STUDIES ON THE ADIANTOID-CHEILANTHOID FERNS OF SOUTH INDIA

Thesis submitted to the University of Calicut
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for the degree of

Doctor of Philosophy

by

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CERTIFICATE

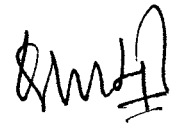
Certified that the thesis entitled "**Studies on the Adiantoid-Cheilanthoid ferns of South India**" submitted by **Mr. Mohana Kurup, K.**, for the degree of **Doctor of Philosophy** in Botany of the University of Calicut is a bonafide record of research work done by him in this Department under my supervision. This has not previously been formed the basis for the award of any degree/ diploma.

Calicut University,
7th March 2003.

Dr. P. V. Madhusoodanan

DECLARATION

The thesis entitled "**Studies on the Adiantoid-Cheilanthoid ferns of South India**" submitted by me for the degree of **Doctor of Philosophy** in Botany of the University of Calicut has not been formed the basis for the award of any degree/ diploma to the best of my knowledge.



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CONTENTS

INTRODUCTION

Importance of the present work

Pteridophytes are the pioneer colonizers of land, the antiquity of which can be traced to some 400 million years back (Puri, 1989). These primitive and ancient vascular land plants survived innumerable cosmic vicissitudes and had become subdivided quite early into distinct branches, some of which still survive and others have become extinct. They occupy an interesting position in the plant kingdom by reason of having independent and heteromorphic alternation of generations between a large, long-lived and asexual sporophytic generation containing an internal water transporting vascular system and a small, inconspicuous, short-lived and sexually reproducing non-vascular gametophytic generation.

The male gametes of pteridophytes are motile, free-swimming 'organisms' looking like animalcules underlining the very primitive nature of the group compared to flowering plants. The motile male gametes need water to swim and this is one of the factors that confine the pteridophytes mostly to a life in places, which are damp at least at certain periods of the year. Their primitive affinities combined with obvious continuing ecological success in appropriate habitats world-wide, is one of the principal features which make the pteridophytes of considerable botanical and evolutionary interest (Page, 1982).

Pteridophytes include ferns and fern-allies. Ferns are megaphyllous plants having leaf gaps in the vascular cylinder and sporophylls bearing more than one sporangium. The ferns as a group generally are shade loving plants, thriving best in humid climates. They are ecological escapists, growing in particular habitats mainly because such habitats are those where flowering plants do not succeed well. To do so, they have evolved a range of extraordinary ecological strategies. Such an ecology puts many of them in an unusually delicate state of ecological balance which can be so easily swayed in the direction of their large-scale elimination (Page, 1982).

Pteridophytes have evolved to occupyl almost every ecological niche, but the greatest species diversity is clearly found in the tropical rain forests. The rapid disappearance of this biome throughout the world with many of their members yet undiscovered is of great concern. So it is important to survey as soon as possible those tropical areas which are under threat (Jermy, 1990).

There are over 12000 living species of ferns and 1000 species of fern-allies in the world, of which about 1200 species of ferns and fern-allies are expected to occur in India (Manickam & Rajkumar, 1999; Chandra, 2000a), where they are mainly distributed in the Eastern Himalayas and the Western Ghats - two of the 25 global hot spots of biodiversity (Khoshoo, 1995). The Western Ghat forests are one of the richest centers of fern floras of the world. More than 300 species of ferns and fern-allies have been recorded from this region (Manickam, 1988). The unique physiography, mountainous terrain with narrow gorges and valleys, heavy rainfall and tropical humid climate have endowed this area with an environment most ideal for luxuriant plant growth (Nampy & Madhusoodanan, 1998). This region is not only rich in diverse ferns, but a good number of them are endemic also. Chandra (1998) recognises Peninsular India, as one of the eight phytogeographical regions in India which possesses about 25% of the total number of ferns endemic to India, which is the highest among all these regions.

But during the last 150 years much of the forests in this area have been destroyed owing to anthropogenic activities. The pace of this destruction is on the increase and still continues unabated. Only small patches of comparatively less disturbed areas now remain in the Western Ghats, which harbour a rich diversity of species including ferns. Since most of the ferns are highly sensitive to ecological perturbations, most species of the South Indian ferns are facing a serious threat of extinction and several taxa are reported to be rare or endangered. Wide spread and continued clearance of forests has led to a progressive contraction of the areas of all woodland species and this may have led to their elimination from the area. So many species of ferns which were reported earlier have not been collected from South India since then. For example, Beddome (1863-1865) discloses that he himself has not succeeded in finding *Anogramma leptophylla* in Nilgiris though it has been collected earlier by several workers from there. The case is same with *Doryopteris ludens*. He (*l.c.*) further says that a specimen in Wight's herbarium of this species is supposed to be from Dindigul mountains in the Madras Presidency. But it has never been found there of late. Nair *et al.* (1992) report that although Beddome (1883) gives Travancore mountains as the area of distribution of *Adiantum soboliferum*, no one seems to have collected this species from southern India after Beddome. All these clearly show that so many species, by now, might have been eliminated due to human activities. Many authors (Nair & Bhargavan, 1981; Bir, 1987; Kaur, 1989; Dixit

& Krishna, 1990; Madhusoodanan, 1991; Irudayaraj & Manickam, 1995; Manickam, 1995; Kumar *et al.*, 1998; Antony *et al.*, 2000; Sinha *et al.*, 2001) have pleaded for taking immediate steps for the protection and conservation of the rare ferns of various floristic regions of India including the Peninsular India. Nair and Bhargavan (*l.c.*) warn that the forests of various parts of Peninsular India are in a process of rapid dwindling resulting in the fast disappearance of several fern taxa or making them extremely rare. Since several regions in Peninsular India are either unexplored or only partially explored, these taxa should be immediately recorded and conserved.

Being a vast country rich in pteridophytes, it will be more practical if detailed studies are undertaken of selected groups or families of particular regions with an objective of preparing a revised pteridophytic flora of India by compiling all such works (Nampy & Madhusoodanan, 1998). Accordingly, some noteworthy works have been done in selected groups of South Indian ferns such as Thelypteridaceae (Leena, 1992), Polypodiaceae (Nampy & Madhusoodanan, 1998) and Hymenophyllaceae (Hameed, 2000). In the present study I have undertaken the detailed morphological and taxonomic studies of the adiantoid and cheilanthoid ferns of South India.

Adiantum is a widely spread genus usually of shady and moist habitat. It is an old and isolated genus among modern ferns. It shows a soral construction much distinct from other groups of ferns. The sporangia are inserted upon the distal part of the veins on the under side of highly specialized and sharply reflexed leaf-flaps which bear the sori and at the same time protect them, an arrangement which was clearly successful as demonstrated by the large number of species belonging to the genus and its wide geographical distribution through out the tropics (Pichi Sermolli, 1957).

Despite its uniqueness, Kramer (1978) points out that *Adiantum* is taxonomically a very difficult genus and is in urgent need of monographic work because the characters, which differentiate between some species, are trivial and not well founded. Not only that, the adiantoid ferns has undergone various taxonomic treatments over the years. Some treated them as belonging to 'gymnogrammoid' ferns and placed in Pteridaceae (Copeland, 1947) or separated as a distinct family, *viz.*, Adiantaceae (Ching, 1940; Holttum, 1947). There is also disagreement among pteridologists regarding the generic composition of adiantoid group. Pichi Sermolli

(1959, 1977) and Tryon *et al.* (1990) consider it as monogeneric, while Ching (*l.c.*) and Nayar (1970) treat it as composed of many genera.

The cheilanthoid group is characterized generally by having superficial sori seated upon the distal region of the vein, but more or less extended backwards from the margin and sometimes appearing to coalesce when mature. A xerophytic character is prevalent throughout the group (Bower, 1928). In cheilanthoid ferns the reflexed margin is an extension of the leaf margin, which has rolled over the lamina to give protection to the sori.

Many authors are of the view that cheilanthoid ferns have been the most contentious and problematic group, which is well reflected in the position attributed to them in different classifications as well as the fact that the genera coming under cheilanthoid group have been assigned to different families by different taxonomists (Huckaby *et al.*, 1981; Pangua & Vega, 1996). According to Tryon and Tryon (1973, 1982), the cheilanthoid ferns have long resisted efforts to circumscribe well defined, phylogenetically natural generic and infrageneric groups, presumably because of homoplastic morphologies associated with their xeric habitats. The genus *Cheilanthes* itself is a phylogenetically problematical taxon, about 15 species of which are separated by some pteridologists (Fee, 1852; Ching, 1940; Copeland, 1947) to constitute a separate but closely related genus *Aleuritopteris* based on the presence of 'farinose' exudation on the lower side of the frond. But this was not accepted by majority of the modern pteridologists. So the genus still has a doubtful homogeneity. Holttum (1973) is of the opinion that *Eriosorus, Cheilanthes, Adiantum* and the 'gymnogrammoid' ferns generally are still not arranged in satisfactory groups of related genera, nor the genera have been adequately monographed. There is also real concern regarding the separation of *Cheilanthes, Pellaea* and *Notholaena* from one another (Knobloch & Volz, 1964).

So, in the present work I have done detailed studies on adiantoid and cheilanthoid ferns of South India for resolving the aforesaid taxonomic and nomenclatural problems.

Economic Importance

Pteridophytes have been a much-neglected group as far as their economic values are concerned. This negligence has not been due to the misunderstood fact that they lack any economic utility, but because of the real fact that enough attention

has not been paid towards assessing the potentialities of ferns and fern-allies for human welfare. According to Nayar (1959), the negligence in the part of scientific workers in the medicinal use of ferns is probably due to the difficulties encountered in the collection, propagation and identification of the material.

But the latter half of the last century witnessed a welcome change in the attitude of man towards ferns and fern allies with the result that many workers started investigating the economic utility of them (May, 1978; Gurung, 1988; Bidin, 1989; Khare, 1996; Manandhar, 1996; Singh & Viswanathan, 1996). Now it is generally accepted that many species of ferns and fern-allies are of much economic importance, the most important of which are their medicinal and aesthetic values.

Medicinal use

The medicinal use of some of the adiantoid-cheilanthoid ferns has had a long history in India. *Adiantum capillus-veneris* is mentioned as of medicinal importance in *Charaka Samhita*, an ancient Indian medical book. van Rheede (1678-1703) described the medicinal properties of 13 species of ferns and two species of fern-allies which include *Adiantum philippense, Parahemionitis cordata* and *Cheilanthes tenuifolia*. Unfortunately, since then there was a let up in the study of medicinal use of ferns. But the last century saw a revival in the awareness of the use of ferns in medicine, as a result of the investigation of many authors (Kirtikar & Basu, 1918; Caius, 1935; Dixit & Nair, 1974; Dixit & Bhat, 1975; Dixit & Vohra, 1984; Graham, 1989). Much literature have been published which deal with the use of ferns and fern-allies, including adiantoid-cheilanthoid ferns, in the treatment of various diseases (Nayar, 1959; Puri, 1970; Jain, 1983; Padala, 1988; Jain *et al.*, 1991; Kaushik & Dhiman, 1995; Dhiman, 1998; Vijayakumar & Pullaiah, 1998; Singh, 1999). There are so many reports from different parts of India by various authors on the ethnic/folk medicinal uses of ferns including adiantoid-cheilanthoid group (Sharma & Vyas, 1985; Singh *et al.*, 1989; Khare & Shankar, 1990; Gaur & Bhatt, 1994; Henry *et al.*, 1996; Joshi, 1997; Mathew *et al.*, 1999; Karappusamy *et al.*, 2001; Kiran & Kapahi, 2001).

Among the different ferns, *Adiantum* spp. are the most important in the usage as medicine (Anand & Shrivastava, 1994). Banerjee and Sen (1980), who investigated the antibacterial activity of 114 species of pteridophytes, reported that ferns of the '*Adiantum* group,' which consists of seven species of *Adiantum*, three

species of *Cheilanthes, Hemionitis arifolia* (N.L.Burm.) T.Moore (=*Parahemionitis cordata* (Roxb. *ex* Hook. & Grev.) Fraser-Jenk.) and *Pityrogramma calomelanos,* were found to be particularly active against Gram-positive Bacteria. The antibacterial effect of *Adiantum capillus-veneris* was confirmed by Kumar and Kaushik (1999) and that of *A. trapeziforme* and *Cheilanthes farinosa* (Forssk.) Kaulf. *(= C. bicolor* (Roxb.) Griff. *ex* Fraser-Jenk.) by Kshirsagar and Mehta (1972). Reddy *et al.* (2001) evaluated the antibacterial activity of *A. lunulatum* Burm.f. (= *A. philippense* L.). Vasudeva (1999) gives a comprehensive account of the economic uses of ferns in India. He explains the medicinal use of 62 species of ferns and fern-allies. They include *Adiantum* (nine spp.), *Cheilanthes* (three spp.), *Pityrogramma* (two spp.) and *Hemionitis* (one sp.).

Use as Ornamentals

Apart from medicinal properties, ferns are very fascinating garden plants because of their exquisite beauty and great diversity of foliage. Since most of them are shade loving, they are very good for interior decoration and green houses (Chandra & Kaur, 1974). Among the adiantoid-cheilanthoid ferns, the *Adiantum* species are the most sought after. Hoshizaki (1970) gives a very detailed account of the cultivars of *Adiantum.* The commonest species in the trade and in florist's decorations is the 'delta maidenhair' – *A. raddianum* with two varieties and 34 cultivars world over. Another 18 species of *Adiantum* are also used as cultivars through out the world. The common cultivated species are *A. capillus-veneris, A. pectinatum, A. peruvianum, A. polyphyllum, A. raddianum, A. rubellum, A. tenerum* and *A. trapeziforme.* The cheilanthoid ferns having aesthetic value in India are Silver fern (*Cheilanthes bicolor*), Golden fern (*Pityrogramma austroamericana*), Rabbit's ear fern (*Parahemionitis cordata*), *Doryopteris ludens*, etc.

Review of Literature

Taxonomy and Phylogeny

The taxonomic treatment of adiantoid and cheilanthoid ferns has undergone considerable changes over the years mainly due to the differences of opinion among pteridologists regarding their phylogenitic relationship. Diels (1899) placed them in the subtribes Adiantinae and Cheilanthinae respectively, both belonging to the tribe Pterideae of family Polypodiaceae. But Bower (1928) separated them from pteroids

on the ground that they probably have an ancestry different from pteroids. He (*l.c.*) placed them in the gymnogrammoids which, according to him, originated from Osmundaceae. Christensen (1938) believes that the gymnogrammoids originated from dicksonioid group and treated them as a subfamily of Polypodiaceae. Ching (1940) also believes that they originated from dicksonioid group. He recognizes five hypothetical ancestral groups within the Polypodiaceae and splits it into 33 families. He placed the genus *Adiantum* in a family of its own and the cheilanthoid ferns in the family Sinopteridaceae. Copeland (1947) believes in their origin from schizaeoid group and considered them as part of the complex group of pteroid ferns and hence placed them in the family Pteridaceae. Holttum (1947, 1949) places both Gymnogrammoideae and Vittarioideae in Adiantaceae and considers that part of Adiantaceae evolved from Marginales of Bower through Schizaeaceae and part from Osmundaceae. Nayar (1970) placed *Adiantum* alongwith some other genera in the family Adiantaceae and proposed a new family Cheilanthaceae to include the cheilanthoid ferns. He considers these families as derived from the Lygodiaceae, each following its own line of specialization. Mickel (1974b) considers that Schizaeaceae provided an evolutionary base for the evolution of gymnogrammoids, which in turn evolved into *Adiantum, Pteris,* cheilanthoids and vittarioids. Crabbe *et al.* (1975) elaborated the circumscription of the family Adiantaceae to include all the gymnogrammoids, pteroids and vittarioids and placed the adiantoid-cheilanthoid ferns in the subfamily Adiantoideae. According to them adiantoid ferns arose from schizaeaceous stock. But Pichi Sermolli (1959, 1977) treats Adiantaceae as a monogeneric family and supports Copeland in regarding the gymnogrammoid ferns as having an immediate schizaeoid ancestry. Tryon *et al.* (1990) treat the adiantoids, cheilanthoids and pteroids in a single family by the name Pteridaceae and give them the status of subfamilies. Kramer (1990) is of the opinion that Pteridaceae may be distantly related to Schizaeaceae, but convincing proof is as yet lacking.

The present approach in plant systematics is to use molecular data in evolutionary studies. Because we are still in the infancy of pteridophyte molecular systematics, most of the present works involve the analysis of a single gene *rbcL* (the gene encoding the large subunit of ribulose 1, 5-biphosphate carboxylase/oxygenase). Gastony and Rollo (1995, 1998) analysed the nucleotide sequence of the chloroplast gene *rbcL* of 25 species of cheilanthoid ferns to gain insight into cheilanthoid phylogeny and generic circumscriptions. On the basis of this

study they have concluded that the genera *Pellaea* and *Cheilanthes* are polyphyletic. They also do not support the transfer of *Doryopteris concolor* to *Cheilanthes* made by Tryon and Tryon (1981). Hasebe *et al.* (1993) analysed *rbcL* from four ferns including *Adiantum capillus-veneris* and inferred their relationship with other land plants. Gastony and Johnson (2001) analysed the *rbcL* of *Actiniopteris radiata* and supported the transfer of it from cheilanthoid group to taenitidoid group effected by Tryon *et al.* (1990). Currently nucleotide sequence of other genes such as nuclear 18Sr RNA, chloroplast 16S ribosomal RNA and the chloroplast gene atpB are also used to infer phylogenetic relationships among ferns (Wolf, 1996, 1997).

Several monographs and revisions dealing with different genera of these groups appeared from different parts of the world. The genus *Adiantum* was revised by Keyserling (1875), Kuhn (1881), Ching (1957), Scamman (1960) and Giudice (1999). Sledge (1973) gave an account of *Adiantum* of Sri Lanka. Hoshizaki (1970) gives a detailed account of various cultivated species of *Adiantum.*

Mettenius (1859) described all the species of *Cheilanthes* known up to that time. According to Mickel (1979) the characters used for segregating *Cheilanthes* and *Notholaena* do not work consistently. Hence he proposes merging *Notholaena* with *Cheilanthes.* Afonso (1981) revised the genus *Cheilanthes* in Portugal while Badre *et al.* (1982) revised that of France. Anthony (1984) revised the South African species of *Cheilanthes* and *Pellaea.* The genus *Cheilanthes* was studied by some other authors also (Fuchs, 1961; Wu, 1981, 1990). Quirk *et al.* (1983) published a monograph of the genus *Cheilanthes* of Australia and described about 15 species and two subspecies most of which are endemic to that country. Chambers and Farrant (1991) made a re-examination of this genus and reduced two earlier species to synonymy, but recognised two new species. Saiki (1984a & b) made a monographic analysis of the *Aleuritopteris farinosa* complex of Asia, Africa and America recognizing a total of 53 species, out of which 13 species were new. He (1984c) further grouped all these species on the basis of spore characters and chemical composition of the farinose components.

Mickel (1974a) revised *Hemionitis* of Central America and suggested that since the South East Asian species, *H. arifolia* was quite different from the new world species, a new genus based on it could be established. It is based on this that Panigrahi (1993) established the new genus *Parahemionitis.*

The genus *Doryopteris* was revised by Tryon (1942, 1962b), Brade (1965) and Cartaginese (1977). Tryon (1962b) studied the genus *Doryopteris* of Brazil and gave description of 15 species which include *D. concolor* with two varieties. Tryon (1957) revised the genus *Pellaea* section *Pellaea* of the New World. Tryon (1962a) studied *Pityrogramma* and concluded that *Pityrogramma* and *Trismaria* should be united and *Anogramma* be maintained as distinct from it. Pichi Sermolli (1962) revised the genus *Actiniopteris* and added three new species to it. He (*l.c.*) separated the genus *Actiniopteris* from pteroid ferns and brought it under a family of its own, *viz.*, Actiniopteridaceae.

Various floristic treatments and regional accounts of ferns including adiantoid and cheilanthoid groups were published from different parts of the world since long. Some important such treatments are *A revised flora of Malaya-Vol. II- Ferns* (Holttum, 1954), *Fern flora of Philippines* (Copeland, 1960), *The ferns of Peru* (Tryon, 1964), *Ferns of Britain and Ireland* (Page, 1982), *Ferns and allied plants with special reference to Tropical America* (Tryon & Tryon, 1982), *Ferns and fern-allies of Southern Africa* (Jacobsen, 1983), *Flora of Southern Africa: Pteridophyta* (Schelpe & Anthony, 1986), *Flora of Australia: Ferns* (Mc Carthy, 1998), etc. Also important are the works of Wagner and Grether (1948a & b), Ching (1949), Pichi Sermolli (1951, 1957, 1963, 1966), Adams and Alston (1955), Alston (1959), Lellinger (1977, 1985), Sledge (1982) and Parris and Latiff (1997).

Revisionary studies of many genera of adiantoid and cheilanthoid ferns of India were done by several authors. In one earlier such studies Blanford (1886) explained the important morphological characters, ecology and altitudinal ranges of five species of *Cheilanthes, viz., C. albomarginata, C. farinosa, C. dalhousiae, C. anceps* and *C. grisea.* The last two species were reduced to varieties of *C. farinosa* later by himself (Blanford, 1888b). Panigrahi (1960) raised them again to the rank of species and brought under the genus *Aleuritopteris.* In his studies on the ferns of India, Nayar (1962c) gives a detailed account of 10 species of *Cheilanthes* under two sections, *viz.*, section *Aleuritopteris* with seven species and section *Cheilanthes* with three species. Jyothi and Madhusoodanan (1993) studied 12 species of cheilanthoid ferns coming under five genera from South India. They treated the farinose members of *Cheilanthes* under the genus *Aleuritopteris.*

The genus *Adiantum* in India has been studied by many authors. Nayar (1961) gives a comprehensive account of 15 species of *Adiantum* growing in India, which he divided into four groups on the basis of morphological and anatomical characters of rhizome and leaf. Vasudeva *et al.* (1991) made a taxonomic revision of *Adiantum* in India. They published an account of 19 species with ecological and distributional data and concluded that two species (*A. assamicum* B.K.Nayar and *A. indicum* Ghatak) are endemic to India. The genus *Adiantum* of different states was also studied by various authors. Madhusoodanan and Sevichan (1991) described the ecology and distribution of 10 species from Kerala, while Sharma and Harsh (1992) studied the *Adiantum* species of Rajasthan.

A comprehensive account of the Indian species of *Hemionitis, viz., H. arifolia* is given by Nayar (1956, 1962b). Although Beddome (1883) described and illustrated two species of *Hemionitis* from India, *viz.*, *H. arifolia* (N.L.Burm) T.Moore and *H. griffithii* (T.Moore) Hook. & Thompson, the latter was transferred to *Stegnogramma* of Thelypteridaceae leaving *H. arifolia* as the only species of the genus in India. Because of its alleged differences from other New World species of *Hemionitis*, Panigrahi (1993) separated it to a new genus *Parahemionitis* Panigrahi.

The earliest reference on the occurrence of *Pityrogramma* in India is by Blatter and d'Almeida (1922) under the name *Gymnogramme calomelanos*. Along with other places, they mentioned Nilgiris in South India also as the area of its distribution. This was again confirmed by d'Almeida (1935). Chandra (1963) recognised two species of *Pityrogramma* in India. *P. chrysophylla* (Sw.) Link (= *P. austroamericana* Domin) is restricted to the Western Ghats while *P. calomelanos* occurs all over India. Verma (1966) states that *P. calomelanos* was first collected from India by Blanford (1886) from Mercara, Coorg (southern Karnataka). This has been agreed by Nair and Ghosh (1975). Panigrahi (1975) discusses the taxonomy, nomenclature and distribution of four species of the genus *Pityrogramma* naturalised in Asia.

Several new taxa belonging to adiantoid and cheilanthoid ferns have been published by different authors. Nair and Dixit (1981) published a list of taxa reported from India after the publication of Beddome's *Handbook to the Ferns of British India* (1883) and its supplement (1892). This includes *Adiantum cuneipinnulum* N.C.Nair & S.R.Ghosh (= *A. raddianum* C.Presl), *A. incisum* Forssk., *A. indicum* Ghatak, *A. thalictroides* Willd. *ex* Schltdl. (= *A. poiretii* Wikstr.), *A. zollingeri* Mett. *ex* Kuhn,

Cheilanthes keralensis N.C.Nair & S.R.Ghosh (= *C. thwaitesii* Mett. *ex* Kuhn), *Pityrogramma calomelanos* (L.) Link and *P. chrysophylla* (Sw.) Link. Chandra (2000b, 2001) gives a list of additions to Indian fern flora published during the period from 1984 to 1998. But all the taxa of this list have already been included in his *Ferns of India* (2000a).

Nayar and Geevarghese (1986, 1993) published three new species of *Adiantum* from Malabar (northern Kerala) that are reported to be endemic to that region. They are *A. lomesum, A. nagnam* and *A. ramyam*. The latter species was reduced to a synonym of *A. concinnum* Willd. by Fraser-Jenkins (1997). Madhusoodanan and Jyothi (1992b) published a new species of *Pellaea* (*P. malabarica* Geev. *ex* Madhus. & Jyothi) endemic to Silent Valley. There are also a few records of taxa new or naturalised in South India (Madhusoodanan & Jyothi, 1992a; Dixit *et al.*, 1995; Kurup *et al.*, 2001).

Various floristic treatments and regional accounts of the ferns of India including adiantoid and cheilanthoid ferns appeared from time to time. The earliest among them is the *Hortus Indicus Malabaricus* of van Rheede (1678-1703). The significance of this book is evident from the fact that Linnaeus (1753) acknowledged it while naming Indian plants in his *Species Plantarum.* Most of the plants described in *Hortus Indicus Malabaricus* are angiosperms. But it also contains illustrations and descriptions of 15 pteridophytes of which three belong to adiantoid and cheilanthoid group.

Since then several authors (Swartz, 1806; Roth, 1821; Zenker, 1835; Graham, 1836; Fee, 1852; Kunze, 1846-1848, 1851) either based South Indian plants for their new descriptions or referred them in their work. In spite of all these publications, until the first quarter of the last century the only source of information about Indian ferns was from Col. R.H. Beddome (1863-1865, 1865-1870, 1876, 1883, 1892). He presented a comprehensive account of the then known ferns from all parts of British India, Sri Lanka and Malay Peninsula. His first book, *The Ferns of Southern India* (1863-1865) contains beautiful illustrations with brief descriptions of all the then known ferns of South India and Sri Lanka which include 15 species of adiantoid-cheilanthoid ferns. Immediately after it, *The Ferns of British India* (1865-1870) was published in two volumes which contain 345 plates and descriptions of ferns not included in his earlier book. This was followed by the publication of 45 plates as

Supplement to the Ferns of Southern India and British India (1876). In 1883, *Handbook to the Ferns of British India, Ceylon and Malay Peninsula* was published with a supplement added in 1892.

The nomenclature used by Beddome had undergone radical changes since then. Still his works, especially the illustrations published by him more than one and a half century back, remain as the most important and useful reference for the identification of Indian ferns. Although the names used by him were highly confused and most of them outdated, Nayar and Kaur (1974) and Chandra and Kaur (1987, 1994) published the valid nomenclatural equivalents for the ferns published by Beddome (*l.c.*) thereby updating the names.

Later several significant contributions have been made to our understanding of Indian ferns. Two very important works of that time are *A Review of the ferns of Northern India* by C.B. Clarke (1880) and *Ferns of North-Western India* by C.W. Hope (1901). Some other important works of that period are those of Blanford (1888a & b), Macpherson (1890), Blatter and d'Almeida (1922) and Mehra (1939). The later half of the 20th century saw a spurt in the study and publication of regional and local fern floras from different parts of the country. Bir and his associates (Bir, 1963,1968; Mehra & Bir, 1964; Bir *et al.*, 1983, 1986, 1989, 1992) made extensive studies of the pteridophyte flora of North-Eastern India and the Himalayas. Ferns of Himalayas were also studied by Hara (1966) and Dhir (1980), while Khullar (1994, 2000) published illustrated fern floras of West Himalaya. The fern flora of Pachmarhi hills and neighbouring areas of Central India was studied by Bir and Vasudeva (1973) and Vasudeva and Bir (1993, 1994). The important state fern floras include those of Andaman and Nicobar Islands (Nayar & Srivastava, 1962; Ellis, 1987; Dixit & Sinha, 2001), Assam (Kachroo, 1953; Borthakur *et al.*, 2001), Karnataka (Rajagopal & Bhat, 1998), Kerala (Nair *et al.*, 1992), Madhya Pradesh (Tiwari, 1964; Dixit, 1989), Meghalaya (Baishya & Rao, 1982), Nagaland (Jamir & Rao, 1988), Orissa (Panigrahi, 1998), Rajasthan (Bohra *et al.*, 1980; Gena, 1998) and Tripura (Das & Sen, 1991).

South India also witnessed some very important studies of regional fern floras since van Rheede (1678-1703). Kunze (1851) published *Filices Nilgiricae*, the earliest noteworthy work on the ferns of South India in which he recorded and described ferns from Nilgiri hills. After the period of Beddome, so many regional and

local floras were published about South Indian ferns, which included the adiantoid and cheilanthoid groups. The earliest among them is *Ferns of Highwavy mountains* by d'Almeida (1926). He describes five species of adiantoid and cheilanthoid ferns and treats them under the tribe Pterideae of the suborder Polypodiaceae. While Rajasekaran and Santhan (1996) reported 10 species of them from the same area. Subramanyam *et al.* (1960, 1961) studied pteridophytes of Shevaroy hills and Pachakumachi hills, while Dwarakan and Ansari (1998) studied those of Kolli hills. Razi and Rao (1971) published an artificial key to the ferns and fern-allies of Mysore city and neighbouring areas. Chandrasekhar (1975) collected *Adiantum caudatum* from Madras city. The fern flora of Kodaikanal was studied by Bir and Vasudeva (1971, 1980) and that of Palni hills by Manickam and Ninan (1976) and Manickam (1986). Manickam and Irudayaraj (1992) published the pteridophytic flora of Western Ghats which contains descriptions and illustrations of 10 species of *Adiantum,* five species of *Cheilanthes,* two species of *Pellaea*, two varieties of *Pityrogramma calomelanos* and one species each of *Actiniopteris*, *Doryopteris* and *Hemionitis.* Recently Karappusamy *et al.* (2001) published an enumeration of the ferns of Sirumalai hills, Tamil Nadu. Some authors (Raju, 1964; Yesoda & Raju, 1985; Nayar & Geevarghese, 1993; Kumar, 1998; Leena & Madusoodanan, 1998) published fern floras which constituted one or more districts, while few state level floras were also published. Nair *et al.* (1992) report 22 species of adiantoid and cheilanthoid ferns from Kerala, while Rajagopal and Bhat (1998) report 15 species of them from Karnataka.

Some authors who studied angiosperm flora of different regions of South India made stray references about the ferns and fern-allies of the region which also included adiantoid and cheilanthoid ferns (Khan, 1953; Lawrence, 1959; Sebastine, 1961; Ellis, 1966, 1968, 1990; Ellis *et al.*, 1967; Kammathy *et al.*, 1967; Naidu & Rao, 1969; Yoganarasimhan *et al.*, 1981; Rao & Sreeramalu, 1986; Rao *et al.*, 1986; Singh, 1988; Pullaiah & Yesoda, 1989; Pullaiah *et al.*, 1992, 1998; Pullaiah & Rao, 1995; Raju & Pullaiah, 1995; Rao *et al.*, 1999). Attempts were also made by some authors to study the ferns of the entire country in the form of checklists or enumerations. The earliest of this kind was the *Album of Indian ferns* by Bayness (1887). Dixit and Vohra (1984) published *A dictionary of the pteridophytes of India* in which all the genera of ferns and fern-allies of India are given in alphabetical order and also the number of species of each genus. *A Census of Indian pteridophytes*

published by Dixit (1984) provided an exhaustive list of all the species of pteridophytes occurring in India with their distribution. According to Dixit (1984) and Dixit and Vohra (1984), India has *ca.* 25 species of *Adiantum, ca.* 25 species of *Cheilanthes,* three species each of *Doryopteris*, *Pellaea* and *Pityrogramma* and one species each of *Actiniopteris, Anogramma* and *Hemionitis* L. *(= Parahemionitis* Panigrahi*).* Chandra (2000a) published *Ferns of India,* which is an enumeration of all the ferns of India. According to him there are 27 species of *Adiantum,* 28 species of *Cheilanthes* (including one hybrid), five species of *Pellaea*, three species each of *Doryopteris* and *Pityrogramma,* two species of *Anogramma,* and one species each of *Actiniopteris* and *Hemionitis* L. Out of this 70 species, only 42 species are occurring in South India. But some of the taxa treated by Chandra (*l.c.*) as distinct species are in fact conspecific or synonymous.

Anatomy and Morphology

The detailed morphological and anatomical treatment of different species of adiantoid-cheilanthoid ferns have been done by various authors (Mitra, 1919; Kachroo & Nayar, 1952; Nayar, 1956, 1961, 1962a, b, c & d, 1963, 1964a; Gopal & Bhambie, 1965; Knobloch, 1976; Mehra & Sandhu, 1976; Nicolas, 1976, 1983; Singh *et al.*, 1985; Mahran *et al.*, 1990; Goswami & Mukhopadyay, 1995). Nayar (1961) reported that the rhizome stele of Indian species of *Adiantum* ranges from solenostele to dictyostele.

There is difference of opinion about the stele of *Cheilanthes.* It is solenostelic (Nayar, 1962c, 1963; Mc Culloch *et al.*, 1974), solenostelic to dictyostelic (Mahabale & Shah, 1950) or dictyostelic except in *C. tenuifolia* in which it is solenostelic (Kaur, 1984). But earlier, Williams (1924) reported that the rhizome of *C. tenuifolia* is dictyostelic. Similar is the case of *Actiniopteris radiata.* Nayar (1962d) reports that its rhizome is solenostelic. But Gopal and Bhambie (1965) contradict it and point out that rhizome of juvenile plants is invariably protostelic and as the development of rhizome proceeds, pith and leaf gaps appear and ultimately a dictyostelic condition is reached. The rhizome of *Hemionitis arifolia* is also dictyostelic (Rao, 1946; Nayar, 1956, 1962b).

The presence of vessels and some peculiar tracheids in some species of *Adiantum* and *Cheilanthes* has been reported by many (Sharma & Bharadwaja, 1978; Purohit & Sharma, 1980; Bhambie & Gupta, 1989; Bhattacharya &

Mukhopadhyay, 1989; Sen *et al.*, 1989; Misra & Shukla, 1996; Carlquist & Schneider, 2000). Sharma (1988) believes that in pteridophytes, vessels are polyphyletic in origin and are more related with function (xeric habit) than phylogeny. Li *et al.* (1999) agree that vessel morphology in ferns is related to ecological conditions. Schneider (1996) studied the root anatomy of 514 species of ferns from 174 genera and divided them into 10 groups on the basis of complexity of cortex. Adiantoid-cheilanthoid ferns show three types of cortex organisation. Knobloch and Volz (1964, 1968) studied the anatomy of ultimate segments and also stipe of over 30 species of *Cheilanthes* and opined that anatomical study did not by itself seem to clarify any of the problems of relationship and speciation known to exist within the group. But Lin and Devol (1977, 1978) are of the view that stipe characters for the most part support its genera and family concepts except in the families Dennstaedtiaceae, Pteridaceae and Adiantaceae where there are some overlapping of characters. Anatomical investigations of different species of *Adiantum* are also done by Khare (1983), Khare and Shankar (1986) and Bidin and Shaari (1996). They observed two types of vascular organisations in this genus. In some species, the petiole is entirely single stranded while in others there are two vascular strands towards lower region of the petiole, which fuse into one in the upper part. Mehra and Sandhu (1976) studied the anatomy of the rhizome of *Anogramma leptophylla* and reported that its stele is a medullated protostele and the medulla also contains a few phloem elements.

Study of the organisation of the shoot and root apex of adiantoid-cheilanthoid ferns by Gopal & Bhambie (1966), Albertis and Paolillo (1972), Bierhorst (1977), Bir and Randhawa (1984), Bhambie and Puri (1985) and Gupta and Bhambie (1992) supported the classical single apical cell concept. But the contention of Bierhorst (*l.c.*) that the leaf primordia of ferns studied by him are traceable to a single superficial cell in the shoot apex, which he called 'the leaf mother cell', was contradicted by Imaichi (1988), who studied the leaf ontogeny of *Adiantum capillus-veneris* and reported that leaf primordium is of multicellular origin.

Zurakovski and Gifford (1988) reported that pinnule enlargement is associated with vein dichotomies and venation pattern is correlated with leaf-form. Nair and Das (1973, 1974) found vein anastomosis in *Adiantum incisum* and opined that the separation of *Hewardia* as a distinct genus is unwarranted. Lommasson and Young (1971) studied the vascularisation in *A. capillus-veneris*.

Stomata of all species of this group are anomocytic and confined to lower surface only (Kondo, 1962; van Cothem, 1973; Chandra & Hashim, 1974; Mehra & Soni, 1983). But Sharma *et al.* (1987), while investigating the ferns of Rajasthan, found stomata on both surfaces of *Adiantum* spp. Rao and Patankar (1976) reported that stomata of *Hemionitis arifolia* are diacytic. Khare (1980) studied the structure and development of stomata and trichomes in *H. arifolia*, while Mahran *et al.* (1990) and Alagesaboopathi (1997) studied the detailed morphology of *A. capillus-veneris*. Wylie (1948) reported that upper epidermis cells in majority of the species of *Adiantum* are 'arm palisade'. Frond indumentation is of potential value for the identification of sterile material in *Adiantum* and *Cheilanthes* (Chandra & Hashim, 1974; Knobloch *et al.*, 1975; Zimmer, 1989; Goswami & Mukhopadyay, 1995).

All the *Adiantum* species having unipinnate fronds are proliferated vegetatively by foliar buds formed at the tip of the rachis. (Sharma & Tripathi, 1969; Gupta & Bhambie, 1992; Chandra & Khare, 1995). Foliar buds are also present in *Hemionitis arifolia* and *Cheilanthes thwaitesii* (Nayar, 1956, 1962b & c; Mahabale, 1962a; Bir & Irudayaraj, 1991; Chandra & Khare, 1995). Reproduction by gemma was reported earlier in *Cheilanthes mysorensis* Wall. *ex* Hook. *(= C. opposita* Kaulf.*)* and *C. thwaitesii* (Abeywikrama, 1952, 1956).

Circinate vernation is usually believed to be a characteristic feature of ferns. But only a limited number of species of *Cheilanthes* of the new world show circinate vernation, while others exhibit noncircinate condition. Knobloch (1965) concludes that these two types of vernations are a fixed genetic response and not changeable to environmental factors. Punetha (1988) studied the filicinian crozier and its uncoiling in 60 species of ferns and concluded that shape, size and uncoiling of the crozier are not constant in any particular family or genus.

Cytology

Eversince the pioneering publication of Manton's (1950) *Problems of cytology and evolution in the Pteridophyta,* a good number of workers initiated cytological studies in ferns from the tropics as well as from the temperate latitudes. This cytological research made its impact felt to such an extent that not only has it been possible to point out defects in existing system of classification and to suggest how things may be improved, but also to have an influence in the formulation of new systems by taxonomists. In many instances now the diagnostic descriptions of new

families or subfamilies include quotation of basic chromosome numbers as important features (Walker, 1973). Cytological investigations of different species of adiantoid-cheilanthoid ferns have been made by many workers such as Manton and Sledge (1954), Fabri (1957, 1963, 1965), Brownlie (1958), Chiarugi (1960), Verma and Loyal (1960b), Abraham *et al.* (1962), Panigrahi (1962), Mehra (1963), Kurita (1965), Mitui (1965), Verma and Khullar (1965), Bhavanandan (1968), Kuriachan (1968), Gastony and Baroutsis (1975), Kuriachan and Ninan (1976), Ghatak (1977), Bir and Vasudeva (1978, 1979), Vasudeva and Bir (1977, 1982), Mahabale and Kamble (1981), Manickam (1984), Irudayaraj and Manickam (1986, 1987), Manickam and Irudayaraj (1988), Bir and Verma (1989), Ammal and Bhavanandan (1991), Kato *et al.* (1992), Irudayaraj and Bir (1994), Bir *et al.* (1996) and Bir and Irudayaraj (2001).

It is now well established that the genera of this group have two base numbers, x =29 and 30, but the latter is more common (Wagner, 1963).

Polyploidy is of common occurrence among adiantoid-cheilanthoid ferns, have been shown by several authors such as Manton (1950, 1953), Manton and Sledge (1954), Mehra (1961), Abraham *et al.* (1962), Manton *et al.* (1970) and Kuriachan and Ninan (1976). *Adiantum, Parahemionitis, Pellaea* and *Pityrogramma* show a higher percentage of polyploidy. These genera are rich in their hybrid and apomictic components.

There exist many species complexes in this group. Different species of *Adiantum* are of complex nature and show a range of cytotypes, biotypes and perhaps ecotypes within each taxon (Singh & Roy, 1969). Mehra and Verma (1960) reported that the Indian plants of *Anogramma leptophylla* are tetraploid, whereas the New Zealand plants are diploid. Verma and Khullar (1965) subsequently confirmed the tetraploid nature of Indian *A. leptophylla* by their report of n = 58. The cytotaxonomy of the species complexes of *Adiantum,* especially *A. lunulatum* and *A. caudatum* was studied by many workers (Mehra & Verma, 1960, 1963; Roy & Sinha, 1962; Singh & Roy, 1969; Manton *et al.*, 1970; Mehra & Khullar, 1977; Sinha *et al.*, 1979, 1981; Sinha, 1982; Bidin & Walker, 1994). Mehra and Verma (1963) while studying the cytogenetics of *A. lunulatum* of Eastern Himalayas detected four cytotypes – the most common and widely distributed triploid apogamous, less common diploid sexual, tetraploid sexual and diploid apogamous. Because of the overall morphological distinctiveness, they segregated the last three cytotypes of

Eastern Himalayas into a new species, *Adiantum teestae* Verma. But Mehra and Khullar (1977) retained such cytotypes from other parts of the country in *Adiantum lunulatum.* Diploid sexual (Abraham *et al.*, 1962) and tetraploid sexual (Abraham *et al.*, 1962; Bir & Irudayaraj, 2001) cytotypes of this taxon have been reported from South India also. Bir and Irudayaraj (*l.c.*) recognized four cytotypes in *A. raddianum* from Nilgiris. They are tetraploid sexual, octaploid sexual, 16-ploid sexual and a sterile octaploid.

The cytological studies of *Cheilanthes farinosa* complex have been done by Panigrahi (1962), Manton *et al.* (1966) and Bir (1976a), while Verma and Singh (1971) studied the cytology of its natural hybrids. Roy and Sinha (1958, 1960) made a karyotypic study of different species in the genus *Adiantum.* The behaviour of chromosomes during meiosis of these taxa were studied by Roy and Sinha (1961), Sinha *et al.* (1986) and Verma (1971, 1977, 1978a & b). Sinha and Verma (1977) conducted the biosystematic studies of three species of *Adiantum* and indicated a close phylogenetic relationship between them. Verma and Loyal (1960a) and Loyal and Verma (1961) succeeded in developing autotetraploids of *Adiantum capillus-veneris* by colchicine treatment and discussed the advantage of this method over the usual method of apospory, while Khare (1994) developed the method of inducing aneuploidy in this species using gamma radiation.

Phytochemistry

The use of flavonoid data has been proved to be extremely useful in helping to solve a variety of taxonomic problems (Giannasi, 1974; Cooper-Driver, 1980; Swain, 1980). Wollenweber (1976a & b, 1978) made extensive studies about the flavonoid exudates in cheilanthoid ferns. He (1978) recommended the use of the term 'farina' in describing the white or yellow deposition on the lower surface of fronds of members of *Pityrogramma* Link, *Cheilanthes* Sw. and *Notholaena* R.Br. He concluded that in species of *Pityrogramma*, chalcones and dihydrochalcones are the most dominant and these compounds are to some extent specific to the genus. *Cheilanthes* and *Notholaena*, on the other hand, produce flavones and flavonols. Wollenweber and Dietz (1980) after studying the chemical composition of 220 samples of 14 species of *Pityrogramma,* concluded that the flavonoid pattern, even of the same plant or the same population, is not constant with regard to the quantities of the farina constituents. Bardouille *et al.* (1978) and Asai *et al.* (1991, 1992) also

studied the farinose exudates of *Pityrogramma calomelanos*. Star (1980) states that chalcones, dihydrochalcones and izalpin are inhibitory to spore germination and gametophyte development of *P. calomelanos* in most concentrations. Erdtman *et al.* (1966) and Khan *et al.* (1971) studied the flavonols from *Cheilanthes farinosa*, while Imperato (1989) studied the flavonol glycosides of the genus *Cheilanthes*. Saiki (1984c) made a classification of *Aleuritopteris* Fee (= *Cheilanthes* Sw.) *farinosa* complex on the basis of chemical contents. Cooper-Driver and Swain (1977) investigated the flavonoids and related compounds in 58 species of *Adiantum*. On the basis of flavonoid patterns, they divided the genus into five sections. They also considered the geographical distribution and evolutionary trends of the genus using flavonoid compounds and concluded that the Old World species of *Adiantum* may be regarded as the most primitive and the New World species as the most advanced. Imperato (1982a, b, & c), Sato and Furuya (1983) and Nakane *et al.* (1999) studied the chemical contents of *Adiantum capillus-veneris*. Giannasi and Mickel (1979) on the basis of study of flavonoids suggested the realignment of the genera *Hemionitis* L. and *Gymnopteris* Bernhardi within a single genus and concluded that this will avoid the rather tenuous dependence on a single vegetative character for generic delimitation. Giannasi (1980) argues that on the basis of phytochemistry, the genera *Hemionitis, Gymnopteris* and *Bommeria* may be treated as a single genus. Murakami and Saiki's (1988) study of the secondary metabolites of 200 species representing 26 genera of Copeland's Pteridaceae revealed that pterosins and pterosides are widely distributed in this family and are absent in other families suggesting that it is a natural group (which contradicts the contention of Manton, 1950).

Compared to morphology, cytology, anatomy and palynology, very little work has been done on the phytochemistry of pteridophytes in India. Rangaswami and Iyer (1969), Bhambie *et al.* (1972), Iyer *et al.* (1972, 1973), Singh *et al.* (1975), Khosa *et al.* (1978), Shanker and Khare (1986), Sharma (1989), Gupta *et al.* (1990), Sharma and Sharma (1992) and Reddy *et al.* (2001) have studied the secondary metabolites, phenolic compounds, flavonoids, esters, and polysaccharides in a number of adiantoid-cheilanthoid ferns. Ramachandran *et al.* (1991) analyzed pigments and starch of six species of ferns including *Pityrogramma calomelanos* var. *aureoflava* (Hook.) Weath. *ex* L.H.Bailey (= *P. austroamericana* Domin), while Rathore and Sharma (1992) compared the pigments in nonstress and stress conditions in 14 species of Rajasthan ferns. Sukumaran and Kuttan (1991) studied

the cytotoxicity and chemotherapeutic activity of 11 species of which four are adiantoid-cheilanthoid ferns and concluded that *Pityrogramma calomelanos* has considerable cytotoxicity and the cytotoxic matter is dihydrochalcone present in the farina. Sengar and Somvanshi (2000) investigated the chemical profile of four ferns including *Cheilanthes farinosa* and recommended not to use ferns as fodder because of their toxic and carcinogenic effects.

Palynology

Importance of palynological studies in fern taxonomy has been stressed by many workers (Brown, 1960; Verma, 1966-67; Bir, 1976b; Nayar & Devi, 1968). Palynological studies on *Adiantum* have been done by Sladkov (1961), Lugardon (1963), Nayar and Devi (1967), Devi (1973a & b, 1977), Nair (1978), Sharma and Sharma (1988), Giudice and Morbelli (1989), Srivastava *et al.* (1992, 1997) Bhavanandan and Ammal (1993), Bidin (1996) and others. All these workers have described the spores of *Adiantum* as uniformly trilete-tetrahedral with simple exine surface. But Large and Braggins (1985) have reported the occurrence of occasional tetralete spores along with trilete spores in *A. hispidulum* from New Zealand. These tetralete spores are associated with spore pentads and hexads and have the same sculptural pattern to that of trilete spores though smaller in size. Similarly Bhattacharya and Mukhopadhyay (1992) while studying the spore morphology of *Adiantum* from different Asian countries report that the spores of all the species are quite similar being trilete except in *A. lunulatum* Burm.f. and *A. venustum,* where some monolete spores are found alongwith trilete spores and in all cases the spores were found covered with a thin or thick hyaline perinous layer.

Spore characters of cheilanthoid ferns were studied by Nayar (1964b), Nayar and Devi (1967), Knobloch (1969), Tryon and Tryon (1973), Devi (1973b, 1977) Quirk and Chambers (1978), Sharma and Sharma (1988), Madhusoodanan and Jyothi (1993) and Srivastava *et al.* (1993, 1997). Cheilanthoid ferns are characterized by large globose or subglobose spores in most of which the laesura is rather faint and often short. In most cases there is a distinct perine, which is often adherent to the exine forming folds. But perine is absent in *Cheilanthes tenuifolia, Pellaea falcata* and species of *Pityrogramma* (Nayar, 1964b; Nayar & Devi, 1967; Devi, 1973b). The perine of a large majority of Indian species of *Cheilanthes* is prominently wrinkled into characteristic thin, flap-like, irregular, crowded folds, which are reticulated in some

species (Nayar & Devi, 1967). In contrast, the spores of the American, Japanese, Australian and Russian species lack this distinctive type of wrinkling of perine (Devi et al., 1971). The spores of cheilanthoid ferns are generally trilete-tetrahedral, but differ markedly in other details of spore morphology (Devi, 1973b). Tryon and Tryon (1973) observed that cheilanthoid ferns show great variation in sporoderm features and offered a classification scheme for the spore types based on this. Quirk and Chambers (1978) report in *Cheilanthes tenuifolia* of Australia, of two distinct spore types associated with distinct geographical distribution patterns. Madhusoodanan and Jyothi (1993) while explaining the spore morphology of South Indian cheilanthoid ferns, report spore dimorphism in *Hemionitis arifolia.* It is having both trilete-tetrahedral and monolete-bilateral spores, the latter being fewer in number.

Gametophyte

Although the gametophyte of ferns is relatively simple in structure, it has considerable value in the study of relationship among ferns and their classification (Stokey, 1951; Atkinson, 1973). The prothallus of homosporous ferns follows a definite pattern of growth and development, which is constant for each species (Stockey, *l.c.*).

Detailed studies of the morphology of the gametophyte are available for *Actiniopteris* (Stokey, 1948; Nayar, 1962d; Bhambie & George, 1972), *Adiantum* (Mehra, 1931, 1932a & b; Kachroo & Nayar, 1953; Kawasaki, 1956; Nayar, 1961, 1962a; Momose, 1967; Sawney, 1968; Nayar & Kaur, 1971; Alagesaboopathi, 1995), *Anogramma* (Cheema, 1980), *Cheilanthes* (Mahabale, 1962b; Nayar, 1963; Nayar & Kaur, 1971; Nayar & Devi, 1973; Quirk & Chambers, 1981), *Doryopteris* (Nayar, 1960), *Hemionitis* (Rao, 1949; Nayar, 1956, 1962b), *Pellaea* (Nayar & Bajpai, 1964) and *Pityrogramma* (Nayar, 1964a).

Adult prothallus of ferns is cordate, thalloid with collenchyma like thickenings at the corners of wing cells of many species (Nayar & Bajpai, 1964; Nayar & Kaur, 1971). Presence of lateral meristems is reported in *Pellaea* spp. (Nayar & Bajpai, *l.c.*) and some species of *Cheilanthes*, which is considered as a distinctive character in cheilanthoid group (Pray, 1961). Cheema (1980) reported that the gametophytes of *Anogramma leptophylla* are lobed, instead of cordate and produce tubers for perennation and vegetative propagation. Pangua and Vega (1996) made a comparison of gametophyte development in *Anogramma* and *Cheilanthes*.

Nayar and Devi (1973) studied the spore germination and prothallial development of 44 species of cheilanthoid ferns of the new world and reported that spore germination is of *Vittaria* type (*cf.* Nayar & Kaur, 1968) and prothallial development is basically of the *Ceratopteris* type (*cf.* Nayar & Kaur, 1969).

Quirk and Chambers (1981) studied the drought tolerance of gametophytes of *Cheilanthes* species of Australia and reported that they have remarkable capacity to withstand severe water deficit and to survive after drying which is important in the establishment and survival of the genus in ecological niches not otherwise colonized by ferns. Chambers (Pers. comm., 2001) is of the view that there is no other fern with this much drought tolerance at the gametophyte stage as that of *Cheilanthes.* Bhambie & George (1972) report that the prothalli of *Actiniopteris* show many features which can be correlated with the xeric habitat of the plant such as variable shape of mature prothalli, occurrence of thick walled cells at the basal region, procambial like tissue in old prothalli and even the conversion of a young detached leaf tip into a prothallus.

Khare and Kaur (1980) and Kaur and Khare (1982) studied the effect of gamma radiation on development of gametophyte of *Adiantum lunulatum* and *Hemionitis arifolia* and reported that there is an inhibition in the growth which may be due to a delay in mitotic division. Verma and Khullar (1966a & b) undertook a detailed study of antheridial development in some species of *Adiantum.* Sawney (1968) reported the development of anomalous sporophytic characters in the gametophyte of *Adiantum lunulatum,* while Mehra (1932a & b) observed some abnormalities in the gametophytes of *A. lunulatum* and *A. capillus-veneris.*

Huckaby *et al.* (1981), based on the studies of the spore germination patterns of *Anogramma, Bommeria, Gymnopteris, Hemionitis* and *Pityrogrmma,* supported their inclusion in the family Adiantaceae as done by Crabbe *et al.* (1975).

Apogamy and Apospory

Apogamy and apospory occur in the life cycle of many ferns. Apogamy is wide spread among different groups of ferns such as Adiantaceae, Cheilanthaceae and Pteridaceae (Nayar & Kaur, 1971). Apogamy in ferns is of the obligate type. In *Adiantum,* apogamy is reported in five diploid, three triploid and one hexaploid members (Tryon, 1968). Apogamous ferns are considered to be of hybrid origin by Manton (1950) and Walker (1966).

It was Mehra (1938) who first reported apogamy in *Adiantum lunulatum* from Sikkim and Dehra Dun. He had previously (1932a) reported the occurrence of fully developed tracheids in the gametophyte of it as a normal feature. After studying the cytology of apogamy in this species presumably from Punjab, he (1949) reported n = 90 and indicated irregular meiosis in the spore mother cells. Ghatak (1959) confirms this chromosome number and concludes that the specimens observed are apogamous triploids. Since a tetraploid has obtained from Assam, he indicates that *A. lunulatum* may be a species complex. Mehra and Verma (1963) report four cytotypes in *A. lunulatum* of which the most widely distributed is the triploid apomict.

Apogamy is very common in *Pellaea* and *Cheilanthes*. Apospory is also reported in some species of *Pellaea* (Steil, 1939). Knobloch (1966) reports that 20 species of *Cheilanthes* are apogamous. Apogamy is predicted from cytological observations in many species of *Pellaea* (Tryon & Britton, 1958) and some species of *Cheilanthes* (Panigrahi, 1962; Manton *et al.*, 1966). Bir and Irudayaraj (2001) report that *Parahemionitis arifolia* (Burm.f.) Panigrahi (= *P. cordata* (Roxb. *ex* Hook. & Grev.) Fraser-Jenk.*)* of the South Indian mountains is triploid apogamous, while Kuriachan and Ninan (1976) reported the occurrence of both triploid (n = 90) and tetraploid (n = 120) apogamous forms of this species in South India.

Nayar and Bajpai (1964) studied various stages in the apogamous sporophyte formation in six species of *Pellaea* and two species of *Notholaena*. Mature prothalli of both the genera possess collenchyma like thickenings at the corners of the wing cells, a character shared also by *Cheilanthes* and *Parahemionitis*. But Whittier (1965) observed no such collechyma like thickenings in the gametophytes of the apogamous *C. tomentosa* and *C. alabamensis*.

Apogamy can be induced under cultural conditions. Kawakami *et al.* (1997) induced apogamy in 12 species of ferns. Padhya and Mehra (1981) induced apogamy in *Adiantum trapeziforme* while Bhambie and Gupta (1994) induced both apogamy and apospory in *A. capillus-veneris*.

Area of study

The area of present study is South India that includes the political states of Andhra Pradesh, Karnataka, Kerala and Tamil Nadu and the Union Territory of Pondicherry (Fig. 1). Geographically the area falls between 8° and 20° North latitudes and 74° and 85° East longitudes. It covers an area of 4,67,186 sq km and is bordered

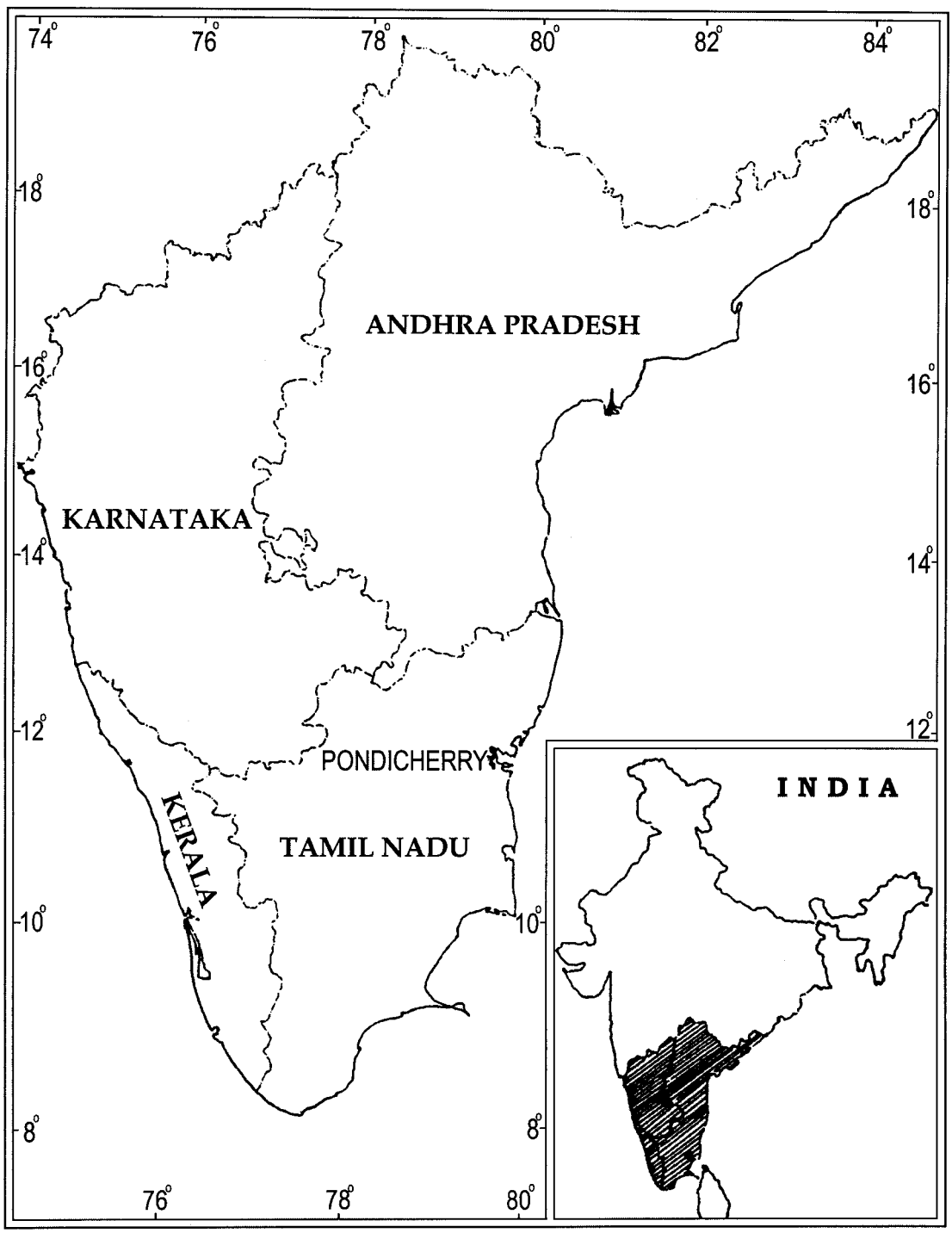

Fig. 1. Map of Southern India

on the north by the states of Maharashtra, Madhya Pradesh and Orissa and on the other three sides by seawaters, *viz.*, the Bay of Bengal on the east, the Indian Ocean on the south and the Lakshadweep sea (Arabian sea) on the west.

South India comprises two major botanical provinces, the Deccan and the Malabar. The great part of the Peninsular India is formed by the central table land of Deccan stretching from the mountain ranges of Central India, *viz.,* the Aravallis, the Vindhyas and the Satpuras in the north, right down to the southern end of the main land, the Kanniya Kumari (Cape Comorin). The eastern and western sides of the plateau are flanked by the Eastern Ghats and Western Ghats respectively.

A notable feature of the Indian Peninsula is that all the main rivers run east. The three longest, namely Godavari, Krishna and Cauvery have their origin in the Western Ghats almost within the sight of the Lakshadweep sea, traverse the Deccan plateau and finally discharge their contents into the Bay of Bengal. The small rivers like Nethravathi, Bharathapuzha, Pampa, Periyar, etc. originate in the Western Ghats, flow westward and pour into the Lakshadweep sea. These rivers are mainly rain fed and many of them shrink into rivulets during summer.

The eastern coastal plain of the Deccan plateau is a broad strip running parallel to the coast of Bay of Bengal (Coromandel coast) and gradually rising from it. It includes the fertile coastal plains mainly formed by the deltas of the river Cauvery in Tamil Nadu and the rivers Godavari and Krishna in Andhra Pradesh and also a number of rivulets and streams.

The Eastern Ghats running along the eastern edge of the Deccan plateau consists of a series of hills that are cut into separate groups. It extends over a length of 1750 km in a northeast–southwest strikes in the Indian Peninsula with an average width of 200 km in the north and 100 km in the south. The Mahanadi basin marks the northern boundary of the Eastern Ghats while the southern boundary is the Nilgiri hills where it meets the Western Ghats. Unlike the Western Ghats, the Eastern Ghats does not form a continuous range since the great rivers Godavari and Krishna cut across it.

Western Ghat mountain ranges run along the western border of Deccan plateau. They descend steeply in the west facing the Lakshadweep sea but merge gradually through a series of hills with the Deccan plateau in the east and give birth to all the important rivers of South India, which flow eastwards into the Bay of Bengal.

Western Ghats covers a distance of about 1600 km from the Tapti valley in Gujarat, where it touches the western edge of the Vindhyas, down to the tip of the peninsula, the Kanniya Kumari in Tamil Nadu. The Western Ghats runs north-south along the west coast traversing the states of Gujarat, Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu. These hill ranges are more prominent and more continuous than the Eastern Ghats and both of these meet at Nilgiris. To the south of Nilgiris occurs the well-known 30 km wide Palakkad gap, which connects the coastal plains of Malabar with the plains of south Tamil Nadu. South to this gap occur the Anamalai hills with their highest peak Anamudi. The Palni hills form an eastern 'spur' of the Western Ghats. The Western Ghats is once again interrupted by the narrow Shenkottah pass. From here it continues as a narrow ridge with steep slopes to both west and east until about 20 km before Kanniya Kumari.

The Western Ghats mountain ranges have an average altitude of 1550 m but rises to 2000 - 2500 m peaks here and there. Anamudi (2697 m), the highest peak south of Himalayas, flanks on the Western Ghats in Kerala. These mountain ranges, criss-crossed by many fast flowing rivers, form a narrow coastal belt which over-looks the Lakshadweep sea and catches the full force of the south-west monsoon winds precipitating heavy rains on the west coast. By virtue of its geographic location, topography and rain fall from both south-west and north-east monsoons, it supports the luxurious growth of tropical wet evergreen, semi-evergreen and moist deciduous forests.

Malabar is a long and narrow strip of land running parallel to the coast of Lakshadweep sea west of Western Ghats and south of Konkan region. Malabar is floristically very rich and includes coastal plains and a series of hill ranges of Western Ghats. The Malabar and Deccan regions together provide a wide variety of climatic and edaphic zones with mountain ranges, hillocks, valleys, swamps, marshy low lands, sandy sea coasts, fresh water streams, rivers, ponds and back waters on the sea front and harbour diverse type of vegetation.

The mature soils of Peninsular India include black soils, laterite soils and red soils. Black cotton soil is the predominant soil type occurring in the Deccan of Andhra Pradesh, Karnataka and Tamil Nadu. Laterite soils occur on the summit hills of Deccan and foothills of Western Ghats in Kerala and Karnataka. Red soils with high percentage of iron compounds occur in Tamil Nadu, north-east Andhra Pradesh and

some parts of Kerala. Alluvial soils occur on the banks of rivers such as Cauvery and Godavari. Soil texture varies from clay to clay-loam. Peaty soil with low pH (3.9) is found in the low lands of Kerala.

The great diversity of the fern flora of this region is due to the combined effect of many factors. The two coast lines of Bay of Bengal on the east and Lakshadweep sea on the west, with sufficient distance in between to allow continental conditions, two main hill ranges running along the coasts within the direct influence of the sea waters, numerous other lesser connected or isolated hills, plenty of open plain and plateau lands, altitudes ranging from sea-level to almost 2700 m, the closeness of the area to the equator; all these factors together with the climatic features they produce, contribute to the variation of vegetation of the area.

The prominent among the hills of South India are the Palni hills, Nilgiris, Bababudan hills, Anamallays and Cardamom hill ranges. The Nilgiris and Anamallays are having small plateau some 2000 m above sea level.

On account of the relatively low temperature prevailing during the winter months, the climate of the hilltops is often referred to as 'the temperate type'. However, Meher-Homji (1967) described this climate as tropical montane type because of their occurrence in mountains with high altitudes. Eventhough in local descriptions only two types of vegetation (*viz.,* forest and grass land), are recognised, Meher-Homji (*l.c.*) classifies the vegetation into three physiognomic types, shola, tree and shrubby zone at the periphery of shola and shrub-savanna. The tree and shrub zone constitute an ecotone between the forest and shrub-savanna.

There is considerable diversity of vegetation as one proceeds from the north to south along the Western Ghats, which in turn is directly related to length of drought and rainy seasons. The vegetation types are determined by several environmental factors (eg. climatic, edaphic, biotic, etc.). Among the bioclimatic parameters, those of prime importance are the rain fall amount, the length of its distribution in the course of the year, the regime of rain, *i.e.*, the seasonal occurrence of rain fall and the mean temperature of the coldest month (Meher-Homji, 1991).

Meher-Homji (*l.c.*) grouped the 29 vegetation types recognized by Indian Council of Agricultural research (ICAR) into 11 phytoclimatic zones which themselves show close links with the climatic and edaphic factors. Groups of allied vegetation types constitute a phytoclimatic zone.

The vegetation types are linked to the climatic factors. Along the gradient of decreasing rainfall, the evergreen forest gives way to moist deciduous forests, then to dry deciduous forests and to savanna-woodland. But in high mountains the rainfall increases under orographic influence and with this change, the moist deciduous forest reappears at the base of the hill. Due to the fall of temperature associated with the higher elevation of the hills, moist deciduous forest is replaced by the montane shola vegetation and its accompanying types like the montane scrub-savanna.

Rainfall is the most important climatic factor that controls the distribution of vegetation including the ferns. South India falls under tropical monsoon climate receiving rain fall from both south-west monsoon (June-August) and north-east monsoon (October-November). The former is more active in Kerala and Karnataka while the latter predominates in Tamil Nadu, Pondicherry and Andhra Pradesh.

Before the south-west monsoon opens its full force in June, there are intermittent rains during April and May, *viz.*, the pre-monsoon showers. The south-west monsoon starts in the west coast of South India at about the beginning of June. The rainfall is ill distributed and varies from place to place. The west coast of South India receives the heaviest rainfall with more than 220 cm annually. The northern parts of Andhra Pradesh and Tamil Nadu receive only 100-200 cm, while southern parts of Andhra Pradesh get only 50 cm.

The prevalence of mist during the winter mornings (October - March) is a very important source of moisture. During the rain less seasons the mist is important to the vegetation by providing enough moisture. It helps to keep the evergreen nature of the forests of Western Ghats. The break period between the two monsoons in hill stations is 0-30 days. Rainfall during the retreating monsoon period (October-December) considerably influences the number of frosty days during these months; if the rains are above normal, the frosty days are fewer in number (Meher-Homji, 1971).

The climate in South India is in general mega-thermal (Subramanyam *et al.*, 1965; Rao *et al.*, 1972). On the basis of the ratio of rainfall to evapo-transpiration, Chowdhury and Sarwade (1982) classified the homoclimatic regions of India into five categories, *viz.,* arid region, semi-arid region, sub-humid region, humid regime and super-humid regime. Among these, South India falls under four homoclimatic types. The coastal districts of Andhra Pradesh, interior Karnataka and some districts of

Tamil Nadu come under semi-arid climate. Northern coastal Andhra Pradesh, southern districts of Karnataka and northern Tamil Nadu experience dry, sub-humid climate, while coastal Karnataka and northern Kerala have moist, sub-humid type of climate. The humid regime predominates in southern districts of Kerala and at higher elevations around Coonoor and Ootacamund in Tamil Nadu, where as super-humid regime occupies only at Kodaikanal (Tamil Nadu).

Distribution and Ecology

The adiantoid-cheilanthoid ferns are worldwide in their distribution. The genus *Adiantum* includes more than 230 species that are chiefly distributed in the tropical and subtropical lands all over the world and is particularly well represented in Tropical America. A few species occur in warm temperate regions as well. *Adiantum* grows in moist shaded habitats; all species are terrestrial, growing in clay or humus soils in ravines on stream banks and on montane slopes and earth cuttings in forests. Some species are rupestral and grow on moist shaded cliffs and ledges or in rocky places in forests or among bushes (Tryon & Tryon, 1982).

The cheilanthoid ferns are mostly adapted to seasonally xeric habitats. They comprise over 300 species in 12 genera. *Cheilanthes* with about 200 species is wide spread in both hemispheres and are mainly confined to semi arid tropics and sub tropics although relatively few species grow outside these regions. *Doryopteris* is world wide in distribution and most of the species occur in the American tropics, while a few species are distributed in the Old World. *Parahemionitis* is a new genus with a single species raised to separate the taxon *Hemionitis arifolia* from other species of *Hemionitis*. It grows in rocky areas along earth cuttings in fully exposed situations. *Anogramma* is restricted to humid places, grows in the crevices of rocks at high altitudes and is world wide in distribution. *Pityrogramma* prefers open moist habitats and are widely distributed through out the world. *Actiniopteris* is adapted to live in more dry and arid situations and grows usually in rocky habitats and are distributed mainly in the Old World.

In South India adiantoid-cheilanthoid ferns are represented by 8 genera and 28 species. Some species recorded by earlier workers from southern India such as *Adiantum soboliferum, Cheilanthes belangeri, Doryopteris ludens,* etc. could not be collected in spite of extensive survey in different parts of the study area suggesting the possible elimination of them from this region. This shows the need of immediate

steps to be taken for the proper conservation of the existing species of the area. All the species of adiantoid-cheilanthoid ferns are terrestrial. Some are lithophytes, which either grow over the rocks or prefer crevices of stony walls and embankments. *Actiniopteris* is represented by a single species in South India. *A. radiata* is present throughout the region in dry arid places on exposed rocks and stone wall crevices. *Adiantum* has 11 species in South India of which *A. incisum* is the most widely distributed one and occurs in all the four states. *A. capillus-veneris, A. zollingeri* and *A. philippense* are also present in all the South Indian states, but are sparsely distributed. *A. capillus-veneris* is a fern of moist and humus rich places along the water channels or where water is trickling. Its occurrence in South India is restricted to certain localities close to streams. *A. philippense* and *A. incisum* form thick carpets on stony walls on account of their capacity for prolific vegetative multiplication by virtue of terminal buds on the fronds. The former is very widely distributed in the plains and lower slopes in Kerala up to 1200 m but is rare in other states. *A. latifolium* is fairly well distributed in the southern districts of Kerala along fully exposed banks of rivers and canals and also earth cuttings below 500 m. In Karnataka it is reported from Dakshina Kannada and in Tamil Nadu from Kanniya Kumari Districts only. It is not reported from any where in Andhra Pradesh. This species, like *A. raddianum* and *A. tenerum,* is recently naturalized and is spreading rapidly in the southern districts of Kerala.

In fully exposed dry places below 1000 m in southern Western Ghats, *A. caudatum* is occasionally present. Among the high altitude species of *Adiantum, A. raddianum* is the most widely distributed one especially in the Western Ghats of Karnataka, Kerala and Tamil Nadu. In South India, *A. concinnum* is restricted to Coorg District of Karnataka, Wayanad District of Kerala and Coimbatore District of Tamil Nadu. *A. poiretii* is confined to Munnar in Kerala and Nilgiris in Tamil Nadu. *A. tenerum* has recently been reported from different localities in Kozhikode District of Kerala and grows luxuriantly in moist and partially shaded earth cuttings on roadsides. It is also found growing on laterite walls of wells in these areas.

Anogramma leptophylla is of very rare occurrence in South India and present only in Bababudan hills in Karnataka. Even though it was reported earlier from Nilgiris by several collectors, Beddome (1863-1865) states that he could not collect it from there, which indicates that this species might have eliminated from the area. This species grows in damp soil in the crevices of rocks under complete shade.

Of the eight species of *Cheilanthes* reported from South India, *C. anceps, C. bicolor, C. opposita* and *C. tenuifolia* are the widely distributed ones and occur in all the four states. *C. opposita* is an elegant fern forming dense rosettes under the shade of big boulders in fully exposed hilly regions in lower altitudes (below 1200 m). *C. bicolor* grows on exposed rocks, boulders or gravelly soil along roadsides under extremely xerophytic conditions, also at low altitudes (below 900 m). *C. tenuifolia* grows extensively in open hilly and reddish laterite soils among grasses and occasionally found growing on rocks in plains and lower elevations in Kerala and is rare in other states. *C. belangeri* is very rare and was reported by Beddome (1863-1865) from Anamallays in Tamil Nadu and later by Rama Rao (in 1913) from Palaruvi in Kerala. Specimens of both of them are lodged at CAL. Since then no one else seems to have collected this species from southern India.

C. anceps, C. bicolor, C. bullosa and *C. thwaitesii* are the farinose members of *Cheilanthes* of the area. They usually curl up during dry seasons but often survive after uncurling during rainy season ('resurrection'). Of these, *C. bicolor* is the widely distributed species and occurring in all the four states. *C. bullosa* is present above 1500 m in Nilgiri and Palni hills in Tamil Nadu and Munnar in Kerala. It grows well on exposed damp rock surfaces near streams forming large colonies. *C. viridis* was earlier reported only from Kothayar hills in India. But recently I could collect it from Coonoor in Nilgiri hills also (both in Tamil Nadu). The report of occurrence of *C. doniana, C. dubia*, and *C. krameri* in South India (Chandra, 2000a) is erroneous.

Parahemionitis cordata and *Pityrogramma calomelanos* are present in all the four South Indian states. Both species occur in lower as well as higher altitudes. *P. cordata* grows in relatively dry localities and on shaded earth cuttings. *P. calomelanos* is abundant in a variety of situations in lower altitudes up to 1200 m in Kerala, such as canal banks, roadsides, riverbeds, hill slopes, waste places, etc. In India, *Pityrogramma austroamericana* is restricted to South India. It is a high altitude species (above 700 m) and common in Shevaroy hills in Tamil Nadu, but of rare occurrence in Kodagu in Karnataka. In Kerala, this fern is very common in the open hilly slopes of high ranges in Idukki District. In lower ranges, it grows mixed with *P. calomelanos* and then many intermediate forms are encountered (Nayar & Geevarghese, 1993). The genus *Pellaea* has three species in South India including one endemic species, *viz., P. malabarica*. All of them are restricted to the Southern

Western Ghats only. *P. boivini* is locally abundant in Kothayar hills. *P. malabarica* is reported only from Silent valley.

The various species that occur both in southern India and northern India are *Actiniopteris radiata, Adiantum capillus-veneris, A. caudatum, A. incisum, A. philippense, A. poiretii, A. zollingeri, Anogramma leptophylla, Cheilanthes anceps, C. belangeri, C. bicolor, C. tenuifolia, Parahemionitis cordata* and *Pityrogramma calomelanos.* The species that occur in southern India and other parts of the world but absent in northern India are *Adiantum concinnum, A. hispidulum, A. latifolum, A. raddianum, A. tenerum, Cheilanthes bullosa, C. opposita, C. thwaitesii, C. viridis, Doryopteris concolor, Pellaea boivini, P. falcata, P. malabarica* and *Pityrogramma austroamericana. C. opposita* and *D. concolor* extend to Southern Orissa, while *A. tenerum* occurs in Andaman Nicobar Islands also. *Pellaea malabarica* is endemic to the Western Ghats of Kerala. *C. bullosa* and *C. thwaitesii* occur in South India and Sri Lanka. Dixit (1984) and Chandra (2000a) give Australia, Bhutan, China and Nepal also as the area of distribution of *C. bullosa*. But, Fraser-Jenkins (Pers. comm., 2001) considers it as restricted to South India and Sri Lanka and the taxon reported from other areas as *C. bullosa* is actually a closely related species, *C. argyrophylla* (Sw.) Cordem. Chandra (*l.c.*) erroneously reported the distribution of *Pityrogramma austroamericana* in Bombay and *Adiantum zollingeri* in Assam.

A large number of species of these genera, which occur in northern India, are absent in southern India. They are *Adiantum flabellulatum, A. capillus-junosis, A. edgeworthii, A. fimbriatum, A. indicum, A. pedatum, A. refractum, A. venustum, Anogramma microphylla, Cheilanthes acrostica, C. argentea, C. chrysophylla, C. dalhousiae, C. doniana, C. duthie, C. formosana, C. grisea, C. persica, C. platychlamys, C. pteroides, C. pulveracea, C. rufa, C. subdimorpha, C. subvillosa, C. trichophylla, C. vermae, Doryopteris ludens, Pellaea hastata and P. nitidula.*

Of the 28 species of adiantoid-cheilanthoid ferns of southern India, 23 species are occurring in Sri Lanka, while only 14 species are common to northern India. Thirty species which are occurring in northern India are absent in southern India. This suggests a continuity in phytogeographical distribution between southern India and Sri Lanka rather than southern India and northern India.

Materials and Methods

Specimens for the present study were collected during the extensive field trips conducted in the study area. Field data on the habitat, ecological niches, infraspecific variations, biological associations and distributional patterns of different taxa were collected during these field trips.

For most of the species the characters were studied in the field itself using live specimens. Many species collected from different localities were brought into cultivation in the Calicut University Botanical Garden. They were grown in earthern pots under uniform environmental conditions in green houses. These living collections provided the opportunity to study morphological variations in frond form as well as made possible the study of spore and dermal appendages. Herbarium specimens were prepared using conventional methods at the collection site itself. Materials were also fixed in Formalin-Acetic-Alcohol (FAA) for further studies.

The Herbarium specimens prepared during the present study are deposited in the Calicut University Herbarium (CALI) and the materials preserved in FAA are kept in the Pteridology Laboratory, Department of Botany, University of Calicut. In addition to the live specimens collected from different locations, herbarium specimens from different national and regional herbaria such as Calicut University Herbarium (CALI), Central National Herbarium, Calcutta (CAL), Madras Herbarium, Coimbatore (MH), Mahatma Gandhi Memorial College Herbarium, Udupi (MGMC), Sri Krishnadevaraya University Herbarium, Ananthapur (SKU) and St. Xavier's College Herbarium, Palayamkottai (XCH) were also studied

The collected materials were identified by using available literature and by consulting the type specimens or their photograph/cibachrome/xerox copies from the following herbaria.

B	Botanisches Museum, Berlin-Dahlem, Germany.
CAL	Central National Herbarium, Calcutta, India.
CALI	Calicut University Herbarium, Calicut, India.
K	Herbarium of Royal Botanic Gardens, Kew, Great Britain.
MH	Madras Herbarium, Coimbatore, India.
NSW	National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, Australia.
P	Museum National d'Histoire Naturelle Laboratoire de Cryptogamie, Paris, France.

Comparative morphological studies of rhizome, paleae, trichomes, pinnae, sporangia and spores of different species were made using fresh, preserved as well as herbarium specimens. Paleae were taken from the apex of rhizome or branch (for young) and from older portions (for mature). Similarly very young pinnae from living plants were observed in most cases to decide whether epidermal hairs and trichomes are present, since the hairs of some species are deciduous and lost when the pinnae become old or when dried. The venation pattern was studied by taking medium sized pinnae with sori from the middle region of the frond. The material was kept in 4% KOH with a few drops of Basic Fuchsin overnight at 60° C in an oven. Then it was washed thoroughly in tap water to eliminate traces of KOH. Basic Fuchsin imparted a purple colour to the veins. The venation pattern was observed in transmitted light under a Leitz Stereo Microscope and camera lucida drawings were made. To observe vein tips and to know whether they end in the sinuses or the teeth on the margin of the pinna, venation study was also made using young pinnae (before the formation of sori). Sori of different developmental stages were observed to understand its structure and the size, shape and nature of indusia. Sporangia were studied by separating them from the indusium and mounting in glycerine. Care was taken to make the stalk of sporangium (if present) intact during this separation and the number of cells of annulus was noted. Camera lucida drawings of the sporangia were made using Carl-Zeiss Light Microscope. For palynological studies spores were collected from fresh material following the method of Chiou and Farrar (1994). Palynological observations were made after acetolysis (Erdtman, 1952, 1957). The spore preparations were made semi-permanent by mounting in glycerine-jelly. Gametophyte morphology as well as chromosome number and etymology of different species were adopted from available literature.

Each species is described with a plate containing illustrations of the whole plant (habit), sterile pinna to show the venation pattern, fertile pinna to show distribution of sori, palea, trichome (if present), sporangium and spore. The illustrations were prepared from authenticated plant material. Except habit sketch, all other diagrams were drawn using camera lucida. For descriptions and illustrations fresh materials were used except in few cases. The ecological notes are based on the field observations and information collected from herbarium sheets. Notes on nomenclature are given in relevant cases.

The thesis is presented with an introduction that explains the importance of the present work. It is followed by an account of the economic importance of the taxa

studied. A comprehensive review of work done in almost all areas such as taxonomy, morphology and anatomy, cytology, phytochemistry, palynology, apogamy and apospory and gametophyte morphology, followed by the salient features of the area of present study and the distribution and ecology of the taxa are given in the introductory part. The systematic part contains a comprehensive treatment of adiantoid-cheilanthoid ferns of South India. For this systematic treatment, the classification of Tryon *et al.* (1990) is adopted, where these taxa are included in the family Pteridaceae. The family is divided into six subfamilies, of which five subfamilies are represented in South India. An artificial key is provided for these five subfamilies. Since adiantoid-cheilanthoid ferns come under only three subfamilies, *viz.,* Adiantoideae, Cheilanthoideae and Taenitidoideae, the present work is limited to these subfamilies which are dealt in detail. The genera coming under each of these three subfamilies, and the species coming under each genus, are treated in alphabetical order. All these taxa are provided with a historical review and a brief description. In the case of subfamilies, the affinity of each of them to other taxa is also provided. Following this a key to the genera is given (if the subfamily has more than one genus). Each genus is provided with a brief general account comprising circumscription and etymological derivation, type species, synonymy, relevant bibliographical data, gametophyte morphology, chromosome number, distribution and ecology and also relevant nomenclatural notes. This is followed by the key to species. For each species, information regarding the correct nomenclature, relevant synonyms, detailed morphological description, chromosome number, distribution and ecology and nomenclatural note are provided. The bibliographical reference is restricted to relevant literature pertaining to the study area only. A list of specimens examined from the area of study with the acronym of the herbarium where they are deposited, is given at the end and are cited by State, District and locality, each in alphabetical order. For author citation of scientific names, *Authors of scientific names in Pteridophyta* compiled by Pichi Sermolli (1996) is followed. Distribution maps are provided for all the species and photos of type specimens are given wherever necessary.

A discussion on comparative morphology and its bearing on the phylogeny follows the systematic treatment. A bibliography of related literature and an index to the scientific names are provided at the end of the thesis.

SYSTEMATIC TREATMENT

ADIANTOID-CHEILANTHOID FERNS

The taxonomic treatment of adiantoid and cheilanthoid ferns had undergone considerable changes over the years. Earlier authors treated them as belonging to the family Polypodiaceae along with all other leptosporangiate ferns having "a vertical incomplete annulus of sporangium opening by a transverse slit" . Diels (1899) also included them under Polypodiaceae and placed in the subtribes Adiantinae and Cheilanthinae respectively, both belonging to the tribe Pterideae of it. But Bower (1928) separated them from Pterideae and placed in gymnogrammoids without assigning any taxonomic rank to it on the ground that they probably have an ancestry different from pteroids. Christensen (1938) assigned the rank of subfamily to the gymnogrammoids of Bower and placed in the family Polypodiaceae. Ching (1940) split the Polypodiaceae into 33 families placing *Adiantum* in a family of its own along with a closely allied genus *Hewardia*. (Most of the authors do not recognize this genus as distinct from *Adiantum*). Cheilanthoid ferns were placed under the families Gymnogrammaceae and Sinopteridaceae. But his system was severely criticized by his contemporaries particularly Copeland (1947), who brought the adiantoid and cheilanthoid ferns in the family Pteridaceae. But Manton (1950) on the basis of cytological studies reported that the genera 31 to 63 of Copeland's Pteridaceae having almost uniform chromosome number (x = 29, 30) are distinct from the rest of the genera. She later (1958) opined that there is nothing wrong in accepting these genera as a separate family to be called, perhaps, Adiantaceae. But Walker (1973) proposed the name 'adiantoid group' for these genera which includes all adiantoid, cheilanthoid and pteroid ferns. Holttum (1947, 1949) separated the gymnogrammoid ferns from the pteroids and grouped them along with vittarioids in a distinct family to which he gave the name Adiantaceae, as *Adiantum* is the largest and most distinctive genus in it. Alston (1956) divided the Pteridaceae of Copeland and all the genera before *Pteris* were brought under the family Adiantaceae. Nayar (1970) separated the adiantoid and cheilanthoid ferns from each other and placed them in separate families. His Adiantaceae include *Adiantum* and a few other genera including *Acrostichum*. He proposed a new family Cheilanthaceae for the cheilanthoid ferns. On the other hand, the family Adiantaceae of Crabbe *et al.* (1975) are having a very broad circumscription and include all the adiantoid, cheilanthoid, pteroid and vittarioid ferns. Pichi Sermolli (1959, 1977) considers that the genus

Adiantum is distinct enough from other genera to be placed in a family of its own. Hence, his family Adiantaceae is monotypic. He placed the cheilanthoid ferns in the families, Hemionitidaceae and Sinoperidaceae. Tryon *et al.* (1990) placed all the ferns of Crabbe *et al.*'s (*l.c.*) Adiantaceae, excluding vittarioids in the family Pteridaceae. They divided it into 6 subfamilies and treated the genus *Adiantum* under a monotypic subfamily Adiantoideae. But Brummitt (1992) once again brought all the adiantoid and cheilanthoid ferns under a single family Adiantaceae and placed the genera in alphabetical order. He (*l.c.*) followed Pichi Sermolli (1977) in the treatment of *Actiniopteris* by placing them in a monotypic family.

Kramer (1990) is very critical of some of these modern systems. He believes that the system of Crabbe *et al.* (1975) is not a true system of classification as only a linear sequence is given, which can only very imperfectly reflect ideas about affinity. He is also of the opinion that Pichi Sermolli's (1977) and Nayar's (1970) systems are based on a philosophy of emphasizing differences rather than similarities, which is alien to the principle of classification. Not only that, Pichi Sermolli tended to retain taxa whose distinctness had long been challenged. The system proposed by Brummit (1992) is simply an alphabetical enumeration of all those families adopted at Kew for the arrangement of Herbarium.

Among these different systems, that of Tryon *et al.* (1990) seems to be more natural as far as the treatment of the families and infrafamilial taxa are concerned, despite the fact that the various families are arranged alphabetically. Kramer (1990) being one of the authors of the system, explains that the alphabetical sequence of families is in accordance with the editorial rules for *The Families and Genera of Vascular Plants.* So he (*l.c.*) gives a resume of his interpretation about family relationships in the leptosporangiate ferns separately. The authors of the system brought under the family name Pteridaceae, all the adiantoids, cheilanthoids and pteroids because of their 'alleged' overall similarities. According to them, the relationships of the genera within the Pteridaceae are complex and there are distinctive groups and poorly defined ones. The chromosome number of n = 29, 30 or multiples, trilete spores and sporangia borne in exindusiate soral lines along the veins or covered by a modified marginal indusium, relate the genera in a natural group. At the same time the differences between them are emphasized by placing them under different subfamilies. Because of the uniqueness of the genus *Adiantum*, as far as soral characters are concerned, they placed it in a monogeneric subfamily Adiantoideae.

PTERIDACEAE Rchb.f.

The Pteridaceae have been variously classified from a very large family (Copeland, 1947) to a restricted one that includes only *Pteris* and its nearest allies (Pichi Sermolli, 1977). Gray (Nat. Arr. Brit. Pl. II, p. 3. 1821) validly published this as a tribe Pterideae Gray of Filices based on *Pteris* L., and Gaudichaud (in Freyc. Voy. Monde Bot. 3: 262. 1828) established the family Pteridaceae Gaudich., but without a validating description and also without reference to Gray (Nat. Arr. Brit. Pl. II, p. 3. 1821). Reichenbach (Handb. Nat. Pflanzensyst. 138. 1837) circumscribed this family (as "Pteroideae") in a very broad sense and included in it many previously described, independent families, making the name Pteroideae Rchb.f., a *nomen superfluum* and hence an illegitimate one. But Article 63.3 of the International Code of Botanical Nomenclature was altered at Sydney Congress with the result that the family name Pteridaceae became legitimate. But since it is antedated by Parkeriaceae Hook., Tryon (1980) proposed the conservation of Pteridaceae Rchb.f. over Parkeriaceae. But the proposal was rejected by the Committee for Pteridophyta (*cf.* Pichi Sermolli, 1986). The name Pteridaceae was adopted as that of a family by Braun (in Ascherson, Fl. Brandenb. 1: 24. 1864), but he also circumscribed the group in a sense broader than that of Reichenbach.

After its publication, the family was continued to be circumscribed in a broad sense so as to include most of the fern genera. It was Ching (1940) who adopted the name Pteridaceae in a narrow sense. But, since then, again it is treated as a very large family (Copeland, 1947; Tryon *et al.*, 1990) or as a restricted one that includes only *Pteris* and its nearest allies (Nayar, 1970; Pichi Sermolli, 1977; Brummitt, 1992).

There is some controversy regarding the authority for the family name Pteridaceae. Copeland (1947) quotes Gaudichaud (in Freyc. Voy. Monde Bot. 3: 262. 1828), where as Ching (1940) credits himself. However, Pichi Sermolli (1970) has argued that the family name Pteridaceae be accredited to Reichenbach (Handb. Nat. Pflanzensyst. 138. 1837) and not to Gaudichaud (in Freyc. Voy. Monde Bot. 3: 262. 1828) because Gaudichaud's 'Pteridaceae' are a subdivision of uncertain rank of the 'class des Gyratae' of "la famille des fougeres" and he did not describe the group. Pichi Sermolli (*l.c.*) further proposed that Reichenbach's family Pteridaceae ought to be conserved. But a proposal for the conservation of the name Pteridaceae Reichenbach over Pteridaceae (S.F.Gray) Gaudich. by Panigrahi (1986a) was also rejected by the Committee for Pteridophyta stating that the name is not in need of

conservation (Lellinger, 1993). Fraser-Jenkins (1997) is of the opinion that such an alteration in the author citation is unnecessary because Gaudichaud's name was clearly invalid as he neither referred to Gray or any other valid description, nor provided a description himself. Despite this, Panigrahi (1998) later used the altered citation himself, *viz.*, Pteridaceae (S.F.Gray) Gaudich.

Note: Reichenbach (Handb. Nat. Pflanzensyst. 138. 1837) called his group 'Pteroideae', which is the correct ending for a subfamily, but at the same time made it clear that he was treating it as a family. So this orthographic error in the Latin termination was subsequently corrected by others and changed the name to 'Pteridaceae'

Pteridaceae Rchb.f., Handb. Nat. Pflanzensyst. 138. 1837, (as 'Pteroideae').

Type: *Pteris* L.

Parkeriaceae Hook., Exot. Fl. 2: t. 147. 1825.

Adiantaceae Newman, Hist. Brit. Ferns 5: 1-5. 1840, *nom. cons.* (over Parkeriaceae).

Acrostichaceae Mett. *ex* A.B.Frank, Syn. Pflanzenk. (Leunis), ed. 2. 3: 1458. 1977.

Sinopteridaceae Koidz., Acta Phytotax. Geobot. 3: 50. 1934.

Gymnogrammaceae Herter, Rev. Sudamer. Bot. 6: 130. 1940, *nom. nud.*

Negripteridaceae Pic.Serm., Nuov. Giorn. Bot. Ital. ser. 2. 53: 160. 1946.

Platyzomataceae Nakai, Bull. Natl. Sci. Mus. (Tokyo) 29: 4. 1950.

Trismeriaceae G.Kunkel, Ber. Schweiz. Bot. Ges. 72: 36. 1962, *nom. nud.*

Actiniopteridaceae Pic.Serm., Webbia 17: 5. 1962.

Cryptogrammaceae Pic.Serm., Webbia 17: 299. 1963.

Hemionitidaceae Pic.Serm., Webbia 21: 487. 1966.

Cheilanthaceae B.K.Nayar, Taxon 19: 233. 1970.

Taenitidaceae (C.Presl) Pic.Serm., Webbia 29: 1. 1974.

Plants terrestrial or rupestral, rarely aquatic (*Ceratopteris*). Rhizome small, erect or creeping, surrounded by old leaf bases and bearing lanceolate scales at the apex. Stipe often dark, terete or adaxially sulcate and bearing scales or multicellular hairs or both, either through out the length or at least towards the base; lamina simple pinnate, pedate or up to 4 times pinnate or pinnatifid; surface glabrous or bearing scales or hairs, some having densely packed ceraceous glands producing white, yellow or orange coloured farina especially on the lower surface; veins free or rarely anastomosing and if so, the areolae are devoid of included veinlets; sori

typically marginal, protected by a reflexed marginal flap forming long or short soral lines along the veins, some times spreading towards the midrib covering more or less the entire fertile surface, then exindusiate or borne on and protected by the reflexed margin (*Adiantum*). Sporangia long stalked; the stalk consists of two or three rows of cells; annulus 15-18 celled, vertical, interrupted by the stomium; spores trilete, tetrahedral, more or less globose without chlorophyll.

Note: The Pteridaceae, when first published by Reichenbach (Handb. Nat. Pflanzensyst. 138. 1837) as 'Pteroideae', was a *nomen superfluum* and hence an illegitimate name, since it contained the type genera of a number of unrelated pre-existing families. But the Sydney Congress (1981) altered Article 63.3 of the International Code of Botanical Nomenclature (ICBN) with the result that the name Pteridaceae became legitimate. But when Pteridaceae are treated in a broad sense to include among others the family Parkeriaceae Hook. (Exot. Fl. 2. ad. t. 147. 1825), the latter name has priority over Pteridaceae Rchb.f. and that would have been the correct name of the combined family. But if Pteridaceae includes Adiantaceae Newman (Hist. Brit. Ferns 5: 1-5. 1840) also, which is post dated to the former but has been conserved over Parkeriaceae Hook., Pteridaceae Rchb.f. is the correct name of the combined family and is adopted here.

Classification: The family is treated here in a broad sense, to include many split families such as Parkeriaceae Hook. and Adiantaceae Newman. Pichi Sermolli (1977) recognized 10 families among the genera of Pteridaceae as treated here.

Tryon *et al.* (1990) divided the family into six subfamilies, *viz.*, Adiantoideae, Ceratopteridoideae, Cheilanthoideae, Platyzomatoideae, Pteridoideae and Taenitidoideae. Of these, the subfamilies Adiantoideae, Ceratopteridoideae and Platyzomatoideae are monotypic. The subfamily Platyzomatoideae are not represented in South India and hence excluded from the present treatment.

Key to subfamilies

1a. Sporangia borne on inner surface of the reflexed margin of lamina along the veins that enter into it — Adiantoideae

1b. Sporangia borne on the abaxial side of lamina which are exindusiate or along the margin of lamina protected by reflexed marginal flaps, but never from them which also lack veins — 2

2a.	Plants aquatic; lamina clearly dimorphic, fertile with narrower segments; sporangia borne distally on veins on entire surface, protected by reflexed margin	Ceratopteridoideae
2b.	Plants terrestrial; lamina not dimorphic; sporangia borne on soral lines on veins or on marginal commissure protected by a reflexed margin, but if borne on entire surface, then without a protective covering	3
3a.	Sporangia not intermingled with trichomes; spores trilete, without equatorial flange	Cheilanthoideae
3b.	Sporangia usually intermingled with trichomes; spores trilete with a definite equatorial flange	4
4a.	Leaf pinnate or pinnatifid; sporangia borne along an inframarginal vascular commissure and covered by linear reflexed leaf flap	Pteridoideae
4b.	Leaf pinnate or pinnatifid and sporangia borne along veins, exindusiate or dichotomously divided and sporangia borne in an inframarginal soral band covered by marginal indusium	Taenitidioideae

The adiantoid and cheilanthoid ferns are distributed in three subfamilies only. They are Adiantoideae, Cheilanthoideae and Taenitidoideae. Hence only these three subfamilies are treated here.

ADIANTOIDEAE (C.Presl) R.M.Tryon

It was Kaulfuss (Wesen Farrenkr. 119. 1827) who for the first time segregated the genus *Adiantum* and allied plants from the rest of Polypodiaceae and brought under the name Adiantoideae. But he did not describe this new taxon. Later Gaudichaud (in Freycinet, Voy. Bot. 10: 402. 1829) validly published this group under the name Adianteae which included *Adiantum* and *Cassebeera* only. Lindley (Nat. Syst. Bot. ed. 2. 401. 1836) also included these two genera in his Adianteae, but treated it as a suborder (which is equivalent to present subfamily) of Polypodiaceae. But Presl (Tent. Pterid. 205. 1836) adopted this group in a wider sense to include many genera and treated the group as a tribe. Newman (Hist. Brit. Ferns 5: 1-5.

1840) for the first time treated it as a family. However, this treatment remained unnoticed till recently with the result that later authors continued to treat it as a taxon under the family Polypodiaceae. For example, Diels (1899) treated *Adiantum* as the only genus of the subtribe Adiantinae of the tribe Pterideae, while Christensen (1938) treated *Adiantum* as a monotypic tribe Adianteae of subfamily Gymnogrammoideae. But Copeland (1947) removed the genus *Adiantum* from the family Polypodiaceae and included it in the family Pteridaceae and made no further taxonomic subdivision to the family. Ching (1940), apparently unaware of Newman's Adiantaceae, raised the tribe 'Adiantaceae' of Presl to the rank of a family and included the genera *Adiantum* L. and *Hewardia* J.Sm. in it. The family Adiantaceae was again recognized by Nakai (J. Jpn. Bot. 24: 8. 1949) who attributed the family name to himself quoting the tribe Adiantaceae of Presl as the basionym of the family name. Most of the other authors such as Holttum (1947, 1949), Alston (1956), Nayar (1970), Crabbe *et al.* (1975) and Brummitt (1992) treated this family in a wider sense. While Alston (1956), Nayar (1970) and Brummitt (1992) distinguish no subdivision to this family, Holttum (*l.c.*) recognizes two groups in it, but does not give them any specific taxonomic rank. But the Adiantaceae of Crabbe *et al.* (1975) are divided into three subfamilies, one of which is Adiantoideae that contain all the adiantoid and cheilanthoid ferns. Pichi Sermolli (1977) considers this family as definitely a monotypic one. But Tryon *et al.* (1990) treat this as a monotypic subfamily of the family Pteridaceae which is followed here.

Note: Although Ching (1940) published the family name Adiantaceae in a very narrow sense, subsequently it was adopted for a very large family which included the types of the family names Acrostichaceae Mett. *ex* A.B.Frank, Parkeriaceae Hook. and Sinopteridaceae Koidz. Although all these family names have priority over Adiantaceae (K.B.Presl) Ching, this name, circumscribed in such a broad sense, has been widely adopted in the floras of many parts of the world and in pteridological literature in general. In order to continue its usage over the above said earlier published family names, Pichi Sermolli (1981) proposed its conservation and was adopted by the subcommittee for family names of Pteridophyta (Pichi Sermolli, 1986) and included in the Appendix IIA of the Berlin Code (1988). But since the tribe Adianteae Gaudich. (in Freycinet, Voy. Bot. 10: 402. 1829) antedate that of the tribe Adianteae Presl (Tent. Pterid. 205. 1836), Panigrahi (1986b) proposed for the conservation of the family name with a change in the parenthetical author citation,

viz., 'Adiantaceae (Gaudich.) Ching', but was rejected by the Committee with the explanation that the correct citation for the name is Adiantaceae Newman, Hist. Brit. Ferns 5: 1-5. 1840 (see Lellinger, 1993), thereby recognizing the name, which was published more than 150 years back, despite the fact that earlier Pichi Sermolli (1970) was of the view that Newman's family Adiantaceae is equivalent to a subdivision of family as intended in modern times and hence Newman cannot be regarded as the author of the family name Adiantaceae. Accordingly this name was included in the Appendix IIA of the Tokyo Code (1994) and Saint Louis Code (2000) replacing Adiantaceae (K.B.Presl) Ching.

Adiantoideae (C.Presl) R.M.Tryon, Amer. Fern J. 76: 184. 1986.

Type: *Adiantum* L.

Adiantaceae C.Presl, Tent. Pterid. 205. 1836, as tribe.

Adiantoideae Kaulf., Wesen Farrenkr. 119. 1827, *nom. nud.*

Adianteae Gaudich. in Freycinet, Voy. Bot. 10: 402. 1829; Lindley, Nat. Syst. Bot. ed. 2. 401. 1836.

Adiantaceae Newman, Hist. Brit. Ferns 5: 1-5. 1840; (K.B.Presl) Ching, Sunyatsenia 5: 229. 1940; (K.B.Presl) Nakai, J. Jpn. Bot. 24: 8. 1949.

Plants terrestrial or rupestral; rhizome sub-erect or short or long creeping, covered with brown, acicular, ovate-lanceolate scales. Leaves almost monomorphic; stipe dark brown to blackish, glossy; lamina simply pinnate to decompound or pedate, very definitely anadromous; veins usually free, dichotomously branched or rarely anastomosing, but without included veinlets. A unique feature of this taxon is that the fertile veins enter the pseudoindusium, where they bear the sporangia and at the same time protect them. Sporangia are borne along the veins in short soral lines or between the veins on a strongly recurved, modified indusioid marginal leaf flap, the capsules facing the abaxial side of the lamina; spores trilete, tetrahedral, globose, non-perinate; exine smooth or granulose.

Affinity: Adiantoideae are undoubtedly linked to cheilanthoid, gymnogrammoid and cryptogrammoid ferns and this affinity, based on the morphological features, is confirmed by cytological investigation. Adiantoid ferns are more closely related to cheilanthoids than with others because of having the characteristic collenchymatous thickenings of the cell walls in the gametophyte. Adiantoid ferns are also linked with Vittariaceae and the link between these two families is shown by the characteristic

'spicular cells' in the epidermis, which are reported, so far, in these two groups only. But Nayar (1962a) points out the differences between the spicular cells of both the taxa and does not regard them as evidence for a relation between the two groups.

ADIANTUM L.

Adiantum, popularly known as 'Maidenhair fern', is an isolated, well defined and old genus. It is a large, terrestrial and wide spread genus with a large number of species which are favourites of horticulturists for their elegant foliage.

Linnaeus (1753) included 15 species in the genus *Adiantum.* He took over this name from Tournefort, who had adopted for the genus the name given by the Greeks to the only species present in Europe, *viz.*, *A. capillus-veneris* L.

The scientific name *Adiantum* is thus derived from the Greek word 'adiantos', meaning 'unwetted' referring to the water repelling properties of the surface of the fronds. Even fronds dipped in water will still appear dry afterwards. The common name 'maidenhair' is because of the resemblance of the black hair like small rachises of the fronds especially those of the European species.

Adiantum is a most natural genus with more than 230 species (Khullar, 1994). The genus is characterized by the extension of veins into the reflexed leaf margin and fertile there only. The sorus of *Adiantum* is a group of sporangia borne by a unit of reflexed margin. The indusium may be at the bottom of a notch in the margin and round or on the edge of a tooth, then elongate. Despite this uniqueness, the genus shows a number of diversities based on the venation pattern, shape of indusium and its extension along the margins, architecture of fronds, shape of pinnules, etc.

Smith (1841) segregated those species with anastomosing veins into a genus *Hewardia* J.Sm., which includes 4 or 5 species endemic to Guiana, with *H. adiantoides* J.Sm. as the type species. This was accepted only by few authors such as Ching (1940). Hooker and Baker (1865-1868) treated these two taxa as two subgenera of *Adiantum*, *viz.*, subgenus *Euadiantum* and subgenus *Hewardia. Euadiantum* is further divided into 7 groups, but these have not been given any taxonomic rank. Similar treatment was done by Smith (1875) and Diels (1899) also. Nayar (1961) divided the Indian species of *Adiantum* into 4 groups mainly on the basis of anatomy of rhizome, while Tryon and Tryon (1982) divided the New World species into 8 groups on the basis of nature of fronds.

Pichi Sermolli (1957) is of the opinion that the genus *Adiantum* is uniform and the distinction of large taxonomical infrageneric taxa is difficult and questionable. Several small groups of closely related species are recognizable, but they are intimately interrelated with each other and represent the links of a chain in which natural gaps are not found, even if the groups at their extremities appear rather different from each other. *Hewardia* J.Sm., according to Pichi Sermolli (*l.c.*), merely represents one of these small groups. Christensen (1906) treated *Hewardia* as a synonym of *Adiantum.* Copeland (1947) is of the opinion that it is not worth while to maintain the generic distinction between them. Holttum (1954) also did not recognize any infrafamilial categories.

Adiantum L., Sp. Pl. 2: 1904. 1753 & Gen. Pl. ed. 5. 485. 1754; Fee, Gen. Fil. 112. 1852; Hook., Sp. Fil. 2: 1. 1851; T.Moore, Ind. Fil. 34. 1857; C.B.Clarke, Trans. Linn. Soc. Lond. Bot. 1: 452. 1880; Bedd., Handb. Ferns Brit. India 82. 1883; C.Hope, J. Bombay Nat. Hist. Soc. 13: 82. 1901; Ching, Sunyatsenia 5: 230. 1940; Copel., Gen. Fil. 78. 1947; Holttum, Rev. Fern Fl. Malaya 2: 596. 1954; B.K.Nayar, Bull. Nat. Bot. Gard. 52: 1. 1961; R.M.Tryon & A.F.Tryon, Ferns Allied Plants 319. 1982; R.M.Tryon *et al.* in Kramer & Green (eds.), Fam. Gen. Vas. Plants 1: 249. 1990; Khullar, Illustr. Fern Fl. W. Himalaya 1: 268. 1994; Bostock *et al.* in Mc Carthy (ed.), Fl. Australia 48: 253. 1998.

Type: *Adiantum capillus-veneris* L., lectotype chosen by J. Smith (Hist. Fil. 274. 1875).

Capillus veneris Hill, Brit. Herb. 528. 1756.

Hewardia J.Sm., J. Bot. 3: 432. 1841.

Rhizome stout, sub-erect and short-creeping or slender and long-creeping, solenostelic or dictyostelic, scaly; scales narrowly lanceolate, usually concolorous, entire, rarely toothed; stipe slender, brittle and adaxially sulcate or flattened, pale brown to black, polished, glabrous, puberulous or scaly; lamina 1-4 pinnate, lanceolate, deltoid or ovate; ultimate segments short stalked or rarely sessile, usually glabrous, some times pubescent; veins free, dichotomously branched from base, no main veins, rarely anastomosing without included veinlets; sori borne along the veins on the inner face of reflexed marginal out growth of lamina which can serve as indusium and bear sporangia. Indusia reniform or lunulate to elongate; sporangia not paraphysate; spores trilete, tetrahedral, globose; exine usually smooth without perispore.

Gametophyte: Mature gametophyte is cordate and naked with collenchymatous wall thickenings on the corners of the wing cells in most of the species (Nayar, 1961).

Chromosome numbers: n = 29, 30 (Fabri, 1957, 1963; Chiarugi, 1960; Manickam & Irudayaraj, 1988; Kato *et al.,* 1992); n = 30 (Abraham *et al.*, 1962).

Distribution and Ecology: *Adiantum* is chiefly distributed to tropical and subtropical lands all over the world. Most species are confined to the New World, some to the Old World. There are, however, a few species such as *A. capillus-veneris, A. hispidulum, A. poiretii* and *A. tetraphyllum,* which are cosmopolitan, and also extend to warm temperate zones. *Adiantum* grows in moist shaded habitats on mountain slopes, earth cuttings or stream banks. Some grow on moist shaded cliffs or in the crevices of rocks. Most species grow between 500-2500 m.

Note: The selection of the lectotype from among names of 15 species published by Linnaeus was not unanimous. Smith (1875) selected *A. capillus-veneris* L. as the lectotype. Majority of the Pteridologists accepted it. But Christensen (1906) did not designate a type for *Adiantum* L., while Ching (1940) accepted *A. pedatum* L. as the lectotype of the genus.

The genus *Adiantum* has about 25 species in India. Of these, the areas of distribution of about 16 species include South India also (Dixit, 1984; Chandra, 2000a). Among these species *A. pectinatum* Kuntze *ex* Ettingsh., *A. peruvianum* Klotzsch., *A. polyphyllum* Willd., *A. rubellum* T.Moore and *A. trapeziforme* L. are cultivated plants. So they are excluded from the present study. *A. wattii* Baker, which is treated as a distinct species by the above authors and also by Vasudeva *et al.* (1991), is considered as a mere morphological variant of *A. capillus-veneris* L. by Khullar (1994) and Fraser-Jenkins (1997). *A. aethiopicum* L. and *A. thalictroides* Willd. *ex* Schldtl. are synonyms of *A. poiretii* Wikstr. (Sledge, 1973; Fraser-Jenkins, 1997). *A. cuneipinnulum* N.C.Nair & S.R.Ghosh is a synonym of *A. raddianum* C.Presl. Sledge (1973) states that the fern described by Nayar (1961) as *A. capillus-veneris* L. var. *dissecta* B.K.Nayar is typical *A. capillus-veneris* L. and what he treats there as typical form of the species is *A. concinnum* Humb. & Bonpl. *ex* Willd.

Nayar and Geevarghese's (1993) *A. caudatum* L. var. *flabellatum* is *A. incisum* Forssk. Chandra (2000a) erroneously cited it as *A. caudatum* var. *flabellulatum* Nayar. The diagram given by Nayar & Geevarghese (1993, p. 141. f. 41) for *A. caudatum* L. is that of *A. incisum* Forssk. Fraser-Jenkins (1997) comments that

Geevarghese's sense of '*A. caudatum*', judging by his illustration (p. 141) may be *A. zollingeri* Mett. *ex* Kuhn. But the judgement of Fraser-Jenkins is wrong. The illustration is a copy of the figure of *A. caudatum* of Beddome's *Ferns of Southern India* (p. 1. pl. 2. 1863) which is actually the diagram of *A. incisum* Forssk.

Adiantum venustum sensu B.K.Nayar & Geev. (1993) is *A. raddianum* C.Presl. Nayar and Geevarhese (1993) apparently misidentified *A. raddianum* C.Presl as *A. venustum*. They (1986, 1993) reported three new species of *Adiantum* from Malabar, Kerala. They are *A. ramyam* B.K.Nayar & Geev., *A lomesum* B.K.Nayar & Geev. and *A. nagnam* B.K.Nayar & Geev. *A. ramyam* was already reduced as a synonym of *A. concinnum* Humb. & Bonpl. *ex* Willd. by Fraser-Jenkins (1997). After examining the holotypes of *A. concinnum* Humb. & Bonpl. *ex* Willd. and that of *A. ramyam* B.K.Nayar & Geev., I fully agree with Fraser-Jenkins and hence this taxon is treated here as *A. concinnum* Humb. & Bonpl. *ex* Willd.

Even though Nayar and Geevarghese (1993) have reported that the holotype and isotypes of *A. lomesum* B.K.Nayar & Geev. and *A. nagnam* B.K.Nayar & Geev. were deposited at Central National Herbarium, Calcutta (CAL) and Calicut University Herbarium (CALI) respectively, there is no type material of these taxa either at CAL or at CALI nor any other specimen of these species. So a verification of these species is not possible. I explored the type locality (Palakkad Dt., Kanjirapuzha, Muthukurrisi) two times during the period of study. But I could not locate any specimen of these species. From the above facts and also from the descriptions of these taxa by the authors, I came to the conclusion that *A. lomesum* B.K.Nayar & Geev. and *A. nagnam* B.K.Nayar & Geev. are minor variants of *A. caudatum* L. and *A. zollingeri* Mett. *ex* Kuhn respectively and do not deserve species status. Hence they are reduced as *A. caudatum* L. and *A. zollingeri* Mett. *ex* Kuhn, respectively.

Vasudeva *et al.* (1991) report the occurrence of 23 species of *Adiantum* in India. This also appears to be not fully correct. For example, the report of occurrence of *A. formosum* R.Br. in India is based on a collection of the taxon from Salem Dt., Yecaud by Ghatak, deposited at CAL. But so far there is no other report of its occurrence either from South India, or anywhere in the country. Subramanyam *et al.* (1960) who explored this locality did not collect *A. formosum*. Dixit (1984) did not include this species in his *Census of Indian Pteridophytes*. Eventhough Chandra (2000a) included this species in his *Ferns of India*, as occurring in South India, it is

definitely based on the report of Vasudeva *et al.* (1991). I visited the locality but could not locate this taxon. I examined the material at CAL (Tamil Nadu: Salem Dt., Cascates Bunglow behind chapel, Yercaud, *Ghatak G 257*). It is very clearly stated by the collector that it is a cultivated species and not naturalized. Vasudeva *et al.* (1991) give South Indian mountains as the area of distribution of *A. edgeworthii* Hook. But the list of specimens examined has no specimen from South India. Not only that, there is no other report of its occurrence in South India. Dixit (1984) and Chandra (2000a) give only North India as its area of distribution in India. Hence it may, probably, be a mistake from the part of the authors.

The report of occurrence of *A. soboliferum* Wall. *ex* Hook. in South India by Dixit (1984) and Chandra (2000a) is based on the collection of it from Travancore mountains by Beddome (1883) in the name of *A. lunulatum* var. *mettenii* (Kuhn) Bedd. Nair *et al.* (1992) report that "no one else seems to have collected this species after Beddome'. There is no specimen of it at CAL or MH or any other major Indian herbarium (Vasudeva *et al.*, 1991). I explored the area at three different seasons during the course of this study, but could not collect this species. Hence it is probable that this species might have been eliminated from this locality and hence it is excluded from the present study.

Although Ghatak (1963) reports Kannikatti and Mundanthurai of Tamil Nadu, South India also as the places of distribution of *A. indicum* Ghatak, there is no other report of its occurrence in South India except perhaps that of Madhusoodanan and Sevichan (1991). Dixit (1984) and Chandra (2000a) include *A. indicum* Ghatak in their enumeration, but do not include South India as its area of distribution. Vasudeva *et al.* (1991) also consider *A. indicum* Ghatak as occurring only in Eastern India and state that they could not work out this species as the specimen of it is not available in any major Indian Herbarium. Madhusoodanan and Sevichan's (1991) report of occurrence of *A. indicum* in Kerala is based on a few herbarium specimens lodged at Calicut University Herbarium (CALI). But a detailed examination of the specimens cited by them as *A. indicum* Ghatak, proved that these are specimens of *A. incisum* Forssk. with comparatively fewer number of hairs (some hairs might have been lost during drying and storage) and not *A. indicum* Ghatak. Recently Kurup *et al.* (2001) reported the naturalization of *A. tenerum* Sw. in Kerala and hence it is included in this study. The species of *Adiantum* naturally occurring in South India and hence included in this study are *A. capillus-veneris* L., *A. caudatum* L., *A. concinnum* Humb. & Bonpl.

ex Willd., *A. hispidulum* Sw., *A. incisum* Forssk., *A. latifolium* Lam., *A. philippense* L., *A. poiretii* Wikstr., *A. raddianum* C.Presl, *A. tenerum* Sw. and *A. zollingeri* Mett. *ex* Kuhn.

Key to Species

1a.	Lamina unipinnate; rachis usually extended at the tip bearing a vegetative bud (walking habit)	2
1b.	Lamina more than one pinnate; rachis not extended; no terminal vegetative bud	5
2a.	Stipe and rachis glabrous; leaflets stalked	*A. philippense*
2b.	Stipe and rachis hairy; leaflets sessile or subsessile	3
3a.	Leaflets prominently striate, hairy on both surfaces, on lower surface fewer number of long pluricellular brown hairs mixed with abundant short, white, unicellular hamate hairs; veins raised on upper side	*A. caudatum*
3b.	Leaflets not prominently striate, hairy or glabrous on one or both surfaces; if hairy, only pluricellular ferruginous hairs and no white unicellular hamate hairs; veins not raised	4
4a.	Stipe and rachis densely hairy through out; leaflets hairy on both surfaces	*A. incisum*
4b.	Stipe and rachis hairy on upper side only, lower side glabrous; pinnae glabrous on both surfaces or with very sparse hairs on lower side	*A. zollingeri*
5a.	Stipe, rachis and leaflets hairy	6
5b.	Stipe, rachis and leaflets glabrous	7
6a.	Rhizome short creeping; frond pedately divided or dichotomously branched; terminal leaflet similar to lateral ones	*A. hispidulum*
6b.	Rhizome long creeping; frond bearing 1-3 pairs of alternate widely spaced pinnae; terminal leaflet dissimilar to lateral ones	*A. latifolium*
7a.	Margin of sterile segments with veins ending in teeth	8

7b.	Margin of sterile segments with veins ending in the sinus between two teeth	9
8a.	Palea highly fimbriate; fronds 3-4 pinnate; pinnules articulated, deciduous; stalk ends in a black disc, from which 2 or more pale green primary veins emerge	*A. tenerum*
8b.	Palea smooth; fronds 2-pinnate; pinnules not articulated, not deciduous; stalk continues into 2 reddish-brown primary veins	*A. capillus-veneris*
9a.	Lower most upper leaflet of pinnae overlapping the main rachis; lamina 3-pinnate, oblong-lanceolate	*A. concinnum*
9b.	Lower most upper leaflet of pinnae not overlapping the main rachis; lamina 4 or more pinnate, deltoid-ovate	10
10a.	Rhizome short creeping; stipes clustered; leaflets with cuneate base, not articulated, not deciduous; sori orbicular to suborbicular	*A. raddianum*
10b.	Rhizome long creeping; stipes widely spaced; leaflets mostly with broadly cuneate to reniform bases, articulated, becoming deciduous with age leaving the base; leaf stalk attached to the rachis of old fronds; sori oblong to lunate	*A. poiretii*

Adiantum capillus-veneris L., Sp. Pl. 2. 1096. 1753; Bedd., Ferns S. India 2. pl. 1863 & Handb. Ferns Brit. India 84. 1883; B.K.Nayar & S.Kaur, Comp. Bedd. Handb. 23. 1974; R.D.Dixit, Census Indian Pterid. 74. 1984; Manickam, Fern Fl. Palni Hills 39. 1984; S.Chandra & S.Kaur, Nomen. Guide Bedd. Ferns S. India & Ferns Brit. India 1. 1987; Madhus. & Sevichan, J. Econ. Taxon. Bot. 15: 150. 1991; S.M.Vasudeva *et al.*, Indian Fern J. 8: 164. 1991; Manickam & Irud., Pterid. Fl. W. Ghats 103. pl. 79. 1992; N.C.Nair *et al.*, J. Econ. Taxon. Bot. 16: 274. 1992; B.K.Nayar & Geev., Fern Fl. Malabar 135. 1993; Fraser-Jenk., New Sp. Syndr. Indian Pterid. Ferns Nepal 31. 1997; Rajagopal & Bhat, Indian Fern J. 15: 10. 1998; S.Chandra, Ferns India 66. 2000. (**Fig. 2A & 3**).

Type: locality unknown. *Magnol s.n.*

Lectotype: Specimen 1252.9 of the Linnean Herbarium (LINN).

Adiantum coriandrifolium Lam., Fl. Franc. 1: 29. 1778.

Adiantum fontanum Salisb., Prod. Stir. Chapel 404. 1796.

Adiantum capillus Sw., Schrad. J. Bot. 1800: 3. 1801.

Adiantum affine Willd., Sp. Pl. 5(1): 448. 1810.

Adiantum emarginatum Bory in Willd., Sp. Pl. 5: 449. 1810.

Adiantum cuneifolium Stokes, Bot. Mat. Med. 4: 612. 1812.

Adiantum africanum R.Br. in Turkey, Narrat. Exped. Zaire. App. 5: 463. 1818.

Adiantum tenerum Buch., Abh. Akad. Berlin 1816-17: 360. 1819, *non* Sw., 1788, *nec.* Schkuhr., 1809.

Adiantum moritzianum Link, Fil. Sp. 71. 1841.

Adiantum pseudo-capillus Fee, Gen. Fil. 118. 1852.

Adiantum trifidum Willd. *ex* Fee, Gen Fil. 114. 1852.

Adiantum capillaceum Dulac, Fl. Hautes-Pyrenees 36. 1867.

Adiantum visianii Schloss. & Vuk., Fl. Croat. 1319. 1869.

Adiantum wattii Baker, J. Linn. Soc. 18. 381. t. 14. f. A. 1881; R.D.Dixit, Census Indian Pterid. 76. 1984; S.M.Vasudeva *et al.*, Indian Fern J. 8: 168. 1991; S.Chandra, Ferns India 75. 2000.

Adiantum capillus-veneris var. *wattii* (Baker) Bedd., Suppl. Ferns Brit. India 18. 1892; B.K.Nayar & S.Kaur, Comp. Bedd. Handb. 23. 1974.

Adiantum michelii Christ., Bull. Geor. Bot. Mans. 12. 1910.

Adiantum capillus-veneris L. var. *dissecta* B.K.Nayar, Bull. Nat. Bot. Gard. 52: 26. 1961; R.D.Dixit, Census Indian Pterid. 74. 1984.

Rhizome creeping, rarely branched, 3-5 cm thick, covered with dense paleae and wiry roots with brownish persistent root hairs, 0.6 mm long. Paleae 3 x 0.75 mm, lanceolate, concolorous, deep brown to black, with a terminal acicular cell with entire margin; reduced scales resembling pluricellular hairs (uniseriate or basally biseriate) are common among paleae. Fronds 0.5–1 cm apart, erect or spreading (or hanging down when growing on walls or earth cuttings), 40 x 15 cm, bipinnate; stipes 22 cm long, 1 mm thick, equal to or longer than lamina, deep brown to black, paleate at base, glabrous and glossy above, shallowly grooved adaxially; lamina 18 x 15 cm, deltoid-ovate with a terminal leaf-let, bipinnate or some times tri-pinnate towards the lower part, but gradually single pinnate distally and ending in 4–5 pairs of lateral lobed pinnae; primary pinnae 5-8, loosely arranged, alternate and distantly placed,

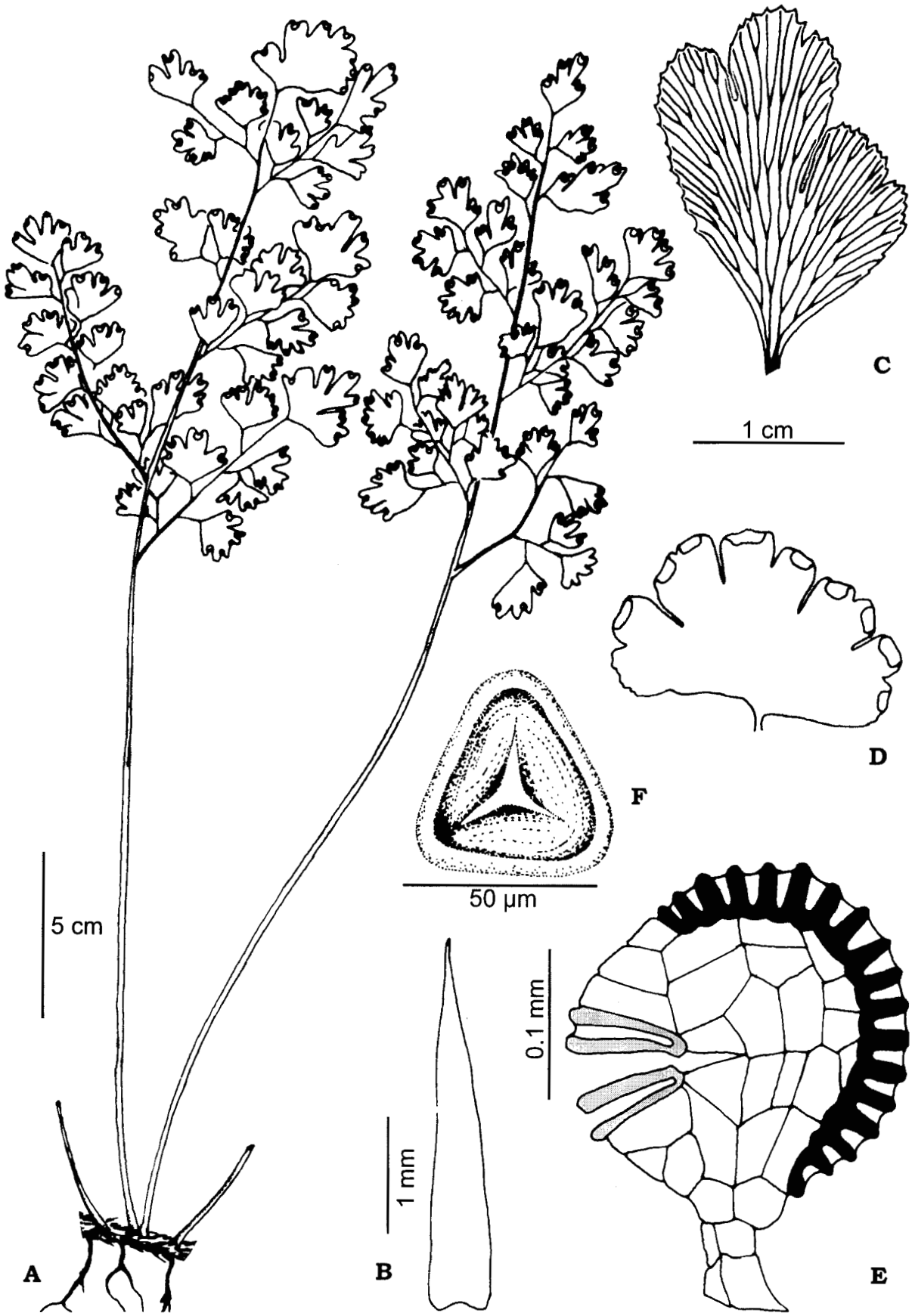

Fig. 2. Adiantum capillus-veneris: **A**- Habit, **B**- Palea, **C**- Sterile pinnule, **D**- Fertile pinnule, **E**- Sporangium, **F**- Spore (from *Madhusoodanan CU 21326*).

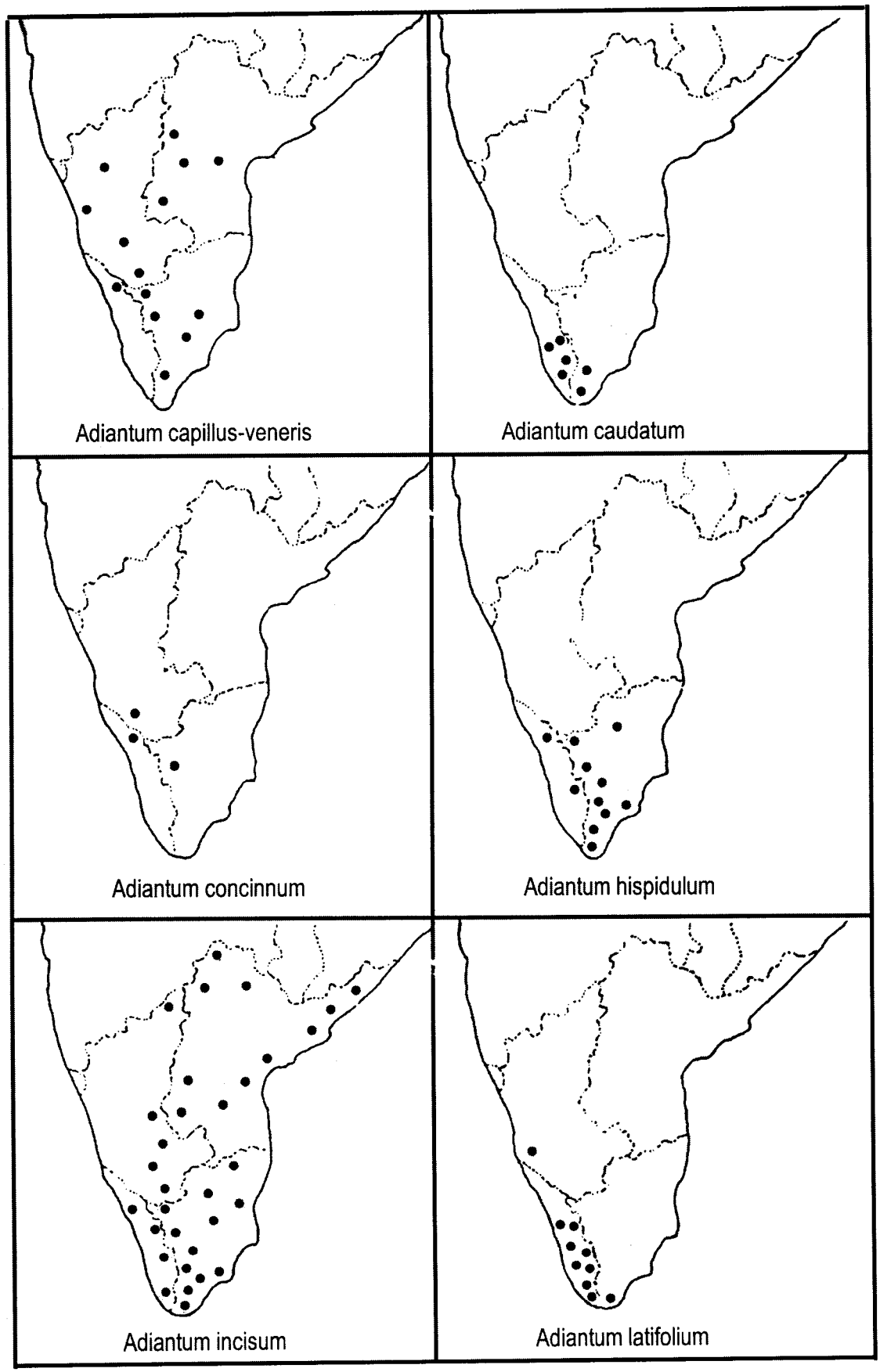

Fig. 3. Distribution of Adiantum capillus-veneris, A. caudatum, A. concinnum, A. hispidulum, A. incisum and A. latifolium in Southern India.

variable in size; lowest pinnae longest, 9 x 4 cm; lowest one or two primary pinnae bipinnate; other pinnate primary pinnae simple pinnate; primary rachis as stipe, flexuous and wiry; secondary rachises very thin, slightly flexuous and shallowly grooved on the upper side; all primary and secondary pinnae as well as primary rachis end in a terminal pinnule which is comparatively larger, sub-deltoid with a cuneate base and concave lower margins and are more deeply lobed on the outer margin. Pinnules distinctly stalked; stalk 3-5 mm long, wiry, black, non-articulated; lateral pinnules 2 x 1.5 cm, flabellate or sub-dimidiate, base broadly cuneate or attenuate; outer margin lobed 1/3 to 1/2 deep into 3-5 primary lobes, each of which again divided into two segments; all the lobes are having smooth lateral margins and a finely serrate–dentate outer margin; pinnules glabrous on both sides, light green and herbaceous. Veins distinct on both surfaces, open dichotomous, 5-6 times forked, veins of first dichotomy reddish brown, the rest pale green; ultimate veinlets terminating in the marginal teeth. Sori 6-10 per pinnule, one each in ultimate lobes, transversely elongated, 2-3 x 1 mm, reflexed margin (pseudo-indusium) entire. Sporangia small, short stalked; stalk two rowed; annulus 16-18 cells long. Spores 40 x 50 μm, trilete, tetrahedral; exine smooth.

Chromosome numbers: n = 30, diploid sexual (Manton & Sledge, 1954; Roy & Sinha, 1958; Mehra & Verma, 1960; Verma & Loyal, 1960a; Kurita, 1965; Mitui, 1965; Verma & Khullar, 1965; Kuriachan, 1968; Singh & Roy, 1969; Sinha & Verma, 1977; Verma, 1978a; Bir & Vasudeva, 1979; Mahabale & Kamble, 1981; Vasudeva & Bir, 1982; Kato *et al.,* 1992; Bir *et al.,* 1996).

Distribution and Ecology: *Adiantum capillus-veneris* is having a limited distribution in South India, but widely distributed in North India. Also occurs in Africa, Australia, southern North America, Amazon region of South America, Bhutan, Nepal, Pakistan and Sri Lanka. It grows terrestrially or lithophytically in moist shaded places close to stream or dripping rocks.

Note: As *Adiantum capillus-veneris* grows in great altitudinal ranges (300– 2000 m), there is great variation in frond size, pinnation, extent of serration and lobing of the outer margin. Consequently, on the basis of size factor of fronds, Verma and Khullar (1965) recognized three different forms of plants, *ie.,* small sized (5-8 cm), medium sized (10-20 cm) and large sized (more than 30 cm). Despite this size variation, *A. capillus-veneris* is a diploid sexual (x = 30) exhibiting extremely uniform cytological

status through out India (Bir *et al.*, 1996). It appears that specimens of Kerala and Tamil Nadu are large sized, but those of Andhra Pradesh and Karnataka are small and medium sized.

Specimens examined: **ANDHRA PRADESH**: Ananthapur Dt., Mobbukona, *Pullaiah 960*; Yadiki R.F., *Pullaiah 494* (SKU). Kurnool Dt., Gundam, *Pullaiah & Raju 3004*; Rangapuram, *Raju 1484*; Yaganti, *Ahamed 13503* (SKU). Mahaboobnagar Dt., Banaloddi, *Kumar 15355* (SKU). Prakasam Dt., Bainnachela, Nallamalais, *R.K.Mohanan 858* (CAL). **KARNATAKA**: Dharwad Dt., Dharwad, *Rajagopal 648* (MGMC). Udupi Dt., Kudluthirta, *Bhat 794* (MGMC). **KERALA**: Wayanad Dt., Lakkidi, *Madhusoodanan 21326* (CALI). **TAMIL NADU**: Coimbatore Dt., banks of Noyil river, *Fischer 2670* (CAL); Valparai, *Manickam 1983* (XCH). Madurai Dt., Ganguvarpatti, *Sebastine 12641* (CAL). Nilgiris Dt., Coonoor, *Manickam 809* (XCH); Kulhati, *Levinge s.n.*; Leeck falls, *Gamble 12151* (CAL). Tiruchirappalli Dt., foot of Pachamalai, *Sebastine 6300* (CAL). Tirunelveli Dt., Thercumalai, Courtallum, *Subramanyam 2916* (CAL).

Adiantum caudatum L., Mant. 308. 1771; d'Almeida, J. Indian Bot. Soc. 5: 22. 1926; B.K.Nayar, Bull. Nat. Bot. Gard. 52: 6. 1961; Subramanyam *et al.*, Bull. Bot. Surv. India 3: 210. 1961; Raju, Bull. Bot. Surv. India 6: 189. 1964; B.K.Nayar & S.Kaur, Comp. Bedd. Handb. 23. 1974; R.D.Dixit, Census Indian Pterid. 74. 1984; S.M.Vasudeva *et al.*, Indian Fern J. 8: 174. 1991; Manickam & Irud., Pterid. Fl. W. Ghats 96. pl. 71. 1992; N.C.Nair *et al.*, J. Econ. Taxon. Bot. 16: 272. 1992; B.K.Nayar & Geev., Fern Fl. Malabar 136 (excluding fig. 41, p. 141). 1993; S.Chandra, Ferns India 67. 2000. (**Fig. 3, 4A-H, 5a & b**).

Type: Ceylon, Burmann, Zeyl. 8. t. 5. f.1. (LINN)

Adiantum hirsutum Bory, Voy. 1. 198. 1804.

Adiantum ciliatum Blume, Enum. 215. 1828.

Adiantum flagelliferum Wall., Num. List no. 76. 1828, *nom. nud.*

Adiantum vestitum Wall., Num. List no. 75. 1828, *nom. nud.*

Adiantum proliferum Roxb., Calc. J. 4: 512. 1844.

Capillus gorgonis Webb. in Hook., Niger Fl. 192. 1849.

Adiatnum radicans Fee, Gen. Fil. 118. t. 29. f. 2. 1852.

Adiantum borneense Gand., Bull. Soc. Fr. 66: 305. 1919.

Adiantum lomesum B.K.Nayar & Geev., Fern Fl. Malabar 140. 1993.

Rhizome erect, 1 x 0.5-1 cm, unbranched, covered with persistent leaf bases and dense paleae towards the apex and a tuft of fibrous roots towards the base. Paleae 4-4.5 x 0.3-0.4 mm, linear-lanceolate, bicolorous with a central dark brown broad sclerotic region and outer narrow pale brown thin walled margins, acicular, ending in a single cell with pointed end; margin entire. Fronds 8-10, tufted, spreading and arching over, 30-50 x 3-3.5 cm, simple pinnate, commonly ending in a leafless prolonged rachis with a terminal vegetative bud which when touches the soil, develops into a daughter plant (walking habit) or rarely ending in a terminal fan shaped leaf-let with cuneate base; stipe 12-15 cm long, 1-1.5 mm thick, dark brown, slightly grooved on the upper side, densely paleate at base, densely covered by long pale brown multicellular hairs through out; hairs uniseriate, 2-3 cells long, basal cell dark brown, others paler; lamina 20–30 cm including leafless part, 3-3.5 cm wide, unipinnate, oblong-lanceolate, gradually tapering to a long narrow end; rachis similar to stipe, densely covered with shorter hairs on upper side and less dense, longer hairs on lower side; pinna almost sessile, attached to the rachis by a pointed base, 40-50 pairs, alternate and closely placed, dimidiate, largest pinna 1.5-2 x 0.5-0.7 cm, gradually become smaller and widely spaced towards the tip of the lamina; basal few pinnae some times smaller and often reflexed; upper base of pinnae generally truncate, lower margin straight or slightly convex, smooth, upper margin convex, regularly dissected 1/2 to 2/3 deep into narrow truncated 5-6 primary lobes; sinuses narrow; primary lobes again shallowly lobed into 2 or 3; ultimate margin broadly crenate in sterile pinnae, each tooth getting a veinlet; pinna strongly striate on upper surface, less striate on lower surface, hairy on both surfaces with 1-1.25 mm long, 3-4 celled (rarely 5 celled) pluricellular, ferrugineous hairs on upper surface and with a fewer number of such hairs mixed with dense small white, 0.2- 0.25 mm long unicellular (or rarely 2-celled) hamate or rarely straight hairs on lower surface. Veins very prominent on upper surface, free, distinct, open dichotomous, 5-6 times forked, ultimate veinlet reaching the marginal tooth of pinna. Sori marginal, 12-15 per pinna, one per each secondary lobe; reflexed margin small, more broad than long, ovate or orbicular and densely hairy on out side. Sporangia 0.35 mm long, stalked; stalk shorter than capsule, 3 seriate, 2 cells long; capsule spherical; annulus 15-16 cells long. Spores 35 x 40 μm, trilete, tetrahedral; exine smooth.

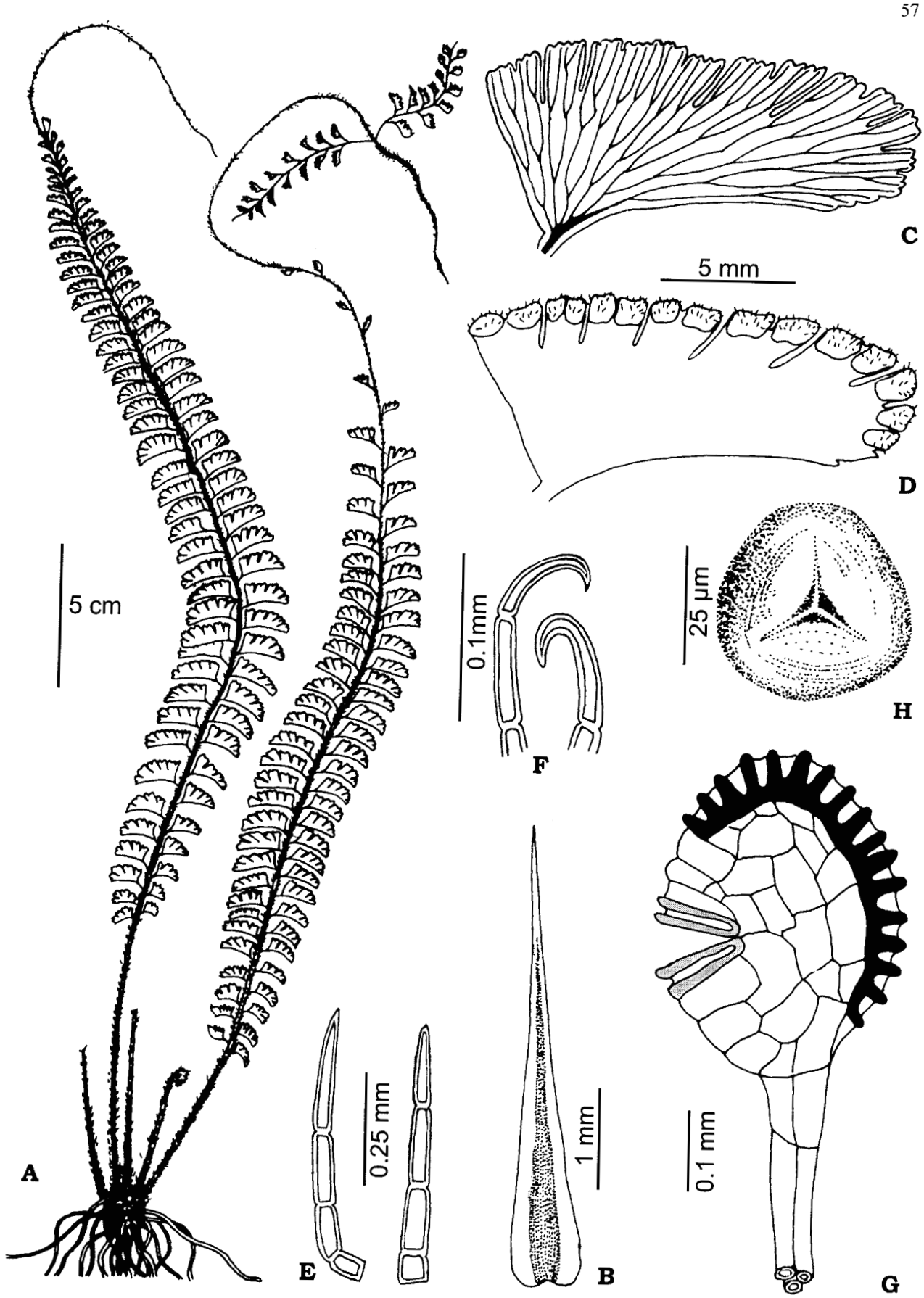

Fig. 4. **Adiantum caudatum**: **A**- Habit, **B**- Palea, **C**- Sterile pinna, **D**- Fertile pinna, **E**- Pluricellualar hairs on pinna, **F**- Hamate hairs on lower side of pinna, **G**- Sporangium, **H**- Spore (from *Mohanakurup CU 52826*).

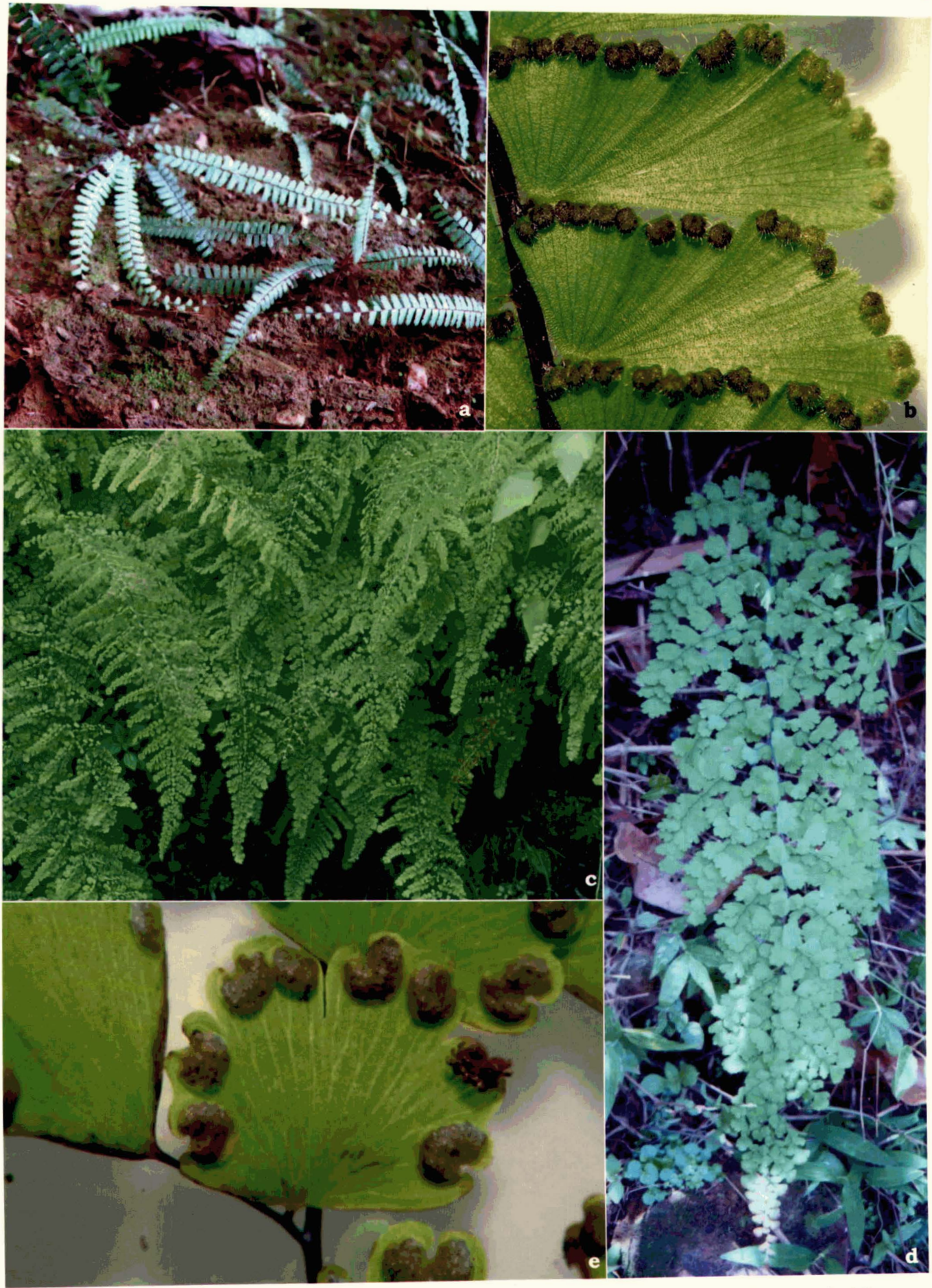

Fig. 5. a. Adiantum caudatum- habit, **b**. part of fertile pinna; **c.& d. A. concinnum**- habits, **e**. a fertile pinnule.

Chromosome numbers: n = 60, tetraploid sexual (Manton & Sledge, 1954); n =2n = 60, diploid apogamous (Verma in Mehra, 1961); n = 2n = 90, triploid apogamous (Verma in Mehra, 1961; Abraham *et al.*, 1962; Mathew in Kuriachan & Ninan, 1976).

Distribution and Ecology: In India *Adiantum caudatum* is largely restricted to some parts of North-Eastern India and southern districts of Kerala and Tamil Nadu in South India. It also occurs in tropical Africa, China, Malay Peninsula, Myanmar, Nepal, Philippines, Sri Lanka, Taiwan and Thailand. It prefers fully exposed dry places along road sides, earth banks or ground in lower altitudes (between 100-900 m). In dry weather the fronds curl up.

Notes: 1. Beddome's (*Ferns of Southern India* p. 1. pl. 2. 1863) figure of *Adiantum caudatum* is in fact *A. incisum* Forssk. The diagram given by Nayar and Geevarghese (Fern Fl. Malabar p. 141. 1993) as *A. caudatum* is a copy of that of Beddome (*l.c.*).

2. The true *A. caudatum* is a triploid apogamous, n = 2n = 90 (Manton & Sledge, 1954). According to Verma and Khullar (1965), the report of a diploid sexual cytotype of *A. caudatum* from South India by Abraham *et al.* (1962) may be *A. incisum.*

Specimens examined: **KERALA**: Idukki Dt., Pindimedu, Pooyamkutty, *Bhargavan 87406* (CAL); Ramakkalmedu, *Mohanakurup 73144, 73161* (CALI); banks of Thannikudithode, *Nair 70172;* Thekkady, *Puri 36787* (CAL), *Rajesh 70101* (CALI). Kollam Dt., Angadi, Ranni, *Nair 50702*; Aryankavu, *Nair & Ghosh 50683*; Kottarakkara, *Nair 50993*; Kulathupuzha, *Nair 50636* (CAL); Palaruvi, *Nair & Ghosh 51992, Ramarao 1756*; Ranni, *Nair 942* (CAL); Thenmala, *Mohanakurup 52856, 52859* (CALI). Kottayam Dt., Edamaruku, *Mohanakurup 52826* (CALI); Kanjirapally, *Manickam 33542*; Meenachil, *Manickam & Mathew 34587* (XCH); Thikoy, *Mohanakurup 52828* (CALI). Pathanamthitta Dt., Pathanamthitta, *Nair 50604;* Vennikulam, Thiruvella, *Nair 50836* (CAL). Thiruvanathapuram Dt., Aruvikkara, *M.Mohanan 63862* (CAL); Kallar, *Madhusoodanan 43864* (CALI), *Nair & Ghosh 51080*; on the way from Kallar to Ponmudi, *Nair & Ghosh 51761* (CAL); Nedumangad, *Manickam & Mathew 33698* (XCH); way to Neyyar dam, *Nair & Ghosh 51575*; way to Ponmudi from Kallar, *M.Mohanan 54756* (CAL); Ponmudi hills, *Manickam & Mathew 31346* (XCH); Puthukad, Ponmudi, *Nair & Ghosh 51879* (CAL). **TAMIL NADU:** Kanniya Kumari Dt., Balmore, *Manickam 2526* (XCH); Kalikesam river side, *Henry 48153* (CAL); Keeriparai, *Mohanakurup 52840, 73132* (CALI), *Nair &*

Ghosh 51913, 51917, 51921, 52620 (CAL); Kothayar hills, *Manickam 3571* (XCH); Kulasekharam, *Manickam 14591*; Pechiparai hills, *Manickam 14592*; Thovalai, *Manickam 33868* (XCH). Tirunelveli Dt., near five falls, Courtallum, *Subramanyam 2933* (CAL); Kannikatti, *Manickam 31805* (XCH); way to Kannikatti, *Sebastine 8478* (CAL).

Adiantum concinnum Humb. & Bonpl. *ex* Willd., Sp. Pl. 5: 451. 1810; Manickam & Irud., Pterid. Fl. W. Ghats 100. pl. 76. 1992; Fraser-Jenk., New Sp. Syndr. Indian Pterid. Ferns Nepal 35. 1997; S.Chandra, Ferns India 67. 2000. (**Fig. 3, 5c-e, 6A-F, 7**).

Syntype: Venezuela, Caracas, "Cunama"; *Humboldt & Bonpland s.n.* (B)

Adiantum tenerum Schkuhr., Kr. Gew. 1. 112. t. 121. 1809, *non* Sw., 1788.

Adiantum affine Mart. & Galeotti, Mem. A. Brux. 15: 70. 1842, *non* Willd., 1810.

Adiantum lutescens Moug. *ex* Fee, Gen Fil. 119. 1852.

Adiantum capillus-veneris sensu B.K.Nayar, Bull. Nat. Bot. Gard. 52: 25. 1961.

Adiantum ramyam B.K.Nayar & Geev., Bull. Bot. Surv. India 28: 133. 1986; B.K.Nayar & Geev., Fern Fl. Malabar 145. f. 37 & 38. 1993.

Rhizome erect or sub-erect, 1.5-2 cm thick, unbranched, covered with persistent leaf bases and dense paleae especially towards the apex. Palea 4-4.5 x 1 mm, lanceolate, concolorous, yellowish-brown, acuminate with entire margin. Fronds tufted, 8-10, spreading or hanging down as the plant usually grows in earth cuttings, 40-70 x 20-25 cm, broadly lanceolate; stipe 15-30 cm long, 1.5-2 mm thick, dark brown, terete with shallow groove on upper side, densely scaly at base, glabrous and glossy above; lamina 50-60 x 20-25 cm, tripinnate, broadly lanceolate; rachis black, glabrous and glossy bearing primary pinnae on alternmate sides, distally flexuous; primary pinnae 2-3 cm apart, the basal 1-2 pairs slightly shorter than others, gradually tapering to a simply pinnate terminal region; largest primary pinna 20 x 5 cm, oblong-lanceolate; main rachis and its branches ending in a terminal ultimate pinnule which is larger than the rest with a cuneate base; 10-12 pairs of basal primary pinnae 1 or 2 pinnate, the rest simple; secondary rachis similar to primary rachis, flexuous, bearing 8-10 alternate pairs of secondary pinnae; basal most secondary pinna is simple or with two or three pinnules, lower most of which is larger than other pinnules, sub-deltoid with almost truncate base, overlapping the main

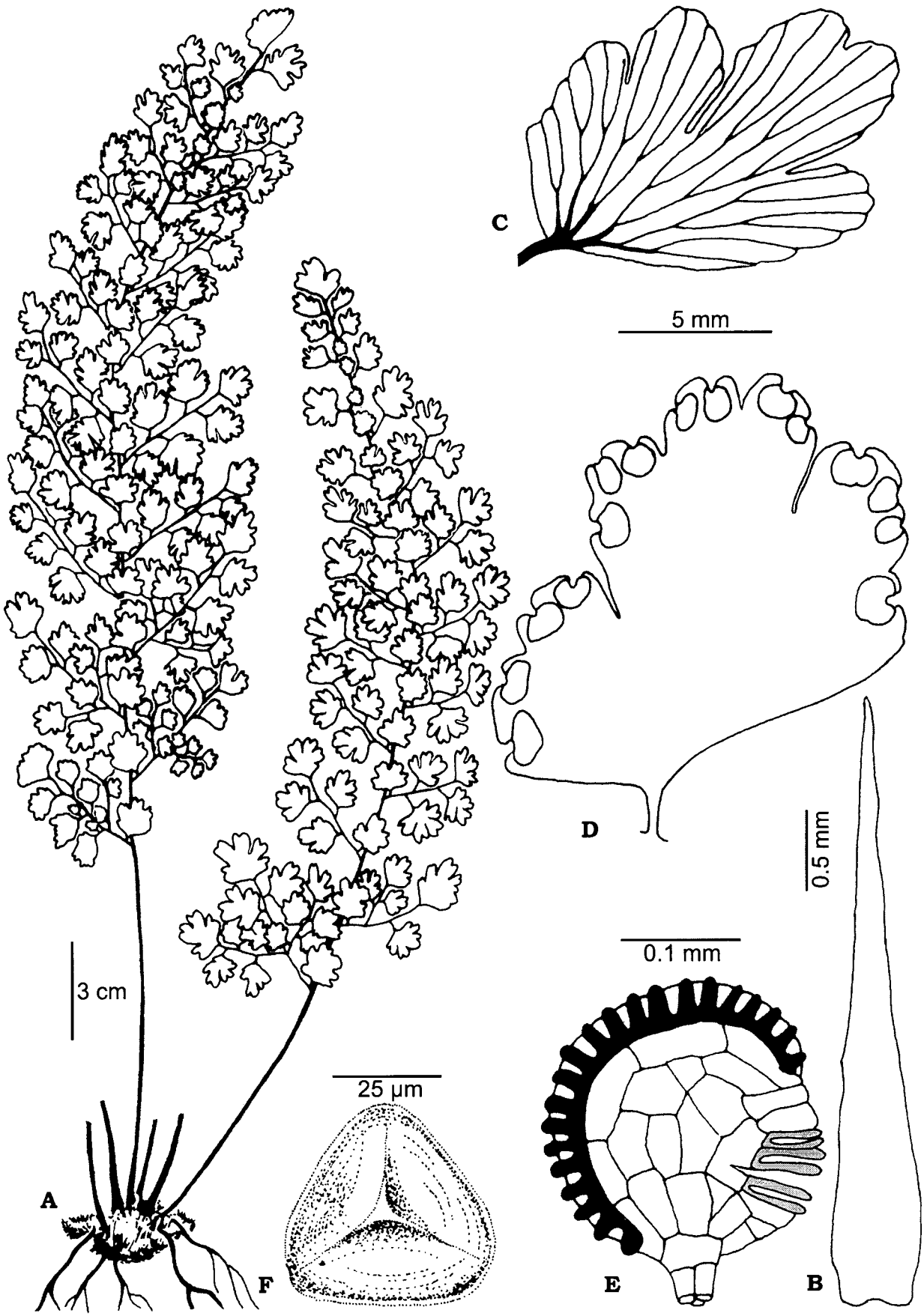

Fig. 6. Adiantum concinnum: **A**- Habit, **B**- Palea, **C**- Sterile pinnule, **D**- Fertile pinnule, **E**- Sporangium, **F**- Spore (from *Mohanakurup CU 52862*).

Fig. 7. Type specimen of Adiantum concinnum: digital image kindly provided by Dr. B. Zimmer, Botanisches Museum, Berlin-Dahlem, Germany.

rachis; other secondary pinnae pinnate; largest secondary pinna 4-5 cm long; lateral pinnules dimidiate,1.5 x 1 cm, shortly stalked; stalk 2-3 mm long, inner and basal margins smooth, upper margin deeply lobed into 3-4 primary lobes which are again shallowly lobed once or twice; ultimate lobes toothed; pinnules glabrous on both surfaces and herbaceous. Veins distinct on both surfaces, open dichotomous, 5-6 times forked; ultimate veinlets ending in the sinuses between marginal teeth. Sori all along the outer and upper margins, 12-15 per pinnule, two in each ultimate lobe, oblong or orbicular with a shallow notch on the outer margin, 1.5 mm across, reflexed margin entire and glabrous on both surfaces. Sporangia sub-sessile, globose; annulus 20 cells long. Spores 40 x 50 μm, trilete, tetrahedral; exine smooth.

Chromosome number: n = 60, tetraploid sexual (Sorsa in Fabri, 1965).

Distribution and Ecology: In India *Adiantum concinnum* is reported only from South India, where it is having a restricted distribution, occurring only in Kodagu and Shimoga Districts of Karnataka, Wayanad District of Kerala and Coimbatore District of Tamil Nadu. It is also reported from Mexico to Peru, Sri Lanka and West Indies. It forms dense colonies on moist semi-shaded earth cuttings along road sides above 500 m.

Note: *A. concinnum* is closely related to *A. raddianum,* but can be easily distinguished from the latter because of having the basal leaflet of each primary pinna much larger than the rest and overlaps the main rachis.

Specimens examined: **KARNATAKA**: Kodagu Dt., Bhagmandala, *Manickam 2776* (XCH); Kakkabbe, *Rajagopal 475*; Kodavaravalli, *Rajagopal 504*; Madikeri, *Rajagopal 180* (MGMC); Sampaje-Somerpet road, *Manickam 2893* (XCH). Shimoga Dt., Kundadri hill, *Rajagopal 164* (MGMC). **KERALA**: Wayanad Dt., Lakkidi, *Madhusoodanan 21326, Mohanakurup 52871*; Meppadi, *Mohanakurup 52862*; Muthanga, *Pradeep 43879*; Pookode, *Mohanakurup 52810, 52836*; Thamarassery ghat road, *Geevarghese 4160*; Vythiri, *Madhusoodanan 7225* (CALI). **TAMIL NADU**: Coimbatore Dt., Anamalai hills, *Mathew 31562*; Sholayar, *Manickam 2292*; Valparai, *Manickam 2027* (XCH).

Adiantum hispidulum Sw., Schrad. J. 1800 (2): 82. 1801; Bedd., Ferns S. India 1. pl. 3. 1863 & Handb. Ferns Brit. India 86. 1883; Subramanyam *et al.*, Bull. Bot. Surv. India 2: 325. 1960; B.K.Nayar, Bull. Nat. Bot Gard. 52: 10. 1961; Subramanyam *et al.*, Bull. Bot. Surv. India 3: 210. 1961; R.D.Dixit, Census

Indian Pterid. 75. 1984; Manickam, Fern Fl. Palni Hills 37. 1986; Madhus. & Sevichan, J. Econ. Taxon. Bot. 15: 147. 1991; Manickam & Irud., Pterid. Fl. W. Ghats 99. pl. 75. 1992; N.C.Nair *et al.*, J. Econ. Taxon. Bot. 16: 275. 1992; B.K.Nayar & Geev., Fern Fl. Malabar 144. 1993; Rajagopal & Bhat, Indian Fern J. 15: 10. 1998; S.Chandra, Ferns India 69. 2000. (**3, 8A-G, 9a 7 b**).

Type: Australia (S).

Adiantum pedatum G.Forst., Prod. 83. 1786, *non* L., 1753.

Adiantum nervosum Sw., Syn. Fil. 123. 1806.

Adiantum pubescens Schkuhr., Kr. Gew. 1: 108. t. 116. 1809; B.K.Nayar & S.Kaur, Comp. Bedd. Handb. 24. 1974; S.Chandra & S.Kaur, Nomen. Guide Bedd. Ferns S. India & Ferns Brit. India 1. 1987; S.M.Vasudeva *et al.*, Indian Fern J. 8: 170. 1991; B.K.Nayar & Geev., Fern Fl. Malabar 144. f. 40. 1993.

Adiantum scabrum Wall., Num. List no. 79. 1828, *nom. nud.*

Adiantum flabellulatum Wall., Num. List no. 2177. 1829, *nom. nud., non* L., 1753.

Adiantum meyerianum Zoll., Nat. Gen. Arch. 2: 204. 1845.

Adiantum lobulatum Kunze *ex* Ettingsh., Farnkr. 82. f. 32. t. 47. f. 7. 1865.

Adiantum rigidum E.Fourn., Ann SC. Nat. V. 18: 329. 1873.

Rhizome erect or sub-erect, 5-7 mm thick, sparsely branched, covered with wiry roots, persistent leaf bases and dense paleae. Palea 3-3.5 x 0.5-1 mm, linear-lanceolate, dark brown, concolorous, ending in an acicular cell with entire margin. Fronds tufted, 8-10, 40-50 x 15-20 cm, erect, pedate; stipe 25-30 cm long, 1-2 mm thick, black, shallowly grooved above, densely paleate at base, densely covered with 2-3 cells long, uniseriate, dark brown hairs above; lamina 15-30 x 10-15 cm, broadly ovate to obovate, dichotomously divided, 3-4 times forked, basal dichotomy unequal, each primary branch forks againto form an outer branch forking once or twice again and an inner branch which does not fork, the outer most branches shortest and the inner most branches longest; the whole lamina 10-15 cm wide; branches of lamina pinnate with numerous pinnules alternately arranged which are gradually become smaller towards the tip; rachis similar to stipe, densely covered with brown hairs all along; pinnules shortly stalked; stalk 1-1.5 mm long, densely covered with hairs; pinnules 1-1.5 x 0.5-0.7 mm, dimidiate, cuneate at base, outer and upper margins irregularly dentate, hairy on both surfaces, less on upper surface, more on lower surface, hairs usually two celled. Veins prominent on upper surface, open

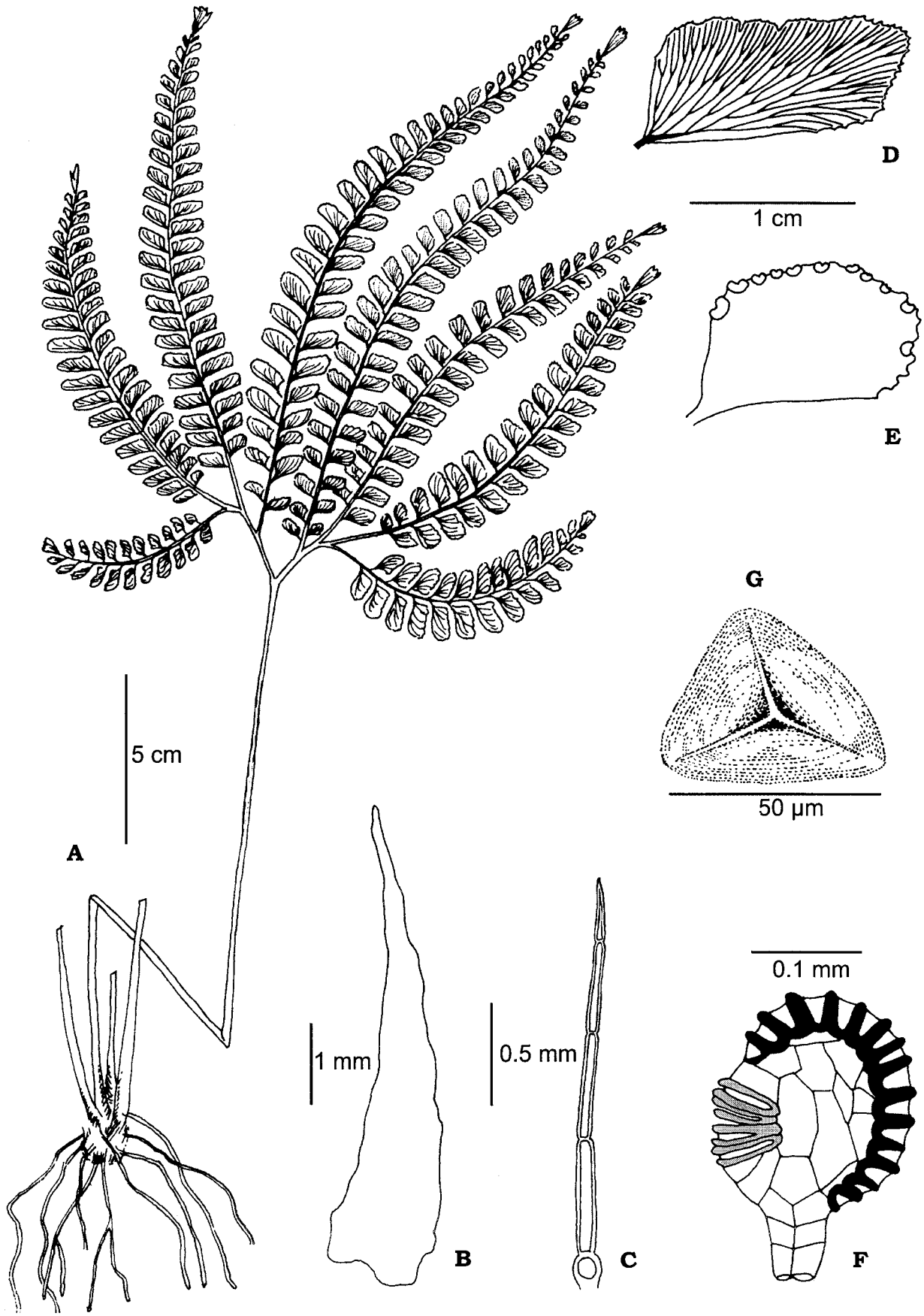

Fig. 8. Adiantum hispidulum: **A**- Habit, **B**- Palea, **C**- Hair on lower side of pinnule, **D**-Sterile pinnule, **E**- Fertile pinnule, **F**- Sporangium, **G**- Spore (from *Mohanakurup CU 52817*).

Fig. 9. a. Adiantum hispidulum- habit, **b.** part of fertile pinna; **c. A. incisum-** habit, **d.** part of fertile pinna; **e. A. latifolium-** habit, **f.** part of fertile pinna.

dichotomous, 5-6 times forked, each ultimate vein-let reaching the marginal tooth of pinnule. Sori all along the upper and outer margins, 10-12 per pinnule, oblong or crescent shaped; reflexed margin with shallow sinuses on the outer edge and bears numerous brown hairs on outer surface. Sporangia small, short stalked; annulus 15 cells long. Spores 40 x 45 μm, trilete, tetrahedral; exine smooth.

Chromosome numbers: n = 2n = 171, hexaploid apogamous (Manton & Sledge, 1954; Abraham *et al.,* 1962; Ghatak, 1977; Manickam & Irudayaraj, 1988).

Distribution and Ecology: *Adiantum hispidulum* is having a restricted distribution in India and occurs only in Kemmangundi of Karnataka, Idukki and Wayanad of Kerala and Kothayar, Nilgiri, Palni and Shevaroy hills of Tamil Nadu of southern India. It is also distributed in Africa, Australia, Fiji, Japan, Mauritius, New Zealand, Pacific Islands, Polynesia, Sri Lanka and Taiwan.

Specimens examined: **KERALA**: Idukki Dt., Kumali, *Madhusoodanan 43843* (CALI); Mlappara, *Augustine 12821* (CALI), *C.N.Mohanan 72810* (CAL, MH), *Nair 69883* (CAL); Peerumedu, *Raveendranathan 384* (CALI); Thekkady, *Sharma 42840* (MH). Wayanad Dt., Chembra peak, *Nayar & Madhusoodanan 21299* (CALI). **TAMIL NADU**: Coimbatore Dt., Attakkatti, *Joseph 12715* (CAL, MH); Tadagam hills, *Fischer 2677* (CAL). Dindigul Dt., Kodaikanal, *Manickam & Mathew 31134* (XCH); Sirumalai, *Chandrabose 54290* (MH). Kanniya Kumari Dt., Kothayar hills, *Manickam & Mathew 34762* (XCH); Panagudi, *Shetty 32319* (MH). Nilgiris Dt., Coonoor, *Sebastine 2148* (MH), *Madhusoodanan 21210* (CALI); Kottagiri, *Gamble 16715* (CAL); Lovedale, *Mohanakurup 73113*; Naduvattom, *Mohanakurup, 52808, 52817*; Ootty, *Devayani 20271, Sulekha 23284* (CALI); Pykara, *Bhargavan 87368* (MH). Ramanathapuram Dt., Muthaliaruthu, *Nair 60938*; Sethur hills, *Makali 68013* (CAL). Salem Dt., Yercaud, *Mohanakurup 52847* (CALI), *Nair 74246* (MH), *Sainaba 24468 (CALI).* Teni Dt., near Kumali, *Subramanyam 8226* (CAL). Tirunelveli Dt., Kalakkad, *Manickam & Mathew 31268* (XCH); Mancholai, *Sebastine 5864* (CAL, MH); Sengaltheri, *Vajravelu 2911* (MH); Upper Kothayar, *Mohanakurup 52849* (CALI). Virudunagar Dt., Nagariar estate, *Srinivasan 86983* (MH).

Adiantum incisum Forssk., Fl. Aeg. Arab. 187. 1775; B.K.Nayar & S.Kaur, Comp. Bedd. Handb. 23. 1974; N.C.Nair & R.D.Dixit, J. Bombay Nat. Hist. Soc. 78: 443. 1981; R.D.Dixit, Census Indian Pterid. 75. 1984; Manickam, Fern Fl. Palni hills 36. 1986; Madhus. & Sevichan, J. Econ. Taxon. Bot. 15: 146. 1991;

S.M.Vasudeva *et al.*, Indian Fern J. 8: 175. 1991; Manickam & Irud., Pterid. Fl. W. Ghats 97. pl. 72. 1992; N.C.Nair *et al.*, J. Econ. Taxon. Bot. 16: 273. 1992; B.K.Nayar & Geev., Fern Fl. Malabar 139. 1993 (including fig. 41. p. 141); Rajagopal & Bhat, Indian Fern J. 15: 10. 1998; S.Chandra, Ferns India 70. 2000. (**Fig. 3, 9c & d, 10A-H**).

Type: Arabia Felix: Hadie, Mar. 1763, *Forsskal* (C).

Adiantum caudatum auct Bedd., Ferns S. India 1. pl. 2. 1863 & Handb. Ferns Brit. India 83. f. 44. 1883, *non* L., 1771.

Adiantum vestitum Wall., Num. List no. 13. 1829, *nom. nud., non* Spreng., 1804.

Adiantum capillus-gorgonis Webb., Spic. Gorg. in Hook. Niger Fl. 192. 1849.

Adiantum zollingeri Carruth., Cat. Welw. 2: 266.1899, *non* Mett. *ex* Kuhn, 1869.

Adiantum caudatum var. *minor* Pirotta, Annuario Ist Bot. Rom. 8(1): 15. 1903.

Adiantum caudatum var. *flabellatum* B.K.Nayar, Bull. Nat. Bot. Gard. 52: 8. 1961; R.D.Dixit, Census Indian Pterid. 74. 1984; B.K.Nayar & Geev., Fern Fl. Malabar 138. 1993.

Adiantum incisum Forssk. subsp. *incisum* Fraser-Jenk., New Sp. Syndr. Indian Pterid. Ferns Nepal 31. 1997.

Adiantum indicum sensu Madhus. & Sevichan, J. Econ. Taxon. Bot. 15: 147. 1991, *non* Ghatak, 1963.

Rhizome erect, 1-1.5 cm thick, unbranched, densely covered with persistent leaf bases and paleae all around and a tuft of wiry roots arising from the base. Palea 2.5-3 x 0.3-0.4 mm, linear-lanceolate, concolorous, brown, acute or acuminate with entire margin. Fronds tufted, 8-10, spreading, arching and often rooting at apex, 45-50 x 4-5 cm, oblong-lanceolate; stipe 8-10 cm long, 1 mm wide, dark brown, terete with a median groove on upper side, scaly at base, covered by uniseriate brown hairs above, more dense on upper side and sparse on lower side; lamina 40 x 5 cm, oblong-lanceolate, simple pinnate, gradually tapering to a leaf less portion; rachis similar to stipe, hairy through out, more on adaxial side, bearing 30-35 pairs of pinnae, terminal portion is much prolonged and terminating in a vegetative bud; pinna 2.5 x 1 cm, basal sub-opposite, gradually become alternate, basal few smaller and deflexed, those towards apex gradually become smaller and widely spaced, sessile, attached by pointed base, dimidiate, lower margin straight, acroscopic inner margin slightly concave, upper and outer margins deeply lobed, incisions reaching 2/3 of the

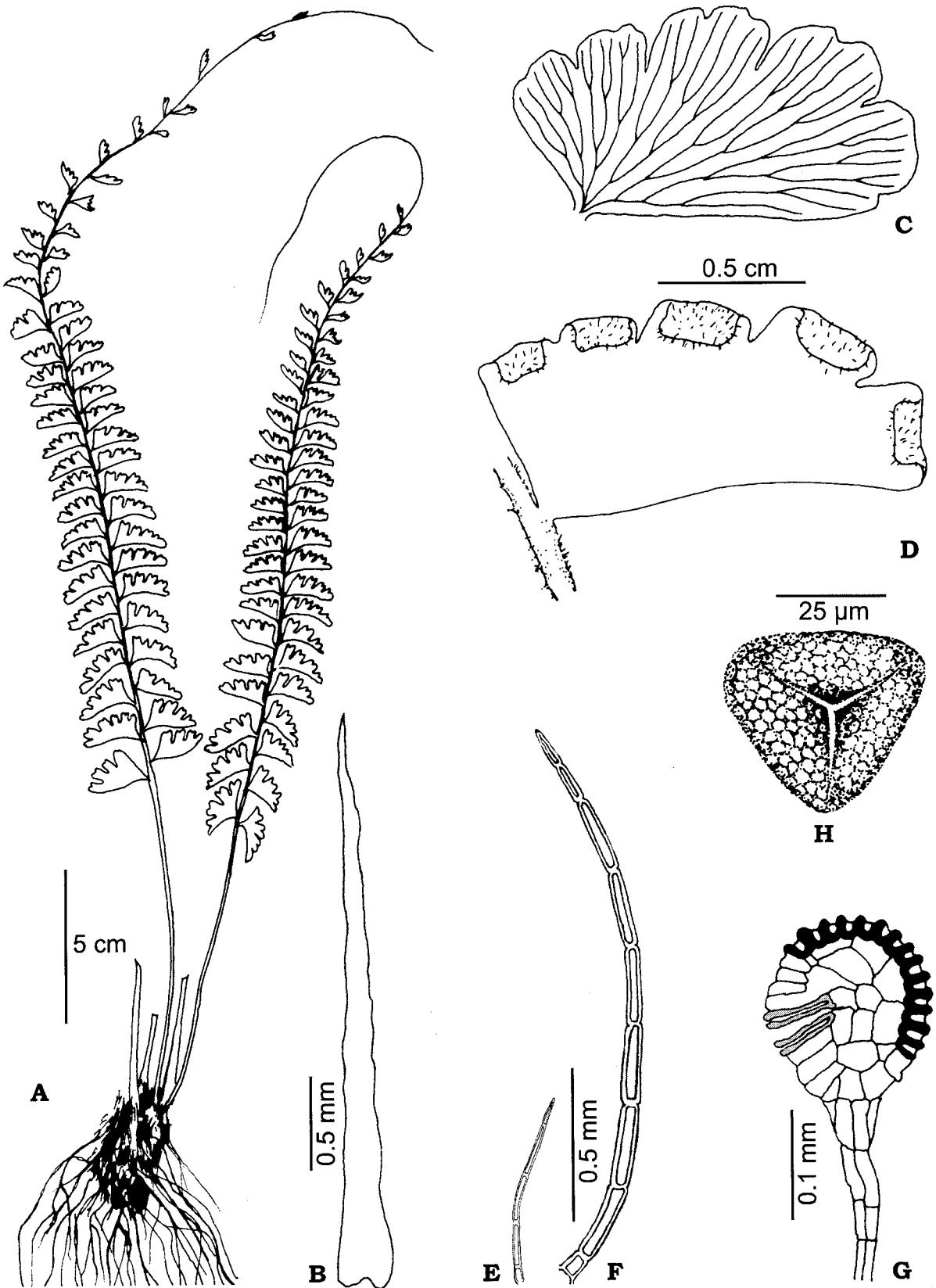

Fig. 10. Adiantum incisum: **A**- Habit, **B**- Palea, **C**- Sterile pinna, **D**- Fertile pinna, **E**- Pluricellular hair on pinna, **F**- Pluricellular hair on stipe, **G**- Sporangium, **H**- Spore (from *Mohanakurup CU 52844*).

width of the pinna; primary lobes 4-5, each dividing into two secondary lobes, margin serrate, densely hairy on lower surface, sparse on upper surface; hairs brown, pluricellular, uniseriate; texture herbaceous. Veins distinct on upper surface, open dichotomous, 5-6 times forked, reaching the margin. Sori 4-5 per pinnae, each primary lobe bearing one sorus; reflexed margin kidney shaped or oblong, more broad than long, externally covered by ferrugineous hairs. Sporangia stalked; stalk as long as capsule; capsule spherical; annulus 15 cells long. Spores 35 x 45 μm, trilete, tetrahedral; exine finely rugulose.

Chromosome numbers: n = 30, 2n = 60, diploid sexual (Mehra & Verma, 1960; Verma & Loyal, 1960b; Verma & Khullar, 1965; Singh & Roy, 1969; Ghatak, 1977; Bir & Vasudeva, 1979; Vasudeva & Bir, 1982); n = 60, tetraploid sexual (Verma in Mehra, 1961).

Distribution and Ecology: Common through out southern India and other parts of the country. Also occurs in tropical and southern Africa, Arabia, Pakistan and Sri Lanka. *Adiantaum incisum* grows in crevices of rocks in open or partially shaded places between 500-1900 m.

Notes: 1. The species is rather polymorphous as regards the size of the plants, dimension and shape of the pinna and the degree of hairiness (Pichi Sermolli, 1957). Previously *A. incisum* has been considered as a synonym of *A. caudatum* (*cf.* Christensen, 1906) because of inadequate description given by Forsskal (Fl. Aeg. 187. 1775). Pichi Sermolli (*l.c.*) segregated it from *A. caudatum* because of having lesser number of pinnae which are not close to each other, deeply lobate with cuneate, rostriform bases and with wide sinuses, slightly striate, upper surface glabrous or provided with few hairs and lower surface covered more or less densely only with pluricellular, ferrugineous hairs, by the rachis hirsute through out with long ferrugineous hairs and by the fertile reflexed out growth of the pinna wide, more broad than long and scarcely hairy out side.

2. *A. incisum* is closely related to *A. zollingeri*. But the latter differs from the former in having pinna glabrous or glabrescent on both surfaces, indusia glabrous and rachis densely hirsute with long ferrugineous hairs only on upper side, the lower side being glabrous.

Specimens examined: **ANDHRA PRADESH**: Adilabad Dt., Madhavaram R.F., *Pullaiah & Obulesu 5474* (SKU). Ananthapur Dt., Kalasamudram, *Mohanakurup*

73147 (CALI). Chittoor Dt., slopes of Balaparallagutta, *Subbarao 46790* (CAL); Kambakam, *Chandrabose 45170*; Talakona, *Subbarao 31992* (MH). Cuddapah Dt., Balapalle, *Ellis 15005* (CAL); Lankamala, *Reddy 10075* (SKU); Palakonda hills, *Subbarayulu & Alimoulavi 7741* (SKU). East Godavari Dt., forest near Anigeri village, *Subbarao 68548* (CAL, MH); Annavaram, *Kiranraj 73167* (CALI); Rampachodavaram, *Subbarao 24484* (MH); Sitharam, Mallammagonda, *Subbarao 67564* (CAL). Karim Nagar Dt., Kodimial, *Subbarao 20069*; Rachepalli, *Subbarao 20159* (MH). Krishna Dt., Dalgattu, *Venkanna 5192* (MH). Kurnool Dt., Chelama, *Ellis 16759* (MH); Devanipenta, *Goud 12687* (SKU). Nizamabad Dt., Mudheli R.F., *Rao & Hanumanthappa 7127* (SKU). Prakasam Dt., Chinarutla, *Vijayakumar 15809* (SKU); Rellapenta R.F., *R.K.Mohanan 916* (CAL). Sreekakulam Dt., Dorajammu, *Subbarao 62474* (CAL, MH); Salur forest, *Balakrishnan 1124* (CAL). Visakhapatnam Dt., Karaka, *Barber 1627* (MH); forest near Sunkarimetta, *Balakrishnan 10898* (CAL); Simhachalam, *Subbarao 19352* (MH); Tamarapilli, Minumuluru, *Subbarao 47313* (CAL); Tyada, *Mohanakurup 73118* (CALI); Visakhapatnam, *Subbarao 22560* (MH). **KARNATAKA**: Bidar Dt., Bidar, *Rajagopal 521* (MGMC). Chithradurga Dt., Chithradurga fort, *Rajagopal 572* (MGMC). Mandhya Dt., Melukote, *Rajagopal 668* (MGMC). Mysore Dt., Biligirirangan hills, *Rajagopal 673;* Chamundy hills, *Rajagopal 397* (MGMC). **KERALA**: Idukki Dt., Kumali, *Nair 40795* (CAL); Ramakkalmedu, *Mohanakurup 73166* (CALI); Thekkady, *Manickam & Mathew 33353* (XCH). Kollam Dt., Aryankavu, *Nair & Ghosh 51973* (MH); Mampazhathara, Punalur, *Nair 50970* (CAL); Punalur, *Nair 50872, 50873* (CAL, MH). Kozhikode Dt., Koyilandy, *Majeed 20680* (CALI). Palakkad Dt., Agali, *Vajravelu 26303* (MH), *60671* (CAL); Cherunelly, *Nayar & Geevarghese 7312;* Dhoni hills, *Madhusoodanan 21286;* Kanjirapuzha, *Geevarghese 4068, Mohanakurup 52892, 52893, Nampy & Pradeep 44835;* Silent Valley, *Nayar & Madhusoodanan 21384* (CALI); Valayar, *Vajravelu 19046* (MH). **TAMIL NADU**: Coimbatore Dt., Aliyar submergible area, *Sebastine 14687* (CAL); Kuridimalai, *Subramanyam 611;* Maruthamalai, *Sebastine 1565* (CAL, MH); Siruvani, *Sebastine 12540* (CAL); Valparai, *Mathew 31564* (XCH). Dindigul Dt., Kodaikanal, *Madhusoodanan 43812* (CALI), *Manickam 3305* (XCH); Pazhani ghat road, *Mohanakurup 73171* (CALI). Kanniya Kumari Dt., Keeriparai, *Nair & Ghosh 51932, 51935, 52617, 52619* (CAL), *Nair & Ghosh 51937* (CAL, MH), *Mohanakurup 52841, 52844* (CALI). Namakkal Dt., Kolli hills, *Mohanakurup 52881, 52888* (CALI). Nilgiris Dt., Bimaka shola, *Subbarao 36358* (MH); Coonoor, *Manickam 815* (XCH).

Ramanathapuram Dt., Periathusagaram, *Nair 60877* (CAL, MH). Salem Dt., Andiappan Kovil area, *Nair 74201* (CAL); Yercaud, *Mohanakurup 52880* (CALI), *Nair 74201* (MH). Teni Dt., Gudalur–Kumali road, *Subramanyam 8054*; Highwavy mountains, *Blatter & Hallberg 423* (CAL). Tirunelveli Dt., Courtallum, *Subramanyam 2946* (CAL, MH), *Usha 30200* (CALI); Kalakkadu, *Joseph 15284* (MH); Nanguneri, *Manickam 2471;* Upper Kothayar, *Manickam 3335* (XCH). Vellore Dt., Amirthi, *Vivekanandan 1081;* way to Kambukudi, *Subramanyam 6482* (CAL, MH). Viluppuram Dt., Gingee R.F., *Ramamurthy 13052* (CAL). Virudunagar Dt., Alagarkoil, *Srinivasan 94412*; Ayyanarkoil, *Nair 61424* (MH); Srivilliputhur, *Manickam 2951* (XCH).

Adiantum latifolium Lam., Enc. Meth. 1. 43. 1783; Madhus. & Sevichan, J. Econ. Taxon. Bot. 15: 150. 1991; Manickam & Irud., Pterid. Fl. W. Ghats 103. pl. 80. 1992; N.C.Nair *et al.*, J. Econ. Taxon. Bot. 16: 275. 1992; Rajagopal & Bhat, Indian Fern J. 15: 10. 1998; S.Chandra, Ferns India 70. 2000. (**Fig. 3, 9e & f, 11A-H**).

Type: uncertain, but possibly Brazil, *Commerson* (P-JU Cat. 1408).

Adiantum lenticulatum Sw., Prod. 135. 1788, *non* Burm., 1768.

Adiantum elatum Desv., Ges. Naturf. Freunde Berlin Mag. 5: 327. 1811.

Adiantum fovearum Raddi, Pl. Bras. 1: 58. t. 77. 1825.

Adiantum haenkeanum C.Presl, Rel Haenk. 1: 62. 1825.

Adiantum brasiliense, Link, Hort. Berol. 2: 13. 1833, *non* Raddi, 1825.

Adiantum humile Kunze, Linn. 9: 80. 1834.

Adiantum argutum Splitg., Tijdschr. Nat. Gesch. 7: 427. 1840.

Adiantum intermedium Hook. & Baker, Syn. Fil. 116. 1874.

Rhizome long creeping, slender, 0.3-0.5 cm thick, often branched, covered with paleae. Paleae 2-3 x 0.5-0.7 mm, ovate-lanceolate, concolorous, dark brown, peltate, acuminate and sparsely ciliate. Fronds 0.5-1 cm apart, erect, 40-60 x 20-30 cm; stipe 20-30 cm long, 1.5-2 mm wide, black, grooved on the upper side, glabrous towards base, gradually becomes covered with multicellular, basally and irregularly branched, brown peltate hairs; lamina 20-30 x 20-30 cm, ovate-deltoid, bipinnate (rarely simple pinnate due to suppression of branches), base broadly cuneate; rachis similar to stipe, covered with brown hairs and scales bearing 1-3 pairs of pinnae which are alternate, 3-4 cm apart; pinnae oblong, acuminate, horizontal or slightly ascending basal and upper pinnae shorter, middle pinnae longer; longest pinna 15 x

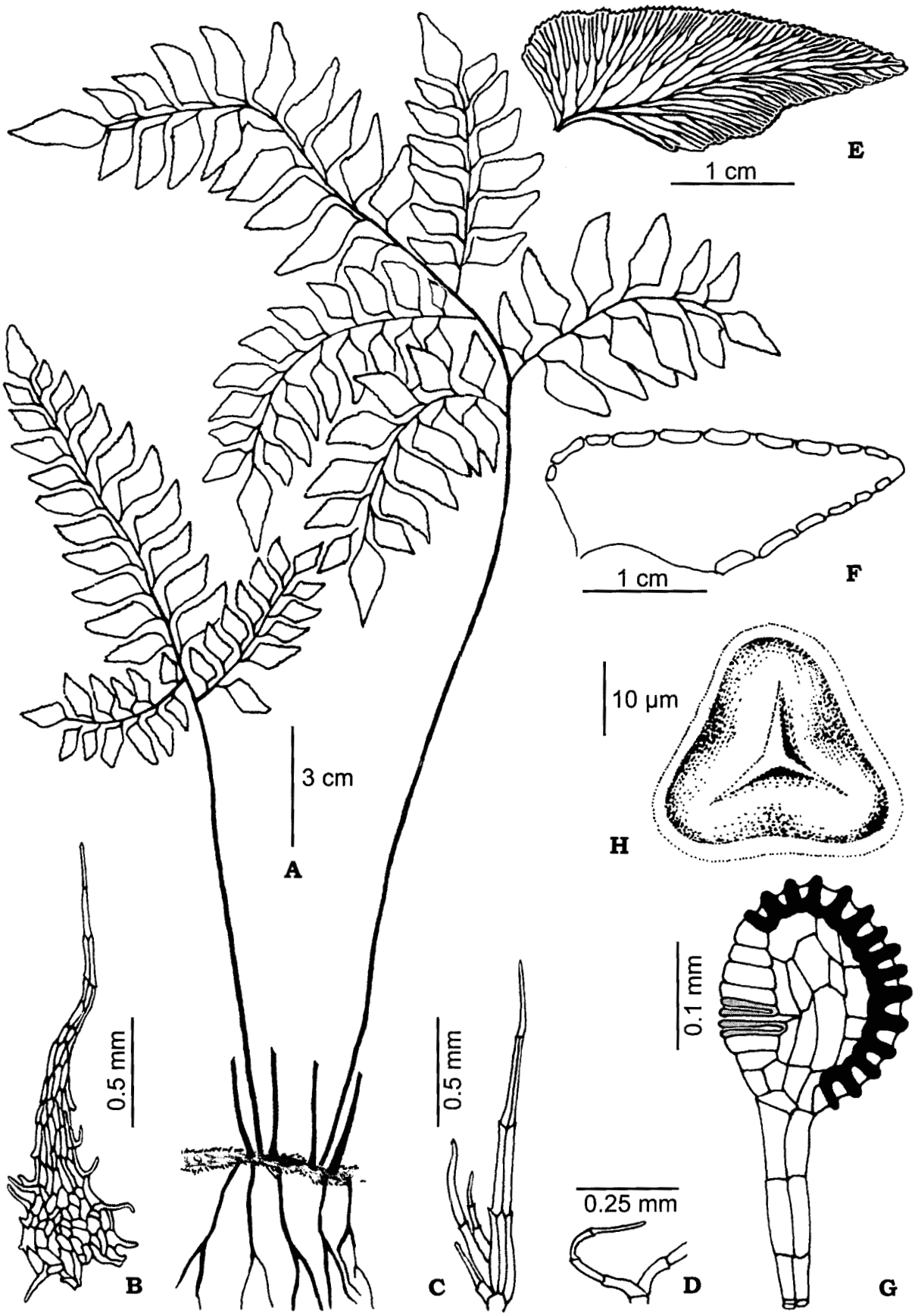

Fig. 11. **Adiantum latifolium**: **A**- Habit, **B**- Rhizome palea, **C** & **D**- paleate hairs on stipe and rachis, **E**- Sterile pinnule, **F**- Fertile pinnule, **G**- Sporangium, **H**- Spore (from *Mohanakurup CU 52821*).

6 cm with 12-15 pairs of pinnules; pinnules alternate, basal 2-3 pairs slightly reduced, sub-sessile, largest pinnule 3.5 x 1cm, ovate-oblong, apex acute, base inequilateral, 1/3 of lower base excised, acroscopic inner margin straight and parallel to the rachis or slightly concave, basiscopic inner marigin smooth, acroscopic and basiscopic outer margins of sterile pinnules finely serrate; texture coriaceous. Veins distinct on both surfaces with a well marked midrib (a feature uncommon among other species of *Adiantum*) extending from base to the middle of pinnule; lateral veins repeatedly forking 4-5 times, each veinlet reaching the marginal tooth; Sori numerous, all along the margins except the acroscopic inner margin and the excised portion of the lower margin; each sorus is formed at the end of adjacent veinlets of a single lateral vein; so on the basis of th number of veinlets developing from a single lateral vein, the sorus will be longer or shorter, oblong; reflexed margin serrate. Sporangia stalked; stalk equal in length to capsule; capsule globose; annulus of 14 cells. Spores 30 x 35 μm, trilete, tetrahedral; exine slightly verrucoid.

Chromosome numbers: n = 60, tetraploid sexual (Mathew in Fabri, 1965); n = 2n = 60, diploid apogamous (Abraham *et al.,* 1962).

Distribution and Ecology: *Adiantum latifolium* is a recently naturalized taxon in southern India. It is also reported from Maharashtra. Usually grows on mountain slopes near forest streams, but some times also in drier and more open situations along road sides. This species is supposed to be an escape from cultivation, now found in the wild and become wide spread all over southern Kerala up to 500 m. It is also distributed in tropical America, Amazon region, Brazil, Columbia, Peru and West Indies.

Specimens examined: **KARNATAKA:** Dakshina Kannada Dt., Vittal, *Rajagopal 276* (MGMC). **KERALA**: Ernakulam Dt., North Paravur, *Mohanakurup 73146* (CALI). Idukki Dt., Pooyamkutty, *Bharqavan 92081* (MH); Tannikkudy, *Rajesh 70053;* Thommankuthu, *Mohanakurup 52833* (CALI). Kollam Dt., Kulathupuzha, *Mohanakurup 52853* (CALI); Perumthenaruvi, *C.N.Mohanan 63455;* Thenmalai, *C.N.Mohanan 63068* (MH). Kottayam Dt., Ayarkunnam, *Mohanakurup 52841;* Aymanam, *Nayar 2499*; Edamaruku, *Mohanakurup 52827* (CALI); Kanjirapalli, *Manickam 33528* (XCH); Kumarakam, *Antony 1250* (CAL), *Manickam 33468* (XCH), *Sevichan 37119* (CALI); Mundakayam, *Antony 669* (MH). Palakkad Dt., Muthukurissi, *Mohanakurup 72123* (CALI). Pathanamthitta Dt., Ranni, *Madhusoodanan 29722*

(CALI); Vennikulam, Thiruvella, *Nair 50833, 50849* (CAL). Thiruvananthapuram Dt., Neyyar dam site, *Nair & Ghosh 51573;* Neyyattinkara, *Nair & Ghosh 51779* (MH); Palode, *Madhusoodanan 29722* (CALI); Pulimath, *M.Mohanan 66677* (CAL); Zoo lake, *M.Mohanan 52759* (CAL, MH); Veli, *Madhusoodanan 43874* (CALI). Thrissur Dt., Kuttikkad, *Nair & Ghosh 52043* (MH). **TAMIL NADU**: Kanniya Kumari Dt., Balmore hills, *Manickam & Mathew 35271* (XCH); Keeriparai, *Mohanakurup 52839, 73131* (CALI); Kuzhithurai, *Henry 49545* (CAL, MH); Mahendragiri hills, *Manickam 12753* (XCH); Nagercoil, *Nagendraprasad 7221* (CALI).

Adiantum philippense L., Sp. Pl. 2: 1094. 1753; B.K.Nayar, Bull. Nat. Bot. Gard. 52: 5. 1961; Subramanyam *et al.*, Bull. Bot. Surv. India 3: 210. 1961; Raju, Bull. Bot. Surv. India 6: 189. 1964; B.K.Nayar & S.Kaur, Comp. Bedd. Handb. 23. 1974; R.D.Dixit, Census Indian Pterid. 75. 1984; Fraser-Jenk., New Sp. Syndr. Indian Pterid. Ferns Nepal 35. 1997. (**Fig. 12A-F, 13a-j, 14**)

Type: Petiver, *Gazophyl. Nat.* Art. Dec. 1(1): t. 4. f. 4. 1702 (in the Library of Linnaean Society, London).

Adiantum lunulatum Burm.f., Fl. Ind. 235. 1768; Bedd., Ferns S. India 1. pl. 1. 1863, Handb. Ferns Brit. India 82. 1883 & Suppl. Ferns Brit. India 17. 1892; Madhus. & Sevichan, J. Econ. Taxon. Bot. 15: 145. 1991; S.M.Vasudeva *et al.*, Indian Fern J. 8: 172. 1991; Manickam & Irud., Pterid. Fl. W. Ghats 98. pl. 73. 1992; N.C.Nair *et al.*, J. Econ. Taxon. Bot. 16: 272. 1992; B.K.Nayar & Geev., Fern Fl. Malabar 142. f. 39. 1993; Rajagopal & Bhat, Indian Fern J. 15: 10. 1998; S.Chandra, Ferns India 71. 2000.

Pteris lunulata Retz., Observ. Bot. 2: 28. t. 4. 1781.

Adiantum lunatum Cav., Descr. Pl. 1: 272. 1802.

Adiantum arcuatum Sw., Syn. Fil. 122. 1806.

Adiantum philippense var. *dolabriforme* (F.M.Bailey) D.A.Sm., Anon. N.Queensland Publ. 3: 7. 1946, *nom. inval.*

Avenka Rheede, Hort. Malab. 12: 72. t. 39. 1693.

Rhizome short erect or sub-erect, 1-1.5 cm thick, unbranched, covered with persistent leaf bases and paleae towards the upper half and a tuft of fibrous roots towards the lower half. Paleae 2-3 x 0.3-0.5 mm, lanceolate, bicolorous with dark brown central region and light brown peripheral region, apex acuminate with entire margin. Fronds 8-10, spreading and arching, often producing young plants from the

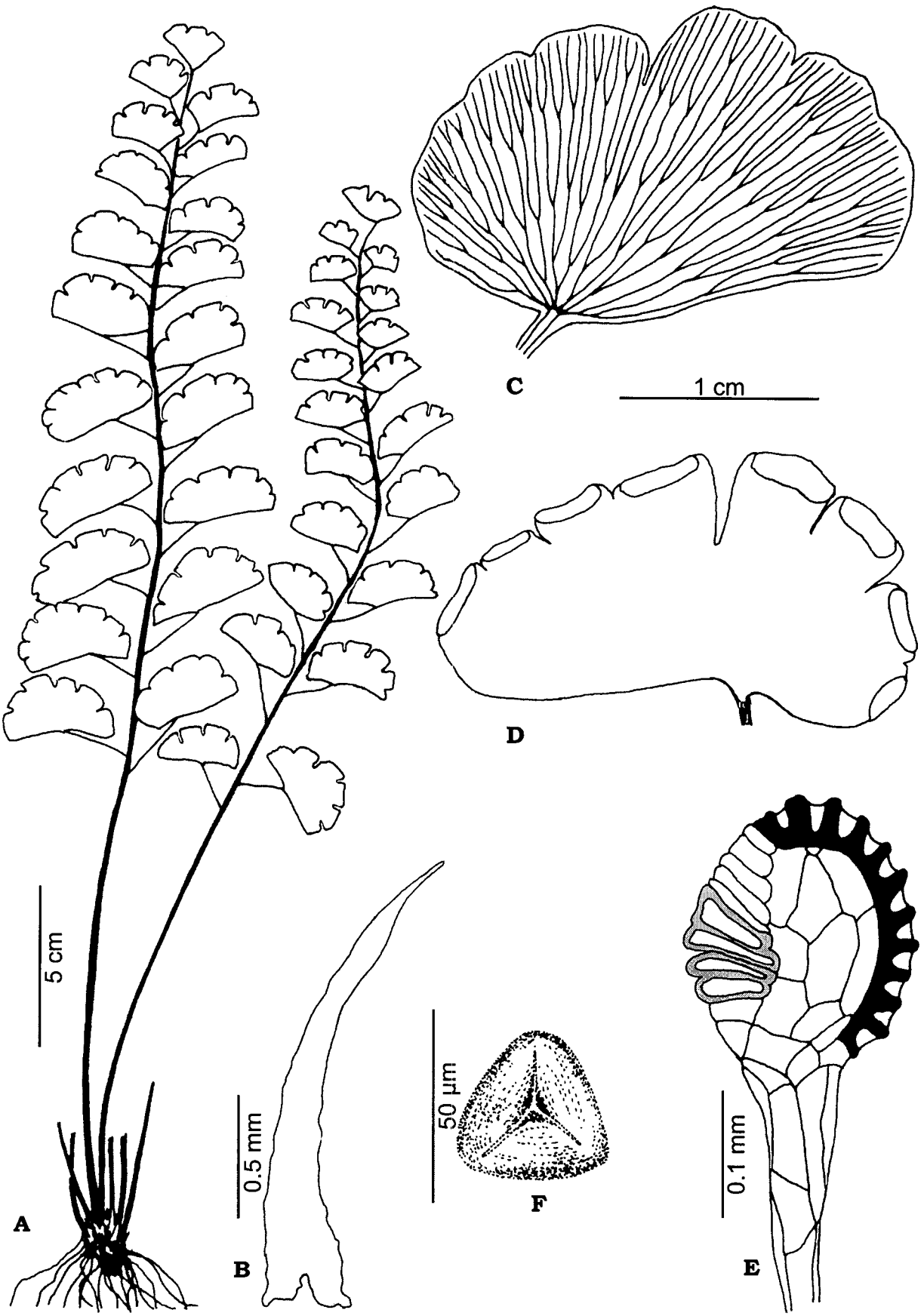

Fig. 12. Adiantum philippense: **A**- Habit, **B**- Palea, **C**-Sterile pinna, **D**-Fertile pinna, **E** -Sporangium, **F**-Spore (from *Mohanakurup CU 73119*).

Fig. 13. Adiantum philippense: a. habit, **b**. part of fertile frond; **c-j**. variation in the form of pinn
A. poretii: k. habit, **l**. part of fertile frond.

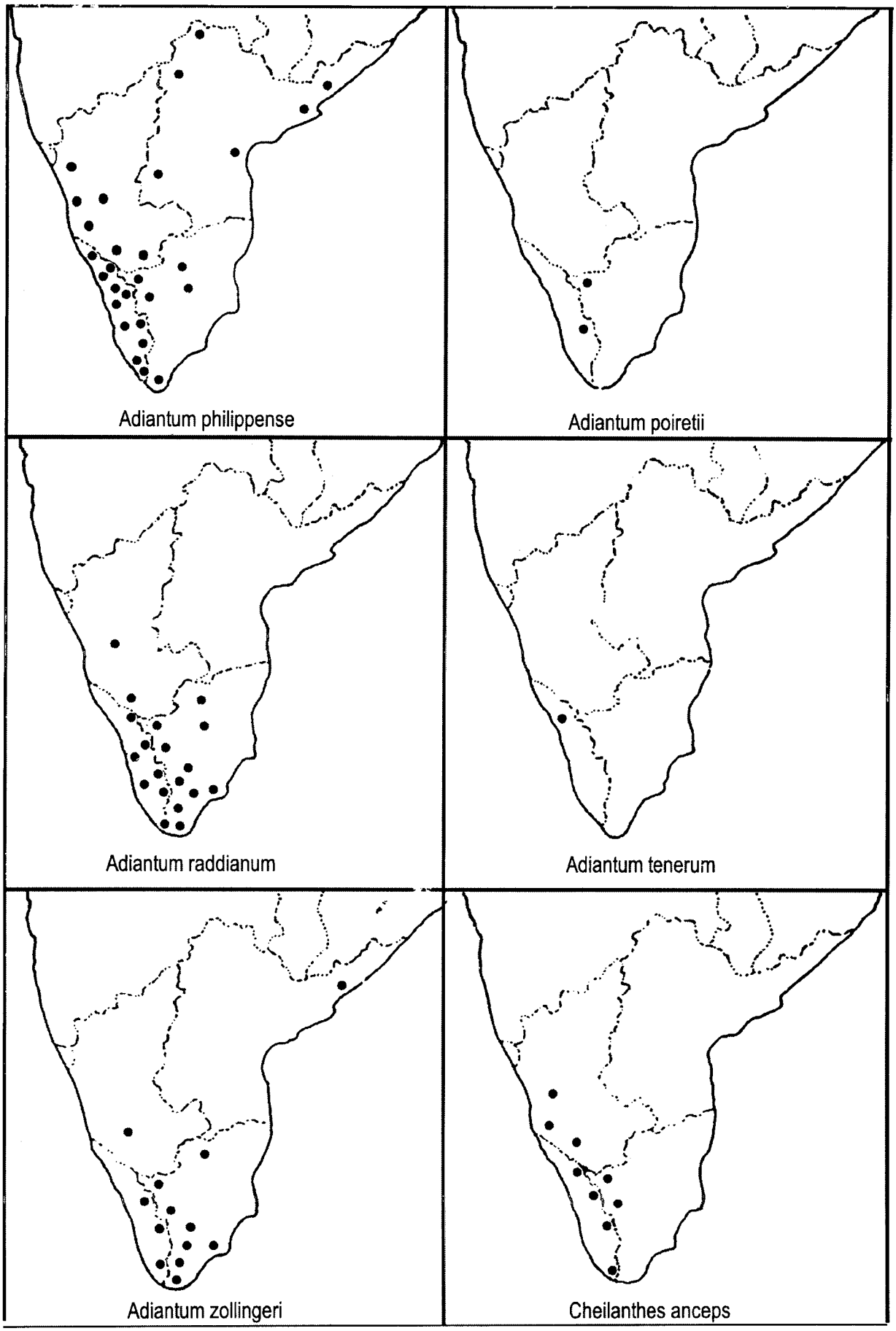

Fig. 14. Distribution of Adiantum philippense, A. poiretii, A. raddianum, A. tenerum, A. zollingeri and Cheilanthes anceps in Southern India.

tip, 40-60 x 6-8 cm; stipe 15-20 cm long 0.5-1 mm wide, shorter than lamina, deep brown to black, terete with a shallow groove on the adaxial surface, basally paleate, glabrous and polished above; lamina 25-35 x 6-8 cm, simply pinnate, widest at base; rachis like stipe, bearing 12-15 pairs of pinnae, usually with a terminal pinnule with broadly cuneate base or prolonged bearing slightly reduced and distantly placed pinnae terminating in a vegetative bud which when touches the ground develops into a new plant (walking habit); pinnae alternate, stalked; stalk 2.5 cm long, 0.2 mm thick, black shing; pinnae 2.5 – 3.5 cm apart, 4.5 x 2 cm lower pinnae semi circular or crescent shaped, the lower two edges almost lie in the same straight line, often with a basal angle where acroscopic and basiscopic edges of pinnae meet the stalk, more than 180°; the basal angle of pinnae placed above gradually decreases to about 120° and in the distal region it becomes close to 90°; outer margin circular; upper pinnae subdimidiate, basiscopic basal margin often in line with stalk, acroscopic basal margin oblique, outer margin entire or shallowly lobed into 4-6 broad primary lobes, each may be further lobed; pinna glabrous on both surfaces, pale green and herbaceous. Sori transversely elongated, extending the entire length of outer margin forming an uninterrupted soral line or interrupted and form 4-8 distinct sori, 1-2 per each primary lobe. Sporangia stalked; stalk equal in length to capsule, 3 cells thick; capsule globose; annulus 12-14 cells long. Spores 35 x 40 μm, trilete, tetrahedral; exine slightly granulose.

Chromosome numbers: n = 30, 2n = 60, diploid sexual (Abraham *et al.*, 1962; Manickam & Irudayaraj, 1988); n = 60, 2n = 120, tetraploid sexual (Verma in Mehra, 1961; Abraham *et al.*, 1962; Bir & Irudayaraj, 2001); n = 2n = 60 diploid apogamous (Verma in Mehra, 1961; Mathew in Fabri, 1965); n = 2n = 90 triploid apogamous (Manton & Sledge, 1954; Roy & Sinha, 1958, 1962; Mehra & Verma, 1960, 1963; Verma & Loyal, 1960b; Verma in Mehra, 1961; Mathew in Fabri, 1965; Singh & Roy, 1969; Ghatak, 1977; Vasudeva & Bir, 1982).

Distribution and Ecology: *Adiantum philippense* is widely distributed in India and occurs all the four South Indian states. Also distributed in tropical Africa, Australia, Central and South America, China, Malay Peninsula, Myanmar, New Guinea, Philippines, Sri Lanka and Taiwan. *A. philippense* grows in moist, fully or partially exposed situations on gravelly soil from sea level to 1500 m.

Notes: 1. Different populations of *A. philippense* exhibit variations in frond size, pinna size, extent of lobing of pinna, soral length and the basal angle formed by acroscopic and basiscopic edges of pinna at the point of attachment of stalk. Four cytotypes exist in India. They are triploid apogamous, diploid sexual, tetraploid sexual and diploid apogamous of which the first three types are reported from southern India (Abraham *et al.*, 1962). Triploid apogamous forms are the most common type and have the widest distribution. This is large sized with a length of 20-58 cm, while diploid sexual form is small with a length ranging from 4-18 cm (Mehra & Verma, 1963). Bir and Irudayaraj (2001) reported that there is no much morphological difference between tetraploid sexual and triploid apogamous forms.

2. The nomenclature of this fern is problematical. Linnaean species is typified on the basis of Petiver plate and it seems that Pichi Sermolli (Webbia 12: 665. 1957) was the first to effect this. According to Petiver (*cf.* Pichi Sermolli, *l.c.*) "this figure was taken from a Design the Reverend Father Joseph Camel sent to Mr. Ray and me, from the Philippine Isles". Before the identification of Linnaean species, this fern had been called *Adiantum lunulatum* Burm.f. Consequently, earlier Indian workers (Beddome, 1863, 1883, 1892; Clarke, 1880; Hope, 1901) used the latter name in their works. Christensen (1906) treated *A. lunulatum* as the correct name of the taxon and *A. philippense* as a synonym. But he later (1934) reversed it making *A. philippense* L. as the correct name and *A. lunulatum* Burm.f. as synonym, but without giving any reason. Since then many taxonomists (Holttum, 1954; Ching, 1957; Nayar, 1961) used *A. philippense* as the correct name.

But alleging that the Petiver plate (the type of *A. philippense*) is very poor, Verma (1962), followed by Morton (1974) and Sledge (1982) regarded it as unidentifiable and rejected it as *nomen dubium*. Owing to this many Indian authors (Vasudeva *et al.*, 1991; Manickam & Irudayaraj, 1992; Nair *et al.*, 1992; Nayar & Geevarghese, 1993; Khullar, 1994; Rajagopal & Bhat, 1998; Chandra, 2000a) accepted *A. lunulatum* as the correct name.

Verdcourt (Pers. Comm., 2001) informs that he has been convinced by Zimmer that we could not use *A. philippense* as its type is unidentifiable and it is impossible to tell whether it really represented the fern in question. But Pichi Sermolli (1957) is of the view that, though the figure is badly drawn, its identity with the species we name *A. philippense* is unquestionable. Fraser-Jenkins (Pers. Comm., 2002) informs that

"now it is known that the Petiver specimen is in Herbarium Sloane and Alston had long back (in 1953) annotated it as *Adiantum philippense.* Schelpe and Anthony in *Flora South Africa: Pteridophyta* (1986) had accepted the plate as an iconotype and say that there is a probable holotype in Herbarium Sloane. Hence a permanent solution to the problem is, in addition to accepting Pichi Sermolli (1957) as having typified the name, to cite the Petiver material in Herbarium Sloane (apparently sent by Camel from Philippine Isles) as an epitype which is permitted by the St. Louis Code, 2000. In the light of this we should not use *A. lunulatum* as it is against the code".

A. philippense has now been almost widely accepted by most of the taxonomists (Nayar & Kaur, 1974; Dixit, 1984; Panigrahi, 1998; Borthakur *et al.*, 2001; Dixit & Sinha, 2001). In this study *A. philippense* has been treated as the correct name.

Specimens examined: **ANDHRA PRADESH:** Adilabad Dt., Madhavaram, *Pullaiah & Obuselu 5469*; Wankidi, *Prasanna 9483* (SKU). East Godavari Dt., Dummakonda, *Subbarao 68635* (MH); Maridipally, *Pullaiah 12863* (SKU); way to Yarlagadda, *Narayanaswami 313* (CAL). Kurnool Dt., Gundlabrahmeswaram, *Ellis 16935*; Ramanathpetta, *Ellis 32635* (MH). Nizamabad Dt., Ibrahimpet, *Pullaiah & Rao 12863*; Mudheli, *Rao & Hanumanthappa 7129* (SKU). Prakasam Dt., Rollapenta R.F., *R.K.Mohanan 878* (CAL). Visakhapatnam Dt., Damaku, *Mohanakurup 73116* (CALI); Satwa, *Balakrishnan 10836* (CAL, MH); Tyada, *Mohanakurup 73119* (CALI). **KARNATAKA**: Dakshina Kannada Dt., Charmadi, *Arora 1061* (CAL); Sampagi, *Barber 2248* (MH); Sitanadi, *Arora 2736* (CAL). Kodagu Dt., Madikeri, *Manickam 2901* (XCH). Mysore Dt., Biligirirangan hills, *Rajagopal 376* (MGMC). Shimoga Dt., Agumbe, *Mohanakurup 73121* (CALI); *Rajagopal 30;* Hulickal, *Rajagopal 35* (MGMC); Kodachadri, *Mohanakurup 52866* (CALI). Udupi Dt., Pillarkhau, *Rajagopal 3*; Udupi, *Rajagopal 1* (MGMC). Uthara Kannada Dt., Brahminkerri, *Rajagopal 121* (MGMC). **KERALA**: Idukki Dt., Anjuruli, *Rajesh 62831* (CALI); Kattappana, *C.N.Mohanan & Ramanujam 72126*; Panamkutty, *Pandurangan 79283* (MH); Pindimedu, Pooyamkutty, *Bhargavan 87415 (*CAL); Ramakkalmedu, *Mohanakurup 73162* (CALI); Thekkady, *Sharma 42070* (MH). Kannur Dt., Pappinisseri, *Ansari 64723* (CAL, MH); Thalassery, *Ramachandran 52375* (MH). Kollam Dt., Konni, *C.N.Mohanan 58322*; Perumthenaruvi, *C.N.Mohanan 63454* (MH); Thenmala, *Mohanakurup 52858* (CALI). Kottayam Dt., Nattakam, *Mohanakurup 52820* (CALI);

Vandiperiyar, *Vivekanandan 21339* (MH). Kozhikode Dt., Chalappuram, *Mohanakurup 52804*; Cheruvannur, *Syamala 18479* (CALI). Malappuram Dt., Calicut University Campus, *Omana 18752*; Kadalundi, *Jose 18382* (CALI). Palakkad Dt., Attappadi, *Vajravelu 26193*; Dhoni, *Joseph 17219* (MH); Mukkali, *Nair 64498* (CAL); Muthukurissi, *Mohanakurup 73124*; Nelliampathi, *Mohanakurup 52894*; Olavakkode, *Leena 29773* (CALI). Pathanamthitta Dt., Pamba, *Nair 50835* (CAL, MH); Sabarimala, *Manickam & Mathew 33263* (XCH). Thiruvananthapuram Dt., Aruvikkara, *M.Mohanan 63873* (CAL, MH); Peringamala, *Mohanakurup 52855* (CALI); Pulimath, *M.Mohanan 63351* (CAL), *58582* (CAL, MH); Puthukkad, *Nair & Ghosh 51877* (MH); Ponmudi, *Nair & Ghosh 51884* (CAL). Thrissur Dt., Vazhachal, *Ramamurthy 74776*; Vettilappara, *Nair & Ghosh 52060* (MH). Wayanad Dt., Chembra peak, *Mohanakurup 52860* (CALI); Sultanbathery, *Ellis 19936*; Tolpetty, *Ramachandran 54171* (CAL, MH), *52275* (CAL). **PONDICHERRY**: Mahe, *Mohanakurup 73115* (CALI). **TAMIL NADU**: Coimbatore Dt., Koochimalai, *Sreemadhavan 882* (MH); Valparai, *Mathew 31546* (XCH). Kanniya Kumari Dt., Keeriparai, *Henry 49447* (CAL, MH); Thovala, *Manickam 2588* (XCH). Namakkal Dt., Kolli hills, *Mohanakurup 52885* (CALI). Nilgiris Dt., Devarshola, *Subramanyam 10417*; Gudalur, *Vajravelu 41707*; Northern Hay R.F., *Sharma 35506* (MH); Ootty, *Mohanakurup 73145* (CALI). Salem Dt., Hansdein, Yercaud, *Ghatak 217, 466* (CAL). Teni Dt., Periyar upper camp, *Vivekanandan 46470* (MH).

Adiantum poiretii Wikstr., Vet. Akad. Handl. 1825: 443. 1826; S.Chandra & S.Kaur, Nomen. Guide Bedd. Ferns S. India & Ferns Brit. India 1. 1987; S.M.Vasudeva *et al.*, Indian Fern J. 8: 176. 1991; Fraser-Jenk., New Sp., Syndr. Indian Pterid. Ferns Nepal 32. 1997; S.Chandra, Ferns India 72. 2000. (**Fig. I, 14, 15A-F, 16**).

Type: Petit-Thouars in Herb Jussieu 1427 (P)

Adiantum crenatum Poir., Enc. Suppl. 1: 137. 1810, *non* Willd., 1810.

Adiantum plicatum Kaulf., Enum. Fil. 201. 1824.

Adiantum aubertii Desv., Prod. 310. 1827.

A. thalictroides Willd. *ex* Schldtl., Adumbr. t. 5: 53. 1832; N.C.Nair & S.R.Ghosh, J. Bombay Nat. Hist. Soc. 75: 246. 1978; N.C.Nair & R.D.Dixit, J. Bombay Nat. Hist. Soc. 78: 444. 1981; R.D.Dixit, Census Indian Pterid. 68. 1984;

S.M.Vasudeva *et al.*, Indian Fern J. 8: 169. 1991; N.C.Nair *et al.*, J. Econ. Taxon. Bot. 16: 274. 1992.

Adiantum cycloides Zenker, Pl. Ind. 11. t. 11. 1835.

Adiantum pellucidum Mart. & Galeotti, Mem. Acad. Bruxelles 15: 72. t. 19. 1842.

Adiantum gratum Fee, Gen. Fil. 119. 1852.

Adiantum aethiopicum auct. Bedd., Ferns S. India 2. pl. 5. 1863, Handb. Ferns Brit. India 84. 1883 & Suppl. Ferns Brit. India 18. 1892; B.K.Nayar, Bull. Nat. Bot. Gard. 52: 27. 1961; B.K.Nayar & S.Kaur, Comp. Bedd. Handb. 23. 1974; R.D.Dixit, Census Indian Pterid. 74. 1984; Manickam, Fern Fl. Palni Hills 38. 1986; Manickam & Irud., Pterid. Fl. W. Ghats 101. pl. 77. 1992; Rajagopal & Bhat, Indian Fern J. 15: 10. 1998, *non* L., 1753.

Adiantum emarginatum sensu Bedd., Ferns Brit. India t. 18. 1865, *non* Bory, 1810.

Rhizome long creeping, 0.5-0.7 cm thick, profusely branched, covered with paleae. Paleae 3 x 0.5 mm, linear-lanceolate, acuminate, concolorous, dark brown, margin irregularly ciliate especially towards the distal end. Fronds lateral to rhizome, erect, 40-60 x 20-25 cm; stipe 20-30 cm long, 1.5-2 mm thick, dark brown, scaly at base, glabrous and glossy above, grooved on the upper side; lamina 20-30 x 20-25 cm, tripinnate, ovate-deltoid; rachis similar to stipe, glabrous and glossy, flexuous bearing 8-12 pairs of alternate, distantly placed primary pinnae; lower primary pinnae pinnate and placed 4-6 cm apart, 10-12 x 6-8 cm, deltoid with broad base; secondary pinnae 5 x 4 cm; terminal 3-4 pairs of primary pinnae simple; main rachis and secondary rachises ending in a larger pinnule with cuneate base; pinnules loosely arranged, stalked; stalk 0.5-1 cm long, pinnule articulated to the stalk, deciduous, leaving the leaf stalks attached to the rachis in old fronds; pinnules variable in size, 1-1.5 x 1 cm, fan shaped with lower edges on either side of stalk straight or concave, outer margins round, deeply or shallowly lobed into 4-5 primary lobes which are again lobed; margin of ultimate lobes crenulate. Veins distinct on both surfaces, open dichotomous, 4-5 times forked, ultimate veinlets ending in the sinuses between marginal crenulations. Sori 5-8, all along the outer margins, 2 per primary lobe, oblong or sub-reniform. Sporangia short stalked; capsule globose; annulus 20 cells long. Spores 35 x 45 μm, trilete, tetrahedral; exine smoth.

Chromosome numbers: n = 30, 2n = 60, diploid sexual (Roy & Sinha, 1958, 1961); n = 60, tetraploid sexual (Verma in Mehra, 1961)

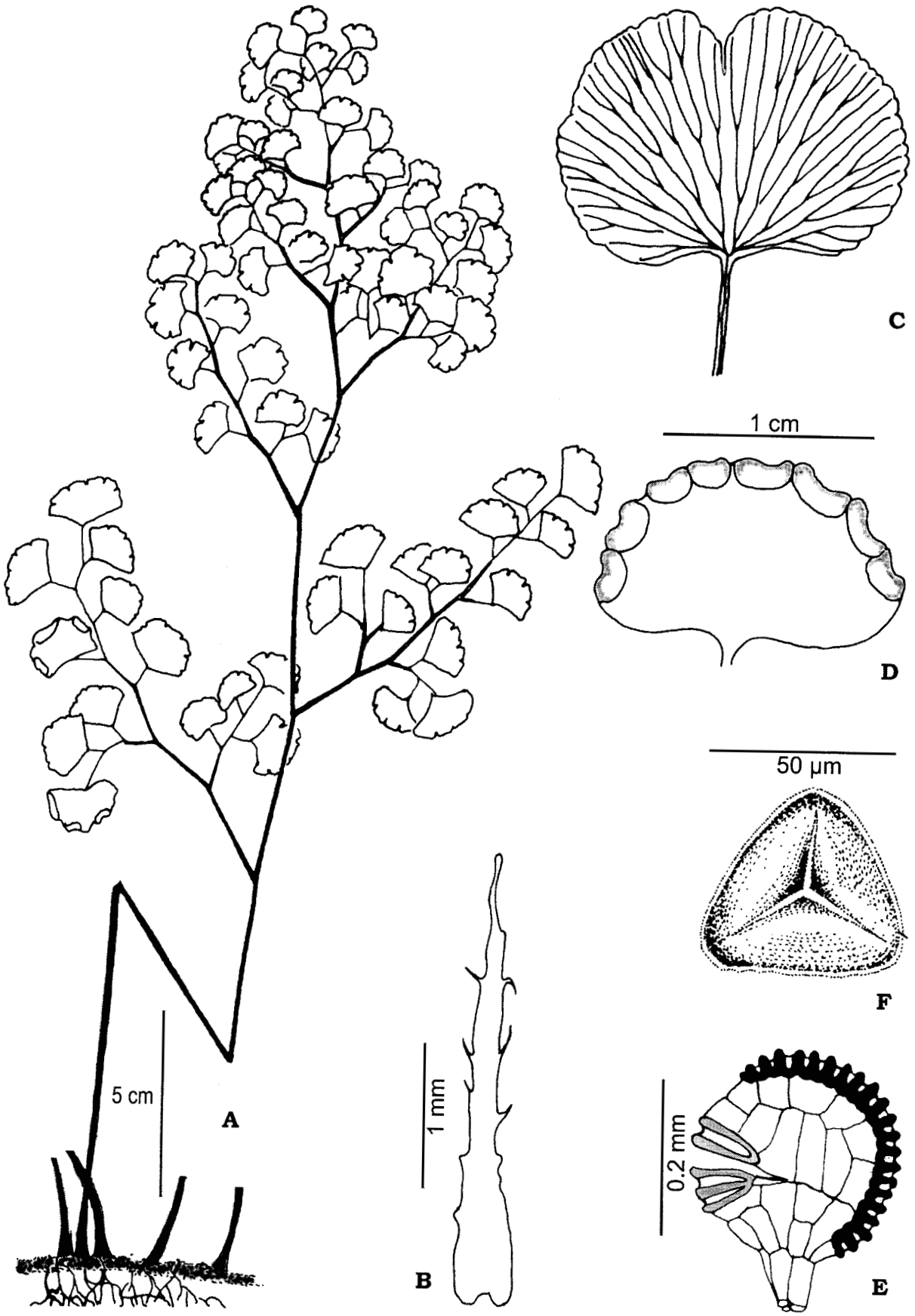

Fig. 15. Adiantum poiretii: **A**- Habit, **B**- Palea, **C**- Sterile pinnule, **D**- Fertile pinnule, **E**- Sporangium, **F**- Spore (from *Mohanakurup CU 73158*).

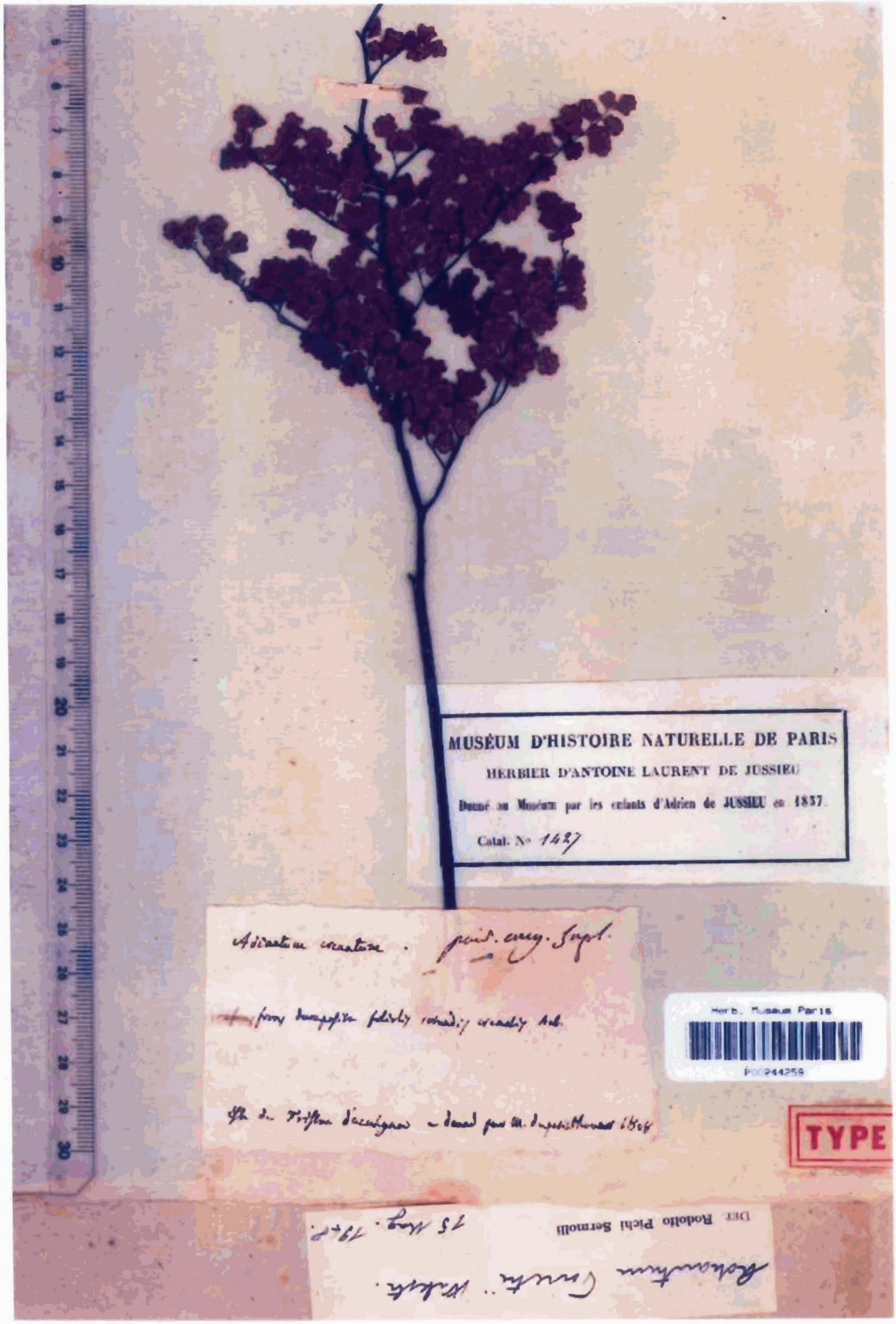

Fig. 16. Type specimen of Adiantum poiretii: digital image kindly provided by Prof. Dr. G.G. Aymonin, Museum National d' Histoire Naturelle, Paris.

Distribution and Ecology: *Adiantum poiretii* is having a restricted distribution in India and reported only from Munnar in Kerala and Nilgiris in Tamil Nadu in southern India and from Himalayas in northern India. Also reported from tropical and temperate Africa, Central and South America, Argentina, New Zealand, Sri Lanka, and West Indies. This species grows in well shaded, moist places along earth cuttings in altitudes between 1000-1500 m.

Note: Beddome (1863-1892) reported *Adiantum aethiopicum* from Nilgiris and Palni hills. Following him, many authors (Nayar, 1961; Manickam, 1986; Manickam & Irudayaraj, 1992; RajagopaL & Bhat, 1998) treated this taxon as *A. aethiopicum.* But Sledge (1973) pointed out that the specimen recorded by Beddome as *A. aethiopicum* from southern India at Kew are *A. poiretii.* Nair and Ghosh (1978) discussed the occurrence of *A. aethiopicum* in India and concluded that the taxon occurring in India is *A. thalictroides* and many authors accepted this (Nair & Dixit, 1981; Dixit, 1984; Nair *et al.*, 1992). Vasudeva *et al.* (1991) treat *A. thalictroides* and *A. poiretii* as distinct species and report that both occur in southern India. But Sledge (1973) followed by Fraser-Jenkins (1997) treats *A. thalictroides* as a synonym of *A. poiretii.* Manickam (1986), who treated the specimen collected from Palni hills as *A. aethiopicum,* later (1995) treats it as *A. poiretii.* The specimen collected by me from Munnar and the specimens lodged at different herbaria agree well with the type of *A. poiretii.*

Specimens examined: **KERALA**: Idukki Dt., Devikulam, *Meebold 13427* (CAL); Munnar, *Mohanakurup 73158* (CALI). **TAMIL NADU**: Nilgiris Dt., Coonoor, *Madhusoodanan s.n.* (CALI); Naduvattam, *Manickam 272* (XCH); Ootakamund, *King s.n.* (CAL); Parsonvalley, *Manickam 324* (XCH); Pykara, *Narayanaswamy 42860* (MH); no precise locality: *Beddome 1858, Blanford s.n.* (CAL).

Adiantum raddianum C.Presl, Tent. Pterid. 158. 1836; R.D.Dixit, Census Indian Pterid. 76. 1984; Manickam, Fern Fl. Palni Hills 40. 1986; Madhus. & Sevichan, J. Econ. Taxon. Bot. 15: 147. 1991; Manickam & Irud., Pterid. Fl. W. Ghats 102. pl. 78. 1992; Fraser-Jenk., New Sp. Syndr. Indian Pterid. Ferns Nepal 31. 1997; Rajagopal & Bhat, Indian Fern J. 15: 10. 1998; S.Chandra, Ferns India 73. 2000. (**Fig. 7A-F, 18a & b**).

Type: Brazil, Rio de Janeiro *Raddi,* t. 48, f. 2 (B).

Adiantum cuneatum Langsd. & Fisch., Ic. Fil. 23. t. 26. 1810, Subramanyam *et al.*, Bull. Bot. Surv. India 2: 325. 1960 & *Ibid* 3: 210. 1961, *non* Frost., 1786.

Adiantum cuneipinnulum N.C.Nair & S.R.Ghosh, Acta Bot. Indica 2: 78. 1974; N.C.Nair & R.D.Dixit, J. Bombay Nat. Hist. Soc. 78: 443. 1981; R.D.Dixit, Census Indian Pterid. 75. 1984; S.M.Vasudeva *et al.*, Indian Fern J. 8: 177. 1991; N.C.Nair *et al.*, J. Econ. Taxon. Bot. 16: 274. 1992.

Adiantum venustum sensu B.K.Nayar & Geev., Fern Fl. Malabar 146. 1993, *non* D.Don, 1825.

Rhizome sub-erect or short creeping, 1-1.5 cm thick, covered with dense paleae, persistent leaf bases and fibrous roots. Paleae 3.5-4 x 0.5-0.7 mm, linear lanceolate, concolorous, yellow when young, becoming brown with age, acuminate with smooth margin. Fronds tufted, 6-8, spreading (or often hanging since the plants grow on earth cuttings), 40-60 x 20-22 cm; stipe 20-25 cm x 1.5-2 mm, equal in length to lamina, deep brown to black, with shallow groove on adaxial surface, densely paleate at base, glabrous and glossy above; lamina 20-35 x 20-22 cm, tri-quadripinnate, ovate or deltoid, broadest at base; rachis similar to stipe, flexuous, bearing alternately 10-12 pairs of primary pinnae; basal 4-6 pairs of primary pinnae bipinnate or rarely tripinnate, ovate-deltoid, gradually becoming one pinnate and at the distal end the primary rachis bears simple pinnae; basal primary pinnae are1.5-2 cm apart, but gradually become closer towards the tip; basal most primary pinnae longest, 8-10 x 4.5 cm, bearing 6-7 pairs of secondary pinnae; basal secondary pinnae simple pinnate, 3-4 cm long, bearing 3-4 pairs of ultimate pinnules; primary rachis and all its branches are glabrous, glossy and flexuous ending in a larger pinnule which is distinctly cuneate and deltoid, 1.5-2 x 1 cm with the basal margins straight or slightly concave and outer margin round and irregularly lobed; lateral ultimate pinnules shortly stalked; stalk 3-5 mm long, pinnules subdimidiate, 1.5 x 0.75 cm, acroscopic basal margin oblique and basiscopic basal margin horizontal to the rachis, both forming an angle of 120° or more in lower pinnules and gradually become 90° or less in the pinnules of the upper region; outer margin deeply lobed into 3 or rarely 4 primary lobes, the sinuses reaching almost half way down the pinnule; the primary lobes again shallowly divided into 2 or 3 lobes; margins of ultimate lobes serrulate; pinnules glabrous on both surfaces and herbaceous. Veins distinct on both surfaces, open dichotomous, 5-6 times forked, ultimate veinlets

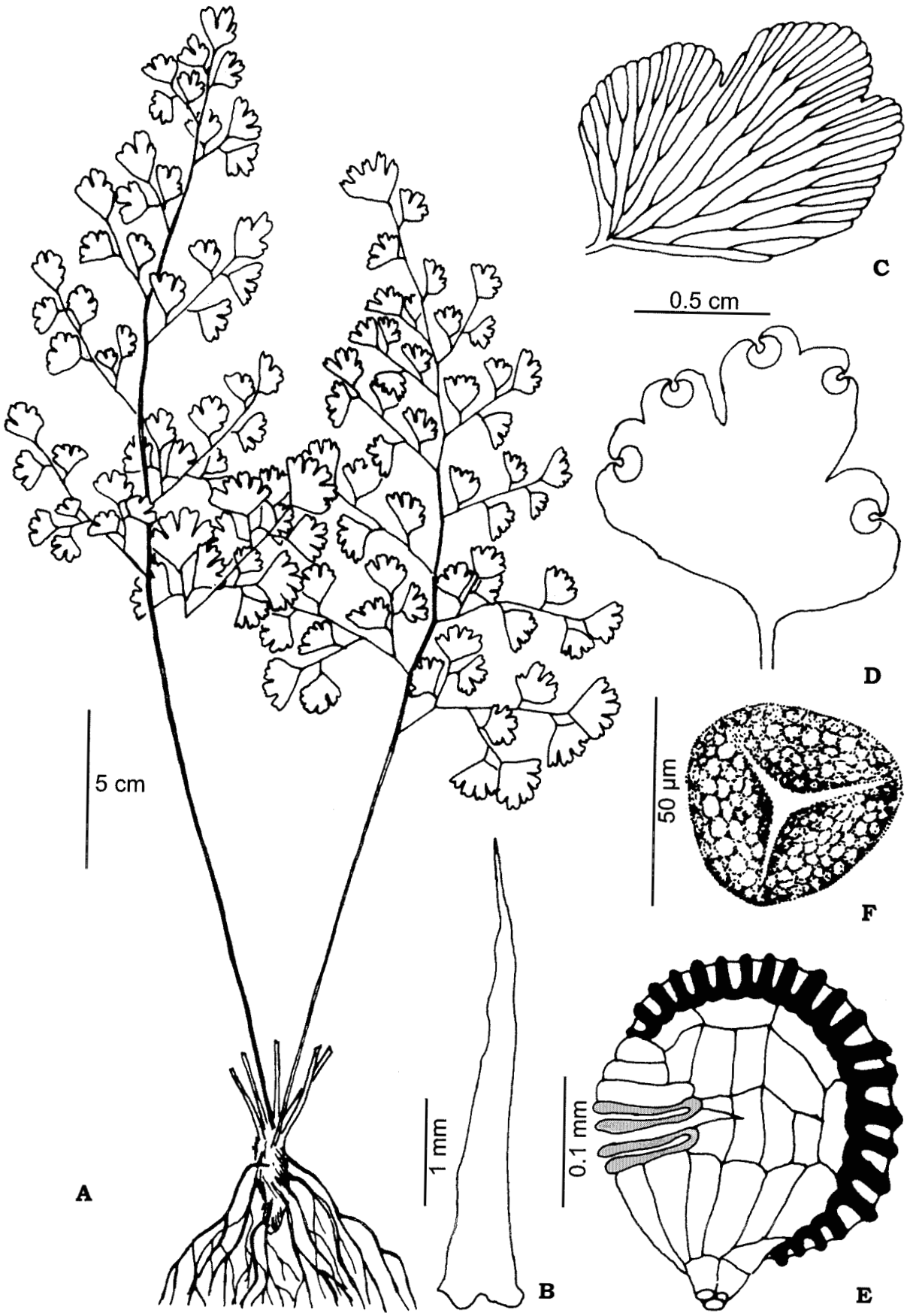

Fig. 17. **Adiantum raddianum**: **A**- Habit, **B**- Palea, **C**- Sterile pinnule, **D**- Fertile pinnule, **E**- Sporangium, **F**- Spore (from *Mohanakurup CU 52818*).

Fig. 18. Adiantum raddianum: **a.** habit, **b**. part of fertile frond; **A. tenerum**: c. habit, **d**. fertile pinnule; **A. zollingeri**: **e.** habit, **f**. part of fertile frond.

ending in the sinuses between marginal teeth of pinnule. Sori 2-3 per primary lobe, reniform or rotundus, situated in the sinuses, 1-1.5 mm long, 1 mm, broad with a prominent circular notch on the outer margin. Sporangia almost sessile; capsule spherical; annulus 20-21 cells long. Spores 35 x 40 μm, trilete, tetrahedral; exine smooth.

Chromosome numbers: n = 60, 2n = 120, tetraploid sexual (Roy & Sinha, 1961, 1962); n = 57, 2n = 114, tetraploid sexual (Abraham *et al.*, 1962; Ghatak, 1977; Bir & Irudayaraj, 2001); n = 116, octaploid sexual (Fabri, 1957); n = 114, 2n = 228, octaploid sexual (Manickam, 1984; Manickam & Irudayaraj, 1988; Bir *et al.*, 1996; Bir & Irudayaraj, 2001); 2n = 228, octaploid sterile (Bir & Irudayaraj, 2001); n = 228, 2n = 456, 16-ploid sexual (Bir & Irudayaraj, 2001); n = 2n = 87, triploid apogamous (Ghatak, 1977).

Distribution and Ecology: *Adiantum raddianum* is having a restricted distribution in India and has been reported from Darjeeling (West Bengal) in eastern India and in Western Ghats of Karnataka, Kerala and Tamil Nadu in southern India. It also occurs in tropical and subtropical Africa, Brazil, Mexico, and Sri Lanka. It is very common in exposed or partially shaded moist earth cuttings along road sides and also moist rock crevices in high altitudes.

Notes: 1. Bir *et al.* (1996) report that *A. raddianum* is a species complex in South India with triploid apogamous and tetraploid and octaploid sexual forms. Bir and Irudayaraj (2001) add two more cytotypes, a sexual 16-ploid (n = 228, 2n = 456) and one sterile octaploid (2n = 228) and explain that these cytotypes show some variation in morphology because of their different habitats. According to them tetraploid plants grow in fully exposed places in dry soil as solitary plants or form isolated small colonies, while octaploid plants, both sexual and sterile grow along wet shaded places intermixed with other ferns forming large colonies. The 16-ploid cytotype grows beneath tea bushes in Nilgiris.

2. Nair and Ghosh (1974) proposed a new name *Adiantum cuneipinnulum* N.C.Nair & S.R.Ghosh for this taxon stating that *A. raddianum* C.presl (Tend. Pterid. 158. 1836) is different from *A. cuneatum* Langsd. & Fisch. (Ic. Fil. 23. t. 26. 1810) and the latter is a later homonym of *A. cuneatum* Forst. (Prod. 84. 1786) and hence there is no valid name for the taxon. But the fact is that Christensen(1906) had treated *A. cuneatum* as a synonym of *A. raddianum* C.Presl. Sledge (1973) again treated *A.*

raddianum as the correct name for the taxon and *A. cuneatum* as a synonym. Kramer (1992) indicates that *A. cuneatum* Langd. & Fisch. is correctly called *A. raddianum* C.Presl. and not *A. cuneipinnulum* N.C.Nair & S.R.Ghsoh, since Presl's name has long become established in the literature. Fraser-Jenkins (1997) opines that, since *A. cuneipinnulum* N.C.Nair & S.R.Ghsoh is originally a *nomen novum,* it has the same type as the replaced name, *A. cuneatum* Langsd. & Fisch.

Specimens examined: **KARNATAKA**: Kodagu Dt., Chettalli, *Rajagopal 118* (MGMC); Sampaje, *Manickam 2891* (XCH); Thalakkavery, *Banerjee 11492* (CAL). Shimoga Dt., Biligirirangan hills, *Rajagopal 363* (MGMC). **KERALA**: Idukki Dt., Devikulam, *Mohanakurup 73154* (CALI), *Nair 40207* (CAL); Kattappana, *Ramanujam 72479* (MH); Kumali, *Madhusoodanan 43848* (CALI), *Nair 40477, 40794*; Kuttikanam, *Nair 813* (CAL); Munnar, *Madhusoodanan 29724* (CALI), *Manickam & Mathew 34558* (XCH); Peerumedu, *Meebold 12894, Nair 40129* (CAL); Thekkady, *Manickam & Mathew 33376* (XCH), *Puri 36790* (CAL), *Sharma 42067* (MH). Kottayam Dt., Kurisumalai, *Antony 747* (MH), *Manickam & Mathew 33568* (XCH); Wagamon, *Mohanakurup 52832* (CALI). Palakkad Dt., Kaikatty, Nelliampathi, *Mohanakurup 52898* (CALI), *Vajravelu 44683* (MH); Karappara, Nelliampathi, *Mohanakurup 52837, 52897* (CALI); Padagiri tea estate, *Nair 69809* (CAL); Silent Valley, *Manickam 3252* (XCH); Silent Valley dam site, *Nayar 10198* (CALI); Silent Valley rest house, *Vohra & Ghosh 56386*; Valiaparathode, *Vohra & Ghosh 56379* (CAL); Vadarimalai, *Bhargavan 56900* (CAL, MH), *Fischer 2764* (CAL). Pathanamthitta Dt., near Pampa dam, *Manickam & Mathew 34317* (XCH). Thiruvananthapuram Dt., Boneccord, *M.Mohanan 59476* (CAL); Ponmudi, *Madhusoodanan 43853* (CALI), *Manickam & Mathew 33674* (XCH), *M.Mohanan 59476* (MH), *M.Mohanan 54767, Nair & Ghosh 51716, 51862* (CAL). Thrissur Dt., Sholayar, *Manickam & Mathew 34713* (XCH). Wayanad Dt., Chembra, *Mohanakurup 52861;* Lakkidi, *Mohanakurup 52873* (CALI); Mananthavady, *Ramachandran 53898* (CAL, MH); Meppadi, *Geevarghese 4177*; Pookode, *Mohanakurup 52835*; Vythiri, *Madhusoodanan 7225* (CALI). **TAMIL NADU**: Coimbatore Dt., near Anamudi forest, *Ramamurthy 78476* (CAL); Lower Poonachi, *Joseph 12782* (MH); Sholayar submergible area, *Sebastine 16671* (CAL); Valparai, *Manickam 1873* (XCH). Dindigul Dt., Kodaikanal, *Sauliere 1015* (CAL); Kodaikanal ghat road, *Manickam 3314* (XCH); Pannaikadu, *Deb 30872* (MH); Shembagannur, Kodaikanal, *Mohanakurup 73172* (CALI); Thandikudi, *Ramamurthi 23637* (MH). Kanniya Kumari Dt., Karimani, *Manickam 2558* (XCH); Kothayar, *Nair & Ghosh*

51799 (CAL); Kothayar hills, *Manickam 3573*; Mahendragiri hills, *Manickam 33912* (XCH). Namakkal Dt., Kolli hills, *Mohanakurup 52882* (CALI). Nilgiris Dt., Avalanchi, *Mohanakurup 73107* (CALI), *Manickam 866* (XCH); Coonoor, *Mohanakurup 52809, 73106* (CALI), *Sebastine 4053* (CAL), *Sharma 40306*; Curzon valley, *Vajravelu 39626* (MH); Konavakkarai, Kottagiri, *Subramanyam 1998* (CAL); Lovedale, Ootty, *Mohanakurup 73110, 73114*; Naduvattom, *Mohanakurup 52807, 52818, 52819* (CALI); way to Naduvattam from Devarshola, *Subramanyam 10501* (CAL); Wellington, *Mohanakurup 73104* (CALI). Ramanathapuram Dt., Mudaliaruthu, *Nair 61032* (CAL, MH). Salem Dt., Andiappankovil area, Yercaud, *Nair 74207*; Balmadies estate, Yercaud, *Ghatak 32* (CAL), *Subramanyam 6561* (MH), *Subramanyam 7515*; Bauxite rock, Yercaud, *Ghatak 231* (CAL); Kaveri peak, *Nair 74236* (CAL, MH); Yercaud, *Dinesh 3598*, *Mohanakurup 52877* (CALI), *Nair 74207* (MH). Teni Dt., near Kumali, *Subramanyam 8131* (CAL). Tirunelveli Dt., Courtallum, *Manickam 33974* (XCH); way to Kannikati, *Sebastine 9607* (CAL, MH); Kanthaparai, *Henry & Chandrabose 19851* (MH); Upper Kothayar, *Mohanakurup 52846* (CALI). Virudunagar Dt., Devathanam, *Manickam 2971* (XCH); Nagariar estate, *Srinivasan 94475* (MH); Sethur hills, *Srinivasan 63513* (CAL, MH).

Adiantum tenerum Sw., Prod. 135. 1788; B.K.Nayar, Bull. Nat. Bot. Gard. 52: 22. 1961; Kurup *et al.*, J. Econ. Taxon. Bot. 25: 716. 2001. (**Fig. 8c & d, 19A-G**)

Adiantum assimile Link, Hort. Berol. 2. 17. 1833, *non* Sw., 1801.

Adiantum littorale Jenman, W. Ind. Guiana Ferns 96. 1899.

Rhizome short creeping, 1-1.5 x 0.5 cm, branched, densely clothed with paleae. Paleae 3.5 x 0.5–1 mm, ovate-lanceolate, pseudo-peltate, terminating in a long acicular cell; margin of palea profusely dentate (in rhizome paleae the teeth grow out as branched hairs). Fronds tufted, 6-8, spreading (or hanging down as the plants grow in steep earth cuttings), 50-60 x 15-20 cm; stipe 25 cm long, 1.5 mm thick, black glossy, grooved on the upper side, paleae restricted to base, glabrous above; lamina 25-30 x 15-20 cm, 3-4 pinnate, deltoid-ovate, broadest at base; rachis like stipe, black and glossy, slightly flexuous, bearing 7-8 pairs of alternate, distantly placed primary pinnae; basal 4-5 pairs of primary pinnae tripinnate or bipinnate, 3-5 cm apart, the upper 3-4 primary pinnae simple and closely placed; basal most primary pinna longest, 24 x 15 cm, deltoid-ovate; secondary rachis flexuous, bearing 6-7 pairs of secondary pinnae, the lower 3 pairs bipinnate or simple pinnate; tertiary

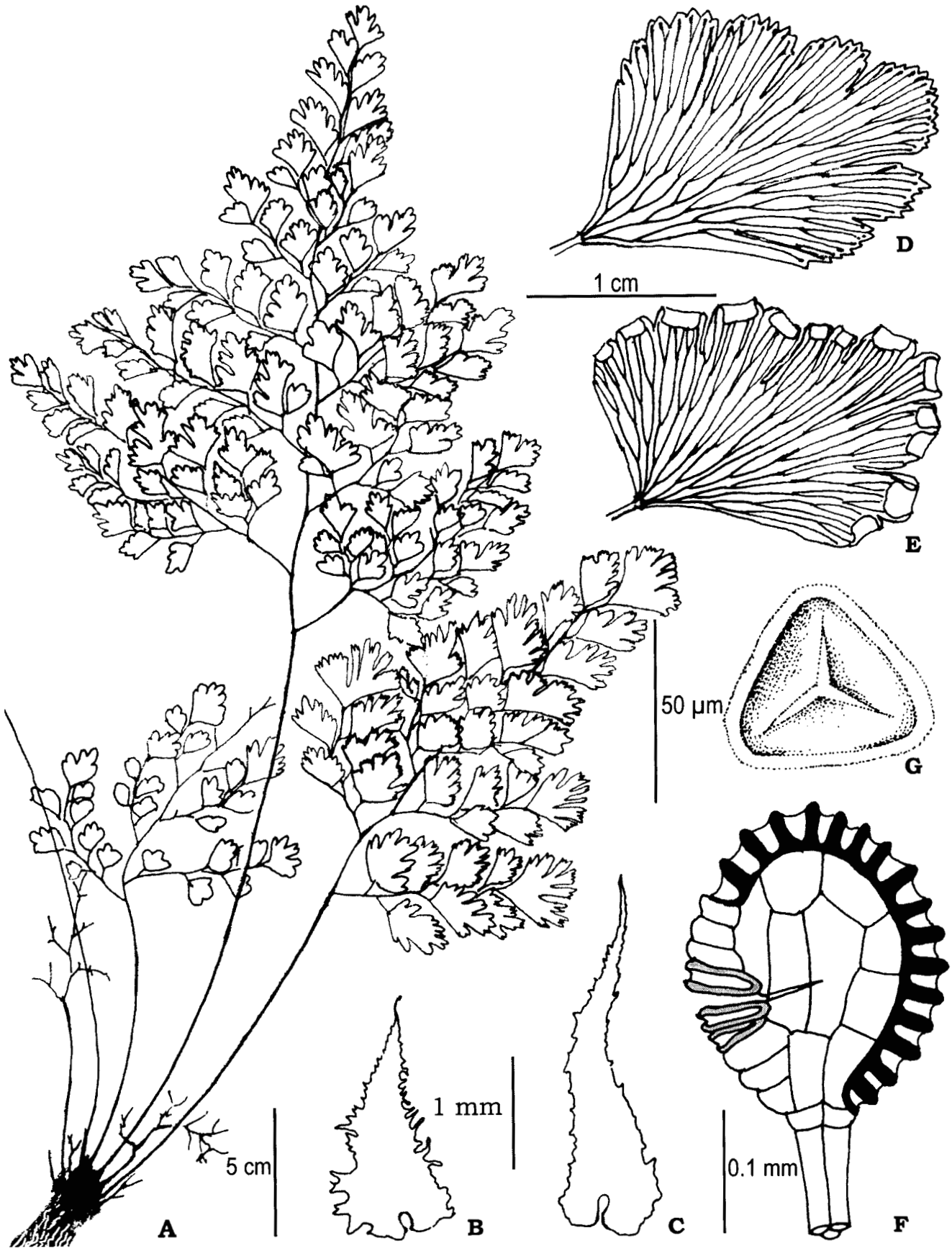

Fig. 19. Adiantum tenerum: **A**- Habit, **B**- Rhizome palea, **C**- Stipe base palea, **D**-Sterile pinnule, **E**- Fertile pinnule, **F**- Sporangium, **G**- Spore (from *Mohanakurup CU 73103*).

pinnae shorter with 1 or 2 pairs of alternate pinnules; the primary rachis and its branches end in a larger pinnule which is distinctly cuneate and deltoid, 3 x 2.5 cm with basal margins straight or concave, outer margin round and irregularly lobed; lateral pinnules variable in shape mostly deltoid to subrhomboid with acroscopic and basiscopic inner margins straight and meeting at an angle of 90°; some pinnules are broadly cuneate, outer margin is deeply lobed into 3-5 primary lobes, the incisions reaching 1/3 of the width, the primary lobes are again shallowly lobed once or twice; the margin of ultimate lobes are finely toothed; all pinnules are distinctly stalked; stalk 3-4 mm long, enlarged at apex forming a small black disc; pinnules articulated, both surfaces glabrous and herbaceous. Veins distinct on both surfaces, open dichotomous, 5-6 times forked, each ultimate veinlet reaching the marginal teeth. Sori 10-15 per pinnule, all along the outer margin, transversely elongated, some times slightly curved. Sporangia short stalked; stalk smaller than capsule, 3-celled thick; annulus 16-18 cells long. Spores 36 x 40 μm, trilete, tetrahedral; exine smooth.

Chromosome numbers: n = 30, 2n = 60, diploid sexual (Mehra & Verma, 1960; Roy & Sinha, 1961, 1962; Abraham *et al.*, 1962; Sinha & Verma, 1977).

Distribution and Ecology: Earlier authors treated *Adiantum tenerum* as a cultivated plant. Now it is reported as naturalized in Kozhikode District of Kerala and also in Andamans. It occurs in West Indies and extend from Florida and Mexico to Peru. It is found growing in fully or partially shaded moist earth cuttings in lower altitudes.

Note: *A. tenerum* is related to *A. capillus-veneris*, but can be easily distinguished because of its larger size, 3-4 pinnate lamina, highly fimbriate paleae and petiole terminating in a black disc towards the base of pinnule.

Specimens examined: **KERALA**: Kozhikode Dt., Kalluthankadavu, *Mohanakurup 52812;* Puthiyara, *Mohanakurup 73103* (CALI).

Adiantum zollingeri Mett. *ex* Kuhn, Ann. Lugd. Bat. 4: 280. 1869; N.C.Nair & R.D.Dixit, J. Bombay Nat. Hist. Soc. 78: 444. 1981; R.D.Dixit, Census Indian Pterid. 76. 1984; Manickam, Fern Fl. Palni Hills 37. 1986; Madhus. & Sevichan, J. Econ. Taxon. Bot. 15: 145. 1991; S.M.Vasudeva *et al.*, Indian Fern J. 8: 176. 1991; Manickam & Irud., Pterid. Fl. W. Ghats 99. pl. 74. 1992; N.C.Nair *et al.*, J. Econ. Taxon. Bot. 16: 271. 1992; Rajagopal & Bhat, Indian Fern J. 15: 10. 1998; S.Chandra, Ferns India 75. 2000. (**Fig. 14, 18e & f, 20A-G**).

Type: Java, *Zollinger 2806* (L).

Adiantum caudatum var. *subglabrum* Holttum, Rev. Fl. Malaya 2: 600. 1954.
Adiantum nagnam B.K.Nayar & Geev., Fern Fl. Malabar 143. 1993.

Rhizome erect, 1.5-2 x 1 cm, unbranched, covered with dense paleae and persistent leaf bases all around and a tuft of fibrous roots towards the base. Paleae 5 x 0.5 mm, linear-lanceolate, bicolorous with dark brown central region and pale brown margins, acuminate, slightly toothed especially towards the distal half. Fronds 8-10, spreading and arching, rooting at apex, 30-50 x 3.5-4 cm; stipe 7-10 cm long, 3-4 mm wide, dark brown, terete with a very shallow groove on the adaxial side, basally scaly, but densely hairy on the adaxial side and glabrous on abaxial side above; hairs of stipe 1-1.75 mm long, pluricellular, uniseriate, brown coloured with basal cells thick walled; lamina 20-30 x 4 cm, simply pinnate, oblong-lanceolate, widest below and tapering towards tip; rachis like stipe, dark brown, hairs dense on adaxial side and glabrous on abaxial side, bearing 25-30 pairs of alternate pinnae which gradually become smaller towards the tip and usually terminating in a vegetative bud; pinnae sessile, 1.5 x 0.7 cm, dimidiate, basal 2 pairs deflexed, inner margin concave and parallel to rachis, lower margin straight and horizontal to the rachis, outer margin divided into 5-6 primary lobes; sinuses 1/3 to 1/2 deep the lamina, margins of lobes slightly toothed; pinnae herbaceous, glabrous on both surfaces or few pluricellular hairs on lower surface towards base; hairs of pinnae much shorter than that of stipe. Veins distinct on both surfaces, open dichotomous, 4-5 times forked, each ultimate veinlet reaching the marginal tooth of lamina. Sori usually 5 or 6, one in each primary lobe, oblong or linear, reflexed margin hairy outside. Sporangium stalked; stalk equal in length to capsule; capsule globose; annulus 18 cells long. Spores 35 x 45 μm, trilete, tetrahedral; exine spinulose.

Chromosome numbers: n = 29, diploid sexual (Manickam, 1984).

Distribution and Ecology: In India the distribution of *Adiantum zollingeri* is restricted to South India, where it is reported from Visakhapatnam in Andhra Pradesh and the southern districts of Kerala and Tamil Nadu. Also distributed in Angola, Southern China, New Guinea, Java, Malaya, Sri Lanka and Thailand. Commonly grows on shaded or partially exposed more or less dry situations in lower altitudes.

Note: *A. zollingeri* is closely related to *A. incisum,* but differs in having pinnae glabrous or glabrescent on both surfaces, indusia glabrous and stipe and rachis

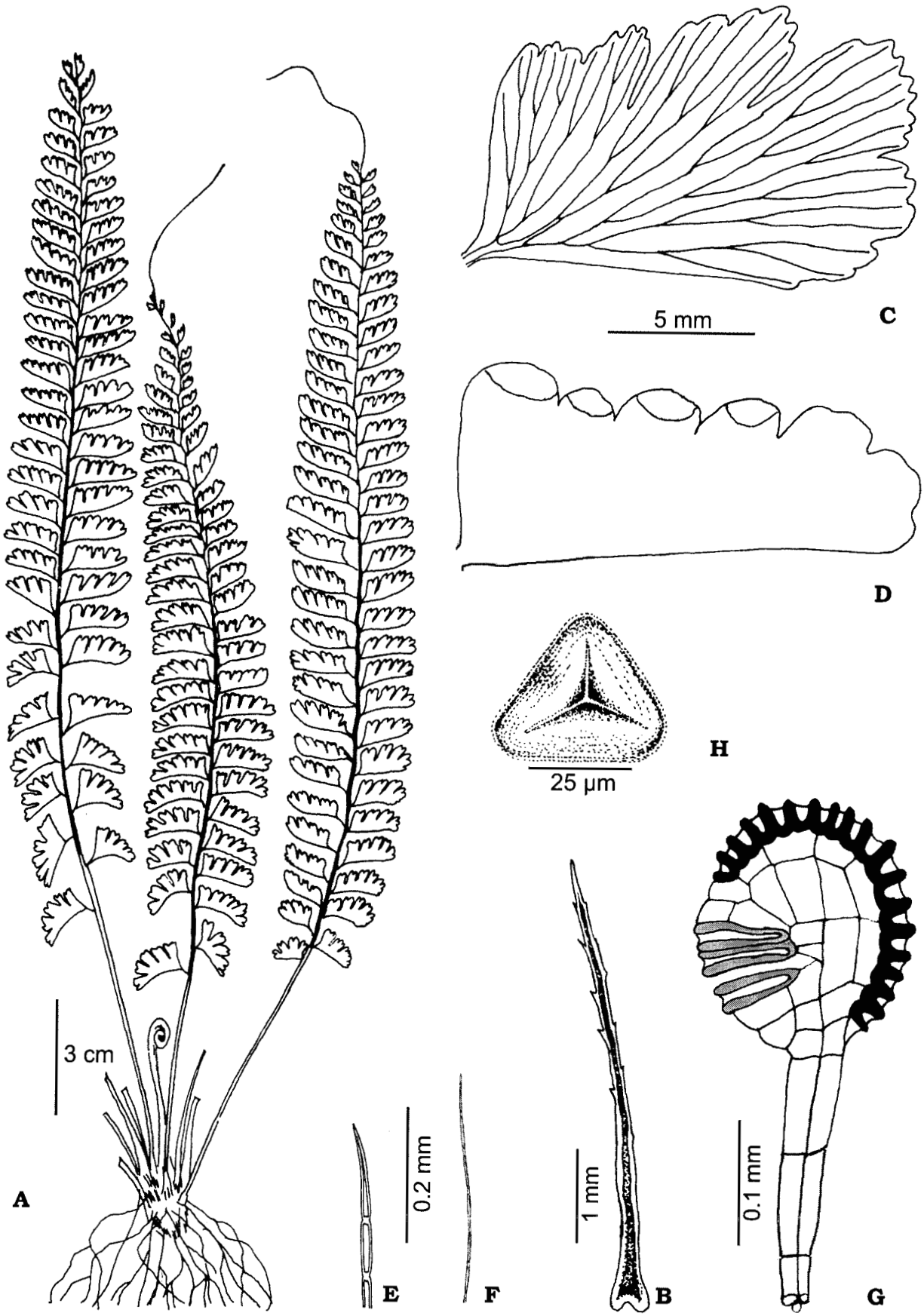

Fig. 20. Adiantum zollingeri: A- Habit, **B**- Palea, **C**- Sterile pinna, **D**- Fertile pinna, **E**- Hair on lower side of pinna, **F**- Hair on stipe, **G**- Sporangium, **H**- Spore (from *Mohanakurup CU 73137*).

densely hirsute with long ferrugineous hairs on the upper surface, but naked on the lower surface.

Specimens examined: **ANDHRA PRADESH**: Visakhapatnam Dt., Panyagiri hill, *Subbarao 19249* (MH). **KERALA**: Idukki Dt., Kottamala, *Augustine 13724;* Mlappara, *Rajesh 70029* (CALI). Kollam Dt., Mambazhathara, *Nair 50970* (MH). Palakkad Dt., Nelliampathi, *Geevarghese 17818*; Padagiri, *Ravindran 18056* (CALI). **TAMIL NADU**: Coimbatore Dt., Anaikatti, *Viswanathan 464;* Anamoolamalai, *Sreemadhavan 97*; Siruvani, *Nair 41492* (MH). Dindigul Dt., Alagar hill, *Subramanyam 3470* (MH); Palamalai, *Manickam 31142* (XCH). Kanniya Kumari Dt., Keeriparai, *Nair & Ghosh 51913*; Panagudi, *Shetty 32281* (MH). Nilgiris Dt., Bokkapuruam, R.F., *Sharma 35412* (MH); Coonoor, *Manickam 1483*; Coonor- Mettupalayam road, *Manickam 1229* (XCH). Ramanathapuram Dt., Ayyanarkoil, *Vajravelu 38636* (MH). Salem Dt., Yercaud, *Madhusoodanan & Revathy 1024* (CALI). Tirunelveli Dt., Courtallum, *Manickam 31050* (XCH), *Sumathykuttyamma 5998, Surendran 514* (CALI); Kalakkad, *Manickam & Mathew 34191* (XCH), *Mohanakurup 73137* (CALI); way to Kannikkatti, *Sebastine 9921* (CAL, MH); Kodumady, *Sebastine 8385* (MH). Virudunagar Dt., Devathanam, *Manickam 2954* (XCH).

CHEILANTHOIDEAE (J.Sm.) W.C.Shieh

According to Tryon and Tryon (1973) cheilanthoids are a complex group of about 325 species containing distinctive single species, well-defined species groups and ill-defined alliances. They are those ferns coming under family Polypodiaceae, subfamily Gymnogrammoideae, Tribe Cheilantheae of Christensen (1938), which include eight genera namely, *Adiantopsis*, *Cheilanthes*, *Cheilanthopsis*, *Doryopteris*, *Notholaena, Pellaea, Saffordia* and *Sinopteris*. Pichi Sermolli (1957) states that cheilanthoid ferns are those genera listed by Ching (1940) in the Tribe Cheilantheae of the family Sinopteridaceae which also include the same number of genera. But instead of the genera *Notholaena* and *Saffordia,* Ching (*l.c.*) included *Aleuritopteris* and *Bakeriopteris*. All the other six gerera are common to both tribes. Bower (1928) included six genera in the cheilanthoid group, namely *Cheilanthes*, *Doryopteris, Notholaena, Pellaea, Saffordia* and *Trachypteris*. All these clearly show that there is no much difference of opinion among different authors with respect to the genera coming under cheilanthoid group.

But there is considerable disagreement among them about the placement of it in higher taxa. Copeland (1947) placed cheilanthoid ferns in Pteridaceae, while Holttum (1949), Alston (1956) and Brummitt (1992) placed them in Adiantaceae. But Ching (1940) and Pichi Sermolli (1977) treated this group under Sinopteridaceae. Nayar (1970) proposed a new family Cheilanthaceae to include cheilanthoid ferns. Crabbe *et al.* (1975) and Tryon *et al.* (1990) treated them as subfamilies. Where as the former included them in the subfamily Adiantoideae of family Adiantaceae, the latter placed them in the subfamily Cheilanthoideae of family Pteridaceae. Tryon and Tryon's (*l.c.*) Cheilanthoideae also contain some other genera such as *Coniogramme* Fee, *Cryptogramma* R.Br., *Hemionitis* L., *Paraceterach* Copel. etc. This classification is followed in this study.

According to Tryon and Tryon (1982), cheilanthoids constitute the largest group of xeric and semi-xeric ferns. There is a concentration of cheilanthoid ferns in six major geographic regions–the Mexican, Andean, Brazilian, African, Sino-Himalayan and Australian, where 282 of the 325 species occur. The American cheilanthoid species are almost completely different from those of Old World. Only *Cheilanthes farinosa* (Forssk.) Kaulf. and *Doryopteris concolor* (Langsd.& Fisch.) Kuhn have amphi-Atlantic ranges.

Cheilanthoids are characterised by sori borne on the distal region of the veins, usually confluent into an intramarginal line, protected by a vein-less marginal flap of lamina. Still they remain as one of the most contentious group of ferns with respect to natural generic classification. *Cheilanthes, Doryopteris* and *Pellaea* are unanimously recognized as independent genera in the group, but the remaining ones are adopted as distinct genera by some authors, while others treat them as synonyms of the above mentioned genera (Pichi Sermolli, 1977). For instance, a number of segregate genera such as *Adiantopsis* Fee, *Aleuritopteris* Fee, *Aspidotis* (Nutt. *ex* Hook.) Copel., *Mildella* Trevis., *Negripteris* Pic.Serm., *Notholaena* R.Br., *Neurosoria* Mett. *ex* Kuhn and Sinopteris C.Chr. & Ching from *Cheilanthes* Sw. (*sensu lato*) and *Cheiloplecton* Fee and *Ormopteris* J.Sm. from *Pellaea* Link (*sensu lato*) are recognised and treated as distinct genera by some authors, while others do not recognize one or more of these segregate genera and treat them as belonging to *Cheilanthes* Sw. (*sensu lato*) or *Pellaea* Link (*sensu lato*) as the case may be.

Many species of the cheilanthoid ferns have morphological characteristics evidently adaptive to seasonally dry habitats like complex leaves with many small ultimate segments or a compact lamina architecture, a densely pubescent or ceraceous lamina indument, very coriaceous leaf tissue and abscission zones in the petiole (Tryon & Tryon, 1973).

The genera coming under subfamily Cheilanthoideae (*sensu* Tryon *et al.*, 1990) which occur in South India are *Cheilanthes* (*sensu lato*), *Doryopteris*, *Parahemionitis* and *Pellaea.*

Cheilanthoideae (J.Sm.) W.C.Shieh, J. Sci. Eng. 10: 211. 1973; (J.Sm.) R.M.Tryon, Amer. Fern J. 76: 184. 1986.

Type: *Cheilanthes* Sw.

Cheilantheae J.Sm., Hist. Fil. 277. 1875.

Sinopteridaceae Koidz., Acta Phytotax. Geobot. 3: 50. 1934.

Cryptogrammaceae Pic.Serm., Webbia 17: 299. 1963.

Hemionitidaceae Pic.Serm., Webbia 21: 487. 1966, in part.

Cheilanthaceae B.K.Nayar, Taxon 19: 233. 1970.

Plants terrestrial or rupestral; rhizome erect or long creeping, covered with ovate-lanceolate, entire scales; stipe dark and polished, terete or adaxially sulcate; lamina uniform (dimorphic in *Parahemionitis*), simple, one to three pinnate or pinnatifid, glabrous, pubescent, scaly or glandular; veins usually free, some times anastomosing (*Parahemionitis*); sporangia either terminal on the veins forming submarginal soral line protected by reflexed marginal flap or spread along the anastomosing veins to form a net work and are exindusiate; sporangia globular, short-stalked; spores trilete, tetrahedral, mostly cristate; no equatorial flange.

Affinity: Cheilanthoid ferns are regarded as closely allied to pteroids due to the similarity in the sorus. Several authors point out that cheilanthoids are related to Schizaeaceae through the genus *Mohria*. The cheilanthoids and adiantoids are related because of having peculiar collenchymatous wall thickenings in the cell walls of the prothalli. Nayar and Devi (1973) state that gametophyte morphology appears to support the view that cheilanthoid ferns are related to the Anemiaceae-Lygodiaceae complex.

Note: 1. The family name Cheilanthaceae was first proposed by Ponce de Leon (Rev. Soc. Cub. Bot. 10: 44. 1953), but it was not validly published as the author

failed to give a description of the taxon. Nayar (1970) validly published this name with a Latin description, but circumscribed it to include genera such as *Cryptogramma* R.Br. and *Hemionitis* L., which are the types of Cryptogrammaceae and Hemionitidaceae respectively. Hence the name was illegitimate. But the amendments made to Article 63.3 of the Code at Sydney Congress made the name legitimate. Still only very few authors such as Chandra (2000a) follow this classification.

2. Panigrahi (1993) separated the Indian species of *Hemionitis*, viz., *H. arifolia* (Burm.f.) T.Moore from the rest and "because it does not fit comfortably in any existing genus", brought under a new generic rank *Parahemionitis* Panigrahi.

Key to Genera

1a.	Lamina simple, entire, dimorphic, sterile lamina ovate-cordate, fertile sagittate; sori continuous along the reticulate veins forming a network all over the lower surface of lamina, exindusiate	*Parahemionitis*
1b.	Lamina simple, palmately lobed or pinnately compound, monomorphic; sori restricted to the margin forming soral lines protected by marginal flap of lamina	2
2a	Lamina simple, palmately lobed	*Doryopteris*
2b	Lamina pinnately compound to decompound	3
3a.	Pinnule ovate-lanceolate, more or less uniform in size; pseudoindusium continuous, unlobed	*Pellaea*
3b.	Pinnule oblong, lower basiscopic pinnules much enlarged; pseudoindusium interrupted, not continuous	*Cheilanthes*

CHEILANTHES Sw.

Cheilanthes is an old genus. But still there is some question as to the homogeneity of the taxon. The generic name *Cheilanthes* comes from two Greek words, 'cheilos' meaning 'lip' and 'anthos' meaning 'flower', referring to the form of indusium. Indusia formed from the reflexed margin, are more or less confluent, but not strictly continuous. This genus is popularly known as 'Silver fern' due to the presence of white farina on the lower side of the lamina.

Eversince its inception, many pteridologists added a number of species to this genus from time to time; others, at the same time have split it variously, so that,

currently there exists great confusion regarding its generic boundary and relationship. As a result, there is no uniformity among pteridologists even in the number of species attributed to the genus. For example, it is given with more than 100 species (Bower, 1928; Ching, 1940), 130 species (Christensen, 1906; Kramer, 1962), 150 species (Nayar, 1963; Tryon & Tryon, 1982; Mabberley, 1987), 180 species (Copeland, 1947; Quirk *et al.*, 1983) or even 260 species (Pers. comm., Fraser-Jenkins, 2002).

Christensen (1938) and Tryon and Tryon (1982) classified the whole group of *Cheilanthes* (*sensu lato*) into three genera, *viz.*, *Cheilanthes* (*sensu stricto*), *Notholaena* and *Adiantopsis*. American species of the genus *Cheilanthes* are divided by Tryon and Tryon (1982) into 11 groups of which 10 groups represent the main lines of diversity and the 11th group includes morphologically isolated species and those "which cannot be placed in any other group". Copeland (1947) divided the genus into *Cheilanthes* (*sensu stricto*), *Aleuritopteris*, *Mildella*, *Cheiloplecton*, *Aspidotis* and *Neurosoria,* but did not accept *Notholaena* and *Adiantopsis* as distinct from *Cheilanthes*.

Among the number of segregate genera that have been proposed within the *Cheilanthes* (*sensu lato*), those that have mostly been accepted include *Negripteris* Pic.Serm., *Neurosoria* Kuhn, *Aleuritopteris* Fee, *Sinopteris* C.Chr. & Ching, *Aspidotis* (Nutt. *ex* Hook.) Copel. and *Mildella* Trev. But still so many authors do not consider one or more of these genera as distinct from *Cheilathes*.

Mainly on the basis of the farinose under surface of lamina, *Aleuritopteris* is separated as a distinct genus by Fee (1852). This treatment was accepted by Ching (1940), Copeland (1947), Panigrahi (1960, 1962, 1998) Pichi Sermolli (1977), Saiki (1984a, b & c), Crabbe *et al.* (1975) and others. Ching (1941) not only accepted *Aleuritopteris* Fee as a good genus, but also divided it into three series, *viz.*, series Argenteae, Farinosae and Dalhousianae. The last series was raised to the rank of a genus by Hsing and Wu (1979), *viz., Leptolepidium* Hsing & S.K.Wu, but it was not accepted by others. Saiki (1984a) followed the classification of Ching (1941) and recognized more than 40 species (most of them new) under the series Farinosae and Dalhousianae of the *Aleuritopteris farinosa* complex from Asia and Africa.

Pichi Sermolli (1977) says that *Aleuritopteris* is not very clearly distinct from *Cheilanthes*, but still it is a natural group and differs from *Cheilanthes* in the shape of frond, in the broad flat ultimate segments, in the long, laterally extended, some times

confluent indusia, in the lower surface of the blade mostly covered with a white, yellow or orange mealy powder and in the few sporangia in each sorus. Manton *et al.* (1966) are of the view that the characters which are considered for the genus *Aleuritopteris* are more or less found in all species and hence it is difficult to establish generic limits between *Cheilanthes* and *Aleuritopteris.* Hooker and Baker (1865-1868) treated *Aleuritopteris* as only a section of *Cheilanthes*, *viz.*, sect. *Aleritopteris* (Fee) Hook. & Baker and this classification is followed by Nayar (1962c).

Cheilanthes Sw., Syn. Fil. 5: 126. 1806, *nom. cons.*; Fee, Gen. Fil. 155. 1852; Hook., Sp. Fil. 2: 75. 1852; T.Moore, Ind. Fil. 38. 1857; C.B.Clarke, Trans. Linn. Soc. Lond. Bot. 1: 454. 1880; Bedd., Handb. Ferns Brit. India 88. 1883; C.Hope, J. Bombay Nat. Hist. Soc. 13(3): 88. 1901; Ching, Sunyatsenia 5: 226. 1940; Copel., Gen. Fil. 65. 1947; Holttum, Rev. Fern Fl. Malaya 2: 589. 1954; B.K.Nayar, Bull. Nat. Bot. Gard. Lucknow 68: 1. 1962; R.M.Tryon & A.F.Tryon, Ferns Allied Plants 249. 1982; R.D.Dixit & Vohra, Diction. Pterid. India 8. 1984; R.M.Tryon *et al.* in Kramer & Green (eds.), Fam. Gen. Vas. Plants 1: 242. 1990; Khullar, Illustr. Fern Fl. West Himalaya 1: 180. 1994; T.C.Chambers & P.A.Farrant in McCarthy (ed.), Fl. Australia 48: 271. 1998;

Type: *Cheilanthes micropteris* Sw., Syn. Fil. 5: 126. t. 3. f. 5. 1806. (lectotypified by Maxon in Ill. Fl. NE. US & Can. 25. 1913).

Allosorus Bernh., Neues J. Bot. 1(2): 36. 1805.

Myriopteris Fee, Mem. Fam. Foug. V. Gen. Fil. 148. 1852.

Aleuritopteris Fee, Mem. Fam. Foug. V. Gen. Fil. 153. 1852.

Cheiloplecton Fee, Mem. Fam. Foug. VII. Gen. Fil. 33. t. 20. 1857.

Cosentinia Tod., Syn. Pl. Acot. Vasc. Sicil. 14. 1866.

Mildella Trevis., Rend. Ist Lombard. II. 9: 810. 1876.

Cheilosoria Trevis., Atti Ist Veneto. V. 3: 579. 1877.

Choristosoria Kuhn, v. Deck. Reis. 3 (3): 13. 1879.

Pomatophytum Jones, Contrib. West Bot. 16: 12. 1930.

Sinopteris C.Chr. & Ching, Bull. Fan. Mem. Inst. Biol. Bot. 4: 359. 1933.

Negripteris Pic.Serm., Giorn. Bot. Italy, ser. 2. 53: 130. 1946.

Aspidotis (Nutt. *ex* Hook.) Copel., Gen. Fil. 68. 1947.

Leptolepidium Hsing & S.K.Wu, Acta Bot. Yunnan. 1: 115. 1979.

Plants terrestrial or lithophytic; rhizome erect to long creeping, solenostelic or dictyostelic with light brown to black, concolorous or bicolorous, linear to ovate-lanceolate scales; paleae entire and smooth, ending in a globose or oval glandular cell; leaves usually monomorphic, or as in a few, slightly dimorphic; the fertile leaves erect, longer and more complex than the sterile ones; stipe thin, fragile, terete, black and polished; rachis as stipe, grooved on upper surface; lamina one to five pinnate or up to three-pinnatifid, more of less deltoid or deltoid-lanceolate, usually glabrous or with white, yellow or orange farinose beneath; basal pinna enlarged on the basiscopic side; veins free, ending near or at the margins, the fertile veins some what dilated; sori confined to the dilated vein ends or in soral lines along a marginal commissure; sporangia large, globular, short-stalked, not paraphysate; the margin of the lamina modified as a marginal indusium covering one or more sori or a soral line; margin of the indusium irregular and flabellate; spores trilete, tetrahedral-globose; sporoderm characteristically verrucose or cristate and no equtorial flange.

Gametophyte: Mature gametophyte is cordate and naked with a prominent, six to eight cells thick midrib. Wing cells may possess collenchyma like thickenings at the corners (Nayar, 1962c). The prothallus has a remarkable capacity to with stand severe water deficit and survive after drying and continued exposure to low humidity. Chambers (Pers. comm., 2001) is of the opinion that *Cheilanthes* gametopytes are remarkably resistant to severe and prolonged drought and there is no other fern with this much drought tolerance at the gametophyte phase.

Chromosome numbers: n = 28, 29, 30 (Abraham *et al.*, 1962); n = 29, 30. (Manton & Sledge, 1954; Chiarugi, 1960; Fabri, 1963; Knobloch, 1966; Manickam & Irudayaraj, 1988).

Distribution and Ecology: *Cheilanthes* is primarily a genus of open habitats. It is distributed worldwide, especially prevalent in semi-arid zones. It is much diverse in Central America, the Mediterranian area, South and East Africa and the Sino-Himalayan region. *Cheilanthes* spp. usually grow in rock crevices as heliophiles (leaves exposed in sun, while the stems are in cooler, moist micro-niches under rocks) or among rocks in open sunny areas or in open soil, stream or road banks or walls.

Note: 1. *Allosorus* Bernhardi (Schrad. Neues J. Bot. 1(2): 36. 1805) was published before *Cheilanthes* Swartz (Syn. Fil. 5: 126. 1806). Consequently *Allosorus* Bernh.

has priority over *Cheilanthes* Sw. and hence, the former is the correct name for the genus. However, the name *Cheilanthes* Sw. has been in general use since its publication and has been adopted in almost all the taxonomical and anatomical works (Diels, 1899; Christensen, 1906; Bower, 1928; Ching, 1940). So, in order to retain this established name, Pichi Sermolli proposed the conservation of *Cheilanthes* Sw. against *Allosorus* Berhn. at the Stockholm Congress (1952) and was accepted (Pichi Sermolli, 1953).

2. Panigrahi (1987) proposed to emend the typification of *Cheilanthes* Sw. *nom. cons.* from *Cheilanthes micropteris* Sw. to *Cheilanthes tenuifolia* (Burm.f.) Sw. on the basis of the argument that *Cheilanthes* Sw. was first lectotypified with *Cheilanthes tenuifolia* (Burm.f.) Sw. by Smith (1875) and therefore, the subsequent lectotypification by Maxon (Ill. Fil. NE. US & Can. 25. 1913 & Pterid. Porto Rico 428. 1925) with *Cheilanthes micropteris* was a mechanical one and had to be set aside. But this proposal was rejected by the Committee for Pteridophyta of the International Code of Botanical Nomenclature.

Cheilanthes (*sensu lato*) is represented in India by about 26 spp. (Dixit, 1984; Chandra, 2000a). Of these, 11-13 species are reported to be occurring in South India. Dixit (*l.c.*) reports the occurrence of *C. albomarginata* C.B.Clarke through out India and *C. dalhousiae* Hook. in the Himalayas. But Fraser-Jenkins (1997) treats the former as a synonym of the latter and *C. flaccida* (Bedd.) Mehra & Bir as a synonym of *C. bullosa* Kunze. *C. laxa* T.Moore has long been treated as a synonym of *C. thwaitesii* Mett. *ex* Kuhn (Christensen, 1906). Nair and Ghosh (1976) collected *C. thwaitesii* Mett. *ex* Kuhn from South India, but misidentified it and erroneously published it as a new species, *viz., C. keralensis* N.C.Nair & S.R.Ghosh (Fraser-Jenkins, 1997). Fraser-Jenkins (Pers. comm., 2001) opines that Thwaites originally collected *C. thwaitesii* Mett. *ex* Kuhn under the erroneous name *C. varians* Wall. *ex* Hook., a synonym of *C. belangeri* (Bory) C.Chr. Dixit (1984) and Chandra (2000a) report the occurrence of *C. belangeri* (Bory) C.Chr. in South India apparently based on Beddome (1864) who reported to have collected it from Anamallays. But Baker does not admit the report of occurrence of this species in South India (Clarke, 1880). Khullar (1994) gives the area of distribution of *C. belangeri* (Bory) C.Chr. in India as East India, Bengal, Assam and Khasi hills only. Although I could not collect this taxon from the study area, there are a few specimens of this species at CAL collected by Ramarao and Beddome from South India. Hence this species is included in the

present study. *C. keralensis* N.C.Nair & S.R.Ghosh, *C. laxa* T.Moore and *C. thwaitesii* Mett. *ex* Kuhn, treated as distinct species by Dixit (1984) are in fact, synonymous, with *C. thwaitesii* Mett. *ex* Kuhn as the correct name.

Fraser-Jenkins (Pers. comm., 2001) is of the opinion that the report of occurrence of *C. doniana* (S.K.Wu) Fraser-Jenk. & Khullar and *C. dubia* C.Hope in South India by Chandra (2000a) is erroneous. This seems to be true because according to Dixit (1984) *C. dubia* C.Hope in India is restricted to North-Western Himalaya and *C. doniana* (S.K.Wu) Fraser-Jenk. & Khullar is not at all occurring in India. Hence, both these species are excluded from the present treatment.

The report of occurrence of *C. contigua* Baker and *C. krameri* Franch. & Sav. in South India by Chandra (2000a) needs confirmation. (Even though Christensen (1906) treated *C. contigua* Baker as a synonym of *C. tenuifolia* (Burm.f.) Sw., he later (1917) considered the former as a good species distributed in tropical Australia). It appears that the report of occurrence of *C. contigua* Baker is based on Quirk *et al.* (1983) who reported its occurrence in South India on account of a herbarium sheet at BM (*L. Faucheux,* Shevaroy hills, S. India, 1939). But there is no literature on the occurrence of either *C. contigua* Baker or *C. krameri* Franch. & Sav. in India, nor any specimen of them in any of the major Indian Herbaria. Not only that, these species are not included in the *Census of Indian Pteridopytes* (Dixit, 1984). More over, Subramanyam *et al.* (1960) who explored Shevaroy hills did not mention about these species. I explored the locality of their reported occurrence (Tamil Nadu, Salem District, Shevaroy hills) during the present study, but could not collect these species from there. Hence, in the present study these two species are not included.

Fraser-Jenkins (1992, 1997) states that Indian *C. farinosa* (Forssk.) Kaulf. is different from that of eastern Africa cytologically. The latter taxon, which is a triploid apomict, is the true *C. farinosa* (Forssk.) Kaulf. and the Indian material is a diploid sexual one. Hence, he (1992) called it *C. bicolor* (Roxb.) Griff. *ex* Fraser-Jenk. and is accepted here. He (1997) further states that the species described by Nayar (1962c) as *C. thwaitesii* is *C. bullosa* Kunze.

Cheilanthes albomarginata C.B.Clarke, *C. farinosa* (Forssk.) Kaulf., *C. flaccida* (Bedd.) Mehra & Bir, *C. keralensis* N.C.Nair & S.R.Ghosh, *C. laxa* T.Moore and *C. swartzii* Webb & Benth., treated as distinct species by Dixit (1984) and *C. contigua* Baker, *C. doniana* (S.K.Wu) Fraser-Jenk. & Khullar, *C. dubia* C.Hope, *C. farinosa*

(Forssk.) Kaulf. and *C. krameri* Franch. & Sav., treated as distinct species by Chandra (2000a) are either synonymous or absent in South India.

The species of *Cheilanthes* considered as occurring in South India and hence treated in this study, are *C. anceps* Blanf., *C. belangeri* (Bory) C.Chr., *C. bicolor* (Roxb.) Griff. *ex* Fraser-Jenk., *C. bullosa* Kunze, *C. opposita* Kaulf., *C. tenuifolia* (Burm.f.) Sw., *C. thwaitesii* Mett. *ex* Kuhn and *C. viridis* (Forssk.) Sw.

Key to Species

1a.	Fronds devoid of white farina	2
1b.	Fronds covered with white farina on the lower side	3
2a.	Fronds more than 10, crowded, narrowly lanceolate, tapering to both apex and base	*C. opposita*
2b.	Fronds less than 10, lax, lanceolate, ovate-deltoid widest at base	4
3a.	Scales of stipe base concolorous, deep red or dark brown	5
3b.	Scales of stipe base bicolorous	6
4a.	Lamina tripinnate or quadripinnate, ovate-deltoid; sori separated at vein ends; scales concolorous	*C. tenuifolia*
4b.	Lamina bipinnate or bipinnatifid, lanceolate; sori spreading along the margin	7
5a.	Stipe base scales deep red, lamina bullate on upper surface, white farina below dense; no vegetative bulbils	*C. bullosa*
5b.	Stipe base scales brown; lamina not bullate on upper surface; white farina below faint or rather nil; bearing small green bulbils on lower surface	*C. thwaitesii*
6a	Scales present throughout the stipe	*C. anceps*
6b.	Scales confined to the very base of the stipe	*C. bicolor*
7a.	Lamina long lanceolate; paleae concolorous; pinnae sessile	*C. belangeri*
7b.	Lamina deltoid-lanceolate; paleae bicolcorous; pinnae and pinnules distinctly stalked	*C. viridis*

Cheilanthes anceps Blanf., J. Simla Nat. Hist. Soc. 1: 21. 1886; B.K.Nayar & S.Kaur, Comp. Bedd. Handb. 25. 1974; R.D.Dixit, Census Indian Pterid. 63. 1984; Fraser-Jenk., New Sp. Syndr. Indian Pterid. Ferns Nepal 68. 1997; S.Chandra, Ferns India 48. 2000. (**Fig. 14, 21A-g, 22a & b**).

Lectotype: India, Simla. *Blanford* (K).

Cheilanthes candida Zoll., Nat. Gen. Arch. Neerl. Ind. 2: 203. 1845, *non* Mart. & Gal., 1842.

Cheilanthes farinosa var. *anceps* (Blanf.) Blanf., J. Asiat. Soc. Bengal 57(2): 301. 1888.

Aleuritopteris anceps (Blanf.) Panigrahi, Bull. Bot. Surv. India 2: 321. 1961; Jyothi & Madhus. J Econ. Taxon. Bot. 17: 31. 1993.

Aleuritopteris pseudofarinosa Ching & S.K.Wu *ex* S.K.Wu, Acta Phytotax. Sin. 19(1): 72.1981.

Aleuritopteris interrupta Saiki, J. Phytogeogr. Tax. 32(1): 5. 1984.

Aleuritopteris javanensis Saiki, J. Phytogeogr. Tax. 32(1): 7. 1984.

Rhizome erect, 2 x 1 cm, usually unbranched, covered with a tuft of wiry roots towards base and dense paleae towards apex. Palea 5 x 1 mm, bicolorous with dark brown center and pale edges, some times the basal portion concolorous, bicolorous above, narrowly lanceolate, acuminate with entire margin. Fronds 8-10, spreading, 40 x 12 cm; stipe 20 cm long, 2 mm thick, more or less equal in length to lamina, black, glossy, rounded below, grooved above, covered with scales through out, scales of stipe longer than rhizome scales; lamina 20 x 12 cm, bipinnate below, bipinnatisect above, lanceolate to oblong-lanceolate, widest towards base, thick herbaceous, upper surface glabrous, dark green; lower surface thickly coated with bright white farina secreted by subsessile globose ceraceous glands; rachis similar to stipe, grooved above, without scales or with very few scattered scales at base, bearing 12-15 pairs of pinnae; pinnae opposite, lower ones distinct, sessile, upper ones adnate to rachis, deltoid-lanceolate, lower 2-3 pairs almost of the same size, 4-5 cm apart, 7 x 4 cm, apex acuminate; upper pinnae gradually reduced and close; pinnules 6-8 pairs, basiscopic pinnules larger than acroscopic ones, lowest basiscopic pinnule of lowest pinna largest, 4 x 1 cm, pinnule apices rounded; lower pinnules deeply lobed, while upper lobes unlobed. Venation pinnate; costa and costules distinct terete, black, glossy below, greenish and flat above; lateral veins

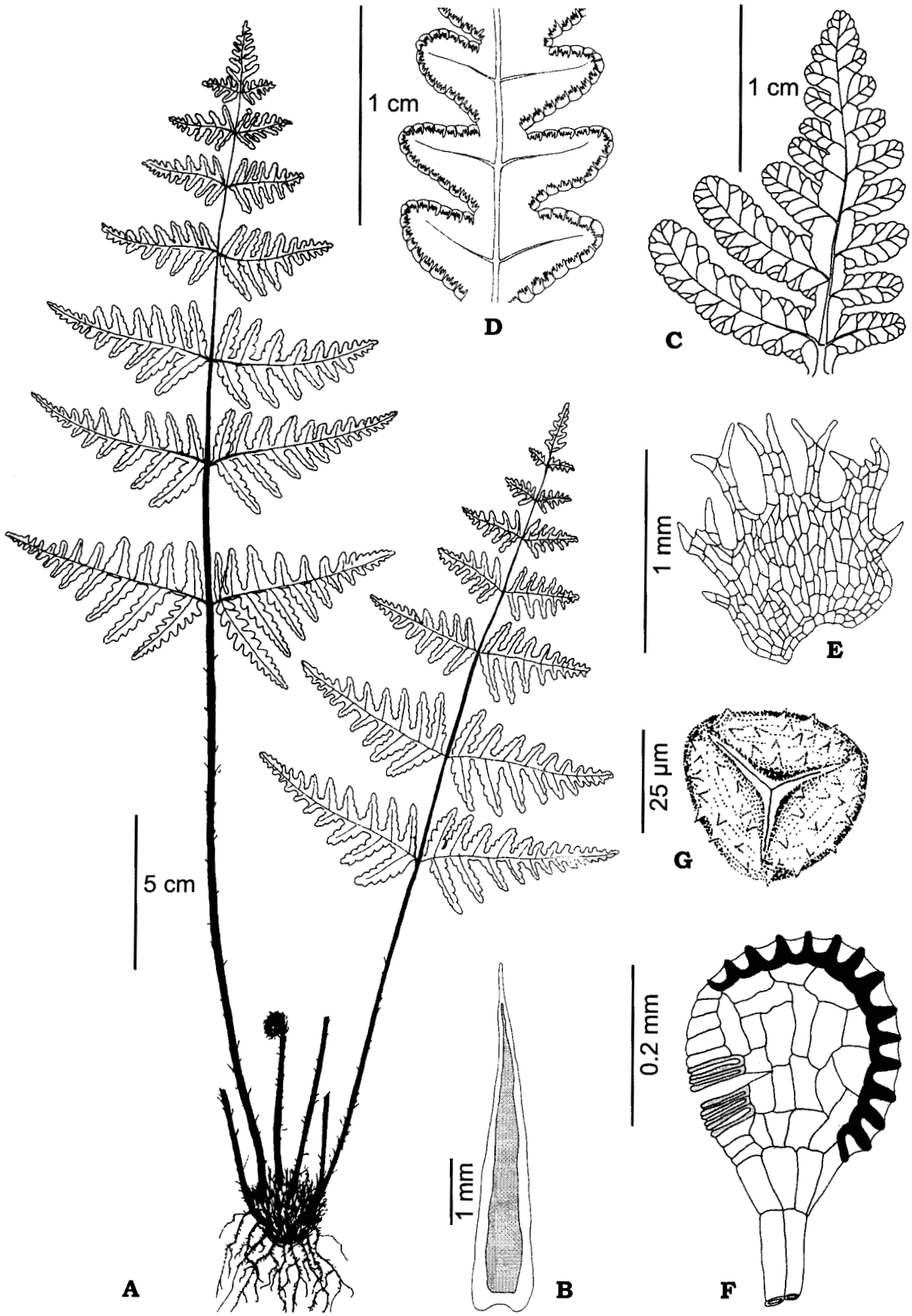

Fig. 21. **Cheilanthes anceps: A**- Habit, **B**- Rhizome palea, **C**- a portion of sterile pinna, **D**- a portion of fertile pinna, **E**- Pseudo-indusium, **F**- Sporangium, **G**- Spore (from *Mohanakurup CU 52869*).

Fig. 22. Cheilanthes anceps: **a.** habit, **b**. part of fertile frond; **C. belangeri**: **c.** herbarium specimen, **d**. part of fertile frond; **C. bullosa**: **e.** habit, **f**. part of fertile pinna.

once or twice forked or simple. Sori continuous at the tip of veins through out the margin of lamina, covered by a series of distinct pseudoindusia; pseudoindusium narrow, pale brown, 1 x 1 mm, margin highly fimbriate. Sporangium stalked; stalk very short; capsule globose; annulus 14 cells long. Spore 40 x 45 μm, trilete, tetrahedral, globose; exine rugulate.

Chromosome numbers: n = 29, diploid sexual (Verma in Mehra, 1961); n = 58, tetraploid sexual (Panigrahi, 1962).

Distribution and Ecology: In India *Cheilanthes anceps* is distributed in Himalayas as well as Peninsular India. In southern India it occurs in certain localities of Karnataka, Kerala and Tamil Nadu. It is also reported from East Africa, Bhutan, China, Indonesia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Taiwan, Thailand and Tibet. It grows on exposed moist rocks and earth cuttings in semi shaded areas. Fronds dry up and curl during dry season.

Notes: This species is a segregate of *Cheilanthes farinosa* complex. Blanford (1886) initially described it as a species, but later (1888b) he himself reduced it to a variety of *C. farinosa*. Panigrahi (1960) raised it again to the rank of species and brought under the genus *Aleuritopteris*. Khullar (1994) points out that the West Himalayan plants from Blandford's type locality are diploid sexual with lanceolate or oblong-lanceolate lamina. But Panigrahi's *Aleuritopteris anceps* is having a deltate-lanceolate lamina; it is a tetraploid and is different from Blandford's plant and should belong to a different species.

Specimens examined: **KARNATAKA**: Kodagu Dt., Bhagmandala, *Manickam 2723* (XCH), *Rajagopal 197* (MGMC); Madikeri, *Manickam 2675* (XCH). Shimoga Dt., Kodachadri, *Mohanakurup 52869* (CALI). Dakshina Kannada Dt., Sitanadi, *Arora s.n.* (CAL). **KERALA**: Idukki Dt., Kuttikanam, *Nair 40030* (CAL); Peerumedu, *Nair 40125, 40139* (CAL), *Premavally 1474* (CALI). Palakkad Dt., Ayyappankovil, *Vajravelu 49711* (CAL); Kaikatty, Nelliampathi, *Mohanakurup 73112*; Pothundi, Nelliampathi, *Mohanakurup 52895*; Silent Valley, *Geevarghese 4044* (CALI), *Manickam 3187* (XCH). Thiruvananthapuram Dt., Ponmudi, *Nair & Ghosh 5182;* Ponmudi estate, *Nair 51018* (CAL). Wayanad Dt., Chembra peak, *Nayar & Madhusoodanan 21301* (CALI). **TAMIL NADU**: Coimbatore Dt., Akkamalai road, *Manickam 3471*; Valparai, *Manickam 2169* (XCH). Nilgiris Dt., Gudallur, *Meebold 11437* (CAL).

Cheilanthes belangeri (Bory) C.Chr., Ind. Fil. 172. 1906; R.D.Dixit, Census India Pterid. 63. 1984; S.Chandra & S.Kaur, Nomen. Guide Bedd. Ferns S. India & Ferns Brit. India 22. 1987; S.Chandra, Ferns India 49. 2000. (**Fig. 22c & d, 23A-F, 25**)

Pteris belangeri Bory, Bel. Voy. Bot. 2: 44. 1833.

Pteris varians Wall., Num. List no. 86. 1828, *nom. nud.*

Cheilanthes varians Wall. *ex* Hook., Sp. Fil. 2: 89. t. 103 A. 1852; Bedd., Ferns S. India 65. pl. 189 . 1864 & Handb. Ferns Brit. India 91. f. 47. 1883.

Pteridella belangeri (Bory) Mett. ex Kuhn, v. Deck. Reis. 3 (3): 16. 1879.

Rhizome erect, 1.5 x 1 cm, unbranched, covered by persistent stipe bases, a tuft of wiry roots and dense paleae. Palea 4 x 0.5 mm, concolorous, dark brown, linear lanceolate, acuminate, gland tipped, margin entire. Fronds 6-8, spreading, 25-35 x 4-6 cm; stipe 10-15 cm long, 1-1.5 mm broad, purplish black, terete below, grooved above, slightly shorter than lamina, densely scaly towards base, sparse upwards; lamina 15-20 x 4-6 cm, bipinnate in the lower half, bipinnatifid distally, oblong-lanceolate, acuminate, widest at base, pinnae 15-20 pairs, subopposite; lower pinnae largest, 5-6 cm apart, gradually become smaller and closer upwards, thin herbaceous, upper and lower surfaces glabrous; rachis similar to stipe, grooved above, glabrous; lower pinnae largest, shortly stalked, deltoid-lanceolate, 3.5-4 x 1-1.5 cm, simple pinnate, basiscopic pinnules larger than acroscopic ones; basal most basiscopic pinnule of lowest pinna longest, 1.5 cm long and lobed; upper pinnae narrowly deltoid, deeply lobed. Venation pinnate; costa and costules distinct, not raised on lower surface; lateral veins once or twice forked; vein tips slightly dilated, not reaching the margin. Sori along the margin of pinnules, at the vein endings forming a vascular commissure which is not continuous, covered by reflexed margin; reflexed margin 0.5 mm broad, margin entire. Sporangium stalked; stalk shorter than capsule, 3 cells thick; annulus 18-20 cells long. Spore 30-35 μm, trilete, tetrahedral; exine smooth; perine granulose with rugulose folds.

Chromosome numbers: n = 60, 2n = 120, tetraploid sexual (Ammal & Bhavanandan, 1991).

Distribution and Ecology: *C. belangeri* is having a restricted distribution in India. In South India it is reported only from Kollam in Kerala and Anamallays in Tamil Nadu. It

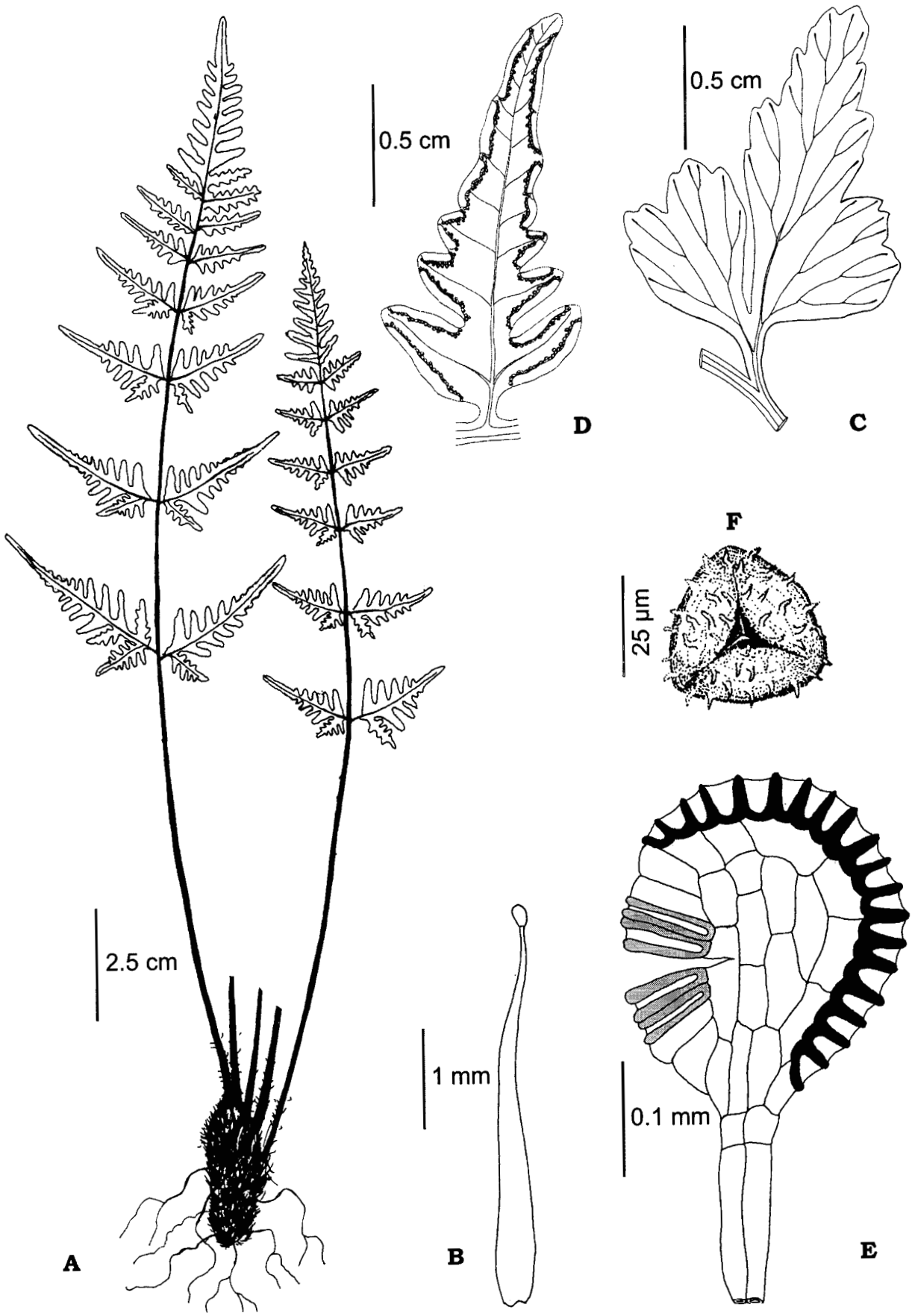

Fig. 23. **Cheilanthes belangeri: A**- Habit, **B**- Palea, **C**- a portion of sterile pinna, **D**- a portion of fertile pinna, **E**- Sporangium, **F**- Spore (from *Ramarao 1754*).

is also distributed in Southern China, Malaya and Myanmar. It grows in open slopes in earth cuttings in damp moist situations.

Specimens examined: KERALA: Kollam Dt., Palaruvi, *Ramarao 1754* (CAL). **TAMIL NADU**: no precise locality: *Beddome 41* (CAL).

Cheilanthes bicolor (Roxb.) Griff. *ex* Fraser-Jenk., Pakistan Syst. 5: 94. 1991; Fraser-Jenk., New Sp. Syndr. Indian Pterid. Ferns Nepal 68. 1997; S.Chandra, Ferns India 50. 2000. (**Fig. 24A-G, 25**)

Type: India, Uttar Pradesh. 'Rohilcund' (BR).

C. farinosa (Forssk.) Kaulf., Enum. Fil. 212. 1824; Bedd., Ferns S. India 65. t. 191. 1864; Handb. Ferns Brit. India 92. 1883; Subramanyam *et al.*, Bull. Bot. Surv. India 2: 325. 1960; B.K.Nayar, Bull. Nat. Bot. Gard. 68: 23. 1962; Raju, Bull. Bot. Surv. India 6: 189. 1964; B.K.Nayar & S.Kaur, Comp. Bedd. Handb. 25. 1974; R.D.Dixit, Census Indian Pterid. 64. 1984; Manickam & Irud., Pterid. Fl. W. Ghats 87. pl. 63. 1992; N.C.Nair *et al.*, J. Econ. Taxon. Bot. 16: 267. 1992; B.K.Nayar & Geev., Fern Fl. Malabar 120. 1993; Rajagopal & Bhat, Indian Fern J. 15: 9. 1998; S.Chandra, Ferns India 53. 2000.

Aleuritopteris farinosa (Forssk.) Fee, Gen. Fil. 154. t. 12B. f. 1. 1850-52; Jyothi & Madhus., J. Econ. Taxon. Bot. 17: 32. 1993.

Rhizome 1 x 1.5 cm, erect, unbranched, covered with persistent stipe bases and a tuft of wiry roots towards base and dense paleae towards apex. Paleae 4 x 1 mm, bicolorous with dark brown center and pale brown margin, linear-lanceolate; apex acuminate; margin entire. Fronds tufted, 5-8, erect or slightly spreading, 50 x 16 cm; stipe 30 x 0.3 cm, reddish brown, terete, 1½ times longer than lamina, densely scaly at the very base, sparse above up to 1/3, glossy and glabrous above; lamina 20 x 16 cm, bipinnate below, bipinnatifd above, deltoid-lanceolate, widest at base, apex acuminate, herbaceous, upper surface yellowish green, glabrous, lower surface with greenish white farina produced by minute sessile globose ceraceous glands; rachis similar to stipe, but narrowly grooved above, bearing 15 pairs of pinnae; pinnae sessile, opposite or sub-opposite, 4-5 cm apart, lowest pinna largest, 9 x 7 cm, deltoid-lanceolate, widest at base, gradually smaller and closer above, with 10-12 pairs of alternate pinnules, basiscopic pinnules larger than the acroscopic ones, basiscoic pinnules of lowest pair of pinnae largest, 6 x 1.5 cm, deeply lobed, 4 times longer than acroscopic; oblanceolate, apex acute; ultimate lobes oblong with rounded

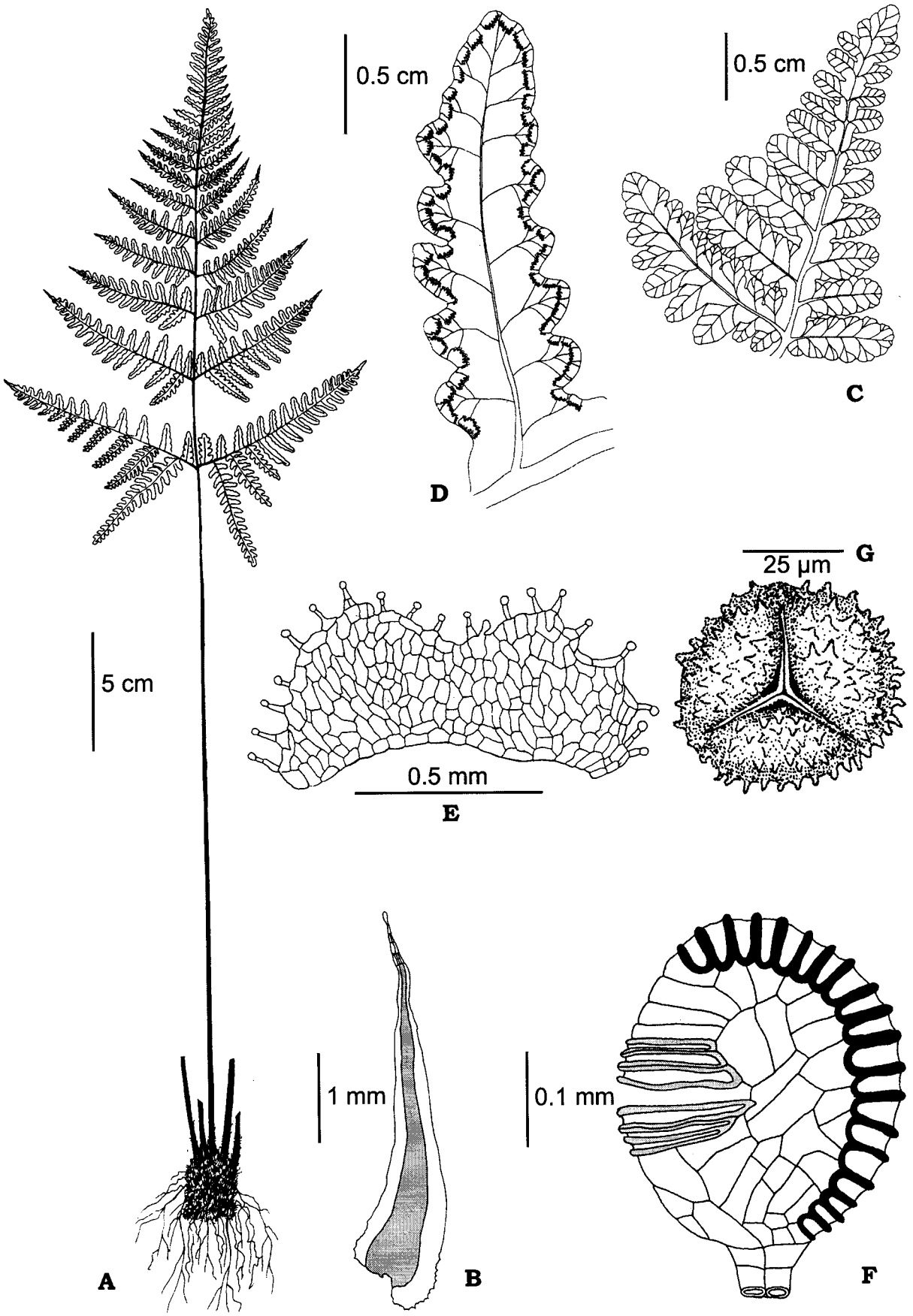

Fig. 24. Cheilanthes bicolor: **A**- Habit, **B**- Palea, **C**- Sterile pinna, **D**- a portion of fertile pinna, **E**- Pseudo-indusium, **F**- Sporangium, **G**- Spore (from *Mohanakurup 73143*).

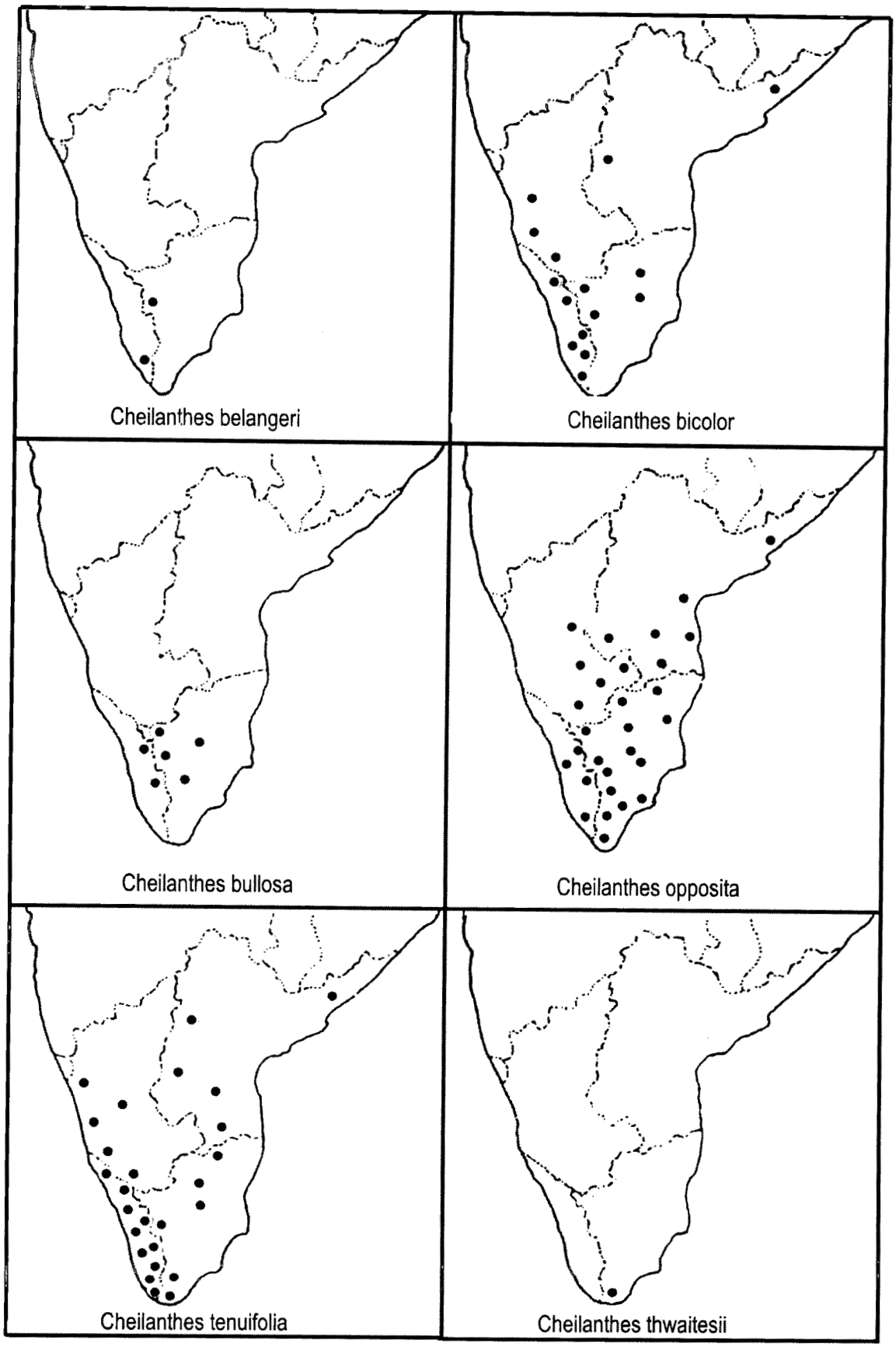

Fig. 25. Distribution of Cheilanthes belangeri, C. bicolor, C. opposita, C. tenuifolia and C. thwaitesii in Southern India.

apex; margin crenate. Venation pinnate, costa and costules distinct, terete and dark brown below, indistinct, slightly grooved and greyish green above; lateral veins once or twice forked reaching the margin. Sori marginal, continuous, protected by a series of pseudoindusia along the tips of ultimate veins; psudoindusium short, light brown, 1 x 0.5 mm, semicircular, margin slightly fimbriate with hairs ending in glandular cells. Sporangium sub-sessile; stalk very short, 2 cells thick; capsule globose; annulus 18 - 20 cells long. Spore 42 x 45 μm, trilete, tetrahedral, globose; exine smooth; perine reticulate with flap like protuberances.

Chromosome numbers: n = 29, diploid sexual (Verma & Loyal, 1960; Verma in Mehra, 1961); n = 30, diploid sexual (Manton & Sledge, 1954; Verma & Khullar, 1965; Ghatak, 1977; Vasudeva & Bir, 1982); n = 58, tetraploid sexual (Manton & Sledge, 1954; Abraham *et al.*, 1962).

Distribution and Ecology: *C. bicolor* is widely distributed in India and occurs in all the four South Indian states. It is also distributed in Bhutan, Java, Laos, Myanmar, Nepal, Sri Lanka and Thailand. *C. bicolor* grows in open or semi exposed earth cuttings in dry cool areas below rocks; often dry up during summer.

Note: In almost all Indian works, this species has been referred to as *C. farinosa* (Forssk.) Kaulf. Manton *et al.* (1966) indicated that true *C. farinosa* is a triploid apomict, which is confined to Africa and Yemen and on cytological grounds separated the Indian diploid taxon, but did not provide a name for it. Fraser-Jenkins (1992) named it *as C. bicolor* (Roxb.) Griff. *ex* Fraser-Jenk.

Specimens examined: **ANDHRA PRADESH**: Kurnool Dt., Gundlabrahmeswaram, *Ellis 22219, 32683* (MH). Visakhapatnam Dt., Cherukinda, *Subbarao 29727* (MH); Dhanakoda hill, *Narayanaswami 488* (CAL); Sunkarimetta, *Balakrishnan 10939* (CAL, MH). **KARNATAKA**: Kodagu Dt., Bhagmandala, *Rajagopal 110* (MGMC); Mabut, *Balakrishnan 359* (MH). Dakshina Kannada Dt., Golpad, *Barber 2326* (MH). Shimoga Dt., Kundadri hills, *Rajagopal 162* (MGMC). **KERALA**: Idukki Dt., way to Eravikulam, *Bhargavan 90933* (MH); Munnar, *Manickam & Mathew 31461* (XCH); Vellimala, *Rajesh 13295* (CALI). Kottayam Dt., Kurisumalai, *Antony 732* (MH); Wagmon, *Mohanakurup 52831* (CALI). Palakkad Dt., Aruvampara slopes, *Nair 64546* (CAL); Kunthipuzha river bank, *Nair 69103* (MH); Nelliampathi, *Mohanakurup 52834*; Silent Valley, *Geevarghese 17921* (CALI), *Nair 64546* (MH), *Nayar & Madhusoodanan 21340* (CALI). Pathanamthitta Dt., Vandiperiyar, *Manikam &*

Mathew 33385 (XCH). Thiruvananthapuram Dt., Ponmudi, *Madhusoodanan 43857* (CALI), *Manickam & Mathew 33812* (XCH), *Nair & Ghosh 51822* (CAL, MH). Wayanad Dt., Chembra, *Mohanakurup 52864*; Lakkidi ghat road, *Mohanakurup 73143* (CALI). **TAMIL NADU**: Coimbatore Dt., Sholayar dam site, *Manickam 2319* (XCH); Sholayar submergible area, *Sebastine 16684* (MH, CAL). Namakkal Dt., Kolli hills, *Divakar & Divakaran 97067* (MH). Nilgiris Dt., Coonoor, *Gamble 13102* (CAL); Devarshola, *Subramanyam 10504* (MH, CAL); Kodanad R.F., *Vajravelu 34972* (MH); Naduvattom, *Mohanakurup 52814* (CALI); Ootty, *Ramakrishnan s.n.*; Pakasuramalai, *Sebastine 3260* (CAL). Salem Dt., Shevaroy hills, Honey rock, *Ghatak 497*, *Subramanyam 7533* (CAL); Yercaud, *Mohanakurup 52876* (CALI), *Rao 26906* (MH).

Cheilanthes bullosa Kunze, Linn. 24: 274. 1851; Bedd., Ferns S. India 65. pl. 192. 1864; B.K.Nayar, Bull. Nat. Bot. Gard. 68: 27. 1962; B.K.Nayar & S.Kaur, Comp. Bedd. Handb. 25. 1974; R.D.Dixit, Census Indian Pterid. 63. 1984; Manickam, Fern Fl. Palni Hills 28. 1986; S.Chandra & S.Kaur, Nomen. Guide Bedd. Ferns S. India & Ferns Brit. India 23. 1987; Manickam & Irud., Pterid. Fl. W. Ghats 88. pl. 64. 1992; Fraser-Jenk., New Sp. Syndr. Indian Pterid. Ferns Nepal 71, 73. 1997; S.Chandra, Ferns India 50. 2000. (**Fig. 22e & f, 25, 26A-G**).

Type: India, Nilgiris, *Schmid 33* (PE).

Cheilanthes rigidula Wall., Num. List no. 2175. 1828. *nom. nud.*

Aleuritopteris indica Fee, Mem. Fam. Foug. 5, Gen. Fil. 154. 1852.

Cheilanthes bullata Baker, Syn. ed. 1. 137. 1867.

Cheilanthes dalhousiae sensu Bedd., Ferns S. India pl. 193. 1863, *non* Hook., 1852.

Cheilanthes farinosa var. *flaccida* Bedd., Handb. Ferns Brit. India 93. 1883.

Cheilanthes farinosa var. *bullosa* (Kunze) Bedd., Suppl. Ferns Brit. India 21. 1892.

Aleuritopteris bullosa (Kunze) Ching, Hong Kong Nat. 10: 202. 1941; Jyothi & Madhus. J. Econ. Taxon. Bot. 17: 32. 1993.

Cheilanthes flaccida (Bedd.) Mehra & Bir, Res. Bull. Punjab Univ. Sci. 15: 110. 1964; B.K.Nayar & S.Kaur, Comp. Bedd. Handb. 25. 1974; R.D.Dixit, Census Indian Pterid. 64. 1984; S.Chandra & S.Kaur, Nomen. Guide Bedd. Ferns S. India & Ferns Brit. India 23. 1987; N.C.Nair *et al.*, J. Econ. Taxon. Bot. 16: 267. 1992.

Cheilanthes thwaitesii sensu B.K.Nayar, Bull. Nat. Bot. Gard. 68: 18. f. 47. 1962, *non* Mett. *ex* Kuhn, 1869.

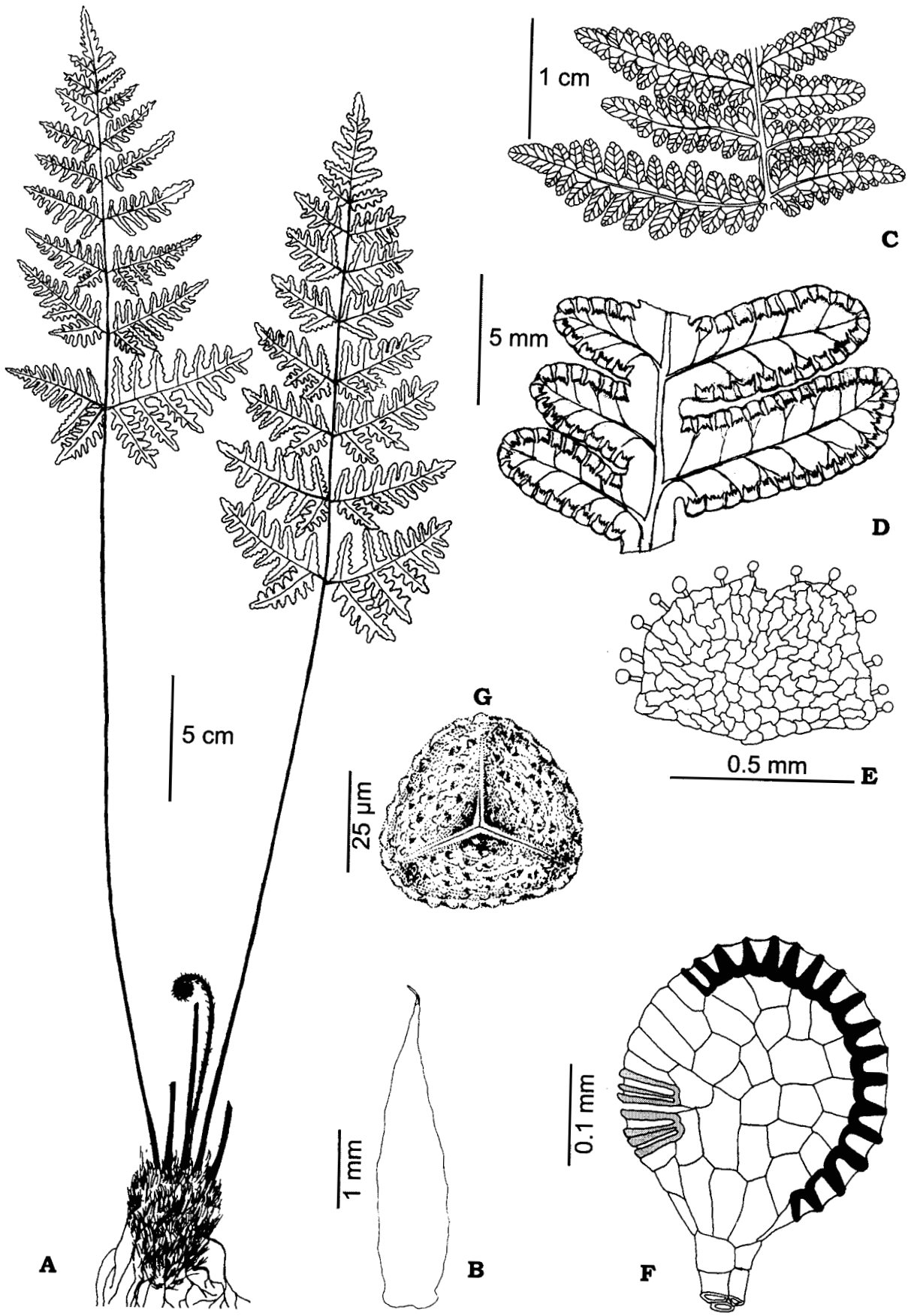

Fig. 26. Cheilanthes bullosa: A- Habit, **B**- Rhizome palea, **C**- a portion of sterile pinna, **D**- a portion of fertile pinna, **E**- Pseudo-indusium, **F**-Sporangium, **G**- Spore (from *Mohanakurup 73105*).

Aleuritopteris flaccida (Bedd.) B.K.Nayar & S.Kaur, Comp. Bedd. Handb. Ferns Brit. India 25. 1974.

Rhizome sub-erect, 3 x 1 cm, unbranched, covered with persistent stipe bases, a tuft of wiry roots and dense paleae. Paleae 4.5 x 0.7 mm, lanceolate, concolorous, reddish brown, acute, terminating in an acicular, non-glandular cell; margin smooth, base slightly cordate. Fronds 10-12, slightly spreading, 50-60 x 12 cm; stipe 25-30 x 0.2 cm, equal in length to lamina, black, glossy, terete, densely scaly at base; lamina 25-35 x 10-12 cm, bipinnate or tripinnatifid below, bipinnatifid above, deltoid-lanceolate, widest towards middle, acuminate thick, herbaceous, upper surface greenish, lower surface covered with yellowish white farina produced by minute glandular cells; upper surface deeply wrinkled with veins deeply impressed with small bulges of lamina in between; rachis similar to stipe, but grooved adaxially bearing 15-20 pairs of pinnae; pinnae opposite; basal pinnae bipinnatifid, 4-5 cm apart, upper pinnae pinnatifid, smaller and closer; larger pinnae, broadly deltoid, 5 x 3 cm, with 10-12 pairs of sub-opposite or alternate pinnules; basiscopic pinnules larger than acroscopic ones; lowest basiscopic pinnule of lowest pinna considerably long, deeply lobed, 4 x 1 cm; lower pinnules deeply lobed or pinnatifid; upper shallowly lobed; apex rounded; margin slightly crenate with veins ending in the sinuses. Venation pinnate; costa and costules distinct, terete, black and glossy below; indistinct and green above; lateral veins once or twice forked, reaching the margin. Sori continuous along the margin at the end of veins, protected by a series of reflexed margins, which are 1.5 x 0.5 mm, with irregular margins; some marginal cells producing short stalked glandular cells. Sporangium sub-sessile; stalk very short, 3 cells thick; capsule globose; annulus 17-18 cells long. Spore 42 x 48 μm, trilete, tetrahedral; exine finely granulose.

Chromosome number: 2n = 87, triploid apogamous (Mathew in Fabri, 1965).

Distribution and Ecology: *C. bullosa* forms large colonies on exposed damp rock surfaces near streams. In India it is restricted to certain localities of Western Ghats in Kerala and Tamil Nadu. It is also reported from Sri Lanka.

Notes: This species is having the largest frond in the genus *Cheilanthes*. Nayar (1962c) described *C. bullosa* under the name *C. thwaitesii*.

Specimens examined: **KERALA**: Idukki Dt., Chinnakanal, *Mohanakurup 73155, 73156, 73159*; Devikulam, *Mohanakurup 73153* (CALI); Munnar, *Manickam 31384*;

Vaguvarai hills, *Manickam & Mathew 34459* (XCH). Palakkad Dt., Nelliampathi, *Madhusoodanan 2733* (CALI). **TAMIL NADU**: Coimbatore Dt., Anamalai hills, *Manickam & Mathew 33077* (XCH); Meliawadayam, *Fischer 408* (CAL); Valparai, *Manickam 1766* (XCH). Dindigul Dt., Kodaikanal, *Madhusoodanan 43827* (CALI), *Manickam & Mathew 32627* (XCH), *Mohanakurup 73174* (CALI), *Saulieres 1011* (CAL). Namakkal Dt., Solakkadu, Kolli hills, *Mohanakurup 52886* (CALI). Nilgiris Dt., Coonoor, *Gamble 11325* (CAL), *Irudayaraj 16* (XCH); Kalhatti, *Sharma 35810* (MH); Oottakamund, *King s.n.* (CAL); Pakkasuramalai, *Sebastine 3954* (MH, CAL); Wellington, *Mohanakurup 73105* (CALI).

Cheilanthes opposita Kaulf., Enum. Fil. 211. 1824; Fraser-Jenk., Sp. Syndr. Indian Pterid. Ferns Nepal 86. 1997; S.Chandra, Ferns India 55. 2000. (**Fig. 25, 27A-F, 28a & b**)

Type: South India, *Rottler s.n.* (C).

Pteris .elegans Poir. in Lam., Encycl. Meth. Bot. 5: 718. 1804.

Cheilanthes swartzii Webb. & Benth., Hist. Nat. Canar. 3(2): 453. 1847; R.D.Dixit, Census Indian Pterid. 66. 1984; N.C.Nair *et al.*, J. Econ. Taxon. Bot. 16: 268. 1992; Rajagopal & Bhat, Indian Fern J. 15: 9. 1998.

Cheilanthes mysorensis Wall. *ex* Hook., Sp. Fil. 2: 94. t. 100A. 1852; Bedd., Ferns S. India 65. pl. 190. 1864 & Handb. Ferns Brit. India 89. f. 46. 1883; d'Almeida, J. Indian Bot. Soc. 5: 22. 1926; Subramanyam *et al.*, Bull. Bot. Surv. India 3: 210. 1961; B.K.Nayar, Bull. Nat. Bot. Gard. 68: 30. f. 49. 1962; B.K.Nayar & S.Kaur, Comp. Bedd. Handb. 24. 1974; Manickam, Fern Fl. Palni Hills 29. 1986; S.Chandra & S.Kaur, Nomen. Guide Bedd. Ferns S. India & Ferns Brit. India 23. 1987; Manickam & Irud., Pterid. Fl. W. Ghats 89. pl. 65. 1992; Jyothi & Madhus., J. Econ. Taxon. Bot. 17: 34. 1993; B.K.Nayar & Geev., Fern Fl. Malabar 121. f. 32. 1993.

Cheilanthes cadieri Christ, J. Bot. 19: 70. 1905.

Cheilosoria mysurensis (Wall. ex Hook.) Ching & K.H.Shing, Fl. Fujian 1: 84. 1982.

Rhizome erect, 1.5 x 1 cm, usually branched, densely covered by old stipe bases, a tuft of wiry roots with persistent brown root hairs and dense paleae especially towards the tip. Paleae 2.5 x 0.3 mm, concolorous, dark brown, apex attenuate, gland tipped; margin entire. Fronds 12 or more, spreading, 20-40 x 4 cm; stipe 8-10 x 0.2 cm, usually 1/5 of the length of lamina, black and glossy, rounded

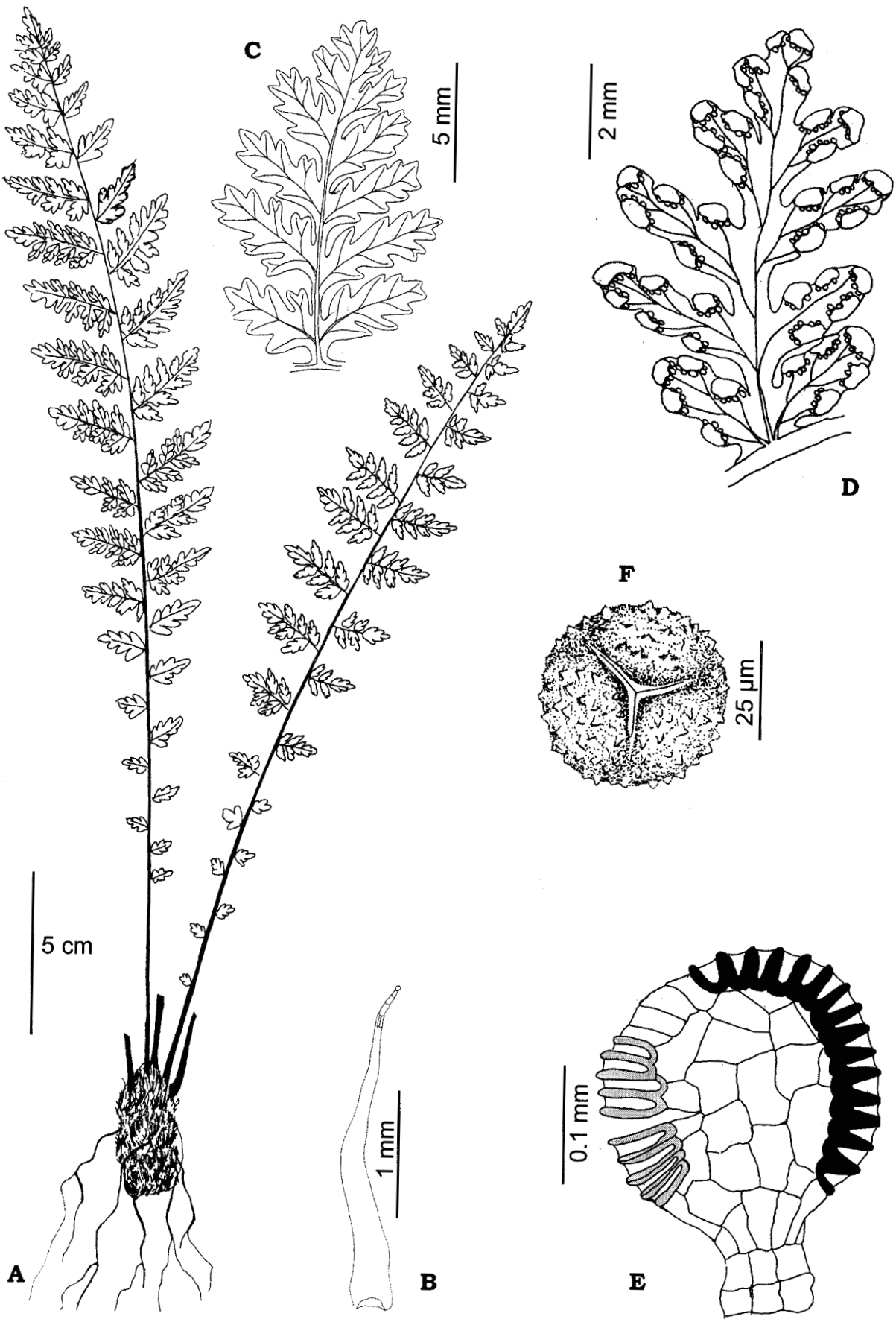

Fig. 27. Cheilanthes opposita: A- Habit, **B**- Rhizome palea, **C**- Sterile pinna, **D**- Fertile pinna, **E**- Sporangium, **F**- Spore (from *Mohanakurup 52843*).

Fig. 28. Cheilanthes opposita: **a.** habit, **b**. part of fertile frond; **C. tenuifolia**: **c.** habit, **d**. portion of partly fertile frond with non-indusiated sorus, **e**. part of fertile frond; **C. thwaitesii**: **f.** habit, **g**. part of frond showing bulbils.

below, shallowly grooved above, densely scaly at base; sparsely above; lamina 15-30 x 4 cm, bipinnatifid, oblong or oblanceolate, widest just above base, narrowing to both ends; rachis similar to stipe, deeply grooved on the upper side with scattered scales all along, bearing 20-25 pairs of pinnae; pinneae sub-opposite, sessile or sub-sessile; adjacent pinnae 1.5 cm apart, ovate-deltoid, widest just above the base; basal few pairs reduced, largest pinna 2 x 1 cm, deeply pinnatifid; bright green; glabrous above; lower surface with few scattered short, 0.05-0.06 mm long, glandular hairs with unicellular stalk; texture herbaceous; pinna lobes 5 pairs; sub-opposite, joined by lamina wing, 3.5 x 1.5 mm, deeply lobed to form usually 2 pairs of lobes with obtuse apices and entire margin. Venation pinnate; costa distinct, terete, blackish below, indistinct and greenish above; lateral veins pinnate; veinlets not reaching the margin. Sori distinct, semicircular, at the tip of veins of ultimate lobes with few sporangia, protected by reflexed tips of the lobes. Sporangium almost sessile; capsule globose; annulus 15 cells long. Spores 38 x 42 μm, trilete, tetrahedral, globose; exine smooth; perine granulose.

Chromosome numbers: n = 30, 2n = 60, diploid sexual (Manton & Sledge, 1954; Abraham *et al.*, 1962; Ghatak, 1977; Manickam & Irudayaraj, 1988).

Distribution and Ecology: In India *C. opposita* is widely distributed in southern India extending up to Orissa. It is also reported from Southern China, Myanmar and Sri Lanka. It is a low altitude fern forming desne patches along road sides and earth cuttings.

Notes: Fraser-Jenkins (Pers. comm., 2002) comments that *C. opposita* has been rather widely over reported due to confusion with its close relative, *C. chusana* Hook. from northern China, Japan, Korea, Philippines and Taiwan

Specimens examined: **ANDHRA PRADESH**: Ananthapur Dt., Kekali R.F., *Pullaiah & Yesoda 775* (SKU). Chittoor Dt., Akashganga, *Ahamed 12811*; Chandragiri hills, *Ahamed 13509*; Kailashkona, *Ahamed 12856* (SKU); Gyanayagundlu, *Subbarao 46822* (MH, CAL); Nerabylu, *Subbarao 32004* (MH). Cuddapah Dt., Balapalle, *Ellis 14998*; Duggamakonda, *Subramanyam 6349* (MH, CAL); Guvvalacheruvu R.F., *Raju & Reddy 7893* (SKU); Seeglabyle, *Gamble 15133* (MH, CAL). Nellore Dt., Mullavakonda, *Ramaswami 1275* (CAL). Prakasam Dt., Pedapenta, *Vijayakumar 15874* (SKU). Visakhapatnam Dt., Krishnapuram, *Barber 1998*; Lakshmipuram, *Barber 1809*; Nattuvarum, *Barber 1848* (MH). **KARNATAKA**: Mysore Dt., Chamundi

hills, *Rajagopal 396* (MGMC); Arsikare, *Meebold 8261* (CAL). **KERALA**: Idukki Dt., Kumali, *Nair 40482, 40793* (CAL); Kumarikulam malai, *Nair 70164* (CAL, MH); Ramakkalmedu, *Mohanakurup 73165* (CALI); Thekkady, *Manickam & Mathew 33351* (XCH). Kollam Dt., Aryankavu, *Nair 50679* (CAL). Palakkad Dt., Walayar, *Joseph 17895* (MH). Thrissur Dt., Parambikulam, *Omana 18798* (CALI), *Sebastine 14523* (MH). **TAMIL NADU**: Coimbatore Dt., Chinnathadagam, *Sebastine 91*; Kuridimalai, *Subramanyam 235* (CAL); Palamalai, *Viswanathan 48* (MH); Parambikulam submergible area, *Sebastine 14523*; Thekkumalai, *Sebastine 1426* (CAL); Valparai, *Manickam 3295* (XCH). Dharmapuri Dt., Anchetty, *Vajravelu 57901* (CAL, MH). Dindigul Dt., Kodaikanal, *Manickam 3317* (XCH); Pannaikadu, *Deb 31057* (MH); Pazhani ghat road, *Mohanakurup 73168* (CALI). Kanniya Kumari Dt., Keeriparai, Nagercoil, *Nair & Ghosh 51920, 52609* (CAL), *Nair & Ghosh 51915* (MH), *Mohanakurup 52843, 73130* (CALI); Kothayar hills, *Manickam 3338* (XCH); Parvathipuram, *Mohanakurup 73134* (CALI); Perumchani, *Henry 48207* (CAL); Thovalai, *Manickam 2583* (XCH), *Mohanakurup 73128* (CALI). Madurai Dt., Murugumalai, *Sebastine 12521* (CAL). Namakkal Dt., Kolli hills, *Manickam & Mathew 33145* (XCH). Nilgiris Dt., Athikkadavu forest, *Vajravelu 46393*; Mailarampatti, *Subbarao 36233* (MH). Ramanathapuram Dt., Aiyanarkoil forest, *Vajravelu 33704*; Rajapalayam, *Vajravelu 39551* (MH); near Moolikaipannai, Senbagathope R.F., *Srinivasan 79704*; Sethur R.F., *Nair 61443* (CAL); Thirupathur, *Nair 52930* (MH). Salem Dt., Andiappankoil, *Nair 74204*; Hogainakal forest, *Vajravelu 20576* (MH); Shevaroy hills, River Vernier, *Ghatak 582*; Shevaroy hills, Honey Rock, *Ghatak 192* (CAL). Teni Dt., Cumbum Valley, *Subramanyam 8059* (CAL, MH); Tiruchchirappalli Dt., Chengattupatti, *Sebastine 7000* (MH); way to top of Pachamalai, *Sebastine 6158* (CAL, MH). Tirunelvely Dt., Courtallum, *Mohanakurup 73141* (CALI), *Ramarao 1911* (CAL); Kalakkad R.F., *Joseph 15247* (CAL, MH), *Mohanakurup 73139* (CALI); Manimuthar dam site, *Sebastine 4532*; Papanasam, *Seastine 9567* (CAL, MH); Thirumalaikoil, *Subramanyam 2975* (MH). Vellore Dt., Andiappanur R.F., *Viswanathan 1165* (CAL, MH)). Viluppuram Dt., Gingee R.F., *Ramamurthy 13040* (CAL, MH). Virudunagar Dt., Devathanam, *Manickam 2952* (XCH); Sethur hills, *Srinivasan 86592* (MH).

Cheilanthes tenuifolia (Burm.f) Sw., Syn. Fil. 129. 332. 1806; Bedd., Ferns S. India 64. pl. 188. 1864, Handb. Ferns Brit. India 92. 1883 & Suppl. Ferns Brit. India

20. 1892; B.K.Nayar, Bull. Nat. Bot. Gard. 68: 29. 1962; Raju, Bull. Bot. Surv. India 6: 189. 1964; B.K.Nayar & S.Kaur, Comp. Bedd. Handb. 25. 1974; R.D.Dixit, Census Indian Pterid. 66. 1984; S.Chandra & S.Kaur, Nomen. Guide Bedd. Ferns S. India & Ferns Brit. India 22. 1987; Manickam & Irud., Pterid. Fl. W. Ghats 90. pl. 66. 1992; N.C.Nair *et al.*, J. Econ. Taxon. Bot. 16: 268. 1992; Jyothi & Madhus., J. Econ. Taxon. Bot. 17: 34. 1993; B.K. Nayar & Geev., Fern Fl. Malabar 122. 1993; Rajagopal & Bhat, Indian Fern J. 15: 9. 1998; S.Chandra, Ferns India 58. 2000. (**Fig. 25, 28c-e, 29A-F**).

Type: Sri Lanka, 'Plantae Zeylanica', *Burmann* (G).

Trichomanes tenuifolium Burm.f., Fl. Ind. 237. 1768.

Adiantum cicutaefolium Lam., Encycl. Meth. Bot. 1: 44. 1783.

Pteris humilis G.Forst., Fl. Ins. Austr. Prodr. 79. 1786.

Acrostichum tenue Retz., Obs. Bot. 6: 39. 1791.

Pteris nigra Retz., Obs. Bot. 6: 38. 1791.

Adiantum tenuifolium (Burm.f.) Sw., Schrad. J. 1800(2): 85. 1801.

Adiantum varians Poir. in Lam., Encycl. Meth. Bot. Suppl. 1: 143. 1810.

Pteris nudiscula R.Br., Prodr. Fl. Nov. Holland 155. 1810.

Cheilanthes micrantha Wall., Num. List no. 68. 1818, *nom. nud.*

Cheilanthes rupestris Wall., Num. List no. 67. 1818, *nom. nud.*

Cassebeera tenuifolia (Burm.f.) J.Sm., J. Bot. 4: 159. 1841.

Pteris gracilis Roxb. in Griff., Calc. J. 4: 508. 1844, *non* Michx., 1803.

Cheilanthes hispidula Kunze, Bot. Zeit. 212. 1848.

Cheilanthes moluccana Kunze, Bot. Zeit. 445. 1848, *non* Bl., 1828.

Notholaena semiglabra Kunze, Farnkr. Abb. Schkuhr. 2: 59. t. 124. f. 2. 1850.

Cheilanthes semiglabra (Kunze) Fee, Gen. Fil. 156. 1850-52.

Cheilanthes javensis T.Moore, Ind. Fil. 244. 1861.

Cheilosoria tenuifolia Trevis., Atti dell'Ittist. Veneto V. 3. 579. 1877.

Cheilanthes kirkii J.B.Armstr., Tr. N. Zeal. Inst. 13: 360. 1881, *non* Hook., 1861.

Cheilanthes sciadioides Domin, Biblioth. Bot. 85: 135. 1915.

Cheilanthes tenuifolia subsp. *queenslandica* Domin, Biblioth. Bot. 85: 140. 1915.

Cheilanthes tenuifolia subsp. *shirleyana* Domin, Biblioth. Bot. 85: 145. 1915.

Kal-panna-marvara Rheede, Hort. Malab. 12: 33. t. 16. 1693?

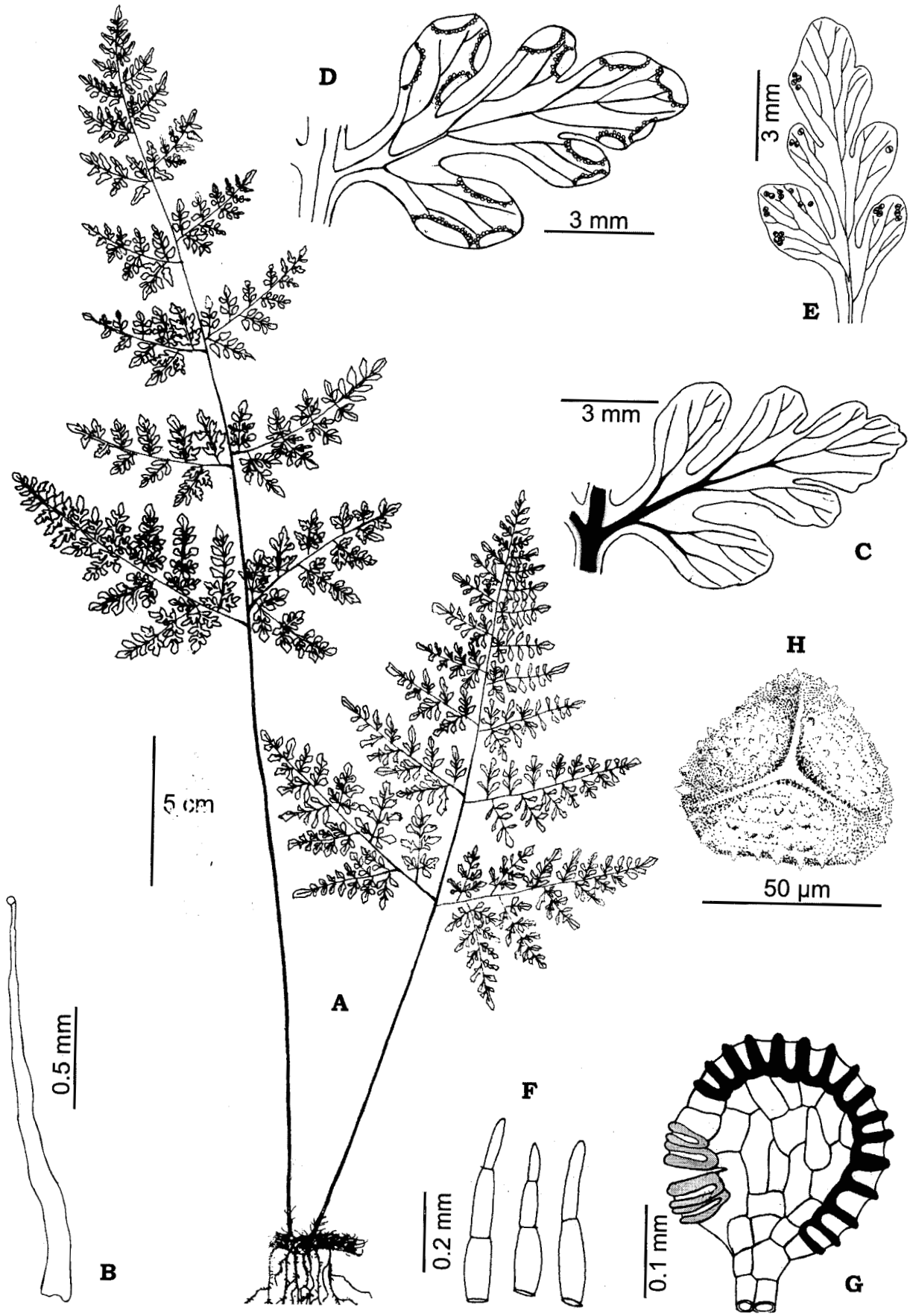

Fig. 29. **Cheilanthes tenuifolia:** **A**- Habit, **B**- Rhizome palea, **C**- a portion of sterile pinna, **D**- a portion of fertile pinna, **E**- a portion of partly fertile pinna, **F**- Hairs on the upper side of pinna, **G**- Sporangium, **H**- Spore (from *Mohanakurup 52852*).

Rhizome short creeping, 1.5-2 x 0.5 cm, occasionally branched; densely covered with paleae and wiry roots. Paleae 2-2.5 x 0.2 mm, linear-lanceolate, concolorous, pale brown, attenuate, gland tipped; margin entire. Fronds 5-6, sub-erect, variable in size, earlier formed small, 10-20 cm long, spreading and sterile; later formed large, 40-60 cm long, erect and fertile; stipe 20-30 x 0.1-0.2 cm, equal to or 1½ times longer than lamina, reddish brown, terete, adaxially shallowly grooved, densely paleate at base, glabrous and glossy above; lamina 15-25 x 10-15 cm, quadripinnate below, grading through tripinnate and bipinnate to bipinnatifid at apex, deltoid-pentagonal, with broadly cuneate base; apex acuminate; rachis widely grooved adaxially; glabrous and glossy, bearing 10-12 pairs of primary pinnae which are sub-opposite; basal pinnae largest, 8 x 6 cm; 5-6 cm apart, deltoid-ovate, widest at base; secondary pinnae 8-10 pairs, alternate; basal pinnae pinnate, pinnatifid above; basiscopic pinnae larger than acroscopic ones; ultimate pinnules sessile, ovate, 1 x 0.5 cm; apex obtuse, entire or shallowly lobed, herbaceous, glabrous on both surfaces in fertile pinnules; sterile pinnules have 2-3 celled uniseriate, 0.3-0.5 mm long, acicular hairs on both surfaces and many 0.1-1.5 mm long, glandular cells with unicellular stalks on lower surface. Venation pinnate; costa distinct on lower side; lateral veins free, 3-4 times forked, not reaching the margin. Sori at the vein ends along the margin of ultimate pinnules except at the tip; either continuous or interrupted, protected by reflexed margin; sori occur in sterile fronds occasionally and are very sparse and naked with 3-4 sporangia at the vein ending. Sporangium short stalked; capsule globose; annulus 15 cells long; occasionally the stalk bears a short acicular uniseriate hair. Spore 45 x 50 μm, trilete, tetrahedral; exine smooth with spinulose perine.

Chromosome numbers: n = 56, tetraploid sexual (Manton & Sledge, 1952; Abraham *et al.*, 1962; Ghatak, 1977; Vasudeva & Bir, 1982).

Distribution and Ecology: *C. tenuifolia* is widely distributed through out India and occurs in all the four south Indian states. It is also distributed in Australia, Bangladesh, China, Malay Peninsula, Nepal, New Zealand, Philippines, Polynesia, Sri Lanka, and Taiwan. Very common in semiarid, partially exposed laterite soil, often among grasses on vertical walls, laterite rock crevices and some times on humus filled tree trunks.

Note: *Kal-panna-maravara, described and illustrated by van Rheede in Hortus Indicus Malabaricus* (Vol. 12: 33. t. 16. 1693) is identified as *Cheilanthes tenuifolia* by Datta (1985) and Nicolson *et al.* (1988). Almeida and Almeida (1993) contradicted it and asserted that *Kal-panna-maravara* belongs to the genus *Leucostegia* and proposed a new combination, *Leucostegia alternifrons* (Dennst.) Almeida & Almeida. But Madhusoodanan and Rejani (1994) still uphold the view of Datta (*l.c.*) and Niocolson *et al.* (*l.c.*) Hence it needs further investigation to ascertain the identity of Rheed's illustration.

Specimens examined: **ANDHRA PRADESH**: Chittoor Dt., near Papanasanam falls, *Subramanyam 6960* (CAL); Thirumala, *Mohanakurup 73151* (CALI). Cuddapah Dt.,. Guvvalacheruvu R.F., *Reddy & Raju 7894* (SKU); Horsley hills, *Gamble 20895* (CAL). Kurnool Dt., Ahobilam, *Ahamed 12825* (SKU); Balagram, *Ellis 25539* (MH). Medak Dt., Narsapur R.F., *Pullaiah & Prabhakar 14052* (SKU). Visakhapatnam Dt., Cherukanda, *Subbarao 30106*; Lakshmipuram, *Barber 1809* (MH); Tyada, *Mohanakurup 73120* (CALI). **KARNATAKA**: Dakshina Kannada Dt., Sullia, *Barber 2168* (MH). Kodagu Dt., Bhagmandala, *Manickam 2744* (XCH). Shimoga Dt., Agumbe, *Mohanakurup 73122*; Kodachadri, *Mohanakurup 52867* (CALI). Udupi Dt., Paniyadi, *Rajagopal 272*; Udupi, *Rajagopal 22* (MGMC). Uthara Kannada Dt., Kaiga, *Rajagopal 76* (MGMC); no precise locality: *Talbot 54* (CAL). **KERALA**: Idukki Dt., Kuttampuzha, *Bhargavan 92080* (MH); Periyar dam site, *Nair 40117*; Pindimedu to Pooyamkutty, *Bhargavan 87408* (CAL). Kannur Dt., Chandanathode, *Ramachandran 62638* (CAL, MH). Kollam Dt., Aryankavu, *Nair 50684* (CAL); Chittar, *C.N.Mohanan 58362* (MH); Kollam, *Nair 50927* (CAL); Kulathupuzha, *Mohanakurup 52854* (CALI); Punalur, *Nair 50875, 50912*; Thenmala, *Ramarao 1778* (CAL). Kottayam Dt., Adukkam, *Fr. Kadavil 1277*; Eera, *Antony 1245* (MH); Karivannur, *Mohanakurup 52822* (CALI); Kottayam, *Nair 40287* (CAL). Malappuram Dt., Calicut University Campus, *Mohanakurup 52852* (CALI). Palakkad Dt., Kanjirapuzha, *Mohanakurup 52890* (CALI), *Sebastine 20893*; Malampuzha, *Joseph 17133* (MH). Pathanamthitta Dt., Thiruvella, *Nair 50828* (CAL). Thiruvananthapuram Dt., Aakulam, Veli, *Madhusoodanan 43873* (CALI); Kottur R.F., *Joseph 41998* (MH); Nedumangad, *Manickam & Mathew 33693* (XCH); Neyyattinkara to Aruvipuram, *Nair & Ghosh 51778*; Ponmudi, *Nair & Ghosh 51573* (CAL); Ponmudi hills, *Manickam & Mathew 31350* (XCH). Thrissur Dt., Chalakkudi, *Sebastine 27536* (MH); Vettilapara, *Nair & Ghosh 52065* (CAL). Wayanad Dt., Lakkidi ghat road, *Mohanakurup 73142;* Pookode

mala, *Mohanakurup 52872* (CALI). **TAMIL NADU**: Coimbatore Dt., Anamalai, *Mathew 31558* (XCH); Sholayar, *Sebastine 17287* (MH). Kanniya Kumari Dt., Balmore, *Manickam 2502* (XCH); Keeriparai, *Nair & Ghosh 51918, 52644* (CAL); Mahendragiri, *Manickam 2581* (XCH). Namakkal Dt., Kolli hills, *Manickam & Mathew 33210* (XCH), *Mohanakurup 52884* (CALI). Salem Dt., Kiliyur water falls, *Nair 74216* (CAL, MH); Yercaud, *Manickam & Mathew 33277* (XCH); Bauxite rock, Yercaud, *Ghatak 221* (CAL); stream below Shevaroy temple, Yercaud, *Ghatak 442* (CAL). Tirunelveli Dt., Upper Kothayar, *Manickam 3336* (XCH). Vellore Dt., Jawadi hills, *Viswanathan 1266* (MH).

Cheilanthes thwaitesii Mett. *ex* Kuhn, Linn. 36. 82. 1869; B.K.Nayar & S.Kaur, Comp. Bedd. Handb. 25. 1974; R.D.Dixit, Census Indian Pterid. 66. 1984; Fraser-Jenk., New Sp. Syndr. Indian Pterid. Ferns Nepal 80. 1997; S.Chandra, Ferns India 58. 2000. (**Fig. 25, 28f & g, 30A-H, 31**).

Lectotype: Sri Lanka, *Thwaites C.P. 1321* (B).

Cheilanthes indica Fee, Gen. Fil. 150. 1850-52.

Cheilanthes laxa T.Moore, Ind. Fil. 245. 1861, *nom. nud.*; Bedd., Handb. Ferns Brit. India 92. 1883; R.D.Dixit, Census Indian Pterid. 65. 1984.

Cheilanthes keralensis N.C.Nair & S.R.Ghosh, J. Indian Bot. Soc. 55(1): 52. 1976; N.C.Nair & R.D.Dixit, J. Bombay Nat. Hist. Soc. 78: 448. 1981; R.D.Dixit, Census Indian Pterid. 65. 1984; N.C.Nair *et al.*, J. Econ. Taxon. Bot. 16: 267. 1992; Jyothi & Madhus., J. Econ. Taxon. Bot. 17: 32. 1993.

Aleuritopteris thwaitesii (Mett. *ex* Kuhn) Saiki, J. Phytogeogr. Tax. 32(1): 11. 1984.

Rhizome 1.5 x 1 cm, erect, unbranched, covered with dense scales towards apex and wiry roots towards base. Paleae 4.5 x 0.5 mm, concolorous, dark brown, margin entire, terminating in a deciduous glandular cell. Fronds tufted, 5-7, erect, 30-45 x 6 cm; stipe 5-8 x 0.3 cm, about ¼ of the length of lamina, terete, purplish brown and glossy bearing many scattered scales all along and farina when young; lamina 25-35 x 6 cm, bipinnate below, bipinnatifid above, lanceolate, widest at base, acuminate, thin herbaceous, covered with white farina produced by minute ceraceous glands, on both surfaces which is lost in mature fronds; rachis similar to stipe, but grooved adaxially, bearing 20-25 pairs of pinnae; pinnae sub-opposite, elongated; lowest pinnae pinnate, larger in size, 2.5 cm apart; upper pinnae smaller and closer; largest pinna 4 x 1.5 cm, very shortly stalked; pinnules alternate, 6 x 3

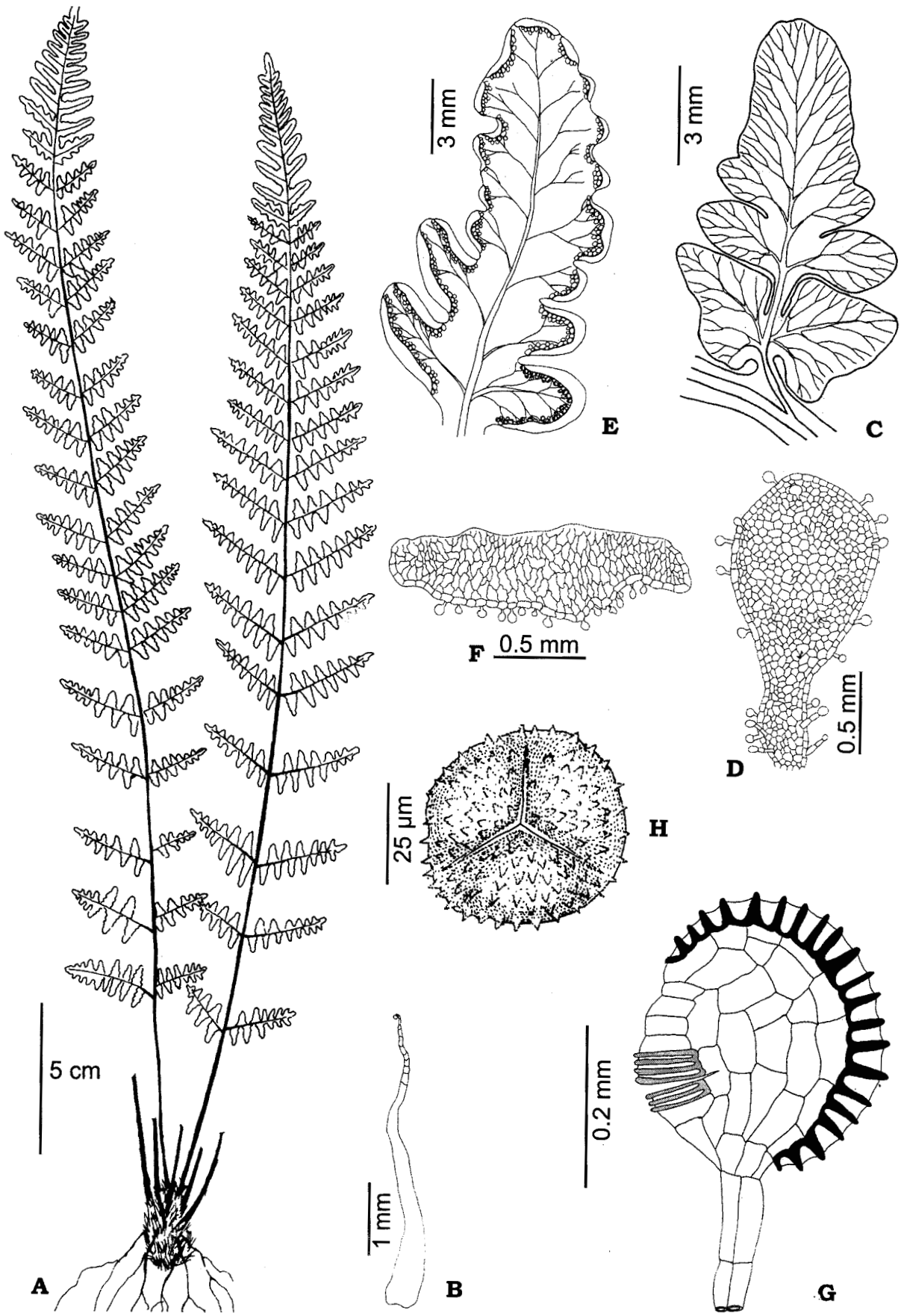

Fig. 30. Cheilanthes thwaitesii: **A**- Habit, **B**- Rhizome palea, **C**- a portion of sterile pinna, **D**- Bulbil, **E**- a portion of fertile pinna, **F**- Pseudo-indusium, **G**- Sporangium, **H**- Spore (from *Mohana kurup 52842*).

Fig. 31. Type specimen of Cheilanthes thwaitesii: digital image kindly provided by Dr. B. Zimmer, Botanisches Museum, Berlin-Dahlem, Germany.

mm, apex rounded; margins entire; segments of sterile pinnae with bulbils attached to the vein endings; bulbil spathulate, 1.5 x 0.7 mm, with a short stalk; many cells thick in the center and thin along the periphery; margin smooth, covered with short staked glandular hairs. Venation pinnate; costa distinct, terete, black and glossy below, indistinct and greenish above; lateral veins free, forking once or twice, reaching the margin. Sori along the margin at vein endings, not continuous, covered with a series of reflexed margins which are semicircular, 0.5 mm wide; margin irregular with glandular hairs developing from almost all marginal cells. Sporangium short stalked; stalk shorter than capsule; capsule globose; annulus 20-21 cells long. Spores 50 x 55 μm, trilete, tetrahedral, globose; exine smooth; perine spinulose.

Chromosome numbers: n = 29-30, diploid sexual (Manton & Sledge, 1954).

Distribution and Ecology: The distribution of this species is restricted to South India and Sri Lanka. In southern India, it is confined to Nilgiris, Palni hills and Nagercoil of Tamil Nadu. It is reported as very common in Sri Lanka. It occurs in seasonally damp mud banks of rivers and road cuttings and in crevices of rocks with moist soil

Notes: 1. Nair and Ghosh (1976) collected this species from Keeriparai, Nagercoil and erroneously published it as a new species, *Cheilanthes keralensis* N.C.Nair & S.R.Ghosh.

2. The figure and description of *C. thwaitesii* by Nayar (Bull. Nat. Bot. Gard. 68: 18. f. 47. 1962) are actually that of *C. bullosa*

Specimens examined: **TAMIL NADU**: Kanniya Kumari Dt., Keeriparai, *Ghosh 51934* (CAL, MH), *Henry 49442* (MH), *Mohanakurup 52842, 73133* (CALI), *Nair & Ghosh 51914, 51936, 52610* (CAL).

Cheilanthes viridis (Forssk.) Sw., Syn. Fil. 127. 1806; Madhus. & Jyothi, J. Econ. Taxon. Bot. 16: 729. 1992; Manickam & Irud., Pterid. Fl. W. Ghats 86. pl. 62. 1992; Jyothi & Madhus., J. Econ. Taxon. Bot. 17: 34. 1993; S.Chandra, Ferns India 59. 2000. (**Fig. 32A-G, 33, 35a**).

Type: Arabia, *Forsskal s.n.* (lost)

Pteris viridis Forssk., Fl. Aeg-Arab. 186. 1775.

Adiantum hastatum L.f., Suppl. 447. 1781.

Adiantum viride Vahl, Symb. Bot. 3: 104. 1794.

Pteris polymorpha Poir., Encycl. Meth. Bot. 5: 719. 1804.

Pteris adiantoides Bory *ex* Willd., Sp. 5: 391. 1810.

Allosorus adiantoides (Bory *ex* Willd.) C.Presl, Tent. Pteid. 153. 1836.
Allosorus hastatus (L.f.) C.Presl, Tent. Pterid. 153. 1836.
Cheilanthes hastata (L.f.) Kunze, Linn. 10: 532. 1836.
Cheilanthes hastata var. *caronica* Kunze, Linn. 10: 532. 1836.
Cheilanthes hastata var. *stenophylla* Kunze, Linn. 10: 533. 1836.
Cassebeera hastata (L.f.) J.Sm., J. Bot. 4: 159. 1841.
Pellaea hastata (L.f.) Link, Fil. Sp. 60. 1841.
Cheilanthes macrophylla Kunze, Linn. 23: 244, 307. 1850.
Pellaea adiantoides (Bory *ex* Willd.) J.Sm., Cat. Kew Ferns 4. 1856.
Platyloma adiantoides (Bory *ex* Willd.) E.J.Lowe, Ferns 3. t. 33. 1857.
Pteridella viridis (Forssk.) Mett. *ex* Kuhn, Deck. Reis. 3(3): 16. 1879.
Pellaea viridis (Forssk.) Prantl, Engl. Jahrb. 3: 420. 1882.
Allosorus viridis (Forssk.) Kuntze, Rev. Gen. Pl. 2: 806. 1891.
Cassebeera viridis (Forssk.) Kaulf *ex* Farw., Amer. Midl. Naturalist 12: 282. 1931.

Rhizome short creeping, 3 x 1-1.5 cm, unbranched, densely covered by paleae and fibrous roots. Paleae 4.5-5 x 0.5-0.7 mm, lanceolate, concolorous and pale brown when young, bicolorous with a dark brown band of cells in the center and light brown cells at periphery when mature, attenuate; margin serrulate; Fronds tufted, 5-8, spreading, 45 x 8 cm; stipe 20 x 0.3 cm, dark brown, rounded below, shallowly grooved above except near the base; densely scaly below, glossy and shining with sparse scales above, especially along the groove; lamina 25 x 8 cm, ovate-lanceolate, or deltoid-lanceolate, widest at base, tripinnate below, gradually become bipinnate, bipinnatifid and simple pinnate towards apex; rachis similar to stipe, rounded below, grooved above, bearing 15-16 pairs of primary pinnae; lower pinnae larger, sub-opposite, 4-5 cm apart, shortly stalked; lowest 1-2 pairs of secondary pinnae pinnate, deeply lobed, secondary pinnae alternate above; ultimate pinnules shortly stalked (2-3 mm long); stalk pubescent with few erect 3 celled uniseriate hairs; ovate to deltoid, variable in size, larger pinnules below, 3.5 x 2.5 cm, trilobed, smaller pinnules above, entire, 1.5 x 1 cm, herbaceous to thin coriaceous, glabrous on both surfaces in mature pinnules; young sterile pinnules have short 75 to 100 μm long glandular cells with unicellular stalk; margins of pinnule crenate. Venation pinnate; costa projected below, grooved above; lateral veins two times forked; veinlets ending in the sinuses between marginal crenulations. Sori continuous

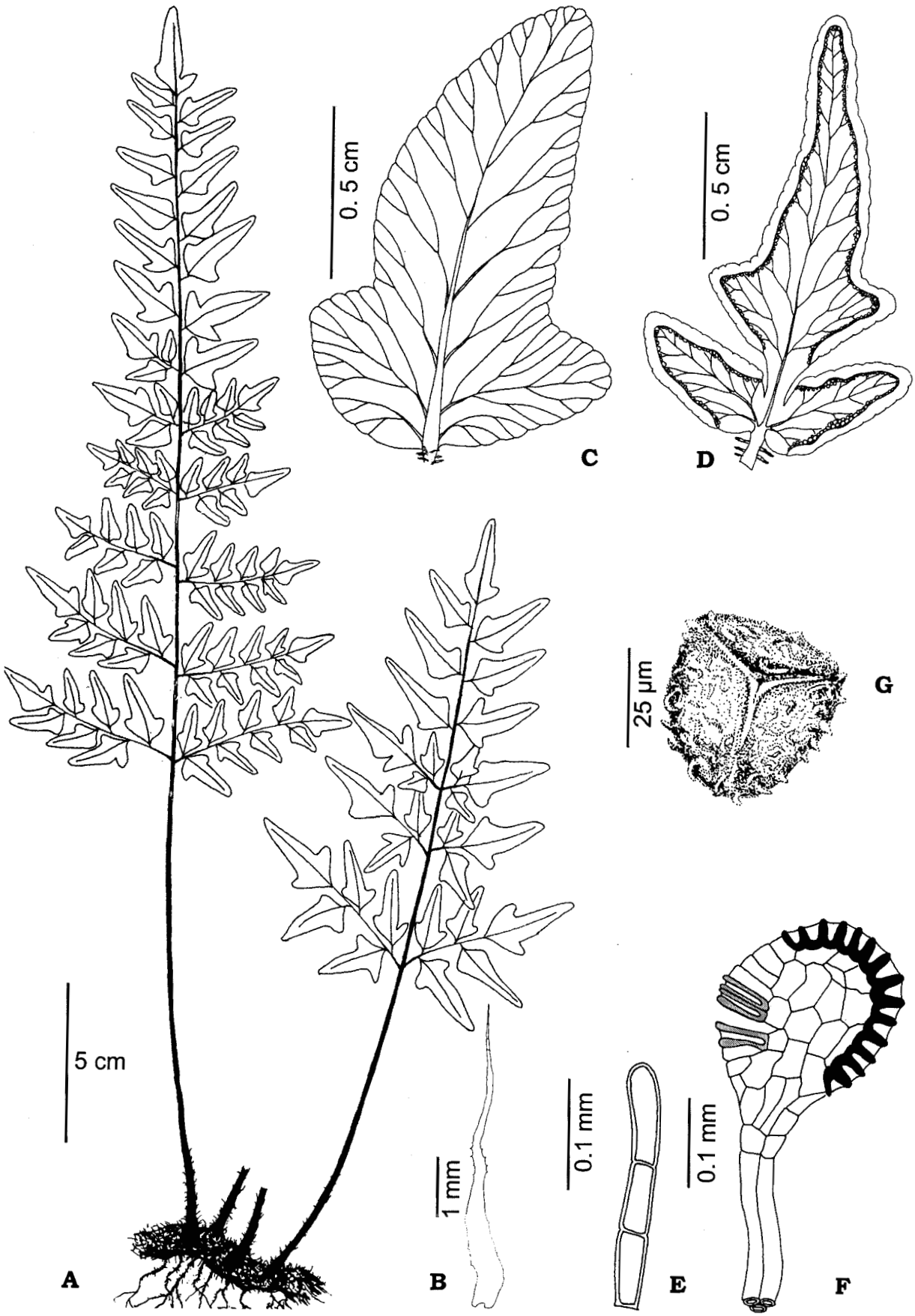

Fig. 32. **Cheilanthes viridis: A**- Habit, **B**- Rhizome palea, **C**- Sterile pinnule, **D**- Fertile pinnule, **E**- Hair on the stalk of pinnule, **F**- Sporangium, **G**- Spore (from *Mohana kurup 52848*).

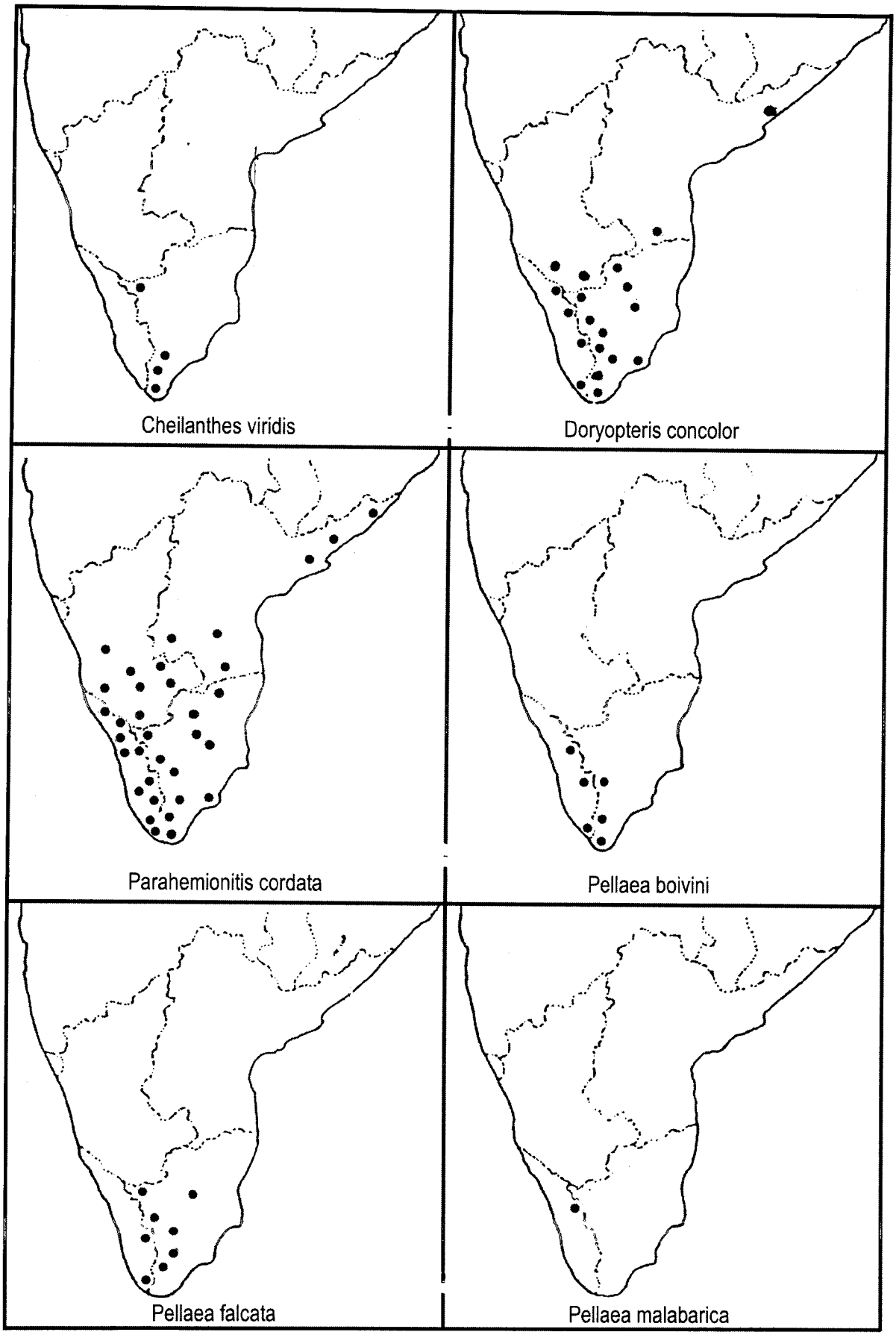

Fig. 33. Distribution of Cheilanthes viridis, Doryopteris concolor, Parahemionitis cordata, Pellaea boivini, P. falcata and P. malabarica in Southern India.

along the margin of pinnule, protected by a continuous marginal flap with undulate margins. Sporangium stalked; stalk equal in length to capsule; annulus 14 cells long. Spores 38 x 42 μm trilete, tetrahedral; exine echinate. '

Chromosome number: n = 2n = 90, triploid apogamous (Irudayaraj & Manickam, 1987; Manickam & Irudayaraj, 1988).

Distribution and Ecology: In India *C. viridis* is of restricted distribution and is confined to a few localities of Tamil Nadu in southern India where it occurs in Kothayar hills and Ootty. It is well distributed in Ethiopia, Kenya, Madagascar, Mosambique, Mauritius, Sudan, Tanzania, Transvaal, Uganda, Yemen and Zimbabwe. It grows in semi-shaded habitats in rock crevices and earth cuttings and beneath the crocks in more exposed areas.

Notes: 1. The type of *Pteris viridis* Forssk. was collected from Arabia by Forsskal and is believed lost. The application of the name has been construed from the expanded description of Vahl, Symb. Bot. 3: 104. 1794 and Kaulfuss, Enum. Fil. 216. 1824 (Schelpe & Anthony, 1986).

2. Schelpe and Anthony recognize 3 varieties to *C. viridis.* They treated the Indian material as *C. viridis* var. *viridis.*

Specimens examined: **TAMIL NADU**: Kanniya Kumari Dt., Kothayar dam area, *Manickam & Mathew 35289*; Kothayar hills, *Manickam 142* (XCH). Nilgiris Dt., Lovedale, Ootty, *Mohanakurup 73111* (CALI). Tirunelveli Dt., Upper Kothayar, *Madhusoodanan 44885, Mohanakurup 52848* (CALI). Virudunagar Dt., Nagariar estate, *Manickam 3010* (XCH).

DORYOPTERIS J.Sm.

Doryopteris is regarded by almost all pteridologists as an independent genus in the cheilanthoid group. But the placement of this genus in the higher taxa is not uniform. Diels (1899) and Christensen (1938) placed it in the family Polypodiaceae. The former author placed it in the tribe Pterideae- sub-tribe Cheilanthinae, while the latter author included it in the subfamily Gymnogrammoideae- tribe Cheilantheae. Copeland (1947) placed it in the family Pteridaceae without any further subdivision of the family. Holttum (1947, 1949), Alston (1956), Crabbe *et al.,* (1975) and Brummitt (1992) placed this genus in the family Adiantaceae. Alston *(l.c.)* and Brummitt (*l.c.*) made no subdivision to the family. But Holttum (*l.c.*) placed it in the subfamily Gymnogrammoideae, while Crabbe *et al.,* (*l.c.*) brought it under the subfamily

Adiantoideae. Nayar (1970) treated this genus with other cheilanthoid ferns in the family Cheilanthaceae. Ching (1940) and Pichi Sermolli (1977) kept it in the family Sinopteridaceae. Tryon *et al.* (1990) included it in the subfamily Cheilanthoideae of the family Pteridaceae.

The term *Doryopteris* comes from two Greek words, 'dory' (a spear or halberd) and 'pteris' (a fern), referring to the shape of the frond of the type species. Even though it is an old genus and recognized by all authors as an independent one, the relationship between species within the genus needs further confirmation. For example, Tryon (1962b) distinguished two sections in the genus namely section *Lytoneuron* and section *Doryopteris.* But he could not include *Doryopteris concolor* (Langsd. & Fisch.) Kuhn in any of these sections and placed it in a separate group of miscellaneous species apart from these two sections. Later, Tryon and Tryon (1981) transferred this species to the genus *Cheilanthes,* but is not followed here.

Doryopteris J.Sm., J. Bot. 3: 404. 1841. *nom. cons.;* Fee, Gen. Fil. 133. 1850-52; Bedd., Handb. Ferns Brit. India 120. 1883; Ching, Sunyatsenia 5: 226. 1940; Copel., Gen. Fil. 71. 1947; Holttum, Rev. Fern Fl. Malaya 2: 594. 1954; R.M.Tryon & A.F.Tryon, Ferns Allied Plants 293. 1982; R.M.Tryon *et al.* in Kramer & Green (eds.), Fam. Gen. Vas. Plants 1: 244. 1990; Bostock *et al.* in Mc Carthy (ed.), Fl. Australia 48: 270. 1998.

Type: *Doryopteris palmata* (Willd.) J.Sm., J. Bot. 4: 163. 1841.(*Pteris palmata* Willd.).

Cassebeera Kaulf., Enum. Fil. 216. 1824.

Heteropteris Fee, Crypt. Vasc. Bras. I. 123. 1869. *non* Fee, 1843.

Bakeriopteris Kuntze, Rev. Gen. Pl. II. 807. 1891.

Tryonella Pic.Serm., Webbia 29: 14. 1974.

Terrestrial plants; rhizome suberect, solenostelic, bearing pale brown, lanceolate,concolorous, entire paleae; stipes crowded, dark brown to blackish, polished, shallowly grooved above, scaly near the base; lamina simple, pinnatifid, monomorphic or dimorphic, fertile leaf with narrow segments, usually pentagonal in out line, glabrous, coriaceous; veins free or reticulate without included veinlets; sori marginal continuous along the margin on a marginal commissure; indusium continuous; spores trilete, tetrahedral, globose without equatorial flange; surface of exine bears sparsely distributed, thin flap like, irregular thickenings.

Gametophyte: Mature prothallus is naked, cordate, broader than long, with a thin central midrib bearing the nearly semi-circular wings on either side. Apex deeply notched. The wings possess prominent collenchymatous thickenings on the corners and thick wart like thickenings distributed along the lateral walls (Nayar, 1960).

Chromosome number: n=29, 30. (Abraham *et al.*, 1962; Fabri, 1963; Manickam & Irudayaraj, 1988); n=30 (Chiarugi, 1960).

Distribution and Ecology: A genus of about 33 species, of which 23 are distributed in the American Tropics, nine in the Old World from India and China to the Philippine Islands, Java and New Guinea. One is pantropical. *Doryopteris* is primarily a genus of moist or at least seasonally moist rocky places growing from near the sea level to 2500 m.

Note: 1. Kaulfuss (Enum. Fil. 216. 1824) published the name *Cassebeera*, 17 years before that of *Doryopteris by* Smith (J. Bot. 3: 404. 1841). So *Cassebeera* Kaulf. has priority. Hence, it would have been the correct name when both are united. But in order to preserve the usage of the well known generic name *Doryopteris*, Tryon (Taxon, 28: 609. 1979) proposed its conservation against *Cassebeera* Kaulf. and was accepted.

2. The type of the genus *Doryopteris*, originally founded by Smith (Hist. Fil. 288. 1875) was *D. pedata* (L.) Fee. Accordingly many authors (Christensen, 1906; Ching, 1940) adopted this as the type of the genus. But Morton (Amer. Fern. J. 34: 26. 1944) selected *D. palmata* (Willd.) J.Sm. as the lectotype of the genus pointing out that J. Smith's choice of *D. pedata* (L.) Fee cannot be maintained as the type, since it was not included in the genus at the time of its establishment.

Dixit (1984) and Chandra (2000a) report that three *Doryopteris* species, *viz., D. concolor* (Langsd. & Fisch.) Kuhn, *D. kirkii* (Hook.) Alston and *D. ludens* (Wall. *ex* Hook.) J.Sm. occur in South India. But according to Verdcourt (Pers. comm., 2001), *D. kirkii* is nothing more than a mere variety of *D. concolor* and is surely present in Africa and Sri Lanka. But there is so far no proof of its occurrence in South India. As far as *D. ludens* is concerned, Beddome (1883) says "a specimen in Wight's herbarium of this or an allied species, is supposed to be from Dindigul mountains in the Madras Presidency". But he further states that it has never been found there by him. Except for Dixit (1984) and Chandra (2000a), there is no literature on wild

occurrence of these two species in South India. Hence, both these species are excluded from the present treatment.

Doryopteris concolor (Langsd. & Fisch.) Kuhn, Deck. Reis. 3(3): Bot. 19. 1879; Subramanyam *et al.*, Bull. Bot. Surv. India 3: 211. 1961; B.K.Nayar & S.Kaur, Comp. Bedd. Handb. 28. 1974; R.D.Dixit, Census Indian Pterid. 61. 1984; Manickam, Fern Fl. Palni Hills 30. 1986; S.Chandra & S.Kaur, Nomen. Guide Bedd. Ferns S. India & Ferns Brit. India 4. 1987; Manickam & Irud., Pterid. Fl. W. Ghats 83. pl. 59. 1992; N.C.Nair *et al.*, J. Econ. Taxon. Bot. 16: 269. 1992; Jyothi & Madhus., J. Econ. Taxon. Bot. 17: 35. 1993; B.K.Nayar & Geev., Fern Fl. Malabar 124. f. 33. 1993; Fraser-Jenk., New Sp. Syndr. Indian Pterid. Ferns Nepal 116. 1997; Rajagopal & Bhat, Indian Fern J. 15: 9. 1998; S.Chandra, Ferns India 60. 2000. (**Fig. 33, 34A-F, 35b &c**).

Type: Marquesas, Nucahiva Island. *Langsdorf* (LE).

Pteris concolor Langsd. & Fisch., Ic. Fil. 19. t. 21. 1810.

Pteris geraniifolia Raddi, Opusc. Sci. Bot. 3: 293. 1819 & Pl. Bras. 1 46. t. 67. 1825; Bedd., Ferns S. India 13. pl. 37. 1863.

Pteris pohliana C.Presl, Del. Prag. 1: 181. 1822.

Doryopteris geraniifolia (Raddi) Klotzsch, Linn. 20: 343. 1847.

Pellaea geraniifolia (Raddi) Fee, Gen. Fil. 130. 1850-52.

Platyloma geraniifolium (Raddi) E.J.Lowe, Ferns 3. t. 27. 1857.

Pellaea concolor (Langd. & Fisch.) Baker, Fl. Bras. 1(2): 396. 1870; Bedd., Handb. Ferns Brit. India 100. 1883; d'Almeida, J. Indian Bot. Soc. 5: 22. 1926; Subramanyam *et al.*, Bull. Bot. Surv. India 2: 325. 1960.

Cheilanthes pohliana (C.Presl) Keyserl., Pol. Cyath. Hb. Bung. 25. 1873.

Allosorus concolor (Langsd. & Fisch.) Kuntze, Rev. Gen. Pl. 2: 806. 1891.

Cheilanthes concolor (Langsd. & Fisch.) R.M.Tryon & A.F.Tryon, Rhodora 83: 133. 1981.

Rhizome sub-erect or decumbent, 2-3 x 2 cm, unbranched, densely covered with paleae, persistent leaf bases and a tuft of fibrous roots. Paleae 3.5-4 x 0.5 mm, linear-lanceolate, acuminate, gland tipped, bicolorous with dark brown central region and light brown periphery, margin minutely toothed especially towards the lower part, as ends of marginal cells protrude outwards, smooth above. Fronds 8-12, spreading, 20-30 x 12-15 cm; stipe 15-20 cm long, 1-2 mm thick, twice as longer than lamina

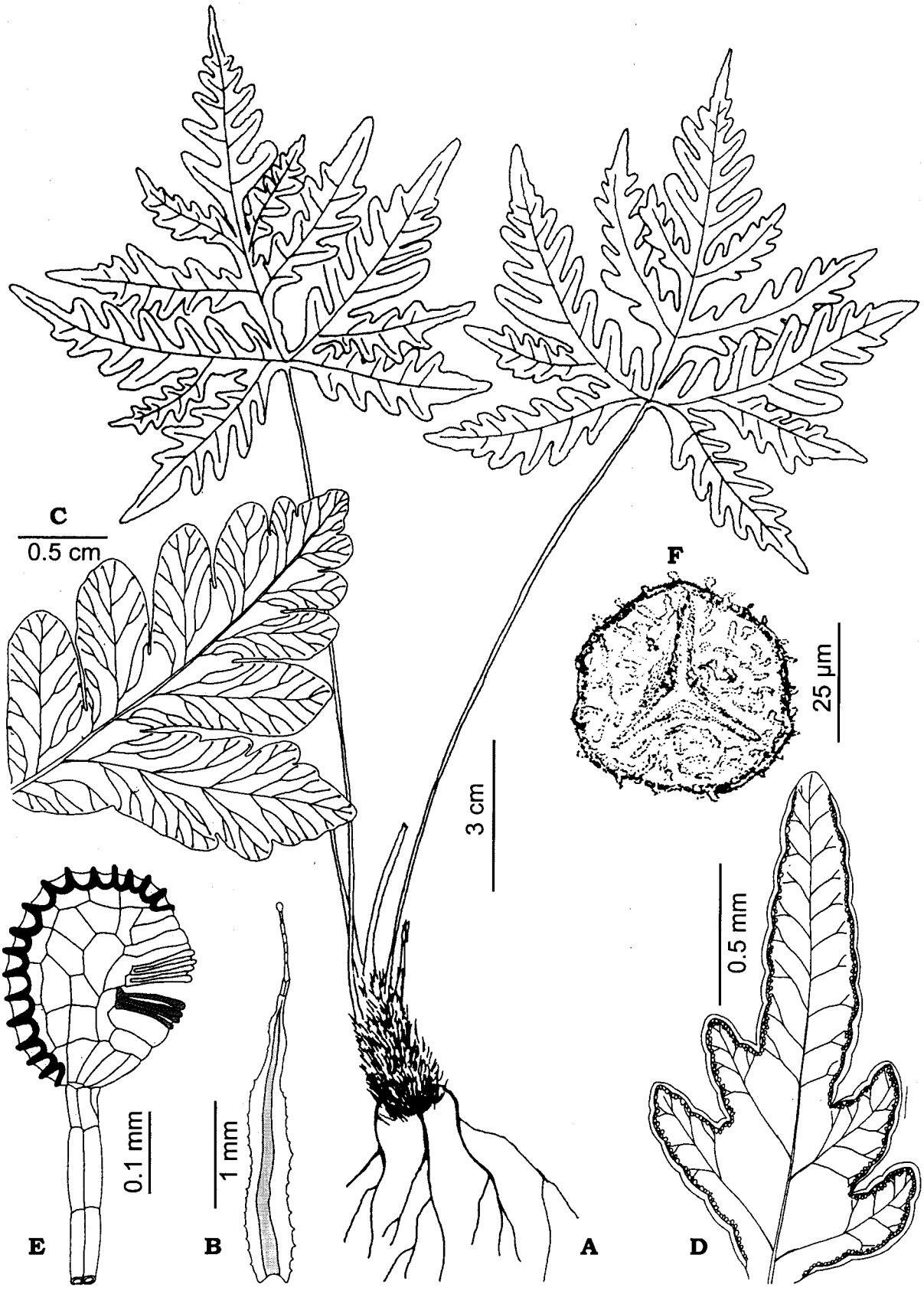

Fig. 34. Doryopteris concolor: A- Habit, **B**- Rhizome palea, **C**- a portion of sterile pinna, **D**- a portion of fertile pinna, **E**- Sporangium, **F**- Spore (from *Mohanakurup 52816*).

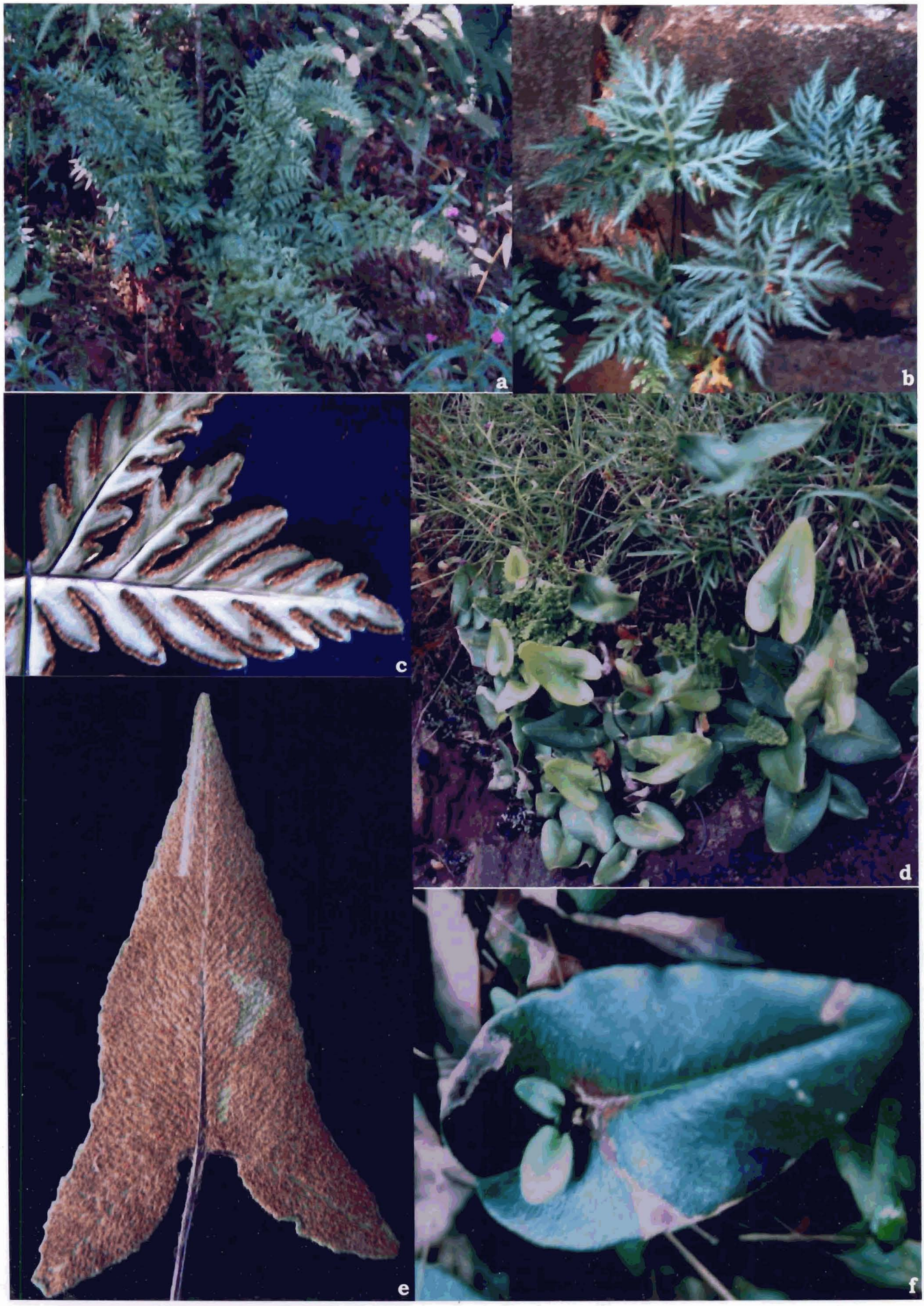

Fig. 35. Cheilanthes viridis: a. habit; **Doryopteris concolor**: **b.** habit, **c**. part of fertile frond; **Parahemionitis cordata**: **d.** habit, **e**. fertile frond, **f**. vegetative propagation by young plants by budding.

blackish brown, polished, densely scaly at the base, sparse above, shallowly and widely grooved on the upper surface, rounded on lower surface; lamina 8-10 x 10-12 cm, broader than long, simple, pinnatisect, deltoid-pentagonal with 3 pairs of basal opposite pinnae like lobes and 4-5 pairs of distal opposite pairs of simple lobes; basal lobes 1.5 cm apart, basal most pinna largest, semi-deltoid, 6 x 6 cm with 5-6 pairs of pinnate lobes; basiscopic lobes longer than acroscopic ones, lowest basiscopic lobe pinnatifid, 5-6 x 2 cm, acroscopoic lobes simple, 1 x 0.5 cm, ultimate lobes linear-oblong, obtuse, glabrous on both surfaces. Venation pinnate; costa and costules distinct, terete, black and glossy below, indistinct above; lateral veins oblique, once or twice forked; vein ends slightly enlarged. Sori marginal, discrete, seated at the vein ends except at the extreme tip of lobes, protected by a continuous marginal flap. Sporangium stalked; stalk 2 cells thick, equal in length to capsule; annulus 17 cells long. Spores 30 x 35 μm, trilete, tetrahedral; exine smooth; perine granulose with irregular reticulations.

Chromosome numbers: n = 30, 2n = 60, diploid sexual (Manton & Sledge, 1954; Abraham *et al.*, 1962; Ghatak, 1977; Bir & Vasudeva, 1978; Irudayaraj & Manickam, 1987; Manickam & Irudayaraj, 1988; Irudayaraj & Bir, 1994).

Distribution and Ecology: In India, *D. concolor* is restricted to southern India. It also occurs in Africa, Central and South America, Australia, China, Philippines, Sri Lanka, Taiwan and West Indies. *D. concolor* grows in open or semi shaded earth cuttings and rock crevices in higher elevations.

Note: Tryon and Tryon (1981) transferred this species to the genus *Cheilanthes* because of its free veins, lamina shape and bicolorous scales, but is not accepted by others.

Specimens examined: **ANDHRA PRADESH**: Chittoor Dt., Akashganga, *Ahamed 12812*; Horsley hills, *Ahamed 13522*, Papavinasanam, *Ahamed 13522* (SKU). Visakhapatnam Dt., Anantagiri, *Subbarao 21778*; Arukuvalley, *Nair 53101*; Chintapalli, *Subbarao 28223*; Minumurulu, *Subbarao 29589* (MH); Sunkurimetta, *Balakrishnan 10894* (CAL). **KARNATAKA**: Kodagu Dt., Chettalli, *Rajagopal 117* (MGMC). **KERALA**: Idukki Dt., Kumali, *Nair 40478* (CAL); Ramakkalmedu, *Mohanakurup 73164* (CALI); Peerumedu, *Nair 40138* (CAL); Thekkady, *Manickam & Mathew 33352* (XCH). Palakkad Dt., Aruvampara, *Nair 69159* (CAL, MH); Kaikatty, *Vajravelu 44788* (MH); Nelliampathi, *Geevarghese 17804, Mohanakurup 52896;*

Silent Valley, Punnamala, *Nayar & party 10627* (CALI). Thiruvananthapuram Dt., Bodimedu, *Meebold 13595* (CAL). Wayanad Dt., Chedaleth, *Ellis 24055* (MH); Chembra, *Mohanakurup 52863, Nayar & Madhusoodanan 21298* (CALI). **TAMIL NADU**: Coimbatore Dt., Anamalai hills, *Mathew 31548* (XCH); Attakatti, *Joseph 12709* (CAL, MH); Valparai, *Manickam 1982* (XCH). Dharmapuri Dt., Guthirayan, *Ravishankar 95596* (MH). Dindigul Dt., Kodairoad ghat road, *Mohanakurup 73173* (CALI); Kodaikanal, *Madhusoodanan 43816* (CALI), *Manickam 35006* (XCH); Sirumalai, *Chandrabose 54287* (CAL, MH). Kanniya Kumari Dt., Kothayar, *Manickam 149;* Mahendragiri hills, *Manickam 33877* (XCH). Namakkal Dt., Kolli hills, *Manickam & Mathew 33268* (XCH), *Mohanakurup 52883* (CALI). Nilgiris Dt., Coonoor, *Beddome 1838* (CAL), *Manickam 1312* (XCH), *Sebastine 4099*; Coonoor ghat, *Gamble 11697* (CAL); Naduvattam, *Mohanakurup 52806, 52816* (CALI); Pakasuramalai, *Sebastine 3956*; near Thattapallam, Kottagiri, *Subramanyam 1116* (CAL, MH). Ramanathapuram Dt., Ayyanarkoil, *Vajravelu 38726* (MH); Mudaliaruthu, *Nair 61024* (CAL, MH). Salem Dt., Kaveri peak, *Nair 74235* (CAL, MH); Yercaud, *Manickam & Mathew 33268* (XCH), *Mohanakurup 52874, 52879* (CALI); Andiappankiol, Yercaud, *Nair 74206*; Hansden, Yercaud, *Ghatak 178* (CAL). Teni Dt., Cumbum valley, Kumali-Gudallur road, *Subramanyam 8073* (CAL, MH); Highwavy mountains, *Blatter & Hallberg 425* (CAL). Tirunelveli Dt., Mancholai, *Sebastine 5456*; Therkumalai, *Subramanyam 5041* (MH); Upper Kothayar, *Madhusoodanan 43816, Mohanakurup 52850* (CALI). Virudunagar Dt., Devathanam, *Manickam 2955* (XCH); Nagariar estate, *Srinivasan 94467* (MH).

PARAHEMIONITIS Panigrahi

Linnaeus (1753) included the ferns with gymnogrammoid sori in the genus *Hemionitis.* Diels (1899) placed this genus in the subtribe Gymnogramminae, tribe Pterideae of family Polypodiaceae. Christensen (1938) placed it in the tribe Gymnogrammeae of subfamily Gymnogrammoideae. He divided the tribe into two groups- Chaetopterides and Lepidopterides. *Hemionitis* was placed in the latter group. Ching (1940) treated the taxon in the same way as Christensen (*l.c.*), but raised the two groups of Christensen as two distinct tribes. Copeland (1947) placed it among other genera of Pteridaceae without any further subdivision to the family. Holttum (1949) retained *Hemionitis* in gymnogrammoids under the family Adiantaceae. Crabbe *et al.* (1975) and Brummiitt (1992) also placed it in the family

Adiantaceae. Pichi Sermolli (1966) published a new family Hemionitidaceae with two tribes - Jamesonieae and Hemionitideae. *Hemionitis* was placed in the latter tribe. Nayar (1970) placed it in the family Cheilanthaceae, while Tryon *et al.* (1990) placed *Hemionitis* in the tribe Cheilantheae of the family Pteridaceae, which is adopted here.

Hemionitis is a small genus with eight species. Seven species are confined to the tropical America while one species occurs in south-eastern Asia. According to Mickel (1974a), this south-east Asian species, *H. arifolia*, is having only superficial resemblance to the American species and it is quite different from them in many characters such as in the scales on the blade, the dark colour of the leaf tissue, a more coriaceous texture, the sagittate leaf architecture, the buds at the base of the blade rather than on the margins and the spores which have noticeably high ridges as opposed to the tuberculate spores of *H. palmata.* Hence, Mickel (1974a) concluded that there was some justification for establishing a new genus based on *H. arifolia*.

Apparently on the basis of the observations made by Mickel (*l.c.*) and also that of Ranker (1987), who had shown that the Indian fern definitely did not belong to true *Hemionitis,* Panigrahi (1993) brought this species under a new generic name *Parahemionitis* Panigrahi, with type and the sole species *P. arifolia* (N.L.Burm.) Panigrahi.

Note: Panigrahi's (1991) attempt to raise a new genus to include the south-east Asian species, *H. arifolia,* failed because he did not provide a Latin description of the genus which was essential according to the Code. But subsequently he (1993) published it with a Latin description and erected the genus successfully.

Parahemionitis Panigrahi, Amer. Fern J. 83: 90. 1993.

Type:*Parahemionitis cordata* (Roxb. *ex* Hook. & Grev.) Fraser-Jenk., New Sp. Syndr. Indian Pterid. Ferns Nepal 187. 1997.

(*Hemionitis cordata* Roxb. *ex* Hook. & Grev., Ic. Fil. t. 64. 1828)

Hemionitis L., Sp. Pl. 2: 1077. 1753, *pro parte*.

Parahemionitis cordata (Roxb. *ex* Hook. & Grev.) Fraser-Jenk., New Sp. Syndr. Indian Pterid. Ferns Nepal 187. 1997. (**Fig. 33, 35d-f, 36A-l**).

Hemionitis cordata Roxb. *ex* Hook. & Grev., Ic. Fil. t. 64. 1828; Bedd., Ferns S. India 18. t. 53. 1863.

Hemionitis cordifolia Wall., Num. List no. 44. 1828.

Hemionitis hastata Wall., Num. List no. 2170. 1829.

Hemionitis intermedia Fee, Gen. Fil. 172. 1850-52.

Hemionitis sagittata Fee, Gen. Fil. 172. t. 14 D. 1850-52.

Hemionitis toxotis Trevis., Atti. 1st Veneto II 2. 168. 1851.

Hemionitis arifolia (Burm.f.) T.Moore, Ind. Fil. 114. 1859; Bedd., Handb. Ferns Brit. India 413. f. 245. 1883; d'Almeida, J. Indian Bot. Soc. 5: 28. 1926; Subramanyam *et al.*, Bull. Bot. Surv. India 3: 211. 1961; B.K.Nayar, Bull. Nat. Bot. Gard. 67: 11. 1962; Raju, Bull. Bot. Surv. India 6: 189. 1964; B.K.Nayar & S.Kaur, Comp. Bedd. Handb. 97. 1974; R.D.Dixit, Census Indian Pterid. 79. 1984; Manickam, Fern Fl. Palni Hills 34. 1984; S.Chandra & S.Kaur, Nomen. Guide Bedd. Ferns S. India & Ferns Brit. India 6. 1987; Manickam & Irud., Pterid. Fl. W. Ghats 93. pl. 68. 1992; N.C.Nair *et al.*, J. Econ. Taxon. Bot. 16: 266. 1992; Jyothi & Madhus., J. Econ. Taxon. Bot. 17: 35. 1993; B.K.Nayar & Geev., Fern Fl. Malabar 125. 1993; Rajagopal & Bhat, Indian Fern J. 15: 9. 1998; S.Chandra, Ferns India 61. 2000.

Gymnogramma sagittata (Fee) Ettingsh., Denkschr. Ak. Wien. 22: 102. t. 11. f. 10. 1864.

Hemionitis cumigiana Fee, 1o Mem. 22. 1865.

Asplenium arifolium Burm.f., Fl. Ind. 231. 1768.

Gymnogramma arifolia (Burm.f.) Kuhn, Ann. Lugd. Bat. 4: 282. 1869.

Parahemionitis arifolia (Burm.f) Panigrahi, Amer. Fern J. 83: 90. 1993.

Patitsjivi maravara Rheede, Hort. Malab. 12: 21. t. 10. 1693.

Rhizome sub-erect or short creeping, 2 x 0.5- 1 cm, branched, densely covered by scales, persistent leaf bases and roots. Paleae 2-3 x 0.5 mm, lanceolate, acuminate, gland tipped, bicolorous with a dark brown central region and light brown peripheral region, margin slightly toothed towards the base as ends of marginal cells protrude out wards. Fronds dimorphic; sterile fronds obliquely placed, smaller, 10-20 cm long, more numerous and forming a rosette; fertile fronds longer, 20-40 cm long, erect; stipe 8-15 cm in sterile fronds, 20-35 cm in fertile ones, dark brown to black, polished, densely scaly and hairy all over, scale become smaller upwards, shallowly grooved above; lamina simple, dimorphic; fertile sagittate, 7-8 x 6-7 cm, margin entire; sterile cordate, ovate; apex rounded; vegetative buds present towards base on the upper side of sterile pinnae; thickly coriaceous, glabrous on upper surface,

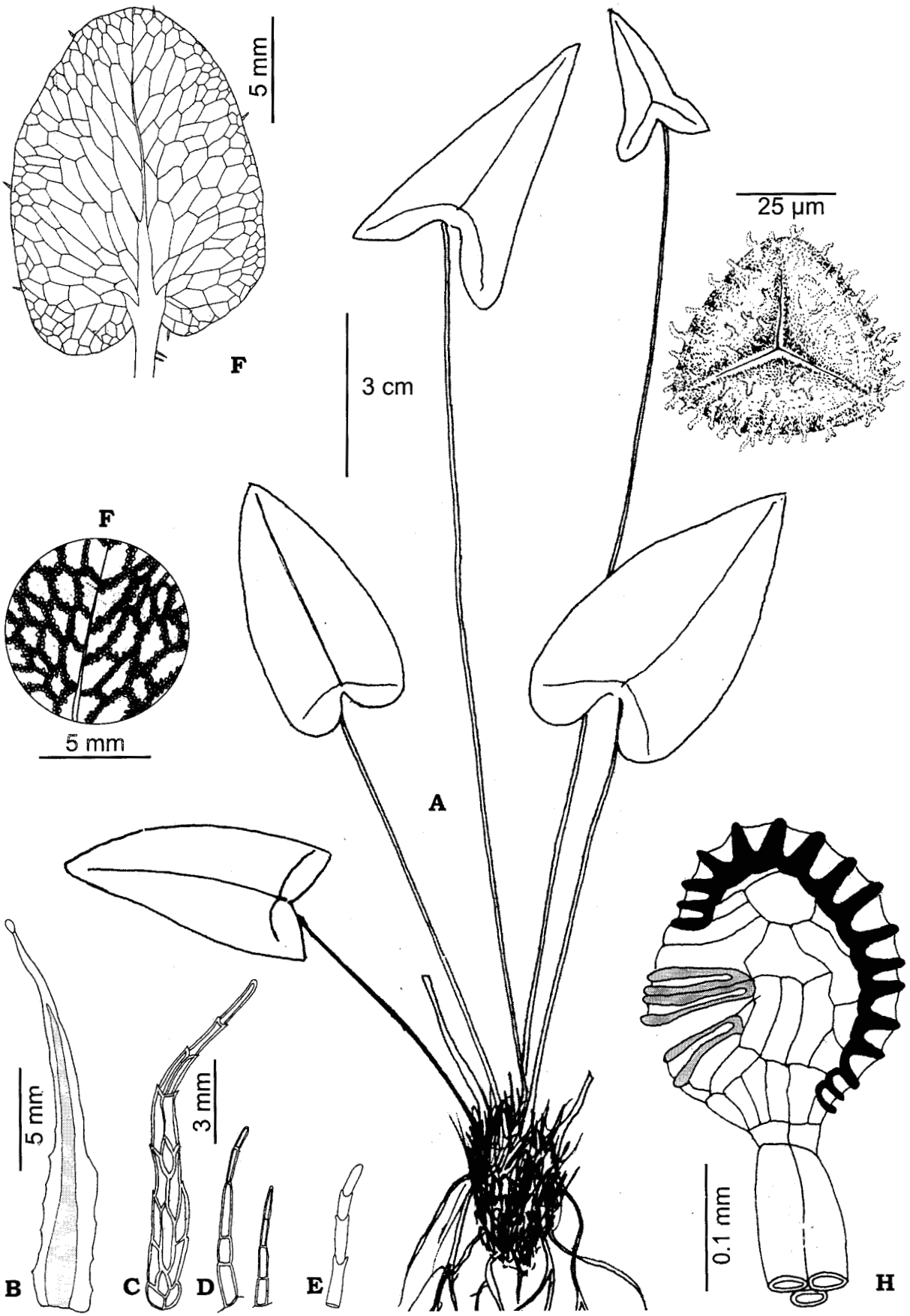

Fig. 36. **Parahemionitis cordata:** **A**- Habit, **B**- Rhizome palea, **C**- Palea on the lower surface of the lamina, **D**- Hairs on the margin of lamina, **E**- Hair on the upper surface of lamina, **F**- Sterile lamina, **G**- a portion of fertile lamina, **H**- Sporangium, **I**- Spore (from *Mohanakurup 52825*).

densely scaly and hairy below; hairs multicellular, uniseriate and acicular. Venation pinnate, reticulate; costa prominent up to middle, projected below, grooved above, with a pair of prominent basal primary veins passing on to the basal lobes of lamina; lateral veins obliquely placed, anastomosing, forming polygonal areoles; areoles elongate, largest towards midrib, gradually become smaller towards margin. Sporangia continuous along the veins through out the lower surface, but absent in midrib, exindusiate, intermixed with hairs and scales. Sporangium stalked; stalk smaller than capsule, consist of two rows of three cells; annulus 16-18 cells long. Spores 45 x 50 μm, trilete, tetrahedral, mixed with lesser number of monolete, bilateral spores; exine smooth enveloped by a perine with flap like out growths.

Gametophyte: Mature prothallus is cordate and naked with a heavy midrib. The wing cells possess collenchyma like thickenings on the corners (Nayar, 1962c).

Chromosome numbers: n = 2n = 90, triploid apogamous (Abraham *et al.,* 1962; Ghatak, 1977; Manickam & Irudayaraj, 1988; Bir & Irudayaraj, 2001); n = 2n = 120, tetraploid apogamous (Manton & Sledge, 1954; Kurita, 1965; Mathew in Fabri, 1965).

Distribution and Ecology: *P. cordata* is well distributed in southern India up to Orissa. It also occurs in Bangladesh, Southern China, Indochina, Malaya, eastern Malaysia, Myanmar, Philippines, Sri Lanka and Taiwan. Usually grows in semi exposed or exposed localities in plains, in damp as well as dry areas on earth cuttings and rock crevices in lower altitudes.

Note: 1. There is often much variation in size depending on habitat; the plants being markedly larger in shaded localities; those of exposed dry localities usually possess narrow sagittate lamina similar to fertile ones (Nayar & Geevarghese, 1993).

2. Panigrahi (1993) erected a new genus Parahemionitis with *P. arifolia* (Burm.f.) Panigrahi as the type and sole species. But according to Fraser-Jenkins (1997), "Morton (1974:316) pointed out Alston's determination of what must be the type-specimen of *Asplenium arifolium* Burm.f. as *Acrostichum aureum* L. As there is no doubt about the determination and that it must have been what Burmann intended, a new combination is necessary to provide the correct name for the present species under the rule of priority". Hence he made the new combination, *Parahemionitis cordata* (Roxb. *ex* Hook. & Grev.) Fraser-Jenk.

Specimens examined: **ANDHRA PRADESH**: Ananthapur Dt., Kekali R.F., *Pullaiah & Yesoda 787* (MH, SKU). Chittoor Dt., Akashaganga, *Ahamed 12810*; Horsley hills,

Ahamed 12829 (SKU); Thirumala, *Mohanakurup 73150* (CALI). Cuddapah Dt., Balapalle, *Ellis 15006* (CAL, MH); Lankamalai, *Reddy 14632* (SKU). East Godavari Dt., Dummakonda, *Subbarao 68621* (MH). Srikakulam Dt., Salur forest, *Balakrishnan 1126* (CAL). Visakhapatnam Dt., Anantagiri, *Pullaiah & Chennaiah 7356* (SKU); Arakuvally, *Nair 53118* (MH); Dhamaku, *Mohanakurup 73117* (CALI); Sankarimetta forest, *Balakrishnan 10940* (CAL, MH). **KARNATAKA**: Dakshina Kannada Dt., Charmadi, *Arora 746* (CAL). Kodagu Dt., Bhagmandala, *Rajagopal 108* (MGMC); Nalkaud palace, *Walker s.n.* (CAL). Mysore Dt., Bandipur, *Naithani 21146* (MH); Biligirirangan hills, *Rajagopal 375* (MGMC); Kachugaranapodu, base of Gollibella, *Rao 80404* (CAL). Shimoga Dt., Kundadri hill, *Rajagopal 163* (MGMC). Udupi Dt., Hebri, *Rajagopal 45* (MGMC). **KERALA**: Idukki Dt., Kozhikanam, *Sharma 41644* (MH); Kumali, *Nair 40481* (CAL); Munnar, *Mohanakurup 73160* (CALI); Periyar dam site, *Nair 40116* (CAL); Pooyamkutty, *Bhargavan 87431* (MH); Ramakkalmedu, *Mohanakurup 73163* (CALI); Thankamani, *Nair 40430*; Thekkady, *Puri 36780* (CAL); Thommankuthu, *Mohanakurup 52823* (CALI); Vandiperiyar, *Viswanathan 21331* (MH). Kannur Dt., Alakode, *Ansari 67863* (CAL, MH). Kollam Dt., Karoor forest, Punalur, *Nair 50893*; Kollam, *Nair 50582*; Kulathupuzha, *M.Mohanan 54800* (CAL); Thenmala, *Mohanakurup 52857* (CALI). Kottayam Dt., Kurisumala, *Antony 724* (MH); Muttom, *Mohanakurup 52825* (CALI); Perunna, Changanassery, *Nair 40276* (CAL). Kozhikode Dt., Thiruvangad, *Ramesh 43881*; Thottumukkam, *George 48560* (CALI). Malappuram Dt., Calicut University Campus, *Devayani 20370, Majeed 20723* (CALI). Palakkad Dt., Aruvampara, *Nair 64455* (MH); Kalladikode, *Geevarghese 4027;* Kanjirapuzha, *Geevarghese 4017, Mohanakurup 52889*; Karappara, Nelliampathi, *Mohanakurup 52899* (CALI); Kunthipuzha river bank, *Vohra & Ghosh 56356* (CAL); Silent Valley dam site, *Nayar & party 10200* (CALI). Pathanamthitta Dt., Adoor, *Nair 50943;* Thiruvella, *Nair 50825* (CAL). Thiruvananthapuram Dt., Kottur R.F., *Joseph 41992*; Neyyattinkara, *Nair & Ghosh 51784* (MH); Ponmudi, *Nair 51618* (CAL). Wayanad Dt., Chembra, *Mohanakurup 52865;* Kalpetta, *Madhusoodanan & Kramer 21317* (CALI). **TAMIL NADU**: Coimbatore Dt., Anaikatti, *Subbarao 36572*; Nellimalai R.F., *Ramamurthy 14870*; Vadakkumalai, *Viswanathan 603* (MH). Dindigul Dt., Pazhani ghat road, *Mohanakurup 73169* (CALI); Poolathur, *Chandrabose 51674*; Vannathiparai, *Subramanyam 9417* (MH). Kanniya Kumari Dt., Keeriparai, *Mohanakurup 52845* (CALI); Panagudi, *Shetty 33011* (MH); Parvathipuram, *Mohanakurup 73136* (CALI). Namakkal Dt., Kolli hills, *Mohanakurup 52887* (CALI).

Nilgiris Dt., Bokkapuram, *Sharma 35464* (MH); Naduvattam, *Mohanakurup 52805* (CALI). Ramanathapuram Dt., Mudaliaruthu, *Nair 60979* (CAL, MH), *Vajravelu 39385* (MH). Salem Dt., Yercaud, *Subramanyam 6582* (MH); Andiappankoil area, Yercaud, *Nair 74203* (CAL). Tiruchirappalli Dt., Narthamalai, *Ramamurthy 25949* (MH). Tirunelveli Dt., Courtallum, *Mohanakurup 73140* (CALI); Kalakkadu R.F., *Joseph 15191* (MH), *Mohanakurup 73138* (CALI); Kannikatti, *Sebastine 8471* (MH). Vellore Dt., Thoppur, *Vajravelu 51956* (CAL, MH). Virudunagar Dt., Sethur hills, *Srinivasan 86958* (MH).

PELLAEA Link

Pellaea is recognized as a natural and independent genus of the cheilanthoid group with about 80 species (Copeland, 1947). This genus, being an indisputed member of the cheilanthoid group, was treated in the same manner as *Cheilanthes* and *Doryopteris* by different taxonomists in their classifications.

Pellaea was established as a natural genus by Link in 1841 incorporating some species earlier placed in the genus *Pteris* by Linnaeus. The term *Pellaea* is derived from the Greek word 'Pellos' meaning dark coloured, referring to the dusky nature of the frond.

Although still considered as a natural genus, some authors recognized different infrageneric categories in it. Fee (1852) divided the genus into six groups, while Prantl (1882) recognized eight sections in it. Tryon and Tryon (1982) and Tryon *et al.* (1990) recognized four sections in the genus. They are sect. *Pellaea*, sect. *Ormopteris* (J.Sm.) R.M.Tryon & A.F.Tryon, sect. *Holcochlaena* Hook. & Baker and sect. *Platyloma* (J.Sm.) Hook. & Baker. The first two sections are largely distributed in the New World, while the other two in the Old World including India. The South Indian species, *Pellaea boivini* Hook. belongs to sect. *Holcochlaena* and *P. falcata* (R.Br.) Fee to sect. *Platyloma*.

Note: The generic names *Pellaea* Link (Fil. Sp. 59. 1841) and *Platyloma* J.Sm. (J. Bot. 4: 160. 1841) were published in the same year for the same taxon. A detailed study of the date of publication of these two names revealed that the publication of *Platyloma* J.Sm. preceded that of *Pellaea* Link and hence, the former has priority over the latter. So in order to use the well known and universally adopted generic name *Pellaea* Link for the genus, Pichi Sermolli (1953) proposed its conservation and was adopted.

Pellaea Link, Fil. Sp. 59. 1841. *nom. cons.* Fee, Gen. Fil. 128. 1850-52; C.B.Clarke, Trans. Linn. Soc. Lond. Bot. 1: 460. 1880; Bedd., Handb. Ferns Brit. India 98. 1883; C.Hope, J. Bombay Nat. Hist. Soc. 13(3): 107. 1901; Ching, Sunyatsenia 5: 226. 1940; Copel., Gen. Fil. 69. 1947; R.M.Tryon & A.F.Tryon, Ferns Allied Plants 284. 1982; R.M.Tryon *et al.* in Kramer & Green (eds.), Fam. Gen. Vas. Plants 1: 243. 1990; Khullar, Illustr. Fern Fl. W. Himalaya 1: 222. 1994; Bostock *et al.* in Mc Carthy (ed.), Fi. Australia 48: 266. 1998.

Type: *Pellaea atropurpurea* (L.) Link, Fil. Sp. 59. 1841.

(Pteris atropurpurea L., Sp. Pl. 2: 1076. 1753).

Platyloma J.Sm., J. Bot. 4: 160. 1841.

Synochlamys Fee, Mem. Fam. Foug. 7: 35. 1857.

Pellaeopsis J.Sm., Hist. Fil. 289. 1875.

Choristosoria Mett. *ex* Kuhn, Deck. Reis. 3 (3): 13. 1879.

Pteridella Mett. *ex* Kuhn, Deck. Reis. 3 (3): 13. 1879.

Plants terrestrial; rhizome suberect or slender, long creeping, solenostelic, covered with ovate-lanceolate, concolorous or bicolorous scales; leaves crowded, monomorphic; stipe black and polished, terete or adaxially sulcate; lamina simply pinnate to tripinnate, imparipinnate; pinnules uniform, sessile or stalked, deltoid-ovate to oblong-lanceolate, glabrous or pubescent, coriaceous, entire; veins free or rarely anastomosing without included veinlets, ending some what behind the margin; sori borne at the vein ends, laterally expanded forming a soral line on marginal commissure, protected by a continuous reflexed margin; sporangia without paraphyses; spores trilete-tetrahedral, globose, reticulate or cristate without an equatorial flange.

Gametophyte: Mature gametophyte is naked, cordate with a thin midrib. In most species the wing cells possess collenchyma like thickenings at their corners (Nayar & Bajpai, 1963).

Chromosome number: n = 29, 30 (Chiarugi, 1960; Fabri, 1963; Manickam & Irudayaraj, 1988).

Distribution and Ecology: *Pellaea* often grows in open rocky places and also on rocky soil on hill-sides and in disturbed forests in relatively xeric conditions between 200 to 3000 m altitude mostly in the tropical and also in temperate regions. It is well

distributed in Africa, North and South America, Australia, India, New Zealand, Spain and Sri Lanka.

Note: The first typification of the genus was done by J. Smith (Hist. Fil. 285. 1875) who selected *Pteris hastata* Sw. as the type species. But it was later understood that this species was actually unknown to Link, the author of the genus *Pellaea*, when he established the genus. Since the selection of such a species as the type of the genus is against the rules of the Code, Christensen (1906) selected, *Pteris atropurpurea* L. as the type species of the genus and it was widely accepted (Ching, 1940; Copeland, 1947; Pichi Sermolli, 1953).

Chandra (2000a) reported five species of *Pellaea* as occurring in India, of which three, *viz.*, *P. boivini* Hook., *P. falcata* (R. Br.) Fee and *P. malabarica* Geev. *ex* Madhus. & Jyothi, are reported from South India. *P. malabarica* is supposed to be endemic to Silent Valley of Kerala.

Key to species

1a.	Rhizome long creeping; scales bicolorous; pinnules sessile or subsessile, scaly above and below	*P. falcata*
1b.	Rhizome erect or suberect; scales concolorous pinnae distincly stalked, glabrous above and below	2
2a.	Lamina tripinnate, deltoid to ovate; veins forked with free ends	*P. boivini*
2b.	Lamina unipinnate, very rarely bipinnate (some pinna showing terminal forking), lanceolate; veins forked, occasionally unite to form marginal loops	*P. malabarica*

Pellaea boivini Hook., Sp. 2: 147. t. 118A. 1858; Bedd., Handb. Ferns Brit. India 102. f. 53. 1883; d'Almeida. J. Indian Bot. Soc. 5: 22. 1926; B.K.Nayar & S.Kaur, Comp. Bedd. Handb. 28. 1974; R.D.Dixit, Census Indian Pterid. 62. 1984; S.Chandra & S.Kaur, Nomen. Guide Bedd. Ferns S. India & Ferns Brit. India 4. 1987; Manickam & Irud., Pterid. Fl. W. Ghats 85. pl. 61. 1992; N.C.Nair *et al.*, J. Econ. Taxon. Bot. 16: 269. 1992; Jyothi & Madhus., J. Econ. Taxon. Bot. 17: 36. 1993; B.K.Nayar & Geev., Fern Fl. Malabar 127. f. 34. 1993; S.Chandra, Ferns India 63. 2000. (**Fig. 33, 37A-G, 38a & b**).

Pteris adiantoides Desv., Prod. 6: 171. 1827, *non* Bory, 1810.

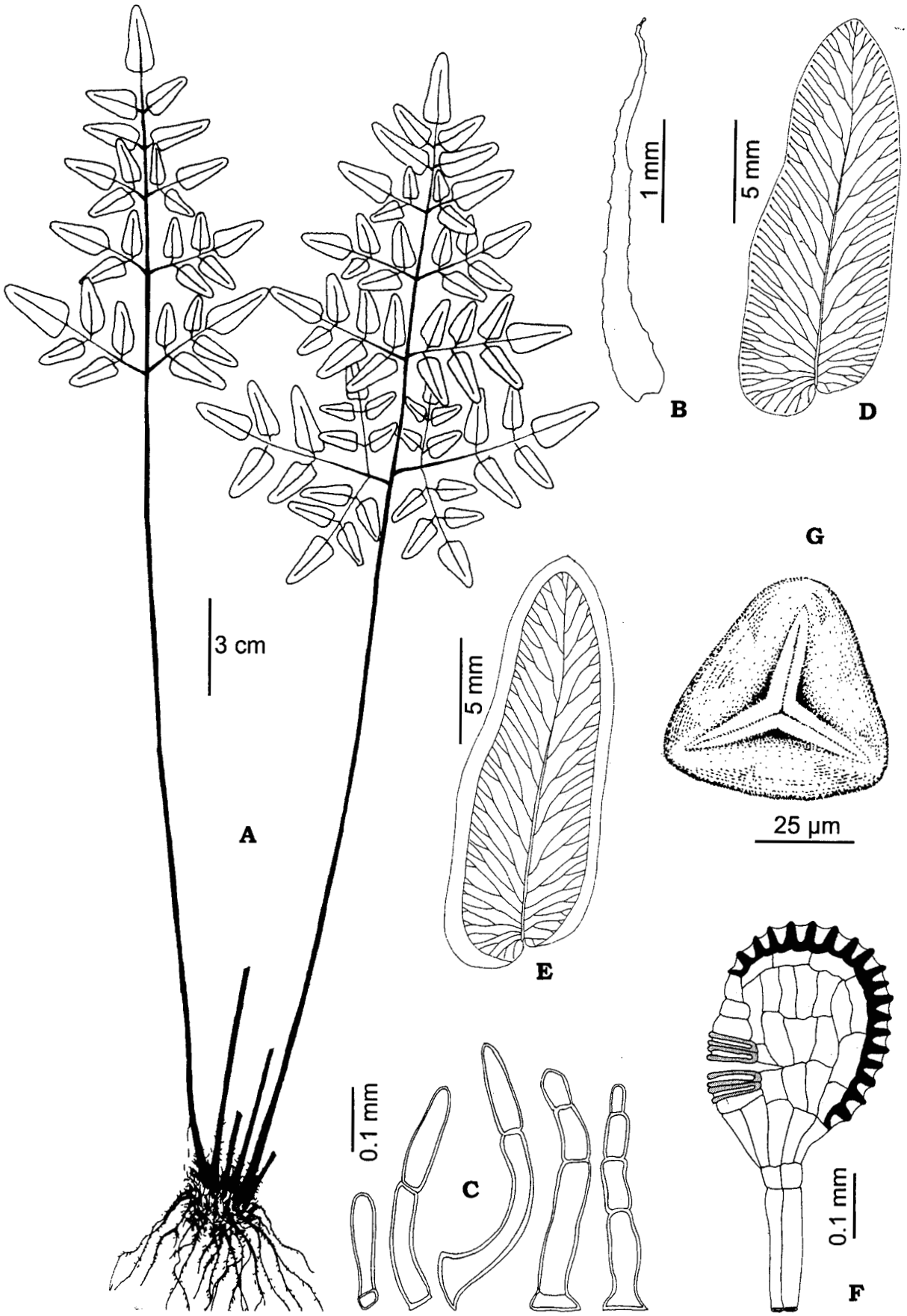

Fig. 37. **Pellaea boivini:** **A**- Habit, **B**- Rhizome palea, **C**- Hairs on the stipe and rachis, **D**- Sterile pinnule, **E**- Fertile pinnule, **F**- Sporangium, **G**- Spore (from *Mohanakurup 52851*).

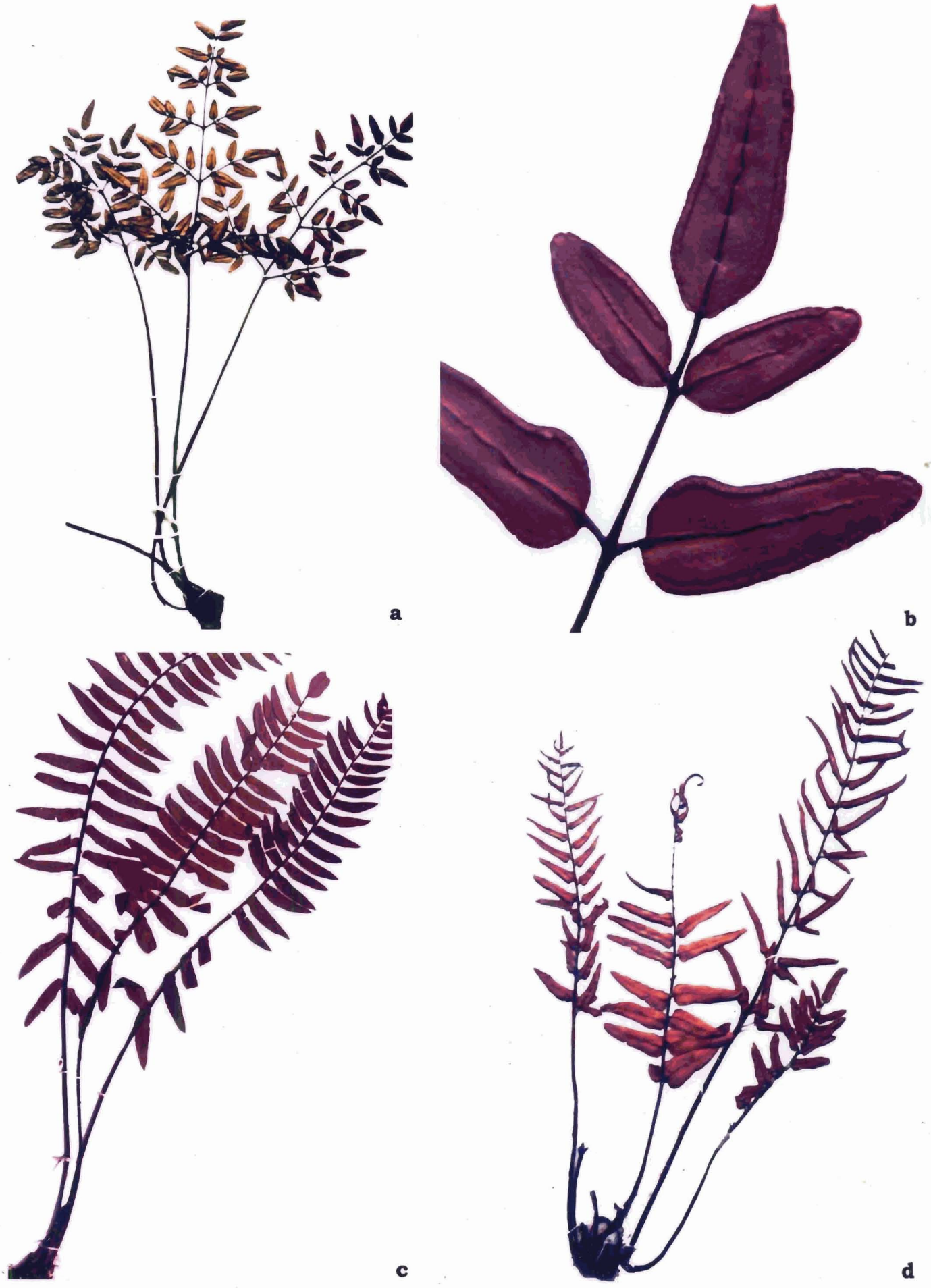

Fig. 38. Herbarium specimens of **a. Pellaea boivini, b**. part of the fertile frond; **c. P. falcata**; **d. P. malabarica**.

Pteris boivini (Hook.) T.Moore *ex* Bedd., Ferns S. India 12. pl. 36. 1863.
Pteridella adintoides (Desv.) Kuhn, Deck. Reis. 3(3): 14. 1879.
Pellaea adiantoides (Desv.) Prantl, Engl. Jahrb. 3: 418. 1882.
Allosorus boivini (Hook.) Kuntze, Rev. Gen. Pl. 2: 806. 1891.

Rhizome erect, unbranched, 3 x 1.5-2 cm, densely covered with paleae, persistent leaf bases and wiry roots. Paleae 3.5-4 x 0.5 mm, lanceolate, concolorous, pale brown, acuminate, terminating in a glandular cell; margin slightly dentate. Fronds tufted, 10-15, erect, 50 x 25 cm; stipe 25-30 cm long, 3mm wide, longer than lamina, black terete, scaly towards base, glossy and glabrous above; lamina 30 x 16 cm, deltoid-lanceolate, tripinnate, widest at base; rachis and its branches densely clothed on the adaxial surface by erect short (0.3-0.4 mm) hairs; primary pinnae 10 pairs, stalked; stalk 2 cm long, basal most pinna largest, gradually become smaller upwards, 4 cm apart; basal 3 pairs bipinnate, next 4 pairs one pinnate and terminal portion of lamina simple pinnate and ends in an ultimate pinnule; secondary pinnae 5-6 pairs, opposite or sub-opposite, stalked; stalk 1 cm, adjacent pinnae 2.5 cm apart, lower most pinnae 12 x 7 cm, ultimate pinnule 1.5 x 0.5 cm, ovate, cordate at base, shortly stalked; texture coriaceous, glabrous on both surfaces; margin entire. Venation pinnate; midrib distinct and raised on lower surface, grooved above; lateral veins free, forked twice; veins reaching the margin. Sori marginal, protected by a continuous 1 mm broad, reflexed margin. Sporangium stalked; stalk shorter than capsule; 2 cells thick; capsule spherical; annulus 18-20 cells long. Spores 45 x 55 μm, trilete, tetrahedral; exine smooth.

Chromosome numbers: n = 30, 2n = 60, diploid sexual (Kuriachan in Fabri, 1963; Kuriachan, 1968; Manickam & Irudayaraj, 1988); n = 60, 2n = 120, tetraploid sexual (Ammal & Bhavanandan, 1991); n = 2n = 90, triploid apogamous (Manton & Sledge, 1954).

Distribution and Ecology: In India it is restricted to southern India, where it is present only in Kerala and Tamil Nadu. It is also reported from Africa, Madagascar and Sri Lanka. *P. boivini* grows on exposed rocky places between bolders above 900 m.

Specimens examined: **KERALA**: Idukki Dt., Devikulam, *Meebold 13487* (CAL); no precise locality: *Calder & Ramaswami 752* (CAL); Vellimala, *Rajesh 62872* (CALI). Palakkad Dt., Silent Valley, *Sabu 10812* (CALI). Thiruvananthapuram Dt., Ponmudi,

M.Mohanan 69210 (CAL, MH), *Sivadas 16028* (CALI); Upper Sanitorium, Ponmudi, *Nair 49888* (CAL, MH). **TAMIL NADU**: Kanniya Kumari Dt., Kothayar hills, *Manickam 32001* (XCH); Mahendragiri, *Shetty 32351* (MH); Muthukuzhyvayal, *Henry 48296* (CAL, MH); Teni Dt., Highwavy mountains, *Blatter & Hallberg 232* (CAL). Tirunelveli Dt., Agasthiar hills, *Barber 2893* (MH), *Manickam 32500* (XCH); Agasthiarmalai peak, *Henry 16346* (CAL); Kakachi, *Sebastine 4499*; Upper Kothayar, *Henry 7707* (CAL, MH), *Madhusoodanan & party 44860, Mohanakurup 52851* (CALI).

Pellaea falcata (R.Br) Fee, Gen. Fil. 129. 1850-52; Bedd., Handb. Ferns Brit. India 102. f. 54. 1883; B.K.Nayar & S.Kaur, Comp. Bedd. Handb. 28. 1974; Manickam, Fern Fl. Palni Hills 30. 1984; S.Chandra & S.Kaur, Nomen. Guide Bedd. Ferns S. India & Ferns Brit. India 3. 1987; Manickam & Irud., Pterid. Fl. W. Ghats 84. pl. 60. 1992; Fraser-Jenk., New Sp. Syndr. Indian Pterid. Ferns Nepal 190. 1997; S.Chandra, Ferns India 64. 2000. (**Fig. 33, 38c, 39A-G**).

Type: Australia, Port Jackson, *Brown 59* (BM).

Pteris falcata R.Br., Prod. Fl. N. Holl. 154. 1810.

Pteris seticaulis Hook., Ic. Pl. t. 209. 1840.

Platyloma falcata (R.Br.) J.Sm., J. Bot. 4: 160. 1841.

Allosorus falcatum (R.Br.) Kunze, Linn. 28: 219. 1850.

Platyloma falcata var. *caudata* E.J.Lowe, Ferns 3: pl. 30. 1857.

Platyloma falcatum var. *setosum* Bedd., Ferns S. India 7. t. 22. 1863.

Platyloma falcata var. *denticulata* Bonap., Notes Pterid. 5: 126. 1917.

Pellaea seticaulis (Hook.) S.R.Ghosh, J. Econ. Taxon. Bot. 7: 681. 1985; R.D.Dixit, Census Indian Pterid. 62. 1984; N.C.Nair *et al.*, J. Econ. Taxon. Bot. 16: 269. 1992.

Rhizome long creeping, unbranched, 5mm thick, densely covered by paleae and wiry roots. Paleae 3 x 0.7 mm, bicolorous with dark sclerotic center and pale brown margins; ovate-lanceolate, apex attenuate, acute, terminating in a small glandular cell. Fronds alternate on both sides of rhizome, scattered, 1 cm apart, 50-60 x 6-8 cm; stipe 12-20 cm long, 1.5 mm wide, dark brown, rounded below, shallowly grooved above, densely covered by brown coloured, 1-1.5 mm long gland tipped scales; lamina 20-40 x 6-8 cm, unipinnate, oblong, widest just above the base, apex acute; rachis similar to stipe, densely covered with scales, bearing 25 pairs of pinnae; pinnae sessile, sub-opposite below, alternate above, 4 x 1 cm, oblong-linear,

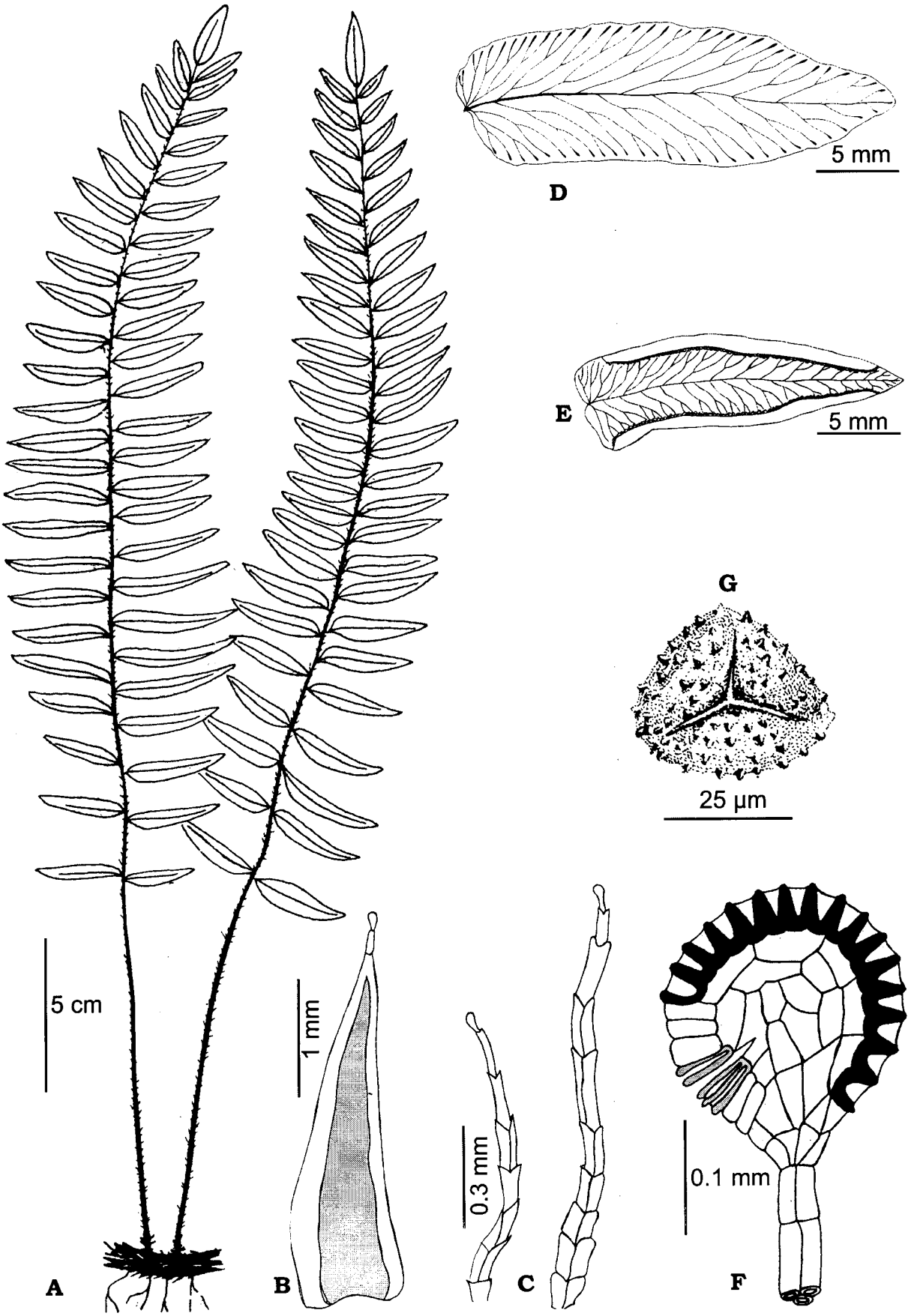

Fig. 39. Pellaea falcata: A- Habit, **B**- Rhizome palea, **C**- Paleate hairs on the stipe and rachis, **D**- Sterile pinna, **E**- Fertile pinna, **F**- Sporangium, **G**- Spore (from *Rajesh 70020*).

1.5-2 cm apart, base truncate or broadly cuneate, apex acute, scaly along the midrib on upper surface and all over the lower surface; margin entire or minutely crenate, texture coriaceous. Venation pinnate, midrib distinct on both surfaces; lateral veins free, two times forked, vein endings slightly dilated, not reaching the margin. Sori continuous along the margin except at tip and base, reflexed margin continuous, bends back to expose sporangia at maturity. Sporangium stalked; stalk equal in length to capsule, 3 cells thick; capsule spherical; annulus 16 cells long. Spores 30 x 38 μm, trilete, tetrahedral; exine echinate.

Distribution and Ecology: In India, *P. falcata* is restricted to southern India where it occurs only in certain localities of Kerala and Tamil Nadu. It is also distributed in Australia, New Zealand, Malay Peninsula, Sri Lanka and Tasmania. It forms dense growth on forest floor on shaded stream banks between 100-1200m.

Chromosome number: n = 58, tetraploid sexual (Brownlie, 1958).

Specimens examined: **KERALA**: Idukki Dt., Mlappara, *Rajesh 70020* (CALI); Mlappara estate, *Nair 70117* (CAL, MH); Vellimala, *Rajesh 18334* (CALI). Thiruvananthapuram Dt., Bodimedu, *Meebold 13548* (CAL). **TAMIL NADU**: Coimbatore Dt., Kuridimalai, *Ellis & Karthikeyan 31341* (MH); Tadagam hills, *Fischer 2695* (CAL). Dindigul Dt., Kodaikanal, *Manickam 31137* (XCH); Sirumalai, *Chandrabose 54294* (CAL, MH). Namakkal Dt., Kolli hills, *Manickam & Mathew 33231* (XCH). Nilgiris Dt., Coonoor ghats, *Gamble 11696* (CAL), *11766* (MH). Tirunelveli Dt., Kalakkad hills, *Manickam 31264* (XCH). Virudunagar Dt., Nagariar, *Manickam 2985* (XCH); Nagariar estate, *Srinivasan 65929*; Sethur hills, *Srinivasan 63511* (CAL, MH).

Pellaea malabarica Geev. *ex* Madhus. & Jyothi, Indian Fern J. 9: 39. 1992; Jyothi & Madhus. J. Econ. Taxon. Bot. 17: 36. 1993; Fraser-Jenk., New Sp. Syndr. Indian Pterid. Ferns Nepal 189. 1997; S.Chandra, Ferns India 65. 2000. (**Fig. 33, 38d, 39A-G**).

Type: South India, Silent Valley, *Sabu 11123* (CAL).

Pellaea malabarica B.K.Nayar & Geev., Fern Fl. Malabar 129. 1993, *nom. superfl.*

Rhizome erect or sub-erect, 1.5 x 1cm, unbranched, covered with persistent leaf bases, dense paleae and black wiry roots. Paleae 4.5 x 0.4 mm, concolorous, dark brown, acuminate, gland tipped with smooth margin. Fronds tufted, 8-10, 40-45

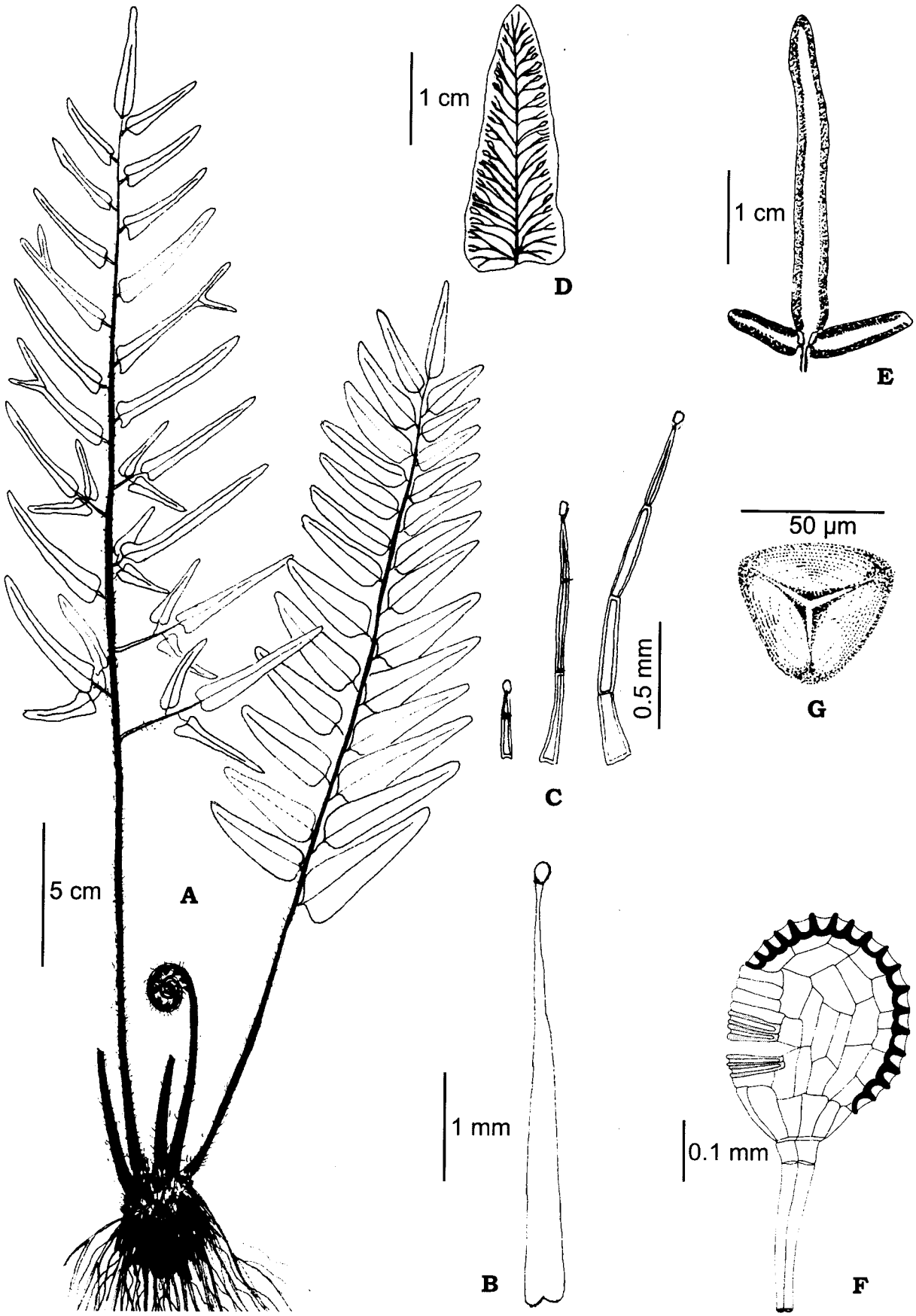

Fig. 40. Pellaea malabarica: **A**- Habit, **B**- Rhizome palea, **C**- Hairs on the stipe and rachis, **D**- Sterile pinna, **E**- Fertile pinna, **F**- Sporangium, **G**- Spore (from *Nair 64413*).

x 8 cm, dimorphic, both unipinnate and bipinnate; bipinnate longer; both types fertile; stipes 8-12 cm long, 2 mm wide, dark brown, terete, basally paleate, densely covered with multicellular, brown, uniseriate hairs all over; hairs 0.5-1.5 mm long, 2-6 celled and gland tipped; lamina unipinnate 18 x 7 cm; bipinnate 28 x 8 cm; both oblong-lanceolate; rachis as stipe densely clothed with brown multicellular hairs, bearing 12-18 pairs of sub-opposite pinnae; basal 5-6 pairs of pinnae simple pinnate, 3-4 cm apart, each with a terminal long pinnule, 4 x 0.5 cm and two shorter lateral pinnules, 1.5 x 0.3 cm; pinnate pinnae distinctly stalked; stalk 1 cm long, densely covered with hairs; pinnae of upper region simple, short stalked or sub-sessile; base oblique or truncate, apex obtuse; some pinnae show terminal forking; unipinnate lamina shorter; pinnae closely placed and sessile; shorter than that of bipinnate lamina; lamina thick herbaceous, bearing sparse pluricellular hairs on both surfaces. Venation pinnate; costa distinct on lower surface; upper surface grooved and bears brown hairs along it; lateral veins forked once or twice; ultimate veinlets some times unite to form small loops. Sori seated on the tip of veinlets forming a continuous soral line along the margin, protected by a continuous reflexed margin; Sporangium stalked;stalk equal in length to capsule; capsule globose; annulus 17-18 cells long. Spore 45 x 50 μm, trilete, tetrahedral; exine smooth.

Distribution and Ecology: *P. malabarica* is endemic to Silent Valley of Kerala and occurs in crevices of rocks and gravelly soils in dry areas in exposed localities.

Note: *P. malabarica* is characterized by the presence of both fertile unipinnate and bipinnate fronds and sterile pinnules showing veins with occasional marginal loops.

Specimens examined: **KERALA**: Palakkad Dt., Aruvampara, Silent Valley, *Nair 64413* (CAL, MH); Silent Valley, *Sabu 11123* (CALI).

TAENITIDOIDEAE (C.Presl) R.M.Tryon

This subfamily is characterised by plants having rhizome with trichomes and sori borne along free veins without the margin modified as an indusium (except in *Actiniopteris*) and spores with one or more equatorial flanges and other prominent ridges and tubercles.

The subfamily includes 14 genera such as *Actiniopteris*, *Anogramma*, *Jamesonia*, *Onychium*, *Pityrogramma*, *Syngramma*, *Taenitis,* etc. These genera were treated under different families by earlier workers. For example, Bower (1928) treated

most of these genera under gymnogrammoid ferns, but *Actiniopteris* was included in pteroid ferns, *Syngramma* in metaxyoid ferns and *Taenitis* in 'genera incertae sedis'. Christensen (1938) included all of them in the family Polypodiaceae; *Taenitis* alone in the subfamily Lindsaeoideae and all others in the subfamily Gymnogrammoideae. Ching (1940) included *Actiniopteris* in Pteridaceae, *Onychium* in Sinopteridaceae, *Taenitis* in Lindsaeaceae and all other genera in Gymnogrammaceae. Holttum (1947) and Crabbe *et al.* (1975) included all these genera in the family Adiantaceae. The former included them in the subfamily Gymnogrammoideae while the latter in the subfamily Adiantoideae. Copeland (1947) included all these genera in his comprehensive family Pteridaceae which have no further subdivision. Nayar (1970) also included them in the family Pteridaceae except *Syngramma* which he included in Adiantaceae. Pichi Sermolli (1977) distributed these genera in five families *viz.*, Actiniopteridaceae (*Actiniopteris*), Cryptogrammaceae (*Onychium*), Hemionitidaceae (*Anogramma*, *Austrogramma*, *Cerosoria*, *Eriosorus*, *Jamesonia*, *Nephopteris*, *Pterozonium*, *Syngramma*), Pteridaceae (*Afropteris*) and Taenitidaceae (*Taeanitis*).

Taenitidoideae (C.Presl) R.M.Tryon, Amer. Fern J. 76: 184. 1986.

Type: *Taenitis* Willd. *ex* Schuhr.

Taenitideae C.Presl, Tent. Pterid. 222. 1836.

Actiniopteridaceae Pic.Serm., Webbia 17: 5. 1962.

Hemionitidaceae Pic.Serm., Webbia 21: 487. 1966, *p.p.*

Taenitidaceae (C.Presl) Pic.Serm., Webbia 29: 1. 1975.

Plants terrestrial and rupestral; rhizome erect or short creeping, solenostelic, grading to dictyostele, covered with trichomes, bristles or scales. Rachis pale brown to black, terete or adaxially sulcate, some times ridged; lamina simple, flabellate or pinnate to pinnatisect, glabrous, pubescent or with a farinose covering underside. Veins usually free, some times anastomosing; sporangia borne along veins in exindusiate soral lines or in an inframarginal soral line covered with marginal flap. Spores trilete, tetrahedral usually with an equatorial flange.

Affinity: The subfamily Taenitidoideae is definitely related to other subfamilies of Pteridaceae by the predominant chromosome numbers, n = 29, 30 or multiples.

The subfamily is represented in South India by three genera only, *viz.*, *Actiniopteris*, *Anogramma* and *Pityrogramma*.

Beddome (1883) reports that he once got a specimen of *Onychium auratum* from '*Paulghaut Hills*' (Palghat hills ?), South India which was probably a cultivated one. Holttum (1968) includes South India as the area of distribution of *Taenitis blechnoides* (Willd.) Sw. without indicating the locality. But there is so far no other report about the occurrence of it in South India. Chandra (2000a) shows Anamallays of Tamil Nadu and Palghat of Kerala as the area of distribution of *Tapeinidium pinnatum* (Cav.) C.Chr. But there is no other report about it. Since the occurrence of all these taxa in South India is not confirmed, they are excluded from the present study.

Key to genera

1a.	Lamina simple, flabellate, dichotomously divided up to six times; segments linear; sori along the edges of ultimate segments, covered by marginal flap	*Actiniopteris*
1b.	Lamina pinnate or pinnatisect; pinnules obovate to spathulate; sori along the veins covering the entire lower surface, exindusiate	2
2a.	Annuals, up to 15 cm long; pinnule obovate to spathulate without farina	*Anogramma*
2b.	Perennials, up to 1 m long; pinnules with yellowish or white farina below	*Pityrogramma*

ACTINIOPTERIS Link

Actiniopteris is an interesting fern genus having a miniature palm like appearance. The generic name is derived from two Greek words, "aktes" meaning a ray and "pteris" meaning fern, referring to the radially dissected fan like lamina with linear segments.

Link (Fil. Sp. 79. 1841) published this genus with two species, *viz.*, *Actiniopteris radiata* and *A. australis* and was unanimously accepted as a good genus by other workers. But the taxonomic position of it remained uncertain. Diels (1899) and Christensen (1906) treated it as a genus of family Polypodiaceae, tribe Pterideae and subtribe Pteridinae. Although Bower (1928) dealt with this genus in the chapter of pteroid ferns, he did not list it among them due to its uncertain affinity. Ching (1940) and Nayar (1970) consider it as a pteroid fern and included it in their Pteridaceae. Copeland (1947), while listing it in his comprehensive family

Pteridaceae, states that *Actiniopteris* has more in common with *Doryopteris*. He considers it as a minor variant of cheilanthoid group. It is also treated with Pteridaceae by Tryon and Tryon (1982) and Tryon *et al.* (1990). But some others such as Crabbe *et al.* (1975), Kornas *et al.* (1982) and Jacobsen (1983) treated it under Adiantaceae. Holttum (1947) treats it in the family Dennstaedtiaceae, subfamily Pteridoideae. Pichi Sermolli (1962) considers it as distinct enough to be treated in a family of its own, Actiniopteridaceae.

Actiniopteris Link was regarded as an Old World genus of cheilanthoid affinities by Tryon and Tryon (1982) and placed in Pteridaceae, tribe Cheilantheae. Later Tryon *et al.* (1990) shifted it from cheilanthoid to taenitidoid affinity by placing in Pteridaceae, subfamily Taenitidoideae, but give no explanation. This transfer appears to be based on spore morphology where the spores of taenitidoids have an equatorial flange. But the spores of cheilanthoid have no such structure. The spores of *Actiniopteris* have such an equatorial flange and hence included in taenitidoid ferns. Brummitt (1992) follows Pichi Sermolli (*l.c.*) in the treatment of *Actiniopteris*. Pichi Sermolli (*l.c.*) recognizes five species in the genus including the two of Link. In South India this genus is represented by a single species, *A. radiata* (Sw.) Link.

Actiniopteris Link, Fil. Sp. 79. 1841; T.Moore, Ind. Fil. 47. 1857; C.B.Clarke, Trans. Linn. Soc. Lond. Bot. 1: 505. 1880; Bedd., Handb. Ferns Brit. India 197. 1883; Ching, Sunyatsenia 5: 224. 1940; Copel., Gen. Fil. 72. 1947; B.K.Nayar, Bull. Nat. Bot. Gard. 75: 1. 1962; Pic.Serm., Webbia 17: 6. 1962; R.M.Tryon *et al.* in Kramer & Green (eds.), Fam. Gen. Vas. Plants 1: 239. 1991; Khullar, Illustr. Fern Fl. West Himalaya 1: 246. 1994.

Type: *Actiniopteris radiata* (Sw.) Link, lectotypified by Pichi Sermolli, Webbia 17: 6. 1962.

Small, palm like, terrestrial plants; rhizome short, ascending, dictyostelic, densely covered with stipe bases and dark brown lanceolate paleae; fronds monomorphic; stipe bicolorous, ventral surface greenish and dorsal surface brown with shallow groove, scaly and fibrillose; lamina semicircular, flabellate, branched dichotomously 5-6 times; segments linear, gradually broadening upwards; basal part of lamina and adjacent upper part of the stipe covered with short rounded pluricellular hairs; paleae ovate-lanceolate, tapering upwards ending in a long hair; sori continuous on either lateral margins of ultimate segments on an intramarginal vein

protected by a modified, broad, continuous, membraneous, reflexed leaf margin; sporangia long stalked, non-paraphysate; spores trilete, tetrahedral, non-perinate with an equatorial 'collar'.

Gametophyte: The mature prothallus is irregularly subcordate with out a conspicuous apical notch and the apex and wings show a tendency to curve upwards so that the prothallus often appears funnel like (Nayar, 1962d).

Chromosome number: n = 29 (Chiarugi, 1960; Manickam & Irudayaraj, 1988).

Distribution and Ecology: The plants grow in rocky habitats often in rock crevices or on arid soil. It prefers well-drained and dry soil in an altitudinal range of 200-1500 m. The genus is distributed in Afghanistan, Tropical Africa and South Africa, Arabia, South Egypt, India, Iran, Madagascar, Mascarenes, Nepal, Sri Lanka, Seychelles and Yemen.

Note: Link (1841) published the genus *Actiniopteris* with two species, *A. radiata* and *A. australis,* but without indicating the type of the genus. Christensen (1906) regarded this genus as monotypic and applied the name *A. australis* to the lone species and adopted it as the type species. Ching (1940) and Copeland (1947) followed this. But Pichi Sermolli (1962) re-established the two original species of Link and adopted *A. radiata* as the lectotype of the genus on the ground that the name '*Actiniopteris*', which Link gave to his genus, fits *A. radiata,* but not *A. australis.* This is now generally accepted.

Actiniopteris consists of five species (Pichi Sermolli, 1962; Tryon *et al.,* 1990) of which only one species, *A. radiata* (Sw.) Link occurs in South India.

Actiniopteris radiata (Sw.) Link, Fil. Sp. 80. 1841; Bedd., Ferns S. India 1. pl. 2. 1863; Raju, Bull. Bot. Surv. India 6: 190. 1964; B.K.Nayar & S.Kaur, Comp. Bedd. Handb. Ferns Brit. India 47. 1974; R.D.Dixit, Census Indian Pterid. 68. 1984; Manickam, Fern Fl. Palni Hills 27. 1984; S.Chandra & S.Kaur, Nomen. Guide Bedd. Ferns S. India & Ferns Brit. India 15. 1987; Manickam & Irud., Pterid. Fl. W. Ghats 81. pl. 58. 1992; N.C.Nair *et al.*, J. Econ. Taxon. Bot. 16: 255. 1992; B.K.Nayar & Geev., Fern Fl. Malabar 97. 1993; Rajagopal & Bhat, Indian Fern J. 15: 8. 1998; S.Chandra, Ferns India 28. 2000. (**Fig. 41A-H, 42a & b, 44**).

Type: India, *Koenig* (Herb. Montin, S-PA).

Asplenium radiatum Sw., Schrad. J. Bot. 1800 (2): 50. 1801.

Acrostichum dichotomum Forssk., Fl. Aeg.-Arab. 184. 1775, *non* L., 1753.

Acrostichum australe M.Vahl, Symb. Bot. 1: 84. t. 25. 1790, *non* L.f., 1781.

Belvisia australis (L.f.) Mirb., Hist. Nat. Veg. 5: 473. 1803.

Acrostichum radiatum (Sw.) J.Konig *ex* Poir., Enc. Bot. Suppl. 1: 128. 1810.

Acropteris australis (L.f.) Link, Hort. Berol. 2: 56. 1833.

Acropteris radiata (Sw.) Link, Hort. Berol. 2: 56. 1833.

Blechnum flabellatum C.Presl, Tent. Pterid. 103. 1836.

Blechnum radiatum (Sw.) C.Presl, Tent. Pterid. 103. 1836.

Pteris radiata (Sw.) Bojer, Hort. Maur. Enum. 399. 1837.

Actiniopteris australis (L.f.) Link, Fil. Sp. 80. 1841; B.K.Nayar, Bull. Nat. Bot Gard. 75: 11. 1962.

Actiniopteris australis Ettingsh., Farnkr. 85. t. 51. f. 10 -13. 1865, *non* Link, 1841.

Pteris dichotoma Kuhn, Fil. Deck. 18. 1867 & Fil. Afr. 79. 1868, *non* L., 1753.

Actiniopteris dichotoma Kuhn, Bot. Zeit. 29: 504. 1871; Bedd., Handb. Ferns Brit. India 197. f. 98. 1883; d'Almeida, J. Indian Bot. Soc. 5: 25. 1926; Subramanyam *et al.*, Bull. Bot. Surv. India 2: 325. 1960 & *Ibid* 3: 210. 1961.

Actiniopteris australis var. *radiata* C.Chr., Dansk. Bot. Ark. 7: 125. 1932.

Rhizome short creeping, 1-3 x 1 cm, branched, covered by dense paleae, persistent leaf bases and a tuft of roots. Paleae 4-5 x 0.5 mm, lanceolate, bicolorous with dark brown central region and yellowish-brown edges, margins entire; apex acute, gland tipped. Fronds tufted, 8-12, spirally arranged, erect, 12-18 x 4-5 cm, fan shaped; fertile fronds longer than sterile ones; stipe 5-18 cm long, 1-1.5 mm thick, scaly through out with brown round lower side and green upper side with a deep groove, margins of the groove are reflexed to the lower side of the stipe; lamina 4 cm long, 6 cm broad, semicircular or flabellate with edges forming an angle of 150°-180°, divided by a deep notch into two equal halves, each of which again dividing dichotomously and repeatedly 4-5 times, each time the inner branch being longer than the outer; ultimate segments 32-48; each segment narrowly linear, 3 x 0.1 cm, gradually broadening upwards, margins smooth, apex divided into 2-4 acute teeth; surface glabrous; texture coriaceous; base of lamina on the lower side and upper part of stipe are covered by fewer number of concolorous yellowish brown, 1.75 x 0.75 mm, ovate lanceolate paleae which are irregularly lobate to coarsely dentate at base and tapering upwards. The basal portion of lamina on the upper side contains

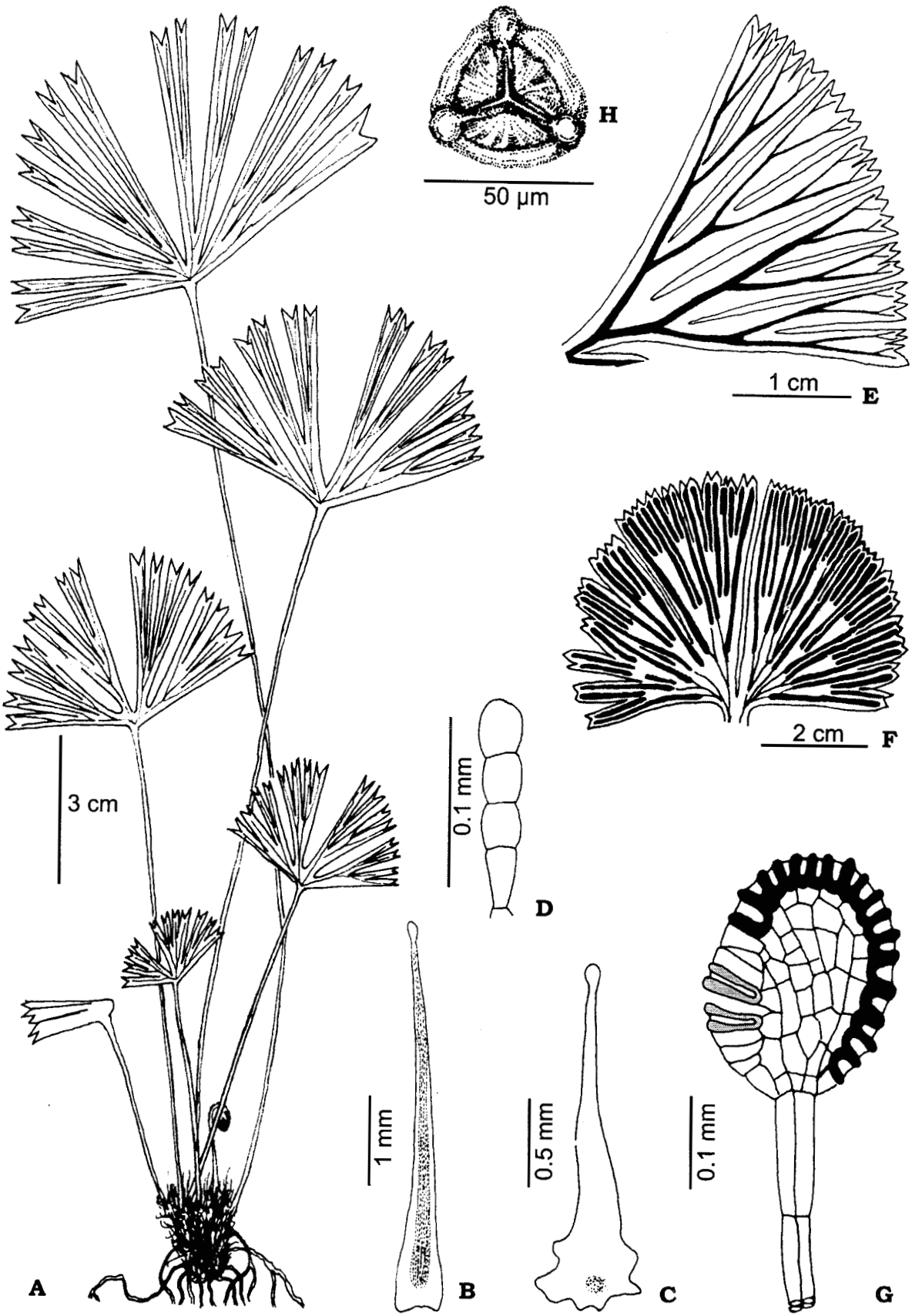

Fig. 41. **Actiniopteris radiata:** **A**- Habit, **B**- Rhizome palea, **C**- Palea on lower side of lamina, **D**- hair on the lower side of lamina, **E**- a portion of sterile lamina, **F**- Fertile lamina, **G**- Sporangium, **H**- Spore (from *Mohanakurup CU 73148*).

Fig. 42. Actiniopteris radiata: **a.** habit, **b**. fertile frond; **Anogramma leptophylla**: **c.** habit, **d.** a part of the fertile pinna; **Pityrogramma austroamericana**: **e.** habit, **f**. a part of the fertile frond; **P. calomelanos**: **g.** habit, **h**. a part of the fertile frond.

numerous short (0.1 mm long) pluricellular, uniseriate, club shaped hairs. Venation open dichotomous, the distal part of each vein running parallel to the edge of the lobe, joins with its apex the corresponding part of the adjacent vein forming an intramargianl fertile line bearing the sporangia. Sori elongated, develop submarginally on the intramarginal commissural strand in the lower surface and are protected by a continuous reflexed marginal flap. Sporangia long stalked; stalk equal in length to capsule, two cells thick; capsule spherical; annulus 16-18 cells long. Spores 50 x 55 μm, trilete, tetrahedral; exine verrucate in the proximal face, while rugulate in the distal part; equatorial collar present, 6 um in height.

Chromosome numbers: n = 2n = 58, Diploid apogamous (Mehra & Verma, 1960); n = 2n = 87, Triploid apogamous (Manton & Sledge, 1954; Mehra & Verma, 1960; Kuriachan in Kuriachan & Ninan, 1976; Ghatak, 1977; Manickam & Irudayaraj, 1988; Bir *et al.,* 1996).

Distribution and Ecology: *A. radiata* occurs all over India. Also distributed in tropical Africa, Afghanistan, Arabia, eastern Egypt, Iran, Madagascar, Mascarene Islands, Myanmar, Sri Lanka and Yemen. It grows in rocky habitats or stony grounds on arid soil and well drained dry grasslands with an altitudinal range between 600-900 m.

Specimens examined: ANDHRA PRADESH: Adilabad Dt., Wankidi R.F., *Pullaiah & Obulesu 5492* (SKU). Ananthapur Dt., Kalasamudram, *Mohanakurup 73148* (CALI); Madakasira fort, *Pullaiah & Yesoda 756, Chennaiah 2842*; Yadiki, *Pullaiah 478* (SKU). Chittoor Dt., Balapalallagutta, *Subba Rao 46791* (CAL). Cuddapah Dt., Balapalle, *Ellis 14930;* Duggama Konda, *Subramanyam 6350* (CAL); Sankamalai coast, *Reddy 10076* (SKU). Guntur Dt., Jayanthipuram, *Ramakrishnaiah 6968* (SKU). Kurnool Dt., Ahobilam, *Ahamed 12822;* Devanipenta, *Goud 12997;* Madhavaram R.F., *Pullaiah & Raju 1328* (SKU). Mahaboobnagar Dt., Mannanur forest, *Dharmachandrakumar 13631* (SKU). Medak Dt., Medak fort, *Prabhakar 11724* (SKU). Nellore Dt., Yerrakonda, *Ramaswami 1211* (CAL). Nizamabad Dt., Arsapally, *Rao & Hanumanthappa 6483* (SKU). Prakasam Dt., Chinarutla, *Vijayakumar 15806* (SKU). Rollapenta, *R.K.Mohanan 914* (CAL). Ranga Reddy Dt., Kondapur, *Mohammed 10319* (SKU). **KARNATAKA:** Bidar Dt., Bidar, *Bhat 522* (MGMC). Chitradurga Dt., Chitradurga fort, *Rajagopal 574* (MGMC). Mysore Dt., Chamundi hills, *Rajagopal 399* (MGMC). **KERALA**: Palakkad Dt., Agali, *Swarup 29314* (CALI). Thiruvananthapuram Dt., Kallar, *Sreenivasan 2957* (CALI). **TAMIL NADU:**

Coimbatore Dt., slope of Kurudimalai, *Subramanyam 234* (CAL); Maruthamalai, *Pradeep 43877* (CALI); Thekkumalai hills, *Sebastine 1633* (CAL). Dindigul Dt., Pazhani ghat road, *Mohanakurup 73170;* Pazhani to Kodaikanal *Madhusoodanan 43810* (CALI). Kanniya Kumari Dt., Parvathipuram, *Mohanakurup 73135;* Thovala, *Mohanakurup 73129* (CALI). Madurai Dt., Murugamalai, *Sebastine 12527* (CAL); Poomparai, Vilpatti R.F., *Chandrabose 51366* (CAL). Nilgiris Dt., Kullar, *Gamble s.n.*; Bosson ghat, *Gamble 12174;* Burlion, *Sengupta 2218* (CAL). Ramanathapuram Dt., Alagarkoil, R.F., *Srinivasan 79721*; Periathusagaram, *Nair 60876* (CAL). Salem Dt., Andiappan Kovil, *Nair 74202* (CAL); Yercaud, *Laxmana 3782* (CALI); ghat road to Yercaud, *Subramanyam 7591;* Shevaroy hills, *Ghatak 70;* Vernier river, *Ghatak 581* (CAL). Teni Dt., Cumbum Valley, Gudalur - Kumali Road, *Subramanyam 8084* (CAL). Thiruchirapally Dt., Pachamalai, *Sebastine 6159* (CAL). Tirunelveli Dt., Kalakkad, *Joseph 15235;* lower dam, Papanasam, *Sebastine 8300*; Papanasam to Mundanthurai, *Hooper & Ramaswami 39294* (CAL). Vellore Dt., Tippukadu, *Ramamurthy 16602;* Perumal temple hill, *Viswanathan 1086* (CAL). Viluppuram Dt., Gingee R.F., *Ramamurthy 13053* (CAL).

ANOGRAMMA Link

Anogramma is unique among ferns having a perennial prothallus and an ephemeral sporophyte. One out standing characteristic of this genus is that the sporophyte remains attached to the gametophyte even at maturity.

When establishing this genus, Link (1841) referred to it two species, *viz.*, *Anogramma leptophylla* based on *Polypodium leptophyllum* L. and *A. chaerophylla* based on *Gymnogramma chaerophylla* Desv. He did not give the etymological origin of *Anogramma*, but probably, the name comes from the Greek words 'ano' meaning upward and 'gramma' meaning a line, perhaps due to the elongate sori turned upwards (Pichi Sermolli, 1966).

Christensen (1938) reported the genus *Anogramma* as having seven species and placed it in the tribe Gymnogrammeae, subfamily Gymnogrammoideae of family Polypodiaceae. Ching (1940) kept it in the tribe Gymnopterideae of his new family Gymnogrammaceae. Pichi Sermolli (1966) alleging that Ching's family name is not validly published, proposed a new family Hemionitidaceae to accommodate the genera of Ching's Gymnogrammaceae including *Anogramma*. Nayar (1970), Crabbe *et al.* (1975) and Brummitt (1992) treat this genus in the family Adiantaceae.

Anogramma is so closely related to *Pityrogramma* that many authors (Chritensen, 1938; Ching, 1940; Crabbe et al., 1975) placed them adjacent to each other in their classifications. Domin (1928) went to the extent of merging *Anogramma* in the genus *Pityrogramma*, but is not followed by others.

Fee (1852) and some others adopted the spelling 'Anogramme'. But the original spelling as given by Link (1841) is 'Anogramma' and it must be used (*cf.* Pichi Sermolli, 1966).

Anogramma Link, Fil. Sp. 137. 1841; Ching, Sunyatsenia 5: 228. 1940; Copel., Gen. Fil. 76. 1947; R.M.Tryon & A.F.Tryon, Ferns Allied Plants 306. 1982; R.M.Tryon *et al.* in Kramer & Green (eds.), Fam. Gen. Vas. Plants 1: 237. 1990; Khullar, Illustr. Fern Fl. West Himalaya 1: 306. 1994; Bostock *et al.* in McCarthy (ed.), Fl. Australia 48: 250. 1998.

Type: *Anogramma leptophylla* (L.) Link [*Polypodium leptophyllum* L.] lectotypified by C.Chr., Ind. Fil. p. XXXVII. 1906.

Dicranodium Newman, Hist. Brit. Ferns ed. 3. 13. 1854.

Pityrogramma sect. *Anogramma* (Link) Domin, Publ. Fac. Sci. Univ. Charles 88: 9. 1928.

Small terrestrial plants; rhizome erect, rudimentary with a medullated protostele, bearing ferruginous scales grading into hairs; leaves monomorphic; stipe brown, glossy, slender, fragile; lamina elongate, triangular, 1-3 pinnate, basal pinna broader than apical; pinnule obovate to spathulate, decurrent, incised, glabrous, membraneous; veins free, simple or forked, not reaching the margin; sori along the veins extending up to its tip and forking with it, spreading over the under surface of pinnule, exindusitae; sporangia without paraphyses; spores brown, trilete, tetrahedral, globose, non-perinate, coarsely ridged with a prominent equatorial flange and one or more parallel ridges.

Gametophyte: Prothallus is naked, typically cordate with two equal or unequal lobes, old prothalli often funnel shaped. The prothalli of *Anogramma* are exceptional as they produce special branches for bearing antheridia and archegonia and give rise to slightly subterranean tubers that contain mycorrhiza. The prothallus is reported to be perennating, surviving the dry season and producing a new sporophyte from these tubers in the next season. But Tryon (1962a) opines that this behaviour of the

gametophyte is reported only in two species of *Anogramma, viz.*, *A. leptophylla* and *A. chaerophylla* and hence cannot be considered as a generic character.

Chromosome number: n = 29 (Chiarugi, 1960; Mehra & Verma, 1960; Fabri, 1963).

Distribution and Ecology: *Anogramma* is restricted to humid places in the crevices of rocks and is often concealed amongst mosses and other small herbs. It grows within an altitudinal range of 1800 to 2400 m. *Anogramma* is widely distributed in Africa, Asia, Australia, Brazil to Argentina, Southern Europe, Malesia, Mediterranean region, Mexico and New Zealand.

Note: When establishing the genus, Link (Fil. Sp. 137. 1841) referred two species, viz., *Anogramma leptophylla* (L.) Link and *A. chaerophylla* (Desv.) Link to it, but did not indicate the type species. Hence, Christensen (1906) selected *A. leptophylla* (L.) Link as the lectotype of the genus and was accepted unanimously by others.

Anogramma consists of seven species (Pichi Sermolli, 1966). According to Tryon and Tryon (1982) and Tryon *et al.* (1990) it has only five species. Two species occur in India, *viz.*, *A. leptophylla* (L.) Link and *A. microphylla* (Hook.) Diels. The former is distributed in Himalayas as well as South India, while the latter is present in the Eastern Himalayas only.

Anogramma leptophylla (L.) Link, Fil. Sp. 137. 1841; B.K.Nayar & S.Kaur, Comp. Bedd. Handb. 92. 1974; R.D.Dixit, Census Indian Pterid. 77. 1984; Rajagopal & Bhat, Indian Fern J. 15: 9. 1998; S.Chandra, Ferns India 76. 2000. (**Fig. 42c & d, 43A-F, 44**).

Type: locality unknown. *Linn 1251.56*

Lectotype: Specimen no. 5337 of the Herbarium Tournefortianum (P).

Polypodium leptophyllum L., Sp. Pl. 2. 1092. 1753.

Asplenium leptophyllum (L.) Sw., Obs. Bot. 403. 1791.

Osmunda leptophylla (L.) Sav. in Lam., Enc. 4: 657. 1797.

Asplenium geminaria Bory, Ess. Isles Fortun. 313. 1803.

Acrostichum leptophyllum (L.) Lam. & DC., Fi. Franc. 2: 565. 1805.

Grammitis leptophylla (L.) Sw., Syn. Fil. 23: 218. t. 1. f. 6. 1806.

Gymnogramma leptophylla Desv., Berl. Mag. 5: 305. 1811; Bedd., Ferns S. India 88. pl. 270. 1864, Handb. Ferns Brit. India 382. f. 220. 1883 & Suppl. Ferns Brit. India 100. 1892.

Hemionitis leptophylla (L.) Lag., Gen. *et* Sp. 33. 1816.

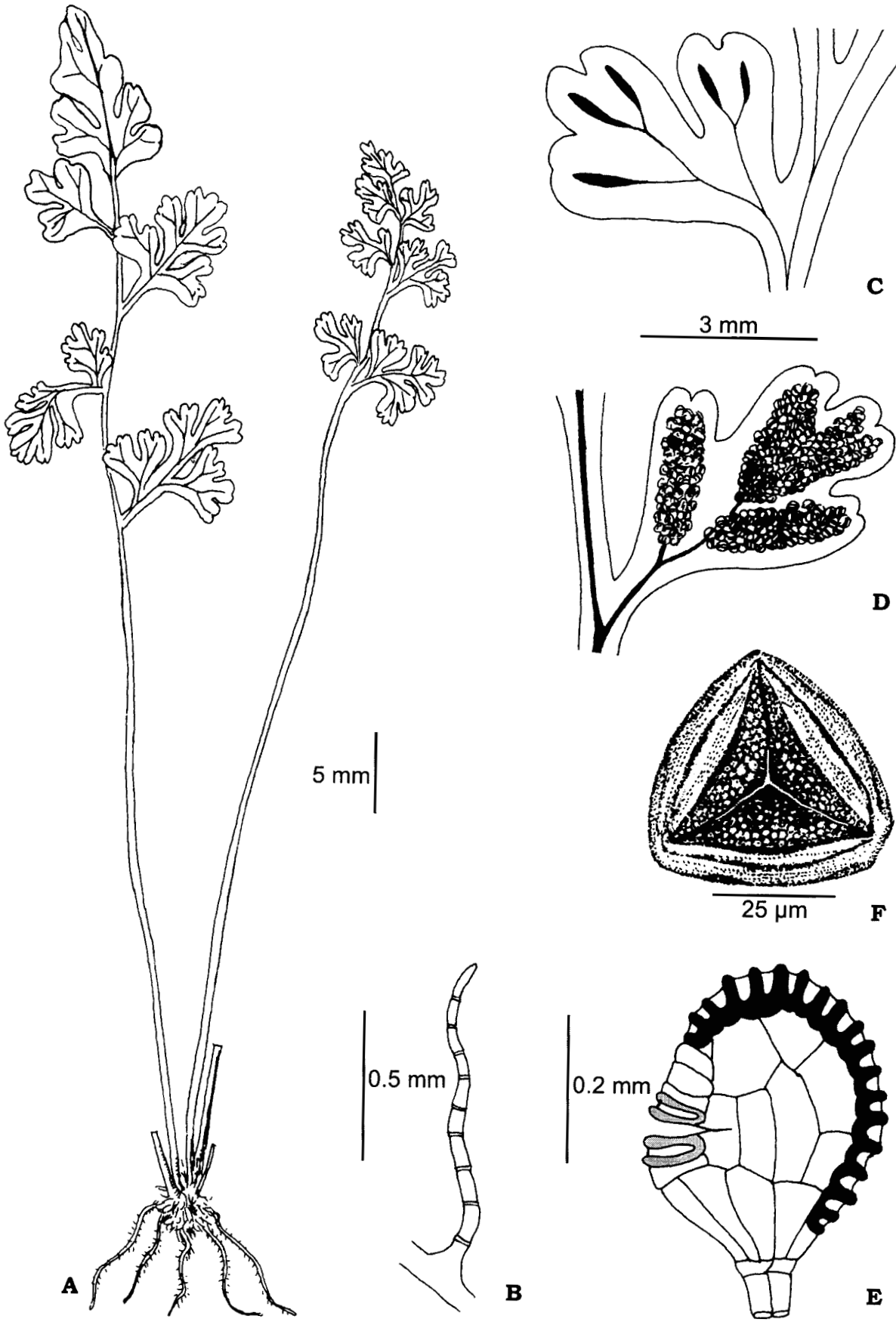

Fig. 43. **Anogramma leptophylla**: **A**- Habit, **B**- Hair on stipe, **C**- a portion of sterile pinna, **D**- a portion of fertile pinna, **E**- Sporangium, **F**- Spore (from *Rajagopal 532*).

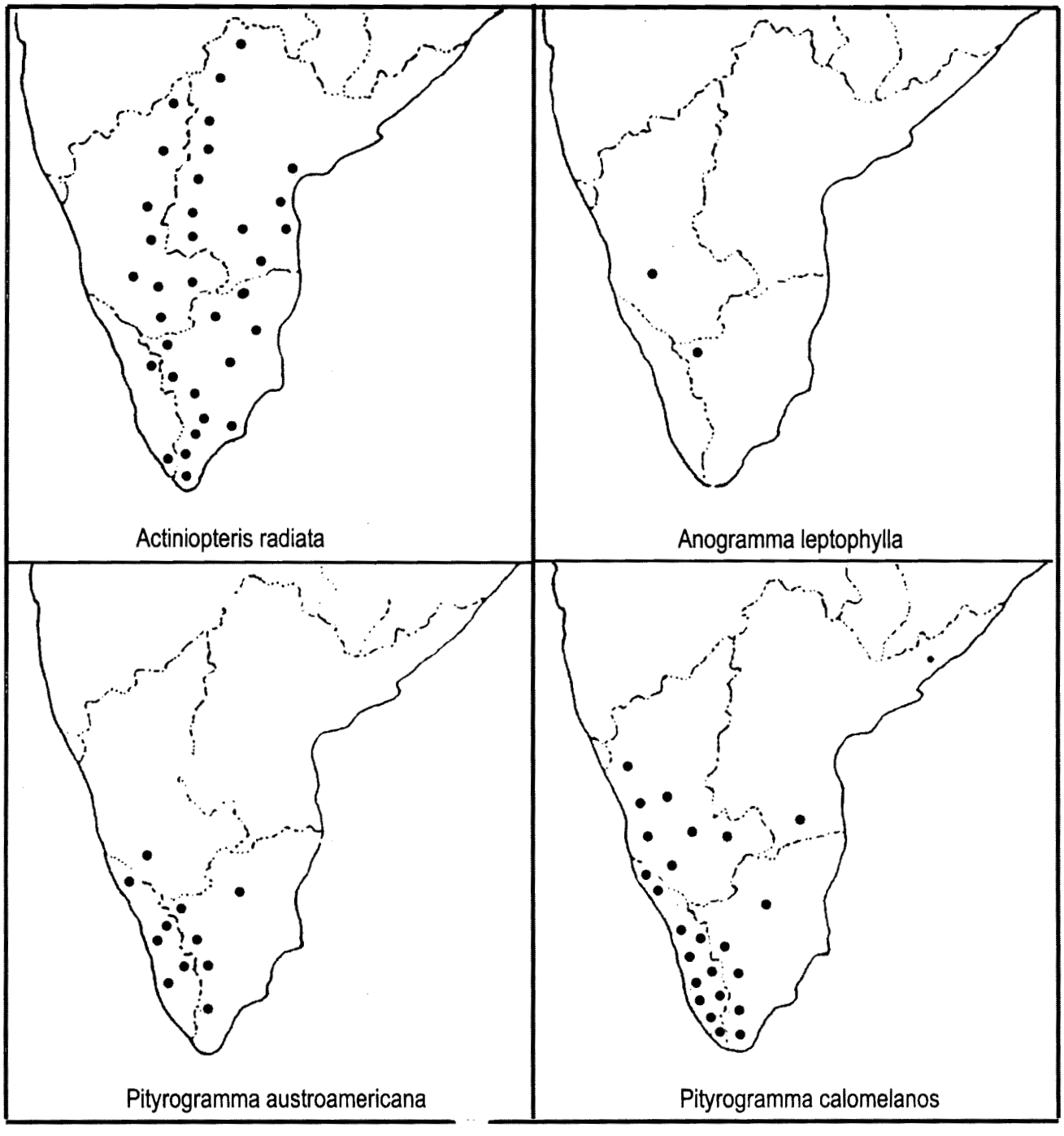

Fig. 44. Distribution of Actiniopteris radiata, Anogramma leptophylla, Pityrogramma austro-americana and P. calomelanos in Southern India.

Tarachia geminaria (Bory) C.Presl, Epim. Bot. 79. 1851.

Riccia tuberosa Taylor, Lond. J. Bot. 5: 415. 1846.

Dicranodium leptophylla (L.) Newman, Hist. Brit. Ferns 13. 1854.

Pityrogramma leptophylla (L.) Domin, Spicy Prior. Fak. Karlovy Univ. 88: 9. 1928.

Rhizome very short, rudimentary, erect, covered with multicellular uniseriate hairs and a few roots arising from the base. Fronds tufted, 3-4, erect, 6-8 x 1.5-2 cm; stipe 4-5 cm long, 0.5 mm broad, brown with few hairs towards the base, glabrous above; hairs multicellular, uniseriate, acute or acuminate, brownish, 1-1.2 mm long; lamina 3-4 x 1.5-2 cm, ovate-oblong, yellowish green, bipinnate or tripinnatifid, with three pairs of primary pinnae, which are alternate, distantly placed; basal pinnae pinnate, 1.5 x 1-1.5 cm, deltoid; lateral pinnae sessile, deeply and once or twice dichotomously lobed, alternate; ultimate lobes small, obtuse or emarginated, herbaceous, glabrous on both surfaces; margin smooth. Veins free, open dichotomous; veinlets not reaching the margin. Sori non indusiate, superficial along veins. Sporangium subsessile; stalk 2 cells thick; annulus 18 cells long. Spores 55 x 50 μm, trilete, tetrahedral, globose, coarsely ridged with a prominent equatorial flange; exine verrucose; perine absent.

Chromosome numbers: n = 58, tetraploid sexual (Verma & Khullar, 1965); n = 56-57, tetraploid sexual (Mehra & Verma, 1960); n = 29, diploid sexual (New zealand specimen - Brownlie, 1958).

Distribution and Ecology: *A. leptophylla* is sparsely distributed in India and occurs in Western Himalayas and Mahabaleswar. In southern India, it is reported from Bababudan hills in Karnataka and Nilgiris in Tamil Nadu. It is also distributed in tropical Africa, Central and South America, Argentina, Australia, Europe (Mediterranean region), Iran, Madagascar, Malaysia, Nepal, New Zealand, Pakistan, Russia, Sri Lanka and Taiwan. It grows in very humid situations in the crevices of rocks at high altitudes.

Specimens examined: **KARNATAKA**: Chikmagalur Dt., Bababudan hills, *Rajagopal 532* (MGMC). **TAMILNADU**: Nilgiris Dt., Ootty, *Gamble 18164* (CAL).

PITYROGRAMMA Link

The genus *Pityrogramma* Link consists of about 40 tropical American species (Copeland, 1947; Holttum, 1973) of terrestrial ferns commonly regarded as of gymnogrammoid affinity. The generic name is derived from the Greek words 'pityron'

meaning husk or bran of grain and 'gramma' meaning line referring to the linear sori embedded in the ceraceous coating.

Hooker and Baker (1865-1868) proposed *Gymnogramme* sect. *Ceropteris* (Link) Hook. & Baker for the farinose species of *Pityrogramma*. Diels (1899) treated it in the subtribe Pteridinae, tribe Pterideae of family Polypodiaceae. Christensen did not mention the genus *Pityrogramma* in his *Index Filicum* (1906), but later included it in the supplement (1917) of it. Bower (1928) did not include this genus in the treatment of gymnogrammoid ferns. But as it is generally accepted as a gymnogrammoid member closely allied to *Anogramma*, Christensen (1938), Ching (1940) and Crabbe *et al.* (1975) placed *Pityrogramma* adjacent to *Anogramma* in their classifications. Christensen (l.c.) placed it in the tribe Gymnogrammeae. Holttum (1947) and Crabbe *et al.* (1975) treated it in the family Adiantaceae, the former in the subfamily Gymnogrammoideae while the latter in the subfamily Adiantoideae. Brummitt (1992) also placed *Pityrogramma* in Adiantaceae but did not attempt any further subdividion of the family. Pichi Sermolli (1977) treated it as a gymnogrammoid fern and included it in the family Hemionitidaceae. But unlike others, Nayar (1970) considered this genus as a pteroid fern and hence placed in the family Pteridaceae.

Tryon (1962a) revised the genus *Pityrogramma* and recognized only 14 species of which seven including *P. calomelanos* and *P. chrysophylla* are the most "typical" of the genus. According to him, *Pityrogramma*, *Trismeria* and *Anogramma* are all closely related and united *Pityrogramma* and *Trismeria* but maintained *Anogramma* as a distinct genus.

Pityrogramma Link, Handb. Gew. 3: 19. 1833; Ching, Sunyatsenia 5: 228. 1940; Copel., Gen. Fil. 75. 1947; Holttum, Rev. Fern Fl. Malaya 2: 592. 1954; R.M.Tryon, Contrib. Gray Herb. 189: 52. 1962; R.M.Tryon & A.F.Tryon, Ferns Allied Plants 216. 1982; R.M.Tryon *et al.* in Kramer & Green (eds.), Fam. Gen. Vas. Plants 1: 237. 1990; Bostock *et al.* in McCarthy (ed.), Fl. Australia 48: 263. 1998.

Type: *P. chrysophylla* (Sw.) Link, Handb. Gew. 3: 19. 1833.

(*Acrostichum chrysophyllum* Sw. in Schrad., J. Bot. 188: 14. 1802.)

Ceropteris Link, Fil. Sp. 141. 1841, *nomen. superfl.*

Trismeria Fee, Mem. Fam. Foug. 5 (Gen. Fil.): 164. t. 14. f. 1. 2. 1852.

Gymnogramma sect. *Isgnogramma* Hieron, Engl. Bot. Jahrb. 34: 474. 1904.

Gymnogramma sect. *Cerogramma* Diels, Nat. Pflanz. 1(4): 260. 1899.
Pityrogramma sect. *Ceropteris* Domin, Publ. Fac. Sci. Univ. Charles 88: 4. 1928.
Pityrogramma sect. *Oligolepis* Domin, Publ. Fac. Sci. Univ. Charles 88: 4. 1928.
Pityrogramma sect. *Trichophylla* Domin, Publ. Fac. Sci. Univ. Charles 88: 4. 1928.

Terrestrial plants; rhizome short, thick, ascending, dictyostelic, covered with closely set leaf bases and scales; paleae brown, narrowly lanceolate, entire, thin, non-peltate terminating in a long uniseriate hair with a terminal globose glandular cell; fronds crowded, monomorphic; stipe hard, strong, purplish black, polished, adaxially sulcate, scaly at base; lamina ovate, 2-3 pinnate, anadromous, not basiscopically enlarged, herbaceous or subcoriaceous, upper surface glabrous, lower surface covered with white or yellow waxy powder; veins free dichotomous, ending behind the margin; sori along the whole length of the veins, appear as dark patches in the farina on the lower surface of fertile leaflets, non-indusiate, non-paraphysate; spores dark brown, trilete, tetrahedral, globose with perispore and a prominent equatorial flange and 1-4 parallel ridges; distal surface irregularly reticulate and proximal surface bears irregularly shaped protuberances.

Gametophyte: Mature prothallus is cordate, naked and with a massive midrib. The wings show a tendency to curve upwards so that fully grown thalli often appear more or less funnel shaped. The wing cells are uniformly thickened and the apical meristem of the prothallus is broad and ill differentiated (Nayar, 1964a).

Chromosome number: n = 29 (Abraham *et al.*, 1962); n = 30 (Chiarugi, 1960) n = 29, 30 (Fabri, 1963; Manickam & Irudayaraj, 1988).

Distribution and Ecology: Native of American tropics, the species are widely distributed in Africa, Columbia, Ecuador, Madagascar, Peru and the southern and western United States.

Pirytogramma species are hardy ferns growing in exposed or semi-exposed earth cuttings and moist open habitats although some species are tolerant to limited or long dry periods. They also grow on land slopes, river banks, cliffs from sea level to 2000 m altitude.

Panigrahi (1975) reports that five species (or varieties) of *Pityrogramma* have so far been recorded from different parts of Asia. Although collections of *Pityrogramma* specimens were made from South India as early as 1881, Beddome (1862-1892) did not mention their occurrence in South India. Blatter and d'Almeida

(1922) first reported the naturalization of *Gymnogramma* (= *Pityrogramma*) *calomelanos* in the Bombay Presidency and Nilgiris and another small fern with golden yellow powder in Nilgiris only. They erroneously identified the latter as *Gymnogramma calomelanos* var. *chrysophylla* (Sw.) Blatt. & d'Almeida. This misidentification was followed by other authors until Panigrahi (1975) identified it as *Pityrogramma austroamericana* Domin. According to him, in South India there occur three species of *Pityrogramma viz.*, *P. austroamericana, P. calomelanos* and *P. chrysophylla*. But the last species is based on a single specimen (*Loventhal, s.n.*) at BM supposed to be collected from Madras (Tamil Nadu). Dixit (1984) and Nair *et al.* (1992) also report the occurrence of the above three species in South India. Although Nair *et al.* (1992) provide separate descriptions for all of them, the specimens, *N.C.Nair 51062* and *K.Vivekanandan 20347* (MH) supposed to be studied for making the description of the species, are cited under both *P. austroamericana* and *P. chrysophylla* which itself indicates that these species are conspecific. I examined all the specimens of *Pityrogramma* with golden yellow farina at MH but could not find any difference between them. Hence all these specimens are treated as *P. austroamericana*. Chandra (2000a) mentions three species, *viz., P. austroamericana* Domin, *P. calomelanos* (L.) Link and *P. calomelanos* var. *aureoflava* (Hook.) Weath. ex Bailey as occurring in South India. Tryon & Tryon (1982) reduced *P. austroamericana* Domin as a variety of *P. calomelanos* (L.) Link following Farwell (Amer. Midl. Nat. 12: 280. 1931) which is not followed here. But their treatment of *P. calomelanos* var. *aureoflava* (Hook.) Weath. *ex* Bailey as a synonym of *P. calomelanos* var. *austroamericana* (Domin) Farw. is followed here. Hence two species of *Pityrogramma, viz., P. calomelanos* (L.) Link and *P. austroamericana* Domin are included in this study.

Pityrogramma austroamericana Domin, Spizy Prir. Fak. Karlovy Univ. 88: 7. 1928; Panigrahi, Kew Bull. 30: 663. 1975; N.C.Nair & R.D.Dixit, J. Bombay Nat. Hist. Soc. 78: 459. 1981; R.D.Dixit, Census Indian Pterid. 79. 1984; N.C.Nair *et al.*, J. Econ. Taxon. Bot. 16: 255. 1992; S.Chandra, Ferns India 32. 2000. (**Fig. 42e & f, 44, 45A-F**).

Lectotype: Bolivia, *Mandon 1549* (K)

Pityrogramma calomelanos var. *austroamericana* (Domin) Farw., Amer. Midl. Nat. 12: 280. 1931.

Pityrogramma chrysophylla auct. non (Sw.) Link, Handb. Gew. 3: 19. 1833: P.Chandra, J. Biol. Sci. 6(1): 3. 1963; N.C.Nair & S.R.Ghosh, J. Indian Bot. Soc. 54: 106. 1975; Panigrahi, Kew Bull. 30: 664. 1975; R.D.Dixit, Census Indian Pterid. 79. 1984; N.C.Nair *et al.*, J. Econ. Tax. Bot. 16: 254. 1992; B.K.Nayar & Geev., Fern Fl. Malabar 100. 1993.

Gymnogramma calomelanos var. *aureoflava* Hook., Gard. Ferns t. 50. 1862.

Gymnogramma calomelanos var. *chrysophylla* (Sw.) Blatter & d'Almeida, Ferns Bombay 177. 1922, *pro parte.*

Pityrogramma calomelanos var. *aureoflava* (Hook.) Weath. *ex* L.H.Bailey, Man. Cult. 64. 1926; Manickam, Fern Fl. Palni Hills 33. 1986; Manickam & Irud., Pterid. Fl. W. Ghats 95. pl. 70. 1992; S.Chandra, Ferns India 33. 2000.

Rhizome 3-5 x 2-2.5 cm, erect, unbranched, covered with persistent leaf bases, a tuft of roots towards the base and dense paleae towards the tip. Paleae 4-4.5 x 0.5-0.7 mm, linear-lanceolate, concolorous, yellowish brown, long acuminate with an apical portion of 4-5 uniseriate cells; apical cell glandular, margin smooth. Fronds tufted, 8-12, spreading, 50-60 x 15-20 cm; stipe 20-30 cm long, 3 mm broad, as long as lamina, blackish brown, median groove on the upper side, lower side rounded, paleate at base, glossy and glabrous above; lamina 30-50 x 15-20 cm, bipinnate towards base, bipinnatifid above, ovate-lanceolate, widest at base; base broadly cuneate, apex acuminate; rachis similar to stipe, grooved on upper side, bearing 20-25 pairs of lateral pinnae, 4 or 5 pairs sub-opposite, rest alternate, lower pinnae longest, 4-5 cm apart, gradually become smaller upwards; lowest pinna 8-10 x 2-3 cm, shortly stalked (stalk 3 mm long), ovate-lanceolate with lower portion pinnate and distal portion pinnatifid to deeply lobed, ultimate lobes sessile, alternate, ovate-oblong, 1 x 0.5 cm, apex acute, basiscopic base decurrent, margin smooth; texture coriaceous, upper surface glabrous; lower surface with dense yellow farina secreted by glandular hairs which are two types, short unicellular (0.1-0.15 mm long), and longer, 2 or 3 celled, uniseriate (0.35 mm long). Venation pinnate; costa distinct on lower side, grooved on upper side; lateral veins once or rarely twice forked, reaching the margin. Sori exindusiate, spreading along the veins through out the lower surface except midrib and extreme base and tip of lateral veins. Sporangium with very short stalk; capsule globose; annulus 17 cells long. Spores 50-55 µm,

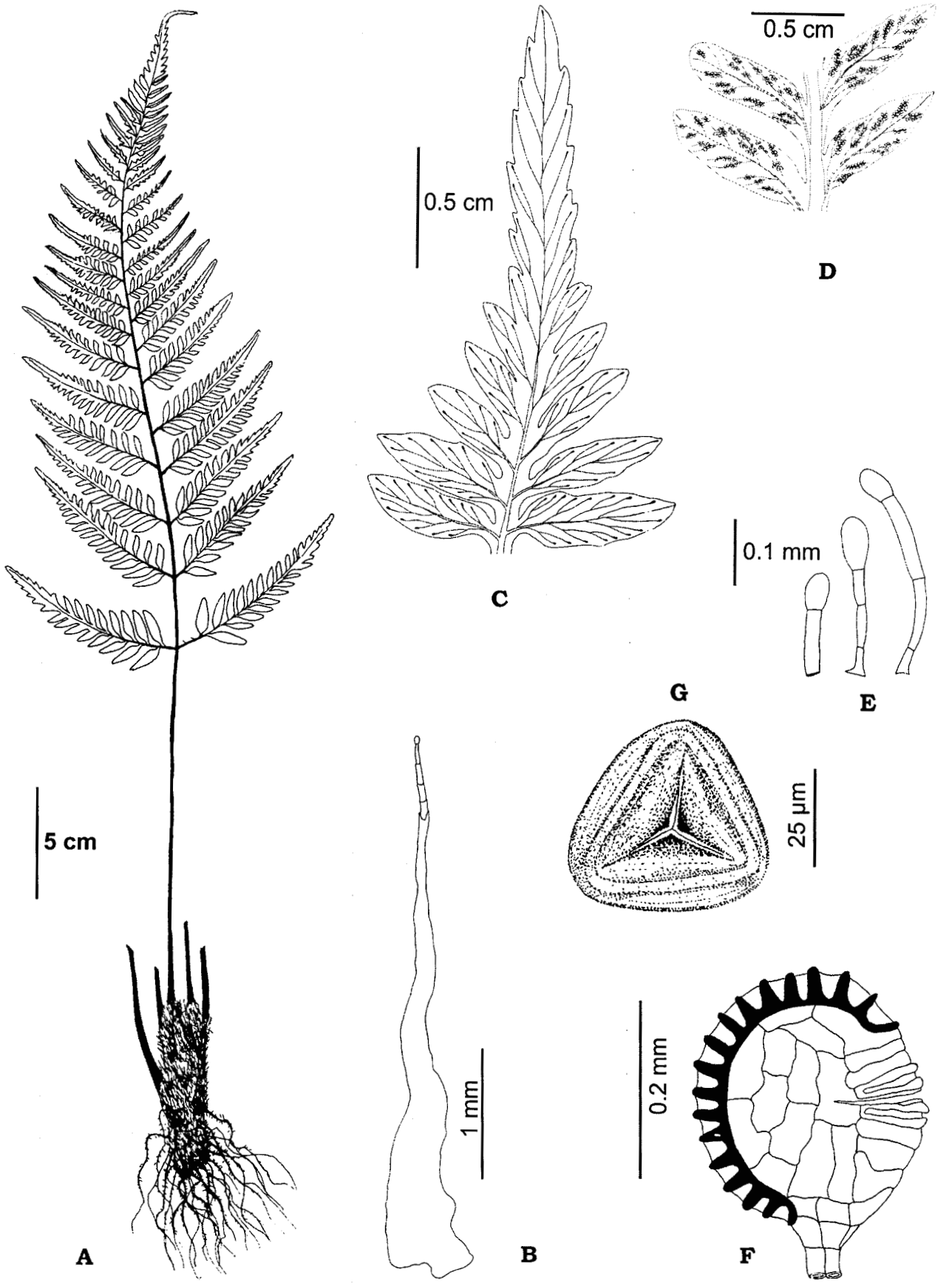

Fig. 45. Pityrogramma austroamericana: A- Habit, **B**- Palea, **C**- a portion of sterile pinna, **D**- a portion of fertile pinna, **E**- Glandular hairs on the lower side of pinna, **F**- Sporangium, **G**- Spore (from *Mohanakurup 52830*).

trilete, tetrahedral; exine with reticulate distal surface, and rugulose proximal surface with an equatorial collar in between.

Chromosome numbers: n = 116, 2n = 232, octaploid sexual (Abraham *et al.*, 1962); n = 120, octaploid sexual (Ghatak, 1963).

Distribution and Ecology: In India, *P. austroamericana* is restricted to southern India where it occurs in a few localities in Karnataka, Kerala and Tamil Nadu. It also occurs in Africa, South America, Australia, Madagascar and Sri Lanka. It grows in open or partially shaded, moist localities along earth cuttings on road sides.

Note: *Pityrogramma austroamericana* is very closely related to *P. calomelanos*, but can be easily distinguished because of having golden yellow farina instead of white farina in the latter.

Specimens examined: **KARNATAKA**: Kodagu Dt., Madikeri, *Rajagopal 183* (MGMC). Mercara, *Blanford s.n.* (CAL). **KERALA**: Idukki Dt., Devikulam, *Mohanakurup 73152* (CALI); Kumali, *Nair 40796* (CAL); Kuttikanam, *Vivekanandan 20347* (MH); Munnar, *Nair 40215* (CAL); Thankachi, *Sharma 40853* (MH). Kannur Dt., Chandanathode, *Ellis 25261* (MH). Kottayam Dt., Murudapalai, *Sebastine 16449* (MH); Wagamon, *Mohanakurup 52830* (CALI). Palakkad Dt., Aruvampara, *Nair 69149* (CAL, MH); Muttikulam, Attapadi hills, *Fischer 2383* (CAL). Thrissur Dt., Sholayar dam site, *Nair & Ghosh 51062* (MH). **TAMIL NADU**: Coimbatore Dt., Sholayar, *Sebastine 16685*; Siruvani, *Subramanyam 3063* (MH). Nilgiris Dt., Coonoor, *Sebastine 4081* (MH); Lovedale, Ootty, *Mohanakurup 73108* (CALI). Salem Dt., Yercaud, *Mohanakurup 52875* (CALI), *Subramanyam 6571* (MH); Shevaroy hills, Yercaud, *Ghatak 30* (CAL); Bauxite hills, Yercaud, *Rao 26769* (MH). Teni Dt., way to Kumali, *Subramanyam 8225* (MH). Tirunelveli Dt., Mancholai, *Sebastine 3589* (MH); Upper Kothayar, *Mohanakurup 52847* (CALI).

Pityrogramma calomelanos (L.) Link, Handb. Gew. 3: 20. 1833; Subramanyam *et al.*, Bull. Bot. Surv. India 3: 211. 1961; P.Chandra, J. Biol. Sci. 6(1): 1. 1963; N.C.Nair & S.R.Ghosh, J. Indian Bot. Soc. 54: 104. 1975; Panigrahi, Kew Bull. 30: 660. 1975; N.C.Nair & S.R.Dixit, J. Bombay Nat. Hist. Soc. 78: 458. 1981; R.D.Dixit, Census Indian Pterid. 79. 1984; N.C.Nair *et al.*, J. Econ. Taxon. Bot. 16: 254. 1992; B.K.Nayar & Geev., Fern Fl. Malabar 99. 1993; Rajagopal & Bhat, Indian Fern J. 15: 10. 1998; S.Chandra, Ferns India 32. 2000. (**Fig. 42g & h, 44, 46A-F**).

Type: South America, *Linn 1245.9* (BM)

Acrostichum calomelanos L., Sp. Pl. 2: 1072. 1753.

Acrostichum ebenum L., Sp. Pl. 2: 1071. 1753.

Gymnogramma calomelanos (L.) Kaulf., Enum. 76. 1824.

Gymnogramma calomelas (L.) Link, Hort. Berol. 2: 52. 1833.

Ceropteris calomelaena Link, Fil. Sp. 141. 1841.

Ceropteris distans Link, Fil. Sp. 142. 1841.

Neurogramma calomelanos (L.) Diels, Nat. Pfl. 1(4): 264. 1899.

Ceropteris calomelanos (L.) Underw., Bull. Torrey Bot. Club 29: 632. 1902.

Pityrogramma chamaesorbus Domin, Spisy Prirod. Fak. Karlovy Univ. 88: 6. 1928.

Pityrogramma insularis Domin, Spisy Prirod. Fak. Karlovy Univ. 88: 6. 1928.

Pityrogramma calomelanos (L.) Link, var. *calomelanos*: Manickam, Fern Fl. Palni Hills 33. 1986; Manickam & Irud., Pterid. Fl. W. Ghats 94. pl. 69. 1992.

Rhizome 3 x 2 cm, erect, unbranched, covered with persistent leaf bases and a tuft of fibrous roots towards the base and dense scales towards apex. Paleae 5 x 0.5 mm, linear-lanceolate, concolorous, yellowish-brown, long acuminate with an apical portion of 8-10 uniseriate cells; terminal cell glandular. Fronds tufted, 10-15, spreading 1 m or more in length; stipe 30-50 cm long, 5 mm wide, equal in length to lamina, dark purple, grooved above, rounded below;sparaely scaly at the very base, glabrous and glossy above; lamina 40-50 x 20-30 cm, bipinnate towards base, bipinnatifid above, ovate-lanceolate, widest at base; base broadly cuneate, apex acuminate; rachis similar to stipe, distinctly grooved above, bearing 20-25 pairs of pinnae, sub-opposite up to 4 pairs, then gradually become alternate; ascending, lower pinnea larger in size, 3-5 cm apart, gradually become smaller upwards; largest pinna 12-15 x 3-4 cm, shortly stalked (5 mm), ovate-lanceolate, apex acuminate, with 10-12 pairs of sub-opposite or alternate, sessile pinnules, which are gradually reduced towards tip; largest pinnule 1.5 x 0.7 cm, ovate-oblong with acute apex, basiscopic base decurrent, margin smooth, texture thick herbaceous, glabrous above, lower surface covered with white farina, secreted by glandular hairs of two types; short unicellular (75 µm long) and longer 2-celled (300 µm long). Venation pinnate in larger lobes; midrib distinct below; lateral veins once or twice forked, reaching the margin. Sori exindusiate, spreading along the veins through out the lower surface. Sporangium short stalked; stalk shorter than capsule, one cell long,

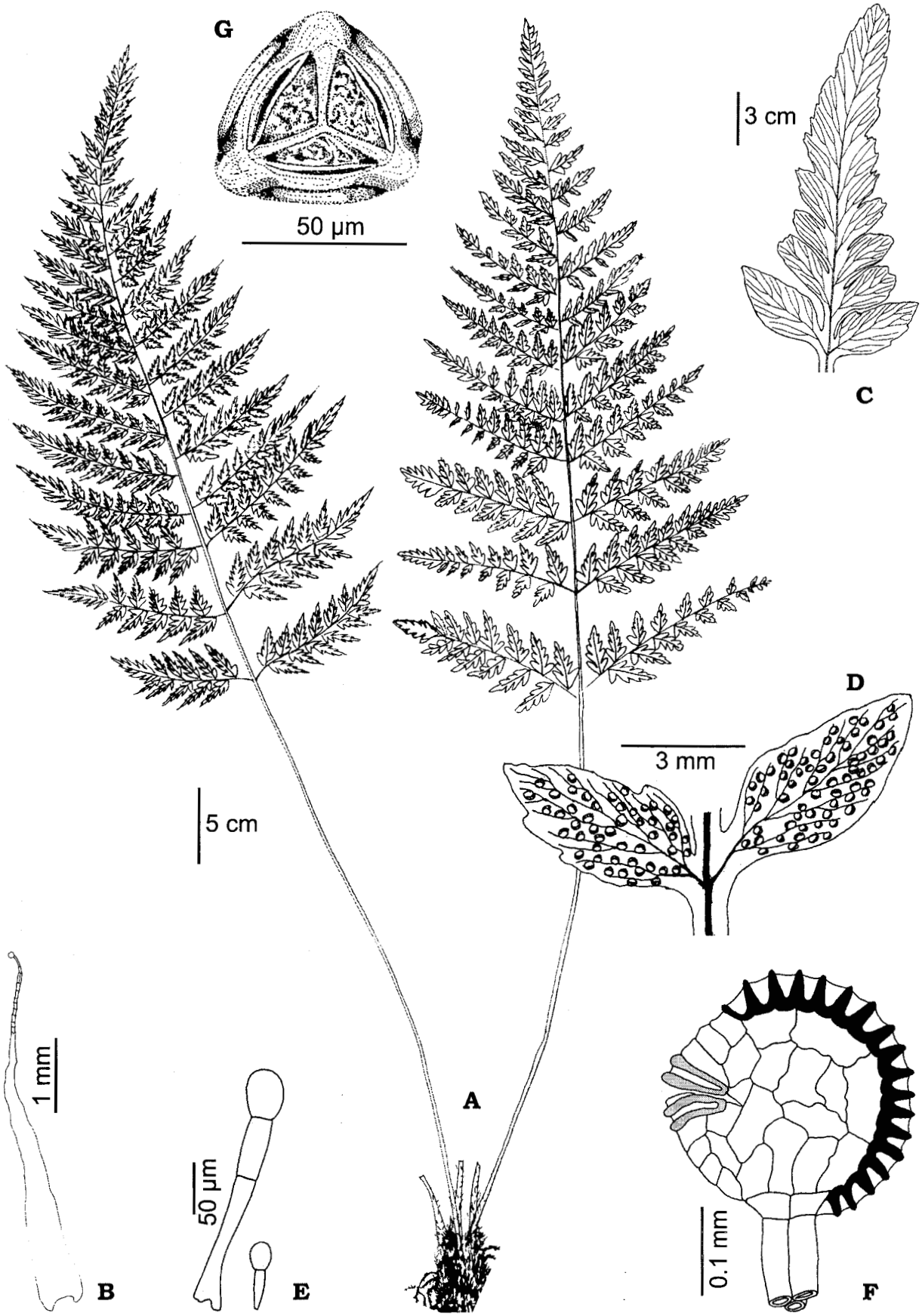

Fig. 46. **Pityrogramma calomelanos: A**- Habit, **B**- Palea, **C**- a portion of sterile pinna, **D**- a portion of fertile pinna, **E**- Glandular hairs on the lower side of pinna, **F**- Sporangium, **G**- Spore (from *Mohanakurup 52824*).

three cells thick; capsule globose; annulus 17 cells long. Spores 40 x 50 μm, trilete, tetrahedral; exine reticulate on distal side, rugulose on proximal side with a prominent equatorial collar in between.

Chromosome number: n = 120, octaploid sexual (Verma in Mehra, 1961); n = 116, 2n = 232, octaploid sexual (Abraham *et al.*, 1962).

Distribution and Ecology: *P. calomelanos* is distributed almost through out India and also occurs all the four south Indian states. It is also distributed in Argentina, Australia, Brazil, Bolivia, Bhutan, China, Ecuador, French Guiana, Columbia, Galapagos Islands, Java, Malaya, Mexico to Panama, Nepal, Paraguay, Philippines, Sri Lanka and Taiwan. It commonly grows on exposed areas along road sides, waste lands, newly cleared grounds and barren slopes nearly always in moist places.

Specimens examined: **ANDHRA PRADESH**: Chittoor Dt., Papavinasanam, *Ahamed 12804* (SKU). Visakhapatnam Dt., Seshachalam hills, *Ahamed 12880* (SKU). **KARNATAKA**: Dakshina Kannada Dt., Arampady, *Rajagopal 458* (MGMC). Kodagu Dt., Thalakkavery, *Srinivasan 72329* (CAL, MH). Shimoga Dt., Agumbe, *Rajagopal 10;* Hulickal, *Rajagopal 41* (MGMC); Kotachadri, *Mohanakurup 52868* (CALI). Udupi Dt., Manipal, *Rajagopal 65* (MGMC). **KERALA**: Alappuzha Dt., R.Block, Kuttanad, *Swaminathan 88248* (CAL, MH). Idukki Dt., Kulamavu, *C.N.Mohanan 72007* (CAL, MH); Malankara, *Mohanakurup 52824* (CALI); Mlappara estate, *Nair 70122* (CAL, MH); way to Periyar, *Pandurangan 78021*; Thankamani, *Nair 40404* (CAL). Kasaragod Dt., Peradala, *Nair 71066* (CAL, MH). Kannur Dt., Karimbam, *Ansari 67818* (CAL, MH). Kollam Dt., Adoor, *Nair 871*; Aryankavu, *Nair 50676*; Kottarakkara, *Nair 50918*; Moozhiyar, *Nair 50608* (CAL); Pathanapuram, *Manickam 32306* (XCH); Punalur, *Nair 50871* (CAL); Ranni, *Nair 50749* (MH). Kottayam Dt., Bharananganam, *Antony 1275* (MH); Changanassery, *Nair 40261*; Kottayam, *Nair 40286* (CAL); Vellikulam, *Mohanakurup 52829* (CALI). Malappuram Dt., Karuvarakundu to Kalikavu, *Nair 81191*; Nedumkayam to Meenmutty, *Nair 81216* (CAL, MH). Palakkad Dt., Aruvampara, *Bhargavan 65597* (CAL, MH); Komattarithode, *Vohra 56318* (CAL); Mukkali forest, *Vajravelu 32111* (MH); Muthikulam to Kudam, *Vajravelu 62927* (CAL); Muthikulam R.F., *Vajravelu 62834* (MH); Nelliampathi, *Mohanakurup 73101* (CALI). Pathanamthitta Dt., Thiruvella, *Nair 50818* (CAL); Vennikulam, Thiruvella, *Nair & Ghosh 50839* (MH). Thiruvananthapuram Dt., Aruvikkara, *M.Mohanan 63680* (CAL); Neyyattinkara, *Nair*

& Ghosh 51785 (MH); Ponmudi, *Manickam 31349* (XCH), *Nair & Ghosh 51873* (CAL). Thrissur Dt., Chalakkudi river side, *Rajan 73038* (CAL, MH); Thumbermuzhy forest, *Rajan 73064*; Wadakkancherry, *Ramamurthy 48429* (CAL). **TAMIL NADU**: Coimbatore Dt., Aliyar submergible area, *Sebastine 14568* (CAL, MH); Muthukulam, Siruvani, *Subramanyam 3063*; Sholayar submergible area, *Sebastine 16685* (CAL). Kanniya Kumari Dt., Chellamkonam, *Henry 53291* (CAL); Lower Kothayar, *Henry 48262, Nair & Ghosh 51903* (CAL, MH). Salem Dt., Yercaud ghat road, *Ghatak 108* (CAL). Teni Dt., near Kumali, *Subramanyam 8225* (CAL); way to Kumali, *Subramanyam 8971* (CAL, MH). Tirunelveli Dt., way to Kadlamalai, *Sebastine 8501* (CAL, MH); Manchola, *Sebastine 3589* (CAL).

DISCUSSION

Comparative morphology

Adiantoid-cheilanthoid ferns are characterised by the absence of a true indusium for protecting the sori. In most of the members the sori are protected by the reflexed margin of the lamina or remain scattered through out the lower surface without any protective covering (acrostichoid condition). They belong to the family Pteridaceae (according to the classification of Tryon *et al.*, 1990). This family is divided into six subfamilies of which five are represented in southern India. The adiantoid-cheilanthoid ferns are distributed in three subfamilies, *viz.*, Adiantoideae, Cheilanthoideae and Taenitidoideae.

Subfamily Adiantoideae are monotypic with 11 species. Cheilanthoideae are represented in South India by four genera, *viz., Cheilanthes* (eight species), *Doryopteris* (one species), *Parahemionitis* (one species) and *Pellaea* (three species). Subfamily Taenitidoideae are represented in southern India by the genera *Actiniopteris* (one species), *Anogramma* (one species) and *Pityrogramma* (two species).

Adiantoid-cheilanthoid ferns, in general, are medium sized plants, but the one like *Anogramma leptophylla* represents the smallest ferns, which grows to a height of only 6-8 cm. On the other hand, *Pityrogramma calomelanos* grows to a height of more than 100 cm. Most of the *Adiantum* species are having a height of more or less 50 cm including those having unipinnate fronds. *A. concinnum* is one among the largest *Adiantum* species reaching a height of over 90 cm. The height of most of the *Cheilanthes* and *Pellaea* species ranges from 40 to 50 cm. *C. bullosa* is one among the largest cheilanthoid ferns reaching a height of almost 75 cm.

The rhizome of adiantoid-cheilanthoid ferns is much variable not only between different genera but also among different species of the same genus. It is very short and rudimentary in *Anogramma leptophylla* while it is short creeping in *Actiniopteris, Parahemionitis* and *Doryopteris*. The rhizome may be short, thick and erect as in *Adiantum caudatum*, sub-erect or ascending and short creeping as in *A. concinnum* and *A. raddianum* or slender and long creeping as in *A. latifolium* and *A. poiretii*. The rhizome is usually unbranched except in few species such as *A. latifolium* and *A. poiretii,* where it is considerably branched. The cheilanthoid ferns show variation in the form of rhizome even in the same genus. The rhizome of *Cheilanthes* is short,

hard, erect to semi-erect becoming massive and decumbent when it grows on vertical substratum. Among the species of *Pellaea* the rhizome is long creeping in *P. falcata,* while it is erect in *P. boivini* and *P. malabarica*, in all of them it remains unbranched. *Pityrogramma* has erect unbranched, stout and rather thick rhizome. The erect or suberect rhizome will produce a tuft of fronds spirally around it, while in the long creeping rhizome the fronds are alternately and distantly placed on either side of the horizontal rhizome. The rhizome in all species is covered by dense paleae especially towards the tip and wiry roots and persistent stipe bases except in *Anogramma leptophylla*, which has uniseriate, multicellular hairs instead of paleae.

The rhizome is dictyostelic in *Actiniopteris*, most species of *Adiantum* and *Cheilanthes,* but solenostelic in *Doryopteris*, *Pellaea, Parahemionitis* and some species of *Adiantum.* As a rule the rhizome of juvenile plants is invariably simple protostelic and as the rhizome matures, pith or medulla forms in the center resulting in a solenostelic condition and gradually leaf gaps appear which overlap and ultimately a dictyostelic condition is attained. Another important feature of the rhizome in some species of *Adiantum* and *Cheilanthes* is the presence of vessels with scalariform thickening and peculiar type of branched tracheids, which is believed to be related to xeric habit of the plant (Sharma & Bharadwaja, 1978; Purohit & Sharma, 1980; Bhattacharya & Mukhopadhyay, 1989).

Roots are adventitious and covered with persistent unicellular, ferrugineous root hairs. The root anatomy shows that in most of the species of *Adiantum,* cortex has an inner sclerenchymatous region and an outer parenchymatous region while the cortex of *Cheilanthes, Parahemionitis*, etc. consists of only thin walled cells and the innermost layer comprises of six or more triangular cells. Most of the species show an exarch protoxylem in the diarch pattern. One important feature of *Adiantum* is that the upper epidermal cells of the pinnae of most of the species are "arm palisade" and are photosynthetic except in *A. philippense,* while the lamina of all the species of *Adiantum* is amphistomatic. But in *Cheilanthes* the stomata are restricted to lower side only. The petiole of adiantoid-cheilanthoid ferns has either a two stranded xylem or a solid xylem core where the shape varies from 'C' to 'V' to 'X' shape.

Paleae are dense in the growing region of the rhizome and the base of the stipe. In some species the paleae extend upwards through out the entire length of stipe as in *Cheilanthes anceps* or both stipe and rachis as in *Adiantum latifolium* and

Pellaea falcata. In some genera such as *Actiniopteris* and *Parahemionitis,* paleae are distributed in the lamina also. The rhizome paleae and stipe paleae are similar in structure, but usually the former will be comparatively smaller in size.

Paleae of adiantoid–cheilanthoid ferns are 3-5 mm long, 0.5-1 mm broad, linear lanceolate and either concolorous or bicolorous. In the former the paleae will be uniformly light brown with thin walled cells and in the latter the central region will be dark brown with thick walled cells and peripheral region yellowish brown and thin walled. The occurrence of these two types of paleae is independent of the species. In *Cheilanthes bullosa* the paleae are concolorous and are uniformly deep red. In *Adiantum* bicolorous paleae occur only in *A. caudatum, A. philippense* and *A. zollingeri,* all of which are having simple pinnate fronds. But there seems to be no relation between bicolorous paleae and unipinnate fronds, since *A. incisum,* another species with unipinnate fronds and also all the species with multi-pinnate fronds have concolorous paleae. Among the taenitidoid ferns, *Anogramma leptophylla* is bereft of paleae. Instead, the rhizome and stipe base contain multicellular uniseriate hairs, while *Actiniopteris* has two types of paleae; bicolorous paleae with entire margin on the rhizome and concolorous paleae with an irregular basal margin on the fronds. Both the species of *Pityrogramma* have concolorous paleae. This shows that these two types of paleae develop independently in different species of adiantoid-cheilanthoid ferns. In adiantoid ferns paleae are invariably aglandular and terminating in a long acicular cell, while in cheilanthoid and taenitidoid ferns paleae are gland tipped. Margin of paleae is smooth in *Adiantum*, except *A. latifolium, A. poiretii* and *A. tenerum* where the margin is dentate to ciliate and in *A. zollingeri* the margin is slightly toothed especially towards the base. In *Parahemionitis* and *Doryopteris* the margin is slightly toothed especially towards the lower part as the ends of marginal cells of the paleae protrude out wards. The margin is smooth in *Cheilanthes, Pellaea* and *Pityrogramma* except in *C. viridis* and *Pellaea boivini* where the margin is slightly dentate. In almost all the species paleae are basifixed except in *Adiantum latifolium* and *A. tenerum* where they are peltate.

The fronds range from simple to quadri-pinnate with all the intermediate forms such as bipinnatifid, bipinnate, tripinnaifid and tripinnate. In *Parahemionitis cordata* and *Doryopteris concolor* the lamina is simple; it is entire in the former while deeply bipinnatifid in the latter. In *Actiniopteris radiata* the lamina is simple and semicircular, fan shaped or reniform which is divided repeatedly and dichotomously resulting in

narrow linear ultimate segments. In *Anogramma leptophylla* lamina is bipinnate to tripinnatifid. In *Adiantum* lamina ranges from simple pinnate to quadri-pinnate. In *A. caudatum, A. incisum, A. philippense* and *A. zollingeri,* the fronds are simple pinnate and are spreading and arching. Some of them terminating in a larger leaflet, while most of the fronds of these species end in a prolonged leafless rachis with a terminal vegetative bud which when touches the ground, develops into a daughter plant (walking habit). But in the other species the fronds are bipinnate (*A. latifolium*), tripinnate (*A. concinnum*) or quadri-pinnate (*A. tenerum*) and the main rachis and all its branches end in an ultimate pinnule and no vegetative bud is formed. In *Adiantum* the pinnules are usually dimidiate, or sometimes cuneate. In *A. latifolium* the pinnules are oblong or slightly falcate with 1/3 of the lower base excised.

In *Cheilanthes* spp. the fronds range from bipinnatifid (*C. opposita*) to quadri-pinnate (*C. tenuifolia*). In all the farinose members the fronds are bipinnate to tripinnatifid. In *Pellaea* the fronds are much variable with simple pinnate in *P. falcata* and tripinnate in *P. boivini. P. malabarica* shows a condition between these two species where the plant produces two types of fronds, one strictly unipinnate while the other bipinnate with a few lower pinnae being pinnate.

In most species of *Adiantum* (except those with unipinnate fronds) and those of *Cheilanthes* and *Pellaea boivini* the fronds are deltoid with lowermost portion showing the maximum pinnate condition and become less pinnate towards the upper region and ending in a simple pinnate portion with a single ultimate pinnule. This is the case of the main rachis as well as lateral rachises.

The stipe of all the species (except *Anogramma leptophylla*) are paleate at base and in most of the species it is glabrous above, with a shallow groove on the upper surface. Such a groove is absent in *Cheilanthes bicolor.* But paleae occur all over the stipe in *Cheilanthes anceps*, *Actiniopteris radiata* and *Pellaea falcata.* Stipe is densely scaly and hairy through out in *Parahemionitis* while in *Adiantum caudatum, A. hispidulum, A. incisum, A. latifolium, A. zollingeri* and *Pellaea malabarica* the stipe above the paleate base is covered with multicellular, uniseriate hairs. In *A. latifolium* the hairs are irregularly branched at the base. The length of the stipe may be less than that of lamina as in *A. caudatum, A. incisum, A. concinnum,* etc., equal to that of lamina as in *A. latifolium, A. poiretii* and most species of *Cheilanthes* and

Pityrogramma or much longer than lamina as in *Parahemionitis, Actinioperis* and *Doryopteris*. In *Cheilanthes bicolor* the stipe is 1½ times longer than the lamina.

In most of the species the fronds are monomorphic. But a clear dimorphy is evident in *Parahemionitis cordata* with the sterile fronds having shorter stipe and broader lamina with a cordate base, while the fertile ones are having longer stipe and narrower lamina with sagittate base. In *Actiniopteris radiata* and *Cheilanthes tenuifolia* also the sterile fronds are smaller compared to fertile ones. In *C. tenuifolia* the shorter and broader 'sterile' fronds may also bear a few sporangia along the veins but without any protective covering unlike in fertile fronds where the sori occur along the margin and are covered with reflexed margin.

In *Adiantum* spp. with unipinnate fronds, the pinnae are sessile as in *A. caudatum, A. incisum* and *A. zollingeri*, while it is distinctly stalked in *A. philippense*. In multi-pinnate forms, the ultimate pinnules are short or long stalked. In *A. tenerum* and *A. poiretii* the pinnules are articulated to the stalk and are deciduous leaving the black, glossy, thin and slender leaf stalk attached to the rachis. In *Cheilanthes* the lowest one or two pairs of pinnae are distinctly stalked, but those of the above adnate to the rachis at their bases. In *Pellaea* the pinnae are sessile in *P. falcata*. *P. malabarica* has both sessile or subsessile pinnae. In simple pinnate fronds the pinnae are sessile or subsessile while in bipinnate fronds the primary pinnae are distinctly stalked with stalk having a length of one cm. In *P. boivini* all the primary pinnae, secondary pinnae and ultimate pinnules are distinctly stlaked.

The pinnae and pinnules of most of the species of *Adiantum* are glabrous, while some species such as *A. caudatum, A. incisum* and *A. zollingeri* have dense or scarce hairs on lower surface or on both surfaces. *A. caudatum* has both multicellular, uniseriate hairs which occur on both surfaces of pinnae and unicellular or bicellular hamate hairs which are restricted to the lower surface. In *A. incisum* only pluricellular hairs are present more on lower surface and fewer on upper surface. The upper surface of pinna is glabrous in *A. zolligeri* and lower surface is nearly glabrous (a few hairs may be present towards the base of lower surface). Both surfaces are glabrous in *Anogramma leptophylla* and *Doryopteris concolor,* while the lamina of *Actiniopteris radiata* has on the lower side towards base fewer number of concolorous, yellowish brown ovate lanceolate paleae and on the upper surface towards the base there are numerous short pluricellular uniseriate and club shaped

hairs. In *Parahemionitis cordata* the lamina is glabrous on upper surface while the lower surface is densely scaly and hairy. In *Pellaea boivini* the pinnule is glabrous on both surfaces while in *P. malabarica* the lamina has sparse pluricellular hairs on both surfaces. In *P. falcata* the lamina is scaly along the midrib on upper surface and all over the lower surface.

Cheilanthes species include both farinose and nonfarinose members. In the former the lamina is glabrous above but coated with a thick white farina produced by sessile globose ceraceous glands on the lower surface. The nonfarinose members such as *C. opposita, C. viridis* and *C. tenuifolia* have small ceraceous glands on the lower surface, but no deposition of farina. Some species such as *C. thwaitesii,* are having farina when young, but is lost when the fronds become mature and hence form a link between the deltoid farinose *Aleuritopteris* species and the nonfarinose, lanceolate and deltoid *Cheilanthes* (*s.s.*) species. This alongwith the fact that the 'so called' nonfarinose species also possess ceraceous glands show that the segregation of farinose members of *Cheilanthes* to constitute the genus *Aleuritopteris* is not proper and justify the contention of Manton *et al.* (1966) that the characters which are considered for the genus *Aleuritopteris* are more or less found in all species and hence it is difficult to establish generic limits between *Cheilanthes* and *Aleuritopteris*. This justifies the treatment of *Aleuritopteris* under the genus *Cheilanthes. C. tenuifolia* has sterile pinnules with 2-3 celled uniseriate acicular hairs on both surfaces in addition to the ceraceous glands. *Pityrogramma* species have pinnules with upper surface glabrous and lower surface covered by white or yellow powder secreted by ceraceous glands.

The texture of lamina is mostly herbaceous in *Adiantum, Cheilanthes* and *Doryopteris*, while it is coriaceous in *Actiniopteris* and *Paraheminoitis. Pityrogramma calomelanos* has herbaceous lamina while that of *P. austroamericana* is thin coriaceous.

Venation is open dichotomous without a midrib in Adiantoideae. The veins fork 5-6 times and the veinlets reach the margin except in *A. latifolium.* In *A. latifolium* there is a well marked midrib extending from the base to the middle of the pinnule. Lateral veins are open dichotomous forking 4-5 times and reach the margin. Veinlets reach either in the marginal tooth as in *A. capillus-veneris, A. tenerum, A. hispidulum* and *A. latifolium* or in the sinuses between adjacent marginal teeth as in *A.*

concinnum, A. poiretii and *A. raddianum*. One characteristic feature of this taxon is that the veins enter the marginal flaps of lamina which protect the sori. In *Anogramma* and *Actiniopteris* also veins are open dichotomous. In *Actiniopteris radiata* the distal part of each vein running parallel to the edge of the lobe joins with its apex the corresponding part of the adjacent vein forming an intramarginal fertile line bearing the sporangia. In the other genera the venation is pinnate with a well-differentiated midrib running the whole length of the lamina through the middle and producing oblique lateral veins which fork once or twice and reach the margin. In Cheilanthoideae the venation is characteristically pinnate with a definite midrib which often projected on the lower surface, but grooved on the upper surface In *Parahemionitis cordata* the venation is reticulate with a prominent midrib and a pair of basal primary veins passing on to the basal lobes of lamina, both produce lateral veins which are obliquely placed and anastomosing forming polygonal areoles with out included veinlets, which are elongated, largest towards midrib and gradually become smaller towards margin. In *Pellaea* the midrib is distinct on both surfaces, lateral veins oblique and free, forking two times, veinlets not reaching the margin. In *P. malabarica* the ultimate veinlets some times unite to form small loops near the lamina margin. In *Cheilanthes* the midrib produces lateral veins which fork once or twice. In *C. opposita* both the midrib and lateral veins are pinnate. The veins produced by these lateral veins remain unbranched or fork only once.

Sporangia are aggregated into sori and are produced superficially along the veins either towards the margin or through out. In *Adiantum, Cheilanthes, Actiniopteris, Pellaea* and *Doryopteris* the sori are formed along the margin and are protected by pseudoindusium formed by the infolding of the margins of the lamina. *Adiantum* is unique in having the veins entering into the reflexed margin and sporagina are produced by these veins. The lamina is fertile only at the reflexed margins. Hence the margin here not only protects the sporangia but also produces them. This makes the genus distinct from others and hence treated as a monotypic subfamily Adiantoideae.

The sorus of *Adiantum* is a group of sporangia borne by a unit of reflexed margin. The indusium may be at the bottom of a notch in the margin where the sori are reniform as in *A. concinnum* or almost circular as in *A. raddianum,* while in others they are on the edge of the teeth or lobe and are elongate. The number and size of sori depend on the size of the pinna and also the nature of lobbing. This variation is

seen even in the same species. For example in *A. philippense* the sori may be extending along the entire length of outer margin forming an uninterrupted single soral line or interrupted into 2-4 or many distinct sori. Among other simple pinnate forms, *A. caudatum* has maximum number of sori per pinna which goes up to 15, while in *A. incisum* and *A. zollingeri* the number is 4-6. In the multi pinnate forms the number of sori per pinnule is comparatively higher which ranges from 10-15, except in *A. raddianum* where the number is only 5-6. Since the pinnules of this species are highly variable in size, the number of sori may range from 3–8.

Among the genera of subfamily Cheilanthoideae, *Cheilanthes, Doryopteris* and *Pellaea* have marginal sori protected by reflexed margin, while *Parahemionitis* has an acrostichoid sori. In *Cheilanthes, s*ori are confined to the dilated vein ends. In the farinose members such as *C. anceps, C. belangeri* and also some non farinose members such as *C. viridis* the sori may be distinct initially, but at maturity adjacent sori may coalesce to form a soral line or vascular commissure along the margins. But in *C. opposita* the sori consists of a few sporangia and are distinct, semicircular at the tip of veins of ultimate lobes and are protected by the tip of these lobes. In *C. tenuifolia* sori occur along the margin of ultimate pinnules but absent at the tip. Sori may be continuous or discontinuous, only partially protected by a pseudoindusium and the sori are exposed when ripe. In the smaller 'sterile' fronds sori often occur which consist of fewer sporangia at the vein ends, but are not protected by reflexed margin. In some species of *Cheilanthes*, especially the farinose members the pseudoindusia are short, distinct and narrow with entire or fimbriate margin. In *C. anceps* the pseudoindudsia are highly fimbriate with marginal acicular hairs while in *C. bicolour, C. bullosa* and *C. thwaitesii* the fimbriate margin of pseudoindusia ends in glandular hairs. In *Pellaea* sori are borne at vein ends and become laterally expanded forming a soral line on marginal commissure protected by a continuous reflexed margin. In *Parahemionitis* the sori are formed continuously along the reticulate veins through out the lower surface except in the midrib and very bases and extreme tips of lateral veins. The sporangia are not protected by a reflexed margin and are showing acrostichoid condition, mixed with paleae and hairs which may provide protection to them. In the taenitidoid ferns, the *Anogramma* and *Pityrogramma* show acrostichoid conditon. In *Anogramma* the sori occur superficially along the veins but are non paraphysate. The sori of *Pityrogramma* are also non indusiate and nonparaphysate, but are mixed with dense farina and appear as dark

patches in the farina. In *Actiniopteris* the sori are continuous on either side of an intra marginal vein protected by a modified broad, continuous membraneous, reflexed lamina margin.

The sporangium is of the leptosporangiate type and are nonparaphysate, the development of sporangia is the 'mixed type'. Sporangia are sessile to long stalked. This character is independent of the genus. Those species of *Adiantum* with unipinnate fronds are invariably having sporangia with long stalks which are three cells thick and the stalk is equal to or longer than capsule. Among the species with multipinnate fronds *A. latifolium* has long stalked sporangium. All the other species are having subsessile or almost sessile sporangia. The capsule is more or less globose with annulus ranging from 15 to 20 cells long. Cheilanthoid ferns are also having both distinctly stalked and sessile or subsessile sporangia. Mainly *Cheilanthes* species are having sessile or subsessile sporangia except in *C. viridis* which has sporangia with stalk equal in length to capsule. In *Cheilanthes tenuifolia* sporangium is short stalked, but occasionally the stalk bears a short acicular uniseriate hair, a condition very common in Thelypteridaceae and Polypodiaceae. *Parahemionitis* and *Pellaea boivini* have stalked sporangia, but the stalk is shorter than capsule, while in *Doryopteris concolor, Pellaea falcata and P. malabarica,* the stalk of sporangium is equal in length to capsule. Among the taenitidoid ferns, *Actiniopteris radiata* has sporangium with long stalk while *Anogramma* and *Pityrogramma* have subsessile sporangia. In the species with acrostichoid sori, the sporangia are very shortly stalked so that they can be protected by hairs or farina.

The spores are invariably trilete, tetrahedral in all species. But in *Adiantum philippense* and *Parahemionitis cordata* monolete, bilateal spores also occur in addition to trilete spores. The spores of *Adiantum* are uniform with smooth exine. But in cheilanthoid ferns the pattern of spore ornamentation varies considerably. In most species there is a distinct perine with smooth surface or with different kinds of ornamentations. Mostly exine is having some ornamentation, but in some cases it is smooth and also both smooth and ornamented perine occur in some others. Smooth exine occurs in *Parahemionitis, Doryopteris* and species of *Pellaea* and most species of *Cheilanthes*. Perine is mainly spinulose, granulose or verrucose. It appears to be absent or completely adhered with exine in a few taxa such as *Pellaea* spp., *Cheilanthes anceps, C. bullosa* and *C. viridis.*

Members of the subfamily Taenitidoideae are characterised by the presence of spores with equatorial collar, which differentiates the proximal and distal parts of the spore. In these taxa perine is absent. In *Actiniopteris radiata* exine is verrucate in proximal face, while rugulose at distal part. *Pityrogramma* spp. also show the same character.

All the genera coming under adiantoid–cheilanthoid ferns are closely related on the basis of cytological characters. Two base numbers, (x = 29, 30) are observed in them. But polyploidy is of common occurrence in most of the genera. Many species are 'species-complexes' with many cytotypes. Within the genus *Adiantum, A. caudatum, A. incisum, A. latifolium, A. philippense, A. poiretii* and *A. raddianum* have two or more cytotypes. The occurrence of ploidy is much more in *A. raddianum* for which triploid, tetraploid, octaploid and even 16-ploid forms have been reported. Comparing to *Adiantum*, the species complexes are less among the cheilanthoid ferns. The taxa having two or more cytotypes are *Cheilanthes anceps, C. bicolor, Parahemionitis cordata* and *Pellaea boivini.* Among the taenitidoids, two or more cytotypes occur in species such as *Actiniopteris radiata.*

Gametophytes of adiantoid-cheilanthoid ferns are characteristically cordate and thalloid. Collenchyma-like wall thickenings on the corners of wing cells are reported from many species of *Adiantum, Cheilanthes, Doryopteris, Parahemionitis* and *Pellaea.* In taenitidoid ferns the apex and wings of mature prothallus curve upwards so that the prothallus often appear funnel like. Prothallus of *Anogramma leptophylla* is peculiar in having special branches for bearing antheridia and archegonia and produce subterranean tubers that contain mycorrhizae. The prothallus is capable of perennating, surviving dry season and producing a new sporophyte from these tubers in the next season. Gametophyte of *Cheilanthes* has a remarkable capacity to withstand severe water deficit and survive after drying.

Vegetative propagation by foliar buds is present in some genera. It occurs in both Adiantoideae and Cheilanthoideae. In *Adiantum* it is restricted to species with unipinnate fronds where the rachis in most of the fronds will elongate and a vegetative bud is formed at the tip of the rachis and when it touches the ground, develops into a new plant (walking habit). But in some fronds where the rachis ends in cuneate pinna, vegetative buds are not formed. Such fronds are comparatively fewer than those with terminal vegetative buds. *Adiantum caudatum, A. incisum, A.*

philippense and *A. zollingeri* form thick colonies due to this vegetative propagation. In species of *Adiantum* with multi pinnate fronds no vegetative buds are formed because the main rachis and all its branches terminate in an ultimate pinnule. In cheilanthoid ferns foliar buds are present in *Parahemionitis cordata* and *Cheilanthes thwaitesii*. But there is much variation in the form of buds or bulbils between them. In *P. cordata* one or more vegetative buds are formed on the upper side of sterile lamina towards the base of highly grooved midrib, which will develop into young plants while they are still in the parent plant. In *C. thwaitesii* the lower surface of sterile fronds contain many spatulate bulbils developing from vein endings which will develop into young plants only when they fall on the ground. So it is believed that these species developed this capacity independently.

Phylogeny

There is considerable disagreement with regard to the origin and relationship of adiantoid-cheilanthoid ferns. The extent of disagreement is well reflected in the position attributed to these taxa in various systems of classification (Ching, 1940; Copeland, 1947; Holltum, 1947, 1949; Alston, 1956; Crabbe *et al.*, 1975; Pichi-Sermolli, 1977; Tryon *et al.*, 1990).

According to Bower (1928), the 'gymnogrammoid ferns' (which include adiantoid and cheilanthoid groups) arose from a non-indusiate fern with superficial sori as shown by members of Schizaeaceae particularly from genera such as *Mohria,* though in his opinion the relationship between them is not clear. Ching's (1940) concept of evolution is that the pteroid-gymnogrammoid series evolved from dicksonioid stock and cheilanthoid ferns (Sinopteridaceae) evolved from Hypolepidaceae through the pteroid stock. Copeland (1947) holds a similar view and regards *Cheilanthes and Pellaea* as closely related to *Doryopteris.* He considers *Actiniopteris* as a minor variant of the group and *Adiantum* as an old and isolated genus having a common ancestry with *Cheilanthes* more immediately than that with *Pteris.* Holltum (1949) believes that Schizaeaceae originated from ancestral ferns with marginal sporangia or sori, but with no indusia and evolved into *Schizaea, Mohria, Anemia* and *Lygodium.* He considers that adiantoids, cheilanthoids, pteroids and vittarioids evolved from the same source.

There is now consensus of opinion among Pteridologists that the pteroid-adiantoid-cheilanthoid groups are derived from a schizaealean stock. According to

Nayar (1970), among Schizaeales, the Lygodiaceae show the closest similarity with these groups. The submarginal nature of the sorus, presence or absence of reflexed margin and solenostelic or dictyostelic nature of vascular bundles suggest that they probably served as ancestors for the evolution of adiantoid-cheilanthoid ferns in different lines. But the extant Lygodiaceae are evidently specialized ferns and it is quite unlikely that they are ancestral to these ferns. It is more likely that the Lygodiaceae as well as the adiantoid-cheilanthoid groups had common immediate ancestors. He believes that pteroids, adiantoids and cheilanthoids arose due to parallel evolution from Lygodiaceae.

The Vittariaceae are some times placed along with the genera of Pteridaceae in the same family due to its relationship with *Adiantum* (Holltum, 1949; Crabbe *et al.*, 1975). The relationship of vittarioid ferns is based on the occurrence of 'spicular cells' in both the genera. But spicular cells are present only in one species of *Adiantum*, *viz.*, *A. macrophyllum. Adiantum* also differs considerably from vittarioid ferns in epidermal characters and stomatal type. Stomata are anomocytic in all species of *Adiantum* where as they are polocytic in vittarioid ferns (Chandra & Hashim, 1974).

Among the subfamilies of Pteridaceae which are treated here, Adiantoideae appear to be most the primitive, although it is probable that all the subfamilies were derived from a schizaeaceous stock in parallel evolution. The nature of reflexed margin in Adiantoideae is quite different from the reflexed margin of other genera. In *Adiantum* the fertile leaf margin itself is rolled and hence the reflexed margin has veins in it and produces sporangia, while in other members, the reflexed margin is an extension of the leaf margin which turns back to cover the sori and are devoid of veins. The spores of *Adiantum* are primitive type. They are trilete, tetrahedral, devoid of a perine and devoid of any prominent ornamentation. All these features make *Adiantum* distinct from other genera and suggest its evolution through an independent line from the schizaeoid stock.

On account of the similarity of sorus, cheilanthoid ferns are included in the Pteridaceae by some authors. But the spores of cheilanthoid ferns are greatly different from those of pteroids in the fact that the spores of the former have a distinct perine and it is characteristically wrinkled and ornamented in more advanced members. Among ferns possessing tetrahedral spores, there is no other group having a distinct perine and this distinguishes cheilanthoids from others. Nayar and

Devi (1967) report that the non-perinate condition is more primitive among the cheilanthoid ferns and that evolutionary progression in the group has been towards the possession of prominent large folds which ultimately become reticulated. Tryon and Tryon (1973) on the basis of geographic analysis and spore characters indicated that the rugulose and cristate forms of sporoderm represent the basic spore type of species derived from a common ancestral group, where as the other form such as echinate, verrucate, reticulate and granulate represent specialization. Among cheilanthoid ferns *Pellaea* is the most primitive having no perine. *Doryopteris* and *Parahemionitis* are having comparatively advanced type of spores. Among *Cheilanthes* species, *C. anceps* and *C. bullosa* are primitive while the other species are advanced. On the other hand, spores of pteroids are having an equatorial collar which also occurs in Taenitidoideae. It is based on the presence of this type of spore that Tryon *et al.* (1990) included *Actiniopteris* alongwith *Pityrogramma* and *Anogramma* in the subfamily Taenitidoideae. But the former remains an alien in this subfamily because of having marginal commissure and reflexed margin instead of acrostichoid condition shown by other genera. Devi (1980) reports that the equatorial collar in *Pteris, Actiniopteris* and *Pityrogramma* is variable in form as it could be single, double, continuous or interrupted as the case may be. It is clearly a prolongation of the exospore in the equatorial plane and most often does not carry the exospore ornamentation on it. In Cheilanthoideae, *Parahemionitis* is also included which shows vein reticulation and acrostichoid condition. Pichi-Sermolli (1977) is of the opinion that acrostichoid condition is only a development of relatively minor taxonomic significance from the genera with marginal sori.

Hence it is concluded that Adiantoideae, Cheilanthoideae and Taenitidoideae were evolved from schizaeoid stock with submarginal sorus and reflexed margin independently. In Adiantoideae the fertile leaf margin rolled up and became the pseudoindusium which contains veins bearing sporangia. *Adiantum,* the sole genus of the subfamily Adintoideae is generally regarded as being neither primitive nor advanced phylogenetically (Mickel, 1974b). It is now generally agreed that the genus occupies a rather isolated position within the gymnogrammoid group and evolved independently in a different line. Those *Adiantum* species with unipinnate fronds and erect rhizome, *viz., A. caudatum, A. incisum, A. philippense* and *A. zollingeri* are considered as primitive which evolved along two lines, one with suberect rhizome and dichotomously branched lamina represented by *A. hispidulum* and the other line

with suberect to short or long creeping rhizome and two to three or four pinnate fronds represented by *A. capillus-veneris, A. concinnum, A. latifolium, A. poiretii, A. raddiantum* and *A. tenerum.* The Cheilanthoid line developed marginal sori covered by sterile marginal flap or acrostichoid condition with reticulate veins. The taenitidoid line is characterized by acrostichoid condition with spores having equatorial collar. But the inclusion of *Actiniopteris* in this subfamily exclusively on the basis of spore characters is untenable since this taxon with sorus developing along a marginal commissural line which is protected by a continuous reflexed margin, with scales and hairs and with spores having equatorial collar is more closely related to pteroids than the taenitidoids.

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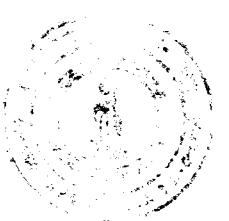

SUPPORTING PUBLICATION

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ADIANTUM TENERUM SW. (ADIANTACEAE, PTERIDOPHYTA), A LITTLE KNOWN MAIDENHAIR FERN FROM SOUTH INDIA

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ABSTRACT

Adiantum tenerum Sw. (Adiantaceae), a little known species in South India is found naturalized in Kerala State. The plant is described with illustrations.

INTRODUCTION

During the course of study on 'maidenhair ferns' of South India, we have collected an *Adiantum* species from the suburb of Calicut city, Kerala (MSL) growing on the laterite wall of a well. Later, it was found growing profusely on the steep earth cuttings in moist semi-shaded areas in a nearby locality. One specimen was sent to Dr. B. Verdcourt of Royal Botanic Gardens, Kew who identified it as *Adiantum tenerum* Sw., which is supposed to be an escape from cultivation. This species is a native of Barbados, West Indies (Rogers, 1998) and extend from Florida and Mexico to Peru (Blatter & d'Almeida, 1922; Hoshizaki, 1970). Its history in India is unknown.

Except for Blatter and d'Almeida (*l.c.*) and Nayar (1961), who described this taxon as a cultivated species, little is known about this species in India. Dixit (1984) and Chandra (2000) while enumerating the ferns of India, including the cultivated species, have not listed this species. Vasudeva *et al.* (1991), who revised the genus *Adiantum* of India and Madhusoodanan and Sevichan (1991), who described this genus for Kerala State, also did not mention about this species. Others who explored this area (Nair *et al.*, 1992; Nayar & Geevarghese, 1993) also have not reported the occurrence of this species in the wild. Recently Dixit and Sinha (2001) reported it as occurring only in Andaman and Nicobar Islands, but not in the mainland India. However, we found this species as already naturalized in Kerala, following other garden escapes such as *Adiantum capillus-veneris* L., *A. latifolium* Lam., *A. raddianum* C. Presl, etc. *A. tenerum* Sw. is a little known species in South India, hence it is described here with illustrations for easy identification.

Adiantum tenerum Sw., Prod. 135. 1788; Nayar, Bull. Nat. Bot. Gard. 52: 22-23. 1961. **[Fig. 1a-g].**

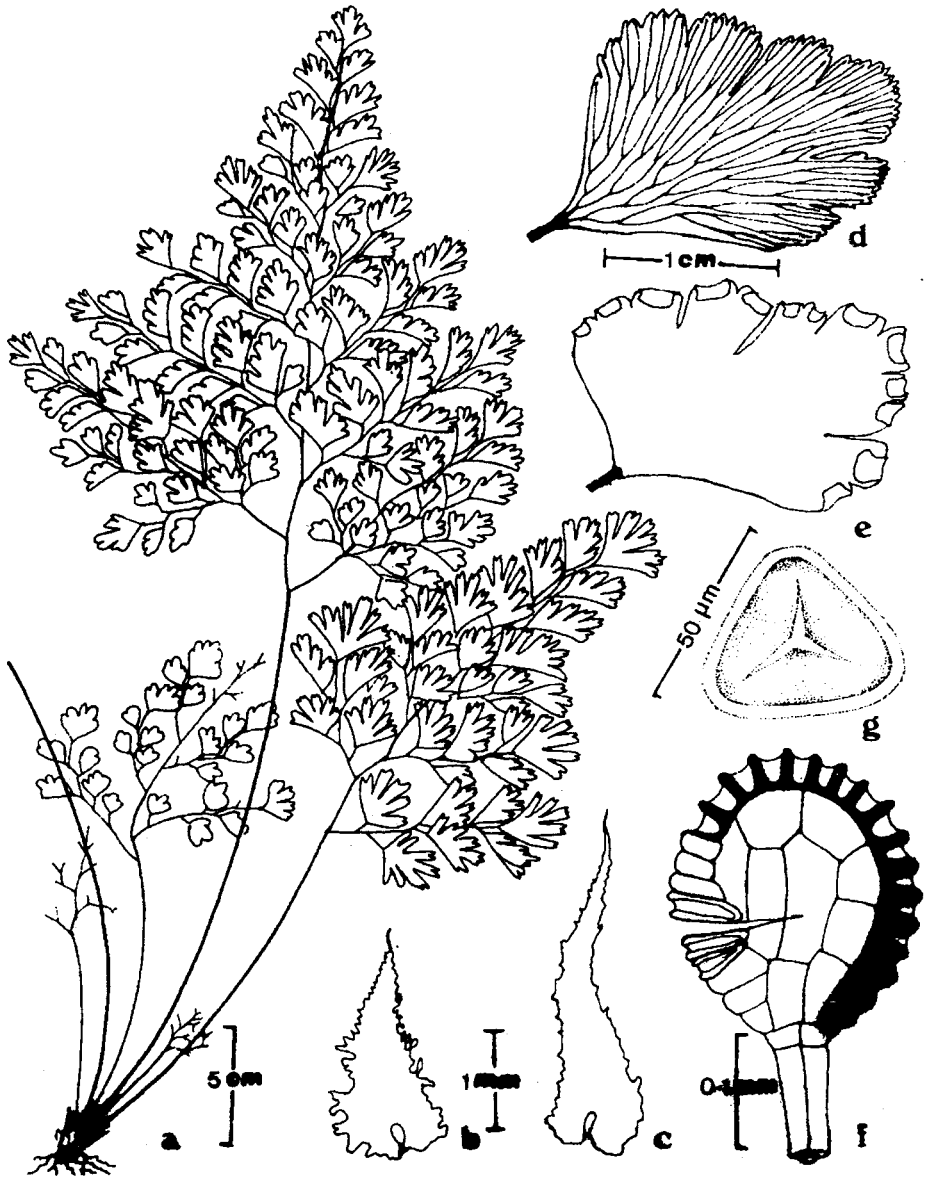

Fig. 1 **(a-g)**. *Adiantum tenerum* Sw.
a. Habit; **b.** Rhizome palea; **c.** Stipe base palea; **d.** Sterile pinnule; **e.** Fertile pinnule; **f.** Sporangium; **g.** Spore

Rhizome short creeping, branched, 1-1.5 cm long, 0.5 cm thick, densely clothed with paleae. Paleae concolorous, dark brown, 3.5 mm long, 0.5-1 mm broad (stipe base paleae longer and narrower than rhizome paleae), pseudo-peltate, terminating in a long acicular cell, margin of the paleae profusely dentate (in rhizome paleae the teeth grow out as branched hairs). Fronds large, 50-60 cm long, 15-20 cm broad, tufted, spreading; stipe 25-30 cm long, 1.5 mm thick, black glossy, grooved on the upper side, paleae restricted to extreme base; lamina 25-30 cm long, 15-20 cm broad, 3-4 pinnate, deltoid-ovate; pinnae alternate; pinnules stalked, stalk 3-4 mm long, enlarged at apex forming a small black disc; pinnules articulated, variable in shape and size, mostly obdeltoid to subrhomboid, 1-2 cm long, 1-2.5 cm wide, glabrous, distal margin of sterile pinnules finely toothed with a vein terminating in each tooth. Sori 10-15 per pinnule, transversely elongated, occasionally slightly curved, limited to the distal margin. Sporangia short stalked, stalk smaller than capsule; spores trilete, tetrahedral, 36 x 40 µm, exine smooth.

Specimens studied: KERALA: Kozhikode District, Kalluthan Kadavu, MSL, 29 June 1999, *K. Mohana Kurup* CU 52813; Puthiyara MSL 2 February 2001, *K. Mohana Kurup* CU 73103 (CALI).

Ecology: A. tenerum Sw. is found growing in fully or partially shaded moist earth cuttings in the lower altitudes.

Note: Nayar (1961) has reported the occurrence of 2-celled paraphyses among the sporangia. But we could not see any such structure in our specimens. *A. tenerum* Sw. resembles *A. capillus-veneris* L. in general appearance but can be readily distinguished from it as follows:

1. Paleae highly fimbriate; fronds 3 or 4-pinnate; pinnules articulated, deciduous; stalk ends in a black disc, from which 2 or more pale green primary veins emerge ..... *A. tenerum*

1. Paleae smooth; fronds 2-pinnate; pinnules not articulated, not deciduous; stalk continues in to 2 dark brown primary veins ..... *A. capillus-veneris*

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