TAXONOMIC REVISION OF THE FERN FAMILY ATHYRIACEAE IN THAILAND

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การทบทวนอนุกรมวิธานของเฟิร์นวงศ์ ATHYRIACEAE ในประเทศไทย

นายพุทธมน ผ่องกาย

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรดุษฎีบัณฑิต
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พุทธมน ผ่องกาย : การทบทวนอนุกรมวิธานของเฟิร์นวงศ์ ATHYRIACEAE ในประเทศไทย. (TAXONOMIC REVISION OF THE FERN FAMILY ATHYRIACEAE IN THAILAND) อ.ที่ปรึกษาหลัก : ผศ. ดร.รสริน พลวัฒน์, อ.ที่ปรึกษาร่วม : ศ. ดร.ทวีศักดิ์ บุญเกิด,ดร.หลี่ปิง จาง

ข้อมูลล่าสุดของวงศ์ Athyriaceae ในหนังสือพรรณพฤกษชาติของประเทศไทยประกอบด้วย 7 สกุล คือ *Athyrium, Anisocampium, Cornopteris, Deparia, Diplazium, Hypodematium* และ *Kuniwatsukia* ที่ผ่านมาการศึกษาความสัมพันธ์ทางอนุกรมวิธานระหว่างสกุลพบว่ายังไม่มีความชัดเจน และยังไม่เข้าใจอย่างถ่องแท้ รูปวิธาน และคำบรรยายลักษณะที่มีอยู่ยังมีความคลุมเครือ และไม่ครอบคลุมบางหน่วยอนุกรมวิธานที่ยังไม่รู้จัก งานวิจัยนี้มีวัตถุประสงค์เพื่อที่จะแก้ไขสถานะทางอนุกรมวิธานของวงศ์และสกุล โดยใช้ข้อมูลทางสัณฐานวิทยา กายวิภาคศาสตร์ เรณูวิทยา และข้อมูลเชิงโมเลกุล ผลการศึกษาแสดงให้เห็นว่า ชนิดและรูปร่างของใบ ชนิดของเกล็ด รูปร่างของกลุ่มอับสปอร์ รูปร่างของมัดท่อลำเลียง และลวดลายของสปอร์ เป็นลักษณะที่สามารถใช้จัดจำแนกในระดับสกุล และระดับชนิดได้อย่างดี ซึ่งผลการศึกษาทางโมเลกุลนั้นสอดคล้องกับการศึกษาด้านนี้ที่ผ่านมาแล้วกล่าวคือวงศ์ Athyriaceae ประกอบด้วย 5 สกุลคือ สกุล *Athyrium, Anisocampium, Cornopteris, Deparia,* และ*Diplazium* สำหรับสกุล *Kuniwatsukia* นั้นได้ถูกขุบรวมกับสกุล *Anisocampium* นอกจากนี้สกุล *Hypodematium* ได้ถูกแยกออกจากวงศ์ Athyriaceae โดยสรุปวงศ์ Athyriaceae มีจำนวน 47 ชนิด และสกุล *Hypodematium* มีจำนวน 4 ชนิด ซึ่งในจำนวนนี้ 2 ชนิดเป็นชนิดใหม่ของโลก คือ *Hypodematium boonkerdii* Pongkai, Li Bing Zhang & Pollawatn และ *Diplazium thailandicum* Pongkai, Boonkerd & Pollawatn ซึ่งได้ตีพิมพ์แล้ว การศึกษาครั้งนี้พบชนิดที่มีรายงานครั้งแรกในประเทศไทย จำนวน 8 ชนิด คือ *Anisocampium niponicum* (Mett.) Hance., *Athyrium biserrulatum* Christ, *A. brevisorum* (Wall. ex Hook.) T. Moore, *A. pachyphyllum* Ching, *A. wangii* Ching, *Diplazium bellum* (C. B. Clarke) Bir, *D. pallidum* (Blume) T. Moore and *D. procumbens* Holttum ได้ทำการเลือกตัวอย่างพันธุ์ไม้ต้นแบบของเฟิร์น 2 ชนิด คือ *D. bellum* (C. B. Clarke) Bir. และ *D. petelotii* Tardieu และได้จัดให้ *Diplazium axillare* Ching เป็นชื่อพ้องของ *D. bellum* (C.B. Clarke) Bir รูปวิธานจำแนกสกุลและชนิดได้จัดทำขึ้นใหม่ พร้อมกับคำบรรยายลักษณะภาพวาดลายเส้นและข้อมูลการกระจายพันธ์ของแต่ละชนิด

สาขาวิชา พฤกษศาสตร์
ปีการศึกษา 2561

ลายมือชื่อนิสิต .....
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TAXONOMIC REVISION OF THE FERN FAMILY ATHYRIACEAE IN THAILAND. Advisor: Asst. Prof. Rossarin Pollawatn, Ph.D. Co-advisor: Prof. Thaweesakdi Boonkerd, Ph.D., Libing Zhang, Ph.D.

The most up-to-date account of the Athyriaceae is in Flora of Thailand. This account includes seven genera, i.e. *Athyrium*, *Anisocampium*, *Cornopteris*, *Deparia*, *Diplazium*, *Hypodematium* and *Kuniwatsukia*. Previously, the taxonomic relationships among genera were ambiguous and not well understood. The existing keys and descriptions are uncertain and do not include some unknown taxa. This research aims to clarify the taxonomic status of this family and its genera based on morphological, anatomical, palynological and molecular data. The results indicated that the types and shapes of frond, scale types, sorus shapes, shapes of vascular bundle and ornamentation of spores are valuable characters for genus and species determination. The molecular results are congruent with other previous results that the Athyriaceae consisted of 5 genera, i.e. *Athyrium*, *Anisocampium*, *Cornopteris*, *Deparia* and *Diplazium*. The genus *Kuniwatsukia* was merged with *Anisocampium* and the genus *Hypodematium* was excluded from the Athyriaceae. In all, forty seven species of athyriaceous fern and four species of *Hypodematium* were recognized. Of these, two new species, namely *Hypodematium boonkerdii* Pongkai, Li Bing Zhang & Pollawatn and *Diplazium thailandicum* Pongkai, Boonkerd & Pollawatn were published. Eight new records were reported, i.e. *Anisocampium niponicum* (Mett.) Hance., *Athyrium biserrulatum* Christ, *A. brevisorum* (Wall. ex Hook.) T. Moore, *A. pachyphyllum* Ching, *A. wangii* Ching, *Diplazium bellum* (C.B. Clarke) Bir, *D. pallidum* (Blume) T. Moore and *D. procumbens* Holttum. The name: *D. bellum* (C.B. Clarke) Bir. and *D. petelotii* Tardieu are lectotypified. *Diplazium axillare* Ching was considered a synonym of *D. bellum* (C.B. Clarke) Bir. Key to the genera and key to the species were re-constructed, together with descriptions, line drawings and distribution.

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Puttamon Pongkai

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LIST OF ABBREVIATION

B	The herbarium of the Botanic Garden and Botanical Museum Berlin-Dahlem, Berlin, Germany
BCU	Professor Kasin Suvatanhandhu Herbarium, Department of Botany, Chulalongkorn University, Bangkok, Thailand
BK	Herbarium, Botanical Section, Department of Agriculture, Bangkok, Forest Herbarium, Thailand
BKF	National Park, Wildlife and Plant Conservation Department, Bangkok, Thailand
BM	British Natural History Museum Herbarium, England
CMUB	Herbarium, Department of Biology, Chiang Mai University, Chiang Mai, Thailand
K	Royal Botanic Gardens, Kew Herbarium, England
KUN	Herbarium of Kunming Institute of Botany, the Chinese Academy of Sciences, Yunan, China
L	National Herbarium Netherland University of Leiden branch, The Netherlands
P	Muséum national d'Histoire naturelle, Paris, France
PE	The Herbarium, Institute of Botany, the Chinese Academy of Sciences, Beijing, China
QBG	Queen Sirikit Botanic Garden, Herbarium, Thailand
SING	Singapore Botanic Gardens, Singapore

CHAPTERI
INTRODUCTION

Athyriaceae is one of the large families of Pteridophytes, which includes more than 600 species worldwide (Zhongren *et al.*, 2013) It is a family of medium to large terrestrial ferns that have creeping or erect rhizome covering with brown entire or toothed margin scales. Fronds are variously dissected, simple to tripinnate. Stipes bearing groove that may or may not extend to rachis, costa, and costule. The vascular bundle inside stipes are two separated vascular strand that usually unite upward forming a single gutter-shaped. Veins are free or anastomosing that reached to margin of it segment. Sori are various: round-reniform, J-shaped, oblong or elongate along veinltes which were covered by indusium or not.

At present, many species in Thailand were threatened by human activities. They are likely to be extinct in the wild due to over-harvesting. For example, *Diplazium esculentum* (Retz.) Sw. is the most popular fern used as food in S.E. Asia. It is usually collected from nature for consumption as a vegetable, while *D. cordifolium* and *D. tomentisum* were collected for ornamental plants. Thus, Thai Athyriaceous ferns must be studied to gain knowledges for conservation and management. In Thailand, 40 species were previously recognized within 7 genera, i.e. *Athyrium*, *Anisocampium*, *Cornopteris*, *Deparia*, *Diplazium*, *Hypodematium* and *Kuniwatsukia* in Flora of Thailand by Tagawa and Iwatsuki (1988). Recently, the new classification was proposed by (Rothfels *et al.*, 2012) recognized 5 genera, i.e. *Athyrium*, *Anisocampium*, *Cornopteris*, *Deparia* and *Diplazium* in the family (Adjie *et al.*, 2008; Liu *et al.*, 2011)while the genus *Hypodematium* was raised to its own family, Hypodermatiaceae. Moreover, taxonomic status of some Athyriaceous species have been changed, i.e. *Diplazium subsinuatum* was moved to the genus *Deparia* (Sano *et al.*, 2000) and *Athyrium niponicum* was recognized as *Anisocampium niponicum* (Adjie *et al.*, 2008; Liu *et al.*, 2011). PPG I (2016) was proposed classification for extant lycophytes and ferns based on molecular evidence. They recognized Athyriaceae which consist of 3 genera, i.e. *Athyrium* (includes *Anisocampium* and *Cornopteris*), *Deparia* and *Diplazium*. However, Wei *et al.* (2018) treat *Anisocampium* and *Cornopteris* as separate genera.

In addition, many Thai specimens could not be determined to species using key from the Flora of Thailand (Tagawa and Iwatsuki, 1988). Up to now, taxonomic status and boundary of some species in Thailand are still unclear due to status of some species were changed and descriptions together with keys characters are also inaccurate. Thus, it can be seen that Athyriaceae is a poorly understood family, and waiting for intensive investigations. Additional field works in Thailand, together with study of all dried specimens of Thai Athyriaceous species in all herbaria are required to obtain important diagnostic characters that can be further used for taxonomic revision of the family Athyriaceae. Therefore, this research aims to clarify taxonomic status of the Athyriaceous ferns in Thailand based on morphological, anatomical, palynological and molecular data. It is presumed that the result of this research can provide a complete account of the family and clarify taxonomic boundaries of the Thai Athyriaceae. Moreover, the knowledge gained from this study will be useful for sustainable management and conservation of Thai Athyriaceous species, especially rare, endemic or endangered species.

CHAPTER II
LITERATURE REVIEW

2.1 Taxonomic history

Athyriaceae was established in 1956, including 7 genera, i.e. *Athyrium* L., *Cheilanthopsis* Hieron., *Cystopteris* Bernh., *Diplazium* Sw., *Matteucia* Tod., *Stenolepia* v. A. v. R., and *Woodsia* R. Br. (Alston, 1956) but the genus *Woodsia* was formerly included in the family Woodsiaceae and being a type genus (Heter, 1949). Therefore, the name Athyriaceae Alston is redundant and illegitimate name. Afterwards, (Ching, 1978) systematized the family and genera of Chinese ferns which included Athyriaceae. He recognized 19 genera but not included the genus *Woodsia* in Athyriaceae sensu Alston. Nevertheless, (Panigrahi, 1986) proposed a proposal to conserve Athyriaceae Alston. He accepted Athyriaceae sensu Alston, because the publication of the family based on the legitimate generic name *Athyrium* Roth. He transferred the genus *Woodsia* (type genus of Woodsiaceae) from Athyriaceae to the Woodsiaceae Then, status of Athyriaceae returned correct. Recently, the classification of the family Athyriaceae has been recognized in both Athyriaceae and Woodsiaceae depend on authors. For example, Smith *et al.* (2006) they propose a classification for extant fern base on both morphological and molecular evidences. They recognized 37 families including family Woodsiaceae which consisted of 15 genera including the genus *Athyrium*. Christenhusz *et al.* (2011) separated the family Athyriaceae from Woodsiaceae sensu Smith, they recognize family the Athyriaceae which consisted of 5 genera, i.e. *Anisocampium*, *Athyrium*, *Cornopteris*, *Deparia* and *Diplazium*. However, genus *Kuniwatsukia* was sunk in *Anisocampium* while genus *Hypodematium* was raised to its own family, Hypodermatiaceae. The classification was proposed by Rothfels *et al.* (2012), they revised classification of Smith *et al.* (2006). They recognized both Athyriaceae and Woodsiaceae as separate family. Nowadays, the currently fern was proposed by PPG I (2016) they recognized Athyriaceae which consist of 3 genera, i.e. *Athyrium*, *Deparia* and *Diplazium*. However, *Anisocampium* and *Cornopteris* were included in *Athyrium*. Afterwards, Wei *et al.* (2018) published the phylogeny of the lady fern genus *Athyrium* Roth based

on morphological characters and molecular data. They treat *Anisocampium* and *Cornopteris* as separate genera.

In Thailand, Tagawa and Iwatsuki (1988) enumerated 121 genera and 630 species of Thai pteridophytes. Seven genera, i.e. *Athyrium*, *Anisocampium*, *Cornopteris*, *Deparia*, *Diplazium*, *Hypodematium* and *Kuniwatsukia* were recognized as members of family Athyriaceae. However, they noted that the generic classification of the family is still unclear and need further study, moreover some species have to be revised. At present, the genus *Hypodematium* and genus *Kuniwatsukia* in Thailand were included in Athyriaceae sensu Tagawa and Iwatsuki (1988). Moreover, taxonomic status of some Athyriaceous species have been changed. *Diplazium subsinuatum* was moved to the genus *Deparia* (Sano *et al.*, 2000) and *Athyrium niponicum* was moved to the genus *Anisocampium* (Liu *et al.*, 2011) base on both morphological and molecular evidences. Thus, taxonomic account of Thai Athyriaceae is not up-to-date, it should be revised in all taxonomic aspects. For this reason, surveys and preliminary study of some specimens of Athyriaceous ferns were done, it was found that many unknown specimens could not be determined to species using key from the Flora of Thailand. This taxonomic problem probably due to species member of the genus *Athyrium* and *Diplazium* are greatly varied in size and shape of frond. Likewise, fertile fronds can be found from both mature and immature plants of some *Diplazium* species, and made some confusion in identification (Kato and Kramer, 1990). It can be seen that taxonomic account of Thai Athyriaceous ferns are incomplete and remained unclear. Accordingly, it's necessary to perform a taxonomic revision of this fern family in Thailand.

As mentioned above, taxonomic account of Thai Athyriaceae is still unclear and need intensive investigations. Additional field works in Thailand are really needed to collect the whole existing species and covered all morphological variations to clarify the status and boundary of taxa in this fern family. Therefore, this research aims to revise and clarify taxonomic status of the Athyriaceous ferns in Thailand based on morphological, anatomical, palynological and molecular data. It is presumed that the result of this research can provide a complete account of the family and clarify taxonomic boundaries of the Thai Athyriaceae. Moreover, the knowledge

gained from this study were useful for sustainable management and conservation of Thai Athyriaceous species, especially rare, endemic or endangered species.

2.2 Taxonomic history of each genus

2.2.1 *Anisocampium*

The genus was described by Presl (1851) based on a single species, i.e. *A. cumingianum* C. Presl. Later, *Nephrodium sheareri* was transferred to *Anisocampium* then the genus consisted of two species: *A. cumingianum* C. Presl and *A. sheareri* (Baker) Ching (Yintang, 1985). However, Kato and Kramer (1990) treated *Anisocampium* and *Kuniwatsukia* as synonyms of *Athyrium*. Liu *et al.* (2011) studied molecular phylogeny and taxonomy of the genus *Anisocampium* and its related genera. They merged the genus *Kuniwatsukia* with the genus *Anisocampium* and then recognized *Athyrium niponicum* (Mett.) Hance as *Anisocampium niponicum* (Mett.) Y. C. Liu, W. L. Chiou & M. Kato. Now, the genus *Anisocampium* sensu Liu *et al.* (2011) consists of 4 species i.e. *A. cumingianum* C. Presl, *A. cuspidatum* (Bedd.) Y. C. Liu, W. L. Chiou & M. Kato, *A. niponicum* (Mett.) Y.C. Liu, W.L. Chiou & M. Kato and *A. sheareri* (Baker) Ching. However, they have summarized that they did not find any unique diagnostic characters to delimit *Anisocampium*. Rothfels *et al.* (2012) also recognized the genus sensu Liu *et al.* (2011), however, later *Anisocampium* was included in *Athyrium* by PPG I (2016). At present, Wei *et al.* (2018) treated the genus *Anisocampium* as a separated genus again.

Due to the genus *Kuniwatsukia* which was included in *Anisocampium* (Liu *et al.*, 2011), for this study we recognized *Kuniwatsukia* within *Anisocampium* and recognized *Kuniwatsukia cuspidatum* as *Anisocampium cuispidatum* for all method of this study.

2.2.2 *Athyrium*

The genus *Athyrium* Roth was published by Albrecht Wilhelm Roth (1800). The genus *Athyrium* and allied genera were recognized as only one genus *Athyrium* by some authors such as (Copeland, 1908; 1947) and (Holttum, 1947; 1954). Whereas, some workers separated in to several genera at different times (Ching, 1940; Alston, 1956; Sledge, 1962; Holttum, 1968). The genus *Athyrium* was usually recognized with included genus *Diplazium* (Holttum, 1954; 1968), however, it can be

separated by a combination of characters, i.e. scale, sori, shape of pinnae and pinnule and also chromosome number (Manton, 1950; Zhongren *et al.*, 2013). Holttum (1958) distinguished *Dryoathyrium* from Athyrium, however, *Kuniwatsukia*, *Pseudoathyrium* and *Pseudocystoteris* were included in Athyriaceae (Kato, 1977). Later, Tagawa and Iwatsuki (1988) recognized *Athyrium* and *Kuniwatsukia* as separated genera. PPG I (2016) treated *Anisocampium*, *Cornopteris*, *Kuniwatsukia*, *Neoathyrium* and *Pseudocystoteris* to include in *Athyrium*. Recently, the genus *Pseudocystoteris* still included in Athyrium, however, *Anisocampium* and *Cornopteris* were separated from Athyrium.

2.2.3 *Cornopteris*

The Genus *Cornopteris* was published by Takenoshin Nakai (1930) based on *C. decurrenti-alata* (Hook.) Nakai. The genus was characterized by the corniculate at base of pinnae and pinnules and exindusiate sori. Ching (1945) added the opposite arrangement of pinnae and the presence of spine at the base of costules as diagnostic characters of the genus. However, the genus has often been reduced to a synonym of *Athyrium*, *Diplazium* or *Deparia* (Kato, 1979). Ching and Wang (1982) published new genus, *Neoathyrium* Ching and Z.R. Wang based on *C. crenulatoserrulatum* (Makino) Ching & Z.R. Wang. Later, Kato (1986) sunk *Neoathyrium* into *Cornopteris*. At present, the genus *Cornopteris* was recognized as a genus in the Athyriaceae (Kato, 1979; Rothfels *et al.*, 2012; Christenhusz and Chase, 2014).

2.2.4 *Deparia*

The genus *Deparia* Hook. & Grev. was published by Hooker and Greville (1830) based on *D. macrae* Hook. & Grev. Ching (1954) proposed the genus *Dryoathyrium* with in Athyriaceae. Moreover, he separated some genera out of the genus *Athyrium* sensu Copeland (1947), i.e. *Lunathyrium* and *Athyriopsis* which were characterised by an erect rhizome, spore with broadly winged perispore and a creeping rhizome, spore with verrucose perine respectively (Ching, 1964). Bir (1973) treated *Lunathyrium* as a subgenus of *Athyrium*. Moreover, later *Athyriopsis* was also included in *Lunathyrium* (Sledge, 1962; Ohaba, 1965). Kato (1977) recognized the genus *Deparia* with including 4 sections, i.e. *Athyriopsis*, *Lunathyrium*, *Deparia* and *Dryoathyrium*. Later, Smith *et al.* (2006) recognized only genus *Deparia* which

included Kato (1977) sections. At present, the genus *Deparia* was recognized as a genus in Athyriaceae which included any previous genera and treated them as a synonyms (Rothfels *et al.*, 2012; PPG I, 2016).

2.2.5 *Diplazium*

The genus *Diplazium* Sw. was firstly described by Olof Peter Swartz (1800) containing 2 species, i.e. *D. plantagineum* (L.) Sw. and *D. grandifolium* (Sw.) Sw. (Swartz, 1800). The generic boundary between *Diplazium* and *Asplenium* in the past is not very clear. Moore (1930) maintained *Diplazium* as separate genera, and included all species which produced twin sori with this genus. However, the status of *Diplazium* as a separate genus was still problematic. Some taxonomist transfered *Diplazium* to *Athyrium* Roth while some authors maintained them as separate genera. Beddome (1892) also recognized *Diplazium* as a separate genus based on the difference in sori shape of *Athyrium* which having reniform or round sori. Copeland (1908) merged *Diplazium* to the *Athyrium*, however, Holttum (1960) noticed that *Diplazium* and *Athyrium* in Malaya are quite distinct. Later Holttum (1968) proposed that the genus *Diplazium* should be kept because the chromosome number of the two genera were constantly different. Ching (1964) transferred some species of *Diplazium* to *Allantodia* R. Br., most of them do not have distinct terminal pinna. However, most authors accept only the genus *Diplazium* and do not recognize any of the sattelite genera, for example, *Allantodia*, *Dictyodroma*, *Rhachidosorus* and *Athyriopsis* etc. (Kato, 1977; Tagawa and Iwatsuki, 1988; Iwatsuki, 1992; Shieh *et al.*, 1997; Khullar, 2000).

2.2.6 *Hypodematium*

The genus *Hypodematium* Kunze was firstly published by Gustav Kunze (1833) based on *H. onustum* Kunze. Then, Copeland (1947) placed the genus to Aspidiaceae, however, Holttum (1958) and Sledge (1977) placed *Hypodematium* in the Dryopteridaceae. Holttum (1954) recognized the genus in Denstaedtiaceae, while, Ching (1963) recognized it in Thelypteridaceae. Moreover, *Hypodematium* was placed in Athyriaceae by Iwatsuki (1964). The genus *Hypodematium* was first raised to its own family, Hypodematiaceae by Ching (1975), whereas, Tagawa and Iwatsuki (1988) they agree with Iwatsuki (1964) that placed it in Athyriaceae. Afterwards,

Kramer (1990) and Smith *et al.* (2006) placed the genus back to the Dryopteridaceae. Later, Christenhusz and Chase (2014) recognized *Hypodematium* which included in Polypodiaceae, however, the newly classification was proposed by PPG I (2016) they separated and raised *Hypodematium* to its own family, Hypodematiaceae again.

2.3 Methodological reviews

Plant morphology is a field of study relating to the external and gross internal structure of plant organ. It originally developed as a descriptive science to recognize and distinguish the diversity of plants (Krings, 2013). Morphology forms the basis of taxonomy which is the basis of taxonomic description and generally constitutes the most important data in delimiting and circumscribing taxa. It's often used for classification in every group of plant (Simpson, 2010). In pteridophyte, many important morphological characters, e.g. rhizome, frond, stipe, sori, scale, hair and spore, etc. are useful for classification and identification, especially shape and position of sorus and indusium. For example, fern with round sori and is not protected by an indusium belong to the genus *Polypodium* whereas, the fern with elongate sori and covered with indusia on both side of veinlet belong to the genus *Diplazium* (Holttum, 1960).

Holttum (1960) pointed out the important of scales which are good characteristics for each species and can be used in species determination. Furthermore, Hovenkamp (1986) published a monograph of the fern genus *Pyrrosia*. He mentioned that scales at stipe or rhizome of the *Pyrrosia* species are highly variable in shape and colour. It can be divided into 3 types, i.e. basifix scale, pseudopeltate scale and peltate scale which provide many taxonomically useful characters for species determination as well as for key constructions.

Ohta and Takamiya (1999) investigated morphological and cytological characters of *Diplazium mettenianum* complex (Athyriaceae). They analyzed 20 qualitative morphological characters from 374 plants, the result showed that the complex could be divided into five forms. Moreover, the statistical analysis of 16 quantitative morphological characters were supported the distinction of five forms which were regarded as independent species, namely *D. mettenianum*, *D. fauriei*, *D. deciduum*, *D. griffithii* and *D. hayatamae*. In addition, Petchsri *et al.* (2012) revised *Microsorum punctatum* (L.) Copel. complex (Polypodiaceae) by investigate

morphological and anatomical characters of more than 1,500 specimens. The results showed that *M. punctatum* complex comprised of eight taxa namely *M. siamense*, *M. thailandicum*, *M. membranaceum*, *M. musifolium*, *M. punctatum*, *M. glossophyllum*, *M. steerei* and *M. whiteheadii*. The six most important characters that separate these eight taxa are stipe length, number of sori rows between adjacent secondary veins, sori diameter, sori density, primary-areole width and spore width. Moreover, these characters were useful in constructing an identification key to these taxa.

The anatomical characters is important and beneficial to fern taxonomy, it can be used to resolve a problem of relationships among taxa (White, 1974; Hernandez *et al.*, 2012). However, the vascular bundle of the stipe is variable in form and size. Some families, genera or species have distinct characters of vascular bundles and can be used in determination of the species (Ogura, 1972). Lin and Devol (1977) studied stipe anatomy of ferns in Taiwan that belonged to 22 families, 80 genera and 170 species. They found that anatomical data are useful in constructing multiple-choice key to the genera and families.

Palynology is the study of pollen and spores (Hyde and Williams, 1994). Previously, fern spores have actually been objects of study for over a century (Warren and Wagner, 2013) because spores have a number of morphological and ultrastructural features. These features have provided a set of characters that are important for fern taxonomy. The features of spores can often be used to identify a particular plant taxon (Simpson, 2010). In addition, fern spores are becoming increasingly important in fern taxonomy. They have been used successfully to distinguish species in some genera, to differentiate genera and characterize families because they have as much diagnostic value as scales and hairs (Brown, 1960). Liu *et al.* (2000) studied spores of fifty-six Athyrioids fern species in Taiwan. Spores were examined under scanning electron microscope (SEM). The result showed that spores ornamentation of Athyrioids ferns can be divided into three types, i.e. bulliform, muriform and steliform which polymorphic and basically species-specific. Moreover, Salimpour *et al.* (2011) examined spore morphology of the fern family Pteridaceae in Iran. The spores of nine species in five genera were examined under SEM. The five different ornamentation types were observed. Based on these results, the identification key was constructed. Afterwards, Mazooji and Salimpour (2014) studied spore

morphology of 34 species of fern from northern region of Iran. They found that the ornamentation of spores can be divided into six types. From these result they had constructed the identification key by using spore characters.

Molecular data is being used to refine the classification of ferns and to further define the relationship between them. Molecular data can reinforce what has previously been established from morphology and other investigations. However, some scientists find that the molecular data may be not appropriate and suggests that further work need to be done (Perrie, 2014). Recently, the molecular technique is being used to confirm species classification, as well as to determine how closely related of different species. It allows detailed analysis that can reveal information about the evolution and the relationships of different species (Perrie, 2014). Moreover, molecular data is also extensively used for clarifying the related taxa. For example, Sano *et al.* (2000) investigated phylogenetic analysis of *rbcL* nucleotide sequence from the ferns genera, *Deparia* and *Diplazium* (Athyriaceae). The total DNA from 14 species of *Deparia* and 12 species of *Diplazium* were extracted, amplified the *rbcL* gene by PCR method, sequencing and the phylogenetic analysis were performed. From the result of this study, they moved 2 fern species in *Diplazium,* i.e. *D. subsinuatum* and *D. tomitaroanum* to the genus *Deparia*. Moreover, Liu *et al.* (2011) studied molecular phylogeny and taxonomy of the genus *Anisocampium* (Athyriaceae). Twenty species were sampled, total genomic DNA were extracted, 2 plastid genome regions (*rbcL*, *trnL-trnF*) were amplified and phylogenetic were constructed. From their results, they redefined the genus *Anisocampium* which is separated from *Athyrium* s. str. to include *An. cuspidatum* (*Kuniwatsukia cuspidata*) and *An. niponicum* (*Athyrium niponicum*), and separated the genus from *Athyrium* and *Cornopteris*. They also reduced *An. paucijugum* to a synonym of *Athyrium cumingianum*. In addition, Wei *et al.* (2013) studied molecular phylogeny and morphology of the fern genus *Diplazium* (Athyriaceae). Seven plastid genomic regions i.e. *atpA*, *atpB*, *matK*, *rbcL*, *rps4*, *rps4-trnS* and *trnL-trnF* regions were used. From their results, they proposed infrageneric classification by introduce four new subgenera of *Diplazium* (subgenus *Callipteris*, *Diplazium*, *Pseudallantodia* and *Sibrica*).

As mentioned above, it can be concluded that morphological characters, anatomical characters, palynological characters and molecular data are commonly applied to solve taxonomic problems of pteridophytes. Thus, these mentioned data are appropriate use as a basis to solve taxonomic problems of the fern family Athyriaceae in Thailand.

CHAPTER III
MATERIALS AND METHODS

Related taxonomic literatures of the fern family Athyriaceae were studied for taxonomic history, taxonomic problems, number of species, distribution, etc. Herbarium specimens of Athyriaceae sensu Tagawa and Iwatsuki (1988) and Liu *et al.* (2011) was studied which included *Anisocampium*, *Athyrium*, *Cornopteris*, *Deparia*, *Diplazium* and *Hypodematium*. Specimens which were deposited at main Thai herbaria, i.e. the Professor Kasin Suvatabhundu Herbarium, Department of Botany, Chulalongkorn University (BCU), Bangkok Herbarium, Botanical section, Department of Agriculture (BK), The Forest Herbarium, National Park, Wildlife and Plant Conservation Department (BKF) and The Queen Sirikit Botanic Garden (QBG) were examined by observing morphological characters and locality and habitat of each specimen were collected.

3.1 Field explorations and collection specimens

Fern specimens were collected from various localities in all season, at least ten times a year, covering all seven floristic regions throughout Thailand (Tagawa and Iwatsuki, 1988). Three specimens from each population (except rare species) were collected, photographs were taken, GPS were marked, habitats and ecology of living specimens were noted. Pressing and drying herbarium specimens were prepared according to Forman and Bridson (1991) ad Simpson (2010). In addition, stipes and pinnules were collected for anatomical and molecular studies.

3.2 Identification of specimens

Specimens were determined to species using available taxonomic keys and other related taxonomic literatures, e.g. Flora of Thailand (Tagawa and Iwatsuki, 1988), Flora of China (Wang *et al.*, 2013), Flora of Taiwan (Shieh *et al.*, 1997), Flora of Malaya (Holttum, 1960), etc.

Specimens of each species were examined and compared with known and type specimens deposited at The Professor Kasin Suvatabhundhu Herbarium, Department of Botany, Chulalongkorn University (BCU); Bangkok Herbarium, Botanical section, Department of Agriculture (BK); The Forest Herbarium, National Park, Wildlife and

Plant Conservation Department (BKF); Queen Sirikit Botanic Gardens Herbarium (QBG); Chiang Mai University Herbarium (CMU), Khon Khan University Herbarium (KKU) and Prince of Songkhla University Herbarium (PSU). Moreover, herbarium specimens kept at the main herbaria in Europe and Asia, e.g. The Natural History Museum (BM); the Royal Botanic Garden, Kew (K); Kunming Institute of Botany Herbarium (KUN); National Herbarium Netherlands, Leiden University (L); Muséum National d'Histoire Naturelle, Herbier National de Paris (P); Institute of Botany, Chinese Academy of Science Herbarium (PE) and Singapore Botanic Gardens (SING), etc. were also be examined.

3.3 Morphological study

3.3.1 Materials

Athyriaceae sensu Tagawa and Iwatsuki (1988) and Liu *et al.* (2011) were examined. At least 20 characters from vegetative and reproductive parts were investigated for both qualitative and quantitative characters using a stereomicroscope or a light microscope. Qualitative characters including: rhizome type, stipe surface, frond type, frond shape, venation pattern, scale shape, scale color, scale margin, sori shape and indusium shape, etc. and quantitative characters included diameter of rhizome, length of frond, length of blade, width of blade, length of stipe, diameter of stipe, number of lateral pinnae, length of scale, width of scale and length of sori, etc.

3.4 Anatomical study

3.4.1 Anatomy of stipe

3.4.1.1 Materials

Stipes of each species were cut using an Automatic MT-3 microtome (Toyozumi Dengenkiki co., Ltd.) at 80-150 μm thickness without embedding. The transverse sections of upper portion were stained by safranin O for 5-10 minutes and then observed under light microscope. The light micrographs were taken using Nikon *Eclipse E200* microscope equipped with a digital camera.

3.4.2 Epidermal characters

3.4.2.1 Materials

Epidermal study of leaves were focused on stomatal types. Specimens were prepared using a modified Tahir and Rajput (1986) method. Fertile fronds of each species were cut in to small pieces, approximately 5 mm by 5 mm. Then, epidermal

peels were taken using fine point forceps, placed the epidermal peels on the slide and covered with cover glass. Stomatal types were observed under Light microscope (LM). Terminology of stomatal types followed Sen and Hennipman (1981) and Sen and De (1992).

3.5 Palynological study

3.5.1 Materials

Specimens of each species were used for spore morphological study. Un-acetolysed spores were examined by scanning electron microscope (SEM), model JEOL JSM-5410 LV and light microscope, model Olympus CH 30. The SEM micrographs were taken with 1,500 to 3,500 magnification at 15 kV. The spore morphological observations were focused on shape, size and wall ornamentation. Spore size were measured in L× P (L = length of spore, P = width of spore). The terminology of spore ornamentation were followed Huang (1981), Tryon and Lugardon (1990) and Punt (2007).

3.6 Molecular study

3.6.1 Materials

Taxa for molecular work were listed in (Appendix III). Total genomic DNA were extracted from silica-gel dried specimens that were collected from their natural habitats. If fresh materials are not available then herbarium specimens were used instead. In addition sequences available in GenBank were used also. DNA were extracted using a Tiangen Biotech plant genomic DNA extraction kit (Beijing, China) followed the manufacturer's protocol (Appendix II). Quantity and quality of genomic DNA were assessed by 0.8% agarose gel electrophoresis. Genomic DNAs were stored at 20 °C until used. Three plastid genome regions (*rbcL*, *rps4* and *trnL-F*) were amplified by Polymerase Chain Reaction (PCR) using various primers (Table 3.1). Sequence alignment was carried out by Clustal Omega at The European Bioinformatics Institute (https://www.ebi.ac.uk/Tools/msa/clustalo/). Resulting alignment was then visualy inspected and adjusted manualy using Genedoc v.2.7 (Nicholas and Nicholas, 1997). Phylogenetic analyses were done at Cyberinfrastructure for Phylogenetic Research portal (http://www.phylo.org) via the CIPRES Science Gateway V. 3.3 (https://www.phylo.org/portal2/login!input.action).

RAxML was employed for the maximum likelihood phylogenetic analysis with following parameter: HKY8+... For Bayesian inference phylogeny, MrBayes was used with the following conditions: HKY85+… Figtree v.1.4 (Rambuat, 2006) was used to annotate the resulting trees from RAxNML and MrBayes.

Table 3.1 *Primers for plastid genome regions amplification*

No.	Regions	Primers	Primers sequences 5'-3'	References
1	*rbcL*	F1	ATGTCACCACAAACAGAAAC	Fay *et al.* (1997)
		1379R	TCACAAGCAGCAGCTAGTTCAGGACTC	Wolf *et al.* (1999)
2	*rps4-trnS*	rps5	ATGTCCCGTTATCGAGGACCT	Souza *et al.* (1997)
		trnS	TACCGAGGGTTCGAATC	Souza *et al.* (1997)
3	*trnL-trnF*	FERN1	GGCAGCCCCCARATTCAGGGRAACC	Taberlet *et al.* (1991)
		F	ATTTGAACTGGTGACACGAG	Taberlet *et al.* (1991)

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Morphological and Anatomical study

4.1.1 Morpholoical study

4.1.1.1 General morphology of Athyriaceae in Thailand

The morphology of the Athyriaceae sensu Tagawa and Iwatsuki (1988) and Liu *et al.* (2011) was studied which included *Anisocampium*, *Athyrium*, *Cornopteris*, *Deparia*, *Diplazium* and *Hypodematium*. The specimens were carefully examined in both vegetative and reproductive structures. The investigated characters mainly focused on rhizomes, fronds, scales and sori. (Table 4.1).

Rhizome

Generally, rhizome can be categorized into 3 types, i.e. erect, creeping and ascending rhizome (Figure 4.1). There are some variations in size from small to large, sometimes forming a large trunk which can be found in the genus *Diplazium*. Mostly, rhizome clothed with scales especially at the young part and usually detached and shed at the older part. It is noted that rhizome of the genus *Hypodematium* is rather different form the other genera in having both stout and succulent rhizome, densely covered with persistent scales throughout. It is noted that only *Hypodematium* is an epipetric genus while the other genera are terrestrial.

Figure 4.1 Rhizome character. A. erect, B. creeping, C. ascending.

Scales

Scale is the specialized protected structure that commonly found in ferns, especially covering the young sensitive part of rhizomes, fronds as well as sori to prevent damage cause from desiccation by direct contact with arid environment. In

the Athyriaceae, scales are found mainly at rhizome and base of stipe, however some small scales can be observed at the rachis and its ramification. Shapes of scale are varying from linear, linear-lanceolate to narrowly-ovate with long-tail apex. It can be divided into 4 types: (1) scale with entire margin and thin marginal cell walls, (2) scale with entire margin and thick marginal cell walls, (3) scale with toothed margin and thin marginal cell walls, (4) scale with toothed margin and thick marginal cell walls (Figure 4.2). The Genus *Diplazium* has all four scale types, whereas, the other genera have only scale with entire margin and thin marginal cell walls.

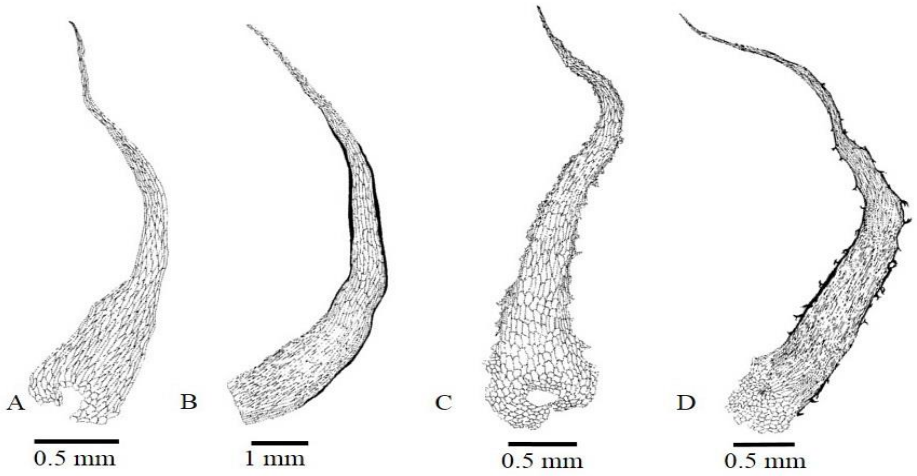

Figure 4.2 Scale types. A. scale with entire margin and thin marginal cell walls, B. scale with entire margin and thick marginal cell walls, C. scale with toothed margin and thin marginal cell walls, D. scale with toothed margin and thick marginal cell walls.

Frond

Fronds differ among genera and species (Figure 4.3), may be simple or pinnately compound leaves, which vary in size and shape of lamina. The genus *Hypodematium* has rather unique tripinnate leaves which are different in texture of lamina from membranaceous to coriaceous.

Figure 4.3 Frond of Athyriaceae. A. simple frond, B. 1-pinnate frond, C. 2-pinnate frond, D. 4-pinnate frond.

Sori

Sori of all studied species are superficial on abaxial surface of lamina, and are placed on veinlets. Their shapes included round-reniform, J-shaped, oblong or elongate which may be enclosed by indusium or naked (Figure 4.4). Indusium of Athyriaceae is glabrous, however, indusium the genus *Hypodematium* is different form the other genera in having acicular or glandular hairs (Table 4.1).

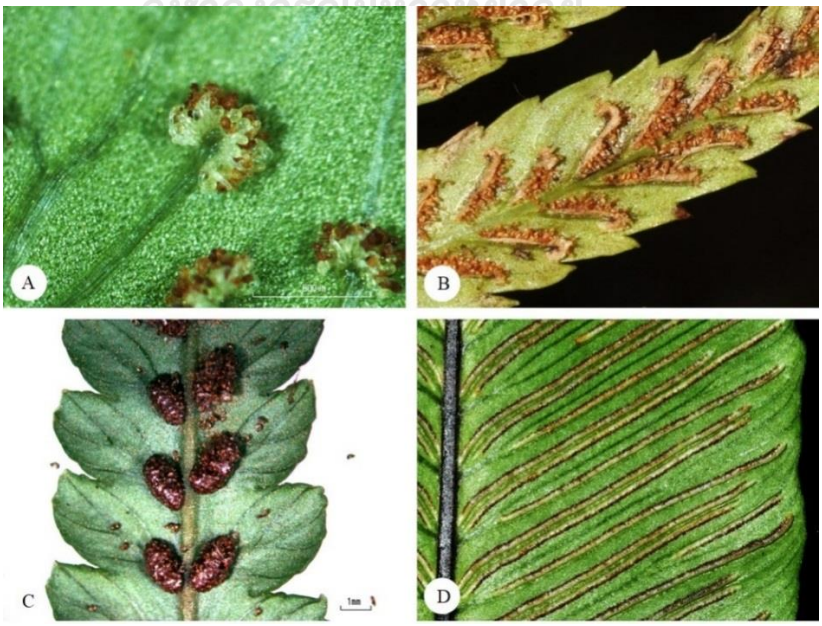

Figure 4.4 Shape of sori. A. round-reniform, B. J-shaped, C. oblong, D. elongate.

Table 4.1 Morphological comparison of the Athyriaceae sensu Tagawa and Iwatsuki (1988) and Liu et al. (2011) in Thailand.

Characters	*Anisocampium*	*Athyrium*	*Cornopteris*	*Deparia*	*Diplazium*	*Hypodematium*
Habit	terrestrial	terrestrial	terrestrial	terrestrial	terrestrial	epipetric
Rhizome	creeping or ascending	creeping or erect	ascending	creeping	creeping or erect	creeping
Scale -shape **-colour** **-margin**	linear-lanceolate concolorous, light-brown entire	linear-lanceolate concolorous, light-brown entire	linear-lanceolate concolorous, light-brown entire	linear-lanceolate concolorous, brown to nearly black entire	linear-lanceolate concolorous, brown to nearly black entire or toothed	linear-lanceolate concolorous, reddish-brown entire
Frond -form	monomorphic	monomorphic or slightly dimorphic	monomorphic	monomorphic	monomorphic	monomorphic
-types	pinnate to bipinnate	pinnate to bipinnate	bipinnate	simple to bipinnate	pinnate to bipinnate	tripinnate to 4-pinnatisect
-texture	papyraceous	papyraceous	papyraceous	papyraceous	papyraceous or coriaceous	membranaceous to coriaceous
Stipe	groove, glabrous, articulate	groove, glabrous, not articulate	groove, glabrous, not articulate	groove, glabrous or hairy, not articulate	groove, glabrous or hairy, not articulate	not groove, glabrous or hairy, not articulate
Rachis	groove, glabrous	groove, spine-like appendage present or not	groove, corniculate	groove, glabrous or hairy	groove, glabrous or hairy	not groove, glabrous or hairy
Vein	free, anastomosing	free	free	free, anastomosing	free, anastomosing	free
Sorus	oblong or round-reniform or J-shaped, indusiate	oblong or round-reniform or J-shaped, indusiate or exindusiate	oblong, exindusiate	oblong or elongate along veinlet, indusiate	oblong or elongate along veinlet, indusiate	round, indusiate
Indusium	oblong, reniform or J-shaped, glabrous	oblong, reniform or J-shaped, glabrous	exindusiate	oblong, reniform or linear, glabrous	linear, glabrous	reniform, hairy
Spore	monolete, kidney-shaped	monolete, kidney-shaped	monolete, kidney-shaped	monolete, kidney-shaped	monolete, kidney-shaped	monolete, kidney-shaped

4.1.2 Anatomical study

4.1.2.1 Anatomy of stipe

Anatomical character of stipe of the Athyriaceae sensu Tagawa and Iwatsuki (1988) and Liu *et al.* (2011) were investigated. The results showed that x-section of stipes are various in shape or outline. In general, they have round to nearly quadrilateral shapes. The stipe tissue is consisted of an outermost single layer of epidermis and several layers of schlerenchyma below the epidermis. The vascular strand is located at the center of stipe in the ground of parenchymatous tissue. The vascular strand is consisted of a central strip of xylem that completely surrounded by phloem, call "amphicribal vascular bundle" (Dickison, 2000; Praptisuwiryo and Darnardi, 2014). The vascular bundle inside stipes are two separated vascular strand that commonly united upward forming a single gutter-shaped which are slightly differed among species (Figure 4.5-4.13).

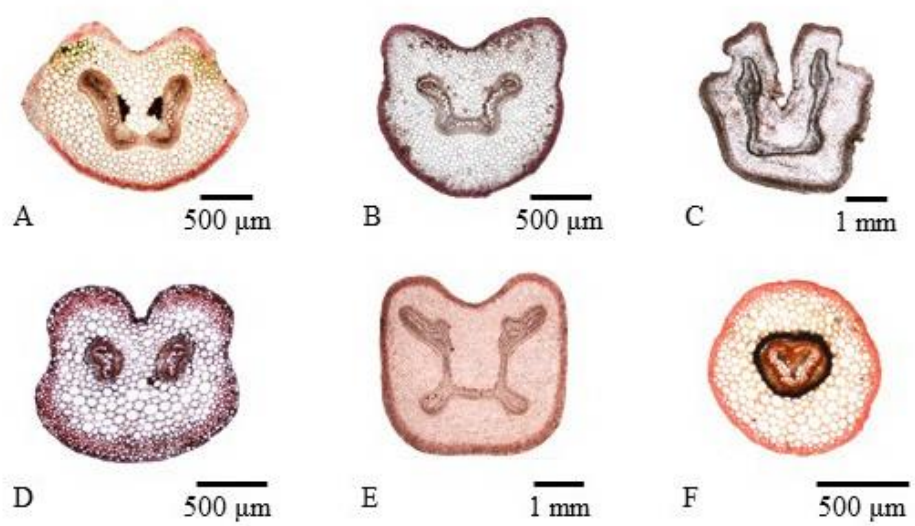

Figure 4.5 X-section of stipe, showed variations of size, shape of stipe in x-section and shape of vascular bundle. A. *Anisocampium cumingianum*, B. *Athyrium biserrulatum*, C. *Cornopteris opaca*, D. *Deparia lancea*, E. *Diplazium esculentum*, F. *Hypodematium boonkerdii*.

Among the studied species in can be seen that the vascular bundle of the genus *Hypodematium* is unique. The vascular bundle was distinctly surrounded by a single-

layered of endodermis that all cells are filled with a dark phenolic compound called “phlobaphene” (Khare and Shanker, 1987) (Figure 4.6).

Shapes of vascular bundle can be classify into three forms, i.e. gutter-shaped, two separated vascular bundle and nearly heart-shaped (Table 4.2; Figure 4.6).

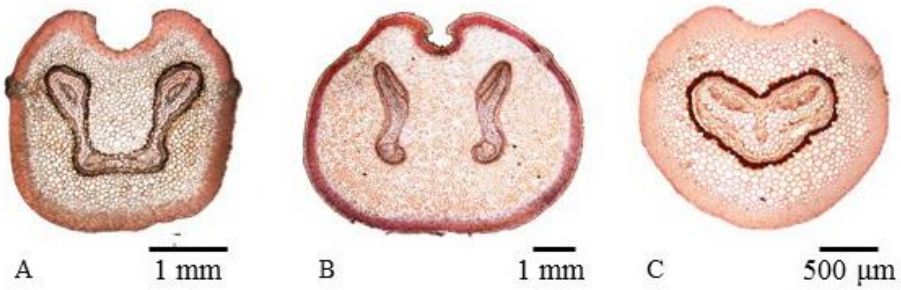

Figure 4.6 Stipe anatomy in the Athyriaceae sensu Tagawa and Iwatsuki (1988) and Liu *et al.* (2011). A. gutter-shaped, B. two separated vascular bundle and C. nearly heart-shaped.

Form 1. Gutter-shaped

This form consists of species that have vascular bundle in gutter-shaped. However, vascular bundle is quite vary in shape from V to U-shaped depend on species. There are 39 species member, i.e. *Anisocampium cumingianum*, *A. cuspidatum*, *A. niponicum*, *Athyrium biserrulatum*, *A. brevisorum*, *A. dissitifolium*, *A. mackinnonorum*, *A. pachyphyllum*, *A. wangii*, *Cornopteris opaca*, *Deparia boryana*, *D. heterophlebia*, *D. japonica*, *Diplazium bantamense*, *D. conterminum*, *D. cordifolium*, *D. crenato-serratum*, *D. dilatatum*,*D. donianum*, *D. esculentum*, *D. kappanense*, *D. leptophyllum*, *D. megaphyllum*, *D. mettenianum*, *D. muricatum*, *D. pallidum*, *D. petelotii*, *D. petrii*, *D. polypodioides*, *D. procumbens*, *D. proliferum*, *D. riparium*, *D. siamense*, *D. simplicivenium*, *D. sorzogonense*, *D. subintegrum*, *D. sylvaticum*, *D. tomentosum*, *D. xiphophyllum* and *D.* sp.

Form 2. Two separated vascular bundles

This form consists of species that have vascular bundle which separated from each other. The shape of separated bundles are nearly round to elongate. There are 7 species, i.e. *Athyrium anisopterum*, *A. strigillosum*, *Deparia lancea*, *Diplazium bellum*, *D. malaccense*, *D. prescottianum* and *D. subserratum*.

Form 3. Nearly heart-shaped

This form consists of species that have vascular bundle in nearly heart-shaped. This group consist of 4 species, i.e. *H. boonkerdii*, *H. crenatum*, *H. glanduloso-pilosum* and *H.* sp.

The result of x-section of stipes showed that most of species of Athyriaceae sensu Tagawa and Iwatsuki (1988) and Liu *et al.* (2011) have gutter-shaped of vascular bundle (Form 1). However, some of them have two separated bundles (Form 2). For this form it was found that vascular bundles may be fused together at the upper part forming gutter-shape like form 1, because the stipes were cut at the junction of stipe and rachis (base of lamina). If stipes were cut at higher position, such as base of rachis then the gutter-shaped vascular bundle will be seen. This character is supported previous noted of diagnostic character of Athyriaceae in having gutter-shaped vascular bundle (Shieh *et al.*, 1997; Khullar, 2000; Zhongren *et al.*, 2013). Moreover, the four species of *Hypodematium* in this study bear a unique character of vascular bundle in having nearly heart-shaped vascular bundle. This result also support the separation of the genus *Hypodematiom* from Athyriaceae (Shieh *et al.*, 1997; Khullar, 2000; Christenhusz *et al.*, 2011; Zhongren *et al.*, 2013; Christenhusz and Chase, 2014; PPG I, 2016). Therefore, the stipe anatomical character is a significant character for fern classification in family level.

Table 4.2 Stomatal type and vascular bundle shape of Athyriaceae and Hypodematium.

Genera	No.	Taxa	stomatal type	vascular bundle shape
Anisocampium	1	*A. cumingianum*	polocytic	gutter-shaped
	2	*A. cuspidatum*	polocytic	gutter-shaped
	3	*A. niponicum*	polocytic	gutter-shaped
Athyrium	1	*A. anisopterum*	polocytic	separated to two bundles
	2	*A. biserrulatum*	polocytic	gutter-shaped
	3	*A. brevisorum*	polocytic	gutter-shaped
	4	*A. dissitifolium*	polocytic	gutter-shaped
	5	*A. mackinnonorum*	polocytic	gutter-shaped
	6	*A. pachyphyllum*	polocytic	gutter-shaped
	7	*A. strigillosum*	polocytic	separated to two bundles
	8	*A. wangii*	polocytic	gutter-shaped
Cornopteris	1	*C. opaca*	polocytic	gutter-shaped
Deparia	1	*D. boryana*	polocytic	gutter-shaped
	2	*D. heterophlebia*	polocytic	gutter-shaped
	3	*D. japonica*	polocytic	gutter-shaped
	4	*D. lancea*	polocytic	separated to two bundles
Diplazium	1	*D. bantamense*	polocytic	gutter-shaped
	2	*D. bellum*	polocytic	separated to two bundles
	3	*D. conterminum*	polocytic	gutter-shaped
	4	*D. cordifolium*	polocytic	gutter-shaped
	5	*D. crenato-serratum*	polocytic	gutter-shaped
	6	*D. dilatatum*	polocytic	gutter-shaped
	7	*D. donianum*	polocytic	gutter-shaped
	8	*D. esculentum*	polocytic	gutter-shaped
	9	*D. kappanense*	polocytic	gutter-shaped
	10	*D. leptophyllum*	polocytic	gutter-shaped
	11	*D. malaccense*	polocytic	separated to two bundles
	12	*D. megaphyllum*	polocytic	gutter-shaped
	13	*D. mettenianum*	polocytic	gutter-shaped
	14	*D. muricatum*	polocytic	gutter-shaped
	15	*D. pallidum*	polocytic	gutter-shaped
	16	*D. petelotii*	polocytic	gutter-shaped
	17	*D. petrii*	polocytic	gutter-shaped
	18	*D. polypodioides*	polocytic	gutter-shaped
	19	*D. prescottianum*	polocytic	separated to two bundles
	20	*D. procumbens*	polocytic	gutter-shaped
	21	*D. proliferum*	polocytic	gutter-shaped
	22	*D. riparium*	polocytic	gutter-shaped
	23	*D. siamense*	polocytic	gutter-shaped
	24	*D. simplicivenium*	polocytic	gutter-shaped
	25	*D. sorzogonense*	polocytic	gutter-shaped
	26	*D. subintegrum*	polocytic	gutter-shaped
	27	*D. subserratum*	polocytic	separated to two bundles
	28	*D. sylvaticum*	polocytic	gutter-shaped
	29	*D. tomentosum*	polocytic	gutter-shaped
	30	*D. xiphophyllum*	polocytic	gutter-shaped
	31	*D. thailandicum*	polocytic	gutter-shaped
	1	*H. boonkerdii*	polocytic	nearly heart-shaped
	2	*H. crenatum*	polocytic	nearly heart-shaped
	3	*H. glanduloso-pilosum*	polocytic	nearly heart-shaped
	4	*H.* sp.	polocytic	nearly heart-shaped

4.1.2.1.1 Comparison of anatomical study with the other works.

According to Ogura (1972) and Kato (1972), they studied the vascular structure of Athyriaceae. They investigated anatomy of rhizome and stipe of 42 species of Athyrioid ferns which included *Athyrium*, *Diplazium*, and *Cornopteris*. They concluded that all Athyrioid ferns have vascular structures in common. They found dictyostelic type of rhizome which consist of 5 to 6 meristeles arranging nearly in a circle. Meristeles are small, circular or short rod-shaped. There are two vascular bundles at the base of stipes, then gradually extended and fused upwards forming gutter-shaped at near the base of rachis. The results from this study are in agreement with their results.

The anatomical structure in stipe of *Hypodematium* in this study is also corresponded with Khare and Shanker (1987). They studied variation of stipe anatomy in *Hypodematium crenatum* and described pattern of parenchyma cells which were surrounded with several layers of a thick-walled lignified zone (3-4 layers). The outermost one layer is the epidermis. The vascular strand is nearly heart-shaped.

Umikalsom (1992) studied stipe anatomy of Aspleniaceae and Athyriaceae from Malaysia. They found that both two family have separated vascular bundles at the base of stipe then gradually fuse together forming a single vascular bundle but vascular bundle at the base of lamina is distinctly different. However, Aspleniaceae have x-shaped vascular bundle in stipe. In contrast, Athyriaceae have gutter-shaped vascular bundle which corresponding to this study. Moreover, they found that some Athyriacae species also have vascular bundle which separated from each other like form 2 of this study.

Sano *et al.* (2000) studied phylogeny of the genus *Deparia* and *Diplazium*. The results show that *Diplazium subsinuatum* and *D. tomitaroanum* should be transferred to the genus *Deparia*. They confirmed their molecular results with morphological and anatomical studies. They found that stipe anatomy of both species is in agreement with the result from molecular studies. Therefore, they move these two species to the genus *Deparia*, namely, *Deparia lancea* and *D. tomitaroanum*, respectively. Sano *et al.*'s study corresponded to this study that the vascular bundle of *D. lancea* is separated to two bundles.

Recently, Praptisuwiryo and Darnardi (2014) studied the anatomy of stipe of *Diplazium* Sw. in 27 species from Malaysia, of these 11 species namely *D. cordifolium*, *D. donianum*, *D. polypodioides*, *D. procumbens*, *D. riparium*, *D. simplicivenium*, *D. sorzogonense*, *D. subserratum*, *D. sylvaticum*, *D. tomentosum* and *D. xiphophyllum* are also found in Thailand. The result corresponded to this study that the vascular bundle is amphicribal vascular bundle. However, they classified the shape of vascular bundle into U, V or W-shaped. Although, the classification of vascular bundle shape is different from this study but vascular bundle of each species show the same results.

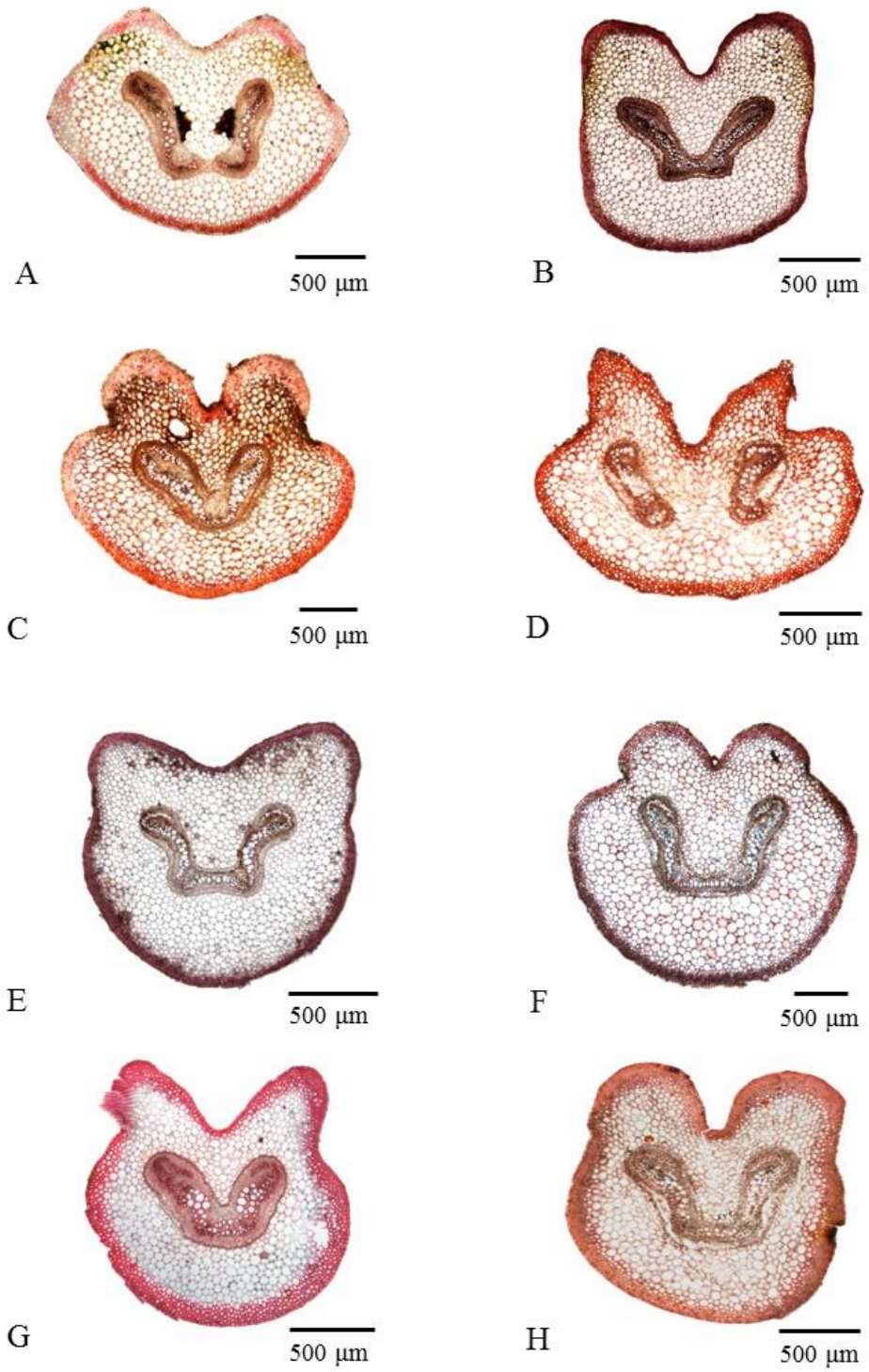

Figure 4.7 X-section stipes. A. *Anisocampium cumingianum*, B. *A. cuspidatum*, C. *A. niponicum*, D. *Athyrium anisopterum*, E. *A. biserrulatum*. F. *A. brevisorum*, G. *A. dissitifolium*, H. *A. mackinnonorum.*

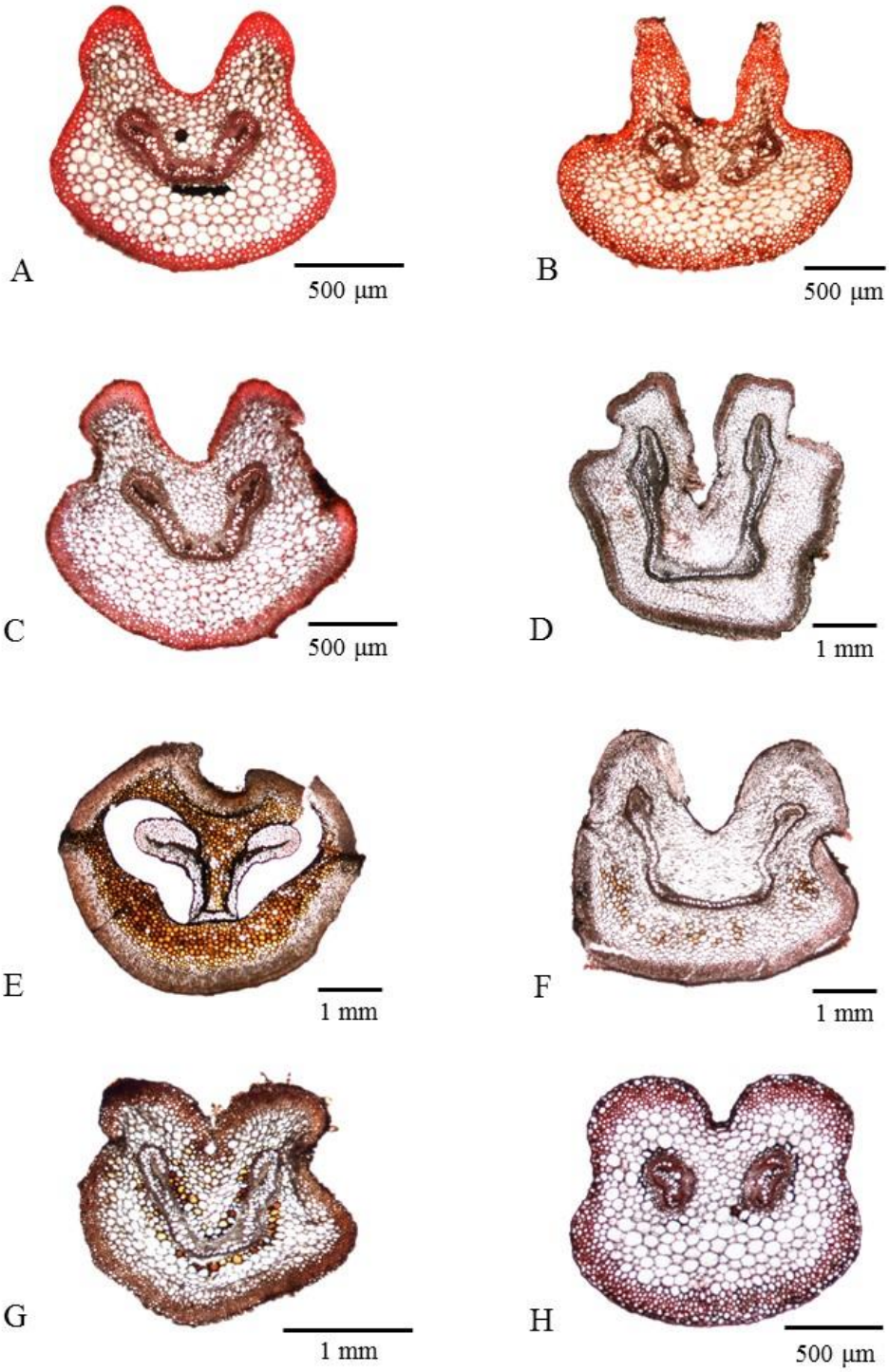

Figure 4.8 X-section of stipes (continued). A. *A. pachyphyllum*, B. *A. strigillosum*, C. *A. wangii*, D. *Cornopteris opaca*, E. *Deparia boryana*, F. *D. heterophlebia*, G. *D. japonica*, H. *D. lancea*.

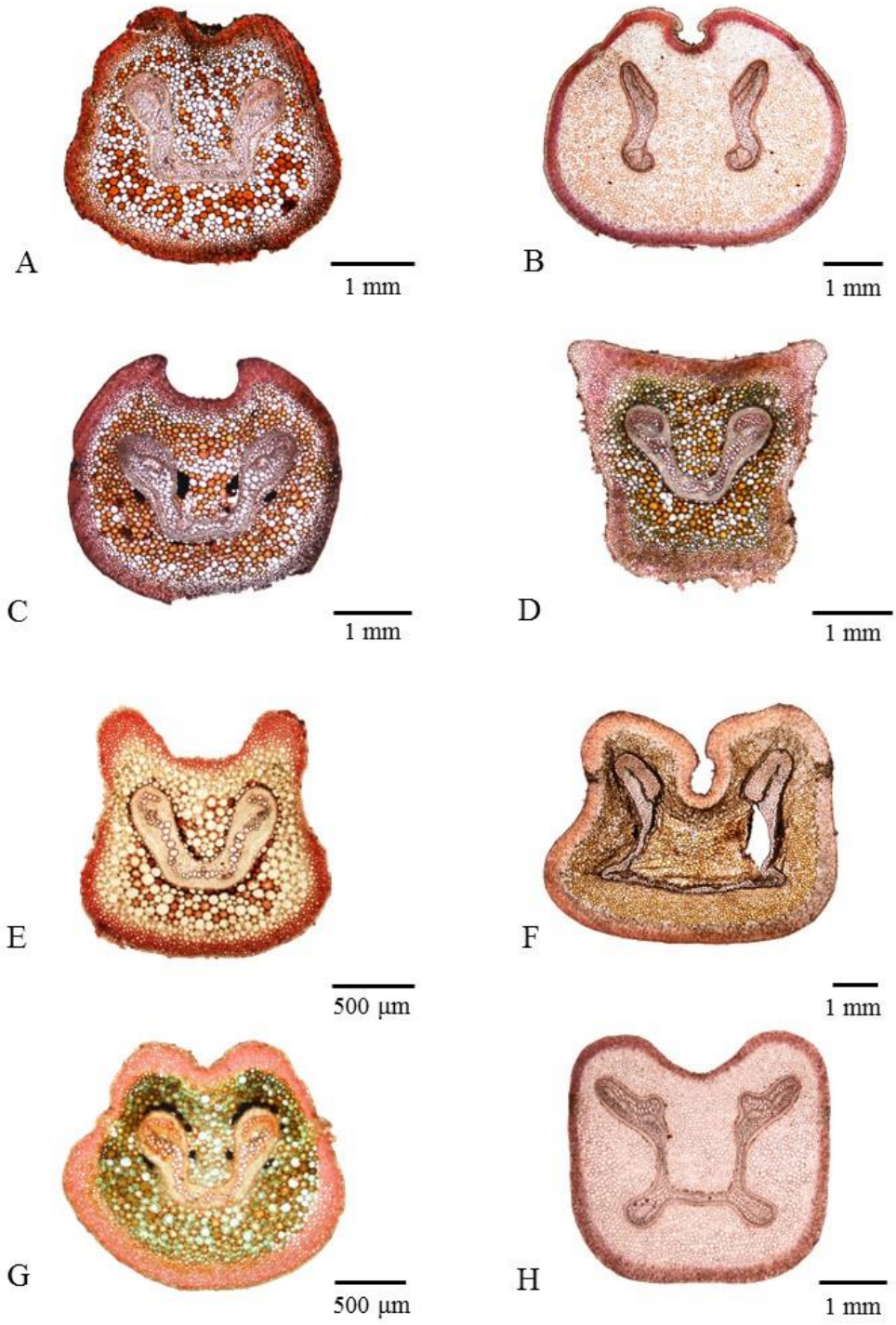

Figure 4.9 X-section of stipes (continued). A. *Diplazium bantamense*, B. *D. bellum*, C. *D. conterminum*, D. *D. cordifolium*, E. *D. crenato-serratum*, F. *D. dilatatum*, G. *D. donianum*, H. *D. esculentum*.

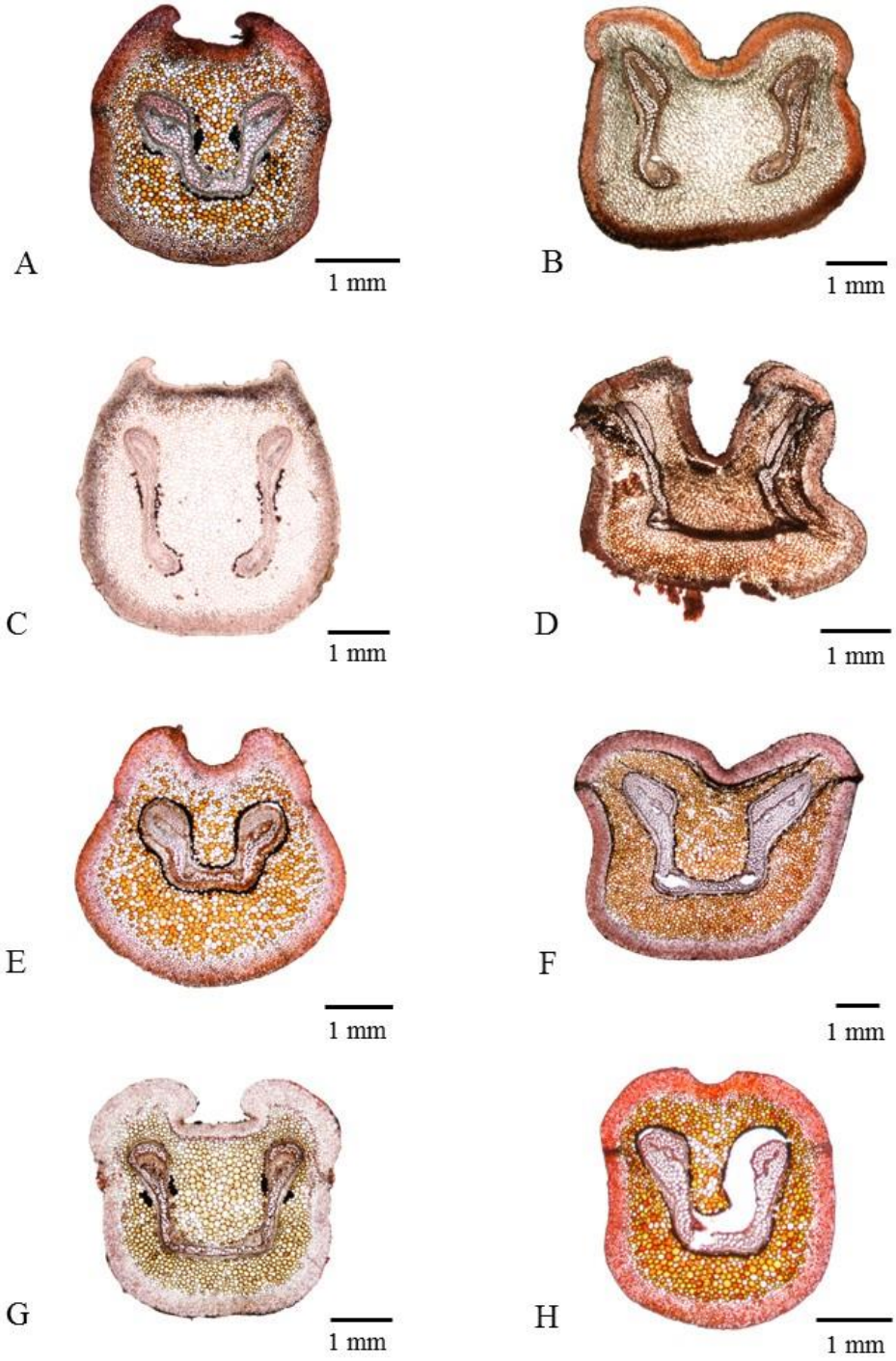

Figure 4.10 X-section of stipes (continued). A.*Diplazium kappanense*, B. *D. leptophyllum*, C. *D. malaccense*, D. *D. megaphyllum*, E. *D. mettenianum*, F. *D. muricatum*, G. *D. pallidum*, H. *D. petelotii*.

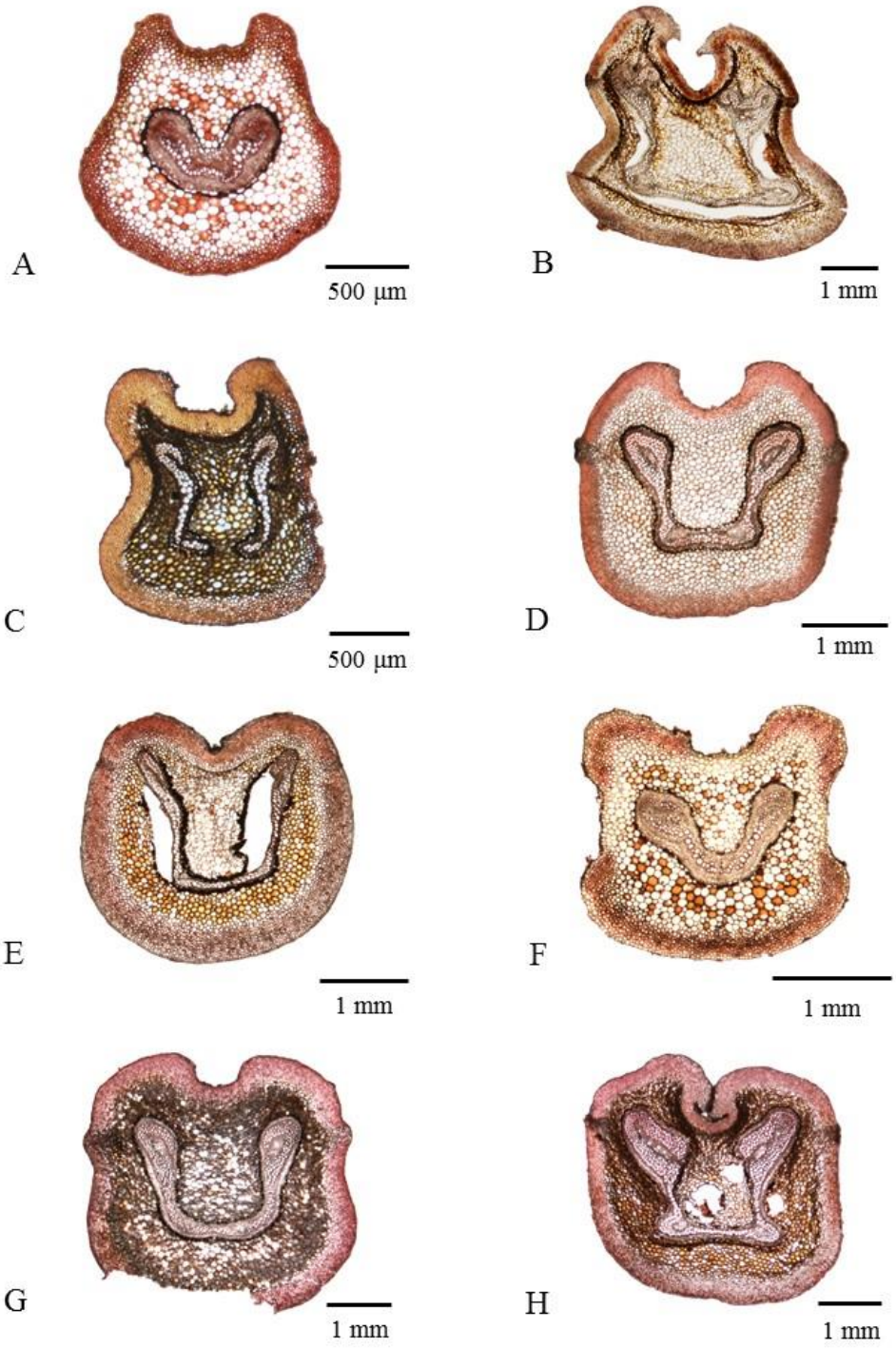

Figure 4.11 X-section of stipes (continued). A. *Diplazium petrii*, B. *D. polypodioides*, C. *D. prescottianum*, D. *D. procumbens*, E. *D. proliferum*, F. *D. riparium*, G. *D. siamense*, H. *D. simplicivenium*.

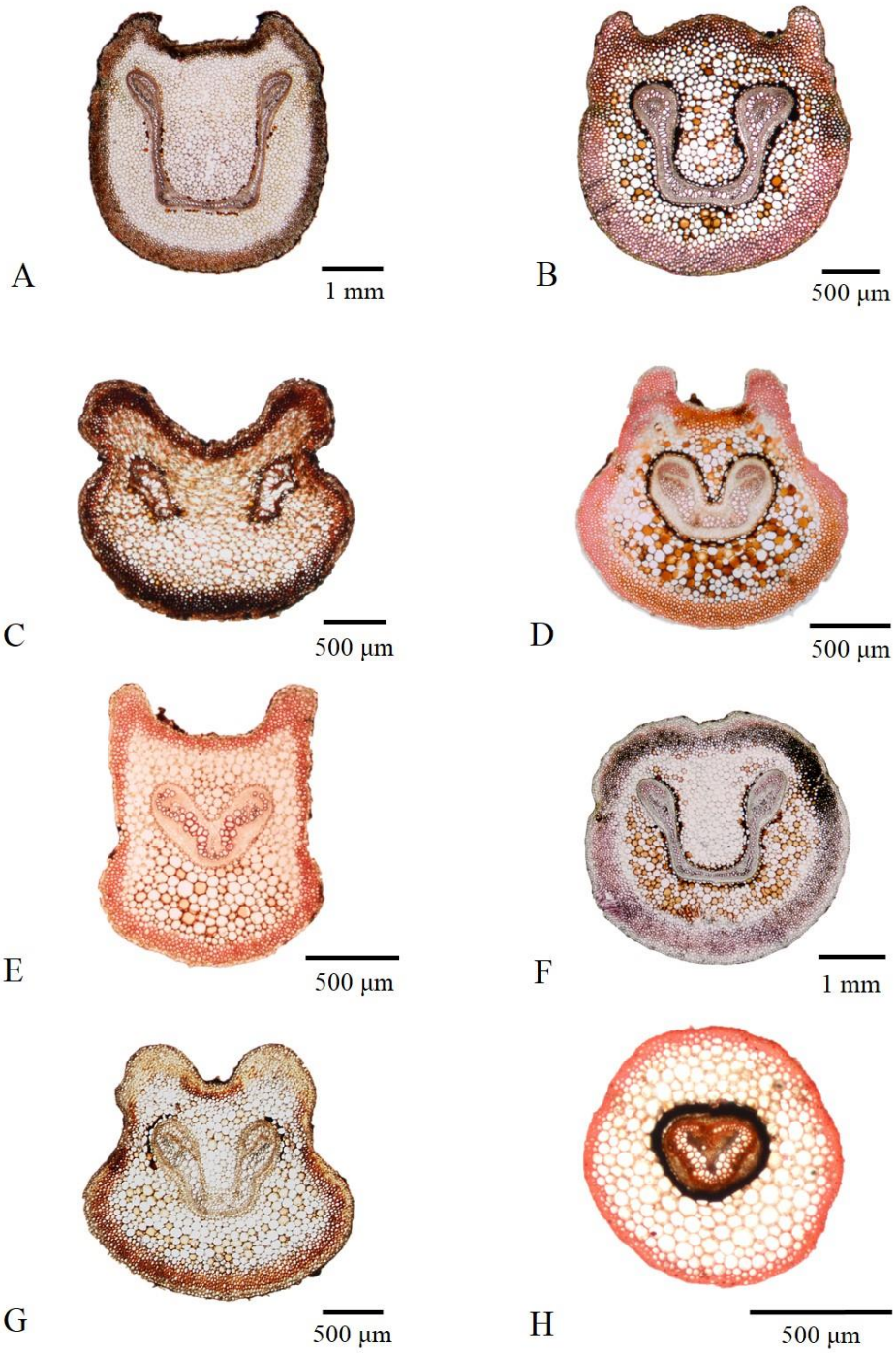

Figure 4.12 X-section of stipes (continued). A. *Diplazium sorzogonense*, B. *D. subintegrum*, C. *D. subserratum*, D. *D. sylvaticum*, E. *D. tomentosum*, F. *D. xiphophyllum*, G. *D. thailandicum*, H. *Hypodematium boonkerdii*.

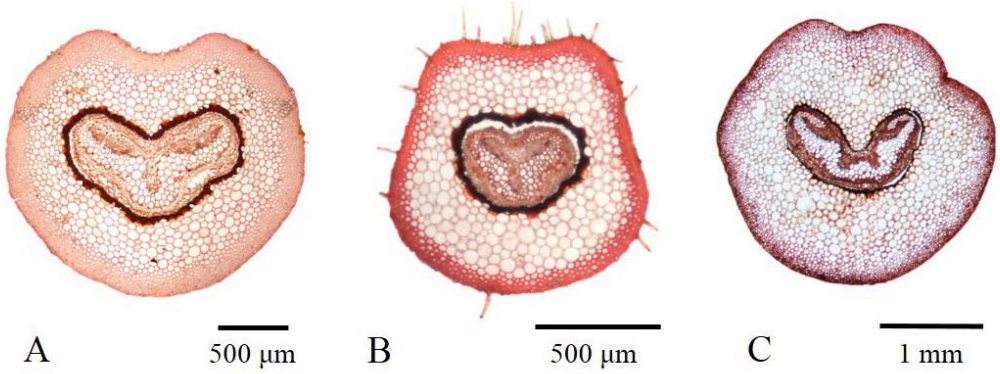

Figure 4.13 X-section of stipes (continued). A. *H. crenatum*, B. *H. glanduloso-pilosum*, C. *H.* sp.

4.1.2.2 Epidermal characters

The epidermal cells of all studied species are irregular in shape, which are varied among species. Epidermal characters of lamina were focus on stomatal type. Stomata of all studied species are show on abaxial surface (Hypostomatic). However, only polocytic stomatal type was found. The polocytic stomata is defined as stomata was surrounded by a single easily recognizable U-shaped or horseshoe-shaped subsidiary cell (Sen and Hennipman, 1981; Sen and De, 1992) (Table 4.2; Figure 4.14-4.20).

4.1.2.2.1 Comparison of stomatal study with the other works.

Cotthem (1970) has made a comparative morphological study of fern stomata. 510 species belonging to 240 genera were investigated. Of these, 10 Athyriaceous species were included, i.e. *Anisocampium cumingianum*, *Athyriumfilix-fermina*, *Callipteris prolifera* (*Diplazium proliferum*), *Diplazum cordifolium*, D. dilatatum, *D. latisquamatum*, *D. montanum*, *D. simplicivenium* and *D. thelypteroides*. The results corresponded with this study that all of the ten studied species have polocytic stomata. Recently, folia epidermal micromorphology of some species of Athyriaceae was carried out Shah *et al.* (2018). Ten species, i.e. *Athyrium atkinsonii*, *A. attenuatum*, *A. mackinnonii*, *A. wallichianum*, *Deparia japonica*, *D. mavdonelii*, *D. petersenii*, *Diplazium esculentum* and *D. polypodioides* were investigated. Their results corresponded with this study, that all studied species have hypostomatic stomata.

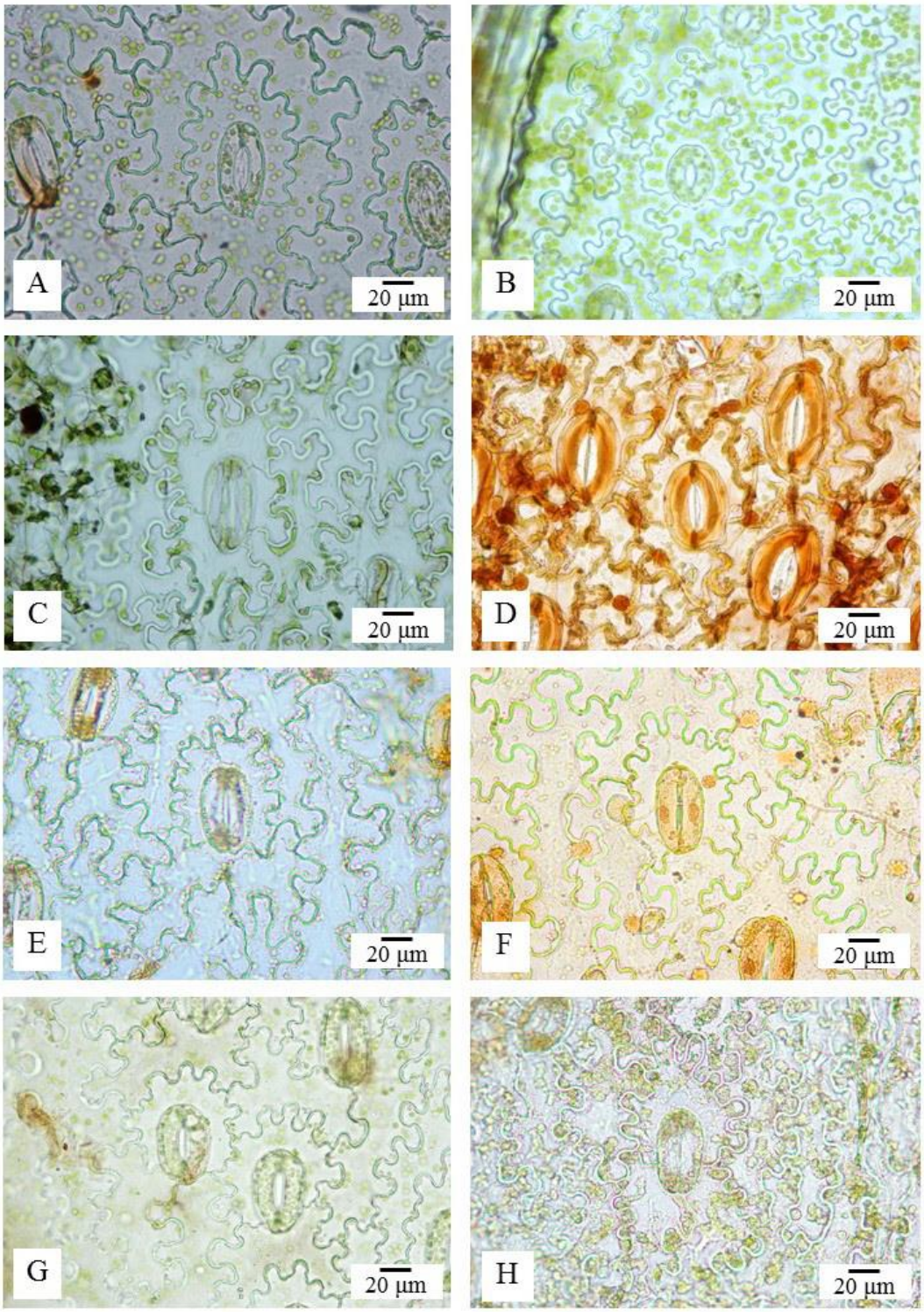

Figure 4.14 Stomatal structure. A. *Anisocampium cumingianum*, B. *A. cuspidatum*, C. *A. niponicum*, D. *Athyrium anisopterum*, E. *A. biserrulatum*. F. *A. brevisorum*, G. *A. dissitifolium*, H. *A. mackinnonorum*.

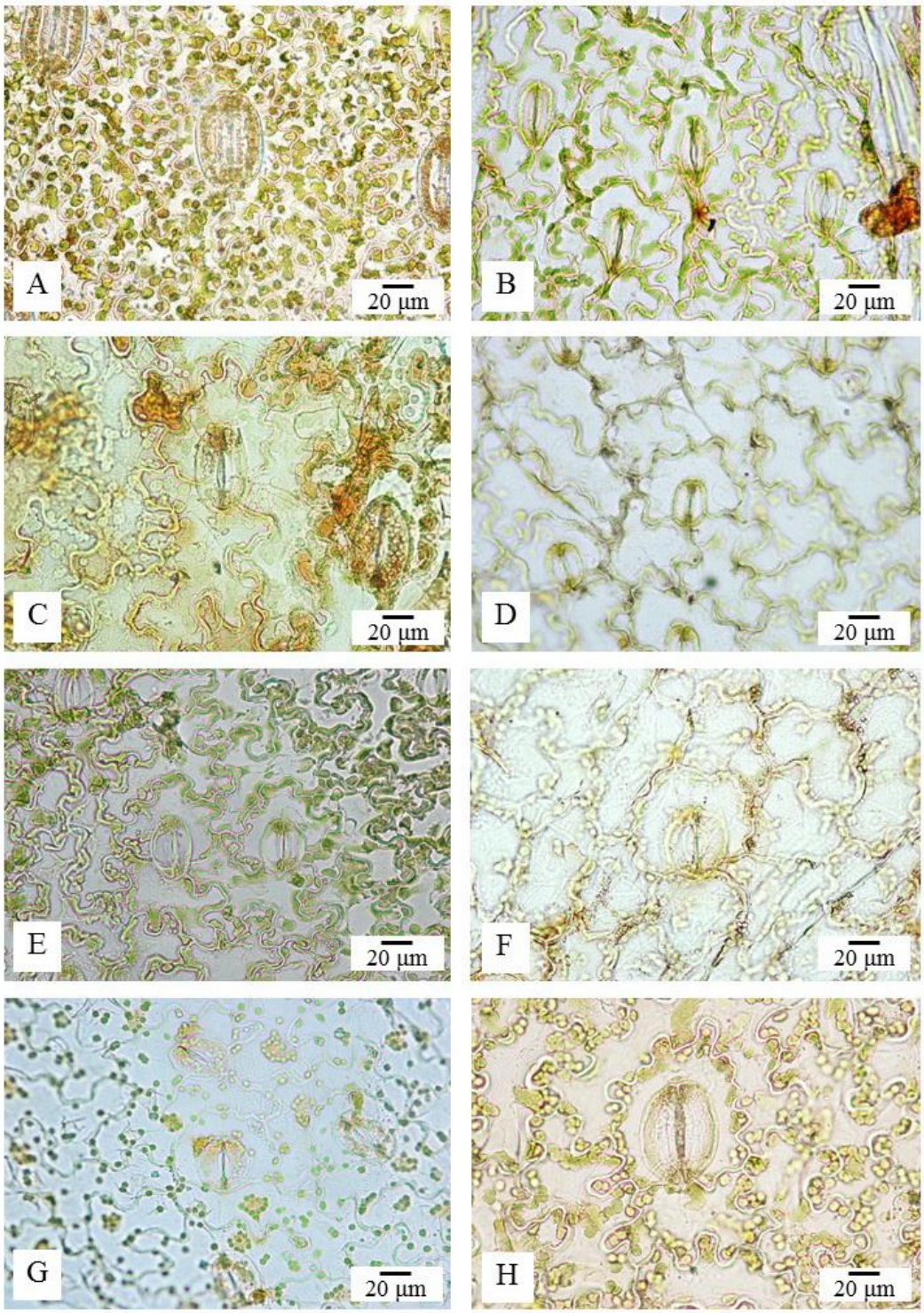

Figure 4.15 Stomatal structure (continued). A. *A. pachyphyllum*, B. *A. strigillosum*, C. *A. wangii*, D. *Cornopteris opaca*, E. *Deparia boryana*, F. *D. heterophlebia*, G. *D. japonica*, H. *D. lancea*.

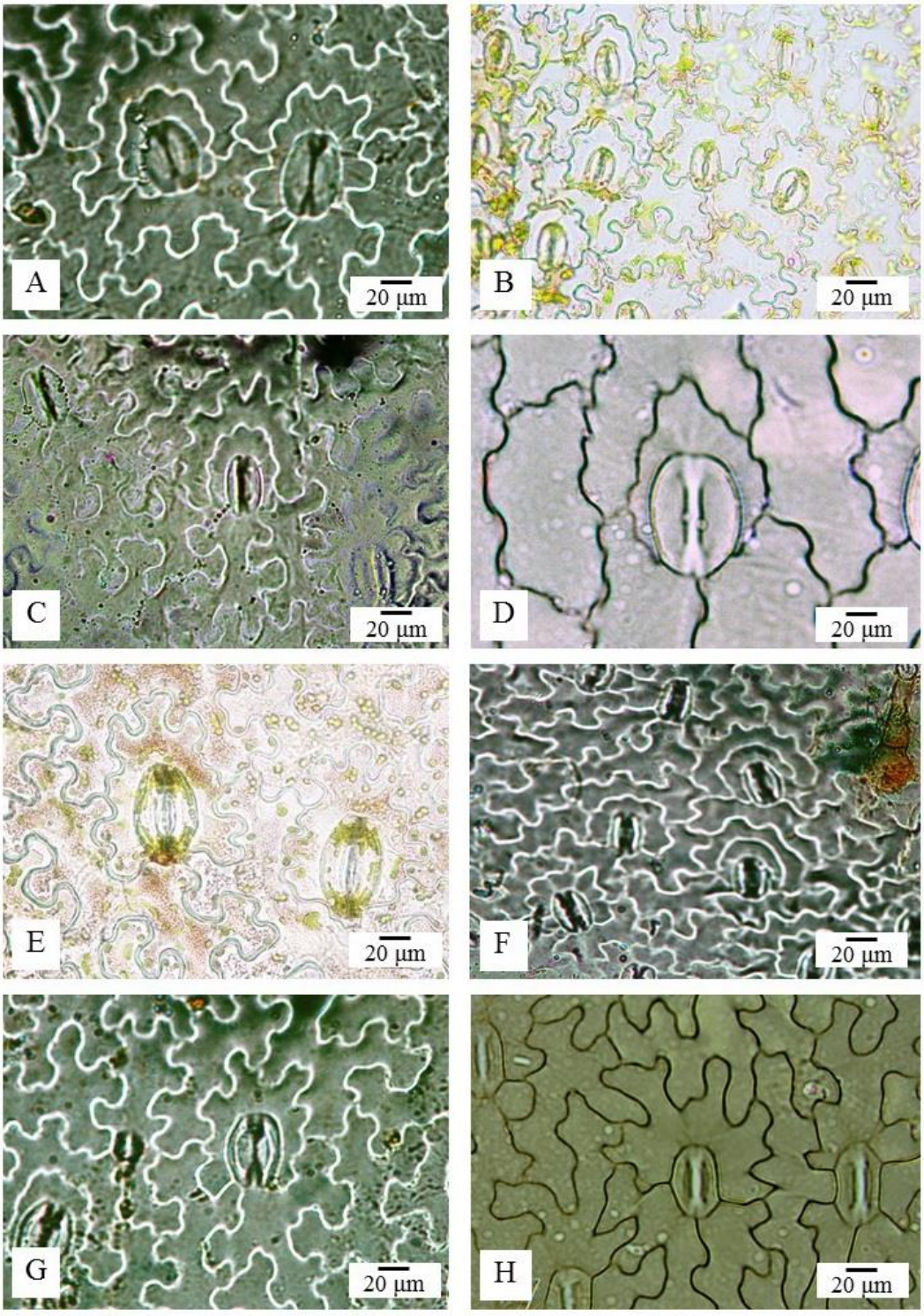

Figure 4.16 Stomatal structure (continued). A. *Diplazium bantamense*, B. *D. bellum*, C. *D. conterminum*, D. *D. cordifolium*, E. *D. crenato-serratum*, F. *D. dilatatum*, G. *D. donianum*, H. *D. esculentum*.

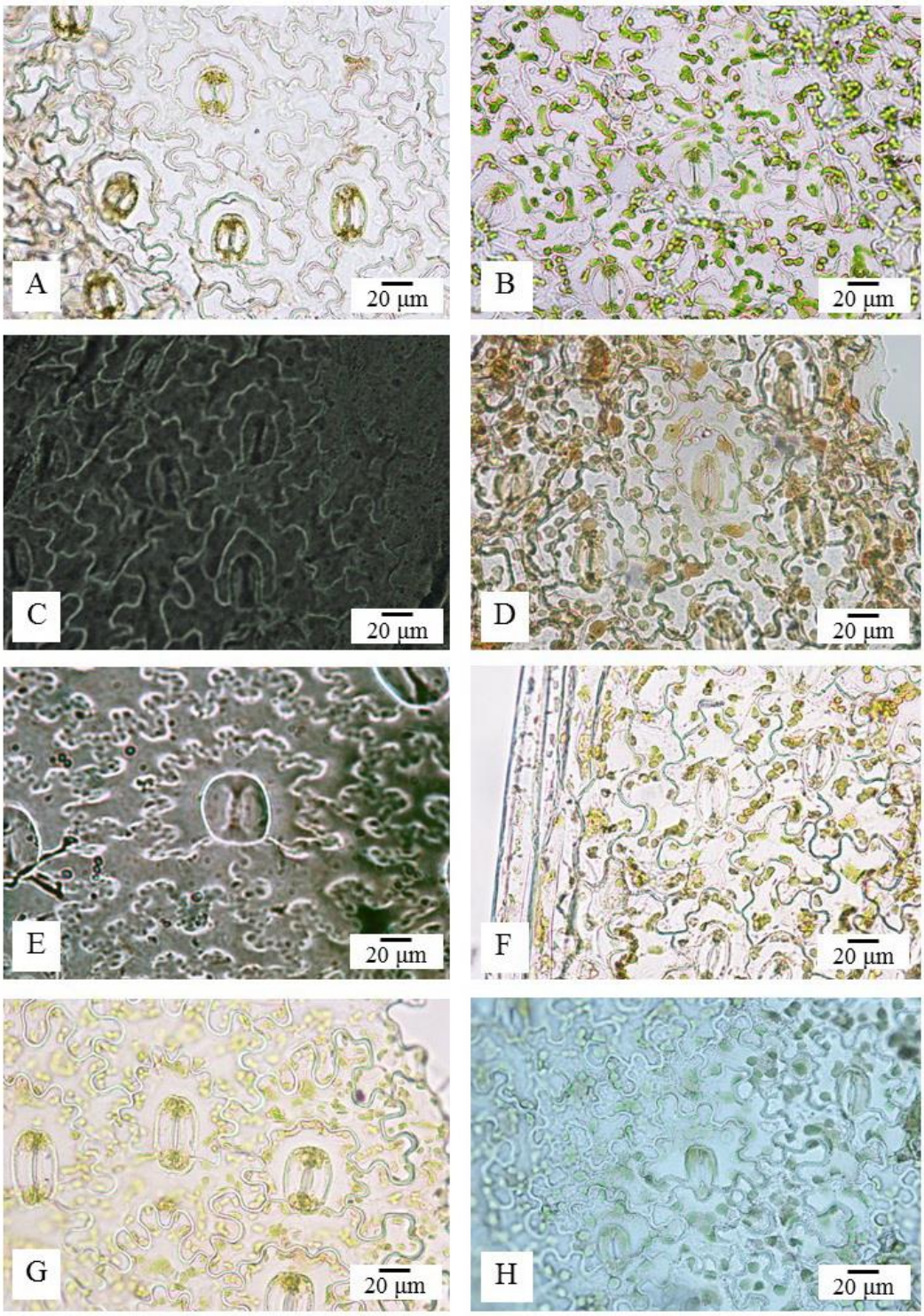

Figure 4.17 Stomatal structure (continued). A. *Diplazium kappanense*, B. *D. leptophyllum*, C. *D. malaccense*, D. *D. megaphyllum*, E. *D. mettenianum*, F. *D. muricatum*, G. *D. pallidum*, H. *D. petelotii*.

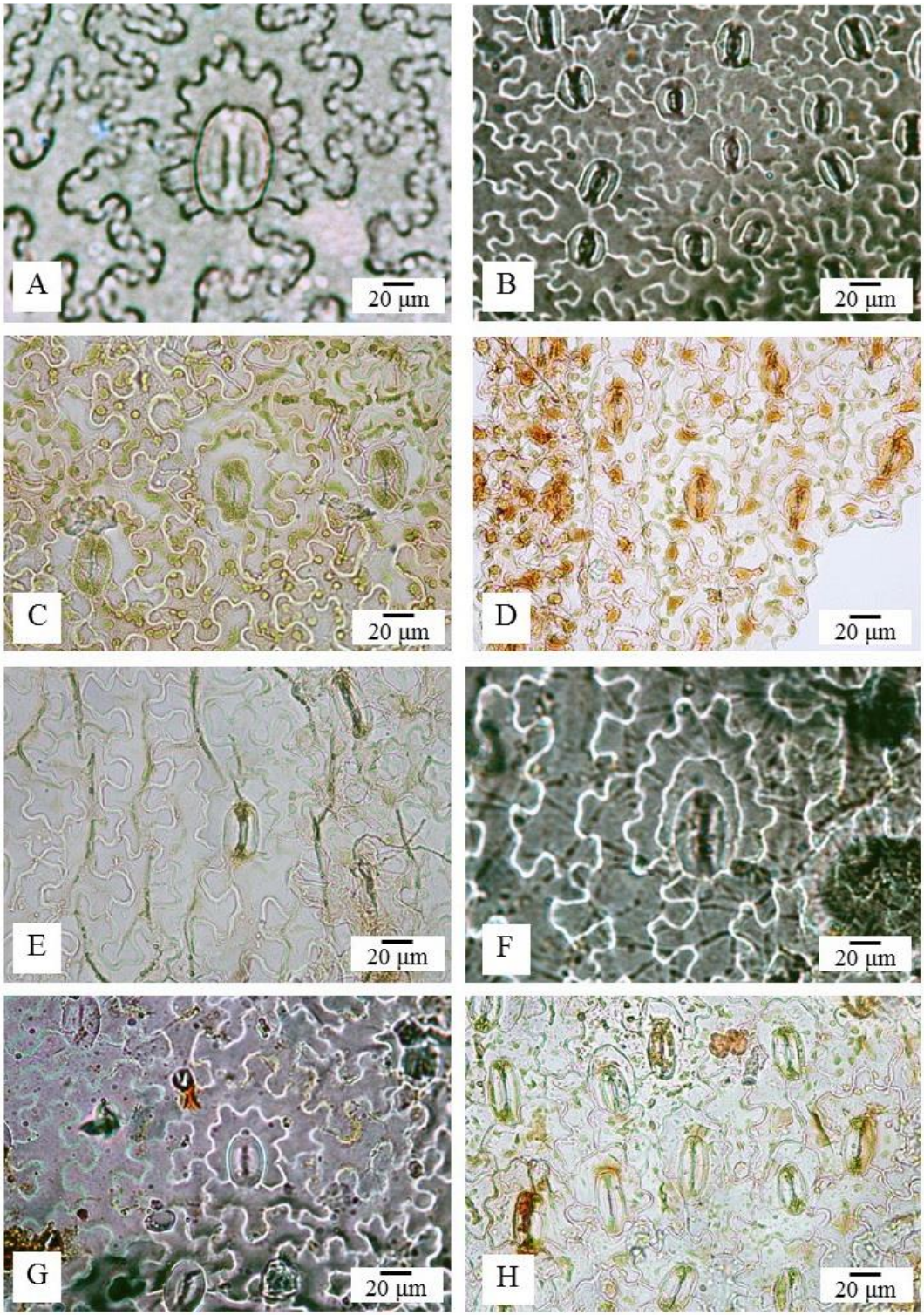

Figure 4.18 Stomatal structure (continued). A. *Diplazium petrii*, B. *D. polypodioides*, C. *D. prescottianum*, D. *D. procumbens*, E. *D. proliferum*, F. *D. riparium*, G. *D. siamense*, H. *D. simplicivenium*.

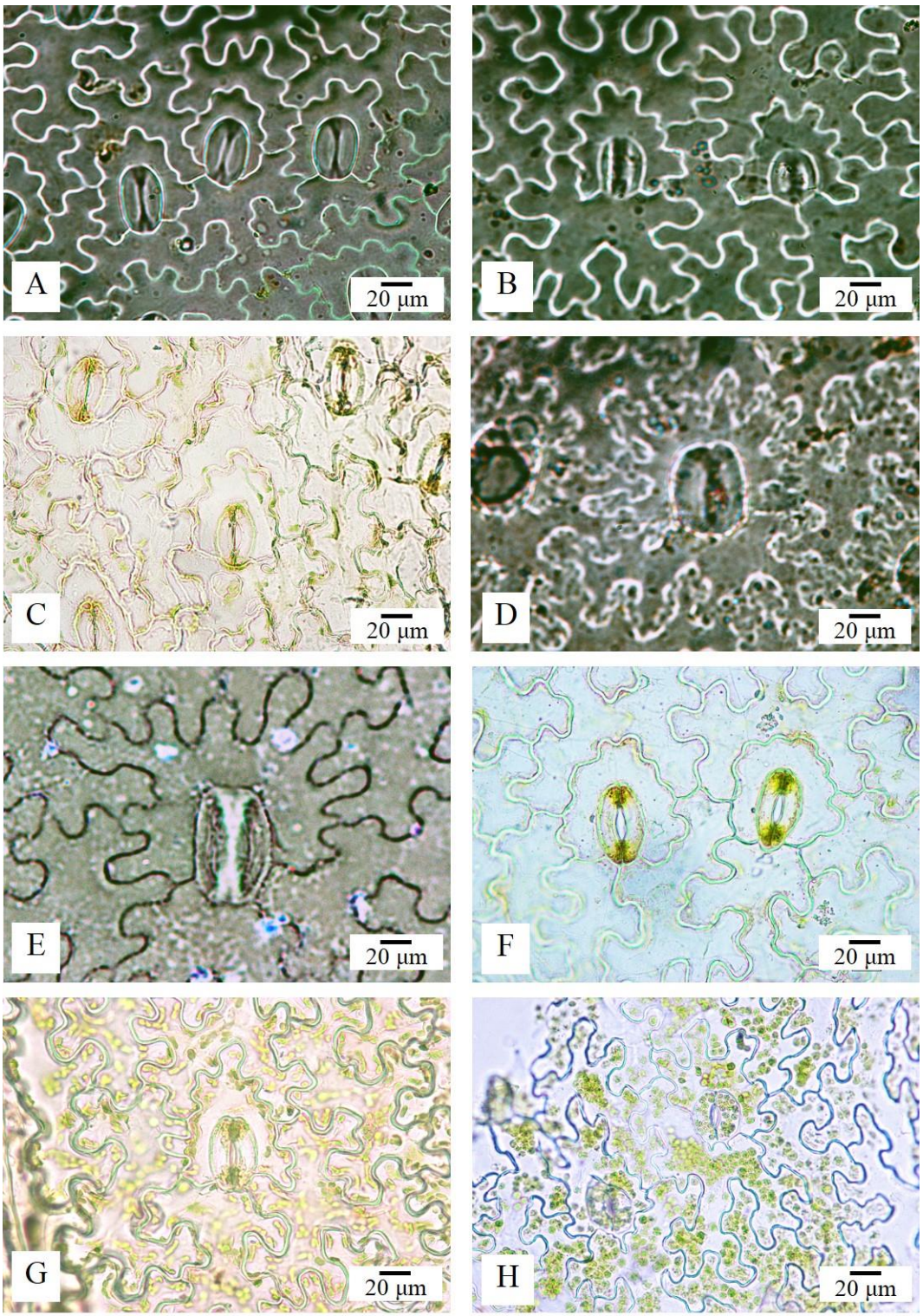

Figure 4.19 Stomatal structure (continued). A. *Diplazium sorzogonense*, B. *D. subintegrum*, C. *D. subserratum*, D. *D. sylvaticum*, E. *D. tomentosum*, F. *D. xiphophyllum*, G. *D. thailandicum*, H. *H. boonkerdii*.

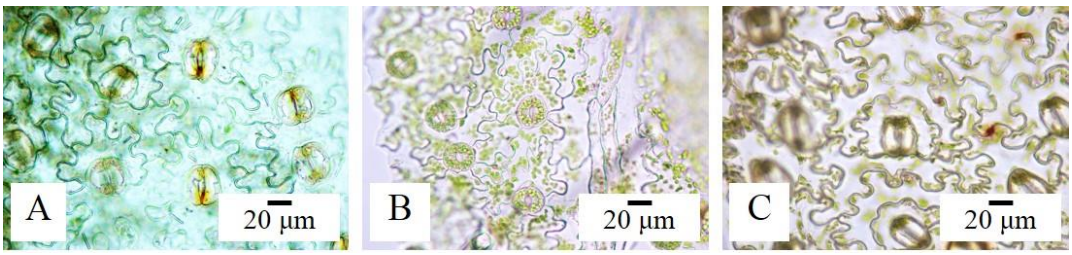

Figure 4.20 Stomatal structure (continued). A. *Hypodematium crenatum*, B. *H. glanduloso-pilosum*, C. *H. sp.*

4.2 Palynological study

Palynological study was focused on spore morphology. Spores were investigated using Scaning Electron Microscope (SEM). The result shows that spore of the Athyriaceae sensu Tagawa and Iwatsuki (1988) and Liu *et al.* (2011) are monolete, bilateral symmetry, kidney-shaped, concavo-convex to plano-convex, perispore present.

The spore ornamentation of the studied species can be classified in to 10 types. (Table 4.3; Figure 4.21-4.28).

1. Baculate type

Perispore includes the apex of baculate process, scattered around spore. Size 25.5-62.0 × 20.0-40.0 µm. There are 4 species, i.e. *Deparia boryana*, *D. heterophlebia*, *D. japonica* and *D. lancea*.

2. Echinate type

Perispore composes of several groups of short spines which united at the apex. Size 30.0-37.5 × 17.5-20.0 µm. There is only one species, i.e. *Diplazium leptophyllum*.

3. Irregular type

Preispore has irregular-shaped elements of the sculptures, covered around spore. Size 35.0-41.5 × 20.0-33.0 µm. There are 2 species, i.e. *Diplazium bellum*, *D. crenato-serratum*.

4. Labyrinth type

Perispore composes of low fold that arrange like labyrinth. Size 30.0-57.5 × 20.0-37.0 μm. There are 4 species, i.e. *Diplazium conterminum*, *D. petrii*, *D. polypodioides* and *D. prescottianum*.

5. Prominent wing type

Perispore has rather low folds or ridges, ridge is smooth. This type is rather common. Size 30.0-72.5 × 17.5-50.0 μm. There are 20 species, i.e. *Diplazium bantamense*, *D. dilatatum*, *D. donianum*, *D. kappanense*, *D. malaccense*, *D. megaphyllum*, *D. mettenianum*, *D. muricatum*, *D. petelotii*, *D. polypodioides*, *D. procumbens*, *D. proliferum*, *D. riparium*, *D. siamense*, *D. simplicivenium*, *D. sorzogonense*, *D. subintegrum*, *D. sylvaticum*, *D. thailandicum*, *D. tomentosum* and *D. xiphophyllum*.

6. Pustulate type

Perispore has scattered pustules around spore. Size 35.0-42.5 × 20.0-25.0 μm. There is only one species, namely *Diplazium esculentum*.

7. Reticulate wing type

Perispore has much wing folds of wing or ridges that connected to each other, forming reticulate pattern around spore. Size 29.5-55.0 × 22.0-44.0 μm. There are 8 species, i.e. *Anisocampium cumingianum*, *A. cuspidatum*, *A. niponicum*, *Athyrium anisopterum*, *A. biserrulatum*, *A. brevisorum*, *A. dissitifolium*, *D. cordifolium*

8. Rough type

Perispore is rough. Size 55.5-62.0 × 37.5-44.5 μm. There is only one species namely *Diplazium subserratum*.

9. Rugate type

The surface of perispore is rugae. Size 35.5-60.5 × 26.5-49.5 μm. There are 4 species, i.e. *Hypodematium boonkerdii*, *H. crenatum*, *H. glanduloso-pilosum* and *H.* sp.

10. Smooth type

Perispore is smooth or slightly rough. Size 29.5-52.5 × 19.0-32.0 μm. There are 6 species, i.e. *Athyrium mackinnonorum*. *A. pachyphyllum*, *A. strigrillosum*, *A. wangii*, *Cornopteris opaca* and *Diplazium pallidum*.

The results of this study showed some overlapping characters in spore ornamentation of the genera in the Athyriaceae sensu Tagawa and Iwatsuki (1988) and Liu *et al.* (2011). *Athyrium* and *Diplazium* have more than one ornamentation type, especially genus *Diplazium* has the most diverse in spore ornamentation which having 7 types. This result probably due to *Diplazium* having the highest species number among the Thai Athyriaceae. However, some ornamentation type is specific with some genera, such as *Deparia* and *Hypodematium*. It is evident from this study that spore ornamentation can be used to differentiate genus, especially *Deparia* and *Hypodematium*.

4.2.1 Comparison of the palynological study with previous works

Spore morphology of Athyriaceae was studied by many authors (Table 4.4), such as Devi (1977), Huang (1981), Tryon and Lugardon (1990) and Liu *et al.* (2000). In general, the results report here are in agreement with those results. However, there are some inconsistent points. For example, Devi (1977) studied spore morphology of Indian ferns, which including Athyriaceae. Six species, namely *Diplazium bantamense, D. bellum, D. dilatatum. D. esculentum, D. polypodioides* and *Hypodematium crenatum* are in common with this study. Devi (1977) noted the absence of perispore in *D. bantamense, D. bellum* and *D. esculentum*, but in fact perispore do present in all of the mentioned species (Figure 4.24 A, B, C). This discrepancy is probably due to the difference of light microscope being used. Moreover, Huang (1981) and Liu *et al.* (2000) studied fern spores from Taiwan. The results mostly corresponded with this study but there are still some differences (Table 4.4).

According to Tryon and Lugardon (1990) who studied spores of ferns using SEM, TEM and LM. Spores of more than 230 genera were investigated, of these 15 Athyriaceous species are in common with this study. The results on spore ornamentation corresponded with the results reported here (Table 4.4).

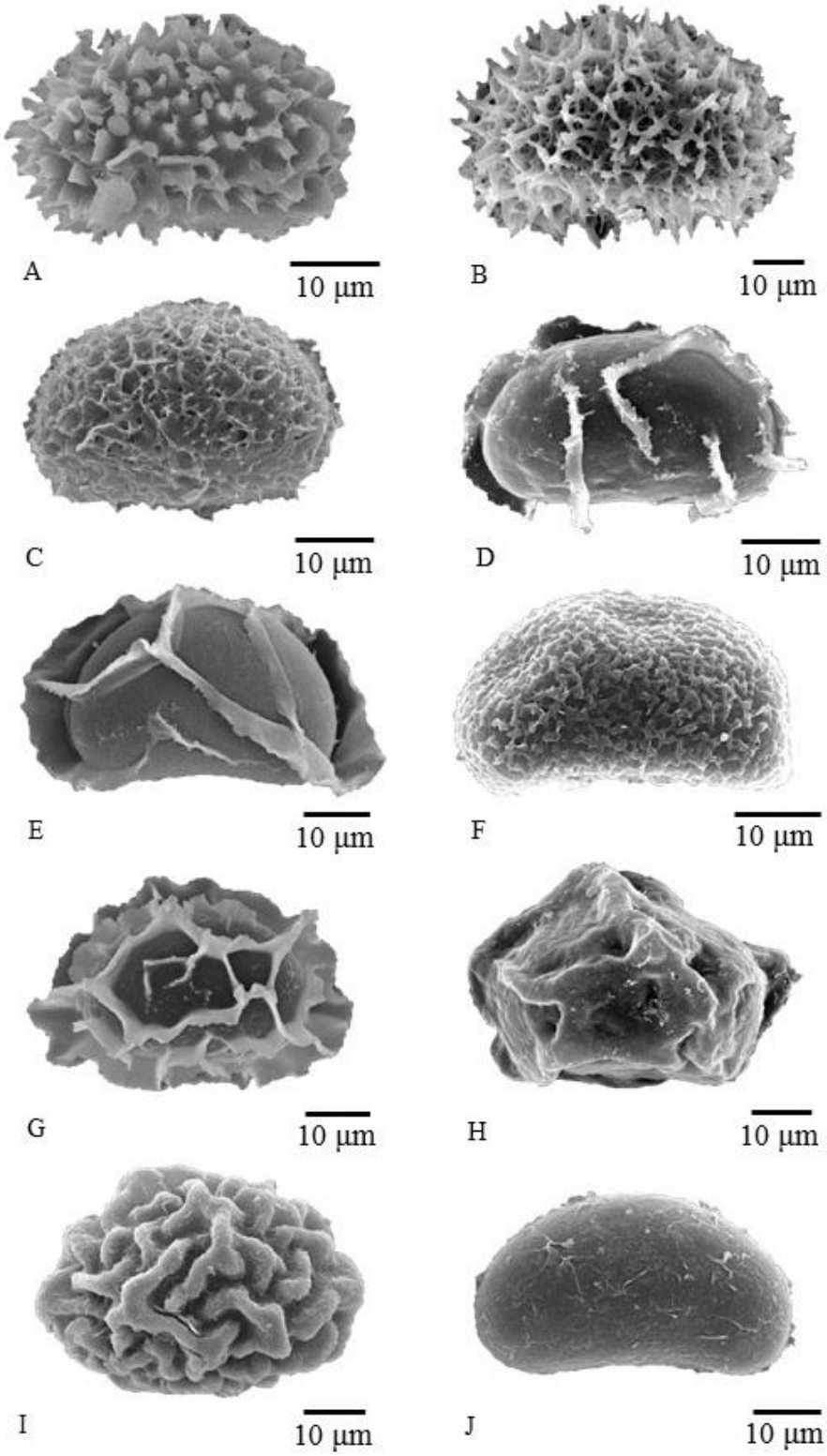

Figure 4.21 Ornamentation types. A. baculate, B. echinate, C. irregular, D. labyrinth, E. prominent wings, F. pustulate, G. reticulate wings, H. rough, I. rugate, J. smooth.

Table 4.3 Spore size and ornamentation type of the Athyriaceae sensu Tagawa and Iwatsuki (1988) and Liu *et al.* (2011).

Genera	No.	Taxa	Spore size, L×P (µm)	Ornamentation
Anisocampium	1	*A. cumingianum*	41.0-48.0 × 31.0-32.5	reticulate wings
	2	*A. cuspidatum*	29.5-36.5 × 22.0-26.0	reticulate wings
	3	*A.. niponicum*	41.0-48.5 × 33.5-39.0	reticulate wings
Athyrium	1	*A. anisopterum*	40.5-51.0 × 30.5-34.0	reticulate wings
	2	*A. biserrulatum*	46.0-50.5 × 28.5-31.5	reticulate wings
	3	*A. brevisorum*	45.5-55.0 × 37.0-44.0	reticulate wings
	4	*A. dissitifolium*	37.5-45.0 × 22.0-26.5	reticulate wings
	5	*A. mackinnonorum*	41.0-43.0 × 24.0-26.5	smooth
	6	*A. pachyphyllum*	41.0-44.0 × 26.0-27.5	smooth
	7	*A. strigillosum*	40.0-42.5 × 24.0-25.0	smooth
	8	*A. wangii*	36.5-40.0 × 23.0-24.0	smooth
Cornopteris	1	*C. opaca*	29.5-35.0 × 19.0-26.5	smooth
Deparia	1	*D. boryana*	25.5-30.0 × 21.0-23.0	baculate
	2	*D. heterophlebia*	60.5-62.0 × 36.0-40.0	baculate
	3	*D. japonica*	36.0-38.0 × 29.0-31.0	baculate
	4	*D. lancea*	30.0-37.5 × 20.0-32.5	baculate
Diplazium	1	*D. bantamense*	62.5-67.5 × 30.0-40.0	prominent wing
	2	*D. bellum*	36.0-41.5 × 28.0-33.0	irregular
	3	*D. conterminum*	47.5-57.5 × 32.5-37.0	labryrinth
	4	*D. cordifolium*	47.5-50.0 × 35.0-45.0	prominent wing
	5	*D. crenato-serratum*	35.0-37.5 × 20.0-22.5	irregular
	6	*D. dilatatum*	40.5-45.0 × 25.0-29.5	prominent wing
	7	*D. donianum*	55.0-72.5 × 35.0-50.0	prominent wing
	8	*D. esculentum*	35.0-42.5 × 20.0-25.0	puslulate
	9	*D. kappanense*	32.5-35.0 × 17.5-22.5	prominent wing
	10	*D. leptophyllum*	30.0-37.5 × 17.5-20.0	echinate
	11	*D. malaccense*	32.5-35.0 × 20.0-22.5	prominent wing
	12	*D. megaphyllum*	52.5-60.0 × 20.0-22.5	prominent wing
	13	*D. mettenianum*	66.0-68.0 × 39.0-42.0	prominent wing
	14	*D. muricatum*	32.5-40.0 × 22.5-27.5	prominent wing
	15	*D. pallidum*	46.0-52.5 × 26.5-32.0	smooth
	16	*D. petelotii*	33.5-53.0 × 26.0-31.0	prominent wing
	17	*D. petrii*	30.0-42.5 × 20.0-22.5	labryrinth
	18	*D. polypodioides*	37.5-45.0 × 22.5-25.0	prominent wing
	19	*D. prescottianum*	40.5-43.0 × 23.5-25.5	labryrinth
	20	*D. procumbens*	47.5-57.5 × 25.0-32.5	prominent wing
	21	*D. proliferum*	49.5-51.0 × 31.0-35.5	prominent wing
	22	*D. riparium*	42.5-50.0 × 25.0-30.0	prominent wing
	23	*D. siamense*	35.0-40.0 × 22.5-27.5	prominent wing
	24	*D. simplicivenium*	51.0-54.5 × 30.5-34.5	prominent wing
	25	*D. sorzogonense*	37.5-45.0 × 22.5-25.0	prominent wing
	26	*D. subintegrum*	37.5-45.0 × 25.0-27.5	prominent wing
	27	*D. subserratum*	55.5-62.0 × 37.5-44.5	rough
	28	*D. sylvaticum*	56.0-60.5 × 32.0-40.0	prominent wing
	29	*D. tomentosum*	30.0-34.5 × 24.5-26.0	prominent wing
	30	*D. xiphophyllum*	32.5-40.0 × 22.5-27.0	prominent wing
	31	*D. thailandicum*	61.5-63.0 × 31.0-32.0	prominent wing
Hypodematium	1	*H. boonkerdii*	37.5-41.0 × 26.5-30.0	rugate
	2	*H. crenatum*	43.0-51.0 × 32.5-41.0	rugate
	3	*H. glanduloso-pilosum*	35.5-48.0 × 27.0-34.0	rugate
	4	*H.* sp.	53.5-60.5 × 43.0-49.5	rugate

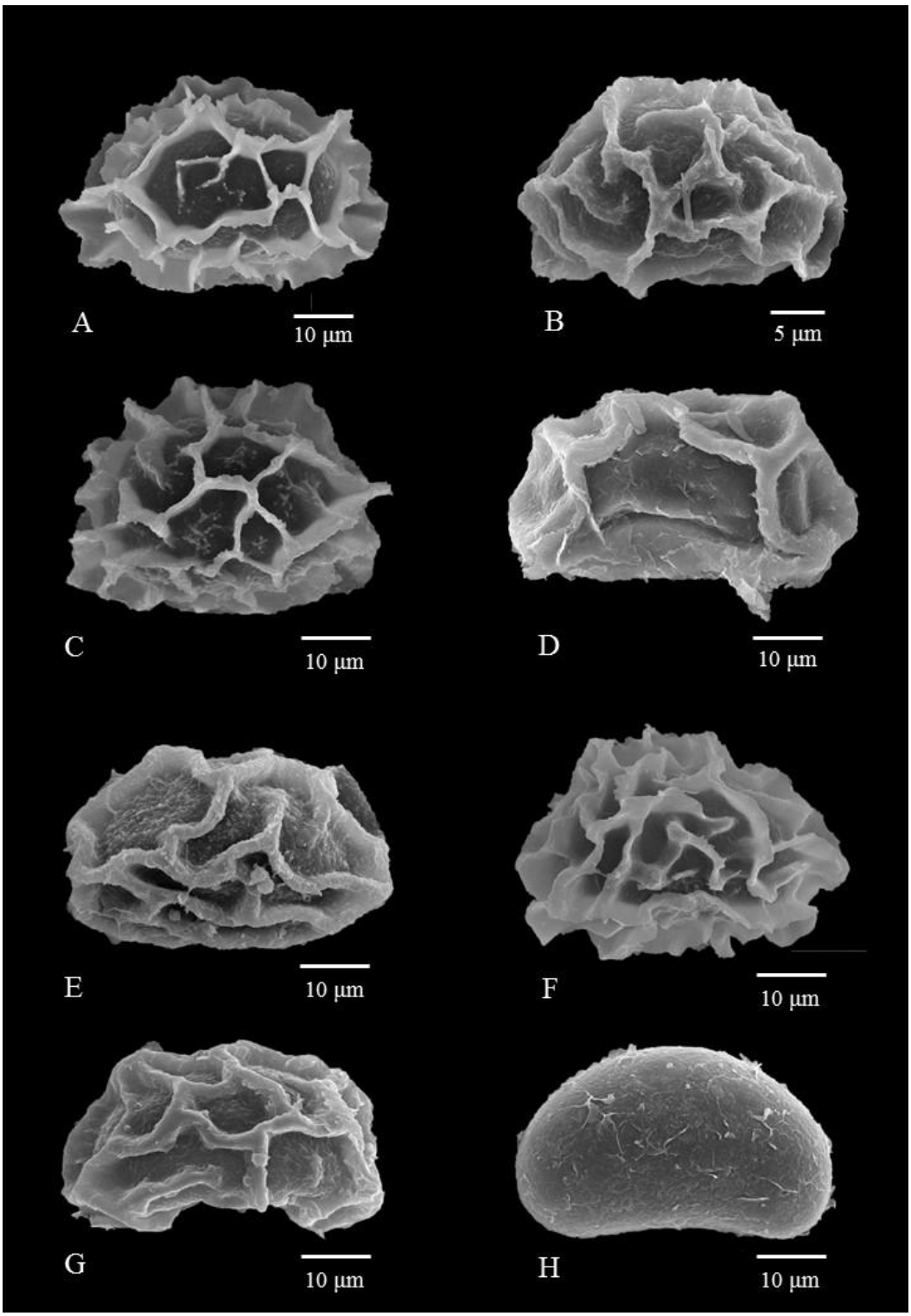

Figure 4.22 *SEM micrographs of spores.* A. *Anisocampium cumingianum,* B. *A. cuspidatum,* C. *A. niponicum,* D. *Athyrium anisopterum* E. *A. biserrulatum.* F. *A. brevisorum,* G. *A. dissitifolium,* H. *A. mackinnonorum.*

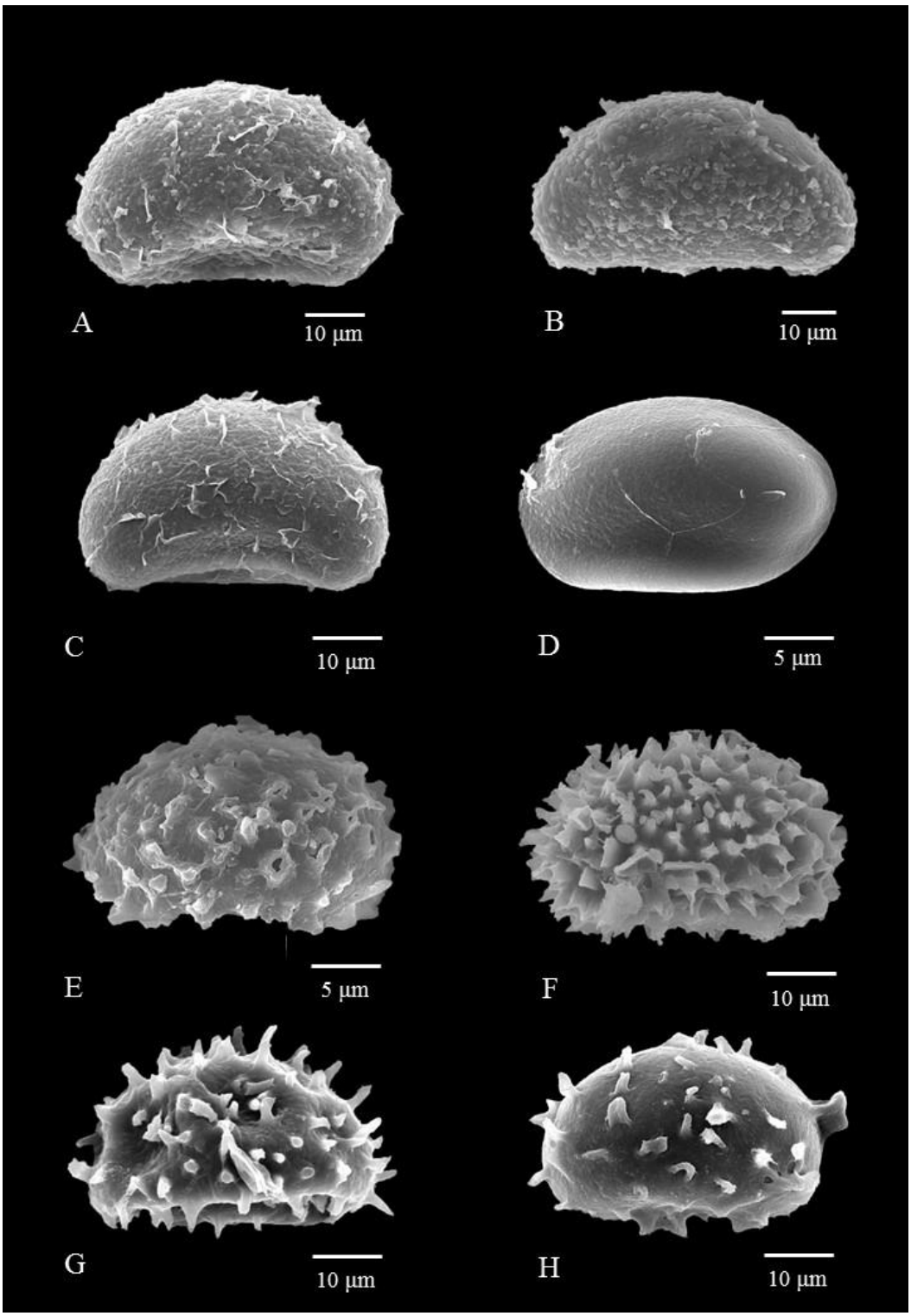

Figure 4.23 SEM micrographs of spores (continued). A. *A. pachyphyllum*, B. *A. strigillosum*, C. *A. wangii*, D. *Cornopteris opaca*, E. *Deparia boryana*, F. *D. heterophlebia*, G. *D. japonica*, H. *D. lancea*.

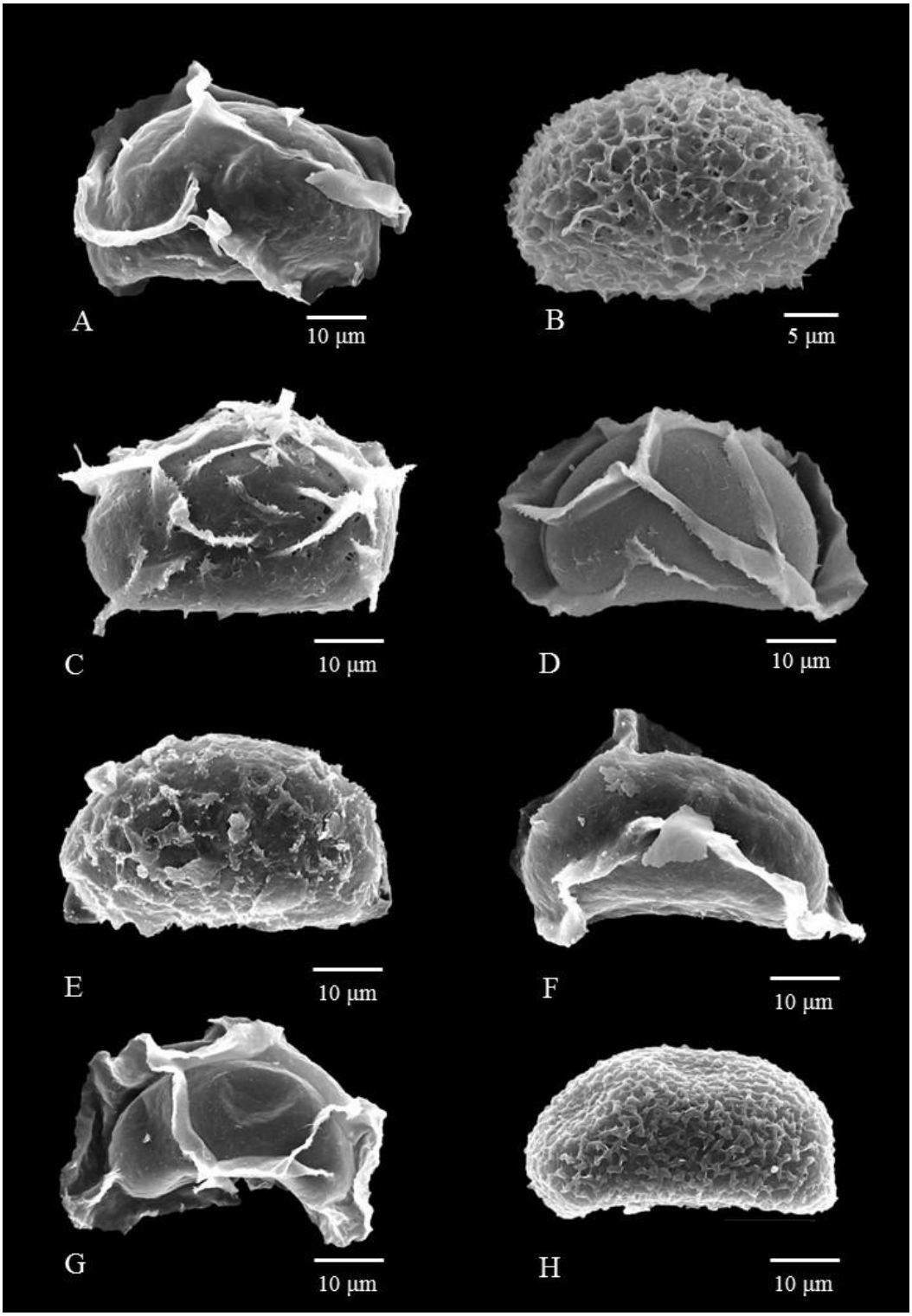

Figure 4.24 SEM micrographs of spores (continued). A. *Diplazium bantamense*, B. *D. bellum*, C. *D. conterminum*, D. *D. cordifolium*, E. *D. crenato-serratum*, F. *D. dilatatum*, G. *D. donianum*, H. *D. esculentum*.

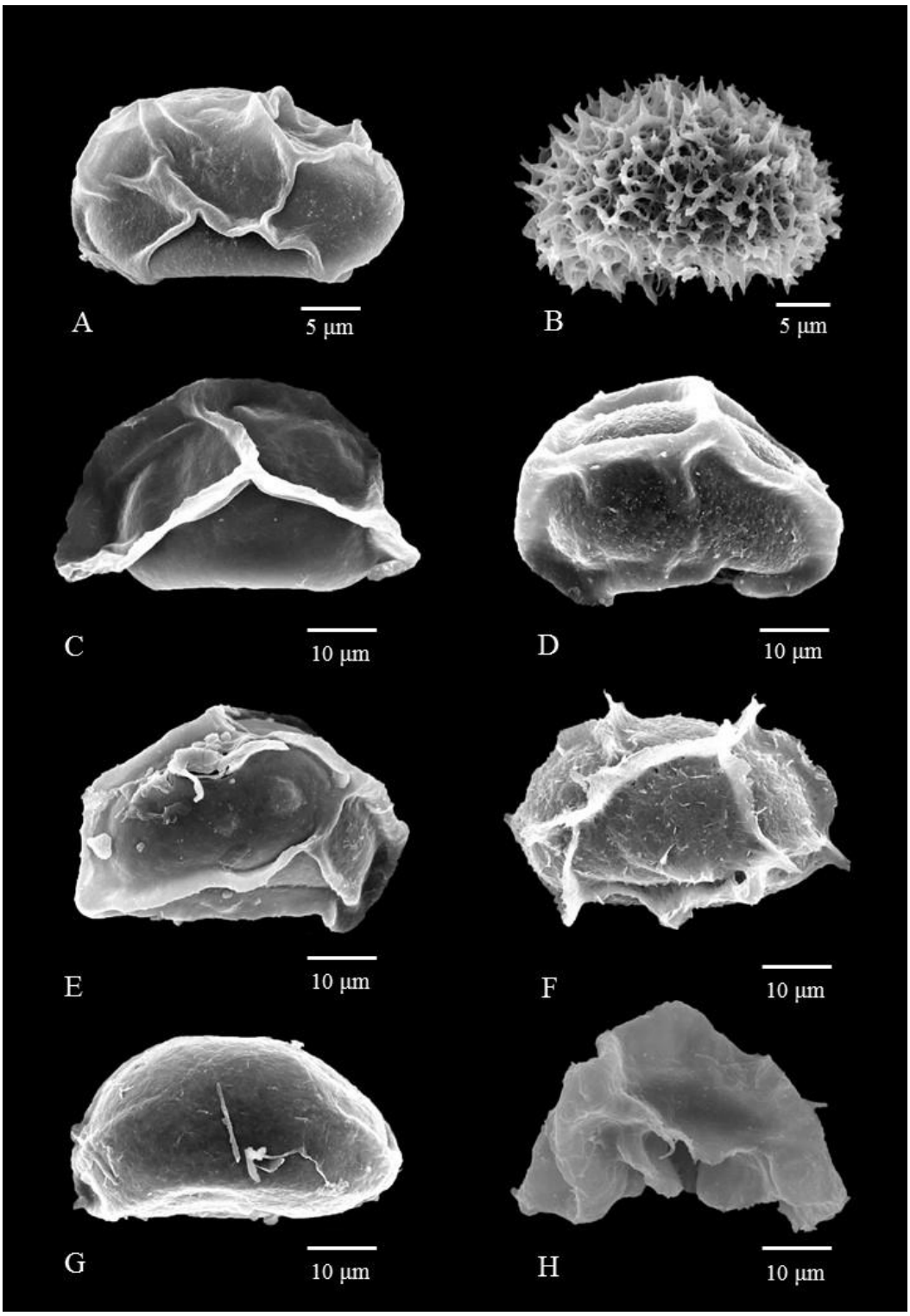

Figure 4.25 SEM micrographs of spores (continued). A. *Diplazium kappanense*, B. *D. leptophyllum*, C. *D. malaccense*, D. *D. megaphyllum*, E. *D. mettenianum*, F. *D. muricatum*, G. *D. pallidum*, H. *D. petelotii*.

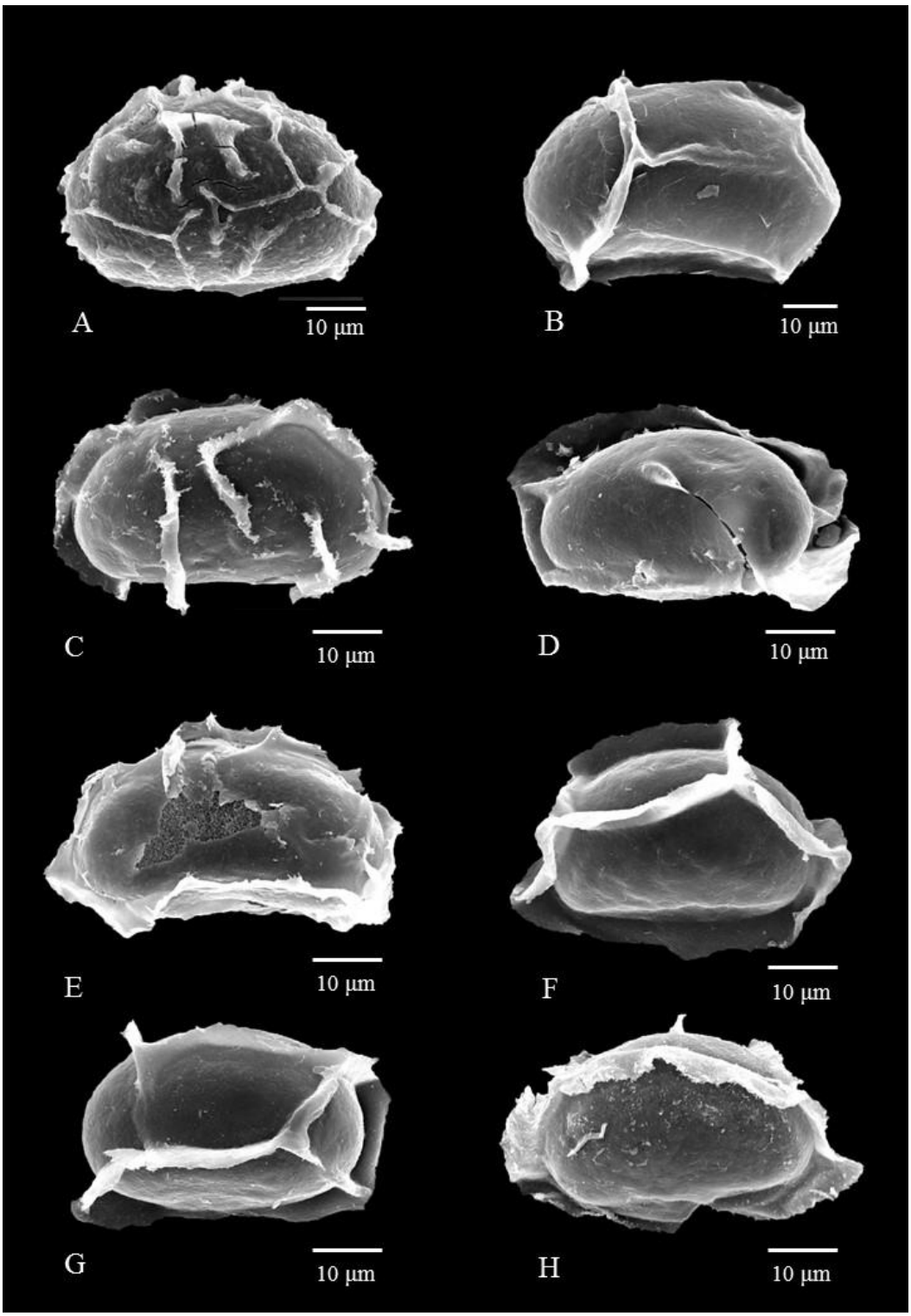

Figure 4.26 SEM micrographs of spores (continued). A. *Diplazium petrii*, B. *D. polypodioides*, C. *D. prescottianum*, D. *D. procumbens*, E. *D. proliferum*, F. *D. riparium*, G. *D. siamense*, H. *D. simplicivenium*.

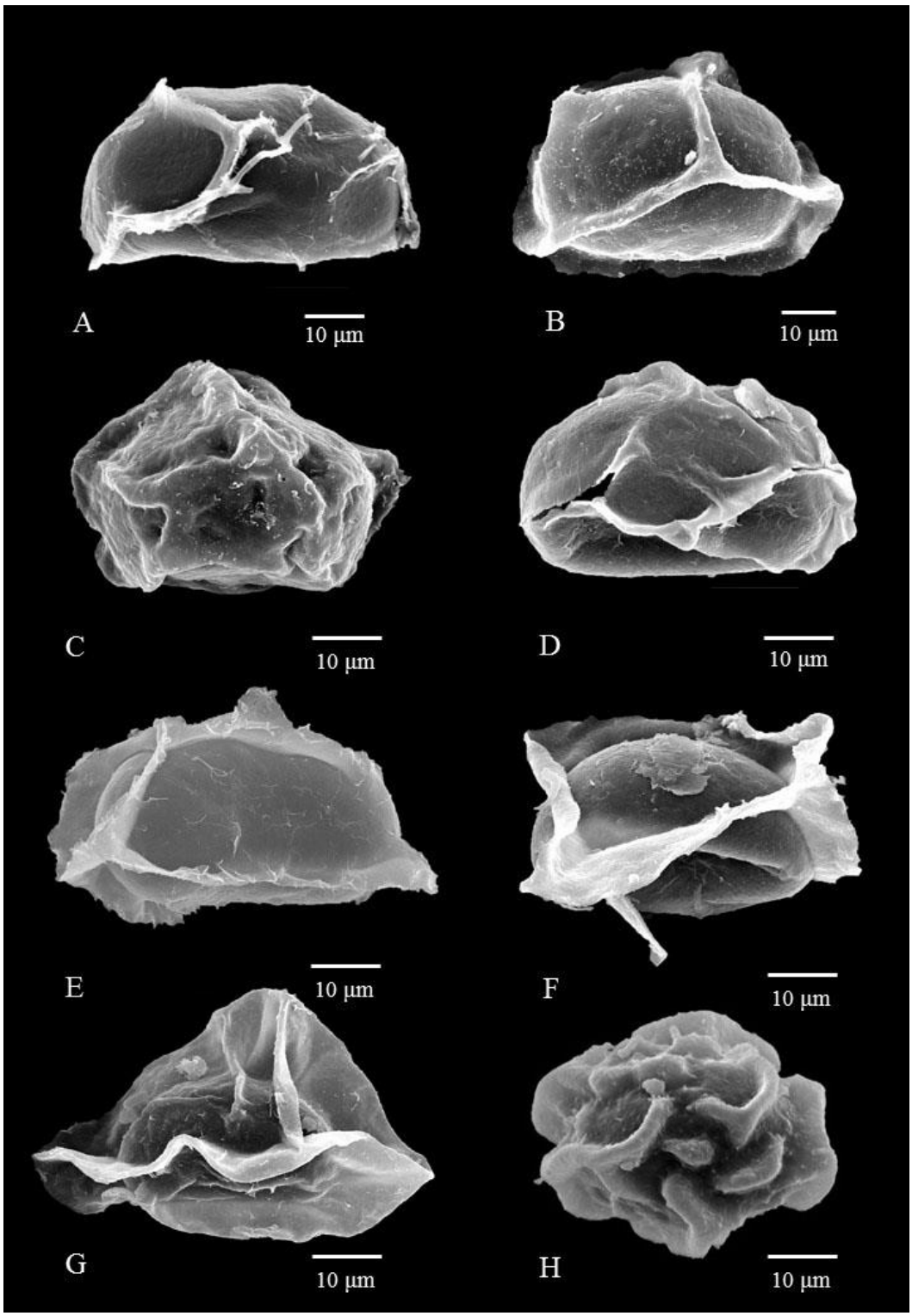

Figure 4.27 SEM micrographs of spores (continued). A. *Diplazium sorzogonense*, B. *D. subintegrum*, C. *D. subserratum*, D. *D. sylvaticum*, E. *D. tomentosum*, F. *D. xiphophyllum*, G. *D. thailandicum*, H. *Hypodematium boonkerdii*.

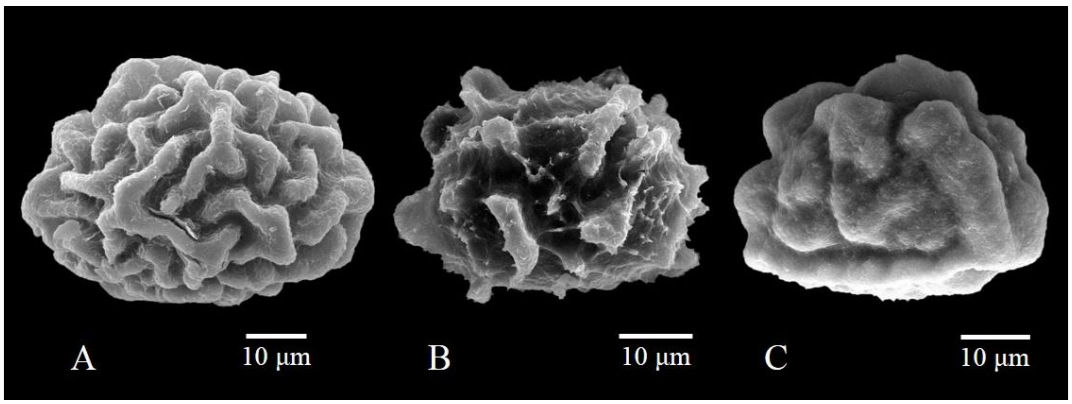

Figure 4.28 SEM micrographs of spores (continued). A. *Hypodematium crenatum*, B. *H. glanduloso-pilosum*, C. *H*. sp.

Table 4.4 Comparative spore morphological study with previous works.

Genera	No.	Taxa	Devi (1977)	Huang (1981)	Tryon *et al.* (1991)	Liu *et al.* (2000)
Anisocampium	1	*A. cumingianum*	-	-	-	✓
	2	*A. cuspidatum*	-	-	-	-
	3	*A. niponicum*	-	✓	-	✓
Athyrium	1	*A. anisopterum*	-	✓	-	✓
	2	*A. biserrulatum*	-	-	-	-
	3	*A. brevisorum*	-	-	-	-
	4	*A. dissitifolium*	-	-	-	-
	5	*A. mackinnonorum*	-	-	-	-
	6	*A. pachyphyllum*	-	-	-	-
	7	*A. strigillosum*	-	-	✓	-
	8	*A. wangii*	-	-	-	-
Cornopteris	1	*C. opaca*	-	-	-	✓
Deparia	1	*D. boryana*	-	-	-	-
	2	*D. heterophlebia*	-	-	-	-
	3	*D. japonica*	-	-	✓	-
	4	*D. lancea*	-	×	-	✓
Diplazium	1	*D. bantamense*	×	-	-	-
	2	*D. bellum*	×	-	-	-
	3	*D. conterminum*	-	-	-	×
	4	*D. cordifolium*	-	-	✓	-
	5	*D. crenato-serratum*	-	-	-	-
	6	*D. dilatatum*	✓	×	-	✓
	7	*D. donianum*	-	✓	✓	✓
	8	*D. esculentum*	×	✓	✓	✓
	9	*D. kappanense*	-	-	-	×
	10	*D. leptophyllum*	-	-	-	-
	11	*D. malaccense*	-	-	-	-
	12	*D. megaphyllum*	-	✓	-	✓
	13	*D. mettenianum*	-	✓	-	✓
	14	*D. muricatum*	-	-	-	-
	15	*D. pallidum*	-	-	-	-
	16	*D. petelotii*	-	-	-	-
	17	*D. petrii*	-	×	-	×
	18	*D. polypodioides*	✓	-	-	-
	19	*D. prescottianum*	-	-	-	-
	20	*D. procumbens*	-	-	-	-
	21	*D. proliferum*	-	-	✓	✓
	22	*D. riparium*	-	-	-	-
	23	*D. siamense*	-	-	-	-
	24	*D. simplicivenium*	-	-	-	-
	25	*D. sorzogonense*	-	-	-	-
	26	*D. subintegrum*	-	-	-	-
	27	*D. subserratum*	-	-	-	-
	28	*D. sylvaticum*	-	-	✓	-
	29	*D. tomentosum*	-	-	-	-
	30	*D. xiphophyllum*	-	-	-	-
	31	*D. thailandicum*	-	-	-	-
Hypodematium	1	*H. boonkerdii*	-	-	-	-
	2	*H. crenatum*	✓	-	✓	✓
	3	*H. glanduloso-pilosum*	-	-	-	-
	4	*H.* sp.	-	-	-	-

✓ = corresponding to this study; × = not corresponding to this study

4.3 Molecular study

After alignment, the algined length of *rbcL*, *trnL-F* and *rps4* regions were 1,358, 1,070 and 1,125 characters, respectively. Both *rbcL* and *rps4* phylogenies indicated all genera are monophyletic groups whereas *trnL-F* phylogeny showed that *Cornopteris* is the polyphyletic group. In addition, relationships among genera are different across all three phylogenies.

Both *rbcL* and *rps4* phylogeny (Figure 4.29, 4.33, 4.30, 4.34) based on ML and BI showed that all genera are monophyletic groups and ladder like. *Athyrium* was the sister group of *Cornopteris*, and in turn the clade of both genera was the sister group to *Anisocampium*. This clade is the sister group to *Diplazium*, and then to *Deparia* with *Hypodematium* at the earliest clade in the tree. In contrast, *trnL-F* phylogeny (Figure 4.31, 4.35) shows the trichotomy of *Athyrium*, *Cornopteris* I and *Anisocampium*, and this trichotomy is the sister group to the clade (*Deparia*, *Diplazium*) clade. Then, this clade is the sister group to the *Cornopteris* II clade with *Hypodematium* at the outgroup position. The incongruence described above is more apparent than real, i.e. all three phylogenies still provide very similar relationships, except placements of *Cornopteris* I and *Deparia* (or *Diplazium*). The only problematic aspect is the polyphyly of *Cornopteris*. This may be because there are no *rbcL* nor *rps4* sequences of taxa in *Cornopters* II

In the combined tree (Figure 4.32, 4.36), in general its topology is similar single-gene trees but shows some differences. Firstly, in the combined tree, all but one genera are monophyletic; only *Anisocampium* is paraphyletic with respect to *Cornopteris* and *Athyrium*. Secondly, *Cornopteris* is monophyletic, similar to *rbcL* and *rps4* trees but differs from the *trnL-F* tree. Thirdly, *Diplazium* is the sister group to the *Athyrium- Anisocampium-Cornopteris* clade, and this large clade then is the sister group to *Deparia*, similar to *rbcL* and *rps4* trees but differs from the *trnL-F* tree.

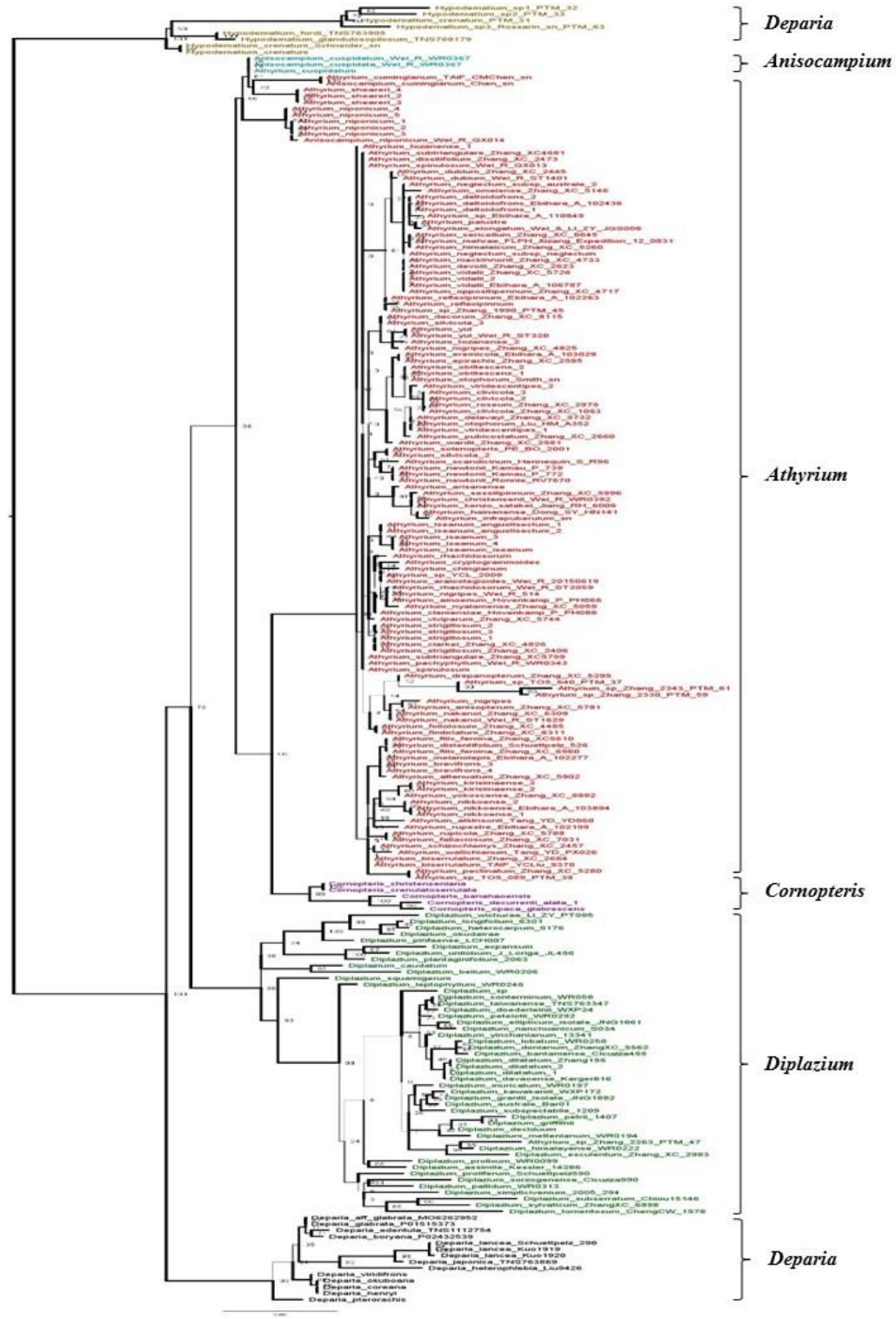

Figure 4.29 ML tree based on *rbcL* region. Taxa are shaded based on generic categories whose name are given on the right of brackets. Thicker internal branch indicates higher bootstrap support value.

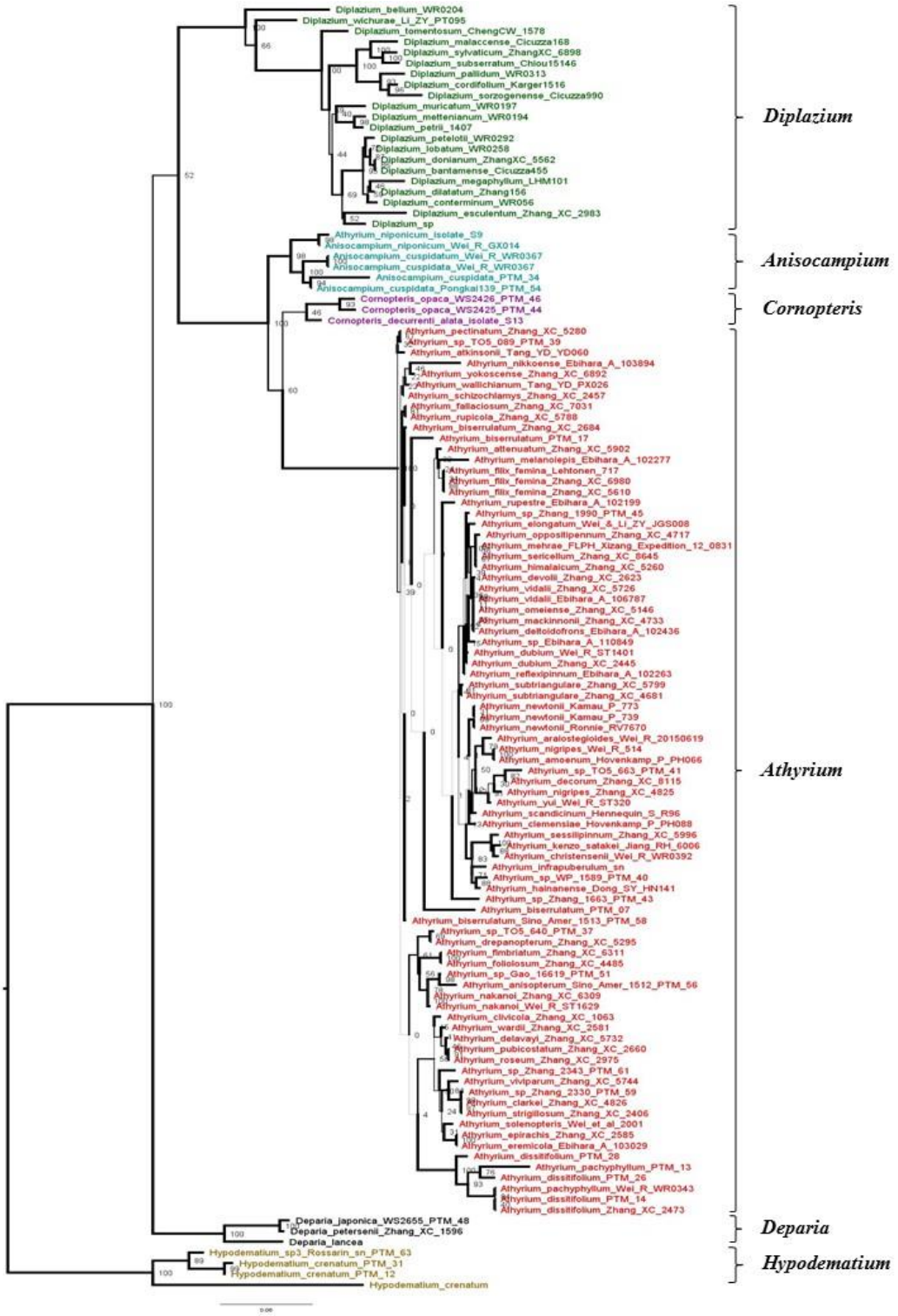

Figure 4.30 ML tree based on *rps4* region. Taxa are shaded based on generic categories whose name are given on the right of brackets. Thicker internal branch indicates higher bootstrap support value.

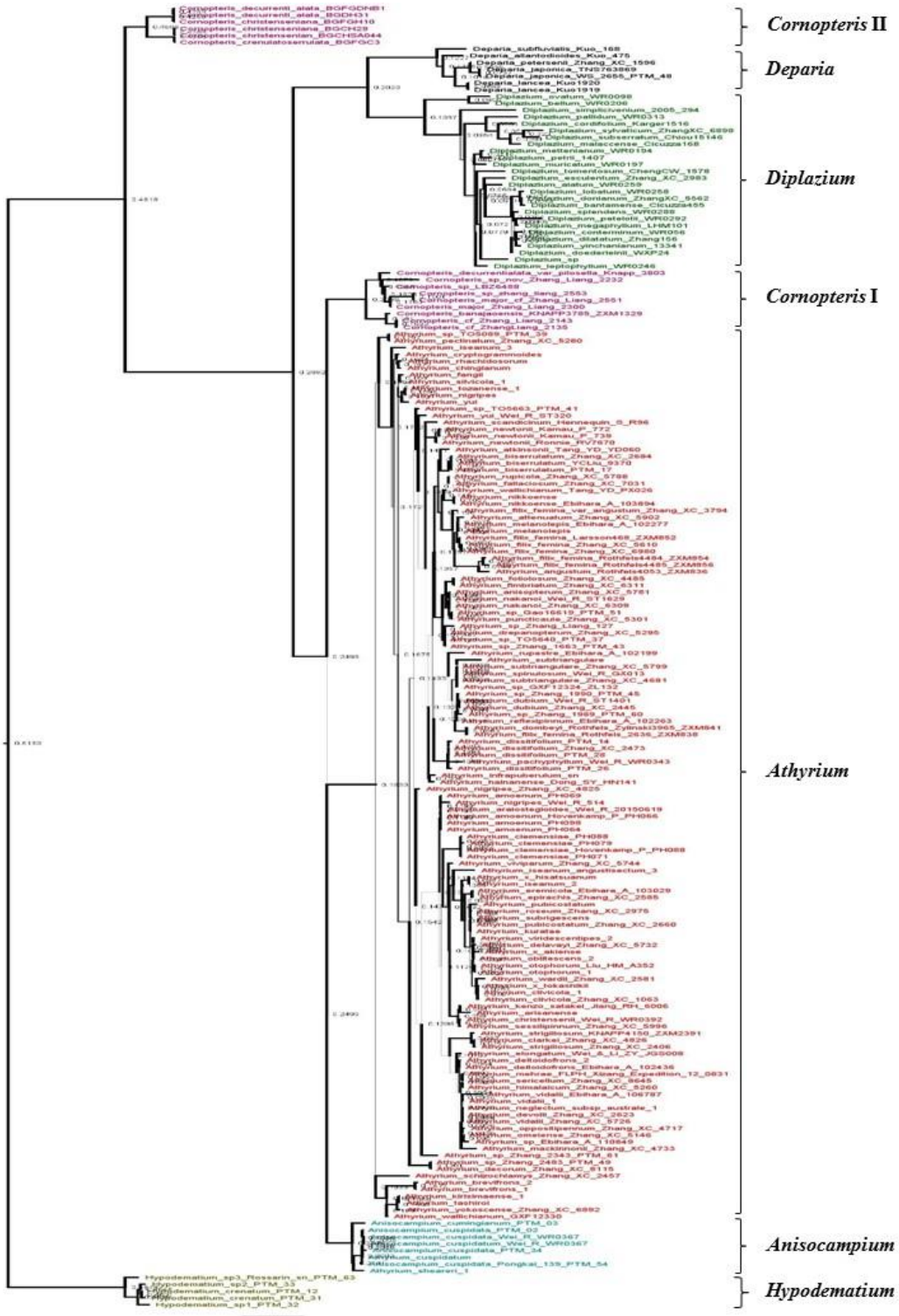

Figure 4.31 ML tree based on *trnL-F* region. Taxa are shaded based on generic categories whose name are given on the right of brackets. Thicker internal branch indicates higher bootstrap support value.

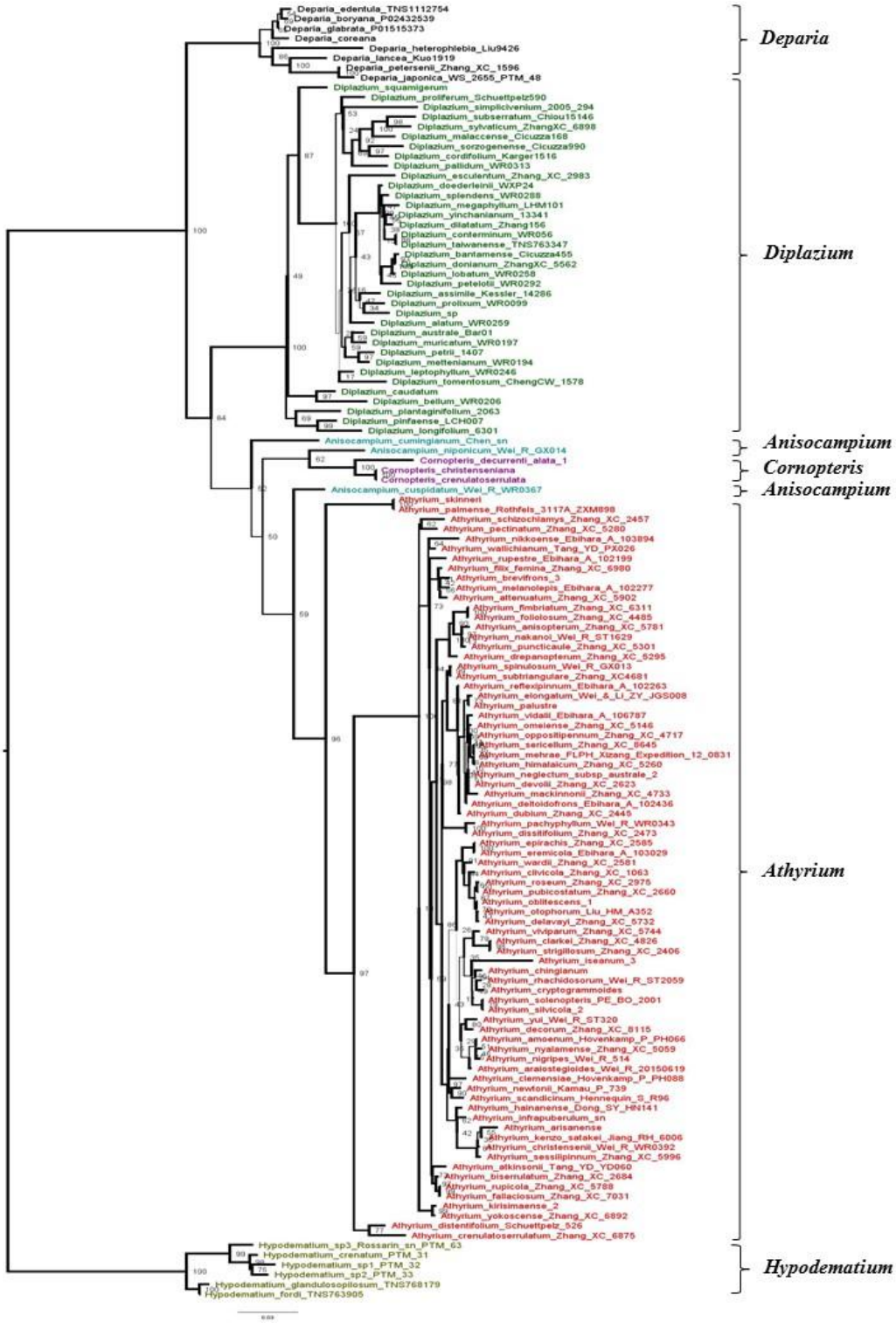

Figure 4.32 ML tree based on combined data (*rbcL*, *rps4* and *trnL-F* region). Taxa are shaded based on generic categories whose name are given on the right of brackets. Thicker internal branch indicates higher bootstrap support value.

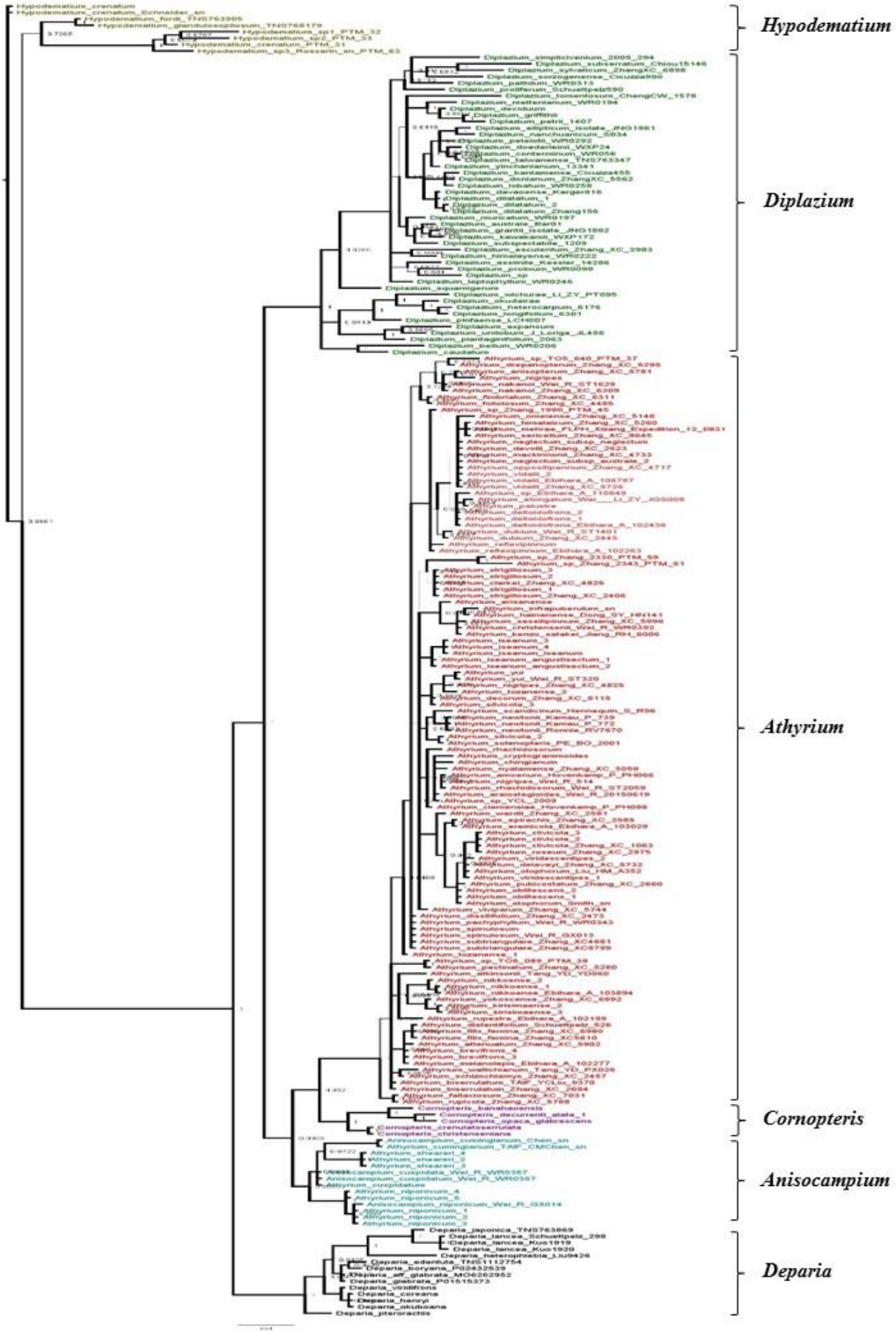

Figure 4.33 BI tree based on *rbcL* region. Taxa are shaded based on generic categories whose name are given on the right of brackets. Thicker internal branch indicates higher bootstrap support value.

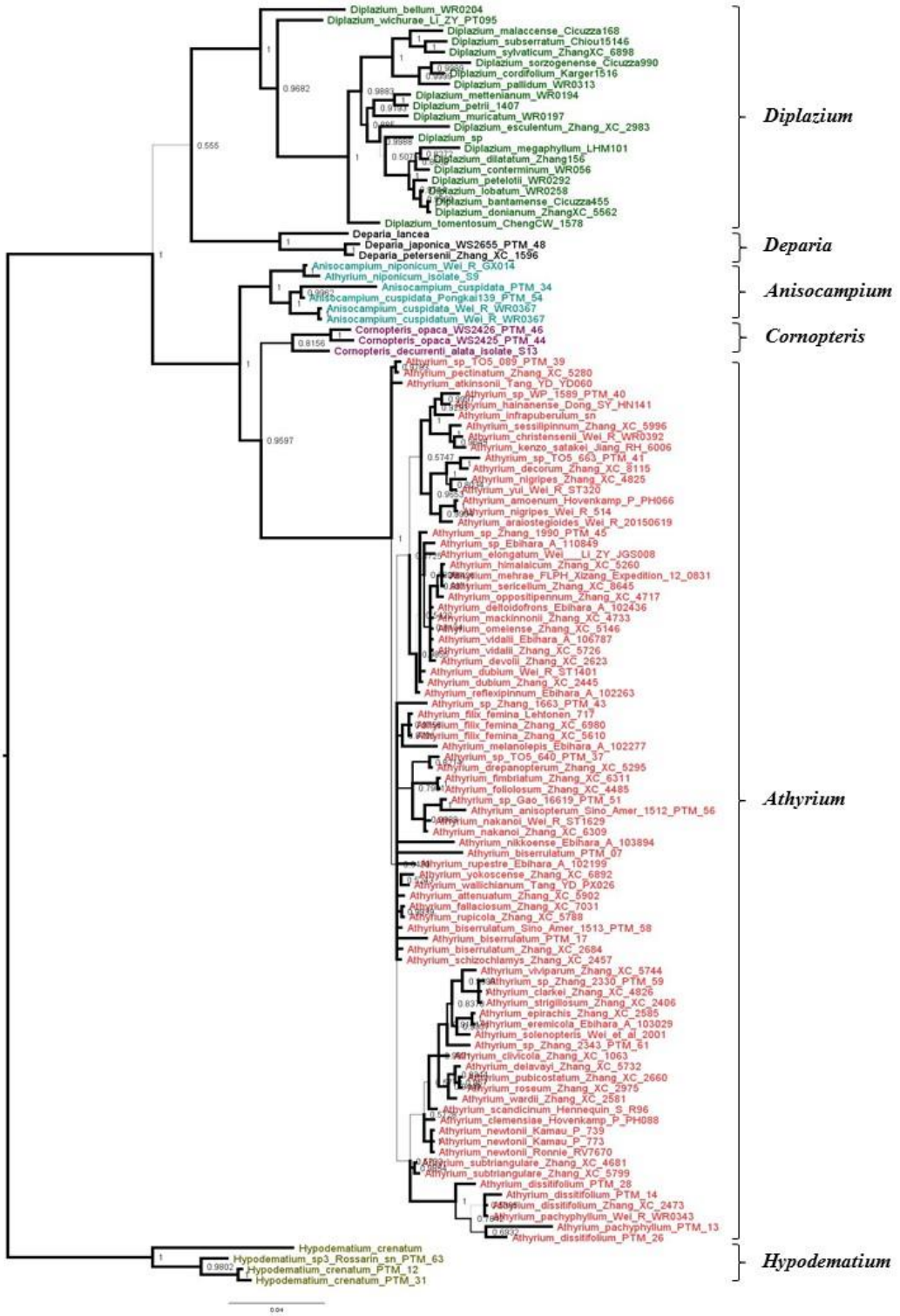

Figure 4.34 BI tree based on *rps4* region. Taxa are shaded based on generic categories whose name are given on the right of brackets. Thicker internal branch indicates higher bootstrap support value.

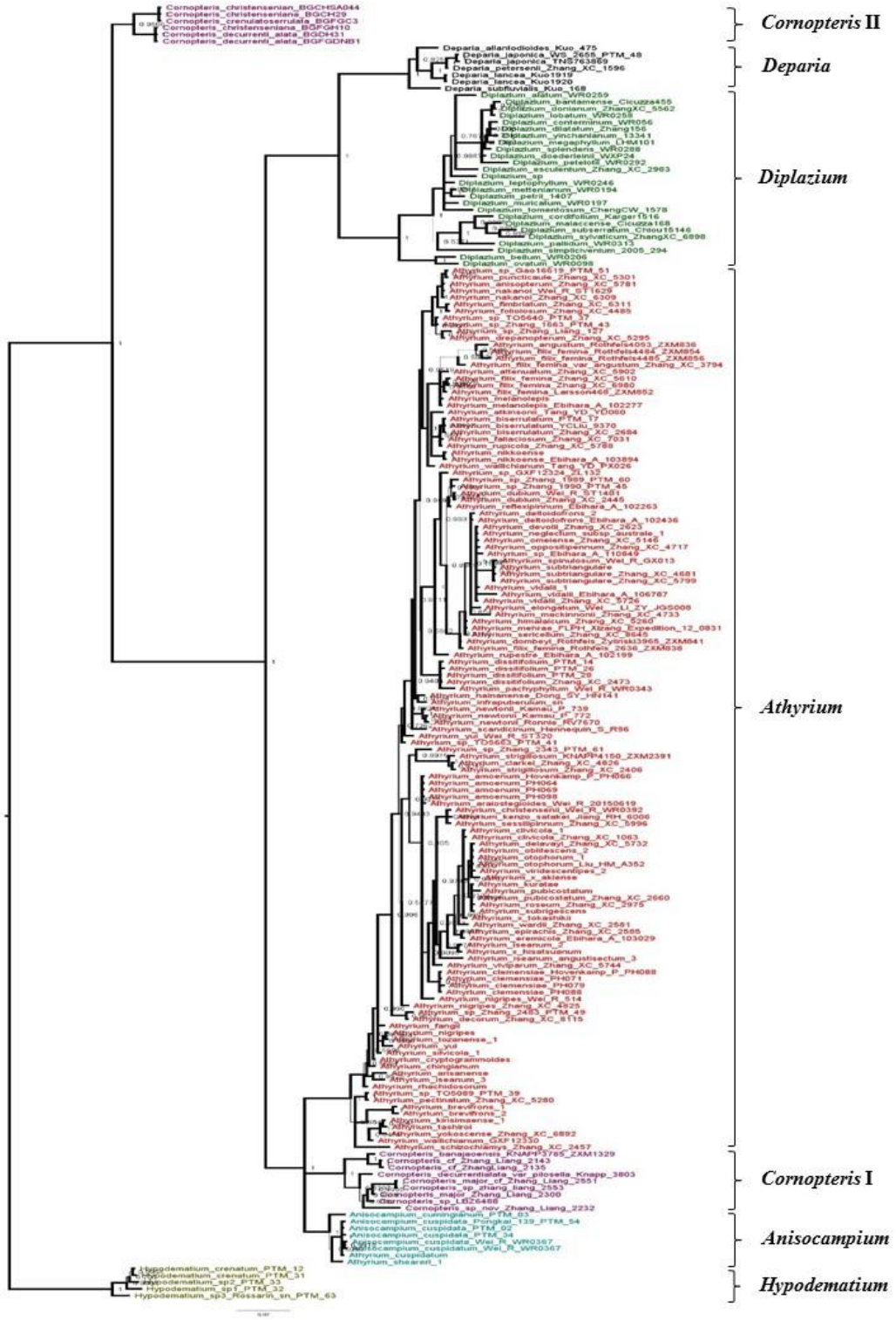

Figure 4.35 BI tree based on *trnL-F* region. Taxa are shaded based on generic categories whose name are given on the right of brackets. Thicker internal branch indicates higher bootstrap support value.

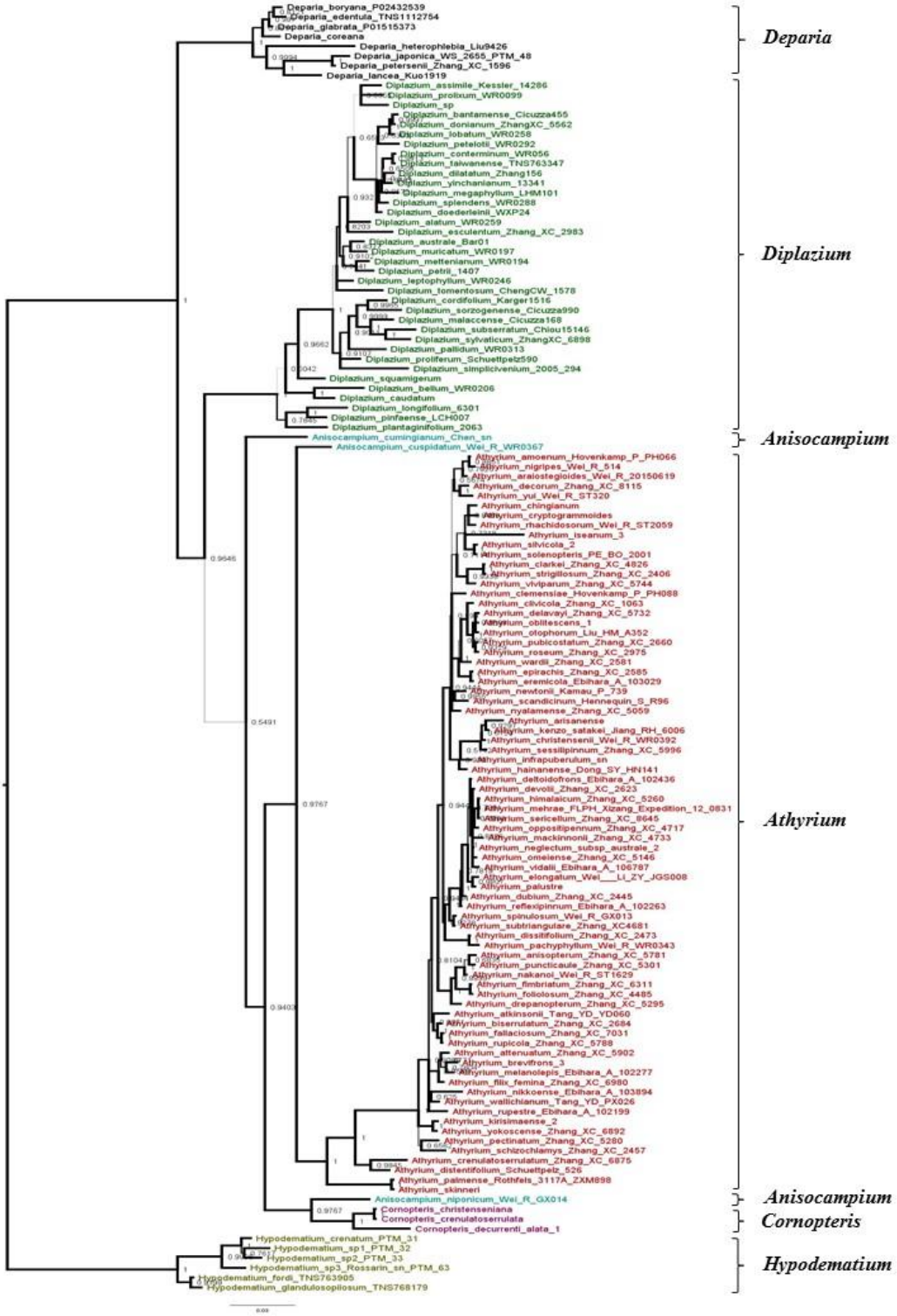

Figure 4.36 BI tree based on combined data (*rbcL*, *rps4* and *trnL-F* region). Taxa are shaded based on generic categories whose name are given on the right of brackets. Thicker internal branch indicates higher bootstrap support value.

The results of molecular study showed that *Athyrium*, *Anisocampium* and *Cornopteris* have more relationship to each other than another genera within the family. The molecular and morphological results are congruence. *Athyrium*, *Anisocampium* and *Cornopteris* shared morphological characters, i.e. scales (Table 4.1). In addition, *Deparia* and *Diplazium* were also showed the relationships among them. They shared morphological characters, i.e. scale and sori (Table 4.1). However, although they have some relationship among genera within family but for each genus, it is a monophyletic genus.

Molecular results are corresponding to another techniques results of this study that *Hypodematium* should be separated from Athyriaceae. Due to every genera in Athyriaceae and *Hypodematium* are monophyletic genera and *Hypodematium* never placed in any other clades of Athyriaceae.

4.3.1 Comparison of the molecular study with previous works

Liu *et al.* (2011) studied phylogenetic analysis using two regions of the chloroplast genome (*rbcL* and *trnL-F*) of fern genus *Anisocampium*. They recognized *Kuniwatsukia cuspidada* as *Anisocampium cuspidatum* which correspond to this study. All results of *rbcL*, *rps4* and *trnL-F* showed that *A. cuspidatum* (*K. cuspidada*) is only placed in *Anisocampium* clade.

4.4 Taxonomic implication

Previously, the Flora of Thailand recognized seven genera: *Anisocampium*, *Athyrium*, *cornopteris*, *Deparia*, *Diplazium*, *Hypodematium* and *Kuniwatsukia* in the family Athyriaceae Tagawa and Iwatsuki (1988). Then, new fern classifications were proposed by many authors such as Christenhusz *et al.* (2011), Wu *et al.* (2013) and PPG I (2016) etc. They recognized *Kuniwatsukia* as a synonym of *Anisocamoium* and moved the genus *Hypodematium* to its own family, Hypodematiaceae. On the basis of morphology, anatomy, palynology and molecular information are strongly supported the synonymous of *Kuniwatsukia* to *Anisocampium* and the segregation of the genus *Hypodematium* from the Athyriaceae (Figure 4.3, 4.5, 4.21; Table 4.1, 4.3). Since *Hypodematium* has unique characters in having epipetric habitat, stout and succulent rhizome, densely covering of persistent scales on rhizome, tripinnate frond with deltoid to pentagonal-ovate in outline, nearly heart-shaped vascular bundle in stipe, hairy indusium and rugate spore ornamentation (Table 4.1). Therefore, it is evident

here to include only 5 genera, i.e. *Anisocampium*, *Athyrium*, *Cornopteris*, *Deparia* and *Diplazium* in the family Athyriaceae and the genus *Hypodematium* should be placed in its own family Hypodematiaceae due to having many unique characters.

CHAPTER V
TAXONOMIC TREATMENT

Plant specimens from Thai and oversea herbaria and addition collections from the fields in Thailand were investigated during September 2015 to April 2018. Fourty six taxa of Athyriaceae and four taxa of *Hypodematium* were enumerated.

ATHYRIACEAE

Alston, Taxon 5: 25. 1956; W.C. Shieh, C. Devol and C.M. Kuo, Fl. Taiwan. 414. 1994. Tagawa & K. Iwats., Fl. Thailand 3(3): 418. 1988; W. Zhongren & M. Kato, Fl. China. 447. 2013.

Terrestrial ferns. *Stems* creeping, ascending or erect, slender to stout, massive and forming small trunk in some species, scaly; scale lanceolate, ovate-lanceolate or linear with longtail apex, concolorous, light brown to nearly black, margin entire or dentate. *Leaves* simple to bipinnae; petioles groove with two separated vascular bundle at base and gradually close together then forming gutter-shaped at rachis, glabrous or hairy, base scaly. *Laminae* linear, ovate or broadly-ovate in outline; vein free or anastomosing. *Sori* round, reniform, oblong, elongate or J-shaped, indusiate or exindusiate. *Spores* monolete, bilaterally symmetrical, kidney-shaped.

A family with five genera in Thailand.

Key to the genera

1a	Groove of rachises continued throughout it branches; multicellular hairs present……	2
1b	Groove of rachises interrupted, not continued to it branches; multicellular hairs not present…….....	**5.4 *Deparia***
2a	Sori round, reniform or J-shaped…….	3
2b	Sori linear or oblong…….....	4
3a	Sori round……	**5.1 *Anisocampium***
3b	Sori reniform or J-shaped……	**5.2 *Athyrium***
4a	Sori exindusiate; fleshy horn-like outgrowths present at	

	junction of rachis and costa……	**5.3 *Cornopteris***
4b	Sori indusiate; fleshy horn-like outgrowths not present..	5
5a	Sori dioplazoid, usually elongated along veinlet……	**5.5 *Diplazium***
5b	Sori not dioplazoid, not elongated along veinlet…….	**5.2 *Athyrium***

5.1 *Anisocampium*

C. Presl, Abh. Königl. Böhm. Ges. Wiss., ser. 5, 6: 418–419. 1851; Tagawa & K. Iwats., Fl. Thailand 3(3): 444. 1988; W. Zhongren & M. Kato, Fl. China 447. 2013.— *Kuniwatsukia* Pic. Serm.,Webbia 28(2): 455. 1973.— *Microchlaena* Ching, Bull. Fan Mem. Inst. Biol., Bot.8(5): 322–325. 1938. Type:—*Anisocampium cumingianum* C. Presl

Plants medium-sized, terrestrial.*Stem* short creeping to ascending, apex scaly; scale narrowly lanceolate, concolorous, brown, margin entire. *Leaves* unipinnate to bipinnate-pinnatifid; petioles grooved, base scaly, light green or purple red, vascular bundle gutter-shaped. *Laminae* ovate to broadly-ovate in outline, vein free or anastomosing. *Sori* indusiate, oblong to linear-oblong, round-reniform or J-shaped; indusia reniform or J-shaped, persistent or caducous.*Spores* monolete, 29.5-48.5 × 22.0-39.0 μm, bilaterally symmetrical, kidney-shaped. Ornamentation: reticulate wing folds.

Four species worldwide, distributed in tropical and subtropical regions of SE Asia and temperate areas of East Asia. Three species in Thailand.

Key to the species

1a	Frond unipinnate; sori round; indusia caducous……	2
1b	Frond bipinnate; sori reniform, J-shaped or oblong; indusia persistent……	**5.1.3 *A. niponicum***
2a	Pinnae 3-5 pairs, 2-4 cm broad; veins anastomosing..	**5.1.1 *A. cumingianum***
2b	Pinnae more than 5 pairs, 1-1.5 cm broad; veins free…….	**5.1.2 *A. cuspidatum***

5.1.1 ***Anisocampium cumingianum*** C. Presl, Abh. Königl. Böhm. Ges. Wiss., ser. 5, 6: 418–419. 1851; Tagawa & K. Iwats., Fl. Thailand 3(3): 444. 1988; W. Zhongren & M. Kato, Fl. China 448. 2013.—*Aspidium otarium* Kunze ex Mett., Abh. Senckenberg. Naturf. Ges.4: 34, no. 73. 1858.—*Nephrodium otarium* (Kunze ex Mett.) Baker, Syn. Fil. 288. 1867.—*Dryopteris otaria* (Kunze ex Mett.) Kuntze, Revis. Gen. Pl. 3: 197. 1930. 2: 813. 1891.—*Athyrium otaria* (Kunze ex Mett.) Posth., Revis. Gen. Pl. 2: 813. 1891.—*Athyrium cumingianum* (C. Presl) Ching, Index Filic., Suppl. 3:40. 1934.Type: Philippines, Luzon, without date, *Cuming 239* [holotype K! (K000428146), isotype K! (K000428147), isotype BM! (BM001048462)]. Figure 5.1, 5.52 A

Plants terrestrial. *Stems* short creeping, 2-5 mm in diameter, covered with scales at apex; scales 1.5-2.0 × 5 mm, lanceolate, concolorous brown, margin entire. Leaves unipinnate, up to 85 cm long; petioles up to 50 cm long, base 3-5 mm in diameter, usually glabrous but sometimes scaly, light green or purplish red when living, stramineous when dry; rachis and costa bearing short glandular hairs. *Laminae* 18-35 × 12-30 cm, broadly ovate to oblong in outline, usually glabrous but sometimes hairy, terminal pinna distinct similar to lateral one, lateral pinnae 3-5 pairs, subopposite to alternate, stalked; stalk 1-3 mm, terminal pinna, 10-20 × 2-5 cm, oblong,apex acuminate, margin subentire to lobe; lobe about 1/5 way to midrib, acute or round; lateral pinnae 8-20 × 2-4 cm, falcate, apex attenuate, base truncate, margin subentire, sometime hairy, pinnae lobe 1/5 to midrib with sharp teeth, herbaceous, light green, glabrous or minutely hairy; vein anastomosing, vein group pinnate; veinlets 4-5 pairs, uniting to the opposite ones of the lateral groups. *Sori* 0.5-2 mm, round, on middle of each veinlets, indusiate; indusia round-reniform, membranaceous, light brown, ciliate at margin, caducous. *Spores* monolete, bilaterally symmetrical, kidney-shaped, 41.0–48.0 µm × 31.0–32.5 µm; perispore ornamentation reticulate with fimbriate wing folds

Thailand.— NORTHERN: Mae Hong Son (Mae La Noi, Khun Yuam), Chiang Mai (Kang Kat, Doi Chiang Dao, Doi Suthep, Doi Makena, Sop Aep), Chiang Rai (Doi Tung), Lamphun (Doi Khun Tan), Lampang (Huai Thak, Mae Mo), Phrae (Mae Ban), Tak (Wang Chao, Lan Sang, Doi Musoe, Khao Phra Wo), Phitsanulok (Thung Salaeng Luang),; CENTRAL: Saraburi (Sam Lan); SOUTH-WESTERN:

Kanchanaburi (Thung Kang Yang); SOUTH-EASTERN: Prachin Buri (Ban Dan Hills);

Distribution.— India, Sri Lanka, Myanmar, China, Taiwan, Laos, Philippines, Indonesia.

Ecology.— On sandy clayey soil or calcareous soil in shady to exposed areas in evergreen forests at 500–1,300 m alt.

Specimens examined.—**THAILAND**. Mae Hong Son, *E. Hennipamn 3491* (L3525176); Mae Hong Son, *K. Larsen, T. Santisuk & C. Phengklai 2283* (K); Chiang Mai, *A.F.G. Kerr 1975* (BM); Chiang Mai, *E. Hennipamn 3022* (L), Chiang Mai, *Eryl Smith 1158* (K); Chiang Mai, *G. Murata, K. Iwatsuki & C Phengklai T-14958* (K); Chiang Mai, *J.F. Maxwell 87-756* (L); ibid., *J.F. Maxwell 88-1142* (L), ibid., *J.F. Maxwell 89-876* (L), ibid., *J.F. Maxwell 06-757* (QBG), ibid., *J.F. Maxwell* 97-*1324* (CMUB); Chiang Mai, *K. Bunchuai 1151* (L); Chiang Mai, *L.Q. Bao 6* (CMUB); Chiang Mai, *Lita M. Banoc 39* (CMUB); Chiang Mai, *M. Tagawa, T. Shimizu, M. Houtoh, H. Koyama & A. Nalampoon T9749* (L); Chiang Mai, *R. Pollawatn 1531* (BCU);ibid., *R. Pollawatn 1534* (BCU);ibid., *R. Pollawatn 1535* (BCU);ibid., *R. Pollawatn 1537* (BCU); ibid., *R. Pollawatn 1565* (BCU);ibid., *R. Pollawatn 1582* (BCU); Chiang Mai, *T. Shimizu & M. Houtoh T10547* (L); Chiang Mai, *U. Intron 1* (CMUB, L); Chiang Mai, *W. Somprasong 168* (BK), Chiang Mai, *W. Somprasong 175* (BK), Payao, *O. Petrmitr 65* (CMUB);Lampang, *M. Tagawa, T. Shimizu, H. Koyama & A. Nalampoon T10636* (L); Lampang, *O. Petrmitr 363* (CMUB), Lamphun, *J.F. Maxwell 93-684* (L), Lamphun, *N. Soontarawong 6* (CMUB, L); Lamphun, *W. Somprasong 219* (BK). Tak, *G. Murata, N. Fukuoka & C. Phengklai T-16653* (K, L); Tak, *M. Tagawa, K. Iwatsuki, H. Koyama & A. Chintayungkun T8653* (K, L); Tak, *T. Boonkerd 1013* (BCU, K);Tak, *T. Boonkerd & R. Pollawatn* 572 (BCU); Loei, *T. Boonkerd et al. 2011-624* (BCU); Phitsanulok, *M. Tagawa, K. Iwatsuki, T Shimizu, N. Fukuoka & M. Houtoh T11217* (L); Phitsanulok, *Pteridophyte trip 98* (BCU); Phitsanulok, *W. La-ongsri, M. Wongnak, P. Tatiya & S. Satatha 2433* (QBG); Nakorn Sawan, *E. Hennipman 3104* (L), Udon Thani, *C. Pengklai 1279* (K, P); Saraburi, *J.F. Maxwell 74-634* (BK, L), Saraburi, *T. Smitinand & H. Sleumer 1325* (L). **TAIWAN**. Pingdong, *R. Knapp 3104* (P), Pingdong, *R. Knapp 1253* (P02437309), Pingdong, *R. Knapp 1264* (P).**SRI LANKA**. Mahaweli, *W.A. Sledge*

945 (BM). **CAMBODIA**. Monduliri, *Long C. CL436* (P). **LAOS**. Champasak, *J.F. Maxwell98-1049* (L). **PHILIPPINES.** Luzon, *Cuming 239* (BM, K); Luzon, *M. Ramos 2-107* (K). **UNKNOWN**. *C.C. Hosseus 47* (BM, P); *M. Thwaites s.n.* (P).

5.1.2 ***Anisocampium cuspidatum*** (Bedd.) Yea C. Liu, W. L. Chiou & M. Kato, Taxon 60(3): 829. 2011; W. Zhongren & M. Kato, Fl. China 448. 2013.— *Lastrea cuspidata* Bedd., Ferns Brit. India pl. 118. 1870.— *Microchlaena cuspidate* (Bedd.) Ching, Acta Phytotax. Sin. 9(1): 99. 1964.— *Kuniwatsukia cuspidate* (Bedd.) Pic. Serm., Webbia 28(2): 455. 1973.— *Athyrium cuspidatum* (Bedd.) M. Kato, Bot. Mag. (Tokyo) 90: 27. 1977.— *Nephrodium cuspidatum* C. Presl, Reliq. Haenk. 1(1): 31. 1825.— *Nephrodium cuspidatum* Baker, Syn. Fil. 260. 1867. .— *Phegopteris elongat*a J. Sm., Hist. Fil. 233. 1875.— *Lastrea elongata* Bedd. ex C.B. Clarke, Ferns Brit. India 118. 1880.— *Dryopteris elongata* Kuntze, Revis. Gen. Pl. 2: 811. 1891.— *Polypodium trinidadensis* Jenman, Gard. Chron., ser. 3 18: 235. 1895.— *Dryopteris trinidadensis* (Jenman) C. Chr., Index Filic. 5: 298. 1905.—*Dryopteris khasiana* C. Chr., Index Filic. 5: 272. 1905.—*Microchlaena yunnanensis* (Christ) Ching, Bull. Fan Mem. Inst. Biol., Bot. 8(5): 325–327, pl. 6, f. 1. 1938.—*Dryopteris yunnanensis* (Christ) Copel., Gen. Fil. (Copeland) 122. 1947.Type:— Nepal, Without locality, 1820, *Wallich Cat. No. 309* [holotype NY! (photo seen NY127703), isotypes K! (K001109770, K001109769)]. Figure 5.2, 5.52 B

Plants terrestrial. *Stems* short creeping, apex ascending, up to 3 cm in diameter, densely scaly; scales 1.0-1.5 × 10-13 mm, narrowly lanceolate, concolorous, brown, margin entire. Leaves unipinnate, about 1 m up to 1.35 m long, monomorphic; petioles 45-70 cm long, base 5-7 mm in diameter, purplish red when living, stramineous to light brown when dried, densely scaly at base; rachis and costa bearing short glandular hairs. *Laminae* 55-65× 25-46 cm, outline oblong, papyraceous; pinnae 15-20 pairs, alternate, suddenly reduced upward, terminal pinna distinct, pinnatifid, 13-17 × 1-1.5 cm, apex long acuminate, margin lobe near base and serrate near apex, lowest pinna not reduced, lateral pinnae 14-24 × 1-2 cm, apex long acuminate, base oblique, margin subentire to lobe and serrate near apex, acroscopic auricle present; vein all free, veinlet 4-5 pairs, free, pinnate, reach to margin. *Sori* small, round, scattering throughout pinna, indusiate; indusia round to reniform, caducous. *Spores*

monolete, bilaterally symmetrical, kidney-shaped, 29.5–36.5 µm × 20.0–26.0 µm; ornamentation prominent low folds of wing or ridge.

Thailand.— NORTHERN: Mae Hong Son (Ban Dong), Chiang Mai (Doi Chiang Dao, Doi Suthep, Doi Inthanon, Doi Pha Hom Pok), Chiang Rai (Mae Suai, Doi Tung, Khun Korn), Lumphun (Doi Khun Tan), Uttaradit (Phu Soi Dao).

Distribution.— China, Bhutan, Nepal, India, Myanmar.

Habitat.— On rather dry mountain slope in mixed evergreen forest at 800–1,800 m alt.

Specimens examined.—**THAILAND**. Mae Hong Son, *W. Pongamornkul 1889* (BKF); Chiang Rai, *P. Ratchata 79* (BCU); ibid., *P. Ratchata 80* (BCU); ibid., *P. Ratchata 95* (BCU); ibid.,*P. Ratchata 117* (BCU); ibid., *P. Ratchata 149* (BCU); ibid., *P. Ratchata 155* (BCU); Chiang Mai, Doi Chiang Dao, *R. Pollawatn & A. Petbanna 76* (BCU); ibid., *R. Pollawatn & A. Petbanna 2011-076* (BCU); ibid., *R. Pollawatn & A. Petbanna 593* (BCU); Chiang Mai, *E. Smith 1169* (BKF); Chiang Mai, Doi Chiang Dao,*P. Pongkai 81* (BCU); ibid., *P. Pongkai 139* (BCU);Chiang Mai, *W. Nanakorn et al. 4518*; Uttaratid, *S. Intamusik, K. Kerdsawang & N. Inthagool 203*; **NEPAL**. Bagmati, *R.L. Fleming 1327*; Bagmati, *Anon. s.n.*; Bagmati, *Wall 1629, 1828*; ibid., *Wall 1828*;Bagmati, *Wallich Cat. 85*; ibid., *Wallich Cat. 309*; ibid., *Wallich Cat. s.n.* **INDIA**. Assam, *G. Mann s.n.*; Meghalaya, *C.B. Clark 1762*; Meghalaya, *C.B. Clark 19093*; Meghalaya, *Hook & Taylor 18*. **CHINA**. Unknown, *Beijing team 891505*; ibid.*Beijing team 897133*; Unknown, *Cai Xi Tao 58-9067*; Unknown, *H. Hara, H. Kanai, S. Kurosawa, G. Murata, M. Togashi & T. Tuyawa 699*; Unknown, *Group plants in Western Yunnan10779*; Unknown, *Qin Haining et al. 962*; Unknown, *Red river plant expedition 652* Unknown, *Red river plant expedition 1685*; Unknown, *South China team 2335*. **MYANMAR**. Shan, *F.G. Dickson 9195*; Shan, *Rock 22/2*.

5.1.3 ***Anisocampium niponicum*** (Mett.) Y.C. Liu, W.L. Chiou & M. Kato, Taxon 60(3): 829. 2011; W. Zhongren & M. Kato, Fl. China 448. 2013.—*Asplenium niponicum* Mett., Ann. Mus. Bot. Lugduno-Batavi 2(8): 240. 1866.—*Asplenium uropteron* Miq., Ann. Mus. Bot. Lugduno-Batavi3(6): 174. 1867.— *Athyrium niponicum* (Mett.) Hance, J. Linn. Soc., Bot.13: 92–93. 1873.—*Athyrium uropteron*

(Miq.) C. Chr., Index Filic.3: 147. 1905.— *Asplenium niponicum* var.*uropteron* (Miq.) Franch. & Sav., Enum. Pl. Jap. 2(1): 224. 1877.—*Asplenium niponicum* var.*longipes* (Miq.) Franch. & Sav., Enum. Pl. Jap. 2(1): 225. 1877.—*Asplenium niponicum* var. *minus* (Miq.) Franch. & Sav., Enum. Pl. Jap.2 (1): 224. 1877.—*Athyrium biondii* Christ, Nuovo Giorn. Bot. Ital., n.s. 4(1): 91. 1897.—*Athyrium yunnanense* Christ, Bull. Acad. Int. Géogr. Bot. 17(212): 134–135. 1907.—*Athyrium fissum* Christ, Notul. Syst. (Paris) 1(2): 47. 1909.—*Athyrium matsumurae* Christ, Bot. Mag. (Tokyo) 24: 241. 1910.— *Athyrium sylvestrii* Christ, Nuovo Giorn. Bot. Ital., n.s. 17(2): 226. 1910.—*Athyrium pachyphlebium* C. Chr., Dansk Bot. Ark.9 (3): 55–56. 1937.— *Athyrium niponicum* var. *pachyphlebium* (C. Chr.) Kitag., Neo-Lineam. Fl. Manshur.31. 1979.Type:—Japan. Without locality, without date, *Keiske s.n.* [holotype L! (L0052439), isotype L! (L0052440)].Figure 5.3, 5.52 C

Plants terrestrial. *Stems* short creeping, 7-10 mm in diameter, scaly; scales 1.5 × 10 mm**,** narrowly lanceolate, concolorous, brown, margin entire. *Leaves* bipinnate, 54-75 cm long, monomorphic; petioles 25-35 cm long, 3-5 mm in diameter, purplish red when living, stramineous when dried, glabrous, base scaly; rachis and costa bearing short glandular hairs. *Laminae* 29-40 × 20-30 cm, ovate in outline, glabrous, papyraceous; rachis glabrous; lateral pinnae 5-9 pairs, lower pairs subopposite, upper pairs alternate, suddenly reduced upward, terminal pinna not distinct, lateral pinnae 10-20 × 3-6 cm, lanceolate-oblong in outline, sometime falcate, apex long acuminate, base obtuse; stalk 0.5-1 cm long; pinnules 13-20 pairs, alternate, about 1-2 × 0.3-0.5 cm, lanceolate, glabrous, sessile or minutely stalk about 1 mm long, apex acute, base oblique, margin serrate; vein free, veinlet 3-4 pairs, pinnate, reach to margin. *Sori* usually round reniform, rarely J-shaped or oblong, 0.5-2.0 mm long, close to midrib of pinnule, usually on basal acroscopic veinlet of vein group, indusiate; indusia J-shaped or oblong to linear-oblong, thin, persistent, glabrous, light brown. *Spores* monolete, bilaterally symmetrical, kidney-shaped, 41.0–48.5 µm × 33.5–39.0 µm; ornamentation reticulate, perispore with fimbriate-reticulate wing folds.

Thailand.— NORTHERN: Chiang Mai (Doi Chiang Dao).

Distribution.— India, China, Korea, Japan, Taiwan, Vietnam

Habitat.— On mountain slopes in semi-shaded area of hill evergreen forest at 1,200–2,000 m alt.

Specimens examined.—**THAILAND**. Chiang Mai, *J. F. Maxwell 95-714* (L); Chiang Mai, *T. Boonkerd et al. 2011-674* (BCU);Chiang Mai, *R. Pollawatn 995* (BCU); ibid., *R. Pollawatn 1097* (BCU); ibid., *R. Pollawatn 1562* (BCU); ibid., *R. Pollawatn 1563* (BCU); Chiang Mai, *R. Pollawatn & A. Petbanna 2011-075* (BCU); ibid., *R. Pollawatn & A. Petbanna 2012-62* (BCU); ibid., *R. Pollawatn & A. Petbanna 2012-69* (BCU); Unknown. *M. Tagawa & K. Iwatsuki 5159* (P). **KOREA**. Jejudo, *Taquet 3778*; Jejudo, *U. Faurie 16*, Jejudo, *U. Faurie 2179*; Unknown, *Kom. 32*. **JAPAN**. Nagano,*H.E. Fox s.n.*; Nagano, *U. Faurie s.n.*; Tokyo, *R. Yatabe s.n.* (BM); Tokyo, *S. Serizawa* 10866; Tokyo, *T. Uno s.n.*; Shizuoka, *Saiki 2430*; Mie, *M. Tagawa 4155*; ibid., *M. Tagawa 4951*; Mie, *Takalto s.n.*; Kyoto, *E.W. Wood & D.E. Boulford 18448*; Kyoto, *Y. Yonedo s.n.*; Kyoto, *M. Tagawa 7481*; Hyogo, *M. Tagawa 4155*; Yamagushi, *M. Tagawa 2437;* ibid., *M. Tagawa 3057*; ibid., *M.Tagawa 5615*; ibid., *M.Tagawa* 5*628*; ibid., *M. Tagawa 7533*; Unknown, *Keiske s.n*. **CHINA**. Bejing, *Bretschn. s.n.*; Shanxi, *Licent 1956*; Shanxi, *Rev. Fr. Hugh s.n.*; Shandong, *Guocheng-yong 20062-399-3*; Jiangsu, *Ching 3559*; Zhejiang, *C.Y. Chiao s.n.*; Guizhou, *Tsiang 5774*; Jiangxi, *De Vol 1299*; Yunnan, *Henry, 13107*; Yunnan, *E.E. Maire s.n.*; Yunnan, *Forrest 25315*; Yunnan, *Iwatsuki et al. 23*; Yunnan, *Y.M. Shui s.n.*; Guangxi, *Ching 6039*; Unknown, *Yan Yuehong 4393*; ibid., *Yan Yuehong 4498* ibid., *Yanyue Hong Xi Qin Linchuan Jianming 5020*; ibid., *Yanyue Hong Xi Qin Linchuan Jianming 5072*; Unknown, *Plant Resources expedition D435*. **TAIWAN**. Aowanda, *Knapp R. 3359*; Dongpu, *Knapp R. 172*; ibid., *Knapp R. 862*.

Note.— This species is the new recoed for Thailand.

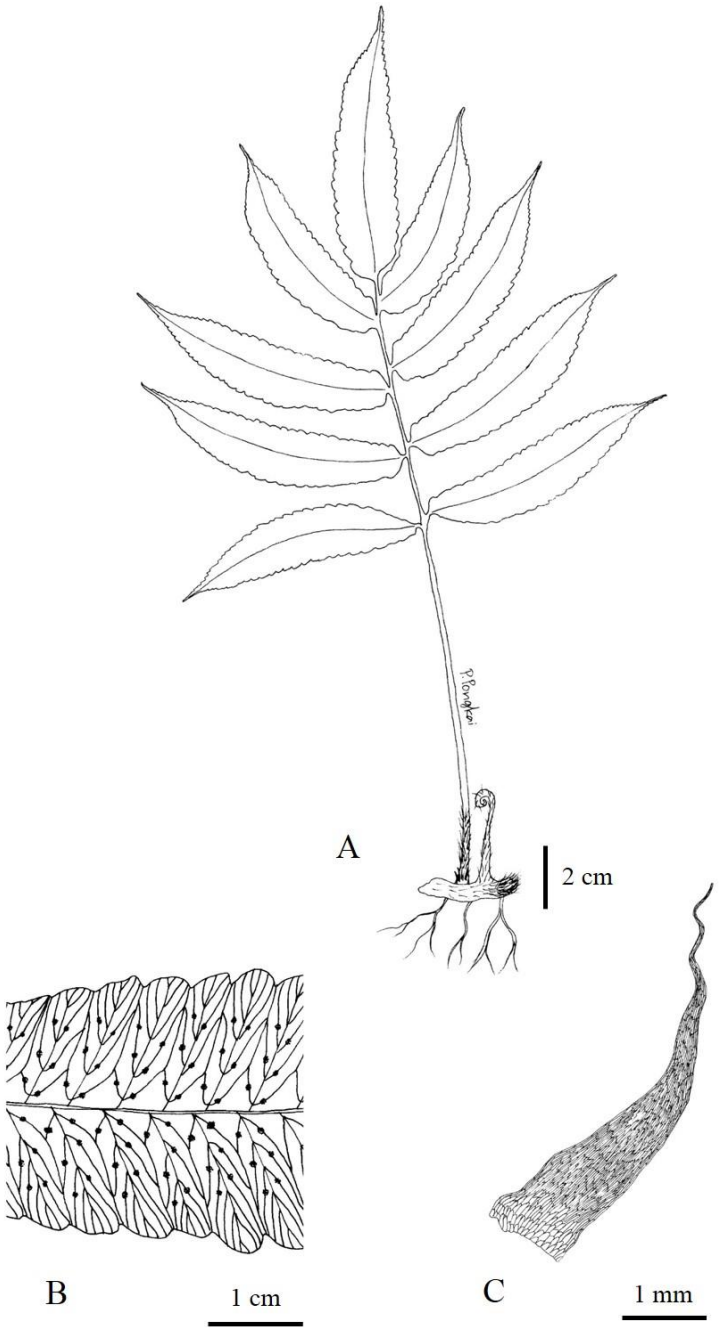

Figure 5.1 *Anisocampium cumingianum* C. Presl. A. whole plant. B. part of a pinna showing sori and venation. C. rhizome scale. Drawn by Puttamon Pongkai from *R. Pollawatn 1563* (BCU).

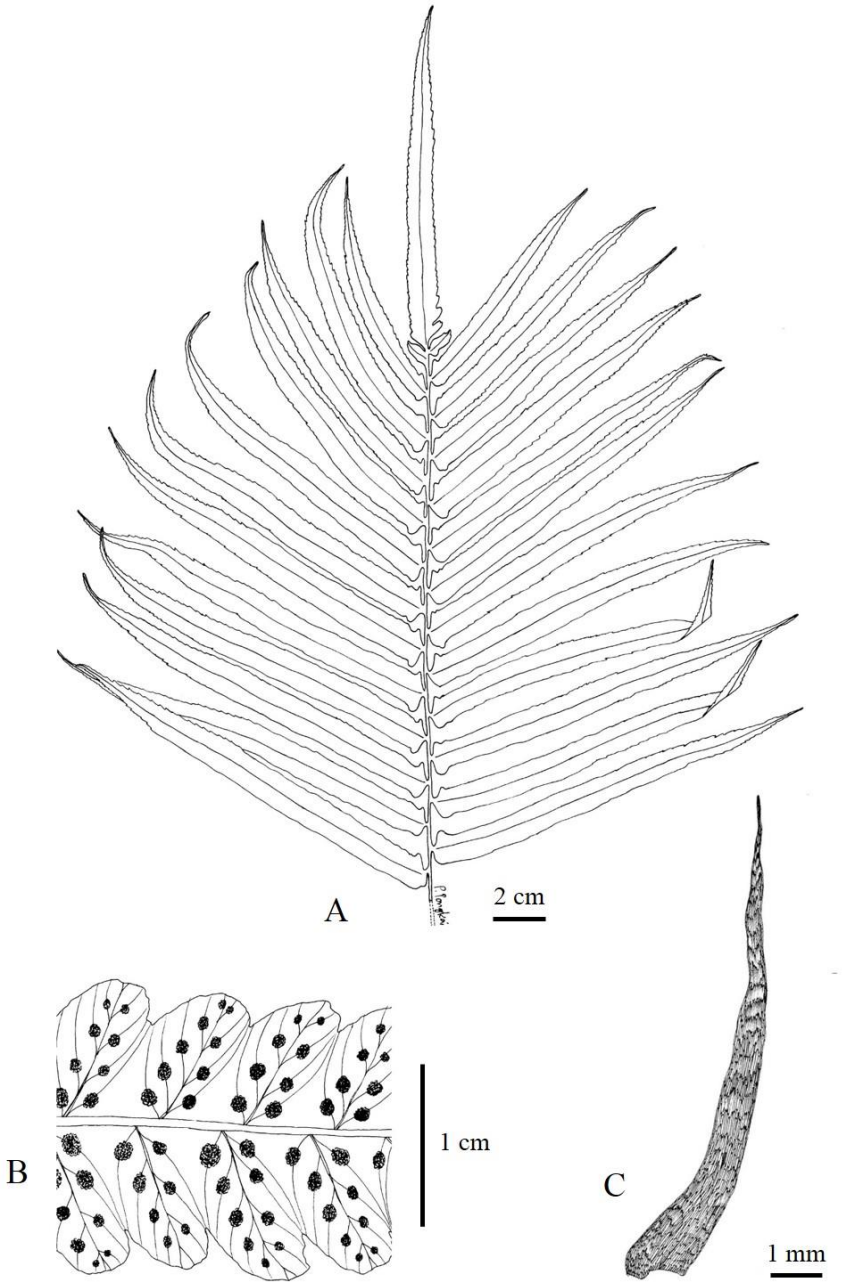

Figure 5.2 *Anisocampium cuspidatum* (Bedd.) Yea C. Liu, W. L. Chiou & M. Kato. A. a part of lamina. B. part of a pinna showing sori and venation. C. rhizome scale. Drawn by Puttamon Pongkai from *P. Pongkai 139* (BCU).

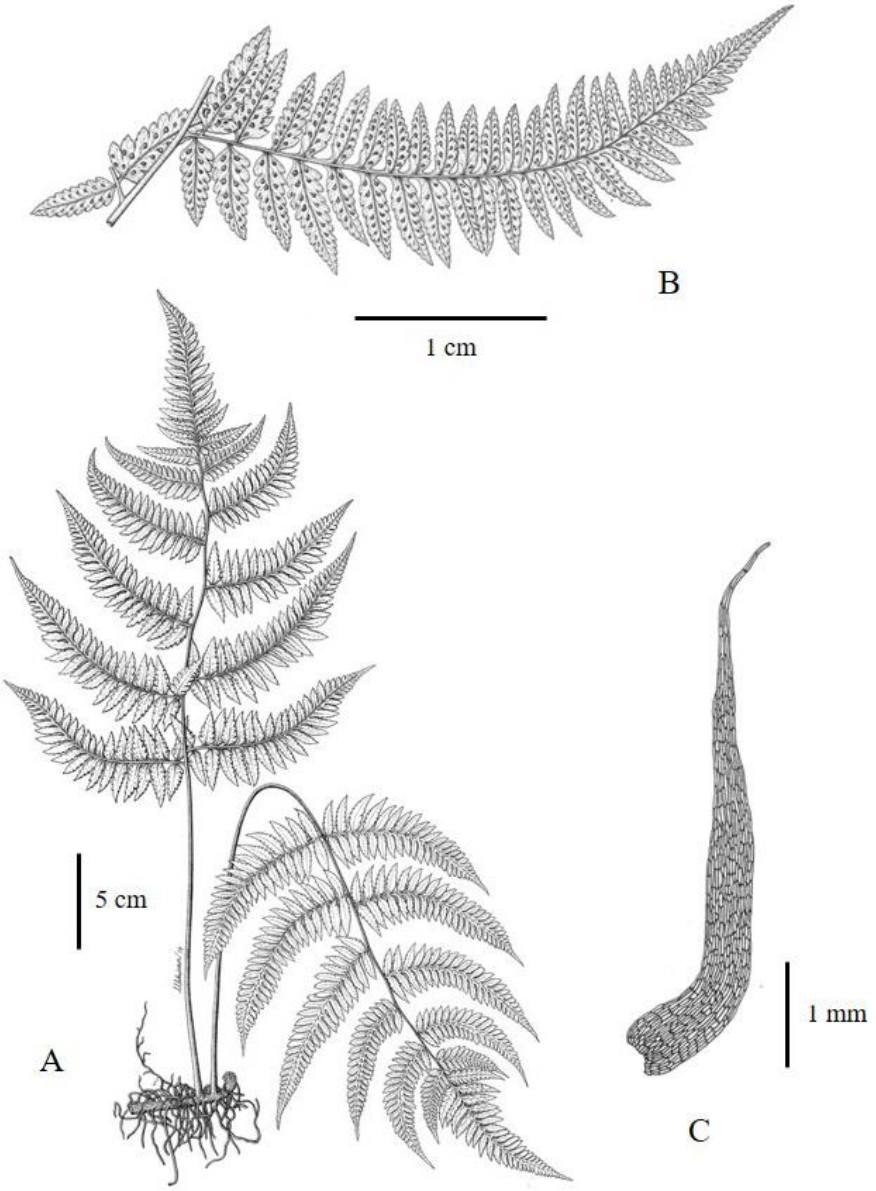

Figure 5.3 *Anisocampium niponicum* (Mett.) Hance. A. whole plant with two fronds.B. a pinna showing sori and venation. C. rhizome scale. Drawn by Wiliwan Nuchthongmuang from *T. Boonkerd et al. 2011-674* (BCU).

5.2. *Athyrium*

Roth, Tent. Fl. Germ. 3(1): 31, 58. 1800; M. Tagawa & K. Iwats. Fl. Thailand 3(3): 445. 1988; M., Kato, & K.U., Kramer, Fam. & Gen. Vasc. Pl. (ed. K.Kubitzki). 132. f. 64. 1990; K., Iwatsuki, Fern and Fern Allies of Japan 230. 1992; W.C., Shieh, C.E., Devol, & C.M., Kuo, Fl. Taiwan 415. 1994; W. Zhongren & M. Kato, Fl. China 449. 2013.—*Brachysorus* C. Presl, Abh. Königl. Böhm. Ges. Wiss., ser. 5 6: 430. 1851.—*Pseudathyrium* Newman, Phytologist 4: 370–371. 1851.—*Hypochlamys* Fée, Gen. Filic. 200. 1852.—*Pseudocystopteris* Ching, Acta Phytotax. Sin. 9(1): 76–77. 1964.—*Cystoathyrium* Ching, Acta Phytotax. Sin. 11(1): 22–23, pl. 4. 1966.—*Kuniwatsukia* Pic. Serm., Webbia 28(2): 455. 1973.—*Homalosorus* Small ex Pic. Serm., Webbia 31(1): 246. 1977. Lectotype: *Athyriumfilix-femina* (L.) Roth., designated by J. Smith, Hist. Fil. 327. 1875.

Plants terrestrial, small to large size. *Stem* creeping, ascending or erect, usually scaly, especially on younger part; scales linear or linear-lanceolate with long tail apex, concolorous, light-brown to black, margin entire. *Leaves* compound, pinnate to bipinnate; petioles with 2 vascular strands at the base, uniting upwards to form a single U or V shaped bundle, glabrous or scaly. *Laminae* broadly ovate or oblong or ovate-oblong, sometimes broadly lanceolate, texture papyraceous; veins free, veinlets pinnate. *Sori* round, reniform, J-shaped or oblong on veinlet, indusiate; indusia reniform, J-shaped or oblong, thin, persistent. *Spores* monolete, 36.5-55.0 × 22.0-44.0 μm, bilaterally symmetrical, kidney-shaped. Ornamentation: smooth or reticulate wing folds.

About 220 species distributed mainly in the temperate zone and subtropical mountain forests

Key to the species

1a	Frond pinnate…….	2
1b	Frond bipinnatisect to bipinnate……	5
2a	Pinnule oblong or ovate, not falcate, stalked ……	3
2b	Pinnule lanceolate, falcate, sessile ……	4
3a	Pinnule oblong, apex acuminate; veinlets 5-7 pairs;	

	sori oblong…….	**5.2.8 *A. wangii***
3b	Pinnule ovate, apex acute; veinlets 3-4 pairs; sori J-shaped or reniform……	**5.2.1 *A. anisopterum***
4a	sori round or oblong, exindusiate……..	**5.2.4 *A. dissitifolium***
4b	sori J-shaped or crescentic, indusiate……	**5.2.6 *A. pachyphyllum***
5a	Rhizome ascending to erect; spine-like present at junction between costa and stalk of pinnule; sori oblong……	6
5b	Rhizome creeping; spine-like not present at junction between costa and stalk of pinnule; sori J-shaped or reniform…….	7
6a	Lowest pinna reduce, smaller than upper one; spine-like present at midrib of pinnule……	**5.2.7 *A. strigillosum***
6b	Lowest pinna not reduce, larger than upper one; spine-like not present at midrib of pinnule ……...	**5.2.5 *A. mackinnonorum***
7a	Rhizome wide creeping; lower pinna reduce; pinnule ovate, margin dentate……	**5.2.2 *A. biserrulatum***
7b	Rhizome short creeping; lower pinna not reduce; pinnule narrowly lanceolate to narrowly elliptic, margin serrate……	8
8a	Pinnae gradually becoming smaller upward forming pintatifid apex; sori usually J-shaped rarely reniform…….	**5.2.3 *A. brevisorum***
8b	Pinnae suddenly becoming smaller upward forming pintatifid apex; sori usually reniform rarely J-shaped.	see ***An. niponicum***

5.2.1 ***Athyrium anisopterum*** Christ, Bull. Herb. Boissier 6(12): 962–963. 1898; M. Tagawa & K. Iwats. Fl. Thailand 3(3): 448. 1988; W. Zhongren & M. Kato, Fl. China 464. 2013.—*Aspidium fauriei* var. *elatius* (Christ) Christ, Bull. Herb. Boissier 6(3): 193. 1898.— *Asplenium macrocarpon* var. *atkinsonii* Hook. & Baker, Syn. Fil. (ed. 2) 489. 1874.—*Athyrium kumaonicum* Punetha, Indian Fern J. 2(1–2): 29–30. 1985.—

Athyrium macrocarpon var. *atkinsonii* (Hook. & Baker) Tardieu, Asplen. Tonkin84. 1932.—*Athyrium woodsioides* Christ, Bull. Acad. Int. Géogr. Bot. 16: 124–125. 1906.—*Dryopteris thysanocarpum* (Hayata) Hayata, Icon. Pl. Formosan.4: 160–161, f. 100. 1914.—*Athyrium thysanocarpum* Hayata, Icon. Pl. Formosan. 4: 160–161, f. 100. 1914. Type: China, Yunnan, *A. Henry 10109* [holotype (P), isotypes (MO, K!, K001089279)]. Figure 5.4, 5.52 D

Plants terrestrial. *Stem* creeping to ascending, 1.0-1.5 cm in diameter, scaly at apex; scales 6-8 × 1.0 cm, linear, concolorous, brown, margin entire. *Leaves* 20-50 cm long, pinnate, monomorphic; petioles 12-20 cm, 1.5-2.0 in diameter, green when living, stramineous when dry, nearly black at lower portion, glabrous, base scaly. *Laminae* 20-25 × 6-10 cm, outline narrowly lanceolate, apec acuminate, glabrous, papyraceous; pinnae more than 12 pairs, 3-5 × 2.0-2.5 cm, basal pinnae subtriangular, apex acute, base oblique, margin lobed, upper pinnae oblique, acroscopis side larger than basiscopic side, apex acute, base oblique, margin lobed, alternate, gradually becoming smaller upward forming pinnatisect apex, stalked; stalk 1-2 mm; vein free, fork. *Sori* reniform or J-shaped, close to costule, indusiate; indusia pale brown, reniform or J-shaped, membranous, glabrous, persistent. *Spores* monolete, 40.5-51.0 × 30.5-34.0 μm, bilateral, concavo-convex to plano-convex, perispore present; ornamentation: prominent wing folds.

Thailand.— NORTHERN: Chiang Mai (Doi Phahom Pok, Doi Suthep, Doi Inthanon).

Distribution.— Sri Lanka, India, Myanmar, China, Taiwan, Japan and Vietnam.

Ecology.— On humus-rich slopes in dense forests at about 1,800 m alt.

Specimens examine.— **THAILAND**.Chiang Mai, Doi Inthanon, *E. Hennipman 3446* (L); Chiang Mai, Doi Inthanon, *G. Murata, K. Iwatsuki, C. Phengklai & C. Charamphol T15967* (K); **INDIA**. Punjap, *S.C. Varma 9* (BM); **CHINA**. Yunan, *A. Henry 13,310* (K); Kunming, *Bot. Exped 1512* (KUN); Kwangtung, *E.D. Merrill 11110* (K); Yunan *H. Kanai et al. 725364* (KUN); ibid., *H. Kanai et al. 725480* (KUN); ibid., *H. Kanai et al. 725690* (KUN); ibid., *H. Kanai et al. 725766* (KUN);Yunan *J. Cavalerie 1920* (K); Yunan, *K. Iwatsuki et al. 52* (KUN); ibid., *K. Iwatsuki et al. 66* (KUN); ibid., *K. Iwatsuki et al. 150* (KUN); ibid., *K.*

Iwatsuki et al. 572 (KUN); ibid., *K. Iwatsuki et al. 795* (KUN); Yunan, *K.M. Feng 10372* (KUN); ibid., *K.M. Feng 11112* (KUN); Yunan, *M. Kato, Y. Shimizu, S.Akiyama & X. Cheng 3614* (KUN).

5.2.2 ***Athyrium biserrulatum*** Christ, Bull. Acad. Int. Géogr. Bot. 17: 135-136. 1907; Wang Zhongren, Zhaorong and Kato, Fl. China 2-3: 459. 2013.—*Asplenium filix-femina* var. *polyspora* (Bernh.) C.B. Clarke, Trans. Linn. Soc. London, Bot.1 (7): 493, pl. 61, f. 1. 1880. —*Athyrium filix-femina* var. *polyspora* (C.B. Clarke) Bedd., Handb. Ferns Brit. India 170. 1883.—*Athyrium polysporum* (C.B. Clarke) Ching ex Mehra & Bir, Amer. Fern J.50 (4): 289. 1960. Type: China, Yunnan, *F. Ducloux 84* [(holotype (P!), P00279931]. Figure 5.5, 5.53 A

Plants terrestrial, *Stems*lender, wide-creeping, 0.7−1.0 cm in diameter, covered with scales; scales 4−7 × 1−3 mm, linear with long-tail apex, light brown, margin entire. *Leaves* monomorphic, bipinnate, 42−55 cm long; petioles 17−25 cm, 0.4−0.5 mm in diameter, glabrous, light green when living, stramineous when dry, dark in lower portion. *Laminae* 25−30 × 15−20 cm, narrowly lanceolate to ovate-lanceolate in out line, apex acuminate, light green, glabrous, chartaceous; lateral pinnae more than 10 pairs, subopppposite, sessile or minutely stalk, 0.5-1 mm, gradually becoming smaller upward to pinnatifid apex, terminal portion not distinct, lower pinnae 2−3 pairs reduced, lowest pinnae suddenly reduced, deflexed ,2.5−4.0 × 1.5−2.0 cm, ovate-lanceolate in outline, acute at apex, auriculate at acroscopic side, lobe close to costa; pinnae 4th pairs from base the largest, 9−12 × 2-3 cm, pinnate, oblong in outline, apex acuminate, base truncate; pinnule more than 12 pairs, 2.0−2.5 × 0.7−1.0 cm, alternate, sessile, lanceolate-oblong, apex acute, base obtuse, margin lobed; lobes half way to 2/3 way to midrib, apex truncate to round, margin tooth; vein free, pinnate. *Sori* reniform, 0.5−1.0 mm, close to midrib, usually on basal acroscopic veinlet of vein group, indusiate; indusia reniform, thin, persistent, glabrous, light brown. *Spores* monolete, 46.0−50.5 × 28.5−31.5 μm, bilateral, concavo-convex to plano-convex, perispore present; ornamentation: prominent wing folds.

Thailand.— NORTHERN: Chiang Mai (Doi Sutep, Doi Chiang Dao)

Distribution.— India, Napal, Bhutan, Myanmar, Tibet,China.

Ecology.— On the mountain ridge in exposed area at 2,000-2,100 m alt.

Specimens Examined.—**THAILAND**. Chiang Mai, Doi Inthanon, *G. Murata, K. Iwatsuki, C. Phenglai & C. Charamphol 15967* (P); Chiang Mai, Doi Sutep, *J.F. Maxwell 02-245* (L); Chiang Mai, Doi Chiang Dao, *P. Pongkai 104* (BCU); **TIBET**. Geelong, *C. Yousheng et al. 278* (PE); Nyalam, *L. Yusheng & L. Hui 14054, 14093* (PE); **NEPAL**: Unknown, *O. Polunin, Sykes & Wiliams 3312* (BM); *H. Tabata et al. 9061* (PE); Maikot, *Stainton, Sykes & Williams 4779* (BM); Maharigan, *O. Polunin, Sykes & Wiliams 196* (BM); Gujakhani, *Stainton, Sykes & Williams 4498* (BM); **INDIA**. Arunachal Pradesh, *C.B. Claek, 24143* (K); Uttar Pradesh, *C.R. Fraser-Jenkins 871* (BM); Sikkim, *S.S. Bir 16, 19, 21, s.n.* (PE); Unknown, *H.G.Champior s.n.* (PE); **CHINA**. Shimla, *Z. Xianchun 2756* (PE); Sichuan, *X.C. 2466, 2480* (PE); *Z. Xianchun & X. Qiaoping 6928* (PE), ibid., *Z. Xianchun & X. Qiaoping 6939* (PE); Yunnan, *K. Iwatsuki et al. 742* (BM); Yunnan, *J. Cavalerie 4772* (K); Yunnan, *X.C. Zhang 148* (L); Yunnan, *Department of Biology, Yunnan University 47*(PE); Yunnan, *F. Ruiqing 22212* (PE); Yunnan, *K.M. Feng 181* (PE); Yunnan, *L. Zhengyu 3197* (PE); ibid., *L. Zhengyu 3207* (PE); ibid., *L. Zhengyu 3220* (PE); ibid., *L. Zhengyu 3221* (PE); Yunnan, *Northwest Yunnan Jinsha team 4692*(PE);ibid., *Northwest Yunnan Jinsha team 63-6635* (PE);ibid., *Northwest Yunnan Jinsha team 63-6872*(PE); Yunnan, *Q. Bingyun 59638* (PE); Yunnan, *Q. Renchang 23155* (PE); ibid., *Q. Renchang 23246* (PE); ibid., *Q. Renchang s.n.*(PE); Yunnan, *S. Betty s.n.*(PE); Yunnan, *T.T. Yu s.n.*(PE); Yunnan, *X.C. Zhang 47* (PE); Yunnan, *X.C. Zhang et al. 4522* (PE); Yunnan, *Z. Weiming & L. Delin 312*(PE); Yunnan, *Z. Weiming & L. Weixi 1809* (PE); Yunnan, *Z. Weiming 268* (PE); ibid., *Z. Weiming 2143* (PE); ibid., *Z. Weiming 2667* (PE); Yunnan, *Z. Xianchun 126* (PE); ibid., *Z. Xianchun 141*(PE); ibid., *Z. Xianchun 145* (PE); ibid., *Z. Xianchun 2799* (PE); Yunnan, *Z. Xianchun et al. 6443*(PE); **UNKNOWN**. *Annonemous s.n.* (B); *Buskarau 27* (B); *Schimper 258* (B); *Schimper 259, Schimper 739* (B); *Schimper 741* (B); *Schimper 1111* (B).

Note.— This species is a new record for Thailand.

5.2.3 ***Athyrium brevisorum*** (Wall. ex Hook.) T. Moore, Index Fil. 117. 1859; Wang Zhongren, Zhaorong and Kato, Fl. China 2-3: 460. 2013.—*Asplenium brevisorum* (Wall. ex Hook.) T. Moore, Index Fil. 117. 1859.—*Asplenium brevisorum* Wall. ex

Hook., Sp. Fil. 3: 229–230. 1859. Type: Toong Dong, *Wall 220* (Holotype: BM! (B200027274). Figure 5.6, 5.53 B

Plants terrestrial. *Stems* short creeping, 3−5 mm in diameter, densely scaly at apex; scales, 8−10 × 6−7 mm, linear with long-tail apex, light brown, concolorous, margin entire. Leaves dimorphic. *Sterile leaves* 47−77 cm, pinnate-bipinnatisect, rarely bipinnate; petioles 23−32 cm, 3−4 mm in diameter, light green or purplish red when living, stramineous when dry. *Laminae* 24−45 × 20−30 cm, ovate in outline, glabrous, subcoriaceous, light green; terminal pinna not distinct, like lateral one, leteral pinnae gradually smaller upward forming pinnatifid apex; lateral pinnae 5−6 pairs, alternate, 10−16 × 2−7 cm, lanceolate-oblong to oblong, shortly-stalked, 1−2 mm, apex acuminate, base obtuse, margin lobed; lobe close to midrib of pinnae, apex acute, margin serrate; veins all free, extending to margin. *Fertile leaves* up to 1.20 m, pinnate-bipinnatisect, rarely bipinnate; petioles 37-68 cm, 3-5 mm in diameter, light green or purplish red when living, stramineous when dry. *Laminae* 28−50 × 15−20 cm, narrowly lanceolate in outline, glabrous, subcoriaceous, light green; terminal pinna not distinct, like lateral one, leteral pinnae gradually smaller upward forming pinnatifid apex; lateral pinnae 5−6 pairs, alternate, 8−17 × 2−5 cm, lanceolate-oblong, shortly-stalked, 1−2 mm, apex acuminate, base obtuse, margin lobe; lobe close to midrib of pinnae, narrowly lanceolate to narrowly elliptic, apex acute, margin serrate; veins all free, extending to margin. *Sori* 1-2 mm, oblong or J-shaped, usually on every veinlet, indusiate; indusia oblong or J-shaped, thin, glabrous, persistent. *Spores* monolete, 46.0−55.0 × 37.0−44.0 μm, bilateral, concavo-convex to plano-convex, perispore present; ornamentation: prominent frimbriate-wing folds.

Thailand. —NORTHERN: Chiang Mai (Doi Chiang Dao).

Distribution. — India, Nepal, Pakistan, Myanmar.

Ecology. — On rather dry ground in half-shade area at 1,500-2,000 m alt.

Specimens Examined.—**THAILAND**. Chiang Mai, Doi Chiang Dao, *R. Pollawatn 1102* (BCU); ibid., *R. Pollawatn 1104* (BCU); ibid., *R. Pollawatn 1105* (BCU); ibid., *R. Pollawatn 1208* (BCU); ibid., *R. Pollawatn 1562* (BCU); Chiang Mai, Doi Chiang Dao, *P. Pongkai 73* (BCU); ibid., *P. Pongkai 82* (BCU); Chiang Mai, Doi Chiang Dao, *R. Pollawatn & A. Petbanna 2012-061* (BCU); ibid., *R. Pollawatn & A. Petbanna 2012-062* (BCU); ibid., *R. Pollawatn & A. Petbanna 2012-*

062 (BCU); ibid., *R. Pollawatn & A. Petbanna 2012-068* (BCU); ibid., *R. Pollawatn & A. Petbanna 2012-069* (BCU); ibid., *R. Pollawatn & A. Petbanna 2012-075* (BCU); **INDIA**. Assam, *Macca s.n.* (BM); **UNKNOWN**: Toong Dong, Ava, *Wall 220* (B).

5.2.4 ***Athyrium dissitifolium*** (Baker) C. Chr., Contr. U.S. Natl. Herb. 26(6): 296. 1931; M. Tagawa & K. Iwats. Fl. Thailand 3(3): 446. f. 48. 1. 1988; W. Zhongren & M. Kato, Fl. China 458. 2013.—*Polypodium dissitifolium* Baker, Bull. Misc. Inform. Kew 1895(99): 54. 1895.— *Dryopteris apicidens* (Baker) C. Chr., Index Filic. 4: 252. 1905.—*Dryopteris dissitifolia* (Baker) C. Chr., Index Filic. 5: 262. 1905.— *Phegopteris incrassata* Christ, Bull. Herb. Boissier 6(12): 963–964. 1898.— *Polypodium apicidens* Baker, Bull. Misc. Inform. Kew 1895(99): 54. 1895.— *Athyrium fasciculatum* Hand.-Mazz., Symb. Sin.6: 31, pl. 2, f. 5. 1929. Type: China, Yunnan, in a deep ravine near Mongtse, *Hancock 45* [holotype K!, (K001089286)]. Figure 5.7, 5.53 C

Plants terrestrial. *Stems* ascending, 1-2 cm in diameter, densely scaly; scales 4-6 × 1.0-1.5 mm, narrow, concolorous, dark brown, margin entire. *Leaves* 35-65 cm, pinnate, monomorphic; petioles 14-28 cm, 0.5-0.7 cm in diameter, purplish red when living, stramineous when dried, glabrous, base densely scaly. *Laminae* 21-37 cm narrowly lanceolate in outline, papyraceous, glabrous, lateral pinnae more than 15 pairs, alternate, gradually reduced to pinnatisect apex, apex long acuminate, terminal pinna not distinct; pinnae 4-7 × 1-2 cm, sessile, lanceolate, falcate, apex acuminate, base obtuse, margin lobe; lobe 2/3 to 3/4 way to midrib of pinnae, 0.5-0.7 × 0.3-0.5 cm, oblong, apex round, margin dentate; veins free, forked, pinnate, veinlets 5-7 pairs. *Sori* 0.5-2.0 mm, reniform or round, exindusiate; *Spore* monolete, 37.5-45.0 × 22.0-26.5 μm,bilateral symmetry, kidkey-shaped; ornamentation: prominent wing folds.

Thailand.— NORTHERN: Chiang Mai (Doi Chiang Dao, Doi Suthep, Doi Pui, Doi Saget, Fang, Mae Cham, Mae Chan, Mae Tang, Muang, Sameung).

Distribution.— India, Nepal, Bhutan, Myanmar, Tibet, Vietnam.

Ecology.— On mountain slopes in mixed or evergreen forest at 1,000-2,000 m alt.

Specimens Examined.—**THAILAND**. Chiang Mai, Doi Pui, *C.F.van Beusekom et al. 1273* (PE); Chiang Mai, Doi Chiang Dao, *D.J. Middleton, S. Lindsay & P. Suksathan 5014* (PSU); Chiang Mai, Mae Tang, *J.F. Maxwell 00-324* (L); Chiang Rai, Mae Fa Luang, *J.F. Maxwell 06-521* (L,QBG); Chiang Mai, Doi Su Thep, *J.F. Maxwell 87-961* (L); Chiang Mai, Mae Chan, *J.F. Maxwell 93-1349* (L); Chiang Mai, Doi Chiang Dao, *J.F. Maxwell 95-164* (L); Chiang Mai, Doi Saget, *J.F. Maxwell 97-152* (L); Chiang Rai, Wieng Bah Bao, *J.F. Maxwell 97-967* (L); Chiang Mai, Sameung, *J.F. Maxwell 98-1069* (L); Chiang Rai, Mae Suai, *K. Buncuai & B. Nimanong 1351* (L); ibid., *K. Buncuai & B. Nimanong 1351* (L); Chiang Mai, Fang, *K. Buncuai 1507* (L); Chiang Mai, Fang, *K. Buncuai 1508* (L); Chiang Mai, Doi Su Thep, *K. Larsen et al. 44920* (L); Chiang Rai, Phan, *P. Palee 425* (L); Chiang Mai, Doi Chiang Dao, *R. Pollawatn 1100* (BCU); ibid., *R. Pollawatn 1554* (BCU); ibid., *R. Pollawatn 1554* (BCU); ibid., *R. Pollawatn 1560* (BCU); ibid., *R. Pollawatn 1856* (BCU); ibid., *R. Pollawatn 575* (BCU); ibid., *R. Pollawatn 997* (BCU); Chiang Mai, Doi Chiang Dao, *P. Pongkai 76* (BCU); ibid., *P. Pongkai 83* (BCU); ibid., *P. Pongkai 87* (BCU); ibid., *P. Pongkai 88* (BCU); ibid., *P. Pongkai 89* (BCU); ibid., *P. Pongkai 90* (BCU); ibid., *P. Pongkai 91* (BCU); ibid., *P. Pongkai 97* (BCU); ibid., *P. Pongkai 98* (BCU); ibid., *P. Pongkai 135* (BCU); Chiang Mai, Mae Chaem, *P. Srisanga, P. Suksathan. P Panyachan & A. Keratikorkul 3077* (QBG); ibid., *P. Srisanga, P. Suksathan. P Panyachan & A. Keratikorkul 3094* (QBG); Chiang Mai, Muang, *P. Thanakorn 22* (L); Chiang Mai, Doi Chiang Dao, *R. Pollawatn & A. Petbanna 2012-095* (BCU); Chiang Mai, Doi Chiang Dao, *S. Sang 347* (QBG); Chiang Mai, Doi Su Thep, *U. Intorn 12* (L); Mae Hong Son, Bahng Mah Pah, *J.F. Maxwell 09-131* (QBG); Lampoon, Mae Tah, *J.F. Maxwell 93-772* (L); Unknown, *K. Bunchuai & B. Niamanong 1351* (K); ibid., *K. Bunchuai 1507* (K); **MYANMAR**. Haka, *F.G. Dickason 694* (L); Chin Hills Falam, *F.E.W. Venning 9* (PE); ibid., *F.E.W. Venning 33* (PE); **CHINA**. Yunnan, *Amanli 256* (PE), Yunnan, *C.W. Wang 84284* (PE); ibid., *C.W. Wang 84034* (PE); Guizhou, *Cavalerie 3779* (PE); Yunnan, *D.E. Boufford & Y. Sheng Chen 43571* (PE); Sichuan, *F.Wenpei 7086* (PE); Sichuan, *G.Zhongtian 6053* (PE); Guizhou, *H. Cavawie s.n.* (PE); Yunnan, *H. Li, S.X. Yang, R. Li 770* (PE); Yunnan, *H.T. Tsai 62282* (PE); Guizhou, *H. Xueyu 2161* (PE); Yunnan, *K.K. Tsoong 4844* (PE); Yunnan, *K.M. Feng 524* (PE); ibid., *K.M. Feng 10368* (PE); ibid., *K.M.*

Feng 3394 (PE); Sichuan, *K. Xianxu 3535* (PE); ibid., *K. Xianxu 3495* (PE); ibid., *K. Xianxu 3489* (PE), ibid., *K. Xianxu 3488* (PE), ibid., *K. Xianxu 3517* (PE); ibid., *K. Xianxu 3496* (PE); Yunnan, *Kunming Workstation 45* (PE); ibid., *Kunming Workstation 6079* (PE); Yunnan, *L. Shunbin 576* (PE); Yunnan, *L. Shenwei 13171* (PE); ibid., *L. Shenwei 14282* (PE); ibid., *L. Shenwei 14224* (PE); ibid., *L. Shenwei 17236* (PE); ibid., *L. Zhengyu 54* (PE); Yunnan, *M. Yilun & X. Qun 198* (PE); ibid., *M. Yilun & X. Qun 40* (PE); ibid., *M. Yilun & X. Qun 198* (PE); ibid., *M. Yilun & X. Qun 190* (PE); ibid., *M. Yilun & X. Qun 191* (PE); ibid., *M. Yilun & X. Qun 29* (PE); ibid., *M. Yilun & X. Qun 193* (PE); ibid., *M. Yilun & X. Qun 29* (PE); Yunnan, *Northwestern Jinshajiang Team 63-6667* (PE); ibid., *Northwestern Jinshajiang Team 4614* (PE); Yunnan, *Qi Shixin et al. 180* (PE); Yunnan, *Qin 23728* (PE Yunnan, *Q. Renchang 23728* (PE); ibid., *Q. Renchang 24767* (PE); ibid., *Q. Renchang 50572A* (PE); Yunnan, *Q. Bingyun 54367* (PE); Yunnan, *T.N. Liou 14244* (PE) Yunnan, *W. Qiwu 62784* (PE) Yunnan, *W. Zhongren 307* (PE); ibid., *W. Zhongren 336* (PE); ibid., *W. Zhongren 307* (PE); ibid., *W. Zhongren 313* (PE); ibid., *W. Zhongren 307-1* (PE); ibid., *W. Zhongren 313 5-1* (PE); ibid., *W. Zhongren 307-8* (PE); ibid., *W. Zhongren 307-5* (PE); ibid., *W. Zhongren 313 5-4* (PE); ibid., *W. Zhongren 313 5-2* (PE); Yunnan, *W. Zhongren & Z. Weiming C497* (PE); ibid., *W. Zhongren & Z. Weiming C497* (PE); ibid., *W. Zhongren & Z. Weiming C489* (PE); Yunnan, *W. Ran WR0343* (PE); Yunnan, *X.C. Zhang 2789* (PE); Sichuan, *X.C. Zhang 2473* (PE); Sichuan, *Y. Junsheng 4666* (PE); ibid., *Y. Junsheng 4687* (PE); ibid., *Y. Junsheng 4688* (PE); ibid., *Y. Junsheng 4301* (PE); ibid., *Y. Junsheng 4692* (PE); ibid., *Y. Junsheng 4699* (PE); ibid., *Y. Junsheng 4655* (PE); ibid., *Y. Junsheng 4678* (PE); ibid., *Y. Junsheng 4696* (PE); ibid., *Y. Junsheng 4675* (PE); ibid., *Y. Junsheng 4675* (PE); ibid., *Y. Junsheng 4317* (PE); Yunnan, *Z. Baiyu 81-1339* (PE); Yunnan, *Z. Gangmin 447* (PE); Yunnan, *Z. Xianchun 2785* (PE); ibid., *Z. Xianchun 2789* (PE); ibid., *Z. Xianchun 136* (PE); Sichuan, *Z. Xianchun 2473* (PE); Yunnan, *Z. Xianchun 2789* (PE); Guizhou, *Z. Zhisong, Z. Yongtian 5836* (PE); ibid., *Z. Zhisong, Z. Yongtian 7616* (PE); Yunnan, *Z. Zhongyun 21536* (PE); Yunnan, *Z. Weiming, W. Jinliang 2237* (PE); ibid., *Z. Weiming, W. Jinliang 1734* (PE); **TIBET**. *X.C. Zhang & L. Wang 4612* (PE).

5.2.5 ***Athyrium mackinnonorum*** (C. Hope); C. Chr., Index Filic.3: 143. 1905; M. Tagawa & K. Iwats. Fl. Thailand 3(3); 446. f. 48. 2. 1988; W. Zhongren & M. Kato, Fl. China 475. 2013.—*Asplenium mackinnonii* C. Hope, J. Bot. 34(399); 124–125. 1896. Type unknown. Figure 5.8, 5.53 D

Plants terrestrial. *Stem*s ascending to erect, 2-3 cm in diameter, scaly; scales 1.0-1.5 × 5-6 mm, subclathrate, linear-lanceolate with long-tail apex, concolorous, brown, margin entire. *Leaves* 37-67 cm long, monomorphic, bipinnate; petioles 16-33 cm long, 3-4 mm in diameter, brown to purplish red when living, stramineous when dried, base dark brown to nearly black, densely scaly. *Laminae* 21-34 × 13-32 cm, deltoid-ovate in outline, appendage present at junction between rachis and costa, papyraceous, terminal pinna not distinct, lateral pinnae 6-8 pairs, gradually reduced upwards forming pinnatisect apex; pinnae 11-22 × 1.5-2.0 cm, narrowly lanceolate in outline, apex acuminate, base oblique, stalked; stalk 2-3 mm; pinnules 2.5-4.0 × 1.5-2.0 cm, lanceolate to lanceolate-oblong, acroscopic auricle present, apex acute, base oblique, margin lobed, stalked; stalk 1 mm; lobe 2/3 to 1/2 way to midrib, apex round, margin dentate, veins free, pinnate, veinlets 2-3 paris, reach to margin. *Sori* 2 mm long, oblong, close to midrib, indusiate; indusia narrowly oblong, thin, persistent, glabrous, brown; *Spores* monolete, 41.0-43.0 × 24.0-26.5 μm, bilateral symmetry, concavo-convex to plano-convex, perispore present; Ornamentation: smooth.

Thailand.— NORTHERN: Mae Hong Son (Khun Mae Lan), Chiang Mai (Doi Inthanon, Doi Phahom Pok), Phitsanulok (Phu Miang); NORTH-EASTERN: Loei (Phu Kradueng); SOUTH-EASTERN: Chantaburi (Khao Soi Dao).

Distribution.— Tibet, Nepal, India, Myanmar, China, Vietnam.

Ecology.— On rather dry mountain slopes in dense evergreen forests at 1,100-1,800 m alt.

Specimens Examined.—**THAILAND.** Mae Hong Son, Khun Mae Lan, *B. Hanson, G. Seidenfaden & T. Smitinand 10914* (BKF); Chiang Mai, Doi Inthanon, *E. Hennipman 3407* (BKF); ibid., *E. Hennipman 3419* (BKF); Chiang Mai, Doi Inthanon, *G. Murata, K, Iwatsuki, C. Pengklai & C. Chareonphol T16071* (BKF); Phitsanukok, Phu Hin Rong Kla, *K. Punchy 116* (BCU); Chiang Mai, Doi Inthanon, *M. Tagawa, K. Iwatsuki & N. Fukuoka T2877* (BKF); **CHINA**. Guizhou, *Beijing team 4177* (PE); ibid., *Beijing team1383* (PE); Guizhou, *C. Jingzhi1264* (PE); Guizhou, *C.*

Quanlong, X. Yuhua & Q. Zhonghai 2104 (PE); Guizhou, *Daisy Plant Investigation Group 11282* (PE); ibid., *Daisy Plant Investigation Group 11284* (PE); Guizhou, *E.E. Maire 6039* (PE); Guizhou, *Eighth Forest Manager Brigade 2559* (PE); Hubei, *F. Guozhen 3239* (PE); ibid., *F. Guozhen 4018* (PE); ibid., *F. Guozhen 50368* (PE); Guizhou, *F.T. Wang 21953* (PE); Guizhou, *Fang Wenpei 2126* (PE); ibid., *Fang Wenpei 3078* (PE); Sichuan, *FLPH Tibet Expedition 12-0830* (PE); Sichuan, *G. Zhongtian 8859* (PE); ibid., *G. Zhongtian 9210* (PE); Sichuan, *J. Shu s.n.* (PE); Sichuan, *K. Xianxu 3505* (PE); ibid., *K. Xianxu 3670* (PE); ibid., *K. Xianxu 3699* (PE); ibid., *K. Xianxu 3784* (PE); ibid., *K. Xianxu 3995* (PE); ibid., *K. Xianxu 4201* (PE); ibid., *K. Xianxu 5300* (PE); Sichuan, *K.M. Feng 4018* (PE); ibid., *K.M. Feng 4018* (PE); ibid., *K.M. Feng 4248* (PE); ibid., *K.M. Feng 5713* (PE); ibid., *K.M. Feng 5715* (PE); ibid., *K.M. Feng 8873* (PE); ibid., *K.M. Feng 9455* (PE); Sichuan, *L. Peiyuan 4378* (PE); Sichuan, *L. Zhengyu 129278* (PE); Sichuan, *Maires 6592* (PE); Sichuan, *Northwest University Long Town 1479* (PE); Yunnan, *Q. Renchang 23546* (PE); Sichuan, *Q. Renchang 23920* (PE); Yunnan, *Qinghai 10053* (PE); ibid., *Qinghai 565* (PE); ibid., *Qinghai 6644* (PE); ibid., *Qinghai 6724* (PE); ibid., *Qinghai 73-201* (PE); Yunnan, *R.C. Ching 5986* (PE); Yunnan , *S. Zizhen 39008* (PE); Yunnan, *T.T. Yu 20192* (PE); ibid., *T.T. Yu 3322* (PE); Yunnan , *W. Peishan 1197* (PE); Yunnan, *W. Yingming 4530* (PE); Yunnan, *Wuling team 228* (PE); Yunnan, *X. Chaojun 42795* (PE); Yunnan, *X.C. Zhang & L. Wang 4682* (PE); ibid., *X.C. Zhang & L. Wang 4733* (PE); ibid., *X.C. Zhang & L. Wang 4800* (PE); ibid., *X.C. Zhang & L. Wang 4849* (PE); Yunnan , *X.C. Zhang 4973* (PE); ibid., *X.C. Zhang 4999* (PE); Yunnan, *Y. Tongpei 79118* (PE); ibid., *Y. Tongpei 79119* (PE); Yunnan, *Y. Tsiang 5811* (PE); Yunnan, *Z. Weiming 658* (PE); Yunnan, *Z. Xianchun 5260* (PE); Yunnan, *Z.X. Shi, R. Youzhuan 7380* (PE); **TIBET**. Unknown, *C. Jingzhi 5839* (PE); Unknown, *D. Tianlun 107373* (PE); Unknown, *G. Zhongtian 8899* (PE); Unknown, *H. Xueyu 852* (PE); ibid., *H. Xueyu 935* (PE); Unknown, *H.T. Tsai 58349* (PE); Unknown, *J. Slope, D. Zhongcheng & Y. Nengqian 50743* (PE); Unknown, *J. Xiaopo & Z. Xiushi 31294* (PE); Unknown, *Qinghai 6323* (PE); ibid., *Qinghai 7755* (PE); Unknown, *Z. Weiming s.n.* (PE); Unknown, *Z. Xianchun 1346* (PE); Unknown, *Z.Weiming, L. Jianwei & Z. Hougao 17499* (PE).

Note.— The epithet of this species was published as "mackinnonii" that would be the grammatically correct termination, however the taxon was named for the brothers Mackinnon; thus the correct termination should be "mackinnonorum" base on ICN Art. 60.12; Rec 60C.1 (a), Shenzhen Code. IPNI treats this as a correctable orthographic error.

5.2.6 ***Athyrium pachyphyllum*** Ching, Acta Bot. Boreal.-Occid. Sin. 6(2): 102. 1986.; W. Zhongren & M. Kato, Fl. China 465. 2013.— *Athyrium xiangxiense* S.F. Wu, Keys Vasc. Pl. Wuling Mountain 36, 563–565, pl. 1. 1995. Type China, Guangxi, Linyun Xian, Qinglong Shan, in sylvis, *R.C. Ching 6827* [holotype PE, (PE50031!), isotypes PE (PE50030!, PE50032!)]. Figure 5.9, 5.54 A

Plants terrestrial. *Stems* short-creeping or ascending, 1-2 cm in diameter, densely scaly near apex; scales 0.4-0.5 ×5-6 mm, linear, brown, margin entire. *Leaves* 30-57 cm long, caespitose, monomorphic, pinnate; petioles 11-26 cm long, 1-2 mm in diameter, purplish red when living, stramineous when dry, glabrous, base scaly. *Laminae* 19-31 × 4-11 cm, narrowly-lanceolate or oblong-lanceolate in outline, apex long-acuminate, glabrous, papyraceous, spine at junction between rachis and midrib not present or at least present near apex, lateral pinnae 8-10 pairs, lower pair subopposite, upper pairs alternate, gradually reduced upwardto from pinnatifid apex, terminal pinna not distinct, sessile to minutely stalked; stalk about 1 mm long; pinnae 2-4 × 0.5-1.0 cm, oblong, apex acute to round, base obtuse, acroscopic auricle presented, margin subentire to lobe; lobe 1/3 way to midrib, apex truncate, margin tooth; veins free, pinnate, veinlet 1-3 paris, reach to margin. *Sori* 1-2 by 0.5 mm, J-shape or oblong or curve, usually on acroscopic veinlets of veins group at middle between midrib and margin, indusiate; indusium J-shape or linear oblong, brown, glabrous, persistant. *Spores* monolete, 41.0-44.0 × 26.0-27.5 µm bilaterally symmetrical, kidney-shaped; ornamentation: smooth.

Thailand.— NORTHERN: Chiang Mai (Doi Suthep), Nan (Doi Phu Kha).

Distribution.— China (Guangxi, Guizhou, Hunan, Yunnan).

Ecology.— Evergreenforest in exposed area at 1400-1500 m alt.

Specimens Examined.— **THAILAND**. Nan, Doi Phu Ka, *P. Pongkai 146* (BCU); ibid., *P. Pongkai 147* (BCU); Chiang Mai, Doi Suthep, *T. Boonkerd 1075*

(BCU); **CHINA**. Guizhou, *C. Ziyu 1179* (PE);Yunnan, *W. Qiwu & L. Wei 82278* (PE); Yunnan,*W. Zhongren 411-01* (PE); ibid., *W. Zhongren 411-03* (PE); ibid., *W. Zhongren 411-04* (PE); ibid., *W. Zhongren 411-05* (PE); ibid., *W. Zhongren 411-06* (PE); ibid., *W. Zhongren 411-07* (PE); ibid., *W. Zhongren 411-08* (PE); ibid., *W. Zhongren 411-09* (PE); ibid., *W. Zhongren 411-10* (PE); ibid., *W. Zhongren 411-11* (PE); ibid., *W. Zhongren 411-12* (PE); ibid., *W. Zhongren 411-13* (PE); ibid., *W. Zhongren 411-14* (PE); Yunnan, *W. Sugong 3963* (PE).

Note.— This species is a new recoed for Thailand.

5.2.7 ***Athyrium strigillosum*** (E.J. Lowe) Salomon, Nomencl. Gefässkrypt. 112. 1883.—*Asplenium strigillosum* E.J. Lowe, Ferns 5: 107–108, pl. 36. 1858.—*Athyrium tenuifrons* Wall. ex Sim, Priced Cat. Ferns 6: 17. 1859.— *Athyrium nigripes* var. *tenuifrons* (Wall. ex Sim) Bedd., Ferns Brit. India 33. 1892.—*Asplenium tenellum* C. Hope, J. Bombay Nat. Hist. Soc. 12: 529–531, pl. 4. 1899.—*Asplenium tenuifrons* Wall. ex C. Hope, J. Bombay Nat. Hist. Soc. 14: 120, pl. 22. 1903.—*Athyrium petiolosum* Christ, Bull. Acad. Int. Géogr. Bot. 17: 134. 1907.—*Athyrium setiferum* C. Chr., Index Filic. 3: 146. 1905. Type unknown. Figure 5.10, 5.54 B

Plants terrestrial. *Stems* ascending to erect, 1.0-1.5 cm in diameter, densely scaly at apex; scales 5-8 × 0.5-1.0 mm, linear with longtail apex, concolorous, brown, margin entire. *Leaves* monomorphic, bipinnate, 35-50 cm, needlelike appendage present at midrib of pinnules and junction between costa and midrib of pinnules; petioles 18-22 cm, 2-3 mm in diameter, glabrous, light green, stramineous when dry, dark and scaly at lower portion. *Laminae* 20-27 × 12-14 cm, narrowly lanceolate in outline, apex acuminate, light green, glabrous, papyraceous, lateral pinnae more than 12 pairs, lowest acroscopic pinnule larger than other, alternate, stalked, stalk 1-3 mm long, gradually becoming smaller upward to pinnatisect apex; pinnae 5-7 × 1.5-2.0 cm, narrowly lanceolate to narrowly oblong in outline, apex acuminate; pinnule more than 12 pairs, alternate, 1.0-1.5 × 0.4-0.5 cm, oblong, minutely stalked, stalk 1-2 mm, apex acute or round, base acute to cuneate, margin serrate to minutely lobed; veins free, veinlets 2 pairs, pinnate, reach to margin. *Sori* oblong, 0.5- 2.0 mm, arranged in two rows and parallel to midrib, close to midrib of pinnule, indusiate; indusia oblong,

thin, glabrous, persistent, light brown. *Spore*s monolete, 40.0-42.5 × 24.0-25.0 μm, bilateral symmetry, kidney-shaped; ornamentation: smooth.

Thailand.— NORTHERN: Chiang Mai (Doi Inthanon).

Distribution.— India, Bhutan, Myanmar, Tibet, China, Japan.

Ecology.— On humus-rich mountain slopes near streams in dense mossy forests at 2,000-2,500 m alt.

Specimens Examined.—**THAILAND**. Chiang Mai, Doi Inthanon, *E. Hennipman 3407* (BKF, L); Chiang Mai, Doi Inthanon, *M. Tagawa, K. Iwatsuki & N. Fukuoka T2877* (L); ibid., *M. Tagawa, K. Iwatsuki & N. Fukuoka T2877* (BKF); ibid., *M. Tagawa, K. Iwatsuki & N. Fukuoka T3009* (BKF); **CHINA**. Yunnan, *Ducloux 32* (PE); Yunnan, *Feng 7367* (PE); Yunnan, *J. Yipo, Z. Xiushi & J. Zexin 31749* (PE); Yunnan, *K.M. Feng 10359* (PE); ibid., *K.M. Feng 10395* (PE); ibid., *K.M. Feng 7367* (PE); ibid., *K.M. Feng 525* (PE); Yunnan, *Khasia s.n.* (PE); Yunnan, *L. Zhengyu 18278* (PE); ibid., *L. Zhengyu 3206* (PE); ibid., *L. Zhengyu 13895* (PE); Yunnan, *Northwestern Jinshajiang Team 4684* (PE); Yunnan, *Q. Linchuan & X. Xingxiang 746* (PE); Yunnan, *Q.Renchang 22890* (PE); ibid., *Q.Renchang s.n.* (PE); Yunnan, *S.S. Bir 20* (PE); Yunnan, *T. Ding 874* (PE); Yunnan, *W. Lei, X. Xingxiang 1086* (PE); Yunnan, *W. Zhonglun 33832* (PE); ibid., *W. Zhongren 318* (PE); ibid., *W. Zhongren C100* (PE); ibid., *W. Zhongren C47* (PE); Sichuan, *W.M. Chu 302* (PE); Sichuan, *Wang Peishan 75560* (PE); Sichuan, *X. Gongxia & L. Yiyong 1195* (PE); ibid., *X. Gongxia & L. Yiyong 5219* (PE); ibid., *X. Gongxia & L. Yiyong 1170* (PE); Sichuan, *X. Gongxia & X. Qun 5228* (PE); ibid., *X. Gongxia & X. Qun 5162* (PE); Sichuan, *X. Qun, M. Yilun 42* (PE); Sichuan, *X. Wenxuan 25A* (PE); Sichuan, *X. Xingxiang & Q. Linchuan 276* (PE); Sichuan, *X.C. Zhang 2406* (PE); ibid., *X.C. Zhang 5029* (PE); Sichuan, *Y. Tongpei 79175* (PE); Sichuan, *Y. Yuehong & Z. Daigui 5355* (PE); Guangxi, *Z. Shuifa 20274* (PE); Guangxi, *Z. Weiming s.n.* (PE); Hunan, *Z. Weiming 2726* (PE); ibid., *Z. Weiming 3526* (PE); Hunan, *Z. Weiming & C. Jiaxiang 1829* (PE); Guizhou, *Z. Xianchun & S. Lei 0539-2* (PE); ibid., *Z. Xianchun & S. Lei 0539-1* (PE); Nanchuan, *Z. Xianchun et al. 2232* (PE); ibid., *Z. Xianchun et al. 531* (PE); **INDIA**. Simla *W. Zhongren, X. Yutang* 135 (PE); Sikkim, *Z. Xianchun et al. 602* (PE); **TIBET**. Chayu, *Z. Xianchun 2786* (PE); Chayu, *Z. Xian-Chun 2750* (PE).

5.2.8 ***Athyrium wangii*** Ching, Bull. Fan Mem. Inst. Biol., n.s. 1(3): 279. 1949; W. Zhongren & M. Kato, Fl. China 465. 2013. Type: China, Yunnan, *Wang & Liu 82277* (holotype PE50152!). Figure 5.11, 5.54 C

Plants terrestrial. *Stems* erect, 1.0-1.2 cm in diameter, densely scaly; scales 8-10 × 0.9-1.0 mm, linear long-tail apex, concolorous, brown, margin entire. *Leaves* caespitose, bipinnate-tripinnatifid, 30-54 cm long, monomorphic; petioles 10-20 cm, 1.0-2.4 mm in diameter, stramineous when dried, glabrous, base densely scaly. *Laminae* 20-34 × 11-18 cm, outline ovate, glabrous, papyraceous; rachis glabrous, spine at junction between rachis and costa not present; lateral pinnae 9-10 pairs, alternate, gradually reduced upward, terminal pinna not distinct, pinnae 5-12 cm long, 1.0-2.5 cm wide, oblong-lanceolate, apex long acuminate, base obtuse, margin lobe; lobe 4/5 way to costa, apex round, margin serrate, stalked; stalk 4-6 mm long, longest at lower pinnae, gradually shorten upward, upper pinnae minutely stalk to sessile; vein free, pinnate, veinlet 6-7 pairs, reach to margin. *Sori* 1-2 mm long, oblong, sometimes J-shaped or reniform, lie on veinlet at middle between midrib and margin of lobe, indusiate; indusium linear oblong or J-shaped or reniform, brown, glabrous, persistent. *Spores* monolete, 36.5-40.0 × 23.0-24.0 µm; bilaterally symmetrical, kidney-shaped, ornamentation smooth.

Thailand:— NORTHERN: Chiang Mai (Doi Inthanon); NORTH-EASTERN: Loei (Phu Luang).

Distribution:— China

Ecology:— Hill every green forest at 1,000-1,500 m alt.

Specimens Examined.—**THAILAND**. Loei, Phu Luang, *E. Hennipman 3620* (B, BM, L); Chiang Mai, Doi Inthanon, *Put 3441* (BK); **CHINA**. Hainan, *D. Shiyong 1495* (PE).

Note:—This species is a new record for Thailand.

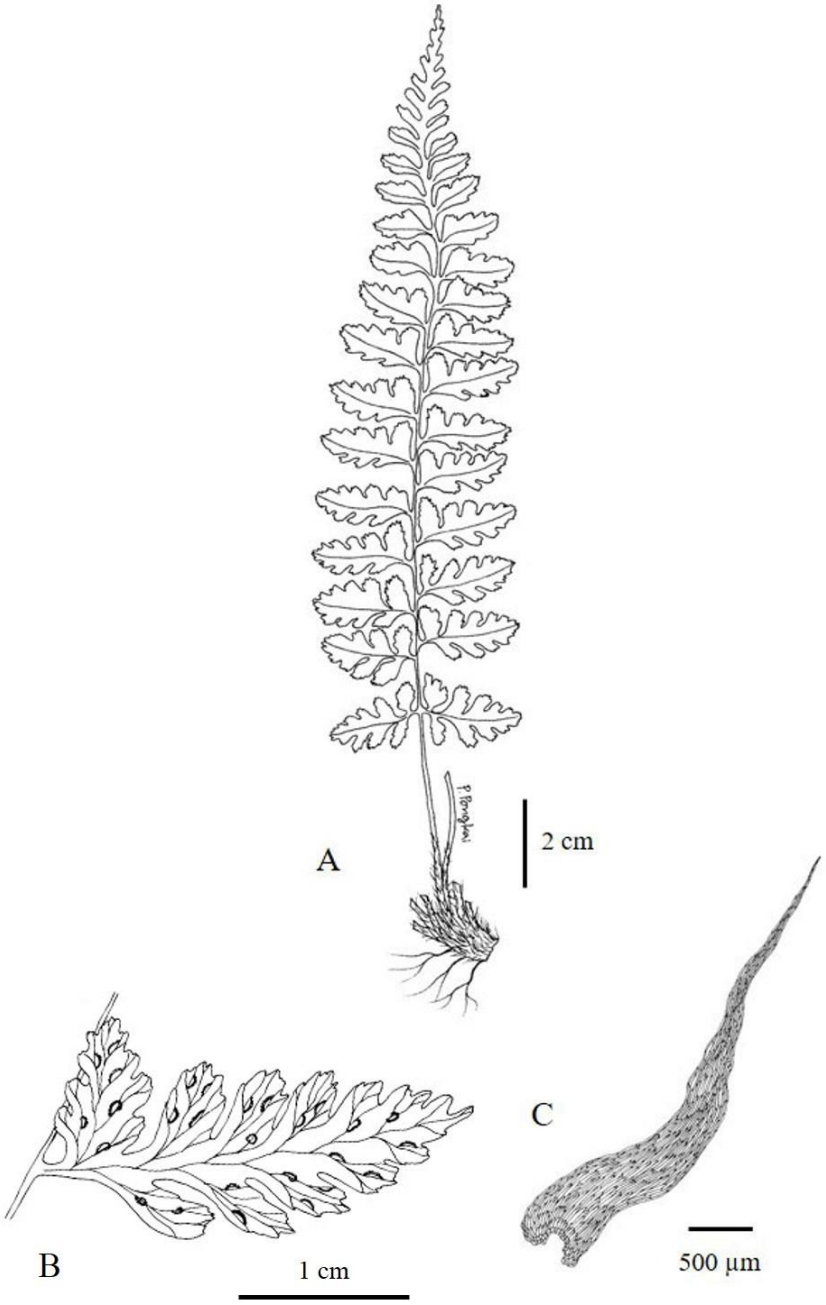

Figure 5.4 *Athyrium anisopterum* Christ. A. a whole plant with one leaf. B. lateralpinnae showing sori and venation. C. rhizome scale. Drawn by Puttamon Pongkai from *E. Hennipman 3446* (L).

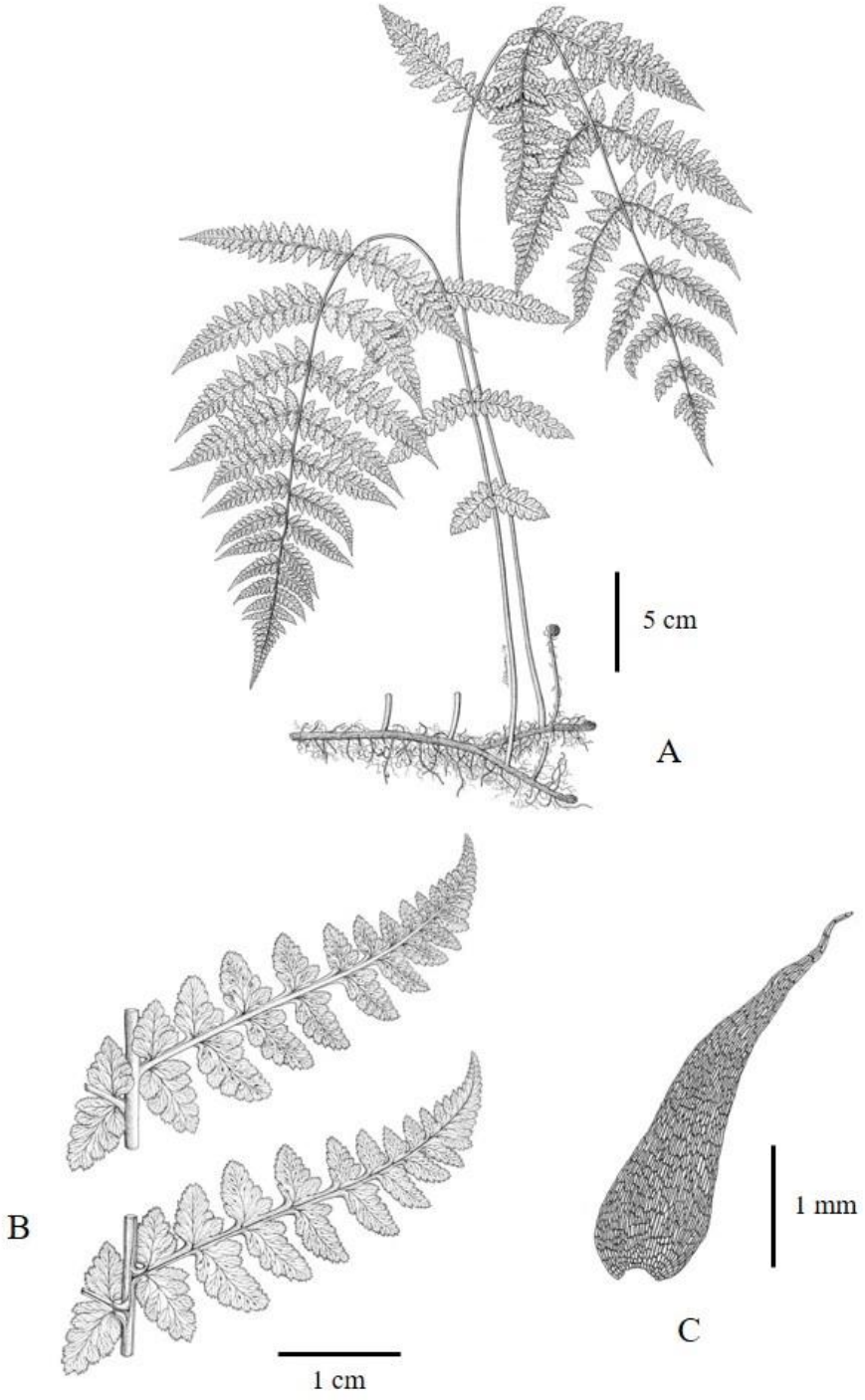

Figure 5.5 *Athyrium biserrulatum* Christ. A. a whole plant with two leaves. B. lateral pinnae showing sori and venation. C. rhizome scale. Drawn by Wiliwan Nuchthongmuang from *P. Pongkai 104* (BCU).

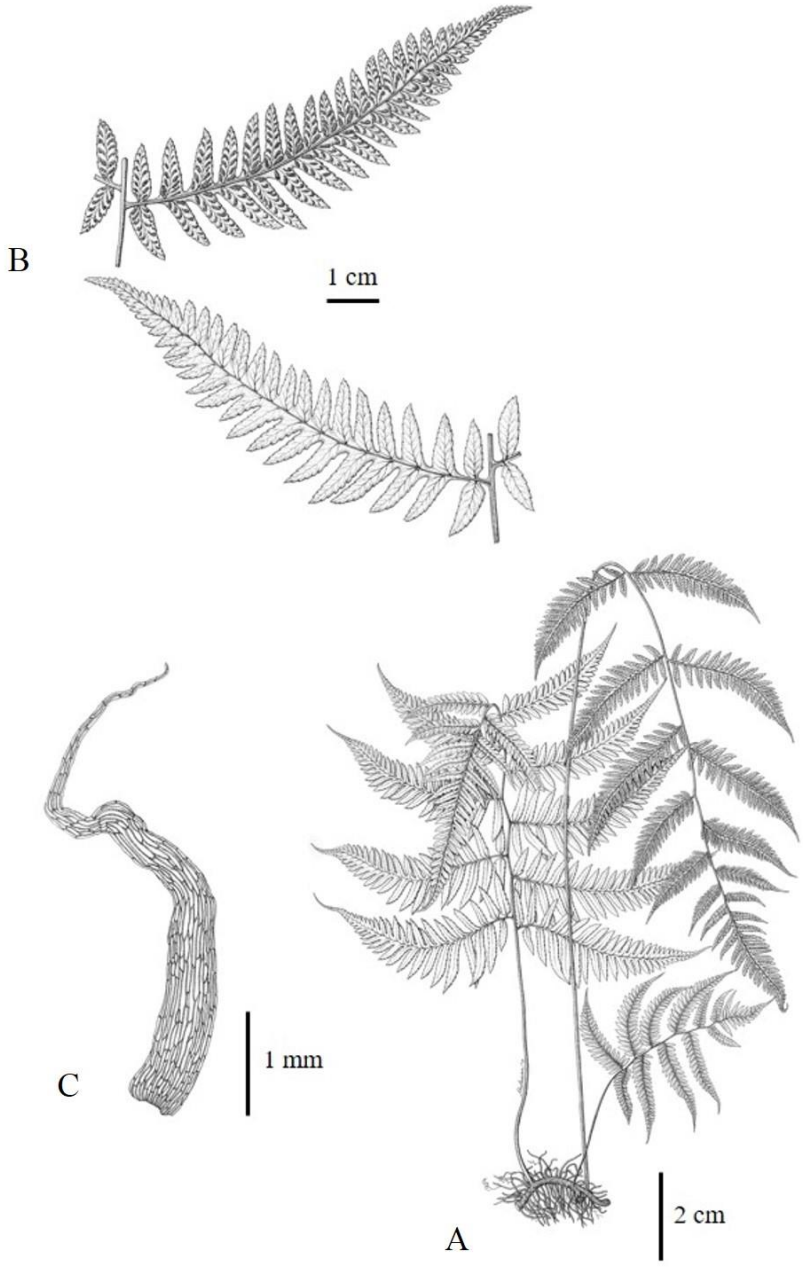

Figure 5.6 *Athyrium brevisorum* (Wall. ex Hook.) T. Moore. A. a whole plant with three leaves. B. lateral pinnae showing sori and venation. C. rhizome scale. Drawn by Wiliwan Nuchthongmuang from *P. Pongkai 82* (BCU).

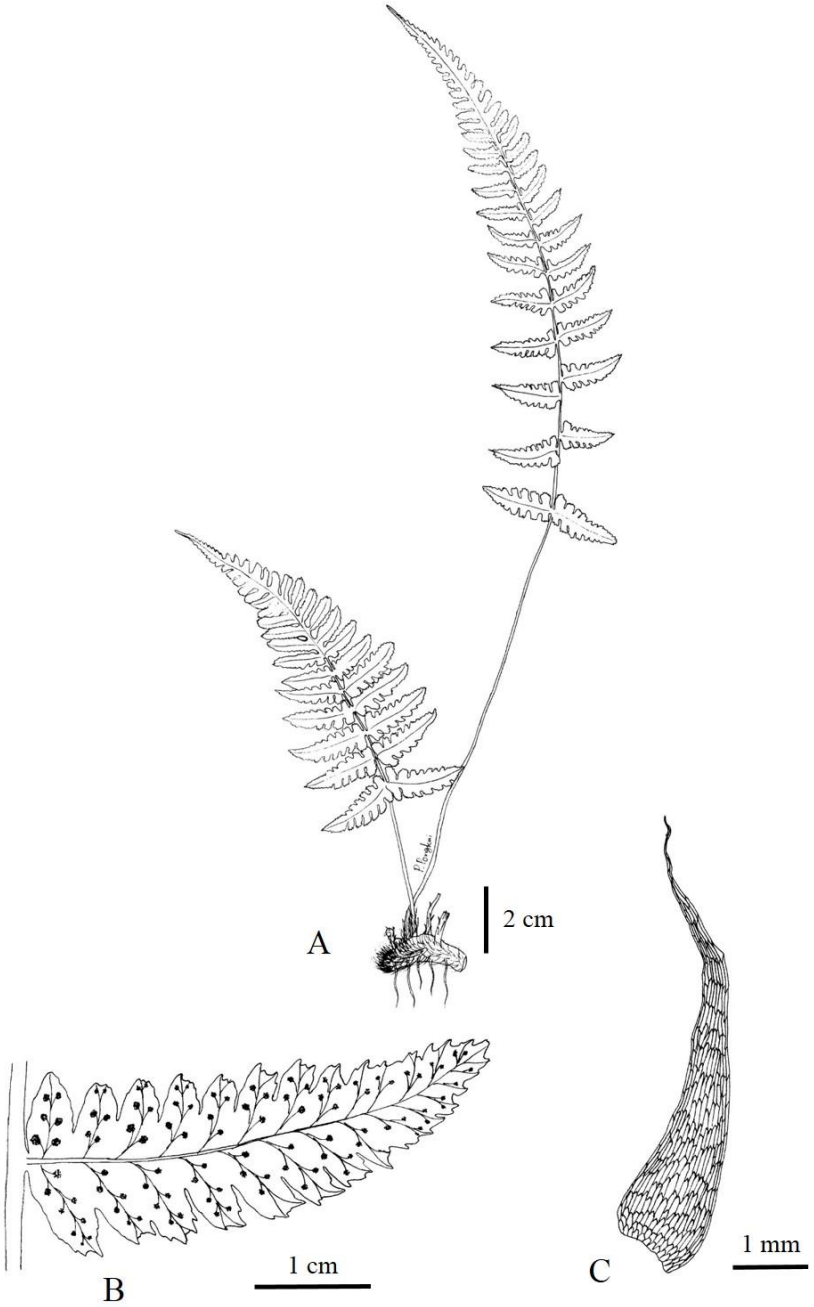

Figure 5.7 *Athyrium dissitifolium* (Baker) C. Chr. A. a whole plant with two leaves. B. lateralpinnae showing sori and venation. C. rhizome scale. Drawn by Puttamon Pongkai from *P. Pongkai 88* (BCU).

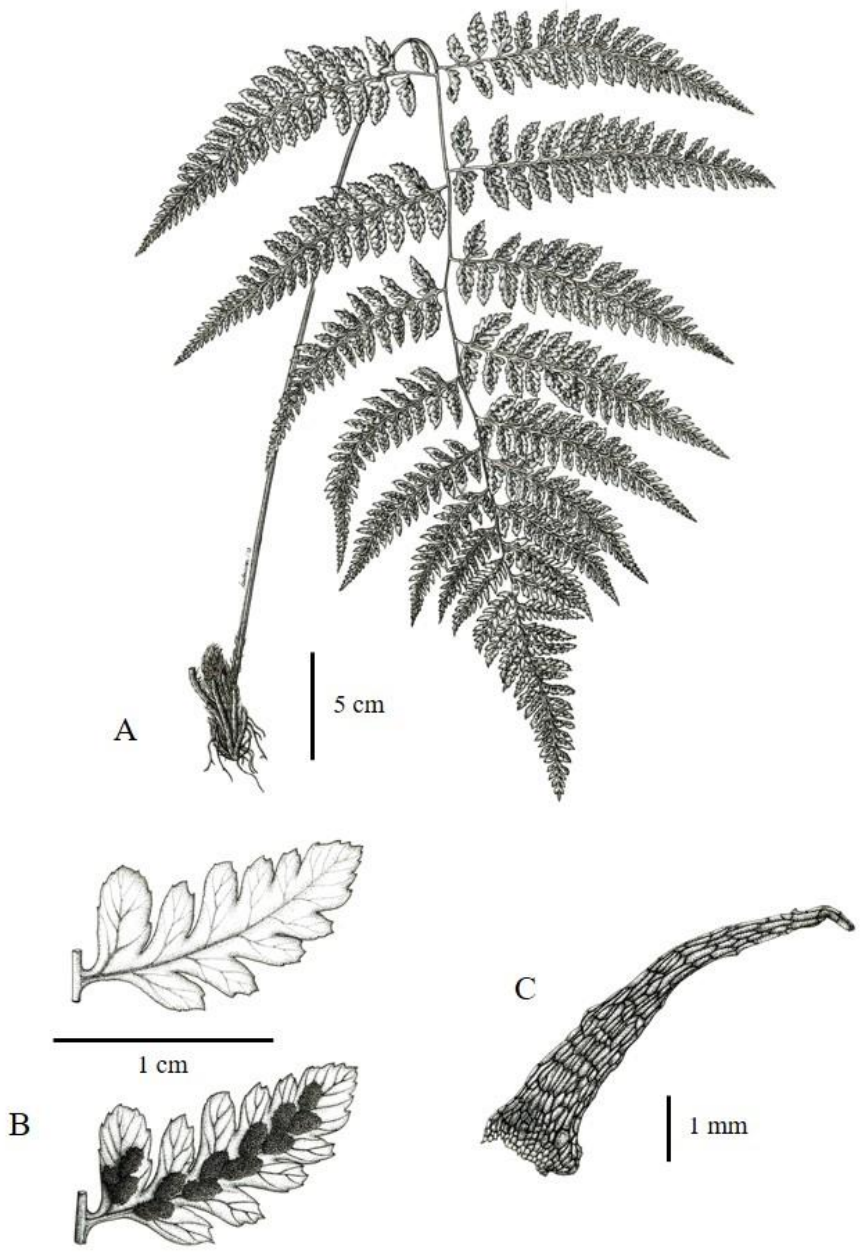

Figure 5.8 *Athyrium mackinnonorum* (C. Hope), C. Chr. A. whole plant with one leaf. B. lateral pinnae showing sori and venation. C. rhizome scale. Drawn by Wiliwan Nuchthongmuang from *K. Punchy 116* (BCU).

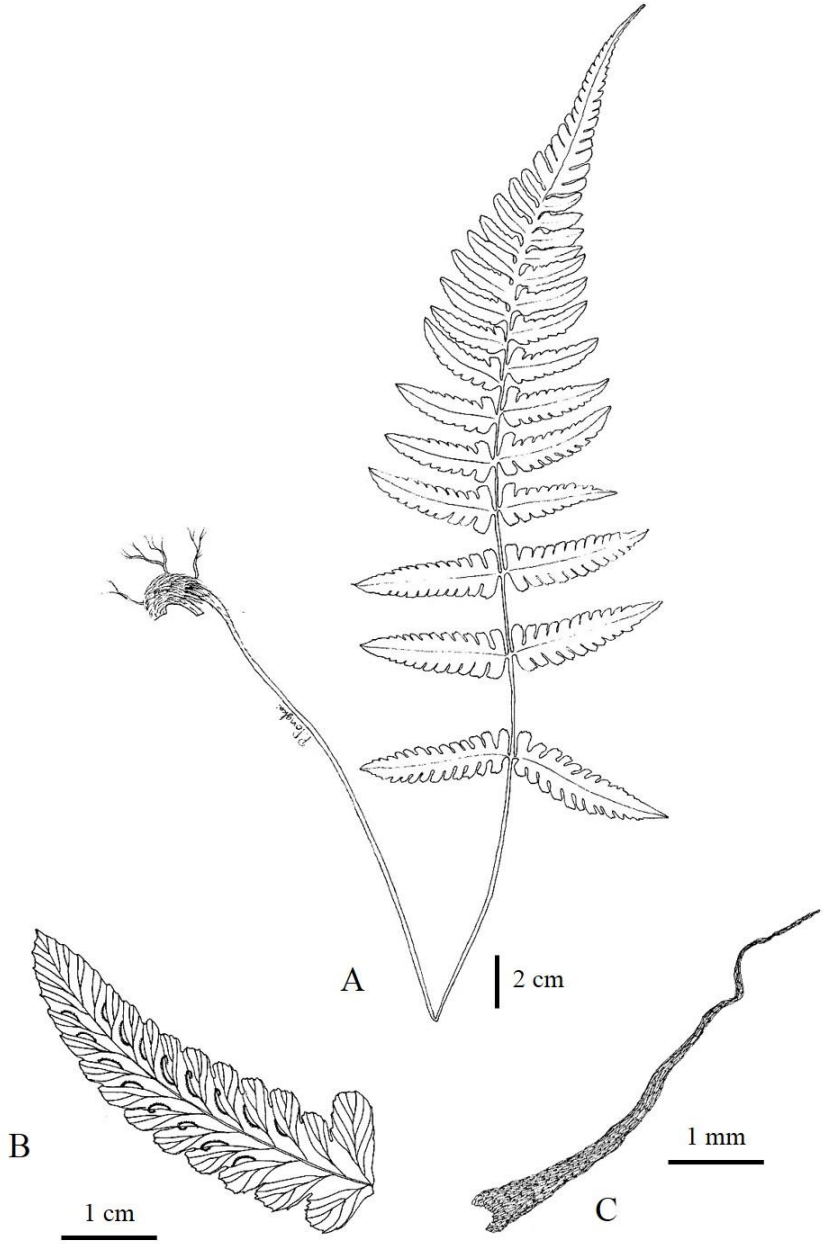

Figure 5.9 *Athyrium pachyphyllum* Ching. A. a whole plant with one leaf. B. part of lateral pinnae showing sori and venation. C. rhizome scale. Drawn by Puttamon Pongkai from *P. Pongkai 146* (BCU).

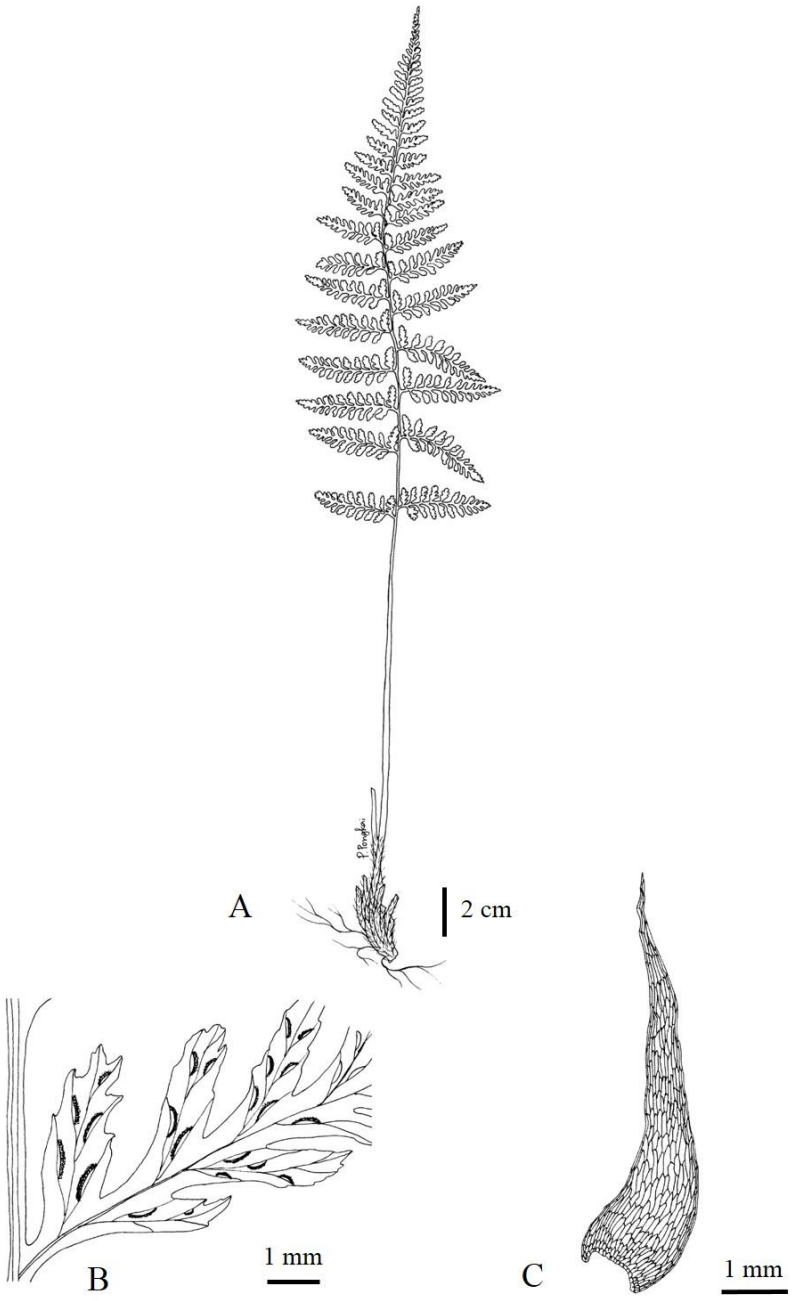

Figure 5.10 *Athyrium niponicum* (Mett.) Hance. A. a whole plant with one leaf. B. part of lateralpinnae showing sori and venation. C. rhizome scale. Drawn by Wiliwan Nuchthongmuang from *E. Hennipman 3407* (BKF).

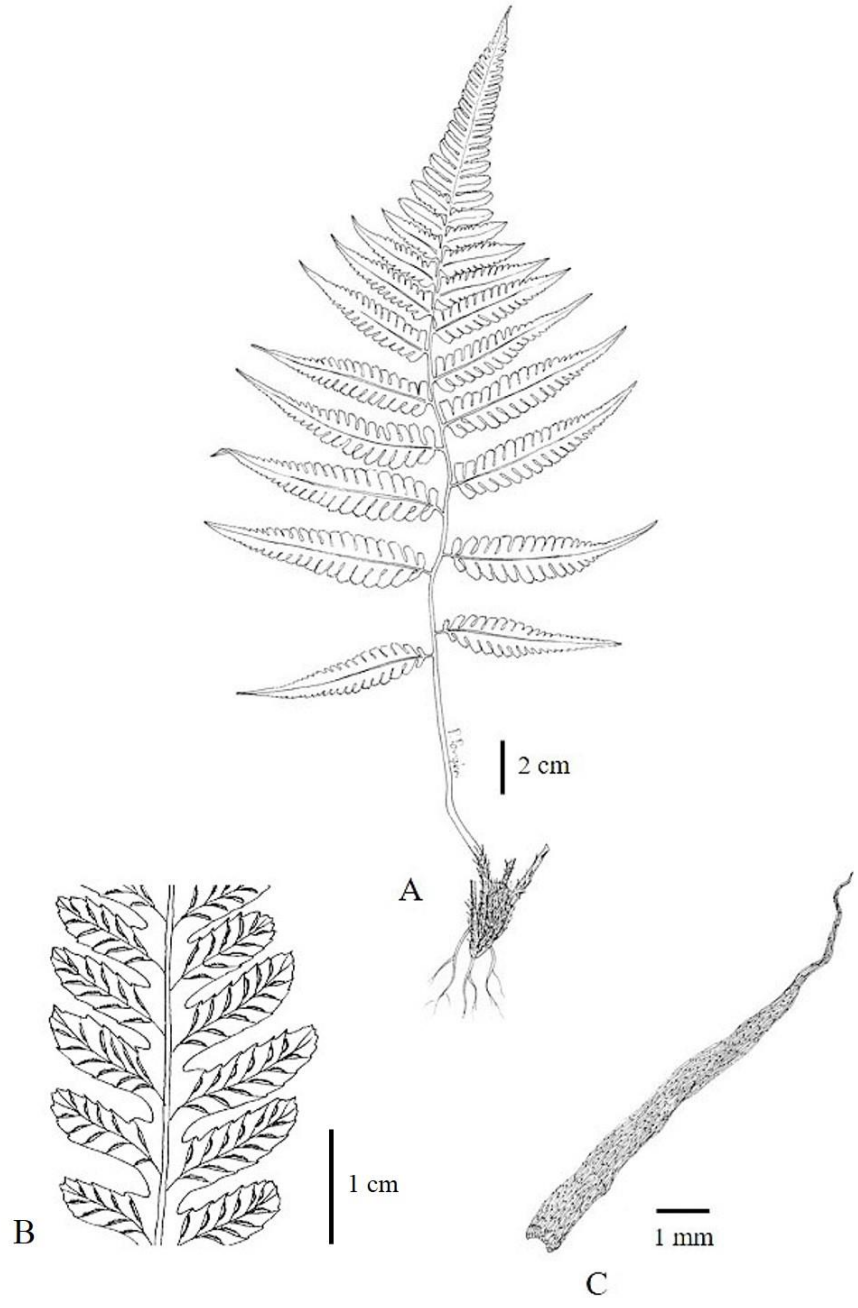

Figure 5.11 *Athyrium wangii* Ching. A. a whole plant with one leaf. B. part of lateral pinnae showing sori and venation. C. rhizome scale. Drawn by Wiliwan Nuchthongmuang from *E. Hennipman 3620* (BM).

5.3. *Cornopteris*

Nakai, Bot. Mag. Tokyo 44: 7. 1930; M. Tagawa & K. Iwats., Fl. Thailand 3(3): 441. 1988; M., Kato, & K.U., Kramer, Farn. & Gen. Vasc. Pl. (ed. K.Kubitzki) 137. 1990; K., Iwats, Fern and Fern Allies of Japan 241. 1994; W. Zhongren & M. Kato, Fl. China 443. 2013.— *Neoathyrium* Ching & Z.R. Wang, Acta Phytotax. Sin. 20(1): 76–77. 1982.Type: *Cornopterisdecurrenti-alata* (Hook.) Nakai

Plants terrestrial. *Stems* ascending, scaly; scales linear, concolorous, brown, margin entire, thin, membranous. *Fronds* bipinnate, softly herbaceous, usually becoming blackish when dry; petioles glabrous, groove above on adaxial surface, groove decurrent to those on costa, horn-shaped outgrowths and small scales present at junction of rachises and costae. *Laminae* lanceolate, veins free, pinnate. *Sori* oblong, on veinlet close to midrib, exindusiate. *Spores* monolete, 29.5-35.0 × 19.0-26.5 μm, bilaterally symmetrical, kidney-shaped. Ornamentation: smooth.

About 16 species, mainly distributed in tropical and subtropical Asia.

5.3.1 *Cornopteris opaca* (D. Don) Tagawa, Acta Phytotax. Geobot. 8(2): 92–94. 1939; Tagawa & K. Iwats., Acta Phytotax. Geobot. 23: 176. 1969; Tagawa & K. Iwats., Fl. Thailand 3(3): 441-442. 1988; K. Iwats., Fern and Fern Allies of Japan: 242. Pl. 162-163: 1992; S. Chandra,The fern of India: 143. 2000.—*Hemionitis opaca* D. Don, Prodr. Fl. Nepal. 13. 1825.—*Phegopteris opaca* (D. Don) Mett., Abh. Senckenberg. Naturf. Ges. 4: 15. 1858.—*Dryopteri sopaca* (D. Don) C. Chr., Index Filic. 5: 280. 1905.—*Diplazium opacum* (D. Don) Christ, Bull. Acad. Int. Géogr. Bot.16(205–206): 242–243. 1906.—*Athyrium opacum* (D. Don) Copel., Philipp. J. Sci. 3(5): 279. 1908.—*Nephrodium obtusatum* (Sw.) C. Presl, Reliq. Haenk. 1(1): 35. 1825.— *Gymnogramma obtusata* Blume, Enum. Pl. Javae 2: 113. 1828.— *Gymnogramma opaca* (D. Don) Spreng., Syst. Veg. [Sprengel] 4(1): 39–40. 1827.—*Leptogramma obtusata* (Blume) J. Sm., Hist. Fil. 232. 1875.— *Leptogramma opaca* (D. Don) Bedd., Handb. Ferns Brit. India 379, f. 217. 1883.— *Phegopteris obtusata* (Blume) Christ, Farnkr. Erde 274. 1897.—*Nephrodium obtusatum* (Blume) Diels, Nat. Pflanzenfam. 1(4): 171. 1899.— *Dryopteris bankinsinensi s*Hayata, Icon. Pl. Formosan. 8: 146, f. 73, f. 74. 1919.— *Dryopteris succulentipes* Hayata, Icon. Pl. Formosan. 8: 149–150, f. 77, f. 78. 1919.—

Athyriumgymn ocarpum Copel., Philipp. J. Sci. 40(3): 301–302, pl. 4. 1929.—*Cornopteris likiangensis* Ching, Lingnan Sci. J. 21(1–4): 32–33. 1945.—*Cornopteris omeiensis* Ching, Bull. Fan Mem. Inst. Biol., n.s. 1: 287. 1949. Type Wallich s.n. Figure 5.12, 5.54 D

*Plant*s terrestrial. *Stems* ascending to suberect, bearing a few fronds near apex, scaly; scales 6-8 × 1-2 mm, narrowly lanceolate, concolorous, brown, membranous. *Leaves* 77-110 cm, bipinnate to tripinnatifid; petioles 25-45 cm long, 6-8 cm in diameter, stramineous to brown, scaly at base. *Laminae* 52-65 × 28-30 cm, ovate in outline, papyraceous; pinnae 9-11 pairs, supopposite, 14-15 × 7.5-9 cm, subsessile or shortly stalked in larger one, lanceolate, apex acuminate, base truncate; rachis groove above, the groove decurrent to those of pinnae, cluster of horn-like outgrowths at junction of rachis and costae, sometimes also at junction of costae and costules with a linear brown scales; pinnule 5-7 pairs, gradually becoming pinnatisect apex of pinna, up to 10 × 2-2.5 cm, lanceolate, apex acute, margin crenate, acroscopic pinnules much smaller than basiscopic pinnules; veins all free, pinnate, veinlets simple or rarely forked, reach to margin. *Sori* 0.5-1.0 mm long, oblong or V-shaped, exindusiate. *Spores* monolete, 29.5-35.0 × 19.0-26.5 μm, bilateral, concavo-convex to plano-convex, perispore present; ornamentation: smooth.

Thailand.—NORTHERN: Mae Hong Son (Mae Sarieng), Chiang Rai, Chiang Mai (Muang, Jom Tong).

Distribution.— India, Nepal, Japan,Vietnam, Laos, Malaysia, Brunei, Indonesia and Malawi.

Ecology.— Terrestrial on mountain slopes at 1,000-1,700 m alt.

Specimens Examined.—**THAILAND**. Mae Hong Son, Mae Sarieng, *J.F. Maxwell 91*-222 (L); Chiang Mai, Jom Tong, *J.F. Maxwell 91-250* (L); Chiang Mai, Muang, *J.F. Maxwell 94-371* (L); Chiang Rai, *J.F. Maxwell 97-157* (BKF);Petchabun, Phu Hin Rong Kla, *K. Punchay 247* (BCU); ibid., *K. Punchay 248* (BCU); Lampang, *Smith 896* (K);**LAOS**. Champasak, *W. Sugoong et al. WS-2425* (KUN); **INDONESIA**. Borneo, *A.C. Jermy & J.M. Rankin J15050* (BM). **MALAWI**. Kaningina F.R., *Lacrolx 4367* (B); Uzumara forest, *Lacrolx 4658* (B); **UNKNOWN**. *M. Tagawa 868* (L).

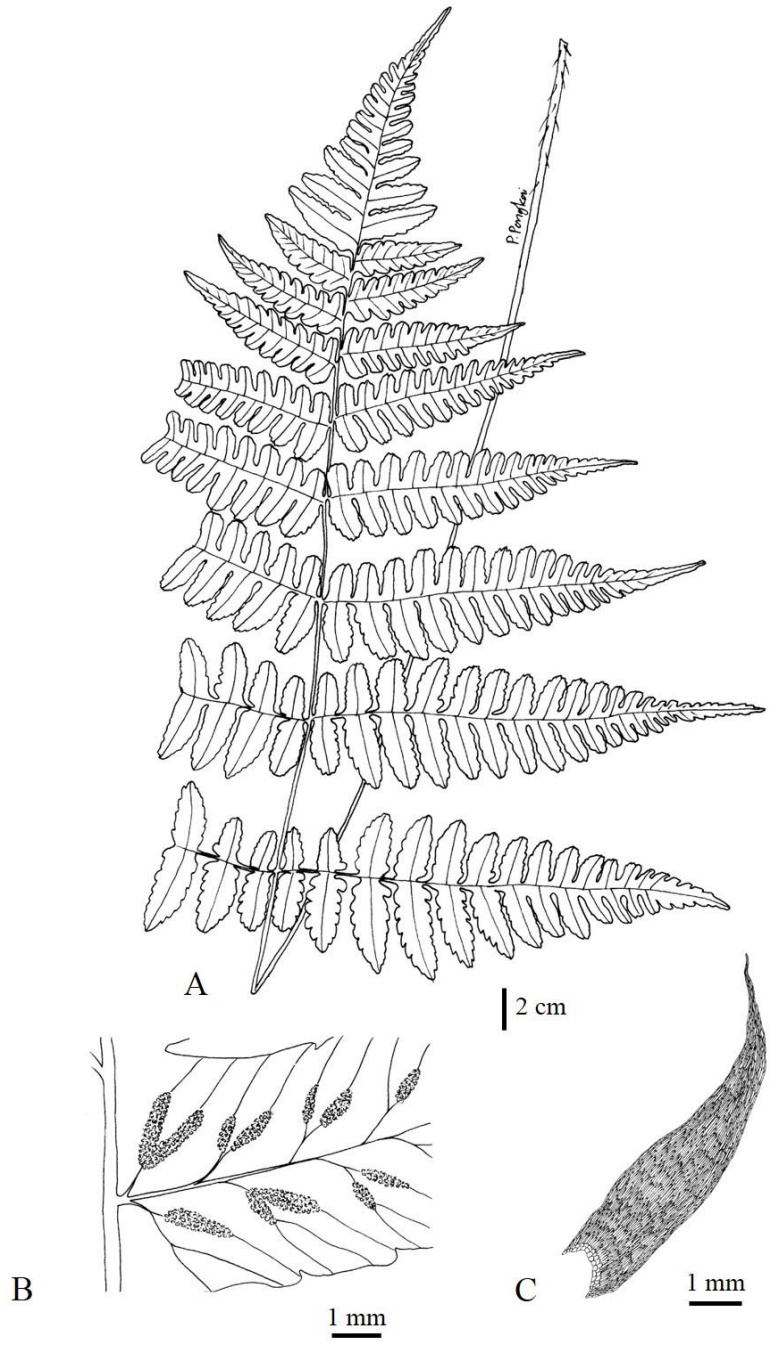

Figure 5.12 *Cornopteris opaca* (D. Don) Tagawa. A. part of a leaf.B. part of a pinna showing sori and venation. C. rhizome scale. Drawn by Puttamon Pongkai from *K. Punchay 248* (BCU).

5.4 *Deparia*

Hook. &Grev., Icon. Filic. 2(8): pl. 154. 1830; M. Tagawa & K. Iwats. Fl. Thailand 3(3): 438. 1988; M., Kato, & K.U., Kramer, Fam. & Gen. Vasc. Pl. (ed. K.Kubitzki). 136. 1990; K., Iwatsuki, Fern and Fern Allies of Japan 243. 1992; W. Zhongren & M. Kato, Fl. China 418. 2013.—*Triblemma* R. Br. ex C. Sprengel, Gen. Pl. 342. 1831.—*Dryoathyrium* Ching, Acta Phytotax. Geobot. 1(1): 30–31. 1932.—*Parathyrium* Holttum, Kew Bull. 13(3): 448. 1959.—*Athyriopsis* Ching, Acta Phytotax. Sin. 9(1): 63–65. 1964.—*Dictyodroma* Ching, Acta Phytotax. Sin. 9(1): 57–58. 1964.—*Triblemma* Ching, Acta Phytotax. Sin. 16(4): 23–24. 1978.

Plants terrestrial, small to medium. *Stems* creeping, ascending or erect, scaly; scale linear or lanceolate, concolorous, brown, margin entire, glabrous, persistant. *Leaves* simple, pinnate or bipinntae; petioles hairy, scaly. *Laminae* linear or ovate, apex acuminate, base attenuate, light to deep green, papyraceous or subcoriaceous; rachis groove but not continue to costa and costule; veins free, fork, pinnate. *Sori* round, oblong or elongate along veinlet, indusiate; indusia reniform, oblong or linear, margin entire, brown, glabrous, persiatant. *Spores* monolete, 25.5-62.0 × 20.0-40.0 μm, bilaterally symmetrical, kidney-shaped. Ornamentation: baculate.

About 70 species distributed in tropical and temperate zones of Asia, tropical Africa, Madagascar, extending to Japan, Korea, Russia, Himalaya.

Key to the species

1a	Frond simple……..	**5.4.4 *D. lancea***
1b	Frond compound……	2
2a	Frond pinnate, sori oblong, indusium oblong, persistent…….	3
2b	Frond bipinnate, sori round, indusium reniform, usually caducous……	**5.4.1 *D. boryana***
3a	Pinnae lanceolate to elliptic, margin lobed; veinsall free……	**5.4.3 *D. japonica***
3b	Pinnae oblong, margin subentire to crenate; veinsan astomosing…….	**5.4.2 *D. heterophlebia***

5.4.1 ***Deparia boryana*** (Willd.) M. Kato, Bot. Mag. (Tokyo) 90(1017): 36. 1977. Tagawa & K. Iwats., Fl. Thailand 3(3): 456. 1988; H. Zhaorong, A. Zhongren & M. Kato, Fl. China 425-426. 2013.— *Aspidium boryanum* Willd., Sp. Pl. 5(1–2): 285. 1810.— *Lastrea boryana* (Willd.) T. Moore, Index Fil. 86. 1858.— *Nephrodium boryanum* (Willd.) Hook.,Sp. Fil. 4: 126. 1862.— *Nephrodium boryanum* (Willd.) Baker, Syn. Fil. 284. 1867.— *Dryopteris boryana* (Willd.) C. Chr., Index Filic. 4: 255. 1905.— *Athyrium boryanum* (Willd.) Tagawa, Acta Phytotax. Geobot. 4(3): 144. 1935.— *Athyrium boryanum* (Willd.) Ching, Lingnan Sci. J. 15(3): 396. 1936.— *Dryoathyrium boryanum* (Willd.) Ching, Bull. Fan Mem. Inst. Biol., Bot. 11(2): 81. 1941.— *Ctenitis boryana* (Willd.) Copel.,Gen. Fil. (Copeland) 123. 1947.— *Cornopteris boryana* (Willd.) Tardieu, Amer. Fern J. 48(1): 32. 1958.—*Parathyrium boryanum* (Willd.) Holttum, Kew Bull. 13(3): 449. 1958.— *Lunathyrium boryanum* (Willd.) H. Ohba, Sci. Rep. Yokosuka City Mus. 11: 53. 1965.— *Aspidium divisum* Wall., Numer. List n. 393. 1828.— *Aspidium edentulum* Kunze, Bot. Zeitung (Berlin) 4: 474–475. 1846.— *Lastrea divisa* (Wall.) T. Moore, Index Fil. 90. 1858.— *Lastrea edentula* (Kunze) T. Moore, Index Fil.90. 1858.— *Lastrea divisa* (Wall. ex Hook.) Bedd., Ferns S. India 35, t. 97. 1863.— *Aspidium divisum* (Wall. ex Hook.) Wall. ex Thwaites, Enum. Pl. Zeyl. 392. 1864.— *Nephrodium divisum* (Wall. ex Hook.), Sp. Fil. 4: 133–134. 1862.— *Nephrodium edentulum* (Kunze) Baker, Syn. Fil. 279. 1867.— *Polypodium subtripinnatum* C.B. Clarke, Trans. Linn. Soc. London, Bot. 1(8): 545, pl. 80, f. 1. 1880.— *Dryopteris divisa* (Wall. ex Hook.) Kuntze, Revis. Gen. Pl.2: 811. 1891.— *Dryopteris edentula* (Kunze) Kuntze, Revis. Gen. Pl. 2: 812. 1891.— *Phegopteris kingie* Bedd., Suppl. Ferns Brit. Ind. 84. 1892.— *Dryopteris kingie* (Bedd.) C. Chr., Index Filic. 5: 273. 1905.— *Dryopteris subfluvialis* Hayata, Icon. Pl. Formosan. 5: 288–289, f. 113a–b. 1915.— *Athyrium subfluviale* (Hayata) Tagawa, Acta Phytotax. Geobot. 4(3): 144. 1935.— *Athyrium edentulum* (Kunze) Ching, Lingnan Sci. J. 15(3): 397. 1936.— *Dryoathyrium edentulum* (Kunze) Ching, Bull. Fan Mem. Inst. Biol., Bot. 11(2): 81. 1941.— *Deparia subfluvialis* (Hayata) M. Kato, J. Fac. Sci. Univ. Tokyo, Sect. 3, Bot. 13(4): 389. 1984.— *Deparia edentula* (Kunze) X.C. Zhang, Lycophytes Ferns China 385. 2012. Type: Madagascar, Mascarene Island, *Bory de St-Vincent s.n.* [Holotype B (B-W19831), Isotype P! (P00483051)]. Figure 5.13, 5.55 A

Plants terrestrial. *Stems* thick, ascending to suberect, sometime forming trunk, up to 25 cm high, frond subcaepitose, apex scaly; scale 10-12 × 1-2 mm lanceolate with long-tail apex, concolorous, brown, margin entire. *Leaves* tripinnatisect to tripinnate, 1.0-1.5 m long, petioles 40-50 cm long, 1.0-1.2 cm in diameter, hairy as well as scaly. *Laminae* 80-120 × 80-95 cm, outline ovate, apex acuminate, base narrowed, papyraceous, light green; rachis, costa and costule beset with coarse articulate hairs; pinnae 10-13 pairs, 40-60 × 16-20 cm, alternate, outline oblong-lanceolate, apex acuminate, base truncate, stalked; pinnule 12-15 pairs, 6-10 × 2-3 cm, alternate, narrowly triangular, apex long-acuminate, base truncate to subcordate, subsessile; altimate segment, 12-15 × 5-7 cm, adnate at base forming broad wings of costules, oblong, apex round, margin lobed; lobe 1/3 way to midrib, entire, oblique; veins free, pinnate. *Sori* round indusiate; indusia small, brown, persistent. *Spores* monolete, 25.5-30.0 × 21.0-23.0 µm, bilaterally symmetrical, kidney-shaped, ornamentation: baculate.

Thailand.— NORTHERN: Chiang Mai (Doi Inthanon, Ban Mae Kham Pong); Tak (Doi Pae Poe, Doi Musoe).

Distribution.— Nepal, Sri Lanka, India, Myanmar, China, Vietnam, Phillipines, Malaysia, Indonesia, Madagascar, Comores.

Ecology.—On wet sandy stream-beds in deep shade at about 1,000-1,400 m alt.

Specimens Examined.—**THAILAND**. Chiang Mai, Ban Mae Kham Pong, *M. Kato 11103* (PE); Tak, Doi Pae Poe, *B. Hansen & T. Smitinand 12913* (BKF, K, L, P); **INDIA**. Darjeling, C.*B. Clarke 8499* (P); Darjeling, *P. morvis s.n.* (P); **VIETNAM**. Tung Duong, *H. van der Werff et al. 23732* (P); **CHINA**. Guangdong, *Lau S.K. 2391* (PE); Guizhou, *Li Zhongyang, W. Ran & Z. Hongrui 7366* (PE); **MALAYSIA**. Pahang, *B.M. Allen 1972* (K); Perak, *B.M. Allen 4006* (K); **INDONESIA**. Java, *Zhang X-C 586* (PE); **MADAGASCAR**. Ambalavao, *F. Rakotondrainibe 124* (P); Antsiranana, *F. Rakotondrainibe 1580* (P); Ambalavao, *F. Rakotondrainibe 2712* (P); ibid., *F. Rakotondrainibe 2740* (P); ibid., *F. Rakotondrainibe 4148* (P); ibid., *Rakotondrainibe 4161* (P); ibid., *Rakotondrainibe 4381* (P); ibid., *Rakotondrainibe 5581* (P); ibid., *Rakotondrainibe 5873* (P); Antsiranana, *S. Malcomber et al. 2382* (P).

5.4.2 ***Deparia heterophlebia*** (Mett. ex Baker) R. Sano, Acta Phytotax. Geobot. 51(1): 17. 2000; H. Zhaorong, A. Zhongren & M. Kato, Fl. China 435. 2013.— *Asplenium heterophlebium* Mett. ex Baker, Syn. Fil.243. 1867.— *Anisogonium heterophlebium* (Mett. ex Baker) Bedd., Ferns Brit. India, pl. 329. 1867.— *Diplazium heterophlebium* (Mett. ex Baker) Diels, Nat. Pflanzenfam.1(4): 228. 1899.— *Athyrium heterophlebium* (Mett. ex Baker) Copel., Philipp. J. Sci. 38(1): 142. 1929.— *Dictyodroma heterophlebia* (Mett. ex Baker) Ching, Acta Phytotax. Sin.9(1): 59, t. 5, f. 9–14. 1964.— *Diplaziopsis heterophlebia* (Mett. ex Baker) M.G. Price, Contr. Univ. Michigan Herb. 17: 269. 1990.— *Diplazium hemionitideum* Christ, Bull. Herb. Boissier 7(1): 12. 1899.— *Diplazium rude* Christ, Index Filic. 4: 238. 1905. Type: India, Assam, *Griffith 22*, holotype K! (K001089385). Figure 5.14, 5.55 B

Plants terrestrial. *Stems* short ascending, bearing wiry root, covered with scales at apex; scales 5-7 × 1-2 mm, ovate with long-tail apex, concolorous, pale brown, membranous, margin entire with caducous membrane near apex. *Leaves* 40-45 × 20-25 cm, unipinnate; petioles 30-35 cm long, 0.4-0.5 cm in diameter, scaly at lower part, brown, black near base; *Laminae* 40-50 × 15-20 cm, outline ovate-oblong, apex acuminate, base obtuse, terminal pinna not distinct, papyraceous; rachis groove, scaly, hairy; pinnae 5-6 pairs, 10-12 × 3.5- 4.0 cm, sessile, oblong, apex attenuate, base truncate or slightly cordate, margin undulate; herbaceous, minutely hairy on surface; veins anastomosing, forming areoles without included veinlets. *Sori* elongate along veinlets; indusia completely covering the sori, not so thin, brown, persistent. *Spores* monolete, 60.5-62.0 × 36.0-40.0 μm, bilateral, concavo-convex to plano-convex, perispore present; ornamentation: baculate.

Thailand.— NORTHERN: Chiang Mai (Doi Inthanon, Doi Chiang Dao).

Distribution.— India, Nepal, Myanmar, China, Japan, Taiwan, Vietnam, Malaysia.

Ecology.— Along streams in moist hill evergreen forest at about 1,750 m alt.

Specimens Examined.—**THAILAND**. Chiang Mai, Doi Inthanon, *E. Hennipman 3432* (K, L); Chiang Mai, Doi Chiang Dao, *E. Smith 1193* (BK); **CHINA**. Yunnan, *W. Hancock 189* (K); ibid.,*W. Hancock 190* (K); Yunnan, *A. Henry 13568* (K); ibid., *A. Henry 11556* (K); **JAPAN**. Yakushima, *H. Ohba 78* (BK, K); **TAIWAN**. Takao, *M. Tagawa 1931* (BM); Kwarenko, *M. Tagawa 3343* (K);

Takao, *M. Tagawa 1510* (K); **MALAYSIA**. Pahang, *D. Nar s.n.* (K); Pahang, *Anonymous 13921* (K).

5.4.3 *Deparia japonica* (Thunb.) M. Kato,Bot. Mag. (Tokyo) 90(1017): 37. 1977; H. Zhaorong, A. Zhongren & M. Kato, Fl. China 440. 2013.— *Asplenium japonicum* Thunb., Syst. Veg. (ed. 14) 934. 1784.— *Diplazium japonicum* (Thunb.) Bedd.,Suppl. Ferns Brit. Ind.12, pl. 292. 1876.— *Athyrium japonicum* (Thunb.) Copel., Philipp. J. Sci. 3(5): 290. 1908.— *Lunathyrium japonicum* (Thunb.) Sa. Kurata, J. Geobot. 9(3/4): 99. 1961.— *Athyriopsis japonica* (Thunb.) Ching, Acta Phytotax. Sin. 9(1): 65. 1964.— *Diplazium thunbergii* Nakai ex Momose, J. Jap. Bot. 14(4): 265. 1938.— *Diplazium japonomettenianum* Nakai, Bull. Natl. Sci. Mus. 27: 18. 1949.— *Deparia pterorachis* (Christ) M. Kato, Bot. Mag. (Tokyo) 90(1017): 35. 1977. Type.unknown. Figure 5.15, 5.55 C

Plants terrestrial. *Stems* creeping, 2-3 cm in diameter, scaly; scales 4-6 × 0.8-1.0 mm, broadly lanceolate, concolorous, light brown, thin, margin entire. *Leaves* pinnate, 50-63 cm long; petioles 20-28 cm long, 4-6 mm in diameter, stramineous when dry, scaly, hairy above. *Laminae* 30-35 × 18-20 cm, outline ovate or ovate-lanceolateapex acuminate, base obtuse, subcoriaceous; rachis groove, hairy; pinna more than 10 pairs, 8-12 × 1.5-2.0 cm, subopposite, pinnatisect, outline lanceolate, apex acuminate, base obtuse, margin lobed; lobe 1.0 × 0.5 cm, nearly close to costule, oblong, apex round, margin slightly dentate, veins free, pinnate, veinlet 6-8 pairs. Sori 3-4 × 1 mm, oblong, on every veinlet, usually diplazoid at lower veinlet of each vein group. *Spores* monolete, 36.0-38.0 × 29.0-31.0 μm, bilateral, concavo-convex to plano-convex, perispore present; ornamentation: baculate.

Thailand.— NORTHERN: Chiang Mai (Doi Inthanon, Doi Chiang Dao).

Distribution.— India, Nepal, Myanmar, China, Taiwan, Japan, Korea, Laos.

Ecology.— On muddy rocks near streams at 600- 1,800 m alt.

Specimens Examined.—**THAILAND**. Unknown, *C. Phengklai et al. 10658* (BCU); Unknown, *E. Rosenstock 40* (BKF); Chiang Mai, Doi Chiang Dao, *E. Smith 1192* (K); ibid.,*E. Smith 1193* (K); Chiang Mai, *J.F. Maxwell 96-932* (CMUB); Lampang, Doi Luang National Park, *J.F. Maxwell 98-699* (CMUB); **JAPAN**. Unknown, *K. Iwatsuki 394* (BKF); **LAOS**. Houa Phanh, *W. Sugong, G. Xun, D. Bo,*

O. Souliya & K. Thepkaysone WS2655 (KUN); ibid., *W. Sugong, G. Xun, D. Bo, O. Souliya & K. Thepkaysone WS2656* (KUN); **MALAYSIA**. Pahang, *A.G. Piggott 2576* (K); Pahang, *B.S. Parris 10879* (K); Perak, *J. Sinclair & Kiah 38794* (K); Cameron, *K.C. Cheang s.n.* (K); **UNKNOWN**. *Wallich 22088* (K).

5.4.4 ***Deparia lancea*** (Thunb.) Fraser-Jenk., New Sp. Syndr. Indian Pteridol.101. 1997; H. Zhaorong, A. Zhongren & M. Kato, Fl. China 436. 2013.— *Asplenium lanceum* Thunb., Fl. Jap. 333–334. 1784.— *Micropodium lanceum* (Thunb.) J. Sm., Hist. Fil. 1: 323. 1825.—*Diplazium lanceum* (Thunb.) C. Presl, Tent. Pterid. 113. 1836.—*Athyrium lanceum* (Thunb.) Milde, Bot. Zeitung (Berlin) 28: 354. 1870.—*Triblemma lancea* (Thunb.) Ching, Acta Phytotax. Sin. 16(4): 24. 1978.—*Asplenium subsinuatum* Wall. ex Hook. & Grev., Icon. Filic.1 (2), pl. 27. 1827.—*Athyrium lanceum* T. Moore, Index Filic. 185. 1860.—*Diplazium simplicifolium* Kodama, Icon. Pl. Koisik.1, pl. 68. 1913.—*Diplazium subsinuatum* (Wall. ex Hook. & Grev.) Tagawa, Coloured Ill. Japanese Pteridophyta 135, pl. 55, f. 298. 1959. Type unknown. Figure 5.16, 5.55 D

Plants terrestrial. *Stems*slender, long creeping 2-4 mm in diameter, covered with scales throughout; scales 7-8 × 0.5-1.0 mm, narrowly lanceolate with long-tail apex, concolorous, dark brown, margin entire. *Leaves* simple, 25-40 cm long; petioles 13-20 cm, 2-3 mm in diameter, brown, lower portion dark. *Laminae* 27-31 × 2.0-2.5 cm, linear-oblong, apex acuminate, base attenuate, margin subentire, coriaceous, glabrous, midrib raised beneath; veins free, veinlets 3 pairs, reaching to margin. *Sori* elongate along veins, 6-9 mm long, oblong, usually on acroscopic veinlets of vein group. *Spores* monolete, 30-37.5 × 20-32.5 μm, bilateral, concavo-convex to plano-convex, perispore present; ornamentation: baculate.

Thailand.— EASTERN: Chiyaphum (Phu Kiew).

Distribution.— India, Nepal, Sri Lanka, Myanmar, China, Japan, Taiwan, Laos, Vietnam, Phillipines.

Ecology.— On sandstone boulders along streams in evergreen forests at about 1,200 m alt.

Specimens examine.— **THAILAND**. Chiyaphum, *A. Sathapattayanon 576* (BCU); Phetchabun, *G. murata et al. T49576* (BKF); **CHINA**.Hainan, *Guangdong 913* (PE); ibid., *Guangdong 932* (PE); Fujian, *H. Guosheng 10092* (PE); Guizhou, *L. Zhixiu & L. Yanli 7014* (PE); ibid., *L. Zhixiu & L. Yanli 7044* (PE); Fujian, *L.Mingsheng & L. Zhenyu 5843* (PE); Jiangxi, *Minnan Collection Team 182* (PE); ibid., *Minnan Collection Team 1354* (PE); Hunan, *Q. Linchuan & Y. Shixin 1442* (PE); Hainan, *S.Y. Dong et al. 625* (PE); Guangdong, *Shenzhen expedition 95* (PE); Jiangxi, *T. Ceming 94825-A* (PE); ibid., *T. Ceming 95975* (PE); ibid., *T. Ceming 9604129* (PE); Hunan, *W. Shifu 1029* (PE); Guangdong, *W.Peishan & X. Qun 77798* (PE); Guangdong, *W.Xueping & W. Ran WXP051* (PE); Fujian, *Wushu team 2604* (PE); Hainan, *Wuzhishan Fern Survev 91* (PE); ibid., *Wuzhishan Fern Survev 279* (PE); ibid., *Wuzhishan Fern Survev 525* (PE); Hunan, *X. Jianming, Z. Sheng 7395* (PE); Hunan, *Yan Yuehong et al. 721* (PE); ibid., *Yan Yuehong et al. 4400* (PE); Jiangxi, *Z. Xianchun & C. Yongjun 1883* (PE); Hunan, *Z. Xile & O. Haibo 341* (PE); Guangxi, *Z. Zhiwei, X. Lei & Z. Qiang 2015-229* (PE); Jiangxi, *Zhang X.C. 1883* (PE); **JAPAN**. Japan, *K.H. Shing 18* (PE); Japan, *M. Furuse 23266* (PE); ibid., *M. Furuse 25158* (PE); ibid., *M. Furuse 42884* (PE); ibid., *M. Furuse 44738* (PE); ibid., *M. Furuse 46396* (PE); **TAIWAN**. Unknown, *A. Henry 1377* (B); Unknown, *Former 9475* (B); Taipei, *G. Meifang3159* (PE); ibid., *G.Meifang 11381* (PE); Taipei, *H. Guosheng s.n.* (PE); Taipei, *L. Huizhou 1539* (PE); Taipei, *P.Jingyi et al 19590* (PE); ibid., *P.Jingyi et al 19625* (PE); Taipei, *S. Binglin 1316* (PE); Taihoku, *T. Tanaka & Y. Shimada 13504* (B); Taihoku, *T. Tanaka 1734* (B); Unknown, *U. Faurie 672* (B); **LAOS**. Saravan, *W. Sugong, G. Xun, D. Bo, O Souliya & K. Thepkaysone WS2345* (KUN).

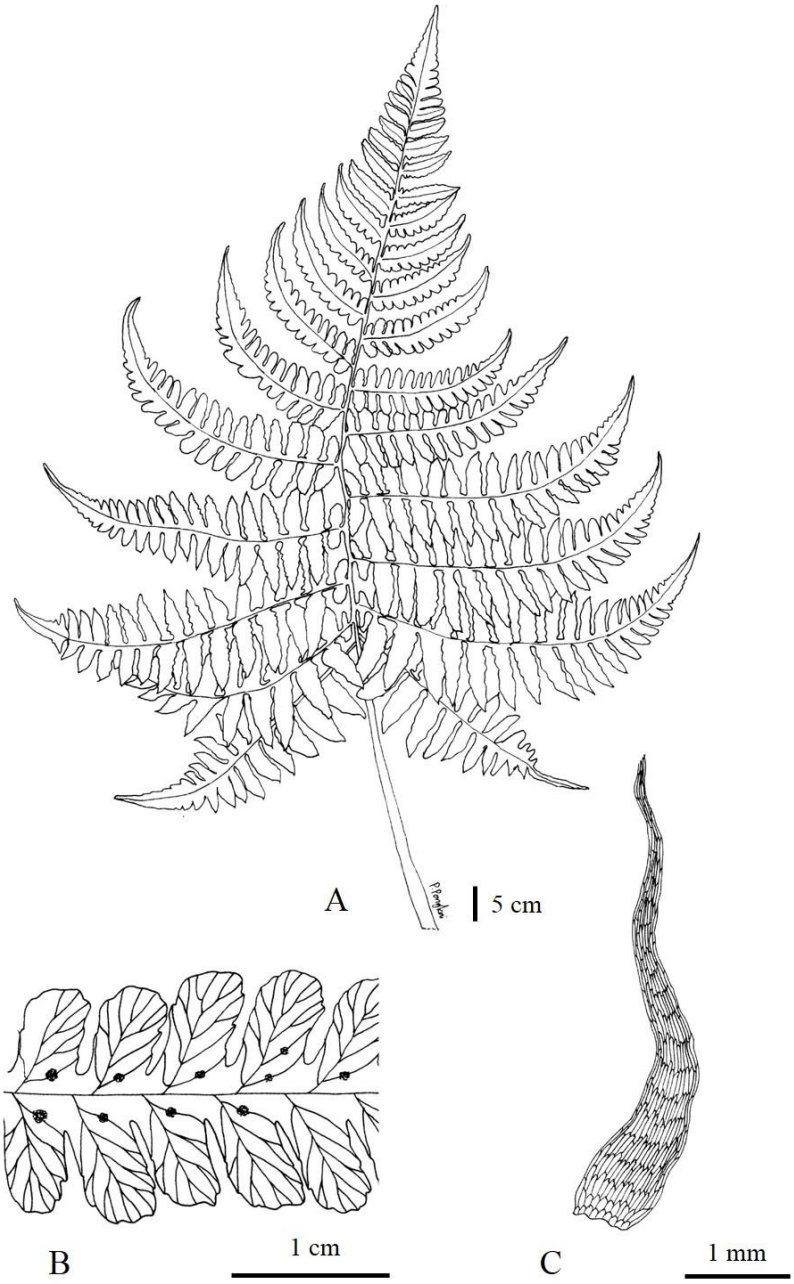

Figure 5.13 *Deparia boryana* (Willd.) M. Kato. A. part of a leaf. B. part of lateral pinnae showing sori and venation. C. rhizome scale. Drawn by Puttamon Pongkai from *B. Hansen & T. Smitinand 12913* (BKF).

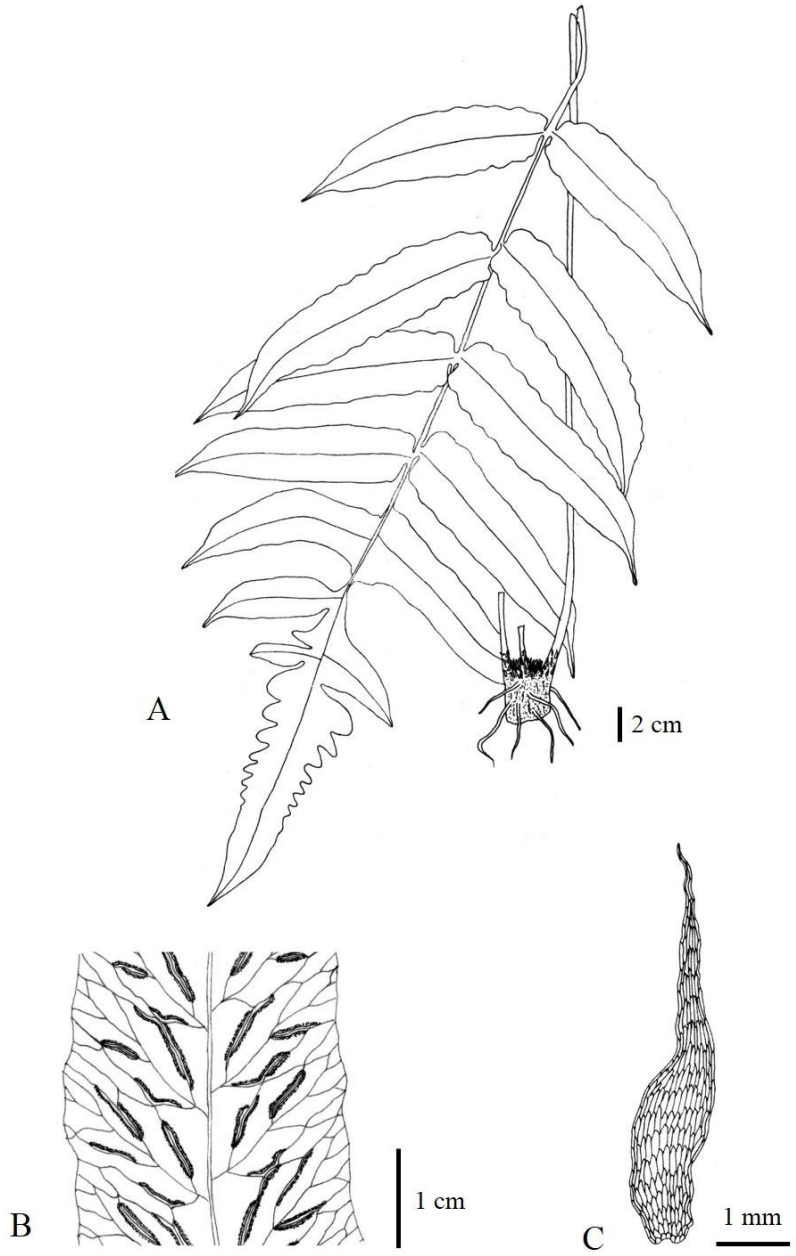

Figure 5.14 *Deparia heterophlebia* (Mett. ex Baker) R. Sano. A. a whole plant with one leaf. B. part of a pinna showing sori and venation. C. rhizome scale. Drawn by Puttamon Pongkai from *E. Smith 1193* (BK).

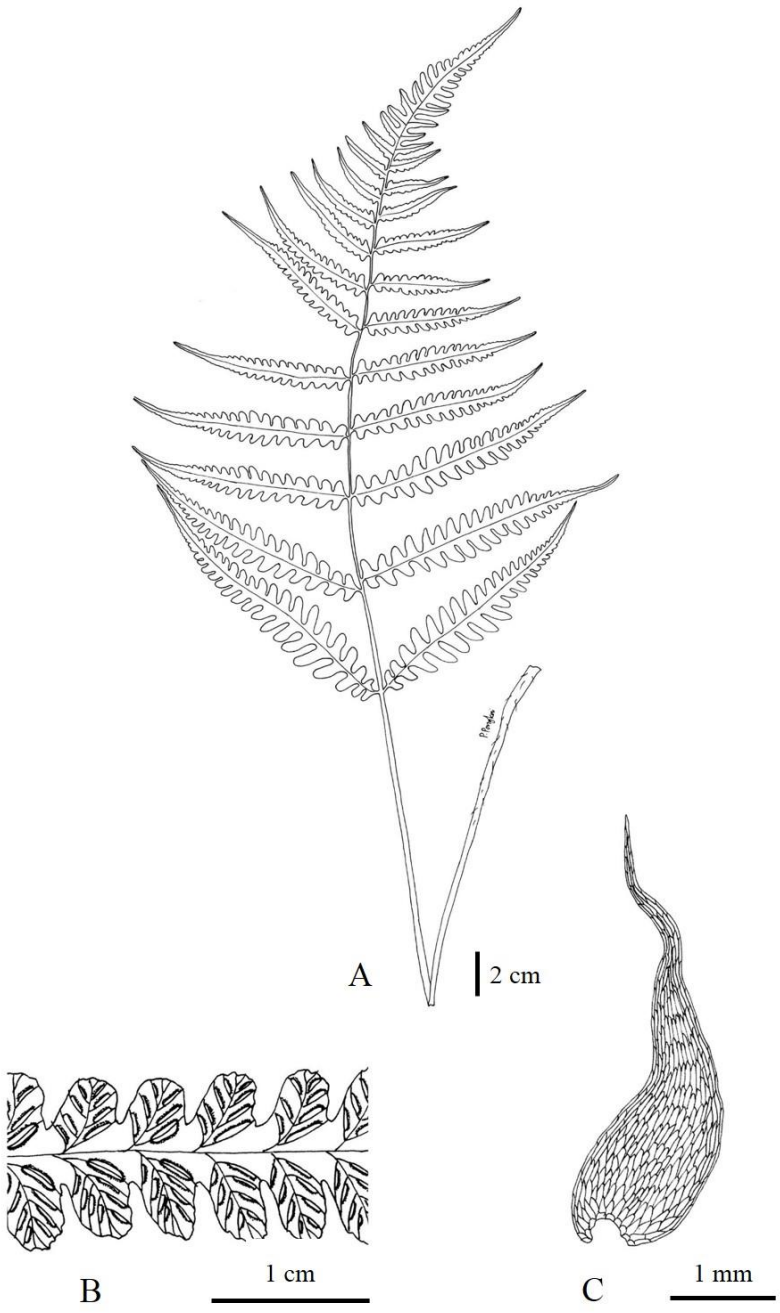

Figure 5.15 *Deparia japonica* (Thunb.) M. Kato. A. part of a leaf. B. part of a pinna showing sori and venation. C. rhizome scale. Drawn by Puttamon Pongkai from *C. Phengklai et al. 10658* (BCU).

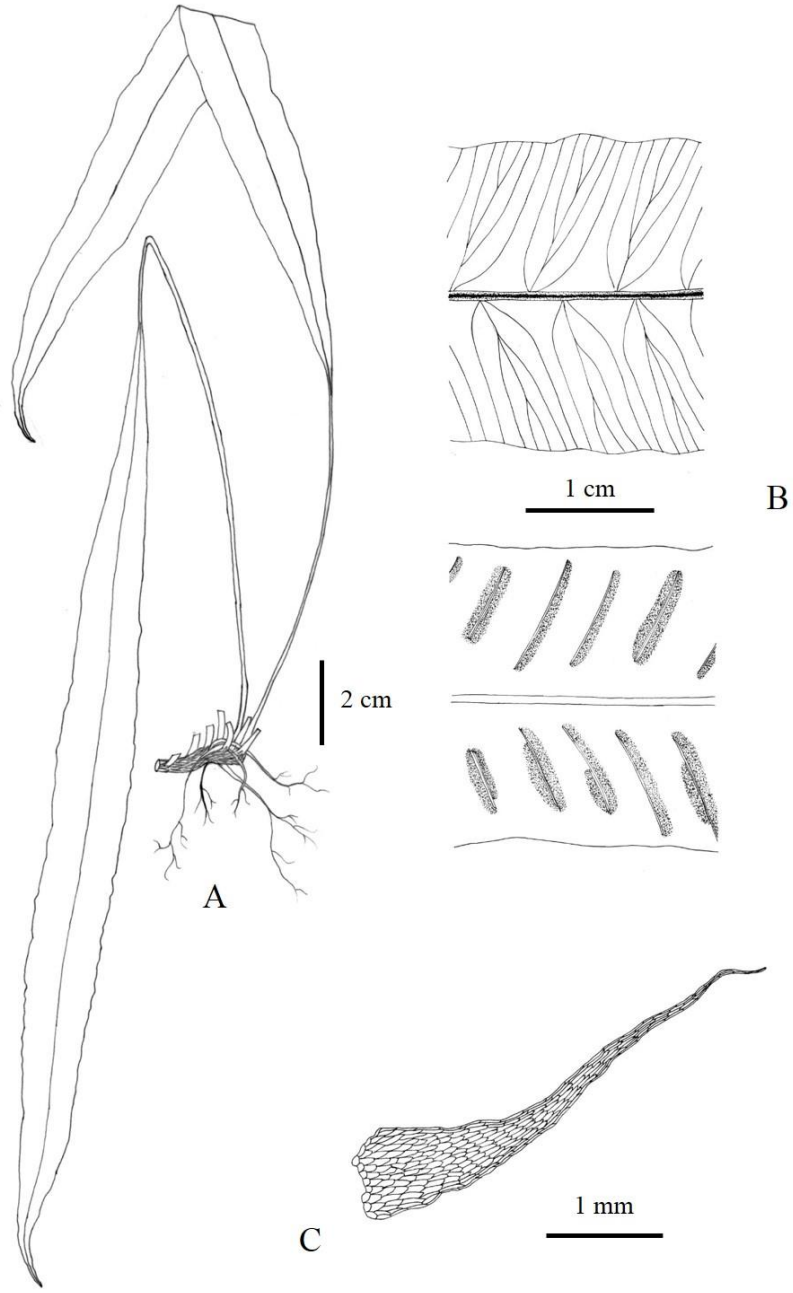

Figure 5.16 *Deparia lancea* (Thunb.) Fraser-Jenk. A. a whole plant with two leaves. B. part of a lamina showing sori and venation. C. rhizome scale. Drawn by Puttamon Pongkai from *A. Sathapattayanon 576* (BCU).

5.5. *Diplazium*

Sw., Schrad. J. Bot. 1800(2): 61. 1801; T. Moore, Index Fil.: 330. 1859; C.R.H. Beddome, Fern of British India: 174. 1892; J. Schmidt, Fl. Koh Chang: 108. 1900; D.B.Lellinger, Fern & Fern-Allies of the United States & Canada: 252. 1985; E.A.C.L.E. Schelpe & N. Anthony, Fl. Southern Africa: 227. 1986; C.J. Goudey, Handbook of Ferns for Australia and New Zealand: 96. 1988; J.T. Mickel & J.M. Beitel, Pteridophyte Flora of Oxaca, Mexico: 151. 1988; M. Tagawa & K. Iwatsuki., Fl. Thailand 3(3): 449. 1988; G. R. Proctor, Fern of Puerto Rico and the Virgin Islands: 237. 1989; M. Kato, Fl. North America: 252. 1993; Zhaorong, H & Kato, M., Fl. China: 499. 2013.—*Athyrium* Roth, Röm. Mag. 2(1): 105. 1799; Copel., Gen. Fil.: 147. 1947.—*Callipteris* Bory, Voy. Îles Afrique 1:282. 1804.—*Allantodia* R. Br., Prodr.: 149. 1810.—*Anisogonium* C. Presl, Tent. Pterid.: 115–116. pl. 4. f. 6, 13, 18. 1836.—*Digrammaria* C. Presl, Tent. Pterid.: 116. 1836.—*Oxygonium* C. Presl, Tent. Pterid.: 117. 1836.— *Microstegia* C. Presl, Abh. Königl. Böhm. Ges. Wiss., ser. 5. 6: 450. 1851.— *Ochlogramma* C. Presl, Abh. Königl. Böhm. Ges. Wiss., ser. 5 6: 453. 1851.— *Diplaziopsis* C. Chr., Index Filic. 4: 227. 1905.—*Monomelangium* Hayata, Bot. Mag. (Tokyo) 42(499): 343. 1928.—*Dictyodroma* Ching, Acta Phytotax. Sin. 9(1): 57. 1964.—*Rhachidosorus* Ching, Acta Phytotax. Sin. 9(1): 73. 1964. Type Species: *D. Plantsaginifolium* (L.) Urb. designated by J. Smith, Hist. Fil. 325. 1875.

Plants terrestrial, or epipetric, small to large size. *Stems* creeping, ascending or erect, sometimes forming a short trunk, scaly, especially on younger part; scales linear or lanceolate with long-tail apex, concolorous brown to black or black at margin, entire or toothed at margin. *Leaves* simple or more compound to bipinnate; petioles with 2 vascular strands at the base, uniting upwards forming a single U or V shaped bundle, glabrous or scaly. *Laminae* broadly ovate, oblong, or deltoid, sometimes broadly lanceolate texture herbaceous to papery; veins free or anastomosing. *Sori* single or paired back-to-black (diplazoid) along vein, oblong to linear, straight or slightly falcate; indusia thin, linear, persistent. *Spores* monolete, 30.0-72.5 × 17.5-50.0 µm, bilaterally symmetrical, kidney-shaped. Ornamentation: echinate, irregular, labryrinth, prominent wing folds, pustulate, rough or smooth.

A genus of about 400 species (Lellinger 1985, Kato 1993, Wang *et al.* 2013) mainly distributed in tropical regions; 30 species in Thailand.

Key to the species

1a	Fronds simple……..…….....	2
1b	Fronds compound……..……	3
2a	Lamina cordate, Scales margin entire……	**5.5.4 *D. cordifolium***
2b	Lamina oblong, Scales margin toothed……..	**5.5.27 *D. subserratum***
3a	Fronds unipinnate……...……..….	4
3b	Fronds bipinnate…….……	23
4a	Rhizome creeping……...…….....	5
4b	Rhizome erect…….....	8
5a	Upper pinnae not reduced; terminal pinna distinct……	6
5b	Upper pinnae gradually reduced; terminal pinna not distinct…….	7
6a	Terminal pinna simple…….……	**5.5.7 *D. donianum***
6b	Terminal pinna pinnatifid……	**5.5.31 *D.* sp.**
7a	Veinlets simple or once forked, 3−4 pairs; sori cresentic, 2−3 mm long……	**5.5.17 *D. petrii***
7b	Veinlets all free, 4−5 pairs; sori elongate along vein, 4−5 mm long……	**5.5.13 *D. mettenianum***
8a	Scales entire……..….	9
8b	Scales toothed……..…….	12
9a	Terminal pinna not distinct……	10
9b	Terminal pinna distinct…….....	19
10a	Stipes and rachis tomentose……..…	**5.5.29 *D. tomentosum***
10b	Stipes and rachis glabrous……...……..	11
11a	Auricle at basiscopic base of pinnule distinct; pinnae-stalks 4−5 mm long…..…….……	**5.5.19 *D. prescottianum***

11b	Auricle not distinct; pinnae-stalks less than 3 mm long….....	**5.5.11 *D. malaccense***
12a	Terminal pinna distinct…….……..	13
12b	Terminal pinna not distinct…….……	15
13a	Lateral pinnae 10−15 pairs; terminal pinna subdeltoid, unlike lateral pinnae; lobed at margin..……...	14
13b	Lateral pinnae 3−5 pairs; terminal pinna similar to lateral one, entire at margin……	**5.5.1 *D. bantamense***
14b	Veins anastomosing; pinnae subentire to crenate at margin; gemmae absent……..	**5.5.12 *D. megaphyllum***
14b	Veins free; pinnae serrate at margin; gemmae usually present between rachis and pinnae….	**5.5.21 *D. proliferum***
15a	Veins all free……...	16
15b	Veins anastomosing……..…….	**5.5.8 *D. esculentum***
16a	Pinnae subentire or crenate at margin; auricle present at acroscopic base……....	17
16b	Pinnae lobed at margin; auricle absent……..	18
17a	Veinlets 1−2 pairs; pinnules 2.5−4 cm broad; distinctly auricled at base…….……..	**5.5.5 *D. crenato-serratum***
17b	Veinlets 3−4 pairs; pinnules 1−1.5 cm broad; moderately auricled at base …….....	**5.5.28 *D. sylvaticum***
18a	Pinnae suddenly becoming smaller upwards, stalks up to 2 cm long ……	**5.5.23 *D. siamense***
18b	Pinnae gradually becoming smaller upwards, stalks less than 0.5 cm long……	**5.5.25 *D. sorzogonense***
19a	Lateral pinnae more than 10 pairs; pinnae 2 cm wide; veins all free…….……..	20
19b	Lateral pinnae less than 7 pairs; pinnae more	

	than 3 cm wide; veins anastomosing……..	21
20a	Veinlets 1 pairs, stalks 1−2 mm long…….	**5.5.15 *D. pallidum***
20b	Veinlets more than 1 pairs, stalks more than 3 mm long……..…….	**5.5.26 *D. subintegrum***
21a	Pinnae ovate-lanceolate, long acuminate at apex, obtuse at base; gemmae usually present at junction between rachis and base of pinnae……...……...	**5.5.4 *D. cordifolium***
21b	Pinnae oblong, acuminate at apex, acute at base; gemmae absent……..	22
22a	Fronds less than 40 cm long; pinnae 2−4 pairs…….....	**5.5.22 *D. riparium***
22b	Fronds up to 60 cm long; pinnae 4−7 pairs…….....	**5.5.30 *D. xiphophyllum***
23a	Rhizome creeping ……..	25
23b	Rhizome erect or ascending……	27
24a	Scales with black margin..……..	**5.5.3 *D. conterminum***
24b	Scales with not black margin …….....	25
25a	Sori curved or cresentic usually lie on acroscopic veinlets of vein group……...	26
25b	Sori oblong, usually lie on all veinlets……	**5.5.20 *D. procumbens***
26a	Sori submarginal, 2−3.5 mm long……..	**5.5.17 *D. petrii***
26b	Sori close to costule, 3−5 mm long……..….	**5.5.10 *D. leptophyllum***
27a	Scales with black margin ……..…..……	28
27b	Scales with not black margin …….	33
28a	Sori oblong, usually less than 3 mm long.....	29
28b	Sori linear, usually more than 5 mm long …..	30
28a	Sori close to midrib of lobe…….	**5.5.18 *D. polypodioides***
28b	Sori medial between margin and midrib of	

	lobe…….	**5.5.9 *D. kappanense***
30a	Veins free; pinnules lobed at margin …….	31
30b	Veins anastomosing; pinnules subentire at margin……....	**5.5.8 *D. esculentum***
31a	Pinnule sessile, base subtruncate to truncate……...	32
31b	Pinnules stalked, base minutely cordate…….	**5.5.6 *D. dilatatum***
32a	Pinnules crenate to lobe at margin, apexlong-acuminate……	**5.5.24 *D. simplicivenium***
32b	Pinnules subentire to serrate at margin, apex acute to acuminate……..	**5.5.16. *D. petelotii***
33a	Pinnae and pinnule subopposite to opposite; sori close to costule…….	**5.5.2 *D. bellum***
33b	Pinnae and pinnule alternate; sori not close to costule.....	**5.5.14 *D. muricatum***

5.5.1 *Diplazium bantamense* Blume, Enum. Pl. Javae 2: 191. 1828; Bedd., Handb.: 177. f. 86. 1892; Tagawa & K. Iwats., SouthE. Asian. Stud. 5: 103. 1967; Acta Phytotax. Geobot. 23: 56. 1968; Tagawa & K. Iwats., Fl. Thailand 3(3): 455. 1988; A.G. Piggott., Fern of Malaya in colour: 305. f. 937-939. 1996.—*Athyrium bantamense* (Bl.) Milde, Bot. Zeit. 353. 1870; Holtt., Rev. Fl. Malaya 2: 558. f. 330. 1955.—*Asplenium bantamense* (Blume) Baker, Syn. Fil.: 231. 1867. Type:—INDONESIA. Java, Jawa Barat, Karang, elev. 5000 ft, *J.C. van Hasselt s.n.* [holotype L! (L0051547)]. Figure 5.17, 5.56 A

Plants terrestrial. *Stems* erect or ascending, 1.0−2.5 cm in diameter, covered with scales on younger part; scales, 8−10 × 1.0−1.5 mm, narrowly lanceolate, long-tail at apex, dark brown, margin thick and irregularly toothed. *Leaves* up to 60 cm, imparipinnate; petioles up to 35 cm long, 0.4−0.5 cm in diameter, brown, dark at lower portion, grooved above. *Laminae* 20−25 × 18−25 cm, oblong in outline, glabrous, subcoriaceous, dark green; terminal pinna distinct, like lateral one, gemmae often present at junction between rachis and costa of terminal pinna; lateral pinnae 3−4 pairs, alternate, 10−20 × 4−5 cm, ovate-lanceolate, shortly-stalked, 2−4 mm,

apex acuminate, base round to acute, margin entire or subentire; veins free, simple or once forked, extending to margin. *Sori* more than 1 cm long, elongate along veins, longest on acrocsopic veinlets of vein group, indusiate; indusia thin. *Spores* monolete, 62.5−67.5 × 30−40 μm, bilateral, concavo-convex to plano-convex; ornamentation: prominent wing folds.

Thailand.— SOUTH-WESTERN: Prachuap Khiri Khan (Huaiyang waterfalls); SOUTH-EASTERN: Chanthaburi (Pong Nam Ron); PENINSULAR: Surat Thani (Khao Khieo range), Nakhon Si Thammarat (Khao Luang, Khao Nan), Trang (Khao Chong), Satun (Kao Khao Yai), Songkla (Ton Nga Chang National Park), Yala (Ban Chana, Ban Malao, Banang Sata, Betong), Narathiwat (Hala-bala).

Distribution.— Philippines, Malaysia, Indonesia, Papau New Guinae.

Ecology.— On mountain slopes near streams in dense evergreen forests at 400-1000 m alt.

Specimens Examined.—**THAILAND**. Satul, *A.F.G. Kerr 14535* (BM); Satun, Kao Khao Yai, *Alun 14535* (K); Nakhon Si Thammarat, Khao Luang, *C.F. van Beusekom & C. Phengklai 754* (B); Nakhon Si Thammarat, Khao Luang, *E. Hennipman 3704* (B); ibid., *E. Hennipman 3784* (BM); ibid., *E. Hennipman 3885* (L), Songkla, Ton Nga Chang National Park, *K. Larsen et al. 45770* (QBG); Nakhon Si Thammarat, Khao Luang, *K. Larsen et al. 45868* (QBG); *Unknown, Kerr 14535* (K); Nakhon Si Thammarat, Khao Luang, *M. Tagawa, K. Iwatsuki & N. Fukuoka T5303* (L); Songkhla, Ton Nga Chang Waterfalls, *N. Putthisawong 88* (PSU); Nakhon Si Thammarat, Khao Luang, *P. Pongkai 32* (BCU); ibid., *P. Pongkai33* (BCU); ibid., *P. Pongkai36* (BCU); ibid., *P. Pongkai,39* (BCU); ibid., *P. Pongkai62* (BCU); ibid., *P. Pongkai63* (BCU); ibid., *P. Pongkai124* (BCU); Chanthaburi, Pong Nam Ron, *P. Suksathan 4462* (QBG); Narathiwat, Hala-bala, *T. Boonkerd & R. Pollawatn 293* (BCU); Yala, Betong, *T. BoonKerd 1165* (BCU); Nakhon Si Thammarat, Khao Luang, *T. Boonkerd, Y. Sirijamorn & C. Sanguansab 237* (BCU); ibid., *T. Boonkerd, Y. Sirijamorn & C. Sanguansab 238* (BCU); ibid., *T. Boonkerd, Y. Sirijamorn & C. Sanguansab416* (BCU); ibid., *T. Boonkerd, Y. Sirijamorn & C. Sanguansab451* (BCU); Nakhon Si Thammarat, Khao Nan, *T.B., S.C. & W.K. 140* (BCU); Prachuap Khiri Khan, Huaiyang Waterfalls, *Y. Yuyen 190* (BCU); **MALAYSIA**. Pahang, *A.G. Piggott 2915* (K); Pahang, *B. Molesworth-Allen 2377* (K); Sarawak *C. Hose 227* (K);

Perak, *C.G. Matthew s.n.* (K); Sarawak *C.J. Brooks s.n.* (K); Perak *Dr. King's Collector 5171* ,(K); ibid., *Dr. King's Collector 5171* (K); ibid., *Dr. King's Collector 8388* (K); ibid., *Dr. King's Collector 8388* (K); Selangor, *G.H. Addison 37159* (K); Perak, *H.N. Ridley 14229* (K); Perak, *G.F., Hose.,* (K); Pahang, *I.H. Burkill & R. E. Holltum 1055* (K); Pahang, *N. Wallich s.n.* (K); Sarawak, *P.W. Richards1557* (K); Pahang, *R.E.Holltum 11473* (K); ibid., *R.E. Holltum23344* (K); Perak, *W. Robinson 41* (K); ibid., *W. Robinson s.n.* (K); Pahang, *W.F. Mactier 38* (K); ibid., *W.F. Mactier s.n.* (K); **PHILIPPINES**. Luzon, *A.D.E. Elmer 6222*(K); ibid., *A.D.E. Elmer 9030* (K); Negros Gimogon River, *E.B. Copeland 60* (K); Sulu Archipelago, *F.W. Burbidge s.n.* (K); Mindanao. *R.S. Williams 2510* (K); **INDONESIA**. Java, *A. Ernst 960* (K); Kalimantan, *Burley & J.S. Tukirin 518* (K); Sumatra, *C.G. Matthew s.n.* (K); Java, *D.R. Pleyte 100* (K); ibid., *D.R. Pleyte 101* (K); Sumatra, *E. Gardette 507* (K); ibid., *E. Gardette 508* (K); ibid., *E. Gardette 509* (K); ibid., *E. Gardette 510* (K); Sunda, *E. Schmutz F96* (K); Kalimantan, *F.H. Endert 4214* (K); Sulawesi, *H.A.B. Bünnemeijer11212* (K); Sumatra, *J.A. Lörzing 14730* (K); Java, *M. Raciborski s.n.* (K); Tehoru, *M. Kato, K. Ueda & Z. Fanani C11295* (K); ibid., *M. Kato, K. Ueda & Z. Fanani C14038* (K); Seram Mansuela Nat. Park, *M. Kato, K. Ueda & Z. Fanani C14352* (K); Tehoru, *M. Kato, K. Ueda & Z. Fanani C14419* (K); Seram Mansuela Nat. Park, *M. Kato, K. Ueda & Z. Fanani C1688* (K); ibid., *M. Kato, K. Ueda & Z. Fanani C1689* (K); Java, *N. Wirawan 172* (K); Java, *PE-BO Team s.n.* (PE); Java, *V.F. Schiffner 189* (K); Sumatra, *W. Hancock 34* (K); Sumatra, *Wardi et al. BOHK305* (K); **PAPAU NEW GUINEA**. Morobe, *B.S. Parris & J.P. Croxall 9525* (K); Morobe, *H. Streimann LAE45073* (K); Sogeri, *H. Streimann LAE51613* (K); Morobe, *R.D. Hoogland s.n.* (K); New Ireland, *J.R. Croft 193* (K); ibid., *Croft 1947* (K); ibid., *J.R. Croft 1975* (K); Misima Island, *J.R. Croft 825* (K); ibid., *J.R. Croft LAE686286* (K); Morobe, *M.G. Bamler 30* (K); New Ireland, *M.J.S. Sands, G.A. Pattison & J.J. Wood 2146* (K); Morobe, *O.G. Gideon 31* (K); New Britain, *P.E. Stevens & Y. Lelean LAE58640* (K); Eastern Highlands Mt., *R.J. Johns NGF44642* (K); Madang, *W. Takeuchi 11064* (K).

Note.— This species is very similar to *D. donianum* but differs in having erected rhizome, scales irregularly toothed at margin. Gemmae are usually found at

junction between rachis and costa of terminal pinna. Stalks of lower pinna shorter than *D. donianum*, less than 5 mm long.

5.5.2 *Diplazium bellum* (C.B. Clarke) Bir, Res. Bull. Panjab Univ. Sci. 15: 148. 1964; H. Zhaorong & M. Kato, Fl. China 509. 2013.— *Asplenium bellum* C.B. Clarke, Trans. Linn. Soc. London, Bot. 1(8): 496, pl. 63, f. 2. 1880.—*Allantodia bella* (C.B. Clarke) Ching, Acta Phytotax. Sin. 9(1): 48. 1964.—*Asplenium umbrosum* var. *bellum* (C.B. Clarke) Hosseus, Beih. Bot. Centralbl. 28(3): 364. 1911.— *Athyrium bellum* (C.B. Clarke) Ching, Index Filic., Suppl. 3, 40. 1934.—*Diplazium axillare* Ching, Lingnan Sci. J. 15: 277. 1936. Type:—BHUTAN. Dumsong, 16 Nov. 1875, *C.B. Clarke 26399* [lectotype (designated here) K! (K001089427); isolectotypes K! (K001089428, K001089429)].Figure 5.18, 5.56 B

Plants terrestrial. *Stems* massive, erect, up to 10 cm in diameter, apex densely scaly; scales 10−14 × 0.1−0.2 cm, linear, concolorous, brown, margin entire. *Leaves* bipinnate, 1.3−1.7 m long; petioles 40−50 cm long, 0.8−1.0 cm in diameter, dark brown, scaly. *Laminae* 1.0−1.2 × 0.5−0.6 m, ovatein outline, apex acuminate to cuspidate, base truncate, glabrous, papyraceous, dark green; rachis grooved above, bearing out- growth at junction of stipe and rachis; pinnae 18−20 pairs, opposite, sessile, lower pairs largest, 35−40 × 13−15 cm, oblong, apex long acuminate, base truncate; pinnule 15−17 pairs, subopposite near base of pinnae but alternate near apex, sessile, the 3rd to the 4th pairs from base the largest, 8−10 × 1−2. cm, oblong, apex long acuminate, base truncate, margin deeply lobe; lobe very deep about 4/5 way to midrib, 1.0 × 0.5 cm, oblong, apex round, margin slightly dentate; vein group pinnate, veinlets 5−6 pairs, reach to margin. *Sori* 1.5−2.0 × 1.0 mm, elliptic, on veinlet close to costule, indusiate. *Sori* totally wrapped by indusium; indusia membranous, irregulary dehiscing when mature. *Spores* monolete, bilaterally symmetrical, kidney-shaped, 36.0−41.5 × 28−33.μm; ornamentation: irregular.

Thailand.— NORTHERN:, Chiang Mai (Doi Pha Hom Pok, Doi Inthanon), Chiang Rai (Khunkorn Waterfalls).

Distribution.— Bhutan, Nepal, India, China, Myanmar

Ecology.— On shady slopes near streamlets in evergreen forests at 1,700−2,000 m alt.

Conservation Status:— A small population has been found at one locality. However, it is distributed in many countries of Asia. Thus, it was considered that *D. bellum* should be assigned as “Least Concern (LC)” according to the IUCN criteria (IUCN, 2012).

Specimens Examined.— **THAILAND**. Chiang Rai, Khunkorn Waterfalls, *P. Ratchata 346* (BCU); Chiang Mai, Doi Pha Hom Pok, *P. Pongkai 138* (BCU); Chiang Mai, Doi Inthanon, *E. Hennipman 3434* (L); ibid., *E. Hennipman 3435* (L); ibid., *E. Hennipman 3436* (L); Unknown, *B. Hansen, et al. 10930* (K); **INDIA**. Sikkim, *C.B. Clarke, 9484* (K); ibid., *C.B. Clarke, 26399* (K); *C.R. Fraser-Jenkins 3279* (L); ibid., *C.R. Fraser-Jenkins* 3298 (L).

Note.—This species is a new record for Thailand.

5.5.3 *Diplazium conterminum* Christ, J. Bot 19: 67. 1905; Tard. & C. Chr., Fl. Indo-Chine 7(2): 258. 1940; Tagawa & K. Iwats., SouthE. Asian. Stud. 5: 105. 1967; Tagawa & K. Iwats., Fl. Thailand 3(3): 462. 1988.— *Allantodia conterminal* (Christ) Ching, Acta Phytotax. Sin. 9(1): 47. 1964.— *Diplazium virescens* var. *conterminum* (Christ) Sa. Kurata, Hokuriko J. Bot. 7: 77. 1958.— *Allantodia allantodioides* (Ching) Ching, Acta Phytotax. Sin. 9(1): 47. 1964.— *Diplazium allantodioides* Ching, Bull. Fan Mem. Inst. Biol. 2(10): 203–204, pl. 18, 19. 1931. Type: Vietnam, Annam, vallée du Long-Gianh, *Cadière 88* [Lectotype P! (P02143203)]. Figure 5.19, 5.56 C

Plants terrestrial. *Stems* long creeping, 0.5−1.0 cm in diameter, densely scaly on younger part; scales 10−12 × 1.0−1.2 mm, linear with long tail apex, dark brown to nearly black, margin thick and toothed. *Leaves* about 1 m long, bipinnate, petioles up to 50 cm, 0.5−1.0 cm in diameter, glabrous, brown, dark at lower portion. *Laminae* 47−53 × 38−42 cm, subdeltoid in outline, glabrous, papyraceous, dark green, terminal pinna not distinct; lateral pinnae 6−8 pairs, alternate, 27−30 × 10−15 cm, long stalk, up to 4 cm, gradually narrowing towards acute apex; pinnules 8−10 pairs, alternate, 6−8 × 2.0−2.5 cm, sessile or shortly stalked, oblong, apex acuminate, base cordate or subtruncate, margin crenate to lobed; veins 4−5 pairs, pinnate. *Sori* 1−2 mm long, oblong, usually on middle of each veinlets or submarginal, indusiate; indusia thin but firm. *Spores* monolete, 47.5−57.5 × 32.5−37.0 μm, bilateral, concavo-convex to plano-convex; ornamentation: labyrinth-like folds.

Thailand.— NORTHERN: Chiang Mai (Doi Chiang Dao), Phitsanulok (Phu Hin Rong Kla, Phu Miang); SOUTH-EASTERN: Chanthaburi (Khao Soi Dao); PENINSULAR: Nakhon Si Thammarat (Khao Luang).

Distribution.— China, Japan, and Vietnam.

Ecology.— On mountain slopes in dense forests at 900−1,500 m alt.

Specimens Examined.— **THAILAND**. Chantaburi, Khao Soi Dao, *K. Iwatsuki & N. Fukuoka T7204* (L); Phitsanulok, Phu Hin Rong Kla *P. Pongkai 15* (BCU); Phitsanulok, Phu Hin Rong Kla, Mun Dang Waterfalls, *P. Pongkai 109* (BCU); Phitsanulok, Phu Miang, *T. Shimizu et al. T11603* (BKF, L); **CHINA**. Guizhou, *Anonymous 1791* (PE).

5.5.4 ***Diplazium cordifolium*** Blume, Enum. Pl. Javae 2: 190. 1828; Tagawa & K. Iwats., SouthE. Asian. Stud. 5: 102. 1967; Tagawa & K. Iwat., Fl. Thailand 3(3): 453. 1988; A.G. Piggott., Fern of Malaya in colour: 293. f. 901-905. 1996.—*Diplazium integrifolium* Blume, Enum. Pl. javae.: 190. 1828.— *Anisogonium cordifolium* (Blume) Bedd., Ferns Brit. India.: t. 331. 1870; Handb. Fern Brit. India: 191, f. 92. 1883.—*Athyrium cordifolium* (Blume) Copel., Philipp. J. Sci. 3: 300. 1908; Holtt., Rev. Fl. Malaya 2: 548. 1955. Type: Indonesia, Java, *Blume s.n.* [Holotype K! (K00473100)]. Figure 5.20, 5.56 D

Plants terrestrials. *Stems* erect, 1−2 cm in diameter, apex covered with scales; scales 6−12 × 1−1.5 mm, narrowly lanceolate with long tail apex, dark brown, margin entire. *Leaves* 65−70 cm, usually simple or sometime imparipinnate; petioles up to 40 cm long, 3−5 cm in diameter, deep green when living, stramineous to brown when dried, lower part black, grooved above. *Laminae*, simple laminae, 25−30 × 8−12 cm, cordate or narrowly cordate, apex acuminate, base cordate, margin subentire to undulate, glabrous, coriaceous, dark green; midrib distinctly raised beneath, glabrous; veins branching a few times near midrib and uniting to form irregularly-anastomosing vein near margin; gemmae usually present at base of lamina between stipe and midrib; imparipinnate lamina, 25−30 × 14−20 cm, ovate in outline, terminal pinna present, usually bigger than lateral ones, 12−15 × 4−5 cm, ovate-lanceolate, apex acuminate, base obtuse, margin entire to subentire; lateral pinnae 3−4 pairs, alternate, 10−15 × 3−5 cm, becoming smaller upward, lower pinnae the largest, sessile, bearing gemmae at junction between rachis and costa, ovate-lanceolate, apex acuminate, base

cordate to obtuse, margin subentire, glabrous, coriaceous, dark green; vein anastomosing. *Sori* up to 4 cm long, elongate along anastomosing veinlets, on both side of each veinlets, indusiate; indusia thin but persistent. *Spores* monolete, 47.5−50 × 35−45 µm, bilateral, concavo-convex to plano-convex; ornamentation: prominent wing folds.

Thailand.—PENINSULAR: Chumphon (Lang Suan), Nakhon Si Thammarat (Khao Luang, Khao Nan), Trang (Khao Chong, Khao Pad Pha), Narathiwat (Ban Phu Klong Thong, Waeng), Pattani, Songkhla, Yala (Ban Chana).

Distribution.— Malaysia, Singapore, Indonesia, Australia, Papua New Guinea.

Ecology.—On moist sandy mountain slopes in dense gloomy forests at 800−1,100 alt., locally fairly abundant.

Specimens Examined.— **THAILAND**. Chumphon, Lang Suan, *A.F.G. Kerr 12008* (BK, BM); Trang, *C. Apasutaya 125* (BCU); Nakhon Si Thammarat, Khao Luang, *C. Thorat 135* (BCU); Nakhon Si Thammarat, Khao Luang, *C.F. van Beusekom & C. Phengklai 944* (L, PE); Nakhon Si Thammarat, Khao Luang, *E. Hennipman 3815* (BKF, BM, L); Nakhon Si Thammarat, Khao Luang, *K. Larsen et al. 45926* (L, QBG); Trang, Khao Chong, *M. Tagawa, K. Iwatsuki & N. Fukuoka T4631* (L); Nakhon Si Thammarat, Khao Luang, *M. Tagawa, K. Iwatsuki & N. Fukuoka T4833* (L); Trang, Khao Chong, *M. Tagawa, K. Iwatsuki & N. Fukuoka T6816* (L); Songkhla, Ton Nga Chang waterfalls, *N. Putthisawong 36* (PSU); Nakhorn Si Thammarat, Khao Nan, *P. Pongkai 34* (BCU); ibid., *P. Pongkai 37* (BCU); ibid., *P. Pongkai 42* (BCU); Nakhon Si Thammarat, Khao Luang, *P. Pongkai 60* (BCU); ibid., *P. Pongkai 121* (BCU); Nakhon Si Thammarat, Khao Luang, *P. Suksathan 1067* (QBG); Trang, Khao Pad Pha, *R. Geesink, T. Haltink & C. C. Charaenpol 7286* (L); Nakhon Si Thammarat, Khao Luang, *S. Sutisorn 824* (BK); Narathiwat, Ban Phu Khao Thong, *T. Boonkerd 1516* (BCU); Nakhon Si Thammarat, Khao Luang, *T. Boonkerd s.n.* (BCU); Nakhorn Si Thammarat, Khao Nan, *T. Boonkerd, Y. Sirijamorn & C. Sanguansab 8* (BCU); ibid., *T. Boonkerd, Y. Sirijamorn & C. Sanguansab 240* (BCU); ibid., *T. Boonkerd, Y. Sirijamorn & C. Sanguansab 491* (BCU); **MALAYSIA**. Pahang, *A. G. Piggott 2994* (K); Pahang, *A. G. Piggott 3103* (K); Kinabalu, *B. S. Parris & J. P. Croxal 9131* (K); Sarawak, *B. S. Parris 6470* (K); Sarawak, *B. S. Parris 6629* (K); Perak, *C. G. Matthew s.n.* (K); Penang, *C. G.*

Matthew s.n. (K); Sabah, *G. Stort & P. van Amdjah 359* (K); Perak, *J. Sinclair & Kiah 38745* (K); Sabah, *P. S. Shim San75407* (K); Sabah, *Pearce 3* (K); Unknown, *R. Schlechter 17821* (PE); Penang, *W. Norris 19* (K); Penang, *W. B. Lorrain s.n.* (K); **PHILIPPINES**. Mindoro Subaan River, *Ridsdale, Coode & Reynoso 5585* (K); **INDONESIA**. Seram Manusela National Park, *B. S. Parris 11121* (K); Java, *Blume s.n.* (L); Sulawesi, *E. Hennipman 5195* (K); Kalimantan, *K. Iwatski, M. Kato, G. Murata & Y.P. Mogea B2171* (K); Seram Manusela National Park, *M. Kato, K. Ueda & U.W. Mahjar C1220* (K); Seram Manusela National Park, *M. Kato, K. Ueda & Z. Fanani C11676* (K); Borneo, *R.E. Holttum 25139* (PE); ibid., *R.E. Holttum 25140* (PE); Pahang, *R. E. Holttum 31219* (PE); Jaya, *R.J. Johns 8189* (K); **PAPOU NEW GUINEA**. Morobe, *A. Kairo 26* (K); Torricelli Mts., *F.R.R. Schlechter 14404* (K); Kaiser-Wilhelmsland Ibo Mountains, *F.R.R. Schlechter 17821* (K); Madang, *H. J. Gay & F. J. Parrott 671* (K); Morobe, *J. Manseima 10* (K); Manus Island, *M. J. S. Sands G. A. Pattison & J. J. Wood 2923* (K); Morobe, *T. Nakaike 54* (K); Morobe, *W. Takeuchi 7396* (K); East Sepik Province, *W. Takeuchi et al. 17862* (K).

Note.— This species has two forms of frond, but pinnate frond is rarely found.

5.5.5 ***Diplazium crenato-serratum*** (Blume) T. Moore, Index Fil.: 121. 1859; Tagawa & K. Iwats., SouthE. Asian. Stud. 5: 104.1967; Tagawa & K. Iwats., Acta Phytotax. Geobot. 23: 56. 1968; Tagawa & K. Iwats., Fl. Thailand 3(3): 459. 1988; A.G. Piggott., Fern of Malaya in colour: 308. f. 947-950. 1996.—*Asplenium crenato-serratum* Blume, Enum. Pl. Javae: 177. 1828.—*Athyrium crenato-serratum* (Blume) Milde, Bot. Zeit. 1870: 353; Holtt., Rev. Fl. Malaya 2: 561. f. 332. 1955. Type: Java, *Blume s.n.* [holotype L! (L0051561)]. Figure 5.21, 5.56 E

Plants terrestrial. *Stems* erect, 1.0−1.5cm in diameter, bearing wiry roots, scaly; scales 5−6 × 0.8−1.5 mm, narrowly lanceolate, concolorous, dark brown to black, margin irregularly toothed. *Leaves* 35−53 cm, unipinnate; petioles 15−20 cm, long nearly black, scaly at base. *Laminae* 20−33 × 12−18 cm, usually longer than stipe, subdeltoid in outline, gradually narrowing upwards, apex attenuate, terminal pinna not distinct, widest at base, glabrous, subcoriaceous, dark green; rachis grooved above, minutely hairy, gammae usually confined to apical portion; lateral pinnae 20−25 pairs, alternate, 8−10 × 1.0−1.2 cm, narrowly oblong, subfalcate, apex

acuminate, base truncate, margin dentate to serrate, distinctly auricle at acroscopic bases, sessile or shortly stalked at lower pinnae, 2−3 mm, longest at lower pinnae; veins pinnate with simple veinlets, veinlets 1 pair. *Sori* 5−6 mm long, elongate along veinlets, usually on acroscopic veinlets of vein group, indusiate; indusia linear, thin, firm, persistent. *Spores* monolete, 35−37.5 × 20−22.5 μm, bilateral, concavo-convex to plano-convex; ornamentation: irregular.

Thailand.—SOUTH-WESTERN: Prachuap Khiri Khan (Huaiyang waterfalls); SOUTH-EASTERN: Chanthaburi; PENINSULAR: Surat Thani (Ban Don, Klong Ton), Phangnga (Toong Rha Suung), Krabi (Khao Ngorn Nark), Nakhon Si Thammarat (Khao Luang, Khao Huai Pampun, Khao Nan, Chawang), Patthalung (Tha Mot), Trang (KHAO Chong), Satun, Songkhla (Ton Nga Chang waterfalls), Yala (Kiong Bla Hot, Ban Mae Prik, Betong).

Distribution.— Malaysia, Brunei, Indonesia.

Ecology.—On moist mountain slopes in dense evergreen forests at low to medium elevations, lower than 1,000 m alt.

Specimens Examined.— **THAILAND**. Satun, *A. F. G. Kerr 14444* (BK); ibid.*A.F.G. Kerr 14590* (BK); Nakhorn Si Thammarat, Khao Luang, *C. Apasutaya 113* (BCU); Nakhorn Si Thammarat, Khao Luang, *E. Hennipman 3799* (B); Trang, Khao Chong, *H. Hennipman 3799* (L); ibid., *H. Hennipman 3915* (L); Nakhorn Si Thammarat, Khao Nan, *J. F. Maxwell 84-481* (PSU); Patthalung, Khao Pu Khao Ya, *J.F. Maxwell 86-385* (PSU); Patthalung, Tamote, *J.F. Maxwell 86-745* (PSU); Patthalung, *J.F. Maxwell 86-747* (L); Nakhorn Si Thammarat, Yong Waterfalls, *K. Jamtsho, M. Stankovic & B. Hassama 5* (PSU); Patthalung, Tha Mot, *K. Larsen et al. 459806* (L, QBG); Thailand, Chantaburi, Koh Chang; *K. Larsen & T. Smitinand & E Warncke 1783* (BKF); Nakhorn Si Thammarat, Khao Luang, *M. Tagawa, K. Iwatsuki & N. Fukuoka T4501* (L); ibid., *M. Tagawa, K. Iwatsuki & N. Fukuoka T5271* (L); Songkhla, Ton Nga Chang Waterfalls, *N. Putthisawong 44* (PSU); Nakhorn Si Thammarat, Khao Luang, *P. Pongkai 116* (BCU); Nakhorn Si Thammarat, Khao Nan, *P. Pongkai 26* (BCU); ibid., *P. Pongkai 27* (BCU); ibid., *P. Pongkai 28* (BCU); ibid., *P. Pongkai 29* (BCU); ibid., *P. Pongkai 40* (BCU); ibid., *P. Pongkai 46* (BCU); ibid., *P. Pongkai 61* (BCU); ibid., *P. Pongkai 64* (BCU); Krabi, Khao Ngorn Nark, *P. Pongkai 159* (BCU); Phangnga, Toong Rha Suung, *P. Suksathan 2509* (QBG);

Nakhorn Si Thammarat, Khao Nan, *T. Boonkerd, Y. Sirijamorn & C. Sanguansab 132* (BCU); ibid., *T. Boonkerd, Y. Sirijamorn & C. Sanguansab 140* (BCU); ibid., *T. Boonkerd, Y. Sirijamorn & C. Sanguansab 144* (BCU); Prachuap Khiri Khan, Huaiyang Waterfalls, *Y. Yuyen 175* (BCU); **MALAYSIA**. Malacca, *A. C. Maingay 3025* (K); Selangor, *A. G. Piggott 2181* (K); Pahang, *A. G. Piggott 3005* (K); Perak, *B. Molesworth-Allen 2716* (K); Sabah, *B.S. Parris & J.P. Croxall 8946* (K); Pahang, *B.S. Parris 10375* (K); Penang, *C. Curtis 1000* (K); Penang, *C.G. Matthew s.n.* (K); Selangor, *C.G. Matthew s.n.* (K); Selangor, *D.W. Lee UL40* (K); ibid., *D.W. Lee UL46* (K); Trengganu, *E. A. Turnau 821* (K); Terengganu, *E. J. H. Corner 30395* (K); Negeri Sembilan Bukit Tangga, *E.S. Hose & G. Hose 5037* (K); Sabah, *Forest Department, Sandakan SAN130860* (K); Perak, *G.F. Hose s.n.* (K); Malacca, *H. Cuming 387* (K); Selangor, *I.H. Burkill 11871* (K); Sabah, *J. Clemens & M.S. Clemens 28155* (K); ibid., *J. Clemens & M.S. Clemens 40565* (K); Pahang, *M. Shah 1637* (K); Penang, *N. Wallich 204* (K); Negeri Sembilan Ulu Bendul, *R. E. Holltum 9865* (K); Sarawak, *S. T. Lai S69628* (K); Penang, *T. Lobb s.n.* (K); Penang, *W. Norris s.n.* (K); Penang, *W. F. Mactier s.n.* (K); **PHILIPPINES**. Palawan, *E. D. Merrill 7260* (K); **BRUNEI**. Temburong, *A. D. Poulsen 91*(K); **INDONESIA**. Kalimantan, *A. C. Church, Ismail & A. Ruskandi 2476* (K); Bangka Island, *Anta* (K); Sumatra, *C. G. Matthew s.n.* (K); Sumatra, *C. J. Brooks 2108* (BM); Kalimantan, *C. S. Awmack 252* (K); Sumatra, *E. Gardette 460* (K); Sumatra, *J. Dransfield 3198* (K); Kalimantan, *J.S. Tukirin 3107* (K); ibid., *J.S. Tukirin 3325* (K); ibid., *J.S. Tukirin 3107* (K); ibid., *J.S. Tukirin 3325* (K); Kalimantan, *M. Kato, G. Murata & Y.P. Mogea B3735* (K); Kalimantan, *M. Kato, M. Okamoto & E.B. Walujo B9202* (K); Sumatra, *P.W. Korthals s.n.* (K); Sumatra, *W.H. de Vriese 501*(K).

5.5.6 ***Diplazium dilatatum*** Blume, Enum. Pl. Javae 2: 194. 1828; Holtt., Gard. Bull. Straits Settlem. 11: 85. 1940; Sledge, Bull. Brit. Mus. (Nat. Hist.), Bot. 2: 303. 1962; Tagawa & K. Iwats., SouthE. Asian Stud. 3(3): 87. 1965; 5:106. 1967; Tagawa & K. Iwats., Fl. Thailand 3(3): 464. 1988.— *Asplenium dilatatum* (Blume) Hook., Sp. Fil. 3: 258–259. 1859.— *Athyrium dilatatum* (Blume) Milde, Bot. Zeitung (Berlin)28: 353. 1870.—*Allantodia dilatata* (Blume) Ching, Acta Phytotax. Sin. 9(1): 54. 1964.— *Allantodia crinipes* (Ching) Ching, Acta Phytotax. Sin. 9(1): 53. 1964.—*Diplazium*

crinipes Ching, Bull. Fan Mem. Inst. Biol. 2(10): 207–208, pl. 23–24. 1931.— *Allantodia veitchii* (Christ) Ching, Acta Phytotax. Sin. 9(1): 51. 1964.— *Diplazium veitchii* Christ, Bull. Acad. Int. Géogr. Bot. 16(199–200–201): 123–124. 1906.— *Allantodia yaoshanica* (Ching) Ching & C.H. Wang, Acta Phytotax. Sin.9(1): 51. 1964.— *Diplazium yaoshanicum* Ching, Bull. Fan Mem. Inst. Biol., Bot. 10(3): 176–177. 1940.—*Diplazium latifolium* (D. Don) T. Moore, Index Filic. 141. 1859.— *Asplenium latifolium* D. Don, Prodr. Fl. Nepal. 8. 1825. Type: Java, *Blume s.n.* [holotype K! (K000472211)].Figure 5.22, 5.56 F

Plants terrestrial. *Stems* massive, erect, densely covered with scales at apex; scales about 10−15 × 1−2 mm, linear with long tail apex, brown to dark brown, margin thick and toothed. *Leaves* 1.5−1.7 m long, bipinnate; petioles 50−70 cm long, 1.0−1.5 cm in diameter, darkgreen, black at lower portion, densely scaly at base, grooved above. *Laminae* 1.0 × 0.6−0.7 m, deltoid in out line, terminal pinna not distinct; pinnae 6−10 pairs, alternate, 20−30 × 10−20 cm, stalks distinct, 1.0−1.2 cm long, oblong in outline, apex acuminate, glabrous, papyraceous, green; pinnules 10−12 pairs, alternate, 8−10 × 2.0−2.5 cm, sessile or shortly stalked, oblong, apex acuminate, base subtruncate, truncate to cordate, margin subentire to lobed; lobes ¼ to ½ way to costule; veins all free, veinlets 4−6 pairs simple or once forked. *Sori* 4−5 mm long, elongate along veinlets, usually more than 5 mm long, diplazoid, indusiate; indusia thin, firm, persistant. *Spores* monolete, 40.5−45.0 × 25.0−29.5 µm, bilateral, concavo-convex to plano-convex; ornamentation: prominent wing folds.

Thailand.—NORTHERN: Chiang Mai (Doi Chiang Dao, Doi Khun Huai Pong, Doi Suthep, Kang Kat, Doi Inthanon), Chiang Rai (Doi Pacho, Doi Langka, Mae Kok), Nan (Doi Phu Ka), Tak (Ban Musoe, Mae Sod, Umm Paang), Sukhothai (Ram Kham Heang National Park), Phitsanulok (Thung Salang Luang, Phu Rom Rot), Nakhon Sawan (Doi Musae); NORTH-EASTERN: Phetchabun (Phu Maing, Kaeng Ratchapruk), Loei (Na Haeo, Phu Kradueng, Phu Luang); EASTERN: Nakhon Ratchasima (Sa kaerat); SOUTH-WESTERN: Uthai Thani (Ban Rai), Kanchanaburi (Khao Ngi Yai), Prachuap Khiri Khan (Huaiyang Waterfalls); CENTRAL: Nakhon Nayok (Khao Yai); SOUTH-EASTERN: Prachin Buri (Khao Yai), Chanthaburi (Khao Soi Dao); PENINSULAR: Surat Thani (Khao Khieo range), Phangnga (Khao

Pok), Nakhon Si Thammarat (Khao Luang, Khao Nan), Trang (Khao Chong), Satun, Yala (Muang Wing).

Distribution.— Nepal, India, Myanmar, China, Japan, Taiwan, Laos, Vietnam, Malaysia, Philippines, Indonesia, Australia.

Ecology.—On moist or humus-rich mountain slopes in dense gloomy forests at 400 – 1,500 m alt.

Specimens Examined.— **THAILAND**. Satun, *A. F. G. Kerr 14561* (BK); Nakhon Ratchasima, *A. F. G. Kerr 9928* (BM); Nakhon Ratchasima, *A. F. G. Kerr 9928* (BK); Chiang Mai, Doi Inthanon, *C. Phengklai et al. 7135* (L); Loei, Phu Luang *C. F. van Beusekom & C. Phengklai 3074* (L); Guangdong, *C. G. Matthew s.n.* (K); Nakhon Sawan, Doi Musae, *E. Hennipman 3005* (L); Chiang Mai, Doi Suthep, *E. Hennipman 3132* (L); Chiang Mai, Doi Suthep, *E. Hennipman 3132* (B); Loei, Phu Luang, *E. Hennipman 3590* (L); Prachinburi, Khao Yai, *E. Hennipman 3969* (L); Nakhon Sawan, Doi Musae, *E. Hinnapman 3005* (BM); Chiang Mai, Doi Inthanon, *E. Hinnapman 3006* (BM); Unknown *Hansen & Smitinand 12811* (K) Chiang Mai, Doi Suthep, *J. F. Maxwell 90-282* (L); Chiang Mai, Doi Inthanon, *J. F. Maxwell 93-109* (L); Chiang Mai, Doi Suthep, *J. F. Maxwell 93-747* (L); Sukhothai, Ram Kham Heang National Park, *J. F. Maxwell 95-51* (L); Chiang Rai, Doi Langka, *K. Iwatsuki & N. Fukuoka T3568* (L); Chiang Mai, Doi Suthep, *K. Iwatsuki & N. Fukuoka T3960* (L); Chantaburi, Khao Soi Dao, *K. Iwatsuki & N. Fukuoka T7184* (L); Chiang Rai, along Nam Mae Kok, *K. Iwatsuki, N. Fukuoka, M. Hutoh & D. Chaiglom T10916* (L); Chiang Mai, Doi Suthep, *M. Tagawa T3849* (L); Loei, Phu Luang, *M. Tagawa, K. Iwatsuki & N. Fukuoka T1269* (L); Chiang Mai, Doi Inthanon, *M. Tagawa, K. Iwatsuki & N. Fukuoka T2654* (L); Chiang Mai, Doi Suthep, *M. Tagawa, K. Iwatsuki & N. Fukuoka T31* (L); Trang, Khao Chong, *M. Tagawa, K. Iwatsuki & N. Fukuoka T6832* (L); Tak, Ban Musae, *M. Tagawa, K. Iwatsuki, H. Koyama & A. Chintayungkun T8608* (BKF, L); Nan, Doi Phu Ka, *P. Pongkai 10* (BCU); Phitsanulok, Phu Hin Rong Kla, *P. Pongkai 13* (BCU); ibid., *P. Pongkai 14* (BCU); Loei, Phu Kradueng, *P. Pongkai 24* (BCU); Nakhorn Si Thammarat, Khao Nan, *P. Pongkai 41* (BCU); Nakhorn Si Thammarat, Krung Ching Waterfalls, *P. Pongkai 51* (BCU); Nakhon Si Thammarat, Khao Luang, *P. Pongkai 55* (BCU); ibid., *P. Pongkai 132* (BCU); Nan, Doi Phuka, *P. Pongkai 149* (BCU); Chiang Rai, Khunkorn

waterfalls, *P. Ratchata 288* (BCU); Phitsanulok, Phu Hin Rong kla, *P. Suksathan 1355* (QBG); Chanthaburi, Khao Soi Dao, *P. Suksathan 4423* (QBG); Phitsanulok, Phu Hin Rong kla, *Pteridophyte Trip 85* (BCU); Nakhon Ratchasima, *Put 3579* (BK, BM), Ratchaburi, Suan Phueng, *Suan Phueng Trip 169* (BCU); Mae Sod, *T. Boonkerd 1213* (BCU); Tak, Uum Paang, *T. Boonkerd 1339* (BCU); Nakhon Ratchasima, Sa Kaerat, *T. Boonkerd 533* (BCU); Nakhorn Si Thammarat, Khao Nan, *T. Boonkerd, Y. Sirijamorn & C. Sanguansab 176* (BCU); Petchchabun, Kaeng Ratchapruk, *T. Nachol 44* (BCU); Phetchabun, Phu Miang, *T. Shimizu et al. T11360* (L); Loei, Phu Kradueng, *T. Shimizu et al. T23038* (L); Unknown, *T. Smitinand 6053* (K); Loei, Na Haeo, *W. Nanakorn 8080* (QBG); Phitsanulok, Phu Hin Rong Kla *W. Rattanathirakul 57* (BCU); Prachuap Khiri Khan, Huaiyang Waterfalls, *Y. Yuyen 21* (BCU); **NEPAL**. Unknown, *N. Wallich 203* (K); ibid., *N. Wallich 209* (K); **CHINA**. Guangdong, *C.G. Matthew s.n.* (K); Unknown, *Tsang 534* (K); ibid., *15907* (K); **MALAYSIA**. Pahang, *A.G. Piggott 2977* (K); Pahang, *B. Molesworth-Allen 3325* (K); Sabah *B.S. Parris & J.P. Croxall 8913* (K); Sabah, *J.H. Beaman, R.S. Beaman & T.E. Beaman 10641* (K); Pahang, *M.R. Henderson 23620* (K); Sabah, *P.S. Shim San 74948* (K); Pahang, *R. E. Holttum 31334* (K); Sarawak, *W.L. Chew 1037* (K); **INDONESIA**. Ruteng, *A.J.G.H. Kostermans & Wirawan 666* (K); Jawa, *C.L. Blume s.n.* (K); Kalimantan, *M. Kato, G. Murata & Y.P. Mogea B3738* (K); **PAPUA NEW GUINEA**. Morobe, *B.S. Parris & J.P. Croxall 4448* (K); Northern District, *C.E. Carr 15712* (K); East New Britain, *G. Boyce 18* (K); South New Ireland, *J.R. Croft 1961* (K); Northern District, *R.D. Hoogland 4179* (K).

Note.—According to Holttum (1960), *D. dilalatum* and *D. simplicivenium* are differed in venation and stalk of pinnule.

5.5.7 ***Diplazium donianum*** (Mett.) Tardieu, Aspl. Tokin: 58. t. 5. 1932; Tard. & C. Chr., Fl. Indo-Chine 7(2): 249. 1940; Tagawa & K. Iwats., SouthE. Asian Stud. 5: 102. 1967; Tagawa & K. Iwats., Fl. Thailand 3(3): 455. f. 48. 4. 1988; Devol & Kuo, Fl. Taiwan 1. 436: 1994.— *Asplenium donianum* Mett., Fil. Lechl. 2: 177, n. 198 b. 1859.— *Diplazium aphanoneuron* Ohwi, J. Jap. Bot. 31(5): 137–138. 1956.— *Diplazium donianum* var. *aphanoneuron* (Ohwi) Tagawa, Acta Phytotax. Geobot. 20: 215. 1962. Type: India, Assam, *Griffith 13* (holotype BRU). Figure 5.23, 5.57 A

Plants terrestrial. *Stems* creeping, 3−5 mm in diameter, covered with scales at apex; scales 4−6 × 1 mm, linear, dark brown, margin thick and toothed. *Leaves* 50−60 cm long, imparipinnate; petioles 20−30 cm long, 5−6 mm in diameter, green when living, brown when dried, black at lower portion, grooved above. *Laminae* 30−40 × 20−30 cm, oblong in outline, terminal pinna distinct like lateral one, glabrous, subcoriaceous, green; lateral pinnae 1−3 pairs, alternate, 15−20 × 3.5−5.0 cm, oblong or narrowly-lanceolate, apex acuminate, base acute or obtuse, margin entire or subentire, stalked; stalks 6−10 mm; costa grooved with minute hairs on adaxial surface; veins free, veinlet simple or forked, extending to margin. *Sori* more than 1 cm long, elongate along veins, longest on acroscopic side of veinlets, indusiate; indusia thin, persistent. *Spores* monolete, 55−72.5 × 35−50 μm, bilateral, concavo-convex to plano-convex; ornamentation: prominent wing folds.

Thailand.— NORTHERN: Chiang Mai (Doi Suthep), Nan (Khao Nok), Tak (Doi Musoe), Phitsanulok (Thung Salaeng Luang); NORTH-EASTERN: Loei (Phu Kradueng); EASTERN: Nakhon Ratchasima (Khao Yai); SOUTH-WESTERN: Kanchanaburi (Thong Pha Poom); CENTRAL: Nakhon Nayok (Khao Yai); SOUTH-EASTERN: Prachin Buri (Khao Yai), Chanthaburi, Trat (Koh Chang); PENINSULAR: Nakhon Si Thammarat (Khao Luang, Khao Nan, Ron Phibun, Khiriwong), Satun.

Distribution.— India, Nepal, Bhutan, Myanmar, China, Japan, Taiwan, Vietnam, Malaysia, Singapore.

Ecology.— On mountain slopes in light shade or in dense evergreen forests, at 800-1,250 m alt.

Specimens Examined.— **THAILAND**. Satun, *A. F. G. Kerr 14535* (BK); Unknown, *A.F.G. Kerr 9309* (BM); Kanchanaburi, Thong Pha Phum, *A. Sathapattayanon 41*(BCU); Loei, Phu Kradueng, *E. Hennipman 3683* (L); Nakhon Si Thammarat, Khao Luang, *E. Hennipman 3684* (L); ibid, *E. Hennipman 3698* (L); Nakorn Ratchasima, Khao Yai, *G. Murata, N. Fukuoka C. Phengklai T16254* (L); Unknown, *J. F. Maxwell 01−139* (L); Nakhon Nayok, Khao Yai, *J.F. Maxwell 01−732* (L); Nakorn Ratchasima, Khao Yai, *J.F. Maxwell 74−875* (BK, L); Prachinburi, Khao Yai, *K. Iwatsuki & N. Fukuoka T7392* (L); Prachinburi, Khao Yai, *K. Larsen, T. Smitinand & E. Warncke 313* (L); Phisanulok, Tung Salaeng Luang, *M.*

Tagawa, K. Iwatsuki & N. Fukuoka T2039 (L); Nakhon Si Thammarat, Khao Luang, *M. Tagawa, K. Iwatsuki & N. Fukuoka T4563* (L); ibid, *M. Tagawa, K. Iwatsuki & N. Fukuoka T5269* (L); Nakhon Si Thammarat, Khao Luang, *M. Tagawa, K. Iwatsuki, H. Koyama & A. Chintayungkun T14641* (L); Kanchanaburi, Thong Pha Phum, *P. Pongkai 150* (BCU); ibid, *P. Pongkai 152* (BCU), Chiang Mai, Doi Inthanon, *P. Srisanga & P. Suksathan 3246* (QBG); Nakhon Nayok, Khao Yai, *S. Chongko 9* (L); Nakhon Nayok, Khao Yai, *S. Chongko 9* (BKF); Unknown, *Sangkachun 749* (K); Unknown, *T. Smitinand 5908* (K); Nan, Khao Nok, *W. La−ongsri et al. 1993* (QBG); **CHINA**. Hong Kong, *Alexander s.n* (K); Guangdong, *C.G. Matthew s.n.* (K); Unknown, *D.E. Boufford & B. Bartholomew 24963* (BM); Unknown, *W.T. Tsang 22367* (BM); **TAIWAN**. *T. Tanaka 367* (BM); **JAPAN**. *K. Iwatsuki 3023* (BM); *M. Ogata 133* (BM); *M. Tagawa 2733* (BM). **VIETNAM**. *W. T. Tsang 29527* (K); **MALAYSIA**. Pahang, *B. Molesworth−Allen 4170* (K); **SINGAPORE**. *T. Lobb 33* (K).

Note.—This species is similar to *D. bantamense* in the fields, but they can be separated by having creeping rhizome, lacking gemmae and having stalk more than 5 mm long.

5.5.8 ***Diplazium esculentum*** (Retz.) Sw., Schrad. J. Bot. 1801(2): 312. 1803; Tard & C. Chr., Fl. Indo-Chine. 7(2): 269. 1940; Tagawa & K. Iwats., SouthE. Asian Stud. 3(3): 88. 1965; 5. 106. 1967; Tagawa & K. Iwats., Fl. Thailand 3(3): 466. 1988; K. Iwatsuki, Ferns and Fern Allies of Japan: 257. Pl. 176-1, 2. 1992; Devol & Kuo, Fl. Taiwan 1. 1994; A.G. Piggott., Fern of Malaya in colour: 303. f. 932-936. 1996.— *Hemionitis esculenta* Retz., Observ. Bot. 6: 38. 1791.—*Anisogonium esculentum* (Retz.) C. Presl, Tent. Pterid. 116. 1836.— *Asplenium esculentum* (Retz.) C. Presl, Reliq. Haenk. 1(1): 45. 1825.— *Athyrium esculentum* (Retz.) Copel., Philipp. J. Sci. 3(5): 295. 1908.— *Callipteris esculenta* (Retz.) J. Sm. ex T. Moore & Houlston, Gard. Mag. Bot. 3: 265. 1851.— *Microstegia esculenta* (Retz.) C. Presl, Abh. Königl. Böhm. Ges. Wiss., ser. 5. 6: 451. 1851— *Athyrium ambigua* (Sw.) Milde, Bot. Zeitung (Berlin) 28: 353. 1870. *Microstegia ambigua* (Sw.) C. Presl, Abh. Königl. Böhm. Ges. Wiss., ser. 5. 6: 451. 1851.—*Asplenium ambiguum* Sw., J. Bot. 1800(2): 54. 1801.— *Digrammaria ambigua* Hook., Gen. Fil. pl. 56 C. 1840.— *Anisogonium serampurens* C. Presl, Tent. Pterid. 116. 1836. *Callipteris serampurens* Fée, Gen. 219.

1850.— *Diplazium serampurens* Spreng., Nova Acta 10: 231, pl. 17, f. 1–2. 1821.— *Diplazium malabaricum* Spreng., Nova Acta 10: 231, pl. 17. f. 1. 1821.— *Asplenium malabaricum* Mett., Fil. Lechl. 74. 1856.— *Callipteris malabarica* J. Sm., J. Bot. (Hooker) 3: 409. 1841.— *Microstegia pubescens* C.Presl, Epimel. Bot. 260. 1851.— *Asplenium moritzii* Mett., Fil. Lechl. 130, t.11, f.4. 1856.— *Asplenium vitiense* Baker, Syn. Fil.245. 1867. *Diplazium pubescens* Link, Hort. Berol. 2: 72. 1833.— *Diplazium vitiense* Carruth., Fl. Vit. 357. 1873.— *Gymnogramma edulis* Ces., Atti Accad. Sci. Fis. 7(8): 28. 1876. Type: India, *J. G., Königs.n.* [Holotype LD, photo seen! (LD1122195); fragment K! (K001089389)]. Figure 5.24, 5.57 B

Plants terrestrial. *Stems* erect, up to 6 cm in diameter, covered with scales at apex; scales 12−15 × 1.0−1.2 mm, linear with long-tail apex, brown, margin thick and toothed. *Leaves* up to 1.30 m long, bipinnate; petioles 50−70 cm long, 0.5−1.0 cm in diameter, dark green, glabrous or pubescent, dark brown and scaly at lower portion. *Laminae* 1−2 pinnate, variable in size, full-grown often more than 60 cm long, ovate-deltoid in outline; pinnae 6−8 pairs, alternate, about 35−40 × 25−30 cm, stalks about 8 cm long, longest at lower pinnae, oblong in outline, rather suddenly narrowing towards acute apex, glabrous, papyraceous, light green; pinnules 9−12pairs, alternate, 8−10 × 1.5−2.0 cm, sessile, oblong, apex acuminate, base truncate or subtruncate; margin subentire to lobed; lobe about ¼ way to costule, apex round, margin serrulate; vein anastomosing, pinnate, veinlets of pinnate groups in each lobe up to 10 pairs, lower 2−3 pairs of adjacent groups anastomosing, forming an irregular intermediate excurrent veins leading towards a sinus between adjacent lobes. *Sori* elongate nearly the whole length of veinlets, often uniting with the opposite ones, indusiate; indusia elongate, thin, persistent. *Spores* monolete, 35−42.5 × 20−25 μm, bilateral, concavo-convex to plano-convex; ornamentation: pustulate.

Thailand.— NORTHERN: Mae Hong Son (Mae La Noi, Mae Su Rin), Chiang Mai (Ban Mae Kon, Doi Chiang Dao, Fang, Mae Klang, Hang Dong, Kang Kat, Sop Aep), Chiang Rai (Khunkorn Waterfalls, Mae Kok), Nan, (Huai Sand village), Lamphun (Mae Tha), Lampang (Jae Sawn), Phrae, Tak, Phitsanulok (Phu Hin Rong kla); NORTH-EASTERN: Loei (Nong Hin); EASTERN: Chiyaphum (Nam Phrom, Phu Kheaw); SOUTH-WESTERN: Kanchanaburi (Kroeng Kawia, Phomphi, Sai Yok, Takean Thong Waterfalls), Prachuap Khiri Khan (Huaiyang Waterfalls); CENTRAL:

Saraburi (Muak Lek), Nakhon Nayok (Khao Yai), Krung Thep Maha Nakhon (Bangkok); SOUTH-EASTERN: Prachin Buri, Rayong (Ban Khai), Chon Buri (Si Racha, Khao kiew); PENINSULAR: Surat Thani (Khao Pok, Ban Don), Satun (Ban Dan), Yala (Ban Beujaw), Narathiwat (Waeng).

Distribution.—Tropics of Asia (type from India), China, Japan, Philippines, Malaysia, Papua New Guinea, Indonesia, Brunei, Singapore.

Ecology.—Usually on moist ground in paddy fields or along stream banks in open places or at least in light shade at 250-1,200 m alt.

Specimens Examined.— **THAILAND**. Unknown, *A. Marcan 761* (BM); ibid., *A. Marcan 765* (BM); Mae Hong Son, *A.F.G. Kerr 5458* (BK, BM); Chon Buri, *C. Chermsirivathana & Pragad 1980* (BK); Kanchanaburi, *C.F. van Beusekom & C. Phengklai 97* (B); Mae Hong Son, Mae La Noi, *E. Hennipman 3481* (L); ibid., *E. Hennipman 3481* (BM); ibid., *E. Hennipman 3481* (B); Prachinburi, Khao Yai, *E. Hennipman 3960* (L); Satul, Ban Dan, *E. Smith 2635* (BM); Samut Prakarn, *J.F. Maxwell 70-24* (BK); Bangkok, *J.F. Maxwell 71-751* (BK); ibid., *J.F. Maxwell 71-752* (BK); Chonburi, Khao kiew, *J.F. Maxwell 74-1096* (BK); ibid., *J.F. Maxwell 74-1097* (L); Chon Buri, *J.F. Maxwell 74-1097* (BK); Yala Ban Beujaw, *J.F. Maxwell 86-867* (L, PSU); Chiang Mai, *J.F. Maxwell 90-117* (L); Chiang Mai, Chiang Dao, *J.F. Maxwell 92-804* (L); Chanthaburi, *J.F. Maxwell s.n.* (BK); Rayong, *K. Kertsawank 367* (QBG); Narathiwat, Sungei Kolok, *K. Larsen & S. Larsen 32875* (BKF, L); Nan, Huai Sand village, *K. Sridith 377* (QBG); Lampang, Jae Sawn, *L.M. Banoc 16* (L); Chaiyaphum, Nong Bua Daeng, *M. Norsaengsri 5422* (QBG); Lamphun, Mae Tha, *N. Rom Kham 275* (QBG); Prachuap Khiri Khan, *O. Neamsuvan 103* (BCU); Lampang, Doi Luang, *O. Petrmitr 369* (L); Nanhon Si Thammarat, Khao Nan, *O. Ratana 25* (BCU); Phitsanulok, Phu Hin Rong kla, *P. Pongkai 110* (BCU); Kanchanaburi, Takean Thong Waterfalls, *P. Pongkai 84* (BCU); ibid., *P. Pongkai 85* (BCU); ibid., *P. Pongkai 86* (BCU); Chiang Rai, Khunkorn Waterfalls, *P. Ratchata 202* (BCU); ibid., *P. Ratchata 208* (BCU); Phitsanulok, *Pragad 563* (BK); Nakhon Nayok, Khao Yai, *S. Chongko 119* (L); Chaiyaphum, Phu Kheaw, *S. Simpa 21* (BCU); ibid., *S. Simpa 45* (BCU); Chiang Mai, Hang Dong, *T. Boonkerd 17* (BCU); Loei, Nong Hin, *T. Boonkerd 2011-10* (BCU); Kanjanaburi Si York, *T. Vongthavone 128* (BK); Nanhon Si Thammarat, *U. Damsri 43* (BCU); Phrae, *W. Somprasing 289*

(BK); Prachuap Khiri Khan, Huaiyang waterfalls, *Y. Yuyen 191* (BCU); **INDIA**. *J. G. König s.n.* (K); **CHINA**. Unknown, *C.G. Matthew s.n.* (K); Hainan, *F.A. Mcclure 7730* (K); Kwangtung, *F.A. Mcclure 13188* (K); Hongkong, *H. H. Edie s.n.* (K); Yunnan, *J. Cavalerie 7261* (K); ibid., *J. Cavalerie 8109* (K); Kwangtung, *K.J. Stward et al. 143* (K); Yunnan, *Li Bao-gui 45074* (QBG); Hongkong, *Shiu Ying Hu 6105* (K); ibid., *Shiu Ying Hu 11884* (K); Unknown, *T. Sampson s.n.* (K); **JAPAN**. Taito, *M. tagawa 2544* (K); **MALAYSIA**. Sabah, *A. Hoare & E. Marong 75* (K); Danum Valley, *A. Karolus 15* (K); Unknown, *B. Allen 1350* (K); Unknown, *B. Scortechini s.n.* (K); Unknown, *B.S. Parris & P.J. Edwards 10474* (K); Unknown, *B.S. Parris 7075* (K); Perak, *Dr. King's Collector 414* (K); Unknown, *E.S. Hose & G. Hose 165* (K); Unknown, *G.H. Spare 36050* (K); Sabah, *G.H.S. Wood 2050* (K); Unknown, *H. Christensen & F. Apu 36C* (K); Sarawak, *H. Christensen 1141* (K); Unknown, *H.N. Ridley 7863* (K); ibid., *H.N. Ridley 14759* (K); Unknown, *H.N. Ridley s.n.* (K); Unknown, *H.P. Fuchs 21223* (K); Sarawak, *J. Clemens & M. S. Clemens 21417* (K); ibid., *J. Clemens & M.S. Clemens 21464* (K); Sarawak, *J. Sinclair SFN38397* (K); Unknown, *M. Giking 10* (K); Unknown, *O. Beccari s.n.* (K); Unknown, *P.J. Edwards 2029* (K); ibid, *P.W. Richards 2627* (K); Unknown, *A.G. Piggott, 2354* (K); Kelantan Kuala Aring, *R.H. Yapp 173* (K); Perak, *W. Robinson 27* (K); **PHILIPPINES**. Unknown, *A. Loher 1236* (K); Unknown, *A.D.E. Elmer 6682* (K); ibid., *A.D.E. Elmer 10115* (K); Basilan Menzi, *A.G. Piggott 2268* (K); Luzon, *E. Quisumbing M195* (K); ibid., *E. Quisumbing M210* (K); Unknown, *E. B. Copeland 604* (K); Unknown, *E.D. Merrill 2542* (K); Luzon, *E.D. Merrill 593* (K); ibid., *E.D. Merrill 2552* (K); Unknown, *H. Cuming 35* (K); ibid., *H. Cuming 167* (K); Mindanao, *H.N. Moseley s.n.* (K); Luzon, *M. Vanoverbergh 1676b* (K); Mindanao, *R. S. Williams 2821* (K); Luzon, *S. Vidal y Soler 18348* (K). **BRUNEI**; Temburong, *A. D. Poulsen 144* (K). **INDONESIA**; Unknown, *A. Ernst 433* (K); ibid., *A. Ernst 930* (K); Java, *Berlanger s.n.* (K); Unknown, *C. Millett s.n.* (K); Unknown, *C.L. Blume s.n.* (K); Unknown, *Docters van Leeuwen 11062* (K); Unknown, *E. de la Savinierre 69* (K); Sumatra, *E. Gardette 388* (K); Sulawesi, *E. Hennipman 5955* (K); Unknown, *E. Smith 2637* (K); Unknown, *F. Newton s.n.* (K); Unknown, *F.H. Endert 3325* (K); Unknown, *G.J. de Joncheere 1062* (K); Unknown, *Heunaka 1321* (K); Unknown, *J.A. Lörzing 12735* (K); Unknown, *J.P. Mousset 48* (K); Sulawesi, *J.S. Tukirin 3544* (K); Java, *M.*

Raciborski s.n. (K); Sulawesi, *M. J. S. Sands 493* (K); Unknown, *P.J. Eyma 3253* (K); Borneo, *P.W. Korthals s.n.* (K); Java, *R. C. Bakhuizen van den Brink 5508* (K); Unknown, *R. J. Johns & C. Cook 9303* (K); Unknown, *T.W. Main 1363* (K); Unknown, *W.H. de Vriese 272* (K); Unknown, *W. J. Lütjeharms 5383* (K); Sumatra, *Y. Aumeeruddy 373* (K); **SINGAPORE**. *H.J. Murton 147* (K); **PAPUA NEW GUINEA**. Unknown, *A. Floyd 5664*(K); Western Highlands, *B.S. Parris & J.P. Croxall 4449* (K); Kanosia, *C.E. Carr 11490* (K); Unknown, *F.R.R. Schlechter 14209* (K); ibid., *F.R.R. Schlechter 17313* (K); Unknown, *H. Streimann & A. Kairo NGF44433* (K); Morobe, *J.R. Croft 667* (K); Unknown, *L.J. Brass 28694* (K); New Ireland Ugana, *S. Peckel 35* (K); Guni Guni, *W. Fitzgerald 1* (K); Morobe, *W. Takeuchi & A. Towati 15251* (K).

Note.—Young fronds locally consumed as vegetable.

5.5.9 ***Diplazium kappanense*** Hayata, Icon. Pl. Formosan.8: 143, f. 69, f. 70. 1919, Zhangren, W., Zhaorong, H. and Kato, M., Fl. China. 531. 2013.— *Allantodia kappanensis*(Hayata) Ching, Acta Phytotax. Sin. 9(1): 56. 1964.— *Diplazium taiwanense*Tagawa, Acta Phytotax. Geobot. 5(4): 259. 1936.— *Diplazium virescens*var.*taiwanense* (Tagawa) Sa. Kurata, Enum. Jap. Pterid. 340. 1961.— *Allantodia taiwanensis* (Tagawa) Ching, Acta Phytotax. Sin. 9(1): 53. 1964. Type: Taiwan, Kappanzan, *U. Faurie s.n.* Figure 5.25, 5.57 C

Plants terrestrial, *Stems* ascending, 2.0−2.5 cm in diameter, covered with scales at apex; scales 7−10 × 0.5−0.6 mm, linear with long tail apex, dark brown to nearly black, margin thick and toothed. *Leaves* up to 1.10 m long, bipinnate; petioles 40−50 cm, 5−6 cm in diameter, deep green, densely scaly and dark at lower part. *Laminae* 50−60 × 40−50 cm, bipinnate, subdeltoid to ovate-deltoid in outline, suddenly narrowing upwards, glabrous, papyraceous, light green; pinnae 8−10 pairs, alternate, 25−30 × 15−20 cm, oblong in outline, apex gradually narrowing towards forming long acuminate apex, stalked; stalks 3−4 cm; pinnule 10−12 pairs, alternate, 8−10 × 1.5−2.0 cm, oblong, apex long acuminate, base obtuse to subtruncate; margin lobed; lobes 1/3 way to costule, apex round, margin dentate; stalked; stalks 2−3 cm; veins pinnate, 5−6 pairs, veinlets free, forked. *Sori* 2−4 mm long, elongate along veinlets, oblong, halfway between midrib and margin of lobe, indusiate; indusial

linear, thin, persistent. *Spores* monolete, 32.5−35 × 17.5−22.5 μm, bilateral, concavo-convex to plano-convex; ornamentation: prominent wing folds.

Thailand.— NORTH-EASTERN: Loei (Phu Kradueng); SOUTH-WESTERN: *Prachuap Khiri Khan* (Khao luang); CENTRAL: Nakhon Nayok (Khao Yai).

Distribution.— China, Japan, Taiwan, Veitnam.

Ecology.— On moist ground along stream banks in light shade at about 800 m alt.

Specimens Examined.— **THAIALND**. Nakhon Nayok, Khao Yai, *D.J. Middleton et al. 3772* (BKF); Loei, Phu Kradueng, *P. Jadprajong 191* (BCU); Prachub Kirikhan, *P. Pongkai 160* (BCU); ibid., *P. Pongkai 161* (BCU); **JAPAN**. Kyushu, *M. Tagawa 8130* (BM, PE); **TAIWAN**. Tai Bei City, *R. Knapp P198* (ATIF).

Note.— According to the Flora of China, *D. taiwanense* Tagawa was treated as synonym of *D. kappanense* Hayata.

5.5.10 *Diplazium leptophyllum* Christ, Index Filic., Suppl. 2. 1: 103. 1916, based on *Asplenium leptophyllum* Baker, Kew Bull. 1906: 10; Tagawa & K. Iwats., SouthE. Asian Stud. 5: 105. 1967; Tagawa & K. Iwats., Fl. Thailand 3(3): 463. 1988.— *Allantodia leptophylla* (Christ) Ching, Acta Phytotax. Sin. 9(1): 56. 1964.— *Asplenium leptophyllum* Baker, Bull. Misc. Inform. Kew 1906(1): 10. 1906. Type: China, Yunnan, Szemao, *A. Henry 13106* [Holotype P! (P01564505); Isotype K! (K00189421)].Figure 5.26, 5.57 D

Plants terrestrial. *Stems* short creeping, 1.0−1.5 cm in diameter, scaly; scales 10−12 × 1.0−1.5 mm, linear, concolorous, dark brown to nearly black, margin entire. Leaves up to 1.20 m, bipinnate to bipinnate-tripinnatifid; petioles 30−50 cm long, glabrous, dark green, dark at lower portion, groove above. *Laminae* 60−70 × 50−60 cm, subdeltoid in outline, terminal pinna not distinct, glabrous, papyraceous, light green; pinnae 6−8 pairs, alternate, 25−30 ×12−15 cm, oblong in outline, apex acuminate, stalked; stalks 1.5−2.0 cm; pinnule 12−14 pairs, alternate, 5−6 × 2.5−3.0 cm, subdeltoid, apex acuminate, base subtruncate to truncate; lobed at margin; lobes ¾ way to costule, apex round, margin serrate, shortly stalked; veins pinnate, veinlets 4−5 pairs, free, simple or once forked. *Sori* 3−5 mm long, elongate along veinlets,

diplazoid, usually on basal veinlets of vein group. Spores monolete, 30.0−37.5 × 17.5−20.0 μm, bilateral, concavo-convex to plano-convex; ornamentation: echinate.

Thailand.—NORTHERN: Chiang Mai (Doi Chiang Dao, Doi Suthep, Mae Jam), Chiang Rai (Mae Lao), Lamphun (Doi Khun Tan).

Distribution.— India, Bhutan, Myanmar, China.

Ecology.—On moist ground or on mountain slopes in dense mixed or evergreen forests at 850 – 1,600 m alt.

Specimens Examined.—**THAILAND**. Chiang Mai, Doi Suthep, *J. F. Maxwell 89-855* (L); Lampoon, Doi Khun Dan, *J.F. Maxwell 93-771* (L); Chiang Mai, Mae Jam, *J.F. Maxwell 98-1444* (L); Chiang Mai, Chiang Dao, *M. Shimizu & M. Hutoh T4396* (L); ibid., *M. Shimizu & M. Hutoh T10210* (L); ibid., *M. Shimizu & M. Hutoh T10210* (BKF); Chiang Mai, Chiang Dao, *M. Tagawa & K. Iwatsuki T4396* (BKF); Lamphun, Doi Khun Tan, *M. Tagawa T9324* (L); Chiang Mai, Chiang Dao, *P. Pongkai 78* (BCU); ibid., *P. Pongkai 79* (BCU); ibid., *P. Pongkai 80* (BCU); Chiang Mai, Doi Suthep, *S. Premwichit 5* (L); **INDIA**. *Manickam RHT34384* (K); *Manickam 31083* (K); *Manickam 582* (K); **CHINA**. Yunnan, *A. Henry 13106* (B, K).

5.5.11 ***Diplazium malaccense*** C. Presl, Abh. Königl. Böhm. Ges. Wiss., ser. 5. 6: 446. 1851, Tard. & C. Chr., Fl. Indo-Chine 7(2): 258. 1940; Tagawa & K. Iwats., SouthE. Asian. Stud. 5: 104. 1967; Acta Phytotax. Geobot. 23: 1968; Tagawa & K. Iwats., Fl. Thailand 3(3): 458. 1988; A.G. Piggott., Fern of Malaya in colour: 297, f. 916-918. 1996.— *Athyrium malaccense* (C. Presl) Holttum, Rev. Fl. Malaya 2: 552. 1995. Type: Malaysia, Malacca, *Cuming 389* [Holotype PRC (PRC450315); Isotypes E (E00782179); K! (K00044337, K000539990, K000539991); MO! (MO1876167)]. Figure 5.27, 5.57 E

Plants terrestrial. *Stems* erect, 3−5 cm in diameter, scaly; scales 10−12 × 1.0−1.5 mm, linear, concolorous, light brown, margin entire. *Leaves* 70−90 cm long, pinnate, unipinnate-bipinnatifid; petioles 25−30 cm long, 5−7 mm in diameter, densly scaly at base, dark brown at base. *Laminae* 55−60 × 20−25 cm, terminal pinna not distinct, oblong in outline, apex long acuminate, glabrous, papyraceous, deep green; lateral pinnae 20−30 pairs, alternate, 12−15 × 2.0−2.5 cm, gradually becoming smaller upwards, oblong, apex long acuminate, base subtruncate; lobed at margin;

lobes 2/3 way to midrib of pinnae, about 5 mm wide, apex round or obtuse, margin subentire, stalked; stalks 1−2 mm long; veins pinnate, 4−5 pairs, free. *Sori* 2−3 mm long, narrowly-oblong, indusiate; indusia linear, persistent. *Spores* monolete, 32.5−35.0 × 20.0−22.5 μm, bilateral, concavo-convex to plano-convex; ornamentation: prominent wing folds.

Thailand.— PENINSULAR: Ranong (Khao Por Ta Luang Kaew), Surat Thani (Ban Don), Nakhon Si Thammarat (Khao Luang), Trang (Khao Chong, Phu Pha Mek), Songkhla (Ton Nga Chang), Yala (Ban Mae Prik).

Distribution.— Indochina to Indonesia.

Ecology.— On mountain slopes in dense evergreen forests at 650-1,250 m alt.

Specimens Examined.—**THAILAND**. Songkhla, Ton Nga Chang, *C. Kraithep 24* (PSU); Trung, Phu Pha Mek, *D.J. Middleton et al. 2029* (BKF); Nakhon Si Thammarat, Khao Luang, *P. Pongkai 122* (BCU); Ranong, Khao Por Ta Luang Kaew, *T. Boonkerd 1473* (BCU); **INDONESIA**. Unknown, *A. J. G. H. Kostermans 6099* (K); Sulawesi, *E. Hennipman 5744* (K); Sumatra, *E. Gardette 306* (K); ibid., *E. Gardette 461* (K); Kalimantan, *J.S. Burley & Tukirin 3255* (K); Kalimantan, *K. Iwatsuki, G. Murata, Jdransfield & Saerudin B2472* (K); Sumatra, *K. Iwatsuki, G. Murata, Jdransfield & Saerudin S845* (K); Unknown, *K. Ueda & D. Darnaedy B8982* (K); Kalimantan, *Kato, M.; Murata, G.; Mogea, Y.P.* (K). **MALAYSIA**. Selangor, *A.A. Samut 148* (K); Malacca, *A.C. Maingay 3233* (K), Johore Mt. *A.G. Piggott 1773* (K); Negri Sembilan Gunong Telepak Burok, *A.G. Piggott 1912* (K); Pahang, *A.G. Piggott 2495* (K); Sabah, *B.S. Parris 11365,* (K); Negri Sembilan Pasoh Forest Reserve, *B.S. Parris & P.J. Edwards 10560* (K); Pahang, *B.S. Parris 10599,* (K); ibid., *B.S. Parris 10960* (K); Sabah, *B.S. Parris 11327* (K); Sarawak, *B.S. Parris 6510* (K); Penang, *C. Curtis 999* (K); Penang, *C. Gaudichaud-Beaupré 13* (K); Perak, *C.G. Matthew s.n.* (K); Negri Sembilan Bukit Putis, *E.S. Hose & G. Hose 174* (K); Negri Sembilan Gunong Angsi, *E.S. Hose & G. Hose 4811* (K); Sarawak, *G.F. Hose 330* (K); Perak, *G.F.Hose s.n.* (K); Malacca, *H. Cuming 389* (K); ibid., *H. Cuming 390* (K); Perak, *H.C. Robinson s.n.* (K); Perak, *J. Sinclair SFN38674* (K); Langkawi, *Jaman, R.; Hamid s.n.* (K); Pahang, *K. M. Kochummen 85251* (K); Perak, *L. Wray 1199* (K); Selangor, *L. W. Lee UL38* (K); Negri Sembilan Gunong Angsi, *M. Nur 11563,* (K); Negri Sembilan Ulu Rembau, *M. Nur s.n.* (K); Selangor, *M.E.D. Poore*

138 (K); Penang, *N. Wallich 205* (K); ibid., *N. Wallich s.n.* (K); Perak, *N. H. Ridley 7271* (K); Pahang, *Native Collector 5818,* (K); Penang *R. E. Holttum SFN 31196* (K); Malacca, *R. E. Holttum 9685* (K); Penang, *W. Norris s.n.* (K); Johore Mt. *Wight 161* (K). **SINGAPORE**. Reservoir woods, *N. H. Ridley 12562* (K).

5.5.12 ***Diplazium megaphyllum*** (Baker) Christ, Bull. Herb. Boissier. 6(12): 961. 1898; Tard. & C. Chr. Fl. Indo-Chine 7(2): 251. 1940; Tagawa & K. Iwats., Acta Phytotax. Geobot. 24: 63. 1969; Tagawa & K. Iwats., Fl. Thailand 3(3): 456. 1988.— *Asplenium megaphyllum* Baker, J. Bot. 28(9): 264. 1890.— *Allantodia megaphylla* (Baker) Ching, Acta Phytotax. Sin. 9(1): 50. 1964.— *Diplazium macrophyllum* Ching, Sinensia 1(1): 6–7. 1929.— *Diplazium megaphyllum* var. *subintegrifolium* Tardieu, Asplen. Tonkin 61. 1932. Type: Vietnam, Tonkin, *Balansa 1836* [Lectotype P! (P00642890); Isolectotypes P! (P00642891); K! (K001089145, K001089146); BM! (BM001045380)]. Figure 5.28, 5.57 F

Plants terrestrial, *Stems* erect, 3−4 cm in diameter, covered with scales at apex; scales 10−12 × 1.0−1.5 mm, lanceolate with long tail apex, dark brown, margin thick and toothed. *Leaves* up to 1.30 m long, imparipinnate; petioles 50−60 cm long, 5−8 cm in diameter, deep green, scaly and dark at base. *Laminae* 60−70 × 40−50 cm, oblong in outline, apex acuminate, terminal pinna distinct, glabrous, papyraceous, deep green; terminal pinna, narrowly-deltoid, apex acuminate, base subtruncate, margin lobed; lateral pinnae 10−12 pairs, alternate, suddenly becoming smaller upward, 15−20 × 4.0−4.5 cm, oblong, apex acuminate, base subtruncate, margin subentire to crenate, sessile or shortly stalked; stalks 3−4 mm, longest at lower pinnae; veins pinnate, free, veinlets 5−6 pairs. *Sori* 4−5 mm long, elongate along veinlets, on all veinlets, diplazoid, indusiate; indusia linear, thin, persistent. *Spores* monolete, 52.5−60.0 × 20.0−22.5 μm, bilateral, concavo-convex to plano-convex; ornamentation: prominent wing folds.

Thailand.— NORTHERN: Chiang Mai (Doi Chiang Dao), Tak (Doi Musoe); EASTERN: Chiyaphum.

Distribution.— Myanmar, China, Taiwan, Vietnam.

Ecology.— Along streamlet banks in moist evergreen forests at about 800 m alt.

Specimens Examined.— **THAILAND**. Chiyaphum, *C.F. van Beusekom et al. 4407* (B); Tak, Doi Musoe, *E. Hennipman 3064* (B, BM, K. L); ibid., *E. Hennipman 3065* (BKF); **CHINA**. Guizhou, *Z. Xianchun, G. Zhiyou & X. Q. Ping 7167* (PE); **TAIWAN**. Nantou, *C.T. Choi 11785* (PE); ibid.,*C.T. Choi 12798* (PE); Nantou, *Lu Bifeng 17764-2* (PE); Kwarenko, *M. Tagawa 3537* (BM); **VIETNAM**. Tonkin, *B. Balansa 1836* (K); Ninh Binh, *H. van der Werff et al. 14220* (PE).

5.5.13 ***Diplazium mettenianum*** (Miq.) C. Chr., Index Filic.4: 236. 1905; Tard. & C. Chr., Fl. Indo-Chine. 7(2): 253. 1940; Tagawa & K. Iwats., SouthE. Asian. Strd. 5: 103. 1967; Tagawa & K. Iwats., Fl. Thailand 3(3): 463. 1988; Devol & Kuo, Fl. Taiwan 1. 442: 1994.—*Asplenium mettenianum* Miq., Ann. Mus. Bot. Lugduno-Batavi 3(6): 174–175. 1867.— *Athyrium mettenianum* (Miq.) Ohwi, Bull. Natl. Sci. Mus. 3(2): 100. 1956.— *Allantodia metteniana* (Miq.) Ching, Acta Phytotax. Sin. 9(1): 51. 1964. Type: China, *Textor s.n.*Figure 5.29, 5.58 A

Plants, terrestrial, *Stems* short creeping, 1.0−1.5 cm in diameter, covered with scales throughout; scales 8−10 × 0.8−1.0 mm, linear-lanceolate, concolorous, light brown, margin minutely toothed. *Leaves* up to 1 m long, unipinnate; petioles up to 50 cm, 6−7 mm in diameter, glabrous, deep green, black at lower portion. *Laminae* 30−50 × 30−40 cm, terminal pinna not distinct, ovate-oblong in outline, apex acuminate, glabrous, thinly chartaceous, deep green when living, brown when dry; lateral pinnae 8−10 pairs, alternate, 20−25 × 2−4 cm, oblong, apex acuminate, base cordate, lobed at margin; lobes about ¼ way to costa, apex round to obtuse, margin subentire to serrate, stalked; stalks 1.5−2.0 cm long, longest at lower pinnae; upper pinnae rather suddenly becoming smaller, adnate and gradually decurrent at base; veins pinnate, veinlets 4−5 pairs, free. *Sori* 4−5 mm long, oblong, elongate along veins, longest at lower veinlets of vein group, diplazoid. *Spores* monolete, 66−68 × 39−42 μm, bilateral, concavo-convex to plano-convex; ornamentation: prominent wing folds.

Thailand.—NORTH-EASTERN: Loei (Phu Kradueng).

Distribution.—China, Japan, Taiwan, Vietnam.

Ecology.—On humus-rich slopes in dense forests at 1,100-1,280 m alt.

Specimens Examined.— **THAILAND**. Loei, Phu Kradueng, *E. Hennipman 3691* (B, L); ibid., *P. Pongkai 18* (BCU); ibid., *P. Pongkai 19* (BCU); ibid., *P. Pongkai 20* (BCU); ibid., *P. Jadprajong 8* (BKF); ibid., *P. Jadprajong 9* (BKF); ibid., *P. Jadprajong 11* (BKF); ibid., *P. Jadprajong 71* (BKF); ibid., *P. Jadprajong 236*(BKF); ibid., *P. Pongkai 23* (BCU); ibid., *T. Boonkerd 1113* (BCU, K); **CHINA**. Yu-Chich, *D.E. Boufford & B. Bartholomew 25003* (BM); Hong Kong *S. Y. Hu 9132* (K); Unknown, *Taam 321* (K); **JAPAN**. Kagoshima, *A. Ebihara et al. KS2007-153* (PE); Kumamoto, *A. Ebihara et al. KS2007-211* (PE); Tinlegang between Thimphu, *B. Bartholomew et al. 3768* (PE); Honshu, *E. Zogg et al. 11394* (PE); Kyushu, *J. Murata at al. 2419* (PE); Unknown, *M. Togasi* (BM); Shikoku, *T. Matsumoto et al. 61630* (QBG); Yunokawa, *T. Miyazaki 1011799* (PE); Unknown, *T. Miyazaki 903136* (PE); Honshu, *T. nakaike 26* (B); **TAIWAN**. Nantou, *E. Schuettpelz 1017C* (BM).

5.5.14 ***Diplazium muricatum*** (Mett.) Alderw., Mal. Ferns: 829 1909; Sledge, Bull. Brit. Mus. (Nat. Hist.) Bot. 2: 312. 1962; Tagawa & K. Iwats., SouthE. As. St. 5: 104. 1967; Tagawa & K. Iwats., Fl. Thailand 3(3): 461. 1988.—*Asplenium muricatum* Mett.,Ann. Lugd. Bat. 2: 239. 1866. Type: Indonesia, *Zipple s.n.* (holotype L). Figure 5.30, 5.58 B

Plants terrestrial. *Stems* assending, 5−8 cm in diameter, densely scaly on apical part; scales 12−18 × 1−2 mm, linear, concolorous, brown, margin minutely toothed. *Leaves* 1.0−1.8 m, bipinnate; petioles 0.8− 1.0 m long, 1.0−1.5 cm in diameter, deep green, densely scaly and dark at base. *Laminae* 60−80 × 50−70 cm, bipinnate-tripinnatifid, subdeltoid in outline, gradually narrowing towards apex, glabrous, papyraceous, light green; pinnae 9 pairs, alternate, lower pinnae 27−34 × 18−23 cm, oblong in outline, apex acuminate, stalked; stalks 4−5 cm; pinnules 9−10 × 2.0−2.5 cm, alternate, oblong, apex acuminate, base subtruncate, margin lobed, lobes nearly to costule, 10−12 × 3−4 mm, oblong, apex round, margin sharply serrate, stalked; stalks 2 mm; veins pinnate, veinlet 7−8 pairs, free, forked. *Sori* 2−3 mm long, oblong, close to midrib, rarely diplazoid, indusiate; indusia thin, fragile. *Spores* monolete, 32.5−40.0 × 22.5−27.5 μm, bilateral, concavo-convex to plano-convex; ornamentation: prominent wing folds.

Thailand.— NORTHERN: Chiang Mai (Doi Chiang Dao, Doi Inthanon), Chiang Rai (Khunkorn waterfalls), Nan (Doi Phuka), Phitsanulok (Phu Hin Rong Kla); SOUTH-WESTERN: Kanchanaburi.

Distribution.— Sri Lanka, India, Myanmar, Indonesia.

Ecology.— On moist mountain slopes in dense forests at 1,000−2,000 m alt.

Specimens Examined.—**THAILAND**. Chiang Mai, Chiang Dao, *C. Chermsirivathana 329* (BK); Chiang Mai, Doi Chiang Dao, *C.F. van Beusekom & C. Phengklai 1319* (L); Kanchanaburi, *C.F. van Beusekom & C. Phengklai 219* (L); Chiang Mai, Doi Chiang Dao, *E. Hinnapman 3259* (BM) Chiang Mai, Doi Chiang Dao, *E. Hinnapman 3259* (B); Chiang Mai, Doi Chiang Dao, *E.C. & C.H. 329* (BKF); Chiang Mai, Doi Inthanon, *M. Tagawa, K. Iwatsuki & N. Fukuoka T2656* (L); Nan, Doi Phuka, *P. Pongkai 7* (BCU); ibid., *P. Pongkai 11* (BCU); Phitsanulok, Phu Hin Rong kla, *P. Pongkai 12* (BCU); Chiang Rai, Khunkorn waterfalls, *P. Ratchata 49* (BCU); Chiang Rai, Khunkorn Waterfalls, *P. Ratchata 137* (BCU); Chiang Rai, Khunkorn waterfalls, *P. Ratchata 142* (BCU); Chiang Rai, Khunkorn Waterfalls, *P. Ratchata 216* (BCU); **PHILIPPINES**. Mindanao, *R.S. Williams 2458* (K).

5.5.15 ***Diplazium pallidum*** (Blume) T. Moore, Index Fil.: 333. 1861; Bedd., Handb.: 175. 1892; A.G. Piggott., Fern of Malaya in colour: 301. f. 926-928. 1996.— *Asplenium pallidum* Blume, Enum. Pl. Jav.: 177. 1828.— *Asplenium calophyllum* J. Sm. ex mett., Abh. Senckenb. Naturf. Ges. Abh. Senckenb. Naturf. Ges. 3: 220. 1859.— *Diplazium vacillans* (Kunze) C. Chr., Index Fil.: 241.1906.— *Asplenium vacillans* Kunze, Bot. Zeitung (Berlin) 6: 172. 1848. Type: Indonesia, Java, *Blume s.n.* [Holotype L! (L0051559). Figure 5.31, 5.58 C

Plants terrestrial. *Stems* erect, 2.5−4.0 cm in diameter, bearing wiry roots, apex scaly; scales 8−10 × 0.5−0.8 mm, linear, concolorous, dark brown to nearly black, margin entire. Leaves 0.73−1.10 m long, pinnate; petioles 46−60 cm, 4−5 mm in diameter, glabrous, dark brown to black, base scaly. *Laminae* 27−50 × 25−35 cm, oblong in outline, glabrous, papyraceous, deep green; terminal pinna distinct; terminal pinnae 10−20 × 1.5−3.0 cm, oblong, apex acuminate, margin entire but serrate near apex; lateral pinnae 8−14 pairs, alternate, 15−22 × 1.5−3.0 cm, oblong, subfalcate, apex acuminate, base round or oblique, margin entire but serrate near apex, lower

pinnae sessile or shortly stalked; stalks 1−2 mm, lower pinnae longest, upper pinnae suddenly becoming smaller upwards; veins all free, veinlets once forked. *Sori* 3−5 mm long, elongate along veinlets, on acroscopic veinlets of vein groups, indusiate; indusia linear, thin, persistent. *Spores* monolete, 46.0−52.5 × 26.5−32.0 μm, bilateral, concavo-convex to plano-convex; ornamentation: smooth.

Thailand.— PENINSULAR: Nakhon Si Thammarat (Khao Luang, Krung Ching Waterfall).

Distribution.— Philippine, Malaysia, Brunei, Indonesia, Papua New Guinea Australia.

Ecology.— On shady area near streamlets in dense evergreen forests at 600−1,100 m alt.

Conservation Status.— Two small populations has been found at two locality. However, it can be found in many country of Southeast Asia and Australia. Thus, it was considered that *D. pallidum* should be registering as "Least Concern (LC)" according to IUCN Conservation Status (IUCN., 2012).

Specimens Examined.—**THAILAND.** Nakhon Si Thammarat, Khao Luang, *P. Pongkai 112* (BCU); Nakhon Si Thammarat, Krung Ching Waterfalls, *P. Pongkai 143* (BCU); Nakhon Si Thammarat, Khao Luang, *E. Hennipman 3998* (BKF); Nakhon Si Thammarat, Khao Luang, *T. Boonkerd & R. Pollawatn 1406* (BCU); ibid, *T. Boonkerd & R. Pollawatn 1408* (BCU); Nakhon Si Thammarat, Khao Luang, *T. Smitinand s.n.* (BKF); **MALAYSIA**. Pahang, *A. Samat bin Abdullah 20902* (K); Salangor, *A. G. Piggott 1011* (K); Pahang, *B. Molesworth-Allen 4539* (K); Sabah, *B. S. Parris & J. P. Croxall 8948* (K); ibid., *B.S. Parris & J.P. Croxall 9154* (K); Pahang, *B. S. Parris & P. J. Edwards 10421* (K); Sarawak, *B. S. Parris 6966* (K); ibid., *B. S. Parris 7028* (K); Perak, *C. Curtis 1268* (K); Pahang, *E. Smith 892* (K); Perak, *Fed. Malay States Museum s.n.* (K); Sabah, *G. Shea & Aban San 77222* (K); Pahang, *H.N. Ridley 2167* (K); Perak, *H. N. Ridley 14209* (K); Perak, *J. Day s.n.* (K); Pahang, *M. R. Henderson 18583* (K); Sabah, *R. Jaman 4021* (K); Pahang, *R.E. Holttum s.n.* (K); ibid., *R.E. Holttum SFN24703* (K); Sabah, *R. E. Holttum SFN25559* (K); **PHILIPPINES**. Luzon, *A. Loher 905* (K); Luzon, *A.D.E. Elmer 9017* (K); Mindanao, *A.D.E. Elmer 11325* (K); ibid., *A. D. E. Elmer 13885* (K); Luzon, *A. D. E. Elmer 18476* (K); Luzon, *B. S. Parris 5736a* (K); Sulu, *F.W. Burbidge s.n.* (K);

Luzon, *H. Cuming 188* (BM, K, L); Camarina, *H. Cuming s.n.* (K); Luzon, *M. Ramos s.n.* (K); Luzon, *M. G. Price 471* (K); **BRUNEI**. *A. D. Poulsen 346* (K); **INDONESIA**. Ruteng, *A. J. G. H. Kostermans & Wirawan 658* (K); Java, *A. MacLeay s.n.* (K); Sumbava, *A. J. G. H. Kostermans 18125* (K); Mbengen, *A. J. G. H. Kostermans 22134* (K); Sumatra, *B. J. Brooks 1205* (BM); Seram Maluka, *B. S. Parris 11129* (K); Java, *C. G. Matthew s.n.* (K); Java, *C. L. Blume s.n.* (K, L); Unknown, *D. Darnaedi 2067* (K); Sumatra, *E. Gardette 300* (K); ibid., *E. Gardette 345* (K); Sulawesi, *E. Hennipman 5151a* (K); Sulawesi, *E. Smith 2492* (K); Unknown, *G. T. de Joncheere 1252* (BM); ibid., *G. T. de Joncheere 1300* (BM); Java, *H. Zollinger 156* (K); ibid., *H. Zollinger 412* (B); Unknown, *J. A. Lörzing 5549* (K); Gunung Totaniwei, *M. Kato C13675* (K); Seram Utara Manusela National Park, *M. Kato, B. Sunarno & H. Akiyama C4497* (K); Kalimantan, *M. Kato, G. Murata & Y.P. Mogea B3795* (K); Seram Utara Manusela National Park, *M. Kato, K. Ueda & U.W. Mahjar C1959* (K); Tehoru, *M. Kato, K. Ueda & Z. Fanani C14417* (K); Kryyan, *M. Kato, M. Okamoto & E .B. Walujo B9168* (K); Java, *M. Raciborski s.n.* (K); Sumatra, *R.E. Holttum s.n.* (K); Java, *T. Lobb s.n.* (K); Sumatra, *T.S. Rahmat 221* (K); Bloaang Mongondow, *W. Kaudern 40* (BM); Java, *W.H. de Vriese 227* (K); ibid., *W.H. de Vriese 270* (K); ibid., *W.H. de Vriese 585* (K); Java, *W.S. Kurtz s.n.* (K); **PAPUA NEW GUINEA**. New Island, *J.R. Croft & M.J.S. Sands, LAE68317* (K); New Island, *J.R. Croft 233* (K); New Island, *J.R.Croft LAE68414* (K); Buso, *K. Palis 26* (K); Unknown, *N.A. Wakefield 1367* (BM), New Britain, *P.F. Stevens & L. Lelean LAE58652* (K), Sepik Lumi River, *R. J. Johns s.n.* (K).

Note.— This species is a new record for Thailand.

5.5.16 ***Diplazium petelotii*** Tardieu, Asplen. Tonkin 66, pl. 8, f. 3–6. 1932; Tagawa & K. Iwats., Fl. Thailand 3(3): 456. 1988. Zhaorong, H. & Kato, M., Fl. China 524. 2013.— *Allantodia petelotii* (Tardieu) Ching, Acta Phytotax. Sin. 9(1): 53. 1964. Type: Veitnam, Tonkin, *Pételot 542* [Lectotype (designated here) P! (P01449498); Isolectotypes P! (P01449495, P01449499)]. Figure 5.32, 5.58 D

Plants terrestrial. *Stems* stout, erect, up to 5 cm in diameter, apex scaly; scales up to 12−15 × 1.0−1.5 mm, linear with long-tail apex, concolorous, dark brown, margin toothed. *Leaves* up to 1.2 m long, bipinnate; petioles 54−58 cm long, 4.5−5.5

cm in diameter, deep green, base scaly, groove above. *Laminae* 60−62 × 40−50 cm, ovate-oblong in outline, glabrous, papyraceous, deep green; pinnae 8−10 pairs, upper pinnae suddenly becoming smaller upward to form pinnatifid apex, terminal pinna not distinct; lateral pinnae 25−30 cm × 5−7 cm, alternate, oblong, apex long acuminate, stalked, stalk 2−3 cm long; pinnules 3.5−4.0 × 1.0−1.5 cm, oblong, apex acute or round, base obtuse, margin subentire to slightly serrate, sometimes lobe at basal pinnules, lobes about ¼ way to midrib; veins free, pinnate; veinlets 2−3 pairs. *Sori* 2−4 mm long, along veinlet, linear, slightly curved, indusiate; indusia linear, thin, persistent. *Spores* monolete, bilaterally symmetrical, kidney-shaped, 33.5−53.0 × 26.0−31.0 µm; ornamentation: prominent wing folds.

Thailand.— NORTHERN: Chiang Rai (Mae Kok), Chiang Mai (Doi Suthep), Phitsanulok (Phu Rom Rot).

Distribution.— China, Vietnam.

Ecology.— On mountain slope in dense evergreen forests at 1,000−1,300 m alt.

Specimen Examined.—**THAILAND**. Chiang Mai, Doi Suthep, *S. Chodchoy 62* (KU); **VIETNAM**. Lao Cai, Van Ban District, *H. van der Werff et al. 17346* (L); Tonkin, *Pételot 542* (P).

Note.— Three syntypes of *D. petelotii* collected by Pételot from Tonkin, Vietnam were found at P. Among them the most complete specimen was selected as a lectotype: *Pételot 542* bis (P01449498!).

5.5.17 *Diplazium petrii* Tardieu, Aspl. Tonkin: 667. pl. 9, 1-2. 1932; Tard. & C. Chr., Fl. Indo-Chine. 7(2): 260. 1940; Tagawa & K. Iwats., SouthE. As. St. 5: 104. 1967; Tagawa & K. Iwats., Fl. Thailand 3(3): 461. 1988; K. Iwatsuki, Ferns and Fern Allies of Japan: 253. Pl. 171-4. 1992; Devol & Kuo, Fl. Taiwan 1. 442: 1994.—*Allantodia petrii* (Tardieu) Ching, Acta phytotax. Sin. 9(1): 53. 1964.— *Athyrium petrii* (Tardieu) Ohwi, Fl. Jap. 127. 1957.— *Allantodia jiulungshanensis* P.C. Chiu & G.H. Yao ex Ching, Bull. Bot. Res., Harbin 2(2): 69–70, pl. 3, f. 1. 1982.— *Diplazium maximum* var. *formosanum* Rosenst., Hedwigia 56(5): 337. 1915.—*Diplazium triangulare* Tagawa, Acta Phytotax. Geobot. 7(2): 79–80. 1938. Type:— Vietnam, Tonkin, *Pételot 1987* [holotype P! (P00642882)]. Figure 5.33, 5.58 E

Plants terrestrial. *Stems* short creeping, 2.0−2.5 cm long, covered with scales throughout; scales 11−20 × 8−10 mm, linear long tail apex, concolorous, black, margin toothed. Leaves 47−96 cm, unipinnate-bipinnatifid to bipinnate; petioles 32−43 cm long, 5−6 mm in diameter, deep green when living, stramineous when dry, dark colour at lower portion, scaly at base. *Laminae* 42−53 × 44−48 cm, deltoid in outline, terminal pinna not distinct, upper pinnae gradually becoming smaller upwards, glabrous, papyraceous, light green; lateral pinnae 20−22 pairs, alternate, 15−18 × 3.0−3.5 cm, narrowing upward, falcate, apex acuminate, base cordate to subcordate, margin lobed, stalked; stalks 1.0−1.7 cm long, longest at lower pinna, the posterior pinnules usually decurrent to the next one; veins pinnate, veinlets 3−4 pairs, simple or once forked. *Sori* 2.0−3.5 mm long, elongate, cresentic, grabrous, persistant. *Spores* monolete, 30.0−42.5 × 20.0−22.5 μm, bilateral, concavo-convex to plano-convex; ornamentation: labyrinth-like folds. The folds are with dentate or fringed margin.

Thailand.— SOUTH-WESTERN: Prachuap Khiri Khan (Huaiyang Waterfalls); SOUTH-EASTERN: Chanthaburi (Khao Soi Dao, Pong Nam Ron); PENINSULAR: Nakhon Si Thammarat (Khao Luang, Khao Nan).

Distribution.— China, Japan, Taiwan, Vietnam, Philippines.

Ecology.— On rather dry mountain slopes in dense evergreen forests at 1,000 – 1,400 m alt., rather rare.

Specimens Examined.—**THAILAND**. Nakhon Si Thammarat, Khao Luang, *M. Tagawa, K. Iwatsuki & N. T4777* (L); ibid., *M. Tagawa, K. Iwatsuki, H. Koyama & A. Chintayungkun T8608* (L); ibid., *M. Tagawa, K. Iwatsuki, H. Koyama & A. Chintayungkun T8387* (BKF); ibid., *P. Pongkai 68* (BCU); ibid., *P. Pongkai 69* (BCU); ibid., *P. Pongkai 72* (BCU); ibid., *P. Pongkai 118* (BCU); ibid., *P. Pongkai 119* (BCU); Chiang Rai, Khunkorn waterfalls, *P. Ratchata 136* (BCU); Chiang Rai, Khunkorn waterfalls, *P. Ratchata 199* (BCU); Prachuap Khiri Khan, Huaiyang Waterfalls, *Y. Yuyen 95* (BCU); **CHINA**. Unknown *W. T. Tsang 22480* (BM); Yunnan, *Z. Y. Han WR0399* (PE). **JAPAN**. Kyushu, *M. Furuse 3853* (PE); ibid.,*M. Furuse 39018* (PE); ibid., *M. Furuse 41609* (PE); Japan, Taito, *M. Tagawa 2745* (BM); Unknown, *M. Tagawa 3551* (PE); Ryukyu, *Y. Saiki 1990* (BM); Unknown, *Y. Saiki s.n.* (PE). **TAIWAN**. Taitung, *C. T. Choi 11471* (PE); ibid., *C. T. Choi 114889*

(PE); ibid., *C. T. Choi 11499* (PE); ibid., *C. T. Choi 12264* (PE); ibid., *C. T. Choi 12834* (PE); Yilan, *D. E. Boufford et al. 25188* (PE); Unknown, *H. Tsung-Hsin & H. Chi-Hsing 1387* (BM); Yilan, *T. T. Chen et al. 11471* (PE); ibid., *T. T. Chen et al. 12691* (PE); Teipei, *Z. Y. Han 3703-1* (PE); ibid., *Z. Y. Han 3703-2* (PE); ibid., *Z. Y. Han 3703-3* (PE).

5.5.18 ***Diplazium polypodioides*** Blume, Enum. Pl. Javae 2: 195. 1828; Beddome, C. R. H., Handb. Ferns Brit. India 184. 1833; Tard. & C. Chr., Fl. Indo-Chine 7(2): 266. 1940; Holtt., Gard. Bull. Straits Settlem 11: 93. 1940; M. Tagawa & K. Iwats., SouthE. As. St.. 3(3): 88. 1965; 5: 105. 1967; M. Tagawa & K. Iwats., Fl. Thailand 3(3): 465. 1988.— *Diplazium polypodioides* Bedd. Ferns S. India 54, pl. 163. 1863. Type: Indonesia, Java, *Blume s.n.* [Holotype L! (L0051563)]. Figure 5.34, 5.59 A

Plants terrestrial. *Stems* massive, erect, 7−8 cm in diameter, apex densely scaly; scales 14−20 by 1.0−1.5 mm, linear long-tail apex, dark brown to nearly black, margin thick. *Leaves* up to 1.70 m long, bipinnate; petioles up to 1 m long, 1.0−1.5 cm in diameter, brown, surface prickly due to scars of fallen scales, densely scaly near base. *Laminae* up to 1.0 × 0.7 m, ovate-deltoid in outline, glabrous, papyraceous, light green; lower pinnae 55−60 × 25−30 cm, alternate, oblong in outline, apex acuminate, stalked, stalks 4−5 cm long; pinnules 10−12 × 3−4 cm, subopposite, oblong, apex acuminate base subtruncate, margin lobed, lobe deep close to costule, about 10 × 5 mm, oblong, oblique, apex round or obtuse, sharply serrate at margin, stalked, stalks 2−3 mm; veins pinnate, about 10 pairs, free or forked. *Sori* 2−3 mm long, along veinlets, close to costule, indusiate; indusia linear, thin, persistent. *Spores* monolete, 37.5−45.0 × 22.5−25.0 μm, bilateral, concavo-convex to plano-convex; ornamentation: prominent wing folds.

Thailand.— NORTHERN: Chiang Mai (Doi Suthep, Mae Klang, Doi Inthanon), Chiang Rai (Mae Lao), Phrae (Mae Sai), Tak, Phitsanulok (Phu Miang); SOUTH-WESTERN: Kanchanaburi, Phetchaburi; SOUTH-EASTERN: Chantaburi (Khao Soi Dao); PENINSULAR: Surat Thani (Ban Don), Ranong (Phato), Nakhon Si Thammarat (Khao Luang).

Distribution.— India, Sri Lanka, Bhutan, Myanmar, China, Japan, Taiwan, Cambodia, Vietnam, Laos, Malaysia, Indonesia, Papua New Guinea.

Ecology.— On humus-rich mountain slopes in high humidity areas at 500−1,200 m. alt. throughout the country, usually at edge of forests or in clearing, not in deep shade.

Specimens Examined.—**THAILAND**. Chumphon, Lanng Suan, *A. F. G. Kerr 12158* (BK); Chiang Mai, Mae Dang, *J. F. Maxwell 90-34* (L); Chiang Rai, Ban Saen Sa-at, *K. Bunchuai & B. Nimanong 1421* (L); Nakhon Si Thammarat, Khao Luang, *M. Tagawa, K. Iwatsuki & N. Fukuoka T5269* (L); Phetchaburi, Kaeng Krachan, *M. F. Newman, T. Boonthavikoon, C. Hemrat & D. J. Middleton 1095* (L); Nan, Doi Phuka, *P. Pongkai 8* (BCU); Chiang Rai, Khunkorn waterfalls, *P. Ratchata 12* (BCU); Chiang Rai, Mae Swai, *Pragad 916* (BK); Chiang Mai, Doi Suthep, *S. Mitsuta T50237* (QBG); Ratchaburi, Suan Phueng, *Suan Phueng Trip 79* (BCU); ibid., *Suan Phueng Trip 81* (BCU); Kanchanaburi, si yok, *T. Vougthavone 153* (BK, BKF) Prachuap Khiri Khan, Huaiyang Waterfalls, *Y. Yuyen 191* (BCU); **BHUTAN**. *B.Barhtolomew et al. 3768* (PE). **INDIA**. Darjiling, *C.B. Clarke 35382* (K); ibid.,*C.B. Clarke 8646* (K); Ponmudi, *K.U. Kramer 6197* (K); Sikkim, *T.C. Jerdon 12* (K); Idukki, *V.S. Manickam RHT3218* (K). **NEPAL**. Mai valley, *J.D. Hooker s.n.* (K). **SRI LANKA**. Central Province, *C.V. 1352* (K); Unknown, *Perad 1352* (B); ibid.,*W. Robinson 81* (K); **JAPAN**. Dalhousie, *F.E.W. Venning 502* (PE); Unknown, *M. Tagawa 2864* (PE); **MYANMAR**. Tuang, Nan Tamwi Tuang, *J. F. Maxwell 75-281* (BK); **VIETNAM**. Ha Giang, *D.K. harder et al. 5382* (PE); **INDONESIA**. Borneo, *M.S. Clemens 40806* (BM); Java, *PE-BO Team 18* (PE); Tahura, *W. R. Yu 18* (PE).

5.5.19 ***Diplazium prescottianum*** (Wall. ex Hook.) T. Moore, Index. Fil.: 156, 334. 1859; Holtt., Gard. Bull. Straits. Setllem 11: 94. 1940; Tagawa & K. Iwats., SouthE. Asian. Strd 5: 103. 1967; Acta Phytotax. Geobot. 23. 56. 1968; Tagawa & K. Iwats., Fl. Thailand 3(3): 457. 1988.— *Asplenium prescottianum* Wall. ex Hook., Sp. Fil. 3: 251. 1860.— *Diplazium sylvaticum* var. *prescottianum* (Wall. ex Hook.) Bedd., Handb.: 178. 1883.— *Athyrium prescottianum* (Wall. ex Hook.) Holtt., Rev. Fl. Malaya 2: 557. 1955. Type:— Singapore, *N.Wallich, 235* [Holotype K! (K000443459); Isotype K! (K000443459)].Figure 5.35, 5.59 B

Plants terrestrial. *Stem*s erect, 5−6 cm in diameter, bearing thick black roots, apex scaly; scales about 15 × 1 mm, narrowly lanceolate, concolorous, dark brown, margin entire.

Leaves up to 1.30 m long, imparipinnate; petioles 60−80 cm long, 5−6 mm in diameter, glabrous, green with dark brownish base. *Laminae* 43−50 × 18−25 cm, outline oblong, suddenly becoming smaller upword, long acuminate apex, terminal pinna not distinct, glabrous, papyraceous, deep green; leteral pinnae 11−12 pairs, alternate, 13−17 × 1.7−2.0 cm, bolong, falcate, apex caudate-attenuate, base obtuse, margin crenate, moderately auricle at acroscopic base; aucicle, apex round to obtuse, margin subentire, stalked; stalk 2.0−2.5cm long, longest at lower pinnae; veins pinnate, veinlets 3−4 pairs. *Sori* 0.5−1.0 cm long, elongate along veinlets, diplazoid, indusiate; indusia thin, firm, persistance. *Spores* monolete, 40.5−43.0 × 23.5−25.5 µm, bilateral, concavo-convex to plano-convex; ornamentation: labyrinth-like folds. The folds are with dentate or fringed margin.

Thailand.— SOUTH-EASTERN: Trat (Koh Chang); PENINSULAR: Nakhon Si Thamarat (Khao Luang), Yala (Ban Chana, Ban Malao).

Distribution.— Malaysia, Singapore.

Ecology.— On humus-rich mountain slopes in dense evergreen forests at about 600 m alt.

Specimens Examined.—**THAILAND**. Prachinburi, Khao Yai, *K. Larsen, T. Smitinand & E. Warncke 312* (BKF); **MALAYSIA**. Perak, *Anonymous s.n.* (K); **SINGAPORE**. Crangie, *H.J. Murton 100* (K); Tanjong Gul, *J. Sinclair 9376* (K); Unknown, *N. Wallich 235* (K); ibid., *T. Lobb 32* (K).

5.5.20 *Diplazium procumbens* Holttum, Gard. Bull. Straits. Settlem. 11(1): 95, f. 4. 1940; Boonkerd et al., Thai For. Bull. (Bot.) 32: 7. 2004.—*Athyrium procumbens* (Holttum) Holtum., Rev. Fl. Malaya 2: 572. f. 399. 1954. Type: Malaysia, Pahang, *Holltum, R.E. 36503* [Holotype K! (K000443463)]. Figure 5.36, 5.59 C

Plants terrestrial. *Stem*s creeping, 1.5−2.0 cm in diameter, densely covered with scales at apex; scales 8−10 × 0.7−1.0 mm, linear with long tail apex, concolorous, brown, margin toothed. *Leaves* up to 1.4−1.6 m long, bipinnate; petioles 70− 80 cm long, 5−6 mm in diameter, glabrous, deep green, dark at lower portion. *Laminae* 75−80 × 67−72 cm, deltoid in outline, gradually narrowing upwards, long acuminate apex, glabrous, papyraceous, light green; pinnae 45−50 × 18−20 cm, alternate, oblong in outline stalked; stalks 2.5−3.0 cm long , largest at lower pinnae; pinnules 8−9 ×2.0−2.5 cm, alternate, oblong, apex long acuminate to attenuate, base truncate, lobed at margin; lobes about ¾ way to costule, apex obtuse, margin

subentire to dentate, stalked; stalks 1−2 mm long; veins pinnate, 4−5 pairs, free, once forked. *Sori* 2−4 mm long, elongate along veinlets, diplazoid, close to midrib, indusiate; indusia linear, very thin, persistent. *Spores* monolete, 47.5−57.5 × 25.0−32.5 μm, bilateral, concavo-convex to plano-convex; ornamentation: prominent wing folds.

Thailand.— SOUTH-WESTERN: Petchaburi (Kaeng Krachan National Park); *Prachuap Khiri Khan (Khao Luang).*

Distribution.— Sri Lanka, Malaysia,.

Ecology.— On moist and shady area, near stream at about 1,300 m alt.

Specimens Examined.—**THAILAND**. Phetchaburi, Kaeng Krachan, *D. J. Middleton et al. 1762* (BKF); **MALAYSIA**. Pahang, *B. E. G. Molesworth-Allen 1439* (BM); Pahang, *R. E. Holltum 21645* (K); ibid., *R. E. Holltum 21646* (K); ibid., *R. E. Holltum 36503* (K); **SRI LANKA**. Namunukula, *W. A. Sledge 1192* (BM, K).

Note.— This species is a new record for Pteridophyte Flora of Thailand.

5.5.21 ***Diplazium proliferum*** (Lam.) Thouars, Esquisse Fl. Tristan D'Acugna. 35. 1808.— *Diplazium proliferum* (Lam.) Kaulf., Enum. Filic. 182. 1824.nom. illeg. superfl. non Thouars, 1808. — *Diplazium proliferum* (Lam.) Desv., Mém. Soc. Linn. Paris 6: 280. 1827.—*Asplenium proliferum* Lam., Encycl.2: 307. 1786. Type: France, La Réunion, *Commerson s.n.* P-LAM: ST, microfiche 742/3-4; BM: photo, Morton Neg. 2765.— *Asplenium proliferum* Sw., Prodr. 129. 1788.— *Anisogonium attenuatum* (C. Presl) C. Presl, Tent. Pterid.116. 1836.— *Callipteris attenuate* (C. Presl) C. Presl, Abh. Königl. Böhm. Ges. Wiss., ser. 5 6: 449. 1851.— *Asplenium attenuatum* C. Presl, Reliq. Haenk.42. 1825.— *Asplenium spinulosum* (Blume) Mett., Farngatt. 6, Asplenium 172. 1859.— *Callipteris spinulosa* (Blume) J. Sm., J. Bot. (Hooker) 3: 409. 1841.— *Diplazium spinulosum* Blume, Enum. Pl. Javae 2: 193. 1828.— *Callipteris accedens* (Blume) J. Sm., J. Bot. (Hooker) 4: 179. 1841.— *Athyrium accedens* (Blume) Milde, Bot. Zeitung (Berlin)28: 353. 1870.— *Diplazium accedens* Blume, Enum. Pl. Javae2: 192. 1828.—*Callipteris prolifera* (Lam.) Bory, Voy. Îles Afrique 1: 283. 1804.— *Asplenium decussatum* Sw., J. Bot. (Schrader) 1800(2): 51. 1801.— *Asplenium luzoniense* Spreng., Syst. Veg. 4(1): 85. 1827.— *Athyrium ridleyi* Copel., Philipp. J. Sci. 11: 39. 1916.— *Digrammaria robusta* Fée,

Mem. Foug., Gen. Filic.218. 1850.— *Diplazium repandum* Blume, Enum. Pl. Javae 2: 191. 1828.— *Diplazium serratum* K. Schum., Beskr. Guin. Pl. 459. 1827.— *Athyrium proliferum* Milde, Bot. Zeitung (Berlin) 28: 353. 1870.— *Diplazium incisum* K. Schum., Beskr. Guin. Pl. 458. 1827. Type: Maurice, *P. Commerson s.n.*[Isotypes MPU photo seen! (MPU018120, MPU018121)]. Figure 5.37, 5.59 D

Plants terrestrial. *Stems* massive, erect, 5−7 cm in diameter, apex scaly; scales, 12−15 × 1.0−1.5 mm, linear, concolorous, brown, margin thick and toothed. *Leaves* 1.0−1.30 m long, imparipinnate; petioles 40− 50 cm long, deep green, minutely scaly, spinose on lower part. *Laminae*, 65−70 × 35−42 cm, oblong in out line, apex acuminate, usually viviparous at apical portion between terminal pinna and rachis, glabrous, papyraceous, deep green; terminal pinna distinct, 12−15 × 8−10 cm, deltoid, apex acuminate, base subtruncate, margin lobe; lateral pinnae 10−15 pairs, alternate, about 12−15 × 5−6 cm, oblong, apex attenuate, base truncate, margin serrate or serrulate, sessile to shortly stalked, stalk 1−2 mm long, longest at lower pinnae; veins strongly anastomosing. *Sori* as long as veinlet length, along veinlet, on some or all the veinlets, indusiate; indusial linear, thin, persistent. *Spores* monolete, 49.5−51.0 × 31.0−35.5 μm, bilateral, concavo-convex to plano-convex; ornamentation: prominent wing folds.

Thailand.— PENINSULAR: Ranong (Phato), Trang, Yala (Banang Sata).

Distribution.— Philippines, Malaysia, Indonesia, Australia, Papua New Guinea.

Ecology.— On moist ground by streams in evergreen forests at 600 m alt.

Specimens Examined.—**THAILAND**. Chumphon Lang Suan, *A. F. G. Kerr 12160* (BK, BM); Trang, *C. Apasutaya 121a*, ibid., *C. Apasutaya 121b* (BCU); **MALAYSIA**. Selangor, *A.G. Piggott 1080* (K); Negri Sembilan Gunong Telapak Burok, *A. G. Piggott 1961* (K); Pahang, *A. G. Piggott 3002* (K); Perak, *C. Curtis 1359* (K); Perak, *E. J. Strugnell 14516* (K); Pahang Telom, *H. N. Ridley 13970* (K); Pahang, *K. Iwatsuki, N. Fukuoka & M. Hutoh 13657* (K); **PHILIPPINES**. Mindanao, *C. M. Weber 1191* (K); Mindanao, *E. Edano 8804* (BK); Luzon, *E. Quisumbing M148* (K); ibid., *E. Quisumbing M263* (K); Luzon, *S. Vidaly Soler 1832* (K); **INDONESIA**. Java, *D.R. Pleyte 2* (K); Jaya, *G.M. Versteeg 1249* (K); Aru Islands, *H. N. Moseley s.n.* (K); Halmahera Toliwang, *Idjan & Mochtar 327* (K); Sulawesi, *J. Dransfield*

3810 (K); Lombok Sewela, *J. Elbert 1979* (K); Sumatra, *J.J. friastini 740a* (K); Sumatra, *K. Iwatsuki, G. Murata, J. Dransfield & D. Saerudin S 1542* (K); Unknown, *L. L. Foman 126* (K); Mankowari, *L. S. Gibbs 6159* (K); Kalimantan, *M. Kato, G. Murata & Y.P Mogea B4390* (K); Moluccas, *M. Treub s.n.* (K), Java, *Millett s.n.* (K); Sumatra, *O. Beccari 428* (K); Sulawesi, *P. Buwalda 3775* (K); Sumatra, *P. W. Korthals s.n.* (K); Batanta, Island, *P. van Royen* (K); Java, *T. Lobb s.n.* (K); Morotai Island, *T. W. Main & Aden 802* (K); Java, *V. F. Schiffner 189* (K); Seram Moluccas, *W. H. de Vriese & J.E. Teysmann 216* (K); Batjan Island Moluccas, *W. H. de Vriese & J. E. Teysmann 602* (K); Java, *W. H. de Vriese 212* (K); **PAPUA NEW GUINEA**. Morobe, *A. Millar & R. E. Holttum NGF15877* (K); New Ireland, *A.C. Jermy 7742* (K); Port Moresby Musgrave river, *B. S. Parris & J.P. Croxall 4463* (K); Madang *B. S. Parris & J. P. Croxall 8401* (K); Unknown, *C. E. Carr s.n.* (P); Kokoda, *C. E. Carr 16302* (K); Madang, *D. B. Foreman & R. I Dobunabu NGF45653* (K); Madang Ramu river, *F. R. R. Schlechter 14147* (K); Kaiser Wilhelmsland Wobbe, *F. R. R. Schlechter 16354* (K); New Ireland, *G. W. Barclay s.n.* (K); Morobe, *H. Streimann & A. Kairo NGF44438* (K); East Sepik *J. Wiakabu LAE73594* (K); Northern Prov., *L. E. Cheesman 60* (K); Madang, *M. Coode & P. Katik NGE32757* (K); Central District *M. Pulsford 68* (K); Central Dist., *R. Gebo & M. Pulsford 477* (K); Northern Division, *R. D. Hoogland 3367* (K); Morobe, *R. E. Holttum 80* (K); Morobe, *T. G. Hartley 10021* (K); St Aignan Island, *W. MacGregor 110* (K); Morobe, *W. Takeuchi & A. Towati 15242* (K); Madang, *W. Takeuchi et al. 13605* (K); New Ireland, *Webb s.n.* (K).

5.5.22 *Diplazium riparium* Holttum, Gard. Bull. S.S. 11: 97. f. 5. 1940; Tagawa & K. Iwats., Fl. Thailand 3(3) : 454. 1988; A.G. Piggott., Fern of Malaya in colour: 300. f. 926-928. 1996.—*Athyrium riparium* (Holttum) Holttum, Rev. Fl. Malaya 2 : 554. f. 326. 1955. Type:— Selangor, Semenyih, *Hume 8186* (holotype SING!). Figure 5.38, 5.60 A

Plants terrestrial. *Stems* erect, 1.5−2.0 cm in diameter, bearing wiry roots, apex scaly; scales up to 17 × 1.0−1.5 mm, linear with long tail, concolorous, dark brown to nearly black, margin entire. *Leaves* 55−80 cm long, imparipinnate; petioles 42−50 cm ling, 4−7 mm in diameters, green when living, stramineous when dry, black at lower portion, scaly at base. *Laminae* 25−30 × 21−25 cm, ovate-oblong in outline,

terminal pinna distinct like lateral one, glabrous, subcoriaceous, light green; lateral pinnae 2−4 pairs, subopposite to alternate, 15−20 × 3−5 cm, oblong, sessile or very short-stalked, apex acuminate, base acute, margin entire or subentire; veins rarely anastomosing. *Sori* 1.0−1.5 cm long, elongate along veins, often on every veinlets, longest on acrocsopic veinlets of vein group. *Spores* monolete, 42.5−50.0 × 25−30 μm, bilateral, concavo-convex to plano-convex; ornamentation: prominent wing folds.

Thailand.— PENINSULAR: Chumphon (Langsuan), Surat Thani (Tako, Ban Don), Nakhon Si Thammarat (Khao Luang, Khao Nan, Krung Ching Waterfalls, Ronpibun), Trang (Khao Chong), Satun; Songkhla (Ton Nga Chang Waterfalls), Yala (Ban Chana).

Distribution.— Philippines, Malaysia, Singapore, Brunei, Indonesia.

Ecology.— On muddy rocks or on earth by streams in dense forests at 250-500 m alt.

Specimens Examined.—**THAILAND**. Nakhon Si Thammarat, Khao Luang, *B. Sangkachun 16024* (K); Trung, *C. Apasuthaya 126* (BCU); Nakhon Si Thammarat, Krung Ching Waterfalls, *D. J. Middleton et al. 5531* (PSU); Pattani, Ban Chauaka, *E. Smith 1920* (K); Satun, *E. Smith 2628* (BM, K); Bandon, *E. Smith 2630* (K); Satun, *E. Smith 2631* (K); Nakhon Si Thammarat, Ronpibun, *E. Smith 415* (K); Trang, Khao Chong, *J. F. Maxwell 85-675* (L); Trang, Khao Chong, *J. F. Maxwell 85-975* (PSU); Nakhon Si Thammarat, Krung Ching Waterfalls, *J. F. Maxwell 86-573* (L, PSU); Songkhla, Ton Nga Chang Waterfalls, *N. Putthisawong 67* (PSU); Nakhon Si Thammarat, Krung Ching Waterfalls, *P. Pongkai 45* (BCU); ibid., *P. Pongkai 48* (BCU); Chumphon, Langsuan, *Put 1659* (K); Unknown, *Put 1689* (BM); Chumphon, Langsuan, *Put 1689* (BK); Unknown, *Sangkachun 16024* (K); Unknown, *T. Seelanan 3* (BCU); Nakhon Si Thammarat, Krung Ching Waterfalls, *W. Klinla-ang et al. 2* (PSU); **PHILIPPINES**. Luzon, *H. G. Gutierrez 78330* (K); Sulu Archipelago, *Y. Kondo & G. Edaño 38694* (K); **MALAYSIA**. Sarawak, *J. A. R. Anderson & H. Keng 24* (K), ibid., *J. A. R. Anderson & H. Keng K96* (K); Pahang, *A. Samat bin Abdullah 229* (K); ibid., *A. Samat bin Abdullah 912* (K); Malacca, *A. Sinclair s.n.* (K); Selangor, *A. G. Piggott 2878* (K); Perak, *B. Molesworth-Allen 2733* (K); Selangor, *B. E. G. Molesworth-Allen 2359* (BM); Pahang, *B.S. Parris & P.J. Edwards 10414* (K); Sarawak, *B.S. Parris 6961* (K); Sabah, *D. Soibeh 659* (K); Johore Gunong Panti, *Dr.*

King's Collector 235 (K); Perak, *Dr. King's Collector 7894* (K); Malacca, *H.N. Ridley 10786* (K); Kelantan Ulu Sungei Keteh, *M. Nur s.n.* (K); Sarawak, *Native Collector* (K); Sabah, *P. J. Edwards 2042A* (K); Pahang, *R. E. Holltum SFN20792* (K); ibid., *R. E. Holltum SFN24780* (K), no nocality, *T. Lobb s.n.* (K); **BRUNEI**. Temburong, *A. D. Poulsen 123* (K); Arboretum, Sg. Liang, *D. S. Edwards 478* (BM); Temburong, *K. M. Wong 854* (K); **INDONESIA**. Java, *A. MacLeay s.n.* (K); Sulawesi, *D. Hicks 208* (K); Borneo, *J. W. Prout s.n.* (K); Kalimantan, *K. Iwatsuki, M. Kato, G. Murata & Y.P. Mogea B3204* (K); ibid., *K. Iwatsuki, M. Kato, G. Murata & Y.P. Mogea B586* (K); Kalimantan, *M. Kato & H. Wiriadinata B6222* (K); Seram, *M. Kato, K. Ueda & U.W. Mahjar C1668* (K); Kalimantan, *M. Kato, M. Okamoto, K. Ueda & D. Darnaedi B8126* (K); **SINGAPORE**. Unknown, *T. Lobb 33* (K).

Note.—This species is similar to *D. bantamense* but differs in having concolorous scales. Scales are entire at margin with caducous membrane. Venation of *D. riparium* is rarely anastomosing.

5.5.23. *Diplazium siamense* C. Chr., Contr. U.S. Natl. Herb.26 (6): 332. 1931.—*Allantodia siamensis* (C. Chr.) Ching & W.M. Chu,Fl. Reipubl. Popularis Sin. 3(2): 426–428, pl. 100, f. 4–6. 1999. Type: Thailand, Chiang Mai, Summit of Doi Chom Cheng, 1500-1650 m, *Rock 1507* [Holotype GH]. Figure 5.39, 5.60 B

Plants terrestrial. *Stems* erect, 3−4 cm in diameter, apex densely scaly; scales 10.0−12.0 × 1.0−1.5 mm, linear, long tail at apex, brown, margin thick and toothed. *Leaves* 0.85−1.2 m long, pinnate; petioles 30−50 cm long, 5−8 cm in diameter, deep green, densely scaly at base. *Laminae* up to 55−70 × 30–40 cm, oblong in outline; terminal pinna distinct, 18−20 cm long, gradually narrowing towards attenuate apex, margin lobed; lateral pinnae 6−8 pairs, alternate, 20−25 × 3.5−4.0 cm, linear-oblong, apex acuminate, base subtruncate, margin lobed; lobe half way to midrib, stalked; stalks 1.5−2.0 cm long; rachis and costa often bearing minute scales; veins free, pinnate, veinlets 8−9 pairs, mostly simple. *Sori* 3−4 mm long, elongate along veinlets, close to main vein. *Spores* monolete, 35−40 × 22.5−27.5 µm, bilateral, concavo-convex to plano-convex; ornamentation: prominent wing folds.

Thailand.— NORTHERN: Chiang Mai (Doi Suthep, Mae Wang), Chiang Rai (Doi Pacho), Nan (Doi Phuka, Khao Nok), Phrae (Mae Sai),Phitsanulok (Phu Hin

Rong Kla, Phu Rom Rot); NORTH-EASTERN: Phetchabun (Phu Miang), Loei (Na Haew, Phu Luang, Phu Suan Sai);

Distribution.— China.

Ecology.— On humus-rich mountain slopes in mixed or evergreen forests at 850 – 1,500 m alt.

Specimens Examined.—**THAILAND**. Phitsanulok, Phu Hin Rong Kla, *AR 69* (BCU); Unknown, *D.J. Middleton et al. 4926* (PSU); Loei, Phu Suan Sai, *D. J. Middleton et al. 5115* (PSU); Loei, Phu Luang, *E. Hennipman 3621* (L); Unknown, *H. Koyama, H. Terao* & *T. Wongprasert* T33676 (BKF); Chiang Mai, Mae Wang, *J. F. Maxwell 03-99* (L); Chiang Mai, Doi Suthep, *J. F. Maxwell 87-791* (L); Chiang Rai, Doi Pacho, *K. Iwatsuki & N. Fukuoka T3681* (L); Chiang Mai, Doi Suthep, *K. Iwatsuki T4462* (BKF, L); Prae, Mae Sai, *K. Winit 959* (BKF); Nan, Doi Phuka, *P. Pongkai 9* (BCU); Phitsanulok, Phu Hin Rong Kla, *P. Pongkai 16* (BCU); ibid., *P. Pongkai 17* (BCU); Nan, Doi Phuka, *P. Pongkai 148* (BCU); Chiang Mai, Doi Inthanon, *P. Srisanga & P. Suksathan 3269* (QBG); Nan, Doi Phuka, *T. Boonkerd 1574* (BCU); Petchchabun, Phu Miang; *T. Shimizu et al. T11367* (L); Nan, Khao Nok, *W. La-ongsri et al. 1987* (QBG); Loei, Na Haew, *W. Nanakorn 3875* (QBG).

5.5.24 ***Diplazium simplicivenium*** Holttum, Gard. Bull. Straits Settlem. 11: 100-101. f. 6. 1940; Holtt., Rev. Fl. Malaya 2: 573. f. 340. 1968, Tagawa & K. Iwats., Fl. Thailand 3(3) : 464. 1988. Type: Malaysia, Pahang, *Holttum, R.E. 36507* [holotype SING; isotype K! (K000443625)]. Figure 5.40, 5.60 C

Plants terrestrial. *Stem*s massive, erect, 5−8 cm in diameter, densely scaly at apex; scales 1.8−2.0 × 0.15−0.20 cm, linear, long tail at apex, brown, margin thick and toothed. *Leaves* 1.8−2.4 m long, bipinnate; petioles 0.8−1.0 m long, 1.5−2.0 in diameter, deep green, densely scaly at base. *Laminae* 1.0−1.4 × 0.8−1.0 m, ovate−deltoid, terminal pinna not distinct; pinnae 6−8 pairs, alternate, 54−60 × 25−28 cm, stalked; stalks about 1 cm, oblong in outline, apex acuminate, glabrous, papyraceous, green; pinnules 12−14 pairs, alternate, 10−12 × 2.0−2.5 cm, sessile, oblong, apex long acuminate, base truncate, margin shallowly lobe; lobes less than ¼ way to midrib of pinnules, 5−8 mm broad subquadrangular, apex obtuse, margin subentire; veins free, pinnate, 5−6 pairs of each vein group. *Sori* usually more than 5

mm long, elongate along veinlets, diplazoid, indusiate; indusia thin, firm, persistant. *Spores* monolete, 51.0−54.5 × 30.5−34.5 μm, bilateral, concavo-convex to plano-convex; ornamentation:prominent wing folds.

Thailand.— NORTHERN: Chiang Mai (Doi Inthanon), Tak (Um Phang); ESTERN: Nakhon Ratchasima (Sa Kaerat); SOUTH-WESTERN: Uthai Thani (Ban Rai), Kanchanaburi (Khao Ngi Yai, Khao Yai, Thong Pha Phum); SOUTH-EASTERN: Chon Buri (Khao Kiew); PENINSULAR: Surat Thani (Klong Ton), Phangnga (Khao Pok), Nakhon Si Thammarat (Khao Luang, Khao Nan), Trang (Khao Chong), Satun, Yala (Muang Wing).

Distribution.— Myanmar, Philippines, Malaysia, Indonesia.

Ecology.— On moist mountain slopes in dense evergreen forests at elevations ranging from 400−1,500 m alt.

Specimens Examined.—**THAILAND**. Kanchanaburi, Thong Pha Phum, *A. Sathapattayanon 122* (BCU); Kanchanaburi, *A. F. G. Kerr 10422* (BK); Satun, *A. F. G. Kerr 10477* (BK); Trung, Khao Chong, *C. Apasutaya 122* (BCU); Trang, Khao Chong, *C. Charoenphol, K. Larsen & E. Warncke 3707* (L); Kanchanaburi, Khao Yai, *C. F. van Beusekom & C. Phengklai 290* (L); Uthai Thani, *C. F. van Beusekom & T. Santisuk 2894* (L); Unknown, *C. F. van Beusekom & T. Santisuk 2894* (K); Chiang Mai, Doi Inthanon, *E. Hennipman 3458* (BKF); ibid., *E. Hennipman 3458* (B); Chon Buri, Khao kiew, *J. F. maxwell 75-665* (L); Chonburi, *J. F. Maxwell 75-665* (BK); Trang, Khao Chong *M. Tagawa & I. Yamada T202* (L); Nakhon Si Thammarat, Khao Luang, *M. Tagawa, K. Iwatsuki & N. Fukuoka T4803* (L); Chiang Mai, Doi Inthanon, *P. Pongkai 94* (BCU); ibid., *P. Pongkai 95* (BCU); ibid., *P. Pongkai 96* (BCU); Nakhon Si Thammarat, Khao Luang, *P. Pongkai 123* (BCU); Nakhon Ratchasima, Sa kaerat, *T. Boonkerd 534* (BCU); Tak, Um Phang, *T. Boonkerd 1848* (BCU); Nakhon Si Thammarat, Khao Nan, *T. Boonkerd, S. Chantanaorapint & W. Khwaiphan 420* (BCU); Nakhon Si Thammarat, Khao Nan, *T. Boonkerd, Y. Sirichamorn & C. Sanguansab 151* (BCU); ibid., *T. Boonkerd, Y. Sirichamorn & C. Sanguansab 208* (BCU); Trang, Khao Chong, *T. Shimizu et al. T27456* (L); Kanchanaburi, *T. Vongthavone 66* (BK); **MYANMAR**. Tenasserim Division, *J.F. maxwell 98-327* (L); **PHILIPPINES**. Rizal, *M. Ramos 956* (K); **MALAYSIA**. Pahang, *A. G. Piggott 3116* (K); Selangor, *B. Molesworth-Allen 4151* (K); Perak, *B.*

Molesworth-Allen 4369 (K); Pahang, *B.E.G.Molesworth-Allen 8329* (BM); Perak, *Dr. King's Collector 2214* (K); ibid., *Dr. King's Collector 2346* (K); ibid., *Dr. King's Collector 8420* (K); ibid., *H. N. Ridley 12411* (K); Selangor, *B. Molesworth-Allen,* (K); Pahang, *R. Jaman et al. RJ6011* (PE); Pahang, *R.E. Holttum 36507* (K); ibid., *R. E. Holttum SFN21636* (K); **INDONESIA**. Borneo, *A. C. Jermy & J.M. Rankin J14840* (BM); Sumatra, *J. A. Lörzing 15667* (K).

5.5.25 ***Diplazium sorzogonense*** (C. Presl) C. Presl, Tent. Pterid.114. 1836; Bedd., Handb. Ferns Brit. India: 181. 1883; Tard. & C. Chr., Fl. Indo-Chine 7(2): 254, f. 28, 3-4. 1940; Tagawa & K. Iwats., Acta Phytotax. Geobot. 23: 56. 1968; Tagawa & K. Iwats., Fl. Thailand 3(3): 456. 1988; A. G. Piggott., Fern of Malaya in colour: 296, f. 912-915. 1996.— *Asplenium sorzogonense* C. Presl, Reliq. Haenk. 1(1): 45. 1825.— *Allantodia sorzogonensis* (C. Presl) Ching, Acta Phytotax. Sin. 9(1): 52. 1964.— *Diplaziumwoodii* Copel., Philipp. J. Sci. 2. 129. 1907. Type:— Philippines, Sorsogon, *Haenke s.n.* Figure 5.41, 5.60 D

Plants terrestrial, *Stems* erect, 4−5 cm in diameter, densely scaly at apex; scales 12−15 × 2−3 mm, linear with long tail apex, brown to dark brown, margin thick and toothed. *Leaves* 1.20−1.35 m long, unipinnate-bipinnatipid, deep green, papyraceous; petioles 40−45 cm long, 5−7 mm in diameter, green, dark brown at lower portion, scaly throughout, grooved above. *Laminae* 80−90 × 35−40 cm, terminal pinna not distinct; rachis grooved above, scaly throughout; lateral pinnae 20−25 pairs, 15−20 × 2−3 cm, linear-oblong in out line, basal one or two pairs more or less reflexed, upper pinnae sessile, lower and middle pinnae shortly stalk, apex acuminate, base truncate or subtruncate, margin deeply lobe; lobes a 8−10 × 4.5−5 mm, to 4/5 way to midrib of pinnae, oblique, narrowly oblong, apex round, margin dentate; veins free, pinnate, veinlets 9−10 pairs, mostly simple. *Sori* 2−3 mm long, elongate along veins, nearly to the margin, not extending to main veins, indisiate; indusia subcrescentic. *Spores* monolete, 37.5−45.0 × 22.5−25.0 μm, bilateral, concavo-convex to plano-convex; ornamentation: prominent wing folds.

Thailand.— PENINSULAR: Chumphon (Khao Tong), Ranong (Kra Buri), Surat Thani, Nakhon Si Thammarat (Khao Luang, Khao Nan, Krung Ching

Waterfalls), Phang Nga (Khao Katha Khwam), Satun (Ban Dan), Yala (Ban Malao, Khao Kalakhiri).

Distribution.— India, Vietnam, Laos, Philippines, Malaysia, Singapore, Indonesia, Papua New Guinea.

Ecology.— On rather dry mountain slopes in dense evergreen forests at 600−1,400 m alt.

Specimens Examined.—**THAILAND**. Chumphun, *A. F. G. Kerr 11547* (BK, BM); Phung Nga, *A. F. G. Kerr 18476* (BM); ibid., *A. F. G. Kerr 18476* (BK); Ranong, Kra buri, *D. J. Middleton et al. 1492* (BKF); Satul, Ban Dan, *E. Smith 2626A* (BM); Nakhorn Si Thammarat, Krung Ching Waterfalls, *P. Pongkai 30* (BCU); ibid., *P. Pongkai 49* (BCU); Nakhon Si Thammarat, Khao Luang, *P. Pongkai 119* (BCU); Surat Thani, *Sakol 1235* (BK); **INDIA**. Khasya, *W. Griffith s.n.* (K); **LAOS**. Pu Bia, *A.F.G. Kerr 21051* (BM); **PHILIPPINES**. Negros, *A. D. E. Elmer 10392* (BM); Mindanao, *A. D. E. Elmer 11805* (K); Surigao, *C. A. Wenzel 2697* (K); Leyte, *H. Cuming 301* (K); Mindanao, *L. Co 3181* (K); Panay, Libacao, *M. Ramos & G. Edaño 31451* (K); **MALAYSIA**. Negeri Sembilan Gunong Telapak Burok, *A. G. Piggott 1670* (K); Negeri Sembilan Gunong Telapak Burok, *A. G. Piggott 1885* (K); Penang, *C. Curtis 572* (K); Perak, *C. G. Matthew s.n.* (K); Perak, *Dr. King's Collector 847* (K); ibid., *Dr. King's Collector 7151* (K); ibid., *G.F. Hose 233* (K), Sabah, *H. F. Comber 4055* (K); Selangor, *H. N. Ridley 13432* (K); Perak, *H. N. Ridley 15991* (K); Perak, *J. Day s.n.* (K); Kedah Gunong Lang, *Kiah, SFN35012* (K), Penang, *L. Dalhousie s.n.* (K); Pahang, *M. Nur 11198* (K); Malacca, *M. D. Maingay 1773* (K); Penang, *N. Wallich 228* (K); Pahang, *R. E. Holttum s.n.* (K); Sabah, *R. E. Holttum SFN25579* (K); Penang, *R. W. Hullet s.n.* (K); Penang, *S. coll. s.n.* (K); Pahang, *T. Shimizu, K. Iwatsuki, N. Fukuoka & M. Hutoh M13886* (K); Penang, *W. S. C. Pinwill s.n.* (K); Penang, *W.B. Lorrain 7043* (K); Penang, *W. F. Mactier s.n.* (K); **INDONESIA**. Sumatra, *A. G. de Wilde & B.E.E. de Wilde-Duyfjes 19408* (K); Sarawak, Gunong Mulu National Park, *C. Jermy* (BM); Sulawesi, *D. Darnaedi 1688* (K); Sulawesi, *G. J. de Joncheere 1597* (K); Sumatra Mt., *H. Wiriadinata 1450* (K); Sumatra, *H. N. Ridley s.n.* (K); Sumatra, *J. A. Lörzing 15934* (K); Sumatra, *K. Iwatsuki, G. Murata, J. Dransfield & Saerudin S871* (K); Seram Manusela Nat. Park Saunulu, Kec. Tehoru, *M. Kato, K. Ueda & Z. Fanani C11660* (K); Seram W. Seram,

M. Kato, K. Ueda & Z. Fanani C12973 (K); **SINGAPORE**. Seletar, *H. N. Ridley 6557* (K); **PAPUA NEW GUINEA**. Morobe Dist., *B.S. Parris & J.P. Croxall 5975* (K); Koitaki, *C. E. Carr 12071* (K); Central Dist., *C. E. Carr 12545* (K); Mt. Dayman, *W.E. Armit 14* (K).

5.5.26 *Diplazium subintegrum* Holttum, Gard. Bull. Straits Settlem. 9: 125. 1937; Tagawa & K. Iwats., SouthE. Asian Stud. 5: 103. 1967; Tagawa & K. Iwats., Fl. Thailand 3(3): 458. 1988; A.G. Piggott., Fern of Malaya in colour: 302. f. 929-931. 1996.— *Athyrium subintegrum* (Holttum) Holttum, Rev. Fl. Malaya 2: 557. f. 328. 1955. Type: Malaysia, Pahang, *Holttum, R.E. 31350* [holotype SING, isotype K! (K000443923)]. Figure 5.42, 5.60 E

Plants terrestrial, *Stems* erect, 5−6 cm in diameter, densely scaly at apex; scales 12−15 × 2−3 mm, narrowly-lanceolate with long-tail apex, brown, concolorous, margin entire with caducous membrane. *Leaves* 60−75 cm long, simple pinnate; petioles 30−40 cm long, 4−5 mm in diameter, nearly black, glabrous, densely scaly at lower part. *Laminae* unipinnate 30−35 × 15−20 cm, outline oblong; terminal pinna distinct, about 10 × 4 cm, subdeltoid, apex acuminate, margin near base lobed; lateral pinnae 10−12 pairs, 10−15 × 2.0−2.5 cm, narrowly oblong, apex acuminate, base round, margin subentire to crenate, dentate or serrate near apex, stalked; stalks 1.5−2.0 mm long; veins free, pinnate, veinlets 2 pairs. *Sori* 8−10 mm long, elongate along veinlets, diplazoid, usually on acroscopic veinlets of vein group, indusiate; indusia linear, thin, pale brown, persistent. *Spores* monolete, 37.5−45.0 × 25.0−27.5 μm, bilateral, concavo-convex to plano-convex; ornamentation: prominent wing folds.

Thailand.— NORTHERN: Phitsanulok (Salaeng Haeng); CENTRAL: Nakhon Nayok (Khao Yai); SOUTH-EASTERN: Prachinburi (Khao Yai), Chanthaburi (Khao Soi Dao), Trat (Koh Chang); PENINSULAR: Nakhon Si Thammarat (Khao Luang, Khao Nan),Yala.

Distribution.— Malaysia, Indonesia.

Ecology.— On rather dry ground near stream banks in light shade at 800−1,000 m alt.

Specimens Examined.—**THAILAND**. Prachinburi, Khao Yai, *C. Khunwasi 54* (BCU); Nakorn Nayok, Khao Yai, *E. Hennipman 3998* (L); Nakorn Nayok, Khao

Yai, *J. F. Maxwell 01-535* (L); ibid., *K. Iwatsuki & N. Fukuoka T7379* (L); ibid., *K. Larsen, T. Smitinand & E. Warncke 163* (L); ibid., *K. Larsen, T. Smitinand & E. Warncke 312* (L); Unknown, *M. Tagawa et al. T4790* (K); Nakhon Si Thammarat, Khao nan, *P. Pongkai 35* (BCU); Nakhon Si Thammarat, Khao Luang, *P. Pongkai 66* (BCU); ibid., *P. Pongkai 67* (BCU) ibid., *P. Pongkai 114* (BCU); ibid., *P. Pongkai 115* (BCU); Nakorn Nayok, Khao Yai, *S. Chongko 50* (L); Nakhon Si Thammarat, Khao Luang, *T. Boonkerd 35* (BCU); Nakhon Si Thammarat, Khao Nan, *T. Boonkerd, Y. Sirijamorn & C. Sanguansab 58* (BCU); Chanthaburi, Khao Soi Dao, *T. Shimizu et al. T-23921* (L); **MALAYSIA**. Pahang, *A. G. Piggott 2424* (K); ibid., *A.G. Piggott 2427* (K); Pahang, *B. Molesworth-Allen 2929* (K); Unknown, *B.E.G. Molesworth-Allen 1328* (BM); Pahang, *B.E.G. Molesworth-Allen 1712* (BM); Pahang, *B.S. Parris 10583* (K); Perak, *C. G. Matthew s.n.* (K); Perak, *H. C. Robinson s.n.* (K); Selangor, *H. N. Ridley 7844* (K); Perak, *J. Day s.n.* (K); Pahang, *K. M. Wong 35205* (K); Perak, *R. Jaman & Z. Mohamad 4148* (K); Pahang, *R. E. Holttum 31350* (K); ibid., *R. E. Holttum SFN23338* (K); **INDONESIA**. Java, *PE-BO Team 28* (K).

5.5.27 ***Diplazium subserratum*** (Blume) T. Moore, Index Fili.: 338. 1862; Bedd., Handb Fern Brit. India: 174. 1883; Tagawa & K. Iwats., Fl. Thailand 3(3): 452. 1988; A.G. Piggott., Fern of Malaya in colour: 292, f. 898-900. 1996.— *Asplenium subserratum* Blume, Enum. Pl. Javae 2: 174. 1828.— *Athyrium subserratum* (Blume) Milde, Bot. Zeitung 1870: 354; Holtt., Rev. Fl. Malaya 2: 546, f. 321. 1955. Type: Java, *Blume s.n.* [holotype L! (L0051577)]. Figure 5.43, 5.60 F

Plants terrestrial. *Stems* short, ascending to erect, 2−6 mm in diameter, bearing a tuft of fronds and wiry roots, apex scaly; scales 1.0−1.2 × 0.3−0.5 cm, ovate, subtriangular, concolorous, dark brown to black, margin irregulary toothed. *Leaves* 50−65 cm long, simple; petioles slender, 10−15 cm long, 3−4 mm in diameter, glabrous, dark brown at base. *Laminae* 40−50 × 3−4 cm, narrowly oblong, gradually narrowing towards at both ends, apex acuminate, base attenuate, margin subentire or irregulary undulate, upper edges serrate, lower edges dentate, glabrous, papyraceous, deep green; veins free, simple or once forked, extending to margin. *Sori* 8−12 mm long, elongate along veins, close to midrib, usually on acroscopic veinlets of vein

group. *Spores* monolete, 55.5−62.0 × 37.5−44.5 μm, bilateral, concavo-convex to plano-convex; ornamentation: rough.

Thailand.— PENINSULAR: Narathiwat (Hala-Bala), Satun (Khao Khieo range), Yala (Ban Phu Khao Thong, Betong).

Distribution.— Malaysia, Indonesia.

Ecology.— On moist mountain slope by streams in evergreen forest at about 700 m alt.

Specimens Examined.—**THAILAND**. Satun, *A. F. G. Kerr 14541* (BK); Narathiwat, Hala-Bala, *T. Boonkerd & R. Pollawatn 287* (BCU); Yala, Ban Phu Khao Thong, *T. Boonkerd 1176* (BCU); **MALAYSIA**. Negri Sembilan Gunong Telapak Burok, *A. G. Piggott 1633* (K); Perak, *B. Scortechini s.n.* (K); Penang, *C. Curtis 570* (K); Perak, *C. G. Matthew s.n.* (K); Sabah, *C. V. Creagh s.n.* (K); Perak, *Dr. King's Collector 2156* (K); ibid., *Dr. King's Collector 7121* (K); Pahang, *E. Smith 865* (K) Perak, *F. E. W. Venning MA68* (K); ibid., *G. F. Hose s.n.* (K); Pahang, *G. H. Addison 37182* (K); ibid., *G. H. Addison SFN37182* (K); Pahang, *H. N. Ridley 13974* (K); Perak, *H. N. Ridley 14225* (K), Sarawak, *J. Clemens & M.S. Clemens 20406* (K); Pahang, *R. E. Holttum 11474* (K); ibid., *W. F. Mactier s.n.* (K); **INDONESIA**. Java, *C. Curtis 10* (K); Sumatra, *E. Gardette 315* (K); ibid., *E. Gardette 540* (K); Sumatra, *H. Wiriadinata 1449* (K); Java, *H. Zollinger 3092* (K); Sumatra, *J. A. Lörzing 14148* (K); Sumatra,*K. Iwatsuki, G. Murata, J. Dransfield & Saerudin S844* (K); Java, *M. Fleisher s.n.* (K); Kalimantan, *M. Kato, G. Murata & Y.P. Mogea B3804* (K); ibid., *M. Kato, G. Murata & Y. P. Mogea B3506* (K); Java, *M. Raciborski s.n.* (K); Java, *T. Lobb s.n.* (K); Sumatra, *W. Hancock 78* (K).

5.5.28 ***Diplazium sylvaticum*** (Bory) Sw., Syn. Fil.: 92. 1806; Bedd., Handb. Fern Brit India: 177. 1883; Holtt., Gard. Bull. Straits Settlem. 11(1): 99. 1940; Tagawa & K. Iwats., SouthE. Asian Stud. 3(3): 87. 1965; Tagawa & K. Iwats., Acta Phytotax. Geobot. 23: 56. 1968; M. Tagawa & K. Iwats., Fl. Thailand 3(3): 459. 1988; A.G. Piggott., Fern of Malaya in colour: 307, f. 944-946. 1996.— *Callipteris sylvativum* Bory, Voy. Iles Atrique 1: 282. 1804.— *Athyrium pinnatum* (Blanco) Copel., Philipp. J. Sci. Bot. 3: 297. 1908; Rev. Fl. Malaya 2: 560, f. 331. 1955.— *Allantodia sylvatica* (Bory) Ching, Acta Phytotax. Sin. 9(4): 356–357. 1964.— *Asplenium sylvaticum*

(Bory) C. Presl, Reliq. Haenk. 1(1): 42. 1825. Type: France, *Bory, J. B. G. M. s.n.*[holotype P photo seen! (P00483043)]. Figure 5.44, 5.61 A

Plants terrestrial. *Stem*s erect, 1.0–1.5 cm in diameter, scaly at apex; scales 5.5−6.0 × 0.4−0.8 mm, linear with long-tail apex, concolorous, dark brown to nearly black, margin toothed. *Leaves* 50−80 cm long, pinnate; petioles 30−50 cm long, 5−6 mm in diameter, deep green when living, stramineous when dry, lower portion black, glabrous, base scaly. *Laminae* 20−30 × 15−20 mm, ovate-subdeltoid in outline, terminal pinna not distinct; lateral pinnae 8−11 pairs, 8−12 × 2.0−4.5 cm, lower pinnae shortly stalked, upper pinnae sessile or adnate with rachis, subfalcate, apex acuminate, base subtruncate or obtuse, less auricled at acroscopic base, margin crenate to lobed, margin near apex dentate to serrate; veins free, pinnate, 3−4 pairs. *Sori* 3−5 mm long, elongate along veins, often on every veinlets, longest on acrocsopic veinlets of vein group, indusiate; indusia linear, thin, persistent. *Spores* monolete, 56.0−60.5 × 32−40 μm, bilateral, concavo-convex to plano-convex; ornamentation: prominent wing folds.

Thailand.— NORTHERN: Phitsanulok (Thung Salaeng Luang); NORTH-EASTERN: Loei (Phu Kradueng); SOUTH-WESTERN: Uthai Thani (Ban Rai), Kanchanaburi (Khao Ngi Yai); SOUTH-EASTERN: Chanthaburi (Kao Soi Dao), Trat (Koh Chang); PENINSULAR: Chumporn (Khao Tong), Surat Thani (Klong Ton, Ban Don), Phangnga, (Khao Pok), Phuket (Khao Pateaw), Krabi (Phanom Bencha), Nakhon Si Thammarat (Krung Ching Waterfalls, Khao Luang, Khao Nan), Trang (Khao Chong), Satun, Songkhla (Ton Nga Chang Waterfalls), Yala (Betong),

Distribution.— India, Myanmar, Philippines, Malaysia, Indonesia, Papua New Guinea.

Ecology.— On mountain slopes in moist places in dense evergreen forests at low to medium elevations, usually below 1,200 m alt.

Specimens Examined.—**THAILAND**. Satun, *A. F. G. Kerr 14494* (BM); Krabi, *A. F. G. Kerr 18667* (BK); Nakhon Si Thammarat, Khao Luang, *E. Hennipman 3773* (L); Nakhon Si Thammarat, Krung Ching Water falls, *J. F. Maxwell 85-1127* (L, PSU); Nakhon Si Thammarat, Khao Luang, *J. F. Maxwell 85-314* (L); Nakhon Si Thammarat, Khao Nan, *J. F. Maxwell 85-314* (PSU); Trang, Khao Chong, *M. Tagawa, K. Iwatsuki & N. Fukuoka T5584* (L); Songkhla, Ton Nga Chang Waterfalls,

N. Putthisawong 83 (PSU); Nakhon Si Thammarat, Khao Nan, *T. Boonkerd, S. Chantanaorapint & W. Khwaiphan 503* (BCU); Phuket, Khao Pateaw, *T. Shimizu et al. T27214* (L); **INDONESIA**. Java, *C.L. Blume s.n.* (K); Halimun Salak Mt., *C. W. Weiran 360* (PE); Kampung Baru, *D. R. Pleyte 448* (K). **PAPUA NEW GUINEA**. Port Moresby Owers corner, *B.S. Parris & J.P. Croxall 4441* (K); Morobe Dist., *S. Parris & J.P. Croxall 8316* (K); ibid., *B. S. Parris & J.P. Croxall 9520* (K); Morobe Dist., *C. Unkau 45* (K); East New Britain, *D. B. Foreman LAE52111* (K); Morobe, *J. R. Croft & J. J. Marsh 894* (K); Rambutyo Island, *J. R. Croft 1150* (K); Manus Island, *J. R. Croft 1197* (K); West Sepik Prov., *J. R. Croft 1548* (K); Unknown, *L.E. Cheesman 54* (K); Morobe, *T. Nakaike 439* (K).

Note.—This species is similar to *D. crenato-serratum* but differed in having scales with distinctly toothed at margin, pinnae are more wider, and small auricle at acroscopic base.

5.5.29 ***Diplazium tomentosum*** Blume, Enum. Pl. Javae 2: 192. 1828; Bedd., Handb.: 179. 1883; Tard. & C. Chr., Fl. Indo-Chine 7(2): 257. 1940; Tagawa & K. Iwats., SouthE. As. St.. 5: 103. 1967; Tagawa & K. Iwats., Fl. Thailand 3(3): 457. 1988; A. G. Piggott., Fern of Malaya in colour: 295, f. 908-911. 1996.— *Athyrium tomentosum* (Blume) Milde, Bot. Zeit. 1870: 354; Holtt., Rev. Fl. Malaya 2: 551. f. 324. 1955.Type: Indonesia, *Blume s.n.* [holotype L! (L0051073)].Figure 5.45, 5.61 B

Plants terrestrial. *Stems* erect, 0.4−1.0 cm in diameter, bearing wiry roots, apex scaly; scales about 1.0 × 0.3 cm, narrowly-lanceolate with long-tail apex, concolorous dark brown, margin entire. *Leaves* 35−52 cm, pinnate; petioles 15−25 cm, 2−3 mm in diameters, tomentose, brown to nearly black, lower portion scaly. *Laminae* 20−27 × 8−13 cm, narrowly-deltoid in outline, deep green, iridescent blue when living; rachis densely covered with short multicellular hairs with brown septa; pinnae 25−30 pairs, terminal pinna not distinct, laterial pinnae gradually becoming smaller upwards, lower pinnae largest, about 5 × 1 cm, linear-lanceolate, sessile or shortly stalked, upper pinnae sessile, lower and middle pinnae shortly stalked, basal pairs more or less reflexed, acroscopic base auricled, apex acute, base subtruncate, margin serrate to lobe; lobes about 5 × 3 mm, 1/3−2/3 way to costa, oblique, oblong, apex acute; veins pinnate, veinlets simple or forked. *Sori* 2−3 mm long, elongate

along vein, on basal acroscopic veinlets, indusiate; indusia narrowly-oblong, crescentic, persistent. *Spores* monolete, 30.0−34.5 × 24.5−26.0 μm, bilateral, concavo-convex to plano-convex; ornamentation: prominent wing folds.

Thailand.— NORTHERN: Nan (Doi Phuka); EASTERN: Nakhon Ratchasima; CENTRAL: Nakhon Nayok (Khao Yai), Prachinburi (Khao Yai); SOUTH-EASTERN: Chanthaburi (Khao Sabap, Khao Sip-ha Chan), Trat (Bo Rai), Prachin Buri; PENINSULAR: Chumphon (Lang Suan, Patoh), Surat Thani (Khao Nom Sao), Krabi (Phanom Bencha), Nakhon Si Thammarat (Krung Ching Waterfalls, Khao Luang, Khao Nan,), Trang (Khao Sung), Songkhla (Ton Nga Chang Waterfalls), Narathiwat (Phu Khao Thong, Sukirin, Waeng).

Distribution.— Myanmar, Veitnam, Philippines, Malaysia, Singapore, Brunei, Indonesia.

Ecology.— On mountain slopes in moist, shady evergreen forests at 200−1,250 m alt.

Specimens Examined.—**THAILAND**. Chumphon, Lang Suan, *A.F.G. Kerr 12015* (BK, BM); Krabi, *A.F.G. Kerr 18673* (BM, BK); Nakhon Ratchasima, *A. F. G. kerr 9511* (BK); Nakhon Si Thammarat, Khao Luang, *B. Ohusing et al. 3* (PSU); Trung, *C. Apasutaya 127* (BCU); Songkhla, Ton Nga Chang Waterfalls, *C. Kraithep 23* (PSU); Nakhon Si Thammarat, Khao Luang, *C. F. van Beusekom & C. Phengklai 806* (L); Nakhon Si Thammarat, Khao Luang, *E. Hennipman 3799A* (L); ibid., *E. Hennipman 3818* (B, BM, L); Prachinburi, Khao Yai, *E. Hennipman 3988* (L); Nakorn Nayok, Khao Yai, *J. F. Maxwell 01-356* (L); Nakhon Si Thammarat, Krung Ching Waterfalls, *J. F. Maxwell 86-327* (L); Narathiwat, Sukirin, *J. F. Maxwell 87-259* (PSU); Nakhon Si Thammarat, Khao Luang, *J. F. Maxwell 87-327* (PSU); Chanthaburi, Khao Sip-ha Chan, *K. Kertsawang 580* (QBG); *K. Larsen et al. 40896* (K); Nakhon Si Thammarat, Khao Luang, *M. Tagawa, K. Iwatsuki & N. Fukuoka T4622* (L); ibid., *M. Tagawa, K. Iwatsuki & N. Fukuoka T4681* (L); ibid., *M. Tagawa, K. Iwatsuki, H. Koyama & A. Chintayungkun T4622* (L); Nan, Doi Phuka, *P. Pongkai 31* (BCU); Nakhon Si Thammarat, Khao Luang, *P. Pongkai 57* (BCU); ibid., *P. Pongkai 58* (BCU); ibid., *P. Pongkai 59* (BCU); ibid., *P. Pongkai 117* (BCU); Narathiwas, Phu Khao Thong, *T. Boonkerd 1518* (BCU); Chumphon, Patoh, *T. Boonkerd 1534* (BCU); Nakhon Si Thammarat, Khao Luang, *T. Boonkerd 330*

(BCU); **MALAYSIA**. Perak, *A. Ernst 1151* (K); Unknown, *A. C. Maingay 1772* (K); Pahang, *A. G. Piggott 1549* (K); Burok, *A. G. Piggott 1864* (K); Negeri Sembilan Gunong Telapak, *A. G. Piggott 1903* (K); Pahang, *A. G. Piggott 2429* (K); Selangor, *A. G. Piggott 2755* (K); Pahang, *A. G. Piggott 3101* (K); Selangor, *B. Molesworth-Allen 3383* (K); Perak, *B. Scortechini s.n.* (K); Pahang, *B. S. Parris & P. J. Edwards 10394* (K); Pahang, *B. S. Parris 10884* (K); Sabah, *B. S. Parris 11373* (K); Sarawak, *B. S. Parris 6566* (K); ibid., *B. S. Parris 6572* (K); Penang, *C. Curtis 1267* (K); Selangor, *C. B. Kloss s.n.* (K); Unknown, *D. F. A. Hervey & H. N. Ridley 4340* (K); Selangor, *D. W. Lee UL28* (K); Perak, *Dr. King's Collector 658* (K); ibid., *Dr. King's Collector 2412* (K); ibid., *Dr. King's Collector 10751* (K); Pahang, *E. Smith 818* (K); Trengganu, *E. J. H. Corner 30104* (K); Negeri Sembilan Bukit Tangga, *E. S. Hose & G. Hose 5043* (K); Perak, *F. E. W. Venning MA85* (K); Perak, *G. F. Hose s.n.* (K); Pahang, *G. H. Addison SFN37191* (K); Borneo, *Giles & Wooliams 294* (K); Malacca, *H. Cuming 131* (K); ibid., *H. Cuming 386* (K); Perak, *H. C. Robinson s.n.* (K); Sabah, *H. F. Comber 4135* (K); Perak, *H. N. Ridley 11428* (K); Selangor, *H. N. Ridley 13438* (K); Perak, *H. N. Ridley 14224* (K); Pahang, *H. N. Ridley 16213* (K); Selangor, *H. N. Ridley s.n.* (K); ibid., *H. N. Ridley s.n.* (K); Selangor, *H. N. Ridley, W. Robinson & C. B. Kloss s.n.* (K); Perak, *J. Day s.n.* (K); Perak, *J. Sinclair & Kiah 38744* (K); Negeri Sembilan Bukit Tannga, *M. Nur s.n.* (K); Johore, *P.J. Edwards 1906* (K); Sabah, *P.S. Shim SAN81806* (K); Selangor Kanching Forest, *R. Melville 4744* (K); Negeri Sembilan Gunong Tampin, *R. E. Holttum 9537* (K); Pahang, *R. E. Holttum s.n.* (K); Perak, *R. H. Yapp 520* (K); Malacca, *W. Griffith s.n.* (K); Perak, *W. Robinson s.n.* (K); **PHILIPPINES**.Unknown, *H. Cuming 336* (K); **BRUNEI**.Tutong Dist., *M. J. E. Coode 6321* (K); Temburong *P. S. Ashton 467* (K); **INDONESIA**. Java, *C. L. Blume s.n.* (K); Halimun-Salak, *C. W. Weiran 197* (PE); ibid., *C. W. Weiran 343* (PE); Sumatra Jambi Prov., *E. Gardette 190* (K); Sumatra, *E. Gardette 351* (K); Borneo, *F.W. Burbidge s.n.* (K); Java, *G. Mettenius 4581* (K); Sumatra, *K. Iwatsuki, G. Murata, J. Dransfield & Saerudin S872* (K); Kalimantan, *K. Iwatsuki, M. Kato, G. Murata & Y. P. Mogea B393* (K); Seram, *M. Kato, K. Ueda & Z. Fanani C13363* (K); Kalimantan, *M. Kato, M. Okamoto & E. B. Walujo B10242* (K); Kalimantan, *T. G. Laman, I. A. Rachman & E. Mirmanto 93* (K); ibid., *T. G. Laman, I. A. Rachman & E.*

Mirmanto 105 (K); ibid., *T. G. Laman, I. A. Rachman & E. Mirmanto 253* (K); Sumatra, *W. Hancock 16* (K); **SINGAPORE**. Bukit Timah, *C. G. Matthew s.n.* (K).

5.5.30 *Diplazium xiphophyllum* (Baker) C. Chr., Ind. Fil.: 241. 1905; Holtt., Gard. Bull. S.S. 11: 106. 1940; Tagawa & K. Iwats., SouthE. As. St. 5: 102. 1967; Acta Phytotax. Geobot. 23: 56. 1968; Tagawa & K. Iwats., Fl. Thailand 3(3): 454. 1988; A.G. Piggott., Fern of Malaya in colour: 299. f. 921-923. 1996.— *Athyrium xiphophyllum* Baker, J. Bot. 1879: 40; Holtt., Rev. Fl. Malaya 2: 553. 1955. Type: Malaysia, *Veitch, s.n.* [holotype K! (K000491792); isotype K! (K000491791)]. Figure 5.46, 5.61 C

Plants terrestrial. *Stem*s erect, 4−5 cm in diameter, clothed with scales at apex; scales 10−15 × 1.5−2.0 mm, linear with long tail apex, concolorous, brown, margin entire. *Leaves* up to 1.4 m long, simple pinnate; petioles up to 80 cm long, 5−6 mm in diameter, glabrous, light green, dark brown and scaly near base. *Laminae* 50−60 × 40−50 cm, oblong in outline, glabrous, subcoriaceous, light green; terminal pinna distinct like lateral one, 15−20 × 3−4 cm, oblong, apex attenuate, base cuneate, margin subentire or lobed; lateral pinnae 4−7 pairs, alternate, 25−30 × 4−5 cm, oblong, apex attenuate, base cuneate, margin subentire, stalked; stalks 2−3 mm long; veins pinnate, veinlets 2 pairs, free, occasionally anastomosing but never copiously; gemmae sometimes present on rachis. *Sori* 2.0−2.5 cm long, elongate along veinlets, usually longest on basal veinlets of vein group, diplazoid; indusia thin, persistance. *Spores* monolete, 32.5−40.0 × 25.5 −27.0 µm, bilateral, concavo-convex to plano-convex; ornamentation: prominent wing folds.

Thailand.— PENINSULAR: Nakhon Si Thammarat (Krung Ching Waterfalls, Khao Luang, Khao Nan), Narathiwat (Ban Waeng), Yala (Ban Chana).

Distribution.— Philippines, Malaysia, Brunei, Indonesia.

Ecology.— On moist mountain slopes in shady dense evergreen forests at 500-1,100 alt.

Specimens Examined.— **THAILAND**. Nakhon Si Thammarat, Khao Luang, *M. Tagawa, K. Iwatsuki & N. Fukuoka T5304* (L); Nakhon Si Thammarat, Khao Luang, *P. Pongkai 113* (BCU); Nakhon Si Thammarat, Krung Ching Waterfalls, *P. Pongkai 143* (BCU); Nakhon Si Thammarat, Khao Nan, *T. Boonkerd, S.*

Chantanaorapint & W. Khwaiphan 62 (BCU); Nakhon Si Thammarat, Khao Nan, *T. Boonkerd, Y. Sirichamorn & C. Sanguansab 241* (BCU); **MALAYSIA**. Pahang, *A. G. Piggott 2915* (K); ibid., *A. G. Piggott 2956* (K); ibid., *A. G. Piggott 2963* (K); ibid., *A. G. Piggott 3000* (K); Selangor, *A. G. Piggott 3139* (K); Pahang, *A. G. Piggott 2963* (K); Selangor, *A. G. Piggott 3139* (K); Perak, *B. Molesworth-Allen 2732* (K); ibid., *B. Molesworth-Allen 2858* (K); Pahang, *B. S. Parris & P. J. Edwards 10403* (K); Sabah, *B. S. Parris 10720* (K); Perak, C. *Curtis 1361* (K); Sabah, *C. B. Kloss SFN19028* (K); Perak, *C. G. Matthew s.n.* (K); Perak, *G. F. Hose 285* (K); Selangor, *H. N. Ridley 7833* (K); Sabah, *J. Clemens & M. S. Clemens 29406* (K); ibid., *J. Clemens & M. S. Clemens 29438* (K); Sabah, *J. Low s.n.* (K); Kalimantan, *K. Iwatsuki, M. Kato, G. Murata & Y.P. Mogea B1910* (K); Kinabalu, *M. S. Clemens 29438* (BM); Sabah, *R. E. Holttum SFN25258* (K); Selangor, *R. E. Holttum SFN37357* (K); Perak, *W. Robinson 39* (K); Sabah, *W. L. Chew, E. J. H. Corner & A. Stainton 1438* (K); **PHILIPPINES**. Mindanao, *A. D. E. Elmer 11319* (K); ibid.,*A. D. E. Elmer 11745* (K); Paragua, *E. D. Merrill 746* (K); Leyte, *H. Cuming 305* (K); **BRUNEI**. Temburong, *A. D. Poulsen 114* (K); **INDONESIA**. Sumatra, *E. Gardette 359* (K); Borneo, *F.W. Burbidge s.n.* (K); ibid.,*Veitch s.n.* (K).

5.5.31 ***Diplazium thailandicum*** Pongkai, Boonkerd & Pollawatn, Phytotaxa 379(2): 227–230. 2018. Type:—THAILAND. Phitsanulok Province: Mun Dang Waterfalls, alt. 1,650 m, 9 July. 2014, *P. Pongkai 107* (holotype BCU!, isotypes KUN!, MO!). Figure 5.47, 5.61 D

Plants terrestrial. *Stem* creeping, 0.5–1.0 cm in diameter, densely corvered with scales; scales 8–10 × 1–2 mm, linear lanceolate with long tail apex, concolorous, dark brown to nearly black, denticulate and thick at margin. *Leaves* 72–93 cm, monomorphic, imparipinnate; petioles 29–47 cm long, 3–5 mm in diameter, deep green when living, brown when dried, black and scaly at base, groove above. *Laminae* 43–50 × 23–33 cm, ovate to lanceolate-oblong in outline, papyraceous; rachises grooved, glabrous; pinnae 5–8 pairs, subopposite to alternate, terminal pinna distinct, different form lateral pinnae; terminal pinna 17–19 × 3.5–8.0 cm, narrowly ovate in outline with usually slightly pinnatisect at base, widest at base, apex long acuminate, base obtuse to subtruncate, margin subentire to slightly lobe; largest lobe

2.0–4.5 × 1.0–1.5 cm, lanceolate, apex acute to acuminate, margin subentire; lateral pinnae 14–22 × 2.5–3.0 cm, oblong, apex long acuminate, base obtuse to subtruncate sometimes slightly oblique, margin subentire, serrate near apex, stalked; stalk 2–4 mm; vein all free, veinlets 3-4 pairs, pinnate, reaching margin. *Sori* curved, elongate along veinlet, 0.5–0.7 cm long, half way between midrib and margin, usually on acroscopic veinlet of each vein group, close to midrib, indusiate; indusia linear, thin, persistence. *Spores* monolete, bilateral symmetric, kidney-shaped, 61.5–63.0 × 31–32 μm, perispore: prominent wing folds.

Thailand.— NORTHERN: Chiang Rai (Me Lao), Phitsanulok *(Phu Hin Rong Kla)*, Nakhon Sawan (Doi Musae).

Distribution.— Endemic to Thailand.

Ecology.— grow in shady valleys at elevations ranging from 580–1650 m.

Specimens Examined.— **THAILAND**. Doi Musoe, Nakhon Sawan Province, *E. Hennipman 3056* (L); Mun Daeng Waterfalls, Phitsanulok Province, *P. Pongkai 107* (BCU); *Phu Hin Rong Kla National Park*, Phitsanulok Province, *Pteridophyte trip 72* (BCU)*; Phu Hin Rong Kla National Park*, Phitsanulok Province, *W. Rattanathirakul 29, 106* (BCU); Me Lao, Chiang Rai Province, *Winit 958* (B, K).

Note.— This new species is similar to *Diplazium chioui* T.C. Hsu and *D. lobatum* (Tagawa) Tagawa in having creeping rhizome, once-pinnate frond, and scale with thick margin, but differs in having a terminal pinna with pinnatisect base, oblong lateral pinnae with stalk < 5 mm, lateral pinnae 5–8 pairs, and sori curved and located half way between midribs and pinna margins. In contrast, *D. chioui* and *D. lobatum* have a terminal pinna with slightly lobed base, oblong lateral pinnae with a stalk of 5–10 mm, lateral pinnae 3–5 pairs, sori straight and usually as long as the length of veinlets.

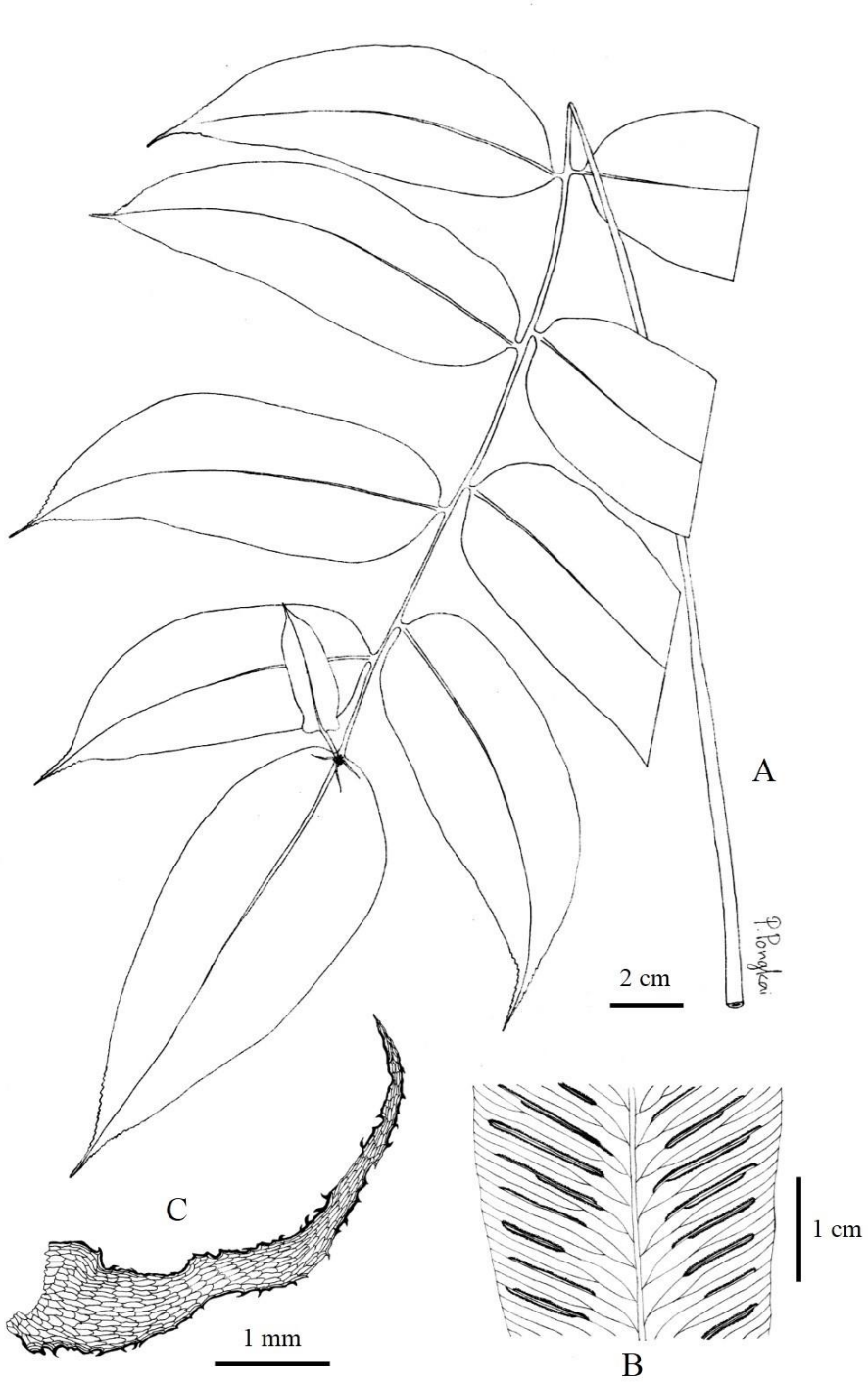

Figure 5.17 *Diplazium bantamense* Blume. A. part of a proliferus frond. B. part of pinna with sori. C, a scale showing toothed and black marginal cells. Drawn by Puttamon Pongkai from *P. Pongkai 62* (BCU).

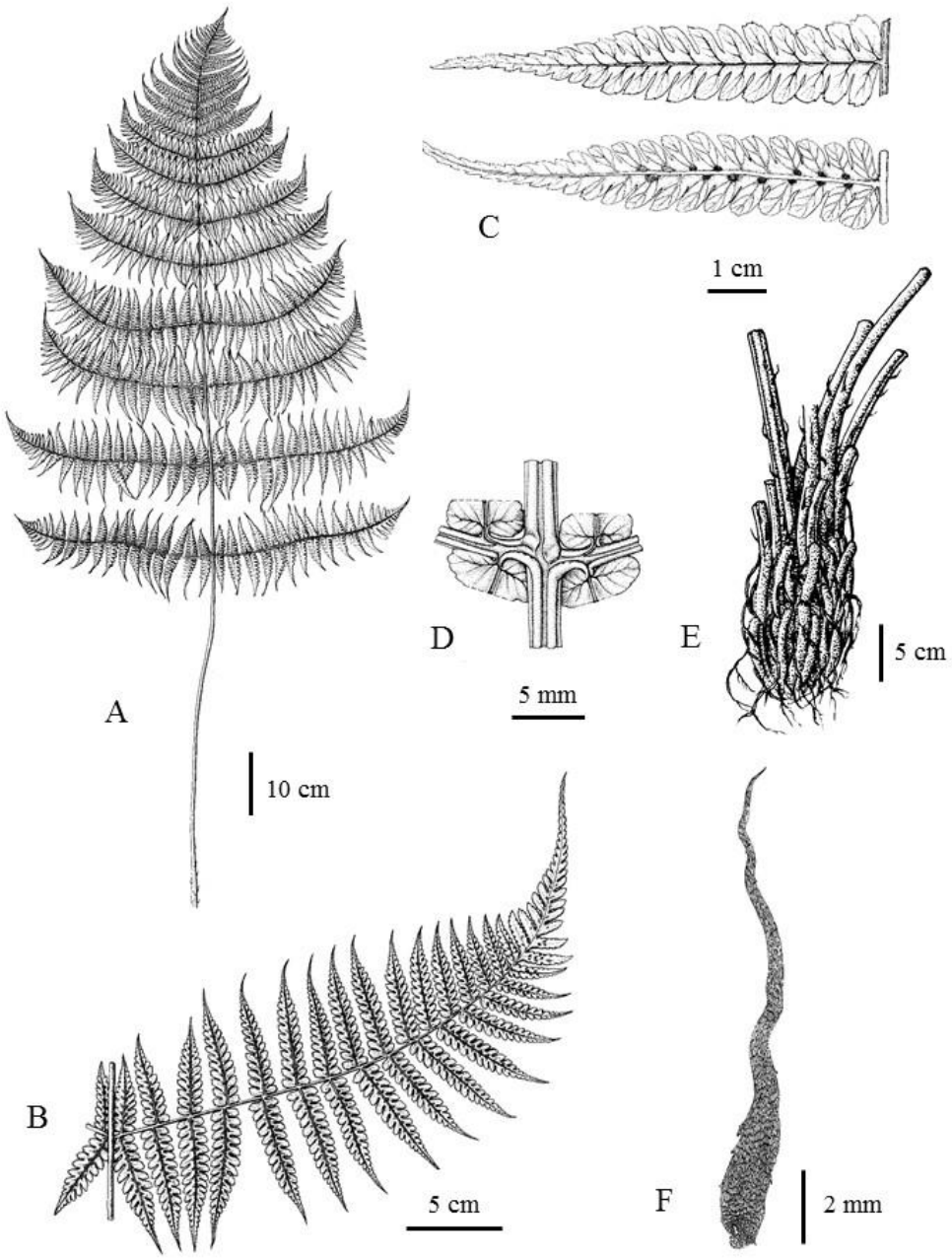

Figure 5.18 *Diplazium bellum* (Blume) T. Moore. A. part of a frond. B. a pinna. C. a pinnule showing venation and sori. D. out growth (wing) at junction between rachis and costa. E. rhizome and F. a scale showing entire and not black marginal cells. Drawn by Wilaiwan Nuchthongmuang from *P. Pongkai 138* (BCU).

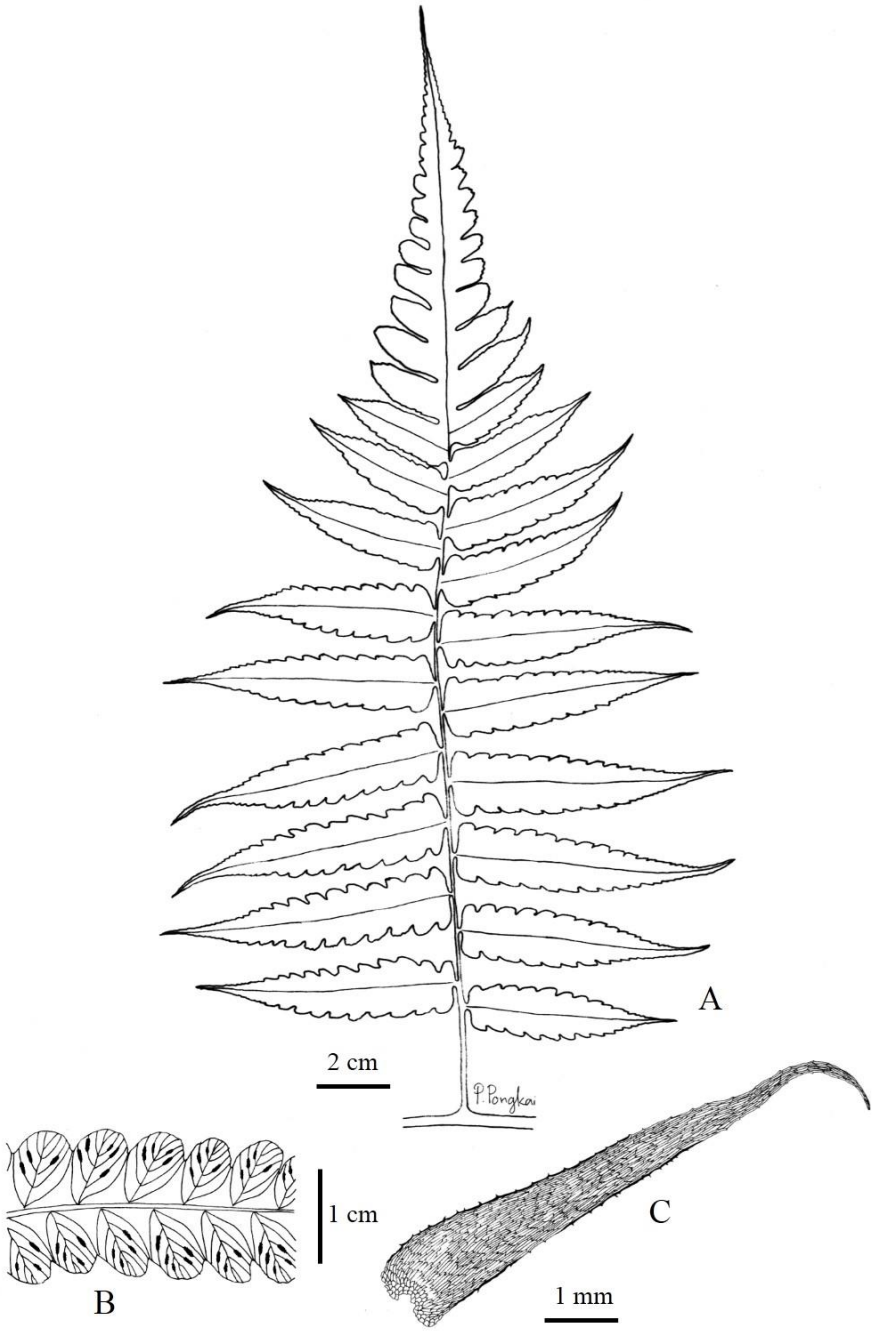

Figure 5.19 *Diplazium conterminum* Christ. A. a lateral pinna. B. part of a pinnule showing venation and sori. C. a scale showing toothed and black marginal cells. Drawn by Puttamon Pongkai from *P. Pongkai 15* (BCU).

Figure 5.20 *Diplazium cordifolium* Blume. A. a whole plant with two fronds. B. part of a lamina showing venation and sori. C. a scale showing entire and black marginal cells. Drawn by Puttamon Pongkai from *T. Boonkerd 1516* (BCU).

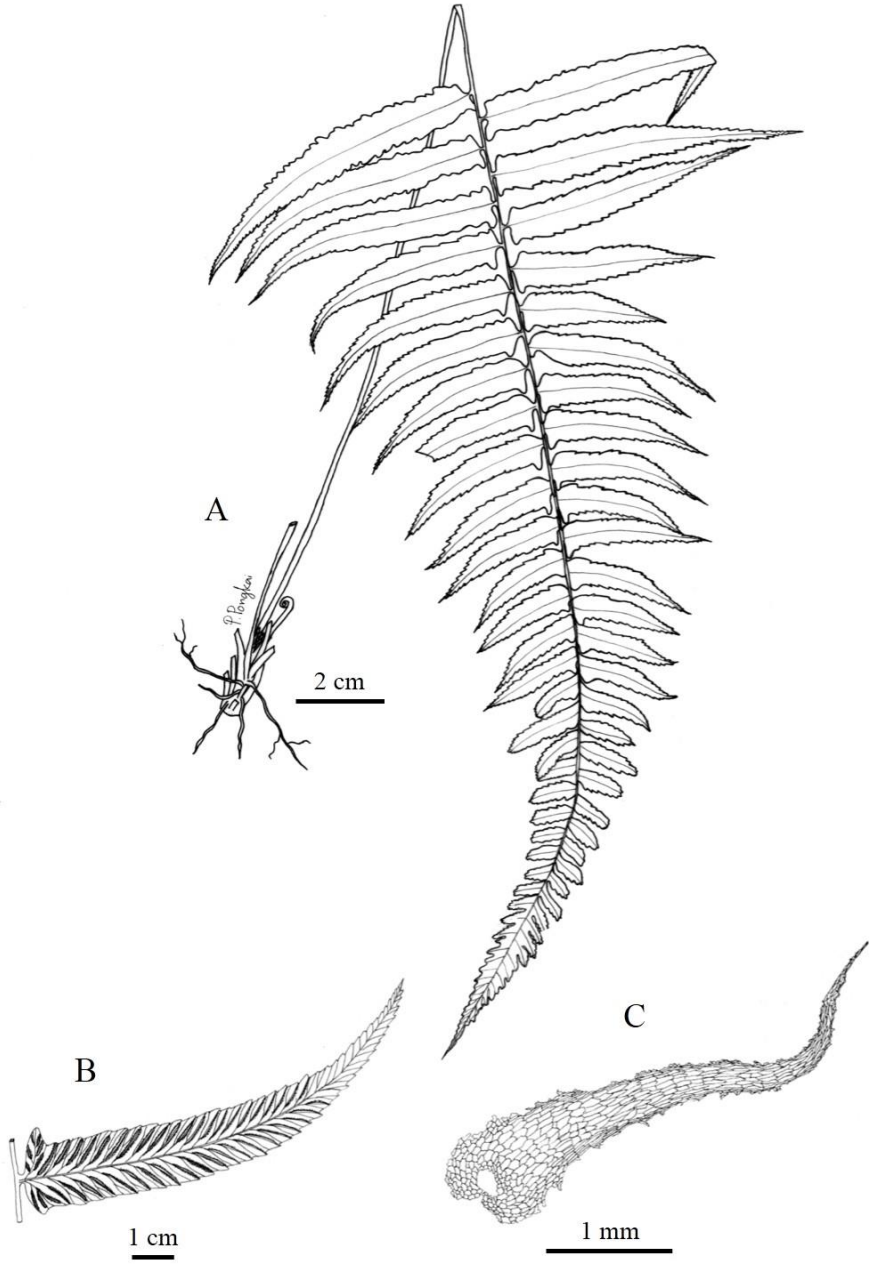

Figure 5.21 *Diplazium crenato-serratum* (Blume) T. Moore. A. a whole plant. B. a pinna with sori. C. a scale showing toothed and not black marginal cells. Drawn by Puttamon Pongkai from *P. Pongkai 27* (BCU).

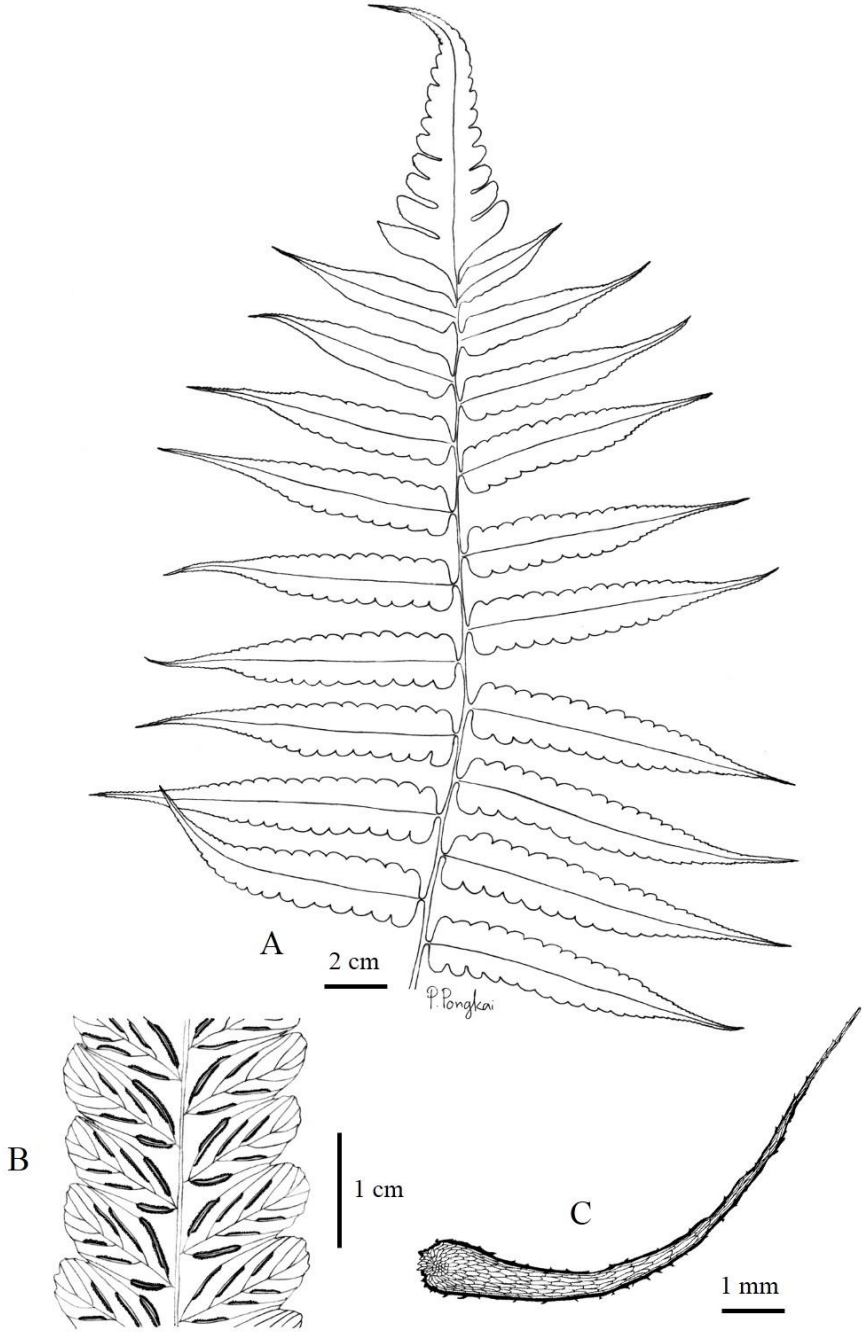

Figure 5.22 *Diplazium dilatatum* Blume. A. part of a pinna. B. part of a pinnule showing venation and sori. C. a scale showing toothed and black marginal cells. Drawn by Puttamon Pongkai from *P. Pongkai 14* (BCU).

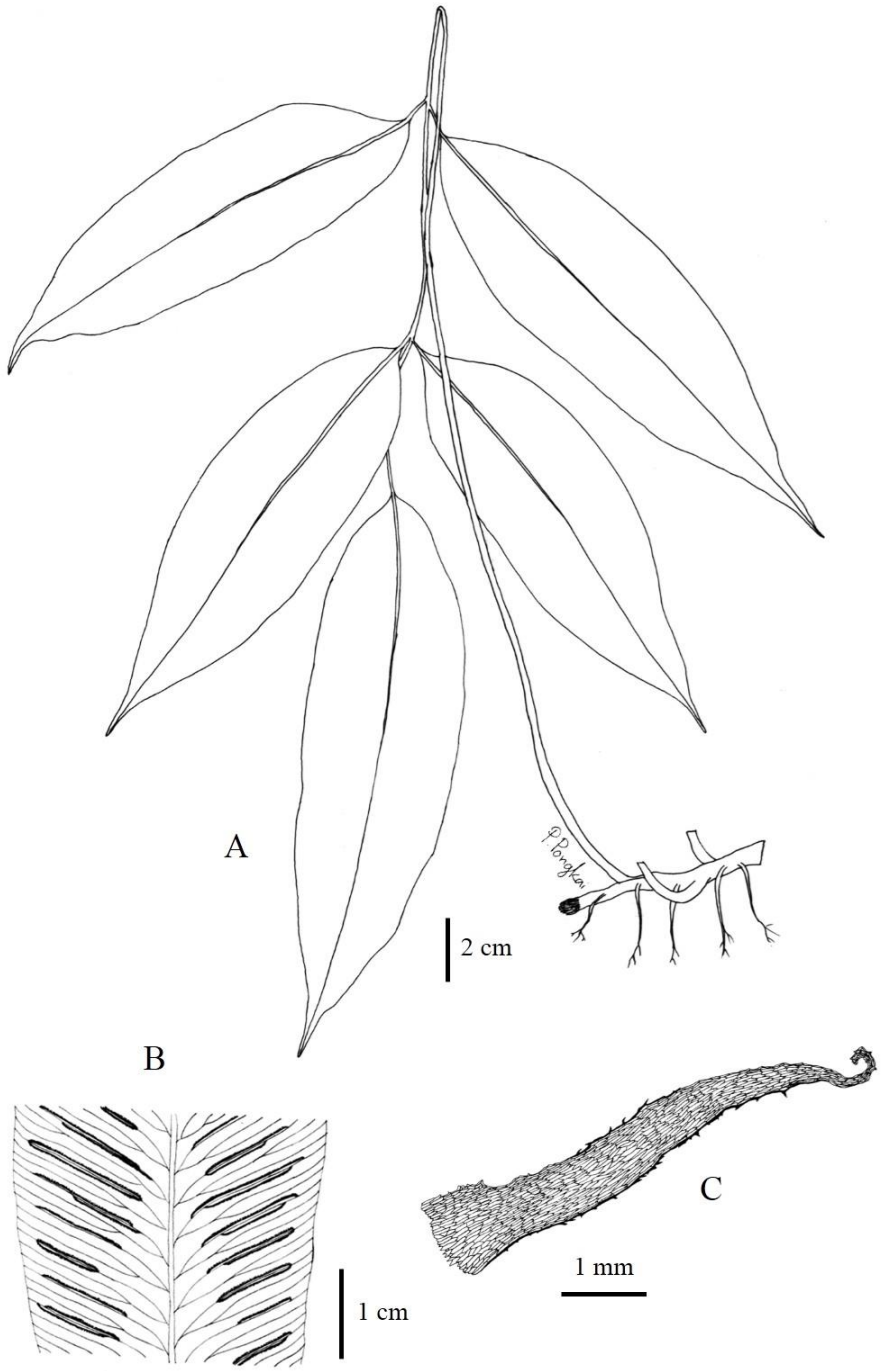

Figure 5.23 *Diplazium donianum* (Mett.) Tardieu. A. a whole plant with one frond. B. part of a pinna showing venation and sori. C. a scale showing toothed and black marginal cells. Drawn by Puttamon Pongkai from *A. Sathapattayanon 41* (BCU).

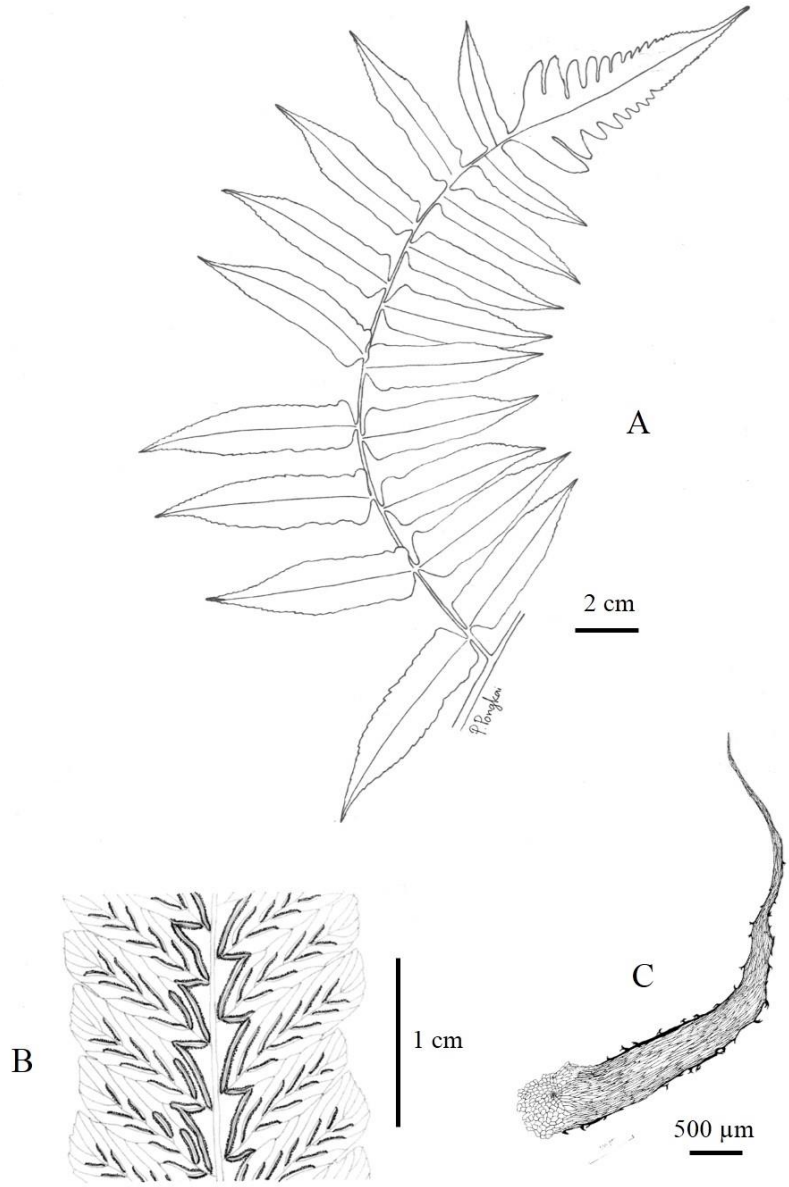

Figure 5.24 *Diplazium esculentum* (Retz.) Sw. A. a lateral pinna. B. part of a pinnule showing venation and sori. C. a scale showing toothed and black marginal cells. Drawn by Puttamon Pongkai from *T. Boonkerd 17* (BCU).

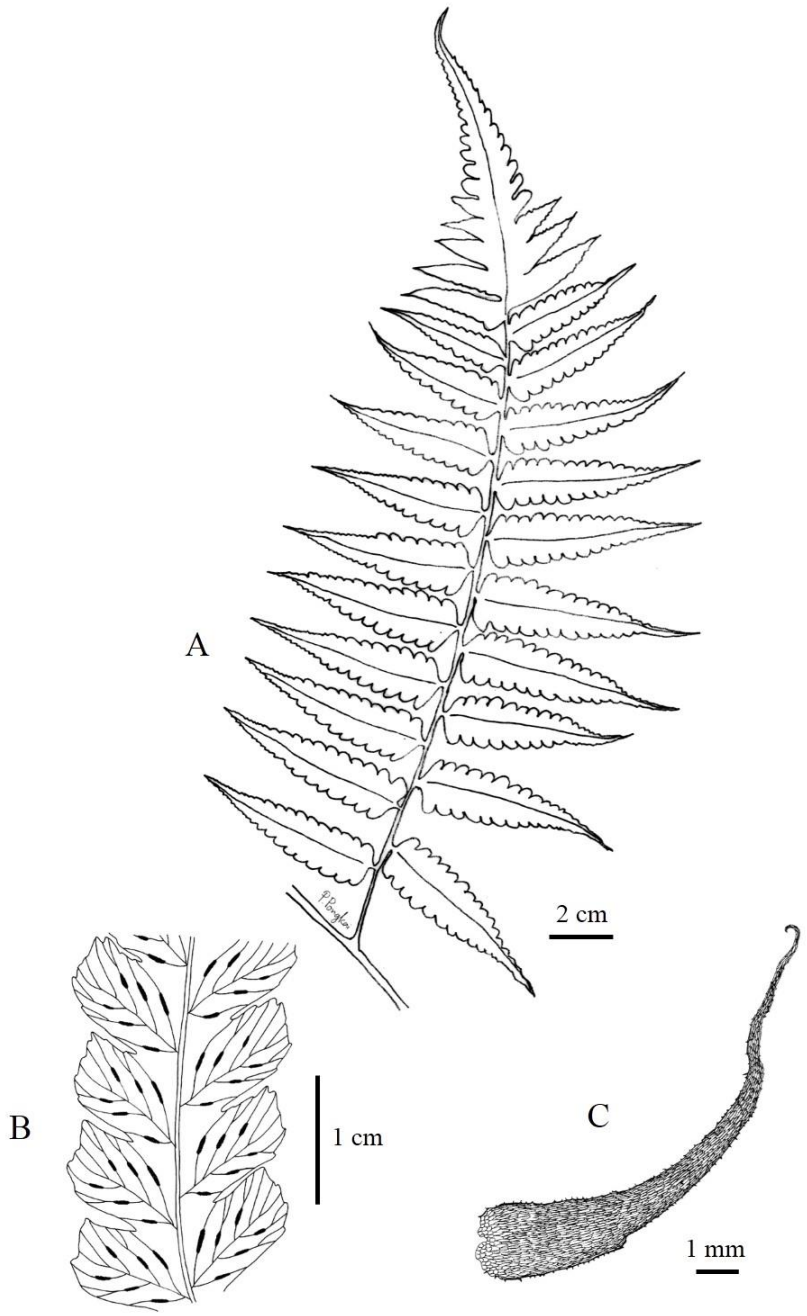

Figure 5.25 *Diplazium kappanense* Hayata. A. a lateral pinna. B. part of a pinnule showing venation and sori. C. a scale showing toothed and black marginal cells. Drawn by Puttamon Pongkai from *P. Pongkai 160* (BCU).

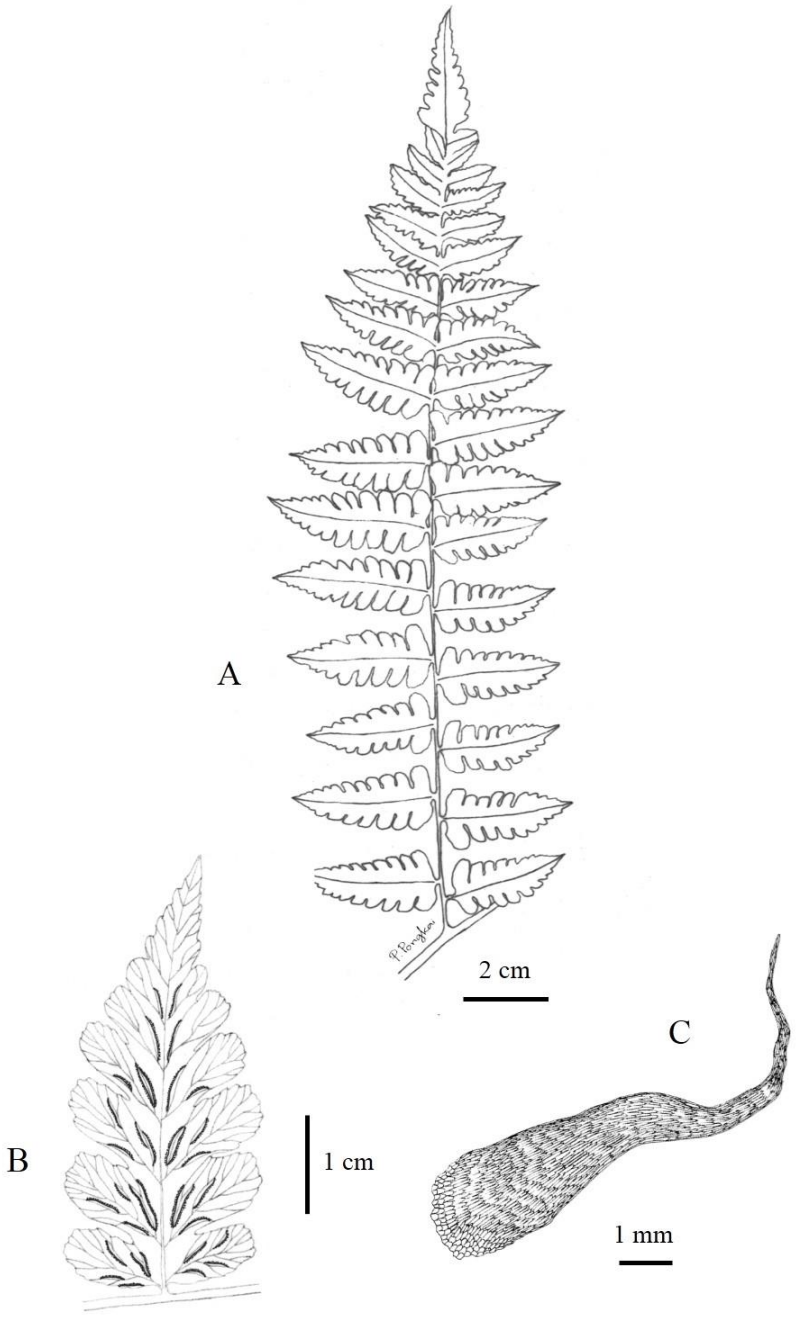

Figure 5.26 *Diplazium leptophyllum* Christ. A. a lateral pinna. B. part of a pinnule showing venation and sori. C. a scale showing entire and black marginal cells. Drawn by Puttamon Pongkai from *P. Pongkai 79* (BCU).

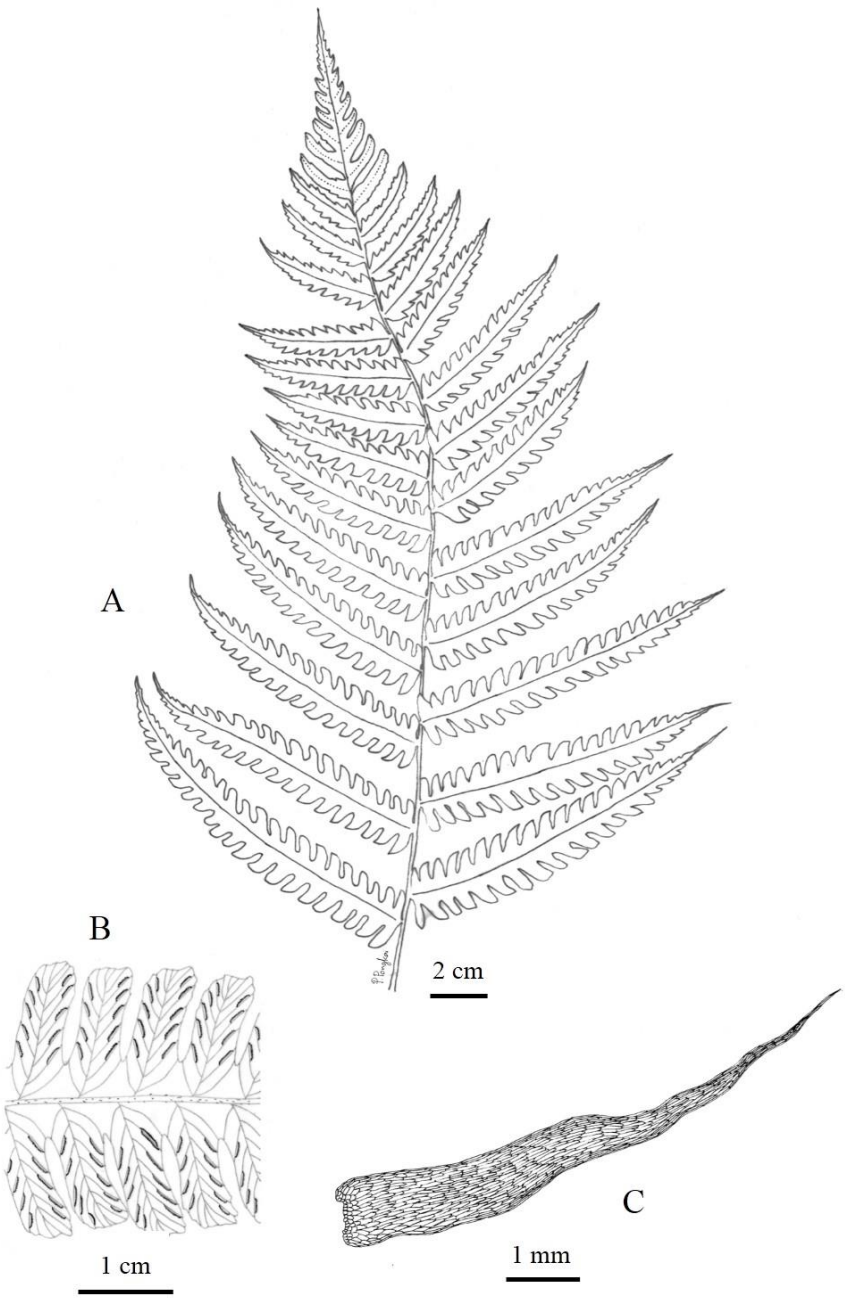

Figure 5.27 *Diplazium malaccense* C. Presl. A. a lamina. B. part of a pinna showing venation and sori. C. a scale showing entire and not black marginal cells. Drawn by Puttamon Pongkai from *T. Boonkerd 1473* (BCU).

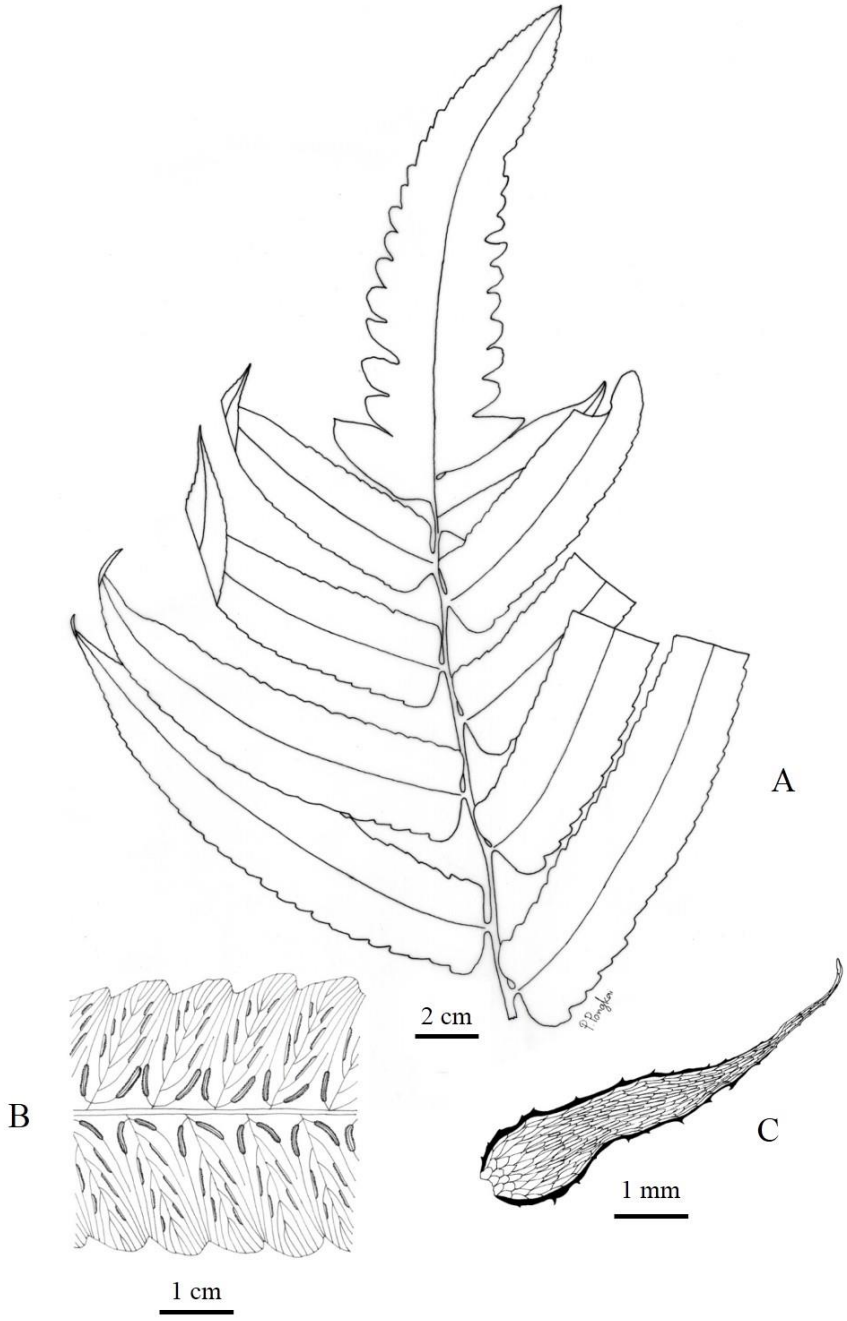

Figure 5.28 *Diplazium megaphyllum* (Baker) Christ. A. a lamina. B. part of a pinna showing venation and sori. C. a scale showing toothed and black marginal cells. Drawn by Puttamon Pongkai from *E. Hennipman 3064* (BKF).

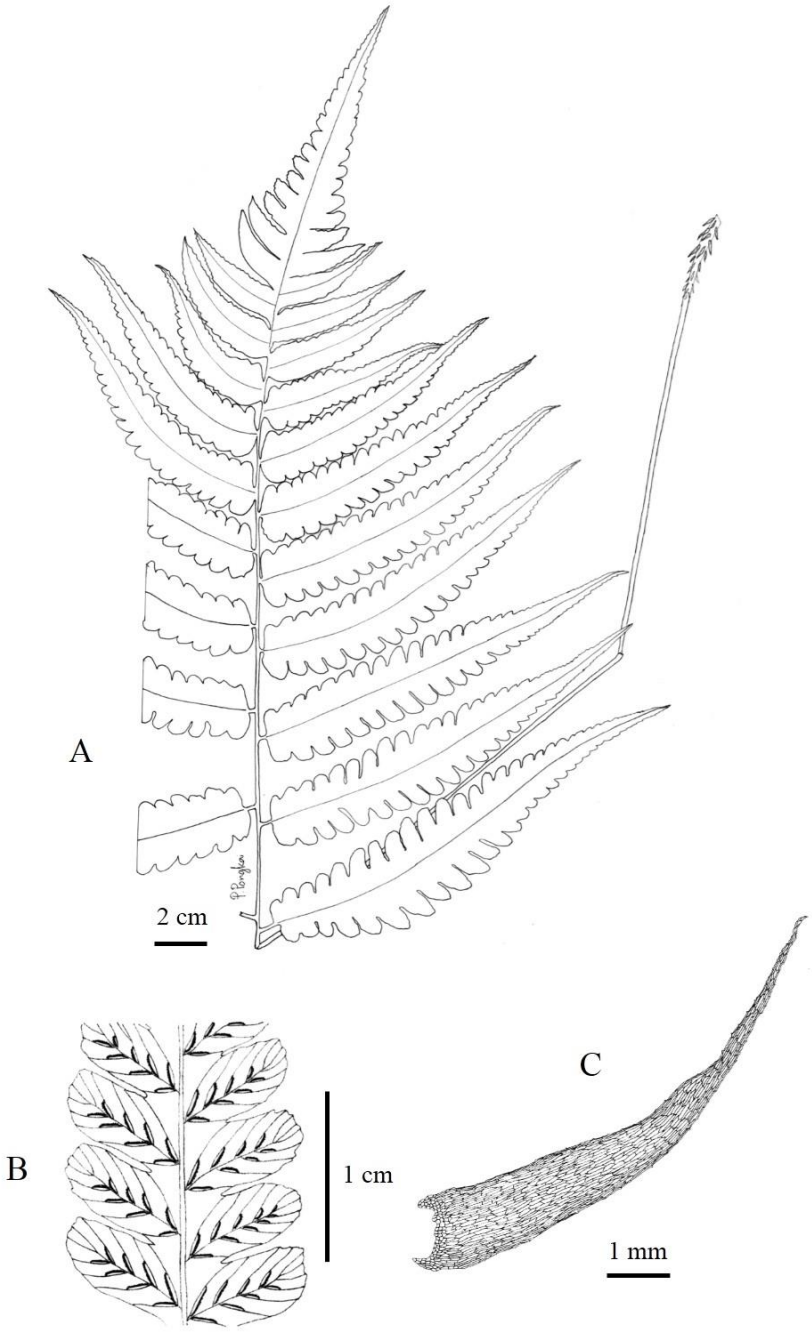

Figure 5.29 *Diplazium mettenianum* (Miq.) C. Chr. A. part of a lamina. B. part of a pinna showing venation and sori. C. a scale showing entire and not black marginal cells. Drawn by Puttamon Pongkai from *P. Pongkai 20* (BCU).

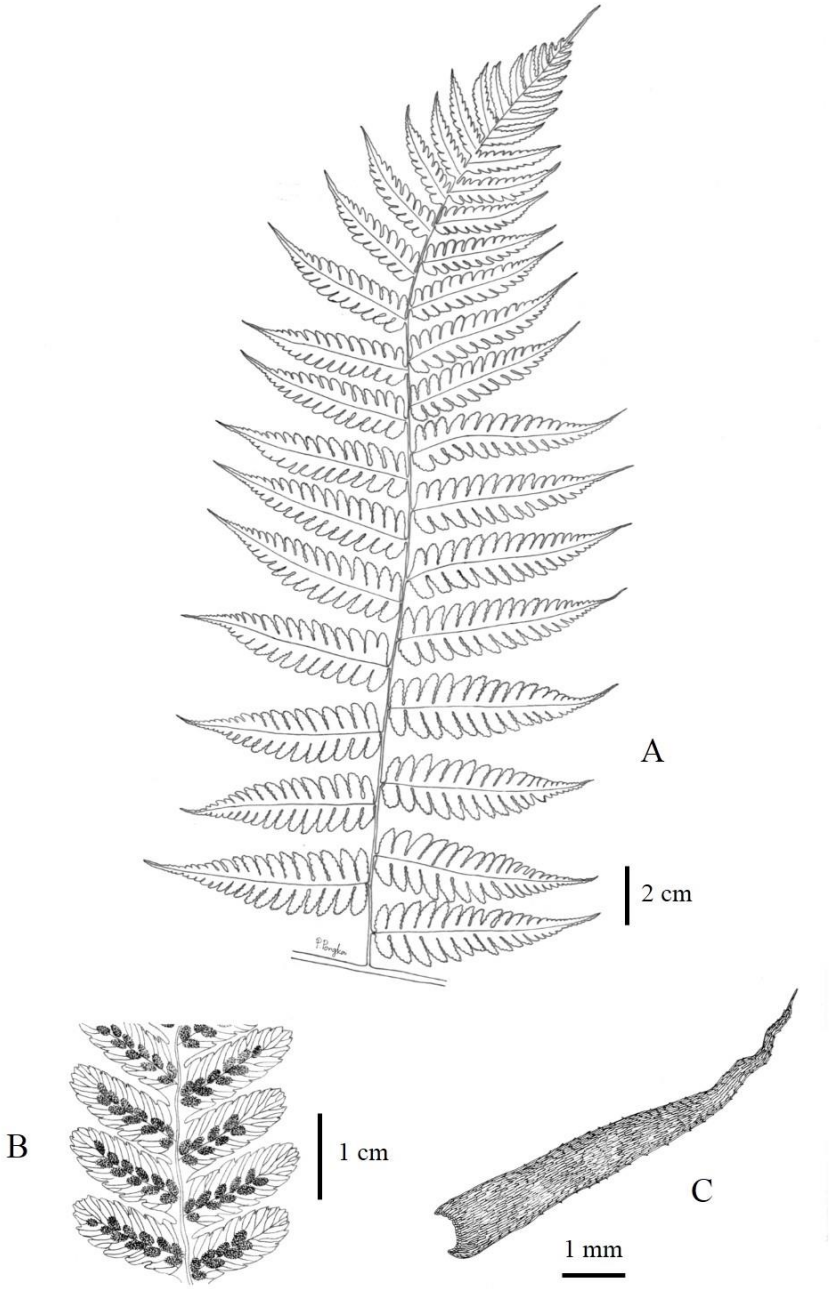

Figure 5.30 *Diplazium muricatum* (Mett.) Alderw. A. a lateral pinna. B. part of a pinnule showing venation and sori. C. a scale showing toothed and not black marginal cells. Drawn by Puttamon Pongkai from *P. Pongkai 12* (BCU).

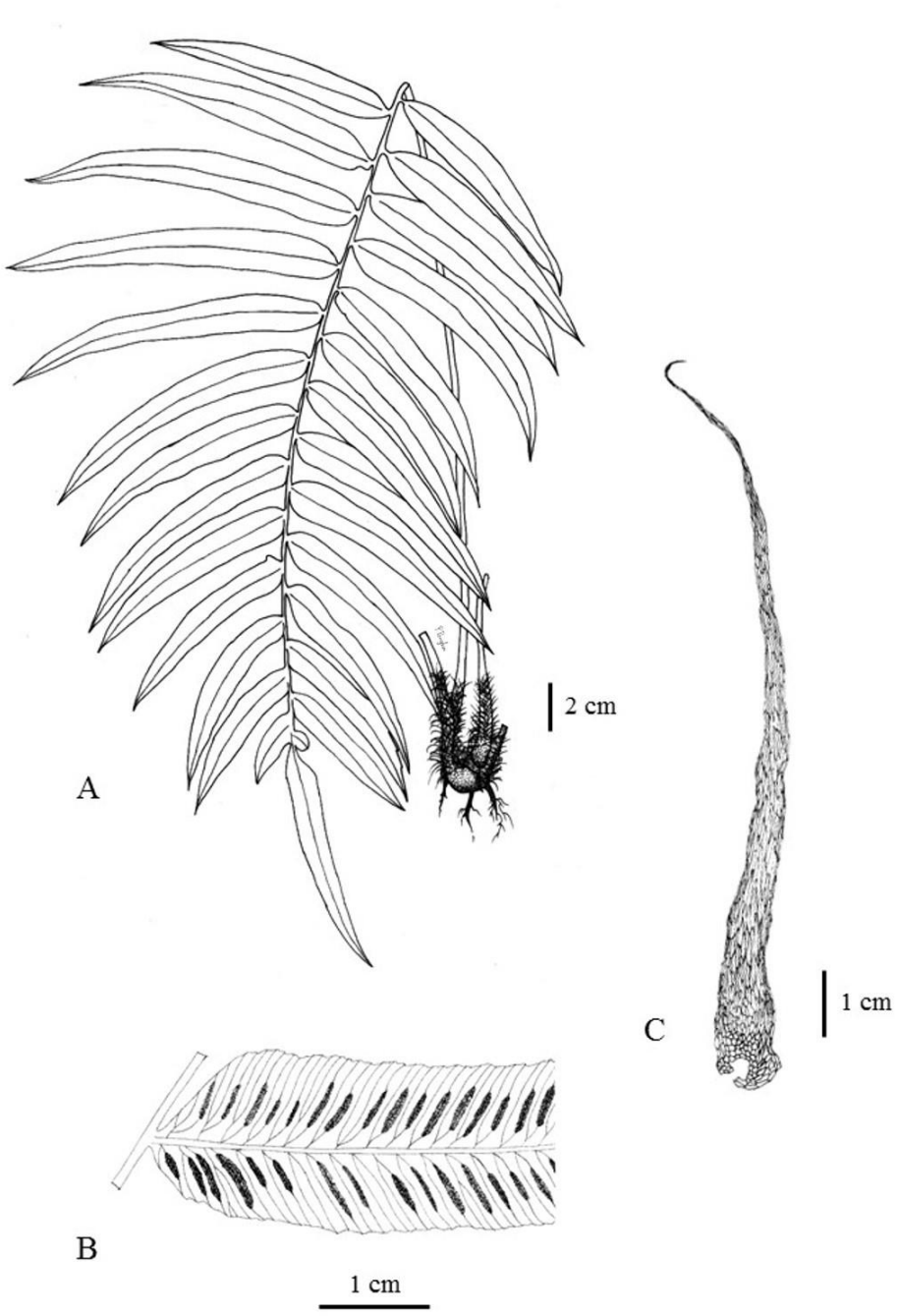

Figure 5.31 *Diplazium pallidum* (Blume) T. Moore. A. a whole plant with one frond. B. part of a pinna showing venation and sori. C. a scale showing entire margin and not black marginal cells. Drawn by Puttamon Pongkai from *T. Smitinand s.n.* (BKF)

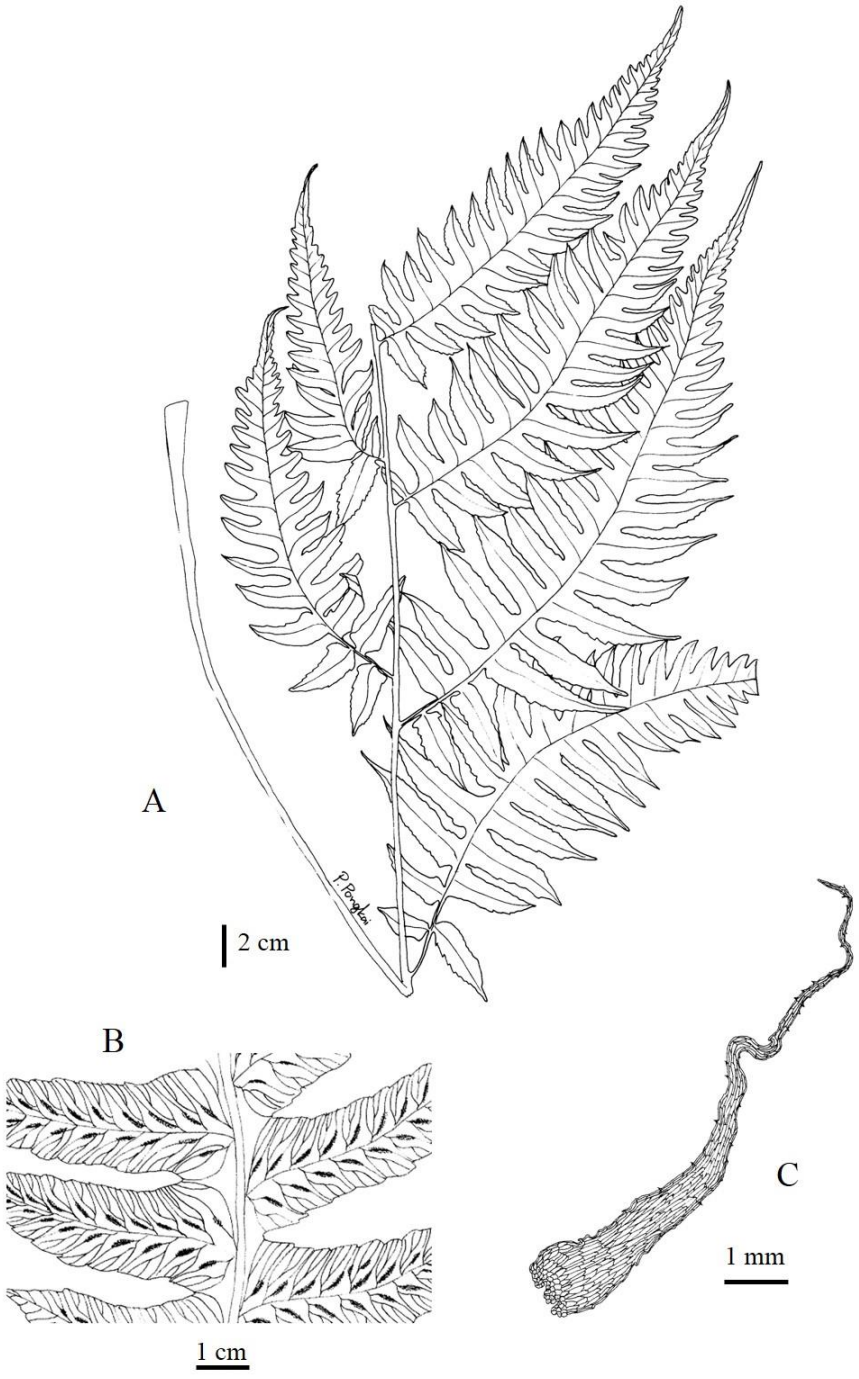

Figure 5.32 *Diplazium petelotii* Tardieu. A. a frond. B. part of a pinna showing venation and sori. C. a scale showing toothed and not black marginal cells. Drawn by Puttamon Pongkai from *Pételot 542 bis* (PL00445732).

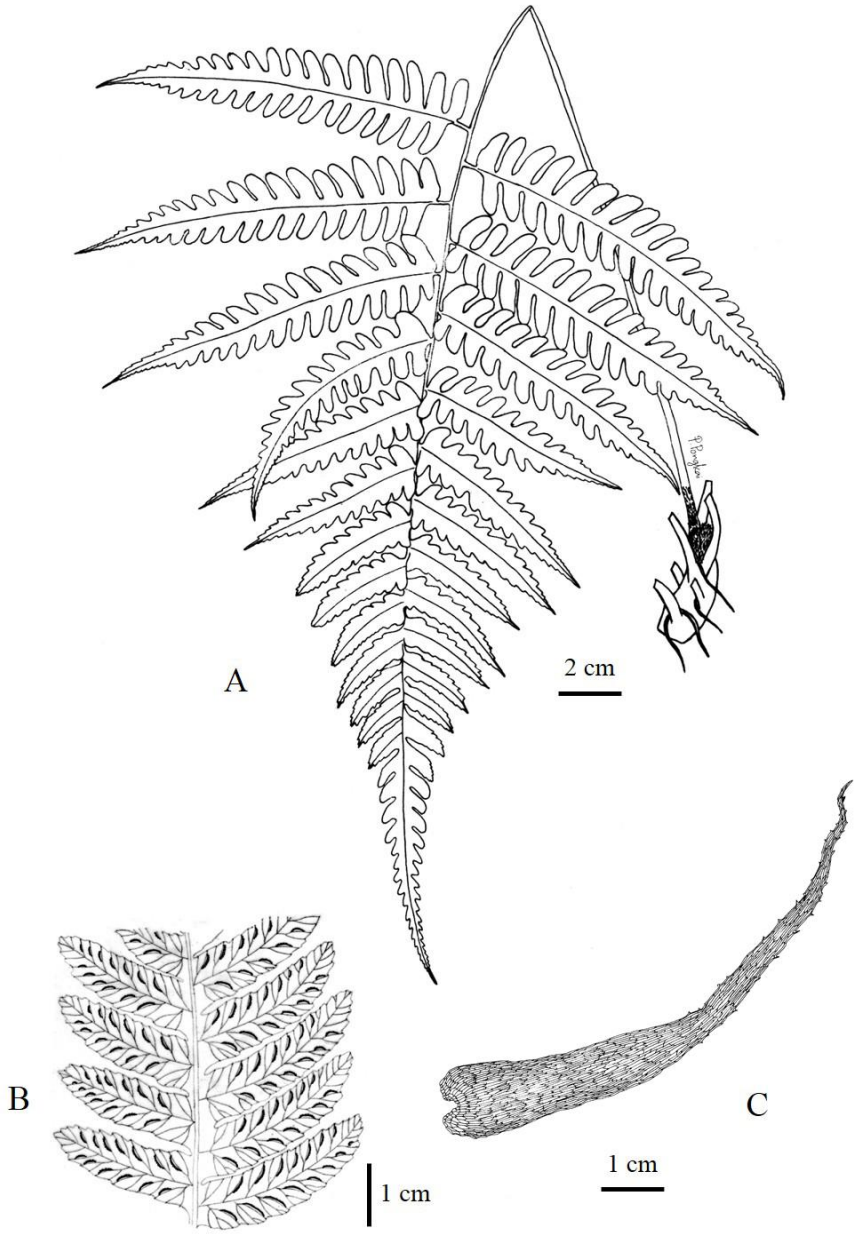

Figure 5.33 *Diplazium petrii* Tardieu. A. a whole plant with one frond. B. part of a pinna showing venation and sori. C. a scale showing toothed margin and not black marginal cells. Drawn by Puttamon Pongkai from *P. Pongkai 68* (BCU).

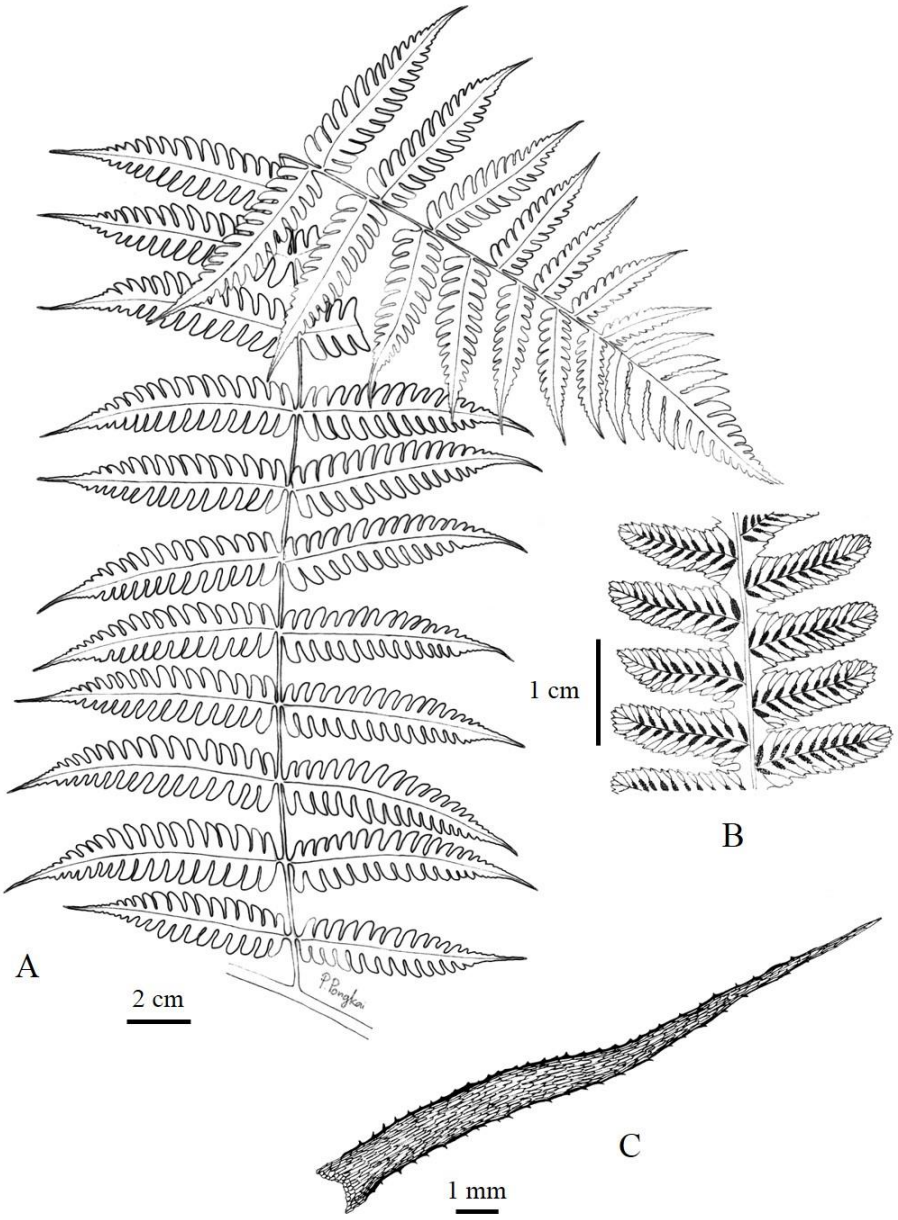

Figure 5.34 *Diplazium polypodioides* Blume. A. a lateral pinna. B. part of a pinnule showing venation and sori. C. a scale showing toothed and black marginal cells. Drawn by Puttamon Pongkai from *P. Ratchata 12* (BCU).

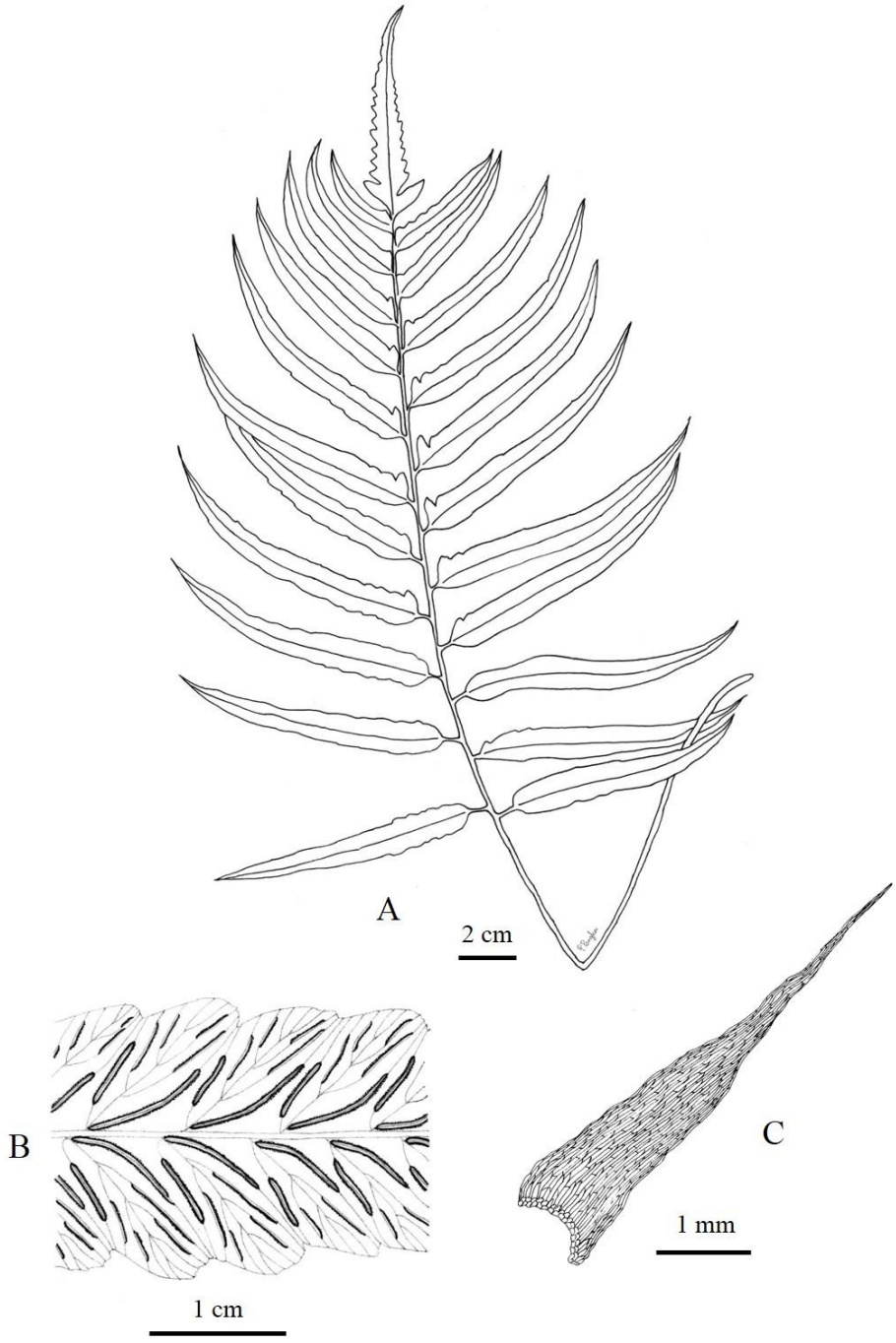

Figure 5.35 *Diplazium prescottianum* (Wall. ex Hook.) T.Moore. A. a frond. B. part of a pinna showing venation and sori. C. a scale showing entire margin and not black marginal cells. Drawn by Puttamon Pongkai from *J. Sinclair 9376* (SING).

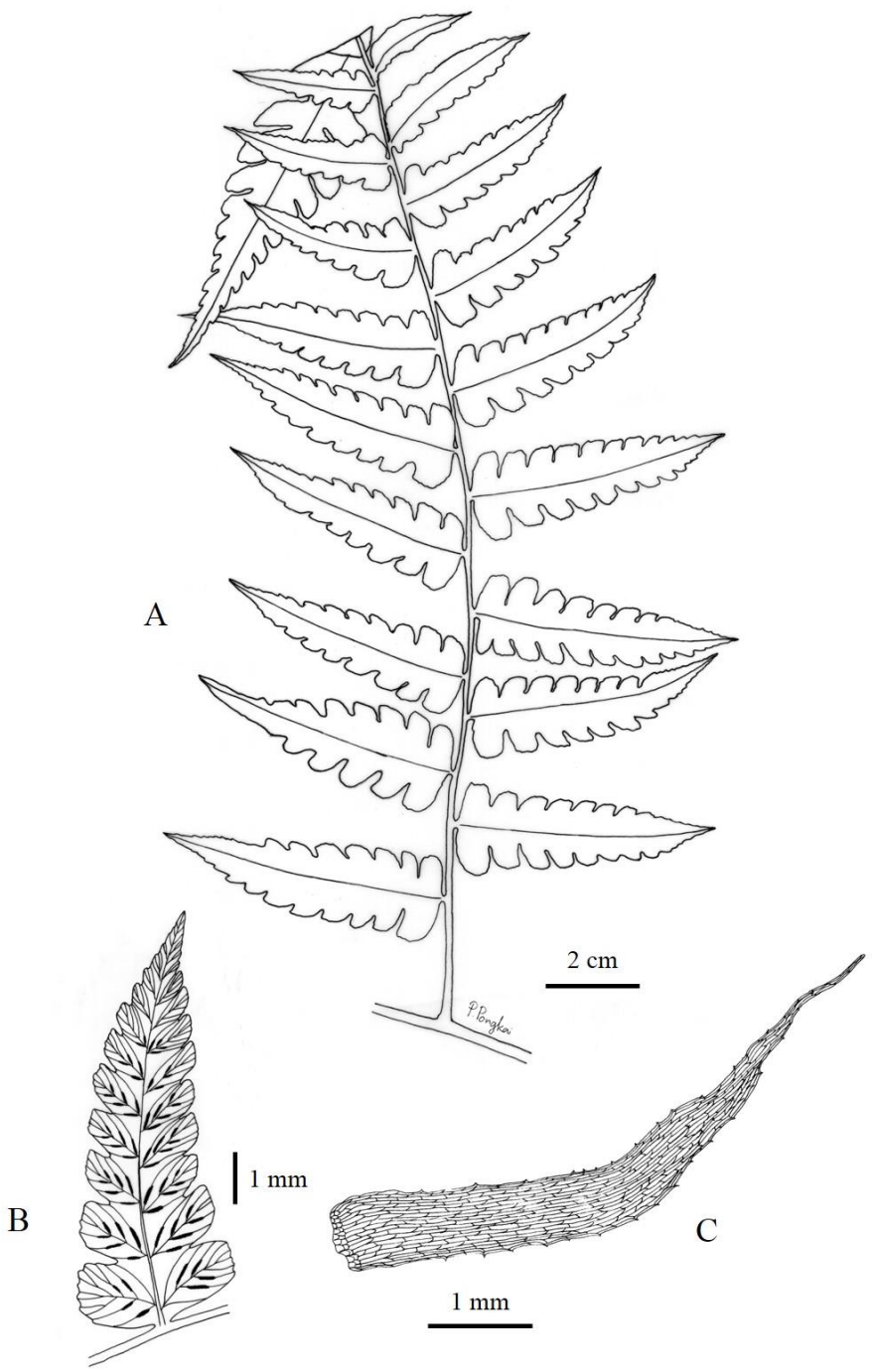

Figure 5.36 *Diplazium procumbens* Holttum. A. a lateral pinna. B. a pinnule showing venation and sori. C. a scale showing toothed margin and not black marginal cells. Drawn by Puttamon Pongkai from *D. J. Middleton et al. 1762* (BKF).

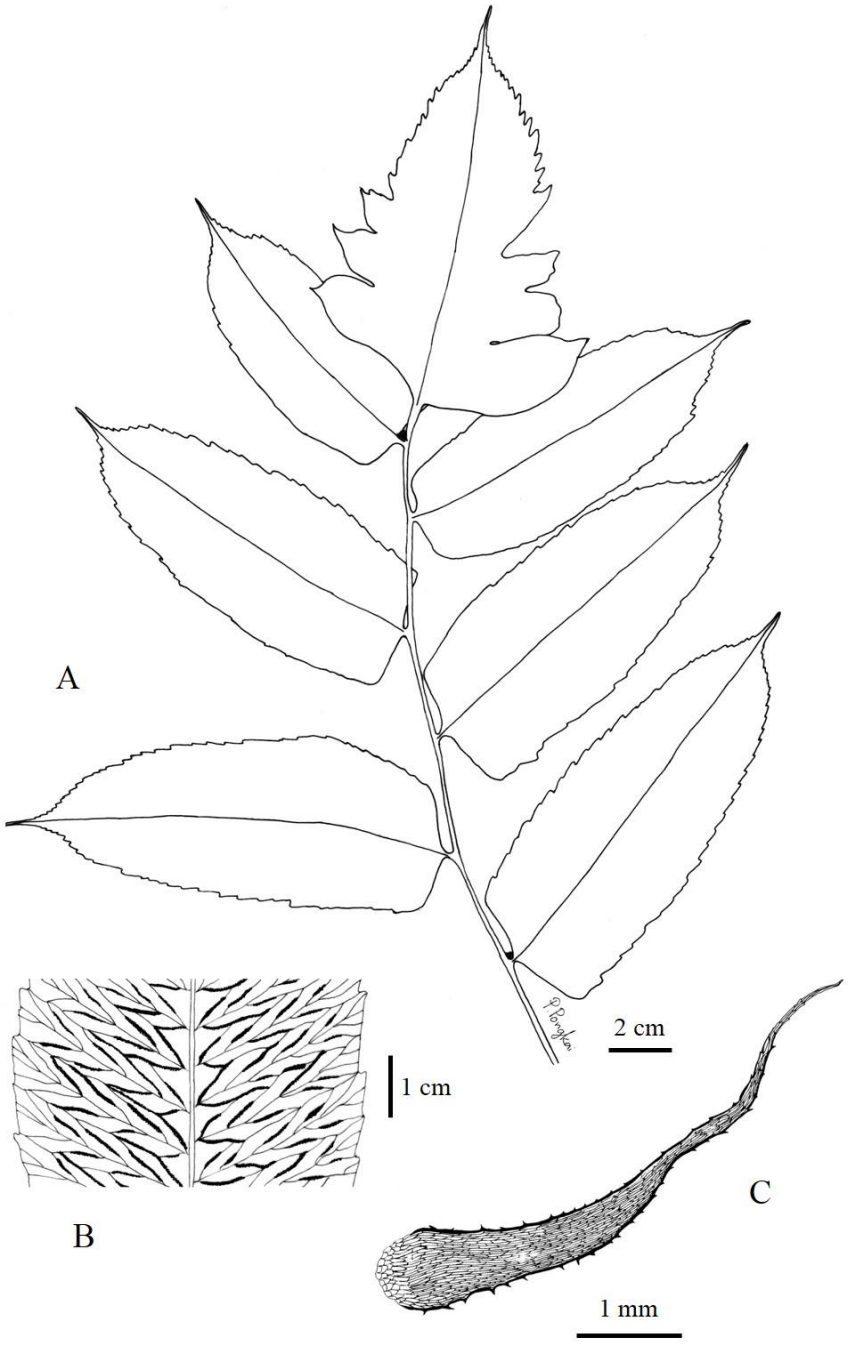

Figure 5.37 *Diplazium proliferum* (Lam.) Thouars. A. a lamina. B. part of a pinna showing venation and sori. C. a scale showing toothed margin and black marginal cells. Drawn by Puttamon Pongkai from Charn Apasutaya 121a (BCU).

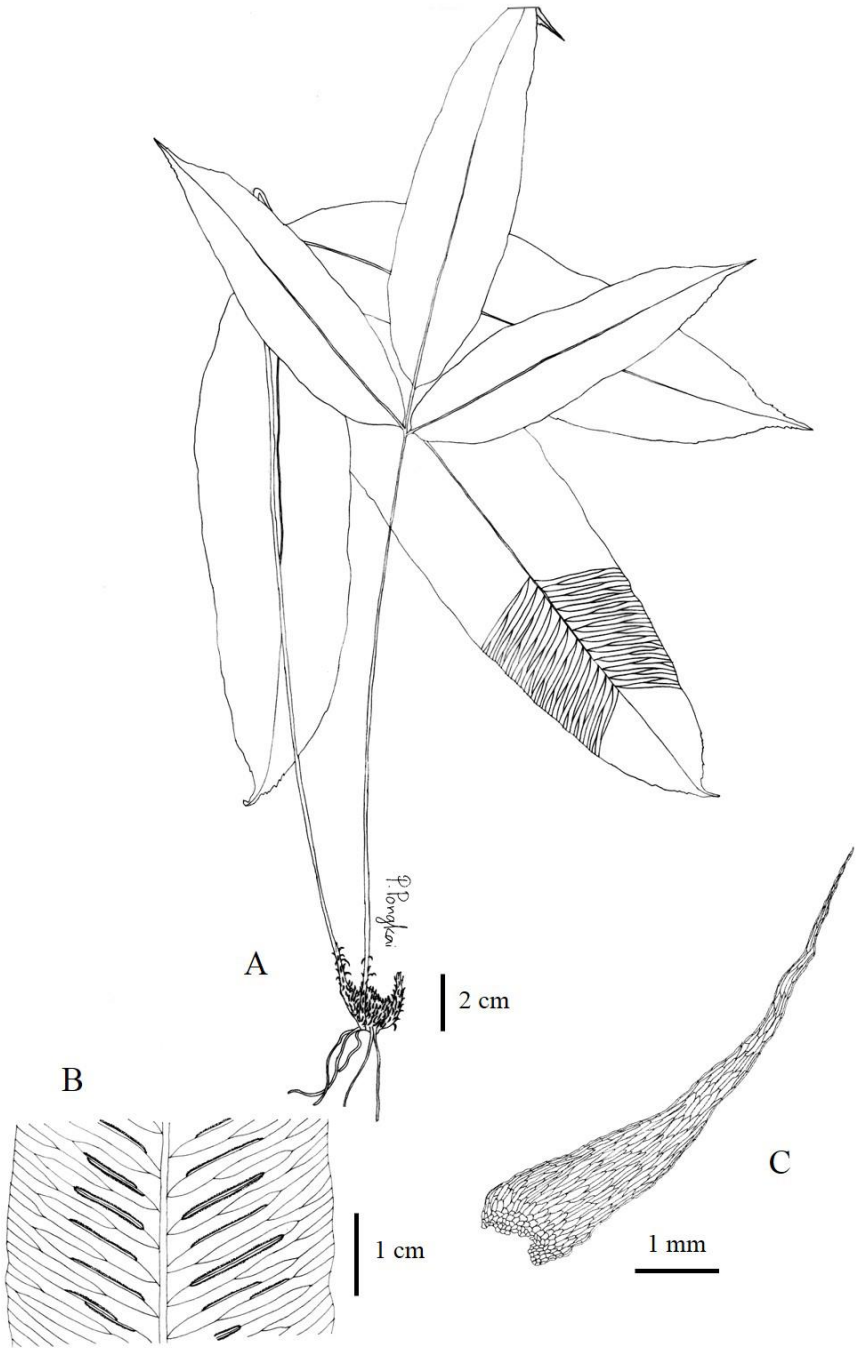

Figure 5.38 *Diplazium riparium* Holttum. A. a whole plant with two fronds. B. part of a pinna showing venation and sori. C. a scale showing entire margin and not black marginal cells. Drawn by Puttamon Pongkai from *P. Pongkai 45* (BCU)

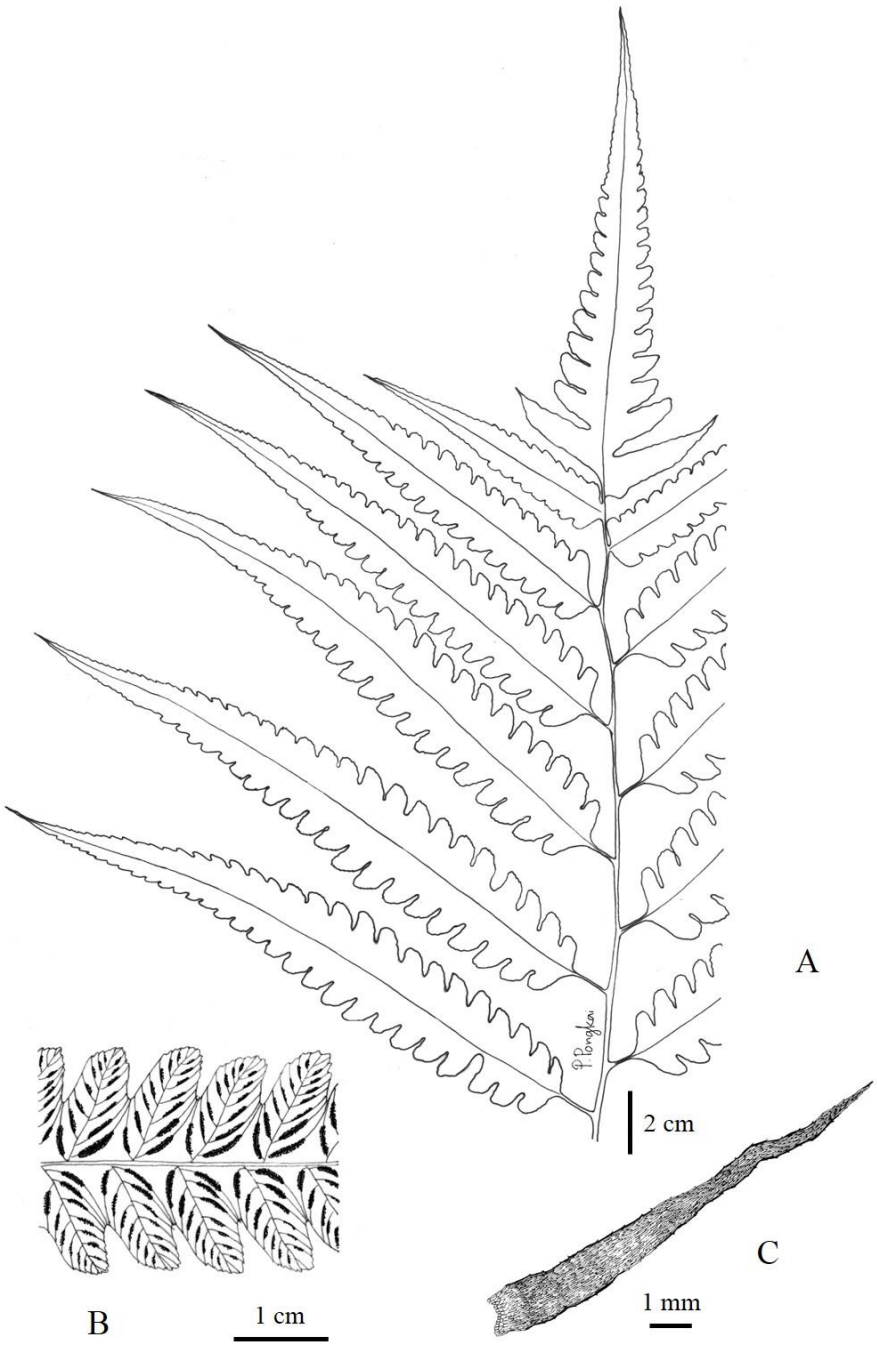

Figure 5.39 *Diplazium siamense* C. Chr. A. part of a lamina. B. part of a pinna showing venation and sori. C. a scale showing toothed margin and black marginal cells. Drawn by Puttamon Pongkai from *P. Pongkai 17* (BCU).

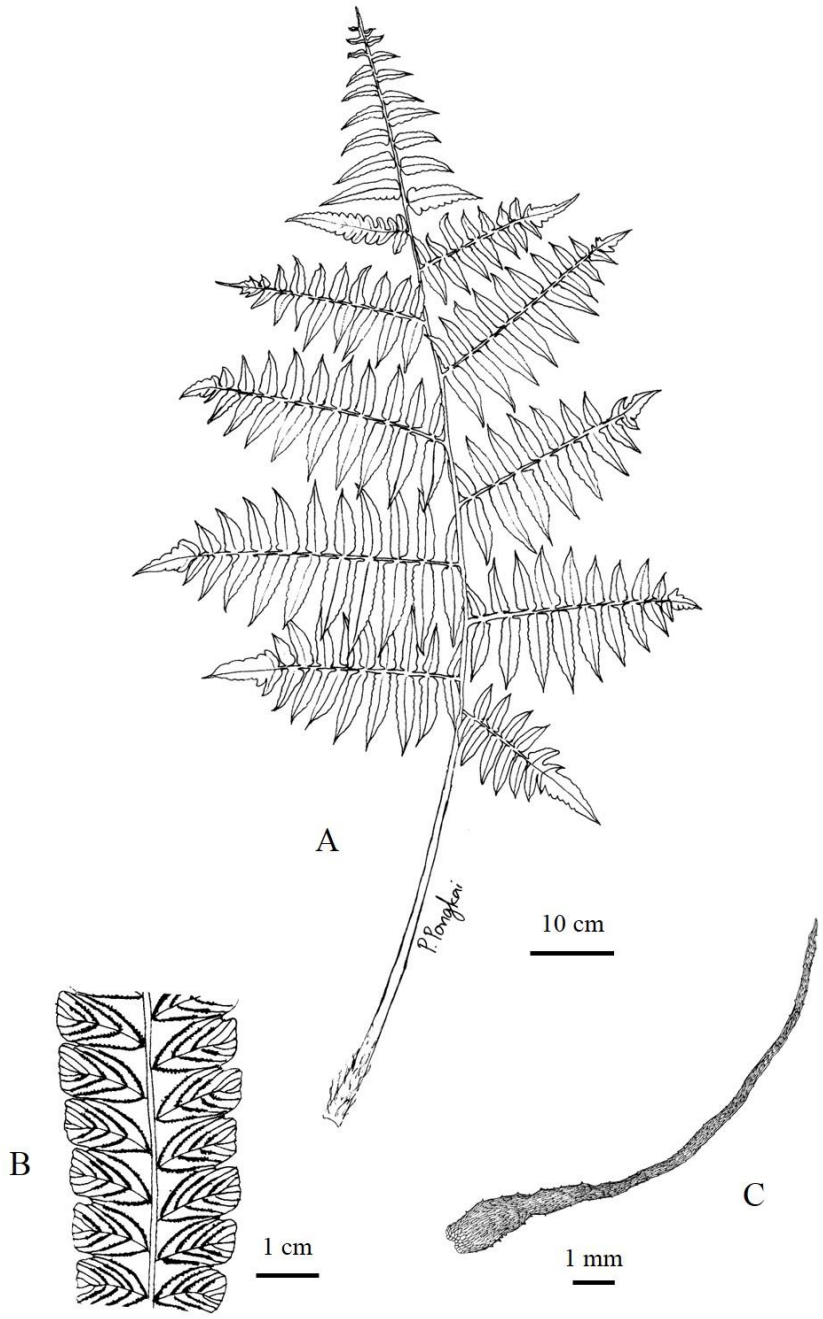

Figure 5.40 *Diplazium simplicivenium* Holttum. A. a frond. B. part of a pinnule showing venation and sori. C. a scale showing toothed margin and black marginal cells. Drawn by Puttamon Pongkai from *P. Pongkai 94* (BCU).

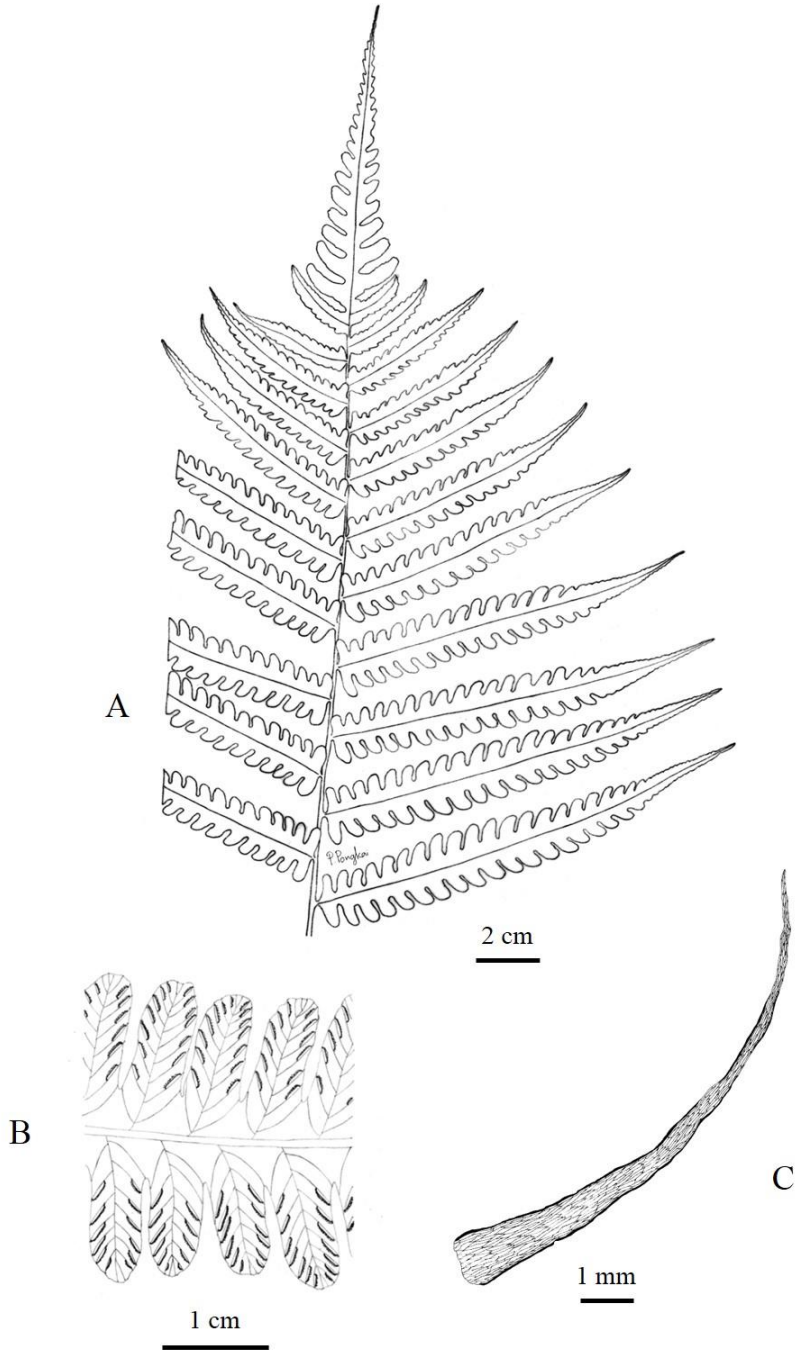

Figure 5.41 *Diplazium sorzogonense* (C. Presl) C. Presl. A. part of a lamina. B. part of a pinna showing venation and sori. C. a scale showing entire margin and black marginal cells. Drawn by Puttamon Pongkai from *P. Pongkai 49* (BCU).

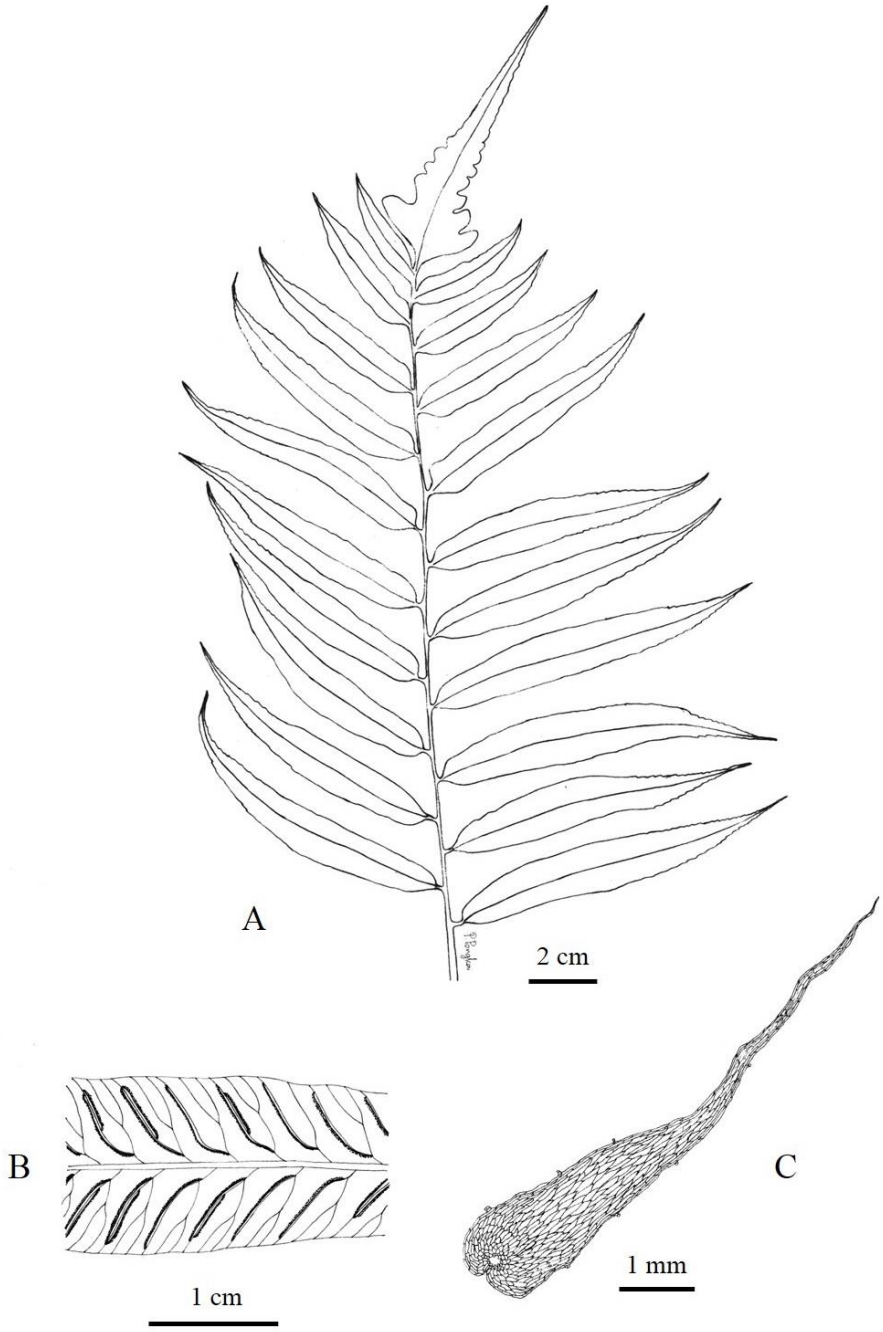

Figure 5.42 *Diplazium subintegrum* Holttum. A. lamina. B. part of a pinna showing venation and sori. C. a scale showing entire margin and not black marginal cells with minutely caducous membrane. Drawn by Puttamon Pongkai from *P. Pongkai 67* (BCU).

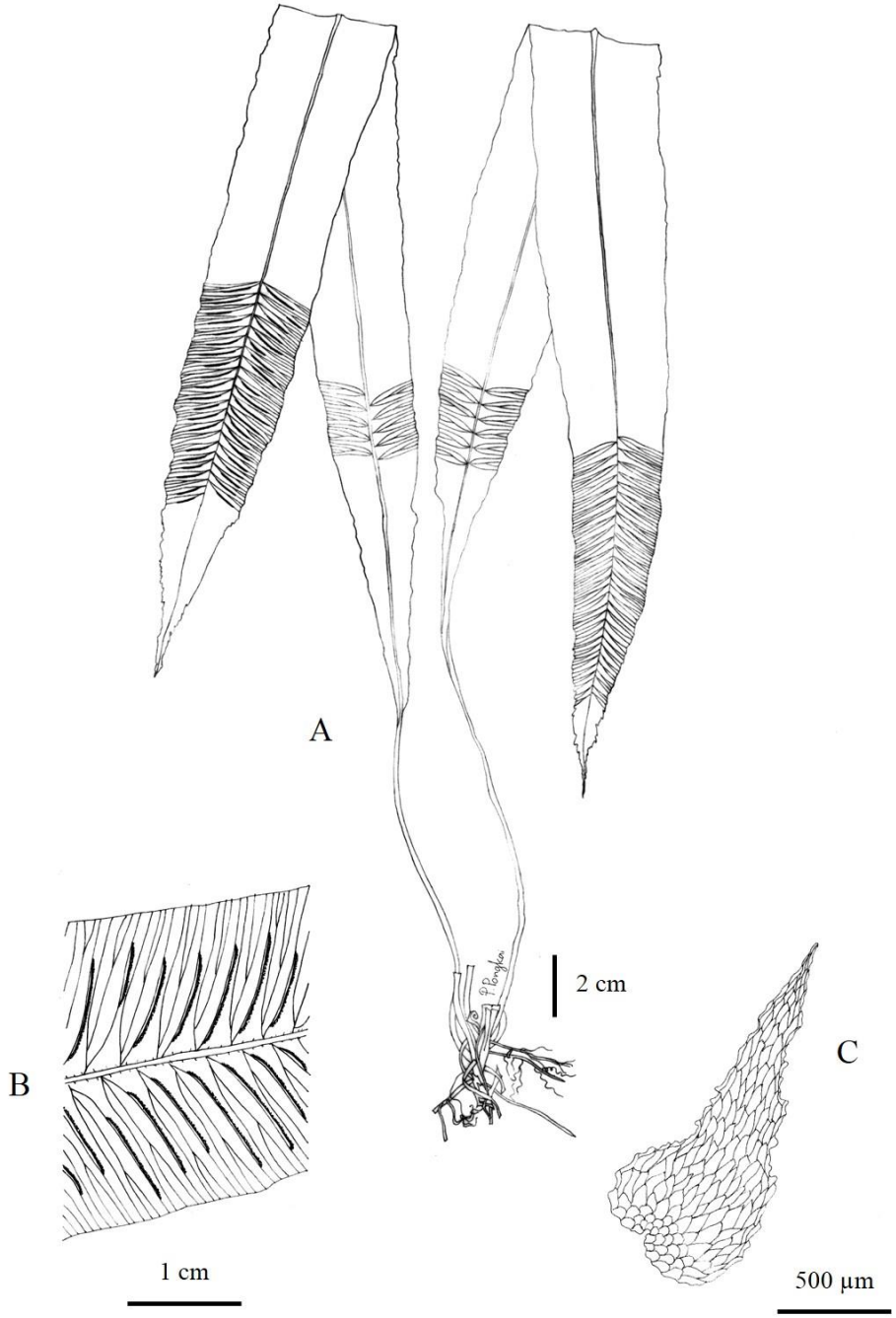

Figure 5.43 *Diplazium subserratum* (Blume) T. Moore. A. a whole plant with two fronds. B. part of a lamina showing venation and sori. C. a scale showing irregulary toothed margin and not black marginal cells. Drawn by Puttamon Pongkai from *T. Boonkerd & R. Pollawatn 281* (BCU).

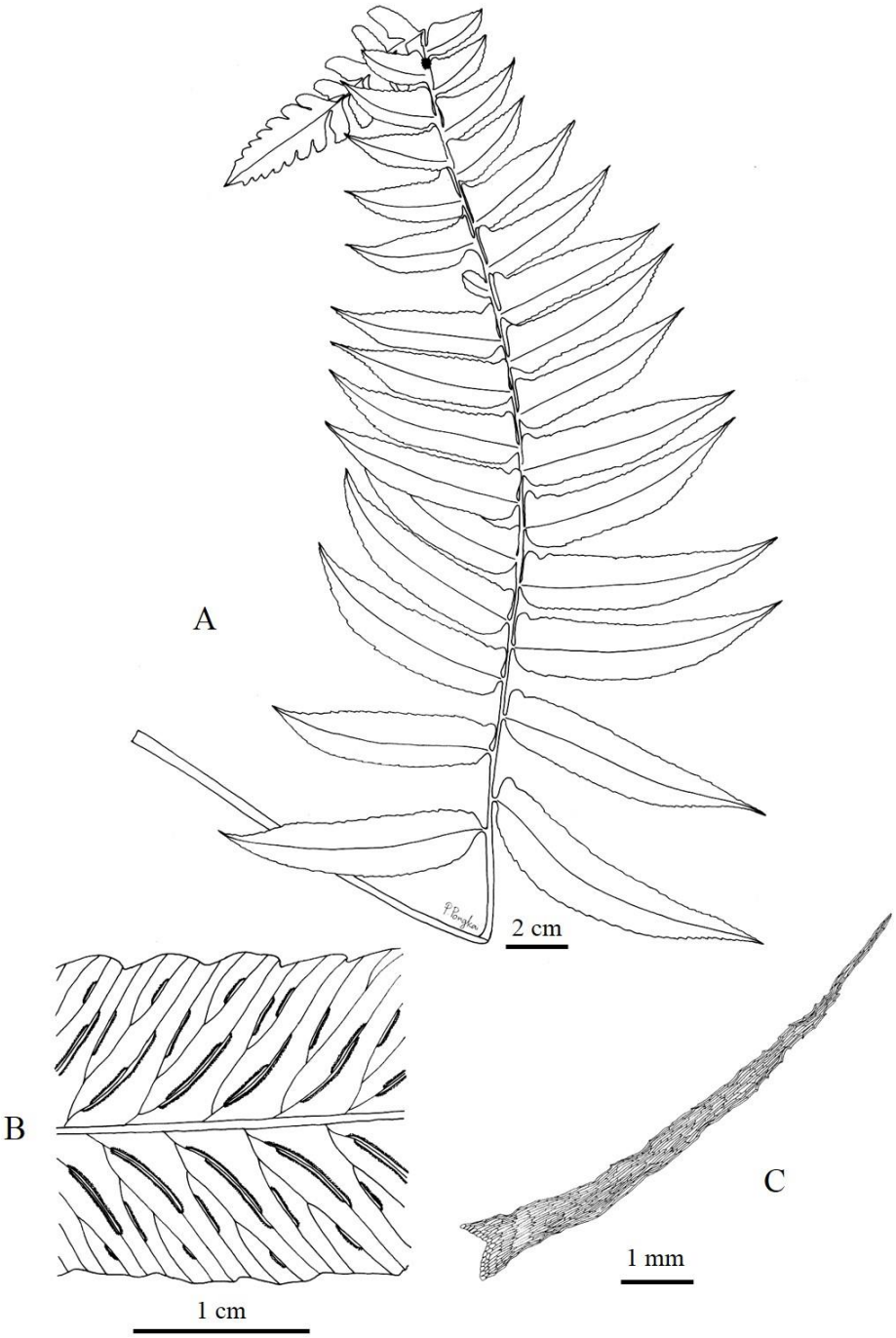

Figure 5.44 *Diplazium sylvaticum* (Bory) Sw. A. a lamina. B. part of a pinna showing venation and sori. C. a scale showing toothed margin and not black marginal cells. Drawn by Puttamon Pongkai from *P. Pongkai 18* (BCU).

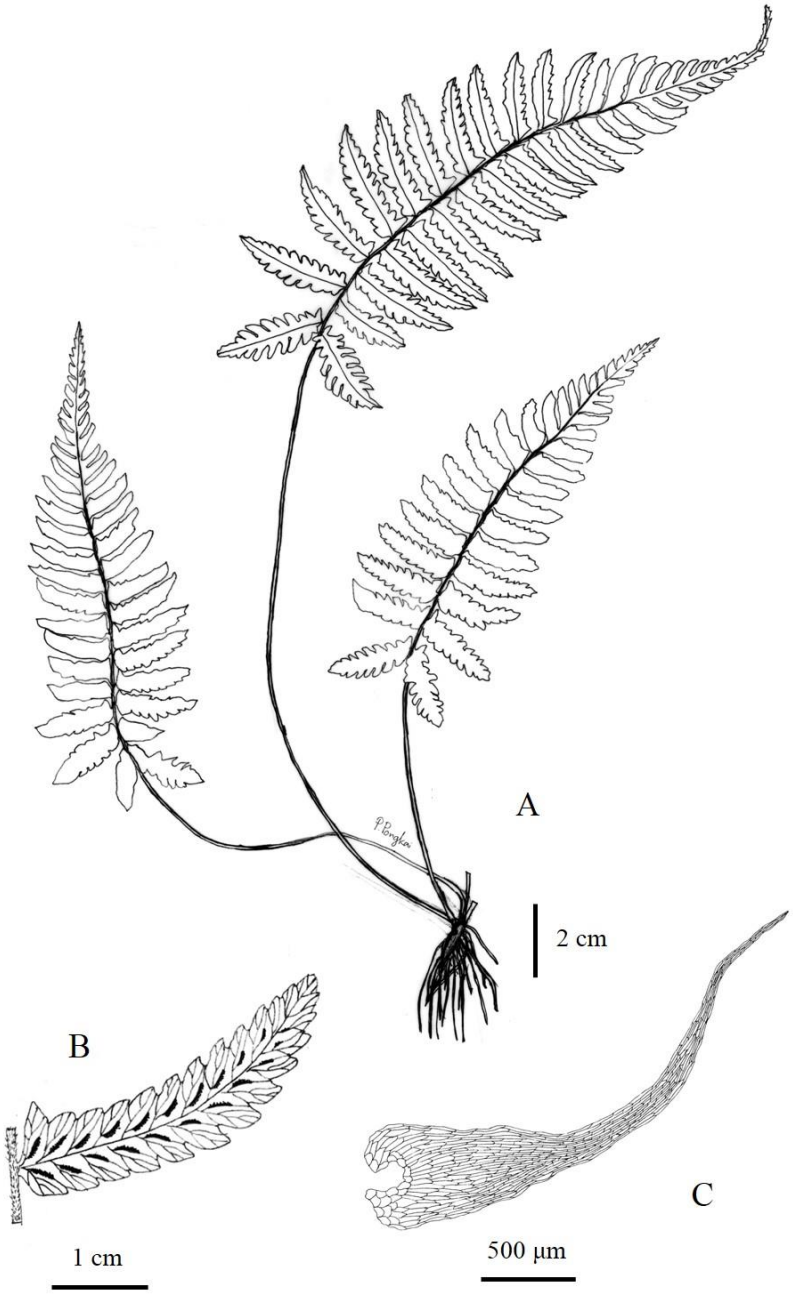

Figure 5.45 *Diplazium tomentosum* Blume. A. a whole plant. B. part of a pinna showing venation and sori. C. a scale showing entire margin and not black marginal cells. Drawn by Puttamon Pongkai from *P. Pongkai 57* (BCU).

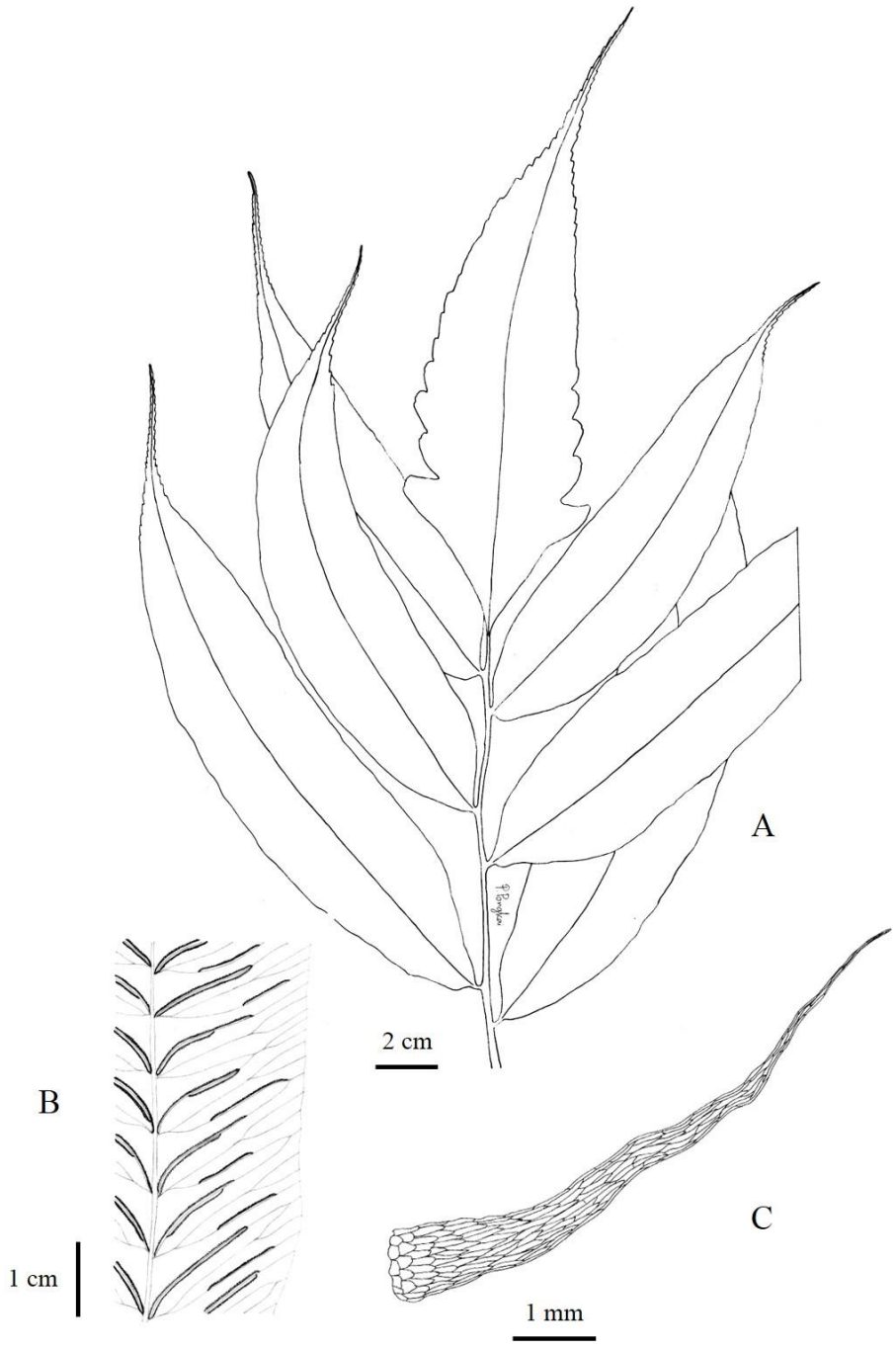

Figure 5.46 *Diplazium xiphophyllum* (Baker) C. Chr. A. a lamina. B. part of a pinna showing venation and sori. C. a scale showing entire margin and not black marginal cells. Drawn by Puttamon Pongkai from *T. Boonkerd et al. 62* (BCU).

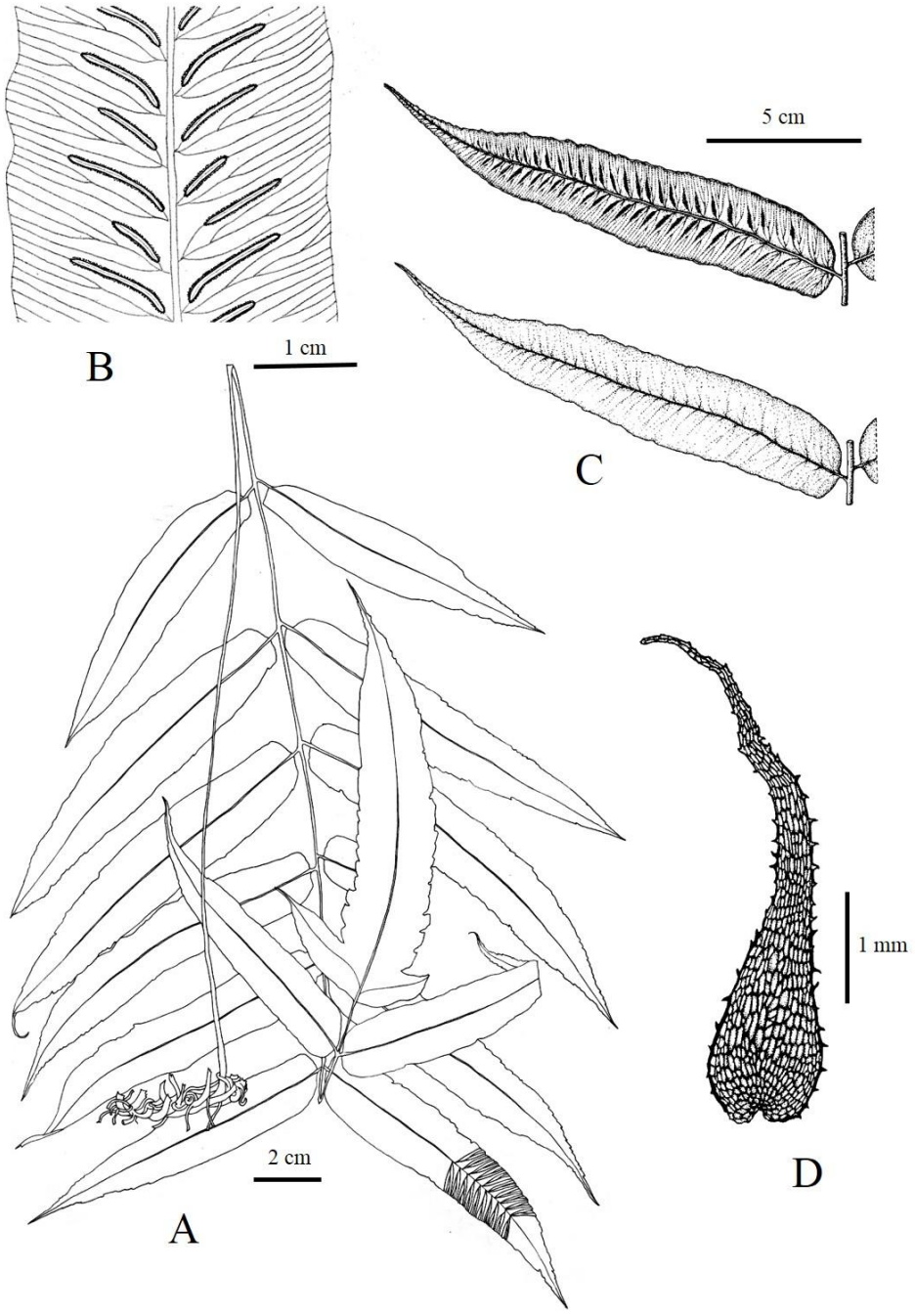

Figure 5.47 *Diplazium thailandicum* Pongkai, Boonkerd & Pollawatn. A. a whole plant. B. part of a pinna showing venation and sori. C. lateral pinnae showing sori and venation, D. a scale showing toothed margin and black marginal cells. Drawn by Puttamon Pongkai from *P. Pongkai 107* (BCU).

HYPODEMATIACEAE

Ching, Acta Phytotax. Sin.13 (1): 96. 1975, Gangmin, Z., Fuwu, X, Faguo, W, Iwatsuki, K. and Nooteboom, H.P., Fl. China. 535. 2013.

Lithophytic or rarely terrestrial ferns, small to medium in size. *Stem* creeping, stout, densely scaly; scale lanceolate to ovate-lanceolate, concolorous, red-brown, margin entire or rarely dentate. *Leaves* tripinnate to tetrapinnatifid; petioles glabrous or hairy. *Lamina* deltoid, ovate-oblong or pentagonal-ovate; vein free. *Sori* orbicular or reniform, indusiate. *Spores* monolete, bilaterally symmetrical, kidney-shaped.

A family with two genera in Thailand.

5.6 *Hypodematium*

Kunze, Flora 16(2): 690. 1833; Nooteboom. H.P., Fl. Males., Ser. 2, Vol. 4. 85. 2012; Z. Gangmin, F. Xing, W. Faguo, K. Iwatsuki & H.P. Nooteboom, Fl. China 535. 2013.

Plants epipetric or terrestrial, small to medium-size. *Stem*s stout, creeping, densely scaly; scales lanceolate or linear-lanceolate, reddish-brown, margin entire, persistent. *Leaves* tripinnate to 4-pinnate; petioles stramineous, hairy or glabrous, base swollen. *Laminae* pentagonal-ovate in outline, acicular hairs and/or glandular hairs present; rachis groove continue to costa and costule; veins free, forked. *Sori* round, located at middle of veinlets, indusiate; indusial round-reniform, acicular hairs and/or glandular hairs present. *Spores* monolete, 35.5-60.5 × 26.5-49.5 µm, bilaterally symmetrical, kidney-shaped. Ornamentation: rugate.

Key to the species

1a	Frond cover with only white long hairs……..	2
1b	Frond cover with white long hairs and glandular hairs……	**5.6.3 *H. glanduloso-pilosum***
2a	Frond pentagonal-ovate in outline, texture coriaceous……	**5.6.2 *H. crenatum***
2b	Frond subdeltoid to ovate-deltoid in outline, texture papyraceous……	3

3a	Pinnae sessile, segment apex dentate, sori flat.	**5.6.1 *H. boonkerdii***
3b	Pinnae long stalk, segment apex round, sori bulge……	**5.6.4 *H.* sp.**

5.6.1 *Hypodematium boonkerdii* Pongkai, Li Bing Zhang & Pollawatn, Phytotaxa 286 (3): 193–197. 2016. Type:—THAILAND. Loei Province: Tham Pha Sawan, Pha Khao District, limestone crevices on shady walls in a cave, alt. 430 m, 25 Jun. 2011, *T. Boonkerd et al. 2011-695* (holotype BCU, isotypes BKF, K, MO). Figure 5.48, 5.61 E

Plants lithophytic. *Stems* creeping, 0.8–1.0 cm in diameter, densely covered with scales; scales 0.7–1.0 × 1–2 mm, linear lanceolate, concolorous, reddish brown, margin near apex denticulate. *Leaves* 21–50 cm long, monomorphic, bipinnate-tripinnatifid; petioles 10–29 cm long, 1 mm in diameter, deep green when living, stramineous when dried, covered with long-unicellular hairs about 1 mm long on both surface, scaly at base. *Laminae* 11–20 × 6–12 cm, widest at base, deltoid in outline, hairy, membranous; rachises hairy and scaly; pinnae 10–14 pairs, lower pairs opposite, upper pairs alternate, gradually becoming smaller upward, terminal pinna not distinct, largest at lower pinnae, 3.4–6.5 × 2.0–3.5 cm, subfalcate, narrowly deltoid in outline, apex acute, base obtuse to truncate, subsessile or shortly stalk at lowest one, less than 2 mm long; pinnule 6–10 pairs, usually anadromous, alternate, lowest acroscopic pinnule of each pinna usually larger than another one, about 3–5 × 1–2 cm, narrowly oblong, apex acute, margin lobe, about ¾ way to costule, sessile; veins all free, veinlets 3–4 pairs, pinnate, reaching margin. *Sori* small, reniform to round, black, on basal acroscopic veinlet of each vein group of lobe, indusiate; indusia round-reniform, thin, persistent, sparsely hairy, light green; hair of 0.2–0.4 mm long. *Spores* monolete, bilateral symmetric, kidney-shaped, about 37.5–41.0 × 26.5–30.0 μm, ornamentation: rugate.

Thailand.—Loei (Tham Pha Sawan).

Distribution.— Endemic to Thailand.

Ecology.— Grow in limestone crevices on shady walls in a cave at an elevation of about 430 m.

Etymology.— The specific epithet *boonkerdii* is named in honor of Prof. Dr. Thaweesakdi Boonkerd, a Thai botanist who has devoted himself a long time to study Thai ferns, and also a member of the team in collecting this fern specimen.

Conservation status.— This species was found only in one site with rather small population of less than 50 mature individuals. In addition, the locality is not in a protected area and is threatened to be removed or trampled by tourists. Therefore, this fern species should be listed as a critically endangered species on a worldwide basis (IUCN, 2015).

Specimen Examined.—**Thailand**. Loei, Tham Pha Sawan, *P. Pongkai* 154 (BCU); ibid, *P. Pongkai* 155 (BCU); Loei, Tham Pha Sawan, *T. Boonkerd et al. 2011-695*; ibid, *T. Boonkerd et al. 2011-753* (BCU).

Notes.— The genus *Hypodematium* has been listed in *Flora of Thailand* by Tagawa & Iwatsuki (1988). Two species are enumerated, i.e., *H. crenatum* and *H. glanduloso-pilosum*. *Hypodematium glanduloso-pilosum* has two kinds of hairs (glandular hairs and long unicellular hairs), while *H. crenatum* has only long unicellular hairs. Comparison of morphological characters of *H. boonkerdii* with the known species in Thailand and China shows that *H. boonkerdii* is closely related to *H. crenatum* in having rugate spores and no glandular hairs, while having glandular hairs on frond is a unique character of *H. glanduloso-pilosum*. However, *H. boonkerdii* and *H. crenatum* can be easily distinguished from each other with characters of lamina, pinna stalk and apex of segments. Ecologically, *H. boonkerdii* grows in shady rock crevices of a limestone cave, while *H. crenatum* usually occurs on partially shaded ground to fully exposed rocks.

5.6.2 ***Hypodematium crenatum*** (Forssk.) Kuhn & Decken, Reisen. Ost-Afr. 3(3): 37, f. a. 1879; J.L., Tsai & W.C. Shieh. Fl. Taiwan 290. 1994; M. Tagawa & K. Iwats. Fl. Thailand 3(3): 437. 1988; Nooteboom, H.P., Fl. Males., Ser. 2, Vol. 4. 85. 2012;H. Gangmin & K. Iwatsuki, Fl. China 536. 2013.— *Polypodium crenatum* Forssk., Fl. Aegypt.-Arab. 185. 1775.— *Aspidium crenatum* (Forssk.) Kuhn, Filic. Afr. 129. 1868.— *Dryopteris crenata* (Forssk.) Kuntze, Revis. Gen. Pl. 2: 811, pl. 2. 1891.— *Lastrea crenata* (Forssk.) Bedd,Suppl. Ferns S. Ind. 18. 1876.— *Aspidium eriocarpum* Wall. ex Mett., Abh. Senckenberg. Naturf. Ges. 4: 60. 1858.— *Lastrea*

eriocarpa (Wall. ex Mett.) C. Presl, Tent. Pterid. 77. 1836.— *Nephrodium eriocarpum* (Wall. ex Mett.) Decne.,Arch. Mus. Hist. Nat. 2: 185. 1841.— *Hypodematium eriocarpum* (Wall. ex Mett.) Ching, Fl. Tsinling. 2: 130. 1974.— *Aspidium odoratum* Bory ex Willd., Sp. Pl. 5: 286. 1810.— *Cystopteris odorata* (Bory ex Willd.) Desv.,Mém. Soc. Linn. Paris 6: 264. 1827.— *Nephrodium odoratum* (Bory ex Willd.) Baker, Syn. Fil. 280. 1867.— *Nephrodium hirsutum* D. Don, Prodr. Fl. Nepal. 6. 1825.— *Lastrea hirsuta* (D. Don) T. Moore, Index Filic. 1857.— *Hypodematium hirsutum* (D. Don) Ching, Indian Fern J. 1(1–2): 49. 1984.— *Aspidium eriocarpum* Wall., Numer. List n. 324. 1828.— *Hypodematium onustum* Kunze, Flora 16(2): 690. 1833.— *Aspidium crenatum* Sommerf., Kongl. Vetensk. Acad. Handl. 1834: 102. 1835.— *Aspidium chrysolepis* Fée, Mém. Foug. 7: 107. 1855.— *Nephrodium crenatum* Baker, Fl. Mauritius 497. 1877.— *Dryopteris fauriei* Kodama, Icon. Pl. Koisik. 2(1): 11, t. 90. 1914.— *Hypodematium pilosum* Ching ex He, Fl. Beijing 1: 669., 25. f. 30. 1984. Type: not seen. Figure 5.49, 5.61 F

*Plant*s lithophytic *Stems* short creeping, 2-4 cm in diameter densely scaly; scales 10-15 × 1.5-2.0 mm, linear-lanceolate, concolorous, reddish-brown, margin entire. *Leaves* tripinnate, up to 80 cm long; petioles 40-50 cm long, 2-5 cm in diameter, stramineous when dry, glabrous. *Laminae* 15-50 × 12-30 cm, outline pentagonal-ovate, apex long acuminate, base obtuse, hairy, coriaceous, light green; rachis groove, hairy; pinnae more than 10 pairs, gradually becoming smaller upward forming long acuminate pinatisect apex, 18-33 × 8-10 cm, subopposite, bipinnate, lowest pinna largest, ovate-deltoid, apex acuminate, base obtuse, stalked; stalk 1-4 cm long; pinnule, more than 6 pairs, 12-12 × 1.0-1.5 cm, pinnate, apex acute, base truncate; pinnulet 1.5-2.0 × 1 cm, pinnatisect to pinnate at lower one, lanceolate-oblong, apex acute, base obtuse, margin lobe; lobe deep close to costule, oblong, apex round, margin entire; veins free, fork. *Sori* 1-3 per segment, rather close to midrib of pinnule, indusiate; indisia reniform, hairy, persistent. *Spore* monolete, 43.0-51.0 × 32.5-41.0 μm, bilateral, concavo-convex to plano-convex, perispore present; ornamentation: rugate.

Thailand.— NORTHERN: Chiang Rai (Doi Tum Yup), Chiang Mai (Doi Chiang Dao), Nan (Doi Phu Ka), Tak (Doi Hua Mod), Lampang (Mae Ngao); NORTH-EASTERN: Phetchabun (Nam Nao National Park), Loei (Nong Hin, Phu

Kradueng); SOUTH-WESTERN: Kanchanaburi (Tha Po), Prachuap Khiri Khan (Khao Sam Roi Yod).

Distribution.— Tibet, India, Sri Lanka, China, Japan, Taiwan, Vietnam, Philippines, Malaysia.

Ecology.— On limestone rocks or terrestrial on calcareous soils in both shade and exposed area from low land to 1,800 m alt.

Specimens examine.— **THAILAND**. Prachuap Khiri Khan, Khao Sam Roi Yot, *A.F.G. Kerr 10954* (BM); Chiang Mai, Doi Chiang Dao, *E. Hennipman 3196* (B, L); Chiang Rai, Doi Tum Yub, *H.B.G. Garrett 264* (BM, K); Rachaburi, *K. Larsen 10608* (K, L); Chiang Mai, Doi Chiang Dao, *M. Tagawa & K. Iwatsuki T4394* (K, L); Chiang Mai, Doi Chiang Dao, *Put 393* (K); Tak, Doi Hua Mod, *R. Pooma, R. Phattarahirankanok, S. Sirimongkol & M. Poopath 4618* (L); Petchabun, Nam Nao National Park, *T. Boonkerd & S. Yannawat 01* (BCU); Tak, Doi Hua Mod, *T. Boonkerd 1233* (BCU, K); Tak, Umphang, *T. Boonkerd 1238* (BCU, K); Tak, Doi Hua Mod, *T. Boonkerd 1327* (BCU); Loei, Suan Sawan, *T. Boonkerd et al. 2011-012* (BCU); Loei, Nong Hin, *T. Boonkerd et al. 2011-222* (BCU); ibid, *T. Boonkerd et al. 2011-229* (BCU); ibid, *T. Boonkerd et al. 2011-481* (BCU); Loei, Phu Kradueng, *T. Shimizu, M. Hutoh & D. Chaiglom T8749* (K, L); Chiang Mai, Doi Chiang Dao, *T. Smitinand & H. Sleumer 1034* (L); **TIBET**. Chayu, *South Tibet Expedition Team (STET) STET0130* (PE); **SRILANKA**. Nuwara-Eliya, *F. Schmid 1335* (BM); **INDIA**. Kalka, *T. N. Liou 6157* (PE); **CHINA**. Guizhou, *B. Bartholomew et al. 712* (PE); Shaanxi, *B. Guangyu 34* (PE); Hainan, *Beijing team 4161* (PE); Guangxi, *Beijing team 896165* (PE); ibid, *Beijing team 897114* (PE); Yunnan, *C. Cavalerie 45* (PE); Guangdong, *C. Wang 36936* (PE); Yunnan, *C. Xitao 58-8452* (PE); Guangxi, *C. Zhaozhou 53145* (PE); Chongqing, *D. Tianlun 103641* (PE); Guangdong, *D. Liang 1484* (PE); Yunnan, *G. Forrest 12318* (PE); ibid, *G. Forrest 26191* (PE); ibid, *G. Forrest 26191* (PE); Sichuan, *G. Kezhen & W. Wencai 1403* (PE); ibid, *G. Kezhen & W. Wencai 3434* (PE); vZhejiang, *H. Xueyu 14476* (PE); Hainan, *H. Xiangxu & C. Youqing & L.Suying & M. Zhonghui 10219* (PE); Guangdong, *K.K. Tsoong 1648* (PE); Yunnan, *K.K. Tsoong 2103* (PE); Guangxi, *L. Guang 15172* (PE); Shandong, *L. Jianxiu 002055-1* (PE); Gansu, *L. Liangqian & W. Zhongtao & D. Yufen & W.Ran GX025* (PE); Gansu, *L. Quanxi & Z. Xingcun 2119* (PE); Jiangxi, *L. Zhongyang & W.*

Ran JGS042 (PE); Shaanxi, *L. Yongshan & etc. 96228* (PE); Guangxi, *L. Hongmei GX051* (PE); Yunnan, *L. Shenwei 20451* (PE); Chongqing, *L. Zhengyu 10754* (PE); ibid, *L. Zhengyu 181214* (PE); ibid, *L. Zhengyu 181504* (PE); ibid, *L. Zhengyu 184396* (PE); Yunnan, *L. Zhengyu 235* (PE); ibid, *L. Zhengyu 246* (PE); ibid, *L. Linbo 0864* (PE); Hainan, *L. Linbo 3140* (PE); Guangxi, *Q. Xinping Q132* (PE); Yunnan, *Qinghai 07326* (PE); Sichuan, *Qinghai 11209* (PE); Hainan, *S. Y. Dong et al. 208* (PE); Hainan, *S. Y. Dong et al. 27* (PE); Chongqing, *Sichuan and Chongqing 0714* (PE); Guizhou, *Sichuan and Chongqing 1419* (PE); Guizhou, *Sichuan and Chongqing 2048* (PE); Guangxi, *Sino-Soviet team 516* (PE); Yunnan, *Sino-Soviet team s.n.* (PE); Sichuan, *T. N. Liou 12435* (PE); Yunnan, *T.N. Liou 13032* (PE); ibid, *T. N. Liou 13198* (PE); ibid, *T. N. Liou 13652* (PE); ibid, *T. N. Liou 13874* (PE); Chongqing, *Wait 15469* (PE); Guangdong, *W. Faguo et al 739* (PE); Guizhou, *W. Peishan 75423* (PE); ibid, *W. Peishan 76099* (PE); ibid, *W. Peishan 78361* (PE); Yunnan, *W. Yinzheng et al 5131* (PE); Yunnan, *W. Zhongren 356* (PE); Yunnan, *W. Ran WR0348* (PE); ibid, *W. Ran WR0366* (PE); ibid, *W. Ran WR0482* (PE); Hainan, *Wuling team 1236* (PE); Sichuan, *X.C. Zhang & L. Shi 953* (PE); Hainan, *X. Jianming & H. Haisheng 7714* (PE); Yunnan, *X. Qun & M. Yilun 950* (PE); Hainan, *X. Gongxia & X. Qun 05777A* (PE); Sichuan, *X. Gongxia & X. Qun 1329* (PE); ibid, *X. Gongxia & X. Qun 1403* (PE); ibid, *X. Gongxia & X. Qun 1404* (PE); ibid, *X. Gongxia & X. Qun 1405* (PE); ibid, *X. Gongxia & X. Qun 1555* (PE); ibid, *X. Gongxia & X. Qun 5021* (PE); Yunnan, *X. Gongxia & X. Qun 6916* (PE); Guangdong, *Y.K. Wang 488* (PE); Guizhou, *Y. Tsiang 8035* (PE); Guangxi, *Y. Haining et al. 1100* (PE); Guangdong, *Y. Yuehong 1640* (PE); Jiangxi, *Y. Yuehong 4092* (PE); Hainan, *Y. Yuehong 5488* (PE); Henan, *Yuntaishan Collection Team 805* (PE); Yunnan, *Z. Xianchun & Fang Zhendong 2740* (PE); Sichuan, *Z. Xianchun & Xiang Qiaoping 6938* (PE); Yunnan, *Z. Xianchun 0092* (PE); Guangxi, *Z. Xianchun 1303* (PE); Sichuan, *Z. Xianchun 2100* (PE); ibid, *Z. Xianchun 2438* (PE); ibid, *Z. Xianchun 2465* (PE); ibid, *Z. Xianchun 9890820* (PE); **JAPAN**. Honshu, *M. Togashi s.n.* (BM); **TAIWAN**. *D.Z. Fu & X.C. Zhang 96036* (PE); *M. Tagawa 1378* (PE); **VIETNAM**. Guangning, *Sino-Soviet team 2553* (PE).

5.6.3 ***Hypodematium glanduloso-pilosum*** (Tagawa) Ohwi, Bull. Natl. Sci. Mus. 3(2): 98–99. 1956; Z. Gangmin & K. Iwatsuki, Fl. China 538. 2013.—*Hypodematium fauriei* fo. *glanduloso-pilosum* Tagawa**,** J. Jap. Bot. 27(10): 321. 1952. Type: not seen. Figure 5.50, 5.61 G

Plants lithophyte. *Stems* short creeping, 1.0-1.5 cm in diameter, densely scaly; scale 10-15 × 0.8-1.3 mm, linear, concolorous, reddish-brown, margin entire with glandular hairs. *Leaves* tripinnate to 4-pinnatisect, 22-46 cm long; petioles 14-24 cm long, 1-2 cm in diameters, stramineous when dry, minutely hairy. *Laminae* 17-21 × 9-18 cm, outline ovate, apex long acuminate, base round, hairy, papyraceous, light green; rachis groove, hairy with both acicular hairs and glandular hairs; pinnae bipinnate, more than 6 pairs, 10-13 × 4-8 cm, subopposite, apex acuminate, base oblique; pinnule pinnatisect to pinnate, more than 5 pairs, 2-3 × 5-7 cm, subopposite, apex acuminate, base obtuse; pinnulet pinnatisect, 0.3-0.5 × 1.0-1.2 cm, apex acute or round, margin lobed; vein free, fork. *Sori* round, 3 per segment, at middle of veinlets, indusiate; indusia reniform, hairy, thin, persistent. *Spore* monolete, 35.5-48.0 × 27.0-34.0 μm, bilateral, concavo-convex to plano-convex, perispore present; ornamentation: rugate.

Thailand.— NORTH-EASTERN: Loei (Phu Kradueng); SOUTH-WESTERN: Prachuap Khiri Khan (Sam Roi Yot).

Distribution.— China, Korea, Japan

Ecology.— On shady rocks in deciduous or mixed forests at about 400 m alt.

Specimens Examined.—**THAILAND**. Loei, Phu Kradueng, *P. Jadprajong 108* (BCU); ibid.,*P. Jadprajong 206* (BCU); ibid., *P. Jadprajong 299* (BCU); ibid., *P. Pongkai 158* (BCU); **CHINA**. Anhui, *Anonymous 13* (PE): Henan, *Liu Mu s.n.* (PE): Jiangsu, *C.N.Chun 2082* (PE): Shandong, *Guo Chengyong 052170-6* (PE): ibid., *Guo Chengyong 052210-1* (PE): ibid., *Guo Chengyong 054203-1* (PE): ibid., *Guo Chengyong 054429-1* (PE): ibid., *Guo Chengyong 1505092-2* (PE): ibid., *Guo Chengyong 1509024-3* (PE): **JAPAN**. Unknown, *Miyoshi Furuse 51881* (PE): ibid.,*Tsugiwo Yamanaka 12571* (PE): **KOREA**. Gyeonggi, *Xian-Chun Zhang 6894* (PE).

5.6.4 *Hypodematium* sp. Figure 5.51, 5.61 H

Plants lithophytic. *Stem*s short creeping, 1.5-2.0 cm in diameter, densely scaly; scales 14-20 × 1-2 mm, linear, conlorous, reddish brown, margin entire. *Leaves* 63-87 cm long, tripinnate; petioles 25-45 cm long, 3-4 cm in diameter, light green when living, stramineous when dried, glabrous at middle, near base hairy, minutely scaly base, lower portion brown. *Laminae* 38-42 × 25-30 cm long, outline ovate-deltoid, hairy, membranous; rachises hairy, minutely scaly; pinnae more than 7 pairs, 20-22 × 9-12 cm, alternate, gradually becoming smaller upward forming long cuneate apex, lowest pinna largest, oblique, narrowly deltoid, basiscopic pinnule larger than acroscopic one, apex cuneate, base oblique, stalked; stalk 2.0-2.5 cm long; pinnule more than 7 pairs alternate, largest at basiscopic one of lowest pinna, 7-8 × 2-3 cm, lanceolate-oblong, apex acute, base obtuse, stalked, stalks 4-5 mm long; pinnulets morthan 6 pairs, alternate, the middle one largest, 1.5-2.0 × 0.7-0.8 cm, lanceolate-oblong, apex round, base obtuse, sessile, margin lobe; lobe deep nearly to midrib of pinnulet, apex round, margin slightly dentate; vein free, fork, veinlet of vein group 3-4 pairs, reaching margin. *Sori* round-reniform, on basal veinlet of each lobe, nearly close to midrib of lobe, forming two rows which parallel with midrib of pinnulet, indusiate; indusia reniform, oblique-reniform or heart-shaped, bulge, thin, bearing white acicular hairs, persistent. *Spores* monolete, bilateral symmetric, kidney-shaped, 53.8-60.4 × 43.0-49.7µm, ornamentation: rugate.

Thailand.—NORTH-EASTERN: Phetchabun (Pha Hong cave, Nam Nao National Park).

Distribution.— Endemic to Thailand.

Ecology.— on limestone crevices in half-shaded area at an elevation of about 300 m.

Specimens Examined.— **THAILAND**. Phetchabun, Pha Hong cave, Nam Nao National Park, *R. Pollawatn 2509* (BCU).

Note.— This species is closed to *H. crenatum* but difference in following characters: papyraceous texture of frond, very long cuneate apex, having one sori per segment (lobe) that forming two rows which parallel with midrib of pinnulet, and having bulge reniform, oblique-reniform or heart-shaped, indusium.

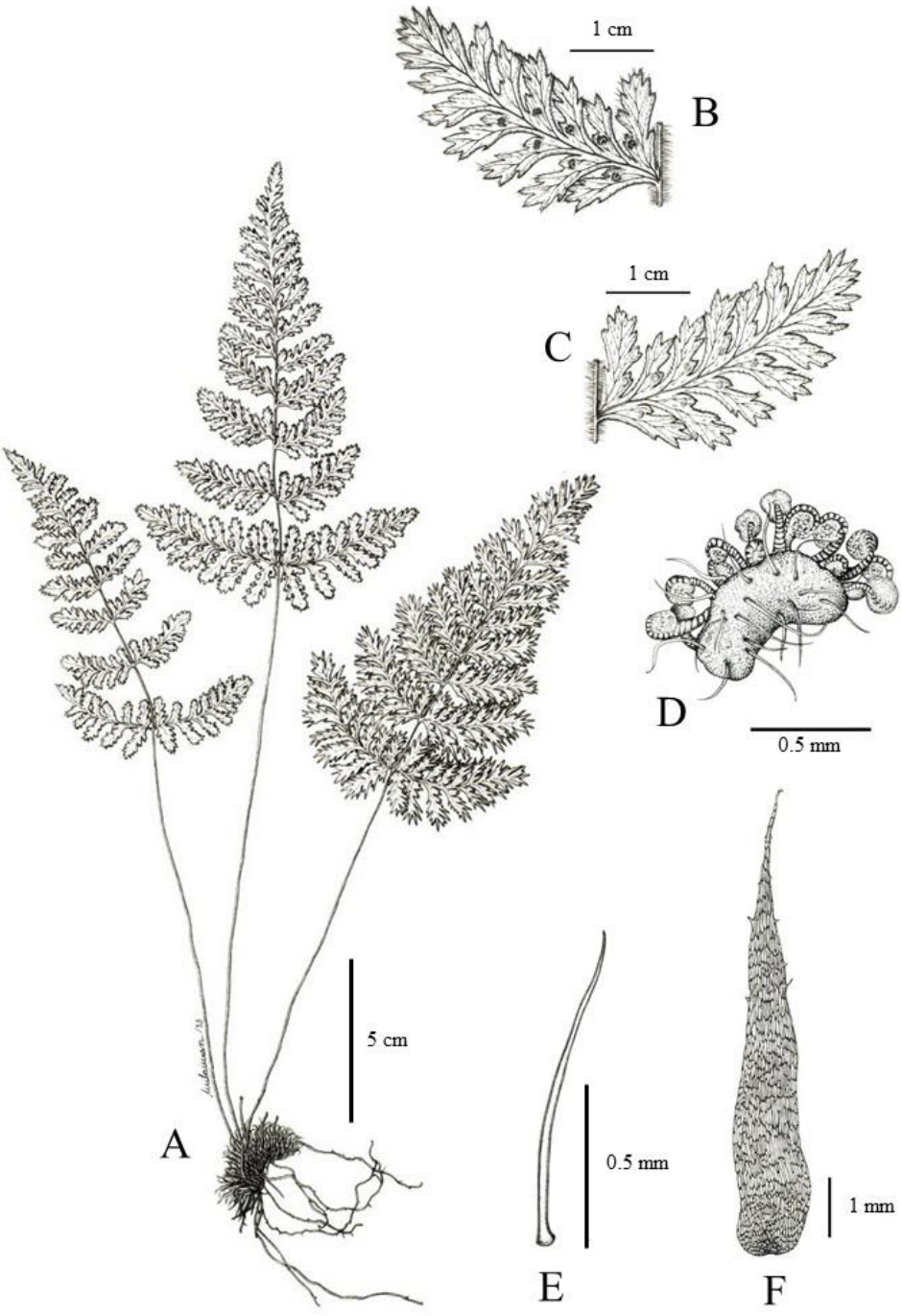

Figure 5.48 *Hypodematium boonkerdii* Pongkai, Li Bing Zhang & Pollawatn. A. habit. B. abaxial view of lower pinna with portion of rachis. C. adaxial view of lower pinna with portion of rachis. D. sorus covering with hairy indusium. E. unicellular hair. F. a rhizome scale with denticulate margins. Drawn by Wilaiwan Nuchthongmuang based on the holotype *T. Boonkerd et al. 2011-695* (BCU).

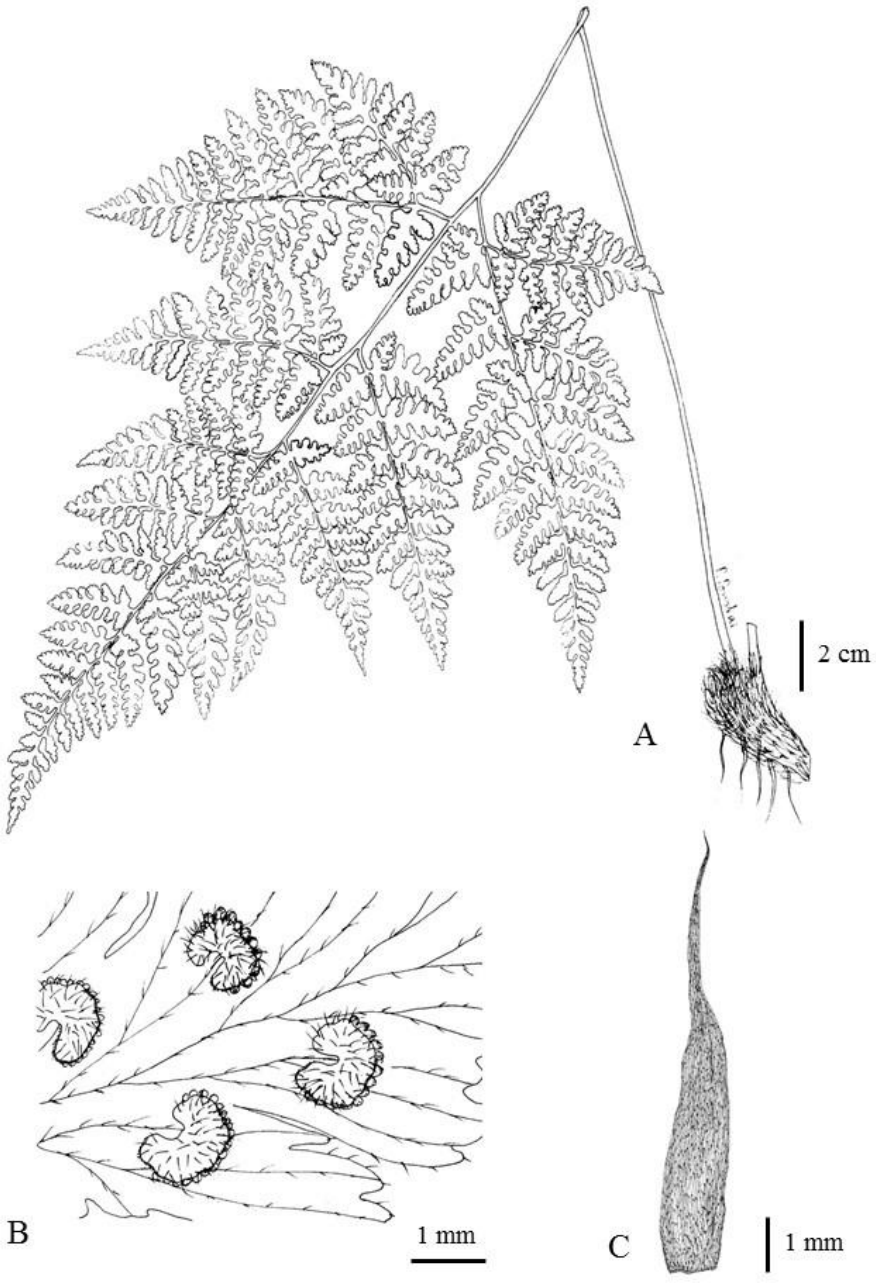

Figure 5.49 *Hypodematium crenatum* (Forssk.) Kuhn & Decken. A. a whole plant. B. part of pinnulet showing venation and sori. C. a rhizome scale. Drawn by Puttamon Pongkai from *T. Boonkerd 1238* (BCU).

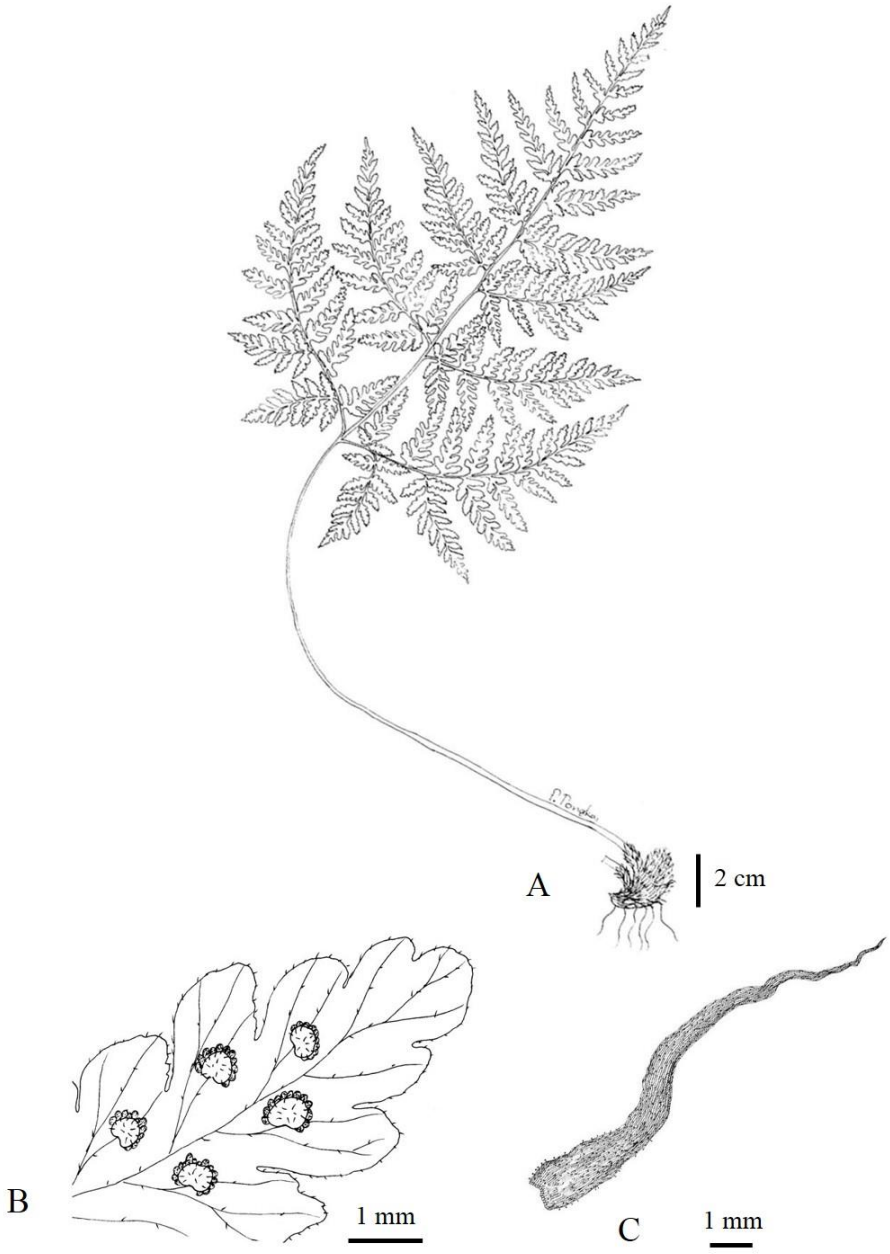

Figure 5.50 *Hypodematium glanduloso-pilosum* (Tagawa) Ohwi. A. a whole plant. B. part of a pinnulet showing venation and sori. C. a rhizome scale. Drawn by Puttamon Pongkai from *P. Pongkai 158* (BCU).

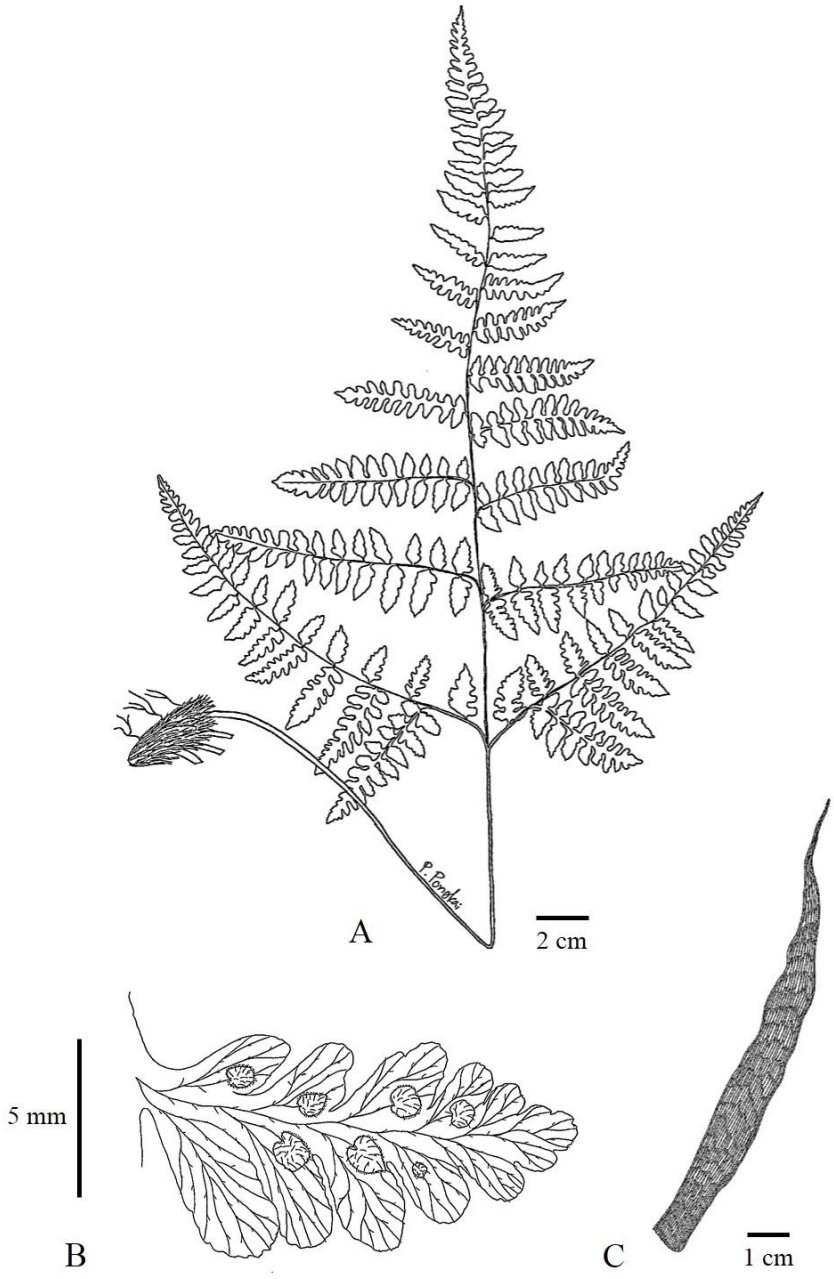

Figure 5.51 *Hypodematium* sp. A. a whole plant. B. a pinnae showing venation and sori. C. a rhizome scale. Drawn by Puttamon Pongkai from *R. Pollawatn 2509* (BCU).

Figure 5.52 Habit/habitat of some Athyriaceous ferns. A. *Anisocampium cumingianum*, B. *A. cuspidatum*, C. *A. niponicum*, D. *Athyrium anisopterum.*

Figure 5.53 Habit/habitat of some Athyriaceous ferns. A. *Athyrium biserrulatum* Christ, B. *A. brevisorum (*Wall. ex Hook.) T. Moore, C. *A. dissitifolium* (Baker) C. Chr., D. *A. mackinnonnorum* (C. Hope) C. Chr.

Figure 5.54 Habit/habitat of some Athyriaceous ferns. A. *Athyrium pachyphyllum* Ching, B. *A. strigillosum* (E.J. Lowe) Salomon, C. *A. wangii* Ching, D. *Cornopteris opaca* (D. Don) Tagawa.

Figure 5.55 Habit/habitat of some Athyriaceous ferns. A. *Deparia boryana* (Willd.) M. Kato, B. *D. heterophlebia* (Mett. ex Baker) R. Sano, C. *D. japonica* (Thunb.) M. Kato, D. *D. lancea* (Thunb.) Fraser-Jenk.

Figure 5.56 Habit/habitat of some Athyriaceous ferns. A. *Diplazium bantamense* Blume, B. *D. bellum* (C.B. Clarke) Bir, C. D. *conterminum* Christ, D. D. *cordifolium* Blume, E. *D. crenato-serratum* (Blume) T. Moore, F. *D. dilatatum* Blume.

Figure 5.57 Habit/habitat of some Athyriaceous ferns. A. *D. donianum* (Mett.) Tardieu, B. *D. esculentum* (Retz.) Sw., C. *D. kappanense* Hayata, D. *D. leptophyllum* Christ, E. *D. malaccense* C.Presl, F. *D. megaphyllum* (Baker) Christ.

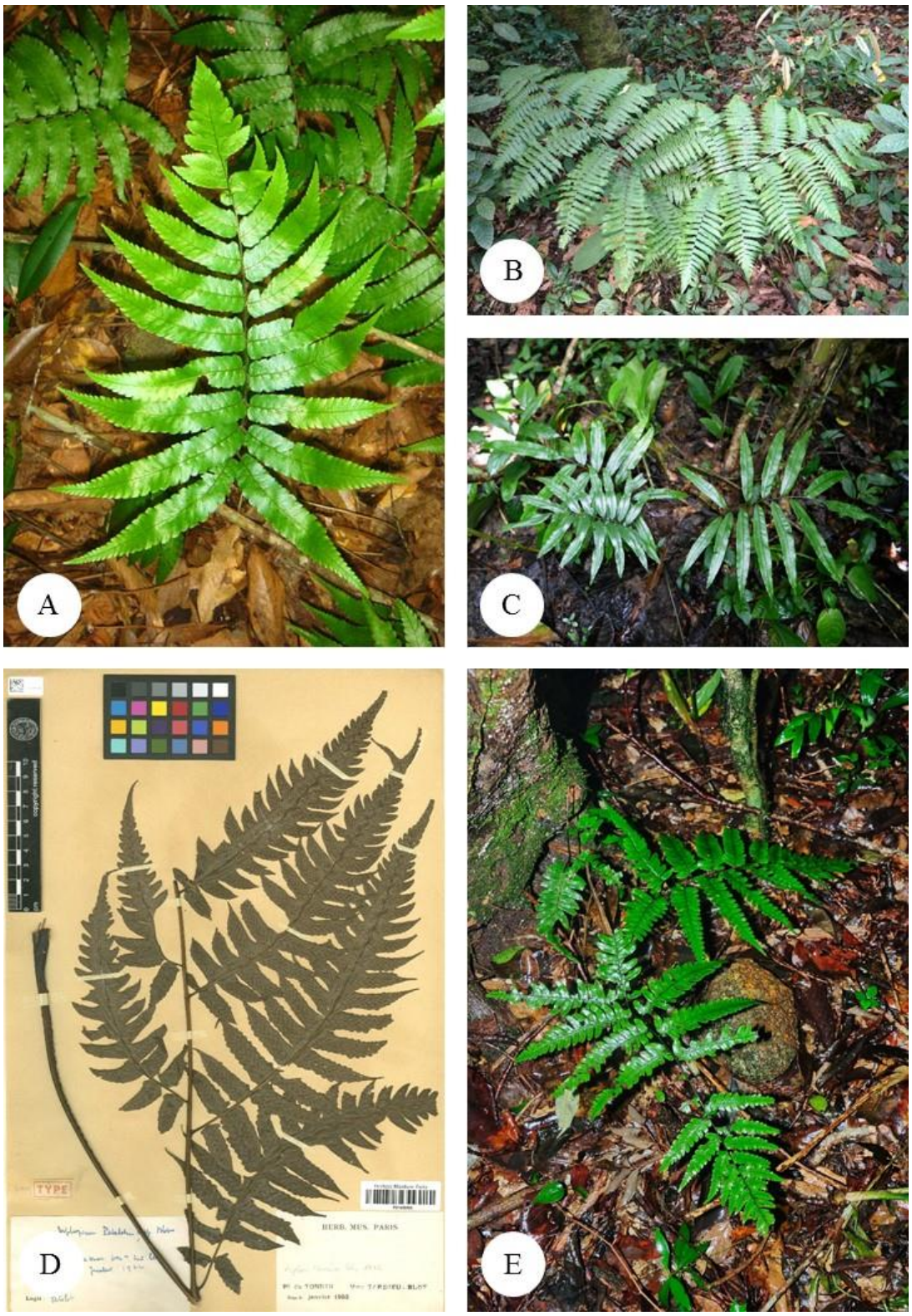

Figure 5.58 Habit/habitat of some Athyriaceous ferns. A. *Diplazium mettenianum* (Miq.) C.Chr., B. *D. muricatum* (Mett.) Alderw., C. *D. pallidum* (Blume) T.Moore, D. *D. petelotii* Tardieu, E. *D. petrii* Tardieu.

Figure 5.59 Habit/habitat of some Athyriaceous ferns. A. *Diplazium polypodioides* Blume, B. *D. prescottianum* (Wall. ex Hook.) T.Moore, C. *D. procumbens* Holttum, D. *D. proliferum* (Larmarck) Kaulf.

Figure 5.60 Habit/habitat of some Athyriaceous ferns. A. *D. riparium* Holttum, B. *D. siamense* C.Chr., C. *D. simplicivenium* Holttum, D. *D. sorzogonense* (C.Presl) C.Presl, E. *D. subintegrum* Holttum, F. *D. subserratum* Blume.

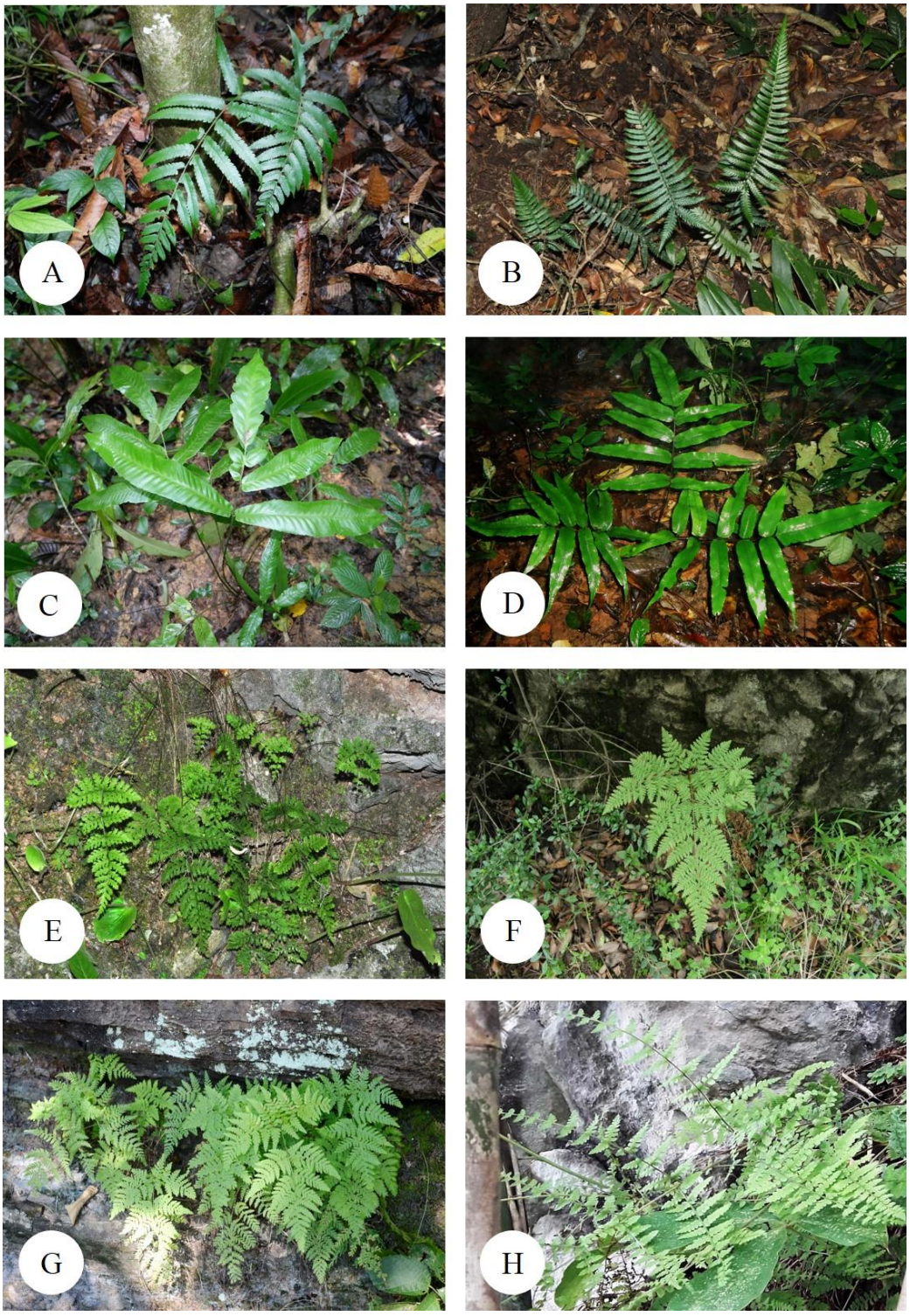

Figure 5.61 Habit/habitat of some Athyriaceous ferns and Hypodematium. A. *Diplazium sylvaticum* (Bory) Sw., B. *D. tomentosum* Blume, C. *D. xiphophyllum* (Baker) C.Chr., D. *D. thailandicum* Pongkai, Boonkerd and Pollawatn., E. *Hypodematium boonkerdii* Pongkai, Li Bing Zhang & Pollawatn, F. *H. crenatum* (Forssk.) Kuhn & Decken, G. *H. glanduloso-pilosum* (Tagawa) Ohwi, H. *H.* sp.

5.7 New species and new record species

Two new species and eight new record species were reported here (Table 5.1). *Hypodematium boonkerdii* is a new species, so far it is endemic to Thailand. Six new records, i.e. *Anisocampium niponicum*, *Athyrium biserrulatum*, *A. brevisorum*, *A. pachyphyllum*, *A. wangii* and *Diplazium bellum* occur from China to the north of Thailand. However, *Diplazium bellum* and *D. pallidum* were found from peninsular Thailand to Malaysia.

Table 5.1 New species and new records from Thailand.

No.	Taxa	Localities in Thailand
1.	*Anisocampium niponicum*	Chiang Mai
2.	*Athyrium biserrulatum*	Chiang Mai
3.	*Athyrium brevisorum*	Chiang Mai
4.	*Athyrium pachyphyllum*	Nan
5.	*Athyrium wangii*	Udon Thani
6.	*Diplazium bellum*	Chiang Mai
7.	*Diplazium pallidum*	Nakhon Si Thammarat
8.	*Diplazium procumbens*	Phetchaburi
9.	*Diplazium thailandicum**	Chiang Rai, Nakhon Sawan, Phitsanulok
10.	*Hypodematium boonkerdii**	Loei

***** New species

5.8 Lectotypification

The lectotypification of two *Diplazium* species were made. They are *D. bellum* (C.B. Clarke) Bir. and *D. Petelotii* Tardieu.

5.9 New Synonym

Diplazium axillare Ching was described by Ching (1936) in Lingnan Science Journal based on *J.F. Rock 7434* (holotype BM001045379!). After thoroughly studied the type specimens of *D. bellum* (C.B. Clarke) Bir. i.e., *Clarke, C.B. 26399* (Holotype K001089427!; Isotype K001089428!, K001089429!) It was found that they are conspecific. Therefore, *D. axillare* Ching was reduced here to a synonym of *D. bellum* (C.B. Clarke) Bir.

5.10 Thai Floristic Regions and Fern Distributions

According to Flora of Thailand, the country was classified into 7 floristic regions, northern, north-eastern, eastern, central, south-eastern, south-western and peninsular (Tagawa and Iwatsuki, 1988). The distribution of Athyriaceous ferns are different and depend on genera. The genera: *Anisocampium*, *Athyrium*, *Cornopteris* and *Deparia* are mainly found in northern Thailand, however, some species can be found in the other region such as north-eastern, central, south-eastern, south-western Thailand. The genus *Hypodematium*, however, occurs mainly in north-eastern Thailand, on the other hand, the genus *Diplazium* are found in all floristic regions of Thailand (Tabel 5.2).

On a worldwide basis, Thailand is considered as the meeting point of four floristic regions, i.e. Indo-Burmese, Sino-Himalayan, Indo-Chinese and Malesian elements (Takhtajan, 1986). Most studied species are member of more than one floristic regions (Table 5.3), while some species have restricted distribution.

5.10.1 Endemic species

So far, three species are endemic to Thailand: *Diplazium thailandicum*. *Hypodematium boonkerdii* and *Hypodematium* sp. (Table 5.3).

Diplazium thailandicum, the endemic species of northern Thailand at Chiang Rai, Phitsanulok *and* Nakhon Sawan province. It grows in shady valleys at elevations ranging from 580–1650 m.

H. boonkerdii, the endemic species of north-eastern Thailand at Loei province. It grows on shady walls in a cave at an elevation of about 430 m.

Hypodematium sp., the endemic species of north-eastern Thailand at Phetchabum province, It grows on limestone crevices in half-shaded area at an elevation of about 300 m.

5.10.2 Sino-Himalayan elements

Four species are members of the Sino-Himalayan elements, i.e. *Athyrium pachyphyllum*, *A. wangii*, *Diplazium siamense*, and *Hypodematium glanduloso-pilosum* (Table 5.3).

A. pachyphyllum was found in China. In Thailand, it was found in northern Thailand at Chiang Mai (Doi Suthep) and Nan (Doi Phu Kha).

A. wangii was found in China. In Thailand, it was found in north-eastern Thailand at Loei (Phu Luang).

D. siamense was found in China. In Thailand, it was found in northern Thailand at Chiang Mai (Doi Suthep, Mae Wang), Chiang Rai (Doi Pacho), Nan (Doi Phuka, Khao Nok), Phrae (Mae Sai), Phitsanulok (Phu Hin Rong Kla, Phu Rom Rot) and also in north-eastern Thailand at Phetchabun (Phu Miang), Loei (Na Haew, Phu Luang, Phu Suan Sai).

Hypodematium glanduloso-pilosum was found in China, Korea and Japan. In Thailand, it was found in north-eastern Thailand at Loei (Phu Kradueng) and south-eastern Thailand at Prachuap Khiri Khan (Sam Roi Yot).

5.10.3 Malesian elements

Ten species are Malesian elements, i.e. *Diplazium bantamense*, *D. cordifolium*, *D.crenato-serratum*, *D. pallidum*, *D.* prescottianum, *D. proliferum*, *D. riparium*, *D. subintegrum*, *D. subserratum* and *D. xiphophyllum* (Table 5.3).

D. bantamense was found in Philippines, Malaysia, Indonesia and Papau New Guinae. In Thailand it was found in south-western Thailand at Prachuap Khiri Khan (Huaiyang waterfalls) and peninsular Thailand at Surat Thani (Khao Khieo range), Nakhon Si Thammarat (Khao Luang, Khao Nan), Trang (Khao Chong), Satun (Kao Khao Yai), Songkla (Ton Nga Chang National Park), Yala (Ban Chana, Ban Malao, Banang Sata, Betong), Narathiwat (Hala-bala).

D. cordifolium was found in Malaysia, Singapore, Indonesia, Australia and Papua New Guinea. In Thailand it was found in peninsular Thailand only at Chumphon (Lang Suan), Nakhon Si Thammarat (Khao Luang, Khao Nan), Trang (Khao Chong, Khao Pad Pha), Narathiwat (Ban Phu Klong Thong, Waeng), Pattani, Songkhla, Yala (Ban Chana).

D. crenato-serratum was found in Malaysia, Brunei and Indonesia. In Thailand it was found in south-western Thailand at Prachuap Khiri Khan (Huaiyang waterfalls), south-eastern Thailand at Chanthaburi and peninsular Thailand at Surat Thani (Ban Don, Klong Ton), Phangnga (Toong Rha Suung), Krabi (Khao Ngorn Nark), Nakhon Si Thammarat (Khao Luang, Khao Huai Pampun, Khao Nan, Chawang), Patthalung (Tha Mot), Trang (KHAO Chong), Satun, Songkhla (Ton Nga Chang waterfalls), Yala (Kiong Bla Hot, Ban Mae Prik, Betong).

D. pallidum was found in Philippine, Malaysia, Brunei, Indonesia, Australia and Papua New Guinea. In Thailand it was found in peninsular Thailand only at Nakhon Si Thammarat (Khao Luang, Krung Ching Waterfall).

D. prescottianum was found in Malaysia and Singapore. In Thailand it was found in south-eastern Thailand at Trat (Koh Chang) and peninsular Thailand at Nakhon Si Thamarat (Khao Luang), Yala (Ban Chana, Ban Malao).

D. proliferum was found in Philippines, Malaysia, Indonesia, Australia and Papua New Guinea. In Thailand it was found in peninsular Thailand at Ranong (Phato), Trang, Yala (Banang Sata).

D. riparium was found in Philippines, Malaysia, Singapore, Brunei and Indonesia. In Thailand it was found in peninsular Thailand only at Chumphon (Langsuan), Surat Thani (Tako, Ban Don), Nakhon Si Thammarat (Khao Luang, Khao Nan, Krung Ching Waterfalls, Ronpibun), Trang (Khao Chong), Satun; Songkhla (Ton Nga Chang Waterfalls), Yala (Ban Chana).

D. subintegrum was found in Malaysia and Indonesia. In Thailand it was found in northern Thailand at Phitsanulok (Salaeng Haeng), central Thailand at Nakhon Nayok (Khao Yai), south-eastern Thailand at Prachinburi (Khao Yai), Chanthaburi (Khao Soi Dao), Trat (Koh Chang) and peninsular Thailand at Nakhon Si Thammarat (Khao Luang, Khao Nan), Yala.

D. subserratum was found in Malaysia and Indonesia. In Thailand it was found in peninsular Thailand only at Narathiwat (Hala-Bala), Satun (Khao Khieo range), Yala (Ban Phu Khao Thong, Betong).

D. xiphophyllum was found in Philippines, Malaysia, Brunei and Indonesia. In Thailand it was found in peninsular Thailand only at Nakhon Si Thammarat (Krung Ching Waterfalls, Khao Luang, Khao Nan), Narathiwat (Ban Waeng), Yala (Ban Chana).

Table 5.2 The distribution of Athyriaceae and Hypodematium in Thailand.

Genera	No.	Taxa	Floristic Regions of Thailand						
			N	NE	E	SW	C	SE	PEN
Anisocampium	1	*A. cumingianum*	✓	-	-	✓	✓	✓	-
	2	*A. cuspidatum*	✓	-	-	-	-	-	-
	3	*A. niponicum**	✓	-	-	-	-	-	-
Athyrium	1	*A. anisopterum*	✓	-	-	-	-	-	-
	2	*A. biserrulatum**	✓	-	-	-	-	-	-
	3	*A. brevisorum**	✓	-	-	-	-	-	-
	4	*A. dissitifolium*	✓	-	-	-	-	-	-
	5	*A. mackinnonorum*	✓	✓	-	-	-	✓	-
	6	*A. pachyphyllum**	✓	-	-	-	-	-	-
	7	*A. strigillosum*	✓	-	-	-	-	-	-
	8	*A. wangii**	✓	✓	-	-	-	-	--
Cornopteris	1	*C. opaca*	✓	-	-	-	-	-	-
Deparia	1	*D. boryana*	✓	-	-	-	-	-	-
	2	*D. heterophlebia*	✓	-	-	-	-	-	-
	3	*D. japonica*	✓	-	-	-	-	-	-
	4	*D. lancea*	-	-	✓	-	-	-	-
Diplazium	1	*D. bantamense*	-	-	-	✓	-	✓	✓
	2	*D. bellum **	✓	-	-	-	-	-	-
	3	*D. conterminum*	✓	-	-	-	-	✓	✓
	4	*D. cordifolium*	-	-	-	-	-	-	✓
	5	*D. crenato-serratum*	-	-	-	✓	-	✓	✓
	6	*D. dilatatum*	✓	✓	✓	✓	✓	✓	✓
	7	*D. donianum*	✓	✓	✓	✓	✓	✓	✓
	8	*D. esculentum*	✓	✓	✓	✓	✓	✓	✓
	9	*D. kappanense*	-	✓	-	✓	✓	-	-
	10	*D. leptophyllum*	✓	-	-	-	-	-	-
	11	*D. malaccense*	-	-	-	-	-	-	✓
	12	*D. megaphyllum*	✓	-	✓	-	-	-	-
	13	*D. mettenianum*	-	✓	-	-	-	-	-
	14	*D. muricatum*	✓	-	-	✓	-	-	-
	15	*D. pallidum **	-	-	-	-	-	-	✓
	16	*D. petelotii*	✓	-	-	-	-	-	-
	17	*D. petrii*	-	-	-	✓	-	✓	✓
	18	*D. polypodioides*	✓	-	-	✓	-	✓	✓
	19	*D. prescottianum*	-	-	-	-	-	✓	✓
	20	*D. procumbens**	-	-	-	✓	-	-	-
	21	*D. proliferum*	-	-	-	-	-	-	✓
	22	*D. riparium*	-	-	-	-	-	-	✓
	23	*D. siamense*	✓	✓	-	-	-	-	-
	24	*D. simplicivenium*	✓	-	✓	✓	-	✓	✓
	25	*D. sorzogonense*	-	-	-	-	-	-	✓
	26	*D. subintegrum*	✓	-	-	-	✓	✓	✓
	27	*D. subserratum*	-	-	-	-	-	-	✓
	28	*D. sylvaticum*	✓	✓	-	✓	-	✓	✓
	29	*D. tomentosum*	✓	-	✓	-	✓	✓	✓
	30	*D. xiphophyllum*	-	-	-	-	-	-	✓
	31	*D. thailandicum*	✓	-	-	-	-	-	-
Hypodematium	1	*H. boonkerdii***	-	✓	-	-	-	-	-
	2	*H. crenatum*	✓	✓	-	✓	-	-	-
	3	*H. glanduloso-pilosum*	-	✓	-	✓	-	-	-
	4	*H.* sp.	-	✓	-	-	-	-	-

Notes:N=NORTHERN; NE=NORTH-ESTERN; E=EASTERN; SE=SOUTH-EASTERN; C=CENTRAL; SW=SOUTH-WESTERN; PEN=PENINSULAR.

Table 5.3 The distribution of Family Athyriaceae and the genus Hypodematium.

Genera	No.	Taxa	Floristic regions
Anisocampium	1	*A. cumingianum*	IB, SH, IC, M
	2	*A. cuspidatum*	IB, SH
	3	*A. niponicum*	SH, IC
Athyrium	1	*A. anisopterum*	IB, SH, IC
	2	*A. biserrulatum*	IB, SH
	3	*A. brevisorum*	IB, SH
	4	*A. dissitifolium*	IB, SH, IC
	5	*A. mackinnonorum*	IB, SH, IC
	6	*A. pachyphyllum*	SH
	7	*A. strigillosum*	IB, SH
	8	*A. wangii*	SH
Cornopteris	1	*C. opaca*	SH, IC, M
Deparia	1	*D. boryana*	IB, SH, IC, M
	2	*D. heterophlebia*	IB, SH, IC, M
	3	*D. japonica*	IB, SH, IC
	4	*D. lancea*	IB, SH, IC
Diplazium	1	*D. bantamense*	M
	2	*D. bellum*	IB, SH
	3	*D. conterminum*	SH, IC
	4	*D. cordifolium*	M
	5	*D. crenato-serratum*	M
	6	*D. dilatatum*	IB, SH, IC, M
	7	*D. donianum*	IB, SH, IC, M
	8	*D. esculentum*	IB, SH, IC, M
	9	*D. kappanense*	SH, IC
	10	*D. leptophyllum*	IB, SH
	11	*D. malaccense*	IC, M
	12	*D. megaphyllum*	IB, SH, IC
	13	*D. mettenianum*	SH, IC
	14	*D. muricatum*	IB, SH, M
	15	*D. pallidum*	M
	16	*D. petelotii*	SH, IC
	17	*D. petrii*	SH, IC, M
	18	*D. polypodioides*	IB, SH, IC, M
	19	*D. prescottianum*	M
	20	*D. procumbens*	SH, M
	21	*D. proliferum*	M
	22	*D. riparium*	M
	23	*D. siamense*	SH
	24	*D. simplicivenium*	IB, M
	25	*D. sorzogonense*	SH, IC, M
	26	*D. subintegrum*	M
	27	*D. subserratum*	M
	28	*D. sylvaticum*	IB, M
	29	*D. tomentosum*	IB, IC, M
	30	*D. xiphophyllum*	M
	31	*D. thailandicum*	E
Hypodematium	1	*H. boonkerdii*	E
	2	*H. crenatum*	SH, IC, M
	3	*H. glanduloso-pilosum*	SH
	4	*H.* sp.	E

Notes: E= Endemic; IB=Indo-Burmese element; SH=Sino-Himalayan element; IC-Indo-Chinese element; M=Malesian element.

5.11 Ecology

The fern family Athyriaceae are terrestrial, occur in many types of land habitat from low land to mountainous areas of about 2,500 m altitude, in exposed to shady areas (Table 5.4). The genera *Cornopteris*, *Deparia* and *Diplazium* occur mainly in shady valleys near stream of tropical rain forest, whereas the genera *Anisocampium* and *Athyrium* usually grow in light shaded areas on mountain slopes of hill evergreen forest or pine forest. The genus *Anisocampium* grow in light shaded area at elevations ranking from 500 to 2,000 m, of these *A. niponicum* is a mountain species occurs up to 2,000 m elevation. The genus *Athyrium* grow in light shaded area, except *A. biserrulatum* which grow in exposed area near summit of the mountains at elevations ranking from 1,000 m to up to 2,500 m. The other two genera, *Cornopteris* and *Deparia* occur in light shaded to shaded area at elevations ranking from 600 to 1,800 m. The most common genus, *Diplazium* occurs in shaded area from near sea level to the high elevation of 2,000 m. It is noted here that *D. esculentum* can be found in exposed area, but usually occupy marsh habitat of stream bank.

The genus *Hypodematium* is lithophytic fern, grow on limestone hills ranging in elevations from 430 to 1,800 m. The *Hypodematium* species are different in their habitat preference. *H. boonkerdii* thrives in shady area of the cave entrance at 430 m alt., whereas *H. glanduloso-pilosum* and *H.* sp. were found in light shaded areas at c. 500 m alt. However, *H. crenatum* can be found in light shaded to fully exposed area at elevation up to 1,800 m.

Table 5.4 Ecological data of Athyriaceae and Hypodematium in Thailand.

Genera	No.	Taxa	Habit	Habitat	Altitude (m)
Anisocampium	1	*A. cumingianum*	T	LA	500-1,300
	2	*A. cuspidatum*	T	LA	800-1,800
	3	*A. niponicum*	T	LA	1,200-2,000
Athyrium	1	*A. anisopterum*	T	LA	c. 1,800
	2	*A. biserrulatum*	T	EA	2,000-2,100
	3	*A. brevisorum*	T	LA	1,500-2,000
	4	*A. dissitifolium*	T	LA	1,000-2,000
	5	*A. mackinnonorum*	T	LA	1,100-1,800
	6	*A. pachyphyllum*	T	LA	1,400-1,500
	7	*A. strigillosum*	T	LA	2,000-2,500
	8	*A. wangii*	T	LA	1,000-1,500
Cornopteris	1	*C. opaca*	T	LA, SA	1,000-1,700
Deparia	1	*D. boryana*	T	LA, SA	1,000-1,400
	2	*D. heterophlebia*	T	LA, SA	c. 1,750
	3	*D. japonica*	T	LA, SA	600-1,800
	4	*D. lancea*	T	LA, SA	c. 1,200
Diplazium	1	*D. bantamense*	T	SA	400-1,000
	2	*D. bellum*	T	SA	1,700-2,000
	3	*D. conterminum*	T	SA	900-1,500
	4	*D. cordifolium*	T	SA	800-1,100
	5	*D. crenato-serratum*	T	SA	up to 1,000
	6	*D. dilatatum*	T	LA, SA	400-1,500
	7	*D. donianum*	T	SA	800-1,250
	8	*D. esculentum*	T	EA, LA	5-1,200
	9	*D. kappanense*	T	SA	c. 800
	10	*D. leptophyllum*	T	SA	850-1,600
	11	*D. malaccense*	T	SA	650-1,250
	12	*D. megaphyllum*	T	SA	c. 800
	13	*D. mettenianum*	T	SA	1,100-1,280
	14	*D. muricatum*	T	LA, SA	1,000-2,000
	15	*D. pallidum*	T	SA	600-1,100
	16	*D. petelotii*	T	SA	1,000-1,300
	17	*D. petrii*	T	SA	1,000-1,400
	18	*D. polypodioides*	T	SA	500-1,200
	19	*D. prescottianum*	T	SA	c. 600
	20	*D. procumbens*	T	SA	c. 1,300
	21	*D. proliferum*	T	SA	c. 600
	22	*D. riparium*	T	SA	250-500
	23	*D. siamense*	T	SA	850-1,500
	24	*D. simplicivenium*	T	SA	400-1,500
	25	*D. sorzogonense*	T	SA	600-1,400
	26	*D. subintegrum*	T	SA	800-1,000
	27	*D. subserratum*	T	SA	c. 700
	28	*D. sylvaticum*	T	SA	up to 1,200
	29	*D. tomentosum*	T	SA	200-1,250
	30	*D. xiphophyllum*	T	SA	500-1,100
	31	*D. thailandicum.*	T	SA	580–1650
Hypodematium	1	*H. boonkerdii*	L	SA	c. 430
	2	*H. crenatum*	L	EA, LA	up to 1,800
	3	*H. glanduloso-pilosum*	L	LA	c. 400
	4	*H.* sp.	L	LA	c. 500

Note: T=terrestrial; L=lithophyte, EA=exposed area; LA=light shaded area; SA=shaded area.

5.12 Comparison with other works

According to Tagawa and Iwatsuki (1988) and Boonkerd and Pollawatn (2000), they recognized Athyriacae which consist of seven genera, however, genus *Hypodematium* was also included. Forty species were reported. For the present study 47 species were recognized to include in the Athyriaceae, whereas the genus *Hypodematium* were treated here to include in Hypodematiaceae and four species were recognized (Table 5.5).

Table 5.5 Comparative treatment of Athyriaceae and Hypodematium in Thailand.

Genus	No.	Taxa	Tagawa & Iwatsuki (1988)	Boonkerd & Pollawatn (2000)	Present study (2018)
Athyriaceae					
Anisocampium	1	*A. cumingianum*	✓	✓	✓
	2	*A. cuspidatum*	*K. cuspidata*	*K. cuspidata*	✓
	3	*A. niponicum**	-	-	✓
Athyrium	1	*A. anisopterum*	✓	-	✓
	2	*A. biserrulatum**	-	-	✓
	3	*A. brevisorum**	-	-	✓
	4	*A. dissitifolium*	✓	✓	✓
	5	*A. mackinnonorum*	*At. mackinnonii*	✓	✓
	6	*A. pachyphyllum**	-	-	✓
	7	*A. strigillosum*	*At. setiferum*	*At. setiferum*	✓
	8	*A. wangii**	-	-	✓
Cornopteris	1	*C. opaca*	✓	✓	✓
Deparia	1	*D. boryana*	✓	*At. boryanum*	✓
	2	*D. heterophlebia*	*Di. heterophlebium*	*Di. heterophlebium*	✓
	3	*D. japonica*	✓	*At. japonicum*	✓
	4	*D. lancea*	*Di. subsinuatum*	*Di. subsinuatum*	✓
Diplazium	1	*D. bantamense*	✓	✓	✓
	2	*D. bellum **	-	-	✓
	3	*D. conterminum*	✓	✓	✓
	4	*D. cordifolium*	✓	✓	✓
	5	*D. crenato-serratum*	✓	✓	✓
	6	*D. dilatatum*	✓	✓	✓
	7	*D. donianum*	✓	✓	✓
	8	*D. esculentum*	✓	✓	✓
	9	*D. kappanense*	*Di. taiwanense*	*Di. taiwanense*	✓
	10	*D. leptophyllum*	✓	✓	✓
	11	*D. malaccense*	✓	✓	✓
	12	*D. megaphyllum*	✓	✓	✓
	13	*D. mettenianum*	✓	✓	✓
	14	*D. muricatum*	✓	✓	✓
	15	*D. pallidum **	-	-	✓
	16	*D. petelotii*	✓	✓	✓
	17	*D. petrii*	*Di. petri*	*Di. petri*	✓
	18	*D. polypodioides*	✓	✓	✓
	19	*D. prescottianum*	✓	✓	✓
	20	*D. procumbens**	✓	✓	✓
	21	*D. proliferum*	*Di. accedens*	*D. accedens*	✓
	22	*D. riparium*	✓	✓	✓
	23	*D. siamense*	✓	✓	✓
	24	*D. simplicivenium*	✓	✓	✓
	25	*D. sorzogonense*	✓	✓	✓
	26	*D. subintegrum*	✓	✓	✓
	27	*D. subserratum*	✓	✓	✓
	28	*D. sylvaticum*	*Di. sivaticum*	*Di. sivaticum*	✓
	29	*D. tomentosum*	✓	✓	✓
	30	*D. xiphophyllum*	✓	✓	✓
	31	*D. thailandicum*	-	-	-
Hypodematiaceae					
Hypodematium	1	*H. boonkerdii***	-	-	✓
	2	*H. crenatum*	✓	✓	✓
	3	*H. glanduloso-pilosum*	✓	✓	✓
	4	*H.* sp.	-	-	✓
Total taxa			41	41	50

Notes: * indicate newly reported taxa, ** indicate newly taxa, (✓= present; - = absent).

CHAPTER VI
GENERAL CONCLUSION

A previous account of the fern family Athyriaceae was in Flora of Thailand Tagawa and Iwatsuki (1988) which included 7 genera: *Athyrium*, *Anisocampium*, *Cornopteris*, *Deparia*, *Diplazium*, *Hypodematium* and *Kuniwatsukia*. The taxonomic relationships among genera are controversial and not well understood depending mainly on data of each investigator (Christenhusz *et al.*, 2011; Rothfels *et al.*, 2012; PPG I, 2016). Previously, using key to the genera and the key to the species were still uncertain due mainly to the ambiguity of the characters being used in the key. Therefore, the existing keys and descriptions should be amended and prepare to include all unknown specimens of the family Athyriaceae in Thailand.

This research was designed to clarify taxonomic status of the fern family Athyriaceae and its lower taxa in Thailand. Herbarium specimens from main herbaria in Asia and Europe and additional collecting specimens throughout Thailand were carefully examined and focused on morphological, anatomical, palynological and molecular data. It is evident that the results of all investigated data are valuable to resolve previous taxonomic problems of the family.

Regarding fern morphology both quantitative and qualitative morphological characters were investigated. The utility of specific taxonomic characters was evaluated, with particular emphasis on rhizome, frond, scale, and sori. It was found that rhizome types, types and shapes of frond, scale types, sorus shapes are valuable characters for genus and species determination.

Stipe anatomy and stomatal structure were investigated and it was found that gutter-shaped vascular bundle in stipes is a diagnostic character of the family Athyriaceae. Moreover, the nearly heart-shaped vascular bundle of the genus *Hypodematium* is exclusive. This unique character supported the segregation of the genus *Hypodematium* from the family Athyriaceae. Therefore, it can be seen that the stipe anatomy is useful for family determination. However, pattern of the *stomatal apparatus* shows absolute constancy of *Polocytic* type in all studied species. As a result this examined characters cannot be used for genera and species determination.

Spores of each studied species were examined by SEM. Ten spore ornamentation types were observed, of these baculate and rugate types are restricted to *Deparia* and *Hypodematium*, respectively. In contrast, spores of the genus *Diplazium* do has the most diverse ornamentation types, this result probably due to the highest variation and diversity of species of this genus. Thus, spore morphology is also a valuable character for genera and species determination.

The results of phylogenetic analysis of three regions in plastid genome (*rbcL*, *trnL-F* and *rps4*) showed that both *rbcL* and *rps4* phylogenies indicated all genera are monophyletic groups whereas *trnL-F* phylogeny showed that *Cornopteris* is the polyphyletic group. Molecular results are corresponding to another techniques results of this study that *Hypodematium* should be separated from Athyriaceae. Due to all genera in Athyriaceae and *Hypodematium* are monophyletic genera and *Hypodematium* never placed in any other clades of Athyriaceae.

To sum up, the Thai Athyriaceae sensu Tagawa and Iwatsuki (1988) and Liu *et al.* (2011) was treated here in to two families: Athyriaceae and Hypodematiaceae based on the results of morphological, anatomical, palynological and molecular data. The Thai Athyriaceae includes 5 genera, i.e. *Athyrium*, *Anisocampium*, *Cornopteris*, *Deparia* and *Diplazium*. *Hypodematium* is placed to its own family Hypodematiaceae.

An updated account of the Thai athyriaceous ferns is reported here which included eight species of *Athyrium*, three species of *Anisocampium*, one species of *Cornopteris*, four species of *Deparia*, thirty one species of *Diplazium* and four species of *Hypodematium*. Of these, two new species, namely *Hypodematium boonkerdii* Pongkai, Li Bing Zhang & Pollawatn and *Diplazium thailandicum* Pongkai, Boonkerd & Pollawatn were published and accepted for publication, respectively. Eight new records were reported, i.e. *Anisocampium niponicum* (Mett.) Hance., *Athyrium biserrulatum* Christ, *A. brevisorum* (Wall. ex Hook.) T. Moore, *A. pachyphyllum* Ching, *A. wangii* Chingm, *Diplazium bellum* (C. B. Clarke) Bir, *D. pallidum* (Blume) T. Moore and *D. procumbens* Holttum. The name: *D. bellum* (C.B. Clarke) Bir. and *D. Petelotii* Tardieu are lectotypified. *Diplazium axillare* Ching was considered a synonym of *D. bellum* (C.B. Clarke) Bir. In addition, a potential new species of *Hypodematium* sp. will be proposed in the near future.

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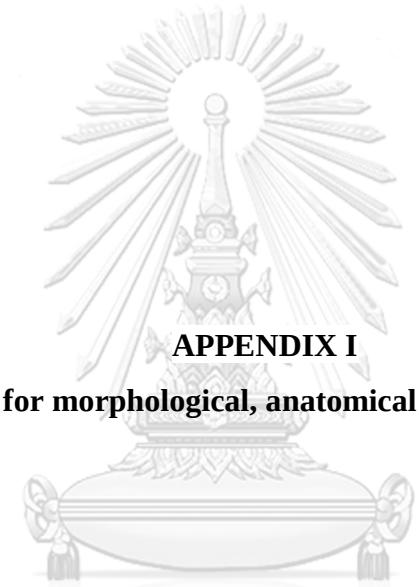
APPENDICES



APPENDIX I

Specimens used for morphological, anatomical and palynological study

Specimens used for morphological, anatomical and palynological study

Genera	No.	Taxa	Specimens (herbatium)
Anisocampium	1	*A. cumingianum*	*R. Pollawatn 1531*, *1535*, *1537*,*1565*, *1582* (BCU); *T. Boonkerd 1013* (BCU); T. *Boonkerd et al. 2011-624* (BCU)
	2	*A. cuspidatum*	*P. Ratchata 117*, *149* (BCU); *R. Pollawatn & A. Petbanna 76*, *593*, *2011-076*, (BCU); *P. Pongkai 81*, *139* (BCU)
	3	*A.. niponicum*	*T. Boonkerd et al. 2011-674* (BCU); *R. Pollawatn 995*, *1097*, *1562*, *1563* (BCU); *R. Pollawatn & A. Petbanna 2011-075*, *2012-62* (BCU)
Athyrium	1	*A. anisopterum*	*E. Hennipman 3446* (L); *G. Murata, K. Iwatsuki, C. Phengklai & C. Charamphol T15967* (K); *K. Iwatsuki et al.* 52, *66*, *150*, *572* (KUN); *K.M. Feng 11112* (KUN)
	2	*A. biserrulatum*	*G. Murata, K. Iwatsuki, C. Phenglai & C. Charamphol 15967* (P); *J.F. Maxwell 02-245* (L); *P. Pongkai 104* (BCU); *J. Cavalerie 4772* (K); *X.C. Zhang 148* (L); *Schimper 258*, *259*, *739*(B)
	3	*A. brevisorum*	*P. Pollawatn 1102*, *1104*, *1105*, *1208*, *1562* (BCU); *P. Pongkai 73*, *82* (BCU)
	4	*A. dissitifolium*	*P. Pollawatn 575*, *997* (BCU); *P. Pongkai 76*, *83*, *87*, *89*, *135* (BCU)
	5	*A. mackinnonorum*	*B. Hanson, G. Seidenfaden & T. Smitinand 10914* (BKF) *E. Hennipman 3407*, *3419* (BKF); *G. Murata, K, Iwatsuki, C. Pengklai & C. Charamphol T16071* (BKF); *K. Punchy 116* (BCU); *M. Tagawa, K. Iwatsuki & N. Fukuoka T2877* (BKF)
	6	*A. pachyphyllum*	*P. Pongkai 146*, *147* (BCU); *T. Boonkerd 1075* (BCU)
	7	*A. strigillosum*	*E. Hennipman 3407* (BKF L); *M. Tagawa, K. Iwatsuki & N. Fukuoka T2877* (BKF, L), *T3009* (BKF)
	8	*A. wangii*	*E. Hennipman 3620* (B, BM, L); *Put 3441* (BK)
Cornopteris	1	*C. opaca*	*J.F. Maxwell 91-222*, *91-250*, *94-371* (L); *J.F. Maxwell 97-157* (BKF); *K. Punchay 247*, *248* (BCU); *Smith 896* (K)
Deparia	1	*D. boryana*	*B.M. Allen 1972*, *4006* (K); *T. Smitinand 12913* (BKF, K, L)
	2	*D. heterophlebia*	*A. Henry* 13568, 11556 (K); *E. Hennipman 3432* (K, L); *E. Smith 1193* (BK); *M. Tagawa 1510* (K); *W. Hancock 189*, *190* (K)
	3	*D. japonica*	*C. Phengklai et al. 10658* (BCU); *E. Rosenstock 40* (BKF); *E. Smith 1192*, *1193* (K); *J.F. Maxwell 96-932*, *98-699* (CMU); *K. Iwatsuki 394* (BKF)
	4	*D. lancea*	*A. Sathapattayanon 576* (BCU); *G. murata et al. T49576* (BKF); *W. Sugong, G. Xun, D. Bo, O Souliya & K. Thepkaysone WS2345* (KUN)
Diplazium	1	*D. bantamense*	*P. Pongkai 32*, *33*, *36*, *39*, *62*, *63*, *124* (BCU)
	2	*D. bellum*	*P. Ratchata 346* (BCU); *P. Pongkai 138* (BCU); *E. Hennipman 3434*, *3435*, *3436* (L); *Hansen, B. et al. 10930* (K)
	3	*D. conterminum*	*K. Iwatsuki & N. Fukuoka T7204* (L); *P. Pongkai 15*, *109* (BCU); *T. Shimizu et al. T11603* (BKF, L)
	4	*D. cordifolium*	*N. Putthisawong 36* (PSU); *P. Pongkai 34*, *37*, *60*, *121* (BCU); *P. Suksathan 1067* (QBG)
	5	*D. crenato-serratum*	*N. Putthisawong 44* (PSU); *P. Pongkai 26*, *27*, *28*, *29*, *40*, *116* (BCU)

Genera	No.	Taxa	Specimens (herbatium)
Diplazium	6	*D. dilatatum*	*P. Pongkai 10*, *13*, *14*, *24*, *41*, *51*, *55* (BCU)
	7	*D. donianum*	*A.F.G. Kerr 14535* (BK), *A.F.G. Kerr 9309* (BM) *A. Sathapattayanon 41* (BCU); *P. Pongkai 150*, *152* (BCU), *P. Srisanga & P. Suksathan 3246* (QBG); *W. La−ongsri et al. 1993* (QBG)
	8	*D. esculentum*	*J.F. Maxwell 70-24*, *71-751*, *71-752*, *74-1096* (BK); *K. Kertsawank 367* (QBG); *K. Larsen & S. Larsen 32875* (BKF, L); *K. Srithi 377* (QBG)
	9	*D. kappanense*	*D.J. Middleton et al. 3772* (BKF); *P. Jadprajong 191* (BCU); *P. Jadprajong 160*, *161* (BCU)
	10	*D. leptophyllum*	*M. Shimizu & M Hutoh T10210* (BKF); *M. Tagawa & K. Iwatsuki T4396* (BKF); *P. Pongkai 78*, *79*, *80* (BCU)
	11	*D. malaccense*	*C. Kraithep 24* (PSU); *D.J. Middleton et al. 2029* (BKF); *P. Pongkai 122* (BCU); *T. Boonkerd 1473* (BCU)
	12	*D. megaphyllum*	*B. Balansa 1836* (K); *E. Hennipman 3064* (B, BM, K. L), *3065* (BKF); *M. Tagawa 3537* (BM).
	13	*D. mettenianum*	*P. Pongkai 18 20* (BCU); *P. Jadprajong 8*, *9*, *11*, *71* (BKF)
	14	*D. muricatum*	*P. Pongkai* 7, *11*, *12* (BCU); *P. Ratchata* 49, *137*, *142*, *216* (BCU)
	15	*D. pallidum*	*P. Pongkai 112*, *143* (BCU); *E. Hennipman 3998* (BKF); *T. Boonkerd & R. Pollawatn 1406*, *1408* (BCU) *T. Smitinand s.n.* (BKF)
	16	*D. petelotii*	*H. van der Werff et al. 17346* (L); *S. Chodchoy 62* (KU)
	17	*D. petrii*	*P. Pongkai 68*, *69*, *72*, *119* (BCU); *P. Ratchata 136*, *199* (BCU); *Y. Yuyen 95* (BCU)
	18	*D. polypodioides*	*P. Pongkai 8* (BCU); *P. Ratchata 12* (BCU); *Pragad 916* (BK); *S. Mitsuta T50237* (QBG); *Suan Phueng Trip 79*, *81* (BCU); *Y. Yuyen 191* (BCU)
	19	*D. prescottianum*	*J. Sinclair 9376* (K); *K. larsen, T. Smitinand & E. Warncke 312* (BKF); *N. Wallich 235* (K); *T. Lobb 32* (K)
	20	*D. procumbens*	*D.J. Middleton et al. 1762* (BKF); *B.E.G. Molesworth-Allen 1439* (BM); *R.E. Holltum 21645*, *21646*, *36503* (K); *W.A. Sledge 1192* (BM).
	21	*D. proliferum*	*A.F.G. Kerr 12160* (BK, BM); *C. Apasutaya 121a*, *121b* (BCU); *A.G. Piggott 1080*, 1961, 3002 (K); *C. Curtis 1359* (K)
	22	*D. riparium*	*N. Putthisawong 67* (PSU); *P. Pongkai 45 48* (BCU); *Put 1689* (BK); *Sangkachun 16024* (K); *T. Seelanan 3* (BCU); *W. Klinla-ang et al. 2* (PSU)
	23	*D. siamense*	*P. Pongkai 9*, *16*, *17*, *148* (BCU); *P. Srisanga & P. Suksathan 3269* (QBG); *T. Boonkerd 1574* (BCU); *W. La-ongsri et al. 1987* (QBG)
	24	*D. simplicivenium*	*P. Pongkai 94*, *95*, *96*, *123* (BCU); *T. Boonkerd 534*, *1848* (BCU); *T. Boonkerd, S. Chantanaorapint & W. Khwaiphan 420* (BCU)
	25	*D. sorzogonense*	*A.F.G. Kerr 11547 18476* (BK); *D.J. Middleton et al. 1492* (BKF); *P. Pongkai 30 49 119* (BCU); *Sakol 1235* (BK)
	26	*D. subintegrum*	*P. Pongkai 35*, *66*, *67*, *114*, *115* (BCU); *T. Boonkerd 35* (BCU); *T. Boonkerd, Y. Sirijamorn & C. Sanguansab 58* (BCU)
	27	*D. subserratum*	*A.F.G. Kerr 14541* (BK); *A.G. Piggott 1633* (K); *T. Boonkerd 1176* (BCU); *T. Boonkerd & R.*

Genera	No.	Taxa	Specimens (herbatium)
Diplazium			*Pollawatn 287* (BCU); *E. Gardette 540* (K); *H. Wiriadinata 1449* (K); *H. Zollinger 3092* (K); *M. Kato, G. Murata & Y.P. Mogea B3506* (K)
	28	*D. sylvaticum*	*A.F.G. Kerr 18667* (BK); *85-314* (L); *85-314* (PSU); *85-1127* (PSU); *M. Tagawa, K. Iwatsuki & N. Fukuoka T5584* (L); *N. Putthisawong 83* (PSU); *T. Boonkerd, S. Chantanaorapint & W. Khwaiphan 503* (BCU)
	29	*D. tomentosum*	*P. Pongkai 31*, *57*, *58*, *59*, *117* (BCU); *T. Boonkerd 1518*, *1534* (BCU);
	30	*D. xiphophyllum*	*M. Tagawa, K. Iwatsuki & N. Fukuoka T5304* (L); *P. Pongkai 113*, *143* (BCU); *T. Boonkerd, S. Chantanaorapint & W. Khwaiphan 62* (BCU); *T. Boonkerd, Y. Sirichamorn & C. Sanguansab 241* (BCU)
	31	*D. thailandicum*	*E. Hennipman 3056* (L); *P. Pongkai 107* (BCU); *Pteridophyte trip 72* (BCU); *W. Rattanathirakul 29*, *106* (BCU); *Winit 958* (B, K)
Hypodematium	1	*H. boonkerdii*	*T. Boonkerd et al. 2011-695*, *2011-753* (BCU)
	2	*H. crenatum*	*Boonkerd & S. Yannawat 01* (BCU); *T. Boonkerd 1233*, *1238*, *1327* (BCU); *T. Boonkerd et al. 2011-012*, *2011-222*, *2011-229* (BCU)
	3	*H. glanduloso-pilosum*	*P. Jadprajong 108*, *206*, *299* (BCU); *P. Pongkai 158* (BCU)
	4	*H.* sp.	*R. Pollawatn 2509* (BCU)

APPENDIX II

Species and GenBank accessions used in this study.

Species and GenBank accessions (*rbcL*) used in this study.

Species	**Accession No.**
*Anisocampium cumingianum*_Chen_sn	HM156338
*Anisocampium cuspidatum*_Wei_R_WR0367	MG183204
*Anisocampium cuspidatum*_Wei_R_WR0367	MG183204
*Anisocampium niponicum*_Wei_R_GX014	MG183205
*Athyrium amoenum*_Hovenkamp_P_PH066	MG183206
*Athyrium anisopterum*_Zhang_XC_5781	MG183207
*Athyrium araiostegioides*_Wei_R_20150619	MG183208
Athyrium arisanense	EU329025
*Athyrium atkinsonii*_Tang_YD_YD060	MG183209
*Athyrium attenuatum*_Zhang_XC_5902	MG183210
*Athyrium biserrulatum*_TAIF_YCLiu_9370	HM156337
*Athyrium biserrulatum*_Zhang_XC_2684	MG183211
*Athyrium brevifrons*_3	AB574897
*Athyrium brevifrons*_4	EU329027
Athyrium chingianum	FJ821342
*Athyrium christensenii*_Wei_R_WR0392	MG183212
*Athyrium clarkei*_Zhang_XC_4826	MG183213
*Athyrium clemensiae*_Hovenkamp_P_PH088	MG183214
*Athyrium clivicola*_2	AB574898
*Athyrium clivicola*_3	EU329028
*Athyrium clivicola*_Zhang_XC_1063	MG183215
*Athyrium crenulatoserrulatum*_Zhang_XC_6875	MG183278
Athyrium cryptogrammoides	FJ821335
*Athyrium cumingianum*_TAIF_CMChen_sn	HM156338
Athyrium cuspidatum	EU329029
*Athyrium decorum*_Zhang_XC_8115	MG183216
*Athyrium delavayi*_Zhang_XC_5732	MG183217
*Athyrium deltoidofrons*_1	AB574899
*Athyrium deltoidofrons*_2	EU329030
*Athyrium deltoidofrons*_Ebihara_A_102436	MG183218
*Athyrium devolii*_Zhang_XC_2623	MG183219
*Athyrium dissitifolium*_Zhang_XC_2473	MG183220
*Athyrium distentifolium*_Schuettpelz_526	EF463304
*Athyrium drepanopterum*_Zhang_XC_5295	MG183221
*Athyrium dubium*_Wei_R_ST1401	MG183222
*Athyrium dubium*_Zhang_XC_2445	MG183223
*Athyrium elongatum*_Wei_&_Li_ZY_JGS008	MG183224
*Athyrium epirachis*_Zhang_XC_2585	MG183225
*Athyrium eremicola*_Ebihara_A_103029	MG183226
*Athyrium fallaciosum*_Zhang_XC_7031	MG183227
*Athyrium filix-femina*_Zhang_XC_6980	MG183229
*Athyrium filix-femina*_Zhang_XC5610	MG183228

Species and GenBank accessions (*rbcL*) used in this study.

*Athyrium fimbriatum*_Zhang_XC_6311	MG183231
*Athyrium foliolosum*_Zhang_XC_4485	MG183232
*Athyrium hainanense*_Dong_SY_HN141	MG183233
*Athyrium himalaicum*_Zhang_XC_5260	MG183234
*Athyrium infrapuberulum*_sn	MG183235
*Athyrium iseanum*_3	FJ821338
*Athyrium iseanum*_4	EU329034
Athyrium iseanum var. *angustisectum*_1	AB574904
*Athyrium iseanum angustisectum*_2	EU329035
Athyrium iseanum var. *iseanum*	AB574903
Athyrium kenzo var. *satakei*_Jiang_RH_6006	MG183236
*Athyrium kirisimaense*_2	AB574905
*Athyrium kirisimaense*_3	EU329036
*Athyrium mackinnonii*_Zhang_XC_4733	MG183237
*Athyrium mehrae*_FLPH_Xizang_Expedition_12_0831	MG183238
*Athyrium melanolepis*_Ebihara_A_102277	MG183239
*Athyrium nakanoi*_Wei_R_ST1629	MG183240
*Athyrium nakanoi*_Zhang_XC_6309	MG183241
*Athyrium neglectum*_subsp_australe_2	EU329040
*Athyrium neglectum*_subsp_neglectum	AB574910
*Athyrium newtonii*_Kamau_P_739	MG183242
*Athyrium newtonii*_Kamau_P_772	MG183243
*Athyrium newtonii*_Ronnie_RV7670	MG183244
Athyrium nigripes	FJ821336
*Athyrium nigripes*_Wei_R_514	MG183246
*Athyrium nigripes*_Zhang_XC_4825	MG183245
*Athyrium nikkoense*_1	AB574912
*Athyrium nikkoense*_2	EU329041
*Athyrium nikkoense*_Ebihara_A_103894	MG183247
*Athyrium niponicum*_1	JF832057
*Athyrium niponicum*_2	D43891
*Athyrium niponicum*_3	AB574913
*Athyrium niponicum*_4	EU329042
*Athyrium niponicum*_5	AB232413
*Athyrium nyalamense*_Zhang_XC_5059	MG183248
*Athyrium oblitescens*_1	AB574914
*Athyrium oblitescens*_2	EU329043
*Athyrium omeiense*_Zhang_XC_5146	MG183249
*Athyrium oppositipennum*_Zhang_XC_4717	MG183250
*Athyrium otophorum*_Liu_HM_A352	MG183251
*Athyrium otophorum*_Smith_sn	EF463305
*Athyrium pachyphyllum*_Wei_R_WR0343	MG183252
Athyrium palustre	AB574917

Species and GenBank accessions (*rbcL*) used in this study.

*Athyrium pectinatum*_Zhang_XC_5280	MG183253
*Athyrium pubicostatum*_Zhang_XC_2660	MG183254
Athyrium reflexipinnum	AB574919
*Athyrium reflexipinnum*_Ebihara_A_102263	MG183255
Athyrium rhachidosorum	FJ821339
*Athyrium rhachidosorum*_Wei_R_ST2059	MG183256
*Athyrium roseum*_Zhang_XC_2975	MG183257
*Athyrium rupestre*_Ebihara_A_102199	MG183258
*Athyrium rupicola*_Zhang_XC_5788	MG183259
*Athyrium scandicinum*_Hennequin_S_R96	MG183260
*Athyrium schizochlamys*_Zhang_XC_2457	MG183261
*Athyrium sericellum*_Zhang_XC_8645	MG183262
*Athyrium sessilipinnum*_Zhang_XC_5996	KX097993
*Athyrium sheareri*_2	D43892
*Athyrium sheareri*_3	AB574922
*Athyrium sheareri*_4	EU329047
*Athyrium silvicola*_2	AB574923
*Athyrium silvicola*_3	FJ821334
Athyrium skinneri	JF832058
*Athyrium solenopteris*_PE_BO_2001	MG183264
Athyrium sp._Ebihara_A_110849	MG183265
Athyrium sp._TO5_089_PTM_39	this study
Athyrium sp._TO5_640_PTM_37	this study
Athyrium sp._YCL_2009	FJ821346
Athyrium sp._Zhang_1990_PTM_45	this study
Athyrium sp._Zhang_2263_PTM_47	this study
Athyrium sp._Zhang_2330_PTM_59	this study
Athyrium sp._Zhang_2343_PTM_61	this study
Athyrium sp._Zhang_2483_PTM_49	this study
Athyrium sp._Zhang_5332_PTM_62	this study
Athyrium spinulosum	AB574924
*Athyrium spinulosum*_Wei_R_GX013	MG183266
*Athyrium strigillosum*_1	AB574925
*Athyrium strigillosum*_2	FJ821337
*Athyrium strigillosum*_3	EU329049
*Athyrium strigillosum*_Zhang_XC_2406	MG183267
*Athyrium subtriangulare*_Zhang_XC4681	MG183268
*Athyrium subtriangulare*_Zhang_XC5799	MG183269
*Athyrium tozanense*_1	EU329051
*Athyrium tozanense*_2	AB574928
*Athyrium vidalii*_2	D43894
*Athyrium vidalii*_Ebihara_A_106787	MG183271
*Athyrium vidalii*_Zhang_XC_5726	MG183270

Species and GenBank accessions (*rbcL*) used in this study.

*Athyrium viridescentipes*_1	AB574930
*Athyrium viridescentipes*_2	EU329053
*Athyrium viviparum*_Zhang_XC_5744	MG183272
*Athyrium wallichianum*_Tang_YD_PX026	MG183273
*Athyrium wardii*_Zhang_XC_2581	MG183274
*Athyrium yokoscense*_Zhang_XC_6892	MG183275
Athyrium yui	FJ821341
*Athyrium yui*_Wei_R_ST320	MG183276
Cornopteris banahaoensis	AB574934
Cornopteris christenseniana	EU329061
Cornopteris crenulatoserrulata	AB574935
*Cornopteris decurrentialata*_1	AB574936
Cornopteris opaca var. *glabrescens*	AB574937
Deparia aff *glabrata*_MO6262952	KX656062
Deparia boryana_P02432539	KX656064
Deparia coreana	AB574942
*Deparia edentula*_TNS1112754	KX656066
*Deparia glabrata*_P01515373	KX656071
Deparia henryi	KY296515
*Deparia heterophlebia*_Liu9426	KX656073
*Deparia japonica*_TNS763869	this study
*Deparia japonica*_WS_2655_PTM_48	AB574945
*Deparia lancea*_Kuo1919	JN673936
*Deparia lancea*_Kuo1920	JN673937
*Deparia lancea*_Schuettpelz_298	EF463306
Deparia okuboana	D43903
Deparia pterorachis	AB574954
Deparia viridifrons	AB574959
*Diplazium assimile*_Kessler_14286	KP318926
*Diplazium australe*_Bar01	KC254392
*Diplazium bantamense*_Cicuzza455	KC254422
*Diplazium bellum*_WR0206	KC254356
*Diplazium bellum*_WS2248_PTM_52	this study
Diplazium caudatum	KP318923
*Diplazium conterminum*_WR056	KC254416
*Diplazium davaoense*_Karger816	KC254419
Diplazium deciduum	AB574964
*Diplazium dilatatum*_1	AB574965
*Diplazium dilatatum*_2	KC254418
*Diplazium dilatatum*_Zhang156	KC254418
*Diplazium doederleinii*_WXP24	KC254412
*Diplazium donianum*_ZhangXC_5562	KC254423
*Diplazium ellipticum*_isolate_JNG1861	KY099793

Species and GenBank accessions (*rbcL*) used in this study.

*Diplazium esculentum*_Zhang_XC_2983	KC254406
Diplazium expansum	KP985729
*Diplazium grantii*_JNG1882	KY099794
Diplazium griffithii	AB574971
*Diplazium heterocarpum*_6176	KC254359
*Diplazium himalayense*_WR0222	KC254407
*Diplazium kawakamii*_WXP172	KC254390
*Diplazium leptophyllum*_WR0246	KC254393
*Diplazium lobatum*_WR0258	KC254421
*Diplazium longifolium*_6301	KC254360
*Diplazium mettenianum*_WR0194	KC254372
*Diplazium muricatum*_WR0197	KC254389
*Diplazium nanchuanicum*_S034	KC254411
Diplazium okudairae	AB042738
*Diplazium pallidum*_WR0313	KP318920
*Diplazium petelotii*_WR0292	KC254414
*Diplazium petrii*_1407	KC254369
*Diplazium pinfaense*_LCH007	KC254358
*Diplazium plantaginifolium*_2063	KC254361
*Diplazium proliferum*_Schuettpelz590	EF463315
*Diplazium prolixum*_WR0099	KC254401
*Diplazium simplicivenium*_2005_294	KP978663
*Diplazium sorzogenense*_Cicuzza990	KC254378
Diplazium sp._P. Pongkai 107	my thesis
Diplazium squamigerum	AB574984
*Diplazium subserratum*_Chiou15146	KC254375
*Diplazium subspectabile*_1209	KC254387
Diplazium *sylvaticum*_ZhangXC_6898	KP318918
Diplazium *taiwanense*_TNS763347	AB574986
Diplazium *tomentosum*_ChengCW_1578	KP318919
Diplazium *unilobum*_J_Loriga_JL456	KP318924
Diplazium *wichurae*_Li_ZY_PT095	MG183280
Diplazium *yinchanianum*_13341	MF460466
Hypodematium crenatum	JF832072
*Hypodematium crenatum*_PTM_31	this study
*Hypodematium crenatum*_Schneider_sn	EF463205
*Hypodematium fordi*_TNS763905	AB575184
*Hypodematium glandulosopilosum*_TNS768179	AB575185
Hypodematium sp.1_PTM_32	this study
Hypodematium sp.2_PTM_33	this study
Hypodematium sp.3_Rossarin_sn_PTM_63	this study

Species and GenBank accessions (*trnL-F*) used in this study.

Species	**Accession No.**
*Anisocampium cumingianum*_PTM_03	FJ807659
*Anisocampium cuspidatum*_Pongkai_139_PTM_54	this study
*Anisocampium cuspidatum*_PTM_02	this study
*Anisocampium cuspidatum*_PTM_34	this study
*Anisocampium cuspidatum*_Wei_R_WR0367	MG183506
*Anisocampium niponicum*_Wei_R_GX014	MG183507
*Athyrium alpestre*_Rothfels_4547_ZXM845	this study
*Athyrium amoenum*_Hovenkamp_P_PH066	MG183508
*Athyrium amoenum*_PH064	KP979052
*Athyrium amoenum*_PH069	KP979008
*Athyrium amoenum*_PH098	KP979074
*Athyrium angustum*_Rothfels4053_ZXM836	this study
*Athyrium anisopterum*_Zhang_XC_5781	MG183509
*Athyrium araiostegioides*_Wei_R_20150619	MG183510
Athyrium arisanense	EU329069
*Athyrium atkinsonii*_Tang_YD_YD060	MG183511
*Athyrium attenuatum*_Zhang_XC_5902	MG183512
*Athyrium biserrulatum*_PTM_17	this study
*Athyrium biserrulatum*_YCLiu_9370	HM156336
*Athyrium biserrulatum*_Zhang_XC_2684	MG183513
*Athyrium brevifrons*_1	AF514834
*Athyrium brevifrons*_2	EU329071
Athyrium chingianum	FJ821327
*Athyrium christensenii*_Wei_R_WR0392	MG183514
*Athyrium clarkei*_Zhang_XC_4826	MG183515
*Athyrium clemensiae*_Hovenkamp_P_PH088	MG183516
*Athyrium clemensiae*_PH071	KP979007
*Athyrium clemensiae*_PH079	KP979046
*Athyrium clemensiae*_PH088	KP979005
*Athyrium clivicola*_1	EU329072
*Athyrium clivicola*_Zhang_XC_1063	MG183517
*Athyrium crenulatoserrulatum*_Zhang_XC_6875	MG183578
Athyrium cryptogrammoides	FJ821320
Athyrium cumingianum	FJ807659
Athyrium cuspidatum	EU329073
*Athyrium decorum*_Zhang_XC_8115	MG183518
*Athyrium delavayi*_Zhang_XC_5732	MG183519
*Athyrium deltoidofrons*_2	EU329074
*Athyrium deltoidofrons*_Ebihara_A_102436	MG183520
*Athyrium devolii*_Zhang_XC_2623	MG183521
*Athyrium dissitifolium*_PTM_14	this study
*Athyrium dissitifolium*_PTM_26	this study

Species and GenBank accessions (*trnL-F*) used in this study.

Species	**Accession No.**
*Athyrium dissitifolium*_PTM_28	this study
*Athyrium dissitifolium*_Zhang_XC_2473	MG183522
*Athyrium distentifolium*_Larsson443_ZXM850	this study
*Athyrium dolosa*_Kuo_1315	JN673871
*Athyrium dombeyi*_Rothfels_Zylinski3965_ZXM841	this study
*Athyrium drepanopterum*_Zhang_XC_5295	MG183523
*Athyrium dubium*_Wei_R_ST1401	MG183524
*Athyrium dubium*_Zhang_XC_2445	MG183525
*Athyrium elongatum*_Wei_&_Li_ZY_JGS008	MG183526
*Athyrium epirachis*_Zhang_XC_2585	MG183527
*Athyrium eremicola*_Ebihara_A_103029	MG183528
*Athyrium fallaciosum*_Zhang_XC_7031	MG183529
Athyrium fangii	FJ821329
*Athyrium filix-femina*_Larsson468_ZXM852	MG183532
*Athyrium filix-femina*_Rothfels_2636_ZXM838	MG183530
*Athyrium filix-femina*_Rothfels4484_ZXM854	MG183531
*Athyrium filix-femina*_Rothfels4485_ZXM856	this study
*Athyrium filix-femina*_var_angustum_Zhang_XC_3794	this study
*Athyrium filix-femina*_Zhang_XC_5610	this study
*Athyrium filix-femina*_Zhang_XC_6980	this study
*Athyrium fimbriatum*_Zhang_XC_6311	MG183533
*Athyrium foliolosum*_Zhang_XC_4485	MG183534
Athyrium giraldii	AF515258
*Athyrium hainanense*_Dong_SY_HN141	MG183535
*Athyrium himalaicum*_Zhang_XC_5260	MG183536
*Athyrium infrapuberulum*_sn	MG183537
*Athyrium iseanum*_1	AF515254
*Athyrium iseanum*_2	EU329077
*Athyrium iseanum*_3	FJ821323
*Athyrium iseanum var. angustisectum*_3	EU329078
*Athyrium kenzo var. satakei*_Jiang_RH_6006	MG183538
*Athyrium kirisimaense*_1	EU329079
Athyrium kuratae	EU329080
*Athyrium mackinnonii*_Zhang_XC_4733	MG183539
*Athyrium mehrae*_FLPH_Xizang_Expedition_12_0831	MG183540
Athyrium melanolepis	EU329081
*Athyrium melanolepis*_Ebihara_A_102277	MG183541
*Athyrium nakanoi*_Wei_R_ST1629	MG183542
*Athyrium nakano*i_Zhang_XC_6309	MG183543
*Athyrium neglectum*_subsp_australe_1	EU329083
*Athyrium newtonii*_Kamau_P_739	MG183544
*Athyrium newtoni*i_Kamau_P_772	MG183545

Species and GenBank accessions (*trnL-F*) used in this study.

Species	**Accession No.**
*Athyrium newtonii*_Ronnie_RV7670	MG183546
Athyrium nigripes	FJ821321
*Athyrium nigripes*_Wei_R_514	MG183548
*Athyrium nigripes*_Zhang_XC_4825	MG183547
Athyrium nikkoense	EU329084
*Athyrium nikkoense*_Ebihara_A_103894	MG183549
*Athyrium oblitescens*_2	EU329086
*Athyrium omeiense*_Zhang_XC_5146	MG183550
*Athyrium oppositipennum*_Zhang_XC_4717	MG183551
*Athyrium otophorum*_1	AF515236
*Athyrium otophorum*_Liu_HM_A352	MG183552
*Athyrium pachyphyllum*_Wei_R_WR0343	MG183553
*Athyrium palmense*_Rothfels_3117A_ZXM898	this study
*Athyrium pectinatum*_Zhang_XC_5280	MG183554
Athyrium pubicostatum	AF514833
*Athyrium pubicostatum*_Zhang_XC_2660	MG183555
*Athyrium pulchrum*_KNAPP4131_ZXM2268	this study
*Athyrium puncticaule*_Zhang_XC_5301	MG183556
*Athyrium reflexipinnum*_Ebihara_A_102263	MG183557
Athyrium rhachidosorum	FJ821324
*Athyrium roseum*_Zhang_XC_2975	MG183558
*Athyrium rupestre*_Ebihara_A_102199	MG183559
*Athyrium rupicola*_Zhang_XC_5788	MG183560
*Athyrium scandicinum*_Hennequin_S_R96	MG183561
*Athyrium schizochlamys*_Zhang_XC_2457	MG183562
*Athyrium sericellum*_Zhang_XC_8645	MG183563
*Athyrium sessilipinnum*_Zhang_XC_5996	MG183564
*Athyrium sheareri*_1	EU329090
*Athyrium silvicola*_1	FJ821319
*Athyrium skinneri*_Rothfels3155	KX656169
*Athyrium skinneri*_Rothfels3155_ZXM909_TRNL_F	this study
Athyrium sp._Ebihara_A_110849	MG183565
Athyrium sp._Gao16619_PTM_51	this study
Athyrium sp._GXF12324_ZL132	this study
Athyrium sp._TO5089_PTM_39	this study
Athyrium sp._TO5640_PTM_37	this study
Athyrium sp._TO5663_PTM_41	this study
Athyrium sp._Zhang_1663_PTM_43	this study
Athyrium sp._Zhang_1989_PTM_60	this study
Athyrium sp._Zhang_1990_PTM_45	this study
Athyrium sp._Zhang_2263_PTM_47	this study
Athyrium sp._Zhang_2343_PTM_61	this study

Species and GenBank accessions (*trnL-F*) used in this study.

Species	**Accession No.**
Athyrium sp._Zhang_2483_PTM_49	this study
Athyrium sp._Zhang_Liang_127	this study
*Athyrium spinulosum*_Wei_R_GX013	MG183566
*Athyrium strigillosum*_KNAPP4150_ZXM2391	this study
*Athyrium strigillosum*_Zhang_XC_2406	MG183567
Athyrium subrigescens	EU329091
Athyrium subtriangulare	AF515234
*Athyrium subtriangulare*_Zhang_XC_4681	MG183568
*Athyrium subtriangulare*_Zhang_XC_5799	MG183569
Athyrium tashiroi	EU329093
*Athyrium tozanense*_1	EU329094
*Athyrium vidalii*_1	AF515231
*Athyrium vidalii*_Ebihara_A_106787	MG183571
*Athyrium vidalii*_Zhang_XC_5726	MG183570
*Athyrium viridescentipes*_2	EU329096
*Athyrium viviparum*_Zhang_XC_5744	MG183572
*Athyrium wallichianum*_GXF12330	this study
*Athyrium wallichianum*_Tang_YD_PX026	MG183573
*Athyrium wardii*_Zhang_XC_2581	MG183574
Athyrium x akiense	EU329100
Athyrium x hisatsuanum	EU329101
Athyrium x tokashikii	EU329102
*Athyrium yokoscense*_Zhang_XC_6892	MG183575
Athyrium yui	FJ821326
*Athyrium yui*_Wei_R_ST320	MG183576
*Cornopteris banajaoensis*_KNAPP3785_ZXM1329	this study
Cornopteris cf Zhang_Liang_2143	this study
Cornopteris cf_ZhangLiang_2135	this study
*Cornopteris christensenian*_BGCHSA044	AB277793
*Cornopteris christenseniana*_BGCH29	AB277796
*Cornopteris crenulatoserrulata*_BGFGC3	AB119531
*Cornopteris decurrenti*_alata_BGDH31	AB182454
*Cornopteris decurrenti*_alata_BGFGDNB1	AB182451
*Cornopteris decurrentialata*_var_pilosella_Knapp_3803	this study
Cornopteris major cf_Zhang_Liang_2551	this study
*Cornopteris major*_Zhang_Liang_2300	this study
Cornopteris opaca_Kuo2323	KX656170
Cornopteris sp._LBZ6488	this study
Cornopteris sp._nov_Zhang_Liang_2232	this study
Cornopteris sp._zhang_liang_2553	this study
*Deparia allantodioides*_Kuo_475	JN673863
*Deparia auriculata*_Kuo1300	KX656145

Species and GenBank accessions (*trnL-F*) used in this study.

Species	**Accession No.**
*Deparia boryana*_P02432539	KX656146
*Deparia emeiensis*_Liu9703	KX656150
*Deparia fenzliana*_OppenheimerH20920	KX656152
*Deparia forsythii*_majoris_P02432852	KX656154
*Deparia glabrata*_P01515373	KX656155
*Deparia heterophlebia*_Liu9426	KX656157
*Deparia japonica*_TNS763869	this study
*Deparia japonica*_WS_2655_PTM_48	JN673873
*Deparia lancea*_Kuo1919	JN673876
*Deparia lancea*_Kuo1920	JN673877
*Deparia medogensis*_Liu9453	KX656160
*Deparia petersenii*_Zhang_XC_1596	MG183579
*Deparia prolifera*_Wood13449	KX656162
*Deparia sichuanensis*_Kuo2243	KX656164
*Deparia subfluvialis*_Kuo_168	JN673899
*Deparia unifurcata*_Kuo2197	KX656167
*Deparia wilsonii*_Kuo2087	KX656168
*Diplazium alatum*_WR0259	KC254480
*Diplazium bantamense*_Cicuzza455	KC254501
*Diplazium bellum*_WR0206	KC254428
*Diplazium conterminum*_WR056	KC254495
*Diplazium cordifolium*_Karger1516	KC254448
*Diplazium dilatatum*_Zhang156	KC254497
*Diplazium doederleinii*_WXP24	KC254490
*Diplazium donianum*_ZhangXC_5562	KC254502
*Diplazium esculentum*_Zhang_XC_2983	KC254484
*Diplazium leptophyllum*_WR0246	KC254468
*Diplazium lobatum*_WR0258	KC254500
*Diplazium malaccense*_Cicuzza168	KC254455
*Diplazium megaphyllum*_LHM101	KC254494
*Diplazium mettenianum*_WR0194	KC254444
*Diplazium muricatum*_WR0197	KC254463
*Diplazium ovatum*_WR0098	KC254427
*Diplazium pallidum*_WR0313	KP318942
*Diplazium petelotii*_WR0292	KC254492
*Diplazium petrii*_1407	KC254441
*Diplazium simplicivenium*_2005_294	KP979014
Diplazium sp.	this study
*Diplazium splendens*_WR0288	KC254499
*Diplazium subserratum*_Chiou15146	KC254447
*Diplazium sylvaticum*_ZhangXC_6898	KP318940
*Diplazium tomentosum*_ChengCW_1578	KP318941

Species and GenBank accessions (*trnL-F*) used in this study.

Species	**Accession No.**
*Diplazium yinchanianum*_13341	MF460458
Hypodematiumcrenatum	AF425122
*Hypodematium*_crenatum_PTM_12	this study
*Hypodematium*_crenatum_PTM_31	this study
*Hypodematium*_sp.1_PTM_32	this study
*Hypodematium*_sp.2_PTM_33	this study

Species and GenBank accessions (*rps4*) used in this study.

Species	**Accession No.**
*Anisocampium cuspidatum*_Pongkai139_PTM_54	this study
*Anisocampium cuspidatum*_PTM_34	this study
*Anisocampium cuspidatum*_Wei_R_WR0367	MG183583
*Anisocampium cuspidatum*_Wei_R_WR0367	MG183583
*Anisocampium niponicum*_Wei_R_GX014	MG183584
*Athyrium amoenum*_Hovenkamp_P_PH066	MG183437
*Athyrium anisopterum*_Sino_Amer_1512_PTM_56	my thesis
*Athyrium araiostegioides*_Wei_R_20150619	MG183438
*Athyrium atkinsonii*_Tang_YD_YD060	MG183439
*Athyrium attenuatum*_Zhang_XC_5902	MG183440
*Athyrium biserrulatum*_PTM_07	this study
*Athyrium biserrulatum*_PTM_17	this study
*Athyrium biserrulatum*_Sino_Amer_1513_PTM_58	this study
*Athyrium biserrulatum*_Zhang_XC_2684	MG183441
*Athyrium christensenii*_Wei_R_WR0392	MG183442
*Athyrium clarkei*_Zhang_XC_4826	MG183443
*Athyrium clemensiae*_Hovenkamp_P_PH088	MG183444
*Athyrium clivicola*_Zhang_XC_1063	MG183445
*Athyrium decorum*_Zhang_XC_8115	MG183446
*Athyrium delavayi*_Zhang_XC_5732	MG183447
*Athyrium deltoidofrons*_Ebihara_A_102436	MG183448
*Athyrium devolii*_Zhang_XC_2623	MG183449
*Athyrium dissitifolium*_PTM_14	this study
*Athyrium dissitifolium*_PTM_26	this study
*Athyrium dissitifolium*_PTM_28	this study
*Athyrium dissitifolium*_Zhang_XC_2473	MG183450
*Athyrium drepanopterum*_Zhang_XC_5295	MG183451
*Athyrium dubium*_Wei_R_ST1401	MG183452
*Athyrium dubium*_Zhang_XC_2445	MG183453
*Athyrium elongatum*_Wei___Li_ZY_JGS008	MG183454
*Athyrium epirachis*_Zhang_XC_2585	MG183455
*Athyrium eremicola*_Ebihara_A_103029	MG183456
*Athyrium fallaciosum*_Zhang_XC_7031	MG183457
*Athyrium filix-femina*_Lehtonen_717	HQ157326
*Athyrium filix-femina*_Zhang_XC_5610	MG183458
*Athyrium filix-femina*_Zhang_XC_6980	MG183459
*Athyrium fimbriatum*_Zhang_XC_6311	MG183461
*Athyrium foliolosum*_Zhang_XC_4485	MG183462
*Athyrium hainanense*_Dong_SY_HN141	MG183463
*Athyrium himalaicum*_Zhang_XC_5260	MG183464
*Athyrium infrapuberulum*_sn	MG183465
Athyrium kenzo var. *satakei*_Jiang_RH_6006	MG183466

Species and GenBank accessions (*rps4*) used in this study.

Species	**Accession No.**
*Athyrium mackinnonii*_Zhang_XC_4733	MG183467
*Athyrium mehrae*_FLPH_Xizang_Expedition_12_0831	MG183468
*Athyrium melanolepis*_Ebihara_A_102277	MG183469
*Athyrium nakanoi*_Wei_R_ST1629	MG183470
*Athyrium nakanoi*_Zhang_XC_6309	MG183471
*Athyrium newtonii*_Kamau_P_739	MG183472
*Athyrium newtonii*_Kamau_P_773	MG183473
*Athyrium newtonii*_Ronnie_RV7670	MG183474
*Athyrium nigripes*_Wei_R_514	MG183476
*Athyrium nigripes*_Zhang_XC_4825	MG183475
*Athyrium nikkoense*_Ebihara_A_103894	MG183477
*Athyrium niponicum*_isolate_S9	JN168077
*Athyrium omeiense*_Zhang_XC_5146	MG183478
*Athyrium oppositipennum*_Zhang_XC_4717	MG183479
*Athyrium pachyphyllum*_PTM_13	this study
*Athyrium pachyphyllum*_Wei_R_WR0343	MG183480
*Athyrium pectinatum*_Zhang_XC_5280	MG183481
*Athyrium pubicostatum*_Zhang_XC_2660	MG183482
*Athyrium reflexipinnum*_Ebihara_A_102263	MG183483
*Athyrium roseum*_Zhang_XC_2975	MG183484
*Athyrium rupestre*_Ebihara_A_102199	MG183485
*Athyrium rupicola*_Zhang_XC_5788	MG183486
*Athyrium scandicinum*_Hennequin_S_R96	MG183487
*Athyrium schizochlamys*_Zhang_XC_2457	MG183488
*Athyrium sericellum*_Zhang_XC_8645	MG183489
*Athyrium sessilipinnum*_Zhang_XC_5996	MG183490
*Athyrium solenopteris*_Wei_et_al_2001	MG183491
Athyrium sp._Ebihara_A_110849	MG183492
Athyrium sp._Gao_16619_PTM_51	this study
Athyrium sp._TO5_089_PTM_39	this study
Athyrium sp._TO5_640_PTM_37	this study
Athyrium sp._TO5_663_PTM_41	this study
Athyrium sp._WP_1589_PTM_40	this study
Athyrium sp._Zhang_1663_PTM_43	this study
Athyrium sp._Zhang_1990_PTM_45	this study
Athyrium sp._Zhang_2330_PTM_59	this study
Athyrium sp._Zhang_2343_PTM_61	this study
*Athyrium strigillosum*_Zhang_XC_2406	MG183493
*Athyrium subtriangulare*_Zhang_XC_4681	MG183494
*Athyrium subtriangulare*_Zhang_XC_5799	MG183495
*Athyrium vidalii*_Ebihara_A_106787	MG183497
*Athyrium vidalii*_Zhang_XC_5726	MG183496

Species and GenBank accessions (*rps4*) used in this study.

Species	**Accession No.**
*Athyrium viviparum*_Zhang_XC_5744	MG183498
*Athyrium wallichianum*_Tang_YD_PX026	MG183499
*Athyrium wardii*_Zhang_XC_2581	MG183500
*Athyrium yokoscense*_Zhang_XC_6892	MG183501
*Athyrium yui*_Wei_R_ST320	MG183502
*Cornopteris decurrenti*_alata_isolate_S13	JN168081
*Cornopteris opaca*_WS2425_PTM_44	this study
*Cornopteris opaca*_WS2426_PTM_46	this study
*Deparia japonica*_WS2655_PTM_48	this study
Deparia lancea	AF425153
*Deparia petersenii*_Zhang_XC_1596	MG183586
*Diplazium bantamense*_Cicuzza455	KC254579
*Diplazium bellum*_WR0204	KC254507
*Diplazium conterminum*_WR056	this study
*Diplazium cordifolium*_Karger1516	KC254573
*Diplazium dilatatum*_Zhang156	KC254527
*Diplazium donianum*_ZhangXC_5562	KC254575
*Diplazium esculentum*_Zhang_XC_2983	KC254580
*Diplazium lobatum*_WR0258	KC254562
*Diplazium malaccense*_Cicuzza168	KC254578
*Diplazium megaphyllum*_LHM101	KC254535
*Diplazium mettenianum*_WR0194	KC254572
*Diplazium muricatum*_WR0197	KC254523
*Diplazium pallidum*_WR0313	KC254543
*Diplazium petelotii*_WR0292	KP318931
*Diplazium petrii*_1407	KC254570
*Diplazium sorzogenense*_Cicuzza990	KC254520
Diplazium sp._P. Pongkai_107	this study
*Diplazium subserratum*_Chiou15146	KC254526
*Diplazium sylvaticum*_ZhangXC_6898	KP318929
*Diplazium tomentosum*_ChengCW_1578	KP318930
*Diplazium wichurae*_Li_ZY_PT095	MG183587
Hypodematium crenatum	AF425151
*Hypodematium crenatum*_PTM_12	this study
*Hypodematium crenatum*_PTM_31	this study
Hypodematium sp. 3_Rossarin_sn_PTM_63	this study

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PUBLICATION	A new species of Hypodematium (Polypodiaceae, Hypodematioideae) from a limestone cave in Thailand Diplazium thailandicum (Athyriaceae), a new fern from Thailand