Taxonomic Studies on the Genus *Pteris* L. (Pteridaceae) in South India

Thesis submitted to the

University of Calicut in partial fulfilment of the

requirements for the Degree of

Doctor of Philosophy

in

Botany

By

SREENIVAS, V. K.

DEPARTMENT OF BOTANY
UNIVERSITY OF CALICUT
KERALA
2011

DECLARATION

I hereby declare that the thesis entitled "**Taxonomic Studies on the Genus *Pteris* L. (Pteridaceae) in South India**" submitted by me in partial fulfilment of the requirements for the Degree of **Doctor of Philosophy** in **Botany**, **University of Calicut** is the bona fide work carried out by me and no part of the work has formed the basis for the award of any other degree or diploma.

C. U. Campus
21/01/2011

Sreenivas, V. K.

University of Calicut

Department of P G Studies and Research in Botany

Calicut University P.O. 673 635, Kerala, India

Ph: (mob.) 09446247014; (Res.) 0494-2400714; email: pvmadhu@gmail.com

Dr. P. V. Madhusoodanan, FIFS
Professor of Botany (Rtd.)

21-01-'11

CERTIFICATE

This is to certify that the thesis entitled **"Taxonomic Studies on the Genus *Pteris* L. (Pteridaceae) in South India"** submitted by **Sreenivas, V. K.** in partial fulfilment of the requirements for the Degree of **Doctor of Philosophy** in **Botany**, University of Calicut, is a bona fide record of the research work undertaken by him in this Department under my supervision during the period 2007-2011 and that no part thereof has been presented before, for the award of any degree or diploma.

21/01/'11

Prof. (Dr.) P. V. Madhusoodanan

ACKNOWLEDGEMENTS

I find it hard to express adequately the very great debt that I owe to my supervising teacher **Prof. (Dr.) P. V. Madhusoodanan**, former Head of the Department of Botany, University of Calicut, for the help that has always most willingly given and also for his love and constant stimulation during my years in Botany department, University of Calicut.

I express my indebtedness to **Prof. K. V. Mohanan**, Head, **Prof. M. Sivadasan** and **Prof. Nabeesa Salim**, former Heads, Department of Botany, University of Calicut, for providing all the necessary facilities to carry out this work.

At Botany department, University of Calicut, I have had much assistance from **Prof. M. Sabu**, Subject expert, Doctoral committee, and the discussions with **Dr. A. K. Pradeep**, Herbarium Curator, CALI, have been of much helpful in completing my work.

I am greatly indebted to **Kerala State Council for Science and Technology** (KSCSTE) for providing me the research fellowship in Taxonomy (Botany).

I also acknowledge **Chief Wild Life Warden** and **Staff**, Kerala Forest Department, for the permission to collect the plant specimens.

No words are adequate to express my gratitude to **Dr. C. R. Fraser-Jenkins** (Fellow of Royal Botanical Gardens, Edinburgh), Kathmandu, for his valuable advice, critical comments, clarifying doubts, providing type specimens, *etc.*

I express my sincere thanks to the **Curators** of **B, BM, CAL, CALI, E, K, KFRI, KYO, L, LD, LINN, MGMC, MH, P, RHT, SKU, TBGT, UPS, US, XCH** and **Z** herbaria.

Mr. M. Roy, KFRI, Thrissur, who prepared the database, is greatly acknowledged for his kind service.

I would like to thank **Mr. W. D. Theuerkauf**, Guurukula Botanical Sanctuary, Wayanad, **Mr. Raju Antony**, TBGRI, Thiruvananthapuram, for their enthusiasm and help rendered me during the study.

I express my sincere gratitude to **Prof. M. Manimohan**, Department of Botany, University of Calicut, **Dr. N. Sasidharan**, Senior Scientist, KFRI, Thrissur, **Dr. V. Irudayaraj**, Associate Professor and **Dr. N. Siva**, Assistant Professor, St. Xavier's College, Tirunelveli, **Dr. A. Benniamin**, Scientist, BSI, Arunachal Pradesh, **Prof. T. Pullaiah**, S.K. University, Anantapur, A.P. for their help.

There is no word to express my gratitude to my **beloved friends** and **colleagues**, who are directly or indirectly supported me to complete this work successfully.

I express my special thanks to all my **Teachers**, **Non Teaching Staff**, **Librarian** and **Gardeners** of this department for their help.

I am much indebted for the support and love of my **family**, who are with me at every step in the preparation of this thesis.

Sreenivas, V. K.

Dedicated to Prof. B. K. Nayar

CONTENTS

INTRODUCTION

INRODUCTION

Pteridophytes are an assemblage of flowerless, seed-free, and spore bearing vascular plants, which originated in the Silurian of Paleozoic era. These are the second largest group of vascular plants with more than 10,000 extant species and having amazing level of diversity and abundance from the Carboniferous to the Jurassic. But their dominance sharply declined during the Cretaceous period due to angiosperm dominance. Since water is inevitable for fertilization, they first diversified in the humid areas of the earth especially in tropical regions and spread to the other parts of the world (Skog, 2001; Schneider *et al.*, 2004). Majority of the pteridophytes inhabit mountains due to the greater environmental heterogeneity, such as different slopes, exposures, parent rocks, soils, microclimates and elevations (Moran, 2008). Generally this group of plants is neglected owing to their less known economic value, but in fact, many pteridophytes are important for their medicinal, food, and aesthetic values. India has a rich and varied pteridophytic flora due to its diversified topography, variable climatic conditions and geographical position and estimated to contain *ca.* 1000 species (Chandra *et al.*, 2008), though Dixit (1984) reported around 1200 species.

Over past few years, many classifications have been proposed for pteridophytes. The most commonly used classifications of the pteridophytes are as follows: Copeland (1947), Holttum (1947 & 1949), Nayar (1970), Bierhorst (1971), Crabbe *et al.* (1975), Pichi Sermolli (1977), Tryon and Tryon (1982) and Kramer (1990). But recently with the advent of molecular techniques, the scenario has changed with increasing interest in classification reflecting evolutionary relationships. Phylogenetic studies revealed that there are two groups in pteridophytes namely, Lycophytes (fern allies; less than 1% of extant vascular plants) and Monilophytes (ferns). Within ferns, four classes have been recognized such as Psilotopsida, Equisetopsida, Marattiopsida and Polypodiopsida (Pteropsida). Pteridaeae are one among the 37 families of Polypodiopsida (Pryer *et al.*, 2004; Smith *et al.*, 2008).

The Pteridaceae Rchb. are a large and diverse family of nearly world wide distribution with around 50 genera and more than 1000 species, and roughly 10 % of the extant leptosporangiate fern diversity (Schuettpelz *et al.*, 2007a). This family is characterized by paraphysate sori borne on submarginal position of lamina and often protected by pseudoindusia. Spores are usually trilete and the chromosome number is n= 29 or 30 or multiples of these. Pteridaceae have a cosmopolitan distribution, concentrated in tropical and arid regions, and occupy an unusually broad range of ecological niches. Owing to the ecological as well as morphological disparity, the classification of these ferns has been controversial. Historically, Pteridaceae were

designated as tribe, subfamily and family. Tryon *et al.*, (1990) recognized six subfamilies under Pteridaceae, *viz.*, Adiantoideae, Ceratopteridoideae, Cheilanthoideae, Platyzomatoideae, Taenitidoideae and Pteridoideae. Pteridoideae is a small subfamily with five genera (*Acrostichum* L., *Anopteris* (Prantl) Diels, *Ochropteris* Sm., *Neurocallis* Fee and *Pteris* L.) and *Pteris* is the largest genus in this subfamily. Recently, Schuettpelz *et al.*, (2007b) subdivided the family into five clades *i.e.*, *Cryptogrammoid*, *Ceratopteridoid*, *Pteridoid*, *Adiantoid*, and *Cheilanthoid* clades.

Pteris is a large, pantropical genus representing in all continents except Antarctica, but only a few species occur in warm temperate regions of the world. This genus is commonly called as "Brake" ferns. It is estimated to contain 280 species (Copeland, 1947); 200 species (Tryon & Tryon, 1982); 300 species (Walker, 1956); 250 species (Holttum, 1968; Tryon *et al.*, 1990) or 350 (Fraser-Jenkins *et al.*, in press) in the world. Molecular and paleantological analyses revealed that the genus *Pteris* originated and diversified in the Late Cretaceous with other pteridoid ferns about 100 Million years ago (Schneider *et al.*, 2004), but Walker (1956) considered *Pteris* is a young genus. *Pteris* can grow in shaded places, from sea level to high mountains, less often in open places, road sides, earth cuttings, on calcareous and other rock crevices (Tryon *et al.*, 1990). Usually different species of *Pteris* are used as ornamental plants (*e.g.*, *P. vittata* L., *P. ensiformis* Burm.f., *P. cretica* L. *etc.*) in homes and gardens, and some of

the species are widely used as heavy metal accumulators. *P. vittata* L. is considered as one of the excellent model organisms in experimental plant biology. The majority of the species are grouped into a number of complexes of various sizes and these complexes show very different biological behaviour according to whether they are predominantly apogamous or a mixture of apogamous and sexual species (Walker, 1962). *Pteris* is characterized by submarginal position of sori, false indusia, trilete, tetrahedral spores, very asymmetrical outline of gametophyte, and chromosome number n= 29 or multiples of it.

Walker (1956) states " a bewildering mass of forms with uncertain taxonomic status contained within the genus *Pteris* and it was felt that these forms would present objects of interest for a taxonomic investigation with a view to delimit specific boundaries". Moreover, the name *Pteris quadriaurita* Retz. has been indiscriminately applied to a number of related species in India. *Pteris* in South India is critical and difficult group to understand, with surprising variation in segment morphology, which leads to confusion and misidentification. Owing to the lack of proper revision work, there has been considerable discrepancy regarding the identification and authentication of *Pteris* species. In order to solve the taxonomic puzzle in the identification as well as taxonomy of the genus *Pteris*, the topic 'Taxonomic studies on the genus *Pteris* L. (Pteridaceae) in South India' has been selected for the present study.

OBJECTIVES OF THE STUDY

- Prepare an illustrated floristic account of the genus *Pteris* in South India with a key to the identification
- Prepare herbaria for future references
- Prepare a database of the species of *Pteris* in South India
- Envisages a detailed taxonomic revision, with updated nomenclature, colour photographs, distribution, *etc.*
- *Ex situ* conservation of *Pteris* spp. in Calicut University Botanical Garden (CUBG).

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Pteridophytic research in India

Pteridology in India dates back to *Charaka Samhitha* (600 BC), in which a few ferns had been mentioned from Peninsular India. van Reede (1703) gave the illustrated account of 15 pteridophytes from the Malabar in his monumental work *Hortus Malabaricus* (Madhusoodanan & Rejani, 1994). Later, Linnaeus (1753) referred them in his *Species Plantarum*. Koenig (1785) had made some observations on ferns of Thanjavur district. Burman (1768) described some ferns from India including four species of *Pteris*. Himalayan fern flora was first studied by Don (1825). Their works were followed by Griffith (1844), Clarke (1880) and Hope (1899-1904). Wallich (1828- 1849) collected ferns from British India and prepared the herbaria, then listed and sent to East India company Museum, London. Kunze (1851) gave an account of ferns collected from Nilgiris (Nair & Bhargavan, 1981b).

Richard Henry Beddome, a British Botanist and Colonel of East India Company, indeed a lover of ferns, published his outstanding works as *Ferns of South India* (1863), *Ferns of British India* (1865), *Supplements to ferns of South India and British India* (1876), and *Handbook of ferns of British India, Ceylon, and Malay Peninsula* (1883). Blatter and d'Almeida (1922) worked on ferns of the erstwhile Bombay. They provided a strong and sound

foundation for the pteridophyte research in India. Even after nearly a century, these works are of great relevance because of their extensive and masterly coverage.

During the last fourty years the extensive works on south Indian fern flora have been carried out by several botanists as follows; Pteridophytes of Godavari regions, Andhra Pradesh (Raju, 1964), Pteridophytes of Shevaroy Hills (Subramanyam *et al.*, 1960; Ghatak, 1977), Ferns of Palni Hills (Manickam, 1986), Pteridophytes of Western Ghats (Manickam & Irudayaraj, 1992), Thelypteridaceae (Leena & Madhusoodanan, 1992), Fern flora of Malabar (Nayar & Geevarghese, 1993), Lomariopsidaceae of Kerala (Majeed *et al.*, 1994), Polypodiaceae (Nampy & Madhusoodanan, 1998), pteridophytes of Karnataka State (Rajagopal & Bhat, 1998), Polymorphic ferns of Western Ghats (Manickam & Rajkumar, 1999), Filmy ferns (Hameed *et al.*, 2003), Adiantoid and Chielanthoid ferns (Kurup, 2003), Pteridophytes of Nilgiris (Manickam & Irudayaraj, 2003), Pteridophytes of Andhra Pradesh (Pullaiah *et al.*, 2003), Documentation of pteridophytes of Kerala (Easa, 2003), Spleenworts (*Asplenium* L.) of South India (Azeez *et al.*, 2008), Primitive ferns of South India (Kurup *et al.*, 2008), Pteridophytes of Kolli Hills (Gowrisankar *et al.*, 2008), Ferns of Belgaum district, Karnataka (Mahamuni & Dongare, 2009) and Pteridophytes of Wayanad (Madhusoodanan *et al.*, in press).

Taxonomic History of the Genus *Pteris*

Pteris is a large, pantropical genus established by Linnaeus (1753) with 19 species. He coined the Latin word "Pteris" from a Greek word "πτερόν" or πτέρνξ, which means feather or wing (Kramer, 1967; Pichi Sermolli, 1968). Proctor (1977) selected *Pteris longifolia* L. as the type species based on the specimen from near Port de Paix, Haiti.

Presl (1836) divided the genus into three separate genera *viz.*, *Pteris* with characteristic free venation, *Campteria* with a single series of costal areoles, and *Litobrochia* with reticulate venation. Bauer and Hooker (1838) also followed Presl's classification. Later Presl (1849) established the genus *Pycnodoria* and selected *Pycnodoria opaca* (J. Sm.) Presl (=*Pteris opaca* J. Sm.) as the type. Agardh (1839) enumerated 94 species of *Pteris* from various parts of the world and divided the genus into four sections *viz.*, *Eupteris*, *Ornithopteris*, *Litobrochia*, and *Histiopteris*. Beddome (1863) also treated *Pteris* under three separate genera based on the arrangements of vienlets, *viz.*, *Pteris*, *Campteria*, and *Litobrochia*. *Pteris* with free veins, *Campteria* (*Kamptose-* arched; the lowest veins meeting and formed an arch) with long arches of veinlets along the costa of the pinnae, but upper veinlet free, and *Litobrochia* (*Lithos-* stone; *brochia-* spots) with net-like veins.

Clarke (1880) treated *Pteris* into five sections as follows; (1) *Eupteris-* veins free, stipes tufted, involucre single, (2) *Paesia-* veins free, involucre

double, (3) *Campteria*- lower veinlets form costal areole, (4) *Doryopteris*- veins copiously anastomosing, without free included veinlet, and (5) *Litobrochia*- veins copiously anastomosing, with some free included veinlets. Christensen (1906) divided the genus into three subgenera as *Eupteris*, *Campteria*, and *Litobrochia*. Bower (1928) considered that the *Eupteris* is primitive with free venation and mixed type of sori and *Litobrochia* is most advanced with reticulate venation.

Scamman (1961) reported 13 species of *Pteris* from Costa Rica, but he did not attempt to rearrange the genus. Shieh (1966) proposed an infra-generic grouping of *Pteris* into two subgenera, *Pteris* (Type- *Pteris longifolia* L.) with pinnate or bipinnatifid frond and *Tripedipteris* (Type- *Pteris tripartita* Sw.) showing tripartite frond with each division bipinnatifid and margin not entire, four sections, and seven subsections for the 34 species in Japan, Ryukyu Islands and Taiwan. Price (1974) established a section of the genus *Pteris*, *viz.*, *Syrrhacra* based on the gradually confluent apical portion of the frond, absence of groove along the costae, minute glandular hairs everywhere on the abaxial side, *etc. Pteris calocarpa*, *P. pachysora* and *P. endoneura* were assigned to this section.

Tryon and Tryon (1982) grouped the genus into different subgeneric or sectional levels based on leaf architecture and venation such as *Campteria* with costal areoles and *Litobrochia* with reticulate or completely areolate

venation. They categorized the tropical American species of *Pteris* into six groups. They are (1) *Pteris chilensis* group, with tripinnatifid and pinnae gradually reduced to the apex and free veins, (2) *Pteris deflexa* group, with basal pinnae tripinnatifid and strongly reduced at the apex, veins free or anastomosing, (3) *Pteris quadriaurita* group, with basal pinnae bipinnate and veins free or anastomosing, (4) *Pteris haenkeana* group, with ultimate segment large, entire and veins anastomosing, (5) *Pteris longifolia* group, with pinnate, entire, imparipinnate and veins free, and (6) *Pteris cretica* group, with dimorphic pinnae. Later Tryon *et al.*, (1990) divided *Pteris* into two subgenera as *Pteris* and *Litobrochia* based on different morphological characters.

Based on molecular studies, Li *et al.* (2004), divided the genus *Pteris* into three sections. The Section 'Pteris' comprises *P. ensiformis* Burm.f., *P. venusta* Kunze, *P. multifida* Poir., *P. henryi* Christ., *etc.*, and Section 'Oudriauricula' includes *P. biaurita* L., *P. aspericaulis* Wall. ex J. Agardh, *P. linearis* Poir., *P. amoena* Blume, *etc.*, and *Pteris vittata* L. alone form a separate Section. Schuettpelz *et al.*, (2007b) suggested the genus is not monophyletic and *P. vittata* L. forms a lone clade as mentioned by Li *et al.* (2004), and showing the affinity with *Platyzoma* and *Taenitis*. They also considered that *P. vittata* L., *P. longifolia* L. and allies form a clade, and the remaining members were included in separate generic names *Litobrochia* C. Presl or *Campteria* C. Presl. From molecular studies, it was found that the

genus *Pteris* is polyphyletic, that the name *Pteris* should apply to species of the *P. vittata* L. group, and not to most of the other species historically regarded as *Pteris*. So, *P. quadriaurita* Retz. and allies will ultimately go into another genus (Smith, Pers. Comm.).

But, Fraser Jenkins *et al.* (in press), criticized these subdivisions based on the molecular analyses. Three apparent clades proposed by Li *et al.* (2004) contained a mixture of often quite obviously unrelated species. In addition, *P. vittata* L. (whose simply pinnate morphology they erroneously thought to be unique in the genus) is closely related to the Central American *P. longifolia* L., the type species of the genus.

According to Pichi Sermolli (1977), *Copelandiopteris* and *Idiopteris* are very close to *Pteris*, in which *Copelandiopteris* is less advanced than *Pteris*. *Neurocallis* showed clear intermediate condition between *Pteris* and *Acrostichum*. He also included the genera *Schizostege* and *Hemipteris* in *Pteris*. Schuettpelz *et al.*, (2007b) have the opinion that *Neurocallis*, *Ochropteris*, and *Afropteris* are allied to *Pteris* based on molecular analyses. *Pteris* is considered as a paraphyletic group and have the affinity with *Afropteris* (Sánchez-Baracaldo, 2004) and *Platyzoma* (Prado *et al.*, 2007).

The exact number of species of the genus *Pteris* in different geographical areas is not known due to the overestimation and synonyms of several species. The available data are presented in Table 1.

Table 1. Distribution of the species of *Pteris* in the world.

Sl. No.	Country	No. of species	References
1	America	60	Mickel & Smith (2004)
2	Bangladesh	15	Fraser- Jenkins (2011)
3	Bhutan	29	Fraser- Jenkins (2011)
4	China	60	Li *et al.*, (2004)
5	Fiji	8	Copeland (1971)
6	India	45	Chandra (2000)
7	Indonesia	23	Kato and Kramer (1990)
8	Japan	27	Kato (Pers. Comm.)
9	Korea	6	Kato (Pers. Comm.)
10	Malaysia	14	Holttum (1968)
11	Mexico	18	Mickel & Smith (2004)
12	Nepal	25	Fraser- Jenkins (2011)
13	Pakistan	4	Fraser- Jenkins (2011)
14	Sri Lanka	15	Sledge (1982)
15	Taiwan	31	Shieh (1994)

Walker (1960) provided detailed description and illustrations of *Pteris quadriaurita* complex from Ceylon, and Walker (1957) established a new genus *Idiopteris* based on the *Pteris hookeriana* J. Agardh after cytological investigations (n= 27). Maxon (1939) and Chandler (1941) reported *Pteris multifida* Poir. from Washington, D. C. and Arkansas, America respectively. Arbelaez (1995) described two new species of *Pteris* from Colombia as *P. muricatopedata* and *P. albertiae* and two new records for Colombia as *P. bakeri* C. Chr. and *P. lechleri* Mett. Recently Prado and Smith (2002) described *Pteris boliviensis*, and *P. krameri* from Bolivia and Guyana respectively. *Pteris herrerae* A. Rojas & M. Palacios, an endemic species, was described from Costa Rica (Rojas & Palacios, 2006). Hawkes (1964) reported *Litobrochia tripartita* from Florida. Kuo (1989) described *Pteris wulaiensis* as a new species from Taiwan. Recently Zheng *et al.*, (2010) added a new species, *Pteris changjiangensis* to the Chinese fern flora.

Beddome (1883) recorded 19 species and 10 varieties of *Pteris* from British India, Ceylon and Malaya Peninsula. Dixit (1984) reported 48 species and one variety from India mainly based on literature survey. Vasudeva and Chhibber (1989), and then Vasudeva and Singla (1991) revised 37 species of *Pteris* from India with special reference with *Pteris quadriaurita* complex. Chandra (2000) reported 45 species, two subspecies, two varieties, and one hybrid from India. Das (2007) revised the simple pinnate species of *Pteris* in India. Srivasthava (2007) carried out molecular assessment of biodiversity

and biosystematics of *Pteris* L. with special reference to *P. vittata* L. in India. Fraser-Jenkins (2008a) reported 50 species from Indian subcontinent. The available data on the occurrence of *Pteris* in India (Table 2) and South India (Table 3) are given below.

Table 2. The distribution and number of *Pteris* in India.

Sl. No.	Locality/region	No. of species	References
1	South India	12	Beddome (1863)
2	North India	15	Clarke (1880)
3	Kashmir	4	Stewart (1945)
4	Himalaya	30	Mehra (1986)
5	Palni Hills	5	Manickam (1986)
6	Nagaland	10	Jamir & Rao (1988)
7	Nainital	7	Khullar *et al.* (1991)
8	Western Ghats	15	Manickam & Irudayaraj (1992)
9	Kerala	18	Nair *et al.* (1992)
10	Malabar	11	Nayar & Geevarghese (1993)
11	Western Himalaya	12	Khullar (1994)
12	Karnataka	10	Rajagopal & Bhat (1998)
12	Assam	16	Borthakur *et al.* (2000)
13	Sirumalai Hills	5	Karuppusamy *et al.* (2001)
14	Periyar Tiger reserve	9	Rajesh (2002)
16	Nilgiri Hills	12	Manickam & Irudayaraj (2003)
17	Andhra Pradesh	5	Pullaiah *et al.* (2003)
18	Kumaon Himalaya	10	Pande & Pande (2003)
19	Eastern India	43	Ghosh *et al.* (2004)
20	Parambikulam Tiger Reserve	5	Sujanapal (2005)
21	Kerala	20	Sreenivas & Madhusoodanan (2010a)
22	Wayanad	7	Madhusoodanan *et al.* (in press)

Table 3. Geographical distribution of *Pteris* in South India

Sl. No.	Species	Districts/ regions	Refernces
1	*P. argyraea*	Salem	Subramannyam *et al.* (1960)
		Nilgiri	Beddome (1863)
			Manickam & Irudayaraj (2003)
		Dindigul	Manickam (1986)
		Coimbatore, Thiruvananthapuram, Tirunelveli	Manickam & Irudayaraj (1992)
		Idukki, Palakkad, Thrissur	Nair *et al.* (1992)
		Idukki, Palakkad, Kozhikode, Thiruvananthapuram, Thrissur, Wayanad	Sreenivas & Madhusoodanan (2010a)
		Malabar	Nayar & Geevarghese (1993)
		Chickmagaluru, Hassan, Mysore	Rajagopal & Bhat (1998)
		Dindigul	Karuppusamy *et al.* (2001)
2	*P. arisanensis*	Belgaum	Mahamuni & Dongare (2009)
		Idukki	Sreenivas & Madhusoodanan (2010a)
3	*P. biaurita*	Dindigul	Manickam (1986)
		Nilgiri	Beddome (1863)
			Manickam & Irudayaraj (2003)

		Coimbatore, Tirunelveli	Manickam & Irudayaraj (1992)
		Malabar	Nayar & Geevarghese (1993)
		Ernakulam, Idukki, Pathanamthitta, Thiruvananthapuram, Thrissur, Wayanad	Nair *et al.* (1992)
		Visakhapatnam, East Godavari	Pullaiah *et al.* (2003)
		Chikmagaluru, Shimoga, Uttara Kannada	Rajagopal & Bhat (1998)
		Dindigul	Karuppusamy *et al.* (2001)
		Belgaum	Mahamuni & Dongare (2009)
		All districts	Sreenivas & Madhusoodanan (2010a)
4	*P. blumeana*	Kodagu, Wayanad	Beddome (1883)
		Coimbatore, Idukki	Manickam & Irudayaraj (1992)
		Idukki, Palakkad,	Nair *et al.* (1992)
		Palakkad	Nair & Geevarghese (1993)
		Kodagu	Rajagopal & Bhat (1998)
		Idukki, Kannur	Sreenivas & Madhusoodanan (2010a)
5	*P. confusa*	Idukki, Ernakulam Thiruvananthapuram	Nair & Ghosh (1974) Nair *et al.* (1992)
		Idukki, Dindigul	Manickam & Irudayaraj (1992)

		Nilgiri	Manickam & Irudyaraj (2003)
		Visakhapatnam, Chittoor	Pullaiah *et al.* (2003)
		All district of Kerala	Sreenivas & Madhusoodanan (2010a)
6	*P. cretica*	Dindugul	Beddome (1863)
			Manickam (1986)
			Manickam & Irudayaraj (1992)
		Salem	Subramannyam *et al.* (1960)
		Malabar	Nayar & Geevarghese (1993)
		Nilgiri	Beddome (1863)
			Manickam & Irudayaraj (2003)
7	*P. ensiformis*	Malabar	Beddome (1863 & 1883)
			Nayar & Geevarghese (1993)
		Palakkad	Nair *et al.* (1992)
		Kannyakumari	Manickam *et al.* (2004a)
		Thiruvananthapuram	Sreenivas & Madhusoodanan (2010a)
		Belgaum	Mahamuni & Dongare (2009)
8	*P. geminata*	Palakkad	Nair & Bhargavan (1985)
		Idikki	Nair *et al.* (1992)
			Sreenivas & Madhusoodanan (2010a)

		Comibatore, Tirunelveli	Manickam & Irudayaraj (1992)
		South India	Chandra *et al.* (2008)
9	*P. gongalensis*	Idukki	Nair & Ghosh (1974)
		Idukki, Pathanamthitta	Nair *et al.* (1992)
		Dindigul	Rajkumar (2002)
		Nilgiri	Manickam & Irudayaraj (2003)
		Idukki, Malappuram	Sreenivas & Madhusoodanan (2010a)
10	*P. heteromorpha*	Visakhapatnam	Manickam *et al.* (2005)
		Kodagu	Manickam *et al.* (2007)
		South India	Chandra *et al.* (2008)
		Palakkad	Antony (2009)
		Kollam	Sreenivas & Madhusoodanan (2010a)
11	*P. linearis*	Tirunelveli	Manickam & Irudayaraj (1992)
		Uttara Kannada	Rajagopal & Bhat (1998)
		Idukki, Palakkad, Wayanad	Sreenivas & Madhusoodanan (2010a)
12	*P. longipes*	Coimbatore	Beddome (1863)
		Idukki, Palakkad	Nair *et al.* (1992)
		Coimbatore	Manickam & Irudayaraj (1992)
		Malabar	Nayar & Geevarghese (1993)
		Shimoga	Rajagopal & Bhat (1998)

		Dindigul	Karuppusamy *et al.* (2001)
		Idukki, Palakkad, Thiruvananthapuram, Wayanad	Sreenivas & Madhusoodanan (2010a)
13	*P. mertensioides*	Kodagu, Waynad, Thiruvananthapuram	Beddome (1883)
		Kollam, Thrissur	Nair *et al.* (1992)
		Thrissur	Manickam & Irudayaraj (1992)
			Sreenivas & Madhusoodanan (2010a)
		Palakkad	Nayar & Geevarghese (1993)
		South India	Chandra *et al.* (2008)
14	*P. multiaurita*	Kollam, Pathanamthitta	Nair & Ghosh (1974)
		Tirunelveli	Manickam & Irudayaraj (1992)
		South India	Chandra *et al.* (2008)
		Kollam, Thiruvananthapuram	Sreenivas & Madhusoodanan (2010a)
15	*P. multifida*	Kozhikode	Sreenivas & Madhusoodanan (2010b)
16	*P. otaria*	Malabar, Kollam	Beddome (1863 & 1883)
		Tirunelveli	Manickam & Irudayaraj (1992)
		Kannyakumari, Kollam, Pathanamthitta, Thiruvananthapuram	Nair *et al.* (1992)
		Belgaum	Mahamuni & Dongare (2009)

		Idukki, Kollam, Palakkad, Thrissur, Thiruvananthapuram	Sreenivas & Madhusoodanan (2010a)
17	*P. pellucida*	Coimbatore	Beddome (1863)
		East Godavari	Raju (1964)
		Coimbatore, Namakkal, Thiruvananthapuram	Manickam & Irudayaraj (1992)
		Idukki, Kollam, Palakkad, Thiruvananthapuram, Thrissur,	Nair *et al.* (1992)
		Chickmagaluru, Dakshina Kannada, Kodagu, Mysore, Shimoga, Uttara Kannada	Rajagopal & Bhat (1998)
		Chittoor, Srikakulam, Visakhapatnam, Vizianagaram	Pullaiah *et al.* (2003)
		Belgaum	Mahamuni & Dongare (2009)
		All districts	Sreenivas & Madhusoodanan (2010a)
18	*P. perrottetii*	Nilgiri	Hieronymus (1914)
			Dixit (1984)
		Palakkad, Wayanad	Sreenivas & Madhusoodanan (2010a)
19	*P. praetermissa*	Idukki, Kollam, Pathanamthitta, Kottayam, Thiruvananthapuram	Nair & Ghosh (1974)
			Nair & Ghosh (1976)
			Nair *et al.* (1992)
		Kannyakumari, Devigar-Nagariar	Rajkumar (2005)

		All districts	Sreenivas & Madhusoodanan (2010a)
20	*P. quadriaurita*	Pathanamthitta	Nair *et al.* (1992)
		Kerala and Tamil Nadu hills	Manickam & Irudayaraj (1992)
		Malabar	Nayar & Geevarghese (1993)
		Dindigul	Karuppusamy *et al.* (2001)
		South India	Chandra *et al.* (2008)
21	*P. reptans*	Kollam	Sreenivas & Madhusoodanan (in press)
22	*P. scabripes*	Palakkad	Nair & Bhargavan, (1981a)
			Ghosh & Ghosh (1982)
			Nair *et al.* (1992)
		Coimbatore	Manickam & Irudayaraj (1992)
		Chikmagaluru	Rajagopal & Bhat (1998)
		Palakkad, Thiruvananthapuram	Sreenivas & Madhusoodanan (2010a)
23	*P. tripartita*	Cochin forests	Beddome (1883)
		Madurai	Manickam *et al.* (2004b)
		South India	Chandra *et al.* (2008)
24	*P. vittata*	Kollam	Nair *et al.* (1992)
		Coimbatore	Manickam & Irudayaraj (1992)
		Malabar	Nayar & Geevarghese (1993)

		Dakshina Kannada, Kodagu, Mysore, Uttara Kannada	Rajagopal & Bhat (1998)
		Dindigul	Karuppusamy *et al.* (2001)
		Anantapur, Chittoor, Kurnool, Srikakulam, Visakhapatnam, Vizianagara	Pullaiah *et al.* (2003)
		Belgaum	Mahamuni & Dongare (2009)
		All districts of Kerala	Sreenivas & Madhusoodanan (2010a)

General aspects of *Pteris*

Life cycle

Like any other leptosporangiate fern, *Pteris* shows distinct alternation of generations *i.e.*, a dominant diploid sporophyte is alternated by an independent cordate haploid gametophyte phase. The sequence is as follows (fig. 1);

1. A sporophyte (diploid) phase produces haploid spores (homospores) in the sporangium by meiosis.
2. The spore germinates and grows by mitosis into a cordate photosynthetic gametophyte.
3. The gametophyte produces both male gametes (haploid) and female gamete (haploid) in antheridium and archegonium respectively.
4. A motile, flagellate sperm (male gamete) fertilizes an egg (female gamete) with in the stationary archegonium and the zygote remains attached to the gametophyte.
5. The fertilized egg (diploid zygote) grows by mitosis into an embryo
6. The embryo develops into a diploid sporophyte.

In some species, gametophye may develop by vegetative growth from the tissues of the sporophyte (apospory) or the sporophyte may develop directly from the tissues of the gametophyte apogamously and not from an egg. (Sheffield & Bell, 1987).

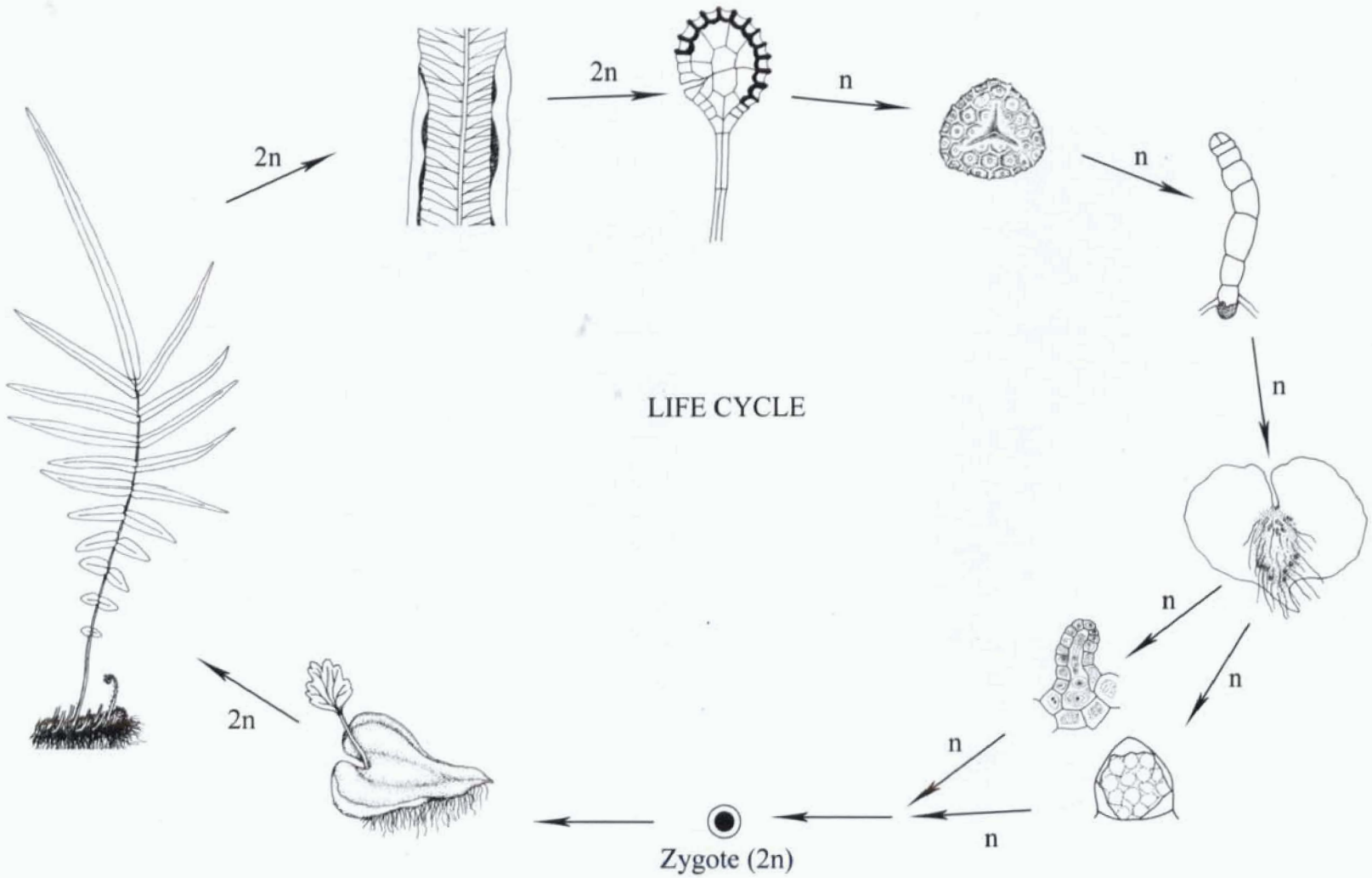


Fig. 1. Life cycle of the genus *Pteris* (*P. vittata* L.)

Morphology and Anatomy

It is now evident that many morphological characters traditionally utilized in fern classification, at family and higher ranks, are still extremely useful in characterizing monophyletic groups at these ranks. Rhizome anatomy, venation pattern, indument type, indusial presence and type, spore type and ornamentation, eusporangiate versus leptosporangiate development, sporangial capacity, annulus position and form, chromosome base number, and gametophyte morphology are considered as most important and useful characters in fern taxonomy (Smith *et al.*, 2008).

Generally the genus *Pteris* has short, erect or sub erect rhizome, however in some species it is slender and long creeping with closely placed leaf bases. The stellar structure may range from solenostele to complicated polycyclic dictyostele, but the leaf trace varies from an uninterrupted horse shoe to two straps formed from the stele of axis (Bower, 1928).

Purple stipe, stipe with green on adaxial side and purple on abaxial side are common in *Pteris* (Lin & Devol, 1978). Transverse section of the stipe of the genus *Pteris* shows the following characters; small epidermal cells covered by smooth cuticular membrane. The ground tissue is composed of outer lignified tissue and inner paranchymatous tissue filled with starch grains. The shape of the vascular strand (leaf trace) in the genus is generally 'U' shaped,

except in a few species. A multilayered pericycle is present in all species and the endodermis is inconspicuous (Khare & Shankar, 1989).

Solenostele is the common vasculature in *Pteris*, but dictyosteles are present in *Pteris cretica* L., *P. pellucida* C. Presl, *P. biaurita* L., *P. tremula* R. Br., *etc.* A single stranded medullary vascular system is present in the adult rhizome of *P. kunzeana* J. Agardh, *P. podophylla* Sw., and *P. wallichiana* J. Agardh. This medullary vascular system acts as compensatory strands to close the leaf gaps. Leaf gaps are spirally arranged and often slightly overlapping in varying degrees. The leaf trace is solitary; deeply gutter-shaped in most of the *Pteris*, but, usually paired ribbon like vascular strands in *P. cretica* L. (Kaur, 1984).

'V' shaped vascular bundles are present in the stipe of *P. cretica* L., *P. dactylina* Hook. and *P. stenophylla* Wall. ex Hook. & Grev. 'U' shaped vascular bundles are present in *P. excelsa* Gaud., *P. quadriaurita* Retz., and *P. biaurita* L., whereas Ω shaped vascular bundles are present in *P. wallichiana* J. Agardh. Based on the number and structure of vascular strand, *P. cretica* and *P. vittata* L. are advanced in pinnately fronded species, whereas, *P. wallichiana* J. Agardh is highly advanced among *Pteris* spp. Anastomosing veins and presence of more than one leaf trace are advanced characters over dichotomous veins and single (solitary) leaf trace (Punetha, 1990).

Pteris is a large genus with different kinds of venation. It varies from free, forking (e.g. *P. vittata* L.) to reticulate form (*P. tripartita* Sw.) and the number of veins also vary depending on the species. A special type of vein, spicular 'false veins' or venuloid idioblast were reported in *P. grevilleana* Wall. ex J. Agardh and *P. multifida* Poir. These false veins are present closely along with the true veins or inter venal areas and seen only in a few taxa of *Pteris* from western pacific and south eastern Asia (Wagner, 1978).

The sorus of *Pteris* was an evolutionary success and the superficial origin of the sorus is a constant generic character. Cells at the intramarginal position at the lower surface of the leaf grow out to form sporangia. Usually the sorus is found in the middle of the fertile area, while younger sporangia lie right and left of mature sporangia and is called as 'mixed' type of sorus (Bower, 1928). Submarginal and marginal sori arise as a result of phase differentiation in leaf development and additional developmental processes. In *Adiantum* and *Pteris*, the submarginal sori have flat or ridge-shaped receptacles with sporangia initiated in mixed sequence. In *P. quadriaurita* Retz., sorus formation takes place when the sufficient vegetative leaf lamina is formed. But, in *P. longifolia* L. and *P. multifida* Poir. the sporangial initials formed after the complete development of marginal membranaceous flap. The sorus of *Pteris* shows similarity with that of *Pteridium* and believed that the 'Pteridium' type might be evolved from 'Pteris' type. The elaborate sori is considered as advanced as the specialized area of the leaf produce the

apparatus of sori with considerable complexity and it is a step by step process from the simple form. The soral construction of *Pteris* can be derived from superficial singly arranged sporangia as observed in *Pityrogramma*. The soral similarity between the *Pteris* and *Pteridium* may be due to analogous convergence (Scholch, 2003).

Usually the annulus of *Pteris* species is composed of 16-20 thickened cells, but, in some cases up to 30 cells may be present in *Pteris vittata* L. (Copeland, 1947). *Pteris confusa* T. G. Walker shows morphological variations in rhizome, lamina and stipe (Manickam & Rajkumar, 1999).

Palynology

Spores provide useful characters to distinguish the genera or species of pteridophytes. The external ornamentation of perispores, size, shape, and leasura length of the spores are important in pteridophyte taxonomy (Lellinger & Taylor, 1997).

The spores of *Pteris* are trilete, tetrahedral and are characterized by the possession of an equatorial collar-like ridge (cingulum) girdling the spore, but the exine ornamentation on the proximal and distal surface varies. The common type of ornamentation is the tuberculate type with the tubercles sometimes verrucate or rugate. The ornamentation is conspicuous on distal surface than that of proximal surface and perine is absent in the genus. Many species of *Pteris* exhibit good deal of variation in spore size as well as

abnormalities in form. The spores of *Pteris* do not generally swell on acetolysis (Nayar & Devi, 1966; Devi, 1977; Mehra, 1986; Martinez & Morbelli, 2009). Spores of American species of *Pteris* are characterized by strong equatorial flange, coarse tubercles fused into ridges and spherical deposit. These characters of *Pteris* resembles those of genera allied to *Pityrogramma* and the basic chromosome number (x= 29) is also same in both genera (Tryon, & Tryon, 1982). Spores of 140 species of pteridophytes from Columbia has been described and illustrated, including five species of *Pteris*, in which majority are with verrucate exine ornamentation (Murillo & Bless, 1974). The typical spore of Pteridaceae is tetrahedral, trilete, with a large cingulum (Tardieu-Blot, 1963).

Devi *et al.*, (1985) studied the air borne spores of ferns in Lucknow city and found that spores of different species were present. The spores of *P. vittata* L. present throughout the year, but spores of *P. cretica* L. were present only in November, December and January. Devi (1977) described the spore morphology of 26 species and four varieties of *Pteris*. Martinez and Morbelli (2009) examined the spore morphology of *Pteris cretica* L. complex, including *P. brasiliensis* Raddi, *P. ciliaris* Eat., *P. cretica* L., *P. denticulata* Sw., *P. denticulata* Sw. var. *tristicula* (Reddi) Prado, *P. ensiformis* Burm.f., *P. multifida* Poir. and *P. mutilata* L. in America. In addition to trilete spores, *Pteris brasiliensis* Raddi, *P. cretica* L. and *P. denticulata* Sw. also produce atypical spores such as tetralete, monolete

and intermediate types. Bhavanandan and Ammal (1993) studied the spore morphology of 15 species of pteridophytes from south India including *P. ensiformis* var. *victoriae* Baker.

Gametophytes

The spore germination in the genus *Pteris* is Vittaria-type and the prothallial development is Ceratopteris-type. The adult gametophytes are cordate, with broad wings, growing very fast, with a distinct cushion. Rhizoids are nearly hyaline or pale brown, distributed in the lower surface of the cushion, with thin cell walls. The adult prothallus is naked and the gametangia are of the common leptosporangiate-type. Differences among species include spore size, germination time, formation time of the gametangia, gametophyte margin shape, number of archegonial neck cells and shapes of the antheridial dehiscence (Nayar & Kaur, 1971; Zhang *et al.*, 2008).

Gametophytes of Indian ferns have been studied by several authors, *i.e*,. Mehra, Nayar, Bir and others. Mehra (1986) illustrated the development of gametophyte of the genus *Pteris* from the Himalayan regions. His works were mainly on *Pteris cretica* L., *P. excelsa* Gaud., *P. wallichiana* J. Agardh, *P. biaurita* L., *P. aspericaulis* Wall. ex J. Agardh, *etc.* Mishra and Sen (1989) studied the trachied development in gametophytes of *Pteris aspericaulis* Wall. ex J. Agardh, *P. asperula* Sm. and *P. biaurita* L. and later Mishra and Sen

(1991) described the structure and ontogeny of the gametophytes of *P. argyraea* T. Moore, *P. asperula* J. Sm. ex Hieron., *P. aspericaulis* Wall. ex J. Agardh, *P. blumeana* J. Agardh, *P. multiaurita* J. Agardh, *P. praetermissa* T. G. Walker, and *P. quadriaurita* Retz.

Ascorbic acid is considered as effective in the germination of stored spore, morphology and sex expression of gametophytes and it was observed that 50µg/ml ascorbic acid is effective for prothallial fertility and sporophyte development in the gametophyte of *Pteris vittata* L. (Bir & Goyal, 1981 & 1982). Varma *et al.*, (2006) found that pH 6 is favourable for the germination of spores of *Pteris vittata* L. Ito (1962) found that the isolated single cells from the young gametophyte of *P. vittata* L. were able to regenerate and produce mature gametophytes. Prada *et al.*, (2008) studied gametophyte development, sex expression and antheridiogen system in *Pteris incompleta* Cav. Khare and Kaur (1983) observed three patterns of differentiation in the gametophytes of *Pteris vittata* L. and Crotty (1967) studied the rhizoid cell differentiation in the gametophytes of *Pteris vittata* L.

Apogamy and Apospory

Formation of sporophyte directly from vegetative cells of the gametophyte is regarded as apogamy. Apospory is the formation of a gametophyte from vegetative cells of sporophyte. Apogamy and apospory serve to circumvent the normal life cycle of ferns involving alternation of

generations between an unreduced sporophyte and a reduced gametophyte. Natural apogamy and apospory occur under ordinary environmental conditions. Natural apogamy is constant in the life cycle of a pteridophyte, but induced apogamy occurs only under cultural conditions, such as strong light, modified nutrient culture solutions, and insufficient water supply for fertilization (Steil, 1939; Raghavan, 1989). Induced apospory in homosporous plants commonly leads to a bisexual gametophyte with fully functional gametes, providing the opportunity for establishing a new cycle at a higher level of ploidy. This may occasionally occur in nature accounting for the diploid and tetraploid forms found in many species of mosses and in some ferns (Bell, 1992).

Farlow (1874) described the nature of the apogamous embryo in *Pteris cretica* var. *albolineata* Hook., where the apogamous embryo resembles the embryo produced in the ordinary way (zygotic embryo). Apogamy could have arisen in a formally sexual species, not by an act of hybridization (Manton, 1950). 34% of the *Pteris* species are apogamous and produce sporophytes directly from the prothalial tissues, but they can produce fuctional antheridia and spermatozoids with diploid chromosome numbers. Though the apogamous species have no fuctional archegonia, they act as male and form hybrid with sexual species. These apogamous hybrids are fertile and true breeding, with reduced spore number (Walker, 1962).

According to some biologists, the obligate apomictic species are the dead ends in the evolutionary process, but Walker (1962) suggested that natural selections must have acted upon several biologically important characters, such as percentage of viable spores and vigour of spermatozoids based on his experiments in *Pteris*. Generally, the obligate apogamous species of *Pteris* undergo modifications in due course under the influence of natural selection. In *Pteris sulcata* L., the gametophyte generation is normally produced by the germination of spore and the embryo sporophyte is of apogamous in origin. A sharp line of demarcation usually exists between the cells of the gametophyte and the sporophyte (Steil, 1919). In *P. biaurita* L., the embryo is formed by apogamous bud, and the archegonia are eliminated from the life cycle of the gametophyte (Mehra, 1938). The gametophyte of *P. cretica* L. var. *albolineata* Hook. bears both antheridia and archegonia. The antheridia develop in a normal manner, but all the archegonia become aborted. Sporophytes are always in apogamous origin and retain reduced chromosome number (Heun, 1939). Recurrent hybridizations contributed the genetic variations among agamosporous species of *Pteris cretica* L. (Suzuki & Iwatsuki, 1990). Steil (1933) reported apogamy in *Pteris flabellata* Thunb. in which prothallia become typically heart-shaped and resemble those of other species of *Pteris*.

Karyology

With the publication of Manton's book "Problem of Cytology and Evolution in the Pteridophyta" in 1950, the cytological investigations have been extensively carried out throughout the world. Mehra, Bir, and Verma contributed enormous cytological investigation on Indian pteridophytes ranging from Himalaya to the southern Western Ghats. In southern India, Abraham *et al.*, (1962) carried out cytological investigation on 100 species of pteridophytes followed by Irudyaraj and Manickam (1987) and Manickam and Irudyaraj (1988 & 1989), who carried out the cytological analysis of south Indian pteridophytes with special reference to Eastern Ghats ferns. Chromosomal studies on different species of *Pteris* have been widely carried out across the world. They are summarized in the table 4.

Manton and Sledge (1954) carried out extensive cytological analysis on more than 150 species of ferns from different regions of the world with special reference to Ceylon, and including seven species of *Pteris*. Walker (1956 & 1962) examined the chromosome number of more than 60 species of *Pteris* and revealed the basic chromosome number is invariably 29. Brownlie (1957) examined cyto-taxonomically the Copeland's Pteridaceae including the genera *Dicksonia, Lindsaea, Hypolepis, Pteridium, Paesia, Pteris, Cheilanthes, Pellaea,* and *Adiantum* and he observed that n= 120 in *Pteris tremula* R. Br. Kuriachan and Ninan (1976) provided a scheme of evolution

of chromosome numbers in the family Pteridaceae (*sensu* Copeland, 1947) (Fig. 2). Ammal and Bhavanandan (1991) cytologically investigated 10 species under 6 genera of Pteridaceae from South India and revealed unrelated chromosome numbers from 26 to 52 in this family. But the *Pteris* is characterized by n=29/30 or multiples and they proposed to separate the *Pteris* from Copeland's Pteridaceae. Bhavanandan (1968) cytologically investigated 16 species of pteridophytes from South India.

Polyploidy

Polyploidy is an intriguing phenomenon that has played an important role in the evolution of many plants. About 45% of homosporous ferns are polyploids and the extant ferns are evolved from the ancestors with same high chromosome numbers. Ploidy is correlated with the mating system, the number of spores in each sporangium, sporogenesis, spore size, and the life span of the gametophyte, *etc.* (Manton, 1950; Duncan & Smith, 1978; Huang *et al.*, 2007). Triploids and tetraploids constitute 64% of naturally occurring apogamous species of *Pteris*. However, though the incidence of polyploidy is common, it is not uniformly distributed among various genera and family because it is absent in Osmundaceae and Cyatheaceae, and rarely in Dicksoniaceae and Gliecheniaceae. Polyploidy is frequently associated with increase in spore and stomatal length and in most cases polyploidy involves hybridization followed by chromosome doubling. A single spore with doubled

chromosome number is potentially capable of germination and its prothallus, can undergo self fertilization to give rise polyploid sporophyte. Polyploids are present in different parts of the world, ranging from tropical to temperate, both old and new world (Walker, 1962 & 1979).

The high chromosome number in some groups of pteridophytes is considered to be a sign of antiquity (in most ancient group) and species with low chromosome numbers appear to be in remote past. The high chromosome numbers tend to show down the evolutionary process (Manton, 1950). Khare (1995) observed diploid, triploid, tetraploid, pentaploid, and hexaploid *P. vittata* L. from different geographical locations in India. In south India, diploid, tetraploid and hexaploid cytotypes are present. Due to the low genetic load in tetraploid cytotype of *P. vittata*, it is adapted to colonize new or distant habitat, even in barren land through the spore dispersal (Khare & Kaur, 1987).

Table 4. Chromosome numbers *Pteris* from various geographical regions

Sl. No	Name of species	Chromos-ome number (n/2n)	Ploidy level	Country/ location	References
1	*P. argyraea*	n = 87	apogamous trioplid	South India	Ghatak (1977)
		n= 29	sexual, diploid	South India	Irudayaraj & Manickam (1987)
		n= 58	apogamous, diploid	Sri Lanka Indonesia	Walker (1956 & 1962)
2	*P. biaurita*	n= 29	apogamous, diploid	South India	Abraham *et al.* (1962)
		n= 87	apogamous, triploid	North India	Ghatak (1961)
		n= 58	apogamous, diploid	Sri Lanka	Manton & Sledge (1954) and Walker (1956 & 1962)
		n= 87	apogamous, triploid	South India	Irudayaraj & Manickam (1987)
		n= 87	apogamous, triploid	Kumaon	Punetha & Sen (1989)
		n= 87	apogamous, triploid	Nepal	Walker (1962)
		n= 58	apogamous, diploid	Ghana	Walker (1962)
3	*P. confusa*	n=58	apogamous, diploid	South India	Manickam & Rajkumar (1999)
		n=58	apogamous, diploid	Sri Lanka	Walker (1956)

4	*P. cretica*	2n= 87	apogamous, triploid	New Guinea	Holttum & Roy (1965)
		n= 87	apogamous, triploid	South India	Irudayaraj & Manickam (1987)
		2n = 58	apogamous, diploid	Japan	Nakato (1975)
		n = 58	apogamous, diploid	Himalaya	Mehra & Verma (1960)
		n= 58	apogamous, diploid	Kumaon	Punetha & Sen (1989)
		n= 58	apogamous, diploid	Italy	Walker (1962)
5	*P. cretica* var. *albolineata*	n= 87	apogamous, triploid	Indonesia	Walker (1962)
6	*P. ensiformis*	n= 58	sexual, tetraploid	South India	Abraham *et al.* (1962)
		n= 58	sexual, tetraploid	Sri Lanka	Manton & Sledge (1954) and Walker (1956)
		n= 58	sexual, tetraploid	Java	Walker (1962)
7	*P. ensiformis* var. *victoriae*	2n= 87	sexual, triploid	India	Jha & Sinha (1987)
		2n= 116	sexual, tetraploid	Java	Walker (1962)
8	*P. gongalensis*	n= 87	apogamous, triploid	Sri Lanka	Walker (1956 & 1962)
9	*P. linearis*	n= 58	apogamous, diploid	Sri Lanka	Manton & Sledge (1954)
10	*P. longipes*	n= 58	apogamous, diploid	South India	Irudayaraj & Manickam (1987)
11	*P. multiaurita*	n=29	sexual, diploid	Sri Lanka	Manton & Sledge (1954) and Walker (1956 & 1962)
		n= 29	sexual, diploid	South India	Irudayaraj & Manickam (1987)

12	*P. multifida*	n= 29	sexual, diploid	Sri Lanka	Manton & Sledge (1954)
		2n = 116	sexual, tetraploid	China	Roy & Holttum (1965)
		n= 58	sexual, tetraploid	Sri Lanka	Walker (1956)
		2n = 116	sexual, tetraploid	Japan	Nakato (1975)
13	*P. otaria*	n= 29	sexual, diploid	South India	Abraham *et al.* (1962)
		n= 29	sexual, diploid	Sri Lanka	Manton & Sledge (1954) and Walker (1962)
14	*P. pellucida*	n= 29	sexual, diploid	South India	Kuriachan (1968)
15	*P.praetermissa*	n= 29	sexual, diploid	Sri Lanka	Walker (1956 & 1962)
16	*P. quadriaurita*	n= 29	sexual, diploid	Sri Lanka	Manton & Sledge (1954)
		2n= 58	sexual, diploid	South India	Irudayaraj & Manickam (1987)
		n= 29	sexual, diploid	Kumaon	Punetha & Sen (1989)
		n= 29	sexual, diploid	Sri Lanka	Walker (1962)
17	*P. reptans*	n= 29	sexual, diploid	Sri Lanka	Walker (1956 & 1962)
18	*P. scabripes*	n= 29	sexual, diploid	Malaya	Walker (1962)
19	*P. tripartita*	n= 29	sexual, diploid	New Guinea	Holttum & Roy (1965)
		n=58	sexual, tetraploid	Malaya	Walker (1962)

20	*P. vittata*	n= 87	sexual, hexaploid	South India	Abraham *et al.* (1962)
		n= 58	sexual, tetraploid	North India	Ghatak (1961)
		n = 87	sexual, hexaploid	South India	Ghatak (1977)
		n= 58	sexual, tetraploid	Sri Lanka	Manton & Sledge (1954) and Walker (1956 & 1962)
		n= 58	sexual, tetraploid	South India	Irudayaraj & Manickam (1987)
		n=58	sexual, tetraploid	Kumaon	Punetha & Sen (1989)
		n=58	sexual, tetraploid	Nepal	Walker (1962)

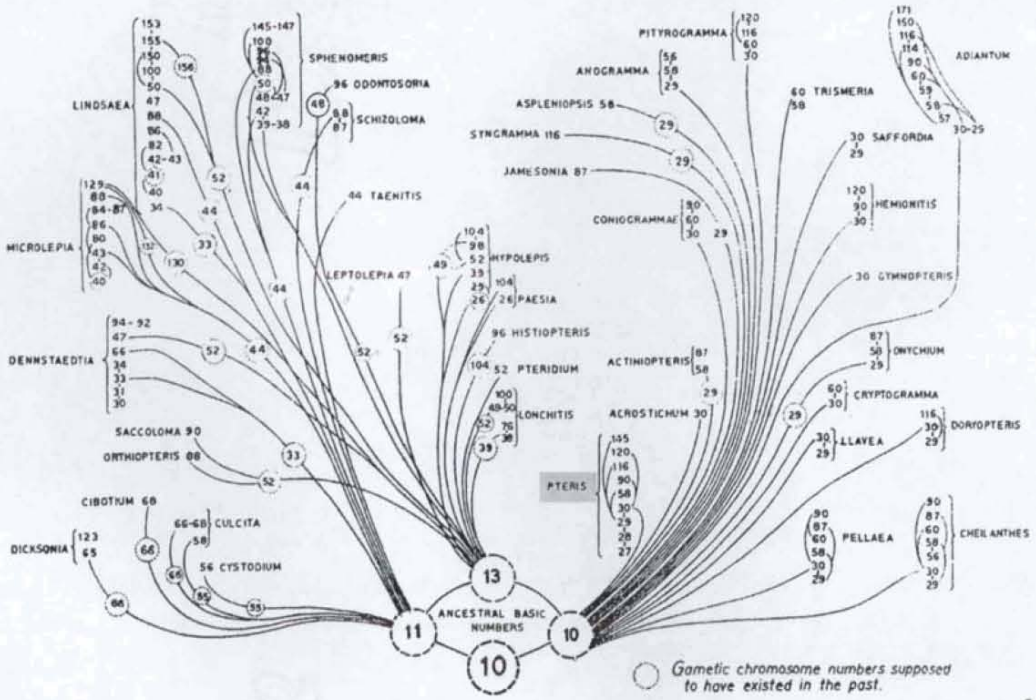


Fig. 2. Diagram showing evolution of chromosome numbers in Pteridaceae (Kuriachan & Ninan, 1976)

Hybridization

Hybridization between different species of *Pteris* is common in nature. Walker (1958) carried out a series of hybridization experiments in *Pteris*, especially in species like *P. quadriaurita* Retz., *P. confusa* T. G. Walker, *P. multiaurita* J. Agardh, and *P. ensiformis* Burm.f. Majority (30%) of the *Pteris* spp. are sexual diploids even though polyploidy is prevalent. This is mainly due to the genetic and chromosomal change (by the multiplication of whole sets of chromosomes or by apogamy). Several species of *Pteris quadriaurita* complex are ecologically and genetically isolated from one another and remain distinct in nature, but some species are hybridized freely resulting in the formation of very conspicuous hybrid swarms. For example, *Pteris quadriaurita* Retz. is a bipinnate species and *P. multiaurita* J. Agardh is a simply pinnate species, both can freely hybridize in nature. These morphological differences are due to the presence of a number of genes and in turn show this difference in its hybrids with a range of morphological variations, despite their considerable genetic difference. Based on Walker's studies (1958, 1960, 1962), Tryon and Tryon (1982) commented that polyploidy, apogamy and free hybridization are common in *Pteris*, which leads to the speciation. Distribution of sexual diploids is restricted compared to the polyploids and apogamous forms.

Phytochemistry

The knowledge about ferns and fern allies is not properly explored so far. These non flowering plants produces cyanogenic glycosides, nucleotides, flavonoids, terpenoids, alkaloids, besides many primary and secondary metabolites, which are used as nutrients as well as medicines, in the form of astringent, expectorant, diuretic, anti-ulcers, stimulant, analgesic, appetizer, anti helminthic, *etc. Pteris biaurita* L., *P. creica* L., and *P. vittata* L. have been used by the Tharus, Oraon and Munda tribes in Rajasthan state (Vyas, 2008). Harborne (1966) identified an anthocyanin (luteolinidin 5-O-glucoside) from *Pteris vittata* L.

3-C-(6'''-acetyl-cellobiosyl)-apigenin and 6-C-cellobiosyliso-scutellarein 8-methyl ether together with quercetin 3-O-glucuronide and rutin were identified from *P. vittata* L. (Imperato & Telesca, 1999 & 2000). Three kaempferol glycosides (3-O-glucoside, 3-O-glucuronide and 3-O-(X",X"-di-protocatechuoyl)- glucuronide) together with quercetin 3-O-(X",X"-di-protoca-techuoyl)-glucuronide, quercetin 3-O-(2", 3"-di-O-p-coumaroyl)-glucosides, Apigenin-7-O-oxy-p-hydroxyhenzoate and 3-Di-C-glycosyl flavones were isolated from *P. vittata* L. by Imperato (2000, 2003 & 2006). C-glycosylflavone (identified as 3, 8-di-C-arabinosyl-luteolin (I)) and 6-C-arabinosyl-8-C-glucosylluteolin (II) (Imperato, 2002) and Vitexin 7-O-rhamnoside were isolated from *Pteris vittata* L. (Imperato, 2004). Isolation of

flavone 0-glycosides from *P. cretica* by Imperato and Nazzaro (1996) confirms the phylogenetic advancement of the genus *Pteris*.

Spore extracts of *Pteris vittata* L. induced DNA strand brake in animal cells *in vitro* and lead to cancer (Siman *et al.*, 2000). Succinic acid, coumeric acid, vanillic acid and kaempferol were isolated from *P. argyraea* T. Moore, and tannins and phenolic acids were reported from *P. biaurita* L., *P. longipes* D. Don and *P. vittata* L. (Karuppusamy *et al.*, 2001). Pterokaurane MI- M3 (1-3) and multifidoside A- C (terpenoids) were isolated from *Pteris multifida* Poir. (Ge *et al.*, 2008). 2*R*, 3*R*-pterosin L 3-*O*-*β*-D-glucopyranoside, β-Dxylopyranosyl (1→2)-7-*O*-benzoyl-β-D-glucopyranoside, and 4-*O*-benzoyl-*β*-D-xylopyranosyl (1→2)-7-*O*-benzoyl-*β*-D-glucopyranoside were isolated from *Pteris ensiformis* Burm. f. (Chen *et al.*, 2008).

As a Hyperaccumulator

Arsenic is a toxic element and is widely distributed in the environment from both natural and anthropogenic sources. Inorganic arsenic, including the oxidized form arsenate and the reduced form arsenite, are the most prevalent in the environment. It is a carcinogen that has been linked to cancers of bladder, liver, kidney, and lungs and millions of people in many parts of the world are affected by arsenic contamination in drinking water.

Ma *et al.* (2001), discovered that the fern *Pteris vittata* L. (brake fern) is extremely efficient in extracting arsenic from soils and translocating it into

fronds. This plant is the first known arsenic hyperaccumulator as well as the first fern found to function as a bioremediation agent.

Although most plant species are severely affected by exposure to as low as 10 mg/litre arsenic in the medium, *P. vittata* L. and related ferns tolerate up to 1000 mg/litre arsenic in the medium, with fronds accumulating the metalloid up to 2.3% of their dry weight. Despite the extraordinary ability of *P. vittata* L. in arsenic accumulation, the mechanisms underlying arsenic resistance and hyperaccumulation in this fern are not clear so far. Arsenate is taken up by *P. vittata* L. *via* phosphate uptake systems, transported *via* xylem, reduced to arsenite in the fronds, and likely stored in the vacuoles. When compared with an arsenic-sensitive fern *P. ensiformis* Burm. f., *P. vittata* L. had significantly greater tolerance to oxidative stress, greater levels of reduced GSH, and antioxidant enzymes. Arsenate reductase gene (*PvACR2*) and arsenate reductase activities, in the gametophytes of *P. vittata* L., play an important role in the arsenite hyperaccumulating process. Recently, a cDNA for a glutaredoxin from *P. vittata* L. frond, involved in the regulation of intracellular arsenite was identified (Ellis *et al.*, 2006; Sundaram *et al.*, 2008; Wang *et al.*, 2002). Root extracts from the Chinese brake fern were shown to be able to reduce arsenate to arsenite (Duan *et al.*, 2005).

An arsenic-resistant bacterium *AsRB1*, was isolated from the fronds of *P. vittata* L. grown in a site contaminated with arsenate, which showed mechanisms to tolerate arsenate, arsenite, and antimony in the culture medium

(Rathinasabapathi *et al.*, 2006). Gametophytes of *P. vittata* L. are able to grow normally in medium containing 20 mM arsenate and accumulate 2.5% of their dry weight as arsenite (Gumaelius *et al.*, 2004). Agely *et al.* (2005), reported that mycorrhizal symbiosis involved in the arsenic uptake by *P. vittata* L.

Zhao *et al.* (2003), suggested that phytochelatins play only a limited role in the hypertolerance of As in *P. vittata*. Dong *et al.*, (2005) isolated full-length cDNA sequence encoding a phytochelatin synthase (PCS) from *P. vittata* L. Zheng *et al.*, (2008) reported the ability of arsenic to reduce Cu phytotoxicity in *P. vittata* L. and suggested to serve as a biological mechanism for the fern to adapt to soils co-contaminated with As and Cu. But, Beri and Bir (1993) reported that heavy metals (Pb and Hg) are deleterious to the rhizoids and the developing gametophytes of *P. vittata* L.

Phytogeography

There are 20 phytogeographical divisions recognized in India based on endemism and species assemblage. Northern Western Ghats, Southern W. Ghats, Northern Eastern Ghats, Southern E. Ghats and costal zone divisions are situated in south India. Western Ghats are one of the mega endemic centres, which contain Agasthyar hills, Cardomom hills, Palni hills, Nilgiri hills, and Shimoga as micro-endemic centres (Nayar, 1996).

Pteris is a pantropical genus with extensions into temperate regions in Chile, the Mediterranean region, South Africa, Korea, Japan, Tasmania and

New Zealand. It has different centres of speciation, *viz.*, Central America, New Guinea, West Indies, Philippines, Madagascar, China, Japan, Indonesia, and Sri Lanka. The American centre of diversity of *Pteris* is in Andes from Venezuela to Bolivia, where nearly half of the neotropical species occur (Tryon & Tryon, 1982).

Fraser-Jenkins (2008b) discussed about different phytogeographical elements present in Indian pteridophytes with special reference to their endemism. They are the following; (1) *European elements*: this group of species, mainly confined to West and West Indo Himalaya, is related to Mediterranean flora, (2) *Sino- Himalayan elements*: this group of species migrated westward from Southwest China, North Myanmar and Taiwan, (3) *Southeast Asian elements*: this group of species is influenced the South Indian pteridophyte flora. The pteridophytes of Peninsular or South Indian regions have their main phytogeographical connection with three regions; namely Northeast India, Malaysia and Tropical Africa, (4) *Afro-Arabian elements*: this group of species is occurring in West Central India in Connection with Northeast Africa south Arabia.

There are three important hill stations in the South India, *i.e.*, Kodaikanal in Palni hills, Dodabetta in Nilgiri range, Anamudi in Anamalai range and the climate is normally tropical montane type. Soil texture varies from clay to clay-loam and acidic in nature (4.5- 6.0) (Meher-Homji, 1967).

Phytogeographically the genus *Pteris* is widely distributed in all five main regions of India, i.e. Eastern Himalaya, Western Himalaya, Southern India, Western India and Central India (Vasudeva & Chhibber, 1989).

Ecology

Pteris, a genus of diverse ecology, occurs in forest, frequently in secondary forests, in openings and along stream banks. Many species grow in wet forests, at the edge of clearing, in thickets, and disturbed or artificial habitat such as road sides, laterite or brick walls, *etc. P. cretica* L. and *P. longifolia* L. are calcifiles and usually found in lime stone sinks. The genus is usually a lower altitude fern from the sea level to 2000m, but *Pteris coriaea* can grow between the altitude of 2800-3500m in Costa Rica and the Andes (Tryon, & Tryon, 1982). *P. vittata* L. occurs at lower level below 1300m usually along the dry slopes on gravelly soil and *P. quadriaurita* Retz. quite common in shady places, ascending up to 2500m (Mehra & Verma, 1960).

Phylogeny

A phylogenetic scheme cannot be made based on arithmetic manipulations of basic chromosome numbers, though these numbers can be used as supporting evidence. However, since chromosomal increase by polyploidy and chromosomal decrease by translocations and loss of centromeres are both acceptable to cytogeneticists. So comparative studies, phytochemical, SEM studies, isozyme studies, fluorescent bands on chromosomes, and DNA hybridization studies, *etc.*, are important for

constructing phylogenetic trees (Britton, 1974). The evolution of the forerunners of the extant pteridophyta was characterized by two distinct periods: a period of polyploidization and subsequent period of stabilization. Ancesters of extant pteridophytes showed different perspective power, genetic plasticity and ecological tendencies, which resulted in the formation of complex groups, with different morphological and phylogenetic levels (Pichi Sermolli, 1987). From the evolutionary point of view, the sorus of *Pteris* shifts from marginal to superficial position and gradate sequence of sporangia has been substituted by mixed type of sorus. Moreover, it is evident that the transitions of dermal hairs to scales, simpler to advanced vascular structures, open to anastomosing venation. These show that the evolution has been parallel in vegetative and sexual characters. Pteroid ferns (*Pteris*) were probably derived from *Dicksonia- Dennstaedtia* series. But in contrast to the above, *Pteris* spp. have flattened scales on rhizome. The presence of recurrent protective scales and the lack of lower indusium in *Pteris* is an advance feature. *Pteris* differs from the Dicksonioid ferns or near groups by the following characters; (1) *Pteris* has no lower indusium, (2) Upper indusium is marginal and continuation of margin of the pinnule or pinnae, (3) Sorus develops superficially without distinct receptacle and (4) Presence of mixed type of sorus. The Thyrsopteridaceae and the Dennsteadtiinae are considered as relatively primitive congeners of the pteroid ferns (Bower, 1928).

According to Copeland (1947), *Pteris* is an old and prosperous genus, but rapid and vigorous speciation is occurring in the genus. This genus seems to be close to *Pteridium* and *Histiopteris*, and even to *Hypolepis*, but its common ancestor is not recent (lived long ago). In Pteridineae, sporangia are borne on the apical portion of the veins, near the frond margin. This is a primitive condition and from which the evolution took place the following two trends. In the families such as Sinopteridaceae, Cryptogamaceae, Actiniopteridaceae and Pteridaceae, the sporangia are present on infra marginal position protected by a reflexed modified frond margin (pseudo indusium/false indusium). In some other families such as Adiantaceae, Hemionitidaceae and Vittariaceae, the sporangia spread considerable distance from the margin to inwards along the underlying veins to attain acrostichoid state. However, in the course of evolution, the spreading of the sporangia from the inframarginal region inwards greatly increased the fertile area as to attain an acrostichoid state, but in this case the pseudo indusium has disappeared (Pichi Sermolli, 1977). *Pteris* shows relationship with Cheilantoid ferns in soral characters and with Taenitoid ferns in spore characters (Tryon & Tryon, 1982).

Economic importance

Many pteridophytes are important for their medicinal, food, and aesthetic values. The genus *Pteris* has been used as food, a source of important metabolites, biologically active compounds, antibiotics, and

phytochemicals of commercial value. In addition to this, several species of *Pteris* are used as ornamental ferns. *P. biaurita* L., *P. cretica* L., *P. longipes* D. Don, and *P. wallichiana* J. Agardh are used as antibacterial agents. Fronds of *P. ensiformis* Burm. f. are edible and used as astringent. *P. multifida* Poir. used as anthelmintic, and *P. vittata* L. used as demulcent and tonic (Singh, 1999; Srivasthava, 2007). Banerjee and Sen (1980) found that extract of *P. longipes* D. Don was effective against *Vibrio cholerae.*

The flavonoid rutin from *P. vittata* L. showed antimicrobial activity against pathogenic gastrointestinal microorganisms including *Pseudomonas aeruginosa* and *Klebsiella pneumoniae* (Singh *et al.*, 2008). Terpenoids isolated from *P. multifida* Poir. showed cytotoxicity against tumor cell lines (HepG2) (Ge *et al.*, 2008). Ethyl extract of *P. biaurita* L. is effective against pathogenic bacteria due to the presence of eicosenes and heptadecanes (Dalli *et al.*, 2007). An antitumor drug was isolated from *P. semipinnata* L. (Deng *et al.*, 2002).

Pteris has got great aesthetic value due to its graceful and delicate beauty, and is cultivated as an ornamental fern. *Pteris* can grow well in entirely different conditions such as moist, shady, and dry situations in gardens.

The species of *Pteris* like *Pteris vittata* L., *P. multifida* Poir., *P. cretica* L., *P. cretica* var. *albolineata* Hook., *P. biaurita* L., *P. ensiformis* Burm. f., *P. ensiformis* var. *victoriae* Bak., *P. tripartita* Sw., *P. semipinnata* L.,

P. tremula R. Br., *P. argyraea* T. Moore, and *P. aspericaulis* Wall. ex J. Agardh are available in shops, gardens, nurseries, and are commonly cultivated in gardens (Walker, 1970). *P. denticulata* Sw., *P. tripartita* Sw., *P. vittata* L., *P. quadriaurita* Retz., *P. tremula* R. Br., *P. semipinnata* L., *P. ensiformis* Burm. f. (var. *victoriae*), *P. cretica* L., *P. multifida* Poir., *P. umbrosa* R. Br. are widely cultivated in American countries (Morton, 1957).

STUDY AREA

STUDY AREA

South India is the area including the political states of Andhra Pradesh, Karnataka, Kerala and Tamil Nadu and the Union Territory of Puducherry. The area is located between 8^0 and 20^0 North latitudes and 74^0 and 85^0 East latitudes and covers 4, 67, 186 Sq. Km. South India lies in the Peninsular Deccan Plateau and is bounded by the Arabian Sea in the west, the Indian Ocean in the south and the Bay of Bengal in the east and on the north by the Vindhya and Satpura ranges.

The geography of the region is diverse, comprising two mountain ranges, the Western and Eastern Ghats, and the Deccan plateau.

Western Ghats are floristically rich area and transversing the states of Gujarat, Goa, Karnataka, Kerala, and Tamil Nadu, extending almost 1600 km from the Satpura Range (Gujarat) in the north to Kannyakumari in the south. The mountain ranges are more or less continuous in south except for Palakkad gap, which separates Nilgiri hills from Anamallai hills. Major hill stations of South India are Bababudan hills, Palni hills, Nilgiri hills, Anamalai hills, and Cardamom hills ranges (Mehar- Homji, 1967). Anamudi is the highest peak (alt. 2695m) in Western Ghats. These hills cover 1,60,000 km^2 and form the catchment area for a complex of river systems that drain almost 40% of India. The average elevation is around 1,200 metres (3,900 ft). The area is one of the

world's ten "Hottest biodiversity hotspots" and has over 4000 species of flowering plants, of which 1500 species are endemic. About 43 species of pteridophytes are endemic to South India (Nayar, 1996).

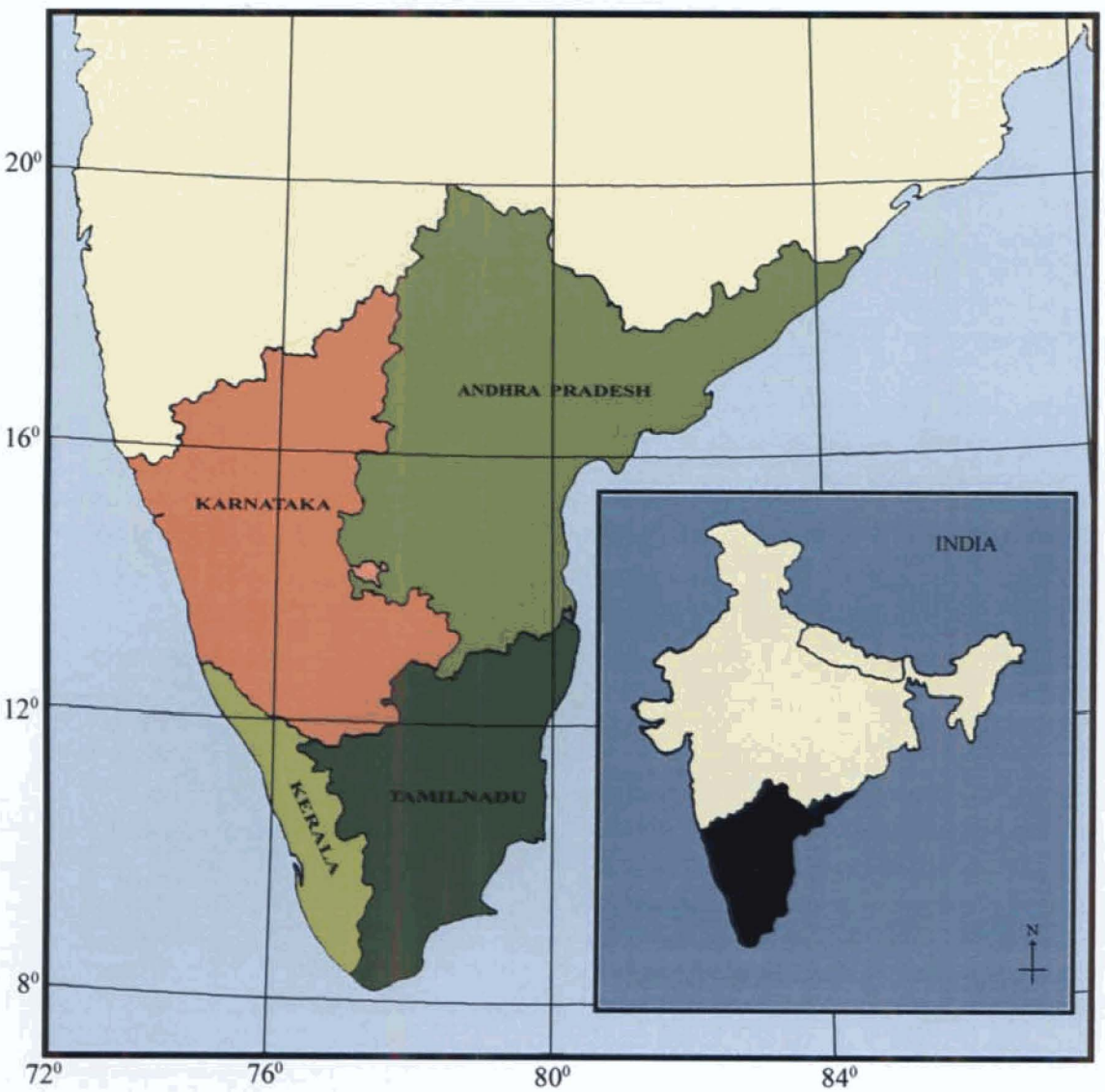
The Eastern Ghats are a discontinuous range of mountains along eastern coast. The Eastern Ghats run from West Bengal state in the north, through Orissa and Andhra Pradesh to Tamil Nadu in the south. They are eroded and cut through by the four major rivers of southern India, the Godavari, Mahanadi, Krishna, and Kaveri. The mountain ranges run parallel to the Bay of Bengal. The major hills in the Eastern Ghats are Sirumalai, Kolli Hills, Shevaroy (Servaroyan) Hills, Kothayar Hills, and Palamalai in Tamil Nadu state. Turiakonda, Chandragiri, Mahendragiri, Velikonda Range, Palikonda-Lankamalla Range, and Nallamalla Ranges in Andhra Pradesh.

Deccan plateau is a rain shadow regions of the Western Ghats and is characterized by the tropical deciduous forest, while in the open places it is replaced by drought resistant species and thorny shrubs.

The Godavari, Krishna, Tungabhadra and Kaveri, Bharathapuzha, Periyar rivers are important perennial sources of water in South India.

Climate in the Western Ghats and Eastern Ghats varies with altitudinal gradation and distance from the equator. The climate is humid and tropical in the lower areas of Western Ghats. Elevations of 2,000 m and above in the southern Western Ghats have a montane temperate climate. Average annual

South India- Study area



temperature here is around 15°C. The average rainfall in this region is 3,000-4,000 mm. The eastern region of the Western Ghats which lie in the rain shadow, receive far less rainfall averaging about 1,000 mm bringing the average rainfall figure to 2,500 mm. The climate of the higher hill ranges of Eastern Ghats are generally cooler and wetter than the surrounding plains.

South India has tropical climate with the monsoons playing a major role. The South - West Monsoon accounts for most of the rainfall in the region and much of it falls from about June to October. Tamil Nadu and southeast Andhra Pradesh receive rains mainly from the North- East Monsoon from November to February. Much of Andhra Pradesh and Karnataka have a distinct dry season from October to May, when there is not much rainfall. This region also experiences cooler nights from October to March while the days are pleasantly warm.

Tropical evergreen forest, wet evergreen forest, moist deciduous forest, dry deciduous forest, shola forest, grass lands and shrub jungle are the major forest types in southern India (Nayar, 1996). Lower elevations of the south Western Ghats are characterized by moist deciduous forests. The moist forests transition to the drier South Deccan Plateau dry deciduous forests, which lie in its rain shadow to the east. Above 1,000 m there are the south Western Ghats montane rain forests, montane grasslands and stunted forests at the

highest elevations. The south Western Ghats montane rain forests are the most species-rich ecoregion in Peninsular India.

Laterite soils, black soils and red soils are major soil types in South India. Laterite soils are predominant in places where heavy rainfall especially in Western Ghats.

MATERIALS AND METHODS

MATERIALS AND METHODS

Materials

The present study is based on the materials collected from different parts of South India including Biosphere reserves, National Parks, and Wild life sanctuaries during May 2007 to April 2010. Habit, habitat, morphological characters, *etc.*, were observed in the field itself and fresh specimens were brought to the laboratory for further analyses. Apart from this, specimens deposited in Central National Herbarium (CAL), Howrah, Calicut University Herbarium (CALI), Kozhikode, Kerala Forest Research Institute Herbarium (KFRI), Thrissur, Mahathma Gandhi Memorial College Herbarium (MGMC), Uduppi, Botanical Survey of India-Southern Circle (MH), Coimbatore, Rapinat Herbarium (RHT), Thiruchirappally, Sri Krishnadevaraya University Herbarium (SKU), Anantapur, Tropical Botanical Garden and Research Institute Herbarium (TBGT), Thiruvananthapuram, St. Xavier's College Herbarium (XCH), Palayamkottai were examined.

Digital images of specimens (including Type) from Herbarium Berolinense (B), Berlin, British Museum Natural History (Botany) Herbarium (BM), London, Royal Botanic Gardens Herbarium (E), Edinburgh, Royal Botanic Gardens Herbarium (K), Kew, Kyoto University Herbarium (KYO), Kyoto, National Herbarium (L), Leiden, Botanical Museum Herbarium (LD),

Lund, Linnaean Society of London (LINN), London, Herbarium Musei Parisiensis (P), Paris, Uppsala University Herbarium (UPS), Uppsala, U.S. National Herbarium (US), New York, Universitat Zurich (Z), Zurich were also examined during the study.

Methods

Descriptions were made from the mature, well developed plant materials based on 3-5 different materials (but sometimes one or two materials).

Rhizome: The length and thickness of the rhizome were noted. The thickness was measured based on the diameter of the broadest part of rhizome.

Scales (Palea): Scales were taken from the growing tip (1-2 cm behind) of the rhizome with the help of a brush, but, needle was used if necessary or it is inserted. Length of the scale (palea) and width of the base were noted.

Stipe: Length and thickness of the stipe were described. Length of the stipe is the distance between the attachment site of stipe to the rhizome and the first pinnae arising point. The thickness of the stipe is measured by taking cross section at 5-10 cm away from the rhizome.

Lamina: Lamina is a part of frond that bears expanded, herbaceous tissues, which is attached to rhizome by the stipe. Length and width of the lamina

measured in fresh materials and the venation as observed under stereo binocular microscope.

Pinna/pinnule: Pinna is the ultimate segment in pinnate species and pinnule is the ultimate segment in bipinnate/tripartite species. The length and width of ultimate segments, intersegmental distance, sinus position, morphology of margin and apex, presence of spines or setae, venation pattern were recorded.

Sori: Length and position of the sori were recorded. The length of the capsule and length of stalk were measured separately.

Spores: Semi-permanent preparations of spores were made by embedding them in glycerine gelly and covered with cover-slip. The length and width were measured at lateral and distal views, and the ornamentations were described by using stereomicroscope.

Observations: Microscopic analyses were made with help of stereomicroscope with drawing device (Nikon SMZ 800) and image analyser (Nikon Eclipse E400 stereo microscope attached with Dxm 1200F digital camera).

Photography: Photographs were taken with the help of NIKON D100 SLR digital camera.

Cultivation/conservation: At least one sample of the collected specimens was cultivated in Calicut University Botanical Garden (CUBG).

Identification: Specimens were identified based on available literature (Including protologues), type specimens, and consulting experts in the field.

Herbarium: Herbarium sheets were made using standard techniques (Bridson & Forman, 1998). The voucher specimens were deposited in CALI.

Nomenclature and citation: Names and associated bibliographical details of the taxa were obtained from International Plant Name Index (IPNI). Abbreviations of periodicals were followed as in *Botanico-Periodicum-Huntianum* (B-P-H) (Lawrence *et al.*, 1968) and *Taxonomic Literature* (Stafleu & Cowan, 1976-1988). Authors' names were used as given in *Authors of Plant Name* (Brummitt & Powell, 1992), and *Authors of Scientific Names in Pteridophyta* (Pichi Sermolli, 1996). Herbarium acronyms were used as in *Index Herbariorum* (Thiers, 2010) and classification of Smith *et al.* (2008) was used in this work.

Terminology: Descriptive terms used in the thesis were based on Tryon (1960), Stearn (1992), Lellinger and Taylor (1997) and Simpson (2006). Sign '!" was used to denote the examined type specimens.

Illustrations and Plates: Illustrations of habit, rhizome, palea, pinnae, fertile and sterile pinnules, sporangium, and spores were made with Rotring isograph (Germany) pens (0.1, 0.2 & 0.3 tips) based on the specimens collected from different parts of South India. Colour photographs were also provided for easy identification of the species.

Database preparation: A database of 'The genus *Pteris* L. in South India' was prepared by using Visual ProxPro (Ver. 6.0) software with the help of a computer programmer. It contains updated nomenclature, synonyms, description, distribution, IUCN status, colour photographs, common names, *etc.* and a search option was also provided for locating the species easily.

Plan of thesis: Introduction deals with the general aspects of Pteridophytes, relevance of the topic and objectives of the study. Review of literature covers various aspects such as life cycle, morphology, anatomy, palynology, gametophytes, apogamy and apospory, karyology, polyploidy, hybridization, phytochemistry, phytogeography, ecology, phylogeny and economic importance. Detailed taxonomic history of the genus *Pteris* is also included in this section. Study area deals with the details of geography, vegetation, climate and soil types of the location of the present study. Details of the materials studied and methodology are provided in materials and methods chapter. Taxonomic part comprises three section, *viz.*, genus description, key to the species, and species description. Genus description includes synonyms, description of the genus, *etc.* Key to the species is prepared based on the morphological data from the south Indian species of *Pteris* and is provided for easy identification. In species description, each species is treated with updated nomenclature, type, synonyms, description, habitat, altitude, distribution, chromosome number, economic importance, etymology, IUCN status (based on IUCN 2001), and notes on relevant aspects and interrelationships. List of

materials examined, illustrations, and colour photographs were also provided. Discussion part comprises the comparative morphology, conservation aspects, and database of the genus *Pteris*. Summary, relevant literature and Index to scientific names were included at the end of the thesis.

Abbreviations used in the thesis:

auct.- authors

alt. - altitude

cult.- cultivated

non- not

s.n.- without number

s.str.- in the strict sense

sensu- in the sense of

syn. nov.- new synonym

N.P.- National Park

PWLS- Parambikulam Wildlife Sanctuary

PTR- Periyar Tiger Reserve

WLS- Wild life sanctuary

R.F.- Reserve Forest

SVNP- Silent Valley National Park

SWLS- Shendurney Wildlife Santuary

Herbarium acronyms:

B - Herbarium Berolinense, Berlin, Germany

BM - British Museum Natural History (Botany) Herbarium, London, England

CAL - Central National Herbarium, Howrah, West Bengal, India

CALI - Calicut University Herbarium, Kozhikode, Kerala, India

E – Royal Botanic Gardens Herbarium, Edinburgh, Scotland

K - Royal Botanic Gardens Herbarium, Kew, England

KFRI - Kerala Forest Research Institute Herbarium, Thrissur, Kerala, India

KYO - Kyoto University Herbarium, Kyoto, Japan

L - National Herbarium, Leiden, Netherlands

LD – Botanical Museum Herbarium, Lund, Sweden

LINN - Linnaean Society of London, London, England

MGMC - Mahathma Gandhi Memorial College Herbarium, Uduppi, India

MH – Botanical Survey of India- Southern Circle, Coimbatore, India

P - Herbarium Musei Parisiensis, Paris, France

RHT - Rapinat Herbarium, Thiruchirappally, Tamil Nadu, India

SKU - Sri Krishnadevaraya University Herbarium, Anantapur, India

TBGT - Tropical Botanical Garden and Research Institute Herbarium, TVM

UPS - Uppsala University Herbarium, Sweden

US - U.S. National Herbarium, New York, USA

XCH - St. Xavier's College Herbarium, Palayamkottai, Tamil Nadu, India

Z - Universitat Zurich, Zurich, Switzerland

TAXONOMIC PART

Genus Description

Pteris L.

Pteris L. Sp. Pl. 2: 1073. 1753; Burm.f., Fl. Ind. 229. 1768; Willd., Sp. Pl. 5: 355. 1810; D. Don, Prod. Fl. Nepal 15. 1825; C. Presl, Reliq. Haenk. 1: 54. 1825; J. Agardh, Recens. Spec. Pter. 1. 1839; Hook., Gen. fil. t (64) 65A. 1842; Hook., Sp. Fil. 2: 154. 1858; Hook. & Baker, Syn. Fil. 153. 1868; Bedd., Ferns S. India 11. 1863 & Handb. Ferns Brit. India 104. 1883; C. B. Clarke, Trans. Linn. Soc. Lond. II Bot. 1: 461. 1880; C. Chr., Ind. Fil. 45. 1906; Hieron., Hedwigia 54: 283. 1914; Copel., Gen. Fil. 60. 1947; C. V. Morton, Amer. Fern J. 47: 8. 1957; Scamman, Rhodora 63: 194. 1961; Shieh, Bot. Mag. Tokyo 79: 283. 1966; K. U. Kramer, Taxon 16: 139. 1967; Pic. Serm., Webbia 23: 201. 1968; Holttum, Rev. Fl. Malaya 2: 393. 1968; T. G. Walker, Brit. Fern Gaz. 10: 143. 1970; B. K. Nayar & S. Kaur, Comp. Bedd. Handb. 28. 1974; R. M. Tryon & A. F. Tryon, Ferns Allied Plants 332. 1982; R. D. Dixit, Cens. Indian Pterid. 68. 1984; Manickam, Fern Fl. Palni Hills 19. 1986; S. M. Vasudeva & Chhibber, Indian Fern J. 6: 205. 1989; S. M. Vasudeva & A. Singla, Asp. Plant Sci. 13: 326. 1991; N. C. Nair et al., J. Econ. Taxon. Bot. 255. 1992; Manickam & Irud., Pterid. Fl. W. Ghats 66. 1992; B. K. Nayar & Geev. Fern Fl. Malabar 101. 1993; Fras.-Jenk., New Sp. Syndr. Indian Pterid. 223. 1997;

Rajagopal & K. G. Bhat, Indian Fern J. 15: 7. 1998; Subh. Chandra, Ferns India 33. 2000; Manickam & Irud., Pterid. Fl. Nilgiris 82. 2003; Easa, Biodiv. Doc. Kerala 5: 18. 2003; Pullaiah et al., Pterid. Andhra Pradesh 51. 2003; Ghosh et al., Pterid. Fl. E. India 1. Ser. 4: 314. 2004; Mickel & Smith, Pterid. Mexico 1: 533. 2004; A. R. Smith et al., Taxon 55: 714. 2006; Das, Indian Fern J. 24: 60. 2007. Fras.-Jenk., Taxon. Rev. Indian Subcont. Pterid. Rev. Cens. List 96. 2008; Fras.-Jenk., Indian Fern J. 25: 22. 2008. Subh. Chandra et al., Taiwania 53: 187. 2008; Fras.-Jenk., Indian Fern J. 26: 119. 2009; Sreenivas & Madhus., Proc. 22nd Kerala Sci. Congr. 866. 2010.

[Plate 1 & 2]

Type: *Pteris longifolia* L. (Lectotype, LINN 1246.2, digital image!).

Campteria C. Presl, Tent. Pterid. 146. 1836.

Type: *C. rottleriana* C. Presl

Litobrochia Presl, Tent. Pterid. 148. 1836.

Type: *L. denticulata* (Sw.) C. Presl

Pycnodoria C. Presl, Epimel. Bot. 100. 1851.

Type: *P. opaca* (J. Sm.) C. Presl

Heterophlebium Fée; Gen. Fil. 139. 1852.

Type: *H. grandifolium* (L.) Fee

Schizostege Hillebr. Fl. Hawaii. 631. 1888.

PTERIS.

* *Frondibus ſimpliciſſimis.*

1. PTERIS fronde ſimplici lanceolata ſubangulata glabra: apice fructificante. *lanceolata.*
Lingua Cervina foliis acutis & ad oras ſummitatum pulverulentis. *Plum. amer.* 28. *t.* 40. *fil.* 116. *t.* 132. *Moriſ. hiſt.* 3. *p.* 558. *Raj. ſuppl.* 52.
Phyllitis lineata hinc inde dentata. *Pet. fil.* 123. *t.* 6. *f.* 5.
Habitat in Domingo.

2. PTERIS fronde ſimplici lineari integerrima longitudinaliter fructificante. *lineata.*
Lingua Cervina longiſſimis & anguſtiſſimis foliis. *Plum. amer.* 28. *t.* 41. *fil.* 123. *t.* 143. *Moriſ. hiſt.* 3. *p.* 558. *Raj. ſuppl.* 52.
Phyllitis lineata, graminis folio longiſſimo. *Pet. fil.* 126. *t.* 14. *f.* 3.
Habitat in Domingo.

3. PTERIS fronde ſimplici lineari: apice trifido. *tricuſpidata.*
Lingua Cervina anguſto trifidoque folio. *Plum. fil.* 121. *t.* 140.
Phyllitis lineata apice trifido. *Pet. fil.* 124. *t.* 10. *f.* 6.
Habitat in Domingo.

4. PTERIS fronde ſimplici dichotoma ſubtus hiſpida: apicibus fructificantibus. *furcata.*
Lingua Cervina furcata. *Plum. fil.* 122. *t.* 141.
Phyllitis aſpera, furcis lineatis. *Pet. fil.* 125. *t.* 6. *f.* 6.
Habitat in America *meridionali.*

* *Frondibus ſimpliciter pinnatis, compoſitis, oblongis.*

5. PTERIS frondibus pinnatis: foliolis pinnatifidis, caudice arboreo aculeato. *arborea.*
Filix ramoſa arboreſcens & aculeata. *Plum. fil.* 6. *t.* 5.
Filix arboreſcens latifolia aculeata. *Plum. amer.* 3. *t.* 3.
Filix lineata arborea, caudice aculeato. *Pet. fil.* 132. *t.* 4. *f.* 2.
Habitat in Martinica.

6. PTERIS frondibus pinnatis: pinnis oppoſitis ovato-linearibus acuminatis integerrimis. *grandifolia.*
Pteris fronde pinnata: pinnis lanceolato-linearibus integerrimis ſeſſilibus erectiuſculis. *Hort. cliff.* 473.
Phyllitis ramoſa ad margines pulverulenta. *Pet. fil.* 127. *t.* 6. *f.* 15.

Plate 1. Protologue of the genus *Pteris* (Linnaeus, C. 1753. *Species Plantarum*)

Plate 2. Lectotype of *Pteris longifolia* L. (LINN)

Type: *S. lidgatii* (Baker) Hilebr.

Hemipteris Rosenst., Fedde Repert. 6. 38. 1908.

Type: *H. warneri* Rosenst.

Idiopteris T.G.Walker; Kew Bull. 1957: 431. t.1. 1958.

Type: *I. hookeriana* (J. Agardh) T. G. Walker

Herbs; terrestrial. Height 15-300 cm. Rhizome erect to suberect, creeping, 2-20 cm long x 1-12 mm thick, usually cylindrical with tuft of stipes and roots, scaly. Palea pale brown to brown, 2-11 mm long, 0.3-0.8 mm wide at base, lanceolate, acuminate or acute, auriculate, middle thickened cells, periphery thin walled cells, sometimes uniformly thick walled cells, margin entire or with minute cellular projections. Stipe 6-165 cm long, 3-14 mm thick, usually green or chestnut brown, sometime carmine red or pink (live specimens) stramineous or chestnut brown (dry specimens), grooved and glabrous above, sometimes terete, and scaly below. Lamina pinnate, bipinnate or tripartite, 12-175 cm long x 20-100 cm broad, ovate, deltoid or lanceolate, herbaceous to coriaceous. Pinnae 2-22 pairs, 6-50 cm long x 0.4-6 cm broad, linear, lanceolate, or oblong, opposite to subopposite, or alternate, usually green above and pale green below, sometime white band along either side of midrib adaxially, basal pinnae bipartite, ternately divided or tripartite, terminal pinnae similar to lateral pinnae, sometimes terminal pinnae larger than lateral ones. Pinnules (ultimate segments) 7-55 pairs, 1.5-3 cm long x 3-5

mm broad, linear, lanceolate, or oblong, acute, acuminate, obtuse, or rounded, apex entire, sometimes serrate or crenate, sinus near to costa- 3 mm away from costa, 0.5- 3 mm inter segmental distance. Costae usually grooved on upper surface with raised edges forming spines at base of costules and raised below, costule grooved above, glabrous or spinules at the base of veins. Veins 6 pairs to numerous, forking, usually free and ending within margin or submarginally within hydathodes, sometimes basal pair of veins united to form costal and costular areoles. Sori pale brown to dark brown, 0.2-22 cm long, linear, submarginal except at apex and base. Indusium false (inflexed segment margin), pale coloured to brown. Sporangium: capsule globose, 170-350 μm long; stalk 200-350 μm long, biseriate; annulus 12-26 celled. Paraphyses numerous, usually a row of uniform cells (uniseriate). Spores brown, 30-50 x 35-60 μm, trilete-tetrahedral, an equatorial collar-like ridge girdling the spores, usually verrucate, rugate or tuberculate sometimes bisculpate.

Habitat: Shows diverse habitat from humid shaded forest to fully exposed area.

Altitude: Sea level-2300m

Distribution: A pantropical genus represent in all continents except Antarctica.

Chromosome number: Invariably n= 29 or multiple of this (Verma, 1959; Walker, 1962).

Notes: Linnaeus (1753) established the genus *Pteris* with 19 species, of which, *P. biaurita* L. and *P. vittata* L. are present in South India. Proctor (1977) designated *P. longifolia* as the Lectotype among the Linnean species based on a plant from near Port de Paix, Haiti. Detailed taxonomic history of the genus *Pteris* is provided in review of literature.

Key to the species of South Indian *Pteris*

1. Lamina regularly or irregularly pinnatifid.....**2**

1. Lamina bipinnatifid or tripartite.....**9**

2. Basal pinnae gradually reduced; pinnae base cordate; spores bisculpate .....**24. P. vittata**

2. Basal pinnae not gradually reduced; pinnae base cuneate, decurrent or oblique; spores verrucate or rugate.....**3**

3. Rhizome erect.....**4**

3. Rhizome creeping.....**6**

4. Sterile pinnae margin distinctly serrate.....**6. P. cretica**

4. Sterile pinnae margin entire or undulate.....**5**

5. Pinnae apex crenate; lowest pinna bipartite; lamina ovate..**22. P. scabripes**

5. Pinnae apex entire; lowest pinna not bipartite; lamina deltoid ....**17. P. pellucida**

6. Lateral pinnae irregularly lobed (heteromorphic); pinna apex entire..... .....**10. P. heteromorpha**

6. Lateral pinnae regularly lobed; pinna apex crenate or serrate.....**7**

7. Pinnae decurrent to form a winged rachis; pinna apex serrate..... .....**15. P. multifida**

7. Pinnae not decurrent; apex crenate.....**8**

8. Spores verrucate; sterile pinna glabrous; lower pinnae deeply lobed.....

.....**7. P. ensiformis**

8. Spores rugate; sterile pinnae with setae; all pinnae bipartite except terminal one.....**14. P. multiaurita**

9. Rhizome creeping.....**10**

9. Rhizome erect or sub erect.....**11**

10. Costa glabrous; sinus *c.* 3 mm away from the costa; lamina ovate or broadly ovate; coriaceous; spores verrucate.....**2. P. arisanensis**

10. Costa with long spinules; sinus below 1 mm away from costa; lamina lanceolate; subcoriaceous; spores rugate.....**21. P. reptans**

11. Basal pair of pinnae tripartite; costular areoles present.....**23. P. tripartita**

11. Basal pair of pinnae bipartite; costular areoles absent. **12**

12. Pinnule apex entire.....**13**

12. Pinnule apex crenate.....**20**

13. Stipe pink; pinnae and pinnule bear pinkish setae adaxially.....

.....**4. P. blumeana**

13. Stipe green or chest nut brown; pinnae and pinnules bear pale setae or glabrous.....**14**

14. Pinnae with white or silvery bands along midrib.....**1. P. argyraea**

14. Pinnae entirely green.....**15**

15. Pinnules glabrous; costal areoles present.....**16**

15. Pinnules with setae; costal areoles absent.....**17**

16. Lowest pair of veins united to form triangular costal areoles; lamina subcoriaceous.....**11. P. linearis**

16. Lowest pair of veins united to form a series of irregular costal areoles; lamina coriaceous .....**3. P. biaurita**

17. Lamina deltoid.....**9. P. gongalensis**

17. Lamina ovate or oblong.....**18**

18. Setae long, conspicuous on costae and costules; lamina membranaceous .....**19. P. praetermissa**

18. Setae short, inconspicuous on costae and costules; lamina subcoriaceous or coriaceous.....**19**

19. Basal pinna bear two accessory pinnae basiscopically; sinus below 1 mm from costa.....**18. P. perrottetii**

19. Basal pinna bear single accessory pinna basiscopically; sinus above 1 mm from costa.....**5. P. confusa**

20. Spores verrucate **21**

20. Spores rugate or tuberculate.....**22**

21. Stipe glabrous; lower pinnae bipartite, sori except at the pinnule apex.....**20. P. quadriaurita**

21. Stipe with prominent spines; lower pinnae ternately divided; sori at the middle portion of pinnule.....**12. P. longipes**

22. Pinnae more than 20 pairs; spores tuberculate.....**13. P. mertensioides**

22. Pinnae less than 20 pairs, spores ruagte.....**23**

23. Veins ending in hydathodes submarginally; pinnules glabrous; acroscopic pinnules not reduced.....**8. P. geminata**

23. Viens ending in margin; pinnules bear prominent setae; basal pair of pinnules reduced at acroscopic side.....**16. P. otaria**

Species Descriptions

1. **Pteris argyraea** T. Moore

P. argyraea T. Moore, Gard. Chron. 671.1859; Hieron., Hedwigia 55: 342. 1914; T. G. Walker, Kew Bull. 331. 1960 & Brit. Fern Gaz. 10: 149. 1970; R. D. Dixit, Cens. Indian Pterid. 68. 1984; Manickam, Fern Fl. Palni Hills 23. 1986; S. M. Vasudeva & A. Singla, Asp. Plant Sci. 13: 330. 1991; N. C. Nair et al., J. Econ. Taxon. Bot. 262. 1992; Manickam & Irud., Pterid. Fl. W. Ghats, 78 pl. 54. 1992; Rajagopal & K. G. Bhat, Indian Fern J. 15: 7. 1998; Subh. Chandra, Ferns India 33. 2000; Manickam & Irud., Pterid. Fl. Nilgiris 87. 2003; Easa, Biodiv. Doc. Kerala 5: 18. 2003; Ghosh et al., Pterid. Fl. E. India 1, Ser. 4: 315. 2004; Fras.-Jenk., Indian Fern J. 25: 22. 2008; Sreenivas & Madhus., Proc. 22nd Kerala Sci. Congr. 866. 2010.

[Fig. 3, 9A & Plate 3]

Type: India, Nilgiris, *Mclvor s. n.* (Holotype, K; Isotype CAL!).

Pteris quadriaurita var. *argentea* Bedd., Ferns S. India 11. 1863; Bedd., Ferns Brit. India 111. 1883; B. K. Nayar & S. Kaur, Comp. Bedd. Handb. 30. 1974; B. K. Nayar & Geev. Fern Fl. Malabar 114 fig. 25. 1993.

Type: India, Annamallays, *R. H. Beddome s.n.* (Isotype, MH!).

Height 90-150 cm. Rhizome suberect, 5-6 cm long x 6-7 mm thick, cylindrical with tuft of roots, scaly. Palea light brown, *c.* 3 mm long, lanceolate, acuminate, auriculate, thick walled cells along centre, thin walled cells at periphery with unicellular projections. Stipe 30-90 cm long, 3-4 mm thick, green with brown patch above (fresh specimens), strameneous with brown patch above (dry specimens), chestnut brown below, grooved, scaly below. Lamina bipinnate, 25-35 cm long x 18-25 cm broad, ovate-lanceolate. Pinnae 5-7 pairs, 18-22 cm long x 2.5-3 cm broad, subopposite or alternate, lanceolate, entire, adaxially green with white stripe along either side of mid-rib, pale green abaxially, basal pinnae bipartite. Pinnules 18-24 pairs, 1.4-1.7 cm long x 5-6 mm broad, oblong, entire, obtuse-rounded, sinus *c.* 2 mm away from costa, 0.5-1.5 mm apart, glabrous. Costae grooved above with spines on attachment site of costules and raised below. Veins 9-15 pairs, free, forking. Sori brown, 1-1.5 cm long, submarginal except apex. Indusium false, brown, fully opened at maturity. Sporangium: capsule globose, 200-250 μm long; stalk 250- 300 μm long, biseriate; annulus 19-23 celled. Paraphyses uniseriate. Spores brown, *c.* 30 x 45 μm, trilete-tetrahedral, verrucate.

Habitat: Usually present in wet evergreen forest floors at high altitudes.

Altitude: 600m-2100m.

Distribution: Java, India (South India: Karnataka, Kerala & Tamil Nadu) and Sri Lanka.

Chromosome number: n = 29 (Goldblatt & Johnson, 1991); 2n=58 (Walker, 1962).

Common name/Trivial name: Silver brake.

Economic importance: Widely cultivated as ornamental fern in many gardens.

Etymology: The specific epithet derived from a Greek word 'argyr', which means silver. The silver or white coloured band along either side of the midrib on adaxial surface indicates the specific epithet 'argyraea'.

IUCN status: Least concern (LC). This is a widespread taxon present in evergreen forests at high altitude and it does not meet any criteria for Endangered, Vulnerable, *etc.* under IUCN red list category.

Notes: *Pteris argyraea* was described by Thomas Moore in 1859 as having introduced in Royal Botanical Garden by Messrs Veitch & Son from central India. Moore stated in the protologue that the species is present only in India. But this species is present in Java and Sri Lanka as well. But, Hieronymus (1914) was doubtful about the occurrence of this species in India.

This species is closely similar to *P. confusa* T. G. Walker in its morphology. In both species, sinus is about 2-3 mm away from costa. In some cases, *P. argyraea* may reach up to 2 m height and vigorous size (*V.K.Sreenivas 124035*, CALI). This species can easily distinguish from other

species especially from *P. confusa* by its silver band along either sides of the midrib. Fraser Jenkins (pers. Comm.) thought that the species is nothing but *P. confusa* except its silver band and need further study in this case. Beddome (1863 & 1883) described this species from South India as *P. quadriaurita* var. *argentea* (Isotype, MH!).

Rajagopal and Bhat (1998) recorded this species from Karnataka state as a rare taxon. This is an altitude specific species and the present author could collect the specimens from wet evergreen forest above 600 m only. It is also introduced in the Botanical garden (CUBG), but it can not grow as healthy as in the natural habitat. But, now *P. argyraea* is widely cultivating as ornamental plant in many gardens across the world.

Materials examined:

KARNATAKA: Kodagu (Dt.): Madikeri-Bhagamandala (alt. 900m), *V.S.Manickam 2773*; Sampage-Somerpet road (alt. 900m), *V.S.Manickam 2900*; (XCH); Valikorja (alt. 850m), *P.K.Rajagopal 722* (MGMC).

KERALA: Idukki (Dt.): Anamudi N.P. (alt. 1650m), *V.K.Sreenivas 113255*; Deviarmedu, PTR (alt. 1400m), *V.K.Sreenivas 124035*; Devikulam (alt. 950m), *V.K.Sreenivas 113264*; Eravikulam N.P. (alt. 1600m), *V.K.Sreenivas 124081*; Vellimala (alt. 1500m), *K.P.Rajesh 18332* (CALI); Munnar-Devikulam road (alt. 1400m), *V.S.Manickam 31426* (RHT); Anamudi hills (alt. 1600m), *V.S.Manickam 34519*; Munnar hills (alt. 1100m), *V.S.Manickam*

32235 (XCH); Munnar (alt. 1400m), *N.C.Nair 40220*; Peerumedu (alt. 1000m), *N.C.Nair s.n.* (CAL). **Kannur** (Dt.): Kannavam forest (alt. 800m), *V.S.Manickam 3115* (XCH). **Palakkad** (Dt.): Silent Valley (alt. 850m), *Geevarghese 17895*; Walakkad SVNP (alt. 950m), *V.K.Sreenivas 119239* (CALI); Kummattanthode (alt. 800m), *V.S.Manickam 3259* (XCH); Aruvanpara (alt. 850m), *P.Bhargavan 65593*; Karivara (alt. 750m), *N.C.Nair 56872*; (MH, CAL). **Thiruvananthapuram** (Dt.): Chemunji (alt. 1300m), *V.K.Sreenivas 124047*; Way to Pandavanpara (alt. 1250m), *V.K.Sreenivas 113273* (CALI); Ponmudi hills (alt. 800m), *V.S.Manickam & K.M Mathew 33847* (XCH). **Wayanad** (Dt.): Chanthanathode (alt. 875m) *V.K.Sreenivas 113283*; Pakranthalam (alt. 600m), *B.K.Nayar & Geevarghese 11614*; Periya (alt. 650m), *B.K.Nayar & Geevarghese 11667* (CALI); Chanthanathode (alt. 875m), *V.S.Ramachandran 61390* (MH, CAL).

TAMIL NADU: Coimbatore (Dt.): Valparai (alt. 1300m), *V.S.Manickam & K.M.Mathew 33109* (RHT); *V.S.Manickam 1938* (XCH); Anamallai hills (alt. 1000m), *V.S.Manickam 3404* (XCH); Anamallays (alt 1600m), *R.H.Beddome s.n.* (MH); Bellagi Shola (alt. 1500m), *C.E.C.Fisher 358* (CAL). **Dindigul** (Dt.): Palamalai, Palni hills (alt. 1200m), *V.S.Manickam 1896* (RHT); Kodaikanal, Palni hills (alt. 1500m), *V.S.Manickam & K.M.Mathew 32562* (XCH). **Kannyakumari** (Dt.): Kalkulam (alt. 1200m), *V.S.Manickam 31961 & 32052*; Vilavancode (alt. 1200m), *V.S.Manickam & K.M.Mathew 34204* (XCH); Way to Mahendragiri Peak (alt. 1275m), *B.D.Sharma 40048*; Upper

Kadayar (alt. 1300m), *A.N.Henry & M.Chandrabose 49669* (MH). **Madurai** (Dt.): Vellimalai (alt. 1450m), *B.V.Shetty 10316* (MH, CAL). **Nilgiri** (Dt.): Way to Avalanche (alt. 2000m), *V.K.Sreenivas 119228* (CALI); Avalanche (alt. 2100m), *V.S.Manickam 896*; Coonoor (alt. 1800m), *V.S.Manickam 1327*; Kotagiri (alt. 1700m), *V.S.Manickam 1402*; Naduvattam (alt. 1900m), *V.S.Manickam 596*; Rock land forest (alt. 2000m), *V.S.Manickam 954*; (XCH); Carrington (alt. 2075m), *B.V.Shetty 34343*; Chemaraj estate (alt. 2000m), *K.M.Sebastine 3333*; Naduvattam (alt. 1825m), *J.K.Ellis 34726* (MH); Old Street, Nilgiri (alt. 1850m), *J.S.Gamble 13083* (CAL). **Salem** (Dt.): Balmadies estate, Yercaud (alt. 1667m), *K.Subramanyam 6562*; *Ghatak 533* (MH, CAL). **Tirunelveli** (Dt.): Ambasamudram (alt. 1000m), *V.S.Manickam 31774*; Kothayar hills (alt. 1200m), *V.S.Manickam 31002* (RHT); Agasthyar hills (alt. 1400m), *V.S.Manickam 32428*; Courtallam Hills, Thankasi (alt. 500m), *V.S.Manickam 33980*; Kakachi (alt. 1300m), *V.S.Manickam 3330*; Kalakkad hills (alt 1200m), *V.S.Manickam & K.M.Mathew 34171*; Thekkumalai estate (alt. 500m), *V.S.Manickam 33983* (XCH); Kakachi (alt. 1700m), *K.M.Sebastine 5840*; Kannikatty (alt. 915m), *K.C.Jacob s.n.*; Sithara- Periyar (alt. 900m), *A.N.Henry & M.Chandrabose 19874* (MH); Manjanamparai (alt. 1400m), *A.N.Henry 16367*; Natrikal (alt. 950m), *E.Hooper & M.S.Ramaswami 38635* (CAL).

2. **Pteris arisanensis** Tagawa

P. arisanensis Tagawa, Acta Phytotax. Geobot. 5: 102. 1936; Shieh, Bot. Mag. Tokyo 79: 291. 1966. Fras.-Jenk., Taxon. Rev. Indian Subcont. Pterid. Rev. Cens. List 115. 2008; Mahamuni & Dongare, Indian Fern J. 26: 140. 2009; Sreenivas & Madhus., Proc. 22nd Kerala Sci. Congr. 866. 2010.

[Fig. 4, 9B & Plate 4]

Type: Taiwan, Mt. Arisan, June 1914, *U. Faurie 603* (Holotype, KYO, digital image!).

Height 130-160 cm. Rhizome long, creeping, 10-20 cm long x 8-10 mm thick, cylindrical with crowded stipes and roots, scaly. Palea brown, 3-4 cm long, 5-6 mm wide at base, lanceolate, acuminate, auriculate, middle thick walled cells, periphery thin walled cells with cellular projectons. Stipe 35-85 cm long, 4-6 mm thick, green (live material), stramineous (dry specimen), grooved throughout, glabrous above, scaly below. Lamina bipinnate, 35-70 cm long x 25-30 cm broad, ovate - broadly ovate, dark green above, pale green below, coriaceous. Pinnae 5-6 pairs, 20-28 cm long x 3-6 cm broad, opposite to subopposite, lanceolate, acuminate, entire, green, basal pinnae bipartite. Pinnules 24-27 pairs, 2.5-3.2 cm long x 4-6 mm broad, oblong, entire, obtuse, sinus *c.* 3 mm away from costa, intersegmental

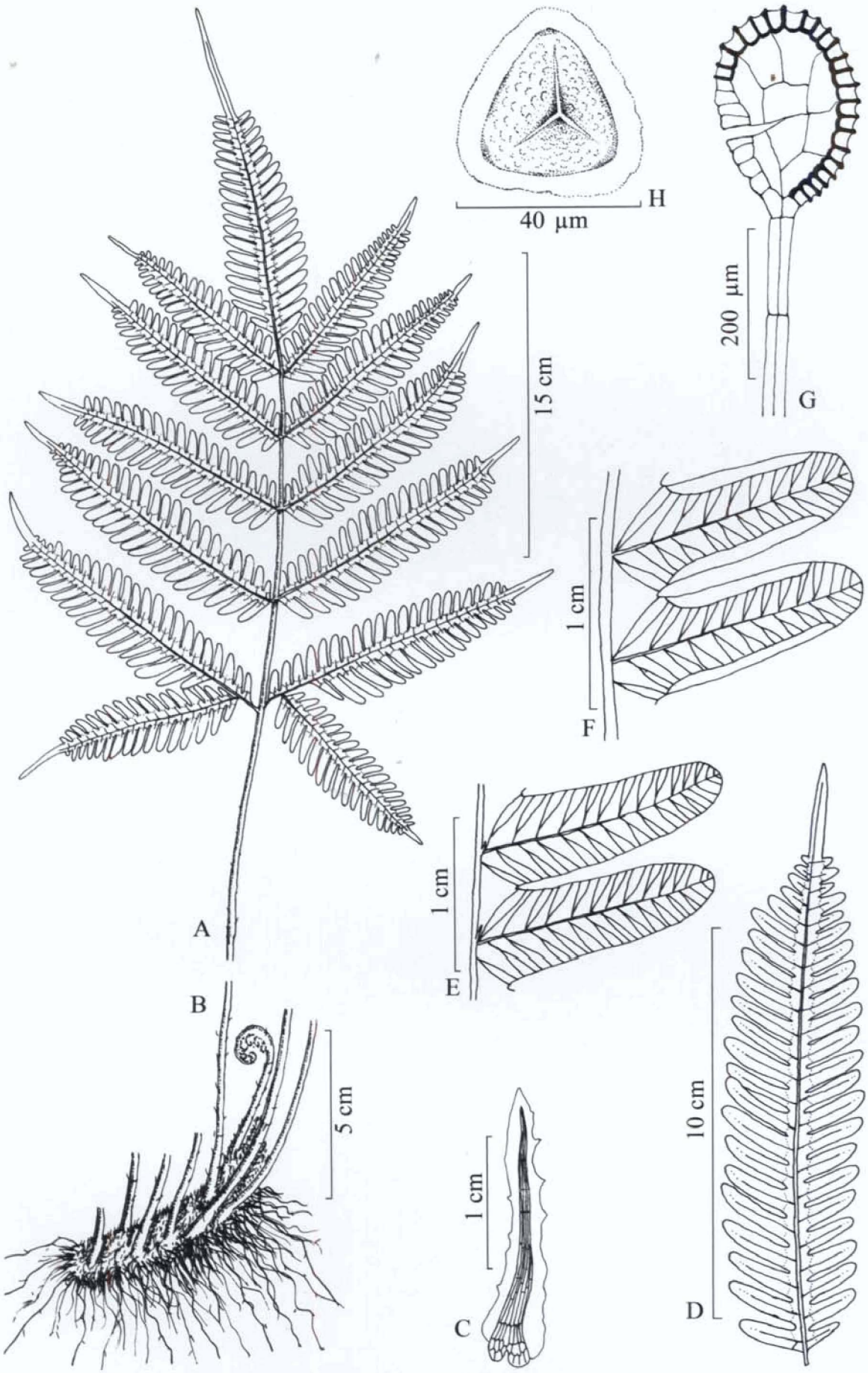


Fig. 3. ***Pteris argyraea*** **T. Moore**: **A-B**. habit; **C**. palea; **D**. single pinna; **E**. sterile pinnules; **F**. fertile pinnules; **G**. sporangium; **H**. spore (*V.K.Sreenivas 119239*, CALI)

Plate 3. ***Pteris argyraea* T. Moore**: **A**. habit; **B**. single pinna; **C**. sterile pinnules; **D**. fertile pinnules; **E**. rhizome; **F**. & **G**. spore ornamentation.

distance *c.* 2 mm apart (in fertile), below 1 mm apart (in sterile), glabrous. Costa grooved above with inconspicuous spines on the attachement site of costule and raised below. Veins 14-18 pairs free, forking, indistinct above. Sori brown, 1- 3.2 cm long, linear, submarginal except at apex, crowded. Indusium false, pale coloured, papery. Sporangium: capsule globose, 200-250 μm long; stalk 300- 350 μm long, biseriate; annulus 16-18 celled. Paraphyses uniseriate. Spores pale brown, *c.* 35 x 40 μm, trilete-tetrahedral, verrucate.

Habitat: Present in evergreen forest floors at high altitude.

Altitude: 1000m-1500m.

Distribution: India (South India: Karnataka & Kerala) and Taiwan.

Etymology: The specific epithet derived from the type locality 'Mount Arisan' in Taiwan.

IUCN status: Endangered (EN). This taxon is currently known from 1-2 locations in South India and meets the criteria EN B1ac(iv)+2aD under Endangered category.

Notes: This species is rare in South India and collected from Periyar Tiger Reserve. The south Indian species is having long rhizome, about 11-12 cm long. Fraser-Jenkins (2008a) stated that *P. arisanensis* resembles to

P. biaurita L. in its pinna lobes. Recently, Mahamuni & Dongare (2009) reported this species from Belgaum district of Karnataka.

Materials examined:

KERALA: Idukki (Dt.): Deviarmedu, PTR (alt. 1400m), *V.K.Sreenivas 124030*; Near Thamarai, PTR (alt. 1200m), *V.K.Sreenivas 124024* (CALI).

3. Pteris biaurita L.

P. biaurita L. Sp. Pl. 2. 1076. 1753; J. Agardh, Recens. Spec. Pter. 26. 1839; Hook., Sp. Fil. 2: 203. 1858; Tagawa, Acta Phytotax. Geobot. 16: 72. 1956; Scamman, Rhodora 63: 200. 1961; Shieh, Bot. Mag. Tokyo 79: 291. 1966; Holttum, Rev. Fl. Malaya 2: 407. 1968; T. G. Walker, Brit. Fern Gaz. 10: 149. 1970; B. K. Nayar & S. Kaur, Comp. Bedd. Handb. 31. 1974; R. D. Dixit, Cens. Indian Pterid. 69. 1984; Manickam, Fern Fl. Palni Hills 21. 1986; S. M. Vasudeva & Chhibber, Indian Fern J. 6: 210. 1989; N. C. Nair et al., J. Econ. Taxon. Bot. 263. 1992; Manickam & Irud., Pterid. Fl. W. Ghats 73 pl. 49. 1992; B. K. Nayar & Geev. Fern Fl. Malabar 104. fig. 23 & 27. 1993; Khullar, Illustr. Fern Fl. W. Himalaya 1: 260. pl. 92. 1994; Rajagopal & K. G. Bhat, Indian Fern J. 15: 8. 1998; Subh. Chandra, Ferns India 34. 2000; Manickam & Irud., Pterid. Fl. Nilgiris 86. 2003; Easa, Biodiv. Doc. Kerala 5: 19. 2003; Pullaiah et al., Pterid. Andhra Pradesh 51. 2003; Ghosh et al., Pterid. Fl. E. India 1, Ser. 4: 338. 2004; Mickel & Smith, Pterid. Mexico 1: 535. 2004; Fras.-Jenk., Tax. Rev. Indian Subcont. Pterid. Rev. Cens. List 113. 2008; Mahamuni & Dongare, Indian Fern J. 26: 140. 2009; Sreenivas & Madhus., Proc. 22nd Kerala Sci. Congr. 866. 2010.

[Fig. 5, 9C & Plate 5]

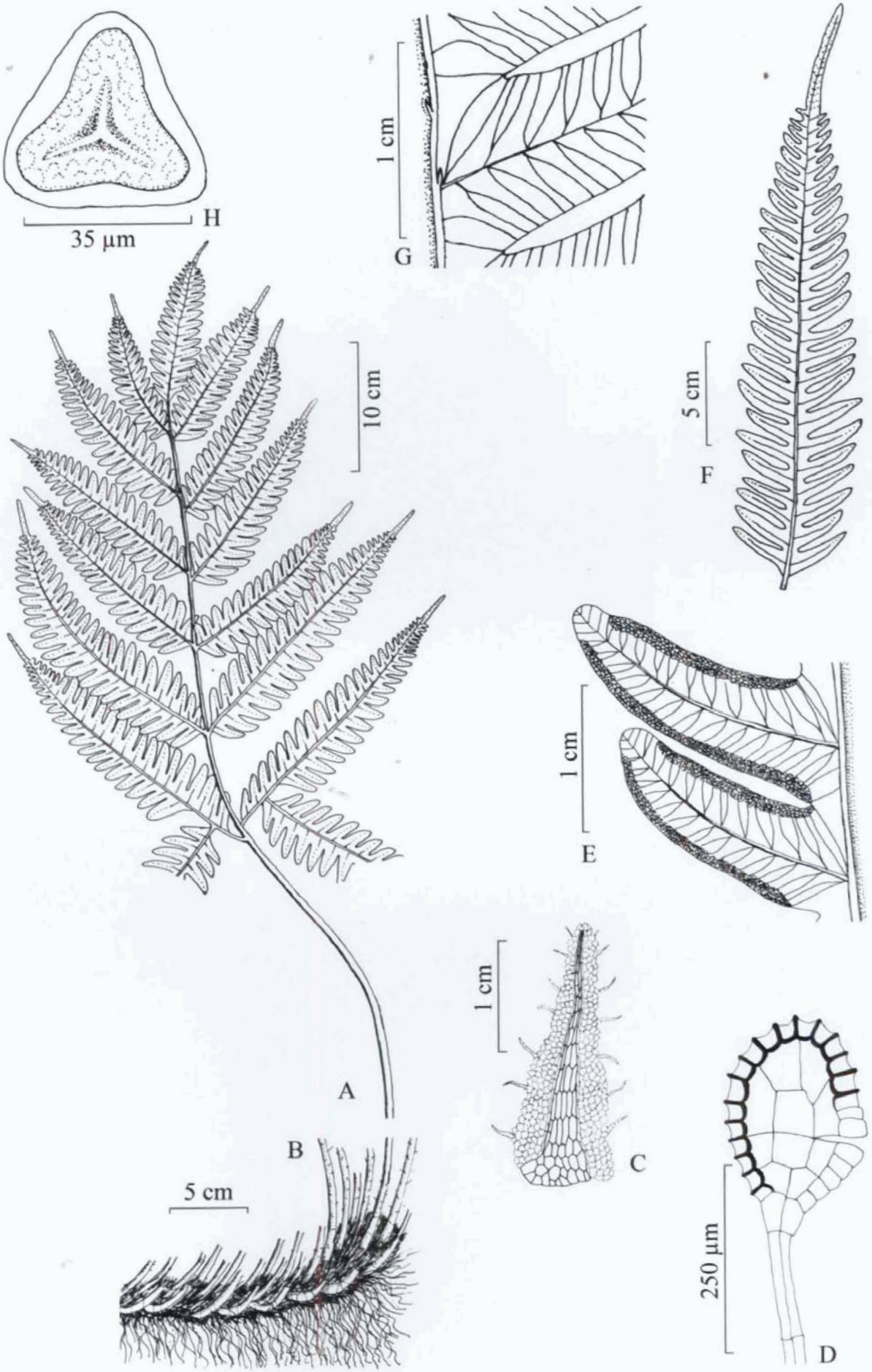


Fig. 4. ***Pteris arisanensis*** **Tagawa**: **A-B**. habit; **C**. palea; **D**. sporangium; **E**. fertile pinnules; **F**. single pinna; **G**. venation; **H**. spore (*V.K.sreenivas 124030*, CALI)

Plate 4. ***Pteris arisanensis*** **Tagawa**: **A**. habit; **B**. single pinna; **C**. rhizome; **D**. adaxial surface of pinnules; **E**. fertile pinnules; **F**. spore.

Type: West Indies, Domingo (Lectotype, LINN 1246.19, digital image!).

Campteria biaurita (L.) Hook., Gen. Fil. pl 65A. 1842; Bedd., Ferns S. India 14. pl. 44. 1863 & Handb. Ferns. Brit. India 116. 1883; C. B. Clarke, Trans. Linn. Soc. Lond. II Bot. 1: 469. 1880.

Pteris quadriaurita var. *biaurita* (L.) J. Bommer & Christ Bull. Soc. Roy. Bot. Belgique. 35, pt 1: 190. 1896.

Pteris biaurita L. subsp. *walkeriana* Fras.-Jenk. & Rajkumar, Fras.-Jenk., Tax. Rev. Indian Subcont. Pterid. Rev. Cens. List 115. 2008. ***syn. nov.***

Type: India, West Bengal, Badamtan, Lebong and Darjeeling, 27 November 1995, *C.R. Fraser-Jenkins 1367A* (Holotype, BM).

Pteris biaurita L. subsp. *fornicata* Fras.-Jenk., Tax. Rev. Indian Subcont. Pterid. Rev. Cens. List 116. 2008. ***syn. nov.***

Type: Sri Lanka, Hunnasgiriya, *T.G. Walker T101* (Holotype, BM).

Height 70-110 cm. Rhizome erect to suberect, 3-5cm long x 6-10 mm thick, cylindrical with tuft of roots, scaly. Palea brown, 2-3 mm long x 0.4-0.6 mm wide at base, lanceolate, acuminate, auriculate, central thick walled cells, thin walled cells at periphery. Stipe 20-61 cm long, 2-3 mm thick, green (fresh material), stramineous (dry material), grooved, glabrous above, scaly below. Lamina bipinnate, 20-30 cm long x 12-25 cm broad, ovate-oblong,

green to pale green, coriaceous. Pinnae 5-8 pairs, 10-19 cm long x 2-3.5 cm broad, opposite or subopposite, lanceolate, entire, green above, pale green below, basal pinnae bipartite. Pinnules 15-30 pairs, 1-2 cm long x 4-7 mm broad, oblong, margin entire, apex obtuse to rounded, sinus 2-3 mm away from costa, 0.5-3 mm apart, glabrous. Costae grooved on upper side with spines on attachment site of costule, and raised below. Veins 11-20 pairs, free, forking, veins near costa united to form costal areoles along either sides of midrib. Sori brown, 1.2-1.4 cm long, submarginal except at extreme apex. Indusium false, white. Sporangium: capsule globose, 250-300 μm long; stalk 200-300 μm long, biseriate; annulus 15-20 celled. Paraphyses uniseriate. Spores brown, *c.* 45 x 50 μm, trilete-tetrahedral, verrucate.

Habitat: Grows in fully exposed areas as well as shaded areas. Commonly seen in road sides, earth cuttings, river banks of high ranges.

Altitude: 50m-2000m.

Distribution: Borneo, Brazil, China, India (South India: Andhra Pradesh, Karnataka, Kerala & Tamil Nadu), Java, Malaysia, South Africa and West Indies.

Chromosome number: n= 58 (Goldblatt & Johnson, 1991).

Common name: Arched-veined Pteris.

Economic importance: Rhizome and sporophyll have antibacterial properties (Singh, 1999).

Etymology: The specific epithet derived from the Latin word 'biauritus' (= with two auricles), though many of the *Pteris* species are having one accessory auricle on lower pinna.

IUCN status: Least concern (LC). This is a widespread taxon present in any type of forests and it does not meet any criteria for Endangered, Vulnerable, *etc.* under IUCN red list category.

Notes: *P. biaurita* is easily distinguished by the costal areoles formed by the fusion of lowest veins on either side of the midribs of the pinna. Mickel and Smith (2004) suggests that it is closely resembles to *P. quadriaurita* Retz. except thesev costal areoles. However, in some cases, the veins are free or mostly free. According to Fraser-Jenkins (2008), the names *P. linearis* Poir. and *P. nemoralis* Willd. were applied to many members of *P. biaurita* cytological complex. He described two subspecies mainly based on venation patterns. These are (1), *Pteris biaurita* L. subsp. *walkeriana* Fras.-Jenk. & Rajkumar with veins united to form triangular shaped areoles and it is an apogamous diploid, (2), *Pteris biaurita* L. subsp. *fornicata* Fras.-Jenk. with irregularly united basal veins and which is an apogamous triploid. In south Indian *P. biaurita* (*V.K.Sreenivas 113285*, CALI), both types of venation patterns were observed in a single pinna. So it is very difficult to distinguish

the plants at subspecies level based on venation pattern. Here both subspecies are treated under the species *P. biaurita* L.

The costal areoles are also present in *P. geminata* Wall. ex J. Agardh and in *P. tripartita* Sw. *P. geminata* can be distinguished by the presence of hydathode at the vein endings and having crenate pinna apex. *P. tripartita* is having costular areoles in addition to costal areoles.

Materials examined:

ANDHRA PRADESH: Godavari (Dt.): Dumakonda (alt. 475m), *G.V.Subbarao 68133A* (MH). **Visakhapattanam** (Dt.): Anantagiri (alt. 1000m), *G.V.Subbarao 32831*; Galikonda (alt. 1142m), *G.V.Subbarao 19610*; Mettur (alt. 625m), *G.V.Subbarao 29572*; Sankari metta (alt. 1075m), *N.P.Balakrishnan 10904* (MH); Galikonda (alt. 1100m), *P.Amrutha Lakshmi 25149* (SKU).

KARNATAKA: Kodagu (Dt.): Near Jodhpala (alt. 610m), *V.K.Sreenivas 113207*; Way to Thalecauvery (alt. 915m), *V.K.Sreenivas 113203 & 113209* (CALI); Bhagamandala (alt. 900m), *V.S.Manickam 2681*; Thalecauvery forest (alt. 1200m), *V.S.Manickam 2631*; (XCH); Near Abbey falls (alt. 900m), *T.A.Rao & B.C.Banerjee 11354* (CAL). **Chikmagaluru** (Dt.): Belahanoor (alt. 900m), *V.K.Sreenivas 124092* (CALI). Bababudan hills (alt. 1900m), *P.K.Rajagopal 722* (MGMC). **Mysore** (Dt.): Mysore (alt. 750m), *Wallich 129*

(CAL). **Shimoga** (Dt.): Agumbe (alt. 1400m), *V.K.Sreenivas 124095* (CALI); Hulikal range (alt. 1000m), *P.K.Rajagopal 722* (MGMC).

KERALA: Ernakulam (Dt.): Neryamangalam (alt. 450m), *N.C.Nair 50719* (MH); *N.C.Nair 40230 & 50988* (CAL). **Idukki** (Dt.): Upper Manalar (alt. 1750m), *Jomy Augustine 12868*; Sabarigiri (alt. 600m), *B.K.Nayar & Party 10088*; Thannikudy (alt. 800m), *V.K.Sreenivas 124036*; Thekkady (alt. 720m), *K.P.Rajesh 18348*, (CALI); Peerumedu (alt. 1000m), *V.S.Manickam & K.M.Mathew 33416*; Sabarimala (alt. 500m), *V.S.Manickam & K.M.Mathew 33625* (RHT); Devikulam (alt. 1400m), *V.S.Manickam & K.M.Mathew 34613* (XCH); Munnar (alt. 1400m), *N.C.Nair & S.R.Ghosh 50762* (MH); Kumali (alt. 750m), *N.C.Nair 802*; Munnar (alt. 1400m), *N.C.Nair 50750*; Sabarimala (alt. 500m), *N.C.Nair 877*; Thankamani (alt. 860m), *N.C.Nair 40770* (CAL). **Kannur** (Dt.): Meenmutty (alt. 450m), *K.P.Rajesh & K.Satheesh Kumar 87831 & 87838* (CALI). **Kollam** (Dt.): Aryankavu hills (alt. 200m), *V.S.Manickam 32311* (XCH); Plappally (alt. 1100m), *N.C.Nair 50842* (MH); Cheenikala (alt. 350m), *Raju Antony 18668* (TBGT). **Kottayam** (Dt.): Kurisumala (alt. 1000m), *V.S.Manickam & K.M.Mathew 34559* (RHT); *V.S.Manickam 34596* (XCH); Peruvanthanam (alt. 535m), *K.Vivekanandan 22969* (MH). **Kozhikode** (Dt.): Kakkayam forest (alt. 750m), *K.Satheesh Kumar 879669* (CALI). **Palakkad** (Dt.): Kaikatty (alt 900m), *B.K.Nayar & Party 7323*; Nellyampathi (alt. 1100m), *Geevarghese 17876*; Panthenthode (alt. 850m), *V.K.Sreenivas 124019*;

Sairendri (alt. 900m), *V.K.Sreenivas 124018*; (CALI); Silent Valley forest (alt. 850m), *V.S.Manickam 3245* (XCH); Padagiri (alt. 1100m), *E.Vajravelu 44761*; Walayar forest (alt. 60m), *E.Vajravelu 19052* (MH); Kaikatty (alt. 900m), *N.C.Nair 69864* (CAL); Muthikulam forest (alt. 850m), *E.Vajravelu 62835* (MH, CAL). **Pathanamthitta** (Dt.): Muzhiar-Kakki road (alt. 600m), *V.S.Manickam & K.M.Mathew 33667* (XCH); Pampanada (alt. 9m), *N.C.Nair 842* (CAL). **Thrissur** (Dt.): Sholayar- Chalakkudy road (alt. 400m), *V.S.Manickam & K.M.Mathew 34719* (RHT); *V.K.Sreenivas 119289*; Sholayar (alt. 450m), *V.K.Sreenivas 119291* (CALI); Vazhachal (alt. 400m), *N.C.Nair & S.R.Ghosh 52071* (MH). **Thiruvananthapuram** (Dt.): Ponmudi hills (alt. 1100m), *V.S.Manickam & K.M.Mathew 33761* (XCH); Kallar (alt. 900m), *N.C.Nair 40048*; Ponmudi hills *N.C.Nair & S.R.Ghosh 51768 & 51828* (CAL). **Wayanad** (Dt.): Chandanathode (alt. 650m), *V.K.Sreenivas 113285*; Edakkayil (alt. 680m), *B.K.Nayar & Geevarghese 11622*; Meppadi (alt. 800m), *Habeeb 102838*; Periya (alt. 750m), *B.K.Nayar & Geevarghese 10707*; Vythiri (alt. 700m), *Geevarghese 17968* (CALI).

TAMIL NADU: Coimbatore (Dt.): Valparai (alt. 800m), *V.S.Manickam 33040* (RHT); Anamallai Hills (alt. 1000m), *K.M.Mathew 31602*; Shakalimudi forest (alt. 1200m), *V.S.Manickam 2188* (XCH). Anamallys (alt. 1500m), *R.H.Beddome s.n.* (MH). **Dindigul** (Dt.): Kodaikanal (alt. 1200m), *V.S.Manickam 1694*; Srivilliputhur (alt. 700m), *V.S.Manickam 3040* (XCH). **Kanyakumari** (Dt.): Kalkulam (alt. 1200m), *V.S.Manickam 31971*; Thovalai-

Karimani (alt. 700m), *V.S.Manickam 2540* (XCH); Kiripara- Nagercoil (alt. 200m), *N.C.Nair & S.R.Ghosh 52616B* (MH). **Nilgiri** (Dt.): Way to Avalache (alt. 2000m), *V.K.Sreenivas 124084* (CALI); Coonoor (alt.1400m), *V.S.Manickam 1223*; Devala (alt. 1200m), *V.S.Manickam 1554*; Gudallur (alt. 1000m), *V.S.Manickam 1630* (XCH). **Salem** (Dt.): Yercaud (alt. 1200m), *V.S.Manickam & K.M.Mathew 33336* (RHT); Shevarayan hills, Yercaud (alt. 1300m), *V.S.Manickam & K.M.Mathew 33269* (XCH); Near Aryanpara kovil (alt. 1000m), *N.C.Nair 74208*; Yercaud (alt. 1333m), *K.Subramanyam 7584* (MH). **Tirunelveli** (Dt.): Kothayar (alt. 450m), *P.V.Madhusoodanan & Party 44881* (CALI); Kothayar hills (alt. 1200m), *V.Irudayaraj 3503* (XCH); Courtallam hills (alt 400 m), *V.S.Manickam 33972*; Kalakkad hills (alt. 1200m), *V.S.Manickam 31242*; Sengeltheri (alt. 1000m), *V.S.Manickam 2341* (XCH). **Vellore** (Dt.): Vizhiyoor-Polur (alt. 250m), *E.Vajravelu 54591* (MH, CAL).

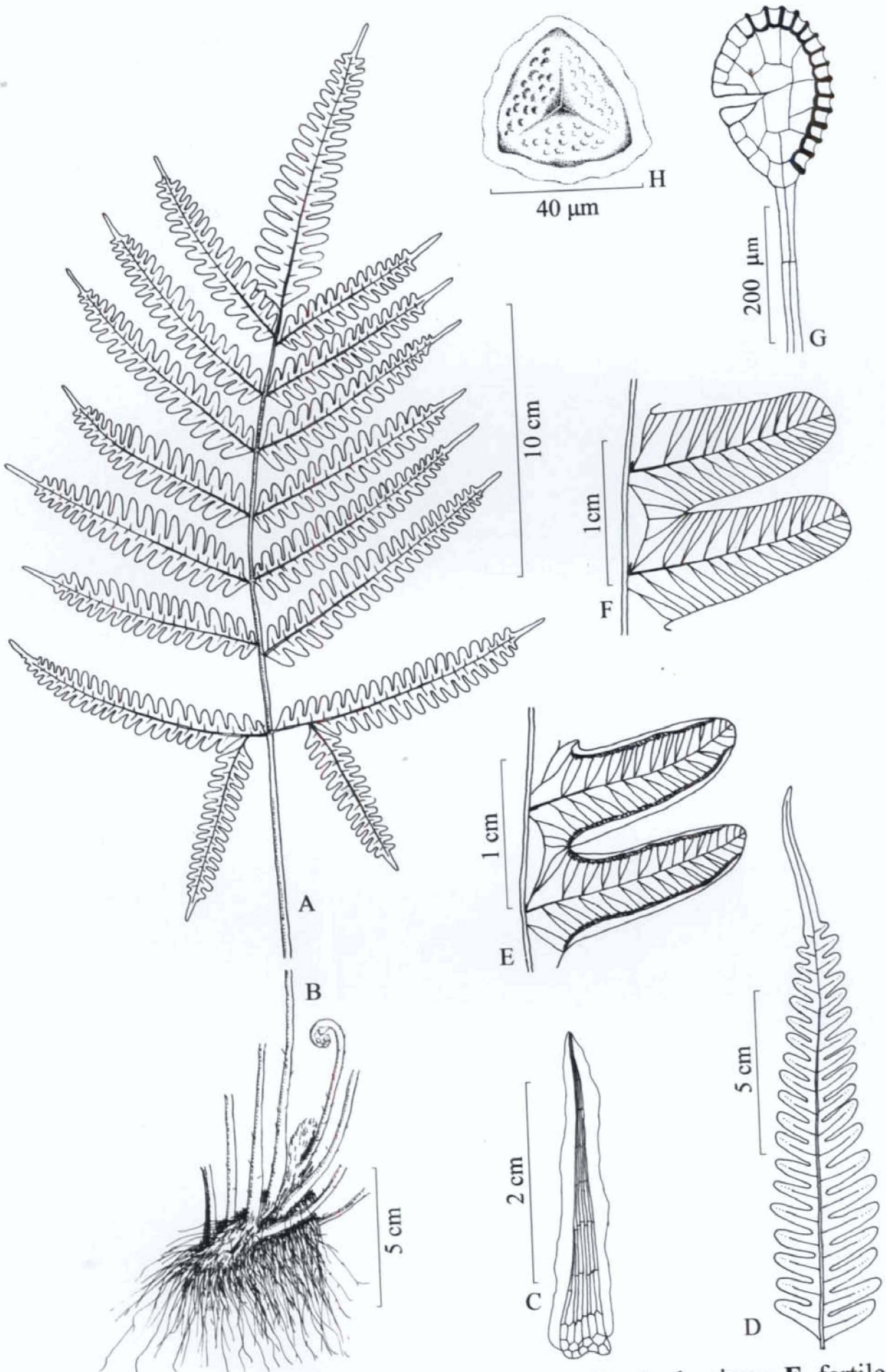


Fig. 5. ***Pteris biaurita*** **L.**: **A-B**. habit; **C**. palea; **D**. single pinna; **E**. fertile pinnules; **F**. sterile pinnules; **G**. sporangium; **H**. spore (*V.K.Sreenivas 113209*, CALI)

Plate 5. ***Pteris biaurita*** **L.**: **A**. habit; **B**. single pinna; **C**. sterile pinnules showing venation and costal areols; **D**. rhizome; **E**. fertile pinnules; **F**. spore.

4. **Pteris blumeana** J. Agardh

P. blumeana J. Agardh, Recens. Spec. Pter. 22. 1839; Hieron., Hedwigia 55: 360. 1914; B. K. Nayar & S. Kaur, Comp. Bedd. Handb. 30. 1974; R. D. Dixit, Cens. Indian Pterid. 69. 1984; Ming & Rong, Acta Bot. Yunn. 22: 260. 2000; Ghosh et al., Pterid. Fl. E. India 1, Ser. 4: 353. 2004; Fras.-Jenk., Taxon. Rev. Indian Subcont. Pterid. Rev. Cens. List 106. 2008.

[Fig. 6, 9D & Plate 6]

Type: Java, *Blume s.n.* (Holotype, L, digital image!; Isotype, B, digital image!).

Pteris quadriaurita var. *rubro-nerva* Bedd., Ferns S. India 11. 1863.

Pteris quadriaurita var. *blumeana* (J. Agardh) C. B. Clarke, Trans. Linn. Soc. Lond. II, Bot. 1: 466. pl. 55. 1880; Bedd., Handb. Ferns Brit. India, 112.1883.

Pteris aspericaulis auct. Manickam & Irud., Pterid. Fl. W. Ghats, 75. Pl. 51. 1992; B. K. Nayar & Geev. Fern Fl. Malabar 102.1993; Rajagopal & K. G. Bhat, Indian Fern J. 15: 8. 1998; Subh. Chandra, Ferns India 34. 2000; Easa, Biodiv. Doc. Kerala 5: 18. 2003. *non* Wall. ex J. Agardh, 1839.

Type: Nepal, *Wallich 107* (Isotype, BM & US, digital image!).

Pteris roseolilacina auct. N. C. Nair & S. R. Ghosh, J. Bomb. Nat. Hist. Soc. 73: 424. 1977; S. M. Vasudeva & A. Singla, Asp. Plant Sci. 13: 337. fig. 25. 1991; N. C. Nair et al., J. Econ. Taxon. Bot. 260. 1992; Easa, Biodiv. Doc. Kerala 5: 22. 2003. *non* Hieron., 1914.

Type: China, Papien river near Talan, Yunnan, 4 September 1901, *A. Henry 13222* (Holotype, B, digital image!).

Height 40-60 cm. Rhizome short, erect, 2-4 cm long x 3-4 mm thick, cylindrical with tuft of roots, scaly. Palea brown 2-3 mm long x 5-8 mm broad at base, lanceolate, acuminate, auriculate, thick walled cells at centre. Stipe 30-38 cm long, 2-3 mm thick, pink or carmine red (fresh specimens) or stamineous (on drying), grooved throughout, glabrous above, scaly below. Lamina bipinnate, 30-35 cm long x 18-25 cm broad, oblong, dark green above and pale green below, subcoriaceous. Pinnae 4-10 pairs, 10-15 cm long x 1.5-3 cm broad, opposite to subopposite, lanceolate, acuminate, green, regular arrangement, basal pinnae bipartite. Pinnules 25-36 pairs, 1.2-1.6 cm long x 2-4 mm broad, oblong, margin entire, obtuse, sinus near to costa, *c.* 1 mm apart, pink spinules on distal part of segment, regular arrangement of segments. Veins 8-14 pairs, free, forking (half the way). Costa grooved above with spines near the attachment of costule, and raised below. Sori brown,

0.7-1.1 cm long, submarginal except at extreme apex. Indusium false, pale white. Sporangium: capsule globose, 170-200 µm long; stalk 200-250 µm long, biseriate; annulus 18-20 celled. Paraphyses uniseriate. Spores brown, *c.* 35 x 40 µm, trilete-tetrahedral, verrucate.

Habitat: This is a rare species seen in earth cuttings and rock crevices in shady forests.

Altitude: 400m-2000m.

Distribution: India (South India: Kerala & Karnataka), Java, Myanamar, Singapore, Vietnam and Thailand.

Economic importance: This species can cultivated as ornamental fern due to its splendid beauty.

Etymology: The specific epithet is derived from the German-Dutch Botanist Carl Ludwig Blume, who first described this species as *Pteris normalis* Blume in 1830. But, David Don described yet another species with same name in 1825, so it became illegitimate. So, J. Agardh (1839) chose the specific epithet in honour of Blume.

IUCN status: Vulnerable (VU). This species is known to occur in limited localities and the population size and occurrence are also fluctuating. This taxon meets criteria VU B1ac(i)C under Vulnerable category.

Notes: Agardh (1839) described this species from Java. This is alittle known and misunderstood species and a number of names have been applied to the *P. blumeana* in India. *P. aspericaulis* Wall. ex J. Agardh and *P. roseolilacina* Hieron. are two widely used names for this species. *P. blumeana* is characterized by the pinkish stipe, non mucronulate, obtuse and narrow pinnules. The sinus is almost reaching to costae and the inter-segmental distance is about 2-3 mm. It has prominent and pale setae at the distal end of the pinnules.

Nair and Ghosh (1977) reported this species as *P. roseolilacina* from Ponmudi Hills (*N.C.Nair 52601*, CAL!). Subsequently, Manickam and Irudayaraj (1992) reported it as *P. aspericaulis* (*V.S.Manickam 2667 & 2705*, *32273*, XCH!) from Western Ghats. Rajagopal and Bhat (1998) also reported this species as *P. aspericaulis* (*P.K.Rajagopal 760*, MGMC!) from Karnataka. But critical examination on these specimens revealed that all the specimens belong to *P. blumeana*.

P. aspericaulis has scabrous stipe and mucronulate pinnule apex, where as *P. roseolilacina* has glabrous stipe and obtuse pinnule apex. Inter-segmental distance is less in both species compared to *P. blumeana*.

Materials examined:

KARNATAKA: Kodagu (Dt.): Thalecauvery (alt. 1200m), *V.K.Sreenivas 113206* (CALI); Bhagamandala (alt. 900m), *V.S.Manickam 2667 & 2705*

(XCH); Madikeri (alt. 850m), *C.A.Barber 386* (MH); *P.K.Rajagopal 760* (MGMC).

KERALA: Kannur (Dt.): Way to Meenmutty (alt. 350m), *V.K.Sreenivas 124060*; *K.P.Rajesh & K.Satheesh Kumar 87839* (CALI). **Idukki** (Dt.): Deviar medu (alt. 1500m), *Jomy Agustine 13251*; Eravikulam N.P. (alt. 1450m), *V.K.Sreenivas 124080* (CALI); Thekkadi-Munnar Road (alt. 1300m), *V.S.Manickam 32169* (RHT); Aruvikad forest-Munnar (alt. 1500m), *V.S.Manickam 32273* (XCH); Poonkavanam-Sabarimala (alt. 1200m), *N.C.Nair 70201*; Sabarimala slope (alt. 650m), *B.D.Sharma 42062*; Uppupara (alt. 1000m), *K.V.Vivekanandan 45366* (MH). **Palakkad** (Dt.): Parambikulam (alt. 750m), *Varghese 17885* (CALI); Pothumala-Karappara (alt. 1100m), *N.C.Nair 69623* (MH). **Pathanamthitta** (Dt.): Karimalakovil (alt. 800m), *B.K.Nayar & Pankaj 7373* (CALI). **Thiruvananthapuram** (Dt.): Ponmudi (alt. 1100m), *N.C.Nair & S.R.Ghosh 52601* (CAL). **Wayanad** (Dt.): Vythiri (alt. 700m), *K.V.Sankar 8821* (CALI).

TAMIL NADU: Coimbatore (Dt.): Akamalai forest- Valparai (alt. 1700m), *V.S.Manickam 2126*; Valparai (alt. 1700m), *V.S.Manickam 1915 & 3029* (XCH); Sholayar (alt. 1100m), *K.M.Sebastine 17294* (MH); **Kannyakumari** (Dt.): Balmore hills (alt. 700m), *V.S.Manickam 2520* (XCH). **Nilgiri** (Dt.): Gudallur (alt. 1600m), *V.S.Manickam 1506* (XCH).

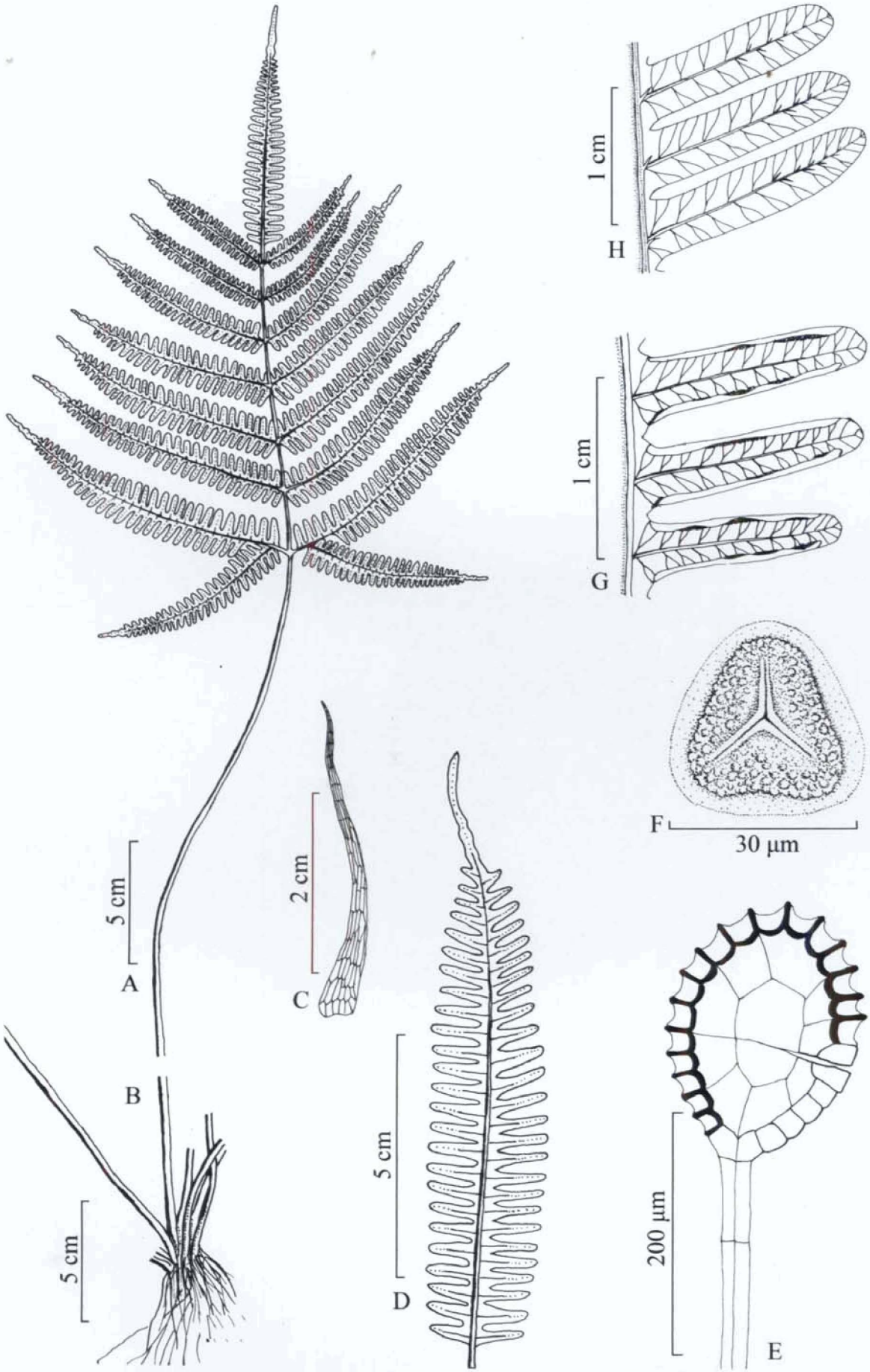


Fig. 6. ***Pteris blumeana* J. Agardh**: **A-B**. habit; **C**. palea; **D**. single pinna; **E**. sporangium; **F**. spore; **G**. fertile pinnules; **H**. sterile pinnules (*V.K.Sreenivas 124060*, CALI).

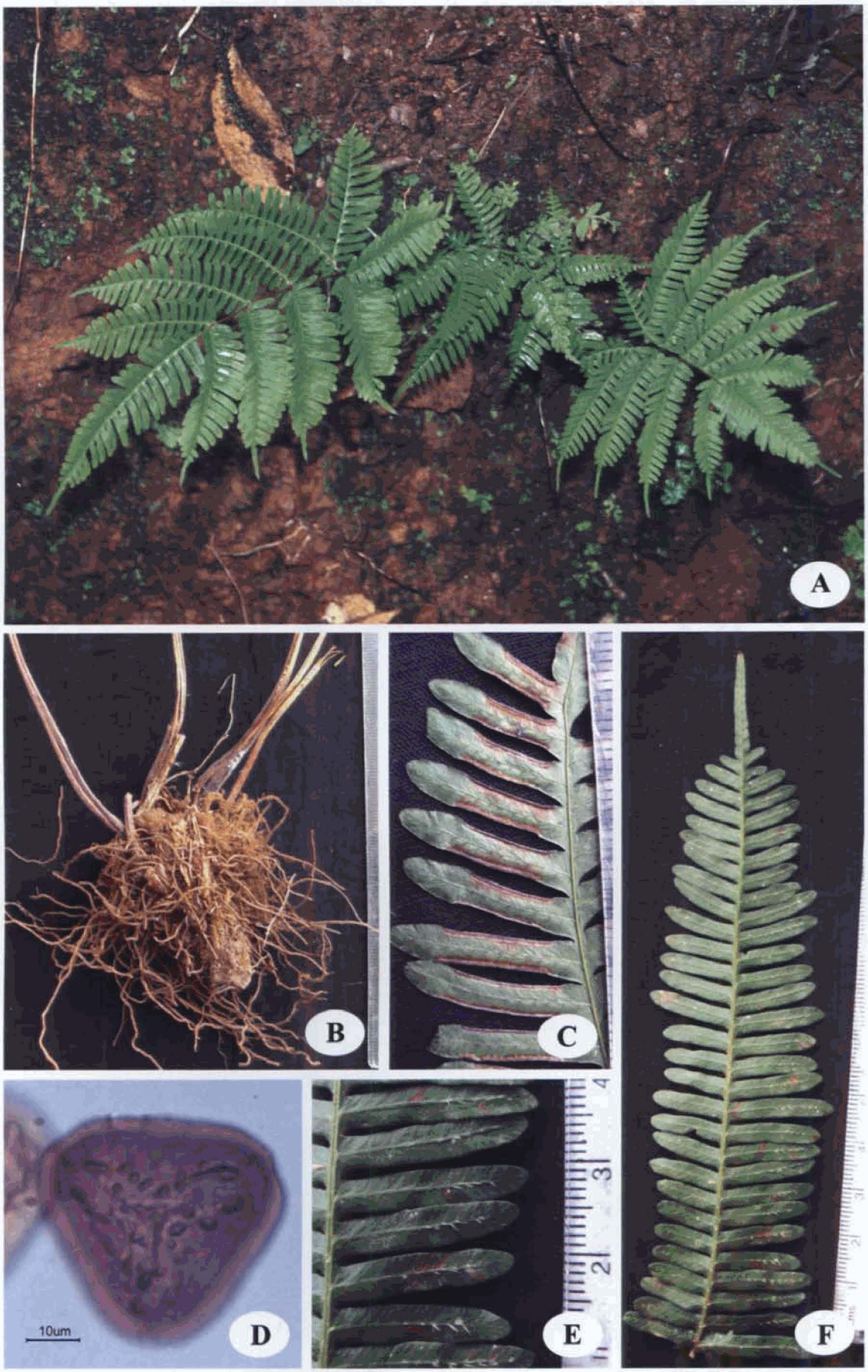


Plate 6. ***Pteris blumeana*** **J. Agardh**: **A**. habit; **B**. rhizome; **C**. fertile pinnules; **D**. spore; **E**. sterile pinnules; **F**. single pinna.

5. **Pteris confusa** T.G. Walker

P. confusa T. G. Walker, Kew Bull. 14: 329. fig. 5, 5a., pl. 5. fig. B, J. 1960; N. C. Nair & S. R. Ghosh, J. Bomb. Nat. Hist. Soc. 73: 441. 1974; R. D. Dixit, Cens. Indian Pterid. 69. 1984; S. M. Vasudeva & A. Singla, Asp. Plant Sci. 13: 332. fig. 16. 1991; N. C. Nair et al., J. Econ. Taxon. Bot. 262. 1992; Manickam & Irud., Pterid. Fl. W. Ghats 80. pl. 57. 1992; Subh. Chandra, Ferns India 35. 2000; Rajkumar & Manickam, Indian Fern J. 18: 83. 2000; Manickam & Irud., Pterid. Fl. Nilgiris 89. 2003; Easa, Biodiv. Doc. Kerala 5: 19. 2003; Pullaiah et al., Pterid. Andhra Pradesh 52. fig. 17. 2003; Sreenivas & Madhus., Proc. 22nd Kerala Sci. Congr. 866. 2010.

[Fig. 7, 9E & Plate 7, 8]

Type: Sri Lanka, Adam's Peak, 9 March 1954, *T. G. Walker T736* (Holotype, BM, digital image!).

Height 60-90 cm. Rhizome erect with tuft of stipes, 4-6 cm long, 1-10 mm thick, cylindrical, scaly. Palea brown, 2-3 mm long, lanceolate, acuminate, auriculate, thick walled cells along centre, thin walled cells at periphery. Stipe 40-50 cm long, 3-4 mm thick, green (fresh specimens) or stramineous (dry specimens) above, chestnut below, grooved, scaly below. Lamina bipinnate, 30-41 cm long x 20-30 cm broad, ovate, coriaceous. Pinnae

2-6 pairs, 14-18 cm long x 3-5 cm broad, opposite or subopposite, lanceolate, acuminate, green, basal pinnae bipartite. Pinnules 18-23 pairs, 1.8-2.2 cm long x 0.3-0.5 cm broad, oblong, margin entire, apex obtuse, sinus *c.* 2 mm away from costa, 1.5-3 mm apart, glabrous. Costae grooved with spines near the attachment site of costule, and raised below. Veins 15-16 pairs, free, forking, distinct above and below. Sori dark brown, 2.5-2.8 cm long, submarginal except at extreme apex. Indusium false, pale coloured. Sporangium: capsule globose, 220-250 μm long; stalk 330-350 μm long, biseriate; annulus 18-21 celled. Paraphyses uniseriate, 7-celled. Spores brown, *c.* 40 x 45 μm, trilete-tetrahedral, verrucate, abortive and misshapen spores are intermixed with normal spores.

Habitat: A common fern found in forests and territorial areas.

Altitude: 100m-2000m.

Distribution: India (South India: Andhra Pradesh, Karnataka, Kerala & Tamil Nadu) and SriLanka.

Chromosome number: n=58 (Manickam & Rajkumar, 1999); 2n=58 (Walker, 1958).

Etymology: Walker (1960) stated in the protologue that "source of confusion in the past in gross morphology" and so the specific epithet was derived from the confusion existing in the correct identification of the species.

IUCN status: Least concern (LC). This species commonly occurs in South India and it does not meet any criteria for Endangered, Vulnerable, *etc.* under IUCN red list category.

Notes: *Pteris confusa* is a member of *P. quadriaurita* complex, and was described by T. G. Walker (1956) from Sri Lanka and indicated that this is probably endemic to Sri Lanka and an extension to Southern India. It is closely related to *P. quadriaurita* Retz. except crenate pinnule apex and the juvenile stage is characterized by the fronds with white mottling.

P. confusa can cross with *P. multiaurita* J. Agardh or *P. quadriaurita* to form a series of morphologically different fertile hybrids, which was nicely illustrated by Walker (1958).

Rajkumar and Manickam (2000) observed the absence of auricles (accessory pinnae) in *P. confusa* from Western Ghats.

Materials examined:

ANDHRA PRADESH: Chittoor (Dt.): Talakona forest (alt. 450m), *V.K.Sreenivas 127803* (CALI); Kailashkona, *A.Ahmad 12855*; Talakona (alt. 400m), *A.M.Reddy 26456* (SKU). **Visakhapattanam** (Dt.): Galikonda (alt. 1200m), *P.Amrutha Lakshmi 25149* (CAL).

KARNATAKA: Chikmagaluru (Dt.): Belahanur (alt. 900m), *V.K.Sreenivas 124091* (CALI). **Kodagu** (Dt.): Thalecauvery (alt. 915m), *V.K.Sreenivas*

113202 (CALI); Sampage estate (alt. 700m), *V.S.Manickam 2814* (XCH). **Shimoga** (Dt.): Jog falls (alt. 1500m), *K.Satheesh Kumar 120829* (CALI).

KERALA: Ernakulam (Dt.): Neryamangalam (alt. 450m), *N.C.Nair & S.R.Ghosh 50711* (CAL). **Idukki** (Dt.): Amarachola (alt. 1950m), *V.K.Sreenivas 113260* (CALI); Way to Kumali (alt. 890m), *K.Subramanyam 8987* (MH); Kumali (alt. 750m), *N.C.Nair 40463*; Kuttikanam (alt. 1050m), *N.C.Nair 40192*; Thankamani (alt. 860m), *N.C.Nair 40417* (CAL). **Kozhikode** (Dt.): Kakkayam forest (alt. 750m), *V.K.Sreenivas 113289* (CALI). **Palakkad** (Dt.): Karappara (alt. 950m), *N.C.Nair 69844* (MH); Way to Sispara (alt. 1750m), *V.K.Sreenivas 119249*; Near Walakkad Camp shed (alt. 1300m), *V.K.Sreenivas 124002* (CALI); Valiyaparathode (alt. 850m), *N.C.Nair 65494* (CAL). **Thiruvananthapuram** (Dt.): Agasthyamala (alt. 1350m), *V.K.Sreenivas 113266 & 113275* (CALI); Chemunji (alt. 1100m), *M.Mohanan 61872* (MH); Ponmudi hills (alt. 1100m), *N.C.Nair 51749* (CAL); Chemunji (alt. 1100m), *Raju Antony 47225* (TBGT). **Wayanad** (Dt.): Chandanathode (alt. 650m), *V.K.Sreenivas 113286*; Chembra peak (alt. 1800m), *V.K.Sreenivas 113278* (CALI); Kuppadi-S. Bathery (alt. 900m), *J.L.Ellis 18533* (MH).

TAMIL NADU: Coimbatore (Dt): Valparai (alt. 500m), *V.S.Manickam 34330* (XCH). **Dindigul** (Dt.): Kodaikanal (alt. 1250m), *Habeeb 102907* (CALI). Palni hills (alt. 1200m), *V.S.Manickam 1687*; Shenbaganur-

Kodaikanal (alt. 1300m), *V.S.Manickam 1723* (XCH). **Kannyakumari** (Dt.): Deviar estate (alt. 1300m), *S.R.Sreenivasan 99151* (MH). **Nilgiri** (Dt.): Karyan Shola-Gudallur (alt. 1300m), *V.S.Manickam 1563*; Kotagiri (alt. 2000m), *V.S.Manickam 1450* (XCH); Naduvattam (alt. 1900m), *J.L.Ellis 43316*, *S.R.Sreenivasan 50585* (MH). **Salem** (Dt.): Balmadies estate, Yercaud (alt. 1333m), *K.Subramanyam 6558*; Near Shevaroyan Temple (alt. 1500m), *N.C.Nair 74220* (MH). **Tirunelveli** (Dt.): Natrikkal (alt. 1250m), *V.S.Manickam 2416*; Sengeltheri (alt. 1000m), *V.S.Manickam 2341* (XCH); Kakachi (alt. 1666m), *K.M.Sebastine 4492*; Sivagiri hills (alt. 1300m), *S.R.Sreenivasan 99178* (MH).

6. Pteris cretica L.

P. cretica L., Mant. Pl. 130. 1767; J. Agardh, Recens. Spec. Pter. 8. 1839; Hook., Sp. Fil. 2: 159. 1858; Bedd., Ferns S. India 13. pl. 39. 1863; Thwaites, Enum. Pl. Zeyl. 386. 1864; Hook. & Baker, Syn. Fil. 154. 1868; C. B. Clarke, Trans. Linn. Soc. Lond. II Bot. 1: 462. 1880; Bedd., Handb. Ferns Brit. India 106. 1883; C. V. Morton, Amer. Fern J. 47: 9. 1957; Scamman, Rhodora 63: 196. 1961; Shieh, Bot. Mag. Tokyo 79: 285. 1966; T. G. Walker, Brit. Fern Gaz. 10: 144. 1970; B. K. Nayar & S. Kaur, Comp. Bedd. Handb. 29. 1974; R. D. Dixit, Cens. Indian Pterid. 69. 1984; Manickam, Fern Fl. Palni Hills 20. 1986; S. M. Vasudeva & Chhibber, Indian Fern J. 6: 208. 1989; Manickam & Irud., Pterid. Fl. W. Ghats, 70. pl. 45. 1992; B. K. Nayar & Geev., Fern Fl. Malabar 105. 1993; Khullar, Illustr. Fern Fl. W. Himalaya 1: 261. pl. 93. 1994; Subh. Chandra, Ferns India 35. 2000; Manickam & Irud., Pterid. Fl. Nilgiris 83. 2003; Mickel & Smith, Pterid. Mexico 1: 536. 2004; Easa, Biodiv. Doc. Kerala 5: 19. 2003; S. Das, Indian Fern J. 24: 62. 2007.

[Fig. 8, 9F & Plate 9]

Type: Greece, Creta (Lectotype, LINN 1246.7, digital image!).

Pycnodoria cretica (L.) Small, Ferns Florida 91. 1931.

Plate 7. Holotype of *Pteris confusa* T. G. Walker (BM)

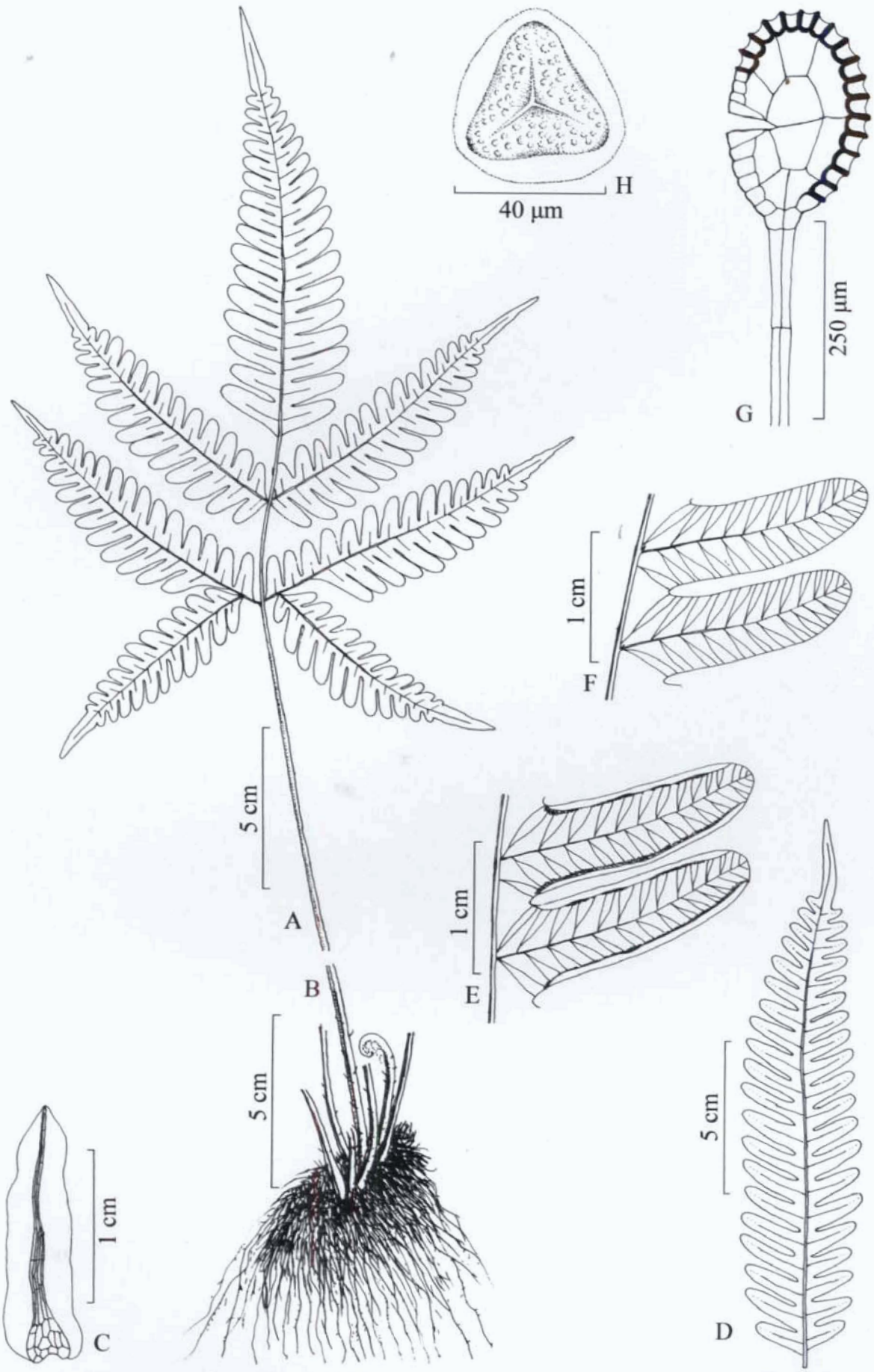


Fig. 7. ***Pteris confusa*** **T. G. Walker**: **A-B**. habit; **C**. palea; **D**. single pinna; **E**. fertile pinnules; **F**. sterile pinnules; **G**. sporangium; **H**. spore (*V.K.Sreenivas113260*, CALI)

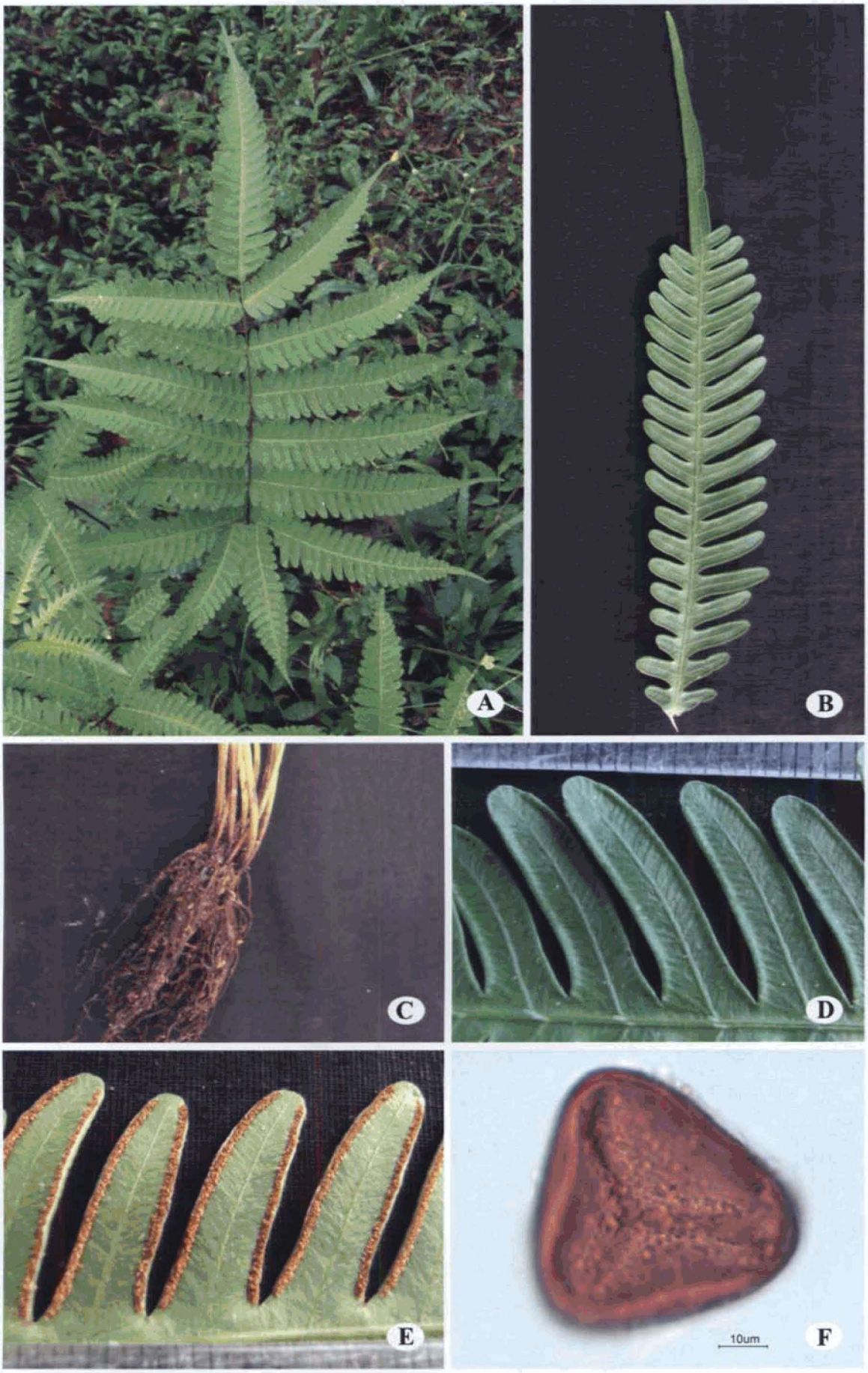


Plate 8. ***Pteris confusa*** **T.G.Walker**: **A**. habit; **B**. single pinna; **C**. rhizome; **D**. adaxial view of pinnules; **E**. fertile pinnules; **F**. spore.

Height up to 100 cm. Rhizome erect, 6-9 cm long, 5-8 mm thick, cylindrical with tuft of roots, scaly. Palea dark brown, 3-4 mm long, 0.5 mm wide at base, lanceolate, entire, acute, auriculate, uniformly thick walled cells. Stipe 45-60 cm long, 2-3 mm thick, green (fresh materials) or stramineous (dry materials) above, chestnut below, shiny, grooved, glabrous. Lamina pinnate, 30-40 cm long x 15-25 cm broad, ovate-lanceolate, green, coriaceous. Pinnae dimorphic, fertile one is narrower than sterile one, 5-6 pairs, 18-22 cm long x 1.7-2 cm broad (sterile), 12-20 cm long x 6-7 cm broad (fertile), opposite-subopposite, lanceolate, acuminate, cuneate, margin distinctly serrate, bipartite, glabrous. Costae grooved above, raised below, glabrous. Veins numerous, free, forking at the base of midrib. Sori brown, 10-17 cm long, submarginal except at apex. Indusium false, brown. Sporangium: capsule globose, 200-250 μm long; stalk 200-300 μm long, biseriate, annulus 17-20 celled. Paraphyses uniseriate. Spores brown, *c.* 45 x 55 μm, trilete-tetrahedral, verrucate.

Habitat: A rare species present only in moist evergreen forest above 1300m.

Altitude: 1300m-2100m.

Distribution: Australia, China, India (South India: Tamil Nadu), Islands of Mediterranean Sea, Japan, Madagascar, Nepal, North and South America, Philippines and Taiwan.

Chromosome number: n= 87 (Irudayaraj & Manickam, 1987).

Common name: Cretan Brake.

Economic importance: Fronds used as antibacterial agent (Singh, 1999).

Etymology: the specific epithet derived from its type locality 'Crete', an Island in Greece.

IUCN status: Endangered (EN). This taxon is currently known from Nilgiri Hills, Palni Hills and Shevaroy Hills in South India and prefer moist high altitude habitat. It meets the criteria EN B1ac(ii)+2a under Endangered category.

Notes: Linnaeus (1753) described this species based on specimens from Crete and Elba Islands of Mediterranean Sea. Margin and apex of sterile pinnae and sterile portion of fertile pinnae are distinctly serrate in this species.

This is a rare species present in wet evergreen forests above 1300m. In south India, *P. cretica* is present in forests of Dindigul, Nilgiri and Salem districts of Tamil Nadu.

Punetha *et al.* (2007) discussed the unusual frond of *P.cretica*, in which one side of rachis bear sterile pinnae and other side is having fertile pinnae.

Materials examined:

TAMIL NADU: **Dindigul** (Dt.): Bear Shola-Kodaikanal (alt. 2300m), *V.S.Manickam 187* (RHT); Gundur shola (alt. 2100m), *V.S.Manickam & K.M.Mathew 32597* (RHT, XCH); Palni hills-Kodaikanal (alt. 2250m), *V.S.Manickam & K.M.Mathew* (XCH). **Nilgiri** (Dt.): Way to Avalanche (alt. 2100m), *V.K.Sreenivas 119231 & 124083*; Avalanche-Ooty (alt. 2100m), *Santhosh Nampy 48812*; *Habeeb 102844* (CALI); Avalanche forest (alt. 2100m), *V.S.Manickam 892*; Coonoor (alt. 1300m), *V.S.Manickam 1318*; Dodabetta road (alt. 2250m), *V.S.Manickam 397*; Kotagiri- Ootty (alt. 2100m), *V.S.Manickam 726*; Near Parson Valley (alt. 2300m), *V.S.Manickam 298*; Pykara (alt. 2000m), *V.S.Manickam 0041*; Rockland forest (alt. 2100m), *V.S.Manickam 944*; Thalakunda (alt.2300m), *V.S.Manickam 0043* (XCH); Bikkapattimundu (alt. 1950m), *G.V.Subbarao 40486*; Bison swamp (alt. 2300m), *B.V.Shetty 34191*; Doddabetta (alt. 2250m), *M.K.Janarthanam 83020*; Hosakkadi (alt. 2030m), *J.L.Ellis 34478*; Kotagiri- Ooty road (alt. 2000m), *B.D.Deb 31538 & E.Vajravelu 35189* (MH); Ooty (alt. 2000m), *C.B.Clarke 11492A*; *H.C.Levinge s.n.*; *G.King s.n.* (CAL). **Salem** (Dt): Brooklyn (alt. 1587m), *K.Subramanyam 6566*; Shevaroy hills (alt. 1300m), *Ghatak s.n.* (CAL).

Pteris cretica var. albolineata Hook.

P. cretica var. *albolineata* Hook., Bot. Mag. 86: Pl. 5194. 1860; T. G. Walker, Brit. Fern Gaz. 10:144. 1970; Graf., Exotica, Ser.4. 1159. 1985.

[Plate 10]

Height up to 50 cm. Rhizome short, creeping, 4-5 cm long, 4-6 mm thick, cylindrical with tuft of shoots, scaly. Scales brown, 1.5-2 mm long, 0.4- 0.5 mm wide at base, lanceolate, entire, acuminate, auriculate, uniformly thick walled cells. Stipe 12-20 cm long, 1-2 mm thick, green, stramineous (dry specimens) above, chestnut below, shiny, grooved, glabrous. Lamina pinnate, 12-20 cm long x 5-8 cm broad, ovate-lanceolate, green, subcoriaceous. Pinnae dimorphic, 1-2 pairs, 4-7 cm long x 1-1.5 cm broad (sterile), opposite, ovate-oblong, cuneate, acute-acuminate, margin distinctly serrate, glabrous, green above with white band along either side of midrib, basal pair bipartite, Costa grooved above, raised below. Veins numerous, free, forking.

Habitat: Seen as cultivated fern in Gardens.

Altitude: Sea level-700m.

Distribution: England, India (South India: Kerala) and Indonesia.

Chromosome number: n= 87 (Walker, 1962).

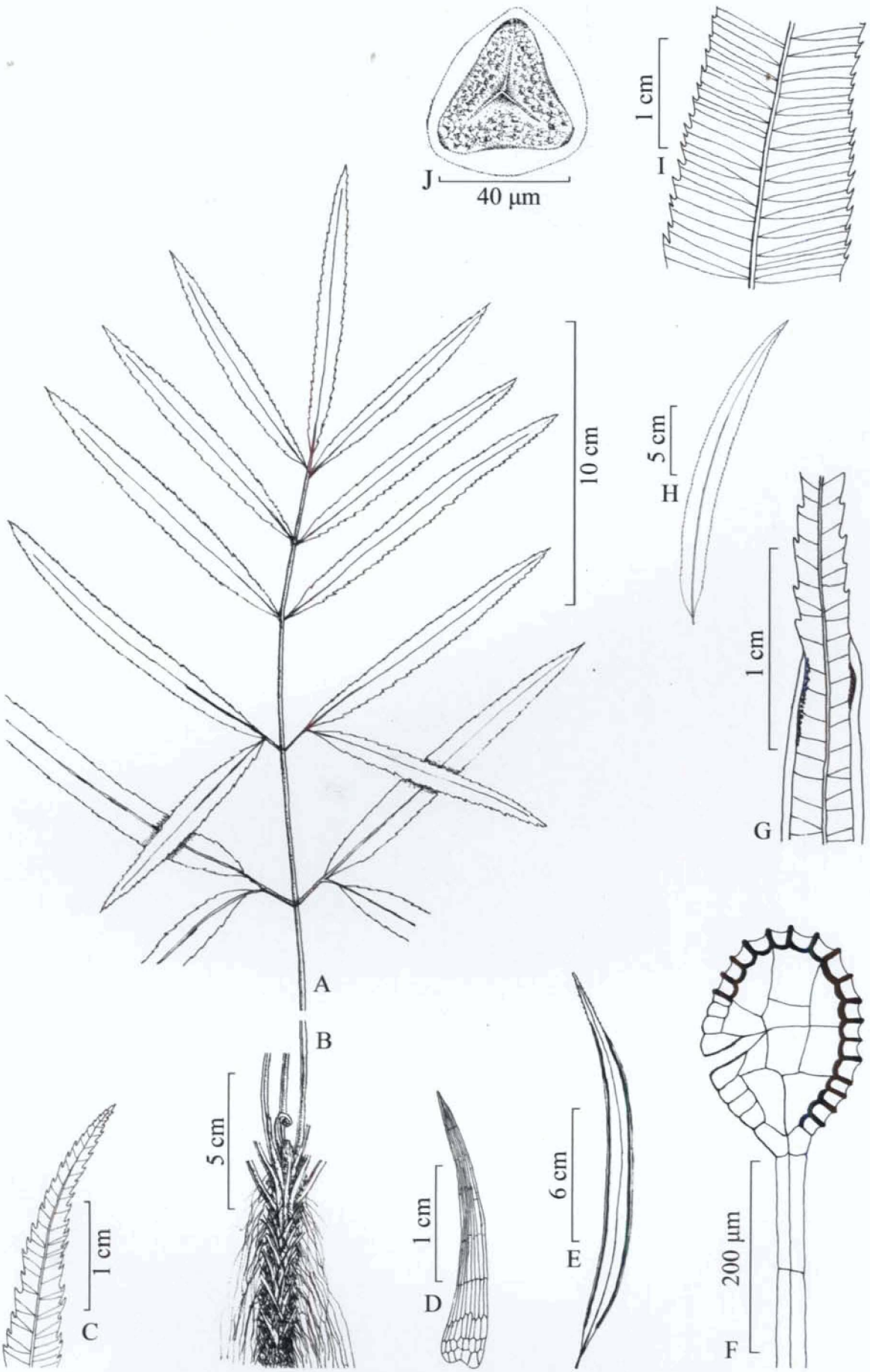


Fig. 8. ***Pteris cretica*** **L.**: **A-B**. habit; **C**. pinna apex; **D**. palea; **E**. fertile pinna; **F**. sporangium; **G**. portion of fertile pinna enlarged; **H**. sterile pinna; **I**. a portion of sterile pinna; **J**. spore (*V.K.Sreenivas 119231*, CALI).

Plate 9. ***Pteris cretica*** **L.**: **A**. habit; **B**. rhizome; **C**. a portion of sterile pinna; **D**. a portion of fertile pinna; **E**. pinna apex; **F**. single pinna; **G**. spore.

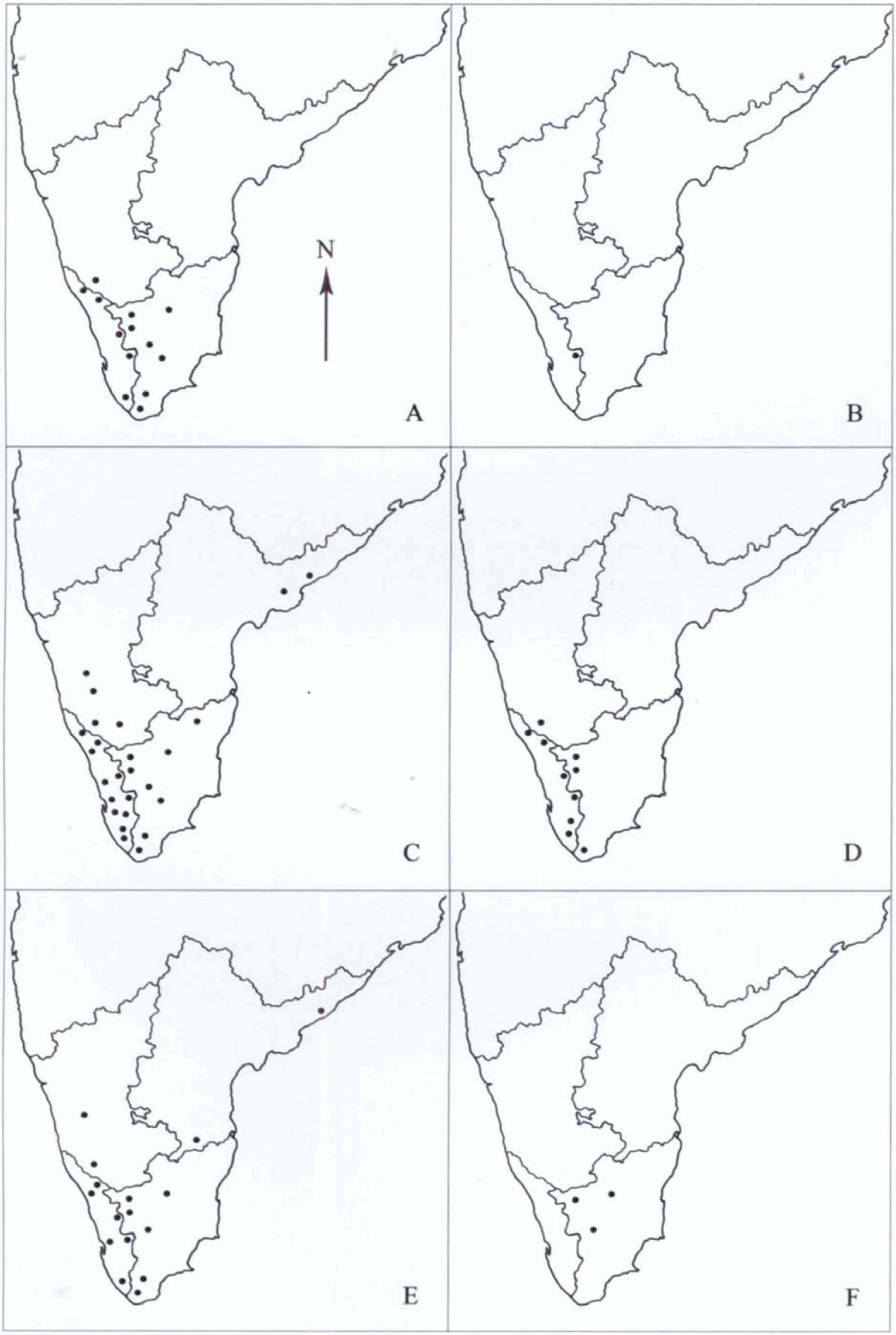


Fig. 9. Distribution of the genus *Pteris* in South India: **A**. *P. argyraea*; **B**. *P. arisanensis*; **C**. *P. biaurita*; **D**. *P. blumeana*; **E**. *P. confusa*; **F**. *P. cretica*.

Common name: White striped Brake.

Economic importance: This variety is cultivated as an ornamental fern.

Note: This fern was collected from Gurukula Botanical Sanctuary, Periya, Wayanad. Fertile specimens are not available for the present study.

Materials examined:

KERALA: Wayanad (Dt.): Gurukula Botanical Sanctuary, Periya (alt. 700m), *V.K.Sreenivas 119220* (CALI).

Plate 10. ***Pteris cretica* var. *albolineata* Hook.**

7. **Pteris ensiformis** Burm.f.

P. ensiformis Burm.f., Fl. Ind. 230. 1768; C. B. Clarke, Trans. Linn. Soc. Lond. II, Bot. 1: 463. 1880; Bedd., Handb. Ferns. Brit. India 107. 1883; C. V. Morton, Amer. Fern J. 47: 10. 1957; Shieh, Bot. Mag. Tokyo 79: 286. 1966; Holttum, Rev. Fl. Malaya 2: 399. 1968; T. G. Walker, Brit. Fern Gaz. 10: 147. 1970; B. K. Nayar & S. Kaur, Comp. Bedd. Handb. 29. 1974; R. D. Dixit, Cens. Indian Pterid. 69. 1984; S. M. Vasudeva & Chhibber, Indian Fern J. 6: 207. 1989; N. C. Nair et al., J. Econ. Taxon. Bot. 263. 1992; B. K. Nayar & Geev., Fern Fl. Malabar 108. 1993; Subh. Chandra, Ferns India 37. 2000; Easa, Biodiv. Doc. Kerala 5: 20. 2003; Ghosh et al., Pterid. Fl. E. India 1, Ser. 4: 334. 2004; S. Das, Indian Fern J. 24: 62. 2007; Fras.-Jenk., Taxon. Rev. Indian Subcont. Pterid. Rev. Cens. List 102. 2008; Mahamuni & Dongare, Indian Fern J. 26: 140. 2009; Sreenivas & Madhus., Proc. 22nd Kerala Sci. Congr. 866. 2010.

[Fig. 10, 16A & Plate 11]

Type: Philippines, Luzon, *Cuming 410* (Isotype, CAL!; Isotype, K & Z, digital image!).

Pteris crenata Sw., Syn. Fil. 96 & 290. 1806; J. Agardh, Recens. Spec. Pter. 14. 1839; Hook., Sp. Fil. 2: 163. t.127 A. 1858; Bedd., Ferns S. India 12. pl. 34. 1863; Thwaites, Enum. Pl. Zeyl. 386. 1864; Hook. & Baker, Syn. Fil. 155. 1868.

Height 30-45 cm. Rhizome short, creeping, 3-5 cm long, 2-4 mm thick, cylindrical, scaly. Palea brown, 2-3 mm long, 0.4-0.6 mm wide at base, lanceolate, acuminate, entire, thick walled cells. Stipe 10-15 cm long, 2-3 cm thick, dark green (live specimens) or stramineous (dry specimens), quadrangular, slightly grooved, glabrous above, scaly below. Lamina pinnate, dimorphic, 15-25 cm long x 10-16 cm broad, ovate to deltoid, membranaceous. Pinnae 3-5 pairs, terminal pinnae larger than lateral pinnae; lateral pinnae 9-10 cm long x 4-5 mm broad (fertile), 7-9 cm long x 2-3 mm (sterile), opposite or subopposite, lanceolate-ensiformis, apex acute-acuminate, crenate-crenulate, green above, pale green below, pinna more or less adnate to rachis, lower pinnae deeply lobed, ovate, lobes up to 5 pairs, glabrous. Costa grooved above and below, glabrous. Veins numerous, free, and forking. Sori brown 2.5-8.5 cm long, submarginal except at base and apex. Indusium false, white. Sporangium: capsule globose, 300-350μm long; stalk 200-250 μm, biseriate; annulus 17-20 celled. Paraphyses uniseriate. Spores brown, *c.* 45 x 50μm, trilete-tetrahedral, verrucate.

Habitat: Usually seen in fully shaded areas to partially shaded areas of forests.

Altitude: 350m-2000m.

Distribution: Australia, Borneo, China, India (South India: Andhra Pradesh, Kerala & Tamil Nadu), Malaysia, Philippines and Sri Lanka.

Chromosome number: n= 58 (Walker, 1962; Goldblatt & Johnson, 1991).

Common name: Sword Brake.

Economic importance: Fronds are astringent, and decoction is anti-dysenteric. Rhizome juice is used in glandular swelling (Singh, 1999; Ghosh *et al.*, 2004). This species is also cultivated as ornamental fern.

Etymology: The specific epithet derived from the Latin word 'ensiformis' (= sword like). Its sword shaped pinnae gave the specific epithet.

IUCN status: Endangered (EN). This taxon is currently known from 3-4 locations in South India. But it is cultivated as an ornamental plant in many gardens as well as houses due to its charming frond architecture. This taxon meets the criteria EN B1a2ac(iv)D under endangered category.

Notes: Agardh (1839) reported this species from Travancore and Cochin of South India as *P. crenata* Sw. Manickam *et al.* (2004a), reported this species from Kannyakumari district of Tamil Nadu as a new distributional record, but no voucher specimen is available at XCH.

Materials examined:

ANDHRA PRADESH: Visakhapattanam (Dt.): Minumuluru (alt. 1000m), *G.V.Subbarao 30060* (MH).

KERALA: Thiruvananthapuram (Dt.): Nedumangadu (alt. 350m), *V.K.Sreenivas 124058*; TBGRI Fern House (alt. 550m), *V.K.Sreenivas 124056* (CALI). Trivandrum-1 (alt. 125m), *M.Mohanan 52786* (MH, CAL); Trivandrum Zoo (alt. 125m), *M.Mohanan 63365* (MH). **Wayanad** (Dt.): Gurukula Botanical Sanctuary, Periya (Cult.) (alt. 700m), *V.K.Sreenivas 113299* (CALI).

TAMIL NADU: Nilgiri (Dt.): Nilgiri hills (alt. 2000m), *G.King s.n.* (CAL).

Pteris ensiformis var. victoriae Baker

P. ensiformis var. *victoriae* Baker, Gard. Chron. Ser. 37: 756. 1890; T. G. Walker, Brit. Fern Gaz. 10: 147. 1970; Graf., Exotica, Ser.4. 1161. 1985; S. M. Vasudeva & A. Singla, Asp. Plant Sci. 13: 338. 1991.

[Plate 12]

Height 50-65 cm. Rhizome short, creeping, 5-6 cm long, 3-4 mm thick, cylindrical, scaly. Palea pale brown, 2-3 mm long, 0.4-0.5 mm wide at base, lanceolate, entire, apex acuminate, auriculate, thick walled cells. Stipe 20-25 cm long, 1-2 mm thick, stramineous, chest nut at extreme base, quadrangular, slightly grooved, glabrous above, scaly below. Lamina pinnate, dimorphic, 30-40 cm long x 20-25 cm broad, ovate, membranaceous, fertile one narrower than sterile one. Pinnae 3-4 pairs, subopposite, terminal pinnae larger than lateral ones; lateral pinnae 14-16 cm long x 4-5 mm broad, lanceolate (fertile), 3-6cm long x 5-9 mm (sterile), apex acute-acuminate, serrulate, glabrous, lower pinnae deeply lobed, lobes up to 5 pairs, green above with white band along either side of midrib, pale green below. Costae grooved above and raised below, glabrous. Veins numerous, free, forking. Sori brown 10-12 cm long, linear, submarginal except base and apex. Indusium false, white. Sporangium: capsule globose, 200-300 μm long; stalk, 200-250 μm, biseriate; annulus 20-22 celled. Paraphyses uniseriate. Spores brown, *c.* 35 x 40μm, trilete-tetrahedral, abortive and misshapen spores.

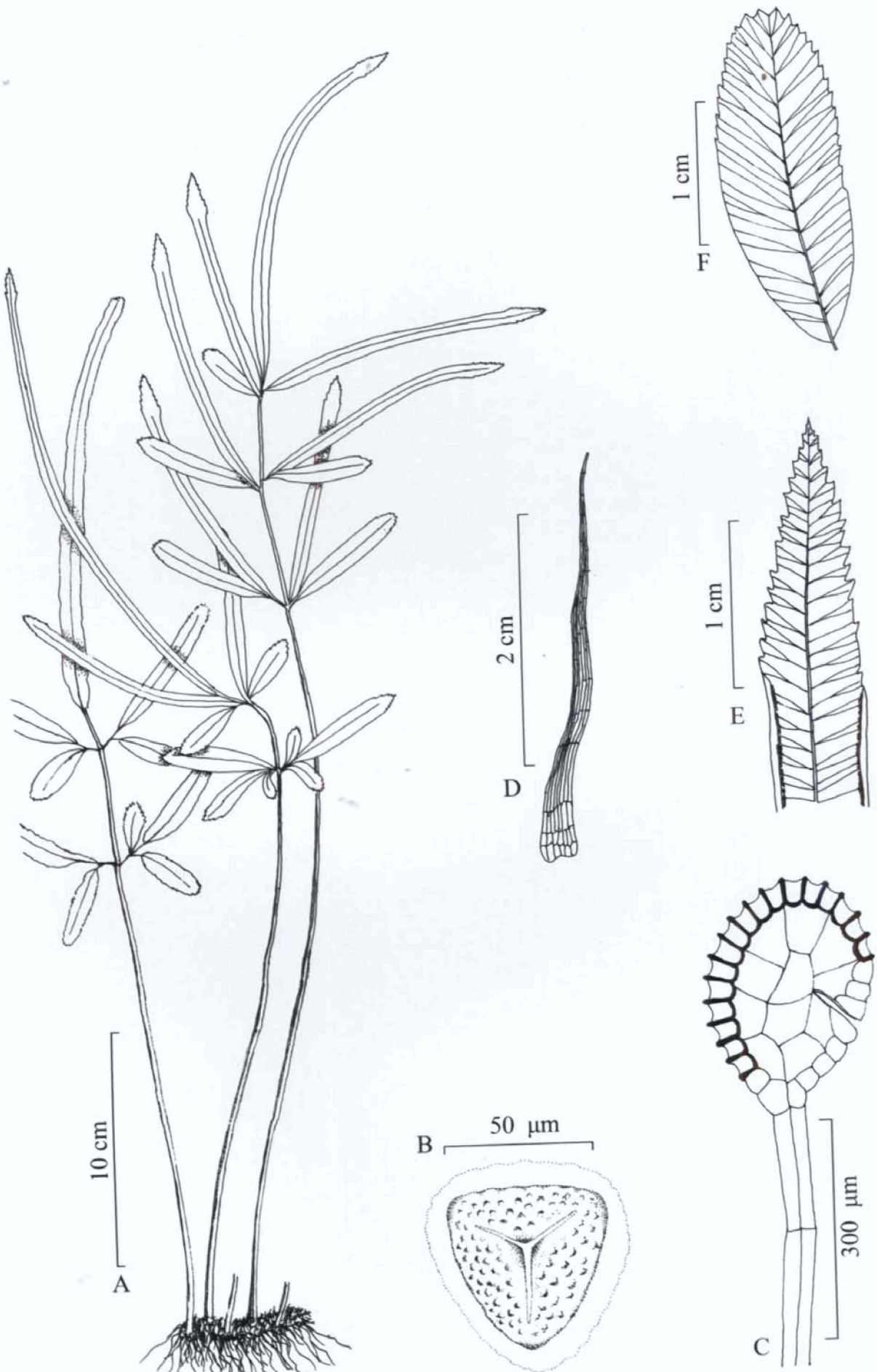


Fig. 10. ***Pteris ensiformis*** **Burm. f.**: **A**. habit; **B**. spore; **C**. sporangium; **D**. palea; **E**. a portion of fertile pinna; **F**. sterile pinna (*V.K.Sreenivas124058*, CALI).

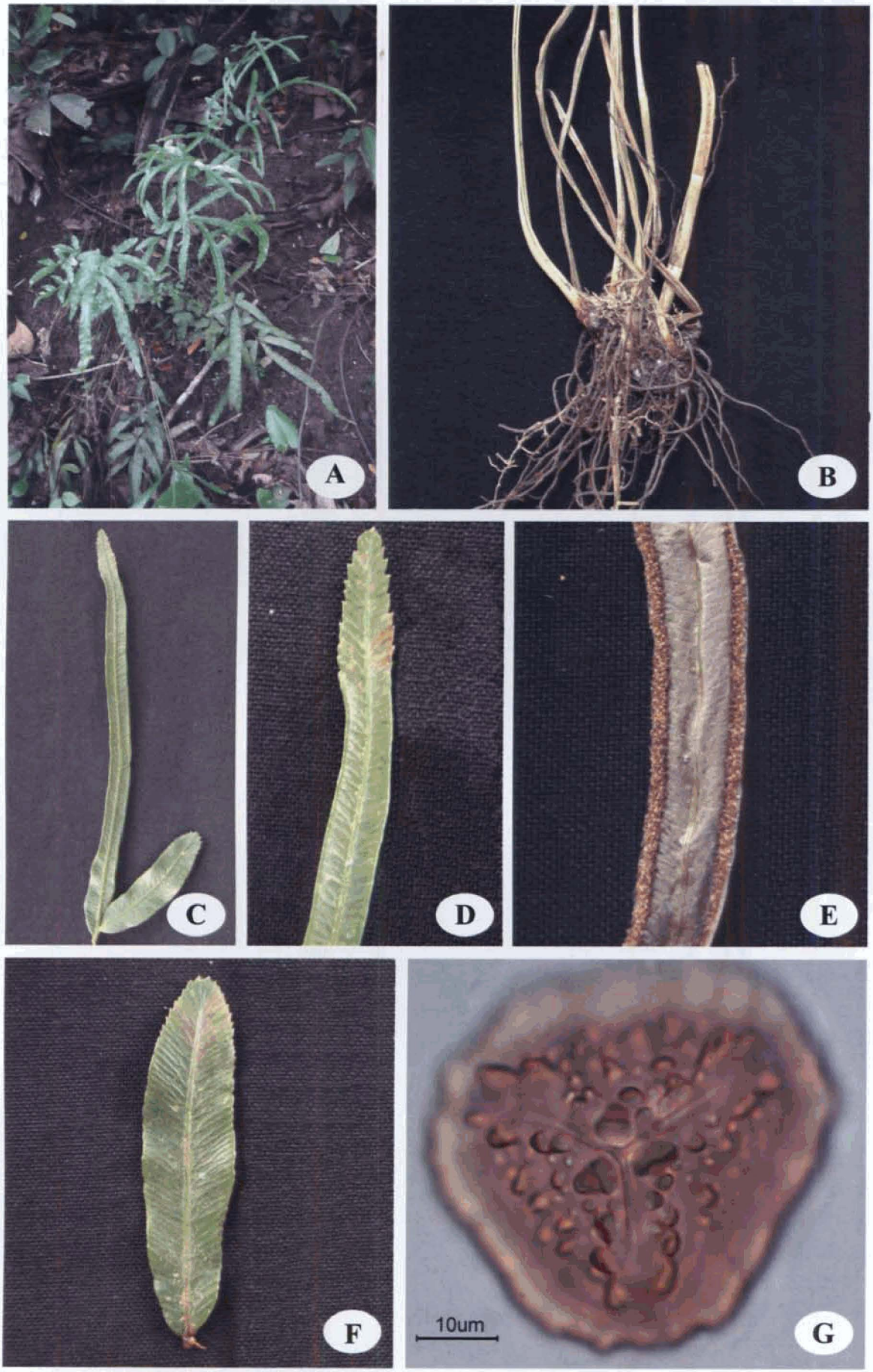


Plate 11. ***Pteris ensiformis*** **Burm. f.**: **A**. habit; **B**. rhizome; **C**. single pinna with accessory pinna; **D**. pinna apex; **E**. a portion of fertile pinna; **F**. sterile pinna; **G**. spore.

Habitat: Usually seen as a cultivated plant in gardens.

Altitude: Sea level-1100m.

Distribution: Australia, China, England, India (South India: Karnataka and Kerala), Java, Malaysia, Philippines and Polynesia.

Chromosome number: 2n= 87 (Jha & Sinha, 1987).

Economic importance: Cultivated as an ornamental fern.

Etymology: This variety named after the Queen Victoria of England.

Materials examined:

KARNATAKA: Dakshina Kannada (Dt.): Mangalore University Garden (alt. sea level), *P.K.Rajagopal s.n.* (MGMC).

KERALA: Malappuram (Dt.): Calicut University Campus (alt. 50m), *V.K.Sreenivas 124074* (CALI). **Kottayam** (Dt.): Changanassery (alt. 30m), *N.C.Nair 833* (CAL). **Pathanamthitta** (Dt.): Pampanada (alt. 600m), *N.C.Nair 855* (CAL). **Thiruvananthapuaram** (Dt.): Rest house garden-Ponmudi (alt. 1050m), *N.C.Nair 51046* (CAL).

8. **Pteris geminata** Wall. ex J. Agardh

P. geminata Wall. ex J. Agardh, Recens. Spec. Pter. 31. 1839; B. K. Nayar & S. Kaur, Comp. Bedd. Handb. 31. 1974; R. D. Dixit, Cens. Indian Pterid. 70. 1984; N. C. Nair & Bhargavan, J. Econ. Taxon. Bot. 6: 268. 1985; N. C. Nair et al., J. Econ. Taxon. Bot. 264. 1992; Subh. Chandra, Ferns India 37. 2000; Easa, Biodiv. Doc. Kerala 5: 20. 2003; Subh. Chandra et al., Taiwania 53: 187. 2008; Sreenivas & Madhus., Proc. 22nd Kerala Sci. Congr. 867. 2010.

[Fig. 11, 16B & Plate 13]

Type: Nepal, *Wallich 2180* (CAL!; CALI, Microfishe!).

Campteria kleiniana C. Presl, Tent. t 5, f 19. 1836; Bedd., Handb. Ferns. Brit. India, 116. fig. 60. 1883.

C. anamallayensis Bedd., Ferns S. India 14. pl. 45. 1863.

Type: India, Anamallays, *Beddome s.n.* (Isotype, MH!).

C. biaurita var. *geminata* (Wall.) C. B. Clarke, Trans. Linn. Soc. Lond. II, Bot. 1: 469. 1880.

Pteris kleiniana Christ, Bull. Boiss. 4: 666. 1896; C. Chr., Ind. Fil. 600. 1906; Manickam & Irud., Pterid. Fl. W. Ghats 74 pl. 50. 1992.

Plate 12. ***Pteris ensiformis*** **var. *victoriae* Baker**: **A**. habit; **B**. a portion of ferile pinna; **C**. fertile pinna; **D**. rhizome; **E**. sterile pinna; **F**. spore.

Height 60-70 cm. Rhizome erect to suberect, 4-6 cm long x 4-6 cm thick, cylindrical with tuft of stipes, scaly. Palea light brown, 3-5 mm long, 0.4-0.6 mm wide at base, lanceolate, entire, acuminate, auriculate, thin uniformly. Stipe 45-55cm long, 3-6 mm thick, green (fresh specimens) or stramineous (dry materials) above and chestnut below, grooved throughout, glabrous above, scaly below. Lamina bipinnate, 35-45 cm long x 25-30 cm broad, ovate, basal pair bipartite, herbaceous (thin). Pinnae 5-7 pairs, 20-25 cm long x 4-6 cm broad, opposite, ovate, acute, basal pinna bipartite, green, and glabrous. Pinnules 16-23 pairs, 30-50 cm long x 3-9 mm broad, oblong, acute, crenate (sterile), only apex is crenate in fertile ones, sinus *c.* 3 mm away from costa, 2 mm apart, glabrous. Costae grooved above with short inconspicuous spines at the near the base of costules, and raised below. Veins 13-16 pairs, free, forking, distinct, lower pair of veins form costal areoles along midrib, veins ending submarginally in hydathodes. Sori brown, linear, crowded, 1.2-2 cm long, submarginal except at base and apex. Indusium false, brown at maturity. Sporangium: capsule globose, 200 μm long; stalk 250 μm long, biseriate; annulus 18-22 celled. Paraphyses uniseriate. Spores brown, *c.* 45 x 50 μm, trilete-tetrahedral, rugate.

Habitat: A rare species present only in moist evergreen forests at higher altitude.

Altitude: 800m-2300m.

Distribution: Australia, China, India (South India: Kerala & Tamil Nadu) and Japan.

Etymology: The specific epithet derived from a Latin word 'geminatus' (= paired). Its lower pinnae bear paired auricles (accessory pinnae) and hence the name geminata.

IUCN status: Endangered (EN). This taxon is present in Silent Valley National Park and Periyar Tiger reserve of Kerala, and Anamalay hills, Nilgiri hills and Kalakkad hills of Tamil Nadu. The population is also very narrow when compared with other species of *Pteris*. It meets the criteria EN B1ac(ii,iv)+2aD under Endangered category.

Notes: Wallich (1828) catalogued this species from 'India orientalis' without description, later Agardh (1839) validly published this species. *P. geminata* Wall. ex J. Agardh is characterized by its veins ending in hydathodes (not reaching in the margin). The sterile pinnule and apex of the fertile pinnule is crenate and lower pair of veins united to form costal areoles along midrib.

Nair and Bhargavan (1985) reported this species from Silent Valley National Park as a new record to Kerala. But subsequent expedition for collecting the same species to that area was not fruitful. *P. geminata* has been reported from Palakkad and Idukki district of Kerala, and Coimbatore, Nilgiri and Tirunelveli districts of Tamil Nadu so far. The population of this species

is very narrow and Chandra *et al.*, (2008) included this species in 'At Risk' category.

P. geminata is related to *P. biaurita* L. in having costal areoles along the midrib of pinnae. But, other morphological characters such as margin, vein endings, texture differ with *P. biaurita*.

Materials examined:

KERALA: Palakkad (Dt.): Panthenthode SVNP (alt. 800m), *B.K.Nayar & Party 10683* (CALI); *N.C.Nair 56857* (MH). **Idukki** (Dt.): Near Injippara-PTR (alt. 900m), *V.K.Sreenivas 124025*; Upper Manalar-PTR (alt. 1750m), *Jomy Augustine 13228*; Thamara-PTR (alt. 1100m), *K.P.Rajesh 18322*; Vellimala- PTR (alt. 1500m), *K.P.Rajesh 62892* (CALI).

TAMIL NADU: Coimbatore (Dt.): Sholayar-Anamalai (alt. 800m), *V.S.Manickam 34698* (XCH); Anamallay (alt. 1500m), *R.H.Beddome s.n.*; Varadimalai-Bolempetti hills (alt. 1350m), *C.E.C.Fisher 2748* (CAL). **Nilgiri** (Dt.): Ell hills (alt. 2300m), *V.Irudayaraj 0026* (XCH). **Tirunelveli** (Dt.): Kalakkad hills (alt 1200m), *V.S.Manickam 31274*; Sengeltheri (alt. 1000m), *V.S.Manickam & K.M.Mathew 34068* (RHT, XCH); Kakachi forest (alt. 1250m), *V.S.Manickam 2379* (XCH).

9. **Pteris gongalensis** T.G. Walker

P. gongalensis T. G. Walker, Kew Bull. 14: 328, fig. 4, 4a, pl. 5, fig. A, G. 1960. N. C. Nair & S. R. Ghosh, J. Bomb. Nat. Hist. Soc. 73: 441. 1976; R. D. Dixit, Cens. Indian Pterid. 70. 1984; S. M. Vasudeva & A. Singla, Asp. Plant Sci. 13: 335. fig. 22-24. 1991; N. C. Nair et al., J. Econ. Taxon. Bot. 261. 1992; Subh. Chandra, Ferns India 38. 2000; Rajkumar, Indian Fern J. 111. 2002; Manickam & Irud., Pterid. Fl. Nilgiris 88. 2003; Sreenivas & Madhus., Proc. 22nd Kerala Sci. Congr. 867. 2010.

[Fig. 12, 16C & Plate 14, 15]

Type: Sri Lanka, Gongala Hills, March 1954, *T.G.Walker T756* (Holotype, BM, digital image!).

Height 30-40 cm. Rhizome short, suberect, 2.5-4 cm long, 4-6 mm thick, cylindrical with tuft of roots, scaly. Palea brown, *c.* 3 mm long, lanceolate, acuminate, auriculate, central thick walled cells and outer thin walled cells with cellular projections. Stipe 16-25 cm long, 2-3 mm thick, green (fresh specimens) or stramineous (dry specimens), grooved, scaly below. Lamina bipinnate, 20-22 cm long x 18-20 cm broad, deltoid, subcoriaceous. Pinnae 3-4 pairs, 6-11 cm long x 2-3 cm broad, lanceolate, opposite or subopposite, green, basal pairs bipartite. Pinnules 13-16 pairs,

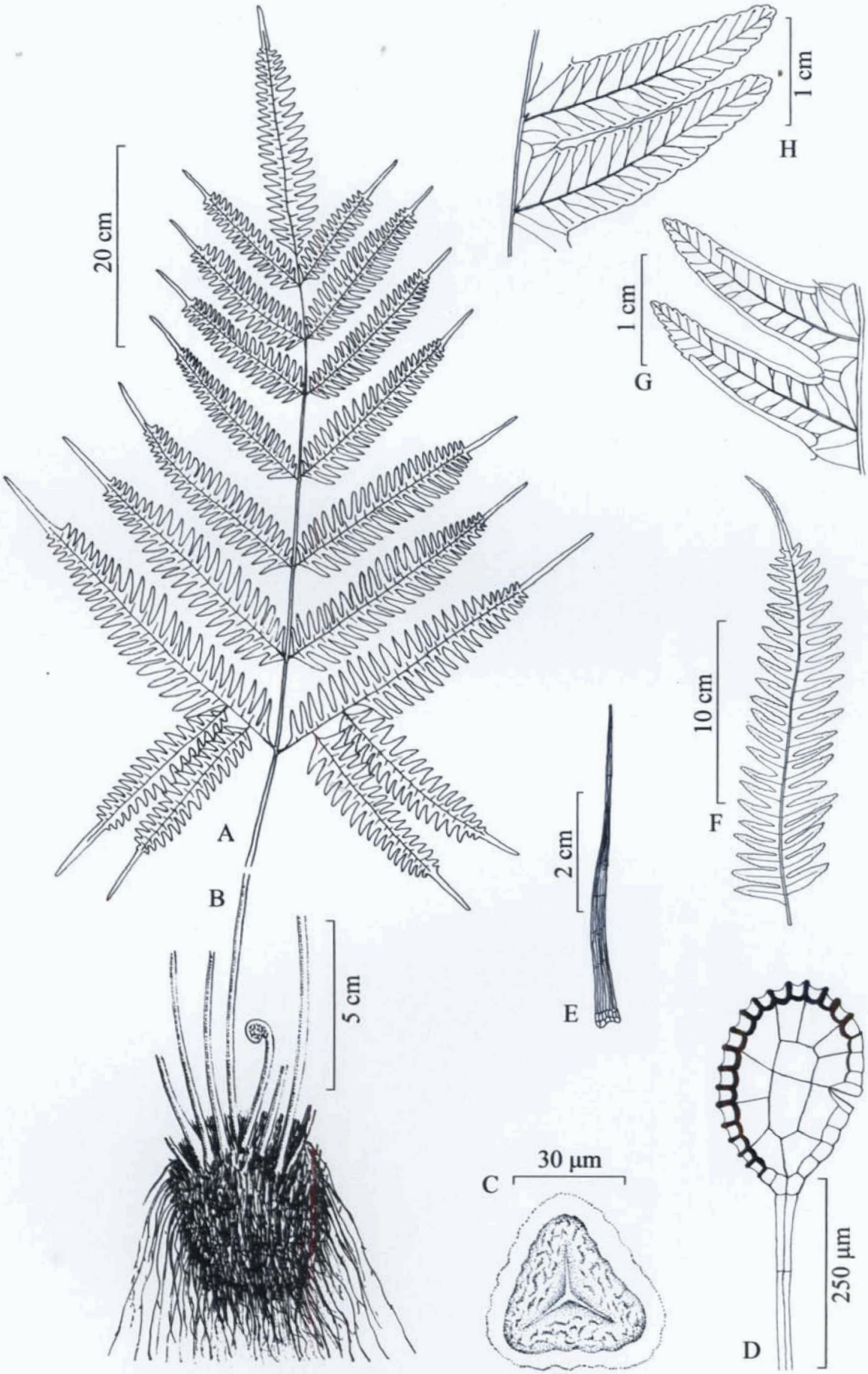


Fig. 11. ***Pteris geminata*** **Wall. ex J. Agardh**: **A-B**. habit; **C**. spore; **D**. sporangium; **E**. palea; **F**. pinna; **G**. fertile pinnules; **H**. sterile pinnules (*V.K.Sreenivas124025*, CALI).

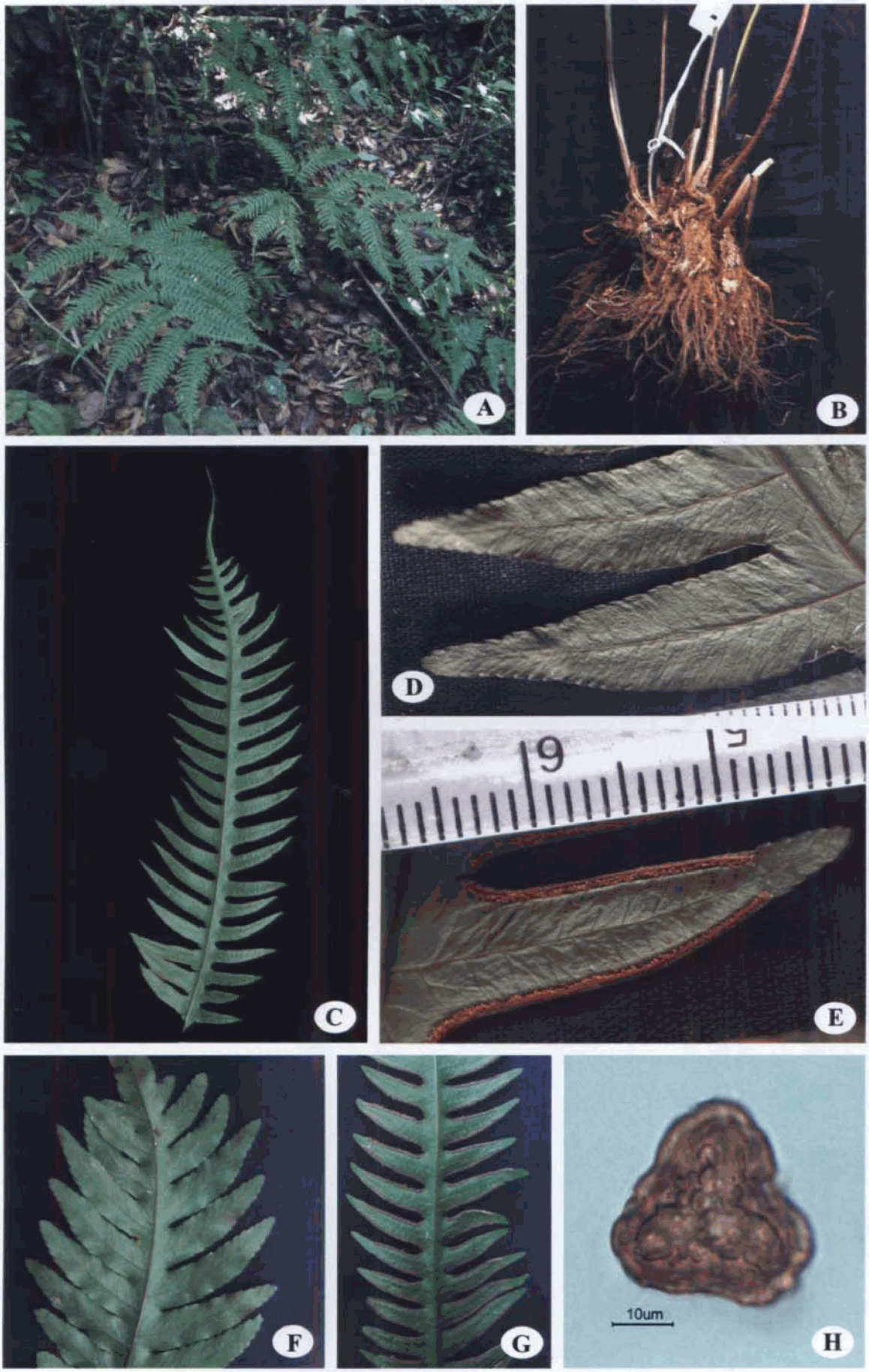


Plate 13. ***Pteris geminata*** **Wall. ex J. Agardh**: **A**. habit; **B**. rhizome; **C**. single pinna; **D**. sterile pinnules; **E**. fertile pinnule; **F**. sterile pinna; **G**. fertile pinna; **H**. spore.

1-1.5 cm long x 4-5 mm broad, oblong, entire, acute, sinus *c.* 1 mm away from costa, *c.* 1 mm apart, inconspicuous spinules present. Costae grooved above with conspicuous spines, and raised below. Veins 10-13 pairs, free, forking. Sori brown, 8-12 mm long, submarginal except at base and apex. Indusium false, brown at maturity. Sporangium: capsule globose, 200-250 µm long; stalk 150-200 µm long, biseriate; annulus 16-18 celled. Paraphyses uniseriate. Spores brown, *c.* 40 x 45 µm, trilete-tetrahedral, verrucate.

Habitat: Seen in fully exposed or partially exposed areas.

Altitude: 10m-1200m.

Distribution: India (South India: Andhra Pradesh, Kerala & Tamil Nadu) and Sri Lanka.

Chromosome number: n= 87 (Walker, 1962).

Etymology: Specific epithet derived from the type locality 'Gongala Hills', in Sri Lanka.

IUCN status: Vulnerable (VU). The distribution of this taxon is narrow in South India and it meets the criteria VU B1a2ac(iv) under Vulnerable category.

Notes: Walker (1960) described this species from Gongala Hills, Sri Lanka as a member of *Pteris quadriaurita* group. *P. gongalensis* is characterized by its deltoid lamina, inconspicuous spinules and regular arrangement of pinnae.

Moreover, this species is smaller than other members of *P. quadriaurita* complex. Walker described this species as endemic to Sri Lanka; however, Nair and Ghosh (1974) reported it from Kerala.

Materials examined:

ANDHRA PRADESH: Chittoor (Dt.): Japalathir dam site (alt. 1100m), *K.Subramanyam 7865* (MH).

KERALA: Idukki (Dt.): Thankamani (alt. 800m), *N.C.Nair 40755* (CAL). **Malappuram** (Dt.): C.U. campus (alt. 50m), *M.P.Ravindra Kumar 24712* (CALI). **Palakkad** (Dt.): Kariyilathode (alt. 526m), *V.K.Sreenivas 113227*; Panthenthode (alt. 800m), *V.K.Sreenivas 119268* (CALI). **Pathanamthitta** (Dt.): Vennikulam (alt. 100m), *N.C.Nair & S.R.Ghosh 50845* (CAL). **Wayanad** (Dt.): Tirunelly (alt. 800m), *V.K.Sreenivas & V.P.Thomas 119280* (CALI).

TAMIL NADU: Tirunelveli (Dt.): Sengaltheri-Natrikkal (alt. 1200m), *V.S.Manickam 2432* (XCH); Kannikatty (alt. 830m), *K.M.Sebastine 9621* (MH).

10. Pteris heteromorpha Fee

P. heteromorpha Fee, Gen. fil. 127. 1852; Hook., Sp. Fil. 2: 166. t. 127 B. 1858; Hook. & Baker, Syn. Fil. 156. 1868; B. K. Nayar & S. Kaur, Comp. Bedd. Handb. 29. 1974; N. C. Nair & R. K. Ghosh, Indian Forester 374. 1978; R. D. Dixit, Cens. Indian Pterid. 70. 1984; S. M. Vasudeva & Chhibber, Indian Fern J. 6: 209. 1989; Subh. Chandra, Ferns India 38. 2000; Manickam et al., J. Bomb. Nat. Hist. Soc. 102: 378. 2005; Manickam & Benniamin, J. Econ. Taxon. Bot. 455. 2007; Subh. Chandra et al., Taiwania 53: 188. 2008; R. Antony, J. Econ. Taxon. Bot. 428. 2009; Sreenivas & Madhus., Proc. 22nd Kerala Sci. Congr. 867. 2010.

[Fig. 13, 16D & Plate 16]

Type: Philippines, Luzon, *Cuming 409* (Holotype, K, digital image!; Isotype, CAL!; Z, digital image!).

Pteris cretica var. *heteromorpha* Bedd. Handb. Ferns. Brit. India, 106. 1883.

Pteris almeidiana Bole & Almeida, J. Bomb. Nat. Hist. Soc. 74: 320. 1977. ***syn. nov.***

Type: India, Bombay Presidency, Savantwadi, *M.R.Almeida 1272* (Holotype, BLAT).

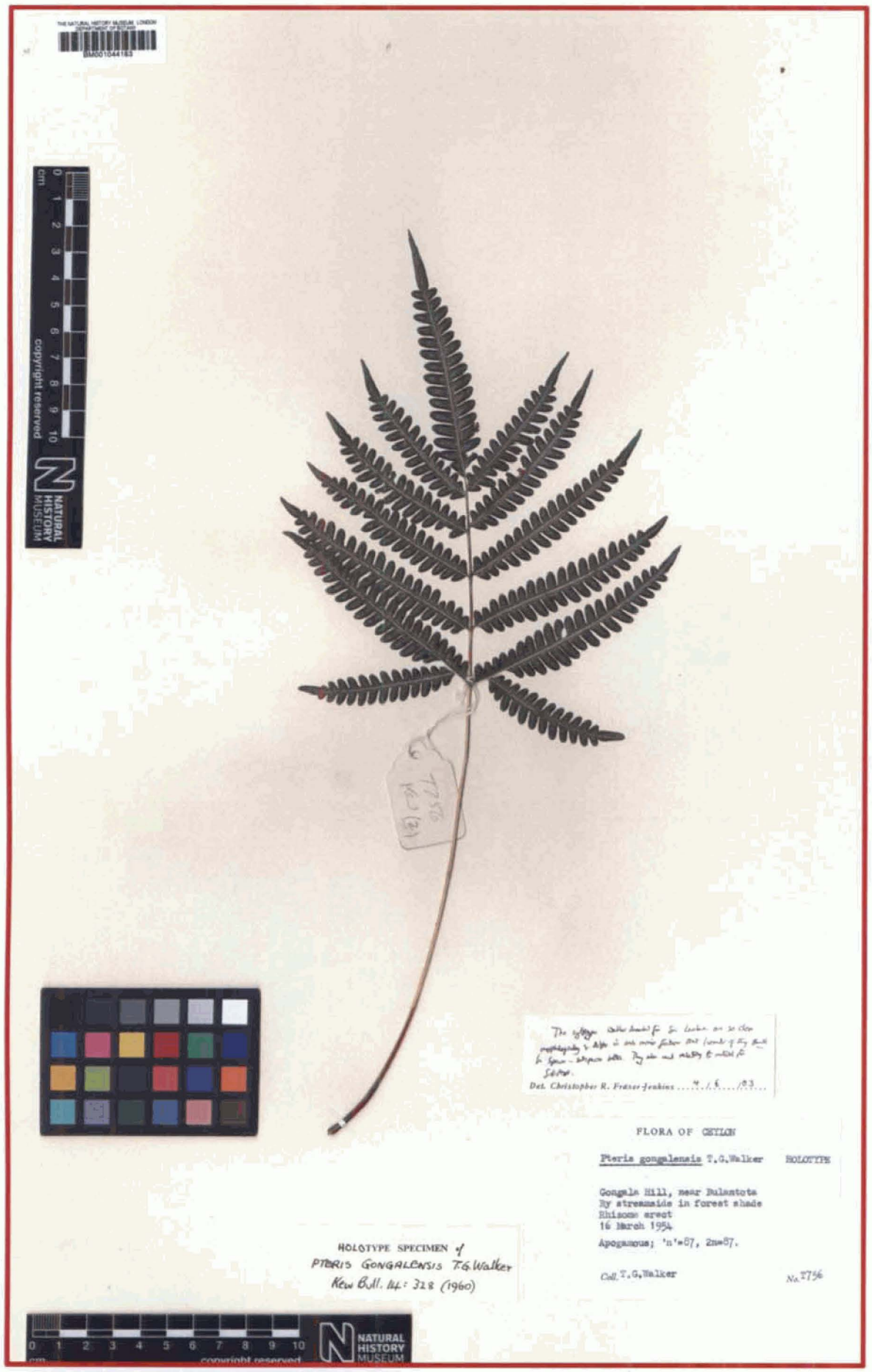


Plate 14. Holotype of *Pteris gongalensis* T. G. Walker (BM)

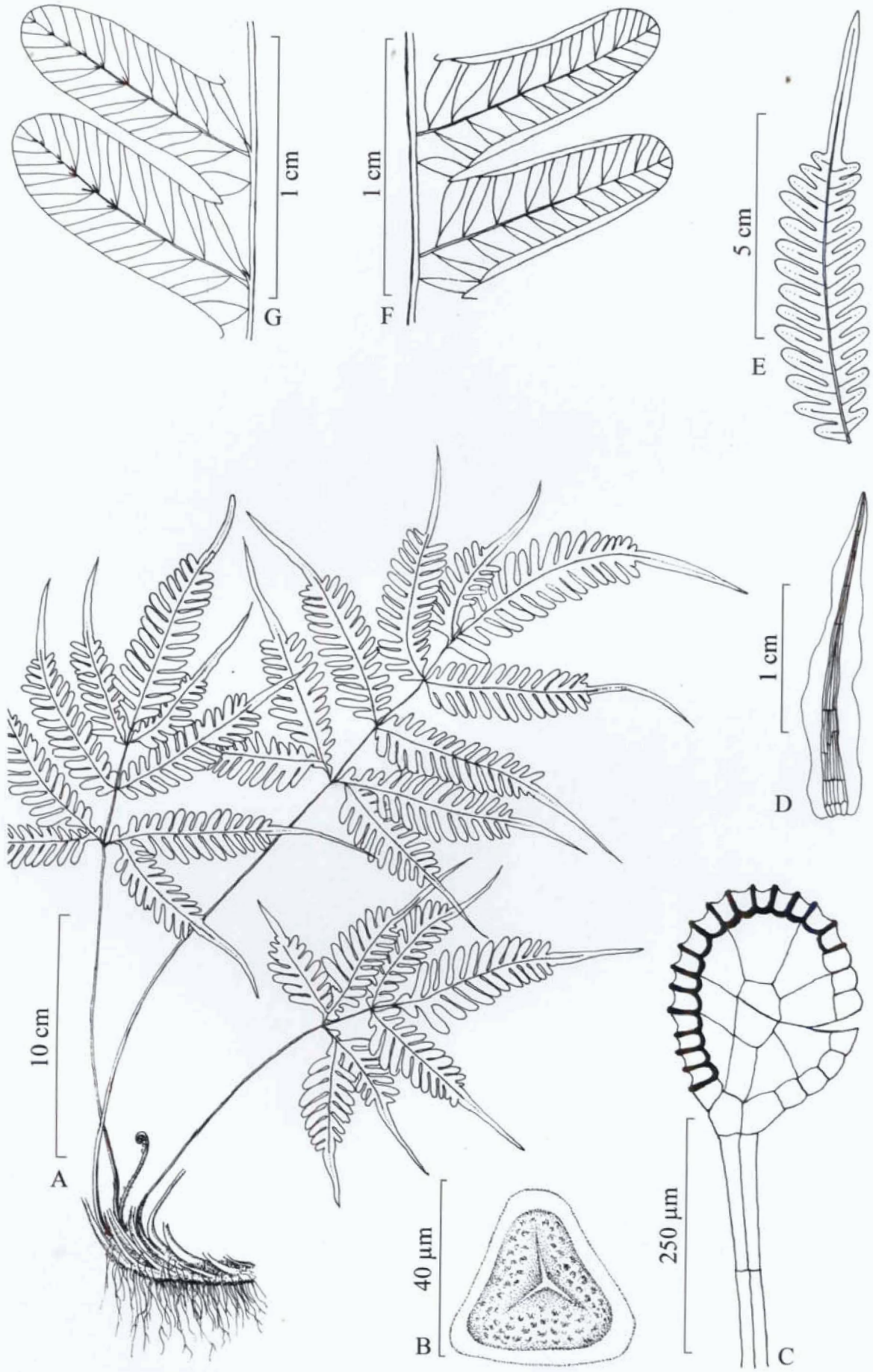


Fig. 12. ***Pteris gongalensis*** **T. G. Walker**: **A**. habit; **B**. spore; **C**. sporangium; **D**. palea; **E**. single pinna; **F**. fertile pinnules; **G**. sterile pinnules (*V.K.Sreenivas 113227*, CALI).

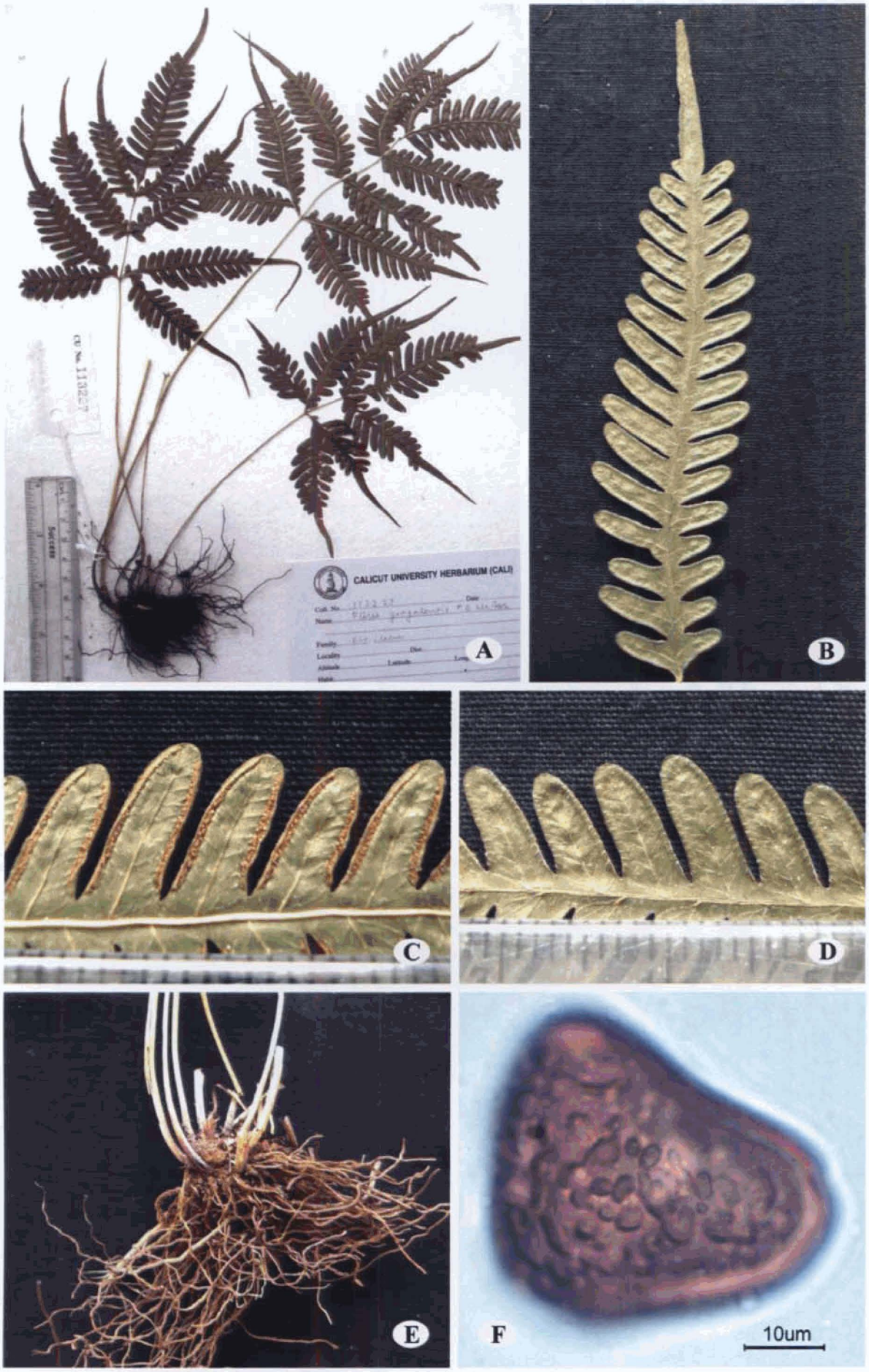


Plate 15. ***Pteris gongalensis*** **T. G. Walker**: **A**. habit; **B**. single pinna; **C**. fertile pinnules; **D**. sterile pinnules; **E**. rhizome; **F**. spore.

Height 30-50 cm. Rhizome short, creeping, 3-5 cm long x 3-5 mm thick, cylindrical, scaly. Palea brown, 3-5 mm long, 0.5-0.6 mm broad at base, lanceolate, acuminate, auriculate at base, thick walled central cells and outer thin walled cells. Stipe 20-22 cm long, 2-3 mm thick, green (fresh specimen) or strameneous (dry material), chestnut at extreme base, grooved throughout except extreme base, glabrous, shining. Lamina pinnate, 20-25 cm long x 15-18cm broad, ovate, green, subcoriaceous. Pinnae 4-5 pairs, 7-15 cm long x 2.2-2.8 cm broad, heteromorphic, opposite, lower pairs petiolate, upper pair adnate to rachis, lanceolate (generally), green, acute (rarely apiculate), entire (rarely wavy), glabrous, pinnae laterally lobed (4-9 pairs) at base, lobes oblong, obtuse, 9-10 cm long x 2.5- 3 cm broad (in some cases very short lobes are present), terminal pinna large and base lobed. Costae grooved above and raised below, glabrous, shining. Veins numerous, free, forking near costa. Sori brown, linear, 6-8 mm long, submarginal except at base and apex. Indusium false, light brown at maturity. Sporangium: capsule globose, 200-250 μm long; stalk 300-350 μm long, biseriate; annulus 15-17 celled. Paraphyses uniseriate. Spores brown, *c.* 50 x 60 μm, trilete-tetrahedral, rugate, broad equatorial ridge.

Habitat: Seen in evergreen forests.

Altitude: 400-900m.

Distribution: India (South India: Andhra Pradesh, Karnataka & Kerala), Myanmar and Philippines.

Etymology: The specific epithet was derived from a Latin word 'heteromorphus' (= having organs of varying forms). Here morphology of pinnae is varying or heteromorphic.

ICUN status: Endangered (EN). This taxon is currently known from 3-4 locations in south India and meets the criteria EN B1ac(i)+2aD under endangered category.

Notes: *P. heteromorpha* Fee was described based on the specimens from Luzon, Philippines. As species name indicates, the plant is characterized by its irregularly lobed pinnae. The type specimens have apiculate or sub apiculate pinnae, though the south Indian specimens have no clear apiculation and are having acute to obtuse pinnae apex. But rarely sub apiculate pinnae are also observed.

Beddome (1883) considered this species is a variety of *P. cretica* L. *viz.*, *P. cretica* var. *heteromorpha* Bedd. Bole and Almeida (1977) described *P. almeidiana* as a new species from Bombay Presidency, based on the specimens from Savantwadi (*M.R.Almeida 1272*, BLAT). Fraser Jenkins (1997) equated *P. almeidiana* to *P. otaria* Bedd. after examining the type specimens. But, from the illustrations and descriptions in the protologue, it is evident that *P. almeidiana* is a synonym of *P. heteromorpha*.

Nair and Ghosh (1978) reported this species from Orissa as a new record to India. Manickam *et al.* (2005), and Manickam and Benniamin (2007) reported *P. heteromorpha* from Andhra Pradesh and Karnataka respectively. Antony (2009) recorded it from Palakkad district as a new distributional record from Kerala, though Sworrupanandhan (*Sworrupanandhan 446*, CALI!) collected this species from Kulathupuzha of Kollam district in 1982.

Most of the South Indian authors were reported *P. heteromorpha* Fee with erect rhizome, though their illustrations are of creeping rhizome. During the present study, the specimens collected from the Shendurney Wildlife Sanctuary (*V.K.Sreenivas 124070,* CALI) are having short creeping rhizome.

This is a rare species and its population and distribution were also narrow. Chandra *et al.* (2008), included this species in "Near Threatened" category.

Materials examined:

KERALA: Kollam (Dt.): Kattilappara, SWLS (alt. 350m), *V.K.Sreenivas 124070*; Kulathupuzha (alt. 450m), *K.Sworrupanandhan 446* (CALI); **Palakkad** (Dt.): Dhoni hills (alt. 500m), *Raju Antony 29879* (TBGT).

ORISSA: Malkangiri (Dt.): Govindappally-Khairput, *N.C.Nair & S.R.Ghosh 51171* & 51234 (CAL).

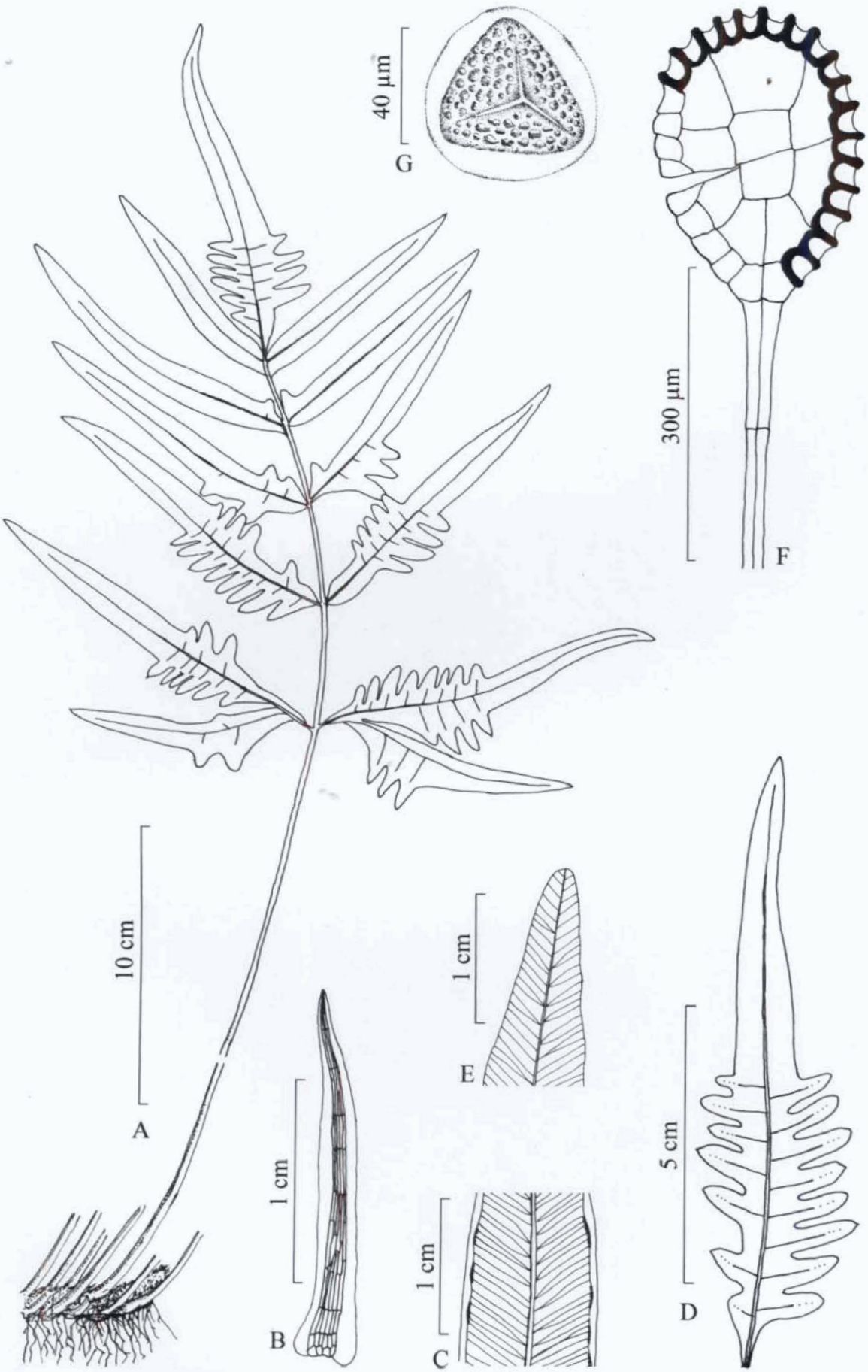


Fig. 13. ***Pteris heteromorpha*** **Fee**: **A**. habit; **B**. palea; **C**. a portion of fertile pinna; **D**. a single pinna; **E**. pinna apex; **F**. sporangium; **G**. spore (*V.K.Sreenivas 124070*, CALI).

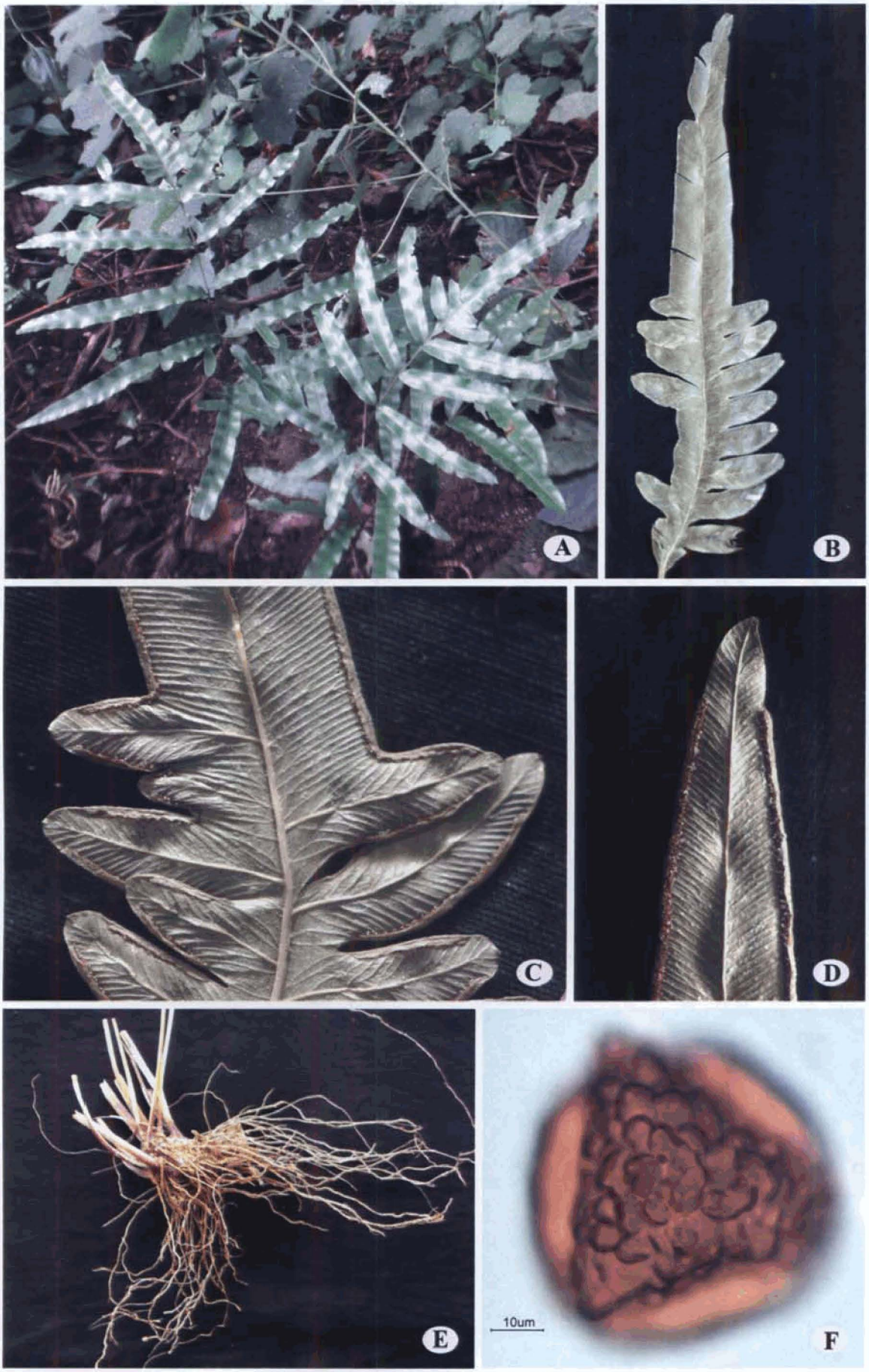


Plate 16. ***Pteris heteromorpha*** **Fee**: **A**. habit; **B**. single pinna; **C**. a portion of fertile pinna; **D**. pinna apex; **E**. rhizome; **F**. spore.

11. **Pteris linearis** Poir.

P. linearis Poir., Lam. Enc. 5: 723. 1804; J. Agardh, Recens. Spec. Pter. 26. 1839; Shieh, Bot. Mag. Tokyo 79: 291. 1966; S. M. Vasudeva & A. Singla, Asp. Plant Sci. 13: 333. 1991; Rajagopal & K. G. Bhat, Indian Fern J. 15: 8. 1998; Manickam & Irud., Pterid. Fl. Nilgiris 88. 2003; Ghosh et al., Pterid. Fl. E. India 1, Ser. 4: 337. 2004; Fras.-Jenk., Taxon. Rev. Indian Subcont. Pterid. Rev. Cens. List 114. 2008; Sreenivas & Madhus., Proc. 22nd Kerala Sci. Congr. 867. 2010.

[Fig. 14, 16E & Plate 17]

Type: Mauritius Islands, *Commerson s.n.* (Isotype, P, digital image!).

Pteris nemoralis Willd., Enum. Pl. Hort. Bot. Berol. 1073. 1809; Sp. Pl. 5: 386. 1810; Hook. Sp. Fil. 2: 202. 1858; N. C. Nair & R. K. Ghosh, J. Indian Bot. Soc. 54: 48. 1975; Nair et al., J. Econ. Taxon. Bot. 16: 263. 1992.

Height up to 160 cm. Rhizome short, erect to suberect, 5-6 cm long, 4-5 mm thick, scaly. Palea brown, 2-3 cm long, 0.3-0.4 mm broad at base, linear- lanceolate, acuminate, auriculate, inner thick walled cells and outer thin walled cells with multicellular projections. Stipe 50-70 cm long, 4-6 mm thick, stramineous above and chestnut on extreme base, grooved throughout, glabrous. Lamina bipinnate, 40-60 cm long x 20-30 cm broad, oblong-

lanceolate, green above, obscure green below, subcoraceous. Pinnae 7-9 pairs, 18-28 cm long x 3-5 cm broad, opposite- subopposite, lanceolate, basal pinnae bipartite, pinna-apex elongated, 5-7 cm. Pinnules 25-32 pairs, 1.5-2.5 cm long x 4-5 mm broad, linear-oblong, obtuse-acute, entire, sinus *c.* 2 mm away from costae, 2-3 mm apart, glabrous. Costae grooved above with spines, raised and polished below. Veins 12-16 pairs, free, forking, lower pair form triangular costal arch. Sori brown, 1.2-1.6 cm long, linear, submarginal except at apex, base not joined. Indusium false, pale brown. Sporangium: capsule globose, 250-300 μm long; stalk 300-350 μm long, biseriate; annulus 14-16 celled. Paraphyses uniseriate. Spores brown, *c.* 50 x 55 μm, trilete-tetrahedral, verrucate.

Habitat: Grows in shady forest areas, usually near stream banks.

Altitude: 350m-1200m.

Distribution: Africa, China, India (South India: Kerala & Tamil Nadu), Myanmar and Mauritius.

Chromosome number: n= 58 (Manton & Sledge, 1954).

Etymology: The specific epithet derived from a Latin word 'linearis' (= linear). The linear shape of pinnules gives the name linearis.

IUCN status: Vulnerable (VU). The distribution of this taxon is narrow in South India and meets the criteria VU B1a2ac(i)C under Vulnerable category.

Notes: Poiret described this species based on Commerson's specimens from Mauritius Islands. *P. linearis* is closely related to *P. biaurita* in having similar morphology of pinnae, except costal areoles in *P. biaurita*. In *P. linearis* pinnules are linear and lower pair of veins united to form triangular costal arch. This species is also characterized by its wide inter segmental distance.

Materials examined:

ANDHRA PRADESH: Chittoor (Dt.): Talakona forest (alt. 500m), *V.K.Sreenivas 127805* (CALI); Akash ganga-Thirumala (alt. 600m), *A.Ahmad 12814* (SKU). **Vizianagaram** (Dt.): Galikonda, *A.Ahmad 12896* (SKU).

KERALA: Kannur (Dt.): Ambayathode (alt. 550m), *V.S.Ramachandran 59152*; Kottiyoor (alt. 225), *V.J.Nair 59803* (MH, CAL). **Palakkad** (Dt.): Nilikkal SVNP (alt. 900m), *V.K.Sreenivas 124012*; Thothanparakuzhi, PWLS (alt. 750m), *V.K.Sreenivas 113234* (CALI). **Thrissur** (Dt.): Athirappally (alt. 350m), *V.K.Sreenivas 119288* (CALI).

TAMIL NADU: Coimbatore (Dt.): Anamalai Hills, Valparai (alt. 500m), *V.S.Manickam & K.M.Mathew 34330* (XCH). **Tirunelveli** (Dt.): Sengeltheri (alt. 1200m), *V.S.Manickam & K.M.Mathew 34132* (RHT, XCH); *V.S.Manickam 2429* (XCH).

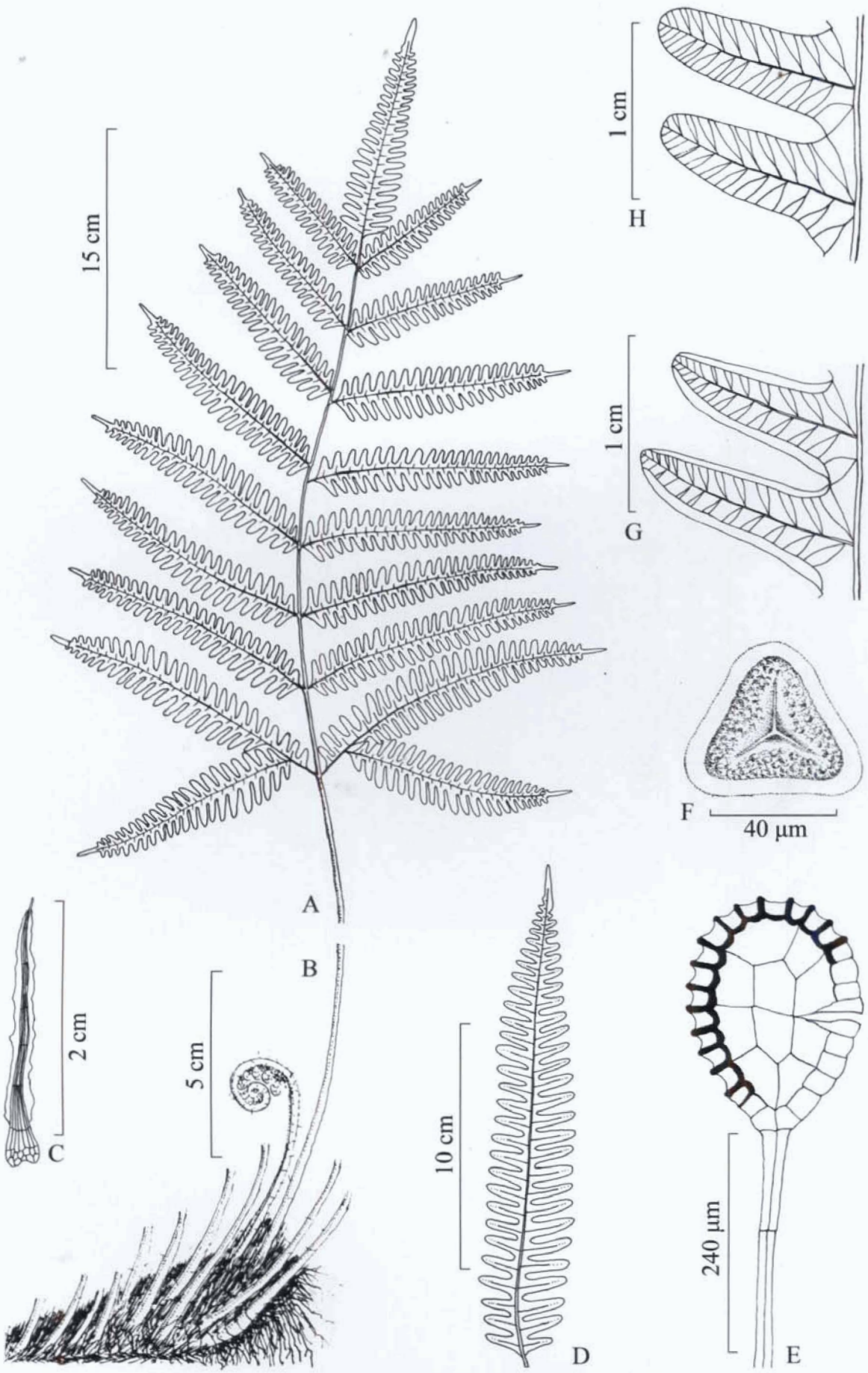


Fig. 14. ***Pteris linearis*** **Poir.**: **A-B**. habit; **C**. palea; **D**. a single pinna; **E**. sporangium; **F**. spore; **G**. fertile pinnules; **H**. sterile pinnules (*V.K.Sreenivas 113234*, CALI).

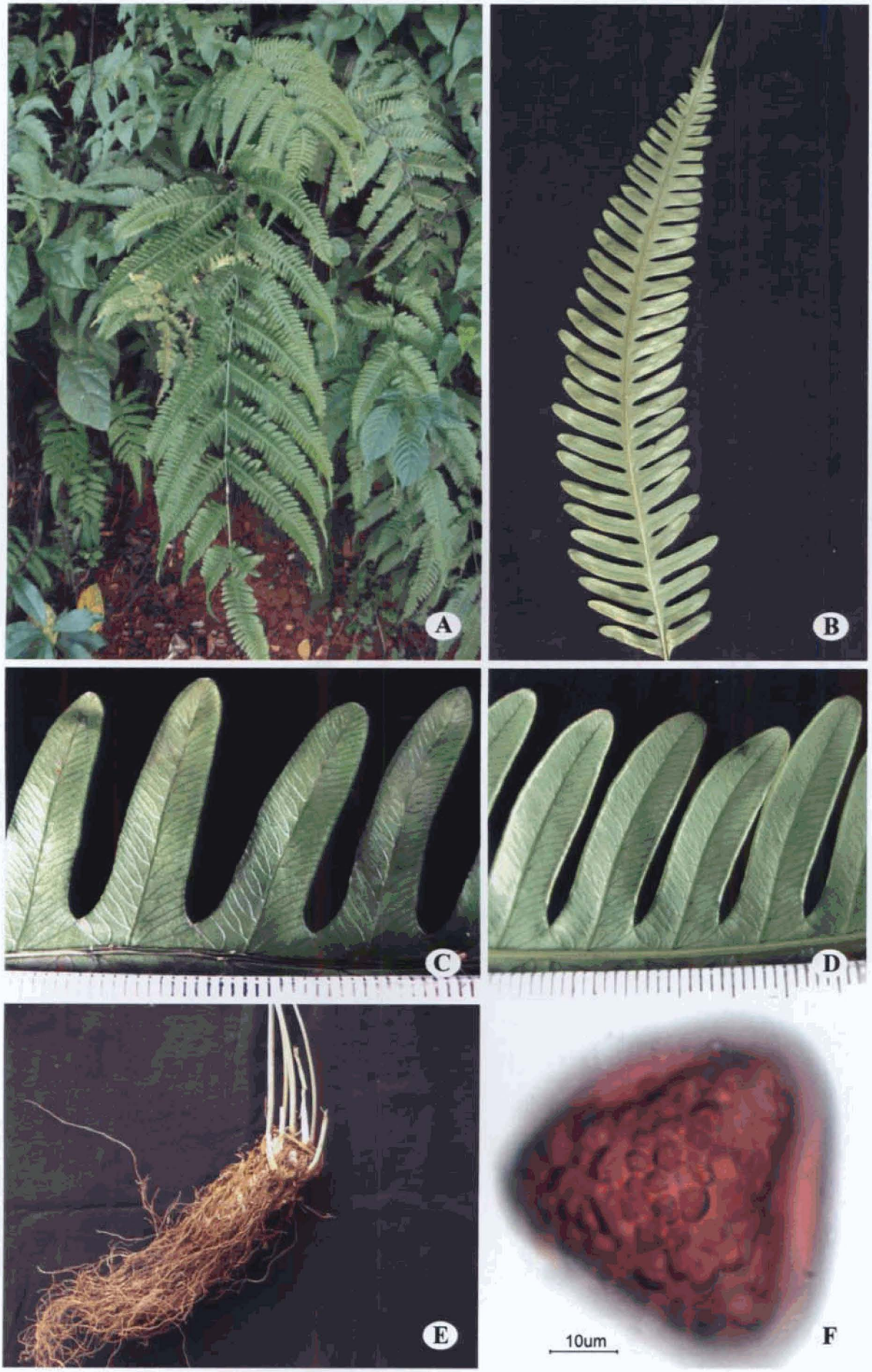


Plate 17. ***Pteris linearis*** **Poir.**: **A**. habit; **B**. single pinna; **C**. sterile pinnules; **D**. fertile pinnules; **E**. rhizome; **F**. spore.

12. **Pteris longipes** D. Don

P. longipes D. Don, Prod. Fl. Nepal, 15. 1825; J. Agardh, Recens. Spec. Pter. 70. 1839; C. B. Clarke, Trans. Linn. Soc. Lond. II, Bot. 1: 468. 1880; Bedd., Handb. Ferns. Brit. India, 115. 1883; Shieh, Bot. Mag. Tokyo 79: 291. 1966; B. K. Nayar & S. Kaur, Comp. Bedd. Handb. 31. 1974; R. D. Dixit, Cens. Indian Pterid. 70. 1984; S. M. Vasudeva & A. Singla, Asp. Plant Sci. 13: 337. 1991; N. C. Nair et al., J. Econ. Taxon. Bot. 263. 1992; Manickam & Irud., Pterid. Fl. W. Ghats, 72. pl. 47 & 48. 1992; B. K. Nayar & Geev., Fern Fl. Malabar 109. fig. 30. 1993; Rajagopal & K. G. Bhat, Indian Fern J. 15: 8. 1998; Subh. Chandra, Ferns India 39. 2000; Manickam & Irud., Pterid. Fl. Nilgiris 85. 2003; Easa, Biodiv. Doc. Kerala 5: 20. 2003; Ghosh et al., Pterid. Fl. E. India 1, Ser. 4: 357. 2004; Sreenivas & Madhus., Proc. 22nd Kerala Sci. Congr. 867. 2010.

[Fig. 15, 16F & Plate 18]

Type: Nepal, *Wallich s.n.* (Lectotype, BM, digital image!).

Pteris pellucens J. Agardh, Recens. Spec. Pter. 43. 1839; Hook., Sp. Fil. 2: 191. 1858; Bedd., Ferns S. India 11. pl. 32. 1863.

Height up to 100 cm. Rhizome short, erect with tuft of roots, 2-3 cm long x 1-2 mm thick, scaly. Palea brown, 2-3 mm long, 0.3-0.4 mm wide at base, lanceolate, acuminate, auriculate, entire, thick walled cells. Stipe 25-45 cm long, 1-2 mm thick, green (fresh material) or stramineous (dry material), chestnut at extreme base, grooved, glabrous above, scaly below; spines at the attachment site of pinnae to stipe, spines 1-2 mm long. Lamina bipinnate, 35-40 cm long x 25-30 cm broad, ovate or broadly ovate, green, basal pair ternately divided, subcoriaceous. Pinnae 10-16 pairs, 7-10 cm long x 1.5- 2.5 cm broad, opposite or subopposite, oblong-lanceolate, 7-12 pairs of accessory pinnae on lower ternately divided pinna. Pinnules 13-18 pairs, 9-12 mm long x 3-4 mm broad, oblong, obtuse, margin entire, apex crenate, sinus up to costa, 0.5-1 cm apart, prominent spinules on costule. Costae grooved above with conspicuous spines at the attachment site of costule, and raised below. Veins 6-8 pairs, free, forking. Sori brown, 2-3 mm long, submarginal except at base and apex (confined to the middle portion). Indusium false, brown. Sporangium: capsule globose, 200-250 μm long; stalk 300-350 μm long, biseriate; annulus 15-18 celled. Paraphyses uniseriate. Spore brown, *c.* 40 x 45 μm, trilete- tetrahedral, verrucate.

Habitat: In shaded floors of evergreen forests.

Altitude: 600m-1500m.

Distribution: India (South India: Karnataka, Kerala & Tamil Nadu), Java, Nepal, New Guinea, Philippines, Sri Lanka and Taiwan.

Chromosome number: n= 58 (Manickam & Irudayaraj, 1988).

Economic importance: Leaf extract is orally given for sore throat (Karuppusamy *et al.*, 2001) and its sporophylls are antibacterial (Singh, 1999).

Etymology: The specific epithet derived from a Latin word 'longipes' (= long stipe).

IUCN status: Least concern (LC). This is a widespread taxon present in evergreen forest at high altitude and it does not meet any criteria for Endangered, Vulnerable, *etc.* under IUCN red list category.

Notes: Don (1825) described this species based on the specimens from Nepal. *P. longipes* is characterized by its ternately divided basal pinnae, lesser number of veins, and the sori usually confined to the middle portion of the pinnules.

This is a common species in Silent Valley National Park and present in high altitudes, and called 'Kadavalai' in Tamil language (Karuppusamy, 2001).

Materials examined:

KARNATAKA: Kodagu (Dt.): Sampage-Madikeri road side (alt. 900m), *V.S.Manickam 2872* (XCH). **Shimoga** (Dt.): Agumbe (alt. 850m), *Santhosh Nampy 48830* (CALI); *P.K.Rajagopal 16* (MGMC).

KERALA: Idukki(Dt.): Anjuruli (alt. 800m), *K.P.Rajesh 70116*; Mlappara PTR (alt. 900m) *K.P.Rajesh 70032*; Palkulam mudi (alt. 1300m), *Jomy Augustine 12855* (CALI); Eravikulam (alt. 1600m), *V.S.Manickam & K.M.Mathew 34512* (RHT); Uppupara (alt. 1200m), *N.C.Nair 70199* (MH, CAL); Peerumedu (alt. 1300m), *A.Meebold 908*; Thekkady (alt. 750m), *N.C.Nair 40500* (CAL). **Palakkad** (Dt.): Kummattanthode (alt. 825m), *V.K.Sreenivas 119255*; Nellyampathi (alt. 1100m), *Geevarghese 17873*; Poopara, PWLS (alt. 1100m), *V.K.Sreenivas & A.J.Roby 119215*; Sairendri (alt. 900m), *V.K.Sreenivas 124021*; Silent Valley NP (alt. 900m), *Geevarghese 4109*, *B.K.Nayar 10011*, *B.K.Nayar & P.V.Madhusoodanan 21336*; Siruvani (alt. 600m), *Sworrupanadhan 29464*; Walakkad-Sispara path (alt. 1000m), *V.K.Sreenivas 119240* (CALI); Kummattanthode (alt. 800m), *V.S.Manickam 3281* (XCH); Aruvanpara (alt. 850m), *N.C.Nair 69174*; Kanhirappuzha dam site (alt. 1000m), *E.Vajravelu 46261*; Karapara (alt. 950m), *N.C.Nair 69846*; Muthikulam (alt. 850m), *E.Vajravelu 62931*; Panthenthode (alt. 800m), *N.C.Nair 50648*; (MH); Poochapara (alt. 1200m), *J.N.Vohra 58417*; Silent Valley dam site (alt. 925m), *P.Bhargavan 65706*

(CAL); Karimala PWLS (alt. 1000m), *P.Sujanapal 30930* (KFRI). **Thiruvananthapuram** (Dt.): Chemunji (alt. 1000m), *Raju Antony 26830* (TBGT). **Thrissur** (Dt.): Sholayar dam site (alt. 450m), *V.S.Manickam & K.M.Mathew 34696* (RHT); *N.C.Nair & S.R.Ghosh 51046* (MH). **Wayanad** (Dt.): Cherunelly (alt. 700m), *B.K.Nayar 7354*; Pakranthalam (alt. 650m), *B.K.Nayar & Geevarghese 11642* (CALI); Brahmagiri (alt. 950m), *V.S.Ramachandran 62701* (MH, CAL); Chandanathode (alt. 700m), *M.Kumar & S. Stephen 6750* (KFRI).

TAMIL NADU: Coimbatore (Dt.): Anakunthy shola-Top slip (alt. 700m), *V.S.Manickam & K.M.Mathew 34636*; Pettimudi path (alt. 1600m), *V.S.Manickam & K.M.Mathew 34530* (RHT); Valparai (alt. 1800m), *V.S.Manickam 3033* (XCH); Anamallay's, *R.H.Beddome s.n.* (MH). **Nilgiri** (Dt.): Gudallur (alt. 1300m), *V.S.Manickam 1529*; Keelenadukani (alt. 1300m), *V.S.Manickam 1514* (XCH); Devala (alt. 1200m), *H.C.Levinge s.n.* (CAL).

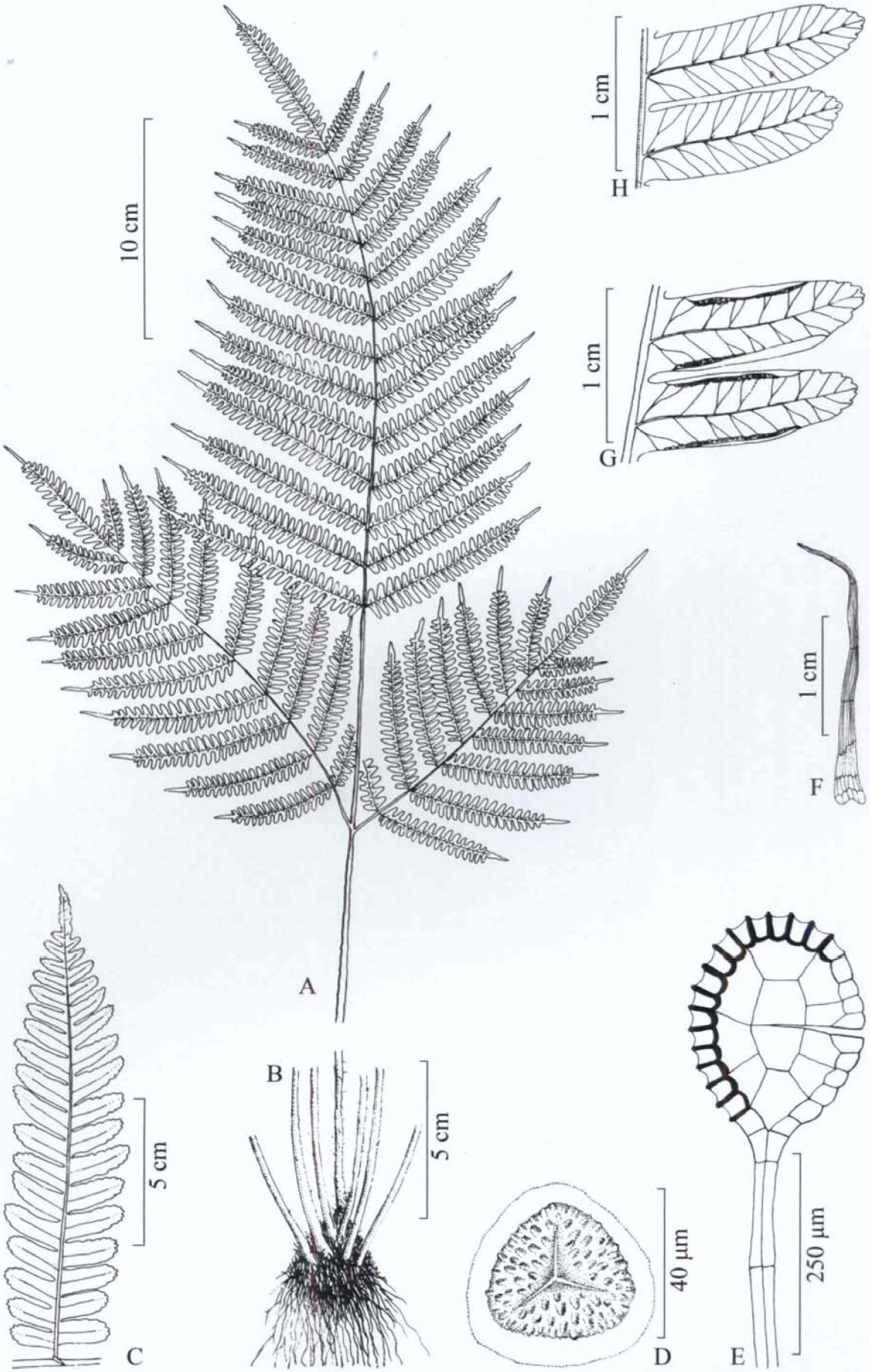


Fig. 15. ***Pteris longipes*** **D. Don**: **A-B**. habit; **C**. a single pinna; **D**. spore; **E**. sporangium; **F**. palea; **G**. fertile pinnules; **H**. sterile pinnules (*V.K.Sreenivas 124021*, CALI).

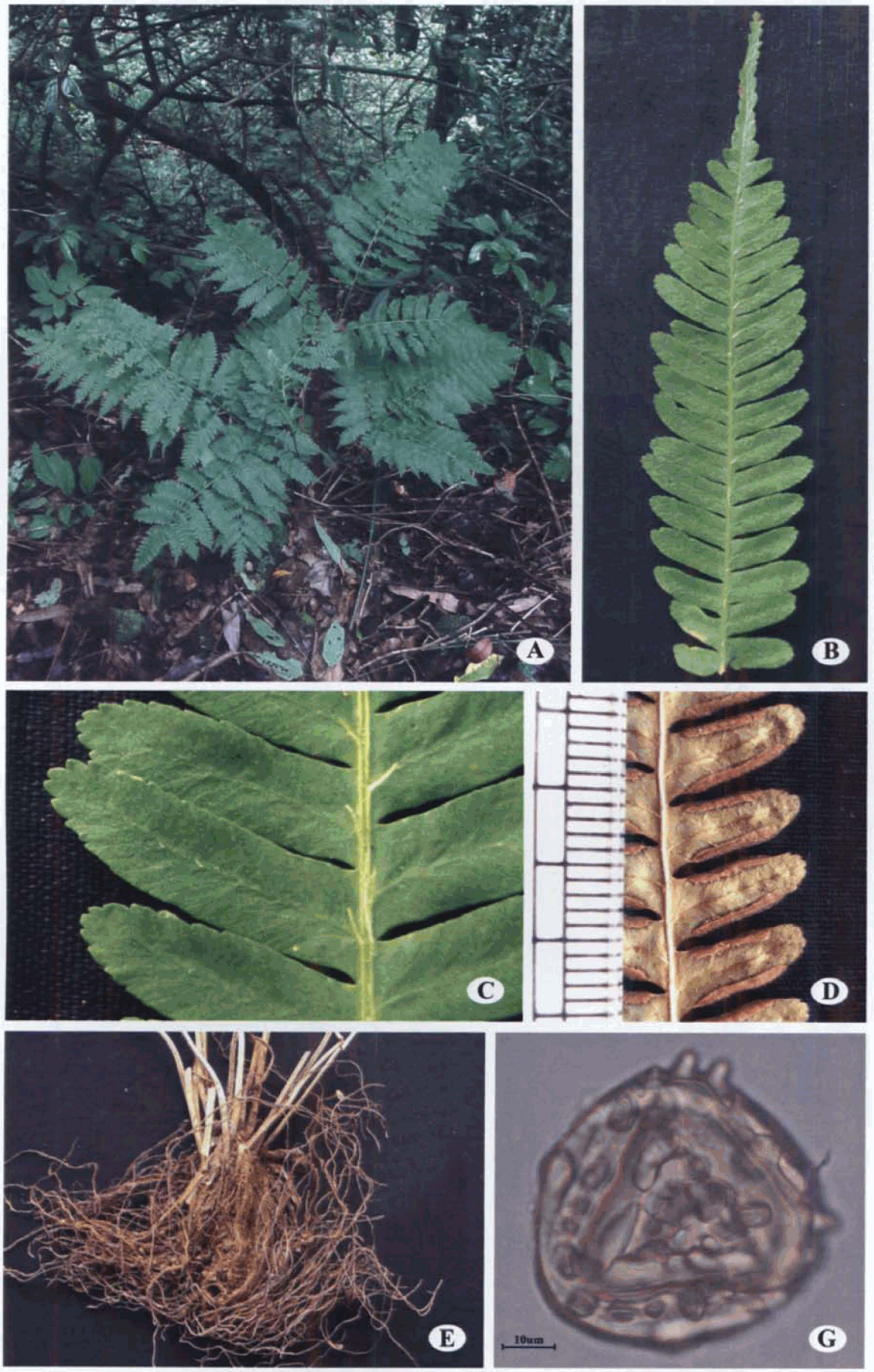


Plate 18. ***Pteris longipes*** **D. Don**: **A**. habit; **B**. single pinna; **C**. sterile pinnules; **D**. fertile pinnules; **E**. rhizome; **F**. spore.

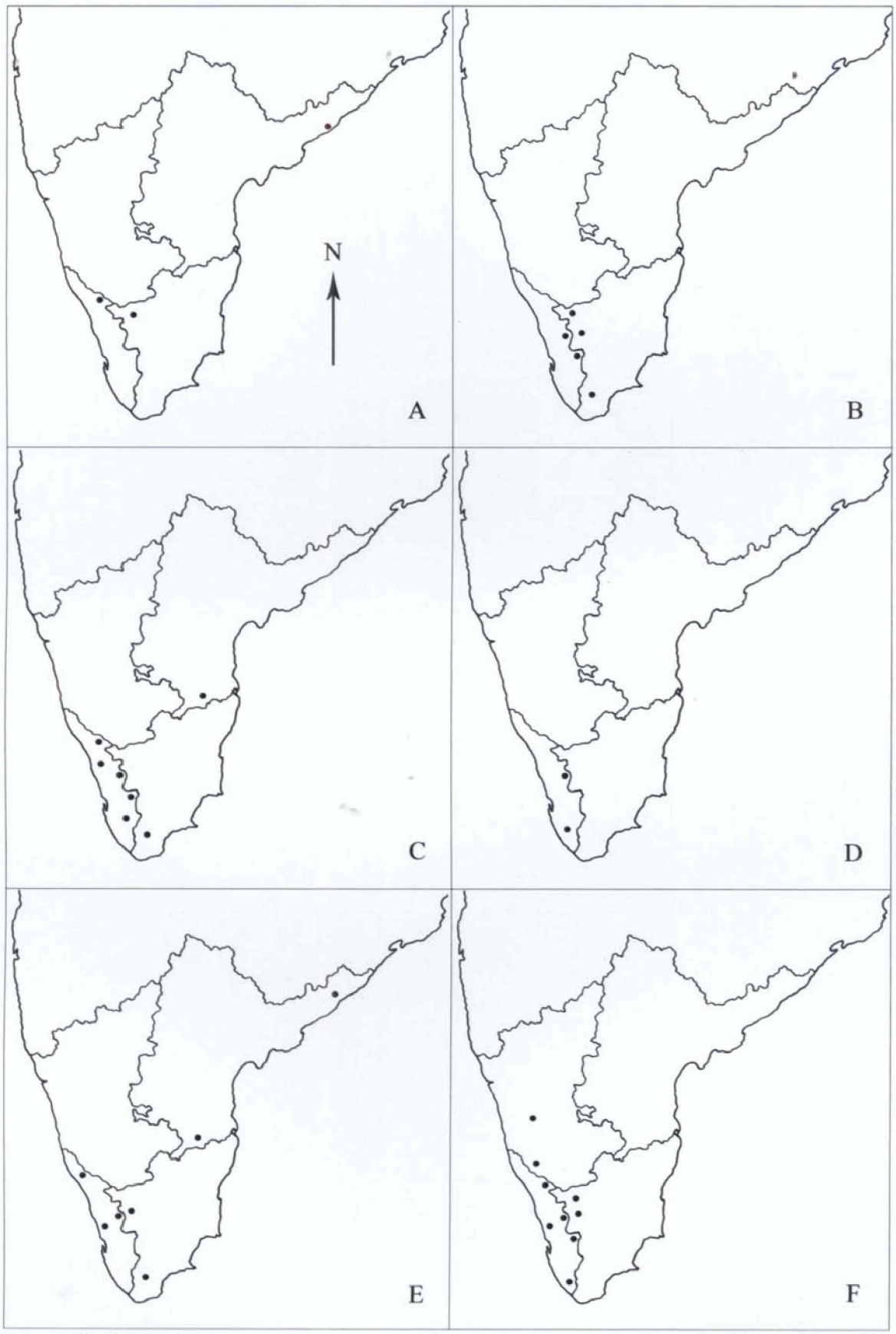


Fig. 16. Distribution of the genus *Pteris* in South India: **A**. *P. ensiformis*; **B**. *P. geminata*; **C**. *P. gongalensis*; **D**. *P. heteromorpha*; **E**. *P. linearis*; **F**. *P. longipes*.

13. **Pteris mertensioides** Willd.

P. mertensioides Willd., Sp. Pl. 5: 394. 1810; Holttum, Rev. Fl. Malaya 2: 404. 1968; B. K. Nayar & S. Kaur, Comp. Bedd. Handb. 31. 1974; R. D. Dixit, Cens. Indian Pterid. 71. 1984; S. M. Vasudeva & A. Singla, Asp. Plant Sci. 13: 337. fig. 30. 1991; N. C. Nair et al., J. Econ. Taxon. Bot. 262. 1992; Manickam & Irud., Pterid. Fl. W. Ghats 72. pl. 52. 1992; B. K. Nayar & Geev., Fern Fl. Malabar 110. fig. 26 & 28. 1993; Subh. Chandra, Ferns India 40. 2000; Manickam & Irud., Pterid. Fl. Nilgiris 86. 2003; Subh. Chandra et al., Taiwania 53: 187. 2008; Sreenivas & Madhus., Proc. 22nd Kerala Sci. Congr. 867. 2010.

[Fig. 17, 23A & Plate 19]

Type: Indonesia, Ambonia, *Ventenat s.n.* (Holotype, B, digital image!).

Pteris patens Hook. Sp. Fil. 2: 177. t. 137. 1858; Bedd., Ferns S. India 69. pl. 205. 1863; Thwaites, Enum. Pl. Zeyl. 386. 1864; Bedd., Handb. Ferns. Brit. India, 114. fig. 59. 1883.

Type: Philippines, Luzon, *Cuming 103* (Holotype, K, digital image!; Isotype-CAL!).

Height 250-300 cm. Rhizome erect, 5-7 cm long x 6-12 mm thick, cylindrical with tuft of roots, scaly. Palea light brown, 7-11 mm long, 0.5-0.6 mm wide at base, linear-lanceolate, acute, auriculate, thick walled cells. Stipe 100-110 cm long, 1-1.4 cm thick, chestnut brown, grooved throughout, densely scaly below, hard. Lamina bipinnate, 160-175 cm long x 80-100 cm broad, ovate, upper surface green, lower pale green, membranaceous (thin). Pinna 20-25 pairs, 40-50 cm long x 5-6 cm broad, alternate, linear-lanceolate, acute, basal pinnae bipartite, glabrous. Pinnules 45-55 pairs, 2-3 cm long x 4-5 mm broad, oblong, acute, margin crenate, only apex crenate in fertile ones, sinus up to costa, 2-3 mm apart, triangular sinus, glabrous. Costae deeply grooved above and its ridges form a flap along either side, and raised below. Veins 15-20 pairs, free, forking. Sori brown, 2.2-2.8 cm long, linear, submarginal except at apex. Indusium false, pale white. Sporangium: capsule globose, 200-250 μm long; stalk 250-300 μm long, biseriate; annulus 16-18 celled. Paraphyses uniseriate. Spores pale brown, *c.* 35 x 40 μm, trilete-tetrahedral, tuberculate, broad equatorial flange girdling the spore.

Habitat: A rare and elegant species present in shady evergreen forests.

Altitude: 400m-1300m.

Distribution: India (South India: Kerala & Tamil Nadu), Malaya, Myanmar, Polynesia, Siam, Sri Lanka and Thailand.

Etymology: The specific epithet derived from a Dutch word 'Mertensienartiger'.

IUCN status: Endangered (EN). This taxon is currently known from 2-3 locations in South India and meets the criteria EN B1ac(ii)2ac(iii) under Endangered category.

Notes: *P. mertensioides* was first reported from India by Beddome in 1863 as *P. patens* Hook. This species is one of the largest *Pteris* in South India and attain up to 3.0 m height. It is characterized by its broad equatorial ridge girdling the spore, triangular sinus, and characteristic smell of crushed pinnae. It is rare species confined to Thrissur and Kollam districts of Kerala, and Nilgiri district of Tamil Nadu in India. Chandra *et al.* (2008), included it in 'At Risk' category.

Materials examined:

KERALA: Kollam (Dt.): Umayur (alt. 650m), *N.C.Nair 50906* (MH, CAL). **Thrissur** (Dt.): Sholayar (alt. 400m), *V.K.Sreenivas 119294* (CALI); Near Ambalappara dam (alt. 600m), *V.S.Manickam & K.M.Mathew 34739*; Valparai-Chalakkudi road (alt. 500m), *K.M.Mathew 31611* (RHT); Mukundapuram (alt. 800m), *V.S.Manickam 34739* (XCH); Sholayar (alt. 400m), *N.C.Nair & S.R.Ghosh 51060* (CAL); Vazhachal (alt. 450m), *N.C.Nair & S.R.Ghosh 510015 & 52079* (MH, CAL).

TAMIL NADU: Nilgiri (Dt.): Keelenadukani forest, Gudallur (alt. 1300m), *V.S.Manickam 1518* (XCH).

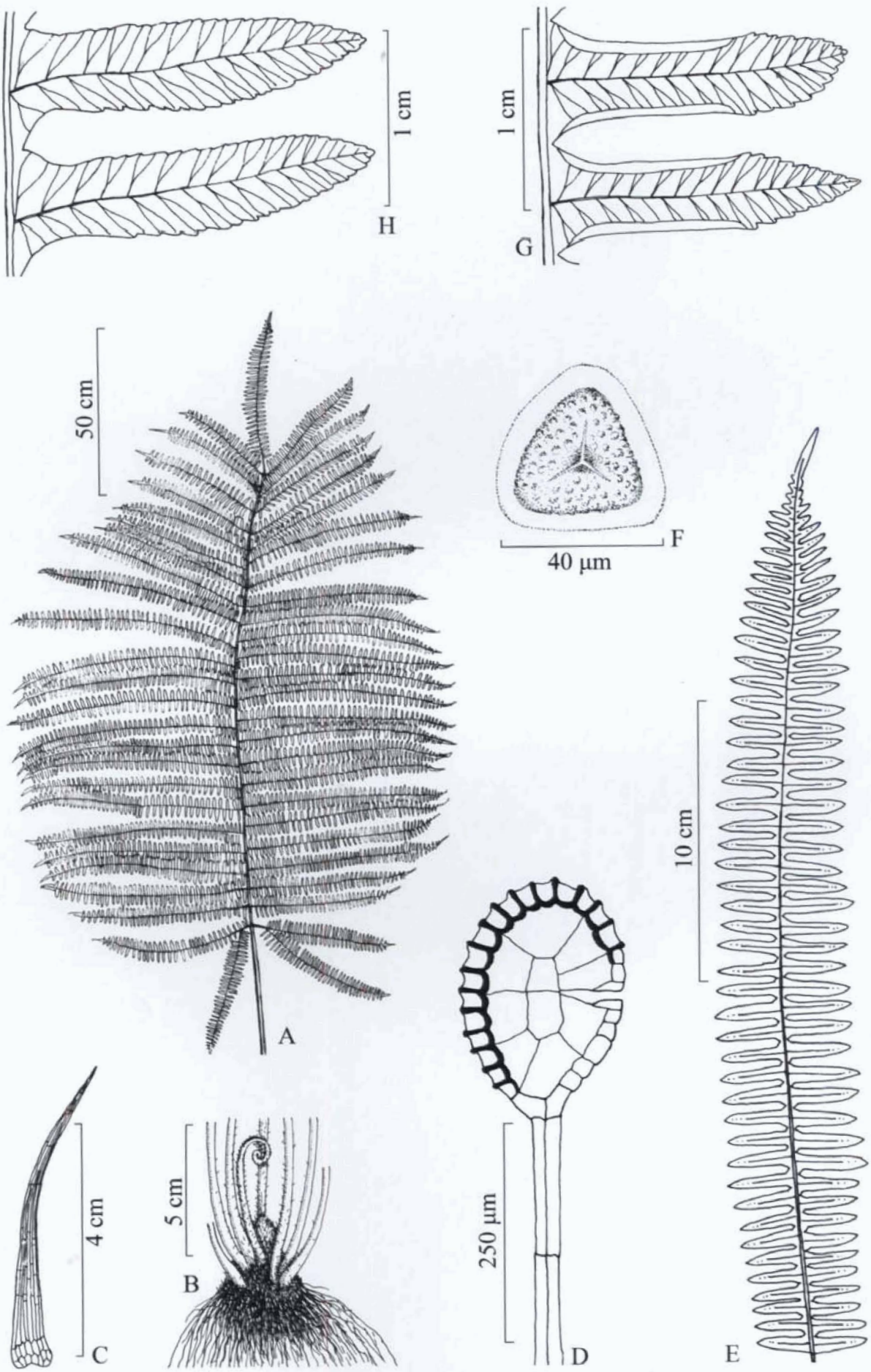


Fig. 17. ***Pteris mertensioides*** **Willd.**: **A-B**. habit; **C**. palea; **D**. sporangium; **E**. a single pinna; **F**. spore; **G**. fertile pinnules; **H**. sterile pinnules (*V.K.Sreenivas 119294*, CALI).

Plate 19. ***Pteris mertensioides*** **Willd.**: **A**. habit; **B**. single pinna; **C**. fertile pinnules; **D**. sterile pinnules; **E**. single frond; **F**. rhizome; **G**. spore.

14. **Pteris multiaurita** J. Agardh

P. multiaurita J. Agardh, Recens. Spec. Pter. 12. 1839; T. G. Walker, Kew Bull.14: 323.1960; N. C. Nair & S. R. Ghosh, J. Bomb. Nat. Hist. Soc. 73: 440. 1976; R. D. Dixit, Cens. Indian Pterid. 71. 1984; S. M. Vasudeva & A. Singla, Asp. Plant Sci. 13: 333. 1991; N. C. Nair et al., J. Econ. Taxon. Bot. 57. 1992; Manickam & Irud., Pterid. Fl. W. Ghats 79. pl. 43. 1992; Subh. Chandra, Ferns India 40. 2000; Easa, Biodiv. Doc. Kerala 5: 20. 2003; Subh. Chandra et al., Taiwania 53: 188. 2008; Sreenivas & Madhus., Proc. 22nd Kerala Sci. Congr. 867. 2010.

[Fig. 18, 23B & Plate 20]

Type: Sri Lanka, *Macrae s.n. & Emerson s.n.* (Syntype, E, digital image!).

Height up to 120 cm. Rhizome short, creeping, 4-7 cm long, 4-5 mm thick, cylindrical with tuft of roots, scaly. Palea dark brown, 2-3 mm long, 0.4-0.5 mm wide at base, lanceolate, acuminate, auriculate, central thick walled cells, outer thin walled cells with celluar projections. Stipe 40-50 cm long, 2-4 mm thick, green (live plants) or stramineous (dry specimens) above, chestnut below, shining, grooved, glabrous. Lamina pinnate, 35-50 cm long x 20-30 cm broad, ovate or oblong, green, leathery. Pinnae dimorphic, fertile one is narrower than sterile one, 8-12 pairs, 5-15 cm long x 5-7 mm broad (sterile), 12-18 cm long x 7-9 mm broad (fertile), subopposite, lanceolate,

acuminate, cuneate, apex crenate, all are bipartite, glabrous (fertile). Costae grooved above with spines on sterile segment and raised below. Veins numerous, free, forking near midrib. Sori brown, 10-15 cm long, linear, submarginal except apex. Indusium false, pale coloured. Sporangium: capsule globose, 250-300 µm long; stalk 250-300 µm long, biseriate; annulus 17-20 celled. Paraphyses uniseriate. Spores brown, *c.* 35 x 40 µm, trilete-tetrahedral, rugate.

Habitat: Seen in shady areas of evergreen forests.

Altitude: 100m-2100m.

Distribution: India (South India: Kerala & Tamil Nadu) and Sri Lanka.

Chromosome number: n= 29 (Irudayaraj & Manickam, 1987).

Etymology: The specific epithet is derived from two Latin words 'multi' (=many) and 'aurita' (=auricles). The name given to this fern was due to the many auricled or many accessory pinnae condition.

IUCN status: Vulnerable (VU). The distribution of this taxon is narrow (8-9 locations) in South India and meets the criteria VU B1a2ac(i)C under Vulnerable category.

Notes: *P. multiaurita* was described by Agardh (1839) based on the specimens collected from Sri Lanka by Macrae and Emerson *s.n.* He also mentioned distribution of this species in Nilgiri in the protologue.

P. multiaurita is characterized by its many auricled pinnae and setae on sterile pinnae. Walker (1960) considered this fern is member of *P. quadriaurita* complex, being its freely hybridizing nature with other members of this complex. Fraser-Jenkins (1997) considered *P. silentvalliensis* Ghosh & Ghosh is a synonym of *P. multiaurita*, but recently, Fraser-Jenkins (2008a) corrected the mistakes and included the former as a synonym of *P. scabripes* Wall. ex J. Agardh.

Materials examined:

KERALA: Palakkad (Dt.): Kaikatty (alt. 900m), *B.K.Nayar s.n.* (CALI). **Malappuram** (Dt.): *B.K.Nayar, P.V.Madhusoodanan & M.J.Molly 29601* (Cult.) (CALI). **Kollam** (Dt.): Kattilappara, SWLS (alt. 350m), *V.K.Sreenivas 124065*; Kulathupuzha-Cheenikala (alt. 400m), *K.Sworrupanandhan 475* (CALI); Umayur (alt. 700m), *N.C.Nair 50886* (MH, CAL); Aryankavu (alt. 200m), *N.C.Nair & S.R.Ghosh 50694*; Kulathupuzha (alt. 400m), *N.C.Nair & S.R.Ghosh 50657* (CAL). **Pathanamthitta** (Dt.): Vennikkulam (alt. 100m), *N.C.Nair & S.R.Ghosh 50840* (CAL). **Thiruvananthapuram** (Dt.): Kallar-Ponmudi (alt. 750m), *N.C.Nair 51064* (MH, CAL); *M.Mohanan 65190* (CAL).

TAMIL NADU: Dindigul (Dt.): Palni Hills (alt. 2100m), *Francis s.n.* (CALI). **Kannyakumari** (Dt.): Balmore Hills (alt. 600m), *V.S.Manickam & K.M.Mathew 35261*; Perunchani rubber estate (alt. 300m),

V.S.Manickam12679 (XCH); Kiripara (alt. 300m), *N.C.Nair & S.R.Ghosh 52659*; Kodayar-Nagercoil (alt. 250m), *N.C.Nair & S.R.Ghosh 51796* (CAL). **Tirunelveli** (Dt.): Kannikatty-Korayan road (alt. 600m), *V.S.Manickam 32540* (RHT, XCH); Way to Injikuzhi (alt. 500m), *V.S.Manickam & K.M.Mathew 35212* (XCH).

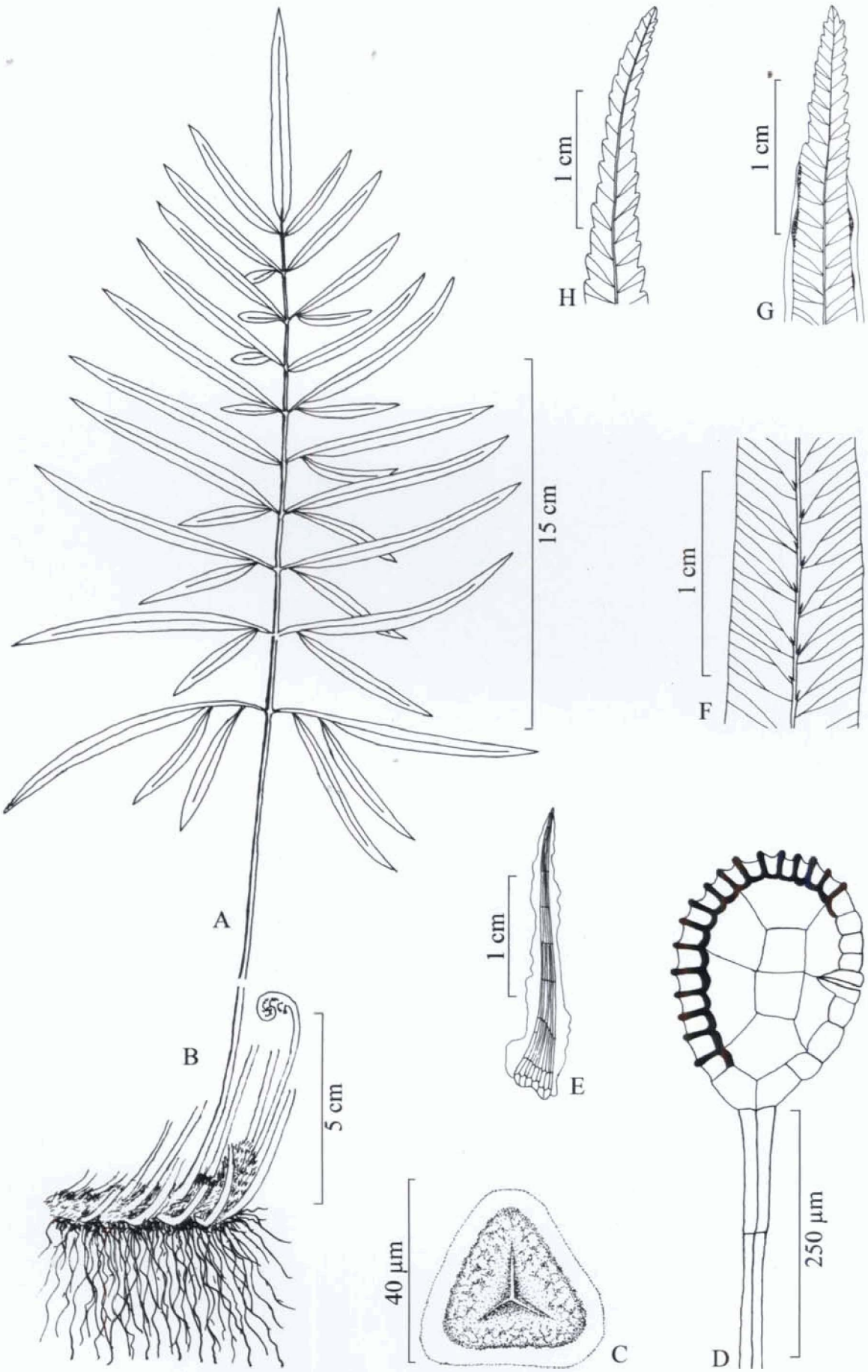


Fig. 18. ***Pteris multiaurita*** **J. Agardh**: **A-B**. habit; **C**. spore; **D**. sporangium; **E**. palea; **F**. a portion of sterile pinna; **G**. fertile pinna apex; **H**. sterile pinna apex (*V.K.Sreenivas 124065*, CALI).

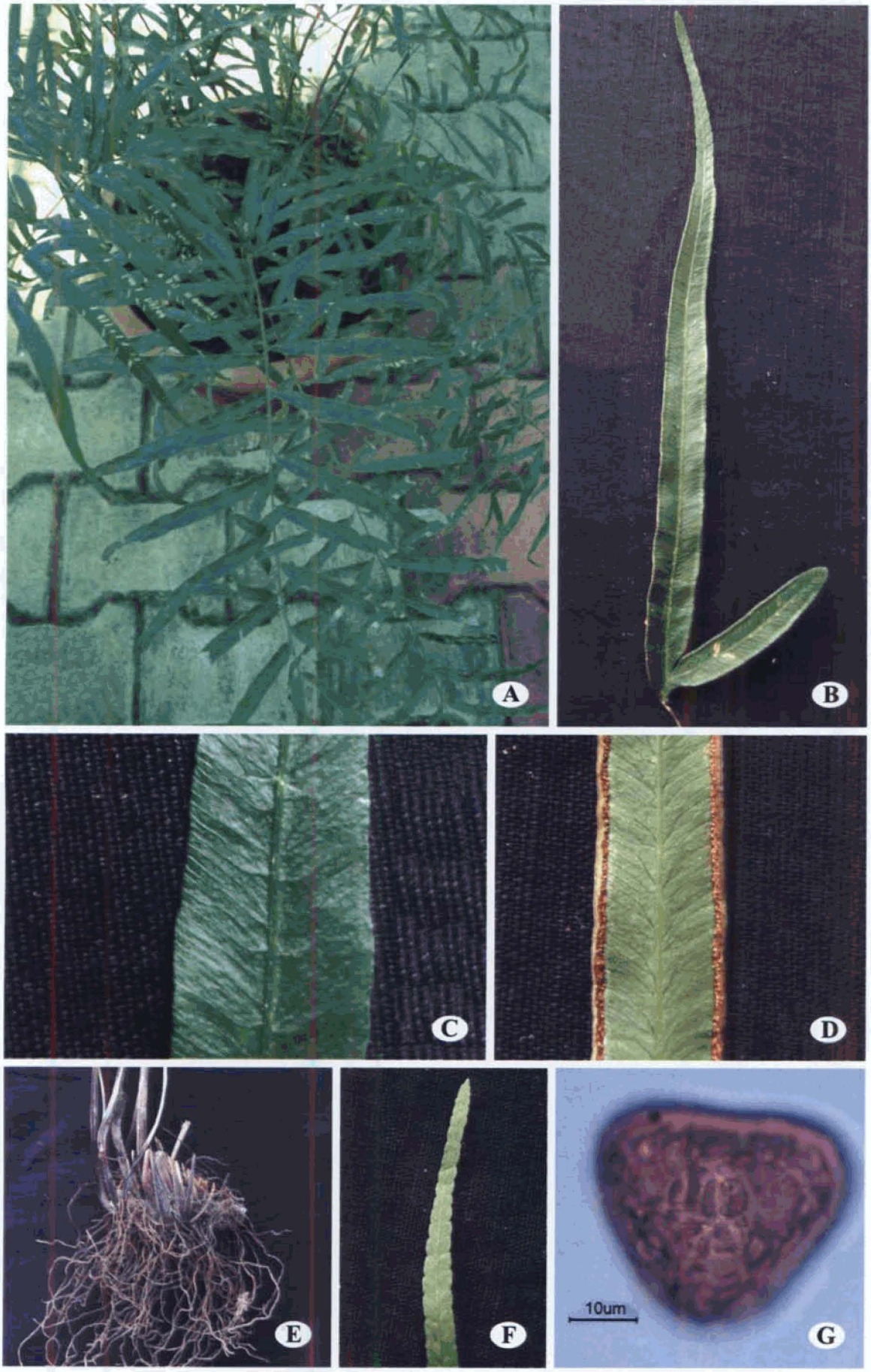


Plate 20. ***Pteris multiaurita*** **J. Agardh**: **A**. habit; **B**. single pinna; **C**. a portion of sterile pinna; **D**. a portion of fertile pinna; **E**. rhizome; **F**. pinna apex; **G**. spore.

15. **Pteris multifida** Poir.

P. multifida Poir., Encycl. (Lamarck) 5 : 714. 1804; Chandler, Amer. Fern J. 31: 112. 1941; C. V. Morton, Amer. Fern J. 47: 11. 1957; Shieh, Bot. Mag. Tokyo 79: 287. 1966; T. G. Walker, Brit. Fern Gaz. 10:147. 1970; Stevens, Amer. Fern J. 67: 63. 1977; S. Singh, Indian J. Forestry 12: 82. 1989; Khullar, Illustr. Fern Fl. W. Himalaya 1: 270. pl. 97. 1994; Subh. Chandra, Ferns India 41. 2000; Ghosh et al., Pterid. Fl. E. India 1, Ser. 4: 334. 2004; S. Das, Indian Fern J. 24: 63. 2007; Sreenivas & Madhus., Proc. 22nd Kerala Sci. Congr. 867. 2010; Sreenivas & Madhus., Acta Bot. Hung. 52. 425. 2010.

[Fig. 19, 23C & Plate 21]

Type: France, a specimen of unknown origin in cultivation at the Jardin du Museum d'histoire naturelle de Paris (Holotype, P; Photo, BM).

Pteris serrulata L. f. Suppl. 425. 1814; J. Agardh, Rec. Sp. Gen. Pter. 13. 1839; Hook., Sp. Fil. 2:167. 1858; Hook. & Baker, Syn. Fil. 155. 1868.

Pycnodoria multifida (Poir.) Small, Ferns S. E. States (Small) 104, 468. 1932.

Height 15-30 cm. Rhizome short, creeping, 2-3 cm long, 5-6 cm thick, cylindrical with tuft of roots, scaly. Palea brown, *c.* 2 mm long, lanceolate,

acute, entire, thick walled cells only. Stipe 6-8 cm long, 1-2 mm thick, green (fresh material) or strameneous (dry materal) above, chestnut brown at base, grooved, glabrous above, scaly below. Lamina pinnate, dimorphic, fertile fronds 25-32 cm height, sterile frond 12-20 cm height, ovate, green. Pinnae 2-3 pairs, opposite, lanceolate, terminal pinna larger than lateral pinnae, terminal pinna 15-16 cm long x 6-8 mm broad, lateral pinna 6-9 cm long x 4-5 mm broad (fertile), 5-6 cm long x 4-5 mm broad (sterile), margin wavy or serrate, apex acute-acuminate, serrate or serrulate, glabrous, thin, papyraceous, pinna decurrent to form a winged rachis, lower pinnae multifidus. Costae grooved above and below, glabrous. Veins numerous, free, forking. Sori brown, linear, 12-14 cm long (terminal), 3-4.5 cm long (lateral pinna), submarginal except base and apex. Indusium false, white. Sporangium: capsule globose, 250-300 µm long; stalk 300-325 µm long, biseriate; annulus 17-18 celled. Paraphyses uniseriate. Spores brown, *c.* 40 x 45 µm, trilete-tetrahedral, misshapen spores, rugate ornamentation.

Habitat: Grows in walls of wells, brick walls, and rocky edges, *etc.*

Altitude: Sea level (± 5m).

Distribution: China, India (South India: Kerala), Japan, Korea, Sri Lanka and Taiwan.

Chromosome number: n= 58 (Walker, 1956).

Common name: Spider brake.

Economic importance: Decoction of rhizome and fronds used in the treatment of dysentery and paste made from roasted frond and rhizome applied to skin diseases (Ghosh *et al.*, 2004). This species is also widely cultivated as ornamental fern in many gardens.

Etymology: The specific epithet derived from a Latin word 'multifidus' (= cleft into many parts). As the name indicates, basal portion of the pinna is lobed.

IUCN status: Critically Endangered (CR). This taxon is currently known from a single locality (Kozhikode) in South India and meets the criteria CR B1ab(ii)+2aD under Critically Endangered category.

Notes: Poiret described this species based on the plant cultivated in Paris Museum and is characterized by its multifid pinnae and the pinnae adnated to the stipe to form a winged rachis. These plants were under cultivation in many countries and escaped from the cultivation and naturalized elsewhere in the world. Spicular veins or false veins are present closely along with true veins or inter venal areas on the pinna (Wagner, 1978).

Singh (1989) reported *P. multifida* Poir. from Muradabad, Uttar Pradesh for the first record from India, and subsequently Ghosh *et al.* (2004),

mentioned its occurrence in West Bengal. Sreenivas and Madhusoodanan (2010b) reported this species for first time from Peninsular India.

P. multifida is thought to be native to China and Japan and subsequently escaped from the cultivation and spread outside its native range.

Materials examined:

KERALA: Kozhikode (Dt.): Puthiyara (alt. 5m), *V.K.Sreenivas 119237* (CALI).

WEST BENGAL: Howrah (Dt.): Indian Botanical Garden (alt. sea level), *A.Biswas 68702* (CAL).

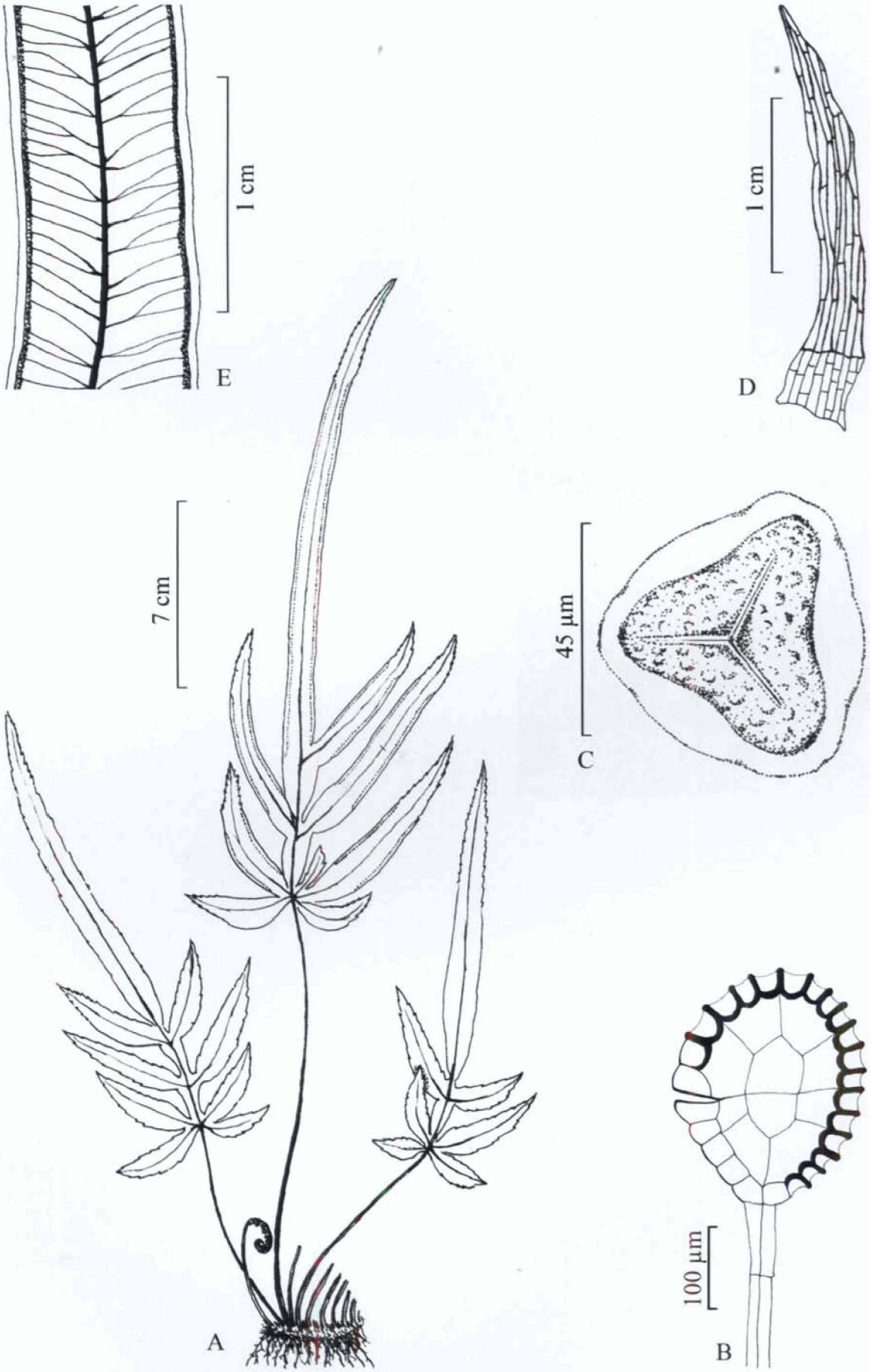


Fig. 19. ***Pteris multifida*** **Poir.**: **A**. habit; **B**. sporangium; **C**. spore; **D**. palea; **E**. a portion of fertile pinna (*V.K.Sreenivas 119237*, CALI).

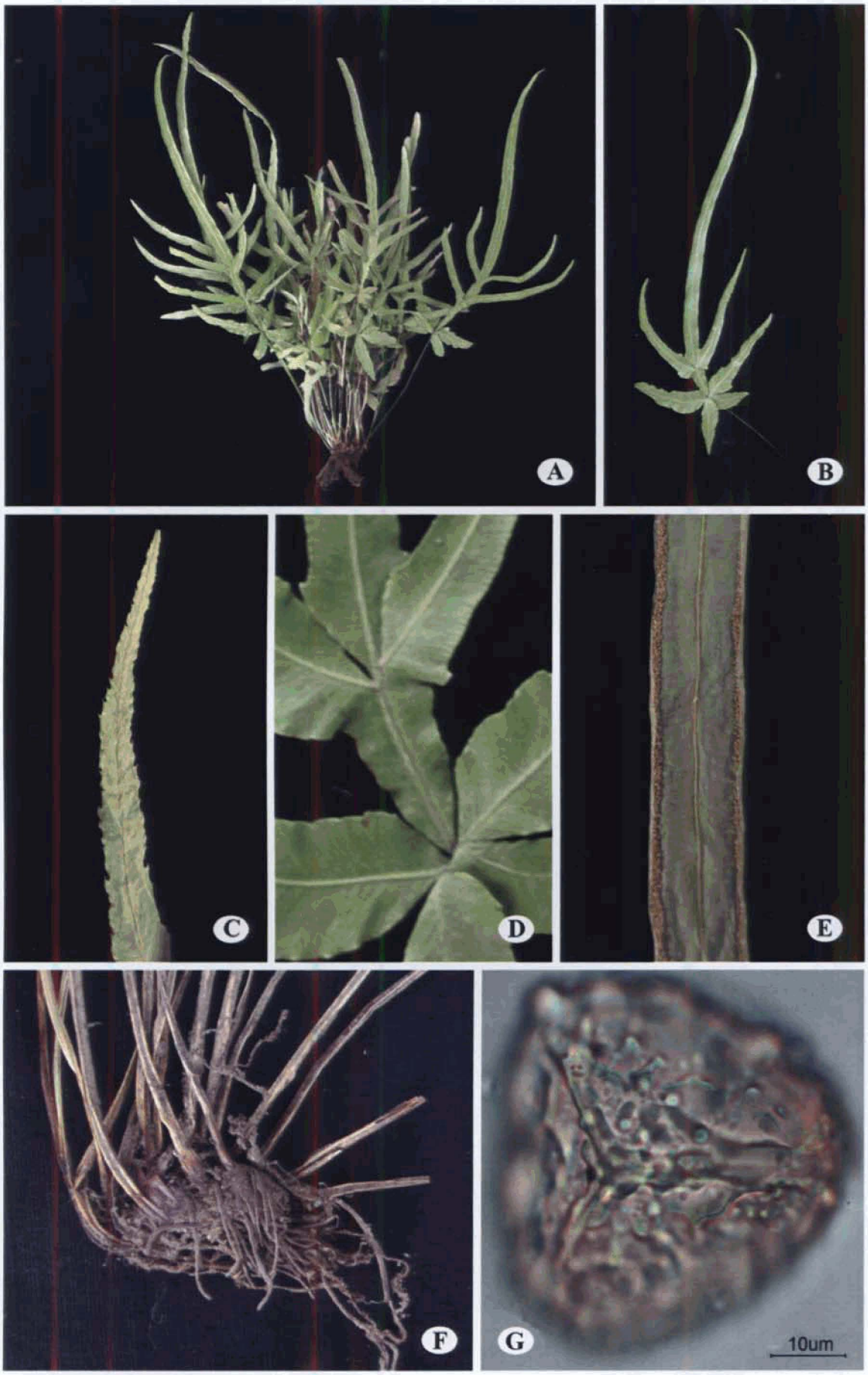


Plate 21. ***Pteris multifida*** **Poir.**: **A**. habit; **B**. single frond; **C**. pinna apex; **D**. winged rachis; **E**. a portion of fertile pinna; **F**. rhizome; **G**. spore.

16. Pteris otaria Bedd.

P. otaria Bedd., Ferns S. India.13, pl. 41. 1863; S. M. Vasudeva & A. Singla, Asp. Plant Sci. 13: 330. fig. 8-12. 1991; Manickam & Irud., Pterid. Fl. W. Ghats 77. pl. 53. 1992; Fras.-Jenk., New Sp. Syndr. Indian Pterid. 223. 1997; Subh. Chandra, Ferns India 41. 2000; Easa, Biodiv. Doc. Kerala 5: 21. 2003; Mahamuni & Dongare, Indian Fern J. 26: 140. 2009; Sreenivas & Madhus., Proc. 22nd Kerala Sci. Congr. 867. 2010.

[Fig. 20, 23D & Plate 22]

Type: India, Nilgiri, Pantaloor, *Beddome s.n.* (Holotype, K).

Pteris quadriaurita var. *ludens* Bedd., Ferns. Brit. India, 111. 1883.

Pteris multiaurita J. Agardh x *P. quadriaurita* Retz., T. G. Walker, Evolution 12: 83. fig. 1. 1958; N. C. Nair et al., J. Econ. Taxon. Bot. 259. 1992.

Height 76-80 cm. Rhizome short, suberect, 3-5 cm long, 2-3 mm thick, cylindrical, scaly. Palea dark brown, 1-2 mm long, lanceolate, acuminate, auriculate, thick walled central cells, thin walled outer cells with cellular projections. Stipe 30-40 cm long, 3-4 mm thick, green (fresh specimens) or stramineous (dry specimens), grooved, glabrous. Lamina bipinnate, 30-38 cm long x 10-16 cm broad, lanceolate, green, subcoriaceous. Pinnae 6-8 pairs, 8-11 cm long x 2-3 cm broad, opposite or subopposite, lanceolate, green,

basal pair bipartite. Pinnules 7-12 pairs, 1-2 cm long x 3-4 mm broad, oblong, margin entire, apex crenate, sinus *c.* 1 mm from costae, *c.* 1.5 mm apart, basal pinnules reduced at acroscopic side, spinules along the costule. Costae grooved above with spines at the base of attachment site of costule, and raised below. Veins 10-16 pairs, free, forking, forking twice at reduced pinnae. Sori brown, linear, 1-1.5 cm long, submarginal except base and apex. Indusium false, pale white. Sporangium: capsule globose, 200-250 μm long; stalk 150-200μm long, biseriate; annulus 18-20 celled. Paraphyses uniseriate. Spores brown, *c.* 30 x 35 μm, trilete-tetrahedral, rugate.

Habitat: Fully exposed area as well as partially exposed areas such as earth cuttings, forest floors, *etc.*

Altitude: 10m-1000m.

Distribution: India and Sri Lanka (South India: Kerala and Tamil Nadu).

Chromosome number: n= 29 (Abraham *et al.*, 1962).

IUCN status: Least concern (LC). This is a widespread taxon present in evergreen and deciduous forests in South India and it does not meet any criteria for Endangered, Vulnerable, *etc.* under IUCN red list category.

Notes: Beddome (1863) described this species from Pantaloor, (now it is in Tamil Nadu), India. Later Beddome (1883) downgraded this species to a

variety, *viz. P. quadriaurita* var. *ludens*. Thwaites (1864) equated this species to *P. quadriaurita* Retz.

P. otaria is characterized by its abortive acroscopic pinnules and crenate apex. Walker (1958) carried out a series of experiments on the hybridization between the members of *P. quadriaurita* complex. He considered *P. otaria* is a fertile hybrid between *P. quadriaurita* and *P. multiaurita* J. Agardh. Abraham *et al.* (1962), of the opinion that it is a distinct taxon. Fraser Jenkins (1997) also commented that '*P. otaria* occurs widely and independently, reproduce itself and has a distinct mixed ecology. It behaves as a species in its own right'. Nair and Ghosh (1974) considered that this is a hybrid and very common in Kerala because of the human interference in the ecological preferences of parent species. One specimen in CAL (*N.C. Nair 50884*) shows a gradation of morphology between *P. multiaurita* and *P. quadriaurita*.

Beddome (1863) reported *Pteris semipinnata* L. from Travancore hills of South India, in which, acroscopic pinnules are completely absent. No subsequent authors are able to collect this species from South India or no materials from South India are available in CAL, CALI, KFRI, MGMC, MH, RHT, SKU, XCH and TBGT herbaria. So it might me Regionally Extinct.

Materials examined:

KERALA: Kollam (Dt.): Kattilappara (alt. 350m), *V.K.Sreenivas 124071*; Palaruvi (alt. 500m), *Habeeb 120974* (CALI); Thenmala (alt. 400m), *V.S.Manickam & K.M.Mathew 33701* (RHT, XCH); Achan Kovil (alt. 350m), *C.N.Mohanan 61286*; Aryankavu (alt. 200m), *N.C.Nair & S.R.Ghosh 50673*; Umayur-Kulathupuzha (alt. 700m), *N.C.Nair 50881*(MH); Kottarakara (alt.100m), *N.C.Nair & S.R.Ghosh 50941* (MH, CAL); Palaruvi (alt. 500m), *N.C.Nair & S.R.Ghosh 51981*; Punalur (alt. 300m), *N.C.Nair & S.R.Ghosh 50884* (CAL). **Kottayam** (Dt.): Near Kanhirappally (alt. 50m), *V.S.Manickam 33522* (XCH). **Pathanamthitta** (Dt.): Moozhiyar-Kakki road (alt. 600m), *V.S.Manickam & K.M.Mathew 33650*; Vadaserikara, Sabarimala Hills (alt. 100m), *V.S.Manickam & K.M.Mathew 33606* (RHT, XCH); Angadi-Ranni (alt. 350m), *N.C.Nair 50705*; Vennikkulam (alt. 100m), *N.C.Nair & S.R.Ghosh 50827* (CAL). **Thrissur** (Dt.): Athirappally (alt. 350m), *V.K.Sreenivas 119286* (CALI). **Thiruvananthapuram** (Dt.): Way to Athirumala (alt. 700m), *V.K.Sreenivas 124039*; Ponmudi (alt. 1000m), *V.K.Sreenivas 124051* (CALI); Ponmudi hills (alt. 1100m), *V.S.Manickam & K.M.Mathew 33719* (RHT); Ponmudi (alt. 1100m), *N.C.Nair & S.R.Ghosh 51767* (MH, CAL); Neyyattinkara (alt. 45m), *N.C.Nair & S.R.Ghosh 51793* (CAL).

TAMIL NADU: Kannyakumari (Dt.): Balmore Hills (alt. 600m), *V.S.Manickam 14724*; Mahendragiri (alt. 400m), *V.S.Manickam 2591* (XCH); Kirippara (alt. 150m), *N.C.Nair & S.R.Ghosh 51931* (CAL). **Tirunelveli** (Dt.): Kannikatty (alt. 700m), *K.M.Sebastine 8477* (MH, CAL).

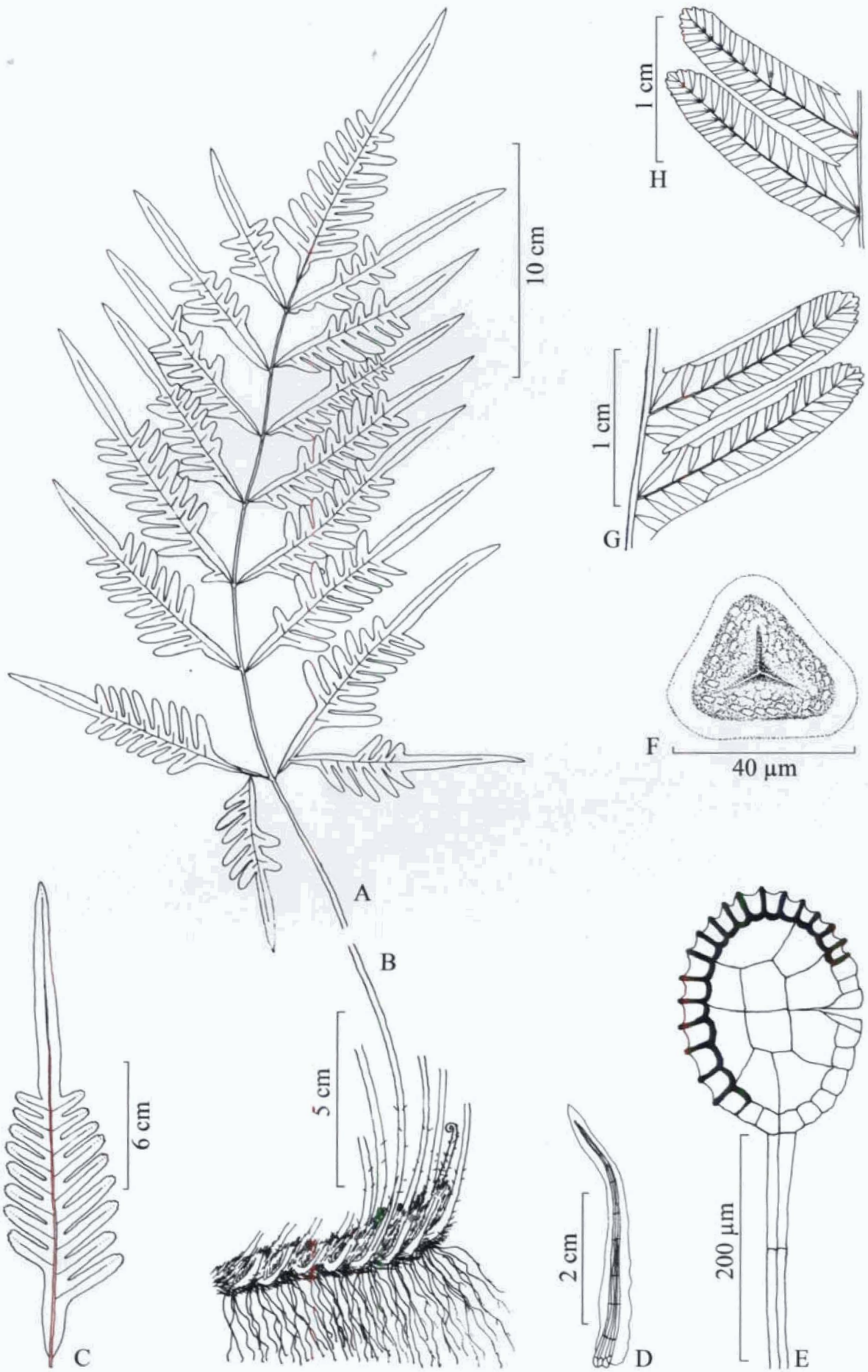


Fig. 20. ***Pteris otaria*** **Bedd.**: **A-B**. habit; **C**. a single pinna; **D**. palea; **E**. sporangium; **F**. spore; **G**. fertile pinnules; **H**. sterile pinnules (*V.K.Sreenivas 124039*, CALI).

Plate 22. ***Pteris otaria*** **Bedd.**: **A**. habit; **B**. single pinna; **C**. sterile pinnules; **D**. fertile pinnules; **E**. rhizome; **F**. spore.

17. **Pteris pellucida** C. Presl

P. pellucida C. Presl, Reliq. Haenk. 1: 55. 1825; J. Agardh, Recens. Spec. Pter. 10. 1839; Hook., Sp. Fil. 2: 161. t. 129B. 1858; Hook. & Baker, Syn. Fil. 154. 1868; Bedd., Ferns South India 13. pl. 38. 1863 & Handb. Ferns. Brit. India 106. 1883; C. B. Clarke, Trans. Linn. Soc. Lond. II, Bot. 1: 462. 1880; B. K. Nayar & S. Kaur, Comp. Bedd. Handb. 29.1974; R. D. Dixit, Cens. Indian Pterid. 71.1984; S. M. Vasudeva & Chhibber, Indian Fern J. 6: 210. 1989; N. C. Nair et al., J. Econ. Taxon. Bot. 259. 1992; Manickam & Irud., Pterid. Fl. W. Ghats 69 pl. 44. 1992; Rajagopal & K. G. Bhat, Indian Fern J. 15: 8. 1998; Subh. Chandra, Ferns India 41. 2000; Manickam & Irud., Pterid. Fl. Nilgiris 85. 2003; Easa, Biodiv. Doc. Kerala 5: 21. 2003; Pullaiah et al., Pterid. Andhra Pradesh 53. fig. 18. 2003; Ghosh et al., Pterid. Fl. E. India 1, Ser. 4: 325. 2004; S. Das, Indian Fern J. 24: 67. 2007; Mahamuni & Dongare, Indian Fern J. 26: 140. 2009; Sreenivas & Madhus., Proc. 22nd Kerala Sci. Congr. 867. 2010.

[Fig. 21, 23E & Plate 23]

Type: Philippines, Luzon, *Haenke 118* (Holotype, PRC; Isotype, K, digital image!).

Pteris venulosa auct. B.K. Nayar & Geevarghese Fern Fl. Malabar 115. 1993; Easa, Biodiv. Doc. Kerala 5: 22. 2003. *non* Blume, 1828.

Type: Indonesia, *Anonymous s.n.* (Holotype, L; Isotype, K, digital images!).

Height up to 70 cm. Rhizome short, erect, 3-4 cm long, 4-5 mm thick, cylindrical with tuft of roots, scaly. Palea brown, *c.* 3 mm long, 0.4-0.5 mm wide at base, lanceolate, acuminate, auriculate, inner thick walled cells and outer thin walled cells. Stipe 20-35 cm long, 2-4 mm thick, green (live materials) or stramineous (dry materials) with chestnut patches, shiny, grooved, glabrous above, scaly below. Lamina pinnate, 20-30 cm long x 15-25 cm broad, deltoid, green, coriaceous. Pinnae 3-4 pairs, 15-20 cm long x 2-2.5 cm broad (sterile), 24-28 cm long x 2.5-3.5 cm broad (fertile), opposite or subopposite, lanceolate, terminal pinna larger than lateral ones, entire, apex acuminate, glabrous, pinnae base adnate to stipe, basal pair not bipartite, green. Costae deeply grooved above, raised below. Veins numerous, free, forking invisible in some cases. Sori brown, linear, 17-22 cm long, submarginal except at base and apex. Indusium false, brown. Sporangium: globose, capsule 200-250 µm long; stalk 200-300 µm long, biseriate; annulus 16-20 celled. Paraphyses uniseriate. Spores brown, *c.* 30 x 35 µm, trilete-tetrahedral, verrucate.

Habitat: Seen in fully exposed as well as shaded forest areas.

Altitude: 50m-1500m.

Distribution: China, Japan, India (South India: Andhra Pradesh, Karnataka, Kerala & Tamil Nadu), Myanamar and Thailand.

Chromosome Number: n= 29 (Kuriachan, 1968).

Etymology: Specific epithet derived from a Latin word 'pellucidus' (translucent but, not hyaline). Its pinnae are translucent.

IUCN status: Least concern (LC). A commonly occurred taxon in South India and it does not meet any criteria for Endangered, Vulnerable, *etc.* under IUCN red list category.

Notes: Presl described this species based on the specimen from Luzon (*Haenke 118*). Beddome (1863) suspected this is a variety of *P. cretica* L. Nayar and Geevarghese (1993) reported *P. venulosa* Blume from Silent Valley National Park (*B.K.Nair, 7320*; *Geevarghese 4005 & 17823*, CALI) in error for *P. pellucida*. This species is resembles to *P. venulosa* Blume and *P. venusta* Kunze in its pinnae arrangements, but, pinnae are adnated to the stipe to form a wing and apex is crenate in the case of *P. venulosa* and *P. venusta*.

P. pellucida is characterized by its entire or undulate pinna and apex. It shows variations in the lower pinnae, sometimes which are bipartite or otherwise not bipartite. Some specimens collected from Silent Valley have

bipartite basal pinna and these are large plants compared to specimens collected from other areas of South India.

Materials examined:

ANDHRA PRADESH: Chitoor (Dt.): Talakona forest (alt. 650m), *G.V.Subbarao 46956* (MH, CAL); **East Godavari** (Dt.): Dummakonda forest (alt. 425), *G.V.Subbarao 68632*; Kutravada (alt. 600m), *G.V.Subbarao 27283*; Talepally (alt. 520), *N.Rama Rao & D.N.Narasimhan 84373* (MH); Ethakonda (alt. 900m), *V.Narayanaswami 592* (CAL); Maridimilli, *A.Ahmad & T.Pullaiah 12871*; Rampa water falls, *A.Ahmad 12878*; Tiger Camp, *P.Amrutha Lakshmi 25197* (SKU). **Srikakulam** (Dt.): Salur forest (alt. 700m), *N.P.Balakrishnan 1123* (CAL). **Visakhapattanam** (Dt.): Mettur (alt. 625m), *G.V.Subbarao 29573*; Pungagiri top (alt. 200m), *G.V.Subbarao 32781*; Venkachinta gedda (alt. 1025), *G.V.Subbarao 47346* (MH); Minumuluru (alt. 1025m), *G.V.Subbarao 47346* (CAL); Lankapakalu, *P.Amrutha Lakshmi 26201* (SKU). **Vizianagaram** (Dt.): Sujankota (alt. 850m), *P.Amrutha Lakshmi 25160* (CAL, SKU).

KARNATAKA: Chikmagaluru (Dt.): Belahanur (alt. 900m), *V.K.Sreenivas 124094* (CALI). **Kodagu** (Dt.): Appagala (alt. 750m), *V.K.Sreenivas 113213* (CALI); Bhagamandala (alt. 1000m), *V.S.Manickam 2717*; Sampage Ghat (alt. 900m), *V.S.Manickam 2885* (XCH); Hoddur, *P.K.Rajagopal s.n.*; Madikeri (alt. 850m), *P.K.Rajagopal 116* (MGMC). **North Kannada** (Dt.):

Kaiga (alt. 1300m), *P.K.Rajagopal 157* (MGMC). **Shimoga** (Dt.): Jog falls-Upper region (alt. 1500m), *P.V.Madhusoodanan 39824* (CALI); Hulikal (alt. 1350m), *P.K.Rajagopal 39A*; Kudachadri hills (alt. 1250m), *P.K.Rajagopal 161* (MGMC).

KERALA: Idukki (Dt.): Anjilathandu (alt. 740m), *V.K.Sreenivas 113244*, Madakkanam (alt. 900m) *K.P.Rajesh 70102*; Thekkady (alt. 720m), *K.P.Rajesh 18346* (CALI); Kozhikkanam (alt. 950m), *V.S.Manickam & K.M.Mathew 34283*; Peerumedu (alt. 1000m), *V.S.Manickam & K.M.Mathew 33418* (XCH); Thankamani (alt. 800m), *N.C.Nair 70751* (CAL). **Kannur** (Dt.): Meenmutty (alt. 450m), *K.P.Rajesh & K.Satheesh Kumar 87837* (CALI); Ambayathode (alt. 550), *V.S.Ramachandran 59153* (MH, CAL). **Kasargode** (Dt.): Meloth (alt. 500m), *V.J.Nair 73816* (MH, CAL). **Kollam** (Dt.): Palaruvi (alt. 500m), *N.Rama Rao 1757* (CAL). **Kozhikode** (Dt.): Kakkayam forest (alt. 720m), *V.K.Sreenivas 113296*; Peruvannamuzhi (alt. 350m), *V.K.Sreenivas 119284, Adoor Varghese 29453* (CALI). **Malappuram** (Dt.): C. U. Campus (alt. 50m), *P.V.Madhusoodanan & M.J.Molly* 21268 (CALI). **Palakkad** (Dt.): Irumbakam Chola, *Santhosh Nampy & A.K.Pradeep* 44837; Kaikatty (alt. 900m), *B.K.Nayar & Pankaj 7320*; Kanhirapuzha (alt. 600m), *Geevarghese 4005 & Santhosh Nampy 43795*; Kiliparakunnu-Parambikulam (alt. 800m), *V.K.Sreenivas 119214*; Nellyampathi (alt. 1100m), *Geevarghese 17823*; Panthenthode (alt. 850m), *V.K.Sreenivas 119264*; Pezha-Parambikulam (alt. 950m), *V.K.Sreenivas 119208*; Thothanparakuzhi (alt.

750m), *V.K.Sreenivas 113220* (CALI); Nellyampathi (alt. 1100m), *N.C.Nair 69646* (MH); Ayyappan kovil (alt. 900m), *E.Vajravelu 49710*; Mukkali (alt. 700m), *J.N.Vohra & R.K.Ghosh 58426*; Mundampathy forest (alt. 525m), *N.C.Nair 64642* (CAL); Nelliampathy (alt. 850m), *C.C.Joy & S.Stephen 7233*; Near Pathrakadavu (alt. 750m), *S.Stephen & C.C.Joy 7503* (KFRI). **Thrissur** (Dt.): Athirappally (alt. 350m), *V.K.Sreenivas 119287* (CALI); Vazhachal (alt. 400m), *N.C.Nair & S.R.Ghosh 51005* (CAL). **Thiruvananthapuaram** (Dt.): Agasthyamala (alt. 1150m), *V.K.Sreenivas 113277 & 124042* (CALI); Ponmudi hills (alt. 800m), *V.S.Manickam & K.M.Mathew 33854* (XCH); Ponmudi hills (alt. 1000m), *N.C.Nair & S.R.Ghosh 52603* (MH). Chemunji (alt. 950m), *Raju Antony 5429* (TBGT). **Wayanad** (Dt.): Thirunelly (alt. 850m), *V.K.Sreenivas & V.P.Thomas 119281*, Tholpetty (alt. 920m) *Manju C.Nair 70290* (CALI); Kuppadi (alt. 900m), *J.L.Ellis 18529* (MH).

TAMIL NADU: Coimbatore (Dt.): Anakunthi shola (alt. 700m), *V.S.Manickam & K.M.Mathew 34637*; Karyan Shola (alt. 750m), *K.M.Mathew 31532*; Top slip- Karyan shola (alt. 750m), *V.S.Manickam & K.M.Mathew 34627*; Sholayar (alt. 800m), *V.S.Manickam & K.M.Mathew 34649* (RHT); Valparai (alt. 700m), *V.S.Manickam 2059*; Varagalur, Pollachi (alt. 800m), *V.S.Manickam & K.M.Mathew 34649* (XCH); Ganaikundhi shola (alt. 750m), *J.Joseph 13811*; Karyan Shola (alt. 760m), *V.Narayanaswami 5353*; Muthukulam-Siruvani (alt. 900m), *K.Subramannyam 5911* (MH).

Kannyakumari (Dt.): Bafield, Thovalai (alt. 600m), *V.S.Manickam 2553*; Balmore shola (alt. 700m), *V.S.Manickam 2525* (XCH); Kalikisan river-Belford (alt. 700m), *A.N.Henry 48149*; Lower Kodayar (alt. 600m), *A.N.Henry 61524* (MH). **Nilgiri** (Dt.): Bospara forest area (alt. 1000m), *V.S.Manickam 1579*; Gudallur (alt. 1300m), *V.S.Manickam 1586*; *V.S.Manickam 1609* (XCH); Devala-Pandalur (alt. 925), *E.Vajravelu 43481* (MH). **Salem** (Dt.): Pongal Kovil shola, Kolli hills (alt. 1200m), *V.S.Manickam & K.M.Mathew 33161* (XCH). **Vellore** (Dt.): Erukkampally, Jaradi hills (alt. 980m), *M.B.Viswanathan 1040* (MH, CAL).

18. **Pteris perrottetii** Heiron.

P. perrottetii Heiron., Hedwigia, 55: 374. 1914; R. D. Dixit, Cens. Indian Pterid. 71. 1984; Subh. Chandra, Ferns India 34 2000; Fras.-Jenk., Indian Fern J. 25: 23. 2008; Sreenivas & Madhus., Proc. 22nd Kerala Sci. Congr. 867. 2010.

[Fig. 22, 23F & Plate 24]

Type: India, Nilgiri, *Perrotet 1476* (Holotype, B, digital image!).

Pteris perrotteti var. *brevilaciniata* Heiron., Hedwigia, 55: 375. 1914; R. D. Dixit, Cens. Indian Pterid. 71. 1984; Subh. Chandra Ferns India 34 2000; Fras.-Jenk., Indian Fern J. 23. 2008. ***syn. nov.***

Type: India, Nilgiris, *Hooker & Thomson s.n.* (Holotype, B, digital image!).

Height up to 125 cm. Rhizome short, erect, 4-5 cm long x 1-2 cm thick, cylindrical with tuft of roots, scaly. Palea dark brown, 2-3 mm long, 0.3-0.4 mm broad at base, lanceolate, acute, central thick walled cells, thin walled cells at periphery with multicellular projections. Stipe 60-70 cm long, 4-5 mm thick, green (live materials) or stramineous (dry materials) above and chestnut below, grooved thoughout, scaly below. Lamina bipinnate, 60-70 cm long x 20-30 cm broad, ovate or lanceolate, obscure green, coriaceous. Pinnae 8-12 pairs, 15-16 cm long x 3.5-5.5 cm broad, opposite to subopposite,

153-A

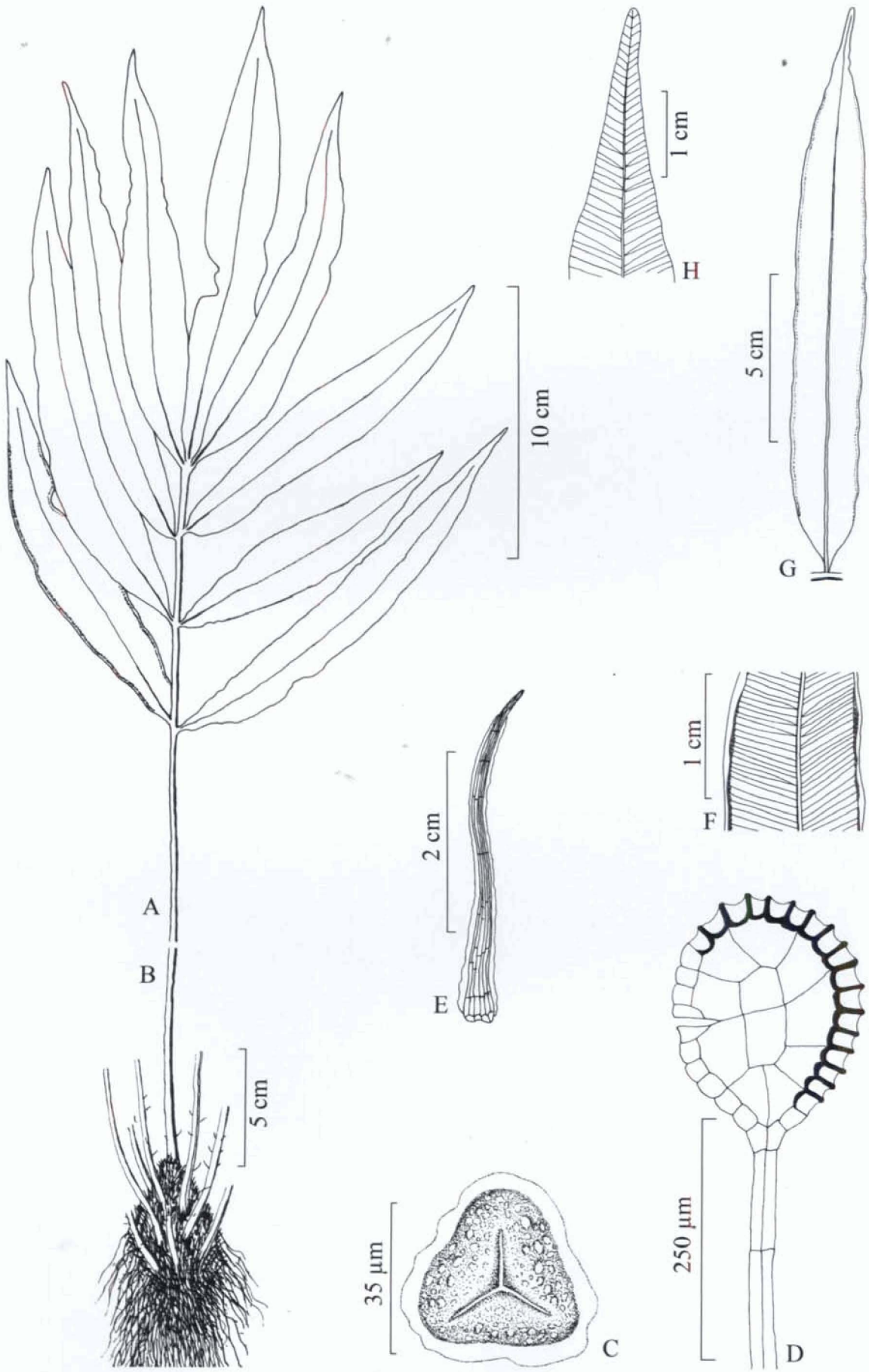


Fig. 21. ***Pteris pellucida*** **C. Presl**: **A-B**. habit; **C**. spore; **D**. sporangium; **E**. palea; **F**. a portion of fertile pinna; **G**. single pinna; **H**. pinna apex (*V.K.Sreenivas 119208*, CALI).

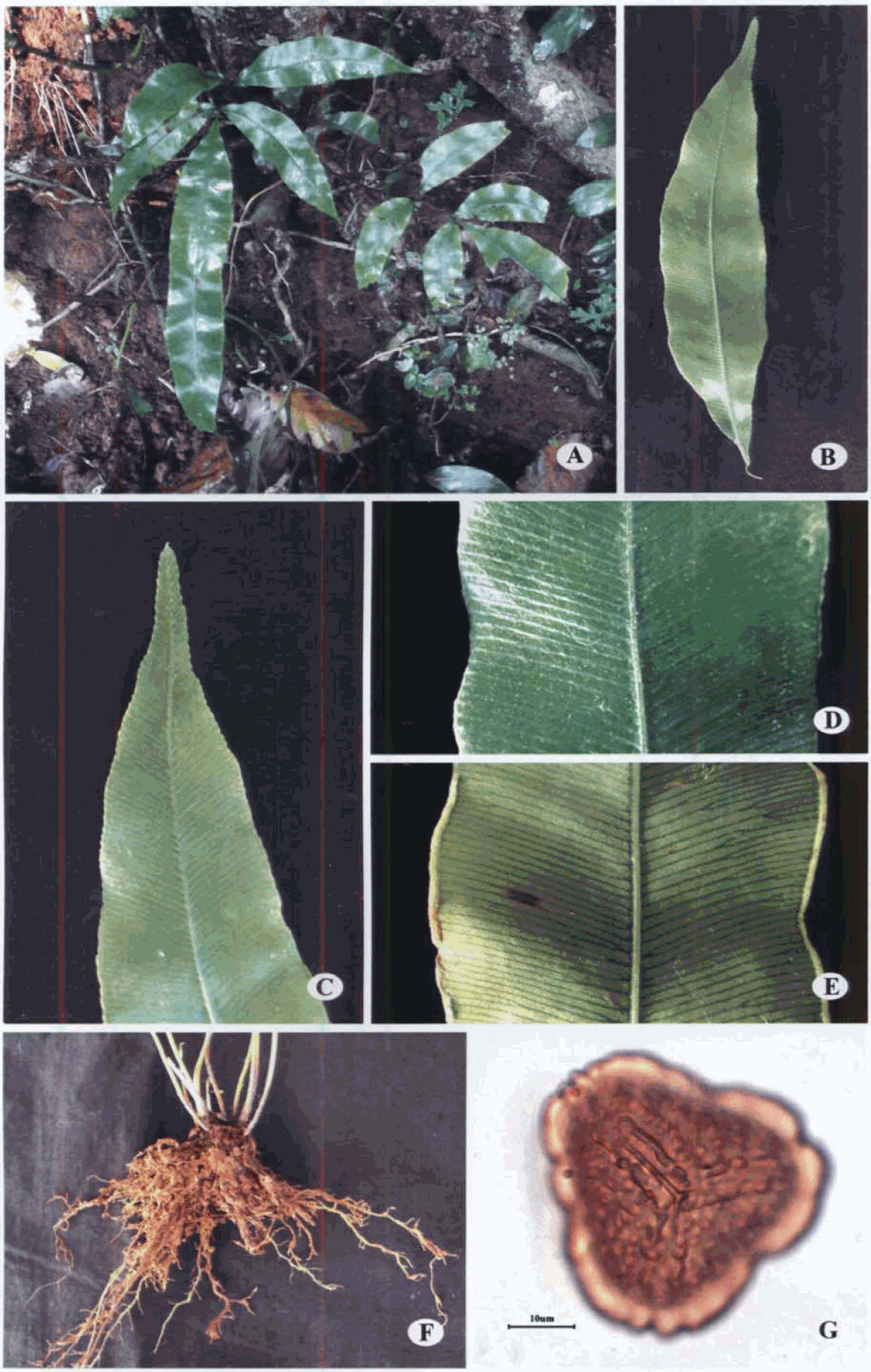


Plate 23. ***Pteris pellucida*** **C. Presl**: **A**. habit; **B**. single pinna; **C**. pinna apex; **D**. a portion of sterile pinna; **E**. a portion of fertile pinna; **F**. rhizome; **G**. spore.

lanceolate, acuminate, entire, elongated pinna-apex, pale green, basal pair bipartite or with more than one accessory pinna. Pinnules 24-28 pairs, 2.5-3.8 cm long x 4-6 mm broad, oblong, margin entire, apex acute, sinus below 1 mm from costa, 2-4 mm apart, spinules (inconspicuous) on costule at distal end. Costae grooved above with inconspicuous spines, and raised below. Veins 16-18 pairs, free, forking, distinct. Sori brown, linear, *c.* 2 cm long, submarginal except at base and apex. Indusium false, white. Sporangium: capsule globose, 200-250 µm long; stalk 300-320 µm long, biseriate; annulus 17-18 celled. Paraphyses uniseriate. Spores brown, *c.* 45 x 50 µm, trilete-tetrahedral, verrucate.

Habitat: Seen in evergreen forest, usually near stream sides or marshy areas.

Altitude: 600-2100m.

Distribution: This species is endemic to South India (South India: Kerala and Tamil Nadu).

Etymology: The specific epithet given after a French Botanist Perrottet, who collected the specimens from Nilgiris, India.

IUCN status: Vulnerable (VU). This is an endemic species and the distribution is confined to South India. This taxon meets the criteria VU B1a2ac(iv)C under Vulnerable category.

Notes: Hieronymus (1914b) described this species based on the specimens sent by G. Perrottet from Nilgiris, South India.This species is endemic to South India and frequently occur in Nilgiri Hills. He also described *P. perrottetii* var. *brevilaciniata* based on the specimens from Nilgiri by Hooker and Thomson. But studies on the type specimens revealed that this variety is only a smaller plant of *P. perrottetii*, though Fraser-Jenkins (2008a) equated it with *P. praetermissa* T. G. Walker. *P. perrottetii* Hieron. is characterized by its large size and narrow, linear pinnules and its inter-segmental distance. The lower pair of pinnae usually bears two accessory pinnae. Fraser-Jenkins (2008b) included this species in endemic category.

Materials examined:

KERALA: Idukki (Dt.): Amarachola (alt. 1950m), *V.K.Sreenivas 113256*; Anamudi N.P. (alt. 2000m), *V.K.Sreenivas 113252*; Near Deviarmedu (alt. 1300m), *V.K.Sreenivas 124027*; Noorupara (alt. 700m), *V.K.Sreenivas 113240*; Pampadum shola N.P. (alt. 2100m), *V.K.Sreenivas 113250* (CALI); Thekkadi hills (alt. 900m), *V.S.Manickam 32168* (XCH); Mlappara (alt. 900m), *N.C.Nair 69896* (MH, CAL); Munnar (alt. 1400m), *N.C.Nair & S.R.Ghosh 50756* (MH); Devikulam (alt. 1650m), *N.C.Nair 40209* (CAL). **Palakkad** (Dt.): Valiyaparathode (alt. 850m), *P.Bhargavan 65636* (MH).

TAMIL NADU: Coimbatore (Dt.): Slope of Konamalai (alt. 695m), *C.P.Sreemadhavan 572A* (MH). **Dindigul** (Dt.): Kodaikanal (alt. 1300m),

B.K.Nayar & Unnikrishnan Nayar 2607 (CALI); Monica forest- Kodaikanal (alt. 1650m), *V.S.Manickam & K.M.Mathew 32698*; Pannaikadu (alt. 1300m), *V.S.Manickam 3629 & 34984*; Perumal malai-Palni Hills (alt. 1700m), *V.S.Manickam & K.M.Mathew 32796*; Sahyapuram forest (alt. 1700m), *V.S.Manickam & K.M.Mathew 32737*; Tiger Shola (alt. 1700m), *V.S.Manickam & K.M.Mathew 32560* (XCH); Sirumalai (alt. 1075m), *M.Chandrabose 54275* (MH). **Nilgiri** (Dt.): Way to Avalache (alt. 2100m), *V.K.Sreenivas 119223 & 119230* (CALI); Avalache area (alt. 2100m), *V.S.Manickam 890*; Coonoor (alt. 1700m), *V.S.Manickam 1087*; Governor shola (alt. 2200m), *V.S.Manickam 679*; Rockland forest (alt. 2000m), *V.S.Manickam 941* (XCH); Bangitapal- Sispara (alt. 2225m), *B.V.Shetty 34167*; Near Gundvada river-Kodanad RF (alt. 1800m), *E.Vajravelu 36809*; Loz falls- Coonoor (alt. 1500m), *B.D.Sharma 40305*; Naduvattam (alt. 2000m), *N.P.Balakrishnan 9697* (MH). **Ramanathapuram** (Dt.): Mudaliaruthu (alt. 1300m), *N.C.Nair 61028* (MH, CAL). **Salem** (Dt.): Shevaroy Bauxite hills (alt. 1530m), *A.V.N.Rao 26780*; Yercaud (alt. 1350m), *K.C.Jacob 18074* (MH); Balmadies estate, Yercaud (alt. 1663m), *Ghatak 40* (CAL).

19. Pteris praetermissa T. G. Walker

P. praetermissa T.G. Walker, Kew Bull. 14: 327. fig. 3, 3a., pl. 5. fig. E, F. 1960; N. C. Nair & S. R. Ghosh, J. Bomb. Nat. Hist. Soc. 73: 442. 1976; R. D. Dixit, Cens. Indian Pterid. 71. 1984; S. M. Vasudeva & A. Singla, Asp. Plant Sci. 13: 338. 1991; N. C. Nair et al., J. Econ. Taxon. Bot. 261. 1992; Subh. Chandra, Ferns India 42. 2000; Rajkumar, Indian Fern J. 111. 2002; Manickam & Irud., Pterid. Fl. Nilgiris 87. 2003; Easa, Biodiv. Doc. Kerala 5: 21. 2003; Sreenivas & Madhus., Proc. 22nd Kerala Sci. Congr. 866. 2010.

[Fig. 24, 30A & Plate 25, 26]

Type: Sri Lanka, forest near Le Vallon Tea Estate, 9 February 1954, *T.G. Walker T343* (Holotype, BM, digital image!).

Pteris furunculata N. C. Nair & S. R. Ghosh, J. Indian Bot. Soc. 55: 38.1976; Easa, Biodiv. Doc. Kerala 5: 20. 2003; Fras.-Jenk., Indian Fern J. 25: 22. 2008.

Type: India, Kerala, Ponmudi, *N.C.Nair 51744A* (Holotype, CAL!); *N.C.Nair 51744B-C* (Isotype, CAL!).

Pteris manickamii Rajkumar, J. Bomb. Nat. Hist. Soc. 102: 313. 2005.

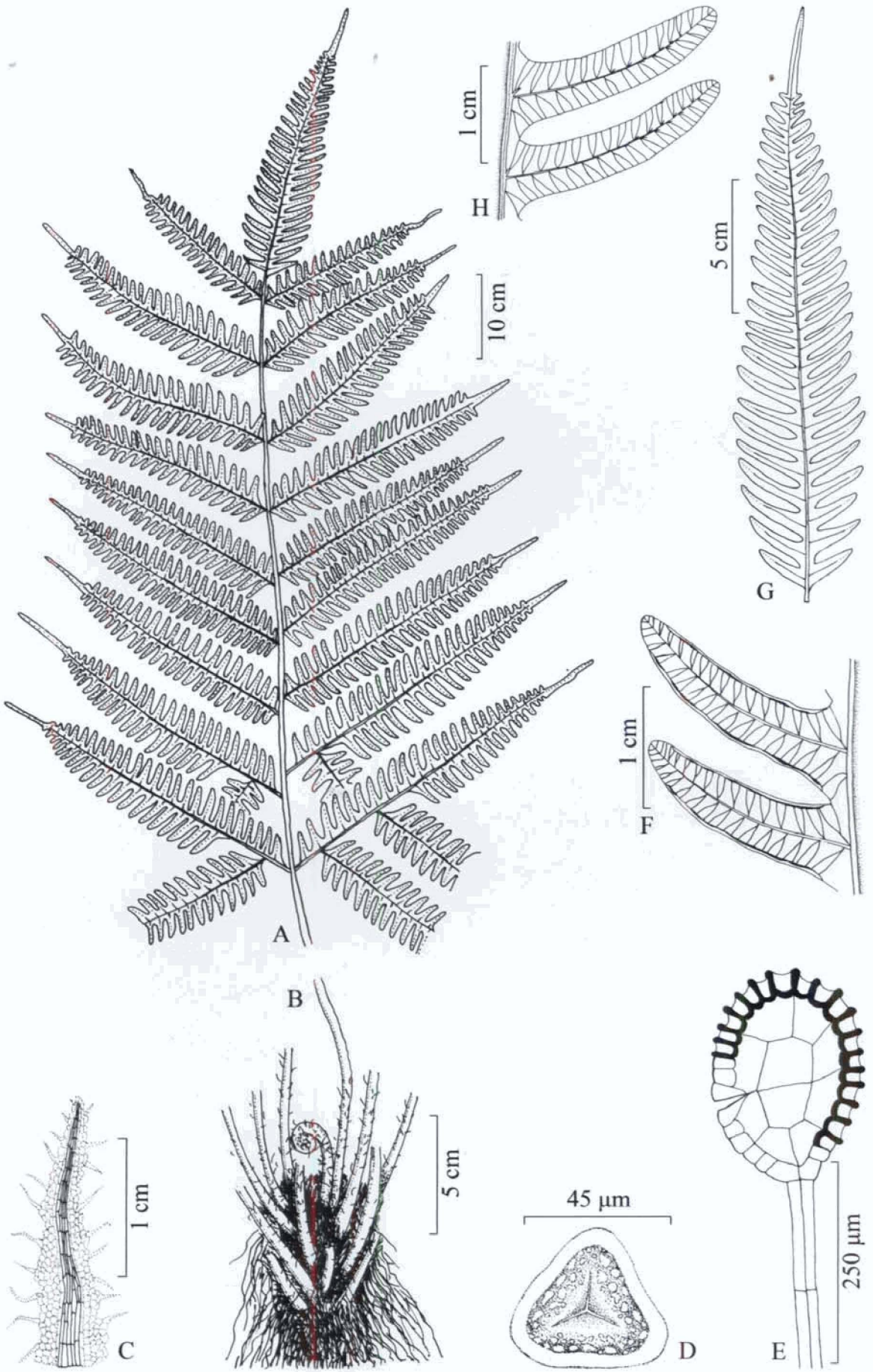


Fig. 22. ***Pteris perrottetii*** **Hieron.**: **A-B**. habit; **C**. palea; **D**. spore; **E**. sporangium; **F**. fertile pinnules; **G**. a single pinna; **H**. sterile pinnules (*V.K.Sreenivas 113256*, CALI).

Plate 24. ***Pteris perrottetii*** **Hieron.**: **A**. habit; **B**. sterile pinnules; **C**. fertile pinnules; **D**. single pinna; **E**. rhizome; **F**. spore.

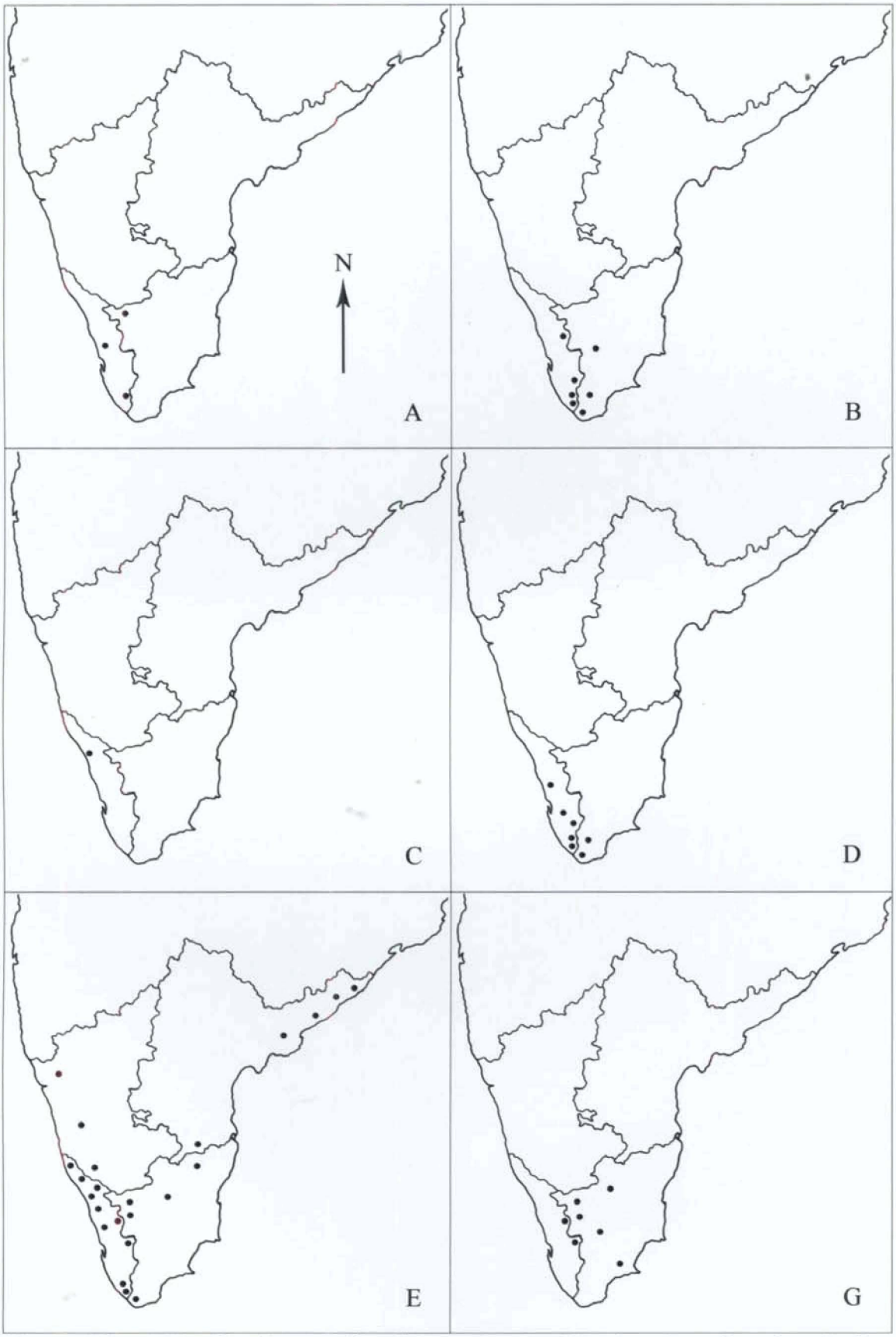


Fig. 23. Distribution of the genus *Pteris* in South India: **A**. *P. mertensioides*; **B**. *P. multiaurita*; **C**. *P. multifida*; **D**. *P. otaria*; **E**. *P. pellucida*; **F**. *P. perrottetii*.

Type: India, Karnataka, Devigar-Nagarigar path, *Manickam 2942* (Holotype, XCH!); Tamil Nadu, Maramalai hills, *Rajkumar 3715* (Paratype, XCH!).

Height 40-45 cm. Rhizome short, suberect, 2-3 cm long x 5-6 mm thick, cylindrical with tuft of roots, scaly. Palea brown, *c.* 3 mm long, *c.* 0.5 mm wide at base, lanceolate, acuminate, auriculate, dark brown along centre, margin with cellular projections. Stipe 25-50 cm long, 2-2.5 mm thick, green or stramineous (dry specimens) above and chestnut below, grooved, scaly below. Lamina bipinnate, 20-35 cm long x 18-25 cm broad, ovate, obscure green, herbaceous (thin). Pinnae 4-6 pairs, 7-15 cm long x 2.2-2.8 cm broad, subopposite, lanceolate, acuminate, entire, pale green, basal pair bipartite. Pinnules 15-23 pairs, 1-1.3 cm long x 2-3 mm broad, oblong, margin entire, apex obtuse, sinus below 1 mm from costa, *c.* 1.5 mm apart, long conspicuous spinules on costule. Costae grooved above with conspicuous spines at the attachment site of costule, and raised below. Veins 11-15 pairs, free, forking. Sori brown, 6-8 mm long, linear, submarginal except at base and apex. Indusium false, pale brown. Sporangium: capsule globose, 200 μm long, stalk 250 μm long, biseriate; annulus 16-18 celled. Paraphyses uniseriate. Spores pale brown, *c.* 35 x 40 μm, trilete-tetrahedral, verrucate.

Habitat: Present both in exposed and shaded forests.

Altitude: Sea level-2100m.

Distribution: India (South India: Karnataka, Kerala & Tamil Nadu) and Sri-Lanka.

Chromosome number: n= 29 (Walker, 1962).

Etymology: Specific epithet derived from a Latin word 'praetermissus' (= overlooked or neglected).

IUCN status: Least concerned (LC). This species occurs widely in forests as well as non-forest areas of South India. It does not meet any criteria for Endangered, Vulnerable, *etc.* under IUCN red list category.

Notes: Walker (1960) described this species from Sri Lanka as a member of *P. quadriaurita* complex and mentioned it was endemic to Sri Lanka. Later, Nair and Ghosh (1974) reported this species from Kerala. Rajkumar (2002) also reported it from Tamil Nadu.

P. praetermissa is a common species in South India and is characterized by long, conspicuous spines on costae and costules. The sinus is almost to the costa and the texture is membranaceous. It is a sexual diploid and frequently misidentified as *P. quadriaurita* Retz. in many Indian herbaria.

Nair and Ghosh (1976) described *P. furunculata* from Ponmudi hills in error for *P. praetermissa*. According to them, this species is closely resembles to *P. confusa* except caducous spinules at the sinus of pinnules and well

marked furunculae on mature pinnae. These caducous spinules are rarely seen in the type specimens and the furunculae are also present in many other species. The present author could not collect this species, with prescribed characters, from the type locality (Ponmudi Hills) and treat the *P. furunculata* Nair & Ghosh is a synonym of *P. praetermissa*. Fraser-Jenkins (1997) equated this species with *P. gongalensis* T. G. Walker, and he considered these laminar furunculae are inconstant and not permanent. Later, Fraser-Jenkins (2008a) used *P. furunculata* is a synonym of *P. praetermissa*.

Rajkumar (2005) described another species *P. manickamii* from South India. He also pointed out that *P. manickamii* is closely related to *P. confusa* except the reduced base of pinnae. He indicated that the type has 20-25 pairs of pinnae, but it was found that the types bear only 10-11 pairs of pinnae. Of course, the basal part of each pinna or basal pinnules aborted on either side. But, *P. manickamii* is treated as a synonym of *P. praetermissa* due to its overall similarities of the specimens (*Manickam 2942 & Rajkumar 3715*, XCH!) except the basal reduced pinnules.

Materials examined:

KARNATAKA: Chikmagaluru (Dt.): Belahanur (alt. 900m), *V.K.Sreenivas 124093* (CALI). **Kodagu** (Dt.): Appagala (alt. 315m), *V.K.Sreenivas 113214 & 113215* (CALI); Sampage Ghats (alt. 700m), *C.A.Barber 2234* (MH). **Mysore** (Dt.): Gopalaswami hills-Bandipur (alt. 1600m), *B.D.Naithani 23221*

(MH). **Shimoga** (Dt.): Kudachadri (alt. 1300m), *P.K.Rajagopal s.n.* (MGMC). **Uduppi** (Dt.): Paniyadi (alt. sea level), *P.K.Rajagopal 267* (MGMC).

KERALA: Idukki (Dt.): Karivanoda (alt. 730m), *V.K.Sreenivas 113245*; Maniyarkutti (alt. 750m), *V.K.Sreenivas 113229, 113231 & 113232* (CALI); Pooyamkutty (alt. 800m), *P.Bhargavan 90046* (MH); Sabarimala (alt. 630m), *N.C.Nair 885* (CAL). **Kannur** (Dt.): Nedumpoyil (alt. 550m), *V.S.Ramachandran 64077* (MH, CAL). **Kottayam** (Dt.): Perunna (alt. 30m), *N.C.Nair 40268* (CAL). **Palakkad** (Dt.): Dhoni Hills (alt. 500m), *K.R.Leena 45125*; Kalakidannal PWLS (alt. 560m), *V.K.Sreenivas 119212*; Kiliparakunnu PWLS (alt.600m), *V.K.Sreenivas 119213*; Madathara PWLS (alt. 700m), *V.K.Sreenivas 113226*; Pezha, PWLS (alt. 970m), *V.K.Sreenivas 119201*; Way to Sispara (alt. 1500m), *V.K.Sreenivas 124008 & 124009* (CALI); Mundapathy forest (alt. 525m), *N.C.Nair 64635* (MH); Karappara dam site (alt. 950m), *N.C.Nair 69844* (CAL). **Pathanamthitta** (Dt.): Kunnumthanam-Thiruvalla (alt. 9m), *N.C.Nair& S.R.Ghosh 50812* (CAL). **Thiruvananthapuram** (Dt.): Agasthyamala (alt. 1100m), *V.K.Sreenivas 113272*; Way to Athirumala (alt. 700m), *V.K.Sreenivas 124040 & 124043* (CALI). **Wayanad** (Dt.): Chandanathode (alt. 650m), *V.K.Sreenivas 113288*; Chembra peak (alt. 1800m), *V.K.Sreenivas 113280*; Thirunelli (alt. 900m), *V.K.Sreenivas & V.P.Thomas 113278 & 113279* (CALI).

TAMIL NADU: Coimbatore (Dt.): Siruvani (alt. 900m), *B.D.Dev 31085* (MH). **Nilgiri** (Dt.): Way to Avalache (alt. 2100m), *V.K.Sreenivas 119229* (CALI). **Salem** (Dt.): Shevaroyan temple area (alt. 1800m), *N.C.Nair 74218* (MH).

20. **Pteris quadriaurita** Retz.

P. quadriaurita Retz., Observ. Bot. 6: 38. 1791; J. Agardh, Recens. Spec. Pter. 24. 1839; Hook., Sp. Fil. 2:179. t. 134 B. 1858; Thwaites, Enum. Pl. Zeyl. 386. 1864; Hook. & Baker, Syn. Fil. 158. 1868; Hieron., Hedwigia 55: 328. 1914; T. G. Walker, Kew Bull. 14: 324. fig. 1, 1a., pl. 5. fig. C, I. 1960; Mickel & Smith, Pterid. Mexico 1: 542. 2004; Subh. Chandra et al., Taiwania 53: 188. 2008.

[Fig. 25, 30B & Plate 27, 28]

Type: Sri Lanka, *Koenig s.n.* (Lectotype, LD, digital image!).

Pteris quadriaurita sensu C. B. Clarke, Trans. Linn. Soc. Lond. II, Bot.1: 465. 1880; Bedd. Ferns S. India 11. pl. 31. 1863; Bedd., Handb. Ferns. Brit. India 110. 1883. C. V. Morton, Amer. Fern. J. 47: 11. 1957; Scamman, Rhodora 63: 198. 1961; T. G. Walker, Brit. Fern Gaz. 10: 150. 1970; N. C. Nair & S. R. Ghosh, J. Bomb. Nat. Hist. Soc. 73: 439. 1976; B. K. Nayar & S. Kaur, Comp. Bedd. Handb. 29. 1974; R. D. Dixit, Cens. Indian Pterid. 71. 1984; Manickam, Fern Fl. Palni Hills 23. 1986; S. M. Vasudeva & Chhibber, Indian Fern J. 6: 213. 1989; N. C. Nair et al., J. Econ. Taxon. Bot. 260. 1992; Manickam & Irud., Pterid. Fl. W. Ghats 79. pl. 55. 1992; B. K. Nayar & Geev. Fern Fl. Malabar 112. fig. 29. 1993; Rajagopal & K. G. Bhat, Indian Fern J. 15:

Plate 25. Holotype of *Pteris praetermissa* T. G. Walker (BM)

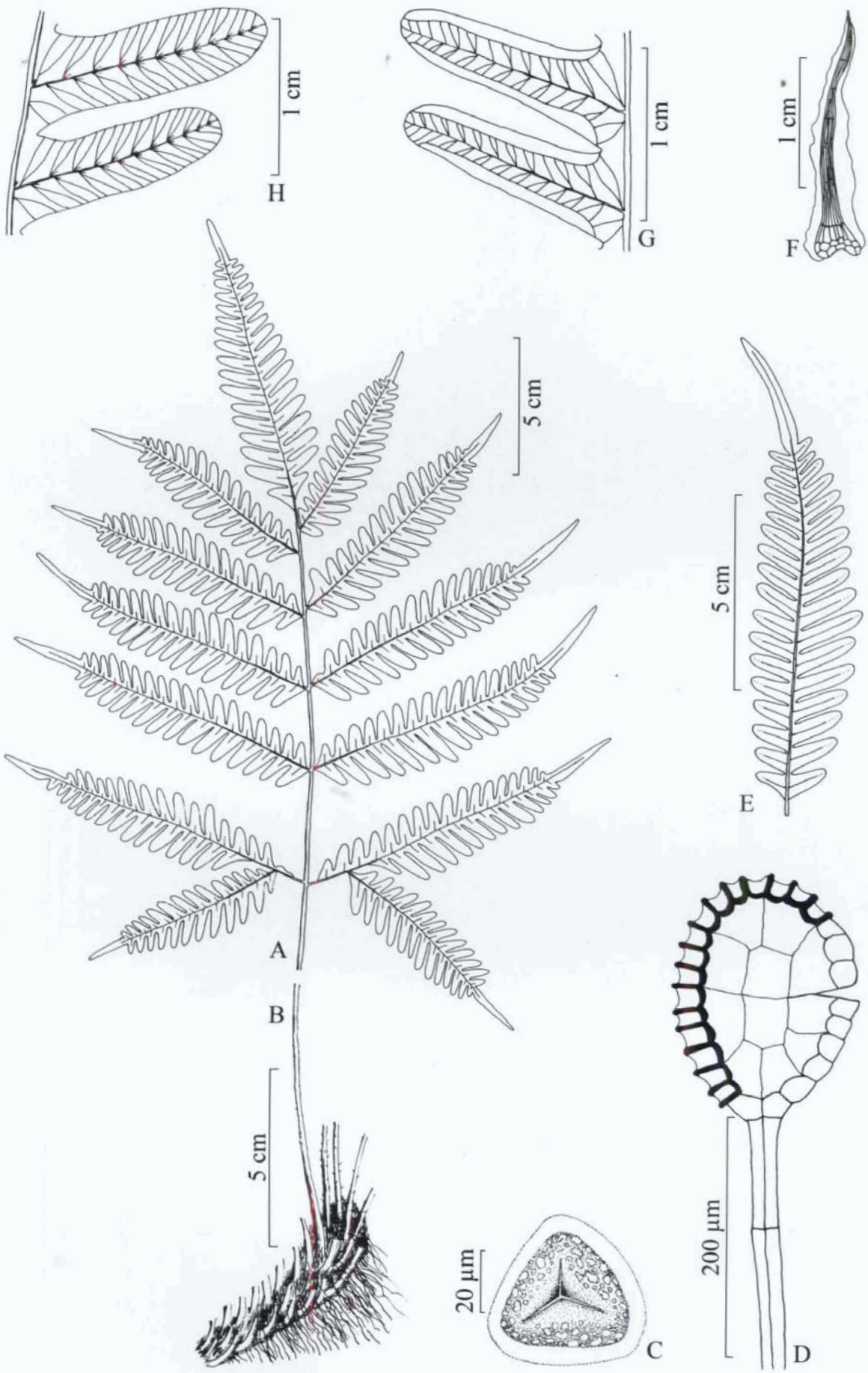


Fig. 24. ***Pteris praetermissa*** **T.G.Walker**: **A-B**. habit; **C**. spore; **D**. sporangium; **E**. single pinna; **F**. palea; **G**. fertile pinnules; **H**. sterile pinnules (*V.K.Sreenivas 119212*, CALI).

Plate 26. ***Pteris praetermissa*** **T. G. Walker**: **A**. habit; **B**. single pinna; **C**. sterile pinnules; **D**. ferile pinnules; **E**. rhizome; **F**. spore.

8. 1998; Subh. Chandra, Ferns India 43. 2000; Easa, Biodiv. Doc. Kerala 5: 21. 2003; Pullaiah et al., Pterid. Andhra Pradesh 55. Fig. 19. 2003. *non* Retz., 1791.

Height up to 100 cm. Rhizome short, suberect, 4-5 cm long x 4-6 cm thick, cylindrical with tuft of roots, scaly. Palea brown 2-3 mm long x 0.5-0.6 mm broad at base, lanceolate, acuminate, auriculate at base, thick cells at centre, thin cells at periphery with cellular projections. Stipe 40-55 cm long, 2-4 mm thick, green (fresh specimens) or stramineous (dry specimens) with brown paches, chestnut coloured below, shining, grooved throughout, glabrous. Lamina bipinnate, 30-50 cm long x 25-30 cm broad, ovate-lanceolate, green above and pale green below, subcoriaceous. Pinnae 6-8 pairs, 18-28 cm long x 4-6 cm broad, opposite to subopposite, lanceolate, acuminate, basal pinnae bipartite. Pinnules 20-25 pairs, 2- 4 cm long x 4-6 cm broad, oblong, margin entire, obtuse- rounded, apex crenate, sinus *c.* 1 mm away from costa, 2-3 mm apart, spinules along costule (conspicuous on live specimen). Costae grooved above with spines, and raised below. Veins 15-17 pairs, free, forking. Sori brown, 2-2.5cm long, linear, submarginal except at extreme apex, not fused at base. Indusium false, pale coloured. Sporangium: capsule globose, 250- 300 μm long; stalk 200- 300 μm long, biseriate; annulus 18-20 celled. Paraphyses uniseriate. Spores brown, *c.* 45 x 50 μm, trilete-tetrahedral, verrucate.

Habitat: Fully shaded places near stream banks in evergreen forests.

Altitude: Sea level-400m.

Distribution: India (South India: Kerala) and Sri Lanka.

Chromosome number: n= 29 (Walker, 1962).

Etymology: The specific epithet derived from a Latin word 'quadri' (= four) and 'aurita' (= auricle or accessory pinnae). Though the name indicated the four accessory pinnae, the plant contains only two accessory pinnae in the type.

IUCN status: Critically endangered (CR). This taxon is currently known from a single locality (Shendurney Wildlife Sanctuary) in South India and meets the criteria CR B1ab(ii)+2aD under Critically Endangered category.

Notes: Retzius (1791) described this species based on the specimen sent from Sri Lanka by Koenig. This species is characterized by crenate pinnule apex and prominent spines on costa and irregularly on costules (*Koening s.n.* LD!).

The name *P. quadriaurita* has been indiscriminately applied a wide range of morphologically similar species in India. Most of the specimens deposited in various Indian herbaria are probably the members of *P. quadriaurita* complex, mainly *P. confusa* T. G. Walker and *P. praetermissa* T. G. Walker.

This species freely hybridize with *P. multiaurita* J. Agardh to produce fertile hybrids, some times these hybrids are also having a range of morphology. This had been clearly illustrated by Walker (1958) in his classical paper.

Several authors were over recorded this species from various localities, but the *P.quadriaurita* Retz. (*s. str.*) present only in South India and Sri Lanka. Chandra *et al.* (2008), included this species in 'Near Threatened' category.

Materials examined:

KERALA: Kollam (Dt.): Shendurney WLS (alt. 400m), *V.K.Sreenivas 124068* (CALI).

Plate 27. Lectotype of *Pteris quadriaurita* Retz. (LD)

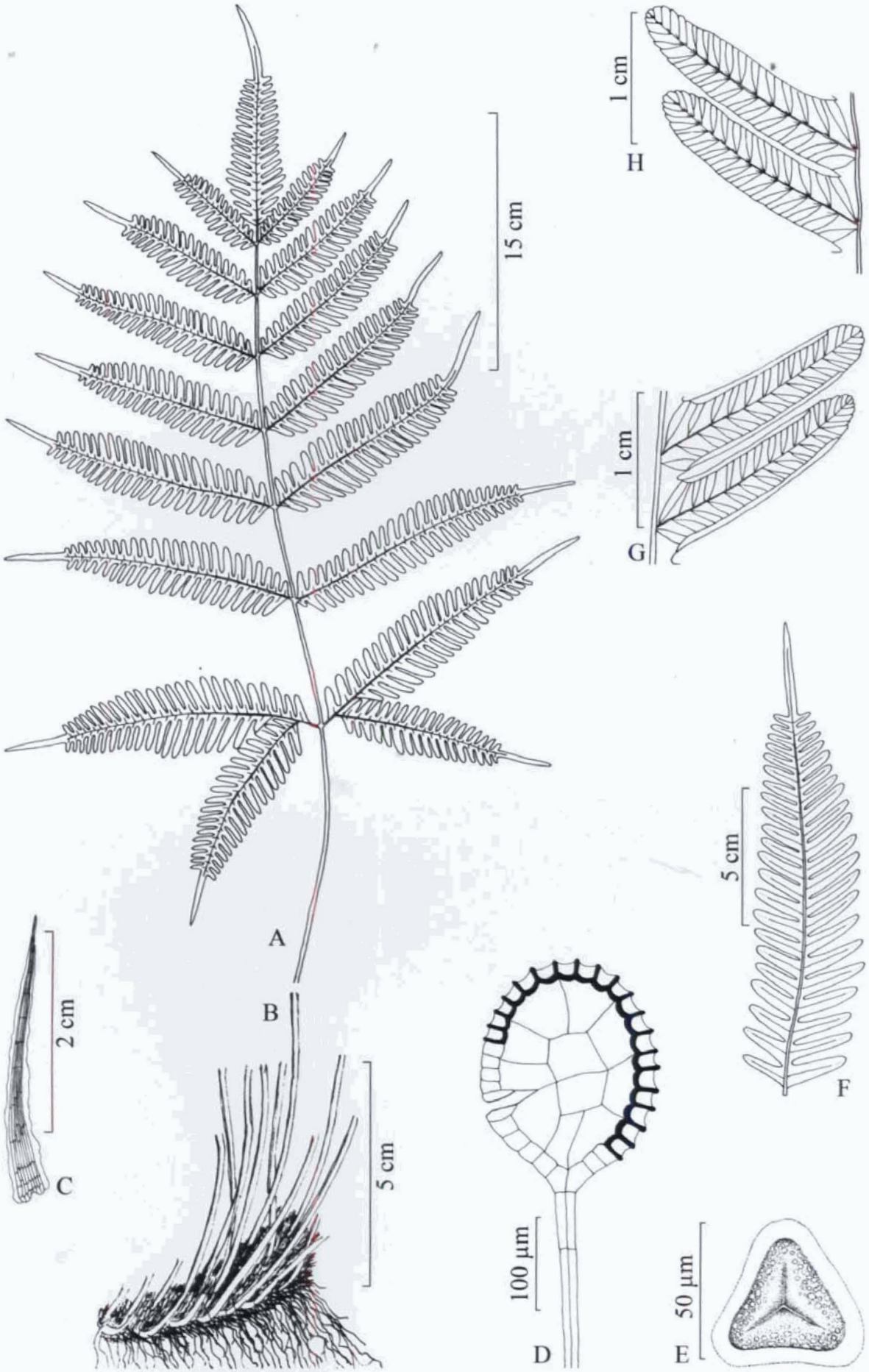


Fig. 25. ***Pteris quadriaurita*** **Retz.**: **A-B**. habit; **C**. palea; **D**. sporangium; **E**. spore; **F**. a single pinna; **G**. fertile pinnules; **H**. sterile pinnules (*V.K.Sreenivas124068*, CALI).

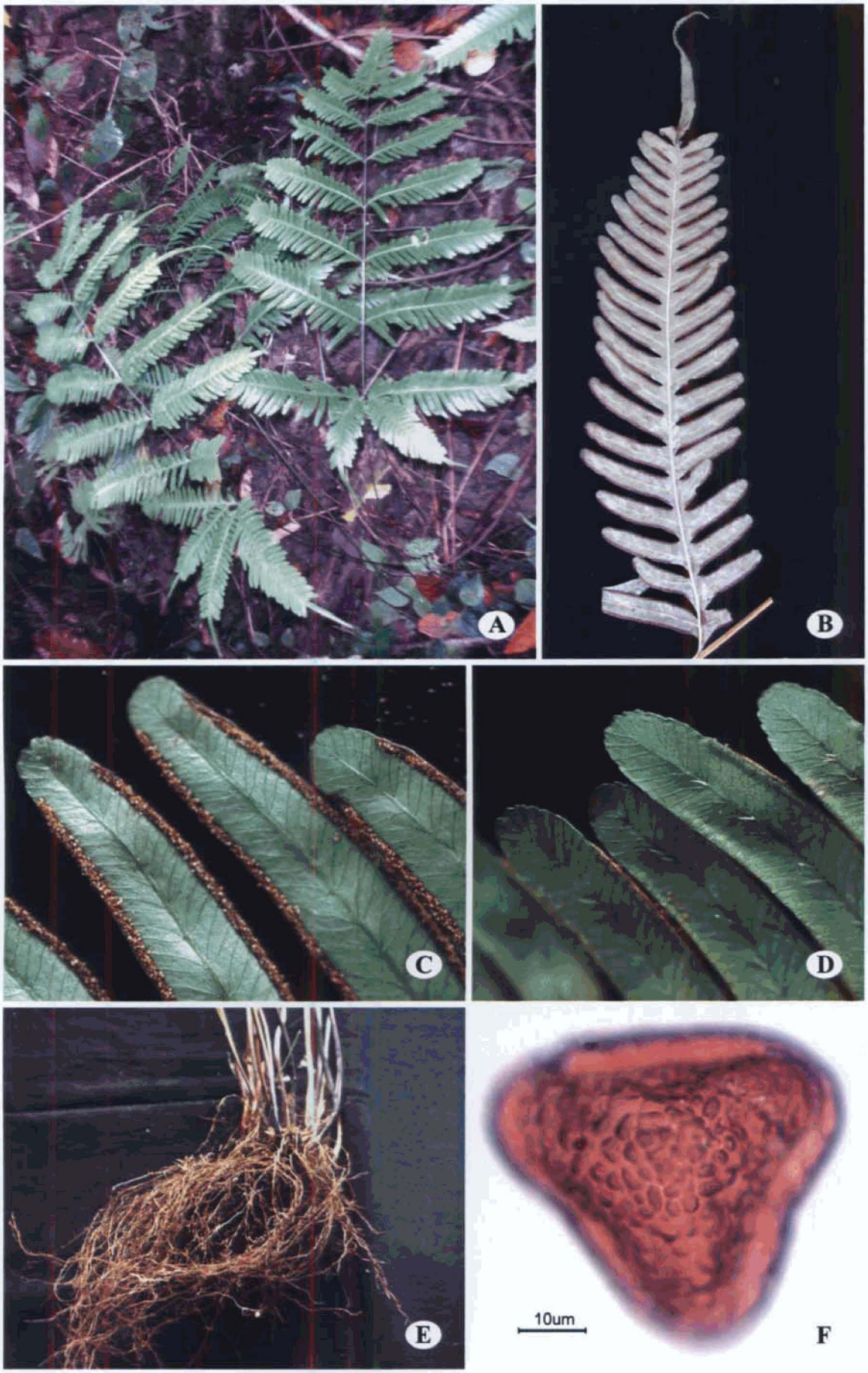


Plate 28. ***Pteris quadriaurita*** **Retz.**: **A**. habit; **B**. single pinna; **C**. fertile pinnules; **D**. adaxial surface of pinnules; **E**. rhizome; **F**. spore.

21. **Pteris reptans** T. G. Walker

P. reptans T. G. Walker, Kew Bull. 14: 325. fig. 2, 2a., pl. 5. fig. D, H .1960.

[Fig 26, 30C & Plate 29, 30]

Type: Sri Lanka, Haputale Reserve forest, 25 February 1954, *T. G. Walker T607* (Holotype, BM, digital image!; Isoparatype, US, digital image!).

Height up to 130 cm. Rhizome creeping, 10-11cm long, 4-6 cm thick, cylindrical, scaly. Palea brown, 2-3 cm long, 0.3-0.4 mm broad at base, linear-lanceolate, acuminate, truncate, inner thick walled cells and outer thin walled cells with cellular projections. Stipe 60-70 cm long, 2-4 mm thick, green (fresh materials) or stramineous (dry materials) above and chestnut on extreme base, grooved throughout, scaly below. Lamina bipinnate, 50-70 cm long x 25-30 cm broad, lanceolate, green above, obscure green below, subcoriaceous. Pinnae 12-14 pairs, 15-20 cm long x 2.3-3.5 cm broad, lanceolate, opposite- subopposite in lower pairs, distinctly alternate on upper pairs, pinna-apex 6-8cm long, basal pinnae bipartite. Pinnules 18-28 pairs, 1.5-2 cm long x 3-4 cm broad, sinus *c.* 1 mm away from costa, 1-2 mm apart, oblong, obtuse, entire, spinules on central parts of costule (inconspicous). Costae grooved with single spines on adaxial surface, raised and polished below. Veins 11-16 pairs, free, forking, prominent on both sides. Sori brown, 12-16 mm long, linear, submarginal except apex, base not joined. Indusium false, pale coloured. Sporangium: capsule globose, 200-250 μm long; stalk 250-300 μm long, biseriate; annulus 16-17celled. Paraphyses uniseriate. Spores brown, *c.* 40 x 45 μm, trilete-tetrahedral, rugate.

Habitat: Seen along stream sides in evergreen forests.

Altitude: 400m.

Distribution: India (South India: Kerala) and Sri Lanka.

Chromosome number: n= 29 (Walker, 1962).

Etymology: The specific epithet derived from its creeping rhizome ('reptans').

IUCN status: Critically endangered (CR). This taxon is currently known from a single location (Shendurney Wildlife Sanctuary) in South India and meets the criteria CR B1ab(ii)+2aD under Critically Endangered category.

Notes: Walker (1960) described this species from Sri Lanka as an endemic to Sri Lanka, and is a sexual diploid.

This species is included in the *P. quadriaurita* complex and is characterized by its creeping rhizome, sinus up to costa, and inconspicuous spinules on costa and costules.

Sreenivas and Madhusoodanan (in press) reported it from Shendurney Wildlife sanctuary, Kollam as a new record to India.

Material examined:

KERALA: Kollam (Dt.): Shendurney WLS (alt. 400m), *V.K.Sreenivas 124067* (CALI).

22. **Pteris scabripes** Wall. ex J. Agardh

P. scabripes Wall. ex J. Agardh, Recens. Spec. Pter. 11. 1839; Hook., Sp. Fil. 2: 165. 1858; Holttum, Rev. Fl. Malaya 2: 399. 1968; S. R. Ghosh, J. Bombay Nat. Hist. Soc. 81: 237. 1984; Manickam & Irud., Pterid. Fl. W. Ghats 71 pl. 46. 1992; Rajagopal & K. G. Bhat, Indian Fern J. 15: 8. 1998; Subh. Chandra, Ferns India 44. 2000; Easa, Biodiv. Doc. Kerala 5: 22. 2003; Ghosh et al., Pterid. Fl. E. India 1, Ser. 4: 332. 2004; S. Das, Indian Fern J. 24: 68. 2007; Sreenivas & Madhus., Proc. 22nd Kerala Sci. Congr. 867. 2010.

[Fig. 27, 30D & Plate 31]

Type: Malaya, Penang Hills, *Wallich 94* (Holotype, CAL!; Isotype, K, digital image!; US, digital image!).

Pteris silentvalliensis S. R. Ghosh & R. K. Ghosh, J. Bombay Nat. Hist. Soc. 79: 385. 1982; N. C. Nair et al., J. Econ. Tax. Bot. 258. 1992; Fras.-Jenk., New Sp. Syndr. Indian Pterid. 229. 1997; S. Das, Indian Fern J. 24: 68. 2007; Fras.-Jenk., Indian Fern J. 25: 23. 2008.

Type: India, Kerala, Silent Valley, Way to Kunthipuzha river, *Vohra & Ghosh 56301* (Holotype & Isotype, CAL!).

1691

Plate 29. Holotype of *Pteris reptans* T. G. Walker (BM)

169 B

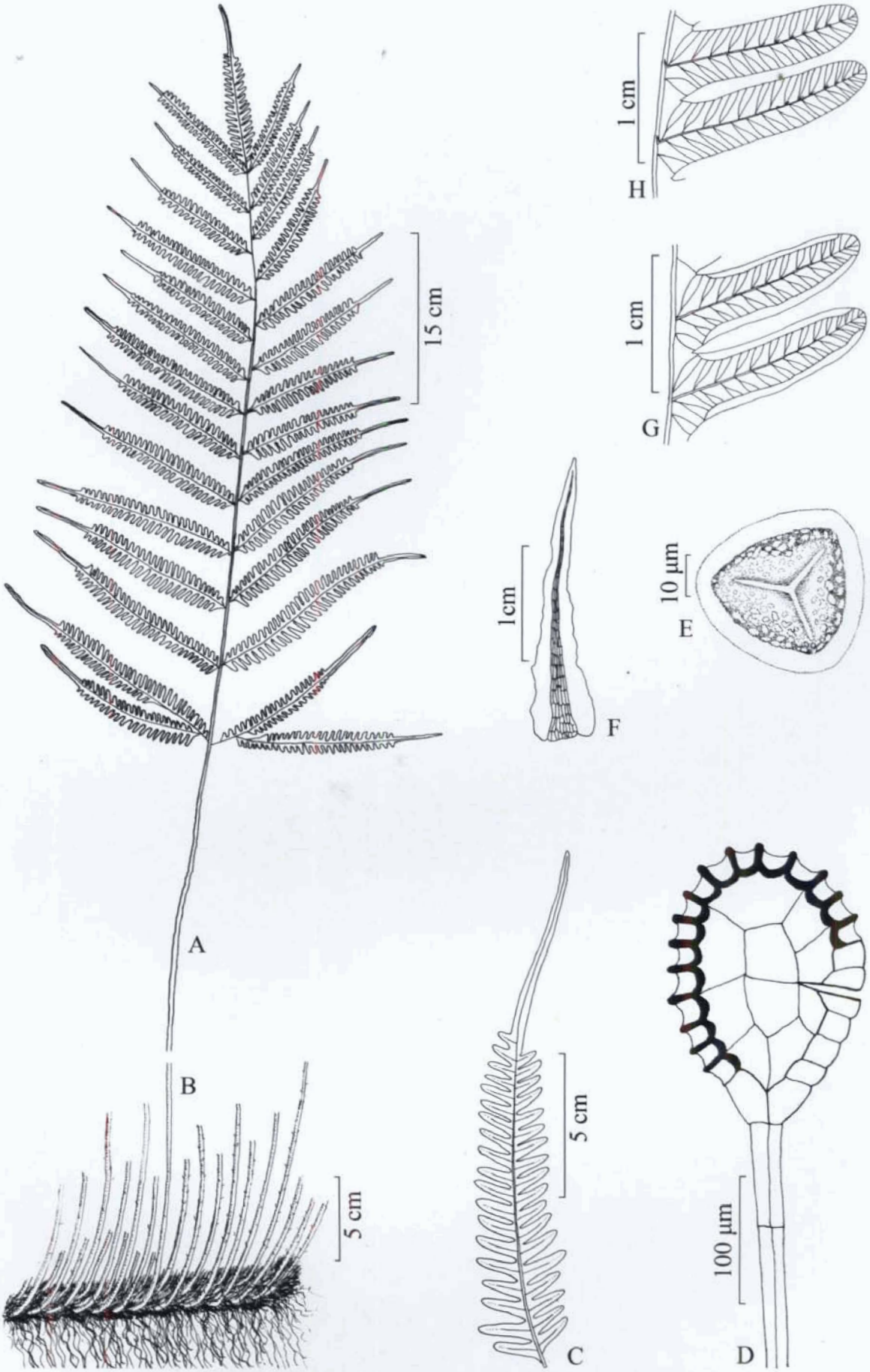


Fig. 26. ***Pteris reptans*** **T. G. Walker**: **A-B**. habit; **C**. single pinna; **D**. sporangium; **E**. spore; **F**. palea; **G**. fertile pinnules; **H**. sterile pinnules (*V.K.Sreenivas 124067*, CALI).

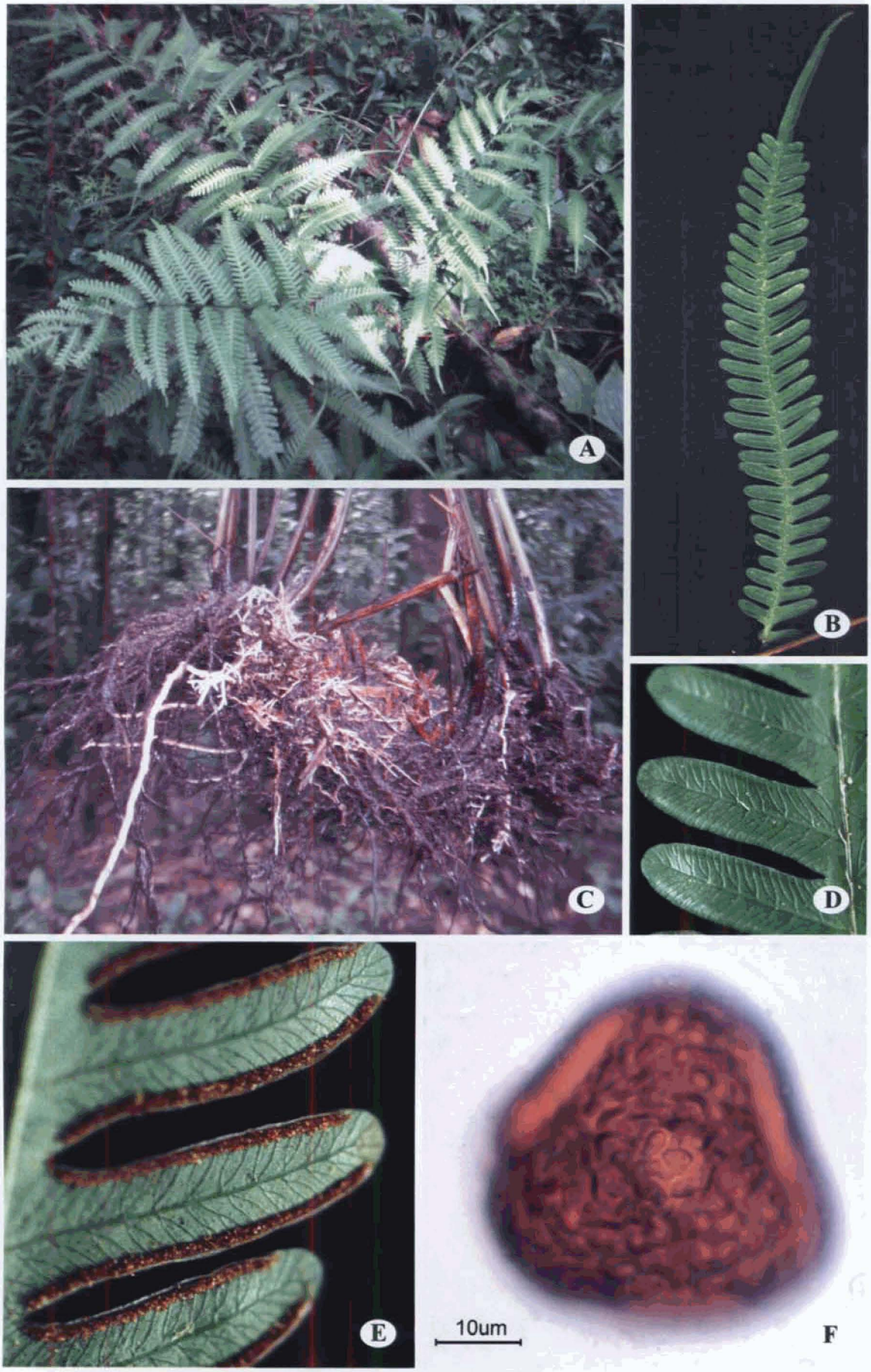


Plate 30. ***Pteris reptans*** **T. G. Walker**: **A**. habit; **B**. single pinna; **C**. rhizome; **D**. adaxial view of pinnules; **E**. fertile pinnules; **F**. spore.

Height 50-90 cm. Rhizome short, erect, 2-4 cm long x 1-2 cm thick, cylindrical with tuft of roots, scaly. Palea brown, 2-3 mm long, 0.4-0.6 mm wide at base, linear-lanceolate, acuminate, auriculate, entire, thick walled cells. Stipe 25-50 cm long, 2-3 mm thick, stramineous or chestnut, shining, grooved above, terete below, glabrous. Lamina pinnate, 15-35 cm long x 10-20 cm broad, ovate or broadly ovate, dark green, subcoriaceous. Pinnae terminal one larger than lateral ones, 3-9 pairs, 10-25 cm long x 9-12 mm broad, opposite or subopposite, linear-lanceolate, acute or acuminate, cuneate, petiolate, entire, apex crenate, basal pair bipartite, glabrous, dark green above, pale green below. Costae grooved above and raised below, glabrous. Veins numerous, free, forking. Sori brown, 12-23.5 cm long, linear, submarginal except at base and apex. Indusium false, brown. Sporangium: capsule globose, 300-350 μm long; stalk 200-250 μm long, biseriate; annulus 18-22 celled, dorsal. Paraphyses uniseriate. Spores brown, *c.* 50 x 55 μm, trilete-tetrahedral, verrucate.

Habitat: In shaded areas of the evergreen forests.

Altitude: 800m-2000m.

Distribution: China, India (South India: Karnataka, Kerala & Tamil Nadu), Malaysia, Myanmar and Thailand.

Chromosome number: n= 29 (Manickam & Irudayaraj, 1988).

Etymology: The specific epithet derived from its scabrous stipe (*scabrous* (Latin) = rough).

IUCN status: Least concern (LC). It does not meet any criteria for Endangered, Vulnerable, *etc.* under IUCN red list category.

Notes: *P. scabripes* was first catalogued by Wallich in 1828 from Penang Hills, in Malaysia without description. Agardh (1839) provided description and validly published it. Ghosh (1984) reported this species from India for the first time.

This species is characterized by scabrous, chestnut brown and elongated frond axis (stipe).

P. scabripes is very common in Silent Valley National Park, Palakkad. Ghosh and Ghosh (1982) described *P. silentvalliensis* (as 'silent-valliensis') based on the specimens from Silent Valley. According to them, this species is closely related to *P. cretica* L. except entire sterile frond and less number of pinnae. They were also related to this species with *P. multiaurita* J. Agardh, but differ in once forking veins and erect rhizome. Fraser-Jenkins (1997) considered that *P. silentvalliensis* Ghosh & Ghosh is a synonym of *P. multiaurita* J. Agardh, but later Fraser-Jenkins (2008a) re-identified it as *P. scabripes* Wall. ex J. Agardh.

Recently, the present author collected specimens from Silent Valley Nation Park (type locality), and studied these specimens and type specimens deposited in CAL! (*Vohra & Ghosh 56301*). It is found that the specimen is nothing but *P. scabripes* and the type specimens of *P. scabripes* (from Penang, *Wallich 94*, K!) is exactly matching with that of specimens from Silent Valley. Ghosh and Ghosh might be unaware of *P. scabripes* at the time of their publication.

Nair and Bhargavan (1981a) recorded *P. dactylina* Hook. from Panthenthode, Silent Valley National Park in error for *P. scabripes*. *P. dactylina* is a high altitude plant occurring in Himalaya. The specimen in MH (*N.C.Nair 65447*) has no crenate margin as in *P. dactylina*. However, the duplicate specimen at CAL is larger and is much more obviously *P. scabripes*.

Malaysian plants of *P. scabripes* have regular teeth on sterile apex and fewer pairs of pinnae. Moreover, the sterile fronds rarely have more than two pairs of pinnae and the fertile pinnae are widely spaced (Holttum, 1968).

Material examined:

KARNATAKA: Chikmagaluru (Dt.): Bababudan Hills (alt. 1200m), *P.K.Rajagopal 543* (MGMC).

KERALA: Kottayam (Dt.): Kurisumala hills (alt. 1200m), *V.S.Manickam & K.M.Mathew 34604* (XCH). **Palakkad** (Dt.): Anguinda (alt. 2200m), *V.K.Sreenivas 119275*; Nilikkal SVNP (alt. 900m), *V.K.Sreenivas 124014*; Panthenthode SVNP (alt. 800m), *V.K.Sreenivas 119261, 119269 & 119270*; *B.K.Nayar & Geevarghese 10682*; Poochapara SVNP (alt. 950m), *V.K.Sreenivas 119250 & 119260*; Sairendri SVNP (alt. 900m), *V.K.Sreenivas 124023*; Silent Valley (alt. 850m), *Geevarghese 4111, P.V.Madhusoodanan 1808, B.K.Nayar & P.V.Madhusoodanan* 21358; Near Sispara SVNP (alt. 2000m), *V.K.Sreenivas 119238*; Walakkad-Sispara path SVNP (alt. 1600m), *V.K.Sreenivas 124004, 124005, 124007, 1240016 & 124044* (CALI); Kummattanthode (alt. 800m), *V.S.Manickam 3272* (XCH); Kunthipuzha river side (alt. 825m), *N.C.Nair 56678*; Panthenthode (alt.800m), *N.C.Nair 56644* (MH); Silent Valley (alt. 800m), *N.C.Nair 65447* (CAL). **Idukki** (Dt.): Arjunan kotta, PTR (alt. 1000m), *Jomy Augustine 12887*; Ezhanakuzhi (alt. 1300m), *Jomy Augustine 12897* (CALI); Munnar hills (alt. 1300m), *V.S.Manickam 32219* (RHT); Devikulam (alt. 1300m), *V.S.Manickam 31447*; Eravikulam-Pettimudi road (alt.1600m), *V.S.Manickam & K.M.Mathew 34524* (XCH). **Thiruvananthapuram** (Dt.): Chemunji (alt. 1000m), *V.K.Sreenivas 124044* (CALI); *Raju Antony 58172* (TBGT).

TAMIL NADU: Coimbatore (Dt): Valparai- Idliar path (alt. 1000m), *V.S.Manickam & K.M.Mathew 34363* (RHT); Attakatti forest area (alt. 850m), *V.S.Manickam & K.M.Mathew 34341*; Shekelmudi forest (alt.

1200m), *V.S.Manickam 2212* (XCH); Andiparai sholai (alt. 1166m), *J.Joseph 13219* (MH, CAL). **Dindigul** (Dt.): Palni hills (alt. 2050m), *V.S.Manickam & K.M.Mathew 32833* (XCH). **Kannyakumari** (Dt.): Selvamkoopu (alt. 1300m), *A.N.Henry 70363* (MH). **Tirunelveli** (Dt.): Kothayar (alt. 1300m), *P.V.Madhusoodanan 4487* (CALI); Kothayar (alt. 1300m), *V.S.Manickam 32118* (RHT), *V.S.Manickam 34220, V.S.Manickam & K.M.Mathew 34769* (XCH); Manjanamparai (alt. 1400m), *A.N.Henry 16369* (CAL).

23. **Pteris tripartita** Sw.

P. tripartita Sw., J. Bot. (Schrader) 1800 (2): 67. 1801; Thwaites, Enum. Pl. Zeyl. 387. 1864; Hook., Syn. Fil. 172. 1867; C. V. Morton, Amer. Fern J. 47: 12. 1957; Scamman, Rhodora 63: 204. 1961; Holttum, Rev. Fl. Malaya 2: 408. 1968; Schelpe, Contr. Bolus Herb. 1: 61. 1969; T. G. Walker, Brit. Fern Gaz. 10: 150. 1970; B. K. Nayar & S. Kaur, Comp. Bedd. Handb. 32. 1974; R. D. Dixit, Cens. Indian Pterid. 73. 1984; S. M. Vasudeva & A. Singla, Asp. Plant Sci. 13: 334. 1991; Subh. Chandra, Ferns India 46. 2000; Mickel & Smith, Pterid. Mexico 1: 542. 2004; Subh. Chandra et al., Taiwania 53: 187. 2008; Fras.-Jenk., Taxon. Rev. Indian Subcont. Pterid. Rev. Cens. List 576. 2008.

[Fig. 28, 30E & Plate 32]

Type: Indonesia, Java, *Thunberg 24968* (Holotype, UPS, digital image!).

Pteris marginata Bory, Voy. Quatr. Princ. Iles Afr. 2: 192.1804.

Type: Réunion, Grand Brûlé, *Bory de St. Vincent s.n.* (Holotype, P, digital image!).

Litobrochia tripartita (Sw.) C. Presl, Tent. Pter. 150. 1836; Bedd., Ferns S. India t. 220. 1863.

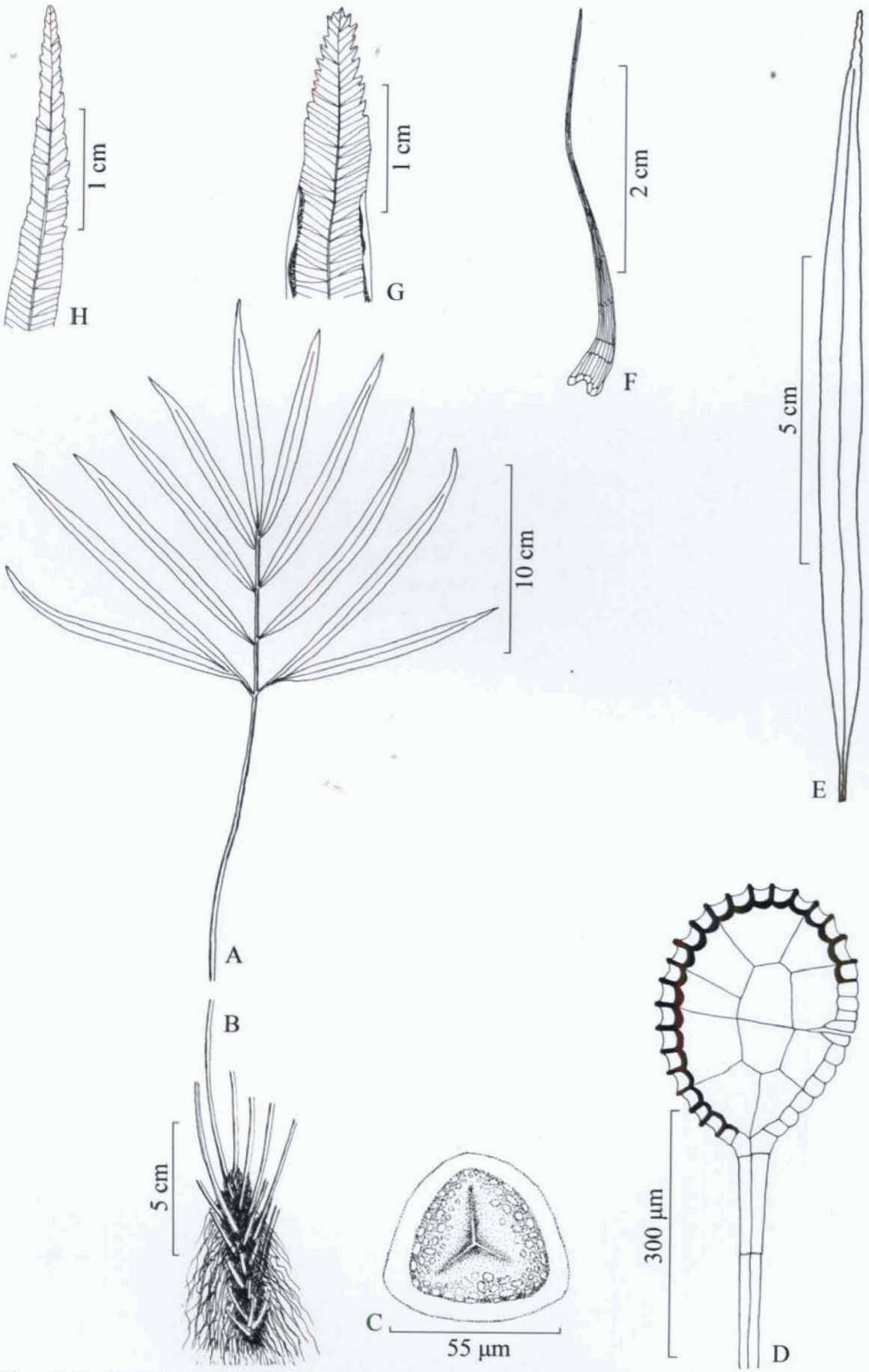


Fig. 27. ***Pteris scabripes*** **Wall. ex J. Agardh**: **A-B**. habit; **C**. spore; **D**. sporangium; **E**. a single pinna; **F**. palea; **G**. a portion of fertile pinna; **H**. sterile pinna apex (*V.K.Sreenivas 119238*, CALI).

Plate 31. ***Pteris scabripes*** **Wall. ex J. Agardh**: **A**. habit; **B**. single pinna; **C**. a portion of fertile pinna; **D**. pinna apex; **E**. a portion of sterile pinna; **F**. rhizome; **G**. spore.

L. marginata C. Presl, Tent. Pter. 149.1836; Bedd., Handb. Ferns Brit. India 122. 1883.

Height up to 300 cm. Rhizome erect, 8-12 cm long, 1-1.4 mm thick, cylindrical with tufts of roots, scaly. Palea pale brown, 2-3 mm long, 0.3-0.4 mm broad at base, lanceolate, acute, auriculate, uniformly thin walled cells. Stipe 150-165 cm long, 1-1.5 cm thick, chestnut brown, grooved throughout, glabrous. Lamina compoundly bipinnate, basal pair tripartite, 100-125 cm long x 70-90 cm broad, ovate, green, subcoraceous. Pinnae 15-20 pairs, 10-20 cm long x 3-4 cm broad, opposite- subopposite, lanceolate, pinna-apex 3-4 cm. Pinnules 12-22 pairs, 1.5-2.0 cm long x 4-5 mm broad, oblong, obtuse, apex crenate, sinus *c.* 3 mm away from costae, 3-4 mm apart, glabrous. Costae grooved above with spines, raised and polished below. Veins 10-14 pairs, united at the base to form costal and costular aereoles. Sori brown, 1-1.6 cm long, linear, submarginal except at apex. Indusium false, white. Sporangium: capsule globose, 200-250 μm long; stalk 250-300 μm long, biseriate; annulus 25-26 celled. Paraphyses uniseriate. Spores brown, *c.* 30 x 40 μm, trilete-tetrahedral, verrucate.

Habitat: Grows in evergreen and shola forests near stream banks.

Altitude: Above 2000m.

Distribution: Australia, China, Fiji, India (South India: Tamil Nadu), Indonesia, Java, Malaysia, Philippines, Sri Lanka, Thailand, Tropical Africa and Vietnam.

Chromosome number: n= 58; 2n= 116 (Goldblatt & Johnson, 1991).

Common name: Trisect brake or Giant brake.

Economic importance: Widely cultivated as ornamental fern.

Etymology: Specific epithet from the Latin *tri* - (three-) and *partire* (to divide), in reference to the frond which has 2 basal branches, each of those side-branches dividing again, giving a 5-branched frond (in large fronds often further divided).

IUCN status: Critically Endangered (CR). This taxon is currently known from a single location (Azhalarkovil forest) in South India and meets the criteria CR B1ab(ii)+2aD under Critically Endangered category.

Notes: Swartz described this species based on the specimens from Java (*Thunberg 24968*, UPS). Beddome (1863) recorded this species from South India as *Litobrochia tripartita* (Sw.) C. Presl. Recently Manickam *et al.* (2004b), reported this species as *P. wallichiana* J. Agardh from Madurai district of Tamil Nadu. But, Fraser-Jenkins (2008a) determined it as *P. tripartita* Sw.

This species is characterized by the partition of fronds, *i.e.*, divided into three major branches at the base and the presence costal and costular areoles on pinnae.

In South India, this species is rare and only reported from Azhalarkovil forest in Madurai district of Tamil Nadu. Chandra *et al.* (2008), included this species in 'At Risk' category.

P. tripartita is closely related to *P. wallichiana* J. Agardh, a Himalayan species, except the later has only costal areoles and all other veinlets are free. Chandra and Khare (1995) reported the occurrence of foliar buds at the tip of the frond.

Materials examined:

TAMIL NADU: Madurai (Dt.): Azhalarkovil forest (alt. 2100m), *N.Siva & V.K.Sreenivas 127801* (CALI).

24. Pteris vittata L.

P. vittata L., Sp. Pl. 2: 1074. 1753; Burm. f., Fl. Ind. 230. 1768; Hieron., Hedwigia 54: 290. 1914; C. V. Morton, Amer. Fern J. 47: 13. 1957; Shieh, Bot. Mag. Tokyo 79: 287. 1966; F. M. Jarrett, Proc. Bot. Soc. Br. Isl. 7: 387. 1968; Holttum, Rev. Fl. Malaya 2: 396. fig. 230. 1968; T. G. Walker, Brit. Fern Gaz. 10: 144. 1970; B. K. Nayar & S. Kaur, Comp. Bedd. Handb. 291. 1974; R. D. Dixit, Cens. Indian Pterid. 73. 1984; Manickam, Fern Fl. Palni Hills 21. 1986; S. M. Vasudeva & Chhibber, Indian Fern J. 6: 209. 1989; N. C. Nair et al., J. Econ. Taxon. Bot. 257. 1992; Manickam & Irud., Pterid. Fl. W. Ghats 68. pl. 42.1992; B. K. Nayar & Geev., Fern Fl. Malabar 116. 1993; Khullar, Illustr. Fern Fl. W. Himalaya 1: 279. pl. 107. 1994; Rajagopal & K. G. Bhat, Indian Fern J. 15: 8. 1998; Subh. Chandra, Ferns India 46. 2000; Manickam & Irud., Pterid. Fl. Nilgiris 83. 2003; Easa, Biodiv. Doc. Kerala 5: 22. 2003; Pullaiah et al., Pterid. Andhra Pradesh 56. fig. 20. 2003; Ghosh et al., Pterid. Fl. E. India 1, Ser. 4: 319. 2004; Mickel & Smith, Pterid. Mexico 1: 543. 2004; S. Das, Indian Fern J. 24: 69. 2007; Fras.-Jenk., Taxon. Rev. Indian Subcont. Pterid. Rev. Cens. List 96. 2008; Mahamuni & Dongare, Indian Fern J. 26: 140. 2009; Sreenivas & Madhus., Proc. 22nd Kerala Sci. Congr. 868. 2010.

[Fig. 29, 30F & Plate 33]

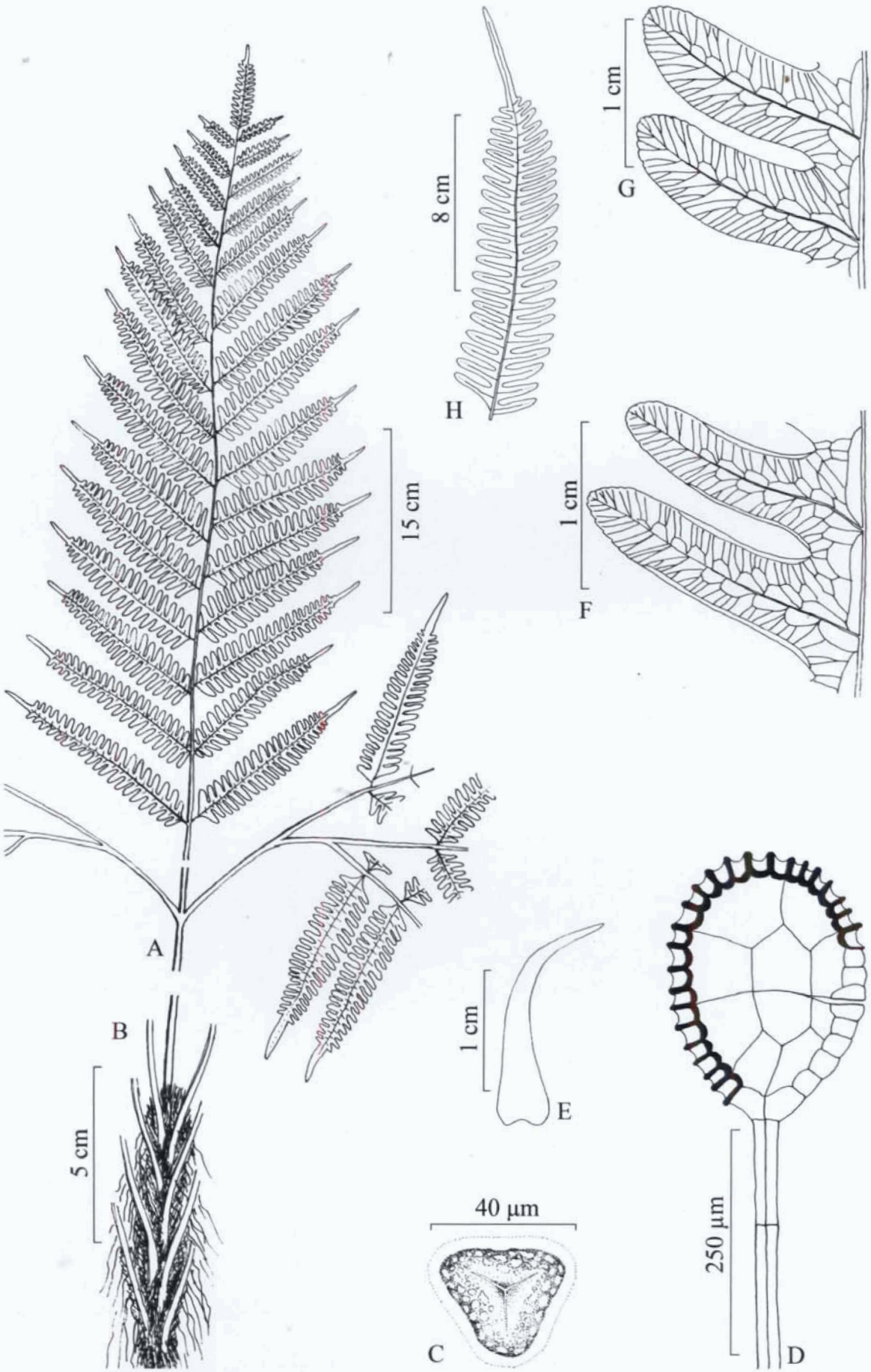


Fig. 28. ***Pteris tripartita*** **Sw.**: **A-B**. habit; **C**. spore; **D**. sporangium; **E**. palea; **F**. fertile pinnules; **G**. sterile pinnules; **H**. a single pinna (*N.Siva & V.K.Sreenivas 127801*, CALI).

Plate 32. ***Pteris tripartita*** **Sw.**: **A**. habit; **B**. frond showing tripartite division; **C**. rhizome; **D**. single pinna; **E**. fertile pinnules; **F**. venation; **G**. spore; **H**. sterile pinnules.

Type: China, *Osbeck s.n.* (Lectotype, LINN 1246.3, digital image!).

Pteris longifolia auct., J. Agardh, Recens. Spec. Pter. 3. 1839; Bedd., Ferns S. India 11. pl. 33. 1863 & Handb. Ferns Brit. India, 106. fig. 55. 1883; C. B. Clarke, Trans. Linn. Soc. Lond. II, Bot. 1: 461. 1880. *non* L., 1753.

Height 45-120 cm. Rhizome short, creeping, 4-5 cm long, 4-5 mm cylindrical with tuft of roots, scaly. Palea pale brown, 3-4 mm long x 0.4-0.5 mm wide at base, lanceolate, entire, apex acuminate, thick walled cells. Stipe 6-15 cm long, 4-5 mm thick, green (fresh specimens) or sramineous (dry specimens) above, light brown at base, grooved and glabrous above, rounded and densely scaly (white to pale brown) below. Lamina pinnate, 45-90 cm long x 6-40 cm broad, obovate, green, subcoriaceous. Pinnae 10-28 pairs, 5-25 cm long x 5-9 mm broad, opposite or subopposite, sessile, linear-lanceolate, entire, acute, base cordate, margin and apex crenate or crenulate except soral region, pinnae gradually reduces towards base, not bipartite at base, green. Costae grooved above, raised below, glabrous. Veins numerous, free, forking, slightly visible. Sori pale brown, 5-7 cm long, linear, submarginal except at apex and base, crowded. Indusium false, pale coloured. Sporangium: capsule globose, 250-300 μm long; stalk 200-250 μm, biseriate; annulus 12-22 celled. Paraphyses uniseriate. Spores brown, *c.* 50 x 55 μm trilete-tetrahedral, bisculpate.

Habitat: Grows in partially exposed areas such as road sides, earth cuttings, walls of old buildings, *etc.*

Altitude: Sea level-1500m.

Distribution: Cameroon, China, Ghana, India (South India: Andhra Pradesh, Karnataka, Kerala & Tamil Nadu), Nepal, New Guinea and Philippines.

Chromosome number: n= 58 (Irudyaraj & Manickam, 1987).

Common name: Chinese brake.

Economic importance: *P. vittata* is considered as an experimental plant in heavy metal accumulation studies. This is also widely cultivated as ornamental plants in many gardens. Tannins and phenolic acids were isolated from this species and the plant is used as demulcent, tonic, antiviral and antibacterial agent (Vasudeva, 1999; Karuppusamy, 2001).

IUCN status: Least concerned (LC). This is a widely distributed taxon in South India and it does not meet any criteria for Endangered, Vulnerable, *etc.* under IUCN red list category.

Notes: Linnaeus (1753) described this species based on Osbeck's collections from China.

P. vittata as confused with *P. longifolia* L., a tropical American species. Hieronymus (1914a) clearly pointed out the differences between

P. vittata and *P. longifolia* as follows: *P. vittata* never shows an articulation at the bases of the short petioles of lateral pinnae, but the petioles of the lateral pinnae run down forming more or less an edge on the rachis. Since articulation is not present, the lateral pinnae are also never shed in *P. vittata.* The lateral pinnae do not stick out horizontally from the rachis, but are mostly directed upwards in a more or less acute angle. In *P. vittata.* the sterile pinnae or sterile portion of the fertile pinnae are always distinctly crenate or crenulate at margin, though teeths are small in some cases, whereas in *P. longifolia*, the sterile pinna margin is always serrate. In *P. vittata*, the lower pinnae considerably reduced than the rest of pinnae. Jarrett (1968) also emphasize the articulation on the stipe is a distinguishing character of *P. longifolia.*

Srivasthava *et al.* (2007), found that the only tetraploid form of *Pteris vittata* L. is present in India, though a gradation of cytotypes (2x to 6x) had been reported over several years from India.

Fraser-Jenkins (1997 & 2008a) recognized three subspecies from Indian subcontinent based on the nature of fronds and cytology, *viz.* *P. vittata* subsp. *emodi* Fras.-Jenk., *P. vittata* subsp. *vittata* Fras.-Jenk., *P. vittata* subsp. *vermae* Fras.-Jenk.

P. vittata subsp. *vittata* has an erect frond and the terminal pinna is larger than that of other subspecies, where as *P. vittata* subsp. *emodi* has pendent frond and smaller terminal pinna. Both subspecies are tetraploid sexual

plants, but the *P. vittata* subsp. *vermae* is sexual diploid plant. Subsequent explorations by Srivasthava to the type localities did not able to collect the mentioned specimens. Moreover, she pointed out that the demarcation of *P. vittata* at subspecies level is complicated because this species shows a range of morphological variations.

In South India, the plants become erect when it grows on floors and pendent when it is gowing on walls of old buildings. Moreover the terminal pinna is also showing morphological variations as larger or smaller. So here it is treated as a distinct species.

Materials examined:

ANDHRA PRADESH: Anantapur (Dt.): Yadiki forest (alt. 350m), *T. Pullaiah & N. Yesoda 1118* (MH, SKU). **Chittoor** (Dt.): Papavinasanam-Thirumala (alt. 600m), *A.Ahmad 12808*, *A.M.Reddy 26487* (SKU). **Kurnool** (Dt.): Rangapuram R.F., *R.R.V.Raju 2332*; Sunnipenta, *R.R.V.Raju 2332* (SKU). **Srikakulam** (Dt.): Gummada (alt. 475m), *G.V.Subbarao 62434* (MH, CAL). **Vizianagaram** (Dt.): Sujankota (alt. 850m), *G.V.Subbarao 19748* (MH), *P.Amrutha Lakshmi 25161* (CAL, SKU); Galikonda (alt. 1100m), *A.Ahmad 12887* (SKU).

KARNATAKA: Kodagu (Dt.): Madikeri (alt. 850m), *P.V.Madhusoodanan 39834*; Near Thalecauvery (alt. 915m), *V.K.Sreenivas 113205* (CALI); Madikeri-Siddapur road side (alt. 1100m), *V.S.Manickam 2624* (XCH); Madikeri (alt. 850m), *P.K.Rajagopal 210* (MGMC). **Mysore** (Dt.): Gundelpet

(alt. 675m), *B.D.Naithani 21251* (MH). **Shimoga** (Dt.): Agumbe (alt. 850m), *P.V.Madhusoodanan 39844*; Jog falls (alt. 1500m), *P.V.Madhusoodanan 39827* (CALI). **Uduppi** (Dt.): Near Srikrishna Temple, Thandelpett (alt. 50m) *V.K.Sreenivas 124067* (CALI); Bailoor (alt. 150m), *P.K.Rajagopal 210* (MGMC).

KERALA: Kannur (Dt.): Kannur st. fort (alt. 5m), *P.V.Madhusoodanan & Sworrupanandhan 27432* (CALI). **Kozhikode** (Dt.): Bank Road, Kozhilode city (alt. 5m), *V.K.Sreenivas 124086*; Meppayyur (alt. 100m), *Ibrahim 18863*; Vengoli peak, *B.K.Nayar & S.Pankaj 7389* (CALI). **Malappuram** (Dt.): Kohinoor (alt. 50m), *V.K.Sreenivas 119236* (CALI). **Palakkad** (Dt.): Walayar dam site (alt. 600m), *E.Vajravelu 19067* (MH). **Thiruvananthapuram** (Dt.): Vithura (alt. 350m), *V.K.Sreenivas 124057* (CALI).

TAMIL NADU: Coimbatore (Dt.): Azhiar dam site- Valparai (alt. 1500m), *V.S.Manickam 3293* (XCH); Vadakkumalai (alt. 950m), *M.V.Viswanathan 716* (MH). **Madurai** (Dt.): Combai river bed (alt. 333m), *K.M.Sebastine 12980* (MH, CAL). **Nilgiri** (Dt.): Bandi Shola (alt. 1500m), *V.S.Manickam 1070* (XCH); Mettupalayam (alt. 850m), *E.Vajravelu 38352* (MH). **Salem** (Dt.): Shevroy hills (alt. 1300m), *Ghatak 276* (CAL). **Tirunelveli** (Dt.): Kothayar (alt. 1200.m), *P.V.Madhusoodanan & P.J.Sevichan 44878* (CALI); Kothayar hills (alt. 1250m), *V.S.Manickam 31070 & 31072* (RHT); Ambasamudram (alt. 400m), *V.S.Manickam 15587*; Kakachi (alt. 1500m), *V.S.Manickam 3331*; Mundanthurai (alt. 600m), *V.S.Manickam 13063* (XCH).

COMPARATIVE MORPHOLOGY

COMPARATIVE MORPHOLOGY

Rhizome

Rhizome of the genus *Pteris* varies from erect to creeping and is approximately cylindrical. Its shape is distorted by tufts of stipes arised all around, but alternately. Rhizome is unbranching and bears numerous roots. Younger portion or growing tip of the rhizome is usually protected by palea or scales. The most common type of rhizome is erect or suberect type and seen in *P. cretica*, *P. pellucida*, *P. scabripes*, *P. argyraea*, *P. biaurita*, *P. blumeana*, *P. confusa*, *P. geminata*, *P. gongalensis*, *P. linearis*, *P. longipes*, *P. mertensioides*, *P. otaria*, *P. perrottetii*, *P. praetermissa*, *P. quadriaurita*, *P. tripartita* (Fig. 31A & B). But, in species like *P. ensiformis*, *P. heteromorpha*, *P. multiaurita*, *P. multifida*, *P. vittata*, it is short creeping. Creeping rhizome can also be observed in bipinnate species such as *P.arisanensis* and *P. reptans* (Fig. 31C & D).

Roots

Large number of roots are formed and irregularly scattered over the rhizome. These are usually branched and almost covered the rhizome.

Palea or Scales

Scales or palea are basally attached to the rhizome or on the base of stipe. Scales are usually lanceolate with acuminate apex and auriculate base.

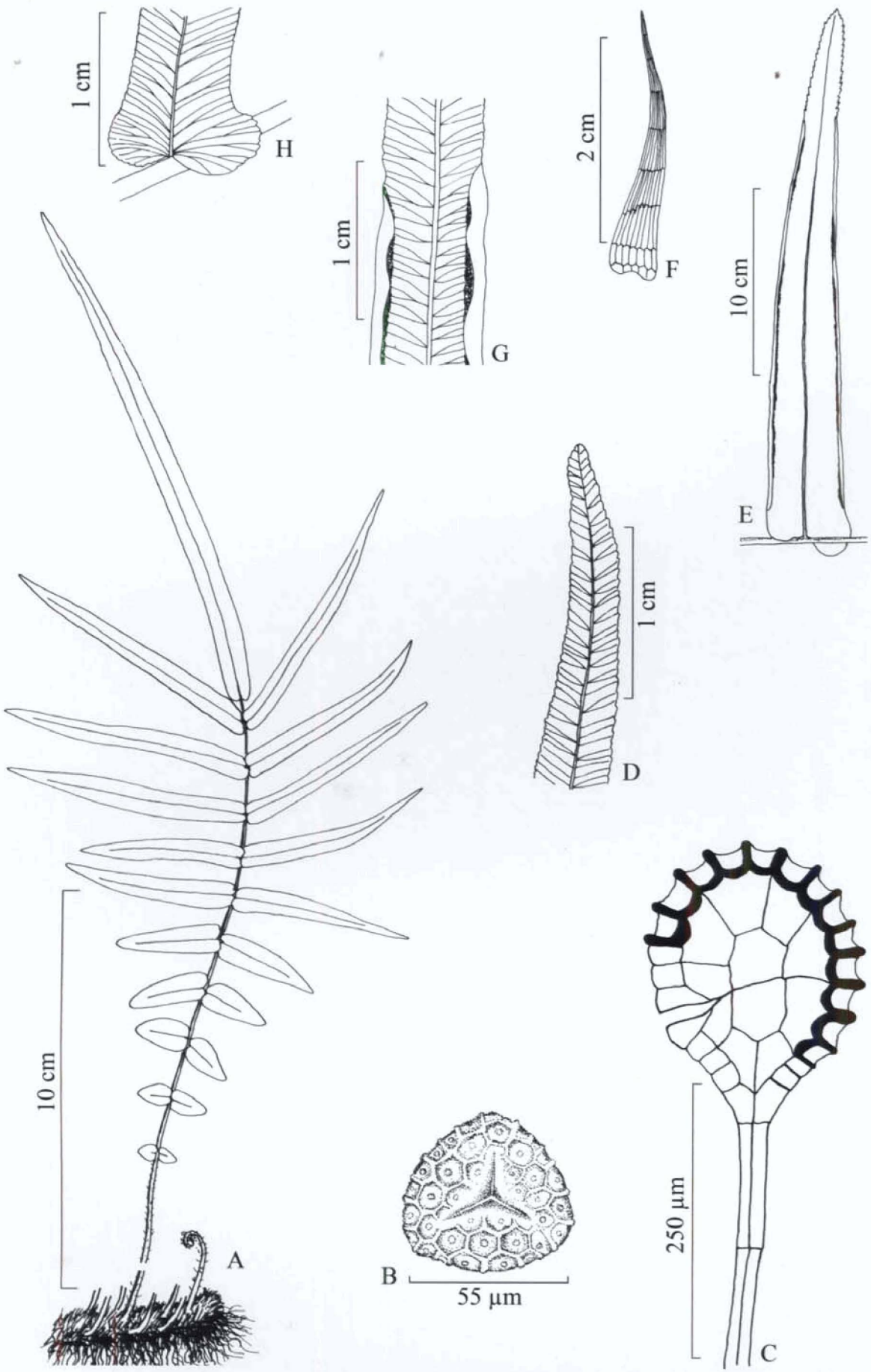


Fig. 29. ***Pteris vittata*** **L.**: **A**. habit; **B**. spore; **C**. sporangium; **D**. sterile pinna apex; **E**. a single fertile pinna; **F**. palea; **G**. a portion of fertile pinna; **H**. pinna base (*V.K.Sreenivas 124086*, CALI).

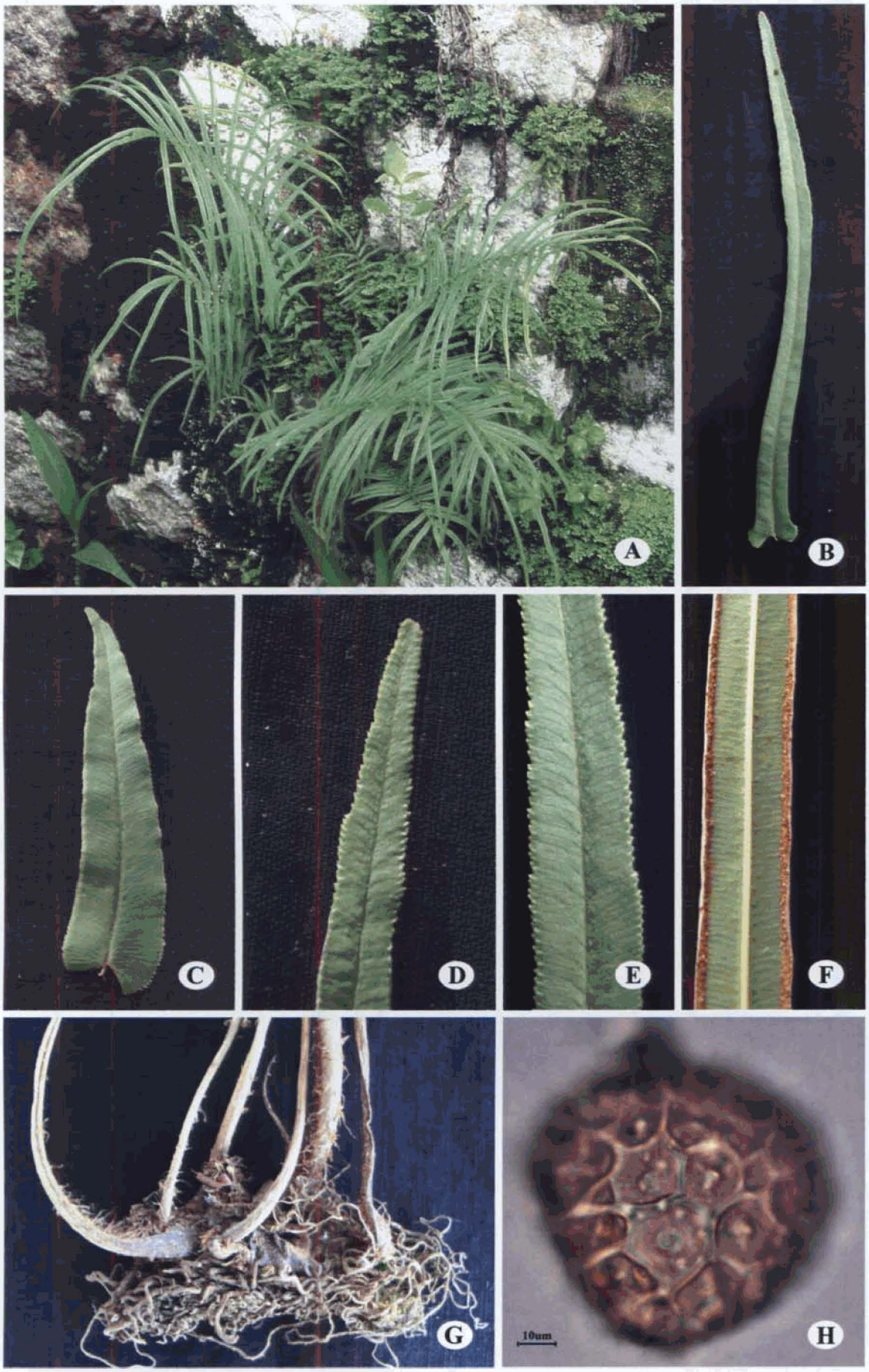


Plate 33. ***Pteris vittata*** **L.**: **A**. habit; **B**. single pinna; **C**. basal sterile pinna; **D**. pinna apex; **E**. a portion of sterile pinna; **F**. a portion of fertile pinna, **G**. rhizome; **H**. spore.

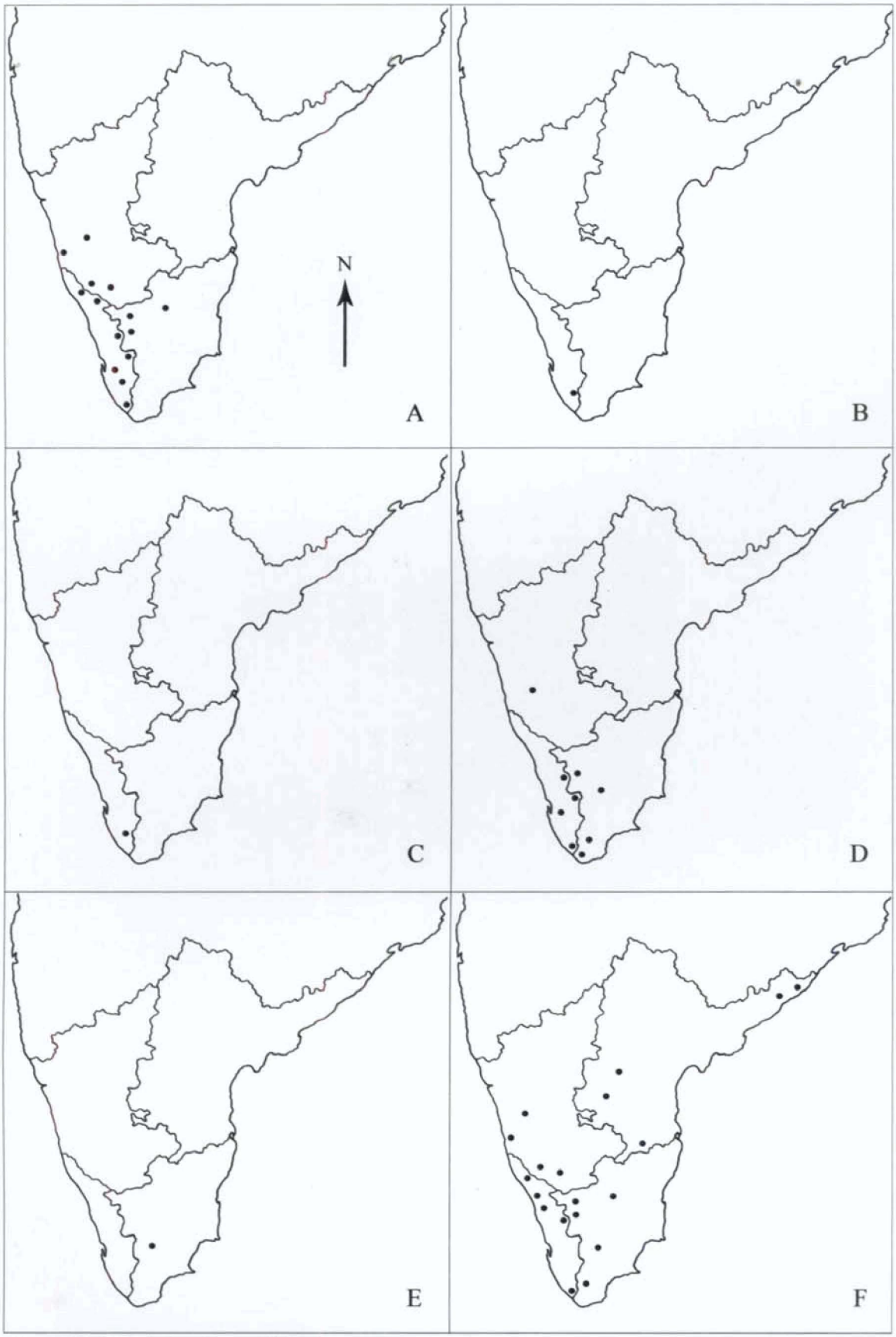


Fig. 30. Distribution of the genus *Pteris* in South India: **A**. *P. praetermissa*; **B**. *P. quadriaurita*; **C**. *P. reptans*; **D**. *P. scabripes*; **E**. *P. tripartita*; **F**. *P. vittata*.

Mainly two types of palea are seen in South Indian *Pteris*; one with uniformly thickened cells (Fig. 31E) and other is centrally thick walled with outer thin walled cells (Fig. 31F). The later may have some cellular projections due to the disintegration of outer thin walled cells (Fig. 31G).

Stipe

The length and width of the stipe varies from species to species. The stipe length ranges from 6-8 cm (in *P. multifida*) to 150-175 cm (in *P. mertensioides*), and the width varies from 0.1 cm (in *P. multifida*) to 1.5 cm (in *P. tripartita*). It is usually shallowly or deeply grooved above and terete below. The colour of the stipe is also vary with species; majority of the species have green stipe or green with chestnut brown patches running parallel to the stipe, but it becomes stramineous on drying. Pink or carmine red stipe is present in *P. blumeana*. Stipe base is either glabrous or sparsely covered with scales. Stipe bears prominent in *P. longipes*.

Lamina

Lamina is a part of frond that attched to the rhizome by stipe. Usually the genus *Pteris* has pinnate or bipinnate lamina. *P. cretica*, *P. ensiformis*, *P. heteromorpha*, *P. multiaurita*, *P. multifida*, *P. pellucida*, *P. scabripes* and *P. viitata* are having pinnate lamina (Fig. 32A). In *P. argyraea*, *P. arisanensis*, *P. biaurita*, *P. blumeana*, *P. confusa*, *P. geminata*, *P. gongalensis*, *P. linearis*, *P. mertensioides*, *P. otaria*, *P. perrottetii*,

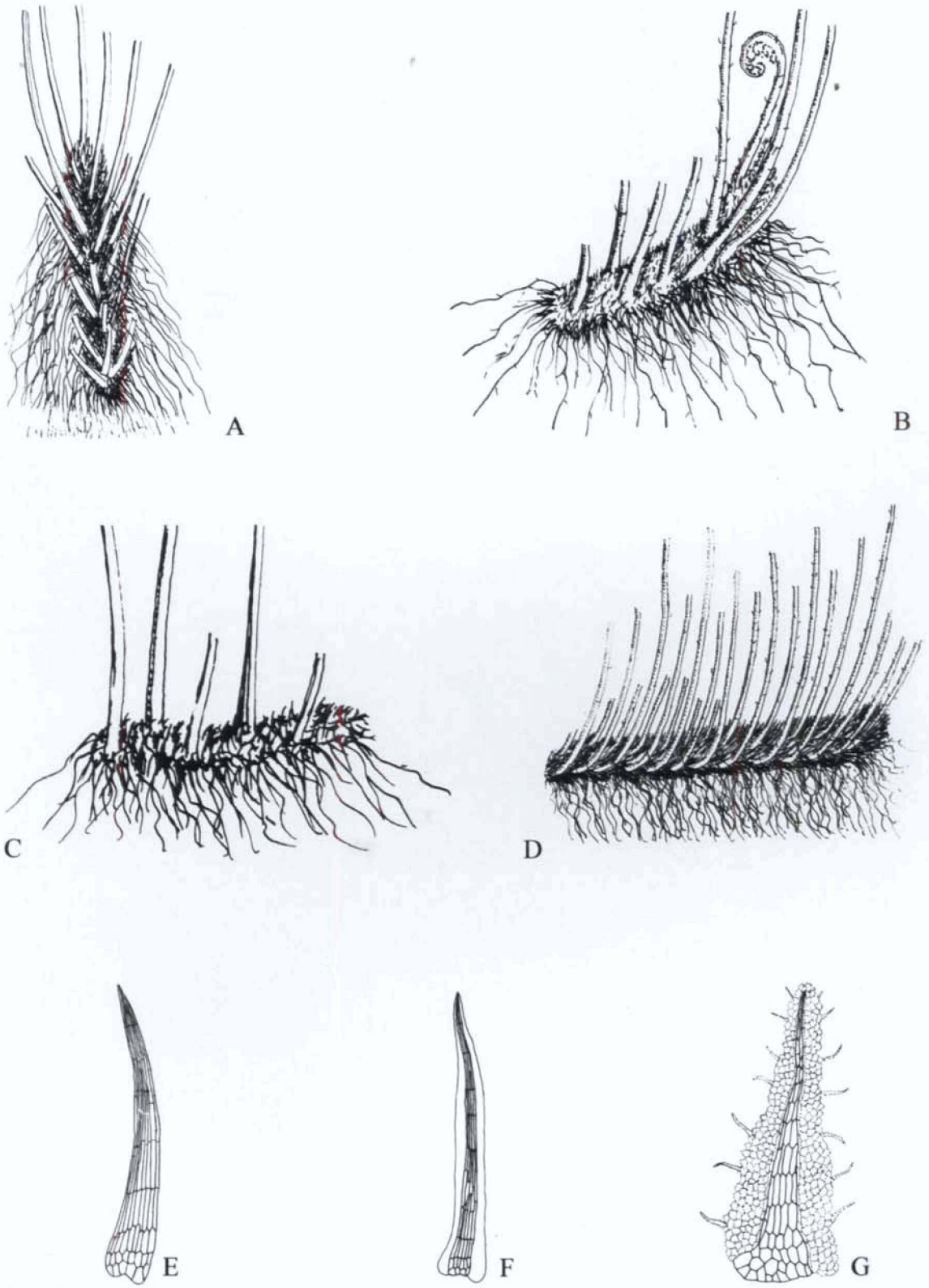


Fig. 31. **Types of rhizome**: **A**. erect (*P. cretica*); **B**. suberect (*P. argyraea*); **C & D**. creeping (**C**. *P. ensiformis*), (**D**. *P. reptans*). **Types of palea/scale**: **E**. *P. cretica*; **F**. *P. heteromorpha*; **G**. *P. arisanensis*.

P. praetermissa, *P. quadriaurita*, *P. reptans*, it is bipinnate (Fig. 32B). In *P. longipes*, the basal pinnae ternately divided (Fig. 32C). But, basal pinnae are tripartite in *P. tripartita* (Fig. 32D). The shape of lamina varies from lanceolate to deltoid. Lanceolate lamina architecture is common in *Pteris*. Deltoid frond is present in *P. gongalensis*. Texture is coriaceous (*e.g. P. cretica*) to membranaceous (*e.g. P. ensiformis*). But, papyraceous lamina is seen in *P. multifida*.

Pinnae

The outline or shape, number, presence of setae, and arrangement of pinnae are important characters in this genus. Pinna is the ultimate segment in pinnate species and pinnule is the ultimate segment in bipinnate or tripartite species. Most of the pinnate species have glabrous pinnae except *P. multiaurita*, sterile pinnae of which bear conspicuous spines adaxially. Pinna is irregularly lobed in *P. heteromorpha* (Fig. 33F), whereas it is regularly lobed and adnated to stipe to form a winged rachis in *P. multifida* (Fig. 33I). Pinnae are usually opposite or subopposite, but in some cases alternate arrangement (*e.g. P. argyraea*). It may be lanceolate to oblong. The apex is acute (*e.g. P. vittata*) to acuminate (*e.g. P. scabripes*), and is entire (*e.g. P. pellucida*), crenate (*e.g. P. multiaurita*) or serrate (*e.g. P. cretica*). Margin of pinna is entire (*e.g. P. scabripes*), undulate (*e.g. P. pellucida*) or serrate (*e.g. P. cretica*). In *P. multiaurita*, pinna bears

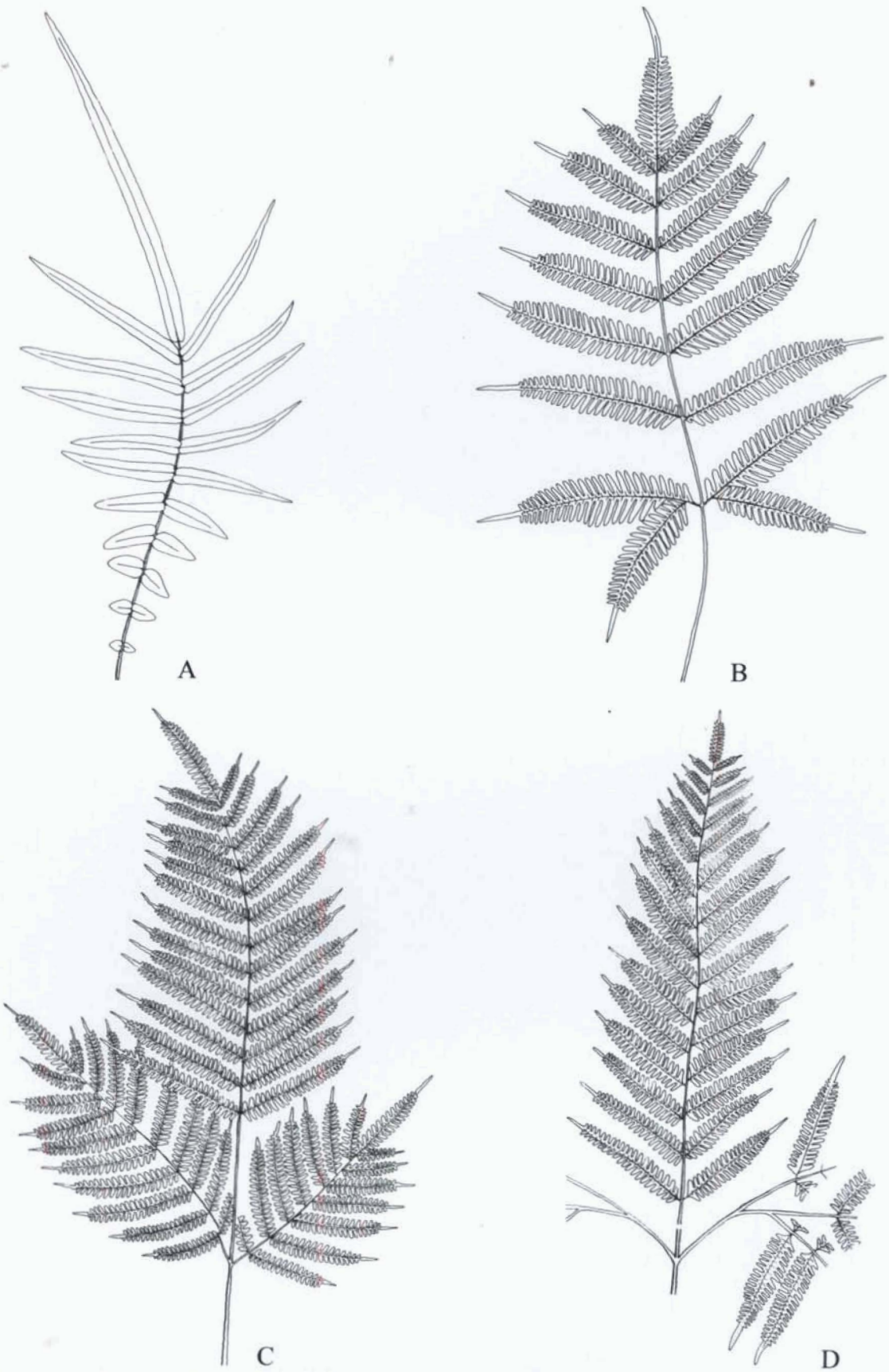


Fig. 32. **Types of lamina/frond**: **A**. simply pinnate (*P. vittata*); **B**. bipinnate (*P. quadriaurita*); **C**. ternately divided (*P. longipes*); **D**. tripartite (*P. tripartita*).

accessory pinna basiscopically, whereas basal pinna regularly lobed in *P. ensiformis*. Base of the pinna varies from cuneate (*e.g. P. scabripes*) to oblique (*e.g. P. cretica*), but it is cordate in *P.vittata* (Fig. 33 A-I). White or silver coloured band is present along either side of costa in *P. argyraea*, *P. cretica* var. *albolineata* and *P. ensiformis* var. *victoriae*.

Pinnules (ultimate segments)

Shape of the pinnule varies from oblong to linear. Majority of the species are having oblong pinnules, but in species like *P. linearis* and *P. perrottetii*, it is linear. Its lobbing is an important character in the species distinction (distance from the costae). Generally sinus is up to costa (*e.g. P. mertensioides*) to about 3 mm away from the costa (*e.g. P. argyreaea*). In some cases caducuous spines are present in sinus. Apex of the pinnule is yet another character to delimit taxa. It is rounded (*e.g. P. biaurita*) or obtuse (*e.g. P. reptans*), and entire (*e.g. P. argyraea*) or crenate (*e.g. P. geminata*). Spinule or setae is present along the entire costular length (*e.g. P. praetermissa*) or distal part of the segment (*e.g. P. blumeana*) or some time glabrous (*e.g. P. biaurita*). Setae are usually pale coloured, but, it is pinkish in *P. blumeana* (Fig. 34 A-O). In *P. otaria*, basal pinnules at acroscopic side are reduced (Fig. 33H).

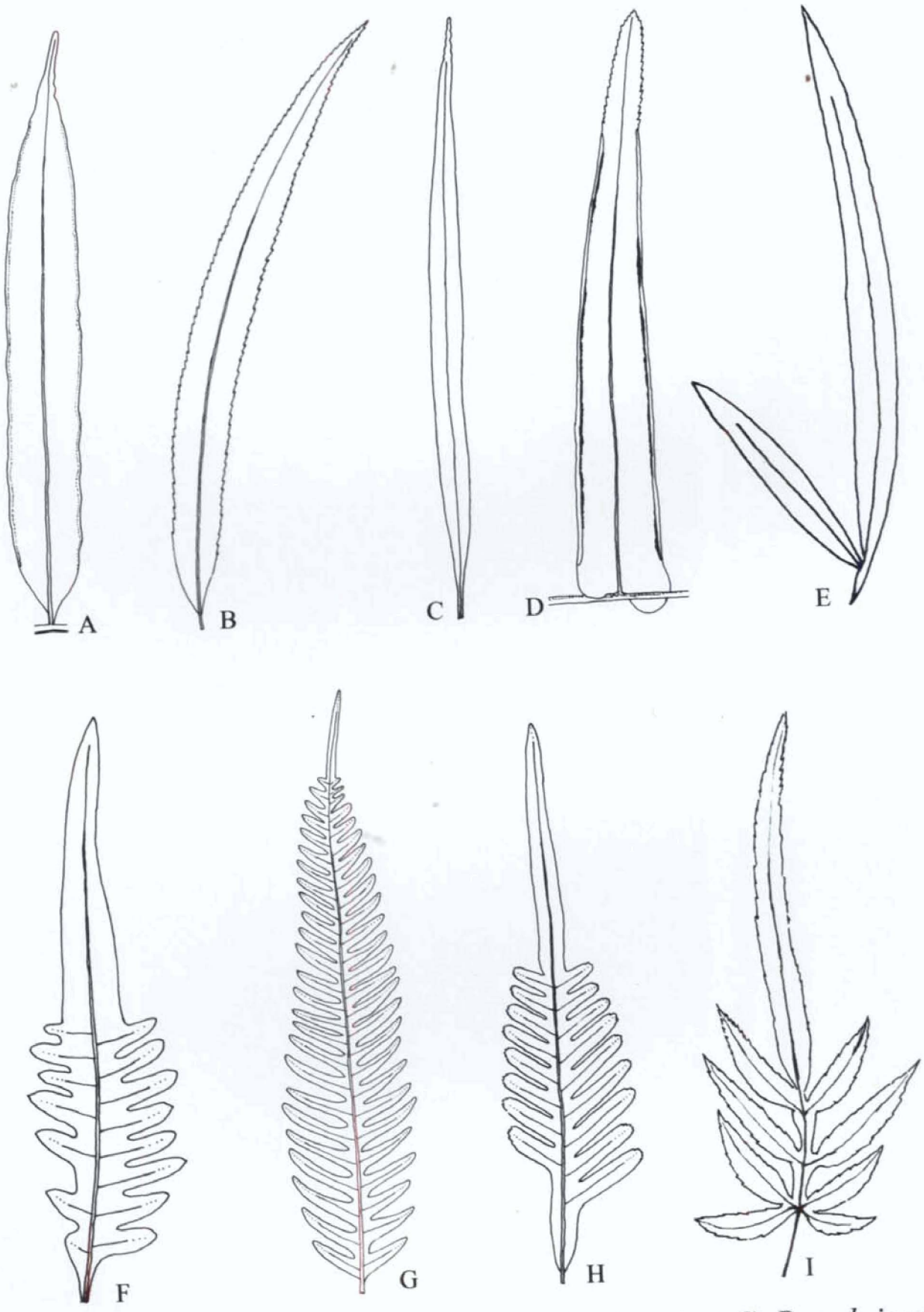


Fig. 33. **Types of pinna**: **A**. *P. pellucida*; **B**. *P. cretica*; **C**. *P. scabripes*; **D**. *P. vittata*; **E**. *P. multiaurita*; **F**. *P. heteromorpha*; **G**. *P. perrottetii*; **H**. *P. otaria*; **I**. *P. multifida*.

Venation

Veins are usually free, forking, numerous or in limited pairs in *Pteris*. In pinnate species, veins are once or twice forked and numerous (Fig. 35A), whereas in bipinnate species it is in limited pairs (Fig. 35B). Basal pair of veins usually reaching just above the sinus (Fig. 35C), but it is united to form triangular costal areole in *P. linearis* (Fig. 35B). It is also united to form a series of costal areoles along either side of midrib as in *P. biaurita* (Fig. 35D) and *P. geminata.* In *P. geminata,* veins are not up to margin, but ending submarginally in hydathodes (Fig. 34C). In *P. tripartita,* veins united to form costal as well as costular areoles (Fig. 35E).

Sori

The arrangement of sori is linear in *Pteris*. Sporangia are borne along the sub marginal position (abaxially) and protected by false indusia (inflexed margin). It appeared as in light brown to dark brown and present all along the margin except at apex and base (Fig. 35H) or except at apex only (Fig. 35F). In *P. longipes* and *P. otaria,* it is confined to middle portion of pinnules (Fig. 35G). Indusium is white in young sporophyll and become light brown in mature sporophyll. Sporangia are mixed type; both young and mature sporangia are seen in sori at a time. Numerous, uniseriate paraphyses are intermixed with the sporangia and the sporangia are globose with biseriate

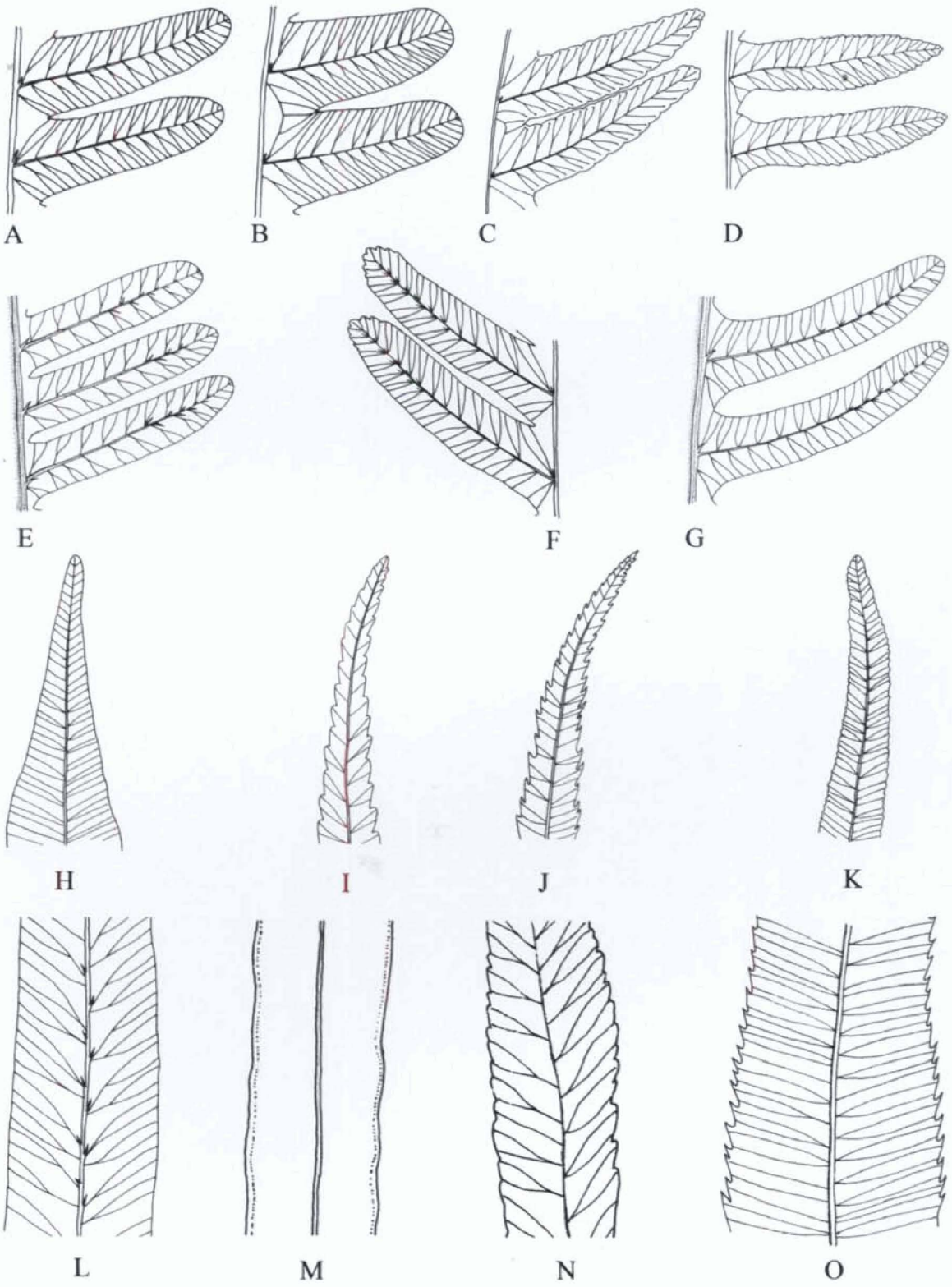


Fig. 34. **Types of Pinnule**: **A**. *P. argyraea*; **B**. *P. biaurita*; **C**. *P. geminata*; **D**. *P. mertensioides*; **E**. *P. blumeana*; **F**. *P. otaria*; **G**. *P. perrottetii*. **Pinnae apices**: **H**. entire (*P. pellucida*); **I**. crenate (*P. multiaurita*); **J**. serrate (*P. cretica*); **K**. crenulate (*P. vittata*). **Margins of pinna/pinnule**: **L**. entire (*P. multiaurita*); **M**. undulate (*P. pellucida*); **N**. crenate (*P.geminata*); **O**. serrate (*P. cretica*).

stalk. The annulus is dorsally placed and the number varies from 12 (*P. vittata*) to 26 (*P. tripartita*).

Spores

The spores are trilete, tetrahedral and have an equatorial collar-like ridge girdling the spore. Perine is absent in *Pteris*. Exine ornamentation is usually verrucate (Fig. 35I), but, rugate (*P. geminata*; Fig. 35J), tuberculate (*P. mertensioides*; Fig. 35K), and bisculpate (*Pteris vittata*; Fig. 35L) spores are also seen. In some cases abortive and misshapes spores (*P. confusa*) are also present. Morphological characters are summarized in table 5.

Table 5. Comparative morphology of the genus *Pteris* in South India.

No	Species/varieties	Height (cm)	Rhizome	Lamina	Pinnae	Pinnules	Veins	Spores	Other characters
1	*P. argyraea*	90-150	suberect	bipinnate, ovate-lanceolate	5-7 pairs, lanceolate, adaxially white band along either side of midrib	18-24 pairs, obtuse-rounded, oblong, entire, sinus 2 mm away from costae, glabrous	9-15 pairs, free	30 x 45 µm, verrucate	texture subcoriaceous
2	*P. arisanensis*	130-160	creeping	bipinnate, ovate-broadly ovate	5-6 pairs, lanceolate	24-27 pairs, oblong, obtuse, entire, sinus 3 mm away from costae	14-18 pairs, free	35 x 40 µm, verrucate	texture coriaceous
3	*P. biaurita*	70-110	erect to suberect	bipinnate, ovate-oblong	5-8 pairs, lanceolate	15-30 pairs, oblong, obtuse-rounded, entire, sinus 2-3mm away from costae	11-20 pairs, basal pair form costal areoles along the midrib	45 x 50 µm, verrucate	texture coriaceous
4	*P. blumeana*	40-60	erect	bipinnate, oblong	4-10 pairs, lanceolate	25-36 pairs, oblong, obtuse, entire, sinus near to costae	8-14 pairs, free, forking half the way to margin	35 x 40 µm, verrucate	regular arrangement of pinnae, and pink stipe

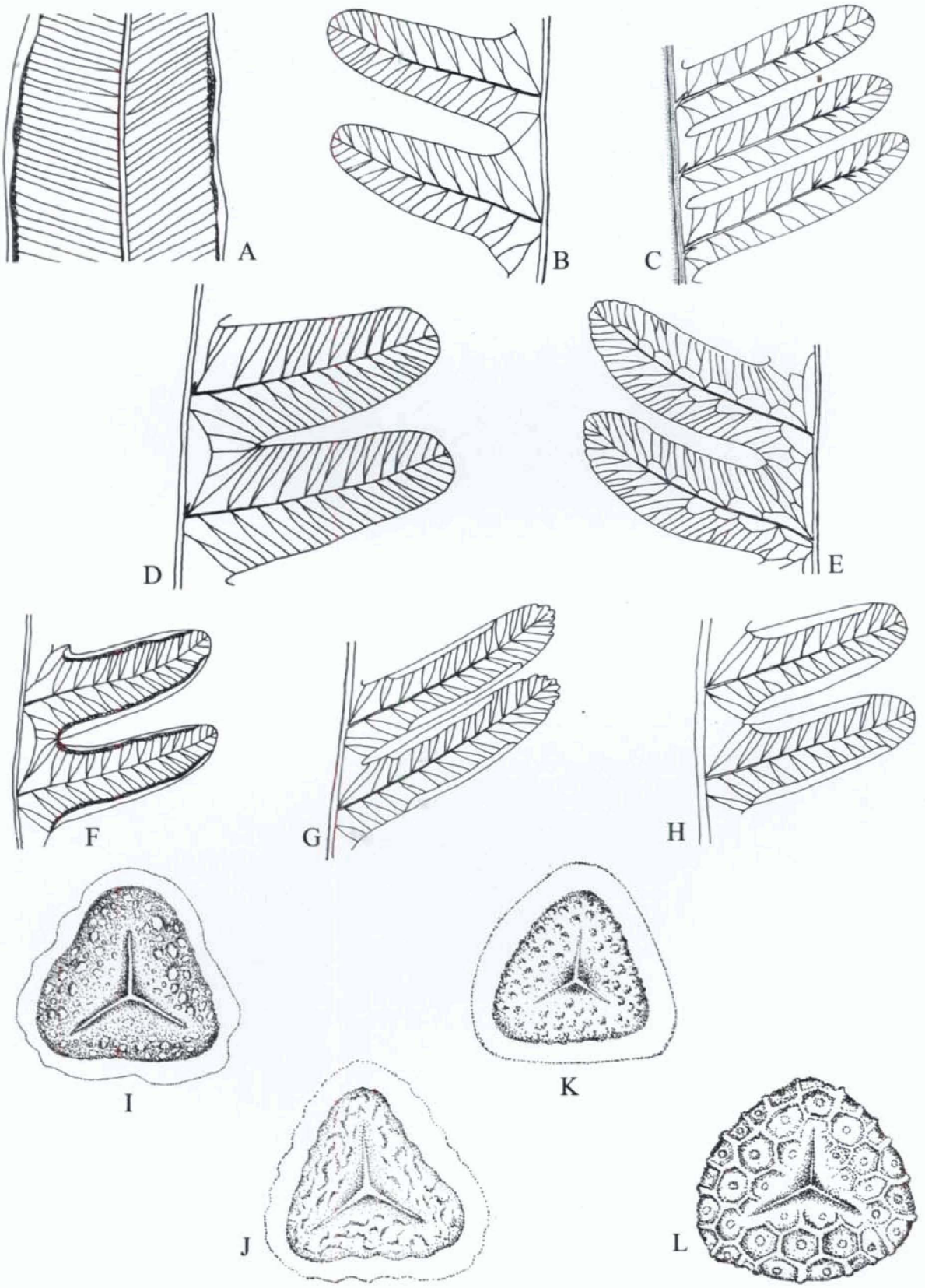


Fig. 35. **Venation patterns**: **A**. *P. vittata*; **B**. *P. linearis*; **C**. *P. blumeana*; **D**. *P. biaurita*; **E**. *P. tripartita*. **Soral arrangements**: **F**. *P. biaurita*; **G**. *P. otaria*; **H**. *P. argyraea*; **Spore ornamentations**: **I**. verrucate (*P. pellucida*); **J**. rugate (*P. geminata*); **K**. tuberculate (*P. longipes*); **L**. bisculpate (*P. vittata*).

5	*P. confusa*	60-90	erect	bipinnate, ovate	2-6 pairs, lanceolate	18-23 pairs, oblong, obtuse, entire, sinus 2 mm away from costae	15-16 pairs, free	40 x 45 µm, verrucate	abortive and misshapen spores present
6	*P. cretica*	50- 100	erect	pinnate, ovate	5-6 pairs, lanceolate, margin distinctly serrate	x	numerous, free	45 x 55 µm, verrucate	texture coriaceous
7	*P. cretica* var. *albolineata*	up to 50	creeping	pinnate, ovate-lanceolate	1-2 pairs, ovate-oblong, margin distinctly serrate, basal pair bipartite	x	numerous, free	not available	adaxially white band along either side of midrib
8	*P. ensiformis*	30-45	creeping	pinnate, ovate-deltoid	3-5 pairs, serrulate, lower pinnae deeply lobed, ovate, upper pairs ensiformis	x	numerous, free	45 x 50 µm, verrucate	stipe quadrangular, texture membranace-ous
9	*P. ensiformis* var. *victoriae*	50-65	creeping	pinnate, ovate	3-4 pairs, serrulate, glabrous, lower pair deeply lobed	x	numerous, free	35 x 40 µm, verrucate	adaxially white band on either side of midrib, abortive spores

10	*P. geminata*	60-70	erect-suberect	bipinnate, ovate	5-7 pairs, lanceolate	16-23 pairs, oblong, crenate (entire except apex in fertile), sinus 3 mm away from costae	13-16 pairs, basal pair form costal areoles along the costae	45 x 50 µm, rugate	veins ending submarginally in hydathodes
11	*P. gongalensis*	30-40	suberect	bipinnate, deltoid	3-4 pairs, lanceolate	13-16 pairs, oblong, acute, sinus 1mm away from costae	11-13 pairs, free	40 x 45 µm, verrucate	inconspicuous spinules on costae and costules
12	*P. heteromorpha*	30-50	creeping	pinnate, ovate	4-5 pairs, pinnae irregularly lobed towards the base, some time apiculate, lower pinnae petiolate	x	numerous, free	50 x 60 µm, rugate	spores girdling broad equitorial ridge; texture of pinnae subcoriaceous
13	*P. linearis*	130-160	erect-suberect	bipinnate, oblong-lanceolate	7-9 pairs, lanceolate	25-32 pairs, linear oblong, obtuse-acute, sinus 2 mm away from costae	12-16 pairs, basal veins form triangular costal archs	50 x 55 µm, verrucate	texture subcoriaceous

14	*P. longipes*	70-100	erect	bipinnate, ovate-braodly ovate	10-16 pairs, oblong-lanceolate	13-18 pairs, oblong, apex crenate, sinus up to costae	6-8 pairs, free	40 x 45 µm, verrucate	basal pinnae ternately divided, inconspicuous spines on costae and costules, spines on stipe, sori at the middle portion of pinnae
15	*P. mertensioides*	250-300	erect	bipinnate, ovate	20-25 pairs, linear-lanceolate	45-55 pairs, oblong, crenate (entire except apex in fertile), sinus up to costae, triangular sinus	15-20 pairs, free	35 x 40 µm, tuberculate	texture membranaceous, spores girdling broad equatorial ridge
16	*P. multiaurita*	80-120	creeping	pinnate, ovate-oblong	8-12 pairs, lanceolate, apex crenate, setae on sterile pinnae, all pinnae bipartite except terminal pinnae	x	numerous, free	35 x 40 µm, rugate	Membranaceous

17	*P. multifida*	15-30	creeping	pinnate, lanceolate	2-3 pairs, margin wavy-serrrate, pinnae deccurrent to form a winged stipe, lower pinnae multifidus	x	numerous, free	40 x 45 µm, rugate	texture papyraceous, misshapes spores are also seen
18	*P. otaria*	75-80	suberect	bipinnate, lanceolate	6-8 pairs lanceolate	7-12 pairs, oblong, apex crenate, sinus 1mm away from the costae	9-11 pairs, free	30 x 35 µm, rugate	basal pinnules reduced at acroscopic side, conspicuous spines on costae and costules
19	*P. pellucida*	up to 70	erect	pinnate, deltoid	3-4 pairs, lanceolate, entire or undulating, acuminate, basal pair not bipartite	x	numerous, free	30 x 35 µm, verrucate	texture coriaceous
20	*P. perrottetii*	100-125	erect	bipinnate, ovate-lanceolate	8-12 pairs, lanceolate	24-28 pairs, entire, acute, sinus up to costae, 2-4 mm inter-segmental distance	16-18 pairs, free	45 x 50 µm, verrucate	usually basal pinna bears 2 accessory pinnae, inconspicuous spinules on distal end of costules

21	*P. praetermissa*	40-45	suberect	bipinnate, ovate	4-6 pairs, lanceolate	15-23 pairs, oblong, obtuse, entire, sinus up to costae	11-15 pairs, free	35 x 40 µm, verrucate	long conspicuous spinules along the costules, texture herbaceous
22	*P. quadriaurita*	70-100	suberect	bipinnate, ovate-lanceolate	6-8 pairs, lanceolate	20-25 pairs, oblong, obtuse-rounded, apex crenate, sinus 1mm away from the costae	15-17 pairs, free	45 x 50 µm, verrucate	sub coriaceous, spinules along the costules
23	*P. reptans*	70-130	creeping	bipinnate, lanceolate	12-14 pairs, lanceolate	18-28 pairs, oblong, obtuse, sinus 1mm away from the costae	11-16 pairs, free	40 x 45 µm, rugate	inconspicuous spinules along the costules
24	*P. scabripes*	50-90	erect	pinnate, ovate	3-9 pairs, linear lanceolate, entire except apex (crenate), glabrous, lower pair bipartite	x	numerous, free	50 x 55 µm, verrucate	texture subcoriaceous
25	*P. tripartita*	200-300	erect	Compoun-dly bipinnate, ovate	15-20 pairs, lanceolate	12-22 pairs, oblong, obtuse, sinus 3 mm away from costae, apex crenate	10-14 pairs, united to form costal and costular areoles	30 x 40 µm, verrucate	texture subcoriaceous

26	*P. vittata*	45-120	creeping	pinnate, obovate	10-28 pairs, linear-lanceolate, sessile, sterile pinnae and apex of fertile pinnae crenate or crenulate, cordate, lower pinnae gradually reduced, basal pair not bipartite	x	numerous, free	50 x 55 µm, bisculpate	texture subcoriaceous

CONSERVATION

CONSERVATION

Pteridophytes are involved to fill every ecological niche, but the greatest species diversity is obviously found in tropical rain forest. The rapid disappearance of many pteridophyte species is of great concern. The venture to conserve pteridophytes is being coordinated by International Association of Pteridologists in conjunction with the Species Survival Commission of IUCN (Jermy, 1990).

India is one of the richest biodiversity regions of the world, but with the ever increasing encroachments on natural vegetation and habitat destruction, huge areas are being bared of forest year by year. So a large numbers of plants are endangered and face the risk of extinction, and conservation of such species has become major concern of the biologists. The important step in the conservation of pteridophytic species is domestication and their introduction in the garden. Botanical gardens play an important role in the conservation of plant diversity.

In the present study, samples of all the specimens collected are introduced in the Fern House of Calicut University Botanical Garden (CUBG). But some of the species are not survived in the Fern House. Presently 18 species of *Pteris* have been growing in the Fern House. These

species were introduced from different localities of South India. A list species with collection locality is provided below (Table 6).

Table 6. *Pteris* spp. Conserved in Calicut University Botanical Garden (CUBG).

Sl. No	Name of species	Collection locality/District
1	*P. argyraea*	Chanthanathode- Wayanad
2	*P. arisanensis*	Periyar Tiger Reserve- Idukki
3	*P. biaurita*	Chanthanathode - Wayanad
4	*P. blumeana*	Aralam Wildlife sanctuary-Kannur
5	*P. confusa*	Malabar wildlife sanctuary Kozhikode
6	*P. cretica*	Way to Avalache (Ooty)-Nilgiri
7	*P. ensiformis*	Nedumangad-Thiruvanathapuram
8	*P. geminata*	Periyar Tiger Reserve - Idukki
9	*P. heteromorpha*	Shedurney Wildlife Santuary-Kollam
10	*P. mertensioides*	Sholayar- Thrissur
11	*P. multiaurita*	Shendurney Wildlife Santuary-Kollam
12	*P. multifida*	Puthiyara- Kozhikode
13	*P. otaria*	Konni- Pathanamthitta
14	*P. longipes*	Silent Valley National Park-Palakkad
15	*P. pellucida*	Silent Valley National Park-Palakkad
16	*P. praetermissa*	Parambikulam Wildlife Santuary-Palakkad
17	*P. scabripes*	Silent Valley National Park-Palakkad
18	*P. vittata*	Kohinoor- Malappuaram

DATABASE OF *PTERIS*

DATABASE OF THE GENUS *PTERIS* IN SOUTH INDIA

Database of the 'Genus *Pteris* in South India' was prepared by using Visual ProxPro (ver. 6.0) software with the help of a computer programmer. Database provides updated information about the genus *Pteris* L. in South India. It includes introduction, updated species name, citations, altitude, descriptions, synonyms, habit, habitat, distribution, common name, IUCN status, endemism, digital images, *etc.* (Plate 34)

The database aims easy identification of the species with any one of the criteria mentioned above. There is a search option to find out a species by species name, synonym(s), common name(s), altitude, *etc.* The database can be updated with recent information.

This may be first of this kind of database of ferns in South India.

BIBLIOGRAPHY

BIBLIOGRAPHY

Abraham, A., Ninan, C. A. & Mathew, P. M. 1962. Studies on the cytology and phylogeny of pteridophytes- VII. Observations in one hundred species of South Indian ferns. *J. Indian Bot. Soc.* 41: 339-421.

Agardh, J. G. 1839. *Recensio Specierum Generis Pteridis*. Lund, Leipzig.

Agely, A. A., Sylvia, D. M. & Ma, L. Q. 2005. Mycorrhizae increase arsenic uptake by the hyperaccumulator *Pteris vittata*. *J. Environ. Quality* 34: 2181-2186.

Ammal, S. L. & Bhavanandan, K. V. 1991. Cytological studies on some members of Pteridaceae (*sensu* Copeland) from South India. *Indian Fern J.* 8: 87-92.

Antony, R. 2009. *Pteris heteromorpha* Fee (Pteridaceae: Pteridophyta): A new record for Kerala. *J. Econ. Taxon. Bot.* 33: 428-429.

Arbelaez, A. L. 1995. Two new species and new records for *Pteris* (Pteridaceae) from Colombia. *Brittonia* 47: 175-181.

Azeez, K., Kurup V. V. G. & Madhusoodanan, P. V. 2008. *Spleenworts (Asplenium* L. - *Pteridophyta) of South India.* Malabar Natural History Society (MNHS), Kozhikode.

Banerjee, R. D. & Sen, S. P. 1980. Antibiotic activity of Pteridophyes. *Econ. Bot.* 34: 284-298.

Bauer, F. A. & Hooker, W. J. 1838. *Genera Filicum.* Henry G. Bohn-4, Covent Garden, London.

Beddome, R. H. 1863. *The Ferns of Southern India.* Gantz Bros., Madras. [Reprinted, 1970. Today and Tomorrow's Printers & Publishers, New Delhi].

Beddome, R. H. 1865. *The Ferns of British India.* Gantz Bros, Madras. [Reprinted, 1973. Oxford and IBH Publishing Co., New Delhi].

Beddome, R. H. 1876. *Supplement to the Ferns of Southern India and British India.* Ganz Bros., Madras. [Reprinted, 1996. International Book Distributors, Dehra Dun].

Beddome, R. H. 1883. *Handbook to the Ferns of British India, Ceylon and the Malay Peninsula.* Thacker Spink & Co., Calcutta. [Reprinted, 1976. Today and Tomorrow's Printers & Publishers, New Delhi].

Bell, P. R. 1992. Apospory and apogamy: Implications for understanding the plant life cycle. *Int. J. Plant Sci.* 153: S123-S136.

Beri, A. & Bir, S. S. 1993. Germination of stored spores of *Pteris vittata* L. *Amer. Fern J.* 83: 73-78.

Bhavanandan, K. V. 1968. Studies on the cytology of sixteen species of south Indian ferns. *Caryologia* 21: 333-338.

Bhavanandan, K. V. & Ammal, S. L. 1993. Studies on the spore morphology of some south Indian ferns. *Indian Fern J.* 10: 12-16.

Bierhorst, D. W. 1971. *Morphology of Vascular Plants*. McMillion Company, New York.

Bir, S. S. & Goyal, P. 1981. Effect of ascorbic acid on fern gametophytes I. Spore germination and 2-D growth in *Pteris vittata* Linn. Pp. 214-219 in: Verma, S. C. (ed.), *Contemporary Trends in Plants Science*. Kalyani Publishers, New Delhi.

Bir, S. S. & Goyal, P. 1982. Effect of ascorbic acid on fern gametophytes II. Gross morphology and sex expression in *Pteris vittata* L. Phyta, Studies on living and fossil plants, Pant memorial Volume. Pp. 15-29.

Blatter, E. & d'Almeida, J. F. 1922. *The ferns of Bombay*. Diocesan Press, Madras.

Bole, P. V. & Almeida M. R. 1977. Four new species of Pteridophytes from Bombay presidency. *J. Bomb. Nat. Hist. Soc.* 74: 320-325.

Borthakur, S. K., Deka, P. & Nath, K. K. 2000. Illustrated manual of fern of Assam. Bishen Singh Mahendra Pal Singh, Dehra Dun.

Bower, F. O. 1928. *The ferns III. The leptosporangiate ferns.* Cambridge University press, Cambridge.

Bridson, D. & Forman, F. 1998. *The herbarium Handbook, 3rd ed.* Royal Botanical Gardens, Kew.

Britton, D. M. 1974. The significance of chromosome numbers in ferns. *Ann. Missouri Bot. Gard.* 61: 310-317.

Brownlie, G. 1957. Cyto-taxonomic studies on New Zealand Pteridaceae. *New Phytol.* 56: 207-209.

Brummitt, R. K. & Powell, C. E. 1992. *Authors of Plant Names.* Royal Botanic Gardens, Kew.

Burman, N. L. 1768. *Flora Indica.* Lugduni, Batavorum. [Reprinted, 1984. Bishen Singh Mahendrapal, Dehra Dun].

Chandler, A. 1941. *Pteris multifida* in Arkansas. *Amer. Fern J.* 31: 112.

Chandra, S. & Khare, P. B. 1995. Natural occuence of foliar buds in Indian ferns. *J. Indian Bot. Soc.* 74: 155-160.

Chandra, S. 2000. *The ferns of India.* International Book Distributors, Dehra Dun.

Chandra, S., Fraser-Jenkins, C. R., Kumari, A. & Srivasthava, A. 2008. A summary of the status of threatened pteridophytes of India. *Taiwania* 53: 170-209.

Chen, Y.-H., Chang, F.-R., Lu, M.-C., Hsieh, P.-W., Wu, M.-J., Du, Y.-C. & Wu, Y.-C. 2008. New Benzoyl Glucosides and Cytotoxic Pterosin Sesquiterpenes from *Pteris ensiformis* Burm. *Molecules* 13: 255-266.

Christensen, C. 1906. *Index Filicum*. H. Hagerup, Copenhagen.

Clarke, C. B. 1880. A review of the ferns of northern India. *Trans. Linn. Soc.* (Lond.), ser. 2, Bot. 1: 425-619.

Copeland, E. B. 1947. *Genera Filicum*. Chronica Botanica company.

Copeland, E. B. 1971. *Ferns of Fiji*. Krans Reprint Co., New York.

Crabbe, J. A., Jermy, A. C. & Mickel, J. T. 1975. A new generic sequence for the pteridophyte herbarium. *Fern Gaz.* 11: 141-162.

Crotty, W. J. 1967. Rhizoid differentiation in the fern gametophyte of *Pteris vittata*. *Amer. J. Bot.* 54: 105-117.

Dalli, A. K., Saha, G. & Chakraborty, U. 2007. Characterization of antimicrobial compounds from a common fern, *Pteris biaurita*. *Indian J. Exp. Biol.* 45: 285-290.

Das, S. 2007. Taxonomic revision of Indian species of *Pteris* L. with simple pinnate fronds. *Indian Fern J.* 24: 60-70.

Deng, Y. F., Liang, N. C. & Liang, T. 2002. Analysis of the diterpenoids in the extract of *Pteris semipinnata* L. by HPLC-APCI-MS. *Yao Xue Xue Bao*. 37: 444-446.

Devi, S. 1977. *Spores of Indian ferns*. Todays & Tomorrow's Printers and Publishers, New Delhi.

Devi, S., Yasmeen & Singh, J. 1985. Incidence of fern spores in the ambient air of Lucknow. *Indian Fern J.* 2: 32-38.

Dixit, R. D. 1984. *A census of the Indian pteridophytes*, Flora of India, ser. 5. Botanical Survey of India, Howrah.

Don, D. 1825. *Prodromus Florœ Nepalensis, sive Enumeratio Vegetabilium quœ in itinere per Nepaliam proprie dictam et regiones conterminas, ann. 1802-1803, detexit atque legit D. D. Franciscus Hamilton (olim Buchanan) M.D. Societ. Reg. et Linnœan. Londin. Soc. Accedunt plantœ a D. Wallich nuperius missœ, secundum methodi naturalis normam disposuit atque descripsit*: i-xii, 1-256. Londinium. [Reprinted, 1976. Dehra Dun & Delhi].

Dong, R., Formentin, E., Losseo, C., Carimi, F., Benedetti, P., Terzi, M. & Schiavo, F. L. 2005. Molecular cloning and characterization of a

phytochelatin synthase gene, *PvPCS1*, from *Pteris vittata* L. *J. Ind. Microbiol. Biotechnol.* 32: 527-533.

Duan, G., Zhu, Y., Tong, Y., Cai, C. & Kneer, R. 2005. Characterization of arsenate reductase in the extract of roots and fronds of Chinese brake fern, an arsenic hyperaccumulator. *Plant Physiol.* 138: 461-469.

Duncan, T. & Smith, A. R. 1978. Primary basic chromosome numbers in ferns: Facts and Fantasies? *Syst. Bot.* 3: 105-114.

Easa, P. S. 2003. Pteridophytes. *Biodiversity Documentation for Kerala Part-5*: KFRI Handbook no. 17, Kerala Forest Research Institute, Peechi, Kerala.

Ellis, D. R., Gumaelius, L., Indirolo, E., Pickering, I. J., Banks, J. A. & Salt, D. E. 2006. A novel arsenate reductase from the arsenic hyperaccumulating fern *Pteris vittata*. *Plant Physiol.* 141: 1544-1554.

Farlow, W. G. 1874. An asexual growth from the prothallus of *Pteris cretica*. *Quart. J. Micros. Sci.* 14: 266-272.

Fraser-Jenkins, C. R. 1997. *New species syndrome in Indian Pteridology and the ferns of Nepal*. International Book Distributors. Dehra Dun.

Fraser-Jenkins, C. R. 2008a. *Taxonomic revision of three hundred Indian subcontinental pteridophytes with a revised census-list.* Bishen Singh Mahendra Pal Singh, Dehra Dun.

Fraser-Jenkins, C. R. 2008b. Endemics and pseudoendemics in relation to distribution patterns of Indian Pteridophytes. *Indian Fern J.* 25: 1-45.

Fraser-Jenkins, C. R., Sreenivas, V. K. &. Madhusoodanan, P. V. (in press). Little known and misunderstood species of *Pteris* L. (Pteridaceae) in India. *Kew Bull.*

Ge, X., Ye, G., Li, P., Tang, W. J., Gao, J. L. & Zhao, W. M. 2008. Cytotoxic diterpenoids and sesquiterpenoids from *Pteris multifida*. *J. Nat. Prod.* 71: 227-231.

Ghatak, J. 1961. Problems involved in the proper identification of ferns. *Bull. Bot. Surv. India* 3: 79-82.

Ghatak, J. 1977. Biosystematic survey of Pteridophyta from Shevaroy Hills, South India. *Nucleus* 20: 105-108.

Ghosh, S. R. & Ghosh, R. K. 1982. A new *Pteris* from Silent valley, Kerala. *J. Bomb. Nat. Hist. Soc.* 79: 385-386.

Ghosh, S. R. 1984. *Pteris scabripes* Wall. ex Hook.- A new find from India. *J. Bomb. Nat. Hist. Soc.* 81: 237-238.

Ghosh, S. R., Ghosh, B., Biswas, A. & Ghosh, R. K. 2004. *The pteridophytic flora of Eastern India*, Flora of India Ser. 4. Botanical Survey of India, Howrah.

Goldblatt, P. and Johnson, D. E. (eds.) 1991. Index to plant chromosome numbers 1988- 1989. *Monogr. Syst. Bot. Missouri Bot. Gard.* 40: i-viii + 1- 238.

Gowrisankar, K., Nandakumar, K., Chandrasekhar, R., & Irudayaraj, V. 2008. Pteridophytic flora of Kolli hills, Eastern Ghats, South India. *Int. Symp. Persp. Pterid.* Lucknow. Abstracts. Pp. 99.

Griffith, W. 1844. The cryptogamic plants of Dr. Roxburg forming the fourth and the last part of the Flora Indica. *Culcutta Journ. Nat. Hist.* 4: 463-489.

Gumaelius, L., Lahner, B., Salt, D. E. & Banks, J. A. 2004. Arsenic hyperaccumulation in gametophytes of *Pteris vittata*. A new model system for analysis of arsenic hyperaccumulation. *Plant Physiol.* 136: 3198-3208.

Hameed, C. A., Rajesh, K. P. & Madhusoodanan P. V. 2003. *Filmy Ferns of South India.* Penta Book Publishers & Distributors, India.

Harborne, J. B. 1966. Comparative biochemistry of flavonoids- II: 3-Desoxyanthocyanins and their systematic distribution in ferns and gesnerads. *Phytochemistry* 5: 589-600.

Hawkes, A. D. 1964. *Litobrochia* in Florida. *Amer. Fern J.* 54: 38-39.

Heun, A. L. 1939. The cytology of apogamy in *Pteris cretica* Linn. var. *albolineata* Hort. *Bull. Torrey Bot. Cl.* 66: 549-562.

Hieronymus, G. 1914a. Beiträge zur Kenntnis der Gattung Pteris 1. Über Pteris longifolia L. und Verwandte arten. *Hedwigia* 54: 283-294.

Hieronymus, G. 1914b. Beiträge zur Kenntnis der Gattung Pteris 2. Über Pteris quadriaurita Retz und einige asiatische, malesische und polynesische Pteris-Arten aus der Gruppe und Verwandtschaft dieser art. *Hedwigia* 55: 325-375.

Holttum, R. E. 1947. A revised classification of leptosporangiate ferns. *J. Linn. Soc. Bot.* 58: 123-158.

Holttum, R. E. 1949. The classification of ferns. *Biol. Rev.* 24: 267- 296.

Holttum, R. E. 1968. *A Revised Flora of Malaya. Vol. 2. Ferns of Malaya.* Govt. Printing Office, Singapore.

Holttum, R. E. & Roy S. K. 1965. Cytological observations on ferns from New Guinea with description of new species. *Blumea* 13: 129-139.

Hope, C. W. 1899-1904. The Ferns of North- Western India. *J. Bomb. Nat. Hist. Soc.* 12-15: 315-429.

Huang, Y.-M., Chou, H.-M., Wang, J.-C. & Chiou, W.-L. 2007. The distribution and habitats of the *Pteris fauriei* complex in Taiwan. *Taiwania* 52: 49-58.

Imperato, F. & Nazzaro, R. 1996. Luteolin 7-*O*-sophoroside from *Pteris cretica*. *Phytochemistry* 41: 337-338.

Imperato, F. & Telesca, A. 1999. 3-C-(6'''-O-acetyl-beta-cellobiosyl) apigenin, a new flavonoid from *Pteris vittata*. *Amer. Fern J.* 89: 217-220.

Imperato, F. & Telesca, A. 2000. 6-C-cellobiosylisoscutellarein-8-methyl ether, a new flavonoid from *Pteris vittata*. *Amer. Fern J.* 96: 42-47.

Imperato, F. 2000. Kaempferol and quercetin 3-O-(X",X"-di-protocatechuoyl) -glucuronides from *Pteris vittata*. *Amer. Fern J.* 90: 141-143.

Imperato, F. 2002. 3, 8-Di-C-arabinosylluteolin, a new flavonoid from *Pteris vittata*. *Amer. Fern J.* 92: 244-246.

Imperato, F. 2003. Kaempferol and quercetin 3-O-(2", 3"-di-O-p-coumaroyl)-glucosides from *Pteris vittata*. *Amer. Fern J.* 93: 157-160.

Imperato, F. 2004. Vitexin 7-O-rhamnoside, a new flavonoid from *Pteris vittata*. *Amer. Fern J.* 94: 159-162.

Imperato, F. 2006. The new flavone ester Apigenin-7-O-oxy-p-hydroxyhenzoate and 3-Di-C-glycosyl flavones from *Pteris vittata*. *Amer. Fern J.* 96: 62-65.

Irudayaraj, V. & Manickam, V. S. 1987. SOCGI Plant chromosome number reports. IV. *J. Cytol. Genet.* 22: 156-163.

Ito, M. 1962. Studies on the differentiation of fern gametophytes-1. Regenaration of single cells isolated from cordate gametophytes of *Pteris vittata*. *Bot. Mag. (Tokyo)* 75:19-27.

IUCN, 2001. *IUCN Red List Categories and Criteria: Version 3.1*. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK.

Jamir, N. S. & Rao, R. R. 1988. *The ferns of Nagaland*. Bishen Singh Mahendra Pal Singh, Dehra Dun.

Jarrett, F. M. 1968. Plant notes. *Proc. Bot. Soc. Br. Isl.* 7: 387.

Jermy, A. C. 1990. Conservation of Pteridophytes. Pp. 15 in: Kramer, K. U. & Green, P. S. (eds.), in: Kubtizki, K. (ed.), *The Families and Genera of Vascular Plants*-1, *Pteridophytes and Gymnosperms*. Springer Verlag, Berlin.

Jha, J. & Sinha, B. M. B. 1987. "*Pteris cretica* var. *victoriae*"- A natural hybrid. *Nucleus* 30: 129-130.

Karuppusamy, S., Karmegam, N. & Rajasekaran, K. M. 2001. Enumeration, ecology and ethnobotany of ferns of Sirumalai hills, South India. *J. Econ. Taxon. Bot.* 25: 631-634.

Kato, M. & Kramer, K. U. 1990. Taxonomic studies of pteridophytes of Ambon and Seram (Moluccas) collected by Indonesian-Japanese expeditions VI. Pteridaceae. *Acta Phytotax. Geobot.* 41: 155-168.

Kaur, S. 1984. Vascular organization of the filicinean rhizome- A comparative study. *New Botanist* 11: 1-76.

Khare, P. B. & Kaur, S. 1983. Gametophyte differentiation of pentaploid *Pteris vittata* L. *Proc. Indian Nat. Sci. Acad.*, ser. B, 49: 740-742.

Khare, P. B. 1995. Studies in *Pteris vittata* Linn. complex. *Indian Fern J.* 12: 43-50.

Khare, P. B. & Kaur, S. 1987. Genetic load in tetraploid cytotype of *Pteris vittata* Linn. *Indian Fern J.* 4: 82-85.

Khare, P. K. & Sankar, R. 1989. On the petiolar structure in some *Pteris* species. *Indian Fern J.* 6: 100-107.

Khullar, S. P. 1994. *An Illustrated Fern Flora of West Himalaya*-1. International Book Distributors, Dehra Dun.

Khullar, S. P., Pangtey, Y. P. S., Samant, S. S., Rawal, R. S. & Singh, P. 1991. *Ferns of Nainital.* Bishen Singh Mahendra Pal Singh, Dehra Dun.

Koenig, D. 1785. Auszug eines Schreibens des Herrn D. Koenig aus Frankebar vom 28. Marz 1783 an den Herrn Confirenzrath O. F. Mueller. *Der Naturforscher Halle* 21: 107-110.

Kramer, K. U. 1967. Pteryx or Pteris. *Taxon* 16: 239.

Kramer, K. U. 1990. Notes on the higher level classification of the recent ferns. Pp. 49-52 in: Kramer, K. U. & Green, P.S. (eds.), *The Families and Genera of Vascular Plants. Vol. 1, Pteridophytes and Gymnosperms*. Springer- Verlag, Berlin.

Kunze, G. 1851. Filices Nilagiricae, *Linnaea* 24: 239-299.

Kuo, C.-M. 1989. Additional knowledge for the fern flora of Taiwan. 7. *Pteris wulaiensis* Kuo, a new species. *Bot. Bull. Acad. Sinica* 30: 143-145.

Kuriachan, P. I. & Ninan, C. A. 1976. Cytological evolution in the fern family Pteridaceae (*sensu* Copeland). Pp. 127-154 in: Nair, P. K. K. (ed.), *Aspects of Plant. Sciences*. Today & Tomorrow's Printers & Publishers, New Delhi.

Kuriachan, P. I. 1968. Cytological observations on some south Indian ferns. *Cytologia* 32: 500-506.

Kurup, M. K. 2003. *Studies on the Adiantoid –Cheilanthoid ferns of South India*. Ph.D. Thesis, Calicut University.

Kurup, V. V. G., Azeez, K. & Madhusoodanan, P. V. 2008. *Primitive ferns of South India*. Rainbow Book Publishers, Chengannur.

Lawrence, G. H. M., Buchheim, A. F. G., Daniels, G. S. & Dolezal, H. 1968. B-P-H, *Botanico-Periodicum-Huntianum*. Hunt Botanical Library, Pittsburgh.

Leena, K. R. & Madhusoodanan, P. V. 1992. Ecology and distribution of Thelypteroid ferns of South India. *Indian Fern J.* 9: 174-183.

Lellinger, D. B. & Taylor, W. C. 1997. A classification of spore ornamentation in the Pteridophyta. Pp. 33–42 in: Johns, R. J. (ed.), *Holttum Memorial Volume*. Royal Botanic Gardens, Kew.

Li, C-X., Lu, S-G., Yang, Q. & Hao, J-S. 2004. Phylogenetics of *Pteris* (Pteridaceae) from China based on the chloroplast *trnL-F* intergenic spacer sequences. *J. Genet. Mol. Biol.* 15: 58-63.

Lin, B. L. & Devol, C. E. 1978. The use of stipe characters in fern taxonomy II. *Taiwania* 23: 75-95.

Linnaeus, C. 1753. *Species Plantarum*. Laurentii Salvii, Holmiae. Pp. 1073-1077.

Ma, L. Q., Komari, K. M., Tu, C., Ahang, C. W., Cai, Y. & Kennelly, E. D. 2001. A fern that hyperaccumulated arsenic. *Nature* 409: 579-580.

Madhusoodanan, P. V. & Rejani, A. 1994. Re-investigation on the present status of the ferns and fern allies of *Hortus Malabaricus*. *Indian Fern J.* 11: 12-19.

Madhusoodanan, P. V., Rajesh, K. P. & Sreenivas, V. K. (in press). Pteridophytes of Wayanad district. In: Kumar, A. (ed.), *Biodiversity Documentation of Wayanad*. M.S. Swaminathan Research Foundation (MSSRF), Kalpetta.

Mahamuni, R. & Dongare, M. 2009. Diversity and distribution of the ferns from Belgaum District, Karnataka. *Indian Fern J.* 26: 137-141.

Majeed, K. K. A., Leena, K. R. & Madhusoodanan, P. V. 1994. Ecology and distribution of Lomariopsid ferns of Kerala. *J. Plant Envt.* 10: 71-74.

Manickam, V. S. 1986. *Fern Flora of Palni Hills (South India)*. International Bioscience Ser. 2. Today and Tomorrow's Printers and Publishers, New Delhi.

Manickam, V. S. & Benniamin, A. 2007. *Pteris heteromorpha* Fee- a new distributional record for Western Ghats of Karnataka, India. *J. Econ. Taxon. Bot.* 31: 455-457.

Manickam, V. S., Benniamin, A. & Harikrishnan, S. 2004a. *Pteris ensiformis* Burm.f. (Pteridaceae)- a new distributional record for Tamil Nadu, South India. *Indian Fern J.* 21: 93-95.

Manickam, V. S., Benniamin, A. & Harikrishnan, S. 2004b. *Pteris wallichiana* Agardh (Pteridaceae) from south India: a new record. *Indian J. Forestry* 27: 151-152.

Manickam, V. S., Benniamin, A. & Harikrishnan, S. 2005. *Pteris heteromorpha* Fee- a new distributional record for Andhra Pradesh. *J. Bomb. Nat. Hist. Soc.* 102: 378-379.

Manickam, V. S. & Irudayaraj, V. 1988. *Cytology of ferns of the Western Ghats* (*South India*). Today & Tomorrow's Printers & Publishers, New Delhi.

Manickam, V. S. & Irudayaraj, V. 1989. Corrections to the cytology of ferns of the Western Ghats. *Indian Fern J.* 6: 131-132.

Manickam, V. S. & Irudayaraj, V. 1992. *Pteridophyte Flora of the Western Ghats - South India*. B. I. Publications, New Delhi.

Manickam, V. S. & Irudayaraj, V. 2003. *Pteridophyte Flora of Nilgiris, South India*. Bishen Singh Mahendra Pal Singh, Dehra Dun.

Manickam, V. S. & Rajkumar, S. D. 1999. *Polymorphic ferns of Western Ghats- South India*. Bishan Singh Mahendra Pal Singh, Dehra Dun.

Manton, I. & Sledge, W. A. 1954. Observations on the cytology and taxonomy of the pteridophyte flora of Ceylon. *Philos. Trans. Roy. Soc. London, Biol.* ser. 238: 127-185.

Manton, I. 1950. *Problems of cytology and evolution in the Pteridophyta.* Cambridge University Press, Cambridge.

Martinez, O. G. & Morbelli, M. A. 2009. The spores of *Pteris cretica* complex (Pteridaceae-Pteridophyta) in America. *Grana* 48: 193-204.

Maxon, W. R. 1939. *Pteris multifida* in Washington, D. C. *Amer. Fern J.* 29: 122-123.

Meher-Homji, V. M. 1967. Phytogeography of the south Indian hill stations. *Bull. Torrey Bot. Club.* 94: 230-242.

Mehra, P. N. & Verma, S. C. 1960. Cytotaxonomic observations on some West Himalayan Pteridaceae. *Caryologia* 13: 619-650.

Mehra, P. N. 1938. Apogamy in *Pteris biaurita* Linn. *Proc. Indian Acad. Sci.* 8: 202-210.

Mehra, P. N. 1986. *Gametophytes of Himalayan ferns*. Raj Bandhu Industrial Company, New Delhi.

Mickel, J. T. & Smith, A. R. 2004. *The pteridophytes of Mexico, Part -1*. New York Botanical Garden, New York.

Mishra, M. & Sen, T. 1991. Ontogeny of gametophytes and sex expression in some species of *Pteris* L. Pp. 75-81 in: Bharadwaj, T. N. & Gena, C. B. (eds.), *Perspectives in Plant Biology: Present and Future*. Today & Tomorrow's Printers and Publishers, New Delhi.

Mishra, M. and Sen, T. 1989. On the differentiation of vascular tissue in the gametophytes of *Pteris* L. *Indian Fern J.* 6: 117-123.

Moran, R. C. 2008. Diversity, biogeography, and floristics. Pp. 332-366 in: Ranker, T. A. & Haufler, C. H. (eds), *Biology and Evolution of Ferns and Lycophytes*. Cambridge Univesrity Press, Cambridge.

Morton, C. V. 1957. Observations on cultivated ferns. Pteris- I. *Amer. Fern J.* 47: 7-14.

Murillo, M. T. & Bless, M. J. M. 1974. Spores of recent Colombian Pteridophyta. *Quart. Colombia* 11: 1-109.

Nair, N. C. & Bhargavan, P. 1981a. *Pteris dactylina* Hook. from Silent valley- a new record for Peninsular India. *J. Bomb. Nat. Hist. Soc.* 77: 356-357.

Nair, N. C. & Bhargavan, P. 1981b. The studies on the ferns of Peninsular India- a review. *Bull. Bot. Surv. India* 23: 170-190.

Nair, N. C. & Bhargavan, P. 1985. Recent finds of ferns- rare and little known pteridophytes from Silent Valley and nighbourhood. *J. Econ. Taxon. Bot.* 6: 267-270.

Nair, N. C. & Ghosh, R. K. 1978. *Pteris heteromorpha* Fee- A new record for India. *Indian Forester* 104: 374-376.

Nair, N. C. & Ghosh, S. R. 1974. *Pteris quadriaurita* Retz. and a few related taxa in Kerala state. *J. Bomb. Nat. Hist. Soc.* 73: 438-443.

Nair, N. C. & Ghosh, S. R. 1976. A new species of *Pteris* from Peninsular India. *J. Indian Bot. Soc.* 55: 38-40.

Nair, N. C. & Ghosh, S. R. 1977. *Pteris roseo-lilacina* Hieron.- A new record for Peninsular India. *J. Bomb. Nat. Hist. Soc.* 73: 424-425.

Nair, N. C., Ghosh, S. R. & Bhargavan, P. 1992. Fern allies and ferns of Kerala, India. Part II. *J. Econ. Taxon. Bot.* 16: 251-283.

Nakato, N. 1975. A cytological study on an intermediate form between *Pteris multifida* and *P. cretica*. *Jap. J. Bot.* 50: 119-125.

Nampy, S. & Madhusoodanan, P. V. 1998. *Fern Flora of South India: Taxonomic Revision of Polypodioid ferns*. Daya Publishing House, New Delhi.

Nayar, B. K. 1970. A phylogenetic classification of the homosporous ferns. *Taxon* 19: 229-236.

Nayar, B. K. & Devi, S. 1966. Spore morphology of Pteridaceae I. The Pteroid ferns. *Grana Palynol.* 6: 476-502.

Nayar, B. K. & Geevarghese, K. K. 1993. *Fern Flora of Malabar.* Indus Publishing Company, New Delhi.

Nayar, B. K. & Kaur, S. 1971. Gametophytes of homosporous ferns. *Bot. Rev.* 37: 295-396.

Nayar, M. P. 1996. *"Hot spots' of endemic plants of India, Nepal and Bhutan.* TBGRI, Palode, Thiruvananthapuram.

Pande, H. C. & Pande, P. C. 2003. *An illustrated fern flora of the Kumaon Himalaya-1.* Bishen Singh Mahendra Pal Singh, Dehra Dun.

Pichi Sermolli, R. E. G. 1968. Fragmenta pteridologiae I. *Webbia* 23: 159-207.

Pichi Sermolli, R. E. G. 1977. Tentamen Pteridophytorum genera in taxonomicum ordinem redigendi. *Webbia* 31: 313-512.

Pichi Sermolli, R. E. G. 1987. A look at the chromosome numbers in the families of pteridophyta. *Webbia* 41: 305-314.

Pichi Sermolli, R. E. G. 1996. *Authors of scientific names in Pteridophyta.* Royal Botanic Gardens, Kew.

Prada, C., Moreno, V. & Galán, J. M. G. 2008. Gametophyte development, sex expression and antheridiogen system in *Pteris incompleta* Cav. (Pteridaceae). *Amer. Fern J.* 98: 14-25.

Prado, J. & Smith, A. R. 2002. Novelties in Pteridaceae from South America. *Amer. Fern. J.* 92: 105-111.

Prado, J., Rodrigues, C. D. N., Salatino, A. & Salatino, M. L. F. 2007. Phylogenetic relationships among Pteridaceae, including Brazilian species, inferred from *rbcL* sequences. *Taxon* 56: 355-368.

Presl, C. B. 1836. *Tentamen Pteridographiae, seu Genera Filicacearum.* Typis Filiorum Theophili Haase, Pragae.

Presl, C. B. 1949. *Pycnodoria opaca.* Epim. Bot. Pp. 100.

Price, M. G. 1974. A new section and species of *Pteris*. *Kew Bull.* 29: 725-730.

Proctor, G. R. 1977. Pteridophyta, in: Howard, R. A. (ed.), *Flora of the Lesser Antilles* 2. Arnold Arboretum, Harvard University, Jamaica Plain, Massachusetts.

Pryer, K. M., Schuettpelz, E., Wolf, P. G., Schneider, H., Smith, A. R. & Cranfill, R. 2004. Phylogeny and evolution of ferns (monilophytes) with a focus on the early leptosporangiate divergences. *Amer. J. Bot.* 91: 1582-1598.

Pullaiah, T., Ahmed, A. & Lakshmi, P. A. 2003. *Pteridophytes in Andhra Pradesh – India*. Regency Publications, New Delhi.

Punetha, N. & Sen, A. 1989. Cytological observations on some species of *Pteris* L. from Kumaon (Northwest Himalaya). *Proc. Indian Acad. Sci. (Plant Sci.)*. 99: 131-134.

Punetha, N. 1990. Vascular morphology of stipe and rachis of some Western Himalayan species of *Pteris* L. *Proc. Indian Acad. Sci. (Plant Sci.)*. 100: 399-407.

Punetha, N., Bhakuni, K. and Punetha, R. 2007. A note on the freak of *Pteris cretica* L. *Indian Fern J.* 24: 122-124.

Raghavan, V. 1989. *Developmental biology of fern gametophytes*. Cambridge University Press, New York.

Rajagopal, P. K. & Bhat, K. G. 1998. Pteridophytic Flora of Karnataka State, India. *Indian Fern J.* 15: 1-28.

Rajesh, K. P. 2002. *Ecological and Taxonomic studies on the pteridophytes of Periyar Tiger Reserve, Kerala, South India.* Ph. D. Thesis, University of Calicut.

Rajkumar, S. D. 2002. Range extension of two species of *Pteris* Linn. to Western Ghats of Tamil Nadu, south India. *Indian Fern J.* 19: 111-112.

Rajkumar, S. D. 2005. A new species of *Pteris* L. (Pteridaceae: pteridophyta) from Western Ghats of south India. *J. Bomb. Nat. Hist. Soc.* 102: 313-314.

Rajkumar, S. D. & Manickam, V. S. 2000. Unusual absence of auricles in *Pteris confusa* T. G. Walker of Western Ghats, South India. *Indian Fern J.* 18: 83-89.

Raju, D. C. S. 1964. Pteridophytes of Godavari Region. *Bull. Bot. Surv. India* 6: 189-190.

Rathinasabapathi, B., Raman, S. B., Kertulis, G. & Ma, L. Q. 2006. Arsenic-resistant proteobacterium from the phyllosphere of arsenic-hyperaccumulating fern *Pteris vittata* reduces arsenate to arsenite. *Can. J. Microbiol.* 52: 695-700.

Retzius, A. J. 1791. *Observations Botanicae sex fasciculis comprehense.* Lipsiae.

Rojas, A. A. F. & Palacios, R. M. 2006. A new species of fern of the genus *Pteris* (Filicales: Pteridaceae) endemic to Costa Rica. *Revista de Biologia Tropical.* 54: 1061-1066.

Roy, S. K. & Holttum, R. E. 1965. Cytological observations on ferns from southern China. *Amer. Fern J.* 55: 154-164.

Sánchez-Baracaldo, P. 2004. Phylogenetic Relationships of the Subfamily Taenitidoideae, Pteridaceae. *Amer. Fern J.* 94: 126-142.

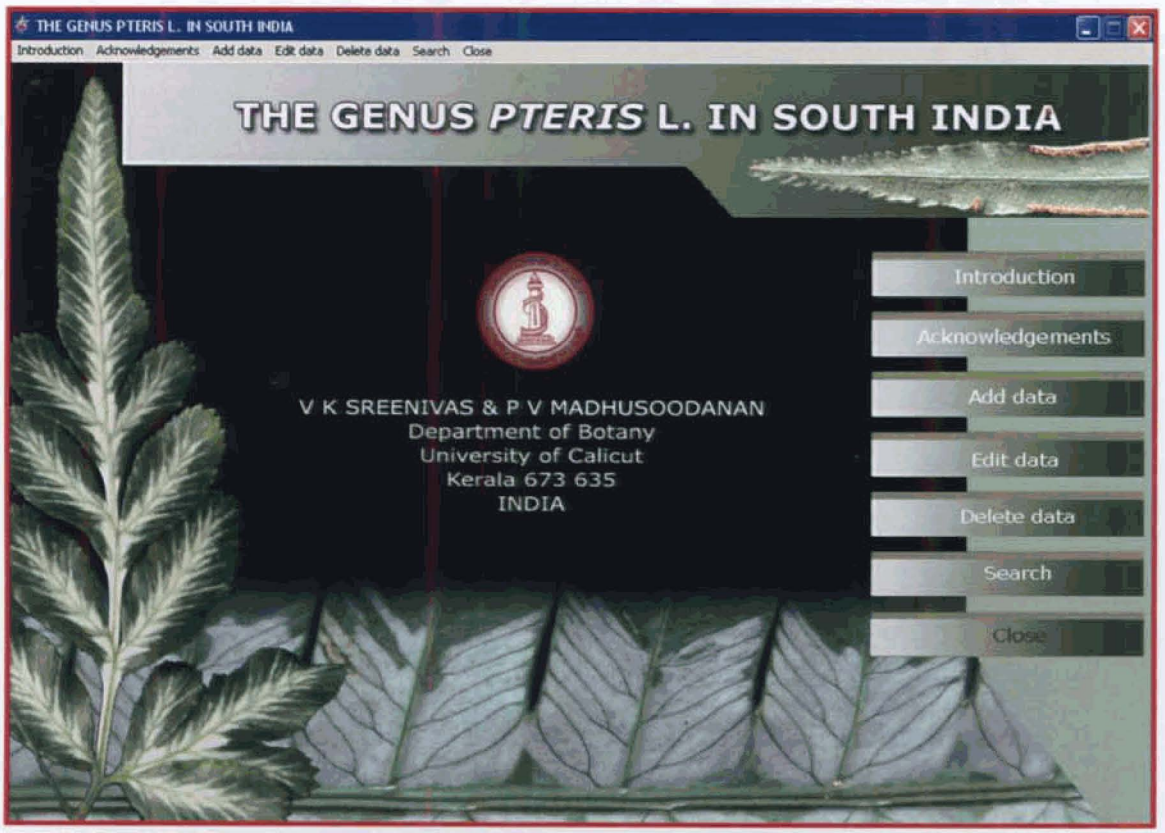
Scamman, E. 1961. The genus *Pteris* of Costa Rica. *Rhodora* 63: 194-205

Schneider, H., Schuettpetz, E., Pryer, K. M., Cranfill, R., Magallón, S. & Lupia, R. 2004. Ferns diversified in the shadow of Angiosperms. *Nature* 428: 553-557.

Schölch, A. 2003. Relations between submarginal and marginal sori in ferns iii. Superficial sori with emphasis on Pteridaceae and morphological relations to marginal sori. *Plant Syst. Evol.* 240: 211-233.

Schuettpelz, E. & Pryer, K. M. 2007a. Fern phylogeny inferred from 400 leptosporangiate species and three plastid genes. *Taxon* 56: 1037-1050.

2013



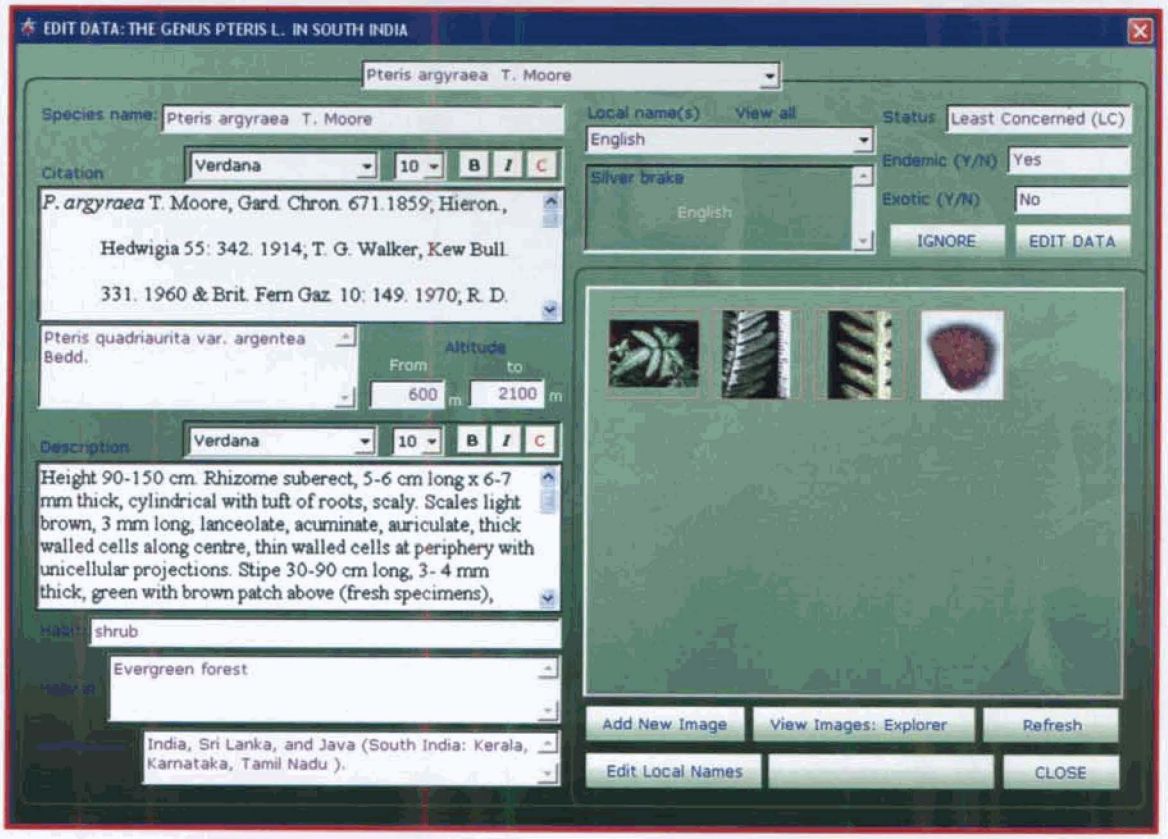


Plate 34. Screen view of the Database of the genus *Pteris* L. in South India

Schuettpelz, E., Schneider, H., Huiet, L., Windham, M. D. & Pryer, K. M. 2007b. A molecular phylogeny of the fern family Pteridaceae: assessing overall relationships and the affinities of previously unsampled genera. *Mol. Phylogen. Evol.* 44: 1172-1185.

Sheffield, E. & Bell, P. R. 1987. Current studies of the pteridophyte life cycle. *Bot. Rev.* 53: 442-490.

Shieh, W. C. 1966. A synopsis of the fern genus *Pteris* in Japan, Ryukyu and Taiwan. *Bot. Mag. (Tokyo)* 79: 283-292.

Shieh, W. C. 1994. Pteridaceae. Pp. 206-233 in: Huang, T. C. *et al.* (eds.), *Flora of Taiwan, 2nd ed. 1*: Editorial Committee of the Flora of Taiwan, Taipei.

Siman, S. E., Povey, A. C., Ward, T. H., Margison, G. P. & Sheffield, E. 2000. Fern spore extracts can damage DNA. *Brit. J. Cancer* 83: 69-73.

Simpson, M. G. 2006. *Plant Systematics*. Elsevier Academic Press, Canada.

Singh, H. B. 1999. Potential medicinal pteridophytes of India and their chemical constituents. *J. Econ. Taxon. Bot.* 23: 63-77.

Singh, M., Govindarajan, R., Rawat A. K. S. & Khare, P. B. 2008. Antimicrobial flavonoid rutin from *Pteris vittata* L. against pathogenic gastrointestinal microflora. *Amer. Fern J.* 98: 98-103.

Singh, S. 1989. *Pteris multifida* Poiret - a new record for India. *Indian J. Forestry* 12: 82.

Skog, J. E. 2001. Biogeography of Mesozoic leptosporangiate ferns related to extant ferns. *Brittonia* 53: 236-269.

Sledge, W. A. 1982. An annotated check-list of the Pteridophyta of Ceylon. *Bot. J. Linn. Soc.* 84: 1-30.

Smith, A. R., Pryer, K. M., Schuettpelz, E., Korall, P., Schneider, H. & Wolf, P. G. 2008. Fern Classification. Pp. 417-467 in: Ranker, T. A. & Haufler, C. H. (eds.), *Biology and Evolution of Ferns and Lycophytes.* Cambridge University Press, Cambridge.

Sreenivas, V. K. & Madhusoodanan, P. V. (in press). *Pteris reptans* – a new record for India. *Brit. Fern Gaz.*

Sreenivas, V. K. & Madhusoodanan, P. V. 2010a. The genus *Pteris* L. (Pteridaceae) in Kerala. *Proceed. of 22th Kerala Sci. Congr.* 28-31 January 2010, KFRI- Peechi. Pp. 866-868.

Sreenivas, V. K. & Madhusoodanan, P. V. 2010b. *Pteris multifida* – a new record from Peninsular India. *Acta Bot. Hung.* 52: 425-427.

Srivastava, J. 2007. *Molecular assessment of biodiversity and biosystematics of Pteris L. a genus of arsenic hyper accumulating ferns, using PCR-*

based methods. Ph.D. Thesis, Chhatrapati Shahu Ji Maharaj University, Kanpur.

Srivastava, J., Ranade, S. A. & Khare, P. B. 2007. Distribution and threat status of the cytotypes of *Pteris vittata* L. (Pteridaceae) species complex in India, *Curr. Sci.* 93: 81-85.

Stafleu, F. A. & Cowan, R. S. 1976-1988. *Taxonomic Literature: A Selective Guide to Botanical Publications and Collections with Dates, Commentaries and Types*-2. Vols. 1-7. Regnum Vegitalis, Utrecht.

Steil, W. N. 1919. Apospory in *Pteris cretica* L. *Bot. Gaz.* 67: 469-482.

Steil, W. N. 1933. New cases of apogamy in certain homosporous leptosporangiate ferns. *Bot. Gaz.* 95: 164-167.

Steil, W. N. 1939. Apogamy, apospory and parthanogenesis in the Pteridophytes. *Bot. Rev.* 5: 433-453.

Stern, W. T. 1992. *Botanical Latin* (4th Ed.). David & Charls, Newton Abbot, Devon.

Stewart, R. R. 1945. The Ferns of Kashmir. *Bull. Torrey Bot. Cl.* 72: 399-426.

Subramannyam, K., Thothathri, K. & Henry, A. N. 1960. On a collection of ferns from Shevaroy hills, Salem Dsitrict, Madras state. *Bull. Bot. Surv. India* 2: 323-327.

Sujanapal, P. 2005. *Vascular Flora of Parambikulam Wildlife Sanctuary.* Ph. D. Thesis, University of Calicut.

Sundaram, S., Rathinasabapathi, B., Ma, L. Q. & Rosen, B. P. 2008. An arsenate-activated Glutaredoxin from the arsenic hyperaccumulator fern *Pteris vittata* L. regulates intracellular arsenite. *J. Biol. Chem.* 283: 6095-6101.

Suzuki, T. & Iwatsuki, K. 1990. Genetic variation in agamosporous fern *Pteris cretica* L. in Japan. *Heredity* 65: 221-227.

Tardieu-Blot, M. L. 1963. Sur Les Spores de Pterideae Malgachis. *Pollen et Spores* 5: 337-353.

Thwaites, G. H. K. 1864. *Enumeratio Plantarum Zeylaniae.* Dulau & Co., London.

Tryon, R. 1960. A glossary of some terms relating to the fern leaf. *Taxon* 9: 104-109.

Tryon, R. M. & Tryon, A. F. 1982. *Ferns and allied plants.* Springer-Verlag, New York.

Tryon, R. M., Tryon, A. F. & Kramer, K. U. 1990. Pteridaceae. Pp. 230-256 in: Kramer, K. U. & Green, P. S. (eds.), in: Kubtizki, K. (ed.), *The Families and Genera of Vascular Plants Vol.1. Pteridophytes and Gymnosperms.* Springer Verlag, Berlin.

van Rheede, D. H. 1703. *Hortus Indicus Malabaricus* 1-12. Amstelodami.

Varma, P. K. V., Ramani, M. P. & Madhusoodanan, P. V. 2006. Effect of pH on spore germination and gametophyte development in three ferns. *Flora & Fauna* 12: 89-92.

Vasudeva, S. M. & Chhibber, S. 1989. Taxonomic studies on some species of *Pteris* Linn. in India. *Indian Fern J.* 6: 204-216.

Vasudeva, S. M. & Singla, A. 1991. Further studies on the taxonomy of the genus *Pteris* L. in India. Pp. 325-342 in: Bharadwaj, T. N. and Gena, C. B. (eds.), *Perspectives in Pteridology: Present and future*: Today & Tomorrow's Printers & Publishers, New Delhi.

Vasudeva, S. M. 1999. Economic importance of pteridophytes. *Indian Fern J.* 16: 130-152.

Verma, S. C. 1959. Basic chromosome number of *Pteris*. *Curr. Sci.* 28: 299-300.

Vyas, M. S. 2008. Phytochemistry of some pteridophytes of Rajasthan. *Indian Fern J.* 25: 61-65.

Wagner, W. H. 1978. Venuloid idioblasts in *Pteris* and their systematic implications. *Acta Phytotax. Geobot.* 29:33-40.

Walker, T. G. 1956. *Cytotaxonomic studies in the tropical fern genus Pteris.* Ph.D. thesis, University of Leeds, Leeds.

Walker, T. G. 1957. *Idiopteris:* a new genus of fern from Ceylon. *Kew Bull.* 3: 428-432.

Walker, T. G. 1958. Hybridization in some species of *Pteris* L. *Evolution* 12: 82-92.

Walker, T. G. 1960. The *Pteris quadriaurita* complex in Ceylon. *Kew Bull.* 14: 321-332.

Walker, T. G. 1962. Cytology and evolution in the fern genus *Pteris* L. *Evolution* 16: 27-43.

Walker, T. G. 1970. Species of *Pteris* commonly in cultivation. *Brit. Fern Gaz.* 10: 143-151.

Walker, T. G. 1979. The cytogenetics of ferns. Pp. 87-132 in: Dyer, A. F. (ed.), *The Experimental Biology of Ferns.* Academic Press, London.

Wallich, N. 1828-1849. *A numerical List of dried specimens of plants in the East India Company's Museum, collected under the superintendence of Dr. Wallich of the Company's Botanic Garden at Calcutta.* London

Wang, J., Zhao, F. J., Meharg, A. A., Raab, A., Feldman, J. & McGrath, S. P. 2002. Mechanisms of arsenic hyperaccumulation in *Pteris vittata.*

Uptake kinetics, interactions with phosphate, and arsenic speciation. *Plant Physiol.* 130: 1552-1561.

Zhang, K. M., Shi, L., Zhang, X. C., Jiang, C. D. & Tim-Chun, W. L. 2008. Gametophyte morphology and development of six Chinese species of *Pteris* (Pteridaceae). *Amer. Fern J.* 98: 33-41.

Zhao, F. J., Wang, J. R., Barker, J. H. A., Schat, H., Bleeker, P. M. & McGrath, S. P. 2003. The role of phytochelatins in arsenic tolerance in the hyperaccumulator *Pteris vittata*. *New Phytol.* 159: 403-410.

Zheng, X. L., Wang, F. G., Zhang, R. J. & Xing, F. W. 2010. *Pteris changjiangensis* (Pteridaceae), a new species from Hainan Island, China. *Ann. Bot. Fennici.* 47: 156-158.

Zheng, Y., Dai, X., Wang, L., Xu, W., He, Z. & Ma, L. Q. 2008. Arsenate reduces copper phytotoxicity in gametophytes of *Pteris vittata*. *J. Plant Physiol.* 165: 1906-1916.

Internet Based Literature

Fraser-Jenkins, C. R. 2011. Nepal's little known pteridophytes, the hidden work of David Don, and the geography and distribution of Indo-Himalayan ferns. Website version-1.

www.groups.yahoo.com/group/Indian-Ferns.

Thiers, B. 2010. Index Herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. http://sweetgum.nybg.org/ih/

IPNI- http://www.ipni.org/

Tropicos- http://www.tropicos.org./

Linnean Herbarium- http://www.linnean-online.org

Berolinense Herbarium- http://ww2.bgbm.org/herbarium

Paris Herbarium- http://coldb.mnhn.fr/Consultation?motif=Pteris

Kew Herbarium- http://www.kew.org/herbcat

Zurich Herbarium- http://www.systbot.uzh.ch/herbarium.html

BM Herbarium- http://www.nhm.ac.uk

SUMMARY

SUMMARY

Pteris is a large, pantropical genus established by Linnaeus (1753) with 19 species. It is estimated to contain about 250 species (Tryon & Tryon, 1990). Although, Das (2007) reported the occurrence of 64 species of *Pteris* in India, this is an overestimate due to the inclusion of many synonyms published by Ghosh *et al.* (2004). Fraser-Jenkins (2008a) enumerated 50 species from India, though Chandra (2000) reported 45 species, two subspecies and two varieties. The majority of *Pteris* spp. in India are found in the East Himalayan region of N.E. India and Western Ghats of South India. Beddome (1863) provided the first illustrated account of 12 species of *Pteris* in South India. Manickam and Irudayaraj (1992) reported 15 species of *Pteris* from the Western Ghats, and later several authors added new species and new records to the south Indian fern flora. *Pteris* in South India is a critical complex to understand, with surprising variation in segment width and length, compounded by the confusion and misidentification. Due to the lack of proper revision work, there has been considerable discrepancy regarding the identification and authentication of *Pteris* spp. In order to solve the taxonomic puzzle in the identification and taxonomy of the genus *Pteris*, the topic 'Taxonomic studies on the genus *Pteris* L. (Pteridaceae) in South India' has been selected for the present study.

Objectives of the present study include 1). Prepare an illustrated floristic account of the genus *Pteris* in South India with a key to the identification, 2). Prepare herbaria for future references, 3). Prepare a database of the species of *Pteris* in South India, 4). Envisages a detailed taxonomic revision, with updated nomenclature, synonyms, distribution map, colour photographs, *etc.*, 5). *Ex situ* conservation of the *Pteris* in Calicut University Botanical Garden (CUBG).

The study area includes the political states of Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and the Union Territory of Puducherry of South India. The area is located between 8^0 and 20^0 North latitudes and 74^0 and 85^0 East latitudes and covers 4, 67, 186 Sq. Km. South India lies in the Peninsular Deccan Plateau and is bounded by the Arabian Sea in the west, the Indian Ocean in the south and the Bay of Bengal in the east and on the north by the Vindhya and Satpura ranges. The geography of the region is diverse, comprising two mountain ranges, the Western and Eastern Ghats, and the Deccan plateau.

The present study is based on the materials collected from different parts of South India including Biosphere reserves, National Parks, and Wild life sanctuaries during May 2007 to April 2010. Apart from this, specimens deposited in CAL, CALI, KFRI, MGMC, MH, RHT, SKU, TBGT, XCH and

digital images of specimens (including Type) from B, BM, E, K, KYO, L, LD, LINN, P, UPS, US and Z were examined for the present study.

Habit, habitat, morphological characters, *etc.*, were observed in the field itself and fresh specimens were brought to the laboratory for further analyses. Detailed morphological descriptions of Rhizome, palea, stipe, lamina, pinnae/pinnules, sori, spores were made from the mature, well developed plant materials based on 3-5 different accessions except a few. Microscopic observations were made with stereomicroscope with drawing device (Nikon SMZ 800) and Image analyser (Nikon Eclipse E400). Photographs were taken with the help of NIKON D100 SLR digital camera. At least one sample of each species is introduced in the Calicut University Botanical Garden.

Specimens were identified based on available literature (including protologues), type specimens, and consulting experts in the field. Herbarium sheets were made using standard techniques and were deposited in CALI. Names and associated bibliographical details of the taxa were obtained from IPNI. Abbreviations of periodicals were followed as in *Botanico-Periodicum-Huntianum* (B-P-H) (Lawrence *et al.*, 1968) and *Taxonomic Literature* (Stafleu & Cowan, 1976-1988). Authors' names were used as given in *Authors of Plant name* (Brummitt & Powell, 1992), and *Authors of Scientific Names in Pteridophyta* (Pichi Sermolli, 1996). Herbarium acronyms were

used as in *Index Herbariorum* (Thiers, 2010) and the Classification of Smith *et al.* (2008) was followed in the work. Descriptive terms used in the thesis were based on Tryon (1960), Stern (1992), Lellinger and Taylor (1997) and Simpson (2006).

The taxonomic part comprises three sections, *viz.*, genus description, key to the species, and species descriptions. Genus description includes synonyms, descriptions of the genus, *etc.* Key to the species is prepared based on the morphological data from the south Indian species of *Pteris* and is provided for easy identification. In species description, each species is treated with updated nomenclature, type, synonyms, description, habitat, altitude, distribution, chromosome number, economic importance, etymology, IUCN status, and notes on relevant aspects and interrelationships. List of materials examined, illustrations and colour photographs were also provided. Comparative morphology, conservation aspects and database preparation were discussed.

During the present study, 26 taxa of *Pteris* are reported from South India, which include 24 species and two vareties. These are *P. argyraea* T. Moore, *P. arisanensis* Tagawa, *P. biaurita* L., *P. blumeana* J. Agardh, *P. confusa* T. G. Walker, *P. cretica* L., *P. cretica* var. *albolineata* Hook., *P. ensiformis* Burm.f., *P. ensiformis* var. *victoriae* Baker, *P. geminata* Wall. ex J. Agardh, *P. gongalensis* T.G. Walker, *P. heteromorpha* Fee, *P. linearis*

Poir., *P. longipes* D. Don, *P. mertensioides* Willd., *P. multiaurita* J. Agardh, *P. multifida* Poir., *P. otaria* Bedd., *P. pellucida* C. Presl, *P. perrottetii* Heiron., *P. praetermissa* T. G. Walker, *P. quadriaurita* Retz., *P. reptans* T. G. Walker, *P. scabripes* Wall. ex J. Agardh, *P. tripartita* Sw. and *P. vittata* L.

P. semipinnata L., a species recorded by Beddome (1863) from Travancore hills, could not rediscover by the subsequent authors or during the present study and this species is currently not available in any of the south Indian herbaria.

P. biaurita, *P. confusa*, *P. pellucida*, and *P. vittata* are widely distributed in South India. But, *P. arisanensis*, *P. blumeana*, *P. cretica*, *P. geminata*, *P. mertensioides*, *P. multifida*, *P. perrottetii*, *P. quadriaurita*, *P. reptans*, *P. scabripes*, and *P. tripartita* are rare in South India. *P. perrottetii* Hieron. and *P. geminata* are endemic to South India. *P. confusa*, *P. gongalensis*, *P. multiaurita*, *P. praetermissa*, *P. quadriaurita* and *P. reptans* are confined to South India and Sri Lanka. Distribution of *P. mertensioides* and *P. tripartita* are confined to South India in India. Based on IUCN criteria, the species are categorized as follows: *P. multifida*, *P. quadriaurita*, *P. reptans* and *P. tripartita* are treated under Critically Endangered category. *P. arisanensis*, *P. cretica*, *P. ensiformis*, *P. geminata*, *P. heteromorpha*, *P. mertensioides* are coming under Endangered category. *P. blumeana*, *P. gongalensis*, *P. linearis*, *P. multiaurita* and *P. perrottetii* under Vulnerable category. *P. argyraea*, *P. biaurita*, *P. confusa*, *P. longipes*,

P. otaria, *P. pellucida*, *P. praetermissa*, *P. scabripes* and *P. vittata* are in Least Concern group. The following species of *Pteris* are new to various regions.

New record to India: *P. reptans*

New record to Peninsular India: *P.multifida*

New record to Kerala: *P. arisanensis* and *P. perrottetii*

New synonyms recognized:

P. biaurita L. - syn: *P. biaurita* L. subsp. *walkeriana* Fras.-Jenk. & Rajkumar; *P. biaurita* L. subsp. *fornicata* Fras.-Jenk. (***syn. nov.***).

P. heteromorpha Fee - syn: *P. almeidiana* Bole & Almeida (***syn. nov.***).

P. perrottetii Hieron. - *P. perrottetii* var. *brevilaciniata* Hieron. (***syn. nov.***)

In the present study, samples of all the specimens collected are introduced in the Fern House of Calicut University Botanical Garden (CUBG). But some of the species are not survived in the Fern House and presently 18 species of *Pteris* have been growing in the Fern House.

A database of South Indian species of *Pteris* was prepared with appropriate software (Visual FoxPro 6.0) and provided the descriptions, synonyms, colour photographs, IUCN status, *etc.*

INDEX TO NAMES OF TAXA

INDEX TO NAMES OF TAXA

APPENDIX

APPENDIX

List of Papers Published:

Sreenivas, V. K. & Madhusoodanan, P. V. 2010. The genus *Pteris* L. (Pteridaceae) in Kerala. *Proceedings of 22th Kerala Science Congress*, 28-31 January 2010, KFRI- Peechi, pp. 866- 868.

Sreenivas, V. K. & Madhusoodanan, P. V. 2010. *Pteris multifida* – a new record from Peninsular India. *Acta Bot. Hung.* 52: 425-427.

Madhusoodanan, P. V. & **Sreenivas, V. K.** 2010. Biological Nitrogen Fixation. *Sastradyuthi* 1: 54-60.

Papers Communicated:

Sreenivas, V. K. & Madhusoodanan P. V. (in press). *Pteris reptans* (Pteridophyta, Pteridaceae)- new record for India. ***Brit. Fern Gaz.***

Madhusoodanan, P. V., Rajesh, K. P. & **Sreenivas, V. K.** (in press). Pteridophytes of Wayanad district. In: Kumar, A. (Ed.) Biodiversity Documentation of Wayanad. M S Swaminathan Research Foundation (MSSRF), Kalpetta.

Antony, R., **Sreenivas, V. K.** & Mohanan, N. (in press). *Diplazium austrosylvaticum* Fras.-Jenk. & Benniamin (Pteridophyta: Woodsiaceae), A new distributional record for Kerala. ***Indian J. Forestry***

Fraser-Jenkins, C. R., **Sreenivas, V. K.** & Madhusoodanan, P. V. (in press). Little known and misunderstood species of *Pteris* L. (Pteridaceae) in India. ***Kew Bull.***

10-67
Proceedings of 22nd Kerala Science Congress, 28-31 January 2010, KFRI, Peechi, pp. 866-868

The genus *Pteris* L. (Pteridaceae) in Kerala

V. K. Sreenivas and **P. V. Madhusoodanan**
Department of Botany, University of Calicut 673 635 Kerala

INTRODUCTION

Pteris L. is a pantropical genus represented in all continents except Antarctica. It has about 200 species with diverse ecology. It occurs in forest, in openings and along stream banks (Tryon, 1982). About 45 species occur in India (Chandra, 2000) and of which, 15 species are present in Western Ghats (Manickam and Irudayaraj, 1991). Detailed account of ferns and fern allies of Kerala was provided by Nair *et al.* (1992) and recently Easa (2003) documented the Pteridophytes of Kerala based on the available literature. *Pteris multifida* Poiret is the smallest and *P. mertensioides* Willd. is the largest species present in Kerala. *P. semipinnata* L., a species reported by Beddome (1863), could not rediscovered in the present study.

MATERIALS AND METHODS

The present study is based on the materials collected from different parts of Kerala including Biosphere reserves, National parks and Wildlife sanctuaries during May 2007 to April 2009. In addition, specimens in the CALI, RHT, and TBGT herbaria were also examined. The morphological characters of rhizome, scale, stipe, lamina, venation, sporangia, and spores were studied in the field as well as in the laboratory. The drawings were made with the aid of Nikon SMZ 800 stereomicroscope.

RESULTS AND CONCLUSIONS

During the study, 20 species of *Pteris* were collected from various parts of the state. *Pteris* shows a wide range of habitats from sea level to 2100 m and is a most successive vascular plant with bewildering morphology. A nomenclatural account and distribution are provided below.

Pteris argyraea T. Moore, Gard. Chron. 671. 1859.
Synonyms: *Pteris quadriaurita* var. *argentea* Bedd., Ferns South India 11. 1863.
Distribution: Wayanad, Kozhikode, Palakkad, Thrissur, Idukki and Thiruvananthapuram.
Note: Commonly called as silver brake. This species is present only at high altitude above 700 m and is characterized by white stripe along either side of the costa.
Pteris arisanensis Tagawa, Acta Phytotax. Geobot. 5: 102. 1936.
Distribution: Idukki
Note: Found in the Periyar Tiger Reserve at 1300m altitude.
Pteris biaurita L., Sp. Pl. 2: 1076. 1753.
Synonyms: *Campteria biaurita* L., Bedd. Ferns South India. 14. Pl. 44. 1863.
Distribution: All districts in Kerala
Note: Very common species, characterized by its costal areole.
Pteris confusa T.G. Walker, Kew Bull. 14: 329. 1960
Distribution: all districts in Kerala
Note: a common species of *Pteris*, but it is little known.
Pteris ensiformis Burm. f., Fl. Ind. 230. 1768.
Distibution: Thiruvananthapuram
Note: a rare species, but cultivated as ornamental plant.

Pteris geminata Wall. ex J. Agardh, Rec. Spec. Gen. Pter. 31. 1839.
Synonyms: *Campteria anamallayensis* Bedd., Ferns S. India 1863;
Campteria biaurita var. *geminata* Clarke, Ferns North India 469. 1880;
Pteris kleiniana (Presl ex Bedd.) christ., Manickam and Irudayaraj, Fern Fl. Western Ghats, 74. 1992.
Distribution: Idukki
Note: A rare species and characterized by its vein endings in a sub marginal dot.
Pteris gongalensis T.G. Walker, Kew Bull.14: 328. 1960.
Distribution: Malappuram and Idukki
Note: a rare species is characterized by deltoid frond.
Pteris heteromorpha Fee, Gen. fil. 127. 1852.
Synonym: *Pteris cretica* var. *heteromorpha* Bedd., Handb. Ferns. Brit. India 106. 1883.
Distribution: Palakkad and Kollam
Note: a rare species related to *P. pellucida* Presl.
Pteris linearis Poir., Encycl. 5: 723. 1804
Distribution: Wayanad, Palakkad, Idukki and Thiruvananthapuram
Note: This species is characterized by the triangular costal areoles.
Pteris longipes D. Don, Prod. Fl. Nepal 15. 1825.
Synonym: *Pteris pellucens* Agardh, Bedd. Ferns South India 11. 1863.
Distribution: Wayanad, Palakkad, Thrissur and Thiruvananthapuram
Note: *Pteris* with ternately divided pinnae.
Pteris mertensioides Willd., Sp. Pl. 5: 394. 1810.
Pteris patens Hook., Bedd. Ferns South India 69.1863.
Distribution: Wayanad and Thrissur
Note: a gorgeous and large species of *Pteris*.
Pteris multiaurita J. Agardh, Rec. Spec. Gen. Pter. 12. 1839.
Distribution: Kollam and Thiruvananthapuram
Note: a rare species in Kerala
Pteris multifida Poiret, Lam. Encycl. 5: 714. 1804.
Distribution: Kozhikode
Note: this species seen at sea level and is cultivated widely
Pteris otaria Bedd., Ferns South India 13. 1863
Pteris quadriaurita var. *ludens* Bedd., Handb. Ferns. Brit. India 111. 1883.
Distribution: Palakkad, Thrissur, Idukki, Kollam and Thiruvananthapuram
Note: Thought to be a hybrid between *P. multiaurita* and *P. quadriaurita.*
Pteris pellucida C. Presl, Rel. Haenk. 1: 55. 1825.
Synonym: *Pteris venulosa* Blume, Nayar and Geevarghese, Fern Fl. Malabar 115. 1993.
Distribution: all districts
Note: a common fern, showing morphological variations as the number of pinnae and its size.
Pteris perrotteti Heiron., Hedwigia 55: 374. 1914.
Distribution: Wayanad and Palakkad
Note: endemic to Nilgiris.
Pteris praetermissa T. G. Walker, Kew Bull. 14: 327. 1960.
Distribution: all districts
Note: distinguished by its strameneous stipe and long spinules on costule.
Pteris roseo-lilacina Hieron. Hedwigia 55: 350. 1914.
Synonyms: *Pteris quadriaurita* var. *rubro- nerva* L., Bedd., Ferns South India 11. 1863;
Pteris quadriaurita var. *aspericaulis* Bedd., Handb. Ferns. Brit. India, 111.1883;
Pteris aspericaulis Wall. ex Agardh, Nayar and Geevarghese, Fern Fl. Malabar 102. 1993.
Distribution: Kannur and Idukki
Note: a rare species found only at high altitudes and is distinguished by its roseo-lilac stipe.
Pteris scabripes Wall. ex J. Agardh, Rec. Spec. Gen. Pter. 12.1839.

Synonym: *Pteris silent-valliensis* S. R. Ghosh and R. K. Ghosh, J. Bombay Nat. Hist. Soc. 79: 385. 1982.
Distribution: Palakkad and Thiruvananthapuram
Note: A rare species, which are abundant in Silent Valley National Park.
Pteris vittata L., Sp. Pl. 2: 1074. 1753.
Pteris longifolia L., *auct. non* Clarke, Ferns North India 461 (1880);
Pteris longifolia L., *auct. non* Bedd. Ferns South India 13. Pl. 33 (1863);
Distribution: all districts
Note: usually present on brick walls and buildings.

In the present study, 20 species of *Pteris* are reported from Kerala. Of which, five species are simply pinnate and 12 species are bipinnate. *Pteris* shows wide range of distribution *i.e.*, in road sides, river banks, earth cuttings, walls of buildings, *etc. Pteris semipinnata* Bedd. could not be found anywhere in Kerala, though Beddome (1863) reported it from Travancore hills.

ACKNOWLEDGEMENTS

The first author is greatly indebted to Kerala State Council for Science, Technology and Environment (KSCSTE) for proving research fellowship in Taxonomy. We are grateful to curators of CALI, RHT, TBGT and Kerala Forest Department for their various help.

REFERENCES

Beddome, R.H. 1863. The Ferns of Southern India. Gantz Bros., Madras. Reprinted 1970. Today and Tomorrowís Printers and Publishers, New Delhi.

Chandra, S. 2000. The Ferns of India. International Book Distributors, Dehra Dun.

Manickam, V.S. and Irudayaraj, V. 1991. Pteridaceae of the Western Ghats of South India. In: T. N. Bharadwaj, and C.B. Gena, (Eds). Perspectives in Pteridology: Present and Future: Today and Tomorrowís Printers and Publishers, New Delhi. 27-41.

Tryon, R.M. and Tryon, A.F. 1982. Ferns and Allied Plants. Springer-Verlag, New York: 213- 341.

Acta Botanica Hungarica 52(3–4), pp. 425–427, 2010
DOI: 10.1556/ABot.52.2010.3–4.16

PTERIS MULTIFIDA – A NEW RECORD FROM PENINSULAR INDIA

V. K. SREENIVAS and P. V. MADHUSOODANAN

Department of Botany, University of Calicut
Kerala, India 673635; E-mails: sreenivasvk@gmail.com, pvmadhu@gmail.com

(Received 28 January, 2009; Accepted 30 June, 2009)

Pteris multifida Poiret (Pteridaceae) has been reported from Kozhikode as a new record for Peninsular India. It is described and illustrated.

Key words: new record, Peninsular India, *Pteris multifida*

INTRODUCTION

The genus *Pteris* comprises of 64 species in India, of which 18 taxa are simple pinnate types (Das 2007). Manickam and Irudayaraj (1991) reported 15 species of *Pteris* from the Western Ghats of South India. From a thorough review of literature, it was found that around 30 species of *Pteris* had been reported from Peninsular India. On the way to Puthiyara (Kozhikode, Kerala) we noticed a fern growing scattered in crevices of the laterite walls. It was similar to *Pteris cretica* L., but critical examination of the material confirmed that it was *Pteris multifida* Poiret commonly called the "spider brake" (Stevens 1977). These are escapes from the cultivation and naturalised elsewhere in the world (Jones 1955). This fern was first described as *Pteris serrulata* by Carolus Linnaeus filius in 1914 and gave type locality in Jamaica, but later found that the correct name should be *Pteris multifida* Poiret. When *Pteris multifida* was described by Poiret in 1804, it had been in cultivation for a long time and the origin had been forgotten (Jones 1955). From India, it was first reported from Muradabad, Utter Pradesh by Singh (1989) subsequently from West Bengal (Das 2007). *Pteris*

0236–6495/$ 20.00

multifida Poiret is different from *Pteris cretica* L. in having thin, papyraceous and lower multifid pinnae.

Distribution: India: Moradabad (Uttar Pradesh), West Bengal, Kozhikode (Kerala); China, Japan, United States, Taiwan.

Specimen examined: India: Kozhikode CU, Coll.: Sreenivas, No. 119237 (CALI).

A short description and illustration are provided for the identification.

Pteris multifida Poiret, in Lam. Encycl. 5: 714 (1804)

Rhizome short, creeping, 1–2 cm long, 0.5–0.8 cm thick, scaly. Scales brown, up to 2.0 mm long, entire, apex acute. Fronds pinnate, dimorphic, fertile fronds 25–32 cm in height; sterile fronds 12–20 cm in height, green, ovate. Stipe

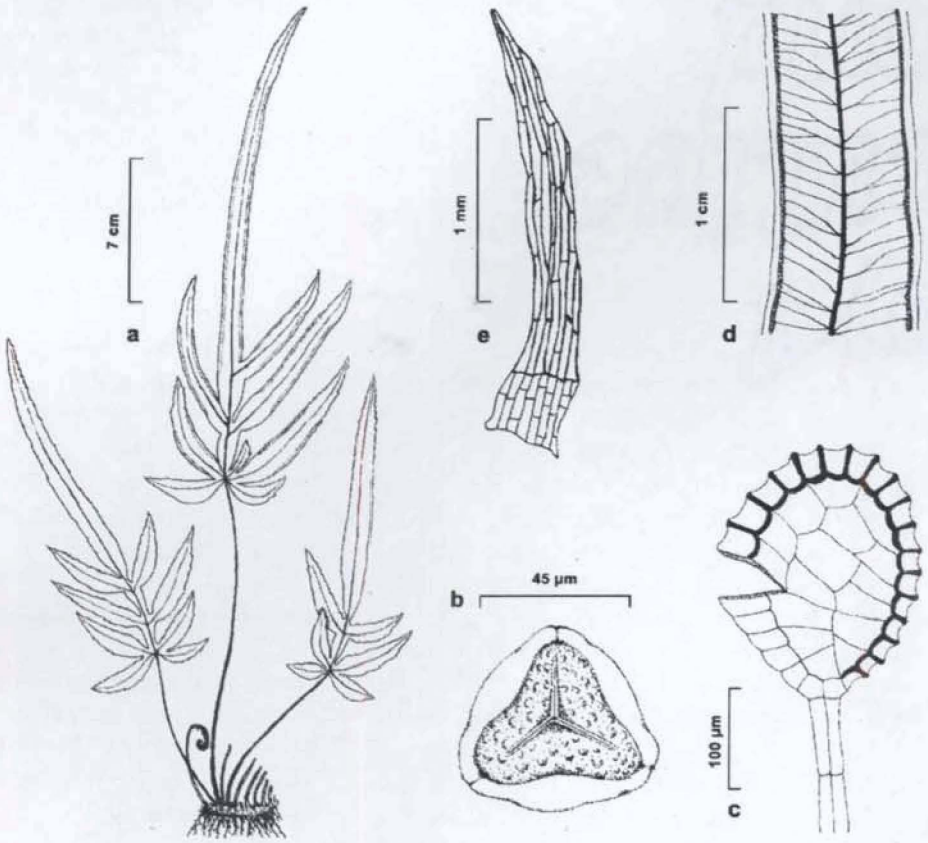


Fig. 1. Pteris multifida Poiret (a = habit, b = spore, c = sporangium, d = a portion of pinna enlarged, e = rhizome palea)

Table 1

Comparison of *Pteris multifida* Poiret and *Pteris cretica* L.

Sl. No.	Character	*Pteris multifida*	*Pteris cretica*
1.	texture	papyraceous	coriaceous
2.	pinnae attachment	decurrent to form a wing	not decurrent
3.	lower pinnae	multifid	bipartite

6–8 cm long, 0.7–1.0 mm thick, stramineous above, chestnut coloured below, grooved, glabrous above, scaly below. Pinnae 2–3 pairs, pinnate, opposite, lanceolate, green, terminal pinnae larger than lateral pinnae, terminal pinnae 15.0–16.0 cm long, and 0.6–0.8 cm broad; lateral pinnae 6.0–9.0 cm long and 0.4–0.5 cm broad (fertile), 5.0–6.0 × 0.4–0.5 cm (sterile); margin wavy, apex acute-acuminate, serrate, glabrous, thin, papyraceous, pinna decurrent to form a winged rachis; lower pinnae multifid; venation free, forking, numerous. Costa raised above and below. Sori brown, 12.0–14.0 cm long (terminal), 3.0–4.5 cm long (lateral pinnae), marginal except base and apex. Indusium white. Sporangium globose, 220–250 μm long; stalk 250–300 μm, 2-celled. Annulus 17–18-celled. Paraphyses not differentiated. Spores brown, 40–45 μm, trilete-tetrahedron, perinate, uneven globose ornamentation.

See Table 1 for the main morphological differences between *Pteris multifida* and *Pteris cretica*.

*

Acknowledgements – The first author is grateful to Kerala State Council for Science Technology and Environment (KSCSTE) for providing Research Fellowship in Taxonomy. We are also grateful to CR Fraser-Jenkins, Kathmandu for confirming the identity of the specimen.

REFERENCES

Das, S. (2007): Taxonomic revision of Indian species of Pteris L. with simple pinnate fronds. – *Indian Fern J.* **24**(1–2): 60–70.

Jones, G. N. (1955): On the occurrence of Pteris multifida in the United States. – *Amer. Fern J.* **45**(3): 107–113.

Manickam, V. S. and Irudayaraj, V. (1991): *Pteridaceae of the Western Ghats of South India.* – In: Bharadwaj, T. N. and Gena, C. B. (eds): Perspectives in pteridology: present and future. Today and Tomorrow's Printers and Publishers, New Delhi, pp. 27–41.

Singh, S. (1989): Pteris multifida Poiret, a new record for India. – *Indian J. Forestry* **12**(1): 82.

Stevens, C. E. (1977): On occurrence of Pteris multifida in Virginia. – *Amer. Fern J.* **67**(2): 63.