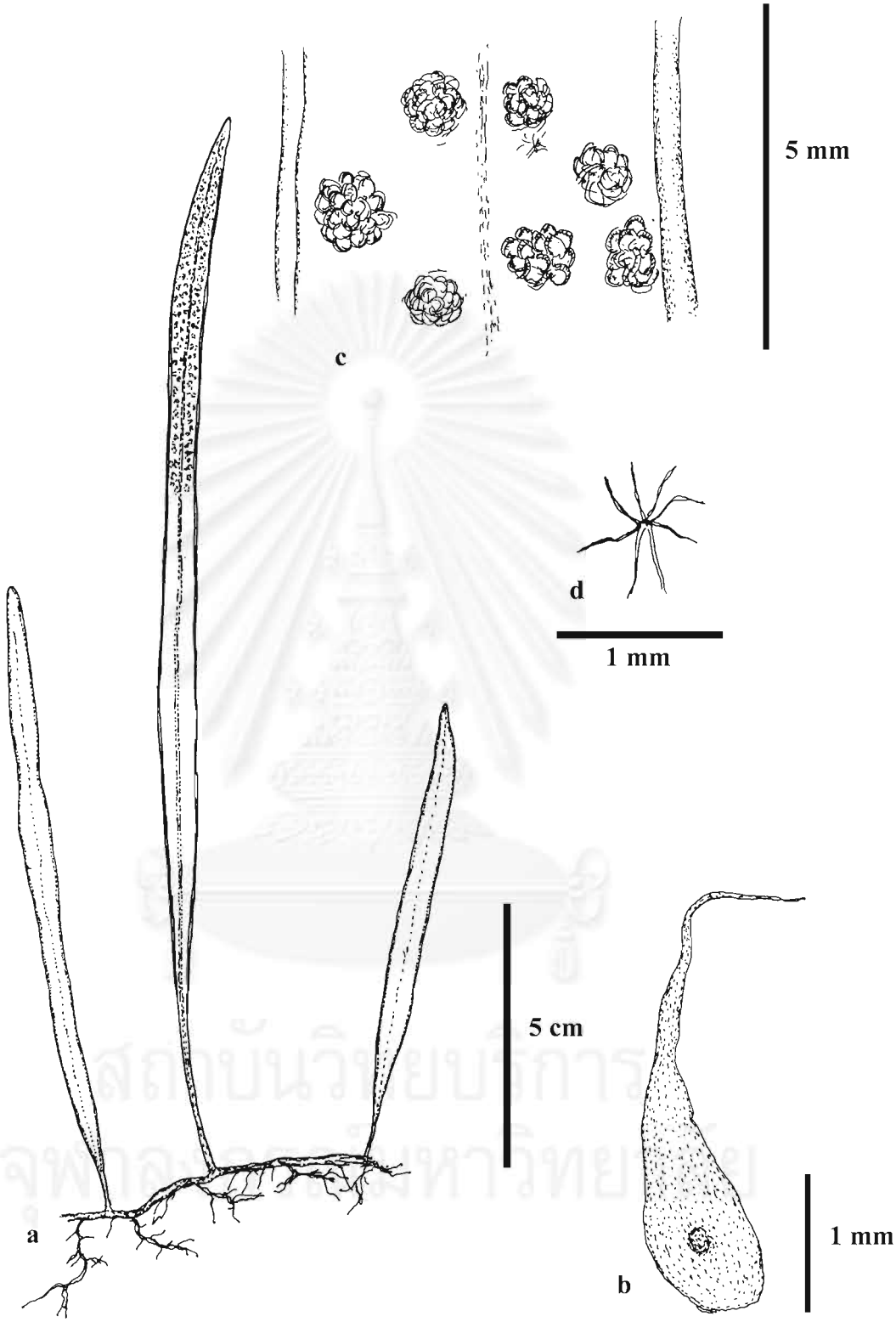


Figure 5.36 *Pyrrosia albicans* (Blume) Ching a. Habit. -- b. Rhizome scale. -- c. Sori. -- d. Stellate hair on lower surface. (A. Sathapattayanon 224)

5. 37 *Lycopodiella cernua* (L.) Pic. Serm., habitat

5. 38 *Lycopodiella cernua* (L.) Pic. Serm., strobili

5. 39 *Selaginella biformis* A. Braun ex Kuhn

5. 40 *Selaginella helferi* Warb., habitat

5. 41 *Selaginella helferi* Warb., spikes

5. 42 *Selaginella lindhardii* Hieron.

5. 43 *Selaginella minutifolia* Spring

5. 44 *Selaginella siamensis* Hieron.

5. 45 *Angiopteris evecta* (G. Forst.) Hoffm., habitat

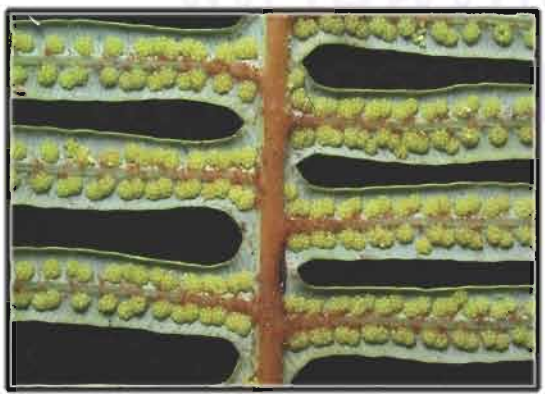
5. 46 *Angiopteris evecta* (G. Forst.) Hoffm., sori

5. 47 *Crepidomanes latealatum* (Bosch) Copel.

5. 48 *Hymenophyllum exsertum* Wall. ex Hook.

5. 49 *Hymenophyllum polyanthos* (Sw.) Sw.

5. 50 *Dicranopteris linearis* (Burm. f) Underw. var. *linearis*, habitat

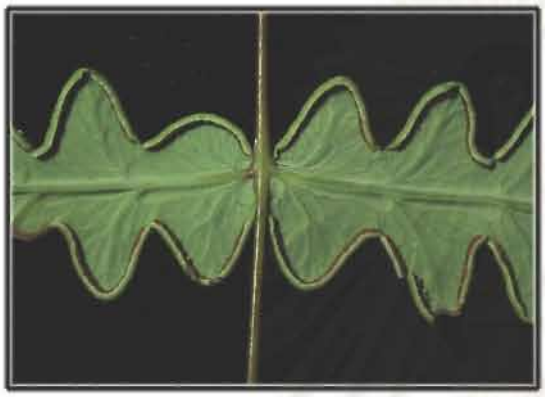


5. 51 *Dicranopteris linearis* (Burm. f) Underw. var. *linearis*, sori

5. 52 *Lygodium microphyllum* (Cav.) R. Br.

5. 53 *Lygodium salicifolium* C. Presl, habitat

5. 54 *Lygodium salicifolium* C. Presl, sori



5. 55 *Histiopteris incisa* (Thunb.) J. Sm.

5. 56 *Hypolepis punctata* (Thunb.) Mett. ex Kuhn, habitat

5. 57 *Hypolepis punctata* (Thunb.) Mett. ex Kuhn, sori

5. 58 *Microlepia speluncae* (L.) T. Moore, habitat

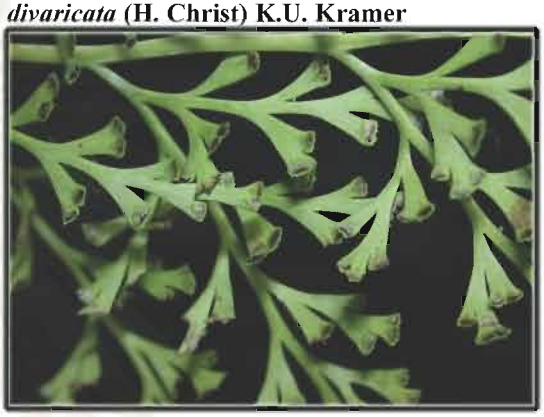
5. 59 *Microlepia speluncae* (L.) T. Moore, sori

5. 60 *Cibotium barometz* J. Sm.

5. 61 *Lindsaea ensifolia* Sw.

5. 62 *Sphenomeris chinensis* (L.) Maxon var. *divaricata* (H. Christ) K.U. Kramer

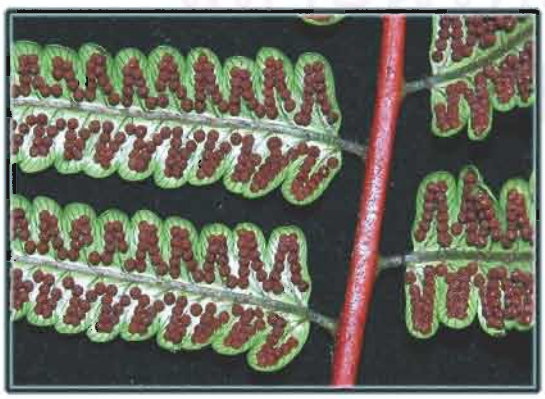
5. 63 *Sphenomeris chinensis* (L.) Maxon var. *rheophila* K.U. Kramer, habitat



5. 64 *Sphenomeris chinensis* (L.) Maxon var. *rheophila* K.U. Kramer, sori

5. 65 *Cyathea borneensis* Copel., habitat

5. 66 *Cyathea borneensis* Copel., sori



5. 67 *Cyathea gigantea* (Wall. ex Hook.) Holttum

5. 68 *Cheilanthes tenuifolia* (Burm. f.) Sw., habitat

5. 69 *Cheilanthes tenuifolia* (Burm. f.) Sw., sori

5. 70 *Pityrogramma calomelanos* (L.) Link., habitat

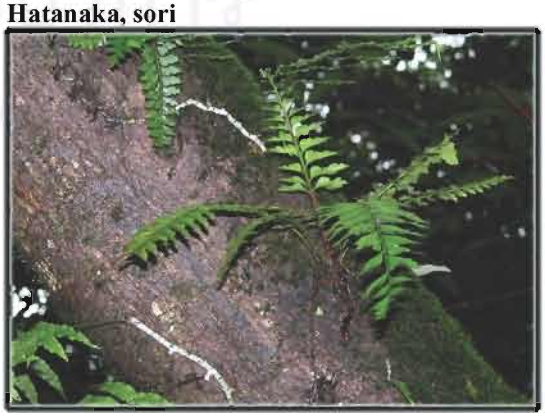
5. 71 *Pityrogramma calomelanos* (L.) Link., sori

5. 72 *Pteris biaurita* L., habitat

5. 73 *Asplenium apogamus* Murakami et Hatanaka, habitat

5. 74 *Asplenium apogamus* Murakami et Hatanaka, sori

5. 75 *Asplenium perakense* B. Mathew et H. Christ



5. 76 *Asplenium yoshinagae* Makino, habitat

5. 77 *Asplenium yoshinagae* Makino, sori

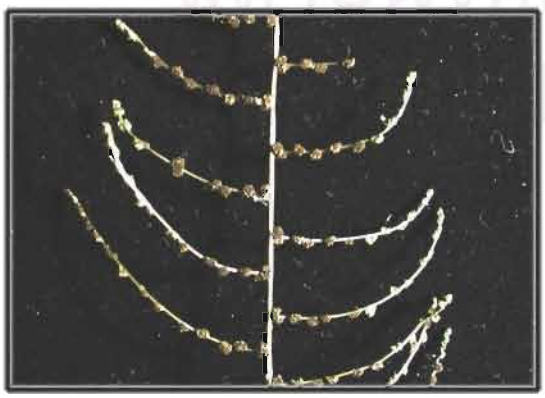
5. 78 *Blechnum orientale* L., habitat

5. 79 *Blechnum orientale* L., sori

5. 80 *Brainea insignis* (Hook.) J. Sm., habitat

5. 81 *Brainea insignis* (Hook.) J. Sm., sori

5. 82 *Bolbitis appendiculata* (Willd.) K. Iwats. subsp. *vivipara* (Hamilt. ex Hook.) Hennipman, habitat



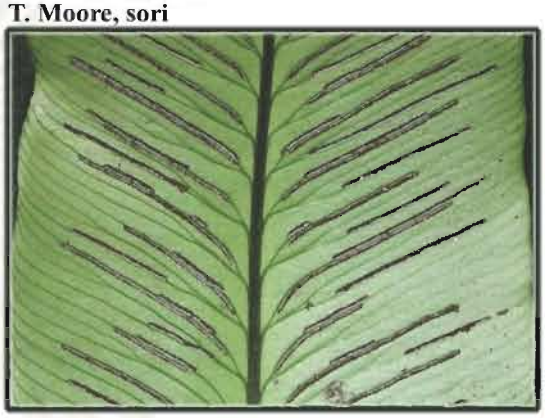
5. 83 *Bolbitis appendiculata* (Willd.) K. Iwats. subsp. *vivipara* (Hamilt. ex Hook.) Hennipman, sori

5. 84 *Bolbitis heteroclita* (C. Presl) Ching, habitat

5. 85 *Elaphoglossum marginatum* (Wall. ex Fée) T. Moore, habitat

5. 86 *Elaphoglossum marginatum* (Wall. ex Fée) T. Moore, sori

5. 87 *Diplazium donianum* (Mett.) Tardieu, habitat



5. 88 *Diplazium donianum* (Mett.) Tardieu, sori

5. 89 *Diplazium esculentum* (Retz.) Sw.

5. 90 *Diplazium simplicivenium* Holttum

5. 91 *Heterogonium sagenioides* (Mett.) Holttum

5. 92 *Pteridrys australis* Ching

5. 93 *Pteridrys syrmatica* (Willd.) C. Chr. et Ching

5. 94 *Tectaria fuscipes* (Wall. ex Bedd.) C. Chr., whole plant

5. 95 *Tectaria fuscipes* (Wall. ex Bedd.) C. Chr., sori

5. 96 *Tectaria impressa* (Fée) Holttum, habitat

5. 97 *Tectaria impressa* (Fée) Holttum, sori

5. 98 *Tectaria polymorpha* (Wall. ex Hook.) Copel., habitat

5. 99 *Tectaria polymorpha* (Wall. ex Hook.) Copel., sori

5. 100 *Tectaria* sp., habitat

5. 101 *Tectaria* **sp., sori**

5. 102 *Christella dentata* **(Forssk.) Holttum, habitat**

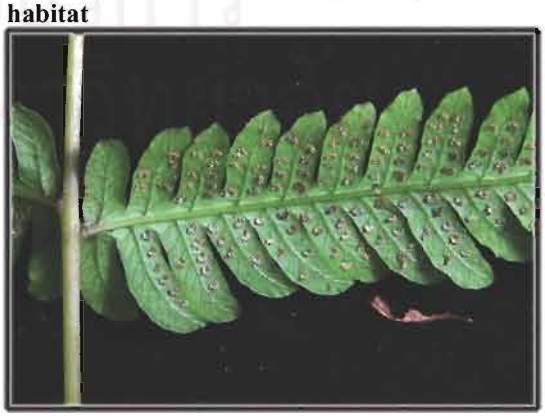
5. 103 *Christella dentata* **(Forssk.) Holttum, sori**

5. 104 *Christella parasitica* **(L.) H. Lév., habitat**

5. 105 *Christella parasitica* **(L.) H. Lev., sori**

5. 106 *Cyclosorus hirtisorus* **(C. Chr.) Ching, habitat**

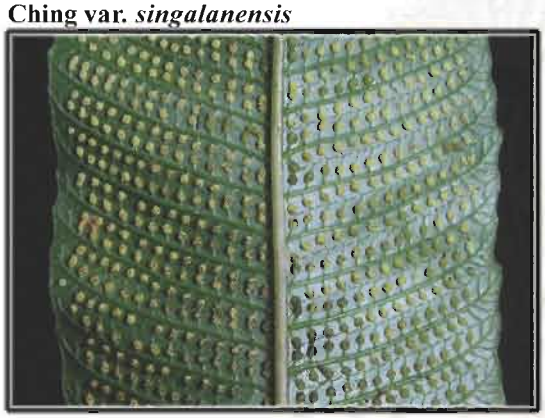
5. 107 *Cyclosorus hirtisorus* **(C. Chr.) Ching, sori**



5. 108 *Metathelypteris dayi* **(Bedd.) Holttum**

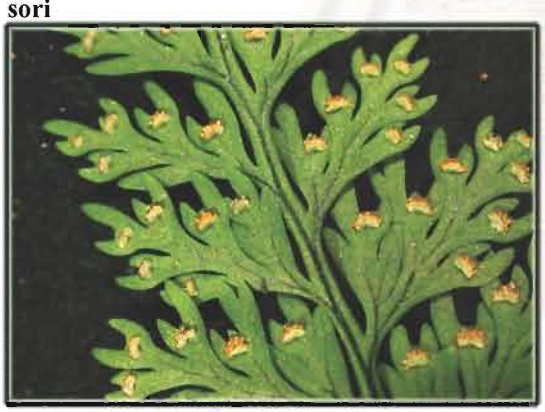
5. 109 *Metathelypteris singalanensis* (Baker) Ching var. *singalanensis*

5. 110 *Pronephrium nudatum* (Roxb.) Holttum, habitat



5. 111 *Pronephrium nudatum* (Roxb.) Holttum, sori

5. 112 *Araiostegia imbricata* Ching, habitat



5. 113 *Araiostegia imbricata* Ching, sori

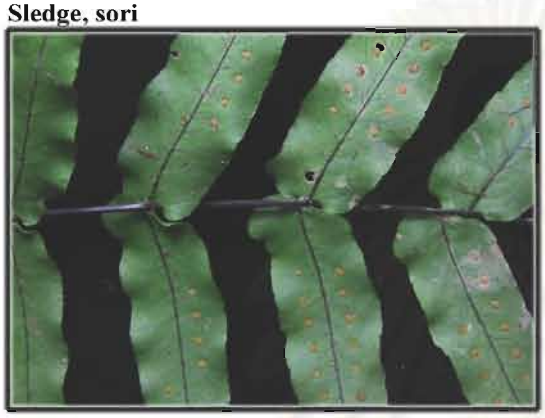
5. 114 *Humata repens* (L. f.) J. Small ex Diels, habitat

5. 115 *Humata repens* (L. f.) J. Small ex Diels, sori

5. 116 *Crypsinus oxylobus* (Wall. ex Kunze) Sledge, habitat

5. 117 ***Crypsinus oxylobus*** **(Wall. ex Kunze) Sledge, sori**

5. 118 ***Crypsinus rhynchophyllus*** **(Hook.) Copel.**



5. 119 ***Goniophlebium subauriculatum*** **(Blume) C. Presl**

5. 120 ***Lepisorus scolopendrium*** **(Buch. -Ham. ex. D. Don) Mehra & Bir, habitat**

5. 121 ***Lepisorus scolopendrium*** **(Buch. -Ham. ex. D. Don) Mehra & Bir, sori**

5. 122 ***Leptochilus minor*** **Fée**

5. 123 ***Pyrrosia albicans*** **(Blume) Ching**

5. 124 ***Pyrrosia lingua*** **(Thunb.) Farw. var.** ***heteractis*** **(Matt. ex Kuhn) Hovenkamp**

CHAPTER 6

DISCUSSION

6.1 Physical factors

6.1.1 Light intensity

Abandoned mine areas are open places and fully exposed because the vegetation was clear since the beginning of mine working. This disturbance resulted in the highest light intensity over the area. However, there are some remnants of the forest in mine areas, especially in areas close to streams. There are plants of various habits in these undisturbed strips. So, ground covers are shaded by canopy of trees and shrubs. The lowest light intensity was observed in these areas. Natural forests in this study are hill evergreen forest, this evergreen forest has some tall trees scattering around. The tree canopy is not so close, so sunlight can reach the forest floor. Light intensity is different among these three habitats. Light has a profound effect on plant growth, especially pteridophytes (Holttum, 1954; Boonkerd, 1996). This plant group responds to light differently. Hurtt and Pacala (1995) working on the consequences of recruitment limitation: reconciling chances, history and competitive differences among plants, they found that all species did not exist in every plot, different species would disappear from different plots because the best light is not present everywhere. Makgomol (1982) working on some ecological characteristics of ferns in hill-evergreen forest at Doi-Pui, Chiang Mai and Vannasri (2002) working on diversity of fern and fern allies in natural forest and along natural gas pipeline in Thong Pha Phum District, Kanchanaburi, also found that light intensity is the important factor to pteridophyte growth in each area.

6.1.2 Leaf temperature

In this study, a ratio of leaf temperature to air temperature was found to be significantly highest at abandoned mines. The high leaf temperature was a consequence of the high light intensity in abandoned mines where leaves of pteridophytes are fully exposed to sunlight. Likewise, Reddy et al. (1997) reported the relationship between leaf water potential and the differences between leaf and air temperatures. They showed that leaf temperature became warmer in times of drought.

6.2 Pteridophytes diversity

6.2.1 Species richness

The lowest mean value of species richness was observed in disturbed areas of mines while the highest mean value was observed in the remnants of the forest in mine area. However, no statistically significant difference of species richness was found between the remnants of the forest in mine areas and the natural forests (Figure 5.3). There were a few species of terrestrial sun-pteridophytes in abandoned mines, while pteridophytes in the remnants of the forest in mine area were terrestrials in shady places. Natural forests have both terrestrials and epiphytes. The low mean value of species richness was also observed in disturbed areas along natural gas pipeline as compared with the pteridophytes in natural forest (Vannasri, 2002). Likewise, disturbed woodland on the shore of lake Texoma, Oklahoma State in USA also has lower number of plant species than undisturbed areas (Corbett et al., 2002).

6.2.2 Species diversity

In this study, the remnants of the forest in mine areas had the highest values of species diversity index. However, there was no statistically significant difference of species diversity between the three studied sites. Abandoned mines have a low number of species of pteridophytes but high in number of all individuals in each plot. In contrast, both remnants of the forest in mine areas and natural forests have a high number of species of pteridophytes but low in number of all individuals in each plot. Therefore, no significant difference was observed among the three studied sites. Similarly, Vannasri (2002) found no significant difference of species diversity between the areas of natural forest and natural gas pipeline. In addition, Corbett et al. (2002) studied vegetational ecology of disturbed woodland on the shore of lake Texoma, Oklahoma State in USA. They selected three representative forest areas: lake area, ravine area and elm grove. The study found that species diversity of undisturbed areas, i.e. lake area and ravine areas, were higher than the disturbed area, elm grove which dominated by *Ulmus alata* Michx. and contained a small number of other species. However, there were no statistically significant differences.

6.2.3 Species evenness

Since the calculated value of species diversity index alone dose not show the degree to which each factor contributes to diversity (Elliott and Swank, 1994), this study calculated both species diversity and species evenness. It was found that abandoned mines have the highest mean value of species evenness and statistically significant difference from the remnants of the forest in mine area was noticed.

The Number of individuals of each pteridophytes species in abandoned mines was rather high and the common species was found in most plots. So, the highest value of species evenness index was observed in this studied site. The common species included *Lycopodiella cernua*, *Blechnum orientale* and *Dicranopteris linearis* var. *linearis*. They are the pioneer species of pteridophytes in disturbed areas (Holttum, 1954; Boonkerd, 1996). While, the remnants of the forest in mine area have fewer number of individuals and the same species occurred only in one or two plots. Examples included *Asplenium apogamus*, *Microlepia hookeriana* and *Tectaria* sp.

In the past, Thong Pha Phum forests may be rather rich in plant diversity, especially pteridophytes. However, after mine working, the forests were cleared except for the strip areas nearby streams, only fragments of the forests can be found from place to place in the mine areas at present. Pteridophytes species in each fragment are rather different because they have a limited distribution. A possible additional explanation of the lowest species evenness in this habitat is that the distance from the natural forest and other fragments are too extensive for spores of the small terrestrial ferns to be dispersed by the wind (Hietz, 1999). However, some medium sized or tree ferns, such as *Cyathea gigantea*, *Angiopteris evecta* and *Pronephrium nudatum* which had rather wide distribution (Tagawa and Iwatsuki, 1979, 1989) were found in several plots of the remnants of the forest in mine areas.

In hill evergreen forest, the common pteridophytes usually occur in a few plots. Therefore, this habitat had a medium value of species evenness index among the three sites.

6.3 Similarity coefficient

Jaccard's coefficient between each pair of study site was calculated. It was found that similarity coefficient between abandoned mines and the remnants of the forest in mine area is 0.21, which is the highest value. Whereas, the value between the remnants of the forest in mine areas and natural forests is 0.13 and the similarity

coefficient between abandoned mines and natural forests is 0.05. From these results, it can be concluded that each study site had a rather small number of species in common. This is probably due to the difference of physical environment between each study site which had different degrees of disturbance. Corresponding result was presented by Vannasri (2002), who found a low value of similarity coefficient of pteridophytes between natural forests and areas along natural gas pipeline.

The highest value of the similarity coefficient between abandoned mines and the remnants of the forest in mine area indicated that there were some common species between these two sites. The common species included *Blechnum orientale* and *Dicranopteris linearis* var. *linearis*. They are species of pteridophytes, which naturally occur along forest edge as well as in exposed areas of disturbed forest.

The lowest value of species similarity coefficient was observed between abandoned mines and natural forests. Only two common species were found, i.e. *Lindsaea ensifolia* and *Pteris biaurita*. These two sites are different in most of the physical factors, for example, light intensity, temperature, moisture and substratum. Furthermore, most of pteridophytes in natural forests are epiphytes, while abandons mines had no tree, and all of pteridophytes are terrestrial.

The species similarity coefficient between the remnants of the forest in mine area and natural forests was low. Eight species of pteridophytes, viz. *Aglaomorpha coronans*, *Asplenium yoshinagae*, *Bolbitis appendiculata* subsp. *vivipara*, *Lindsaea ensifolia*, *Lygodium salicifolium*, *Microlepia speluncae*, *Pteris biaurita* and *Tectaria polymorpha* are common between these two sites and the first two of them are epiphytes. Also, there occur some trees in the remnants of the forest in mine areas. Epiphytic species in this site was rather small as compared with those in the natural forest. Epiphytic species usually confines to host trees with large size, rough bark and branching patterns. Furthermore, mode of water uptake in pteridophytes makes them more dependent on substrate chemistry (Hietz, 1999).

6.4 Relationship between pteridophyte diversity and physical factors

Light intensity and leaf temperature were the two physical factors investigated in this study. The two factors were negatively significantly correlated with species richness index (Figure 5.6 and 5.8). Similarly, Vannasri (2002) reported the negative correlation between light intensity and species richness index. In addition, Bhattarai and Vetaas (2003) who studied the variation of species richness of different life forms

along a subtropical elevation gradient in Himalayas, east Napal, found that potential evapotranspiration has a negative relationship with species richness of pteridophytes.

Furthermore, light intensity and leaf temperature were positively significantly correlated with species evenness index (Figure 5.7 and 5.9). It is probable that the terrestrial sun-pteridophytes had their spores effectively dispersed by the wind. However, these two factors had no correlation with species diversity index.

6.5 Taxonomic diversity of pteridophytes

One hundred and eighty-four specimens were collected. A total of 65 species, 1 subspecies, and 5 varieties in 40 genera and 20 families were classified. Among these, 8 species in 2 genera in 2 families are fern allies. Polypodiaceae had the highest number of species, including 9 species, whilst Dryopteridaceae and Selaginellaceae had 8 and 7 species, respectively. There were five families, viz. Pteridaceae, Marattiaceae, Lycopodiaceae, Gleicheniaceae and Dicksoniaceae, which included only 1 species. The number of species in each family is shown in Figure 6.1. There were 46 species of terrestrials, 16 species of epiphytes and 2 species of lithophytes.

6.5.1 Comparison of pteridophytes diversity among the studied sites

Abandoned mines were fully exposed areas, without trees. Few flowering plants including *Chromoleana odoratum* (L.) R.M. King et H. Rob., *Melastoma* spp., *Bambusa* spp. and *Thysanolaena* spp. were found in this area. Due to mine working in the past, most of the rocky hills were excavated and turned into little rocks. Hill slope was about 10°-40°. Most part of the area were covered with *Thysanolaena* spp. and *Dicranopteris linearis* var. *linearis*. There were 15 species of terrestrial pteridophytes in this area.

The remnants of the forest in mine area were found along or close to streams. It was a shady forest, with 10°-50° slope. Most plant species were shrubs, with a few small to medium sized trees. The ground consisted of humus rich soil and boulders. This area had rather high air humidity due to the streams nearby. Forty-two species of pteridophytes were found. They were 11 species of terrestrials, 2 species of epiphytes and 2 species of lithophytes.

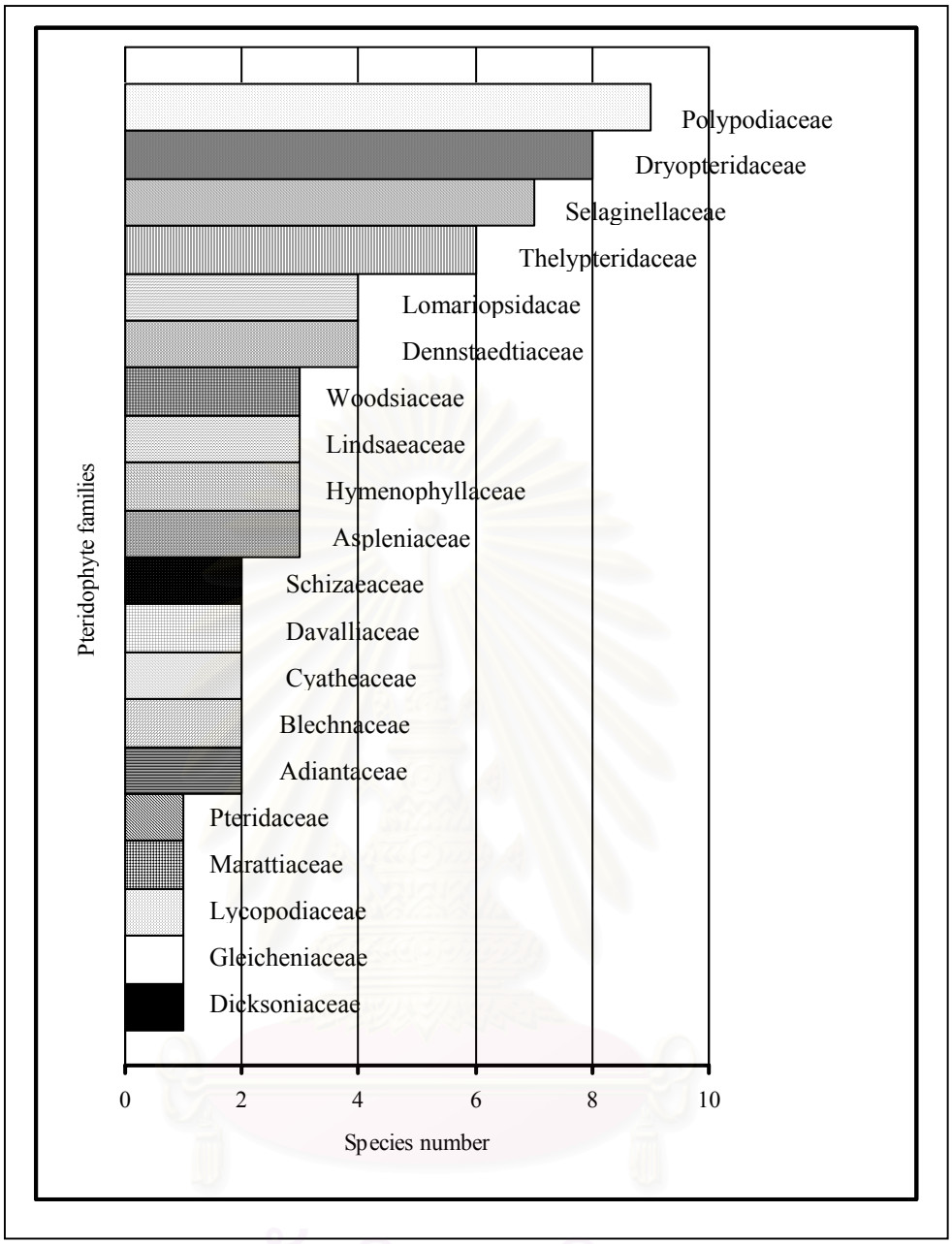


Figure 6.1 The number of species in each family

Natural forests are the hill evergreen forests with large to medium-sized trees mixed with bamboo. The common terrestrials were Fabaceae, *Calamus* spp., *Cinnamomum* spp., and *Rubus* spp. The forest floor was humus-rich soils. Air humidity in hill evergreen forest was rather high, especially at mossy tree trunks. There were 26 species of pteridophytes, consisting of 11 species of terrestrials, 14 species of epiphytes and 1 species of lithophyte (Figure 6.2). Moreover, there were some species occurred in more than one area (Figure 6.3).

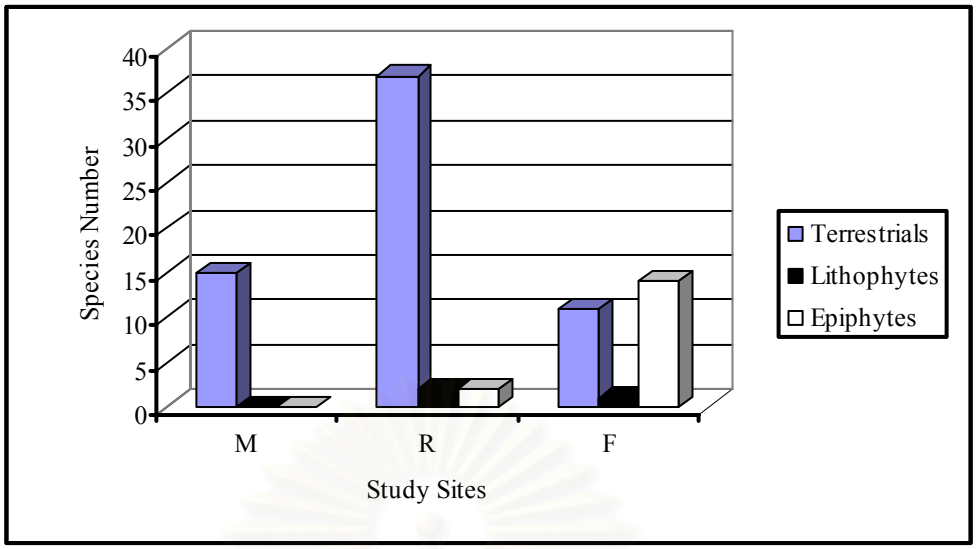


Figure 6.2 Habit of pteridophytes in each study site; M= Abandoned mines, R= Remnants of the forest in mine area, F= Natural forests.

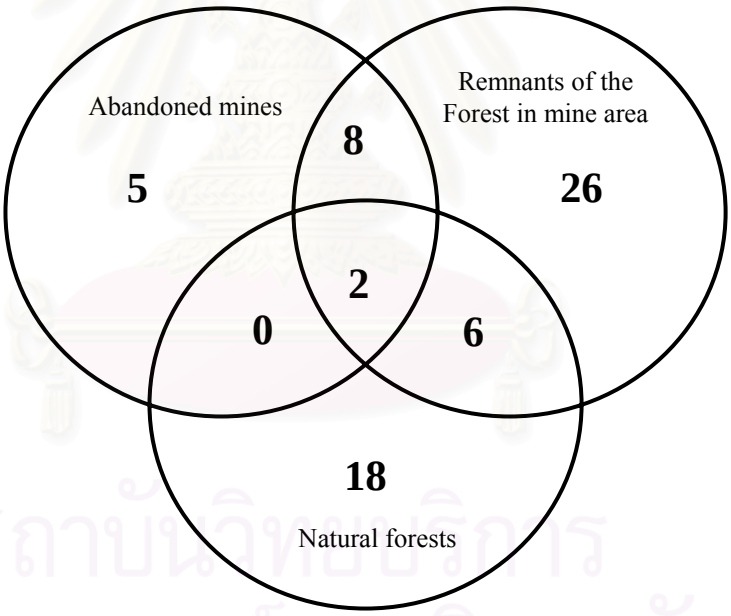


Figure 6.3 Number of pteridophytes in each study site.

Among the 65 species, there were some species found in only one area, and some species were commonly found in two or three areas (Figure 6.3). Table 5.4 shows 15 species of pteridophytes in the abandoned mines, 41 species in the remnant of the forest in mine areas and 26 species in the natural forests. It was found that *Cheilanthes tenuifolia*, *Selaginella lindhardii*, *Selaginella minutifolia*, *Sphenomeris chinensis* var. *divaricata* and *Lycopodiella cernua* were found only in abandoned

mines. However, the first three species grow in shady places usually under the shade of shrubs or in rock crevices, where there was some moisture underneath. While, *Dicranopteris linearis* var. *linearis*, *Pityrogramma calomelanos*, *Sphenomeris chinensis* var. *divaricata* and *Lycopodiella cernua* have characteristics of drought resistance, such as dissected and/or coriaceous fronds and were able to withstand full sunlight of abandoned mines.

Holttum (1954) noted that pteridophyte species that occur in fully exposed areas usually have a wide geographical distribution. Similarly, species of pteridophytes that occur in fully exposed areas of abandoned mines also have a wide distribution (Tagawa and Iwatsuki, 1979, 1985, 1988, 1989). Environmental factors at each microhabitat seem to be important for successful germination of pteridophyte spores. The evidence in favour of this interpretation has been presented by Nondorf et al. (2003). They studied spore germination of *Cheilanthes feei* T. Moore, a lithophyte which grew in full sunlight. They found that the spores had high germination rate at temperature of 25° C and light intensity of 100 $\mu mol \cdot m^2 \cdot sec^{-1}$. In contrast, the spores of *Dicranopteris* spp. find suitable growing places on sheltered bare earth of disturbed forest where there is little direct sunlight, and young sporophytes, growing from prothalli, are often very abundant (Holttum, 1989). In Malaysia, most areas of disturbed forest are covered with thickets of *Dicranopteris linearis* or with hardy pioneer species, such as *Blechnum orientale* and *Pityrogramma calomelanos* (Piggott, 1996). These same species also occupied the studied abandoned mines.

The remnants of the forest in mine area which are areas along or close to streams had 41 species of pteridophytes (Table 5.4). The greatest number of species among the three study sites probably due to suitable light intensity and humidity for pteridophyte growth. It is worth noting that some species are rather rare and found in only one sampling plot. These species include *Histiopteris incisa*, *Metathelypteris singalanensis* var. *singalanensis*, *Tectaria fuscipes*, *Leptochilus minor* and *Pteridrys syrmatica*. It is possible that each species can find a niche, such as the cracks and crevices of shattered rocks in a variety of habitats at each sampling plot. Furthermore, some large-sized ferns, *Angiopteris evecta, Cyathea borneensis, Cyathea gigantea* and *Cibotium barometz* were commonly found in this area. They usually thrive in moist grounds with partial sun-light at the edge of the forest. Piggott (1996) also found stands of tree ferns grow where the forest edge cuts across valleys of mountain

stream in Malaysia. It is postulated that these tree ferns are indicators of undisturbed forest, especially in Thong Pha Phum area.

Natural forests in this study are hill evergreen forests which situated near the head quarter of the national park. There were many species which are members of the hill evergreen forest, for example, *Brainea insignis*, *Humata repens*, *Elaphoglossum marginatum*, *Crypsinus oxylobus* and *Crypsinus rhynchophyllus.* Holttum (1954) sorted these species as mountain ferns. In addition, filmy ferns (Hymenophyllaceae) are confined to hill evergreen forest, where high air humidity retained most of the year.

Most pteridophytes in natural forest are epiphytes. They grow on mossy tree trunks, which had rather high humidity. In contrast, there were no epiphytes in abandoned mines and only a few were found in the remnants of the forest in mine area.

It may be expected to have many terrestrial species in natural forests where soils are rich in humus. Anyhow, only 11 species were found, it was the smallest number of terrestrial species among the three study sites. It appears likely that pteridophytes failed to complete with fast growing species of flowering plants, especially monocots. (Fairchild, 2002)

There are pteridophytes species commonly found in both abandoned mines and the remnants of the forest in mine area, but they are different in their full size. It was found that pteridophytes growing in abandoned mines have smaller frond size than those growing in remnants of the forest in mine area. This finding agreed with a previous study in *Davallia* spp. by Sudhishurnark (1989), who found that *Davallia* spp. in exposed plots had smaller size of fronds than that in shady plots.

Pteridophytes which occurred in both the natural forests and the remnants of the forest in mine areas have a rather wide distribution. They can grow in several forest types. These pteridophytes included *Aglaomorpha coronans*, *Lygodium salicifolium* and *Microlepia speluncae* (Tagawa and Iwatsuki, 1979, 1989).

It was found that two terrestrial ferns, namely *Lindsaea ensifolia* and *Pteris biaurita* were commonly found in all study sites. *Lindsaea ensifolia* is a fairly common and locally abundant throughout Thailand and the old world tropics. It is extremely variable in form and size of fronds, especially in different habitats (Tagawa and Iwatsuki, 1985). This species can be found on rather dry slopes or sandy ground, usually in open areas, but rarely on rocks. Likewise, *Pteris biaurita* is also one of

a wide distribution ferns, it was found in more than 3 forest types at Huaiyang Waterfall National Park (Yuyen, 2000). This species was also found in both natural forest and disturbed areas along natural gas-pipeline in Thong Pha Phum District (Vannasri 2002). It can be found from low to high altitudes of the lower montane forest in Thailand and has a pantropical distribution (Tagawa and Iwatsuki, 1985).

6.5.2 Comparison with pteridophytes from the nearby areas

Yuyen (2000) carried out a taxonomic study of pteridophyts at Huaiyang Waterfall National Park, Prachuap Khiri Khan Province, a total of 126 species in 57 genera from 26 families were found. However, pteridophyte diversity at Huaiyang Waterfall National Park can not be compared with that in the Thong Pha Phum District. Since most of the forests in Thong Pha Phum District have been disturbed, the balance of the forest has been upset, however a state of equilibrium is achieving. Anyhow, if considered only the species composition in the hill evergreen forest, it could be assumed that Huaiyang Waterfall National Park has greater pteridophytes diversity than the hill evergreen forest at Thong Pha Phum national park due to the fertility of the forest. There are some common species from these two areas, for example, *Asplenium yoshinagae*, *Araiostegia imbricata*, *Microlepia speluncae*, *Goniophlebium subauriculatum*, *Pyrrosia lingua* var. *heteractis*, etc. (Table 6.1). Moreover, Vannasri (2002) also studied the diversity of pteridophytes in natural forests and areas along natural gas-pipeline in Thong Pha Phum District, Kanchanaburi Province. There are 22 common species between these two areas. The common species included *Lycopodiella cernua*, *Selaginella minutifolia*, *Pityrogramma calomelanos*, *Asplenium apogamus*, *Cyathea borneensis*, *Humata repens*, *Cibotium barometz*, *Pteridrys syrmatica*, *Tectaria impressa*, *Dicranopteris linearis* var. *linearis*, *Lindsaea ensifolia*, *Lygodium microphyllum*, *Angiopteris evecta*, etc. (Table 6.1).

Table 6.1 The comparison of pteridophyte diversity from this study (abandoned mine, remnant of the forest in mine area and natural forest), Vannasri (2002) and Yuyen (2000).

Remark: + = presence, - = absence

Family	Taxon (this study)	Vannasri (2002)	Yuyen (2000)
Lycopodiaceae	- *Lycopodiella cernua*	+	+
Selaginellaceae	- *Selaginella biformis*	-	-
	- *Selaginella helferi*	-	-
	- *Selaginella inaequalifolia*	-	-
	- *Selaginella lindhardii*	-	-
	- *Selaginella minutifolia*	+	+
	- *Selaginella siamensis*	-	-
	- *Selaginella tenuifolia*	-	-
Adiantaceae	- *Cheilanthes tenuifolia*	-	+
	- *Pityrogramma calomelanos*	+	+
Aspleniaceae	- *Asplenium apogamus*	+	-
	- *Asplenium perakense*	+	-
	- *Asplenium yoshinagae*	+	+
Blechnaceae	- *Blechnum orientale*	+	+
	- *Brainea insignis*	-	-
Cyatheaceae	- *Cyathea borneensis*	+	-
	- *Cyathea gigantea*	-	-
Davalliaceae	- *Araiostegia imbricata*	-	+
	- *Humata repens*	+	-
Dennstaedtiaceae	- *Histiopteris incisa*	-	-
	- *Hypolepis punctata*	-	-
	- *Microlepia hookeriana*	-	-
	- *Microlepia speluncae*	+	+
Dicksoniaceae	- *Cibotium barometz*	+	-
Dryopteridaceae	- *Dryopteris polita*	-	-
	- *Heterogonium sagenioides*	-	-

Family	Taxon (this study)	Vannasri (2002)	Yuyen (2000)
Dryopteridaceae (cont.)	- *Pteridrys australis*	-	-
	- *Pteridrys syrmatica*	+	-
	- *Tectaria fuscipes*	-	-
	- *Tectaria impressa*	+	+
	- *Tectaria polymorpha*	+	+
	- *Tectaria* sp.	-	-
Gleicheniaceae	- *Dicranopteris linearis* var. *linearis*	+	+
Hymenophyllaceae	- *Crepidomanes latealatum*	-	-
	- *Hymenophyllum exsertum*	+	-
	- *Hymenophyllum polyanthos*	-	-
Lindsaeaceae	- *Lindsaea ensifolia*	+	+
	- *Sphenomeris chinensis* var. *divaricata*	-	+
	- *Sphenomeris chinensis* var. *rheophila*	-	-
Lomariopsidaceae	- *Bolbitis appendiculata* subsp. *vivipara*	+	+
	- *Bolbitis heteroclita*	+	-
	- *Bolbitis virens* var. *virens*	+	+
	- *Elaphoglossum marginatum*	-	-
Marattiaceae	- *Angiopteris evecta*	+	-
Polypodiaceae	- *Aglaomorpha coronans*	+	-
	- *Crypsinus oxylobus*	+	-
	- *Crypsinus rhynchophyllus*	-	-
	- *Goniophlebium subauriculatum*	-	+
	- *Lepisorus scolopendrium*	+	+
	- *Leptochilus minor*	-	-
	- *Microsorum punctatum*	+	-
	- *Pyrrosia albicans*	-	-
	- *Pyrrosia lingua* var. *heteractis*	+	+
Pteridaceae	-*Pteris biaurita*	+	+
Schizaeaceae	- *Lygodium microphyllum*	+	-
	- *Lygodium salicifolium*	+	+
Thelypteridaceae	- *Christella dentata*	+	+
	- *Christella parasitica*	+	-

Family	Taxon (this study)	Vannasri (2002)	Yuyen (2000)
Thelypteridaceae (cont.)	- *Cyclosorus hirtisorus*	+	+
	- *Metathelypteris dayi*	-	-
	- *Metathelypteris singalanensis* var. *singalanensis*	-	-
	- *Pronephrium nudatum*	-	+
Woodsiaceae	- *Diplazium donianum*	+	-
	- *Diplazium esculentum*	+	-
	- *Diplazium simplicivenium*	+	-

6.5.3 New records

It is found that *Sphenomeris chinensis* var. *rheophila* and *Metathelypteris dayi* are newly recorded species for Thailand.

Sphenomeris chinensis var. *rheophila* has been reported in Malesia. There are a number of this species in Thong Pha Phum District, especially in exposed area. The var. *rheophila* is similar to var. *chinensis*, they differ in the pattern of venation.

Metathelypteris dayi has also been reported in Malesia. This species is very rare in Thong Pha Phum District.

6.5.4 Dubious species

In this study, there is one species of the genus *Tectaria*, which cannot be determined to species level, despite many attempts to use key determination from the Flora of Thailand as well as keys from neighboring countries. Herbarium specimens of related species are also studied from BCU and BKF, but it is still unidentified.

Tectaria sp. is a terrestrial pteridophyte, found on moist and humus-rich mountain slopes in the remnants of the forest in mine areas at about 900 m altitude. It is closed to *Tectaria griffithii* (Baker) C. Chr. However, their details of frond and sori are different.

6.5.5 Pteridophyte distribution

From phytogeographic point of view, pteridophytes in Thailand are belonged to three phytogeographical elements, viz. Indo-Burmese, Indo-Chinese and Malesian elements. Examples of members of each element are listed below.

Selaginella inaequalifolia occurs in Madras, Assam and Myanmar and was found in Tak Province. The presence of this species at Thong Pha Phum District is still in agreement with the distribution of Indo-Burmese element.

Araiostegia imbricata is a member of Indo-Chinese element. In Thailand, it was found in Lumphun Province, so it can be concluded that this species has the wide distribution outside the boundary of Indo-Chinese element.

Six species of pteridophytes from this study are members of Malesian element, i.e. *Asplenium perakense*, *Pteridrys syrmatica*, *Sphenomeris chinensis* var. *rheophila*, *Pyrrosia albicans*, *Metathelypteris dayi* and *Diplazium simplicivenium*.

Geographically speaking, Thong Pha Phum District is in the boundary of the Indo-Burmese element, however, one species of Indo-Chinese element and 6 species of Malesian element flourish here. So, Thong Pha Phum District may be the northernmost limit of the Malaysian element as well as the meeting point of plants from Indo-Burmese, Indo- Chinese and Malesian element.

6.6 Recommendation

The permanent plots should be established, in order to carry out a long term study of plant succession in these study sites. Further eco-physiological study of pteridophytes will enhance our understanding of ecological adaptation of this plant group.

REFERENCES

Alston, A. H. G. 1951. Lycopodiacées. In Humbert, H. (ed.), Flore Générale De L'Indo-Chine. Tome. VII (2^e Partie), Fasc. 7. pp. 548. Masson et Cie, Paris: Editeurs.

Alston, A. H. G. 1951. Selaginellacées. In Humbert, H. (ed.), Flore Générale De L'Indo-Chine. Tome. VII (2^e Partie), Fasc. 7. pp. 570. Masson et Cie, Paris: Editeurs.

Anderson, K. 2000. Old Mine Road: Coppermine area, Flatbrook, and rocky slope. [Online]. Available from: http://torreybotanical.com/njaptofc/oldmine.html [2001, June 29]

Anonymous, 2004. Western Forest Complex Ecosystem Management Project. [Online]. Available from: http://www.forest.go.th/wefcom/ [2004, January 12]

Avery, E. 2001. Nutrient input effects from fire retardant on exotic species, species richness, and species diversity in a coastal California grassland. [Online]. Available from: http://www.redshift.com/~bigcreek/project/fire_retardant_study.html [2003, January 10]

Baimai, V. 1989. Biodiversity. In Wongsiri, S., and Lourlohakan, S. (eds.), Biodiversity in Thailand. pp. 1-13. Bangkok: Prachachon Publishing.

Beddome, R. H. 1969. Handbook to the Ferns of British India. Reprint Edition. Faridabad: Today & Tomorrow's Printers & Publishers.

Bhattarai, K. R., and Vetaas, O. R. 2003. Variation in plant species richness of different life forms along a subtropical elevation gradient in the Himalayas, East Nepal. Global Ecology & Biogeography. 12: 327-340.

Boonkerd, T. 1996. Noteworthy Ferns of Thailand:Multimedia CD-ROM. Bangkok: Chulalongkorn University Press.

Boonkerd, T., et al. 1987. Plant specimens collection and maintainence. Bangkok: Aroon- amarin Printing.

Boonkerd, T. 1998. Thai Ferns. In Sintawanon, K. (ed.), Thai Junior Encyclopedia. 23. pp. 152-191. Bangkok: Amarin Printing and Publishing.

Boonkerd, T., and Pollawatn, R. 2000. Pteridophytes in Thailand. Bangkok: Office of Environmental Policy and Planning.

Boonkerd, T., and Pollawatn, R. 2002. *Leptochilus minor* Fée (Polypodiaceae), a New Record for Thailand. The Natural History Journal of Chulalongkorn University. 2(3): 1-3

Borthakur, S. K., Deka, P., and Nath, K. K. 2001. Illustrated Manual of Ferns of Assam. India: Gajendra Singh Gahlot at Shiva Offset Press.

Bosman, M. T. M. 1991. A Monograph of the Fern Genus *Microsorum* (Polypodiaceae). Leiden: Rijks Herbarium/Hortus Botanics.

Bridson, D. and Forman, L. 1992. The Herbarium Handbook. Rev. ed. Great Britain: Whistable Litho Printers.

Brummitt, R. K., and Powell, C. E. 1992. Authors of Plant Names. Kent: Royal Botanic Garden Kew.

Chandra, S. 2000. The Ferns of India: Enumeration, Synonyms & Distribution. India: Prashant Gahlot at Valley Offset Printers and Publishers.

Chin, W. Y. 1983. A Guide to the Ferns of Singapore. Singapore: Singapore Science Center.

Corbett, E. A., Bannister, D. L., Bell, L., and Richards C. 2002. Vegetational Ecology of Distubed Woodland on The Shore of Lake Texoma, Oklahoma: Oklahoma Academy of Science. 82: 15-25.

de Winter, W. P., and Amoroso, V. B., eds. 2003. Plant Resources of South-East Asia. Cryptograms: Ferns and Ferns allies. 15(2). Leiden: Backhuys Publishers.

Devol, C. E. 1980. Dicksoniaceae. In Li, H., Liu, T., Huang, T., Koyama, T., and Devol, C. E. (eds.), Flora of Taiwan. I. pp. 131-133. Second Edition. Taiwan: Epoch Publishing Co., Ltd.

Devol, C. E. 1980. Marattiaceae. In Li, H., Liu, T., Huang, T., Koyama, T., and Devol, C. E. (eds.), Flora of Taiwan. I. pp. 73-78. Second Edition. Taiwan: Epoch Publishing Co., Ltd.

Devol, C. E. 1980. Selaginellaceae. In Li, H., Liu, T., Huang, T., Koyama, T., and Devol, C. E. (eds.), Flora of Taiwan. I. pp. 42-52. Second Edition. Taiwan: Epoch Publishing Co., Ltd.

Devol, C. E. and Kuo, C. 1980. Aspleniaceae. In Li, H., Liu, T., Huang, T., Koyama, T., and Devol, C. E. (eds.), Flora of Taiwan. I. pp. 476-492. Second Edition. Taiwan: Epoch Publishing Co., Ltd.

Devol, C. E. and Kuo, C. 1980. Athyriaceae. In Li, H., Liu, T., Huang, T., Koyama, T., and Devol, C. E. (eds.), Flora of Taiwan. I. pp. 441-492. Second Edition. Taiwan: Epoch Publishing Co., Ltd.

Devol, C. E. and Kuo, C. 1980. Blechnaceae. In Li, H., Liu, T., Huang, T., Koyama, T., and Devol, C. E. (eds.), Flora of Taiwan. I. pp. 149-160. Second Edition. Taiwan: Epoch Publishing Co., Ltd.

Devol, C. E. and Kuo, C. 1980. Dryopteridaceae. In Li, H., Liu, T., Huang, T., Koyama, T., and Devol, C. E. (eds.), Flora of Taiwan. I. pp. 354-400. Second Edition. Taiwan: Epoch Publishing Co., Ltd.

Devol, C. E. and Kuo, C. 1980. Lomariopsidaceae. In Li, H., Liu, T., Huang, T., Koyama, T., and Devol, C. E. (eds.), Flora of Taiwan. I. pp. 347-353. Second Edition. Taiwan: Epoch Publishing Co., Ltd.

Devol, C. E. and Kuo, C. M. 1980. Polypodiaceae. In Li, H., Liu, T., Huang, T., Koyama, T., and Devol, C. E. (eds.), Flora of Taiwan. I. pp. 165-215. Second Edition. Taiwan: Epoch Publishing Co., Ltd.

Devol, C. E. and Yang, T. 1980. Davalliaceae. In Li, H., Liu, T., Huang, T., Koyama, T., and Devol, C. E. (eds.), Flora of Taiwan. I. pp. 271-280. Second Edition. Taiwan: Epoch Publishing Co., Ltd.

Dhir, K. K. 1980. Ferns of North-Western Himalayas. In Cramer, J. (ed.) Bibliotheca Pteridologia. Band 1. Germany: Strauss & Cramer Gmbh.

Elliott, K. J; and Swank, W. T. 1994. Changes in Tree species diversity after successive clearcuts in Southern Appalachians. Vegetatio. 115: 11-18.

Fairchild, G. 2002. Plant species competition for light within the Australian tropical rainforest. [Online]. Available from: http://www.biology.iastate.edu/intop/1Australia/Australia%20papers/FAIRCHILDPLANTLIGHT/ [2004, April 8]

Ferreira, L. V., and Stohlgren, T. J. 1999. Effect of river level fluctuation on plant species richness, diversiy, and distribution in a floodplain forest in Central Amazonia. Oecologia. 120: 582-587.

Foosombati, A. 1985. Relationship of Ferns and Environment in Hill-evergreen Forest at Doi Suthep-Pui, Chiang Mai. M. Sc. Thesis, Department of Botany, Kasetsart University, Thailand.

Fraser-Jenkins, C. R. 1986. A Classification of the Genus *Dryopteris* (Pteridophyta: Dryopteridaceae). Bulletin of the British Museum (Natural History). Botany series. 14(3): 183-218.

Fraser-Jenkins, C. R. 1989. A Monograph of the Genus *Dryopteris* (Pteridophyta: Dryopteridaceae) in the Indian subcontinent. Bulletin of the British Museum (Natural History). Botany series. 18(5): 323-477.

Goudey, C. J. 1989. A Handbook of Ferns for Australia and New Zealand. Singapore: Island Graphics.

Harris, J. G. and Hrarris, M. W. 1994. Plannt Identification terminology: an Illustration Glossary. Utah: Spring Lake Publishing.

Hennipman, E. 1970. Some Novelties in *Bolbitis* from Asia and The Pacific (Filices). Blumea. 18(1): 147-149.

Hietz, P. 1999. Diversity and Conservation of Epiphytes in a Changing Environment: Pure and Applied Chemistry. [Online] Available from: http//www.iupac.org/symposia/proceedings/phuket97/hietz.html. [2003, January 10]

Hobbs, E. R. 1988. Species richness of urban forest patches and implications for urban landscape diversity. Landscape Ecology. 3(2): 141-152.

Holttum, R. E. 1954. A Revised Flora of Malaya. II. Singapore: Government printing office.

Holttum, R. E. 1959. In van Steenis, C. G. G. J., and Holttum, R. E. (eds.), Flora of Malesiana Series II. I. Indonesia: Lembaga Biologi Nasional Botanic Gardens of Indonesia.

Holttum, R. E. 1970. Studies in The Family Thelypteridaceae III. A New System of Genera in The Old World. Blumea. 19(1): 17-52.

Holttum, R. E. 1981. Thelypteridaceae. In van Steenis, C. G. G. J., and Holttum, R. E. (eds.), Flora of Malesiana Series II. I. pp. 331-560. Indonesia: Lembaga Biologi Nasional Botanic Gardens of Indonesia.

Holttum, R. E. 1990. Studies in The family Thelypteridaceae IV. The genus Pronephrium Presl. Blumea. 20(1): 105-126.

Holttum, R. E. 1990. Studies in The fern-genera allied to *Tactaria.* III. Agenigmopteris and Ataxipteris, Two new genera allied to *Tactaria* Cav., with Comments on Psomiocarpa Presl. Blumea. 30(1): 1-11.

Holttum, R. E., and Hennipman, E. 1982. Lomariopsis Group. In van Steenis, C. G. G. J., and Holttum, R. E. (eds.), Flora of Malesiana Series II. I. pp. 255-330. Indonesia: Lembaga Biologi Nasional Botanic Gardens of Indonesia.

Hovenkamp, P. H. 1986. A Monograph of Fern Genus *Pyrrosia* (Polypodiaceae). Leidenh Botanical Series. 9. Leiden: E. J. Brill/Leiden University Press.

Hovenkamp, P. H. 1990. Some new names and combinations in *Pyrrosia* Mirbel (Polypodiaceae). Blumea. 30(1): 207-208.

Hovenkamp, P. H., et al. 1998. Polypodiaceae. In Kalkman, C., Saw, L. G., Kirkup, D. W., Stevens, P. F., Nooteboom, H. P., and De Wilde, W. J. J. O. (eds.), Flora Malesiana Series II, 3. pp.1-234. Netherlands: Rijksherbarium/ Hortus Botanicus.

Hurtt, G. C., and Pacala, S. W. 1995. The Consequences of Recuitment Limitation: Reconciling Chance, History, and Competitive Differences between Plants. Journal of Theoretical Biology. 176: 1-12.

Jarrett, F. M. 1985. Index Filicum: Supplementum Quintum. Oxford: Oxford University Press.

Jones, D. L., and Clemesha, S. C. 1981. Australian Ferns and Fern Allies. 2nd Edition. Singapore: Kyodo-Shing Loong.

Kamo, K., Vacharangkura, T., Tiyanon, S., Viriyabuncha, C., Nimpila, S., and Doangsrisen, B. 2002. Plant species diversity in tropcal planted forests and implication for Restoration of Forest Ecosystems in Sakaerat, Northeastern Thailand. Japan Agricultural Research Quarterly. 36(2): 111-118.

Khullar, S. P. 1994. An Illustrated Fern Flora of West Himalaya. I. India: Mohit Gahlot at Valley Offset Printers and Publishers.

Khullar, S. P. 2000. An Illustrated Fern Flora of West Himalaya. II. India: Prashant Gahlot at Valley Offset Printers and Publishers.

Kirkman, L. K., Mitchell, R. J., Helton, R. C., and Drew, M. B. 2001. Productivity and species richness across an environmental gradient in a fire-dependent ecosystem. American Journal of Botany. 88 (11): 2119-2128.

Kokjalearnsap V., Rachatasuwan N., and Patchimnan P. 1988. Mineral resources survey at National Park areas in Thong Pha Phum and Sangkhla Buri District. Economic geology report no. 43/1988, Economic geology division, Department of mineral resources. (Unpublished Manuscript)

Kramer, K. U. 1967. The Lindsaeoid ferns of The old world II. A revision of Tapeinidium. Blumea. 15(2): 545-556.

Kramer, K. U. 1971. Lindsaea group. In van Steenis, C. G. G. J., and Holttum, R. E. (eds.), Flora of Malesiana Series II. I. pp. 177-254. Indonesia: Lembaga Biologi National Botanic Gardens of Indonesia.

Kramer, K. U. 1990. The Lindseaoid ferns of The old world. V. The smaller Pacific islands. Blumea. 18(1): 157-194.

Kramer, K. U., and Green, P. S. (eds.). 1990. The Families and Genera of Vascular Plants. I. Germany: Springer-Verlag Berlin Heidelberg.

Krebs, C. J. 1998. Ecological Methodology. 2nd Edition. The United States of America: Benjamin/Cummings.

Kuo, C. 1980. Thelypteridaceae. In Li, H., Liu, T., Huang, T., Koyama, T., and Devol, C. E. (eds.), Flora of Taiwan. I. pp. 401-440. Second Edition. Taiwan: Epoch Publishing Co., Ltd.

Linder, G. R. 1990. A Monograph of The Fern Genus *Goniophlebium* (Polypodiaceae). Blumea. 18(1): 277-423.

Linnaeus, C. 1959. Species Plantarum. II. pp. 1100-1106. A Fascimile of the first edition.Great Britain: Uwin Brother Limited.

Ludwig, J. A., and Reynolds, J. F. 1988. Statistical Ecology. United States of America: John Wiley & Sons.

Magurran, A. E. 1988. Ecological Diversity and its Measurement. Great Britain: the University Press, Cambridge.

Makgomol, K. 1982. Some Ecological Characteristics of Ferns in Hill-evergreen Forest at Doi Suthep-Pui, Chiang Mai. M. Sc. M. Sc. Thesis, Department of Botany, Kasetsart University, Thailand.

Manickam, V. S. 1986. Fern Flora of the Palni Hills (South India). International Bioscience Series. 11. New Delhi: Today and Tomorrow's Printers & Publishers.

Meteorological Department. 2003. Climatological data from Thong Pha Phum Climatic Station, Kanchanaburi Province, 1973-2003. Bangkok: Data Processing Subdivision, Climatology Division, Meterological Department.

Money, D. C. 1982. Climate, Soils and Vegetation. Great Britain: Fletcher & Son Ltd.

Moreno-Peñaranda, R. (n.d.). Plant species diversity as indicator of restoration quality: The case of soil amended with sewage sludge in abandoned quarries. [Online]. Available from: http://www.desertification.it/asv/doc/AlgheroWEB/Moreno-Penaranda.html [2003, January 10]

N. S. Consultant Ltd. 1989. Environmental impact assessment (EIA) report: Patent permit no. 18/2532. Gearvanich, Pilok Subdistrict, Thong Pha Phum District, Kanchanaburi Province. (Unpublished Manuscript)

Nanakorn, V. 1994. Plant Biodiversity of Thailand. Biodiversity Meeting. Man and Nature: Lose Biodiversity Crisis and Stable Solution, 1993, December 24, Santimitri Building. Government's Residence.

Nampy, S and Madhusoodanan, P. V. 1998. Fern Flora of South India: Taxonomic Revision of Polypodioid Ferns. India: Daya Publishing House.

Nondorf, S. L., Dooley M. A., Palmieri M., and Swatzell L. J. 2003. The Effect of pH, Temperature, Light Intensity, Light Quality, and Moisture Levels on Spore Germination in *Cheilanthes feei* of Southeast Missouri: American Fern Journal. 93(2): 56-59.

Nooteboom, H. P. 1997. The Microsoroid Ferns (polypodiaceae). Blumea. 42(2): 261-396.

Nooteboom, H. P. 1998. Davalliaceae. In Kalkman, C., Saw, L. G., Kirkup, D. W., Stevens, P. F., Nooteboom, H. P., and De Wilde, W. J. J. O. (eds.), Flora Malesiana Series II, 3. pp.235-276. Netherlands: Rijksherbarium / Hortus Botanicus.

Office of Environmental Policy and Planning. 2000. Biodiversity Conservation in Thailand: A National Report. Bangkok: Ministry of Science, Technology, and Environment.

Øllgaard, B. 1990. Lycopodiaceae. In Kramer, K. U., and Green, P. S. (eds.), The Families and Genera of Vascular Plants. I, pp. 31-39. Germany: Springer-Verlag Berlin Heidelberg.

Parris, B. S., Beaman, R. S. and Beaman, J. H. 1992. The Plants of Mount Kinabalu I. Ferns and Fern allies. Great Britain: Whitstable Litho Printers.

Piggott, A. G. 1996. Fern of Malaysia in Colour. Reprinted. Malaysia: Art Printing Works.

Reddy, K. R., Hodges, H. F., McCarty, W. H., and McKinion, J. M. 1997. Weather and Cotton Growth: Present and Future. [Online] Available from http://msucares.com/pubs/bulletins/b1061.htm. [2004], February

Royal Forest, Department. (n.d.). National Park: Sai Yok, Khao Laem, Thong Pha Phum. Brochure.

Royal Institute. 2002. Thai Gazetteer. 1. Bangkok: Aroon Publisher Ltd.

Santisuk, T. 1989. Flora of Thailand: Past, Present and Future. In Wongsiri, S., and Lourlohakan, S. (eds.), Biodiversity in Thailand. pp. 81-90. Bangkok: Prachachon Publishing.

Seefeldt, S. S., and McCoy, S. D. 2003. Measuring plant diversity in the tall threetip sagebrush steppe: Influence of previous grazing management practices. Enviromental Management. 32(2): 234-245.

Seidenfaden, G. 1958. Short notes. The Natural History Bulletin of The Siam Society. 19: 84-91.

Sermolli, R. E. G. P. 1996. Authors of Scientific Names in Pteridophyta. Italy: Litografia Europa, La Spezia.

Shieh, W. 1980. Adiantaceae. In Li, H., Liu, T., Huang, T., Koyama, T., and Devol, C. E. (eds.), Flora of Taiwan. I. pp. 302-317. Second Edition. Taiwan: Epoch Publishing Co., Ltd.

Shieh, W. 1980. Lindsaeaceae. In Li, H., Liu, T., Huang, T., Koyama, T., and Devol, C. E. (eds.), Flora of Taiwan. I. pp. 259-269. Second Edition. Taiwan: Epoch Publishing Co., Ltd.

Shieh, W. 1980. Pteridaceae. In Li, H., Liu, T., Huang, T., Koyama, T., and Devol, C. E. (eds.), Flora of Taiwan. I. pp. 281-301. Second Edition. Taiwan: Epoch Publishing Co., Ltd.

Smitinand, T. 2001. Thai Plant Names. 2nd ed. Bangkok: The Forest Herbarium, Royal Forest Department.

Soil Survey, Division. 1994. The detailed reconnaissance soil survey of Kanchanaburi Province. Land Development Department. (Unpublished Manuscript)

Sudhishurnark, P. 1989. Morphologcal and Some Autecological Studies on the Genus Davallia. M. Sc. Thesis, Department of Botany, Kasetsart University, Thailand.

Tagawa, M., and Iwatsuki, K. 1979. In Smitinand, T., and Larsen K. (eds), Flora of Thailand. 3(1). Bangkok: The Tistr Press.

Tagawa, M., and Iwatsuki, K. 1985. In Smitinand, T., and Larsen K. (eds), Flora of Thailand. 3(2). Bangkok: Phonphan Printing Company, Limited.

Tagawa, M., and Iwatsuki, K. 1988. In Smitinand, T., and Larsen K. (eds), Flora of Thailand. 3(3). Bangkok: Chutima Press.

Tagawa, M., and Iwatsuki, K. 1989. In Smitinand, T., and Larsen K. (eds), Flora of Thailand. 3(4). Bangkok: Phonphan Printing Company, Limited.

Tardieu, M. L., and Christensen, C. F. A. 1939. Asplénioidées. In Humbert, H. (ed.), Flore Générale De L'Indo-Chine. Tome. VII (2e Partie), Fasc. 7. pp. 212-282. Masson et Cie, Paris: Editeurs.

Tardieu, M. L., and Christensen, C. F. A. 1939. Blechnioidées. In Humbert, H. (ed.), Flore Générale De L'Indo-Chine. Tome. VII(2e Partie), Fasc. 7. pp. 205-212. Masson et Cie, Paris: Editeurs.

Tardieu, M. L., and Christensen, C. F. A. 1939. Davallioidées. In Humbert, H. (ed.), Flore Générale De L'Indo-Chine. Tome. VII(2e Partie), Fasc. 6. pp. 103-117. Masson et Cie, Paris: Editeurs.

Tardieu, M. L., and Christensen, C. F. A. 1939. Dennstaedtioidées. In Humbert, H. (ed.), Flore Générale De L'Indo-Chine. Tome. VII (2e Partie), Fasc. 6. pp. 90-102. Masson et Cie, Paris: Editeurs.

Tardieu, M. L., and Christensen, C. F. A. 1939. Dicksoniacées. In Humbert, H. (ed.), Flore Générale De L'Indo-Chine. Tome. VII (2e Partie), Fasc. 6. pp. 77-80. Masson et Cie, Paris: Editeurs.

Tardieu, M. L., and Christensen, C. F. A. 1939. Dryoptéridées. In Humbert, H. (ed.), Flore Générale De L'Indo-Chine. Tome. VII (2e Partie), Fasc. 7. pp. 297-442. Masson et Cie, Paris: Editeurs.

Tardieu, M. L., and Christensen, C. F. A. 1939. Gleichéniacées. In Humbert, H. (ed.), Flore Générale De L'Indo-Chine. Tome. VII (2e Partie), Fasc. 6. pp. 44-51. Masson et Cie, Paris: Editeurs.

Tardieu, M. L., and Christensen, C. F. A. 1939. Gymnogrammèoidées. In Humbert, H. (ed.), Flore Générale De L'Indo-Chine. Tome. VII (2e Partie), Fasc. 7. pp. 166-196. Masson et Cie, Paris: Editeurs.

Tardieu, M. L., and Christensen, C. F. A. 1939. Lindsayoidées. In Humbert, H. (ed.), Flore Générale De L'Indo-Chine. Tome. VII (2e Partie), Fasc. 6. pp. 118-135. Masson et Cie, Paris: Editeurs.

Tardieu, M. L., and Christensen, C. F. A. 1939. Polypodioïdées-Chaetopteridées. In Humbert, H. (ed.), Flore Générale De L'Indo-Chine. Tome. VII (2e Partie), Fasc. 7. pp. 443-538. Masson et Cie, Paris: Editeurs.

Tardieu, M. L., and Christensen, C. F. A. 1939. Ptéridoïdées. In Humbert, H. (ed.), Flore Générale De L'Indo-Chine. Tome. VII (2e Partie), Fasc. 6-7. pp. 135-165. Masson et Cie, Paris: Editeurs.

Tardieu, M. L., and Christensen, C. F. A. 1939. Schizaeacées. In Humbert, H. (ed.), Flore Générale De L'Indo-Chine. Tome. VII (2e Partie), Fasc. 6. pp. 33-43. Masson et Cie, Paris: Editeurs.

The Missouri Botanical Garden. W3TROPICOS [Online] (n.d.). Available from: http://www.mobot.org/welcome.html [2004, March 22].

Thommathawan, S., and Thommathawan, A. 1983. A Survey of the Sunny Ferns on Phu Kradung. Department of Biology, Khon Kaen University, Thailand.

Tuleewan, A. 2000. Edge of Thailand at Pilok Mine. In Thipanan, S. (ed.), Advanced Thailand Geographic. pp. 128-147. Bangkok: Rungrueng Printing Ltd.

Vannasri, O. 2002. Diversity of Ferns and Fern Allies in Natural Forest and Natural Gas Pipeline in Thong Pha Phum District, Kanchanaburi Province. M. Sc. Thesis, Department of Botany, Chulalongkorn University, Thailand.

Whittaker, R. H. 1970. Communities and Ecosystems. New York: The Macmillan Company.

Wilson, E. O. (ed.). 1988. Biodiversity. The United States of America: National Academy Press.

Yuyen, Y. 2000. Taxonomic Study of Ferns and Fern Allies at Huaiyang Waterfall National Park, Prachuap Khiri Khun Province. M. Sc. Thesis, Department of Botany, Chulalongkorn University, Thailand.

BIOGRAPHY

Miss Apirada Sathapattayanon was born on December 22nd, 1979, in Nonthaburi Province. She was graduated in Bachelor degree of Biology, Faculty of Science, Srinakharinwirot University in 2000. Then, she continued her study for Master of Science in Botany at Department of Botany, Faculty of Science, Chulalongkorn University from 2001-2003.