

STUDIES ON THE ASPLENIACEAE OF SOUTH INDIA



*Thesis submitted to the University of Calicut
in partial fulfilment of the requirements for the degree of*

Doctor of Philosophy

AZEEZ. K

**Department of Botany
University of Calicut
Kerala, India**

May, 2007

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DEPARTMENT OF BOTANY
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CERTIFICATE

Certified that the thesis entitled "***Studies on the Aspleniaceae of South India***" submitted by **Mr. Azeez. K** for the Degree of **Doctor of Philosophy** in Botany of the University of Calicut is a bona fide record of research work done by him in this Department under my supervision and this has not been formed the basis for the award of any Degree.

C.U. Campus

02.05.2007

A handwritten signature in blue ink, followed by the date '02/05/07' written below it.

Dr. P. V. Madhusoodanan

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DECLARATION

The thesis entitled "*Studies on the Aspleniaceae 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 of any degree/diploma to the best of my knowledge.

C.U. Campus

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*I Dedicate
this research work to
Prof.(Dr.) P.V. Madhusoodanan.
My most beloved Teacher,
he has been the true force of inspiration for my
Teaching career as well as my Research inclinations.
As the motive behind all my Academic accomplishments,
my humble offering to you sir.....*

*"The fragrance of flowers spreads
only in the direction of the wind.
But the goodness of a person spreads in all directions."*

Chanakya

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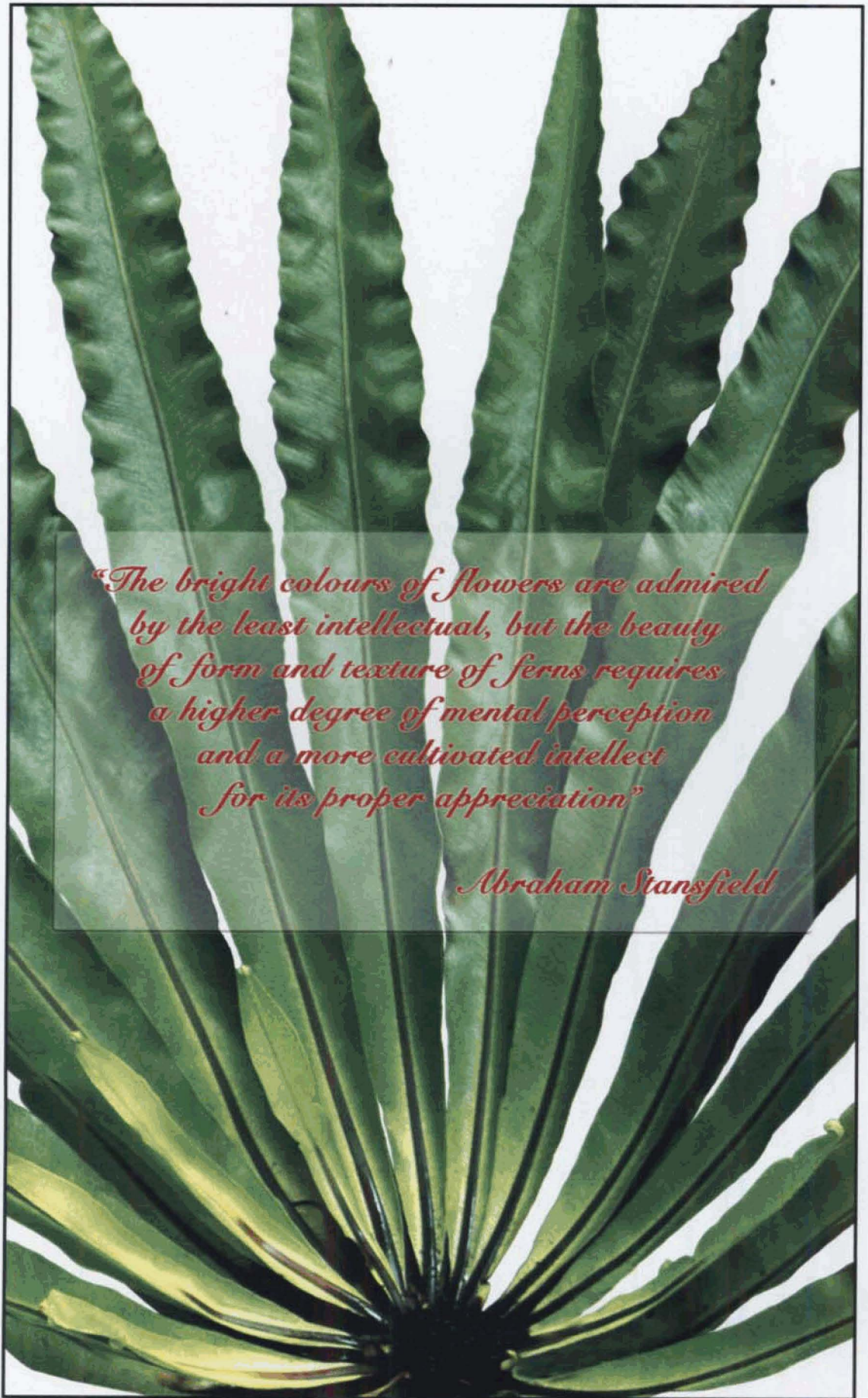
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*"The bright colours of flowers are admired
by the least intellectual, but the beauty
of form and texture of ferns requires
a higher degree of mental perception
and a more cultivated intellect
for its proper appreciation"*

Abraham Stansfield

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INTRODUCTION



INTRODUCTION

The word "Pteridophyte" is derived from the Greek words "Pteron" meaning feather and "Phyta" meaning plant, due to their feather-like leaves. The Pteridophytes represent the most primitive vascular plants having a simple reproductive system and lacking flowers and seeds. In the case of these plants sporophytes are the dominant phase of the life cycle. The Pteridophytes are ancient plants whose antecedents go back to the Devonian and Cambrian periods of Palaeozoic era. Many extant groups can be regarded as continuing lineages that separated from each other far back in the remote geological past (Given, 2002). However, today this primitive group of land plants have world wide distribution, spread in all continents, except Antarctica, favouring moist temperate and tropical climate, and can be found everywhere, but for the most frigid and most arid environments. They have evolved to occupy almost every ecological niche, however, the greatest species diversity is found in tropical and temperate rain forests. There has been rapid fragmentation of this biome over recent decades with many of their Pteridophytes yet undiscovered, let alone scientifically described.

The Pteridophytes consist of ferns and fern allies, which remain one of the most enigmatic groups of vascular plants even after centuries of work on their phylogeny and classification (Vasudeva, 2002). The fern allies dominated the earth, about 300 million years ago, in a period called the Carboniferous (literally "coal-bearing"). Unlike today's herbaceous fern

allies, these plants were huge and giant forming the first arborescent members of the earth. About 85% of the living Pteridophytes are ferns. In fact, there are probably about 12000 species of Pteridophytes in the world, most of these found in tropics. Unlike the fern allies which are a relic group, the ferns are highly successful and are virtually found in any habitat where the flowering plants are found.

A keypoint to note on the life of ferns is that the location of the sporophyte is determined by the gametophyte. The gametophyte can only grow in places where there is enough water to develop and survive, even if this is only a few weeks in a year. This gametophyte is generally much similar to that of a leafy liverwort. Two important generalizations about the ecology of Pteridophytes are that they are rarely dominant in climax vegetation, and that their presence is dependent on conditions that, at least seasonally, allow development of gametophytes and reproduction (Given, 2002).

The ferns and fern allies are generally unfamiliar to the layman, but have attracted the attention of botanists since long, mainly on account of their unique position in the plant kingdom, *i.e.*, intermediate between the higher vascular plants and the lower cryptogams, and also because of their characteristic life cycle in which the sporophytic and gametophytic generations are not only independent of each other, but are autotrophic and morphologically quite distinct. The main bulk of the extant Pteridophytes is constituted by the ferns (Filicales). The other members are whisk ferns

(Psilotales), horse-tails (Equisetales), club mosses (Lycopodiales), spike mosses (Selaginellales), quillworts (Isoetales), commonly termed as fern-allies, are fewer in number. There is a long geological history for the ferns and fern allies. The present day ferns originated some 240 million years ago, about 100 million years before the flowering plants appeared on the earth's surface, although most of the modern ferns have no fossils. Because of their antiquity, the study of the classification of the present day ferns has assumed great significance (Vasudeva, 2002).

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 and 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 (Koshoo, 1995). Pteridophytes constitute a sizable portion of the extant flora of India (5% of the total vascular plants), yet have not attracted good attention from plant scientists of the country (Bir, 1987). 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 and Madhusoodanan, 1998). This region is not only rich in diverse ferns, but a good number of them are endemic also. Chandra (1998) recognised

Peninsular India, as one of the eight phyto-geographical regions in India since this region possesses about 25% of the total number of ferns endemic to India, which is the highest among all these regions.

As many two-thirds of the world's plant species are in danger of extinction in nature during the 21st century, threatened by explosive human population growth, deforestation, habitat loss, destructive development, the spread of alien invasive species and agricultural expansion. Further loss of plant diversity is predicted through genetic erosion and narrowing of the genetic basis of many species. The disappearance of such vital and massive amounts of biodiversity poses one of the toughest challenges faced by the present world community; to halt the destruction of the plant resources that are so essential for present and future needs (BGCI, 2000). So it is important to survey as soon as possible those tropical areas which are under threat.

Ferns in general and asplenioid ferns in particular are very sensitive to environmental imbalance and anthropogenic activities. As a result, these ferns are facing the threat of extinction. In this context, a detailed study based on their distribution, ecology, morphology, systematics, anatomy and palynology of the genus *Asplenium* L. of South India is very pertinent.

The genus *Asplenium* L., known in English as "spleenwort", in French as "doradille", and in Spanish as "daradilla", is the type genus of the family Aspleniaceae with about 74 taxa including variety and forma are representing nearly 10-12% of the total fern flora of the country. All species of *Asplenium* L. are shade loving ferns usually grow as epiphytes or

lithophytes at an altitude 1200-2700m except a very few terrestrial species (Das, 2004). Both the scientific name and the common name spleenwort are derived from an old belief based on the "*doctrine of signature*" that the fern was useful for ailments of the spleen (In Greek 'Splēn' means spleen), due to the spleen shaped sori on the under surface of the frond (wort is an ancient name that simply means plant).

The genus *Asplenium* L. is rather easily recognizable by a combination of characters –usually the small size, thin texture, veins usually free and ending far short of the margin, often in hydathodes visible from the upper surface, sori elongate, dorsal, on the veins, and indusia conspicuous and persistent, elongate, membranous, glabrous, entire, directed proximally and covering the sporangia while young. One of the most important characteristic features is the rhizome scales (and blade scales where they exist, although they are not abundant in most species), which are "clathrate" that is to say like a window with numerous small panes of clear colourless glass (Morton *et al.*, 1966).

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REVIEW OF LITERATURE

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TAXONOMY AND PHYLOGENY

Asplenium L. is one of the largest and most distinct genera of ferns, consisting of nearly 650 species (Christensen, 1938; Ching, 1940; Tryon and Tryon, 1982) of which 82 (Dixit and Vohra, 1984), 65 (Singh and Bir, 1989; Bir, 1998), 74 (Das, 2005) species are reported in India. It is one of the earliest recognised genera and was included among the 14 genera of ferns listed by Linnaeus (1753) in 'Species Plantarum'. It is one of the 15 genera of ferns and fern allies reported by Van Rheede (1678-1703) in his *Hortus Indicus Malabaricus*, the first illustrated account on the plant wealth of India and was even used by Linnaeus (1753) while naming them in his 'Species Plantarum'. Most of the plants described in *Hortus Malabaricus* are flowering plants; volume XII contains monocots and 15 species of Pteridophytes in 20 plates, of which one species is *Asplenium falcatum* Lam. (Nella-Panna-Maravara) as recognized by Madhusoodanan *et al.*(1994), while it is identified as *Asplenium decrescens* Kunze by Manilal (2003).

The asplenioid ferns are circumscribed into family Aspleniaceae and centred around the type genus *Asplenium* L. (Pichi-Sermolli, 1977). The family Aspleniaceae is included under the order Cyatheaales of subclass Filicidae of the class Filicopsida (Nayar, 1970). In contrast to Copeland's (1947) recognition of nine genera of asplenioid ferns, Pichi-Sermolli (1977) attributed as many as 17 genera to this group. In India, these ferns are

represented by only three genera viz., *Asplenium* L., *Ceterach* Willd, and *Phyllitis* Ludwig with only about 50 representatives scattered over the entire Indian subcontinent but mainly concentrated in the Himalayas and mountains of South India. Majority of the species are either epiphytic or lithophytic and true terrestrial species are very few (Bir *et al.*, 1981). The detailed distribution, ecology, phyto-geography, systematics and taxonomy of Indian asplenioid ferns have been given by Singh and Bir (1989); Bir (1998) and Das (2004, 2005). Bir (1998) critically worked on asplenioid fern in his monograph of asplenioid fern with conspectus of different classification and phylogenies in relation to the asplenioid genera or the family Aspleniaceae.

According to Diels (1898-1900) the family Aspleniaceae is a heterogenous group of 15 genera and is composed of two subdivisions Aspleninae and Blechninae. Later, Bower (1928) separated these two sections as asplenioid and blechnoid ferns. The former group was subdivided into two sections consisting of 'Sori indusiate' (*Asplenium* L., *Athyrium* Roth., *Diplazium* Sw. and *Diplaziopsis* C. Chr.) and 'Sori exindusiate' (*Ceterach* Willd., and *Pleurosorus* Fee). Bower (1928) assembled *Asplenium* L. and *Athyrium* Roth. in the same group of his indusiate asplenioid ferns, though these genera differ markedly in the matter of vascular supply to sorus (Bir, 1962). Bower (1928) considered that the whole group probably had a dryopteroid affinity, while the blechnoid ferns were of cyatheoid origin. Among contemporary pteridologists Ching (1940)

follows Bower (1928) in his concept of the asplenioid ferns but postulates an affinity to the thelypteroid instead of the dryopteroid ferns. Referring to chromosome numbers alone Abraham *et al.* (1962) have suggested that the Cyatheaceae, Thelypteridaceae, Blechnaceae, and Aspleniaceae possibly have originated from types like the Gleicheniaceae. Spore morphology, however, does not support this view: the Gleicheniaceae and the Cyatheaceae have tetrahedral spores, while the others have bilateral periniferous spores (Nayar & Devi, 1964).

Christensen (1938) and Ching (1940) utilised the information afforded by Bower and segregated these two genera namely *Asplenium* L. and *Athyrium* Roth. and their allies in sections or tribes under the same group. It pertains to subfamily Asplenoideae of Christensen and family Aspleniaceae of Ching. Dickason (1946) accepts Ching's numerous families but arranges them, in two groups on the basis of the position of sorus on the vein and implies that the main groups of families arose more or less simultaneously from common basic stock. His family Aspleniaceae remains the same as that of Ching. Copeland (1947) removed *Athyrium* Roth. and its allied genera to his family Aspidiaceae while Holttum (1947, 1949) created subfamily athyrioideae of the family Dennstaedtiaceae to include this group of ferns. Alston (1956) raised Holttum's subfamily Athyrioideae to a family rank as Athyriaceae, the position of Aspleniaceae being the same, composed only *Asplenium* L. and its allies. Later Pichi-Sermolli (1958, 1959) placed these two families, Aspleniaceae of Copeland (1947) and Athyriaceae of Alston

(1956) in the order Aspidiales of subclass Filicideae, but without the assignment of various genera (Bir, 1962). Mehra (1961) while presenting a phyletic classification of ferns based on cytological evidence accepted this view of assigning *Asplenium* L. and *Athyrium* Roth. and their allied groups of genera to separate families, Aspleniaceae and Athyriaceae respectively. He considered these families to have evolved from Gleicheniaceae stock. According to him (Mehra, 1961) Athyriaceae is allied to Aspidiaceae as earlier assumed by Copeland (1947). Also Thelypteridaceae and Aspleniaceae seemed to be allied as assumed by Ching (1940). This is being supported on evidence from cytology, both having primarily $x=36$ though they must have evolved independently from the same immediate stock. But both of these belong to Gleicheniaceae series of Mehra (1961). A few years later (Mehra & Bir, 1964) adopted the separation of *Asplenium* L. and *Athyrium* Roth. group of genera into separate families in 'Pteridophytic Flora of Darjeeling and Sikkim Himalayas'. Holttum (1959) in 'Flora Malesiana' preferred to call these families as *Asplenium* L. and *Athyrium* Roth. group of ferns. But both belong to Gleicheniaceae series of Mehra (1961).

The widely accepted view that emerged by late 1960s was to split the conventional family Aspleniaceae into two and segregate *Asplenium* L. and *Athyrium* Roth. group of genera into separate families. *Asplenium* L. and *Athyrium* Roth. groups of genera are two diverse elements of the leptosporangiate ferns and they appear to have developed from different

sources. They differ apart from chromosome numbers, in scale structure, mode of vascular supply to the sorus, architecture of leaf traces in the petiole and rachis, and finally in the structure of meristeles (Bir, 1962, 1998). Pichi-Sermolli (1977) included Aspleniaceae under the suborder Asplenineae of the order Aspidiales.

The Aspleniaceae constitutes an obviously successful group of ferns. Their nearest ally among modern ferns seems to be the thelypteroid genera. Both groups share several characters in common including a common chromosome number ($x=36$) as well as characteristically similar spores and prothalli. However, the Aspleniaceae are not probably descended from the Thelypteridaceae or vice versa. Both groups derived from cyatheoid stock. Thus the Dryopteridaceae and the Aspleniaceae-Thelypteridaceae group are assigned the same parentage; they however represent independent line of descent (Nayar and Kaur, 1974). The basic plan of rhizome structure of *Asplenium* L. resembles that of *Blechnum* L. The presence and origin of perforations observed in the basal region of *A. ensiforme* Wall. ex Hook. & Grev. resembles that seen in *Stenochlaena palustris* (Burm.) Beddome. It is concluded that these anatomical comparisons give good support to the natural affinities of asplenioid and blechnoid ferns (Mehra and Chopra, 1951).

Asplenioid ferns were long confused with *Athyrium* Roth. and have remained as a group of uncertain affinity (Holttum, 1968; Devi, 1974). The genus *Asplenium* L. and *Athyrium* Roth. have sori of similar shape, and

some species of the latter may easily be confused with *Asplenium* L., but there is little doubt that *Athyrium* Roth. and *Asplenium* L. have had different origins, as indicated by the constant difference in the vascular strands in their stipes, by their scales, and in the more finely dissected species by the rachis structure. Moreover majority of *Asplenium* L. are epiphytes or rock-ferns, in contrast to the terrestrial *Athyrium* Roth. species (Holttum, 1968). Various Pteridologists suggested their origin directly or indirectly from the cyatheoid (Copeland, 1947), gleichenioid (Alston, 1956; Pichi-Sermolli, 1956; Abraham *et al.*, 1962), thelypteroid (Ching, 1940; Mehra, 1961) or dennstaedtoid (Holttum, 1947) group of ferns.

Ching (1940) introduced Aspleniaceae as a family, though this name was used by Presl (1836) as name of a tribe. According to Copeland (1941) the citation should be family Aspleniaceae (Presl) Ching. Later on Copeland (1947) attributed familial name Aspleniaceae to Division. Holttum (1954) in Flora of Malaya treated Asplenioidae as subfamily and within this subfamily the large genus *Asplenium* L.. Alston (1956) raised Holttum's subfamily to family rank Aspleniaceae. At present most of the taxonomists of Pteridophyta in India follow Pichi-Sermolli (1977) with a little modification based on Ching (1978). So according to Pichi-Sermolli (1977) the correct citation is family **Aspleniaceae Mettenius Lx-Frank**. Tryon and Tryon (1982) cited Aspleniaceae Frank. According to Kramer in Kubitzki (1991) Aspleniaceae is a rather isolated family with a single genus *Asplenium insertaesedis* among higher Leptosporangiates. He stated that *Asplenium* L.

seems to be a fairly recent genus fully in process of evolution with a high degree of interfertility between morphologically divergent members. He also stated that at present we do not have any idea as to which part of *Asplenium* L. may be basal (Primitive) and this cause difficulty in relating the family to another one.

Pichi-Sermolli (1977) recognised 17 genera, Kramer and Viane (in Kubitzki, 1990) accepted only one genus *Asplenium* L., after merger of *Phyllitis* Ludwig, *Scolopendrium* Adans., *Ceterach* Willd., *Camptosorus* Link, *Neottopteris* J. Smith, *Asplenidictyum* (Hook.) J. Smith, *Ceterachopsis* (J. Smith) Ching, *Hymenasplenium* Hayata, etc. into it. Kramer and Viane in Kubitzki (1990) noted that as to the recognition of natural infrageneric groups, whether subgenera or sections *Asplenium* L. is still extremely poorly known. But in the multiple genera family Aspleniaceae (of Copeland 1947, Pichi-Sermolli 1977, Tryon and Tryon 1982 etc.) intergeneric hybrids are well known eg. as *Asplenium* L. members form hybrids with *Ceterach*, *Camptosorus*, *Ceterachopsis*, *Phyllitis* (= *Scolopendrium*) etc. (Bir, 1998).

It is to be noted that genus *Asplenium* L. thus construed is a diversified genus and as already been pointed out by Bir (1962) and Bir *et al.* (1985) that in order to represent the various evolutionary tendencies of morphological nature within the genus, such genera as *Ceterach* Willd., *Ceterachopsis* J. Smith ex Ching, *Neottopteris* J. Smith, *Asplenidictyum* J. Smith, *Hymenasplenium* Hayata and *Phyllitis* Ludwig attributed to the asplenoid ferns are treated as subgenera for the reason that these do not

merit a generic status because some of these not only form intergeneric hybrids with *Asplenium* L. (*Ceterach*, *Ceterachopsis*) but also exhibit great similarities of anatomical, gametophytic and morphological characters. (*Asplenidictyum*, *Neottopteris*) with members of *Euasplenium* although all of these share the same basic chromosome number $x=36$ (or rarely 40) Bir (1998).

Asplenium L. is essentially a world wide genus that occurs in all continents, flourishing in all habitable lands, usually found in moist forests. Beddome (1863) reported 24 species of *Asplenium* L. from South India, the Madras Presidency, where as Beddome (1883) reported 38 species from British India, Ceylon and the Malay Peninsula. Manickam and his co-workers made detailed studies of *Asplenium* L. from certain selected pockets of South India. He reported 16 species and 3 varieties of *Asplenium* L. from Palnihills (1986), whereas Manickam and Ninan (1976) reported 17 species from the same locality. Manickam *et al.* (2004) reported 2 species of *Asplenium* L. from Sirumalai Hills, South India. Manickam and Irudayaraj (1992) reported 22 species and 3 varieties of *Asplenium* L. from the Western Ghats, South of Palghat gap, South India, of which 9 are cytologically analysed. Manickam and Irudayaraj (2003) reported 15 species of *Asplenium* L. from Nilgiris, South India. All these species are common with the Western Ghats, South of Palghat gap (Manickam and Irudayaraj, 1992). Nair and Ghosh (1978) reported the rare Fern *Asplenium grevillei* Wall. ex

Hook. & Grev. from the Kulathupuzha Forest Division, Kerala State, South India and is a new record to Peninsular India.

Singh and Bir (1989) reported the occurrence of 31 species of *Asplenium* L. from South India of these six species viz., *A. aethiopicum* (Burm. f.) Becher., *A. auritum* Sw., *A. decrescens* Kunze, *A. erectum* Bory ex Willd., *A. serricula* Fee and *A. zenkeranum* Kunze are endemic to South India. Nayar and Geevarghese (1993) reported 10 species of *Asplenium* L. and 4 varieties of *A. unilaterale* Lam. from Malabar, Northern half of Kerala state, South India. Azeez *et al.* (1996) made a critical study about the morphology, taxonomy, palynology, ecology and distribution of 20 taxa of *Asplenium* L. from the state of Kerala. Pullaiah *et al.* (2003) reported 6 species of *Asplenium* L. (*A. formosum* Willd., *A. obscurum* Bl., *A. indicum* Sledge, *A. polydon* G. Forst., *A. laciniatum* D. Don, and *A. aethiopicum* (Burm. f.) Becher.) from the State of Andhra Pradesh, South India. All these 6 species are reported from other parts of South India also. Rajagopal and Bhat (1998) conducted a detailed study on the pteridophyte flora of Karnataka State, South India. In their study they estimated a total of 174 species (153 ferns and 21 fern allies) including 16 species of *Asplenium* L. Kumar (1998) reported the occurrence of 17 species of *Asplenium* L. from Sylvan Valley, Munnar, Kerala State. Kumar *et al.* (1998) reported 14 species of epiphytic *Asplenium* L. from Kerala part of Western Ghats, South India. Karuppusami *et al.* (2001) reported 3 species of *Asplenium* L. (*A. decrescens* Kunze, *A. indicum* Sledge, and *A. aethiopicum* (Burm. f.)

Becher.) out of 39 species of ferns belonging to 16 families from Sirumalai Hills of Dindigal District, Tamil Nadu, South India. Kishorkumar *et al.* (1998) reported 7 rare, endangered and endemic species of *Asplenium* L. (*A. aethiopicum* (Burm. f.) Becher., *A. auritum* Sw., *A. erectum* Bory ex Willd., *A. formosum* Willd., *A. polydon* G. Forst., *A. tenuifolium* D. Don, and *A. zenkeranum* Kunze) from the Shola forest of Kerala State. Kumar *et al.* (1998) reported a little known species of *Asplenium* L. (*A. laciniatum* D. Don) which is a new record to Kerala and two other species, *A. auritum* Sw. and *A. tenuifolium* D. Don are re-discovered from Kerala Hills after a lapse of over hundred years. Easa (2003) enumerated a total of 30 species of *Asplenium* L. from Kerala, South India, as a part of bio-diversity documentation for Kerala. He made this study based on published reports only and he included the habit, habitat, status of the taxon, distribution in Kerala and global. Irudayaraj *et al.* (1995) studied intraspecific variation in *A. affine* Sw. from India. They reviewed the nomenclatural problems in general for this taxon and determined the ploidy level of South Indian gatherings. The cytological study reveal the presence of 144 bivalents (XCH 3382) during meiosis (Irudayaraj and Manickam, 1995) and thus proved to be octaploid based on $x = 36$. The present study shows that the South Indian gatherings are of *A. affine* forma *affine* and are confined to Tirunelveli Hills in India, While three intraspecific taxa (forma *affine*, forma *majus* Sledge and forma *tennuisectum* Sledge) and two cytotypes (Octaploid and dodecaploid) have been reported from Srilanka (Manton *et al.*, 1954; Sledge, 1962; Sledge, 1965). Previous reports show the presence of both forma *affine* and

forma *majus* of *A. affine* in South India (Sledge, 1962,1965; Beddome, 1864; Dixit, 1984; Sing *et al.* 1989). Rajkumar (2004) reported a second distributional area in South India for the rare little known species, *A. affine* Sw. from the Western Ghats ranges of Kudremukh National Park of the Karnataka State, South India, as it was previously collected only from Tirunelveli Hills of Tamil Nadu (Manickam and Irudayaraj, 1992; Chandra, 2000).

The detailed distribution, ecology, phyto-geography, systematics and taxonomy of Indian asplenioid ferns have been done by Singh and Bir (1989); Bir *et al.* (1991); Bir, (1998); Pandey (1990); Vasudeva (1995); Azeez and Madhusoodanan (1996); Pandey *et al.* (2002); Das (2004, 2005) etc. Das (2004) reported a detailed distribution patterns of Aspleniaceae in India. It reveals that 56.9% are Eastern Himalayan, 41.5% are Western Himalayan and 47.6% are Southern Indian species. 5.4% species are present in Andaman and Nicobar island. Detailed study of distribution of *Asplenium* L., five major zones have been noted in India. The largest number of species of *Asplenium* L. are concentrated in the 1500-2700m altitudinal zone of the Himalaya (Warm temperate forest) and *Asplenium* spp. of this region are represented in North-Eastern Himalayas and the species reported from this region have great similarity with Chinese species of *Asplenium* L. Second largest number is met within the South Indian Hills (Palnis, Anamalais and Nilgiris) have similarities with Srilanka, and Eastern and Western African species. Thirdly in Western Himalayas, *Asplenium* L.

species are common with European and Central Asian members. The central Indian region although have quite thick forest at Pachmarhi hills in Madhya Pradesh but *Asplenium* L. in these forest are not many. In Mount Abu in Rajasthan only one species of *Asplenium* L. (*A. pumilum* var. *hymenophylloides*), a small fern with thin membranous lamina is reported and is well distributed in Ethiopia. The *Asplenium* L. of Andaman and Nicobar Islands are very similar to Sri Lankan, African and Malaysian species.

Das (2004) reported 34 species of *Asplenium* L. from Eastern Himalayan Zone (Darjeeling, Sikkim, Assam, Meghalaya, Manipur, Nagaland, Tripura, Arunachal Pradesh) of which 14 species are endemic to that region and 11 species, are common with South India (Table 1). Out of 24 species of Western Himalayan Zone (Garhwal West ward to Kashmir) 14 species are endemic to that region and four species like *A. cheilosorum* Kunze ex Mett, *A. nidus* L., *A. obscurum* Bl., and *A. tenuifolium* D. Don, are common in South India. Out of 31 species in South India, seven species are endemic to this region and four species like *A. aethiopicum* (Burn f.) Becher., *A. affine* forma *majus* Sledge, *A. decreascens* Kunze and *A. disjunctum* Sledge have become rare and endangered (Das, 2004). Out of eight species of *Asplenium* L. reported from central Indian zone (Madhya Pradesh and mountains of Pachmarhi Hills) four species like *A. cheilosorum* Kunze ex Mett., *A. inequilaterale* Willd., *A. normale* D. Don, *A. obscurum* Bl., are common in South India where as from Andaman and Nicobar Islands a

total of six species are reported, of which three species like *A. nidus* L., *A. nitidum* Sw., and *A. tenerum* G. Forst. are common in South India. A final scrutiny of the distribution of *Asplenium* L. in India reveals that only five species like *A. ensiforme* Wall. ex Hook. & Grev., *A. nidus* L., *A. obscurum* Bl., *A. cheilosorum* Kunze ex Mett. and *A. unilaterale* Lam. are common in Eastern Himalaya, Western Himalaya and South India.

Das (2000) made a detailed distributional analysis of 20 multipinnate species of *Asplenium* L. from India, of which 12 species are endemic to India. Three species are confined to North-Western Himalayas, four species confined to South India, while five are confined to Eastern India and the rest of species have wider distribution in both South and North - East India. Recently (Das, 2005a) completed the Taxonomic revision of *Asplenium* L. in India, and reported 43 unipinnate species by providing correct nomenclature, key to the species, brief description, ecology and conservation strategies. This list includes 13 species from South India, viz., *A. formosum* Willd., *A. normale* D. Don, *A. obscurum* Bl., *A. erectum* Bory ex Willd., *A. zenkeranum* Kunze, *A. decrescens* Kunze, *A. polydon* G. Forst., *A. crinicaule* Hance, *A. inequilaterale* Willd., *A. tenerum* G. Forst., *A. serricula* Fee, *A. auritum* Sw., and *A. unilaterale* Lam.. Das (2005b) reported nine species of *Asplenium* L. with simple fronds out of 74 species reported from India. Of the nine species reported, only three species viz., *A. ensiforme* Wall. ex Hook. & Grev., *A. nidus* L. and *A. phyllitidis* D. Don occur in South India.

Bir and his co-workers made detailed taxonomic study of *Asplenium* L. in India, especially North-Eastern and Central India. Bir (1964) reported three varieties of *A. laciniatum* D. Don (*A. laciniatum* D. Don var. *laciniatum*, *A. laciniatum* D. Don var. *subintegrifolium* Hook. and *A. laciniatum* D. Don var. *acutipinna* Bir (var. nov.); one variety of *A. planicaule* Wall. (*A. planicaule* Wall. var. *obtusum* Bir (var. nov.)); one variety of *A. crinicaule* Hance (*A. crinicaule* Hance var. *sikkimense* Bir (var. nov.)) and three varieties of *A. nidus* L. (*A. nidus* L. var. *nidus*, *A. nidus* L. var. *acutifolium* Bir (var. nov.) and *A. nidus* L. var. *phyllitidis* (D. Don) Bir (Comb. nov.). Bir and Shukla (1968) reported 11 species and two varieties of *A. unilaterale* Lam. from Simla Hills, North Western Himalayas of which only three species like *A. ensiforme* wall. ex Hook. & Grev., *A. unilaterale* Lam. and *A. indicum* Sledge are common with South India. Bir *et al.* (1985) reported a new 'spleenwort', *A. punjabense* Bir, Fras.-Jenk. & Lovis and a new hybrid, *Asplenium* x *genicoalatum* Fras.-Jenk. (*A. dalhousiae* x *A. punjabense*) from India. Bir *et al.* (1991) made a detailed ecological, distributional and phyto-geographical account of the genus *Asplenium* L. in North-Eastern India. They reported the occurrence of 13 species of *Asplenium* L. from Low Hill tropical to subtropical forests up to 900m altitude from the North-Eastern States like Arunachal Pradesh, Assam, Mizoram, Nagaland, Tripura, Manipur and Meghalaya of which three species are common with South India (Table. 1). They further reported the occurrence of 27 species of *Asplenium* L. from Middle Hill sub-tropical forest of 750-1500m altitude of which nine species are common with South India (Table 1), while they reported 21 species from

Upper forests of 1500-2400m altitude; of which only seven species are common with South India (Table 1). Also, they reported 11 species of *Asplenium* L. from cold temperate forests of 2400-3000m altitude including six species common with South India (Table 1).

Table 1. South Indian Species of *Asplenium* L. Common with North-Eastern Himalaya*

Sl. No.	Name of Species	Locality	Reference
1.	<i>A. affine</i> Sw.	Eastern Himalaya	Das (2004)
2.	<i>A. cheilosorum</i> Kunze ex Mett.	Sikkim Himalaya North-Eastern India North-Eastern upper Hill Forest of 1500-2400m; Cold temperate Forests of 2400-3000m Eastern Himalaya	Mehra & Bir (1964) Vasudeva <i>et al.</i> (1990) Bir <i>et al.</i> (1991) Das (2004)
3.	<i>A. crinicaule</i> Hance	North-Eastern Himalaya Sikkim Himalaya North-Eastern India North-Eastern Himalaya, Middle Forests of 750-1500m; Upper Hill Forests of 1500-2400m	Bir (1964) Mehra & Bir (1964) Vasudeva <i>et al.</i> (1990) Bir <i>et al.</i> (1991)
4.	<i>A. ensiforme</i> Wall. ex Hook. & Grev.	Sikkim Himalaya North - Eastern India	Mehra & Bir (1964) Vasudeva <i>et al.</i> (1990)

Sl. No.	Name of Species	Locality	Reference
		North - Eastern Himalaya Middle Hill Forests of 750 - 1500m; Upper Hill Forests of 1500 - 2400m; Cold Temperate Forests of 2400-3000m. Eastern Himalaya	Bir <i>et al.</i> (1991) Das (2004)
5.	<i>A. formosum</i> Willd.	Eastern Himalaya	Das (2004)
6.	<i>A. nidus</i> L.	North-Eastern Himalaya Sikkim Himalaya Kamarup Dt., Assam North-Eastern India North-Eastern Himalaya, Low Hill Forests up to 900m ; Upper Hill Forests of 1500-2400m Cachar Hills District, Assam Assam Eastern Himalaya	Bir (1964) Mehra and Bir (1964) Barua <i>et al.</i> (1989) Vasudeva <i>et al.</i> (1990) Bir <i>et al.</i> (1991) Bhattacharya <i>et al.</i> (1995) Borthakur <i>et al.</i> (2000) Das (2004)
7.	<i>A. nitidum</i> Sw.	Sikkim Himalaya North-Eastern India North-Eastern Himalaya, Low Hill Forests up to 900m; Middle Hill Forests of 750-1500m Assam Eastern Himalaya	Mehra & Bir (1964) Vasudeva <i>et al.</i> (1990) Bir <i>et al.</i> (1991) Borthakur <i>et al.</i> 2000 Das (2004)
8.	<i>A. normale</i> D. Don	Sikkim Himalaya North-Eastern India	Mehra & Bir (1964) Vasudeva <i>et al.</i> (1990)

Sl. No.	Name of Species	Locality	Reference
		North-Eastern Himalaya, Middle Hill Forests of 750-1500m. Cold temperate Forests of 2400 - 3000m Assam Eastern Himalaya	Bir <i>et al.</i> (1991) Borthakur <i>et al.</i> 2000 Das (2004)
9.	<i>A. obscurum</i> Bl.	North-Eastern India North-Eastern Himalaya, Middle Hill Forests of 750-1500m Eastern Himalaya	Vasudeva <i>et al.</i> (1990) Bir <i>et al.</i> (1991) Das (2004)
10.	<i>A. phyllitidis</i> D. Don	North-Eastern Himalaya Sikkim Himalaya Kamarup Dt. Assam North-Eastern India North-Eastern Himalaya, Low Hill Forests of up to 900m; Middle Hill Forests of 750-1500m Assam Eastern Himalaya	Bir (1964) Mehra & Bir (1964) Barua <i>et al.</i> (1989) Vasudeva <i>et al.</i> (1990) Bir <i>et al.</i> (1991) Borthakur <i>et al.</i> (2000) Das (2004)
11.	<i>A. tenerum</i> G. Forst.	Eastern Himalaya	Das (2004)
12.	<i>A. tenuifolium</i> D. Don	Sikkim Himalaya North-Eastern India North-Eastern Himalaya, Middle Hill Forests of 750-1500m ; Upper Hill Forests of 1500-2400m; Cold temperate Forests of 2400-3000m Eastern Himalaya	Mehra & Bir (1964) Vasudeva <i>et al.</i> (1990) Bir <i>et al.</i> (1991) Das (2004)

Sl. No.	Name of Species	Locality	Reference
		West Kamerup Dt. Arunachal Pradesh	Bhattacharya & Chakravorty (2005)
13.	<i>A. unilaterale</i> Lam.	North-Eastern India North-Eastern Himalaya, Middle Hill Forests of 750-1500m; Upper Hill Forests of 1500-2400m; cold temperate Forests of 2400-3000m Cachar Hills Dt. Assam Assam	Vasudeva <i>et al.</i> (1990) Bir <i>et al.</i> (1991) Bhattacharya <i>et al.</i> (1998) Borthkur <i>et al.</i> (2000)

*Darjeeling, Sikkim, Arunachal Pradesh, Assam, Meghalaya, Manipur, Nagaland, Tripura.

Bir *et al.* (1991) also reported seven species of *Asplenium* L. from North-Eastern Himalaya common with Western Himalayas (West of Nepal), based on Bir (1963), Dhir (1980), Bir *et al.* (1983), Dhir and Saiki (1984), Khullar and Sharma (1987), Khullar *et al.* (1987) and Pande (1990 a & b). Of the seven species reported, six species like *A. cheilosorum* Kunze ex Mett., *A. ensiforme* Wall. ex Hook. & Grev., *A. nidus* L., *A. tenuifolium* D. Don, *A. unilaterale* Lam. and *A. yoshinagae* Makino are common with South India. They reported ten species of *Asplenium* L. common with Sri Lanka based on Sledge (1982), of which eight species, like, *A. cheilosorum* Kunze ex Mett., *A. ensiforme* Wall. ex Hook. & Grev., *A. nidus* L., *A. nitidum* Sw., *A. normale* D. Don, *A. obscurum* Bl., *A. tenuifolium* D. Don, and *A. unilaterale* Lam. are common with South India. They also reported 3 species of *Asplenium* L. common with Pachmarhi-Satpura Hills, Central India based on Tiwari (1964),

Bir & Vasudeva (1972, 1973), Vasudeva & Bir (1987) and all the three species, *A. cheilosorum* Kunze ex Mett., *A. normale* D. Don, and *A. unilaterale* Lam. are common with South India also. By referring Beddome (1863), Bir & Vasudeva (1971, 1979), Manickam (1986), Chandra & Kaur (1987), Manickam & Irudayaraj (1991), Bir *et al.* (1991) reported 14 species of *Asplenium* L. Common in South India and North-Eastern States. They reported 6 species of *Asplenium* L. common with Tropical Africa, by referring Alston (1959), of which *A. nitidum* Sw. and *A. unilaterale* Lam. are reported from South India. They reported 14 species of *Asplenium* L. common with Malaya, based on Holttum (1954), among that, *A. nidus* L., *A. normlae* D. Don, *A. cheilosorum* Kunze ex Mett., *A. nitidum* Sw., *A. phyllitidis* D. Don and *A. unilaterale* Lam. are common with South India. They further reported the occurrence of 10 species common with Japan based on Tagawa (1968), Nakaike (1975), Kurata & Nakaike (1979, 1981, 1983, 1985, 1987); 15 species common with Burma based on Dickason (1946), Dixit (1984); 11 species common with Tibet based on Wu (1983) and 13 species common with Nepal by referring Alston & Bonner (1956), Hara (1966, 1971), and Ohashi (1975). Of the 10 Japan species reported, *A. cheilosorum* Kunze ex Mett., *A. laciniatum* D. Don, *A. normale* D. Don, *A. unilaterale* Lam., *A. ensiforme* Wall. ex Hook. & Grev., *A. nidus* L. are common with South India; while among the species of Burma, *A. cheilosorum* Kunze ex Mett., *A. ensiforme* Wall. ex Hook. & Grev., *A. laciniatum* D. Don, *A. nitidum* Sw., *A. obscurum* Bl., *A. tenuifolium* D. Don, *A. unilaterale* Lam., *A. crinicaule* Hance, *A. nidus* L. and *A. normale* D. Don are common with South India.

Among the 11 species reported from Tibet, *A. ensiforme* Wall. ex Hook & Grev., *A. laciniatum* D. Don, *A. normale* D. Don, *A. phyllitidis* D. Don, and among the 13 species reported from Nepal *A. crinicaule* Hance, *A. nitidum* Sw., *A. tenuifolium* D. Don, *A. unilaterale* Lam., *A. cheilosorum* Kunze ex Mett., *A. ensiforme* Wall. ex Hook. & Grev., *A. laciniatum* D. Don, *A. normale* D. Don are common with South India. They further reported a single species of *Asplenium* (*A. khasianum* Sledge) endemic to North-Eastern India, based on Chandra (1982), Chandra & Kaur (1984), Dhir & Saiki (1984), Dixit (1984), Bir (1987), Dixit and Krishna (1990). This *A. khasianum* Sledge was reported by Sledge (1962) from Khasi Hills of Assam. Pande & Bir (1994) reported nine rare and threatened species of *Asplenium* L. from Kumaun Himalaya.

Detailed taxonomic and distributional study of *Asplenium* L. in central India was made by Dixit and his associates. Dixit (1984) reported the occurrence of 49 species and 17 varieties of *Asplenium* L. from India. Vasudeva and Bir (1987) reported one variety of *A. unilaterale* Lam. (*A. unilaterale* Lam. var. *majus* (C. Chr.) Sledge) from Tamia Hills and Patakot valley of Chindwara District, Madhyapradesh, which is collected from different localities of South India. Dixit (1989) reported six species of *Asplenium* L. from Madhya Pradesh, of which, four species, like *A. Cheilosorum* Kunze ex Mett., *A. obscurum* Bl., *A. indicum* Sledge, and *A. laciniatum* D. Don are common with South India. Vasudeva (1995) studied the peculiarities of pteridophytic flora of Pachmarhi, Satpura Hills of Madhya

Pradesh Central India. In this study he reported three lithophytic species of *Asplenium* L., *A. cheilosorum* Kunze ex Mett., *A. inequilaterale* Willd., and *A. normale* D. Don. All these three species are reported from South India. Also he pointed out that the pteridophytic flora of Pachmarhi, Satpura Hills is more akin to the South Indian members (87.17%) than the Himalayan ones (83.33%), although the percentage difference is very insignificant. The similarity appears to be correlated with intensive rains and the sub-tropical to tropical climatic conditions with higher temperatures prevailing at the Central and South Indian mountains as compared to the comparatively cooler climate in the Himalayas. Dixit and Singh (2003) reported four rare endangered and endemic species of *Asplenium* L. from Central India, of which, *A. inequilaterale* Willd., *A. normale* D. Don and *A. unilaterale* Lam. are reported from South India also. Dixit and Singh (2005) reported six species of *Asplenium* L. from the Chattisgarh state, Central India of which *A. cheilosorum* Kunze ex Mett. *A. indicum* Sledge; *A. laciniatum* D. Don; and *A. obscurum* Bl. are common with South India and Singh *et al.* (1995) reported a single species, *Asplenium cheilosorum* Kunze ex Mett. from Amarkantak, Anup pur District of Madhya Pradesh, which is collected from the different localities of South India.

Detailed taxonomic studies on Pteridophytes in general and asplenioid ferns in particular of Kumaun Himalaya (North-Eastern Himalaya) was made by Pande and his co-workers. Pande & Dashila (1988) reported seven species of *Asplenium* L. from Kunapokhari, Nachani and Munsyari

Hills of Kumaun Himalaya, of which, *A. nidus* L., *A. ensiforme* Wall. ex Hook. & Grev., *A. semivarians* Viane & Reichst. are common with South India, where as Pande and Basera (1988) reported two species of *Asplenium* L. from Berinag Hills (Western Himalaya), among that *A. indicum* Sledge is very common in South India. Pande (1990) reported the occurrence of 24 species of *Asplenium* L. from Kumaun Himalaya of which *Asplenium tenuicaule* Hayata var. *indopakistanicum* is a new report and eight species are common with South India (Table 2). Pande & Pande (1991) added one more species, *Asplenium bullatum* Wall. ex Mett. to the list of ferns reported in 1990.

Table 2. South Indian Species of *Asplenium* L. Common with North-West Himalaya*

Sl. No.	Name of Species	Locality	Reference
1.	<i>A. aethiopicum</i> (Burm. f.) Becher.	Kumaun Himalaya Almora & Bageswar Dt. of West Himalaya Kumaun Himalaya	Pande (1990) Pande & Pande (2002) " "
2.	<i>A. cheilosorum</i> Kunze ex Mett.	Kumaun Himalaya North-West Himalaya West Himalaya Pithorgarh & Champawat Dt. Kumaun Himalaya Kumaun Himalaya Western Himalaya	Pande (1990) Bir <i>et al.</i> (1991) Khullar (1994) Pande & Pande (2002) Pande & Pande (2003) Das (2004)
3.	<i>A. ensiforme</i> Wall. ex Hook. & Grev.	Simla Hills, North-West Himalaya Kumaun Himalaya " " North-West Himalaya	Bir & Shukla (1968) Pande & Dashila (1988) Pande (1990) Bir <i>et al.</i> (1991)

Sl. No.	Name of Species	Locality	Reference
		Kumaun Himalaya Roopkund Hills, Garhwal West Himalaya West Himalaya Almora & Bageswar Dt. West Himalaya Kumaun Himalaya Ninital & Udham Singh Nagar Dts, Kumaun Himalaya Kumaun Himalaya Almora Dt. Kumaun Himalaya	Pande & Pande (1993) Pande & Bhandari (1994) Khullar (1994) Pande & Pande (2002) " " " " Pande & Pande (2003) Baluttia (2004)
4.	<i>A. nidus</i> L.	Kumaun Himalaya " " North West Himalaya Kumaun Himalaya West Himalaya Pithorgarh & Champawat Dts. Kumaun Himalaya Kumaun Himalaya " " Western Himalaya	Pande & Dashila (1988) Pande (1990) Bir <i>et al.</i> (1991) Pande & Pande (1993) Khullar (1994) Pande & Pande (2002) Pande & Pande (2002) Pande & Pande (2003) Das (2004)
5.	<i>A. obscurum</i> Bl.	Western Himalaya	Das (2004)
6.	<i>A. tenuifolium</i> D. Don	Kumaun Himalaya North-West Himalaya	Pande (1990) Bir <i>et al.</i> (1991)
		West Himalaya Pithorgarh & Champawat Dt., Kumaun Himalaya Kumaun Himalaya Ninital & Udham Singh Nagar Dt. Kumaun Himalaya	Khullar (1994) Pande & Pande (2002) " " " "

Sl. No.	Name of Species	Locality	Reference
		Kumaun Himalaya Western Himalaya	Pande & Pande (2003) Das (2004)
7.	<i>A. unilaterale</i> Lam.	Simla Hills, North-West Himalaya Kumaun Himalaya North-West Himalaya Roopkund Hills - Garhwal West Himalaya West Himalaya Almora & Bageswar Dt. West Himalaya Pithorgarh & Champawat Dt., Kumaun Himalaya Kumaun Himalaya Ninital & Udham Singh Nagar Dt. Kumaun Himalaya Kumaun Himalaya Almora Dt., Kumaun Himalaya Nanda Devi Biosphere Reserve, Uttaranchal	Bir & Shukla (1968) Pande (1990) Bir <i>et al.</i> (1991) Pande & Bhandari (1994) Khullar (1994) Pande & Pande (2002) " " " " " " Pande & Pande (2003) Baluttia (2004) Samant <i>et al.</i> (2005)
8.	<i>A. yoshinagae</i> Makino subsp. <i>indicum</i> (Sledge) Fraser-Jenk. (<i>A. indicum</i> Sledge)	Simla Hills, North-West Himalaya Berinag Hills, West Himalaya Kumaun Himalaya North-West Himalaya West Himalaya Almora & Bageswar Dts. West Himalaya	Bir & Shukla, (1968) Pande & Basera (1988) Pande (1990) Bir <i>et al.</i> (1991) Khullar (1994) Pande & Pande (2002)

Sl. No.	Name of Species	Locality	Reference
		Pithorgarh & Champawat Dt. Kumaun Himalaya	" "
		Nital & Udham Singh Nagar Dt. Kumaun Himalaya	" "
		Simla, Himachal Pradesh	Seth <i>et al.</i> (2004)
		Almora Dt. Kumaun Himalaya	Baluttia (2004)

- Kumaun Himalaya, Almora, Simla, Garhwal, Nital, Jammu & Kashmir, Himachal Pradesh, Uttaranchal *etc.*

Pande and Pande (1993) reported five epiphytic species of *Asplenium* L. from Kumaun Himalaya, of which *A. ensiforme* Wall. ex Hook. & Grev., *A. laciniatum* D. Don, *A. nidus* L. are reported from South India, whereas Pande and Bhandari (1994) reported four species from Roopkund Hills of Garhwal, Himalaya, among that, three species are common with South India (Table. 2). Khullar (1994) in his *Illustrated Fern Flora of West Himalaya* reported 30 species of *Asplenium* L., out of that seven species are common with South India (Table 2). Kiran (2000) in his pteridophyte flora of Poonch District of Jammu and Kashmir state reported a total of 12 species of *Asplenium* L. including a single South Indian member, *A. laciniatum* D. Don. Verma and Maniselvan (2001) reported only one species of *Asplenium* L. (*Asplenium dalhousiae* Hook.) in his check list of ferns from Kalka and Kasauli Hills of North-Western Himalaya. Pande and Pande (2002) made a detailed distributional study of ferns from the different parts of Kumaun Himalaya. From Nital and Udham Singh Nagar districts, they reported seven species

of *Asplenium* L. of which five species are common with South India (Table 2), where as they reported 10 species from Almora and Bageswar districts, of which five species are common with South India (Table 2); at the same time 16 species are reported from Pithoragarh and Champawat districts of Kumaun Himalaya, of which six species are common with South India (Table 2). Pande and Pande (2002) reported 25 species of *Asplenium* L. from Kumaun Himalaya of which seven species are common with South India (Table 2). Pande and Pande (2003) in their *Illustrated Fern Flora of Kumaun Himalaya*, reported 23 species of *Asplenium* L. of which six species are common with South India (Table 2). Seth *et al.* (2004) reported four species of *Asplenium* L. from Simla, Himachal Pradesh, of which, *A. laciniatum* D. Don and *A. indicum* Sledge are common with South India, whereas Seth *et al.* (2004) reported four species of *Asplenium* L. from Kinnaur District of Himachal Pradesh, which are not reported so far from South India. Baghla and Khullar (2004) reported four species of *Asplenium* L. from Solan District, Himachal Pradesh, of which only *A. laciniatum* D. Don is reported from South India. Baluttia (2004) studied the taxonomy and ecology of ferns and fern allies of Ranikhet in Almora District of Kumaun Himalaya. In this study she reported six species of *Asplenium* L., of which four species are common with South India (Table.2). Samant *et al.* (2005) in their study on the diversity, distribution and conservation of Pteridophytes of Nanda Devi Biosphere Reserve, Uttaranchal State of West Himalaya, reported 15 species of *Asplenium* L. of which two species are common with South India (Table.2).

The taxonomic and phytogeographic studies of ferns in general and the genus *Asplenium* L. in particular in North-Eastern Himalayan states like Assam and Arunachal Pradesh was made by Bhattacharya and his co-workers. Bhattacharya *et al.* (1995) reported three species of *Asplenium* L. from Cachar Hills District of Assam, North-East India, of which only *A. nidus* L. common with South India; whereas Bhattacharya *et al.* (1998) added one more species to the same locality (*A. unilaterale* Lam.), which is also common in South India. Bhattacharya and Chakravorty (2005) studied the Pteridophyte flora of West Kameng District of Arunachal Pradesh and they reported only one species (*A. tenuifolium* D. Don) out of a total of 25 species of ferns belonging to 12 families. Chandra (1982) made an attempt to ascertain the endemic status of a species which is presently based on a broad survey of published accounts in scientific and technical journals, bulletins, reports, monographs, manual and floras of adjacent regions from time to time, and information obtained through consultations with or personal communications from pteridologists here and abroad. Based up on this study he reported 4 species of *Asplenium* L. endemic to India, including the South Indian taxa, *A. unilaterale* Lam. var. *rivale* Bedd., Whereas Chandra and Kaur (1984) reported two endemic varieties of *A. laciniatum* D. Don from India.

Further Taxonomic studies on the distribution of *Asplenium* L. in North-Eastern Himalaya was made by Mehra and Bir (1964), Vasudeva and Bir (1990), Nath *et al.* (2002), Barua *et al.* (1989), Borthakur *et al.* (2000),

etc. Mehra and Bir (1964) reported a total of 18 species of *Asplenium* L., three varieties of *A. unilaterale* Lam. and one variety of *A. laciniatum* D. Don from Darjeeling and Sikkim Himalaya, of which 10 species are common with South India (Table 1). Barua *et al.* (1989) reported frequent growth of *A. nidus* L. and *A. nidus* L. var. *phyllitidis* D. Don, from Kamarup District, Assam. Both these taxa are reported from South India. Vasudeva *et al.* (1990) reported 29 species and three varieties of *Asplenium* L. from North-Eastern India, of which 11 species are common with South India, based on Manickam and Irudayaraj (1992) (Table 1). Nath *et al.* (2002) reported three rare species of *Asplenium* L. like, *A. finlaysonianum* Wall. ex Hook., *A. falcatum* Lam., and *A. pellucidum* Lam. from Barak Valley of Cachar, Haikandi, and Karimganj Districts of Southern Assam, which are new record to that area. Borthakur *et al.* (2000) reported seven species of *Asplenium* L. from Assam of which five species are common with South India (Table 1). Deka *et al.* (2001) reported *A. falcatum* Lam. from Assam, which is a new record to that area.

A few scattered taxonomic and distributional studies on the genus *Asplenium* L. were carried out in Western Indian states, especially Rajasthan, and also in Eastern Indian states like West Bengal and Orissa. Bir and Verma (1963) presented a detailed taxonomic account of the ferns of Mt. Abu, in which they reported two species of *Asplenium* L. out of a total of 22 species of ferns reported. These species were not reported so far from South India. Sharma (2002) reported 11 species of *Asplenium* L. from

some protected areas of Rajasthan state like Mt. Abu Wild life Sanctuary, but only one species, *A. semivarians* Viane & Reichst. is common with South India. Yadav *et al.* (2002) reported a new species of *Asplenium* L. (*A. dalhousiae* Hook.), which was supposed confined to North–Western Himalayas, from Mt. Abu, Rajasthan and is a new record for Rajasthan.

Majumdar *et al.* (1984) reported three species of *Asplenium* L. (*A. tenuifolium* D. Don, *A. ensiforme* Wall. ex Hook. & Grev., and *A. laciniatum* D. Don) from Neora Valley in Kalimpong Forest Division, West Bengal. All the three species are reported from South India also. Panigrahi (1998) studied the pteridophytic flora of Orissa, in which he reported a total of 136 species of ferns and fern allies from the state of Orissa. This list includes seven species of *Asplenium* L. of which five species like *A. erectum* Bory ex Willd., *A. inequilaterale* Willd., *A. obscurum* Bl., *A. formosum* Willd., and *A. unilaterale* Lam. are common with South India. Singh & Medhi (2006) reported three species of *Asplenium* L. (*A. adiantoides* (L.) C.Chr., *A. nidus* L., *A. phyllitidis* D. Don) out of a total of 64 species of ferns reported from South Andaman.

WORLD DISTRIBUTION

The genus *Asplenium* L. is one of the largest and most distinct genus, consist of about 650 species in the world (Christenson, 1938; Ching, 1940; Holttum, 1954; Tryon & Tryon, 1982). The detailed distribution, ecology, phyto-geography, systematics and taxonomy of this genus was studied in

detail throughout the different part of the world by many workers, are listed below in Table 3.

Table 3. Distribution of *Asplenium* L. in the world

Sl. No.	Locality	No. of species reported	South Indian species reported	Reference
1.	Admiralty Island, Pacific Ocean	5	<i>A. nidus</i> L. <i>A. Phyllitidis</i> D. Don	Wagner & Grether (1948)
2.	Guam, Marianus Island, Pacific Ocean	5	<i>A. nidus</i> L. <i>A. unilaterale</i> Lam.	"
3.	Fiji	3	nil	Copeland (1949)
4.	Japan	35	<i>A. cheilosorum</i> Kunze ex. Mett. <i>A. ensiforme</i> Wall. ex Hook. & Grev. <i>A. nidus</i> L. <i>A. normale</i> D. Don <i>A. unilaterale</i> Lam.	Namegata & Kurata (1961)
5.	Polland	4	nil	Karpowicz (1962)
6.	Ceylon	2	<i>A. affine</i> Sw.	Sledge (1962)
7.	Netherlands Antilles	6	<i>A. formosum</i> Willd. <i>A. auritum</i> Sw.	Kramer(1962)
8.	Japan	3	nil	Kurata (1962)
9.	Japan	4	<i>A. normale</i> D. Don	Kurata (1963)
10.	Nepal, Himalaya	3	<i>A. cheilosorum</i> Kunze ex Mett. <i>A. ensiforme</i> Wall. ex Hook. & Grev. <i>A. indicum</i> Sledge	Nishida (1966)
11.	Borneo	15	<i>A. nidus</i> L. <i>A. phyllitidis</i> D. Don <i>A. tenerum</i> G. Forst. <i>A. unilaterale</i> Lam.	Tagawa (1965)
12.	China	11	<i>A. unilaterale</i> Lam.	Ching (1965)
13.	Venezula	47	<i>A. auritum</i> Sw. <i>A. formosum</i> Willd.	Morton & Lellingner (1966)
14.	Thailand	28	<i>A. cheilosorum</i> Kunze ex Mett. <i>A. crinicaule</i> Hance	Tagawa & Iwatsuki (1967)

Sl. No.	Locality	No. of species reported	South Indian species reported	Reference
			<i>A. ensiforme</i> Wall. ex Hook. & Grev. <i>A. nidus</i> L. <i>A. normale</i> D. Don <i>A. obscurum</i> Bl. <i>A. phyllitidis</i> D. Don <i>A. tenerum</i> G. Forst. <i>A. unilaterale</i> Lam.	
15.	USA	2	nil	Morton (1967)
16.	Malaya	27	<i>A. cheilosorum</i> Kunze ex Mett. <i>A. nidus</i> L. <i>A. normale</i> D. Don <i>A. phyllitidis</i> D. Don <i>A. tenerum</i> G. Forst. <i>A. unilaterale</i> Lam.	Holttum (1968)
17.	Zambesiaca, Africa	39	<i>A. aethiopicum</i> (Burm. f.) Becher. <i>A. auritum</i> Sw. <i>A. erectum</i> Bory ex Willd. <i>A. formosum</i> Willd. <i>A. inequilaterale</i> Willd. <i>A. normale</i> D. Don <i>A. obscurum</i> Bl. <i>A. unilaterale</i> Lam. <i>A. varians</i> Hook. & Grev.	Schelppe (1970)
18.	Southern Appalachian	5	nil	Wagner <i>et al.</i> (1970)
19.	Tropical Africa	2	nil	Pichi-Sermolli (1972)
20.	USA	17	<i>A. laciniatum</i> D. Don <i>A. normale</i> D. Don <i>A. tenuifolium</i> D. Don	Morton (1973)
21.	Taiwan	33	<i>A. cheilosorum</i> Kunze ex Mett. <i>A. ensiforme</i> Wall. ex Hook. & Grev. <i>A. laciniatum</i> D. Don <i>A. nidus</i> L. <i>A. normale</i> D. Don <i>A. obscurum</i> Bl.	De Vol & Kuo (1975)

Sl. No.	Locality	No. of species reported	South Indian species reported	Reference
			<i>A. tenerum</i> G. Forst. <i>A. tenuifolium</i> D. Don <i>A. unilaterale</i> Lam.	
22.	North Borneo	27	<i>A. affine</i> Sw. <i>A. nidus</i> L. <i>A. nitidum</i> Sw. <i>A. normale</i> D. Don <i>A. phyllitidis</i> D. Don <i>A. tenerum</i> G. Forst. <i>A. unilaterale</i> Lam.	Tagawa (1976)
23.	Ethiopia	12	<i>A. formosum</i> Willd. <i>A. inequilaterale</i> Willd. <i>A. unilaterale</i> Lam.	Pichi-Sermolli (1977)
24.	Tropical Africa	4	nil	Pichi-Sermolli (1977)
25.	Guatemala – Central America	1	nil	Stolze (1978)
26.	Suriname, South America	15	<i>A. auritum</i> Sw.	Kramer (1978)
27.	Burren – Republic of Ireland	7	nil	Willmot (1979)
28.	Kalimantan, Japan	23	<i>A. affine</i> Sw. <i>A. nidus</i> L. <i>A. nitidum</i> Sw. <i>A. normale</i> D. Don <i>A. phyllitidis</i> D. Don <i>A. tenerum</i> G. Forst. <i>A. unilaterale</i> Lam.	Iwatsuki & Kato (1980)
29.	Chiapas, Mexico	2	nil	Smith (1980)
30.	Scotland	6	nil	Willmot (1981)
31.	Tropical America	150	<i>A. auritum</i> Sw. <i>A. formosum</i> Willd.	Tryon & Tryon (1982)
32.	Killarney Dt., Co-Kerry, Ireland	8	nil	Willmot (1983)
33.	Kalimantan, Japan	6	<i>A. normale</i> D. Don	Iwatsuki & Kato (1983)
34.	East Aegean Island, Anatolia	1	nil	Greuter <i>et al.</i> (1983)
35.	Ecuador – South America	4	nil	Stolze (1984)

Sl. No.	Locality	No. of species reported	South Indian species reported	Reference
36.	France	1	nil	Labatut <i>et al.</i> (1984)
37.	West Sumatra	12	<i>A. affine</i> Sw. <i>A. nidus</i> L. <i>A. normale</i> D. Don <i>A. phyllitidis</i> D. Don <i>A. tenerum</i> G. Forst. <i>A. unilaterale</i> Lam.	Mitsuta (1984)
38.	East Nepal	7	<i>A. ensiforme</i> Wall. ex Hook. & Grev. <i>A. indicum</i> Sledge <i>A. laciniatum</i> D. Don <i>A. normale</i> D. Don <i>A. tenuifolium</i> D. Don <i>A. unilaterale</i> Lam.	Sinha & Gurung (1985)
39.	Central Nepal	3	<i>A. aethiopicum</i> (Burm. f.) Becher.	"
40.	Langtang National Park, Central Nepal	5	<i>A. ensiforme</i> Wall. ex Hook. & Grev. <i>A. indicum</i> Sledge <i>A. laciniatum</i> D. Don <i>A. unilaterale</i> Lam.	Gurung (1985)
41.	Seram Island, Moluccas, InD. Donesia	1	<i>A. unilaterale</i> Lam.	Kato & Iwatsuki (1985)
42.	Mwanihana Forest Reserve, Tanzania	14	<i>A. aethiopicum</i> (Burm. f.) Becher. <i>A. formosum</i> Willd. <i>A. inequilaterale</i> Willd. <i>A. obscurum</i> Bl. <i>A. unilaterale</i> Lam.	Lovett & Thomas (1986)
43.	Nepal	10	<i>A. cheilosorum</i> Kunze ex Mett. <i>A. ensiforme</i> Wall. ex Hook. & Grev. <i>A. normale</i> D. Don <i>A. obscurum</i> Bl. <i>A. phyllitidis</i> D. Don <i>A. tenuifolium</i> D. Don <i>A. unilaterale</i> Lam.	Nakaike (1986)
44.	Tasmania	5	nil	Jarman <i>et al.</i> (1986)

Sl. No.	Locality	No. of species reported	South Indian species reported	Reference
45.	Soller, Mallorca, Spain	1 hybrid	nil	Bennert <i>et al.</i> (1987)
46.	Belgium	2	nil	Viane (1987)
47.	Anatalya Province, South Turkey	1	nil	Fraser-Jenkins & Schneller (1987)
48.	Zarate, Andes, Central Peru	3	<i>A. aethiopicum</i> (Burm. f.) Becher.	Leon & Valencia (1988)
49.	Kathmandu, Nepal	11	<i>A. ensiforme</i> Wall. ex Hook. & Grev. <i>A. normale</i> D. Don <i>A. obscurum</i> Bl. <i>A. tenuifolium</i> D. Don <i>A. unilaterale</i> Lam.	Nakaike & Gurung (1988)
50.	Madeira Island, Atlantic Ocean	1	nil	Gibby & Lovis (1989)
51.	Zamba Mountain, Central Africa	16	<i>A. aethiopicum</i> (Burm. f.) Becher. <i>A. ensiforme</i> Wall. ex Hook. & Grev. <i>A. formosum</i> Willd.	Berrie (1989)
52.	Mallorca, Spain	1 hybrid	nil	Rosello <i>et al.</i> (1990)
53.	Pakistan	1	nil	Nakaike & Malik (1992).
54.	Pakistan	10 sps. 2 ssp.	nil	Nakaike & Malik (1993)
55.	Manongarivo Special Reserve, Madagascar	18	<i>A. auritum</i> Sw. <i>A. nidus</i> L. <i>A. normale</i> D. Don <i>A. unilaterale</i> Lam.	Rakotondrainibe (1994)
56.	Taveuni, Fiji	3	nil	Parris (1994)
57.	Turkey	6	nil	Kaynak <i>et al.</i> (1996)
58.	France	1 hybrid	nil	Prelli (1996)
59.	Xizang, Tibet	7	<i>A. cheilosorum</i> Kunze ex Mett. <i>A. crinicaule</i> Hance	Zhang (1997)
60.	Blacksea Region, Turkey	3	nil	Benlioglu <i>et al.</i> (1997)
61.	Eastern Nepal	5	<i>A. ensiforme</i> Wall. ex Hook. & Grev. <i>A. indicum</i> Sledge	Siwakoti & Sharma (1998)

Sl. No.	Locality	No. of species reported	South Indian species reported	Reference
			<i>A. obscurum</i> Bl. <i>A. phyllitidis</i> D. Don	
62.	Rathlin Island, Near Ireland	1	nil	Gastrang <i>et al.</i> (1998)
63.	Fial Island, Azores Atlantic Ocean	9 species & 2 hybrids	nil	Schäfer (2001)
64.	São Tome and Principe Islands, Gulf of Guinea	2	<i>A. unilaterale</i> Lam.	Figueiredo (2001)
65.	China	2	<i>A. tenuifolium</i> D. Don <i>A. yoshinagae</i> Makino	Xian-Chun <i>et al.</i> (2001)
66.	Hawaii	3 varieties, 4 forma	nil	Palmer (2002)
67.	Falkland Islands, South Atlantic Ocean	1	nil	Broughton & Mcadam (2003)
68.	Johor forests (Peninsular Malaysia) and Singapore	4	<i>A. nidus</i> L.	Yusuf <i>et al.</i> (2003)
69.	Northern Luzon, Philippines	1	nil	Salgado (2003)
70.	Mt. Iraya, Batan Island, N. Philippines.	7	<i>A. nidus</i> L. <i>A. unilaterale</i> Lam.	Barcelona (2003)
71.	Azores Island, Northern Atlantic Ocean	1 species & 2 hybrids	nil	Rumsey <i>et al.</i> (2004)
72.	Karst Forest, Bohol Island, Philippines	16	<i>A. affine</i> Sw. <i>A. nidus</i> L. <i>A. phyllitidis</i> D. Don <i>A. polydon</i> G. Forst. <i>A. tenerum</i> G. Forst. <i>A. unilaterale</i> Lam.	Barcelona <i>et al.</i> (2006)

CYTOLOGY

With the availability of cytological information during the last two decades, plant taxonomy, particularly that of ferns, has assumed new dimensions. Basic chromosome numbers of almost all the fern genera are now known (Chiarugi, 1960; Fabbri, 1963, 1965; Ornduff, 1967-1969; Moore, 1970-1972; Bir, 1973) and these data have been helpful in solving many taxonomic enigmas. Basic chromosome number of certain genera of ferns are helpful in clarifying the systematic position and taxonomic tangles particularly the case of border-line species between allied and confusing genera. This paves a way for discarding the old generic and specific concepts (Bir, 1976).

Walker (1979) reported that the two outstanding features of ferns are the occurrence of high base numbers (usually falling between 22 and 69) and high incidence of polyploidy, which occur at a conservative estimate in 50-60% of the cytotypes. *Asplenium* L. is predominantly polyploid (ca.77%) and here almost a fifth are at the higher levels, some are reaching the 12 and 16-ploid stage (Walker, 1979). Sledge (1965) also reported the wide range of polyploidy and occurrence many hybrids in *Asplenium* L. A number of species like *A. semivarians* Viane & Reichst., *A. exiguum* Bedd., *A. trichomanes* L., *A. ensiforme* Wall. ex Hook. & Grev., *A. planicaule* Wall., etc. were cytologically investigated (Mehra and Bir, 1957). They suggested the basic chromosome number of the genus *Asplenium* L. as 36. The chromosome numbers of a few species of *Asplenium* L. from South India

were reported by Abraham *et al.* (1962); Bir (1965); Kuriachan (1965, 1967, 1973, 1978); Ghatak (1977) and Manickam and Irudayaraj (1988). Cytology and Chromosome behaviour of seven species of *Asplenium* L. from Kerala and Tamil Nadu states were reported by Ammal & Bhavanandan (1991). Out of these, two species are diploid; two are tetraploid; two are hexaploid (*A. achillifolium* (Lam.) C.Chr. and *A. wightianum* Wall.) and the remaining one is decaploid (*A. falcatum* Lam.) (Table 4). According to them, chromosome numbers based on $x=36$ and 40 are met within different cytotypes. Majority of the species studied by previous workers like Abraham *et al.* (1962); Kuriachan (1968, 1978); Ghatak (1977); Manickam and Irudayaraj (1988) are based on $x=36$. Tatuno and Kawakami (1969) made a detailed Karyotype analysis on three species, and suggested that $x=12$ could be the ancestral chromosome number of the genus. While studying the cytology of different populations of *Asplenium indicum* Sledge from the Himalayas, Bir (1960, 1972) showed these populations to be with $n=72$. However, the materials of this species from Sikkim Himalayas studied by Singh and Roy (1988) showed an additional set of four chromosomes making the haploid complement $n=40$. It may be noted that the possibility of origin of $n=40$ being derived from $n=36$ by aneuploid increase of four chromosomes would be rather remote. It is suggested that $x=36$ itself could be a secondarily derived number from the ancestral number $x=9$ through polyploidization and $x=40$ might be a polyploid derivation from $x=10$ which in turn derived from $x=9$ by aneuploid increase of one chromosome (Ammal and Bhavanandan, 1991).

All the species studied from South India except *A. unilaterale* Lam. showed that this is a cytologically uniform genus with a single basic chromosome number $x=36$ (Abraham *et al.*, 1962). They have given the cytology of 5 species of *Asplenium* L. from South India (Table 4). Bir (1965) reported the cytology of seven species of *Asplenium* L. from Kodaikanal, South India, of which four tetraploid with $n=72$, two diploid with $n=36$ while *A. cheilosorum* Kunze ex Mett. is exceptional in that it is not sexual but triploid apogamous (Table 4). Kuriachan (1978) reported the cytology of four species of *Asplenium* L. from South India of which one is tetraploid, two diploid and a triploid hybrid (Table 4). Irudayaraj *et al.* (1993) reported chromosome number and ploidy details of two species (one tetraploid sexual and one diploid sexual) from Nilgiris, South India (Table 4). Irudayaraj and Bir (1994) reported the chromosome number and ploidy level of 3 species (2 diploid and one octoploid) of *Asplenium* L. from Nilgiris, South India (Table 4). Bir and Irudayaraj (2001) made chromosomal analysis of 11 species of ferns from the Nilgiris, South India, including *A. laciniatum* D. Don. This is a diploid sexual with $n=36$ and is conformity with the previous reports from South India; Kodaikanal (Bir, 1965), Eastern Ghats (Manickam & Irudayaraj, 1998; Ghatak, 1977) and Western Ghats (Kuriachan, 1978) (Table 4).

Table 4. Cytology of the Genus *Asplenium* L. in South India

Sl. No.	Name	Locality	Chromosome Number		Ploidy	References
			n	2n		
1.	<i>Asplenium aethiopicum</i> (Burm. f.) Becher.	Naduvattom.	144	--	Octoploid	Irudayaraj & Bir (1994) Manickam & Irudayaraj (1988) (Abraham <i>et al.</i> (1962)
		Palni Hills.	"	--	"	
		Ponmudi Hills.	--	288	--	
2.	<i>A. cheilosorum</i> Kunze ex Mett.	Pillar rock – Kodaikanal.	--	108	Triploid apogamous	Bir (1965)
3.	<i>A. crinicaule</i> Hance	Ponmudi Hills.	144	--	Octoploid	Kuriachan (1968)
4.	<i>A. decrescens</i> Kunze	Naduvattom.	72	--	Tetraploid	Irudayaraj <i>et al.</i> (1993) Irudayaraj (1990) Manickam & Irudayaraj (1988)
		Agasthiar Hills.	"	--	"	
		Kothayar.	"	--	--	
5.	<i>A. ensiforme</i> Wall. ex Hook. & Grev.	Shambagnoor –Kodaikanal.	72	--	Tetraploid	Bir (1965)
6.	<i>A. erectum</i> Bory ex. Willd.	Pykara – Nilgiri.	36	--	Diploid	Irudayaraj <i>et al.</i> (1993) Irudayaraj (1990) Manickam & Irudayaraj (1988) Ghatak (1977) Kuriachan (1968)
		Palni Hills.	"	--	"	
		"	"	--	"	
		Sheveroy Hills.	"	--	"	
		Kodaikanal.	"	--	"	
7.	<i>A. formosum</i> Willd.	Thekkadi, Periyar, Ponmudi & Thenmala.	36	--	Tetraploid	Ammal & Bhavanandan (1991) Kuriachan (1968)
		Bear Shola - Kodaikanal, Palaruvi & Ponmudi Hills.	"	--	"	
8.	<i>A. grevillei</i> Wall. ex Hook. & Grev.	Bonaccad - Upper Kothayar.	36	72	Diploid	Ammal & Bhavanandan (1991) Kuriachan (1978)
		South India.	72	--	Tetraploid	

Sl. No.	Name	Locality	Chromosome Number		Ploidy	References
			n	2n		
9	<i>A. hindusthanensis</i> Bir (<i>A. unilaterale</i> Lam. var. <i>rivale</i> Bedd.)	Naduvattom.	40	--	Diploid	Irudayaraj & Bir (1994)
		Pillarrock - Kodaikanal.	"	--	"	Kuriachan (1968)
10.	<i>A. inequilaterale</i> Willd.	Tirunelveli Hills.	36	--	Diploid	Irudayaraj (1990)
		Kothayar Hills.	72	--	Tetraploid	Manickam & Irudayaraj (1988)
		Munnar Hills.	"	--	"	"
		South India.	36	--	"	Kuriachan (1965)
11.	<i>A. nidus</i> L.	South India.	72	--	Tetraploid	Abraham <i>et al.</i> (1962)
12.	<i>A. normale</i> D. Don	Pillar rock – Kodaikanal.	36	--	Diploid	Kuriachan (1968)
		"	72	--	Tetraploid	Bir (1965)
13.	<i>A. obscurum</i> Bl.	Kannikatti - Kothayar Hills	72	--	Diploid apogamous	Manickam & Irudayaraj (1988)
		South India.	"	--	"	Abraham <i>et al.</i> (1962)
14.	<i>A. polydon</i> G. Forst.	South India.	72	--	Tetraploid	Abraham <i>et al.</i> (1962)
15.	<i>A. semivarians</i> Viane & <i>Reichst.</i> (<i>A. laciniatum</i> D. Don)	Nilgiris.	36	--	Diploid	Bir & Irudayaraj (2001)
		Kuttalum.	"	--	"	Irudayaraj <i>et al.</i> (1993)
		Kolli Hills.	"	--	"	Manickam & Irudayaraj (1988)
		Western Ghats.	"	--	"	Kuriachan (1978)
		Sheveroy Hills.	"	--	"	Ghatak (1977)
		Kodaikanal.	"	--	"	Bir (1965)
16.	<i>A. serricula</i> Fee	Sengeltheri- Western Ghats.	72	--	Tetraploid	Irudayaraj (1990) Manickam & Irudayaraj (1988)
		"	"	--	"	

Sl. No.	Name	Locality	Chromosome Number		Ploidy	References
			n	2n		
17.	<i>A. tenuifolium</i> D. Don	Naduvattom.	36	--	Diploid	Irudayaraj & Bir (1994)
		Palni Hills.	"	--	"	Manickam & Irudayaraj (1988)
		Kodaikanal.	"	--	"	Kuriachan (1978)
		Shembaganoor - Kodaikanal.	"	--	"	Bir (1965)
18.	<i>A. unilaterale</i> Lam.	Kodaikanal.	40	--	Diploid	Ammal & Bhavanandan (1991)
		Kodaikanal & Kothayar.	"	--	"	Irudayaraj (1990)
		Kodaikanal.	"	--	"	Manickam & Irudayaraj (1988)
		"	--	116	Triploid hybrid	Kuriachan (1978)
		Munnar.	76	ca. 152	Tetraploid	Kuriachan (1968)
19.	<i>A. yoshinagae</i> Makino subsp. <i>indicum</i> (Sledge) Fraser-Jenk. (<i>A. indicum</i> Sledge)	Ooty.	36	--	Diploid	Ammal & Bhavanandan (1991)
		Bear Shola - Kodaikanal & Ponmudi Hills.	--	144	Octoploid	Kuriachan (1968)

The investigation of hybrids among fern species has been of significant value in untangling a number of taxonomic problems. Fern hybrids, like those in other groups of higher plants, generally in all respects, are intermediate between the parents. They present many interesting biological problems - geneecological, morphogenetic and cytogenetic. Their study during the last two decades has been greatly accelerated. Bir (1960) reported that the incidence of polyploidy and hybridization in this genus is quite high and evidently shows that the genus is in an active state of

evolution. Various ploidy levels are noticed among different species. Diploid condition ($x=36$) is observed in *A. dalhousiae* Hook. and *A. semivarians* Viane & Reichst. (Mehra and Bir, 1957), triploid ($n=108$) in *A. unilaterale* Lam., tetraploid ($n=72$) in *A. nidus* L. and *A. phyllitidis* D. Don and octoploid ($n=144$) in *A. nitidum* Sw. and *A. aethiopicum* (Burm. f.) Becher. (Abraham *et al.*, 1962). In *A. cheilosorum* Kunze ex Mett. the number of bivalents may vary from any number between 28-41 and univalents from 19-49 (Mehra and Bir, 1960). The cytology of *Asplenium* L. in India reveals that the incidence of hybridity (16.67%) and percentage of polyploidy (77.78%) within the genus is significantly high, but polyploidy is known only to an octoploid level (Mehra and Bir, 1957; Bir, 1959, 1960).

Table 5. Cytology of the Genus *Asplenium* L. in North India

Sl. No.	Name	Locality	Chromosome Number		Ploidy	References
			n	2n		
1.	<i>Asplenium adiantum - nigrum</i> L.	Daichigam - Kashmir	72	--	Tetraploid	Razdan & Kachroo (1986)
2.	<i>A. bullatum</i> Wall.	Sikkim-E. Himalaya	72	--	Tetraploid	Bir (1960)
3.	<i>A. capillipes</i> Makino	Almora – N. W. Himalaya	72	--	Tetraploid	Bir <i>et al.</i> (1994)
4.	<i>A. ceterach</i> L.	Harwan - Kashmir	72	--	Tetraploid	Razdan & Kachroo (1986)
5.	<i>A. cheilosorum</i> * Kunze ex Mett.	Darjeeling – E. Himalaya	--	108	Triploid Apogamous	Mehra & Bir (1960)
6.	<i>A. crinicaule</i> * Hance	Sikkim Himalaya	72	--	Tetraploid	Bir (1960)
7.	<i>A. dalhousiae</i> Hook.	Mt. Abu Rajasthan	36	--	Diploid	Kothari <i>et al.</i> (2004)
		Chakrata – N. W. Himalaya	"	--	"	Bir <i>et al.</i> (1994)

Sl. No.	Name	Locality	Chromosome Number		Ploidy	References
			n	2n		
		Mahora-Kashmir	"	--	"	Razdan & Kachroo (1986)
		Bathri Valley - Punjpulla	"	--	"	Bir & Shukla (1967)
		Simla	"	--	"	Bir (1962)
8.	<i>A. ensiforme</i> * Wall. ex Hook. & Grev.	Pithorgarh	72	--	Tetraploid	Bir <i>et al.</i> (1994)
		Glen	"	--	"	Bir (1962)
		Darjeeling - Sikkim	"	--	"	Bir (1960)
		Mussoorie - W. Himalaya	"	--	"	Mehra & Bir (1957)
9.	<i>A. exiguum</i> Bedd.	Mussoorie - W. Himalaya	72	--	Tetraploid	Mehra & Bir (1957)
10.	<i>A. falcatum</i> Lam.	Darjeeling - E. Himalaya	72	--	Tetraploid	Bir (1960)
11.	<i>A. finlaysonianum</i> Wall. ex Hook.	Sikkim - E. Himalaya	72	--	Tetraploid	Bir (1960)
12.	<i>A. griffithianum</i> Hook	Sikkim - E. Himalaya	72	72	Diploid hybrid	Bir (1960)
13.	<i>A. kukkoneii</i> Viane <i>et al.</i>	Chakrata - N. W. Himalaya	72	--	Tetraploid	Bir <i>et al.</i> (1994)
14.	<i>A. laciniatum</i> * D. Don	Darjeeling & Sikkim - E. Himalaya	72	--	Tetraploid	Bir (1960)
15.	<i>A. macrophyllum</i> Sw.	Darjeeling - E. Himalaya	72	--	Tetraploid	Bir (1960)
16.	<i>A. nidus</i> * L.	Darjeeling & Sikkim - E. Himalaya	72	--	Tetraploid	Bir (1960)
	<i>A. nidus</i> L. var. <i>Phyllitidis</i> * D. Don = (<i>A. phyllitidis</i> D. Don)	"	"	--	"	"
	<i>A. nidus</i> L. var. <i>acutifolia</i> Bir.	"	"	--	"	"
17.	<i>A. nitidum</i> Sw. var. <i>obtusum</i> Sw.	Sikkim - E. Himalaya	72	--	Tetraploid	Bir (1960)
18.	<i>A. normale</i> * D. Don	Darjeeling & Sikkim - E. Himalaya	72	--	Tetraploid	Bir (1960)
19.	<i>A. obliquissimum</i> (Hayata) Sugimoto & Kurata	Almora - N.W. Himalaya	40	--	Diploid	Bir <i>et al.</i> (1994)

Sl. No.	Name	Locality	Chromosome Number		Ploidy	References
			n	2n		
20.	<i>A. paucivenosum</i> (Ching) Copel	Darjeeling - E. Himalaya	72	--	Tetraploid	Bir (1960)
		Darjeeling & Sikkim - E. Himalaya	144	--	Octoploid	Bir (1960)
21.	<i>A. planicaule</i> Wall. <i>A. planicaule</i> Wall. var. <i>obtusum</i> Bir	Glen	72	--	Tetraploid	Bir (1960)
		Darjeeling & Sikkim - Himalaya	"	--	"	Bir (1960)
		Mussoorie - W. Himalaya	"	--	"	Mehra & Bir (1957)
		"	"	--	"	"
22.	<i>A. pellucidum</i> Lam. var. <i>sikkimensis</i> Bir	Sikkim - E. Himalaya	72	--	Tetraploid	Mehra & Bir (1957)
23.	<i>A. pumilum</i> Sw. var. <i>hymenophylloides</i>	Mt. Abu - Rajasthan	40	--	Diploid	Kothari <i>et al.</i> (2004)
24.	<i>A. punjabense</i> Bir.	Kulu - N.W. Himalaya	108		Hexaploid	Bir <i>et al.</i> (1994)
25.	<i>A. sevellii</i> Hook.	Summer Hill-Simla	72	--	Tetraploid	Bir (1962)
26.	<i>A. tenuicaule</i> Hayata var. <i>indopakistanicum</i> Reichstein	Almora- N.W. Himalaya	36	--	Diploid	Bir <i>et al.</i> (1994)
27.	<i>A. tenuifolium</i> * D. Don	Darjeeling & Sikkim - E. Himalaya	36	--	Diploid	Bir <i>et al.</i> (1994)
28.	<i>A. trichomanes</i> L.	Almora, Pithoragarh - Kulu	72	--	Tetraploid	Bir <i>et al.</i> (1994)
		Botanic Garden - Kashmir University	"	--	"	Razdan & Kachroo (1986)
		Kalatop forest -Way to Khajjar	"	--	Diploid	Bir & Shukla (1967)
		The Mall	72		Tetraploid	"
		Summer Hill	"	--	"	Bir (1962)
		Manali - Kulu-valley	"	--	"	Bir (1959)
		Mussorie - W. Himalaya	"	--	"	Mehra & Bir (1957)

Sl. No.	Name	Locality	Chromosome Number		Ploidy	References
			n	2n		
29.	<i>A. unilaterale</i> * Lam.	Darjeeling - E. Himalaya	40	--	Diploid	Bir (1960)
	<i>A. unilaterale</i> Lam. var. <i>delicatulum</i> Pay	Chadwick falls	40	--	Diploid	Bir (1962)
		Darjeeling - E. Himalaya	"	--	"	Bir (1960)
	<i>A. unilaterale</i> Lam. Var. <i>udum</i> Atk.	Chadwick falls	40	--	Diploid	Bir (1962)
		Darjeeling - E. Himalaya	"	--	"	Bir (1960)
	<i>A. unilaterale</i> Lam. var. <i>unilaterale</i> *	Almora-Pithorgarh	40	--	"	Bir <i>et al.</i> (1994)
30.	<i>A. varians</i> Hook. & Grev. (<i>A. laciniatum</i> D. Don)	Almora - Simla	72	--	Tetraploid	Bir <i>et al.</i> (1994)
		Kalatop forest, Way to Khajjar	36	--	Diploid	Bir & Shukla (1967)
		Summer Hill - Simla	"	--	"	Bir (1962)
		Sikkim - E. Himalaya	"	--	"	Bir (1960)
		" "	72	--	Tetraploid	" "
		Manali-Kuluvalley	"	--	"	Bir (1959)
		Musoorie - W.- Himalaya	36	--	Diploid	Mehra & Bir (1957)
31.	<i>A. viride</i> Huds	Minamarg - Kashmir	36	--	Diploid	Razdan & Kachroo (1986)
32.	<i>A. yoshinagae</i> Makino var. <i>planicaule</i> (Wall. ex Mett.) Morton	Pithorgarh	72	--	Tetraploid	Bir <i>et al.</i> (1994)

* Species common with South India.

The cytology of North Indian species of *Asplenium* L. was studied mainly by Bir. Mehra and Bir (1957) reported the cytology of five species of *Asplenium* L. (Table 5) from Mussoorie, Western Himalayas, of which only A.

ensiforme Wall. ex Hook. & Grev. (Tetraploid with $n=72$) is common with South India, whereas, Mehra and Bir (1960) made a detailed cyto-taxonomic study on the Himalayan Spleenwort, *A. cheilosorum* Kunze ex Mett., since it was mentioned as an exceptionally difficult species as far as cytology is concerned and requires intensive study by Manton and Sledge (1954). They reported it as a triploid apogamous member with $n=108$. This species is also reported from South India. Bir (1962) reported the chromosome number and ploidy levels of seven species of *Asplenium* L. from Simla, Western Himalaya. Of these seven species three are diploid and four are tetraploid and only one species (*A. ensiforme* Wall. ex Hook. & Grev.) is common with South India (Table 5). Bir (1966-67) worked out the cytology of a number of species of Himalayan asplenioid ferns and analysed the correlation between the polyploid-level and spore size as reported by Hagenah (1961) in North American species of *Cystopteris* Bernh. From his studies it is evident that the largest average spore size found in *A. paucivenosum* (Ching) Bir, (tetraploid race *ca.* 70 x 54 μm and octoploid race *ca.* 86 x 62 μm) are in relation to high poloidy. The smaller spores are observed in the diploid members like *A. trichomanes* L. (37 x 27 μm) and *A. attenuatum* (32 x 21 μm). Though many of the diploid species of this genus possess spores much larger in size as compared to the tetraploid ones, the tetraploid members like *A. normale* D. Don, *A. nitidum* Sw. and *A. laciniatum* D. Don possess spores markedly smaller than the diploid members like *A. dalhousiae* Hook. and *A. unilaterale* Lam. complex. Thus Bir (1966-67)

clearly suggested that among these Himalayan members of asplenioid ferns, there is hardly any correlation between polyploidy and spore size at the species level. Bir and Shukla (1967) reported the cytology of three species of *Asplenium* L. from Dalhousie and Kulu regions of North-Western Himalaya. All the three species investigated are sexual and of these *A. dalhousiae* Hook. and *A. semivarians* Viane & Reichst. are rare and diploid ($n=36$), whereas in the case of *A. trichomanes* L. both diploid ($n=36$) and tetraploid ($n=72$) cytotypes are reported. Razdan *et al.* (1986) reported the cytology of five species of *Asplenium* L. from Kashmir (Table 5). Bir *et al.* (1994) studied the chromosome number and ploidy levels of 11 species of *Asplenium* L. from North-West Himalayas, of which only *A. ensiforme* Wall. ex Hook. & Grev. (Tetraploid with $n=72$) and *A. unilaterale* Lam. var. *unilaterale* (diploid with $n=40$) are also found in South India (Table 5). They further reported that the genus *Asplenium* L. is characterised by the preponderance of polyploids. In their study 83.75% are polyploids with hexaploid plants being observed only for *A. punjabense* Bir, the rest being all tetraploids (Table 5). Kothari *et al.* (2004) reported the chromosome number and ploidy details of two species of *Asplenium* L. from Rajasthan. Both species are diploid and represent the only two species reported so far from Rajasthan (Table 5).

Holttum (1968) and Devi (1974) reported that apart from one small species complex in *Asplenium* L. (*A. unilaterale* Lam.) all other species possess chromosome numbers based on $x=36$. These ferns were long

confused with or grouped with *Athyrium* Roth. and has remained as a group of uncertain affinity (Devi, 1974; Holttum, 1968). The cytology supports the separation of Aspleniaceae from Athyriaceae where the basic chromosome number is 40 in *Athyrium* Roth. and 36 in *Asplenium* L. (Manton, 1950; Fabbri, 1963; 1965).

Manickam and Irudayaraj (1988) reported 40 bivalents in meiosis of *A. unilaterale* Lam. collected from Kodaikanal which is in conformity with the earlier report by Kuriachan (1967) from the same locality. About 10 cytotypes have been reported for this species; $n=76$, $n=40$ (Kuriachan, 1967) and $2n=112$, $2n=116$ (Abraham *et al.* 1962) have been reported from South India. It is also interesting to note that $n=80$ from Sri Lanka (Manton and Sledge, 1954), $n=72$ from Japan (Kurita, 1960) and $n=36$ from U.S.A. (Wagner, 1955) were also reported. Bir (1961) suggested that this species represents one of the most interesting cytological situations that has been observed in the ferns so far. The presence of 10 cytotypes within a single species is an interesting one. It indicates the active state of evolution of this species in particular and of the family in general. Bir (1960, 1963) has suggested the segregation of *A. unilaterale* Lam. group of species to a subgenus *Hymenasplenium* (Hayata) Bir.

HYMENASPLENIUM

The genus *Hymenasplenium* (Hayata) Bir was established with a single species, *A. unilaterale* Lam. (Hayata, 1927). He made this segregation mainly based on the observation of a dorsiventral stele in *A.*

unilaterale Lam. and decided on this anatomical character to separate this species generically from *Asplenium* L. He observed two meristemes, a broader ventral and a narrower dorsal strand, leaf gaps arranged in two dorsal rows between the strands each strand providing to one of the two leaf traces, root traces borne only on the ventral strand, etc. in this species. In *A. unilaterale* Lam. Iwatsuki and Kato (1975) also reported the root trace which are not found on the dorsal strand but only on the ventral and connecting strands in all cases, as shown by Hayata (1927). *A. unilaterale* Lam. is a typical petrophyte and it is suggested that the dorsiventrality of the rhizome of this species has been established as a result of its characteristic habitat, although petrophytes do not necessarily have dorsiventral rhizome. The dorsiventral rhizome of this species and its allied species is considered to have evolved from the radial steles common in the Aspleniaceae in relation to a petrophytic habitat. The change in vasculature in this case is significant because no intermediate stages are known to exist. The process can be imagined to have occurred in two stages, first the alteration of an erect radial rhizome to a long creeping radial rhizome and the modification to dorsiventrality (Iwatsuki and Kato, 1975).

Hayata (1927) considered that the dorsiventral construction of the rhizome stele was in itself sufficient to warrant a generic separation. However the dorsiventrality of the rhizome of *A. unilaterale* Lam. and its allied species seems to be an elaboration of the radial rhizome typical for *Asplenium* L. formed in adapting to a petrophytic habitat. The establishment

of dorsiventrality in rhizome steles is known in various phyletic lines in parallel with each other. Therefore there is no adequate basis to segregate *Hymenasplenium* (Hayata) Bir generically from *Asplenium* L.

The entire data on the genus throughout the world shows that *A. unilaterale* Lam. is the only species with $x=40$ while the rest are based on $x=36$. The detection of $x=40$ in *A. unilaterale* Lam. also gives some support to Hayata's (1927) segregation of this species into a new genus *Hymenasplenium* (Hayata) Bir which was erected on certain supposed anatomical peculiarities of *A. unilaterale* Lam., the type species of the genus. However, Tagawa's (1938) and Holttum's (1954) study of *A. cheilosorum* Kunze ex Mett. and *A. normale* D. Don with *A. unilaterale* Lam. reveal that the evolution of all these ferns is from a remote common element in *Asplenium* L. Since there are no specific morphological or anatomical characters on which *Hymenasplenium* (Hayata) Bir can stand separately from other species of *Asplenium* L. and a genus cannot be segregated purely on cytological grounds, *A. unilaterale* Lam. deserves a place in *Asplenium* L. The different basic chromosome number in *A. unilaterale* Lam. clearly shows that the genus *Asplenium* L. is dibasic, composed of cytologically two distinct elements, although not so morphologically. The basic chromosome number $x=40$ of *A. unilaterale* Lam. in all probability has evolved by aneuploidy from $x=36$ (Bir, 1961).

The natural placement of *A. unilaterale* Lam. within *Asplenium* L. is evident on the basis of its morphology which is in no respect exceptional for

the genus, but varies with the orthodox $x=36$. Indeed, *A. unilaterale* Lam. may itself contain forms with $x=36$, counts of $n=72$ from Japan (Kurita, 1960) and $x=36$ from Hawaii (Wagner, 1963) were attributed to this species. The interpretation that the cytological peculiarity of *A. unilaterale* Lam. is of local and rather recent origin within *Asplenium* L. is strongly supported by the discovery of Bir (1960; 1963) of a natural dibasic hybrid (with $2n=76$ or 112) between *A. unilaterale* Lam. and another unidentified species of *Asplenium* L.. Finding of sexual diploids of *A. unilaterale* Lam. with $n=40$ from Pachmarhi, Satpura Hills is interesting, for the fact that it clearly supports the earlier contention of Bir (1960, 1963) that the genus *Asplenium* L. is dibasic ($x=36$, $x=40$). This gives at least a cytological basis for Hayata's segregation of *A. unilaterale* Lam. group of species under the new genus *Hymenasplenium* (Hayata) Bir which should be better be given a subgeneric status under *Asplenium* L. Since the species show all the basic morphological, anatomical, palynological and gametophytic characters to the genus *Asplenium* L. (Vasudeva, 1995). The cytological assessment of the *A. unilaterale* Lam. complex in the Eastern Himalayan area by Bir (1973) explains the exceptional record of $n=40$ and 76 . Three varieties of the species are reported as $n=40$, while the widespread sexual tetraploids of Southern India with $n=76$ is considered a dibasic hybrid. Its origin is proposed as a hybrid between a sexual form with 36 and one with 40 , that formed a diploid with 76 single chromosomes and then doubled to become a sexual tetraploid (Tryon and Tryon, 1982).

Much detailed work on the cytology, chromosome behaviour and polyploid levels of *Asplenium* L. are conducted by many workers, at different parts of the world. The cytology of *Asplenium* L. in the American tropics is scarcely known although the genus has been extensively studied especially in temperate America and Europe (Tryon and Tryon, 1982). *Asplenium* spp. are mostly diploid or tetraploid based on $n=36$ with exceptional reports of $2n=39$ bivalents or 40 bivalents in some members in Chiapas, Mexico (Smith and Mickel, 1977). Higher ploidy levels to octoploid are reported in New Zealand and to 16-ploid in the neotropics. The American tropical species are largely known from the work of Walker (1966, 1973) in Jamaica, reporting about equal numbers of diploids and tetraploids but also higher levels to 16-ploid.

The European *Asplenium* L. includes about equal numbers of diploids and tetraploids among reports of some 38 taxa. Eleven of the tetraploids have originated as genomic allopolyploids, six as autopolyploids and numerous hybrids are recognised between the *Asplenium* L. and *Ceterach* Willd. In temperate America a complex in the Appalachian region involves a core of three diploids, two species of *Asplenium* L. and *Camptosorus* Link. These have given rise to tetraploids and triploids as depicted by the morphological and cytological assessment by Wagner (1954) and confirmed by chromatographic studies of Smith and Levin (1963) and Harborne *et al.* (1973). The New Zealand species are wholly polyploid according to Brownsey (1977a, 1977b), and include nine widely distributed tetraploids

and eight largely endemic octoploids. Five Japanese species of *Asplenium* L. with $2n=144$, and Karyotypes of four with $2n=72$ were examined by Tatuno and Kawakami (1969) and Kawakami (1970). They arrange the chromosomes into six basic types each consisting of 12 chromosomes and on the basis of these analyses propose the primary base number $x=12$ for *Asplenium* L. Wagner and Wagner (1969) reported the taxonomic significance of a new spleenwort hybrid, *A. pinnatifidum* \times *trichomanes* from Southern Illinois of USA, while the same hybrid was later reported by Gastony (1971) from the state of Indiana, U.S.A. Page and Bennel (1979) reported a new species of *Asplenium* L. (*A. cuneifolium* Viv.) from England, and is new to the English Flora. Rasbach *et al.* (1990) reported the chromosome numbers and meiotic pairing behaviour of chromosomes of three Taxa (2 species and 1 hybrid) from Medeira, an island of Atalantic Ocean. Wagner *et al.* (1991) reported the first records of an alternate leaved sterile triploid hybrid *Asplenium* \times *alternifolium* Wufen (syn. *A. germanicum* Weis) from the New World. They reported that this hybrid is much like the results reported as *A. germanicum* Weis by Manton (1950). Kato *et al.* (1992) reported the chromosome number and ploidy of four species of *Asplenium* L. from Yunnan, South-Western China including the South Indian species *A. unilaterale* Lam. Rasbach *et al.* (1994) reported an allohexaploid species of *Asplenium* L. (*A. chihuahuense*) from Chihuahua, Durago and is endemic to North-Western Mexico.

ECOLOGY

Asplenium L. is essentially a world wide genus that occurs in all continents, most Atlantic Islands, and the Pacific eastward to the Hawaiian Island, Pitcairn Island and Easter Island. It grows north to lat. 70°N in Europe and to lat. 61°N in Greenland and south to southernmost South America, Amsterdam Island and New Zealand. *Asplenium* L. is primarily a genus of moist or wet forests, where it grows in ravines, along streams, on the forest floor, among rocks or on cliffs or as an epiphyte. This genus commonly occurs from sea level to above 3500m, most commonly from 500 to 2500m, but in the Andes it grows to 4700m (*A. triphyllum* Presl) and to 5100m (*A. castaneum* Schlect. & Cham.) (Tryon and Tryon, 1982). Manickam and Ninan (1984) reported the distribution of different species of *Asplenium* L. with difference in altitude in the Palni Hills, Tamil Nadu, South India.

In India, the genus *Asplenium* L. is mainly distributed in the Eastern Himalayas and the Western Ghats - two of the 25 global hot spots of biodiversity (Koshoo, 1995). The Western Ghats comprising an area of approximately 1.6 lakh sq. kms, stretching as a narrow belt over a distance of 1600 kms from Tapthi Valley in Gujarat to Kanyakumari in Tamil Nadu support thousands of species of both flowering plants as well as ferns, endemic to this region. The Western Ghats possess various types of tropical forests ranging from the wet evergreen to the dry deciduous. On higher elevations, it also holds montane subtropical and montane temperate

forests. Due to human interferences such as destruction of the habitat for various non forestry purposes, unscientific exploitation, etc. several species have become rare or endangered. This dangerous situation may lead to total elimination of certain plant species from the globe itself, especially in view of the fact that about 1500 species are not available any where else except on the Western Ghats.

ANATOMY

Morphologically the genus *Asplenium* L. is better known, particularly the Indian members (Bir, 1957, 1959, 1960, 1962, 1963, 1966) than most other genera, but its relationships to other groups of ferns is arbitrary. Vascular organisation of some asplenioid ferns were described by Bir (1970) and some details of stelar morphology of several species by Bower (1914); Davie (1918); Tardieu-Blot (1932); Ogura (1938); Wagner (1952) and Mitsuta *et al.* (1980). Chandra and Nayar (1975) studied the anatomy of Indian members of *Asplenium* L. In their study they noted the meristeles are nearly uniform in all species they have studied. They are broad, with a ribbon-like uniformly thick xylem band in the centre, consisting of 4-6 layers (up to 10 layers in *A. adiantum-nigrum* L.) of large scalariform tracheids. Protoxylem is in small groups scattered on the side facing the cortex of the rhizome but in *A. adiantum-nigrum* L. and *A. unilaterale* Lam. they are usually present on the extreme ends. In the *Asplenium* spp. with slender creeping rhizome, the xylem tissue consists usually of two or three layers (*A. unilaterale* Lam., *A. decrescens* Kunze) or in some other species (*A.*

cheilosorum Kunze ex Mett.) only a single layer of tracheids becoming two layered here and there. There is no parenchyma in between the xylem tracheids as also observed by Bir (1970), but contrary to the observations by Bir (1970) *A. nidus* L. possesses a few cells of xylem parenchyma intermixed with xylem tracheids. In *A. erectum* Bory ex Willd. xylem parenchyma are mostly found as intrusions and rarely in between the xylem tracheids. The peripheral sheath of xylem parenchyma which surrounds the xylem band contains starch deposits and is usually 2-3 layered, but in *A. decrescens* Kunze, *A. fontanum* (L.) Bernh., *A. unilaterale* Lam. it is only one layered, whereas in *A. normale* D. Don it is 4-5 layered. However it is absent in *A. affine* Sw. and *A. cheilosorum* Kunze ex Mett.

The phloem is restricted to both the flat surfaces of the xylem band (in *A. decrescens* Kunze it surrounds on all the sides) is usually 2-4 layers. It has scattered parenchyma except in *A. fontanum* (L.) Bernh.. The pericycle is prominent in all the species consisting of 2-5 layers of large, thin walled cells (5-8 layered in *A. erectum* Bory ex Willd. and *A. pellucidum* Lam.) arranged in irregular radial rows. Endodermis is ill differentiated in all species except *A. cheilosorum* Kunze ex Mett. in which the endodermis is often two layered on the pith side of the meristele; the inner walls of the endodermal cells are conspicuously thickened (slight thickening in *A. erectum* Bory ex Willd. and *A. laciniatum* D. Don). The ground tissue of the rhizome is parenchymatous and thin walled. In *A. decrescens* Kunze where all cells of the ground tissue possess collenchyma-like thickenings at the corners,

which is more conspicuous in the cells towards the centre. In some species, there are a few layers (2-6) of hypodermal cells with slightly thickened walls which are devoid of starch deposits, usually forming discontinuous sheath. In *A. adiantum-nigrum* L., *A. cheilosorum* Kunze ex Mett., *A. affine* Sw., *A. fontanum* (L.) Bernh., *A. laciniatum* D. Don and *A. unilaterale* Lam. the hypodermal sheath is not distinct, while in *A. nidus* L. there is a distinct continuous hypodermal sheath (8-10 layers of cells). In *A. nidus* L. and *A. cheilosorum* Kunze ex Mett. each meristele has a 5-7 layered sclerenchymatous sheath surrounding it; which is broader and more conspicuous in the inner region adjacent to pith (Chandra and Nayar, 1975).

Chandra and Nayar (1975) studied the vascular organisation of 18 species of *Asplenium* L. The vascular cylinder among the different species included in the study varies from simple dictyostele to dissected dictyostele, bearing spirally arranged leaf gaps and binary leaf trace. The association of a solitary and usually slender and unbranched root trace on the posterior base of the leaf trace is a common feature, but in some of them there is a stout composite root trace. Several slender root traces are associated with the posterior margin of the lacuna splitting the leaf trace in *A. nidus* L.. In *A. decrescens* Kunze a protostelic branch is associated with the composite root trace at the abaxial end of the leaf trace. The meristeles have 3-8 layered pericycle. Xylem comprises 1-8 layers of tracheids with no xylem parenchyma except in *A. nidus* L. and *A. erectum* Bory ex Willd.. Phloem

consists of 2-4 layers of thin walled sieve cells and is interrupted at the region of the leaf gaps (Chandra and Nayar, 1975).

The vascular cylinder in *A. adiantum-nigrum* L., *A. nidus* L., *A. ensiforme* Wall. ex Hook. & Grev., *A. normale* D. Don, *A. pellucidum* Lam. and *A. tenuifolium* D. Don is nearly similar. In all of them, the rhizome is short, either ascending erect or short creeping. Successive leaf gaps of the same spiral overlap conspicuously in *A. ensiforme* Wall ex Hook. & Grev., *A. nidus* L. and *A. normale* D. Don, but in *A. adiantum-nigrum* L., *A. pellucidum* Lam. and *A. tenuifolium* D. Don successive gaps of the same spiral overlap only partially. The leaf gap is widest a little beyond the posterior end. The leaf trace is channel shaped at origin with its margin prominently curved outward and the trace split longitudinally. The lacuna splitting the leaf trace extends a little beyond the region of origin of leaf trace bundles in *A. adiantum-nigrum* L. and *A. tenuifolium* D. Don. In contrast, in *A. ensiforme* Wall. ex Hook. & Grev., *A. nidus* L. and *A. pellucidum* Lam. the lacuna of the leaf extends conspicuously onto the vascular cylinder, appearing to originate from the margin towards the middle of the gap (Chandra and Nayar, 1975).

There is a distinct association of roots with the leaves but roots other than those associated with leaves are absent. In *A. adiantum-nigrum* L., *A. ensiforme* Wall. ex Hook. & Grev. and *A. normale* D. Don, there is a single median root trace on the posterior base of the leaf trace. The lacuna splitting the leaf-trace may extend slightly downwards on one side of the posterior root trace in *A. ensiforme* Wall. ex Hook. & Grev., which agrees with Bir

(1970). In *A. pellucidum* Lam., the root trace bundle is conspicuously thick as in *A. aethiopicum* (Burm. f.) Becher., *A. affine* Sw., *A. crinicaule* Hance, *A. decrescens* Kunze, *A. falcatum* Lam. and *A. finlaysonianum* Wall. ex Hook. and after origin splits into a large number of branches (6-10) which spreads fan like through the cortex of the rhizome supplying a cluster of roots at the leaf base (Chandra & Nayar, 1975). Bir (1970) observed a solitary root trace at the posterior base of the leaf trace in *A. nidus* L., but according to Chandra & Nayar (1975), instead of a solitary root trace there is a cluster of 3-6 root traces originate from the posterior margin of the lacuna dissecting the leaf trace, which may further branch. The median root trace may occasionally divide in *A. tenuifolium* D. Don which is in conformity with the reports of Bir (1970).

Though the vascular cylinder is similar in *A. crinicaule* Hance, *A. erectum* Bory ex Willd. and *A. laciniatum* D. Don (all having short ascending rhizome), as well as *A. aethiopicum* (Burm. f.) Becher. and *A. affine* Sw. (both having short creeping rhizome), but the spirals of leaf gaps are less crowded so that the vascular cylinder is more intact and the meristemes are broad and ribbon-like. Only 3 or 4 of them are seen in a transection of a vascular cylinder. Successive leaf gaps are distantly placed and overlap only partially in *A. crinicaule* Hance and *A. erectum* Bory ex Willd.. In *A. aethiopicum* (Burm. f.) Becher., *A. affine* Sw. and *A. crinicaule* Hance, the root trace bundle is thick and soon splits into a large number of branches as in *A. pellucidum* Lam.. In *A. erectum* Bory ex Willd. and *A. laciniatum* D.

Don the root trace bundle is comparatively thin and branches only 2 or 3 times while traversing the cortex. The lacuna splitting the leaf trace may extend slightly downwards on one side of the posterior root trace in *A. laciniatum* D. Don and *A. affine* Sw.. Roots other than those associated with leaves are absent in all. The vascular cylinder is still less dissected and often simple dictyostelic in *A. auritum* Sw., *A. finlaysonianum* Wall. ex Hook., *A. falcatum* Lam. and *A. fontanum* (L.) Bernh.. In all the species, the rhizome is short and ascending. The leaf gaps are in 2 or 3 loose spirals and distantly placed so that in a transection there are only 2 or 3, sometimes only a single large meristele. In *A. auritum* Sw. the root trace occasionally branches and rarely may further split once or twice only, where as in others like *A. falcatum* Lam. and *A. finlaysonianum* Wall. ex Hook. the root trace is a composite trace (Chandra &Nayar, 1975).

The vascular cylinder is simple dictyostelic in *A. cheilosorum* Kunze ex Mett., *A. decrescens* Kunze and *A. unilaterale* Lam., in all of which the rhizome is long creeping. The leaf gaps are large, elongated and are arranged in two loose spirals around the vascular cylinder. The gaps are rather distantly placed so that in a transection of a stele in any plane generally only two large channel shaped meristeleles are seen. Leaf gaps are sometimes nearly as broad as stelar cylinder in *A. cheilosorum* Kunze ex Mett. and *A. unilaterale* Lam., they are ellipsoidal and tapered to a bluntly rounded anterior end. In both these cases the leaf gap is extended more on the dorsal surface than on the ventral surface of the rhizome (so that the two

leaf traces appear to originate one after the other, the dorsal one separating earlier than the ventral). Leaf traces are paired strands as in other species and similarly shaped. The large lacuna splitting the leaf trace extends prominently on to the stelar cylinder of the rhizome on the posterior side of the leaf trace. In *A. cheilosorum* Kunze ex Mett. the gap extends up to and terminates at the solitary root trace at the posterior base of the leaf trace. In *A. unilaterale* Lam. the lacuna of the leaf trace may extend slightly beyond the root trace in one side. The root traces are simple solitary structures one associated with each leaf. In addition, to the leaf associated roots there are a few superficial root traces borne on the ventral side of the rhizome in both the species. In *A. decrescens* Kunze the root trace is large and irregularly branched at different levels and does not become flattened and channel like before branching. *A. decrescens* Kunze differs from all other species in having a characteristic association of branches with leaves, nearly every leaf is associated with a branch. Vascular connection to the leaf associated branch and leaf associated root originate together as a solitary composite vascular strand which is solid and cylindrical (protostelic). The branch trace separates from the root trace as a superficial bundle on the posterior side of the root trace. In most cases the branch trace and the large root trace separates soon after origin, but in some cases it may originate only after the composite strand is given off a few root traces (Chandra & Nayar, 1975).

From the point of view of vascular organization of the rhizome the major characteristics of the asplenioid ferns are the spirally arranged leaf

gaps, the meristeles having a multilayered pericycle, paired ribbon-like leaf traces and the characteristic association of roots with the leaves, having the root traces regularly originating at the posterior base of the leaf trace. A few species possess regular and characteristic association of branches with the leaves. Such species in which the association occurs are apparently more advanced evolutionarily. Thus among the species studied, *A. decrescens* Kunze may be held as comparatively more advanced. It is characterised by long creeping rhizome, pinnate fronds, with distantly placed leaf gaps, the leaf gap extending markedly on the posterior side of the leaf trace, there is a composite root trace at the posterior base of the leaf trace, and a simple dictyostelic vascular cylinder. *A. cheilosorum* Kunze ex Mett. and *A. unilaterale* Lam. have a similar type of vascular organization and possess elongated creeping rhizome and pinnate fronds, and thus appear to be evolutionarily close to *A. decrescens* Kunze. The meristeles of these species in having only a thin layer of xylem (2 or 3 rows of tracheids) support this. A vascular organization nearly similar to that of the above species (similar leaf gaps, and composite root trace as in *A. decrescens* Kunze), but dictyostelic due to the leaf gaps being crowded is found in *A. falcatum* Lam., *A. laciniatum* D. Don and *A. pellucidum* Lam.. All these have simply pinnate fronds and an ascending rather elongated rhizome. At the other extreme one species such as *A. adiantum-nigrum* L. and *A. tenuifolium* D. Don in which the leaf gap extends only slightly on the posterior side of the leaf trace and the vascular cylinder becomes a finely dissected dictyostele. These species

possess a highly dissected leaf lamina and short erect or ascending rhizome (Chandra and Nayar, 1975).

Thus, it seems possible that the more primitive condition in *Asplenium* L. is one having a highly dissected lamina as concluded by Holttum (1954). As far as the rhizome is concerned the erect habit is apparently the more primitive, with the vascular cylinder having a finely dissected dictyostele and the leaf gap scarcely extending abaxial to the leaf trace. This characteristic leaves a group of species with a simple lamina and erect to sub-erect rhizome, like *A. nidus* L. and *A. ensiforme* Wall. ex Hook. & Grev.. The vascular cylinder in these species is a highly dissected dictyostele, but the leaf gaps extend markedly on the posterior side of the leaf trace as found in the comparatively advanced species. Also, in *A. nidus* L. instead of a composite root trace bundle at the posterior base of each leaf trace, there are several root traces given off from the posterior margin of the leaf gap. This combination of characters possibly indicates that *A. nidus* L. and *A. ensiforme* Wall. ex Hook. & Grev. represent a line of evolution separate from that of the other species studied. The simple undissected leaf lamina of these species probably indicates an advanced evolutionary status within the genus. The possession of xylem parenchyma mixed with the xylem tracheids in *A. nidus* L. also supports this conclusion (Chandra and Nayar, 1975).

Chandra and Nayar (1975) noted that the vascular organization in the rhizome of asplenioids, *Athyrium* Roth. and other related athyroid ferns are basically the same. In both the groups, the structure of the rhizome is

dictyostelic, spirally arranged leaf gaps, binary leaf trace, presence of a root trace at the posterior base of each leaf trace, are common. However, athyroid ferns differ from asplenioid ferns in having non-clathrate scales, outline of the leaf trace in petiole and rachis, in chromosome numbers, short sporangial stalk with 3 or even 2 rows of cells with mostly non-perinate spores and the presence of xylem parenchyma in xylem elements. Therefore it appears that these two diverse elements may have developed from different sources and thus indicate parallel evolution.

The asplenioid ferns have their nearest allies in the thelypteroid genera. Both are related families (Ching, 1940; Mehra, 1961; Nayar, 1970, 1974) and have common characters in general like radiosymmetric dictyostele, spirally arranged leaf gaps, binary leaf trace, leaf gaps extending markedly on the posterior side of the leaf trace, common chromosome number and characteristically similar spores and prothalli. However, thelypteroid ferns differ from asplenioid ferns in having non-clathrate scales, presence of xylem parenchyma in xylem elements and roots without any regular association with leaves. However, the asplenioid ferns are not probably descended from thelypteroid ferns or vice-versa. The close similarity between the two groups may be taken as an indication of close affinity. Both the groups are presented by Nayar (1970, 1974) as cognate and derived together from the cyatheoid stock, they however, represent independent line of descent. The similarities of the vascular organization of asplenioid and thelypteroid ferns indicated by various authors from time to

time seem to suggest nothing more than a remote ancestry (Chandra & Nayar, 1975).

Singh (1963) conducted detailed ecological and anatomical studies of four species of *Asplenium* L. from Mussoorie, North-Western Himalaya. Iwatsuki and Kato (1975) studied the stelar morphology of *A. unilaterale* Lam. and some of its allied species like *A. normale* D. Don, *A. subnormale* Copel., *A. excisum* Presl, *A. cheilosorum* Kunze ex Mett. and *A. obscurum* Bl.. Based on the dorsi-ventral construction of the rhizome stele, Hayata (1927) proposed to segregate *A. unilaterale* Lam. and thereby describing the genus *Hymenasplenium*. They concluded that the dorsiventral rhizome of *A. unilaterale* Lam. and its allied species is considered to have evolved from the radial steles commonly known in the Aspleniaceae in relation to a petrophytic habitat, as reported by Holttum (1965). The process can be imagined to have occurred in two stages – first the alteration of an erect radial rhizome to a long creeping radial rhizome and then the modification to dorsiventrality. Because of this dorsi-ventral construction of the rhizome stele Hayata (1927) made the generic separation of *A. unilaterale* Lam. to the genus *Hymenasplenium* (Hayata) Bir. But Iwatsuki *et al.* (1975) reported that the dorsiventrality of the rhizome of *A. unilaterale* Lam. and its allied species seems to be an elaboration of the radial rhizome typical for *Asplenium* L., formed in adaptation to petrophytic habitat and hence there is not adequate basis to segregate *Hymenasplenium* (Hayata) Bir generically from *Asplenium* L. Mitsuta *et al.* (1980) studied the rhizome anatomy of 24

species of Aspleniaceae (includes 16 species of *Asplenium* L.) from Japan and reported the presence of a radial dictyostele with two leaf traces and a single root trace at each leaf-gap is the common type in the Aspleniaceae, whereas dorsiventral dictyosteles are present in *Asplenium* sect. *Hymenasplenium* and *A. lepturus* J. Sm. ex Pr.. Seth *et al.* (2005) reported the length, breadth and length/breadth ratio of the tracheids and vessels of *A. dalhousiae* Hook. from Bilaspur, Himachal Pradesh.

ROOT ANATOMY

Some work on the anatomy of the root of *Asplenium* L. was conducted by Schneider (1997), and applied the details in the systematics of this family. He studied the root anatomy of about 140 species of *Aspleniaceae* including the members of *Hymenasplenium* (Hayata) Bir and nearly all satellite genera of *Asplenium* L. such as *Ceterach*, *Diellia* etc. The division of the family into two genera, *Asplenium* L. and *Hymenasplenium* (Hayata) Bir is supported by characters of the cortex. The occurrence of sclereids with an eccentric lumen (asplenium-sclereids) distinguishes *Asplenium* L. from *Hymenasplenium* (Hayata) Bir as well as from all other ferns. Root anatomical characters are mostly constant at species level and therefore they are an appropriate marker for species groups of *Asplenium* L.

The roots of Aspleniaceae have similar construction to other advanced ferns (Schneider, 1996). From a taxonomic viewpoint cross sections illustrate all characters well and longitudinal sections do not provide additional information. The outermost limit of the root is the one cell layer

thick rhizodermis which usually possess a large number of root hairs. The adjacent cortex consist two regions, an outer cortex with thin walled cells and inner cortex with very thick walled cells. The central cylinder of the root is bounded by the one cell layer thick, secondary endodermis, within which pericycle comprises one or rarely two layers of parenchymatous cells. The metaxylem occupies the centre and the two protoxylem poles with 3-4 tracheids are located in an exarch position opposite each other. The number of tracheids (4-16) in the metaxylem correlates with the size of the plant, whereas structure of the cortex shows a systematically relevant diversity.

STOMATA

The significance of stomatal ontogeny and patterns in phylogeny and systematics had been recognised by Van Cotthem (1970a, 1973) and their usefulness in taxonomy and phylogeny has been described by various workers (Thurston, 1969; Chandra and Hashim, 1974; Chandra P, 1977, 1979; Khare, 1978; Chandra S, 1979; Kaur 1979a, b; Bir and Trikha 1979a, b; Bir *et al.*, 1979, 1980, 1981). So far, quite important contributions to stomatal studies, stomatal frequency, size of guard cells, etc. of 33 species (38 taxa) of *Asplenium* L. from India, were provided by Bir *et al.* (1981). The following formula is used for calculating stomatal index.

$$\text{Stomatal index} = \frac{\text{Number of stomata per unit area}}{\text{Number of stomata per unit area} + \text{Number of epidermal cells per unit area}} \times 100$$

In addition to normal stomata, some abnormalities like displaced, juxtaposed or obliquely oriented contiguous stomata are also reported in

some members like *A. aethiopicum* (Burm. f.) Becher., *A. ensiforme* Wall. ex Hook. & Grev., *A. adiantum-nigrum* L. and stomata with unequal guard cells in *A. inequilaterale* Willd.. Bir *et al.* (1983) studied the epidermal cell characteristics and stomatal patterns of eight species (10 taxa) of *Asplenium* L. that include the South Indian species like *A. aethiopicum* (Burm. f.) Becher., *A. cheilosorum* Kunze ex Mett. and *A. zenkeranum* Kunze. The cells of upper and lower epidermis of leaf are some what squarish or rectangular or irregular but more often they are elongated. The upper epidermal cell walls are usually wavy to feebly undulated, but in *A. zenkeranum* Kunze cell walls are straight or may be slightly wavy. Lower epidermal cells are characterised by thick and deeply undulated sinusoidal walls. The cells of upper and lower epidermis of *A. aethiopicum* (Burm. f.) Becher. are more or less similar, whereas in *A. zenkeranum* Kunze cells are quite distinct on both the surfaces. Generally, the size of the stomata are inversely proportional to the frequency, stomata are larger where the frequency is less (*A. cheilosorum* Kunze ex Mett., *A. zenkeranum* Kunze) and are smaller in size where the frequency is higher (*A. aethiopicum* (Burm. f.) Becher. (Bir *et al.*, 1983). It is generally observed that the size of the guard cells is larger in tetraploids in comparison to diploid or triploid cytotypes of these species (Bir *et al.*, 1981).

Stomata are restricted to only lower surface of the lamina *i.e.*, exhibiting hypostomatic condition (Bir *et al.*, 1981) and are predominantly polycytic (Van Cotthem, 1970b) and acyclic (Patel, 1979). More than one

type/subtype of stomata may also occur within the same species. However, their frequency is much lower than the main type. In *A. aethiopicum* (Burm. f.) Becher., the stomata are of anomocytic (Van Cotthem, 1970b, Patel, 1979), where as in *A. cheilosorum* Kunze ex Mett. they are polocytic containing sub-type parietocytic (Van Cotthem, 1970b) and acyclic with sub-type polohaplo-acyclic (Patel, 1979), at the same time in the case of *A. zenkeranum* Kunze, the stomata are polocytic with sub-type parietocytic and coprietocytic (Van Cotthem, 1970b) but acyclic with sub-type polohaplo-acyclic and duplo-twi-acyclic (Patel, 1979). The closely allied species, *A. aethiopicum* (Burm. f.) Becher. (anomocytic) and *A. auritum* Sw. (anisocytic) can be easily distinguished by the nature of their stomata (Bir *et al.*, 1981). The occurrence of similar type of stomata in a few but confusing species like *A. erectum* Bory ex Willd., *A. inequilaterale* Willd. (Coprietocytic), *A. aethiopicum* (Burm. f.) Becher., and *A. nitidum* Sw. (anomocytic), etc. does not corroborate with their phylogenetic relations and hence could not be used in the circumscription of these species. However, the presence of same type of stomata in *A. nidus* L. and *A. phyllitidis* D. Don supports their very close morphological resemblance. Bir *et al.* (1981, 1983) concluded that, the usefulness of stomatal patterns is of limited value in segregation of closely allied taxonomic identities. However, stomatal and epidermal characteristics may play an important role when taken into consideration in conjunction with other taxonomic characters. They further revealed that the size of stomata, their frequency and index are good criteria not only for

differentiation of closely allied species but also for differentiation of different intraspecific cytotypes.

PALYNOLOGY

In recent years the study of spore morphology has assumed great importance and its role in the taxonomy of ferns has increasingly been felt. Important contributions are being made by Knox (1951); Harris (1955); Erdtman (1957); Nayar and Devi (1964) and others. While presenting a new system of fern classification Alston (1956) made use of spore characters as one of the taxonomic criteria in distinguishing various groups of families (Bir, 1966-67). Fern spores offer both reliable and stable morphological characters, which may be employed as criteria in the identification of genera and species as well as in the tracing of possible affinities and trends of evolution between the genera and the higher systematic categories (Sorsa, 1964).

The spores of Pteridophyta, like the pollen grains of phanerogams, have a highly resistant, outer protective coat. Consequently they are well preserved in most of the fossil bearing horizons, ranging from the palaeozoic to the present, making them favourite objects for microfossil analysis. Also, as indicated by fossils, the pteridophytes occupied as far more important position in the world flora of ancient times than what it is today (Nayar, 1964).

Spores of *Asplenium* L. are characteristically monolete and bilateral, with a well defined perine which is variously folded and almost invariably possessing a supralaesural fold. The exine and perine are ornamented in many species, the most common one being the exine and perine both spinulose (Devi, 1977). The spore characters which can conveniently be taken into consideration include the shape, size, thickenings on the exospore and presence or absence and nature of the perispore (Whether transparent or opaque, smooth or folded or reticulated). The spore size can also prove to be very important character in case of those species which do not show intraspecific polyploidy. The closely allied species can conveniently be segregated on the basis of the size of their spores (Bir, 1966-67). The spore size varying much in the different species (20-40 x 28-56 x 20-38 μ) but mostly *ca.* 26 x 40 x 28 μ and many *ca.* 22 x 32 x 22 μ , plano-convex to slightly concavo-convex in lateral view and usually oblong in polar view. The colour of mature spores is also an important character in distinguishing the closely allied species. In *A. nidus* L. the spores are yellowish or light brown with distinct sac like broad perispore having irregular, somewhat anastomosing surface folds, while in *A. finlaysonianum* Wall. ex Hook. these are dark brown with broad, transparent perispore having irregular reticulations (Bir, 1966-67). Exine is dark brown, smooth to spinose, but usually densely and prominently granulose with circular or oval non-ornamented areas irregularly scattered all over. Perine deep brown, more or less loose, often with spinulose or densely granulose ornamentation (sometimes smooth) and often wrinkled into thin elongated, sinuous folds

which are papillate in optical section and with smooth crests; there is often a supralaesural fold distinct from other folds (Devi, 1977). The characteristic feature of the surface of the perine based on the light microscope observations is the presence of regular perforations and specific unornamented (nude) areas (Nayar & Devi, 1964; Nayar *et al.*, 1964; Devi, 1966). The presence of these nude areas is not reported in any other major group of ferns and can serve as a diagnostic feature, even though there are some exceptions within the genus. Also, in some of the lomariopsidoid ferns the perine is sometimes perforated; the perforations appear like the nude areas found in *Asplenium* L. (Devi, 1966).

The spore morphology is one of the important and the most dependable taxonomic criterion for the subdivision of the genus *Asplenium* L. (Bir, 1966-67). Considerable work has been done on the spore morphology in various members of family Aspleniaceae. Sledge (1962) was the first to emphasize the importance of spore characters in the taxonomy of this group of ferns. Sledge (1962) utilised the spore characters in segregating his new species *A. khasianum* Sledge from *A. gardneri* Baker (Bir, 1966-67). Nayar & Devi (1964) reported the spore morphology of 36 Indian species of *Asplenium* L. Among the various species discussed, *A. dalhousiae* Hook., *A. fontanum* (L.) Bernh., *A. tenuifolium* D. Don and *A. viride* Hudson are diploids (Mehra & Bir, 1957, 1960; Bir, 1959, 1960; Manton & Sledge, 1954; Abraham *et al.*, 1962). Their spores are comparatively small. Spore morphologically *A. fontanum* (L.) Bernh. seems

to represent the most primitive type among these: its spores have a thick, spinulose exine and a loose, spinulose, scarcely folded perine; a prominent supra-laesural fold is also present (Nayar & Devi, 1964). Nayar *et al.*, (1964) made a detailed palynological study of 12 species of *Asplenium* L. out of a total of 55 species of ferns from West Tropical Africa. Of these only *A. aethiopicum* (Burm. f.) Becher., *A. inequilaterale* Willd. and *A. unilaterale* Lam. are common with South India. Welman (1970) reported the palynology of 43 species of *Asplenium* L. from South Africa. Of these five species like *A. erectum* Bory ex Willd., *A. formosum* Willd., *A. inequilaterale* Willd., *A. obscurum* Bl. and *A. unilaterale* Lam. are common with South India.

Holttum (1954) considered that a division of *Asplenium* L. based on spores is a more satisfactory than one based on the state of dissection of the frond, and state that some vegetative characters are linked with spore characters.

GAMETOPHYTES

The pteridophyte taxonomy and evolution were concerned only with the morphology of the sporophyte, the sporophyte being by far the dominant phase in the life history. The gametophytes of ferns has always been a neglected generation, ignored by morphologists and taxonomists alike (Nayar and Kaur, 1971). However, Stokey (1951), after a lifetime of work on fern gametophytes, most effectively presented a classical account dealing with the contribution of gametophyte morphology to the classification of the

ferns. She proved beyond doubt that the fern gametophyte, though simple in structure when compared to the sporophyte, affords dependable criteria for taxonomic and phyletic studies.

The prothallial morphology of *Asplenium* L. is known (Lagerberg, 1907; Freer, 1926; Karpowicz, 1927, 1963; Faegri, 1934; Wagner, 1952; Momose, 1941b, 1959-1962; Bir, 1962, Nayar *et al.*, 1968). Momose (1959) observed 43 kinds of prothallia for asplenioid ferns and based upon these characters observed, he justified Aspleniaceae as a natural family of Filicales and the family is related to Polypodiaceae and Davalliaceae.

The prothalli of asplenioid ferns are cordate-thalloid, with light median midrib and large spread out wings, and usually broader than long (but having a tendency in some cases to elongate slightly). The adult thallus is hairy except in some species like *A. nidus* L., *A. pekinense* Hance, *A. tenuifolium* D. Don, *A. marinum* L., *A. unilaterale* Lam. and *A. dalhousiae* Hook. in which the prothallus is naked throughout; the margin of the thallus is smooth in most species having naked prothalli, but in some like *A. trichomanes* L. and *A. viride* Hudson, some of the marginal cells possess conspicuously protruded outer walls, the protrusions resembling stout hairs. In species which possess hairy prothalli the abundance of hairs varies with the species, some (*A. adiantum-nigrum* L. and *A. rutamuraria* L.) being very profusely hairy, nearly each marginal cell bearing a hair. The nature and form of the hair also vary, but in a large number of species the hairs are unicellular, slender and papillate but most often devoid of any extracellular secretion. In

some cases the papillate hairs are septate, either occasionally as in *A. adiantum-nigrum* L. or rather frequently as in *A. septentrionale* (L.) Hoffm., and *A. rutamuraria* L.. In some species the hairs are mammillate with a conspicuously swollen base and suddenly narrowed, short, sub-conical apex. Marginal hair bearing cells of the prothallus sometimes grow out as a short filamentous or broad protrusions (which make the hair appeared multicellular) in many species. In a few species like *A. leucostegioides* Bak. hairs are sparse, club shaped, 2-5(up to eight) cells long, with a distinct glandular apical cell (often with an extra-cellular secretion around it).

The spore germination is of the *Vittaria*-type, producing a proximal rhizoid and a uniseriate germ filament lateral to it. Prothallial development in most species of *Asplenium* L. is mainly of the *Aspidium*- type, with most of the germ filaments developing an obconical meristematic cell in one of the daughter cells of the terminal cell developing a hair before initiating plate formation. In such cases the prothalli are hairy from the early stages of development onwards (Nayar & Kaur, 1971).

Sex organs of the *Aspleniaceae* are of the common leptosporangiate-type. Antheridia are produced from early stages of prothallial development onwards; on adult thalli they are restricted to the midrib and the nearby areas on the lower surface. In *Asplenium* L. the distribution of antheridia (either restricted to the basal part or spread along the sides of the midrib) is regarded as a specific character by Momose (1959-1962). Antheridial dehiscence is by a pore like opening developed in the cap cell; the pore

widens soon, and the cap cell ultimately is torn apart. However, in some cases (*A. normale* D. Don) the process of opening is rather sudden and the development of a pore is not very obvious. Structural development of archegonium is of the common type in advanced ferns. The neck is slender and curved away from the apex of the prothallus. The neck canal cell is binucleate and swollen towards the apex at maturity.

ECONOMIC IMPORTANCE

Pteridophytes constitute an important part of the flora of this world and this country next to the flowering plants. Not much had been known regarding the economic value of this group of plants. This is not because of 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 towards human welfare (Vasudeva, 1999). The pteridophytes are known to man for more than 2000 years for their medicinal values. The ferns in general and asplenioid ferns in particular have been successfully used in the Ayurvedic, Unani, Homeopathic and other systems of medicine (Kumar *et al.*, 2003).

It has been observed that the forests play a vital role in the life and economy of the tribal people of our country. This is because of the fact that they generally depended upon the forest flora for their livelihood and collect and utilize many plants including pteridophytes for food, fuel, fibre, oil, medicines and shelter. The ethnobotanical surveys and studies conducted in the mountainous regions of various parts of the country gathered the

ethnobotanical data on various ferns and fern allies from the tribal communities and medical practitioners. Further, the information on the economic utility of this group of plants were given by various workers (Christensen, 1995; Good, 1933; Fosberg, 1942; Lewis & Lewis, 1977; Lloyd, 1964; May, 1978; Lawrence, 1951; Turner & Bell, 1973; Chopra *et al.*, 1956; Dixti, 1974, 1975; Dixit & Bhatt, 1975; Nayar, 1957; Puri, 1970; Chandra & Kaur, 1974; Kaur, 1986, 1989; Kaur & Chandra, 1977; Kachroo, 1968; Singh *et al.*, 1989) from time to time clearly indicates that the pteridophytes are of immense economic importance and there is a great need for their exploitation towards the economic utility in our day to day life. It has been observed that a large majority of pteridophytes grow in the tropical forests on higher altitudinal mountainous regions. Besides having various economic values as food and fodder, indicators, bio-fertilizers, insect repellants, medicines and folk remedies, quite a large number of them are cultivated as ornamentals either indoors in the houses or outdoors in the botanical gardens due to their delicate beauty and grace (Vasudeva, 1999).

Quite a number of ferns in general and asplenioid ferns in particular are of great medicinal value. *Asplenium* L. popularly known as "spleenwort" is supposed to cure diseases of the spleen and is so named. The medicinal qualities of ferns, real or imaginary are mentioned as early as 300 B.C by the Greek philosopher Theophrastus (Corne, 1924a) and his Indian contemporaries Sushrut and Charak (Puri, 1970). It is one of the earliest recognised genera as reported in Van Rhee's (1693) *Hortus Malabaricus*.

The plate No.18 of Rheede's *Hortus Malabaricus* named as "Nella Panna Maravara" was recognised as *Asplenium falcatum* Lam. by earlier workers (Dutta, 1985; Nicolson *et al.*, 1988 Madhusoodanan & Rejani, 1994), while it is identified as *A. decrescens* Kunze by Remesh *et al.* (2003) and Manilal (2003). The powdered root of this plant mixed with cow milk cures dysentery. The juice of the crushed leaves mildly moves the bowels and also used for the purification of the blood. The extract of the whole plant mixed in bathing water and sitting in tub immersed up to the navel, promotes easy delivery; reduces the phlegm of lungs, opens and softens the hardened and obstructed spleen if and when the juice is taken with the root of the tree 'Canella' (*Cassia fistula* L.).

Ferns have long been used medicinally. As far back as Dioscorides and Galen have been accepted as good drug sources. Today, ferns are used as medicinal plants all over the world.

(1) *A. adiantum-nigrum* L. (Black spleenwort) is used as Anthelmintic, emetic in South Sotho and South Africa (Watt, 1962; May, 1978). The plant is bitter, used as laxative, diuretic, useful in ophthalmia, jaundice and diseases of spleen in India (Chopra, 1956; May, 1978; Vasudeva, 1999; Kiran & Kapahi, 2001; Kaushik & Dhiman, 1995 and Trivedi, 2002; Singh,2003). Decoction of fronds is used as an expectorant, pectoral and emmenagogue (Caius, 1935; Trivedi, 2002; Vasudeva, 1999). The plant is used in swellings and induration of liver, calculus, malaria and also in treating hiccough (Asolkar *et al.*, 1992). The decoction of fronds is also used

to cure cough and for bringing sterility in women (Kiran & Kapahi, 2001; Singh, 2003). The rhizome is anthelmintic (Singh, 2003).

(2) *A. falcatum* Lam. The plants are used in malaria, jaundice, enlargement of spleen, urine trouble and calculus (Vasudeva, 1999; Trivedi, 2002; Chopra, 1956; Ambasta, 1986). The rhizome is used as anthelmintic (Jain, 1991). The rhizome is used to treat jaundice and prolonged malaria in North Africa (Hare *et al.*, 1916). The whole plant is anthelmintic and chiefly used against tape worm (Singh, 2003).

(3) *A. trichomanes* L. (common spleenwort) - The plant is used as laxative, expectorant and used in pulmonary diseases. Leaf smoked for the cold in the head and chest by the tribals (Vasudeva, 1999; Trivedi, 2002; Caius, 1935). The plant is used in abscess of uterus as anthelmintic (Asolkar *et al.*, 1992; Jha *et al.*, 2003) and also used for hypochondriac affections (Asolkar *et al.*, 1992). Decoctions of fronds is used in jaundice and for curing enlargement of liver and the leaves smoked in bad cold and chest pain (Kiran & Kapahi, 2001). The whole plant is used as expectorant, refrigerant, pectoral, laxative, anthelmintic, insecticide and pesticidal and it also contains medicinally important chemicals like catechol, pyrogallol and gallic acid (Singh, 2003).

(4) *A. rutamuraria* L. ("Wall Rue") The plant is used as expectorant and deobstruent. It is valuable medicine in pulmonary diseases. Plant is used in induration of liver, knots and swellings (Asolkar *et al.*, 1992; Kaushik & Dhiman, 1995; Singh, 2003). The plants are used as expectorant and the

fronds are used as a cure for rickets (Vasudeva, 1999; Chopra *et al.*, 1956; May, 1978; Trivedi, 2002; Singh, 2003). The roots anthelmintic and astringent while the leaves pectoral and diuretic in North Carolina (May 1978).

(5) *A. fuliginosum* Hook. The rhizome is used as an anthelmintic (Vasudeva, 1999; Trivedi, 2002).

(6) *A. nidus* L. the whole plant body is used as a deputed and sedative in philippines (Quisumbing, 1951; May, 1978) and also it is antibacterial and used in sore and ulcer (Singh, 1999,2003).

(7) *A. polydon* G. Forst. var. *bipinnatum* (Sledge) Sledge (*A. bipinnatum* (Sledge) Azeez & Madhus., stat. nov.) The whole plant is used in the treatment for the enlargement of spleen, incontinence of urine, jaundice and malaria in North Africa (Manickam & Irudayaraj, 1992).

(8) *A. ceterach* L. The plant is used for cure of enlarged spleen, pectoral and aprient in Europe (Grieve, 1971; May, 1978).

(9) *A. cuneatum* Lam. The plant is used as emetic in South Africa (Watt *et al.*, 1962; May, 1978).

(10) *A. furcatum* Thunb. The rhizome is used as anthelmintic in Basutoland (Chopra, 1956; May, 1978).

(11) *A. monanthes* L. The leaves smoked for cold in South Africa (Watt, 1962) where as it is used as diaphoretic in Peru (May, 1978).

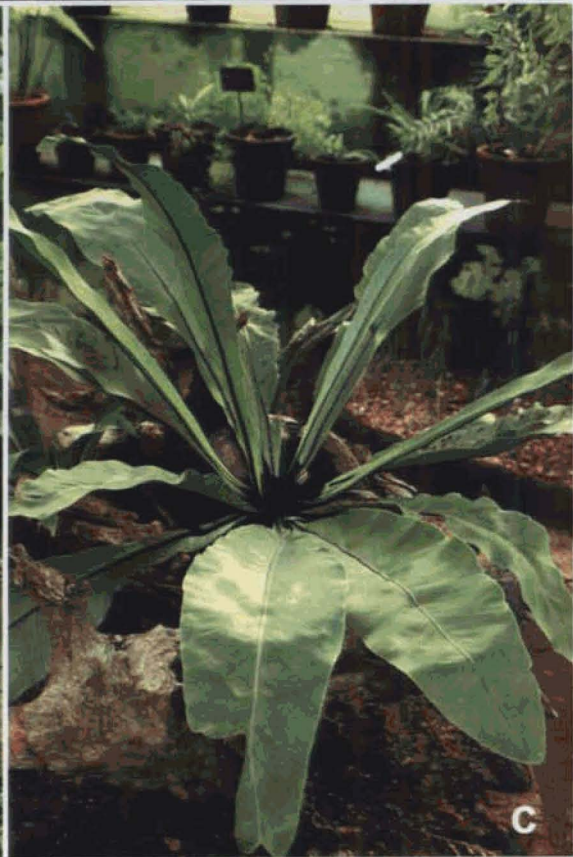


Plate 01. *Asplenium nidus* L. Photographs taken from **A.** Calicut flower Show 2005; **B.** Gurukula Botanic Sanctuary Periya, Wayanad; **C.** Tropical Botanic Garden & Research Institute (TBGRI), Thiruvananthapuram.



Plate 02. *Asplenium nidus* L. Photographs taken from **A.** Indian Institute of Spices Research (IISR), Calicut; **B.** Gurukula Botanic Sanctuary - Periya, Wayanad; **C.** KFRI Teak Museum, Nilambur; **D.** 'Fern House' Padanilam, Calicut.

- (12) *A. repandum* Mett. ex Kuhn. Decoction of leaves used against gonorrhoea in Malaya (May 1978).
- (13) *A. singaporianum*. Decoction of leaves used after childbirth in Malaya (May, 1978).
- (14) *A. dalhousiae* Hook. The whole plant is antibacterial (Singh, 2003).
- (15) *A. ensiforme* Wall. ex Hook. & Grev. The plant is eaten as food and it yield a red dye (Singh, 2003).
- (16) *A. finlaysonianum* Wall. ex Hook. It is used in decoction , diuretic and also used in the treatment of beriberi (Singh, 2003).
- (17) *A. polydon* G. Forst. It is used in the treatment of enlarged spleen, incontinence of urine, calculus, jaundice, malaria and is anti-cancerous also (Singh, 2003).
- (18) *A. yoshinagae* Makino var. *planicaule* (Wall. ex Hook) Morton The extract of the plant cause burning effect on skin. It contains medicinally important chemicals like vit. K3, octatriacontane, phthicol, β -sterol, glycoside, sucrose, glucose, galactose, arabinose (Singh, 2003).
- (19) *A. ramosum* L. The fronds applied on burns (Singh, 2003).
- (20) *A. pumilum* var. *hymenophylloides* (Fee) Clarke It contain the medicinally important flavenoid hesperidin (Singh, 2003).



Plate 03. Photographs of *Asplenium* spp. cultivated in gardens; A. *A. phyllitidis* D. Don from ' Fern House' Padanilam, Calicut; B. *A. zenkeranum* Kunze; C. *A. semivarians* Viane & Reichst.; D. *A. polydon* G. Forst.; E. *A. serricula* Fee from Gurukula Botanic Sanctuary - Periya, Wayanad.

Watt & Bryer - Brandwijk (1962) reported *A. flabellatum* Cav. as a commercial source of Hydrocyanic acid in South Africa. Sharma & Harsh (1992) reported two species of *Asplenium* L. (*A. pumilum* var. *hymenophylloides* (Fee) Clarke and *A. dalhousiae* Hook.) with ascending rhizome and bearing profusely branched adventitious roots, bind the soil surface and enrich it with humus and microflora.

Some species of *Asplenium* L. has great aesthetic value due to their grace and delicate beauty and hence are cultivated as ornamental plants (Plate 1, 2 & 3) The bird's nest fern, (*A. nidus* L.) and several very similar closely related species and *A. zenkeranum* Kunze are cultivated as an ornamental due to its grace (Vasudeva, 1999). The most beautiful Indian species of *Asplenium* L. Like *A. nidus* L. and *A. phyllitidis* D. Don in which the simple shining and leathery fronds remain attached to the rhizome for several years and can withstand desiccation. Now "bird's nest" fern is very much fancied by the indoor and garden plant lovers in North Eastern and Southern India. Every year during rainy season a large number of wild plants are collected by nursery men resulting in massive depletion of natural populations of this beautiful and highly ornamental fern (Das, 2005).

CONSERVATION

The disappearance of many fern species clearly indicates the degree of disturbances inflicted on these delicate plants by disturbing their 'houses' - forests - by human activities. There is no chance to think that it is due to natural extinction for some biological reasons, because Western Ghats are

older than the Himalayas and the species growing here are the well established ones unless there is any disturbance caused to their habitat. The bio-diversity is still increasing in the Western Ghats by natural evolution. It is evident by the discovery of many new species and cytotypes (Irudayaraj and Manickam, 1995).

From the conservation point, it can be quoted that "Much of India's future prosperity rests on the management and conservation of its natural resources. Climatic and topographical variations have endowed the sub-continent with one of the world's richest flora. But it is a flora under threat owing to population increase, urbanisation, mining, logging, dams and hydroelectric power schemes, agricultural expansion, overgrazing and now tourism" (Ray, Desmond 1992). The first National symposium on biosphere reserves established the first one in the tropical and sub tropical forests of the Nilgiris. It is estimated that about 60% of the country's vascular flora of 15,000 species is endemic. Nearly 200 species of ferns and fern allies are endemic to India especially in the Western Ghats and the Himalayas (Irudayaraj and Manickam, 1995).

It is up to the Government, the scientists, and the public to preserve this valuable wealth of our Nation without causing any direct or indirect disturbance to the natural environment on which future generations depend (Irudayaraj & Manickam, 1995).

STUDIES ON THE ASPLENIACEAE OF SOUTH INDIA



*Thesis submitted to the University of Calicut
in partial fulfilment of the requirements for the degree of*

Doctor of Philosophy

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*"The highrange with its deeply dissected valleys
and massive peaks is surpassingly grand
and incomparably beautiful.*

*The views from these mountains are the grandest and
most extensive I have ever heard.
This is far beyond my power to
describe and must be seen
to be appreciated."*

Genl. Douglas Hamilton

AREA OF THE STUDY

AREA OF THE PRESENT STUDY

The present study area is of South India, that includes the political states of Kerala, Tamil Nadu, Karnataka, Andhra Pradesh 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 on the north by the states of Maharashtra, Madhya Pradesh and Orissa, on east by the Bay of Bengal, on the South by Indian Ocean and on the West by Arabian sea or Lakshadweep sea.

South India consists of two major floristic regions – the Deccan Plateau and the Malabar. The Deccan plateau stretching from the mountain ranges of Central India like Aravallis, the Malva, the Vindhyas, the Satpura and the Chota Nagpur Hills in north and almost right down to Kanyakumari in the South. The Western and Eastern Ghats borders it on either side. The northern part of the Plateau slopes west-wards while the Southern part slopes towards the south east. It is the rain shadow region of the Western Ghats and is characterised by the tropical deciduous forest while in the open plains it is replaced by drought resistant thorny shrubs. The eastern coastal plains 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 consists of fertile coastal plains mainly formed by the deltas of Cauveri in Tamil Nadu,

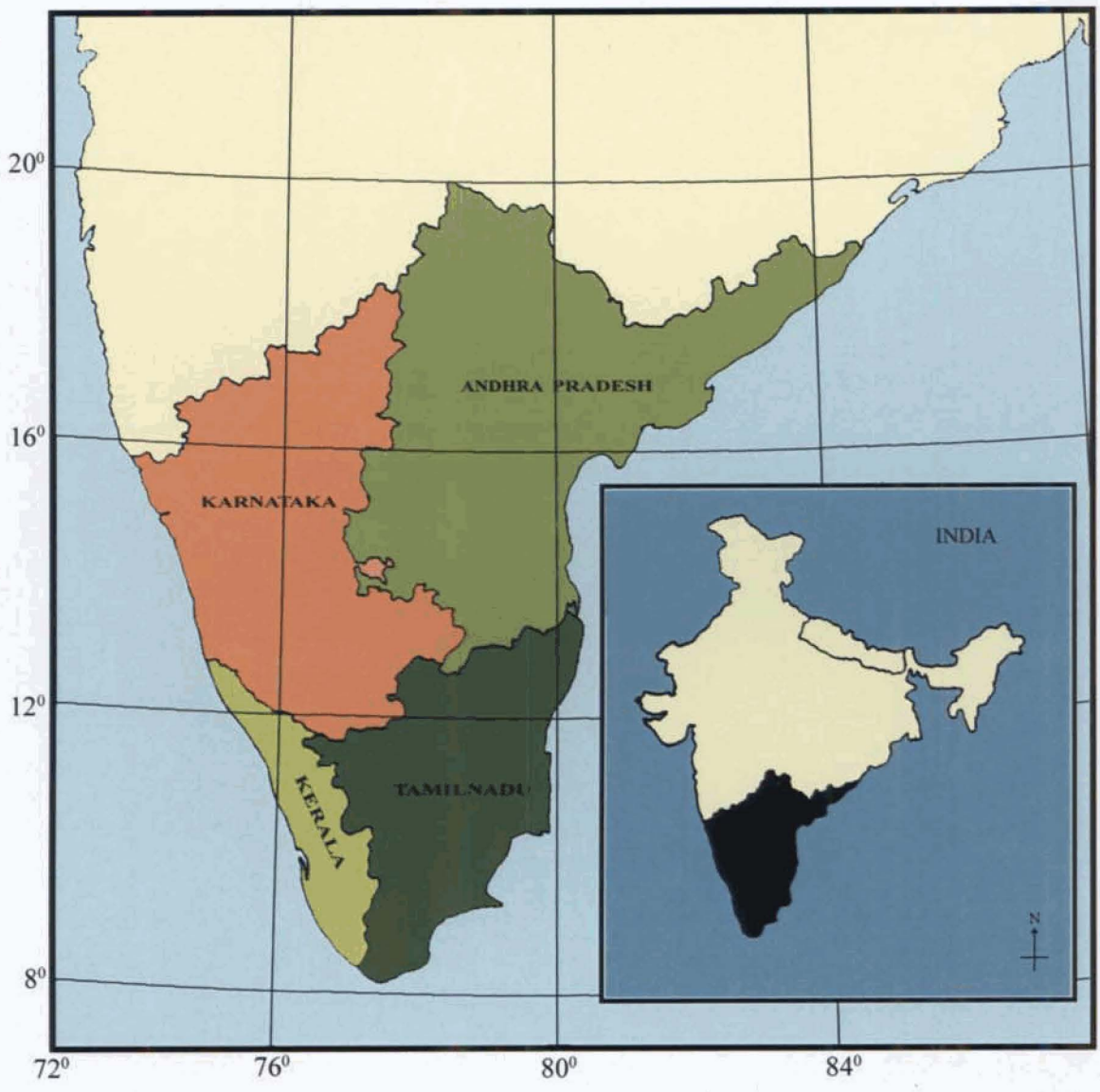


Fig. 01. Map of South India

Godavari and Krishna in Andhra Pradesh and a number of small rivulets and streams.

The Eastern Ghats, run along the eastern border of the Deccan plateau, are less prominent and less continuous than the Western Ghats. It extends over a length of 1750 km in a north east - south west 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 Godaveri and Krishna cut across it.

The Malabar coast is a long and narrow strip of land running parallel to the Arabian sea, west of Western Ghats and south of Konkan. This region is floristically rich and includes coastal plains and a series of hill ranges of the Western Ghats, which support hundreds of species of both flowering as well as ferns endemic to this region. The Malabar and the Deccan regions together provide a wide range of climatic and edaphic zones with mountain ranges, hillocks, valleys, swamps, marshy lowlands, sandy sea-coasts, fresh water streams and back waters on the sea-front and harbours diverse type of vegetation.

The Western Ghats comprising an area of approximately 1.6 lakh sq.km run along the western border of Deccan Plateau and give birth to all the important rivers of South India. The Western Ghats stretches as a narrow belt over a distance of 1600 km. from Tapi Valley in Gujarat where it

90 A
Plate 04



Thekkady - Idukki Dt., Kerala



Munnar - Idukki Dt., Kerala



Munnar - Idukki Dt., Kerala



Thekkady - Idukki Dt., Kerala



Silent Valley - Palakkad Dt., Kerala



Wayanad Dt., Kerala



Agasthyamala
Thiruvananthapuram Dt., Kerala



Paandavanpara, Agasthyamala
Thiruvananthapuram Dt., Kerala

Plate 05



Sirumalai Hills
Dindigal Dt., Tamil Nadu



Sheveroy Hills
Salem Dt., Tamil Nadu



Kodaikanal
Dindigal Dt., Tamil Nadu



Palni Hills
Dindigal Dt., Tamil Nadu



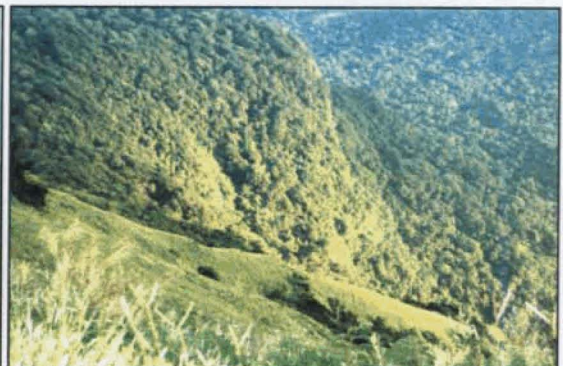
Ooty
Nilgiri Dt., Tamil Nadu



Valparai
Coimbatore Dt., Tamil Nadu



Kudajadri - Shimoga Dt., Karnataka



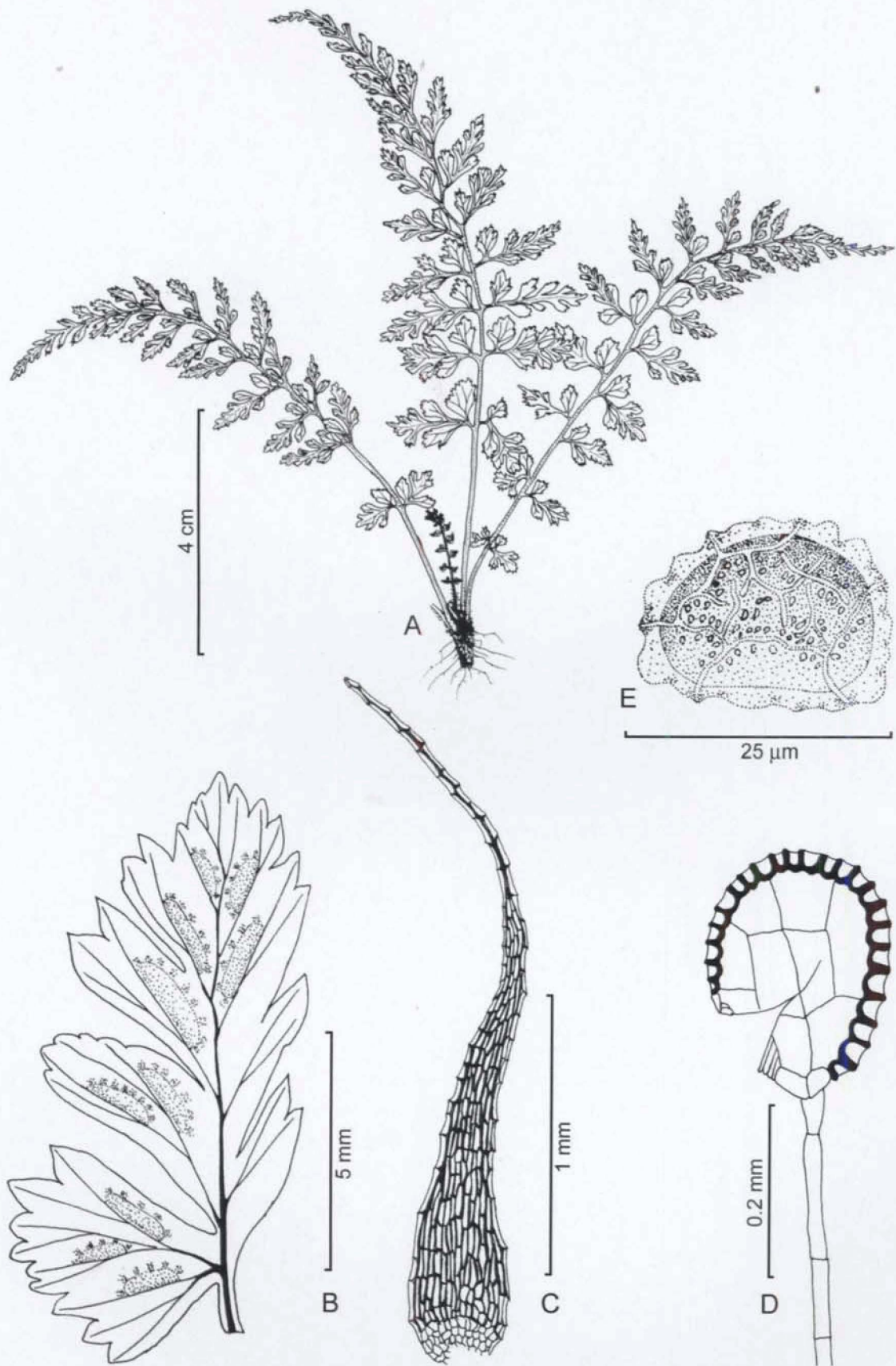


Fig. 27. *Asplenium semivarians* Viane & Reichst.. A. Habit; B. Pinna showing venation and position of sori; C. Palea on the rhizome; D. Sporangium; E. Spore.

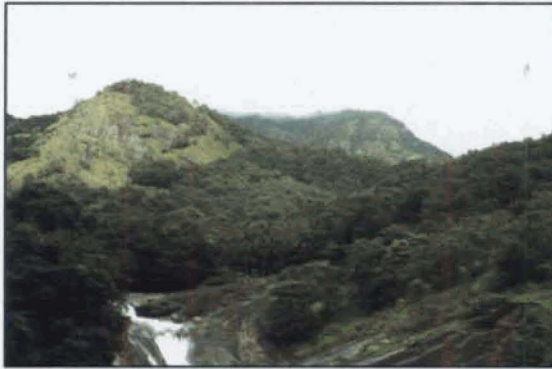
touches the Western edge of the Vindhyas, down to the tip of the Peninsula, the Kanyakumari in Tamil Nadu. These mountain ranges runs north-south along the west coast traversing the states of Gujarat, Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu. These hill ranges are more prominent and more continuous than the Eastern Ghats and both of these meet at Nilgiris. To the south of Nilgiris occurs the well known Palakkad gap, extending 30 km, which connects the coastal plains of Malabar with the plains of South Tamil Nadu and separating the Nilgiri ranges from the Anamalais. South to the gap occur the Anamalai Hills with their highest peak Anamudi. The Palni Hills form an eastern 'spur' of the Western Ghats. The Western Ghat 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 Kanyakumari. 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 of Kerala. These mountain ranges, criss-crossed by many fast flowing rivers, form a narrow coastal belt which overlooks the Arabian 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 rainfall from both south-west and north-east monsoon, it supports the luxurious growth of tropical wet evergreen, semi-evergreen and moist deciduous forests.

The major South Indian Hills with an attitude of more than 1800 m are the Palni Hills (Kodaikanal, 2328m), Nilgiri Hills (Dodabeta, 2621 m; Ootacamund, 2245 m), Anamalais (2678 m), Bababudangiri (1925m) and Cardamom Hill ranges (Meher-Homji, 1967). On account of the comparatively low temperature prevailing in the South Indian Hills, the climate and vegetation of these areas are often spoken of as temperate type. However, Meher-Homji (1967) described the climate of this region as tropical montane type.

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

Rainfall is the most important climatic factor that controls the distribution of vegetation including the ferns. South India receives both North-East monsoon (October - December) and South-West monsoon (June - September). The former is more active in Tamil Nadu, Pondicherry and Andhra Pradesh, while the latter is more vigorous in Kerala and Coastal Karnataka. The west coast of South India receives the heaviest rainfall with more than 2200 mm annually, whereas Andhra Pradesh and Tamil Nadu

Plate 06



**Aadyanpara - Nilambur
Malappuram Dt., Kerala**



**Sholayar Reservoir
Thrissur Dt., Kerala**



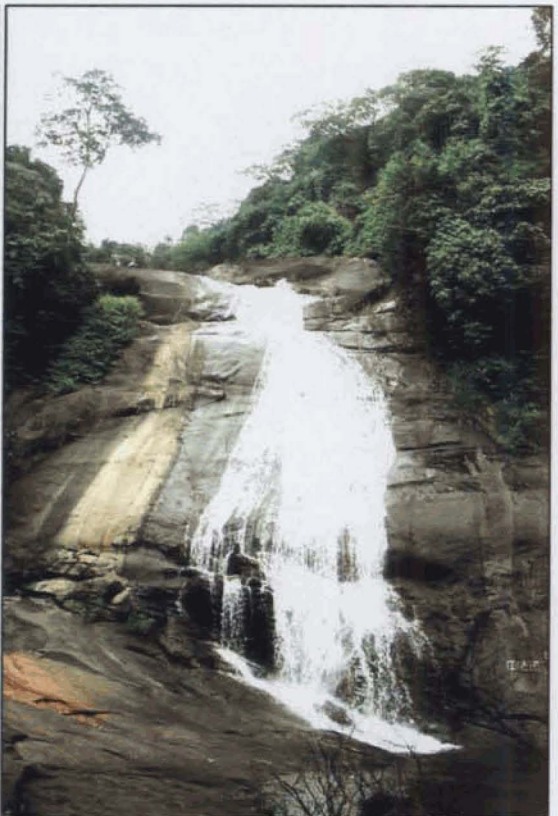
**Vaazhachal Waterfalls
Thrissur Dt., Kerala**



**Aathirapalli Waterfalls
Thrissur Dt., Kerala**



**Paalaruvi Waterfalls
Thenmala - Kollam Dt., Kerala**



**Thusharagiri Waterfalls
Kozhikode Dt., Kerala**

receive only 1000 - 2000 mm rain fall, and the southern part of Andhra Pradesh gets only less than 500 mm annually. Before the beginning of South-West monsoon in June, there are intermittent rains, the pre-monsoon showers during April and May. The prevalence of mist during the winter mornings (October - March) is an important source of moisture. During the rain-less seasons the mist is useful to the vegetation by providing some 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 nature of soil in Peninsular India consist of 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 soil occurs on the summit hills of Deccan and foothills of Western ghats in Kerala and Karnataka. Red soil 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 big rivers such as Cauvery and Godaveri. Soil texture varies from clay to clay-loam, peaty soil with low pH (3.9) is found in the low lands of Kerala.

The climate in South India is in general megathermal (Subramanyam *et al.* 1965; Rao *et al.* 1972). Chowdhury and Sarwade (1982) classified

the homoclimatic regions of India into five categories, namely arid region, semi-arid region, sub-humid region, humid regime and super-humid regime. Among them, South India falls under four homoclimatic types. The coastal districts of Andhra Pradesh, interior area of Karnataka and some districts in 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 Ooty (Tamil Nadu), whereas super-humid regime occupies only at Kodaikanal (Tamil Nadu).

STUDIES ON THE ASPLENIACEAE OF SOUTH INDIA



*Thesis submitted to the University of Calicut
in partial fulfilment of the requirements for the degree of*

Doctor of Philosophy

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DISTRIBUTION AND ECOLOGY

DISTRIBUTION AND ECOLOGY OF THE GENUS *ASPLENIUM* L. IN SOUTH INDIA

Asplenium L. is a world wide genus and primarily a fern of moist wet forests. In South India, *Asplenium* L. is usually growing in exposed or semi-exposed forests where it grows in ravines along streams, on forest floor (terrestrial), on rock (epilithic) or on the branches or trunk of forest trees (epiphytic) exhibiting a wide range of habitats. The members are mainly distributed along the Western Ghat forests.

Asplenium crinicaule Hance, *A. formosum* Willd., *A. phyllitidis* D. Don, *A. yoshinagae* Makino subsp. *indicum* (Sledge) Fraser- Jenk., etc. are some of the widely distributed species and are usually seen at an elevation of above 700m. *A. auritum* Sw., *A. bipinnatum* (Sledge) Azeez & Madhus., stat. nov., *A. ensiforme* Wall. ex Hook. & Grev., *A. erectum* Boxy ex Willd., *A. grevillei* Wall. ex Hook. & Grev., *A. nitidum* Sw., *A. obscurum* Bl., *A. serricula* Fee, *A. tenerum* G. Forst., *A. tenuifolium* D. Don, *A. semivarians* Viane & Reichst. and *A. zenkeranum* Kunze are found to be rare and collected only from one or two localities from South India. Most of the members are found growing in places having higher altitude, usually from 700 m to 2500 m. *A. polydon* G. Forst. is the only member reported from South India growing in lower elevations like Muhamma in Alapuzha Dt. and Kannothe of Kannur Dt. in Kerala. Another member reported from lower elevations (ca. 110 m) is *A. grevillei* Wall. ex Hook. & Grev., which is reported from a single locality from South India, the Dally forests of

Kulathupuzha forest division, Kollam Dt. of Kerala state. This species is seen in a very special habitat, the 'Myristica Swamp', where they are mainly seen epiphytically on the knee roots of *Myristica fatua* and also as epilithic. *A. aethiopicum* (Burm.f.) Becherer, *A. affine* Sw., *A. erectum* Bory ex Willd., *A. inequilaterate* Willd., *A. normale* D. Don, *A. tenuifolium* D. Don, *A. zenkeranum* Kunze etc. are commonly found growing in higher altitudes. The ecology and distribution of *Asplenium* L. in South India are given in Table 6.

Table 6. Ecology and Distribution of *Asplenium* spp.

Sl. No.	Species	Altitude & Habitat	Distribution in South India	Distribution in India	World Distribution
1.	<i>Asplenium aethiopicum</i> (Burm. f.) Becherer	Usually epiphyte, rarely epilithic or terrestrial 1700-2600m	Kerala Thekkady, Munnar (Idukki Dt.). Tamil Nadu Valparai-Anamalai Hills (Coimbatore Dt.); Sirumalai Hills, Kodaikanal (Dindigal Dt.); Uthamapalayam (Madurai Dt.); Kolli Hills, Yercaud (Selam Dt.).	Kumaun Himalaya; Almora and Bageswar (Dt.) of West Himalaya.	Sri Lanka, Tropical America, South Africa, Jawa, Zamba mountain - Central Africa, Hawaii, Central Nepal, Tanzania, Central Peru, Polynesia Islands, Ethiopia, Mascareen Island and Canaries.
2.	<i>A. affine</i> Sw.	Epiphyte 1300-1600m	Kerala Agasthyamala (Thiruvananthapuram Dt.). Tamil Nadu Upper Kothayar, Sengeltheri (Tirunelveli Dt.).	Eastern Himalaya	Sri Lanka, Mascareen Island, Bohol Island - Philippines, Borneo, Fiji, Sandwich Island, Kalimantan - Japan and West Sumatra.

Sl. No.	Species	Altitude & Habitat	Distribution in South India	Distribution in India	World Distribution
3.	<i>A. auritum</i> Sw. (In India, restricted to South India)	Epiphyte or rarely epilithic 1200 - 2400m	Tamil Nadu Palni Hills, Kodaikanal (Dindigal Dt.); Uthamapalayam (Madurai Dt.)	nil	Tropical America, West Indies, Mascareen Islands, Netherlands, Venezuela, Zambesiaca - Africa, Suriname - South America and Madagascar.
4.	<i>A. bipinnatum</i> (Sledge) Azeez & Madhus., stat. nov. (In India, restricted to South India)	Terrestrial or epilithic 600 - 1400m	Kerala Palada – Mlappara, Munnar (Idukki Dt.); Poovanchola, Panchalithode (Palakkad Dt.). Tamil Nadu Karyan Shola-Anamalai Hills (Coimbatore Dt.); Kodaikanal, Palamalai-Thalayar (Dindigal Dt.); Kumbukarai (Madurai Dt.); Madaliaruthu, Devi-ar estate - Sethur forest (Ramanatha-puram Dt.); Ayyanar estate - Sirumalai (Selam Dt.); Kalakkad Hills, Kannikatti Hills - Ambasamudram (Tirunelveli. Dt.).	nil	Si Lanka, Malaysia, Australia, Indonesia, Malagasy, New Zealand, Philippines, Polynesia and China.
5.	<i>A. cheilosorum</i> Kunze ex Mett.	Terrestrial. 1000 - 1900m	Kerala Munnar (Idukki Dt.); Silent Valley (Palakkad Dt.); Sabarigiri	Sikkim Himalaya, North-Eastern India, Eastern Himalaya, Kumaun Himalaya,	Sri Lanka, Burma, Nepal, Xizang-Tibet, Malaysia, Japan, Philippines, Thailand, China, Taiwan, Borneo, Afganistan, Myanmar,

Sl. No.	Species	Altitude & Habitat	Distribution in South India	Distribution in India	World Distribution
			(Pathanamthitta Dt.); Agasthyamala, Ponmudi (Thiruvananthapuram Dt.). Tamil Nadu Valparai – Anamalai Hills (Coimbatore Dt.); Kothayar, Kannikatti Hills, Kalakkad Hills (Tirunelveli Dt.).	North-West Himalaya, West Himalaya.	Ethiopia, Indonesia and Bhutan.
6.	<i>A. crinicaule</i> Hance	Usually epiphyte, rarely epilithic 700 - 1000m	Kerala Vallakadavu, Kulamavu (Idukki, Dt.); Anakkampoyil (Kozhikode Dt.); Silvent Valley (Palakkad Dt.); Anathode, Sabarimala, Moozhiyar (Pathanamthitta Dt.); Athirumala (Thiruvananthapuram Dt.); Sholayar (Thrissur Dt.); Chandanathode, Periya (Wayanad Dt.). Tamil Nadu Valparai – Anamalai Hills (Coimbatore Dt.); Palni Hills (Dindigal Dt.); Chellankode forest (Nilgiri Dt.); Kolli Hills (Selam Dt.).	North-Eastern Himalaya, Sikkim Himalaya, North-Eastern India.	China, Thailand and Xizang-Tibet.

Sl. No.	Species	Altitude & Habitat	Distribution in South India	Distribution in India	World Distribution
			Karnataka Kudajadri (Shimoga Dt.).		
7.	<i>A. decrescens</i> Kunze (In India, restricted to South India)	Terrestrial, epilithic or epiphyte 1000-2100m	Kerala Thekkady, Devikulam, Anamudi, Munnar Hills (Idukki Dt.); Vellarimala (Kozhikode Dt.); Silent Valley, Karasuryamalai (Palakkad Dt.); Anathode, Sabarigiri, Elampampa (Pathanamthitta Dt.); Athirumala, Agasthyarkoodam Mundanthurai (Thiruvanantha- puram Dt.). Tamil Nadu Valaparai – Anamalai Hills (Coimbatore Dt.); Kodaikanal, Palni Hills (Dindigal Dt.); Naduvattam, Lakkadi, Kadanad (Nilgiri Dt.). Kolli Hills (Selam Dt.); Nagariar estate (Ramanatha- puram Dt.); Kothayar Hills, Kannikkatty Hills (Tirunelveli Dt.). Karnataka B.R. Hills (Mysore Dt.).	nil	Sri Lanka, Malaysia, Australia, Africa and Brazil.
8.	<i>A. ensiforme</i> Wall. ex Hook. & Grev.	Epiphyte. 1500-2000m	Kerala Devikulam, Eravikulam	Sikkim Himalaya, North- Eastern	Sri Lanka, Burma Thailand, Indo-

Sl. No.	Species	Altitude & Habitat	Distribution in South India	Distribution in India	World Distribution
			(Idukki Dt.); Agasthyamala (Thiruvananthapuram Dt.). Tamil Nadu Valapari - Anamalai Hills (Coimbatore Dt.). Karnataka Kudremukh (Chikmangalur Dt.).	Eastern India, North-Eastern Himalaya, Simla Hills (North West Himalaya), Kumaun Himalaya, Roopkund Hills (Garhwal), West Himalaya, Almora, Nital, West Bengal	China, Japan, Nepal, Taiwan, Central Africa and Vietnam.
9.	<i>A. erectum</i> Bory ex Willd.	Terrestrial 1100-2200m	Kerala Munnar Hills, Anamudi Hills (Idukki Dt.). Tamil Nadu Valparai – Anamalai Hills (Coimbatore Dt.); Kodaikanal, Palni Hills (Dindigal Dt.); Uthamapalayam (Madurai Dt.); Ooty, Naduvattom, Avalanchi, Dodabetta (Nilgiri Dt.); Yercaud (Selam Dt.); Kalakkad, Ambasamudram, Naterikal Kothayar Hills.(Tirunelveli Dt.).	Orrissa.	Sri Lanka, South Africa, Zambesiaca - Africa, Java, Timor, Samoa and Hawaii Islands.



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Sl. No.	Species	Altitude & Habitat	Distribution in South India	Distribution in India	World Distribution
10.	<i>A. excisum</i> Presl (<i>A. unilaterale</i> Lam. var. majus (C. Chr.) Sledge.)	Usually terrestrial, rarely epilithic 1000-1500m	Kerala Mlappara, Gundumala Shola - Munnar (Idukki Dt.); Silent Valley, Karapara estate (Palakkad Dt.); Moozhiyar, Sabarimala (Pathanamthitta Dt.); Bonnakad, Agasthyamala, Ponmudi Hills, (Thiruvananthapuram Dt.). Tamil Nadu Siruvani, Valparai - Anamalai (Coimbatore Dt.); Walayar estate, Kothayar Hills, Periyar, Kannikatti Hills (Tirunelveli Dt.). Andhra Pradesh	North Sikkim- Eastern Himalaya, Assam, Manipur, Meghalaya Khasi Hills.	Sri Lanka, Africa, China, Hawaii Islands, Indonesia, Japan, Madagascar, Mascareen Islands, Moluccas, New Guinea, Philippines, Polynesia, Seychelles, Taiwan and Thailand.
11.	<i>A. excisum</i> Presl var. <i>serratum</i> Azeez & Madhus. nov. (endemic to South India)	Terrestrial 1000-2000m	Galikonda (Vishakapatanam Dt.). Kerala Athirumala- Agasthyamala Hills (Thiruvananthapuram Dt.).	nil	nil
12.	<i>A. formosum</i> Willd.	Eplithic or terrestrial 600 - 1800m	Kerala Thekkady, Pambar, Kulamavu, Vandenmettu (Idukki Dt.); Palaruvi, Kulathupuzha (Kollam Dt.); Meenachil (Kottayam Dt.);	Eastern Himalaya, Orissa.	Sri Lanka, Tropical America, West Indies, Africa, Angola, Congo, Netherlands Antilles, Venezuela, Tanzania, Zamba Mountain

Sl. No.	Species	Altitude & Habitat	Distribution in South India	Distribution in India	World Distribution
			<p>Anakampoyil (Kozhikode Dt.); Nilambur - Nadukani (Malappuram Dt.); Silent Valley, Nelliampathi, Parambikulam, Dhoni Hills, Karapara, Kaikatty (Palakkad Dt.); Moozhiyar, Pamba (Pathanamthitta Dt.); Ponmudi Hills, Chinnar, Bonnakad (Thiruvananthapuram Dt.); Sholayar forest (Thrissur Dt.); Chembra Peak, Tirunelli, Chandanathode (Wayanad Dt.).</p> <p>Tamil Nadu Valparai – Anamalai Hills (Coimbatore Dt.); Palamalai - Palni Hills (Dindigal Dt.); Karianshola (Nilgiri Dt.); Yercaud (Selam Dt.); Mudaliaruthu (Ramanathapuram Dt.); Kuttalam, Ambasamudram, (Tirunelveli Dt.).</p> <p>Karnataka Bababudan Hills (Chikmangalur Dt.).</p> <p>Andhra Pradesh Galikonda,</p>		(Central Africa) and Australia.

Sl. No.	Species	Altitude & Habitat	Distribution in South India	Distribution in India	World Distribution
			Sunkermetta (Vishakapattanam Dt.).		
13.	<i>A. grevillei</i> Wall. ex Hook & Grev.	Epiphyte 100m	Kerala Kulathupuzha Forest (Kollam Dt.).	Meghalaya, Central and Eastern Himalaya, North-East India.	Burma and China.
14.	<i>A. hindusthanenss</i> Bir (endemic to Kerala and Tamil Nadu)	Terrestrial 1500 - 2300m	Kerala Eravikulam, Munnar, Gundumala Shola Idukki Dt.); Silent valley (Palakkad Dt.); Agasthyamala (Thiruvananthapuram Dt.). Tamil Nadu Kodaikanal (Dindigal Dt.); Naduvattom (Nilgiri Dt.).	nil	nil
15.	<i>A. inequilaterale</i> Willd.	Terrestrial 900 -2200m	Kerala Gundumala Shola, Eravikulam, Devikulam, Kallar (Idukki Dt.); Karapara (Palakkad Dt.); Agasthayamala (Thiruvananthapuram Dt.). Tamil Nadu Valparai – Anamalai Hills (Coimbatore Dt.); Kodaikanal, Palni Hills Perumalmalai (Dindigal Dt.); Aruna estate (Madurai Dt.);	Orissa	Sri Lanka, Zambessiaca – Africa, Ethiopia, Tanzania, South America and Malagasy.

Sl. No.	Species	Altitude & Habitat	Distribution in South India	Distribution in India	World Distribution
			<p>Ooty, Bikapattimund (Nilgiri Dt.); Deviar estate (Ramanathapuram Dt.); Sheveroy Hills - Yercaud, Kolli Hills (Selam (Dt.); Kothayar Hills Kalakkad, Walayar estate (Tirunelveli Dt.).</p> <p>Karnataka Bababudan Hills (Chikmangalur Dt.); Agumbe R.F. (Shimoga Dt.).</p> <p>Andhra Pradesh Galikonda, Sunkerimetta (Vishakapatanam Dt.).</p>		
16.	<i>A. nidus</i> L.	Epiphyte 1000m	<p>Kerala Pooyamkutty (Idukki Dt.).</p> <p>Tamil Nadu Walayar estate (Tirunelveli Dt.).</p>	<p>North-Eastern Himalaya, Sikkim Himalaya, Assam, Eastern Himalaya, Kumaon Himalaya, North-West Himalaya, West Himalaya.</p>	<p>Admiralty Island, Guam (Marianus Island), Borneo, Thailand, Malaysia, Taiwan, Kalimantan - Japan, Sumatra, Madagascar, Bohol Island-Philippines, Tropical America, Polynesia, Hawaii and Mauritius.</p>
17.	<i>A. nitidum</i> Sw.	Terrestrial 1100m	<p>Kerala Silent Valley, Walakkad (Palakkad Dt.).</p> <p>Tamil Nadu Kodaikanal (Dindigal Dt.);</p>	<p>Sikkim Himalaya, North-Eastern India, North-Eastern Himalaya, Assam, Eastern</p>	<p>Sri Lanka, Kalimantan - Japan, Malaysia, South Africa, Bhutan, Borneo, Java, Nepal and Sumatra.</p>

Sl. No.	Species	Altitude & Habitat	Distribution in South India	Distribution in India	World Distribution
			Sengeltheri (Tirunelveli Dt.).	Eastern Himalaya.	
18.	<i>A. normale</i> D.Don	Terrestrial 1000-2100m	Kerala Gundumala Shola - Munnar (Idukki Dt.). Tamil Nadu Valparai - Anamalai Hills (Coimbatore Dt.); Kodaikanal, Palni Hills (Dindigal Dt.); Vellimalai (Madurai Dt.); Pakasuramalai, Kaikatti, Coonoor, Kotagiri, Kodamalai, (Nilgiri, Dt.); Yercaud, Sheveroy Hills, Kolli Hills (Selam Dt.); Kothayar Hills, Peyar Valley (Tirunelveli Dt.). Karnataka Kemmangudi (Chikmangalur Dt.).	Sikkim Himalaya, North-Eastern India, North-Eastern Himalaya, Eastern Himalaya.	Sri Lanka, Thailand, Malaysia, Zambesiaca - Africa, USA, Taiwan, Borneo, Kalimantan-Japan, Sumatra, Nepal, Madagascar, Bhutan, Australia, Hawaii, Hong Kong, Vietnam, Java, Korea, Malagasy and Polynesia
19.	<i>A. obscurum</i> Bl.	Terrestrial 1000 - 2000m	Kerala Eravikulam - Petimudi Path (Idukki Dt.); Silent Valley, Siruvani, Poovancholai (Palakkad Dt.); Gavi-Moozhiyar road (Pathanamthitta Dt.); Agasthyamala, Ponmudi Hills (Thiruvananthapuram Dt.).	Orissa, North-Eastern India, Eastern Himalaya, Western Himalaya.	Sri Lanka, Africa, Thailand, Myanmar, Zambesiaca - Africa, Taiwan, Tanzania, Nepal, Vietnam, China and Java.

Sl. No.	Species	Altitude & Habitat	Distribution in South India	Distribution in India	World Distribution
			<p>Tamil Nadu Valparai – Anamalai Hills (Coimbatore Dt.); Kodaikanal (Dindigal Dt.); Ellamalai Forest, Naduvattom (Nilgiri Dt.); Pongalkoil Shola (Selam Dt.); Kothayar Hills (Tirunelveli Dt.).</p> <p>Andhra Pradesh Galikonda (Vishakapatanam Dt.).</p>		
20.	<i>A. phyllitidis</i> D. Don	Epiphyte 700 - 2000m	<p>Kerala Kuttampuza (Ernakulam Dt.); Thekkadi, Vallakadavu, Kuttikanam, Painavu (Idukki Dt.); Begur R.F (Kannur Dt.); Vellarimala (Kozhikode Dt.); Silent Valley, Nelliampathi, Kunthipuzha, Kaikatti, Karapara, Parambikulam, (Palakkad Dt.); Moozhiyar, Sabarigiri, Plapally Pamba Hills (Pathanamthitta Dt.); Sholayar, Vazhachal Peringalkuthu (Thrissur Dt.).</p> <p>Tamil Nadu Karianshola, Valparai –</p>	North-Eastern Himalaya, Sikkim Himalaya, Assam, North-Eastern India, Eastern Himalaya.	Admiralty Island, Borneo, Thailand, Malaysia, Kalimantan - Japan, Sumatra, Nepal and Bohol Island - Philippines.

Sl. No.	Species	Altitude & Habitat	Distribution in South India	Distribution in India	World Distribution
			Anamalai Hills, Sholayar top (Coimbatore Dt.); Santhi estate (Nilgiri Dt.); Lower Kothayar, Ambasamudram (Tirunelveli Dt.). Karnataka Kudajadri, Nagodi-Nettur (Shimoga Dt.).		
21.	<i>A. polydon</i> G. Forst.	Epilithic or rarely epiphyte 0-950m	Kerala Muhamma, Vennikulam (Alappuzha Dt.); Puyamkutty, Tidanadu (Idukki Dt.); Ezhimala, Kannothe (Kannur Dt.); Palaruvi, Aryankavu Hills, Punaloor, Umayar (Kollam Dt.); Meenachil (Kottayam Dt.); Nilambur (Malappuram Dt.); Kanjirapuzha, Palakayam (Palakkad Dt.); Moozhiyar, Sabarigiri, Vennikulam, Konni, Pamba (Pathanamthitta Dt.); Valvara (Thiruvananthapuram Dt.); Sholayar, Chalakkudi (Thrissur Dt.). Tamil Nadu Perumalmudi (Coimbatore Dt.);	Assam, Meghalaya, West Bengal.	Sri Lanka, Malaysia, Bohol Island - Philippines, Australia, South Africa, Bangladesh and Polynesia.

Sl. No.	Species	Altitude & Habitat	Distribution in South India	Distribution in India	World Distribution
			<p>Kiripara-Nagarcoil (Kanyakumari Dt.);</p> <p>Nagariyar estate, Sethur Hills,</p> <p>Deviar estate (Ramanathapuram Dt.);</p> <p>Kannikatti Hills, Ambasamudram (Tirunelveli Dt.).</p> <p>Andhra Pradesh</p> <p>Papavinasam Tirumala (Chittoor Dt.).</p>		
22.	<p><i>A. semivarians</i> Viane & Reichst. (<i>A. laciniatum</i> D. Don/ <i>A. varians</i> Wall. ex Hook. & Grev.)</p>	<p>Terrestrial 1000 - 2250m</p>	<p>Kerala</p> <p>Devikulam, Munnar, Elapara, (Idukki Dt.);</p> <p>Palaruvi (Kollam Dt.);</p> <p>Ichampetty - Chinnar W.L.S. (Thiruvananthapuram Dt.).</p> <p>Tamil Nadu</p> <p>Maruthumalai, Perumalmalai, Kottadi (Coimbatore Dt.);</p> <p>Kodaikanal, Tandigudi- Palni Hills (Dindigal Dt.);</p> <p>Deviar estate, Muthaliaruthu (Ramanathapuram Dt.);</p> <p>Yercaud, Kolli Hills (Selam Dt.);</p> <p>Kalakkad (Tirunelveli Dt.).</p> <p>Andhra Pradesh</p> <p>Sunkerimetta (Vishakapatnam Dt.).</p>	Manipur	<p>Sri Lanka, Philippines, Uganda, Zimbabwe, China and Congo.</p>

Sl. No.	Species	Altitude & Habitat	Distribution in South India	Distribution in India	World Distribution
23.	<i>A. serricula</i> Fee (In India, restricted to South India)	Epiphyte or epilithic 1000 - 2000m	<p>Kerala Meenmutty, Tannikuzhi, Kallar - Munnar (Idukki Dt.); Silent Valley, Pulippara (Palakkad Dt.); Moozhiyar - Sabarigiri (Pathanamthitta Dt.); Agasthyamala, Kurishumala – Bonnakad, Ponmudi Hills (Thruvananthapuram Dt.).</p> <p>Tamil Nadu Neerar-Valparai, Sholayar top (Coimbatore-Dt.); Kodaikanal (Dindigal Dt.); Vellimalai (Madurai Dt.); Deviar estate - Sethur Hills (Ramanathapuram Dt.); Kothayar, Muthukuzhi, Kalakkad Hills, Naterikal, Kannikkatti Forest, Walayar estate (Tirunelveli Dt.).</p>	nil	Sri Lanka, Myanmar, Malaysia, Taiwan and Philippines.
24.	<i>A. tenerum</i> G. Forst.	Epilithic 700 - 1300m	<p>Kerala Kallar - Munnar Hills, Sivagiri - Eltheri, Vellimla (Idukki Dt.); Karapara top (Palakkad Dt.); Anathode, Sabarigiri, Moozhiyar, Gavi</p>	Eastern Himalaya.	Sri Lanka, Borneo, Thailand, Malaysia, Taiwan, Kalimantan-Japan, Sumatra, Bohol Island - Philippines, Java, Marianus Islands, New

Sl. No.	Species	Altitude & Habitat	Distribution in South India	Distribution in India	World Distribution
			(Pathanamthitta Dt.); Agasthyamala, Ponmudi Hills (Thiruvananthapuram Dt.); Sholayar Forest (Thrissur Dt.). Tamil Nadu Valparai - Anamalai (Coimbatore Dt.); Way to Agasthyamala (Tirunelveli Dt.).		Guinea, Vietnam, Mascareen Islands and Polynesia.
25.	<i>A. tenuifolium</i> D. Don	Terrestrial or epilithic 1600 - 2400m	Kerala Eravikulam, Naimakad, Vagavarai - Munnar Hills (Idukki Dt.); Vellarimala (Kozhikode Dt.); Karapara (Palakkad Dt.); Sabarigiri (Pathanamthitta Dt.); Agasthyamala (Thiruvananthapuram Dt.). Tamil Nadu Valparai-Anamalai, Thankamalai (Coimbatore Dt.); Kodaikanal, Palni Hills (Dindigal Dt.); Mahendragiri top (Kanyakumari Dt.); Naduvattom, Avalanchi, Kurisumalai, Lakkadi-Upper Bhavani (Nilgiri Dt.).	Sikkim Himalaya, North-East India, North-Eastern Himalaya, Eastern Himalaya, Arunachal Pradesh, West Bengal.	Sri Lanka, Bhutan, USA, Taiwan, Nepal, China and Burma

Sl. No.	Species	Altitude & Habitat	Distribution in South India	Distribution in India	World Distribution
			Karnataka B.R. Hills (Mysore Dt.).		
26.	<i>A. trilobatum</i> Azeez & Madus. sp. nov. (endemic to South India)	Terrestrial 1800 - 2300m	Tamil Nadu Avalanchi, (Nilgiri Dt.).	nil	nil
27.	<i>A. unilaterale</i> Lam. Var. <i>birii</i> Nayar & Geev. (endemic to South India)	Terrestrial 1000-2000m	Kerala Panthenthode- Attapady (Palakkad Dt); Agasthyamala Hills (Thiruvananthapuram Dt.).	nil	nil
28.	<i>A. unilaterale</i> Lam. var. <i>unilaterale</i>	Terrestrial 1200-1800m	Kerala Vellimala, Petimudi, Thekkady (Idukki Dt.); Silent Valley (Palakkad Dt.); Pamba (Pathanamthitta Dt.); Agasthyamala, Ponmudi Hills (Thiruvananthapuram Dt.); Sholayar forest (Thrissur Dt.). Tamil Nadu Sholayar - Anamalai Hills (Coimbatore Dt.); Kodaikanal (Dindigal Dt.); Muthukuzhi (Tirunelveli Dt.).	North- Eastern India, North Eastern Himalaya, Assam, Orissa, Simla, Kumaun Himalaya, North-West Himalaya , Garhwal, West Himalaya, Ninital, Almora, Nanda Devi Biosphere Reserve (Uttaranchal)	Sri Lanka, Malaysia, Bhutan, Polynesia, Japan, Nepal, Tropical Africa, Philippines, Hawaii, Vietnam, Myanmar, Taiwan, Ethiopia and Madagascar.
29.	<i>A. yoshinagae</i> Makino subsp. <i>indicum</i> (Sledge) Fraser- Jenk. (<i>A. indicum</i>)	Epilithic, or epiphyte 700 - 2300m	Kerala Eravikulam, Vallakadavu, Naimakad, Thekkadi Hills, Devikulam, Parriaru	Simla Hills, Berinag Hills - West Himalaya, Kumaon Himalaya, North-West	Srilanka, China, Nepal, Bhutan, Malagasy, Taiwan, Tibet, Myanmar, Thailand, Indo- China,

Sl. No.	Species	Altitude & Habitat	Distribution in South India	Distribution in India	World Distribution
	(<i>A. indicum</i> Sledge)		<p>Parriaru (Idukki Dt.);</p> <p>Anakampoyil, Vellarimala (Kozhikode Dt.);</p> <p>Silent Valley, Karapara, Walakkad, Mukkali, Parambikulam, Kunthi river, Punnamala (Palakkad Dt.);</p> <p>Kakki, Moozhiyar, Karimala, Pamba road (Pathanamthitta Dt.);</p> <p>Agasthyamala, Ponmudi Hills, Bonnakad, (Thiruvananthapuram Dt.);</p> <p>Chembra Peak, Sugandhagiri (Wayanad Dt.).</p> <p>Tamil Nadu</p> <p>Konalar – Anamalai Hills (Coimbatore Dt.);</p> <p>Kodaikanal, Manalur - Palni Hills (Dindigal Dt.);</p> <p>Uthamapalayam (Madurai Dt.);</p> <p>Pykara, Governor Shola, Avalanchi, Naduvattom, Upper Bhavani (Nilgiri Dt.);</p> <p>Kolli Hills, Yercaud (Selam Dt.);</p> <p>Tirunelveli Hills (Tirunelveli Dt.).</p> <p>Karnataka</p> <p>Tadiyan Dam - Coorg (Dt.);</p>	Himalaya, Almora, Nital, Himachal Pradesh	philippines and Japan

Sl. No.	Species	Altitude & Habitat	Distribution in South India	Distribution in India	World Distribution
			Kudajadri (Shimoga Dt.). Andhra Pradesh Sunkerimetta forest, Kappakonda (Vishakapatanam Dt.).		
30.	<i>A. zankeranum</i> Kunze Kunze(1851) described this species from Nilgiris (In India, restricted to South India)	Usually epilithic, rarely terrestrial 1900-2200m	Kerala: Gundamala Shola, Eravikulam, Devikulam - Munnar Hills, Kanthallur, (Idukki Dt.); Vellarimala (Kozhikode Dt.); Minnampara (Palakkad Dt.); Chembra peak (Wayanad Dt.). Tamil Nadu Valparai – Anamalai Hills, Thankamalai (Coimbatore Dt.); Kodaikanal, Palni Hills, (Dindigal Dt.); Vellimalai, Uthamapalayam (Madurai Dt.); Conoor, Avalanchi, Pakkasuramalai (Nilgiri Dt.); Kothayar Hills, Kakachi, Muthukuzhi (Tirunelveli Dt.).	nil	Sri Lanka

The Western Ghats region of South India, especially the Kerala region was earlier covered with dense, impenetrable tropical forests which also abode a very rich tropical Pteridophyte flora. But during the past few years of indiscriminate deforestation has drastically reduced the extent of forests, threatening the existence of many sensitive Pteridophyte species. A number of species of *Asplenium* L. which were very frequently collected from these areas earlier are now become rare and many are at the verge of extinction.

STUDIES ON THE ASPLENIACEAE OF SOUTH INDIA



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Doctor of Philosophy

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GENERAL MORPHOLOGY

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The genus *Asplenium* L. is the largest fern genus in South India and the members are widely distributed. The size of the plant varies from a few cm to 1m. They are terrestrial (*A. erectum* Bory ex Willd., *A. excisum* Presl, *A. inequilatrale* Willd., *A. nitidum* Sw., *A. normale* D. Don, *A. unilaterale* Lam.), epilithic (*A. formosum* Willd., *A. tenerum* G. Forst., *A. yoshinagae* Makino subsp. *indicum* (Sledge) Fraser-Jenk., *A. zenkeranum* Kunze or epiphytic (*A. affine* Sw., *A. crinicaule* Hance, *A. ensiforme* Wall. ex Hook. & Grev., *A. nidus* L., *A. phyllitidis* D. Don, *A. serricula* Fee). Some members occupy more than one type of habitat. For example, *A. aethiopicum* (Burm. f.) Becher. and *A. decrescens* Kunze are found in terrestrial, epiphytic and epilithic habitats. The rhizome is erect (*A. crinicaule* Hance, *A. erectum* Bory ex Willd., *A. nidus* L., *A. normale* D. Don, *A. polydon* G. Forst., *A. tenerum* G. Forst., *A. tenuifolium* D. Don), suberect (*A. ensiforme* Wall. ex Hook. & Grev., *A. serricula* Fee) or creeping (*A. affine* Sw., *A. cheilosorum* Kunze ex Mett., *A. decrescens* Kunze, *A. excisum* Presl, *A. hindusthanensis* Bir, *A. nitidum* Sw., *A. obscurum* Bl. and *A. unilaterale* Lam.). The fronds are tufted and spirally arranged in the case of erect and suberect rhizome, and in creeping they are arranged in two alternate dorsal rows. Fronds vary in their form; simple (*A. ensiforme* Wall. ex Hook. & Grev., *A. grevillei* Wall. ex Hook. & Grev., *A. nidus* L. and *A. phyllitidis* D. Don); simply pinnate (*A. cheilosorum* Kunze ex Mett., *A. crinicaule* Hance, *A. decrescens* Kunze, *A. erectum* Bory ex Willd., *A. excisum* Presl, *A. formosum* Willd., *A.*

hindusthanensis Bir, *A. inequilaterale* Willd., *A. normale* D. Don, *A. obscurum* Bl., *A. polydon* G. Forst., *A. serricula* Fee, *A. tenerum* G. Forst., *A. unilaterale* Lam., *A. yoshinagae* Makino subsp. *indicum* (Sledge) Fraser-Jenk. and *A. zenkeranum* Kunze or bipinnate (or binnate-tripinnatifid) as in *A. aethiopicum* (Burm. f.) Becher., *A. affine* Sw., *A. auritum* Sw., *A. bipinnatum* (Sledge) Azeez & Madhus., stat. nov., *A. nitidum* Sw., *A. tenuifolium* D. Don. and *A. semivarians* Viane & Reichst.

The rhizome is usually covered by dark brown, clathrate scales. The stipe and rachis are also scaly in *A. aethiopicum* (Burm. f.) Becher., *A. crinicaule* Hance and *A. yoshinagae* Makino subsp. *indicum* (Sledge) Fraser-Jenk., whereas in members like *A. affine* Sw., *A. auritum* Sw., *A. cheilosorum* Kunze ex Mett., *A. decrescens* Kunze, *A. erectum* Bory ex Willd., *A. excisum* Presl, *A. formosum* Willd., *A. hindusthanensis* Bir, *A. inequilaterale* Willd., *A. nitidum* Sw., *A. normale* D. Don, *A. obscurum* Bl., *A. polydon* G. Forst., *A. serricula* Fee, *A. tenerum* G. Forst., *A. tenuifolium* D. Don, *A. unilaterale* Lam. and *A. zenkeranum* Kunze both the stipe and rachis are glabrous. The paleae are usually narrow, vary in their length and the presence or absence of marginal glands. The palea are small, falcate with a few sessile glands along the margin in *A. formosum* Willd. (Fig. 15 C) while in *A. crinicaule* Hance (Fig. 11 B,C) the palea are long, the tip with a terminal hair ending in a gland with many gland-tipped hairs along the margins. In *A. cheilosorum* Kunze ex Mett., *A. ensiforme* Wall. ex Hook. & Grev., *A. inequilaterale* Willd., *A. nitidum* Sw., *A. yoshinagae* Makino subsp. *indicum*

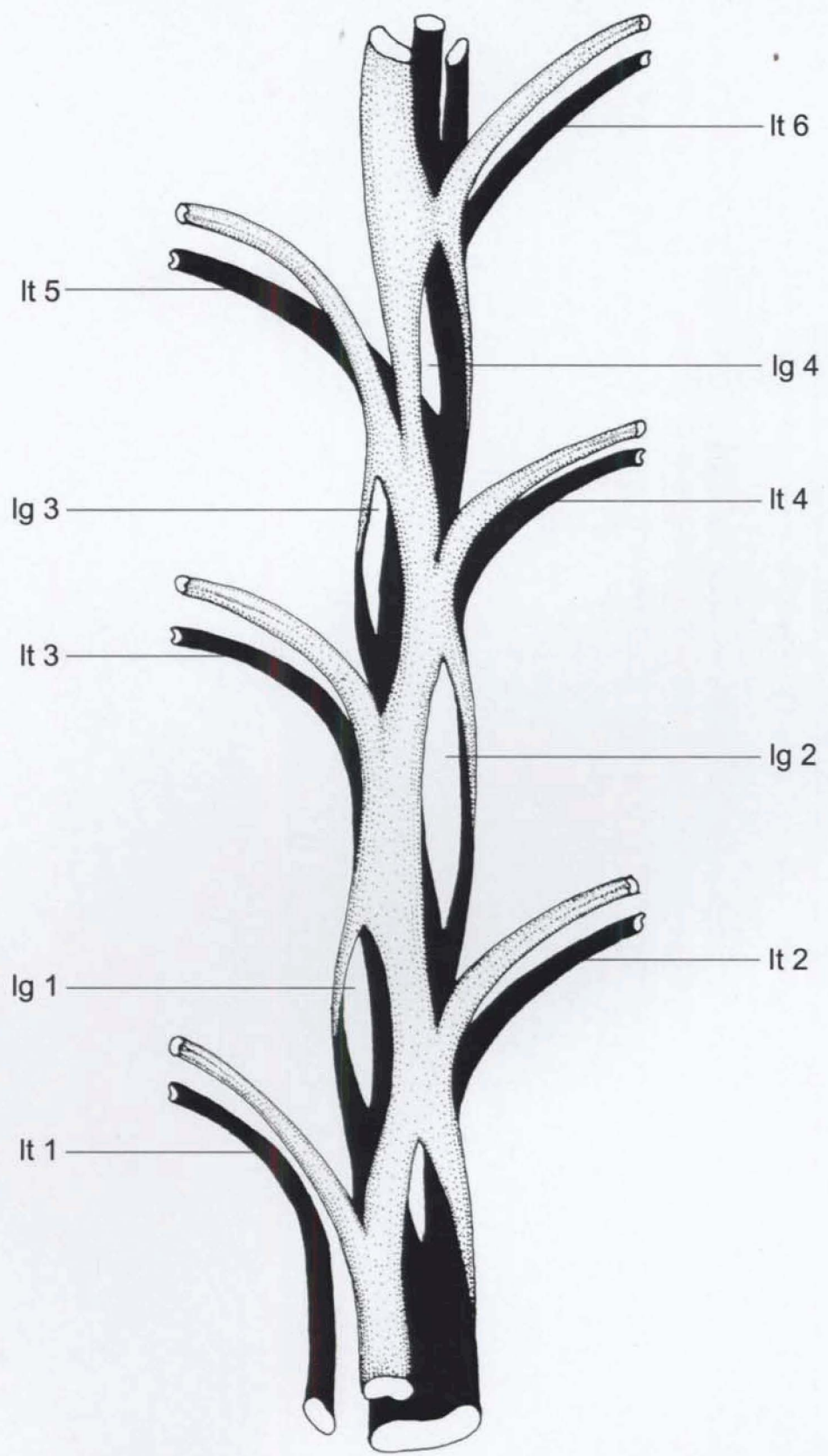


Fig. 02. Three dimensional diagram of vascular cylinder of a portion of the rhizome of *Asplenium cheilosorum* Kunze ex Mett. *lg* - leaf gap; *lt* - leaf trace.

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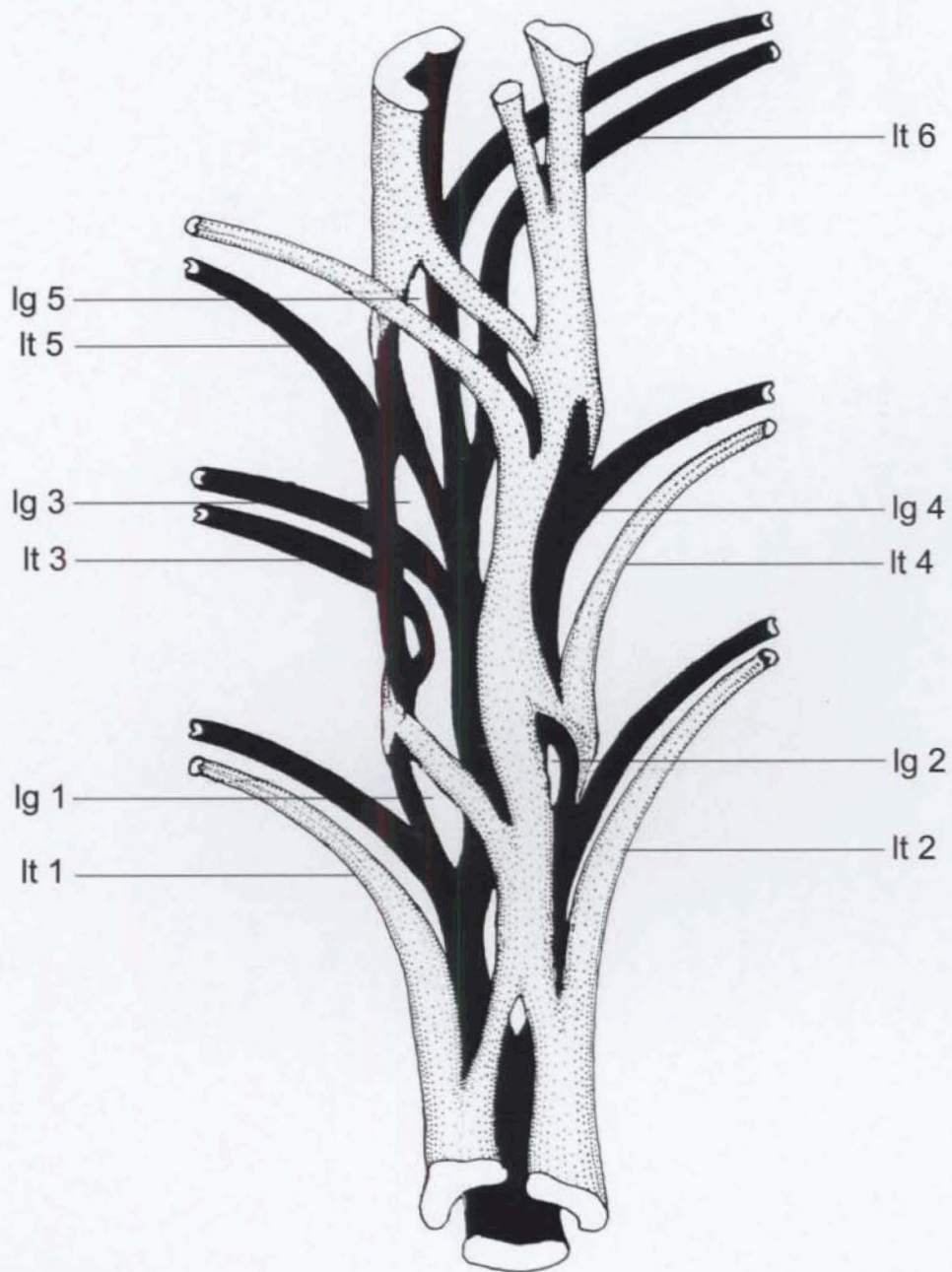


Fig. 03. Three dimensional diagram of vascular cylinder of a portion of the rhizome of *Asplenium yoshinagae* Makino subsp. *indicum* (Sledge) Fraser-Jenk. *lg* - leaf gap; *lt* - leaf trace.

(Sledge) Fraser-Jenk., etc. the paleae are long, narrow and without any glands on their margins. In *A. phyllitidis* D. Don (Fig. 23 C) paleae are long, broad and with many glands on long biseriate stalk, while in *A. polydon* G. Forst. (Fig. 24 B) the stalked glands are mainly confined to the base of the palea. In *A. nidus* L. (Fig. 19 E) the paleae are big, provided with large number of much elongated, biseriate, glandless hairs throughout the margin and the palea ends in such a long hair.

The venation is simple or forked, in *A. tenerum* G. Forst. (Fig. 26 B) the acroscopic basal vein alone is forked, others simple, while in all other members the veins are forked once or twice. In *A. phyllitidis* D. Don (Fig. 23 B) the veins are forked once or twice and show intramarginal fusion. Sori are indusiate, indusia attached laterally along the acroscopic branches of veins, but in *A. polydon* G. Forst. (Fig. 24 C) sori are seen on both acroscopic and basispic veins.

The rhizome of *Asplenium* L. is dictyostelic with overlapping leaf gaps and a massive central pith. In both erect and creeping rhizomes each frond receives two leaf traces. In the case of creeping rhizome, the leaf gaps are seen in two alternate dorsal rows and are distantly placed (*A. cheilosorum* Kunze ex Mett., Fig. 2) while in erect rhizomes, traces arise in a spiral manner and are closely placed (*A. yoshinagae* Makino subsp. *indicum* (Sledge) Fraser-Jenk., Fig. 3). Since each frond receives two traces from the stele of the rhizome the basal region of the stipe possesses two separate bundles which unite above to form a 'X' shaped xylem with a massive central

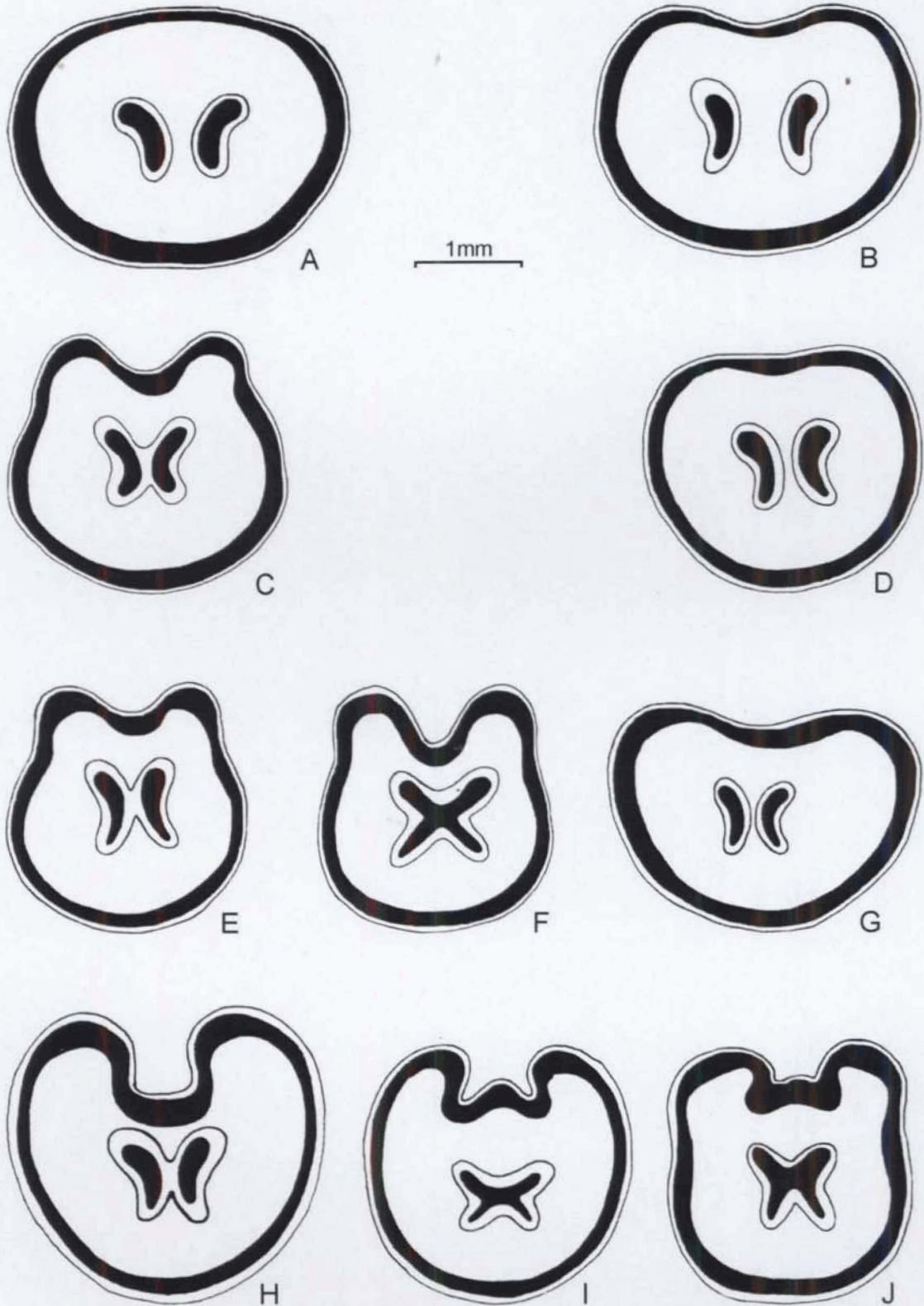


Fig. 04. Transections of the stipe of *Asplenium* spp. A-C. *A. aethiopicum* (Burm. f.) Becher. A. Basal region; B. Middle region; C. Just below the lowest pinna. D-F. *A. decrescens* Kunze. D. Basal region; E. Middle region; F. Just below the lowest pinna. G-J. *A. yoshinagae* Makino subsp. *indicum* (Sledge) Fraser-Jenk. G. Basal region; H. 1/3 from base; I. Middle region; J. Just below the lowest pinna.

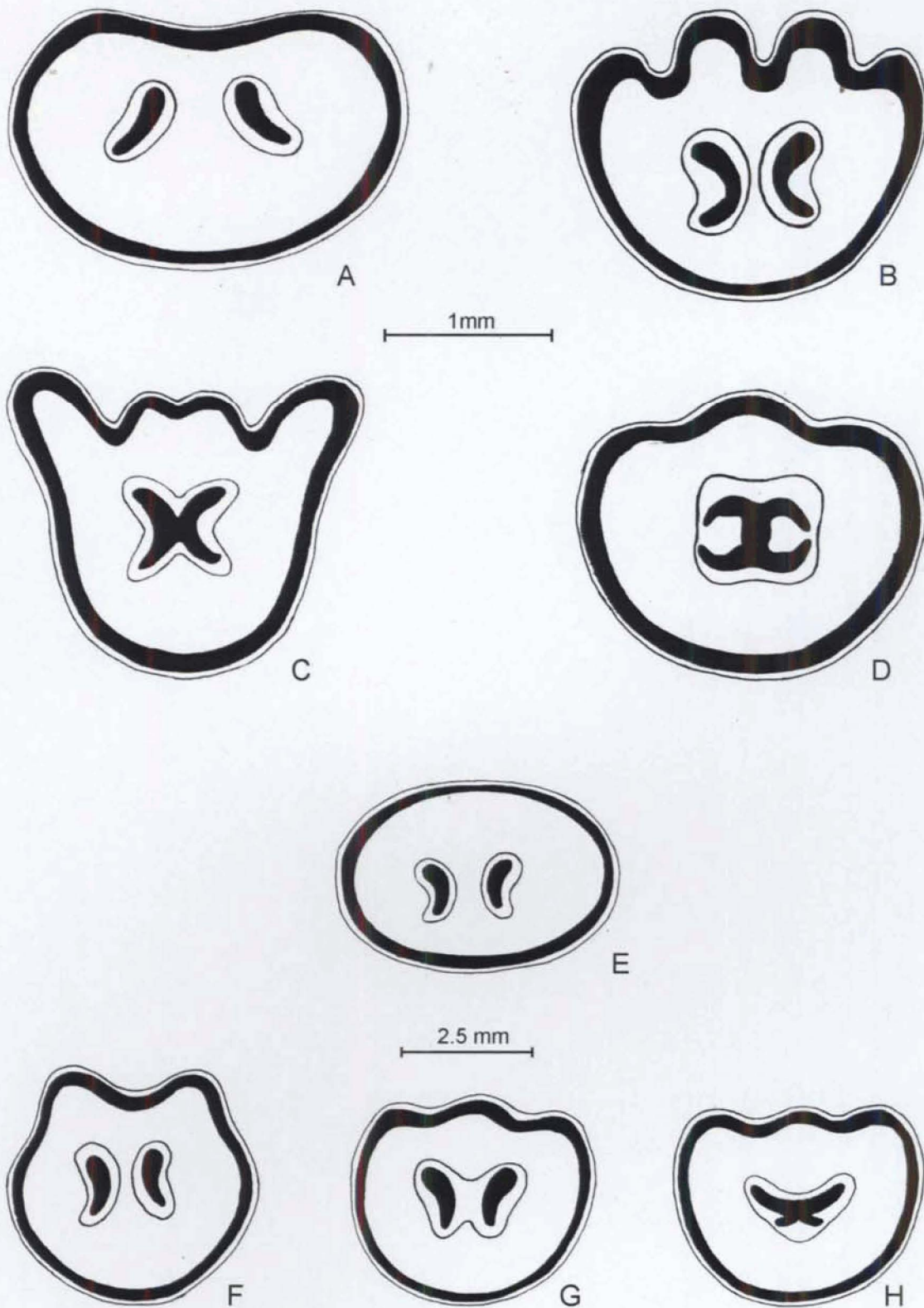


Fig. 05. Transections of the stipe of *Asplenium* spp. **A-D.** *A. nitidum* Sw. **A.** basal region; **B.** 1/3 from base; **C.** Middle region; **D.** Just below the lowest pinna. **E-H.** *A. zenkeranum* Kunze, **E.** Basal region; **F.** Middle region; **G.** 2/3 from base; **H.** Just below the lowest pinna.

core and a pair of diverging upper and lower arms, usually the upper arms are longer than the lower arms. In *A. aethiopicum* (Burm. f.) Becher. (Fig. 4 A-C) fusion of bundles occurs near the upper region of the stipe usually 1 or 2 cm below the lowest pair of pinnae, while in *A. yoshinagae* Makino subsp. *indicum* (Sledge) Fraser-Jenk. (Fig. 4 G-J) fusion of the bundles occurs at the one-third distance and near the middle vascular traces also shows fusion. In *A. zenkeranum* Kunze (Fig. 5 E-H) leaf trace bundles fused at a two-third distance from the base of the stipe. In *A. decrescens* Kunze (Fig. 4 D-F) fusion of bundles occurs near the middle part of the stipe and becomes 'X' shaped just below the lowest pinna, whereas, in *A. nitidum* Sw.(Fig. 5 A-D) the bundles fuse and becomes 'X' shaped near the middle of the stipe.

The spores of *Asplenium* L. are monoletic, bilateral with a smooth, granulate or spinulose exine and enveloped by a granulate to spinulose, undulating, loose perine. Supralaesural fold is distinct and extend from end to end of the spore in *A. nitidum* Sw. (Fig. 20 E), *A. polydon* G. Forst. (Fig. 24 E), *A. zenkeranum* Kunze (Fig. 35 E), etc. In most cases exine is granulate (*A. crincaule* Hance, *A. tenerum* G. Forst., *A. yoshinagae* Makino subsp. *indicum* (Sledge) Fraser-Jenk., etc.), while in *A. cheilosorum* Kunze ex Mett. (Fig. 10 E), *A. hinduthanensis* Bir (Fig. 17 E) the exine is spinulose whereas in *A. serricula* Fee (Fig.25 E) the exine surface bears very small outgrowths with blunt tips. The perine is loose, undulating and with anastomosing surface folds. Perine is granulate in most cases (*A. aethiopicum* (Burm. f.) Becher., *A. serricula* Fee, *A. yoshinagae* Makino

subsp. *indicum* (Sledge) Fraser-Jenk., *A. zenkeranum* Kunze, etc. while in *A. cheilosorum* Kunze ex Mett. (Fig. 10 E), the perine is densely spinulose. Among various spores studied, only *A. cheilosorum* Kunze ex Mett. (Fig. 10 E) possesses densely spinulose exine and perine. The spores of *A. obscurum* Bl. (Fig. 22 E) are characteristic in that both exine and perine are clothed with narrow, elongated, sharp, straight or curved spines.

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MATERIALS AND METHODS

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Specimens for the present study were collected from different localities of South India, especially from the Western Ghats mountain ranges and characters were studied preliminary by observing live plants in the field. Since most of the asplenioid members grow only in undisturbed forests of high altitude, extensive field study trips were conducted to different forests of South India to understand the ecological niches, intraspecific variation, biological associations and distributional patterns of each species. Several species collected from wild are cultivated in the Green House of Calicut University Botanic Garden. Materials for Herbaria were pressed using conventional methods in the collection site itself and are deposited in the Calicut University Herbarium (CALI). Photographs of the specimens were taken in the field and close up view in the lab using NIKON D-100 Digital camera.

Comparative morphological study of different species collected from various localities of South India were made in the Laboratory. Materials kept in the herbaria of the Botanical survey of India, Southern circle, Coimbatore (MH), Central National Herbarium, Calcutta (CAL), Calicut University Herbarium (CALI), Mahatma Gandhi Memorial College Herbarium, Udupi (MGMC), Sri Krishnadevaraya University Herbarium, Anantpur (SKU), Rapinet Herbarium, Tiruchirapally (RHT), the herbaria of Tropical Botanic Garden and Research Institute (TBGT) were also consulted.

Detailed morphological studies of rhizome, paleae, pinnae, sporophylls, sporangia and spores of different species were made using fresh or preserved as well as herbarium specimens. Anatomical studies of some species were done using fresh materials. In the case of dried materials, they were softened by boiling in (50%) glycerine. The stellar morphology was studied by taking serial hand sections and 3-dimensional scale to scale reconstruction is made out of Camera lucida drawings of transverse sections, following Nayar (1963). Paleae were taken from the extreme apex of the rhizome or from its lateral buds (for young) and several centimeters behind the apex of the rhizome (for mature). Observations were made using Leitz stereo microscope and the average size is noted by measuring different samples. The venation pattern of some of the species was studied by soaking the lamina with 95% alcohol, and observed this in transmitted light. Coriaceous leaves were cleared by keeping the pinnae in 5-10% of KOH with a few drops of Basic Fuchsin at 60°C overnight. After clearing they were washed several times and mounted in glycerine. Camera lucida drawings were made using Leitz stereo microscope

Sori of different developmental stages were observed for studying sporangia, and were drawn with Leitz stereo microscope. Spore morphology was studied by the acetolysis method of Erdtman (1952, 1957) and Nayar (1964). The spores were mounted in glycerine jelly and the figures were drawn using Carl Zeiss Jena light microscope with Camera lucida.

Gametophyte morphology, chromosome numbers of the different species were adopted from available literature.

For each species, there is an illustration of a whole plant (habit) together with details of venation, palea on the rhizome, palea on the stipe (if present), sporangium and spore. Except the habit sketch, all others were drawn using camera lucida. The taxonomic description of each species is also provided with a plate of photographs, showing habit, entire frond, fertile frond showing sori, part of fertile frond magnified, rhizome, bulbils (if present), *etc.* The habit photographs of most of the species were taken during field study, while other photographs were taken in the lab, using NIKON D-100 Digital Camera. Descriptions and illustrations were done using fresh materials. The ecological notes are based on author's own field observations and informations collected by referring various Herbaria and published datas.

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*"Merit in a classification depends upon many subjective factors -
history, tradition, acceptability to colleagues,
consistency, convenience and usefulness.*

*A floristician might regard as 'useful' a classification that
would not serve the aims of a monographer.*

*A Professor might find one system convenient while
a Herbarium Curator might find another system
more convenient."*

Wagner

SYSTEMATIC TREATMENT

SYSTEMATIC TREATMENT

Asplenium L.

Sp. Pl. 2.1078. 1753.

Terrestrial, epiphytic or epilithic. Rhizome erect, suberect or creeping, covered by narrow, dark brown, clathrate, entire or toothed scales. Fronds simple, uni, bi, tripinnate or quadripinnatifid. The stipe and rachis green or dark brown and may be glabrous or provided with scales. Veins forked once to many times, free or rarely anastomosing without included veinlets near the margin. Pinnae herbaceous to coriaceous. Sori linear, elongated, formed only on acroscopic branches of a forked vein and with laterally attached indusia. Sporangial stalk uniseriate and elongated. Spores monoletate, bilateral with granulose or spinulose exine covered by loose undulating and anastomosing perine. Stipe with two vascular strands from the main stele of the rhizome which unite upwards into a single 'X' shaped bundle.

KEY TO SPECIES

- 1a. Fronds simple 2
- 1b. Fronds pinnate 3
- 2a. Fronds large, broad, 1-1.5 m long, tufted
and nest like 4
- 2b. Fronds small, narrow, 20-30 cm long, not
tufted and nest like 5

- 4a. Fronds up to 1 m long, 8-10 cm broad,
midrib greenish except at the base; sori
formed only on one of the branch of a
forked vein along the distal half of the
lamina *A. phyllitidis*
- 4b. Fronds up to 1.5 m long, 14-20 cm broad,
midrib dark brown except for 1/3 distance
from the tip; sori formed on both branches
of a forked vein along the 2/3 part of the
lamina *A. nidus*
- 5a. Lamina linear lanceolate, stipe highly
reduced, 1.5-3 cm; veins free *A. ensiforme*
- 5b. Lamina ovate lanceolate, stipe
10-30 cm long; veins show intra-marginal
fusion *A. grevillei*
- 3a. Fronds simply pinnate 6
- 3b. Fronds bipinnate to quadripinnatifid 7
- 6a. Rhizome erect or suberect 8
- 6b. Rhizome creeping 9
- 8a. Stipe and rachis densely scaly 10
- 8b. Stipe and rachis glabrous 11
- 10a. Margin of the pinnae deeply and
irregularly lobed; rhizome scales entire *A. yoshinagae* Makino
subsp. *indicum*

- 10b. Margin of the pinnae crenate or very shallowly lobed; rhizome scales provided with long gland tipped hairs at the base *A. crinicaule*
- 11a. Lamina ends in a single or lobed pinna 12
- 11b. Lamina not ending in a single pinna, gradually reduced to the tip forming a regularly lobed apex 13
- 12a. Terminal pinna bilobed or trilobed *A. polydon*
- 12b. Terminal pinna similar to lateral ones *A. serricula*
- 13a. Stipe grey green, pinnae narrow and elongated; acroscopic basal vein forked once, others simple *A. tenerum*
- 13b. Stipe grey brown to dark brown, polished; venation forked 14
- 14a. Pinnae small, 1-1.5 x 0.5 cm, 30-40 pairs present 15
- 14b. Pinnae big, 3 x 1 cm, up to 15 pairs present *A. inequilaterale*
- 15a. Lower pinnae reduced to auricles, pinnae not showing overlapping, upper margin of the pinnae incised 16
- 15b. Lower pinnae not reduced, pinnae are overlapping each other, upper margin sub-entire or very slightly cut *A. normale*

- 16a. Sori 6-10 per pinna, arranged in two
oblique rows on either side of the costa *A. erectum*
- 16b. Sori 2 or 3 per pinna, confined to lower
unexcised part of the pinnae *A. formosum*
- 9a. Rhizome short creeping, fronds big,
0.5-1 m; gemmiparous at the tip *A. zenkeranum*
- 9b. Rhizome long creeping, fronds 50-70 cm,
not gemmiparous 17
- 17a. Stipe greenish *A. obscurum*
- 17b. Stipe dark brown 18
- 18a. Pinna 6-8 cm, subcoriaceous,
basispic base slightly excised; sori
arranged closely and parallel to the costa
on either side *A. decrescens*
- 18b. Pinna up to 3 cm, herbaceous, basispic
base partially or fully excised; sori
numerous..... 19
- 19a. Upper margin of the pinna deeply cut and
sori confined to these lobes; basispic base
fully excised..... *A. cheilosorum*
- 19b. Upper margin of the pinna inciso-crenate;
one-third to two-third part of the basispic
base excised 20

- 20a. Sori numerous, distributed all along the
pinna on either side of the costa, margin
of the pinna toothed21
- 20b. Sori 2 or 3 pairs, confined to distal half
(apices), margin not toothed*A. hindusthanensis*
- 21a. Pinna falcate, big, up to 5-7 cm, one-third
portion of the basiscopic base excised..... *A. excisum*
- 21b. Pinna not falcate, small, up to 2-3 cm
two-third portion of the basiscopic base
excised..... *A. unilaterale*
- 7a. Fronds bipinnate to tripinnatifid 22
- 7b. Fronds tripinnate to quadripinnatifid 23
- 22a. Rhizome creeping 24
- 22b. Rhizome erect 25
- 24a. Fronds small, up to 16 cm, stipe purplish
below, greenish above, pinnae
herbaceous..... *A. semivarians*
- 24b. Fronds big, 50-80 cm..... 26
- 26a. Stipe and rachis greenish, fronds
gemmiparous..... *A. affine*
- 26b. Stipe and rachis brownish, not polished
fronds not gemmiparous..... *A. nitidum*
- 25a. Fronds big, up to 70 cm, stipe dark
brown, bears sparsely distributed hairs..... *A. bipinnatum*

- 25b. Fronds small, up to 30-35 cm, stipe
brownish and glabrous..... 27
- 27a. Lowermost 1-3 pairs of pinnae clearly
pinnatifid, bears up to 15 pairs of pinnules;
lowermost pinna 8-11 cm long *A. trilobatum*
- 27b. Lowermost pinnae not clearly pinnatifid,
only 1 or 2 pinnules distinct, others adnate,
up to 8 pairs only; pinnae small, 3-8 cm *A. auritum*
- 23a. Stipe and rachis glabrous; fronds tripinnate
or quadripinnatifid; pinnules small and
membraneous *A. tenuifolium*
- 23b. Stipe and rachis densely scaly; fronds
bipinnate or tripinnatifid; pinnules
subcoriaceous *A. aethiopicum*

***Asplenium aethiopicum* (Burm. f.) Becher.**

Candollea, 6: 23, Fig. 1 (1935)

Sledge, Bull. Br. Mus. Nat. Hist. Bot. 3: 267 (1965); Nayar & Kaur, Comp. Beddome Handb. 38 (1974); Dixit, Cens. Ind. Pterid. 116 (1984); Manickam, Fern Fl. Palni Hills 97 (1986); Chandra & Kaur, Nom. Guide Beddome F.S.I. & F.B.I. 17, 27 (1987); Singh & Bir, Ind. Fern J. 6(1-2): 272, 279 (1989); Manickam & Irudayaraj, Pterid. Fl. Western Ghats 228, Pl. 176 (1992), Pterid. Fl. Nilgiris 131 (2003); Azeez *et al.*, J. Econ. Tax. Bot. 20(2) 435-455

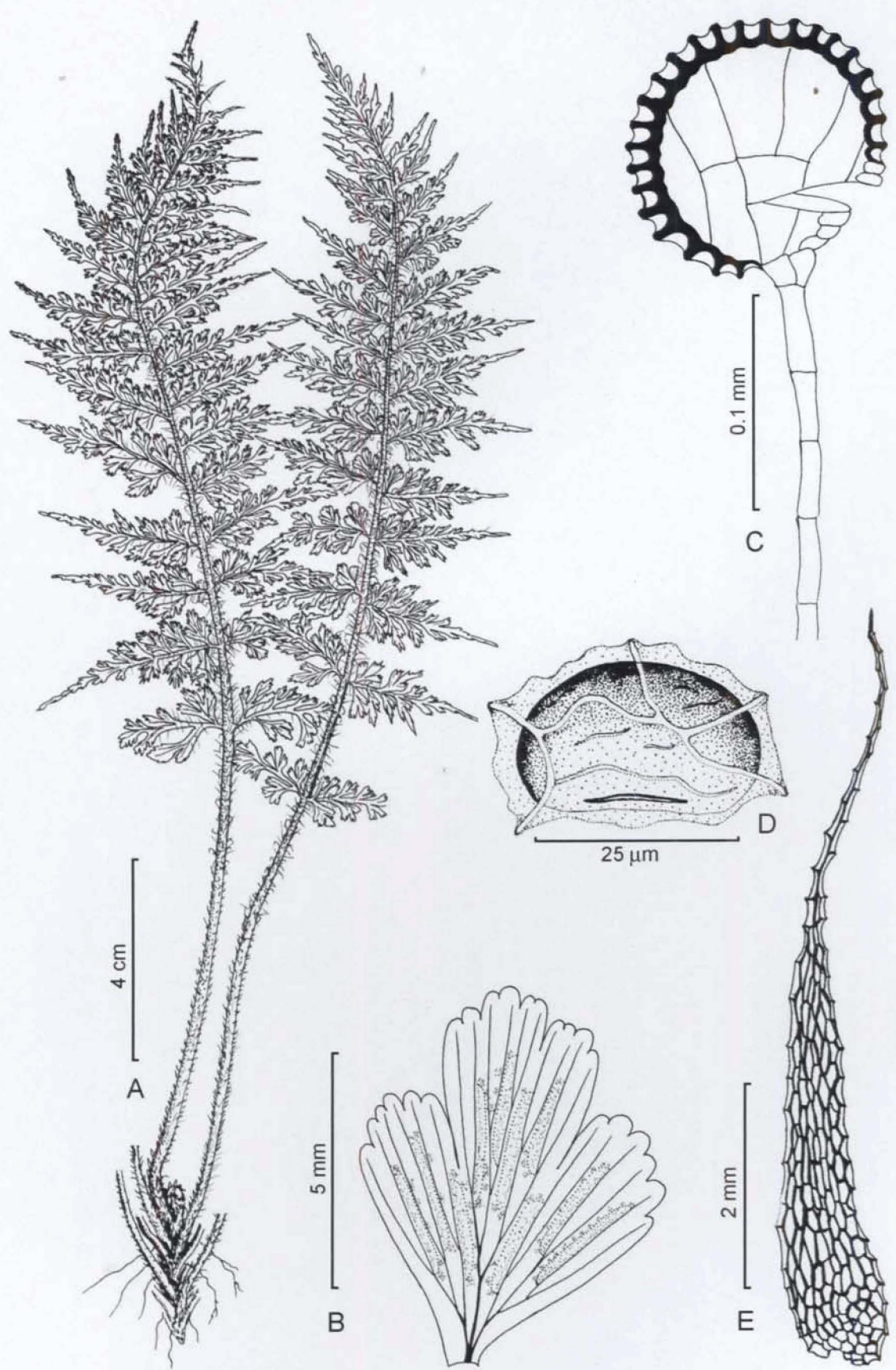


Fig. 06. *Asplenium aethiopicum* (Burm. f.) Becher. A. Habit; B. Pinna showing venation and position of sori; C. Sporangium; D. Spore; E. Palea on the the rhizome.

(1996); Manickam & Rajkumar, Polymorphic ferns of Western Ghats 19
(1999); Pullaiah *et al.*, Pterid. Andhra Pradesh 120, pl. 51(2003).

Trichomanes aethiopicum Burm. f., Ind. Fl. Cap. Prodr. 32 (1768).

Asplenium furcatum Thunb., Prodr. Pl. Cap. 172 (1794); Beddome, Handb.
Ferns Br. India 157 (1883).

Asplenium laserpitiifolium sensu Beddome, Ferns S. India t. 225 (1863).

Fig. 6 (A-E); Plate 7 (A-E)

Rhizome erect or suberect, ca. 0.5-1 cm thick, densely clothed by palea all over; palea ca. 9 x 0.8 mm, dark brown, glossy, linear-lanceolate, clathrate, tip pointed, base broad, slightly cordate, basally attached, margin slightly toothed. Fronds up to 50 cm long; stipe ca. 19 cm long, purplish black, abaxially rounded, deeply grooved above. Lamina ovate-lanceolate, bipinnate-tripinnatifid, 25-28 x 5-8 cm, primary pinnae 20-25 pairs, oblong-lanceolate, alternate or opposite, 4-5 cm long, petiole short, primary pinnae gradually reduced towards the tip into a lobed broad wing, subopposite below and alternate above; pinnules 5 or 6 pairs, shortly stalked, ca. 4 x 0.7 cm, split into 2 or 3 incised lobes with serrated margin, primary pinnae gradually reduced upwards into a winged prolongation with oblique lobes; both stipe and rachis clothed by small deciduous palea similar to those on the rhizome, ca. 3 x 0.4 mm, stalk of the primary pinna and both surfaces of pinnules also bear similar type of palea which are sparsely distributed, texture subcoriaceous; veins distinct below, not so above, not raised, forked once or twice. Sori linear, ca. 5 mm long, formed only on acroscopic veins.

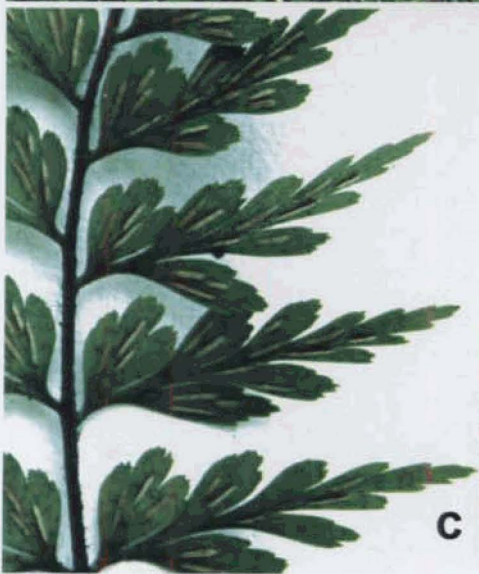


Plate 07. *Asplenium aethiopicum* (Burm. f.) Becher. A. Habit; B. Fertile frond; C. Part of frond showing sori; D. Pinna magnified; E. Rhizome.

Spores 50 x 33 μm , monolete, bilateral, perinate, exine granulose, perine loose, forming a median undulate wing and irregular anastomosing folds on the surface; unacetolysed spores 46 x 30 μm .

Distribution and Ecology: This taxon is not common in Kerala forests. Collected from Munnar Hills. Very common in Palni Hills and Nilgiri Hills. It has also been collected from Kolli Hills and Sheveroy Hills. Also, reported from Kumaun Himalaya and West Himalayas. The distribution is extended to Sri Lanka, America, South Africa, Jawa, Central Africa, Hawaii, Nepal, Tanzania, Peru, Polynesia Islands, Ethiopia, Mascareen Island and Canaries. Frequently found growing in fully or partially shaded forest stream banks and along roadside earth cuttings and as epiphytes above 1000 m.

Cytology: $n = 144$, octoploid (Irudayaraj & Bir, 1994; Irudayaraj & Manickam, 1987; Manickam & Irudayaraj, 1988. $2n = 288$ (Abraham *et al.*, 1962).

Note: *Asplenium aethiopicum* (Burm. f.) Becher. is highly variable with regard to the size and degree of dissection of the pinnules. Plants from Palni Hills and Nilgiri Hills are larger in size (Plates 8&9 A-B) while plants from other localities (Anamalais, Kannikatty, Kolli Hills and Sheveroy Hills) are stunted (Plates 8&9 C-D). In relation to altitude, normally the larger forms occur between 2000-2250 m (Kodaikanal & Ooty), while the smaller forms occur between 700-1900 m (Kolli & Yercaud). The Sri Lanka plants are with creeping rhizome (Sledge, 1965). Manickam and Rajkumar (1999)



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 Locality: Kalli Hills, I. C. N. S.
 Name: *Asplenium* sp. C

Plate 09. Polymorphism in *Asplenium aethiopicum* (Burm. f.) Becher.
 A&B. Plants from Kodaikanal; C&D. Plants from Kolli Hills.



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Plate 09. Polymorphism in *Asplenium aethiopicum* (Burm. f.) Becher.
A&B. Plants from Kodaikanal; **C&D.** Plants from Kolli Hills.

collected a single specimen (RHT 31730) with creeping rhizome from South India. The plants collected from different localities for this study are with erect or suberect rhizome.

Specimens examined: **ANDHRA PRADESH:** Chittoor Dt., Horsley Konda, *Fischer* 4334 (CAL); Horsely Hills, *Ameer Ahamed* 12836 (SKU). **Cudappa Dt.**, *Gamble* 20981 (CAL). **Golkonda Dt.**, *Amruthalakshmi & Kavitha* 25143 (CAL). **Vishakapatanam Dt.**, Kappakonda, *Rao* 29626B (MH, CAL). **KARNATAKA:** Mysore Dt., Castle Rock, B.R. Hills, *Rajagopal* 370 (MGMC). **KERALA:** Idukki Dt., Munnar, *Nampy* 51936 (CALI); *Sebastine* 17590 (MH); *Manickam & Mathew* 33135 (RHT); *Nair* 40218, 50727, 50739 (CAL); *Antony Raju* 17800 (TBGT); Devikulam, *Manickam & Mathew* 34487 (RHT); *Shetty* 26575 (MH). **TAMIL NADU:** Coimabtoire Dt., Valparai, *Mathew* 31673 (RHT), *Manickam & Mathew* 32926 (RHT), *Joseph* 12703 (MH). **Dindigal Dt.**, Sirumalai Hills, *Azeez* 102732 (CALI); Kodaikanal, *Sauliers* 1087 (CAL); *Madhusoodanan* 12824, 43822 (CALI); *Guinet* 612 (CAL); *Manickam* 32664 (RHT), *Nayar* 12815 (CALI). **Madhurai Dt.**, Uthamapalayam, *Manickam* 31497 (RHT). **Nilgiri Dt.**, Naduvattom, *Azeez* 102709, 102711 (CALI), *Subramanyam* 10508 (MH,CAL); Ooty, *Azeez* 102705 (CALI); *Meebold* 11819 (CAL); Bimakashola, *Rao* 36351, 41508 (MH); Avalanchi, *Nampy* 48814 (CALI); Thalakundha, *Sharma* 35844 (MH); Dodabetta, *Madhusoodanan* 21214 (CALI); Kalhatti, *Sharma* 35812 (MH); Bikkapatimund, *Rao* 41535 (MH); Sim's Park, Coonoor, *Srinivasan* 50596 (MH, CAL). **Selam Dt.**, Kolli Hills, *Manickam & Mathew* 33163, 33251

(RHT), Ghatak 83,247,255,489,591 (CAL);Yercaud, Manickam & Mathew 33321 (RHT), Nair 74211 (CAL), Bharghavan 74211 (MH); Honey rock estate, Bharghavan 74239 (MH); Balmadies estate, Yercaud, Subramanyam 6588 (MH,CAL). Tirunelveli Dt., Kannikatty Hills, Manickam & Mathew 31745 (RHT).

Asplenium affine Sw.

Schrad. J. Bot. 1800(2): 56 (1801)

Sledge, Kew Bull. 15: 401, fig. 2 (1962), Bull. Br. Mus. Nat. Hist. Bot. 3(6): 269. Fig. 2 (1965); Bot. J. Linn. Soc. 84: 14 (1982); Nayar & Kaur, Comp. Beddome Handb. 38 (1974); Dixit, Cens. Ind. Pterid. 116 (1984); Chandra & Kaur, Nom. Guide Beddome F.S.I. & F.B.I. 18 (1987); Singh & Bir, Ind. Fern J. 6(1-2): 272, 279 (1989); Manickam & Irudayaraj, Pterid. Fl. Western Ghats 226, Pl. 173 (1992).

Asplenium spathulinum J. Smith, Hook. Journ. Bot. 3: 408 (1841) nom. nud.
Asplenium spathulinum J. Smith ex Hook., Sp. Fil. 3: 170 (1860) nom. illegit. pro parte, quoad specim. ex Luzon, Borneo et Sri Lanka; non *A. spathulinum* Kunze (1984).

Fig. 7 (A-E); Plate 10 (A-F)

Rhizome short creeping ca. 1 cm thick, paleaceous allover, densely scaly at the apex; palea small ca. 4 x 0.5 mm, ovate-lanceolate, base cordate, margin entire. Fronds ca. 50 cm; stipe up to 20 cm, crowded,

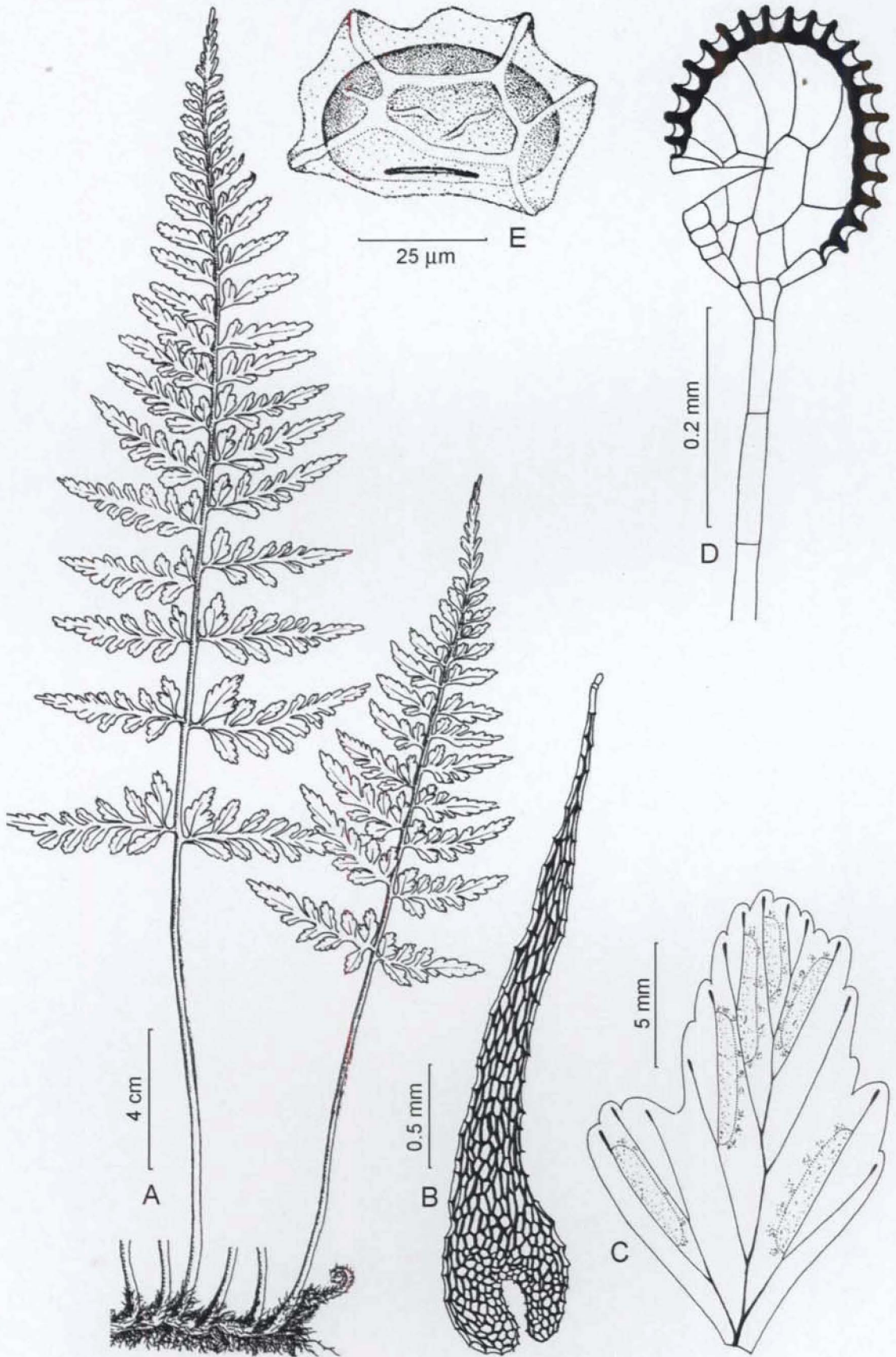


Fig. 07. *Asplenium affine* Sw. A. Habit; B. Palea on the rhizome; C. Pinna showing venation and position of sori; D. Sporangium; E. Spore.

rounded below and grooved above, grey to dark brown, glabrous. Lamina ovate-lanceolate, ca. 25-28 cm x 9-12 cm, bipinnate, apex acuminate, primary pinnae up to 20 pairs, 2.5-4 cm apart, sub-opposite below, alternate above, largest pinna 5-7 x 2-2.5 cm, lanceolate, apex acuminate, primary pinnae gradually reduced upwards into a slightly incised wing-like prolongation, each primary pinna gradually reduced towards the tip into a broad, regularly and slightly lobed wing; pinnules 5-7 pairs, alternate, sessile, ovate or oblong, small, ca. 1-1.5 x 0.5-0.8 cm, texture stiff and leathery, glabrous above and below; veins distinct above, not so below, mid vein slightly raised above, veins forked once or twice. Sori linear ca. 5 mm long, formed only on acroscopic veins, number of sori vary with size of the pinnule, usually 1-7 per pinnule, sori are very closely arranged in two oblique rows on broad part of the primary pinna in which each sorus overlap half to one-third portion of the succeeding one, sporangium stalk longer, usually twice the length of the capsule. Spores ca. 53 x 34 μm , monoletic, bilateral, perinate, exine granulate, with a conspicuous undulate perispore wing and anastomosing surface folds; unacetolysed spores ca. 43 x 31 μm .

Distribution and Ecology: Very rare species, confined to Kothayar Hills of Tirunelveli (Dt.), Tamil Nadu. Also, collected from Agasthyamala Hills of Thiruvananthapuram (Dt.) in Kerala. Rajkumar (2004) collected this species from Kudremukh National Park, Karnataka. No record elsewhere from South India. Also reported from Eastern Himalaya. The distribution is extended to Sri Lanka, Mascareen Island, Philippines, Borneo, Fiji, Sandwich Island,

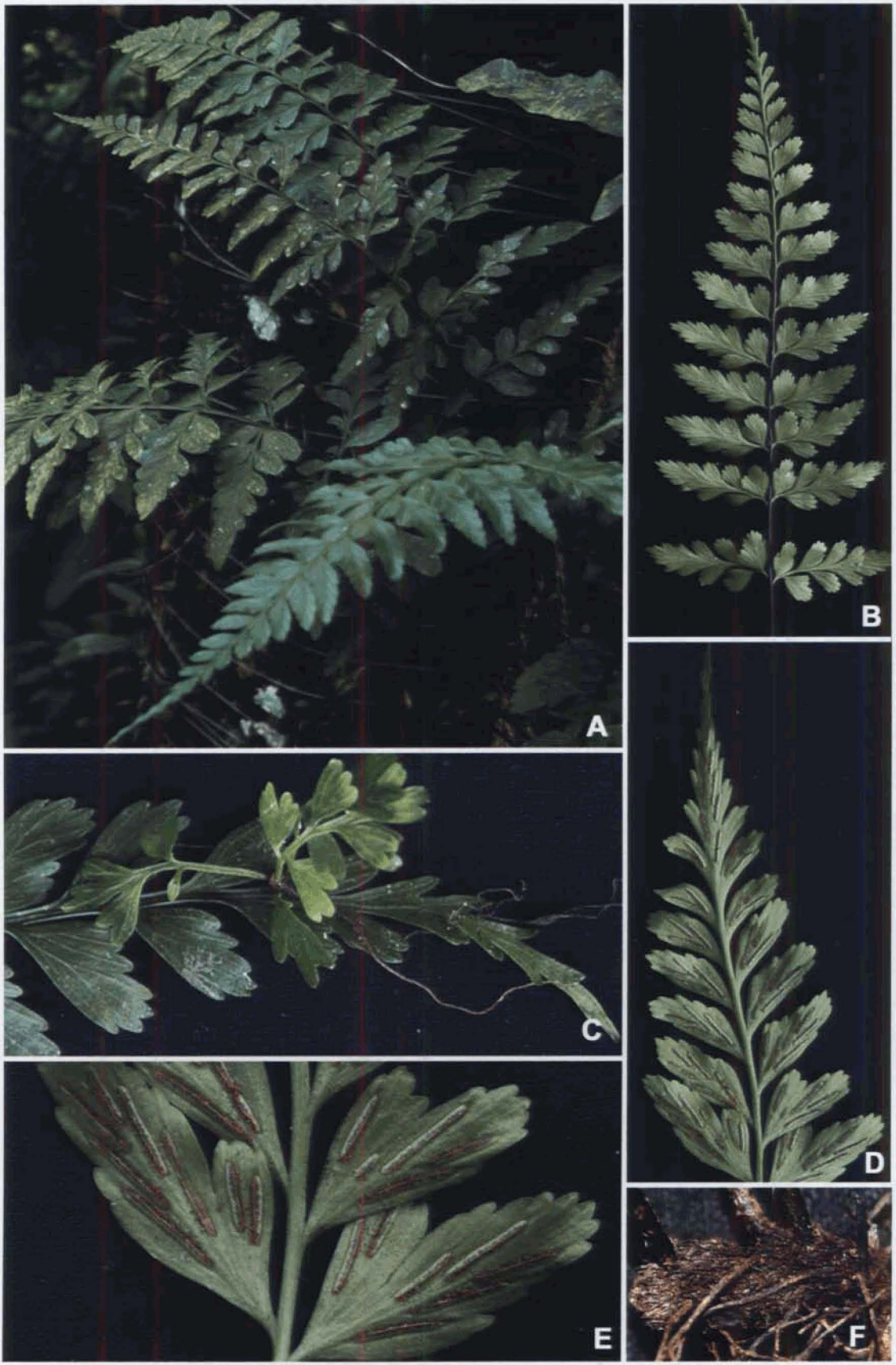


Plate 10. *Asplenium affine* Sw. A. Habit; B. Entire frond; C. Bulbils from tip of frond; D. Part of frond showing sori; E. Pinna magnified; F. Rhizome.

Japan and West Sumatra. It grows as an epiphyte in fully shaded forests between 1300-1600m.

Cytology: No report.

Note: Sledge (1965) reported that, *A. affine* Sw. is a highly variable species in Sri Lanka. He reported three different forms. The present gatherings are in accordance with *A. affine* forma *affine* Sledge with moderate size fronds (30-60 x 10-15 cm). Owing to the rare occurrence of this species in South India, the range of variations could not be ascertained.

Specimens examined: **KERALA:** Thiruvananthapuram Dt., Athirumala, Agasthyamala, Azeez 102773 (CALI); Chimanji, *Raju Antony* 18652 (TBGT). **TAMIL NADU:** Tirunelveli Dt., Upper Kothayar, Azeez 65946 (CALI), *Madhusoodanan & Sevichan* 44873 (CALI); Solapalam-Sengeltheri path, *Manickam & Mathew* 34251 (RHT); Sengeltheri-Kakachi path, *Manickam & Mathew* 34094 (RHT).

***Asplenium auritum* Sw.**

Schrad, Journ. Bot. 1800(2): 52 (1801)

Beddome, Ferns S. India 47, t. 137 (1863), Handb. Ferns Br. India 149 (1883); Nayar & Kaur, Comp. Beddome Handb. 36 (1974); Dixit, Cens. Ind. Pterid. 116 (1984); Manickam, Fern Fl. Palni Hills 99 (1986); Chandra & Kaur, Nom. Guide Beddome F.S.I. & F.B.I. 17 (1987); Mickel & Beitel, Pterid. Fl. Oaxaca 54, Fig. 92 C.D. (1988); Singh & Bir, Ind. Fern J. 6(1-2): 272,

134-1A

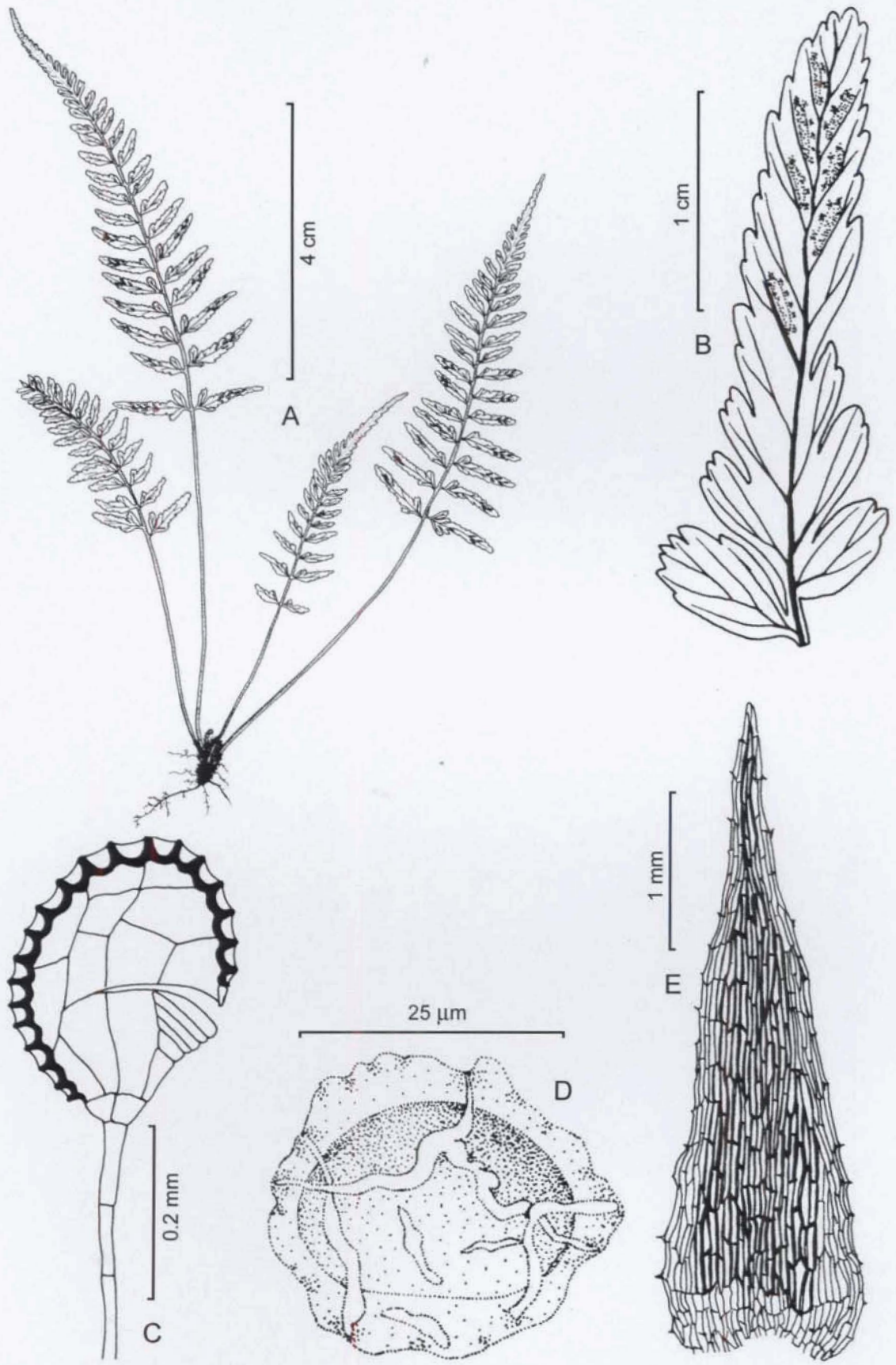


Fig 08. *Asplenium auritum* Sw. A. Habit; B. Pinna showing venation and position of sori; C. Sporangium; D. Spore; E. Palea on the rhizome.

279 (1989); Manickam & Irudayaraj, Pterid. Fl. Western Ghats 227, Pl. 174 (1992), Pterid. Fl. Nilgiris 131 (2003).

Fig. 8 (A-E); Plate. 11 (A-E)

Rhizome erect or suberect, 0.5 to 1 cm thick, densely scaly at the apex; palea small, ca. 5 x 1 mm, uniformly pale brown. Fronds tufted, up to 32 cm long, stipe 9-13.5 cm x 1 mm, round below, grooved above, dark brown, glabrous, not polished; lamina 15-18 cm long, 6-12 cm wide, simply pinnate or bipinnatifid or bipinnate depending upon the size, wider at the base, progressively narrowed towards acuminate apex, lower part of rachis similar to stipe, upper region green; pinnae 15-18 pairs, alternate, shortly stalked, 1.5 cm apart, lowermost pair biggest, gradually reduced toward the tip into a slightly lobed wing; largest pinna 3-8 x 1.5-2.5 cm, lanceolate, apex caudate, acuminate, pinnules up to 8 pairs, alternate, basal one or two distinct, others adnate, basal acroscopic pinnule larger than the others, 1-2 x 0.4-0.7 cm, ovate or oblong, apex rounded, margin crenate or inciso-crenate, veins slightly distinct above and below, forked once or twice, free, not reaching the margin; pinnae pale green, glabrous above and below; texture subcoriaceous. Sori linear along the veins, in two oblique rows on either side of the costa, ca. 3 mm long, indusiate, indusia pale brown; spores dark brown, 41 x 36 μm , monolete, bilateral, perinate, exine uniformly granulose, perine smooth, loose and forming undulating surface folds. Unacetolysed spores 50 x 30 μm .

135.4



Plate 11. *Asplenium auritum* Sw. A. Habit; B. Fertile frond; C. Part of frond showing sori; D. Pinna magnified; E. Rhizome.

Distribution and Ecology: This is a rare species in South India. Not widely distributed, reported from Palni Hills and Uthamapalayam forests of Madurai Dt. No report elsewhere from India. Also occurs in Tropical America, West Indies, Mascareen Island, Netherlands, Venezuela, Africa, South America and Madagascar. It grows as an epiphyte on fully shaded trees along stream banks between 1300-1800 m.

Cytology: No report.

Specimens examined: **KERALA:**Wayanad Dt., Gurukula Botanic Sanctuary – Periya, Azeez 103709 (CALI). **TAMIL NADU:** Dindigal Dt., Kodaikanal, *Manickam* 31197 (RHT); Pannaikadu-Kodaikanal, *Ramamurthy* 23488 (MH); Thevankari-Palni Hills, *Manickam* 31956 (RHT). **Madurai Dt.,** Uthamapalayam-Top Station Hills, *Manickam* 31477 (RHT).

***Asplenium bipinnatum* (Sledge) Azeez & Madhus., stat. nov.**

Asplenium polydon G. Forst. var. *bipinnatum* (Sledge) Sledge, Bot. J. Linn. Soc. 84: 6 (1982); Manickam & Irudayaraj, Pterid. Fl. Western Ghats 219, Pl. 167 (1992).

Asplenium falcatum var. *bipinnatum* Sledge, Bull. Br. Mus. Nat. Hist. Bot. 3(6): 262 (1965); Manickam & Ninan New Botanist 1: 26 (1976); Dixit, Cens. Ind. Pterid. 118 (1984); Manickam, Fern Fl. Palni Hills 98 (1986); Singh & Bir, Ind. Fern J. 6 (1-2): 272, 278 (1989).

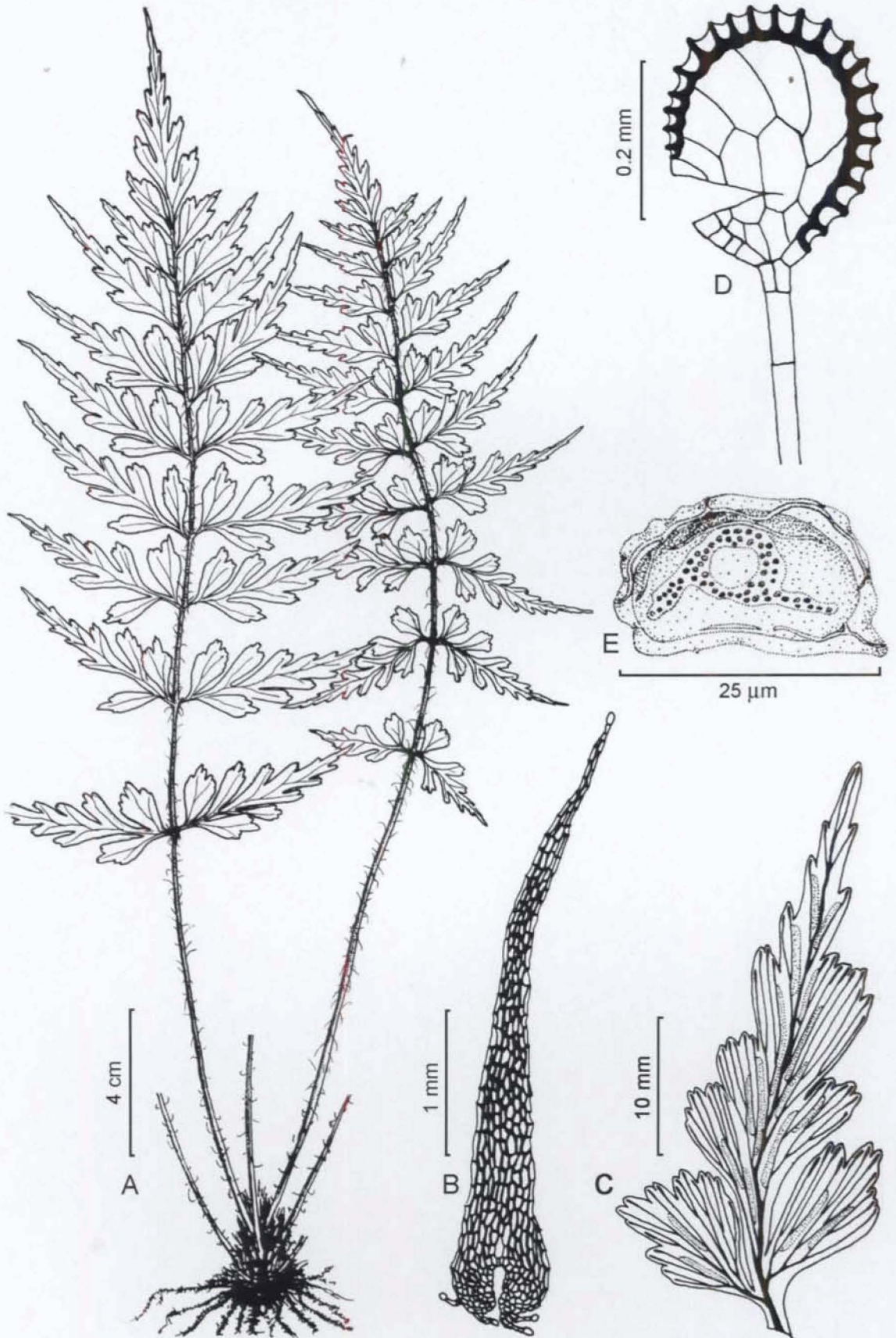


Fig. 09. *Asplenium bipinnatum* (Sledge) Azeez & Madhus., stat. nov.
 A. Habit; B. Palea on the rhizome; C. Pinna showing venation and position of sori;
 D. Sporangium; E. Spore.

Asplenium mysorense Roth, Nov. Pl. Sp. 395 (1821) pro parte.

Tarachia furcata var. *platyphylla* C. Presl in Abhandl. K. Bohm. Ges. Wiss. Folge 6: 440 (1851) pro parte.

Asplenium praemorsum var. *latum* sensu T. Moore, Index Fil. 156 (1859) pro parte: non Desv.

Asplenium spathulinum sensu Beddome, Ferns S. Ind. 75, t. 226 (1863); non J. Smith ex Hook.

Fig. 9 (A-E); Plate 12 (A-E)

Rhizome suberect, about 1.5-2.5 cm thick, densely scaly all over; scales linear-lanceolate, about 0.8 x 1 mm, uniformly dark brown, long acuminate and entire. Fronds up to 70 cm long, tufted; stipe 20-27 cm long, grey to dark brown, rounded below, grooved above, densely scaly when young, sparsely scaly at maturity, lamina lanceolate or oblong lanceolate, bipinnate about 35-40 x 15-19 cm, nature and colour of the rachis similar to stipe, but more scaly, bears up to 15 pairs of primary pinnae; pinnae shortly stalked, stalk 0.5 cm, subopposite, placed 2-4 cm apart, basal pinnae not reduced; largest pinna 8-10 x 2-3 cm, lanceolate, acuminate, cuneate, one-third to half distal part of the primary pinna shallowly lobed without bearing distinct pinnules; pinnules upto five pairs, sessile, alternate, ovate or wedge shaped, about 3 x 1.5 cm, base cuneate, apex rounded and irregularly incised, veins marked by striations above, slightly distinct below, forked two to three times, free, parallel, reaching the margin; pinnae pale green, glabrous above and below; texture subcoriaceous; bears a few soft, dark



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Plate 12. *Asplenium bipinnatum* (Sledge) Azeez & Madhus., stat. nov.
A. Habit; B. Fertile frond; C. Part of frond showing sori; D. Single pinna magnified; E. Rhizome.

brown scales especially at the junction of primary pinnae. Sori numerous, all along the veins except the extreme apex, about 1-1.5 cm long, indusiate. Spore 56 x 37 μm , monolete, bilateral, perinate, exine granulose, provided with a characteristic band which bears few dark, oval raised spots, perine loose forming a narrow undulating wing. Unacetolysed spores 55 x 40 μm .

Distribution and Ecology: It is not widely distributed. Reported from Thekkady and Chinnar Wild Life Sanctuary of Kerala state, Palni Hills, Tirunelveli Hills, Anamalai Hills, Kolli Hills, Sheveroy Hills, Sirumalai Hills and Sethur Hills of Tamil Nadu. No report from other parts of South India and North India. The distribution is extended to Sri Lanka, Malaysia, Australia, Indonesia, Malagasy, New Zealand, Philippines, Polynesia and China. It is commonly found growing as terrestrial or epilithic in fully or partially exposed forests, between 1000-2000 m.

Cytology: No report.

Notes: Sledge (1965) described this variety as *A. falcatum* var. *bipinnatum* Sledge. Later, Sledge (1982) made a new combination, *A. polydon* G. Forst. var. *bipinnatum* (Sledge) Sledge. According to him, this taxon has a very narrow range of distribution. Apart from Sri Lanka and South India, bipinnate specimens are reported only from Malaysia. Dixit (1984) reported wide distribution of this species such as Madagascar, South China, Indonesia, Philippines, Polynesia, Australia and New Zealand.

Singh and Bir (1989) reported that depending up on the habitats, open exposed rocks or roadsides or shaded and well protected situations, the size of the frond and pinnae of this taxon is highly variable. According to them the variety *bipinnatum* of Sri Lanka and South India easily merit a specific status. The present author on the basis of extensive survey and detailed morphological observations holds the view that *A. polydon* G. Forst. var. *bipinnatum* (Sledge) Sledge is entirely different and easily distinguishable with permanent characters like the plant size, bipinnate nature of frond and the large size of the spore, this taxon should be elevated to a specific status.

Economic importance: The whole plant is used in the treatment for the enlargement of spleen, incontinence of urine, jaundice and malaria in North Africa (Manickam & Irudayaraj, 1992).

Specimens examined: **KERALA:** Idukki Dt., Karadikavala-Thekkadi, Azeez 102740 (CALI); Palada - way to Mlappara, Nair 70101 (MH). **Thiruvananthapuram Dt.**, Ichampatty-Chinnar W.L.S., Rajesh 87750 (CALI). **TAMIL NADU:** Coimbatore Dt., Karyan Shola-Anamalai, Mathew 31529 (RHT). **Dindigal Dt.**, Kodaikanal, Azeez 103704 (CALI); Palamalai-Palni Hills, Manickam 31127 (RHT); Ayyanar estate-Sirumalai, Chandrabose 54280 (MH, CAL). **Madurai Dt.**, Kumbukarai, Sebastine 12955 (CAL). **Ramanathapuram Dt.**, Nagariar estate-Sethur Hills, Srinivasan 86985 (MH); Deviar estate-Sethur Hills, Srinivasan 63515, 98324 (MH); Muthaliaruthu, Nair 60440 (MH, CAL). **Tiruneveli Dt.**, Kalakkad Hills, Manickam 31269

(RHT), *Parthasarathy* 514 (MH); Kannikatti Hills-Ambasamudram, *Manickam* & *Mathew* 31745 (RHT).

***Asplenium cheilosorum* Kunze ex Mett.**

Abhandl. Senkenb. Naturforsch. Ges. 3: 177, t. 5, figs. 12, 13 (1859)

Mehra & Bir, Res. Bull. (n.s.) Punjab Univ. 15: 157 (1964); Sledge, Bull. Br. Mus. Nat. Hist. Bot. 3(6): 245 (1965), Bot. J. Linn. Soc. 84: 14 (1982); Nayar & Kaur, Comp. Beddome Handb. 37 (1974); Baishya & Rao, Ferns & Fern Allies Meghalaya 113 (1982); Dixit, Cens. Ind. Pterid. 116 (1984); Chandra & Kaur, Nom. Guide Beddome F.S.I. & F.B.I. 16 (1987); Jamir & Rao, Ferns Nagaland 277, pl. 62 (1988); Singh & Bir, Ind. Fern J. 6(1-2): 268-284 (1989); Manickam & Irudayaraj, Pterid. Fl. Western Ghats 211, Pl. 159 (1992), Pterid. Fl. Nilgiris 126 (2003); Nayar & Geevarghese, Fern Fl. Malabar 274 (1993); Azeez *et al.*, J. Econ. Tax. Bot. 20(2): 435-455 (1996).

Asplenium heterocarpum Wall., Numer. List. 9, n.218 (1829) nom. nud.

Asplenium heterocarpum Wall. ex Hook., Sp. Fil. 3: 132, t. 175 (1860); Beddome Handb. Ferns Br. India 153, t. 131 (1883).

Fig. 10 (A-E); Plate 13 (A-F)

Rhizome short creeping, ca. 5 mm thick, paleaceous all over, densely scaly at the apex; palea narrow, ca. 4 x 0.5 mm, pale brown, lanceolate, clathrate, basally attached, margin entire without glands. Stipe 10-22 cm long, slender, dark brown, polished, base a little broad and scaly, remaining

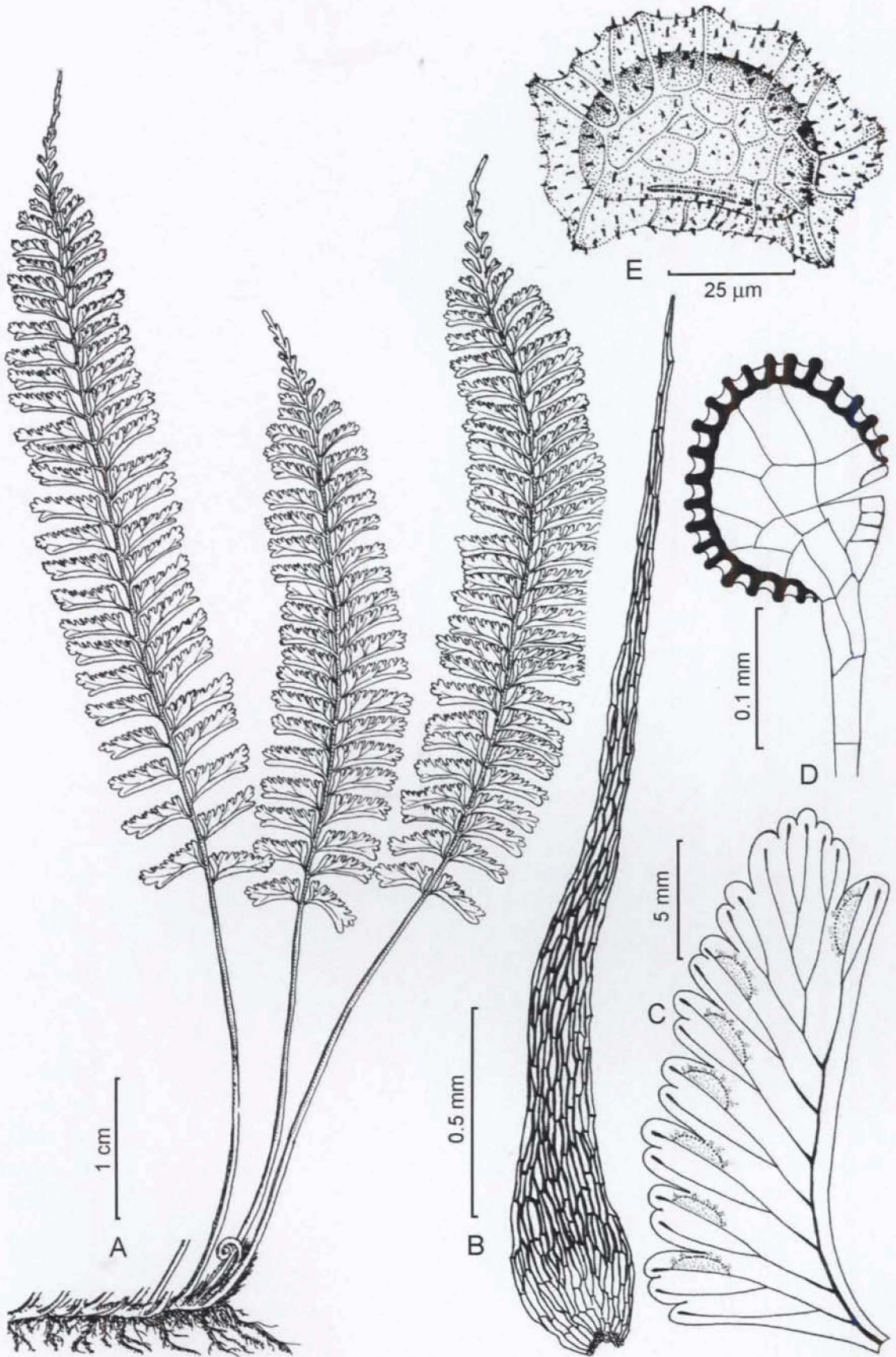


Fig. 10. *Asplenium cheilosorum* Kunze ex Mett. A. Habit; B. Palea on the rhizome; C. Pinna showing venation and position of sori; D. Sporangium; E. Spore.

portion glabrous. Lamina unipinnate, ca. 30-40 x 4-4.5 cm, rachis similar to stipe, bears up to 40 pairs of pinnae which are closely arranged, 0.7-1 cm apart, lower ones very shortly stalked, upper margin and extreme portion of the lower margin bifid, apex rounded, lateral pinnae gradually reduced towards the tip into a narrow lobed wing, basal pinnae not reduced, rachis grooved above, round below, possesses a thin, green, membranaceous wing on either side of the groove, pinnae dark green, texture thin, membranaceous, glabrous above and below; largest pinna 2.5-3 x 1 cm, oblong, straight or slightly falcate, lower half of the pinna excised nearly to the apex of the pinna. Veins slightly distinct above and below, acroscopic basal vein forked twice, others forked once. Sori small, 1-2 mm, confined to the lobes of the pinna, formed only on acroscopic veins, usually one sorus is seen on the first lobe of the basispic side near the tip of the pinna. Spores 53 x 34 μm , monoletic, bilateral, perinate, exine sparsely and uniformly spinulose, perine loose, densely spinulose, wings broad having reticulately anastomosing surface folds; unacetolysed spores 47 x 32 μm .

Distribution and Ecology: Not widely distributed, common in Tirunelveli Hills and some restricted areas of Kerala Ghats. Reported from Kothayar Hills and Anamalai Hills of Tamil Nadu, Agasthyamala Hills, Ponmudi Hills, Sabarigiri, Silent Valley and Upper Manalar regions (Munnar) of Kerala Ghats. Also reported from Kumaon Himalaya, Sikkim Himalaya, North-Eastern India, North-West Himalaya and West Himalaya. The distribution is extended to Sri Lanka, Burma, Nepal, Tibet, Malaysia, Japan, Philippines,

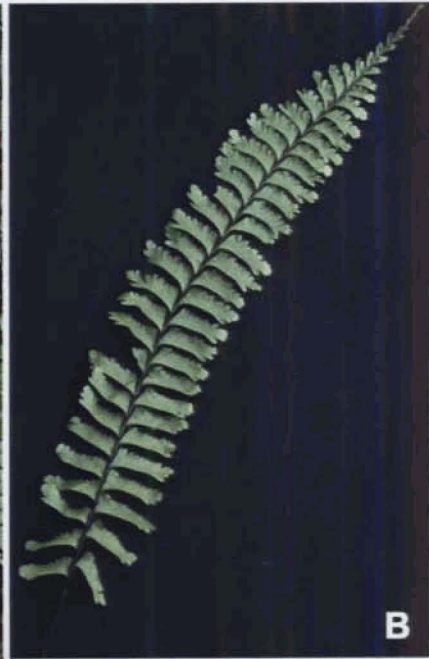


Plate 13. *Asplenium cheilosorum* Kunze ex Mett. A. Habit; B. Frond (dorsal); C. Fertile frond; D. Part of frond showing sori; E. Pinna magnified; F. Rhizome.

Thailand, China, Taiwan, Borneo, Afghanistan, Myanmar, Ethiopia, Indonesia and Bhutan. Commonly found growing as epilithic or terrestrial on fully shaded forest floor between 950-1900 m.

Cytology: $2n = 108$, Triploid apogamous (Bir, 1965).

Specimens examined: KERALA: Idukki Dt. Upper Manalar, *Jomy Augustine* 12873 (CALI); Kallar ravine, Munnar Hills, *Manickam* 32218 (RHT). **Palakkad Dt.** Silent Valley, *Nayar & Geevarghese* 10619 (CALI), *Nair* 65464 (MH, CAL), *Bharghavan* 81134 (MH, CAL); Punnamala, Silent Valley, *Nayar* 10619 (CALI); Walakkad, Silent Valley, *Nayar* 10663 (CALI), *Nair*, 77232(CAL). **Pathanamthitta Dt.** Anathode, Sabarigiri, *Nayar* 10116 (CALI). **Thiruvananthapuram Dt.** Agasthyamala, *Azeez* 102763 (CALI), *Raju Antony* 22538, 18676 (TBGT), *Mohanan* 66013 (MH, CAL), *Nampy & Madhusoodanan* 51932 (CALI); Ponmudi Hills, *Manickam* 33839 (RHT), *Nair* 51742 (MH), *Nair & Ghosh* 51686 (CAL). **TAMIL NADU: Coimbatore Dt.,** Valparai-Anamalai Hills, *Manickam & Mathew* 32987 (RHT). **Nilgiri Dt.** Lamb's rock, *Gamble* 11600 (MH). **Madurai Dt.,** Vellimalai, *Shetty* 10359 (MH, CAL). **Tirunelveli Dt.,** Kothayar Hills, *Henry* 17427 (MH), *Manickam* 31061 (RHT); Sengeltheri-Kalakkad Hills, *Manickam* 31262 (RHT); Kalakkad-Kakachi Hills, *Manickam & Mathew* 34123 (RHT); Sengeltheri, *Vajravelu* 29107 (MH).

***Asplenium crinicaule* Hance**

Annal. Sci. Nat. Ser. V. 5: 259 (1866)

Clarke, Trans. Linn. Soc. Lond. II Bot. 1: 479 (1880); Beddome, Handb. Ferns Br. India 150 (1883); Nayar & Kaur, Comp. Beddome Handb. 36 (1974); Dixit, Cens. Ind. Pterid. 117 (1984); Manickam, Fern Fl. Palni Hills 103 (1986); Chandra & Kaur, Nom. Guide Beddome F.S.I. & F.B.I. 17 (1987); Singh & Bir, Ind. Fern J. 6(1-2): 272, 279 (1989); Manickam & Irudayaraj, Pterid. Fl. Western Ghats 216, Pl. 164 (1992); Azeez *et al.*, J. Econ. Tax. Bot. 20(2) 435-455 (1996).

Asplenium falcatum sensu Beddome, Ferns S. India t. 141 (1863).

Fig. 11 (A-F); Plate 14 (A-F)

Rhizome erect, ca. 1.5 cm thick, densely clothed by paleae all over; palea long and narrow, ca. 7.5 x 0.8 mm, linear-lanceolate, clathrate, uniformly dark brown, tapering into uniseriate hair, gland tipped, basally attached, base cordate, margin entire with few long bi-seriate gland tipped hairs which are more prominent on the basal region. Fronds up to 30 cm long, tufted; stipe ca. 7 cm long, abaxially rounded, adaxially grooved, dark brown. Lamina unipinnate, oblong-lanceolate, ca. 20-23 x 6 cm; both stipe and rachis covered by many small gland-tipped paleae all over which are ca. 3.6 x 0.3 mm, and are similar to those on the rhizome, lamina gradually reduced towards the tip into a narrow wing having oblique lobes; rachis dark brown to greenish, bears up to 20 pairs of shortly stalked lateral pinnae; pinnae 2-3 x 1 cm, basal 2-3 pairs slightly reduced, light green, ovate-

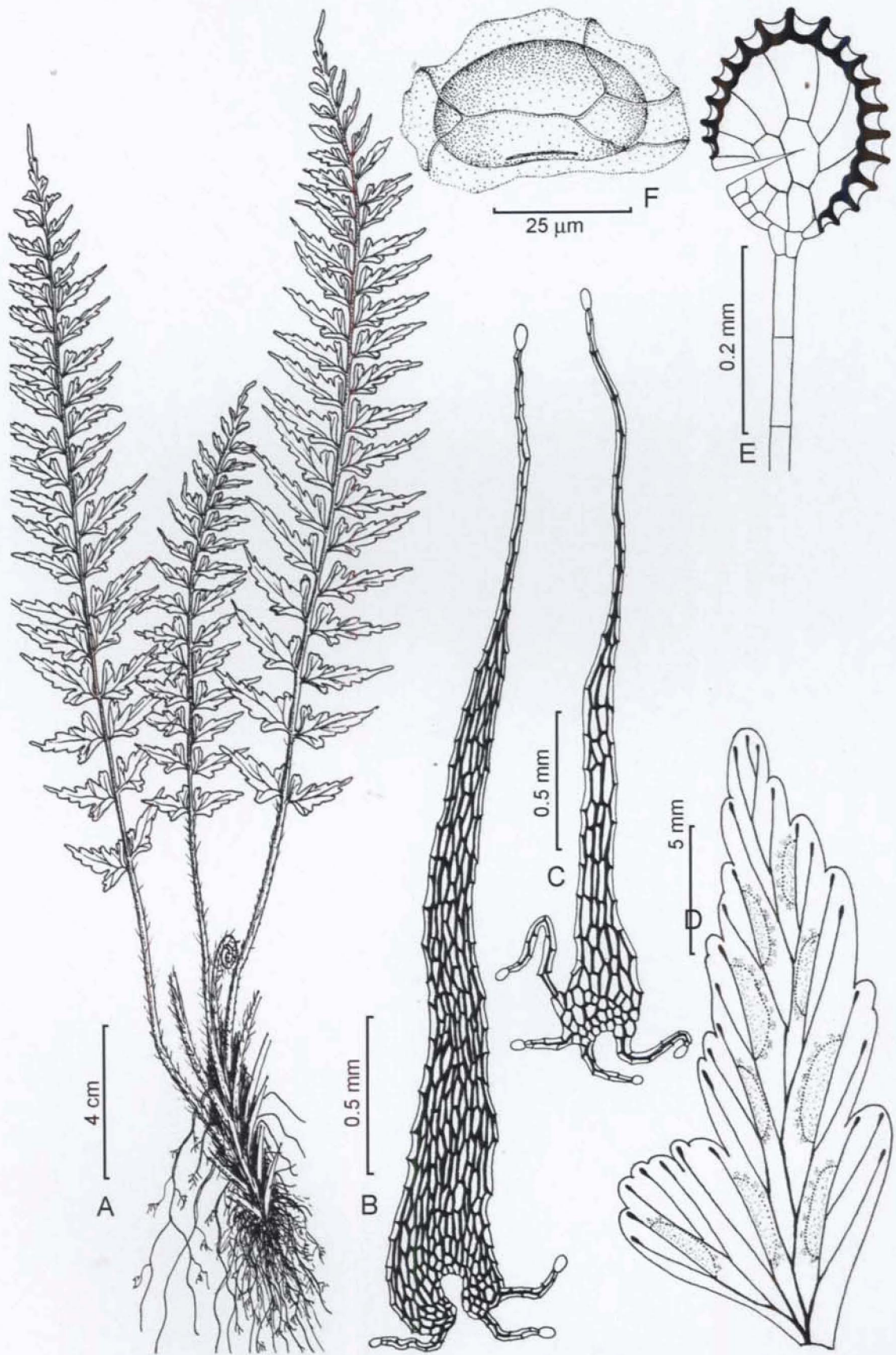


Fig. 11. *Asplenium crinicaule* Hance A. Habit; B. Palea on the rhizome; C. Palea on the stipe; D. Pinna showing venation and position of sori; E. sporangium; F. Spore.

lanceolate, dimediate, acroscopic base truncate, lobed, lobes serrate, subcoriaceous, bears few sparsely distributed scales on both surfaces; veins distinct below, free and forked, costa distinct and slightly grooved above, vein endings swollen, reaching the margin. Sori linear, ca. 5 mm long, arranged in two oblique rows on either side of the costa, only along the acroscopic veins, 8-10 per pinnae. Spores 47 x 28 μm , monoletate, bilateral, perinate, exine granulose, perine more or less loose, smooth and wrinkled into elongated sinuous folds; unacetolysed spores 43 x 25 μm .

Ecology and Distribution: One of the most widely distributed species in South India. Reported from Nilgiri Hills, Palni Hills, Kannikatty Hills, Valparai and Kolli Hills of Tamil Nadu. It is widely distributed along Kerala Ghats. Also collected from Kudajadri Hills of Karnataka. Also reported from North-Eastern Himalaya, Sikkim Himalaya and North-Eastern India. The distribution is extended to China, Thailand and Tibet. Commonly found growing on partially shaded trees or stones mainly along roadsides between 500-1200 m.

Cytology: $n = 144$, octoploid (Kuriachan, 1968).

Specimens examined: **KARNATAKA:** Shimoga Dt., Agasthyatheertham-Kudajadri, Azeez 102734 (CALI). **KERALA:** Idukki Dt. Vallakadavu, Azeez 102744 (CALI); Kulamavu, Mohanan 79970 (MH). **Kozhikode Dt.,** Anakampoyil, Azeez & Nampy 45928, 45930 (CALI), Madhusoodanan 29685 (CALI). **Palakkad Dt.,** Silent Valley, Azeez 102719, 102720 (CALI),

144

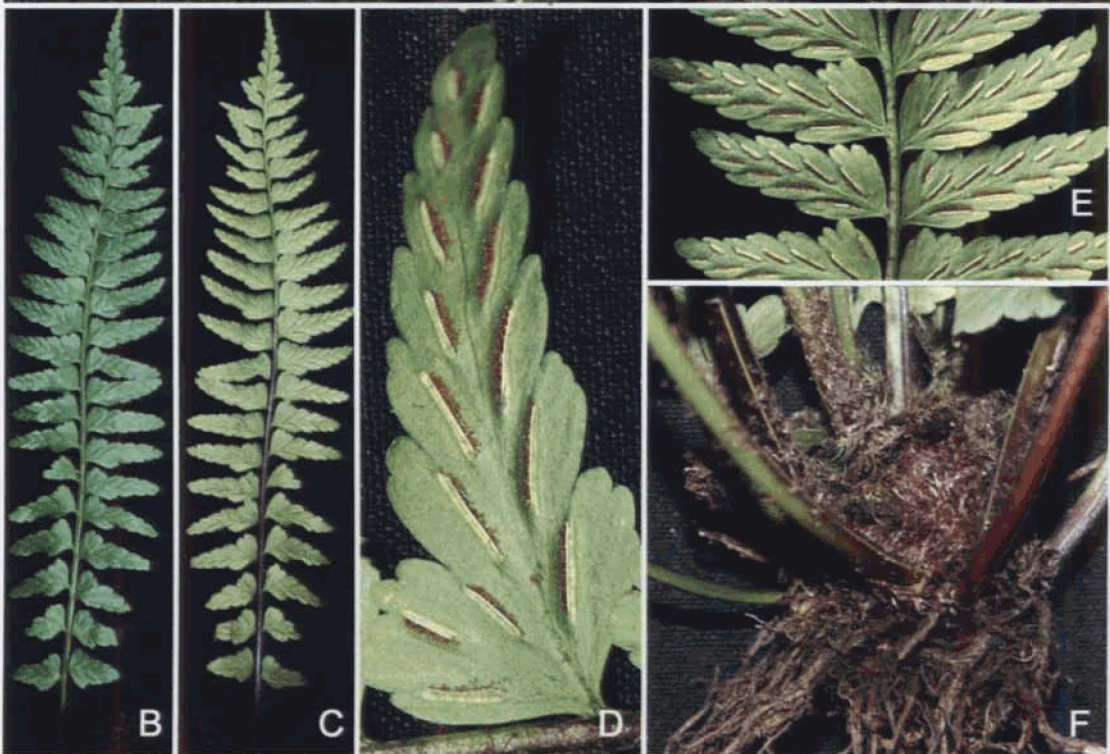


Plate 14. *Asplenium crinicaule* Hance A. Habit; B. Frond (dorsal); C. Fertile Frond; D. Pinna magnified; E. Part of frond showing sori; F. Rhizome.

Nayar 10175 (CALI), *Nayar & Geevarghese* 21382 (CALI), *Geevarghese* 4051 (CALI), *Nayar & Madhusoodanan* 29637 (CALI), *Vajravelu* 26102 (MH), *Bhargavan* 69591 (MH), *Nair* 67307 (MH). **Pathanamthitta Dt.**, Anathode, *Azeez* 102747 (CALI); Sabarimala Hills, *Manickam & Mathew* 33620 (RHT); Moozhiyar, *Manickam & Mathew* 33655 (RHT). **Thrissur Dt.**, Sholayar, *Azeez* 102796 (CALI). **Thiruvananthapuram Dt.**, Athirumala, *Azeez* 102771 (CALI). **Wayanad Dt.**, Chandanathode-Periya, *Azeez* 102714 (CALI), *Geevarghese* 4093 (CALI), *Madhusoodanan & Nampy* 43765 (CALI); Kallanpuzha, *Madhusoodanan* 12839 (CALI), *Ramachandran* 61650, 62636 (MH). **TAMIL NADU: Coimbatore Dt.**, Valparai-Anamalai Hills, *Manickam* 33085 (RHT). **Dindigal Dt.**, Manalur-Palni Hills, *Manickam* 589, 31882 (RHT). **Nilgiri Dt.**, Chellankode forest, *Vajravelu* 44892 (MH). **Selam Dt.**, Kolli Hills, *Manickam & Mathew* 33253 (RHT). **Tirunelveli Dt.**, Kannikatty Hills, *Manickam* 32372 (RHT).

Asplenium decrescens Kunze

Linnaea, 24 (1851)

Sledge, Bull. Br. Mus. Nat. Hist. Bot. 3: 259 (1965); *Nayar & Kaur*, Comp. Beddome, Handb. 36 (1974); *Dixit*, Cens, Ind. Pterid. 117 (1984); *Manickam*, Fern Fl. Palni Hills 100 (1986); *Chandra & Kaur*, Nom. Guide Beddome F.S.I. & F.B.I. 17 (1987); *Manickam & Irudayaraj*, Pterid. Fl. Western Ghats 210, Pl. 157 (1992), Pterid. Fl. Nilgiris 125 (2003). *Azeez et al.*, J. Econ. Tax. Bot. 20(2) 435-455 (1996).

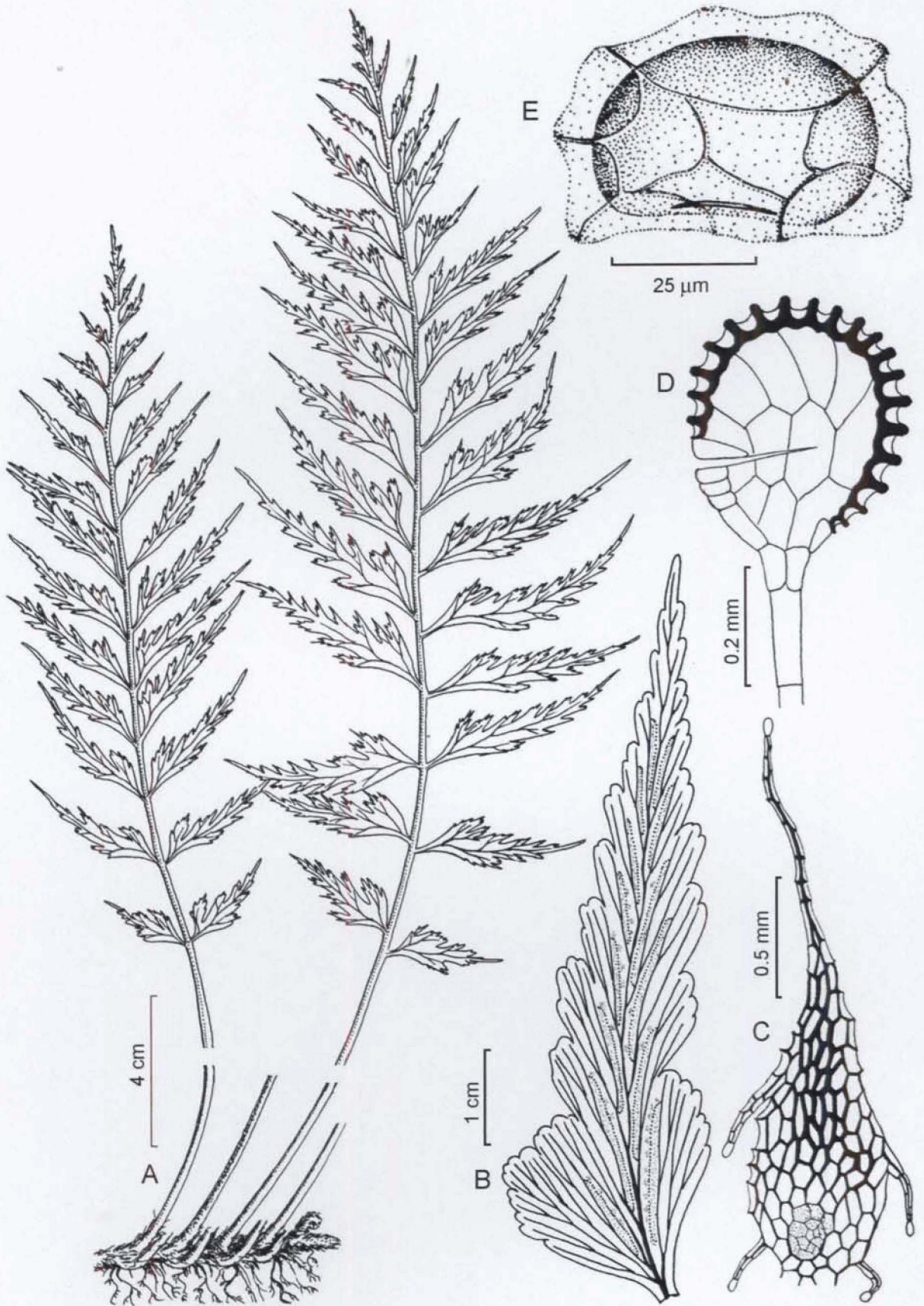


Fig. 12. *Asplenium decrescens* Kunze. A. Habit; B. Pinna showing venation and position of sori; C. Palea on the rhizome; D. Sporangia; E. Spore.

Asplenium contiguum sensu T. Moore, Ind. Fil. 121(1859); quoad specim, Zeyl. an Kaulf., Beddome Ferns S. India t. 140 (1863).

Asplenium caudatum sensu Hook., Sp. Fil. 3: 152 (1880); quoad specim, Zeyl. p.p. non Forst. f., Beddome Handb. Ferns Br. India 151 (1883); Nayar & Geevarghese, Fern Fl. Malabar 273 (1993).

Fig. 12 (A-E); Plate 15 (A-E)

Rhizome long creeping, stout, 8 mm thick, covered by scales all over, densely scaly at the apex; palea small, 2 x 0.5 mm, brittle, dark brown, ovate-lanceolate, clathrate, margin entire, bearing few glands on biseriate stalk, apex long acuminate and gland-tipped. Fronds 40-70 cm long, placed 1.5 cm apart; stipe 12-28 cm long, pale brown to dark brown, rounded below, grooved above, scaly at first, becoming almost glabrous except at the base, slightly polished; lamina unipinnate, 20-40 x 10-13 cm, oblong-lanceolate, nature and colour of rachis similar to stipe, bears 12-25 pairs of pinnae; pinnae shortly stalked, falcate, subopposite below, alternate above, lowermost pinna slightly reduced, the tip of the lamina not pinna like, ends in a lobed wing like prolongation, pinnae 6-8 x 1-2 cm, basisopic base slightly excised, acroscopic base truncate, narrowed gradually to an acuminate apex, both edges more or less deeply lobed, the lobes oblique and sharply toothed, pinnae pale green, texture chartaceous, sparsely scaly above and below; veins many, crowded, forked 4-5 times, distinct below, slightly raised above. Sori linear 0.5-1 cm, produced on the vein forks near the costa, at first slightly diverging, but later form two parallel rows close to the costa, few



Nella panna maravara L.
Hort. Mal.
Trin. & Walt.

Fig. 12a. *Nella panna maravara*, identified as *Asplenium decrescens* Kunze (*Hortus Malabaricus*, Vol. 12, t. 18, pp. 36)

obliquely arranged sori can be seen on the basal lobes. Spores 45 x 33 µm, monolete, bilateral, perinate, exine granulose, perine loose, forming an undulate wing and few surface folds; unacetolysed spores 41 x 31 µm.

Distribution and Ecology: Widely distributed, reported from Kerala Ghats, Palni Hills, Nilgiri Hills, Anamalai Hills, Kolli Hills of Tamil Nadu and B.R. Hills of Karnataka. No report elsewhere from other parts of India. The distribution is extended to Sri Lanka, Malaysia, Australia, Africa and Brazil. Commonly found growing in a variety of habitats, seen as terrestrial along road side earth cuttings or as epilithic along stream banks or as epiphytes inside the forest between 1000-2100 m in partially or fully shaded places.

Cytology: n = 72, Tetraploid (Manickam & Irudayaraj, 1988; Irudayaraj, 1990; Irudayaraj *et al.*, 1993).

Specimens examined: **KARNATAKA:** Mysore Dt., B.R. Hills, *Rajagopal* 355 (MGMC). **KERALA:** Idukki Dt., Gundumala Shola, Munnar, *Azeez* 102775 (CALI); Eravikulam National Park, *Azeez* 102787 (CALI); Mangala Devi, Thekkadi Hills, *Manickam & Mathew* 33362 (RHT); Devikulam, Munnar, *Manickam & Mathew* 34483 (RHT); Parapayar, Anamudi Hills, *Manickam & Mathew* 34544 (RHT). **Kozhikode Dt.**, Vellarimala, *Satheeshkumar* 70356 (CALI). **Palakkad Dt.**, Silent Valley, *Nayar* 10037 (CALI); Karasuryamalai, Anamalai Hills, *Vajravelu* 60515 (MH, CAL). **Pathanamthitta Dt.**, Anathode, *Azeez* 102746 (CALI); Sabarigiri, *Nayar* 10133 (CALI); Elampampa, *Nayar* 10114 (CALI). **Thiruvananthapuram Dt.**,

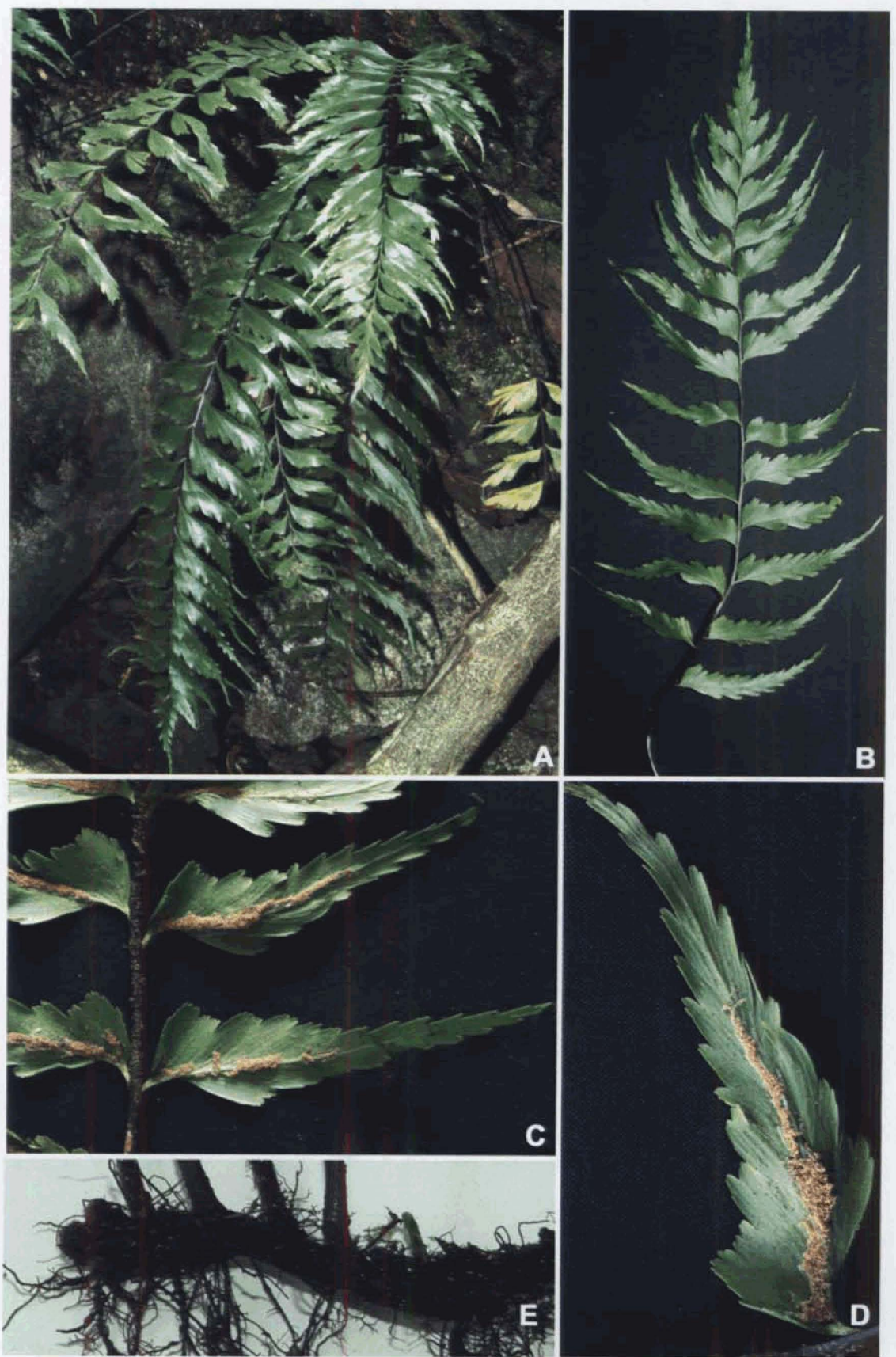


Plate 15. *Asplenium decrescens* Kunze A. Habit; B. Frond (dorsal); C. Part of frond showing sori; D. Pinna magnified; E. Rhizome.

Athirumala, *Azeez* 102770 (CALI); Vazhukumpara, Athirumala, *Azeez* 102772 (CALI); Agasthyamala, *Azeez* 102759 (CALI); Mundhanthurai, *Raju Antony* 41097 (TBGT). **TAMIL NADU: Coimbatore Dt.**, Valparai- Anamalai Hills, *Mathew* 31569 (RHT). **Dindigal Dt.**, Kodaikanal, *Azeez* 102730 (CALI); *Nayar & Unnikrishnan* 2735 (CALI); *Manickam* 31927, 32658 (RHT), *Gamble* 1187 (MH); Palni Hills, *Manickam & Mathew* 34832 (RHT). **Nilgiri Dt.**, T.R. Bazar, *Ellis* 43338 (MH); *Sharma* 39871 (MH); Kadanad R.F., *Vajravelu* 36864 (MH); Nilgiri Hills, *King* 59432 (MH), *Gamble* 11787 (CAL); *Sharma* 39871 (MH); Kadanad R.F., *Vajravelu* 36864 (MH); Naduvattom, *Sharma* 35916 (MH), *Ellis* 34725 (MH), *Vajravelu* 46069 (MH); *Subramanyam* 10510 (CAL); Lakkadi, *Shetty* 34060 (MH). **Ramanathapuram Dt.**, Nagariar estate, *Srinivasan* 94478, 65951 (MH). **Selam Dt.**, Kolli Hills, *Azeez* 102797 (CALI), *Manickam & Mathew* 33230 (RHT), *Diwakar* 97074 (MH); **Tirunelveli Dt.**, Kothayar, *Azeez* 45949 (CALI), *Madhusoodanan & Sevichan* 44870 (CALI), *Nampy* 45102 (CALI), *Manickam* 32035 (RHT); Muthukuzhi, *Henry* 68843 (MH, CAL); Kannikatti Hills, *Manickam & Mathew* 31739 (RHT).

***Asplenium ensiforme* Wall. ex Hook. & Grev.**

lc. Fil. t. 71 (1829)

Beddome, *Ferns S. India* t. 125 (1863), *Hanb. Ferns Br. India* 141, t. 71 (1883); Clarke, *Trans. Linn. Soc. Lond. II Bot.* 1: 476 (1880); Sledge, *Bull. Br. Mus. Nat. Hist. Bot.* 3(6): 242 (1965), *Bot. J. Linn. Soci.* 84: 14 (1982);

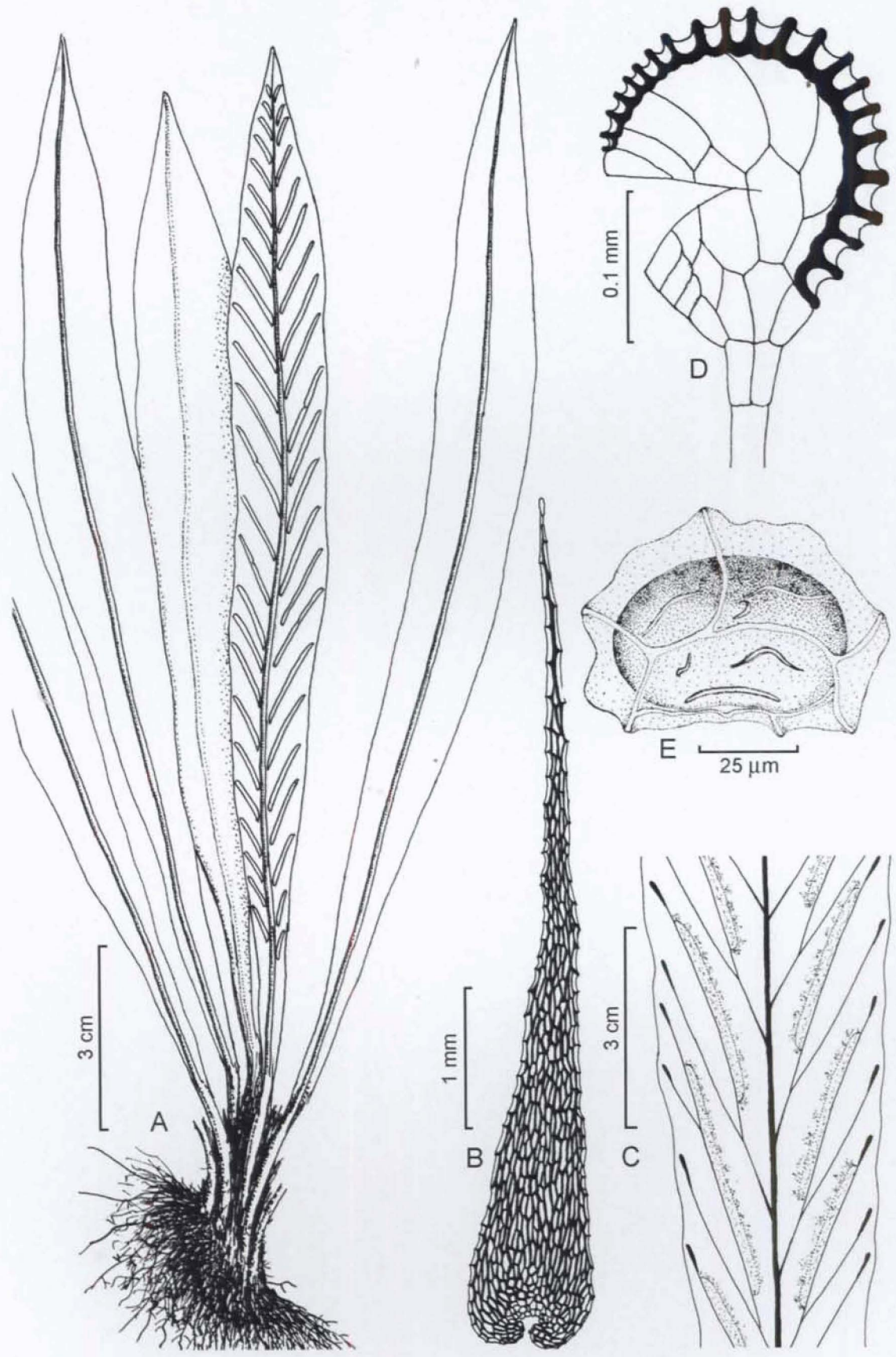


Fig.13. *Asplenium ensiforme* Wall. ex Hook. & Grev. A. Habit; B. Palea on the rhizome; C. Part of frond showing venation and position of sori; D. Sporangium; E. Spore.

Nayar & Kaur, Comp. Beddome Handb. 34 (1974); Iwatsuki, Hara Fl. East Himal. (3 Rep.) 194 (1975); Baishya & Rao, Ferns & Fern Allies, Meghalaya 113 (1982); Dixit, Cens. Ind. Pterid. 117 (1984); Chandra & Kaur, Nom. Guide Beddome F.S.I. & F.B.I. 15 (1987); Jamir & Rao, Ferns Nagaland 279, pl. 63 (1988); Singh & Bir, Ind. Fern J. 6(1-2): 268-284, fig. 1 (1989); Manickam & Irudayaraj, Pterid. Fl. Western Ghats 207, Pl. 154 (1992); Azeez *et al.*, J. Econ. Tax. Bot. 20(2): 435-455 (1996).

Asplenium ensiforme Wall., Numer. List. 8. no. 200 (1829) nom. nud.

Fig. 13 (A-E); Plate 16 (A-E)

Rhizome short, sub-erect, ca. 2 cm thick, paleaceous all over; densely scaly at the apex; palea ovate-lanceolate, 7 x 1.5 mm, dark brown, base broad, cordate, basally attached, clathrate, margin entire without any glands. Fronds tufted, simple, 20-28 cm long; stipe highly reduced, 1.5-3 cm long, close together, pale reddish brown when dry, base paleaceous; lamina simple, long, 20-24 x 1.5-2 cm, yellowish to brownish when dry, base paleaceous, middle portion broad, gradually narrowed towards both sides, apex acuminate, margin entire to slightly wavy, texture stiff, sub-coriaceous, glabrous above and below; veins obscure above and below, forked once or twice, reaching the margin, no intramarginal fusion, vein endings swollen, midrib slightly raised below, not well above. Sori elongated, ca. 1.5-2 cm long, arranged in two oblique, regular rows on either side of the midrib, adjacent sori overlap half to two-third length, sori produced from the extreme base to the tip of the lamina, not restricted to a particular area. Spores 46 x



Plate 16. *Asplenium ensiforme* Wall. ex Hook. & Grev. A. Habit; B. Fertile fronds; C. Frond (dorsal); D. Part of frond showing sori; E. Rhizome.

32 μm , monolete, bilateral, perinate, exine granulose, perine loose, wide, wings undulate with anastomosing surface folds; unacetolysed spores 45 x 32 μm .

Distribution and Ecology: Very rare species. Reported from Anamalai Hills, Tamilnadu, Munnar Hills and Agasthyamalai Hills of Kerala and Kudremukh of Karnataka. Also reported from Sikkim Himalaya, North Eastern India, North Eastern Himalaya, North-West Himalaya, Kumaun Himalaya, West Himalaya, Nital and West Bengal. The distribution is extended to Sri Lanka, Burma, Thailand, Indo-China, Japan, Nepal, Taiwan, Central Africa and Vietnam. Commonly found growing as epiphytes on fully shaded shola trees between 1500-2000 m.

Cytology: $n = 72$, Tetraploid (Bir, 1965).

Specimens examined: **KARNATAKA:** Kudremukh, *Rajagopal* 786 (MGMC). **KERALA:** Idukki Dt., Devikulam, *Manickam* 51922 (CALI); Vagavarai Hills, Eravikulam, *Manickam* 34504 (RHT). **Thiruvananthapuram Dt.,** Agasthyamala, *Joseph* 44625 (MH). **TAMIL NADU:** Coimbatore Dt., Valparai- Anamalai Hills, *Manickam & Mathew* 34409, 34423 (RHT); Konalar, Anamalai Hills, *Chandrabose* 69009 (MH, CAL). **Nilgiri Dt.,** Gudallur, *Meebold* 11597 (CAL).

Asplenium erectum Bory ex Willd.

Linn. Sp. Pl. ed. 4, 5: 328 (1810)

Sledge, Bull. Br. Mus. Nat. Hist. Bot. 3: 248 (1965); Nayar & Kaur, Comp. Beddome Handb. 36 (1974); Dixit, Cens. Ind. Pterid. 117 (1984); Manickam, Fern Fl. Palni Hills 106 (1986); Chandra & Kaur, Nom. Guide Beddome F.S.I. & F.B.I. 16 (1987); Manickam & Irudayaraj, Pterid. Fl. Western Ghats 209 Pl. 156 (1992), Pterid. Fl. Nilgiris 124 (2003).

Asplenium brasiliensis sensu Beddome, Ferns S. India 45, t. 135 (1863).

Asplenium lunulatum var. *camptorachis* (Kunze) Beddome, Handb. Ferns Br. India 148 (1883).

Asplenium lunulatum var. *erectum* (Bory ex Willd.) Sm., Ferns S. Afr. ed. 2: 145 (1915).

Fig. 14 (A-E); Plate 17 (A-D)

Rhizome erect ca. 1 cm thick, covered by scales; palea small ca. 2.5 x 0.5 mm, ovate lanceolate, base broad, cordate, basally attached, clathrate, margin entire, bears some glands on small uniseriate stalk, gland tipped, not pointed. Fronds tufted, up to 40 cm long; stipe 6-8 cm long, glabrous, more or less shining, grey brown; lamina unipinnate, 25-32 x 2-3 cm, colour and nature of the rachis similar to stipe, bears upto 40 pairs of pinnae, which are sessile, light green, 1.5-2 x 0.5-0.8 cm, placed 0.5-1 cm apart, dimediate, acroscopic base lobed, this lobe and the remaining portion of the pinna is regularly incised, tip rounded, middle pinnae are larger, gradually reduced in size towards both sides, few basal pairs deflexed and gradually reduced to

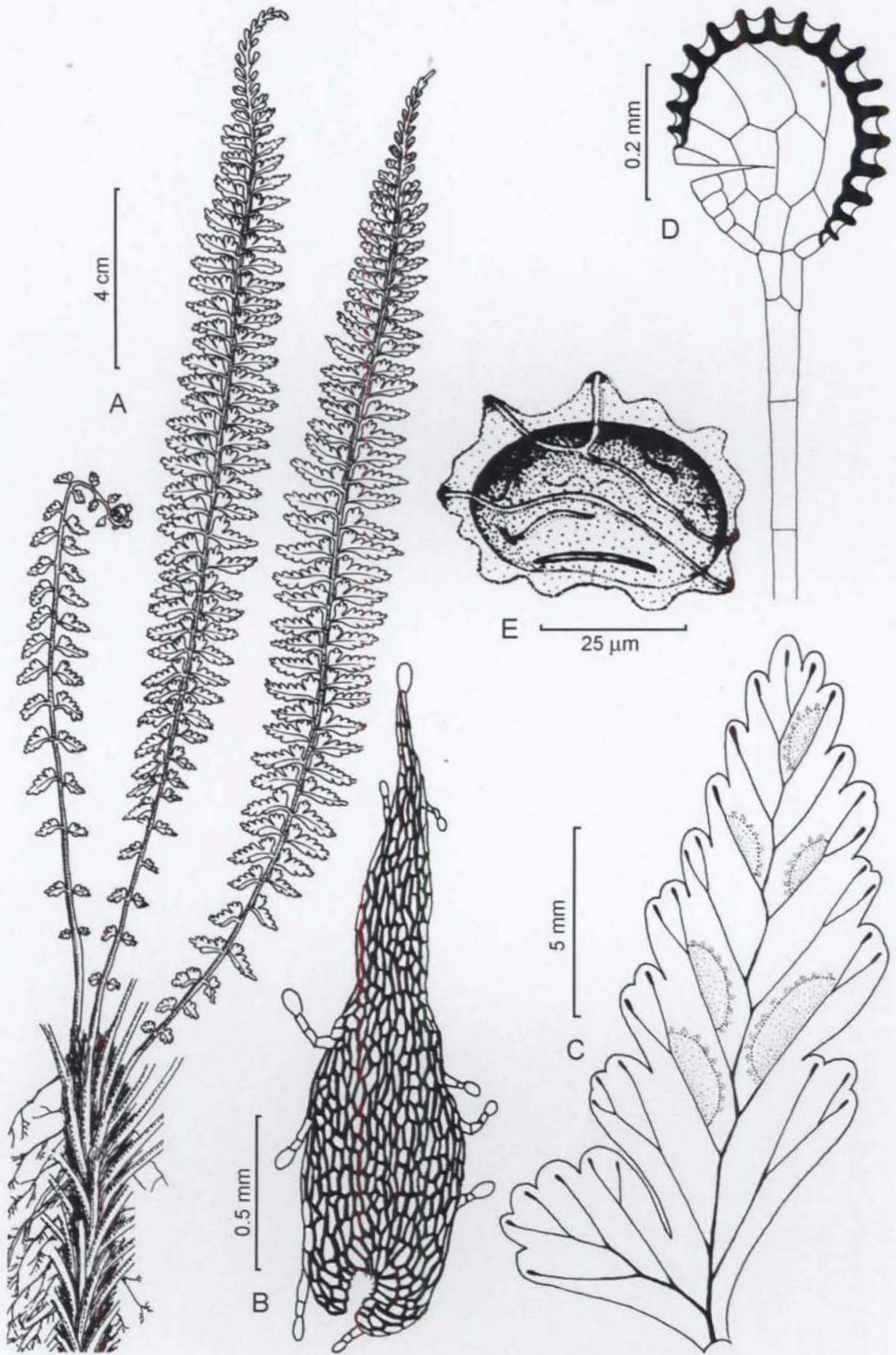


Fig. 14. *Asplenium erectum* Bory ex Willd. A. Habit; B. Palea on the rhizome; C. Pinna showing venation and position of sori; D. Sporangium; E. Spore.

auricles, lamina gradually reduced towards the tip into a lobed narrow wing, texture herbaceous, glabrous above and below, rachis grooved above, possess a very narrow green wing on either side of the groove; veins forked once or twice, midvein distinct above and below, not raised. Sori small, 2-3 mm long commonly restricted to the distal half, arranged in two regular oblique rows on either side of the costa, usually 6-10 per pinna; sporangium stalk usually more than twice the length of the capsule. Spores ca. 38 x 28 μm , monoletic, bilateral, perinate, exine granulate, perine loose, having narrow undulate wings and irregular surface folds; unacetolysed spores ca. 31 x 25 μm .

Distribution and Ecology: Widely distributed in Tamil Nadu. Reported from Nilgiri Hills, Palni Hills, Tirunelveli Hills, Anamalai Hills and Yercaud. In Kerala reported only from Munnar and Anamudi Hills. No report from other areas of present study. Also reported from Orissa. The distribution is extended to Sri Lanka, South Africa, Zambesiaca – Africa, Java, Timor, Samoa and Hawaii Islands. Commonly found growing as terrestrial or epilithic along stream banks inside fully shaded forests between 1100-2200 m.

Cytology: n = 36, diploid (Kuriachan, 1968; Ghatak, 1977; Manickam & Irudayaraj, 1988; Irudayaraj, 1990; Idurayaraj *et al.*, 1993).

Specimens examined: KERALA: Idukki Dt., Mattupetti, Munnar, Azeez 102779 (CALI); Munnar Hills, *Manickam* 31396, 32293 (RHT); Parappayar,

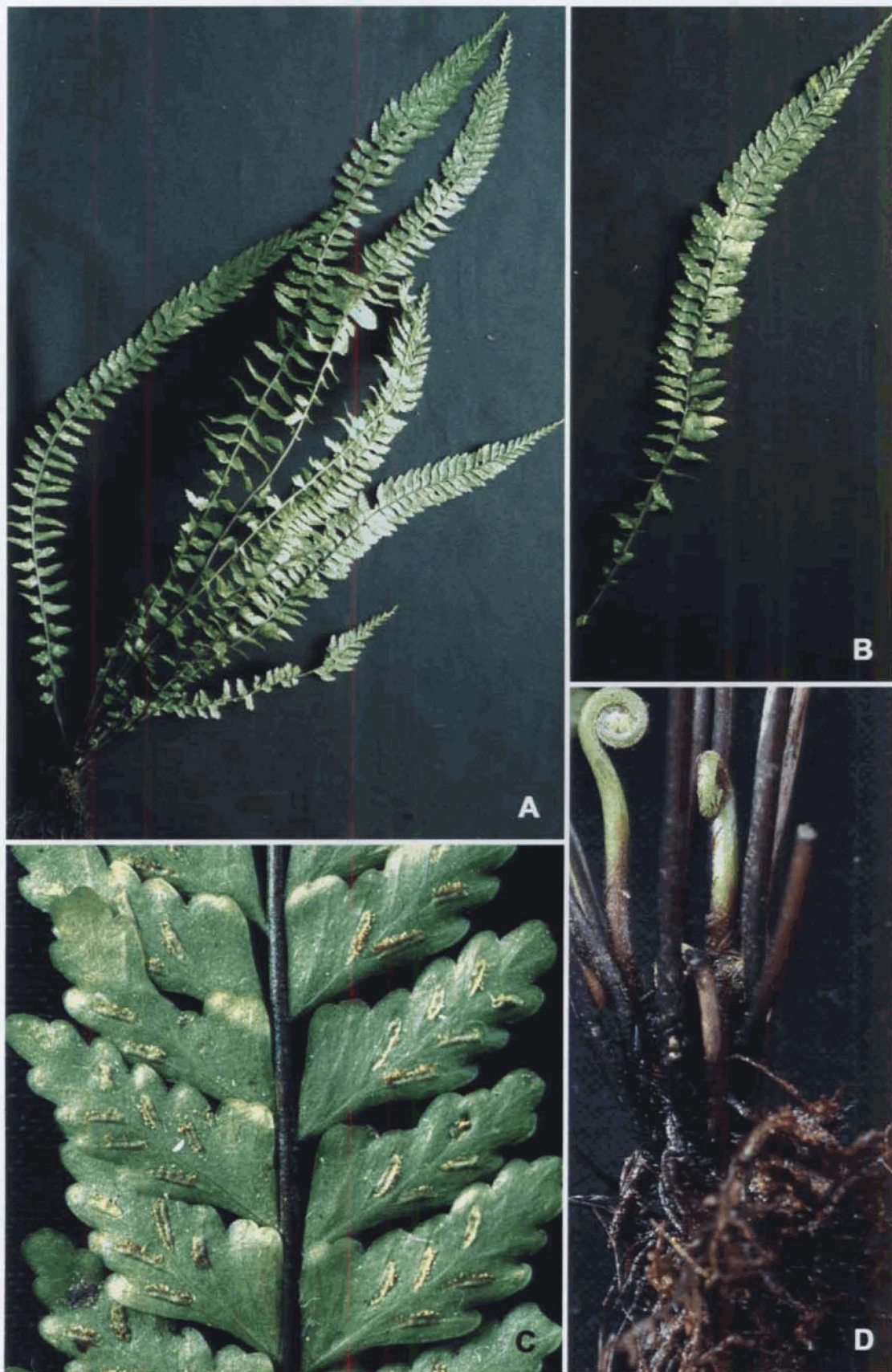


Plate 17. *Asplenium erectum* Bory ex Willd. A. Habit; B. Frond; C. Part of frond showing sori; D. Rhizome.

Anamudi Hills, *Manickam & Mathew* 34546 (RHT); Deikulam, Munnar, *Meebold* 13501, 13536 (CAL). **TAMIL NADU: Coimbatore Dt.**, Valparai-Anamalai Hills, *Manickam & Mathew* 33116 (RHT). **Dindugal Dt.**, Kodaikanal, *Azeez* 102731 (CALI), *Madhusoodanan* 12825 (CALI), *Nayar* 2657, 2605 (CALI), *Manickam* 31914 (RHT), *Manickam & Mathew* 32855 (RHT); Kukal Shola, Palni Hills, *Manickam & Mathew* 32641 (RHT). **Madurai Dt.**, Uthamapalayam, *Manickam* 31507 (RHT). **Nilgiri Dt.**, Naduvattom, *Azeez* 102707 (CALI), *Ooty*, *Azeez* 102703, 102704 (CALI), *Gamble* 11497 (CAL), *Guinet* 609 (CAL), *Ellis* 34562 (MH); Avalanchi, *Nampy* 48813 (CALI), *Shetty* 34089 (MH); Chamaraj estate forest, *Sebastine* 3331 (MH, CAL); Kothagiri, *Deb* 31539 (MH); Dodabetta, *Madhusoodanan* 21215 (CALI); Lakkadi, Upper Bhavani, *Shetty* 34058 (MH); Bikkapattimund, *Rao* 37392 (MH). **Selam Dt.**, Kakka Shola, Yercaud, *Nair* 74225 (MH, CAL), *Ghatak* 250, 491, 492, (CAL); Balmadies estate, Yercaud, *Subramanyam* 7514 (MH). **Tirunelveli Dt.**, Kalakad, *Manickam* 31256 (RHT); *Manickam & Mathew* 34140 (RHT); Agasthiar Hills, Ambasamudram, *Manickam* 32431 (RHT); Way to Naterikal, *Vajravelu* 29254 (MH); Kothayar Hills, *Manickam* 32087 (RHT).

Asplenium excisum Presl

Epim. Bot. 74 (1849)

Holttum, Fl. Mal. 2: 439 (1954); Mehra & Bir, Res. Bull. Punjab Univ. (n.s) 15, 158 (1964); Ching, Acta Phytotax. Sin. 10: 190 (1966); Nakaike, Enum.

153.19

289

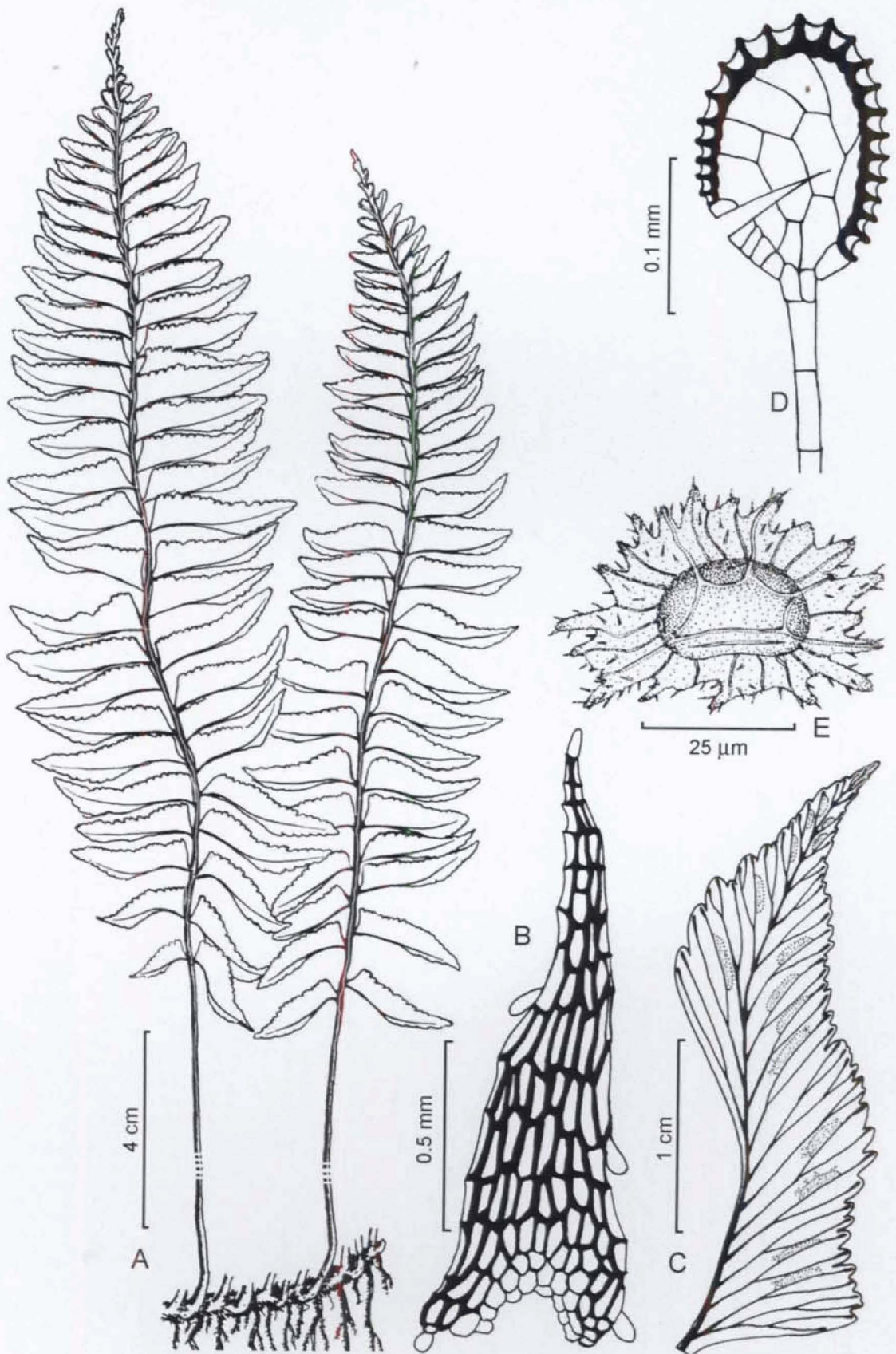


Fig. 15. *Asplenium excisum* Presl A. Habit; B. Palea on the rhizome; C. Pinna showing venation and position of sori; D. Sporangium; E. Spore.

Pterid. Japan Fil. 96 (1975); Vasudeva *et al.*, Indian fern J. 7: 66-85 (1990); Kato, J. Fac. Sci. Univ. Tokyo III 15: (1992).

Asplenium unilaterale forma *majus* C. Chr., Bernice P. Bishop Mus. Bull. 177: 67 (1943); Sledge, Bull. Br. Mus. Nat. Hist. Bot. 3(6): 246 (1965), Bot. J. Linn. Soci. 84: 14 (1982); Nair & Dixit, J. Bombay Nat. Hist. Soc. 78: 466 (1981); Dixit, Cens. Ind. Pterid. 122 (1984); Kuo, Taiwania 30: 38 (1985); Chandra & Kaur, Nom. Guide Beddome F.S.I. & F.B.I. 16 (1987).

Asplenium unilaterale Lam. var. *majus* Manickam & Irudayaraj, Pterid. Fl. Western Ghats 213, Pl. 161 (1992); Azeez *et al.*, J. Econ. Tax. Bot. 20(2): 435-455 (1996).

Asplenium resectum sensu Bedd., F.S.I. t. 132 (1864).

Hymenasplenium rahaoense (Yabe) H. Ito ex Tuyama in Bot. Mag. Tokyo 51: 126 (1937); Tagawa, J. Jap. Bot. 23: 77 (1949).

Asplenium obscurum sensu Ogata, Icons. Fil. Jap. 5: pl. 208 (1993), non Blume.

Fig. 15 (A-E); Plate18 (A-E)

Rhizome short creeping, ca. 6 mm thick, clothed by paleae allover, densely scaly at the apex; palea 2.6 x 0.6 mm, uniformly dark brown, ovate-lanceolate, clathrate, basally attached, margin entire bearing few sessile glands. Fronds up to 60 cm long; stipe 17-20 cm, glossy, dark brown to blackish, bears few sparsely distributed scales, rounded below, grooved above; lamina unipinnate, oblong-lanceolate, 30-43 x 8-10 cm; rachis glabrous and polished, grooved above, bears a narrow green membranous



A



C



B



D



E

Plate 18. *Asplenium excisum* Presl A. Habit; B. Fertile frond; C. Part of frond showing sori; D. Pinnae magnified; E. Rhizome.

wing on either side of the groove, bears 25-35 pairs of shortly stalked lateral pinnae which are 1-1.5 cm apart; pinnae 5-6 x 1-1.5 cm, nearly one-third portion of the basisopic base excised, margin regularly and slightly lobed, lobes bifid, having blunt tip, falcate, gradually reduced towards the tip, apex acuminate, lower pinnae not or only slightly reduced, pinnae gradually reduced towards the tip of the lamina into a regularly lobed narrow wing, light green, herbaceous, glabrous above and below; veins distinct above and below, costa greenish to brownish, slightly raised below, acroscopic basal vein forked twice or thrice, others forked only once. Sori small, ca. 0.5 mm long, distributed all along the pinna except the base, but more sori are confined to the distal half, on either side of the costa as oblique rows, few are also seen on the proximal half in some pinnae, usually restricted to the middle of the acroscopic veins, not touching the forked region, protected by a pair of similar flap-like indusia one on either margin of the sorus. Spores 36 x 29 μm , monoletic, bilateral, perinate, exine granulose, perine loose, densely spinulose, highly wrinkled into irregular thin, sharp folds with angular crests; unacetolysed spores 31 x 25 μm .

Distribution and Ecology: Limited to Silent Valley, Karapara, Munnar Hills and Moozhiyar-Sabarimala region of Kerala. Occasional on Anamalai Hills, Kothayar Hills, Kodaikanal of Tamil Nadu. Reported only from Galikonda region of Andhra Pradesh. No report from Karnataka and other parts of India. The distribution is extended to Sri Lanka, Indonesia, Malaysia, New

Guinea, Philippines, Japan and Indo China. Usually terrestrial, rarely epilithic on shaded stream banks between 1000-1500 m.

Cytology: n = 76 (Manickam & Irudayaraj, 1992).

Specimens examined: **ANDHRA PRADESH:** Vishakapatnam Dt., Galikonda, Rao 19651 (MH). **KERALA:** Idukki Dt., Gundumala Shola-Munnar, Azeez 102777, 102778 (CALI); Mlappara, Mohanan 72809 (MH, CAL). Palakkad Dt., Silent Valley, Nair 56858, 65455 (MH, CAL), 65458 (MH), Nampy & Madhusoodanan 45990 (CALI), Geevarghese 29270 (CALI), Ghosh 56380 (CAL); Karapara estate, Nair 69745, 69824 (MH, CAL); Kunthipuzha-Silent Valley, Madhusoodanan & Nampy 51927 (CALI). Pathanamthitta Dt., Sabarimala, Nair 70205 (MH), 874 (CAL), Sharma 42058 (MH); Vandiperiyar-Moozhiyar Road, Manickam & Mathew 34301 (RHT). Thiruvananthapuram Dt., Bonnakad-Koviltheri forest, Joseph 46556 (MH); Ponmudi, Nair & Ghosh 51828 (CAL). **TAMIL NADU:** Coimbatore Dt., Siruvani, Subramanyam 2456 (MH); Valparai-Anamalai Hills, Manickam & Mathew 33087, 34332 (RHT). Dindigal Dt., Kodaikanal, Azeez 102727 (CALI). Tirunelveli Dt., Upper Kothayar, Azeez 45945 (CALI); Periyar, Henry & Chandrabose 19163 (MH); Walayar estate, Sebastine 9936 (MH); Tirunelveli Hills, Manickam & Mathew 34098 (RHT).

Key to *A. excisum* Presl var. *serratum*

- 1a. Lamina bears 25-35 pairs of pinnae,
margin of the pinna serrate, teeth blunt,
pinna conspicuously falcate and
gradually reduced to an acuminate
apex *A. excisum*
- 1b. Lamina bears 15-25 pairs of pinnae,
margin of the pinna serrate, teeth
pointed, pinnae slightly falcate and
narrowed towards the tip and ends
in an irregular forking..... *A. excisum* var. *serratum*

***Asplenium excisum* Presl var. *serratum* Azeez & Madhus. nov.**

Similis ad *Asplenium excisum* Presl sed dissimile in natura pinnarum, cum margin dentata, dentatae acuta, apex pinnarum finita in furca irregulare et margina perinae non lobata penitus.

Fig. 16 (A-E); Plate 19 (A-F)

Rhizome short creeping, ca. 5 mm thick, sparsely covered by scales; palea small, 2 x 0.6 mm, lanceolate, uniformly dark brown, clathrate, base broad, basally attached, margin entire with some sessile glands. Fronds up

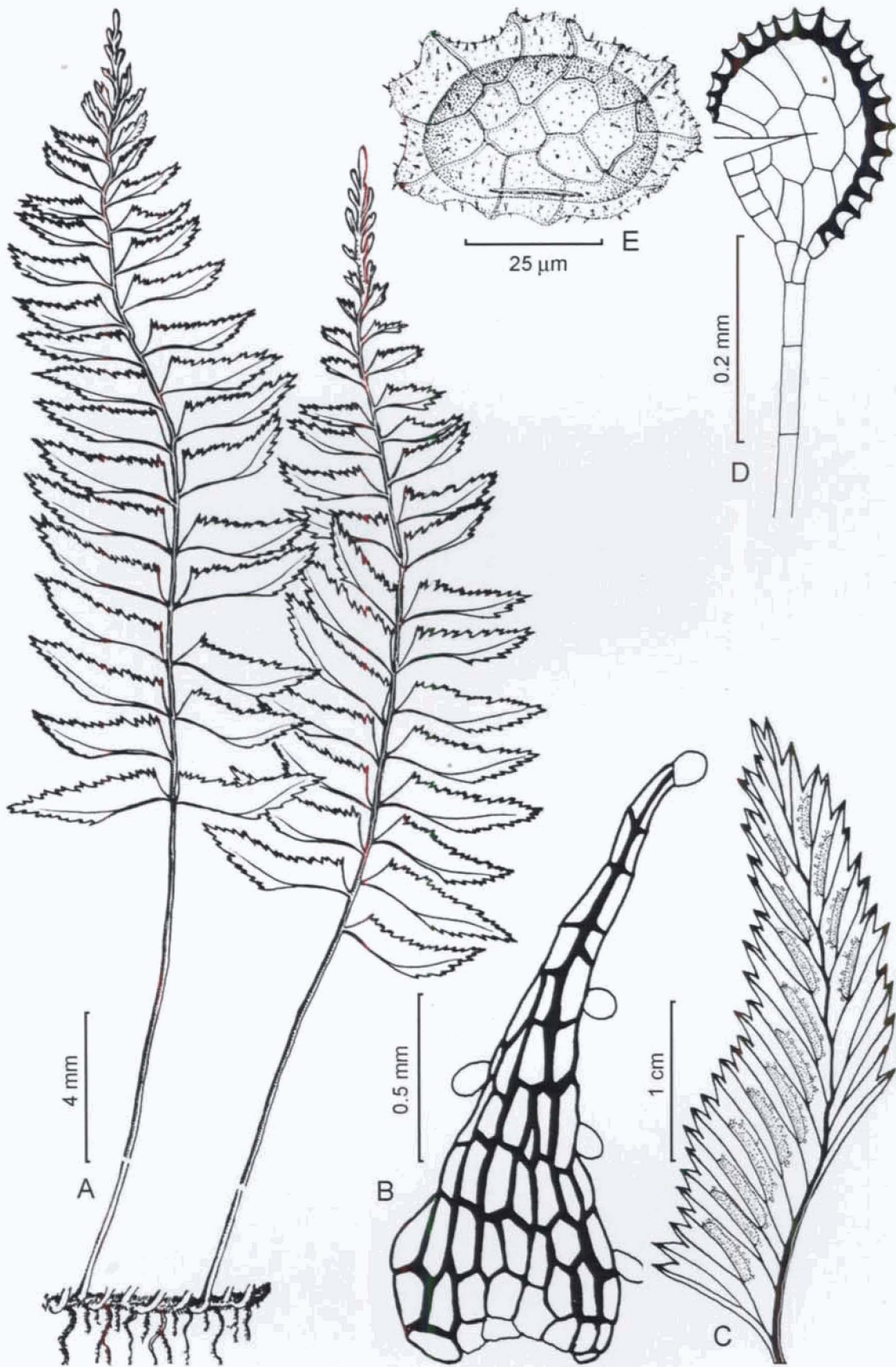


Fig. 16. *Asplenium excisum* Presl var. *serratum* Azeez & Madhus. nov.
 A. Habit; B. Palea on the rhizome; C. Pinna showing venation and position of sori; D. Sporangium; E. Spore.

to 65 cm long; stipe ca. 30 cm long, dark brown to blackish, glossy, 1-1.5 cm apart; lamina simply pinnate, oblong-lanceolate, 22-26 x 7-9 cm, colour and nature of the rachis similar to stipe, bears 15-25 pairs of very shortly stalked pinnae, rachis grooved above, having a narrow green membranous wing on either side of the groove; pinnae sub-opposite below, alternate above, largest pinna 6-7 x 1-1.5 cm, slightly falcate, lower ones slightly reduced or not, gradually reduced towards the tip into a lobed wing, ca. one-fourth portion of the basisopic base excised; margin toothed, teeth pointed, irregular and arranged in groups of two, gradually narrowed towards the tip and usually ends in an irregular forking, dark green, herbaceous, glabrous above and below; costa greenish above, brownish and raised below, veins distinct below, continuous to the tip of the teeth, acroscopic basal vein forked twice, others forked once. Sori 3-5 mm long, produced on both sides of costa in acroscopic veins only; sporangial stalk usually more than twice the length of the capsule. Spores 46 x 37 μm , monolete, bilateral, perinate, exine granulose, perine loose, densely spinulose, forming fine reticulations; unacetolysed spores 45 x 36 μm .

Distribution and Ecology: Very rare. Reported only from Agasthyamala Hills, Thiruvananthapuram Dt., Kerala State. No report elsewhere from other parts of India. It is commonly found growing in fully shaded forest floors at an elevation of 1800m.

Note: This taxon is similar to *A. excisum* Presl but differs in the nature of lamina, structure and the margin of the pinnae. In *A. excisum* Presl the



Plate 19. *Asplenium excisum* Presl var. *serratum* Azeez & Madhus. nov. A. Habit; B. Frond (dorsal); C. Fertile frond; D. Part of frond showing sori; E. Pinnae magnified; F. Rhizome.

lamina bears 25-35 pairs of pinnae whereas in var. *serratum* only 15-25 pairs. In var. *serratum* the margin of the pinna toothed, teeth pointed and tip of the pinna ends in an irregular forking while in *A. excisum* Presl the margin of the pinna serrated, teeth blunt and the pinna gradually reduced to an acuminate apex. The pinna in *A. excisum* Presl is clearly falcate, but here only slightly falcate. The margin of the perine is not deeply lobed as in *A. excisum* Presl.

Specimens examined: KERALA: Thiruvananthapuram Dt., Athirumala-Atasthyamala Hills, Azeez 102762, 102769 (CALI).

***Asplenium formosum* Willd.**

Linn. Sp. Pl. ed. 4, 5: 329 (1810)

Hook. Sp. Fil. 3: 143 (1860); Beddome, Handb. Fern Br. India 152 (1883); Sledge, Bull. Br. Mus. Nat. Bot. 3(6) 243 (1965), Bot. J. Linn. Soc. 84: 14 (1982); Nayar & Kaur, Comp. Beddome Handb. 37 (1974); Dixit, Cens. Ind. Pterid. 118 (1984); Manickam, Fern Fl. Palni Hills 105 (1986); Nayar & Kaur, Nom. Guide Beddome F.S.I. & F.B.I. 17 (1987); Singh & Bir, Ind. Fern. J. 6 (1-2): 272 (1989); Manickam & Irudayaraj, Pterid. Fl. Western Ghats 208, Pl. 155 (1992), Pterid. Fl. Nilgiris 124 (2003). Nayar & Geevarghese, Fern Fl. Malabar 278 (1993); Azeez *et al.*, J. Econ. Tax. Bot. 20(2): 435-455 (1996); Pullaiah *et al.*, Pterid. Andhra Pradesh 121, pl.52 (2003).

Fig. 17 (A-E); Plate 20 (A-E)

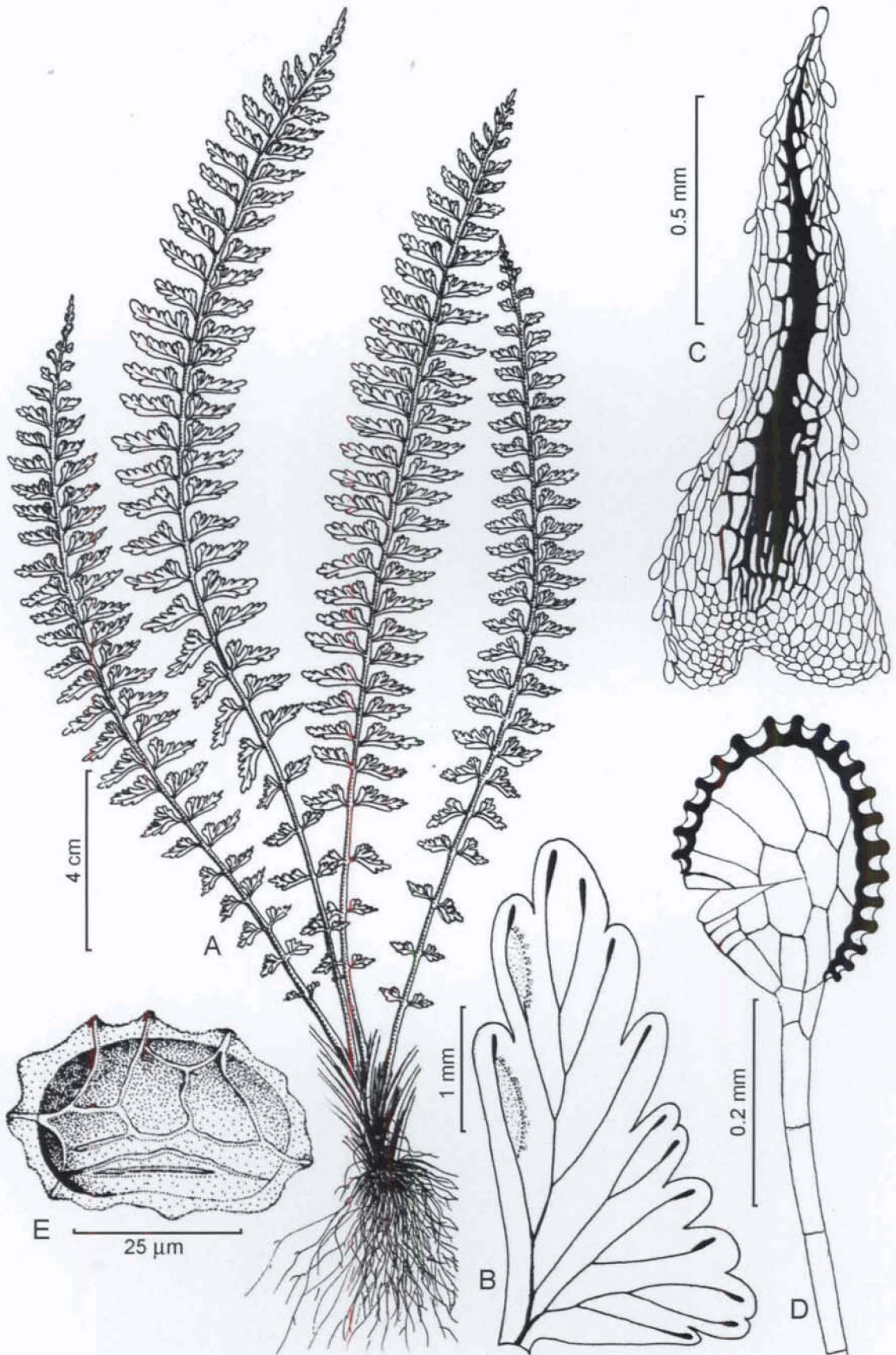


Fig. 17. *Asplenium formosum* Willd. A. Habit; B. Pinna showing venation and position of sori; C. Palea on the rhizome; D. Sporangium; E. Spore.

Rhizome erect, 5-10 mm thick, densely scaly at the apex; palea small, 2.5 x 0.5 mm, ovate-lanceolate, dark brown at the centre, margin light brown, base broad, basally attached, gland tipped, some sessile unicellular glands present along the margin. Fronds tufted, 20-30 cm long; stipe reduced, up to 2-3 cm, glabrous and glossy, dark brown; lamina unipinnate, 30-40 pairs of lateral pinnae which are sessile, light green, 1-1.5 x 0.3-0.4 cm, placed 0.6-1 cm apart, dimediate, pinnae gradually reduced towards both sides, about half of the basiscopic base cut away, upper margin and distal part of lower margin deeply incised, lobes mostly bifid, tip rounded, few basal pairs of pinnae are deflexed and gradually reduced to auricles, lamina gradually reduced towards the tip into a regularly lobed narrow wing, texture herbaceous, glabrous above and below, rachis grooved above, possess a very narrow green wing on either side of the groove; veins obscure above and below, forked only in one or two acroscopic basal lobes, in others simple, reaching the margin, vein endings swollen. Sori small, 2 mm long, 2 or 3 per pinna and are restricted to the lower unexcised part of the pinnae, sori are more or less parallel to the excised portion of the pinna. Spores 42 x 29 μm , monoletic, bilateral, perinate, exine granulose with an undulating perispore wing and anastomosing surface folds; unacetolysed spores 40 x 27 μm .

Distribution and Ecology: One of the most widely distributed species in South India. Reported throughout Kerala, Tamil Nadu and some localities of Karnataka and Andhra Pradesh. Also reported from Eastern Himalaya and



Plate 20. *Asplenium formosum* Willd. A. Habit; B. Part of frond; C. Part of frond showing sori; D. Pinnae magnified; E. Rhizome.

Orissa. The distribution is extended to Sri Lanka, America, West Indies, Africa, Angola, Congo, Netherlands Antilles, Venezuela, Tanzania, Central Africa and Australia. Commonly found growing as epilithic, epiphytic or terrestrial along stream banks and roadside earth cuttings between 600-1800 m.

Cytology: $n = 36$, diploid (Kuriachan, 1968; Ammal & Bhavanandan, 1991).

Specimens examined: **ANDHRA PRADESH:** Vishakapatanam Dt., Galikonda, *Ameer Ahamed* 12882 (SKU), *Amrathalakshmi* 25175 (CAL); Sunkerimetta, *Balakrishnan* 10910 (MH, CAL); Anantagiri, *Rao* 21754, 44292 (MH); Way to Agraharam, *Rao* 42791 (MH). **KARNATAKA:** Chickamangalur Dt., Bababudan Hills, *Rajagopal* 545 (MGMC). **KERALA:** Idukki Dt., Karadikavala, Thekkadi, *Azeez* 102739 (CALI); Koonanal forest, Thekkadi, *Azeez* 102736 (CALI); Vallakadavu, *Azeez* 102741 (CALI); Thekkadi, *Manickam & Mathew* 33375 (RHT); Pambar, *Manickam & Mathew* 33442 (RHT); Kulamavu, *Mohanan* 79968 (MH, CAL); Thannithode, *Nair* 70173 (MH,CAL); Vandanmettu, *Vivekanantham* 50532 (MH, CAL); Kuttikanam, *Nair* 812 (CAL); Thankamani, *Nair* 40760, 40769 (CAL); Munnar, *Nair* 50765, 50766 (CAL); Peerumedu, *Meebold* 225 (CAL). **Kollam Dt.**, Palaruvi, Thenmala, *Azeez* 102751 (CALI); Kulathupuzha, *Florence* 6173 (CALI). **Kottayam Dt.**, Meenachil, *Manickam & Mathew* 33570 (RHT). **Kozhikode Dt.**, Olichuchattam, Anakampoyil, *Azeez* 45927 (CALI). **Malappuram Dt.**, Nilambur-Nadukani, *Azeez* 102723 (CALI), *Geevarghese & Madhusoodanan* 29445 (CALI). **Palakkad Dt.**, Silent Valley,

Azeez 102717 (CALI), *Geevarghese* 4042, 4072 (CALI), *Nayar & Madhusoodanan* 21366 (CALI); Karapara estate, *Nair* 69747 (MH, CAL); Ayyapankovil Shola, *Vajravelu* 48718 (MH, CAL); Kaikatty, *Vajravelu* 44668 (MH); Aruvampara slope, *Nair* 69139 (MH, CAL); Karapara top, *Nair* 69747, 69785 (MH); Thuthampara, *Vajravelu* 60498 (MH, CAL); Nellyampathi, *Madhusoodanan & Pradeep* 44821 (CALI); Karimalagopuram, Parambikulam, *Geevarghese* 4072 (CALI); *Nayar* 7380 (CALI); Parambikulam, *Remani* 16483 (CALI); Dhoni Hills, *Geevarghese* 4133 (CALI). **Pathanamthitta Dt.**, Kakki-Moozhiyar route, *Azeez* 102745 (CALI); Pamba bridge, *Manickam & Mathew* 33428 (RHT). **Thiruvananthapuram Dt.**, Ichampatty, Chinnar W.L.S., *Rajesh* 87732 (CALI); Ponmudi Hills, *Manickam* 31360 (RHT); *Nair* 51854 (MH, CAL), *Nair & Ghosh* 51640 (CAL), Bonnakad, *Joseph* 46406 (MH). **Thrissur Dt.** Sholayar Forest, *Azeez* 102794 (CALI). **Wayanad Dt.**, Chembra Peak, *Azeez* 102716 (CALI), *Madhusoodanan & Nampy* 45908 (CALI), *Nayar & Madhusoodanan* 21312 (CALI); Vythiri, *Madhusoodanan* 7212 (CALI); Chandanathode, Periya, *Ellis* 25216 (MH), Tirunelli R.F., *Ramachandran* 62755 (MH, CAL). **TAMIL NADU: Coimbatore Dt.**, Valparai-Anamalai Hills, *Manickam & Mathew* 32919 (RHT); Andiparai Shola, *Joseph* 13215 (MH); Tadagam Hills, *Fischer* 2685 (MH). **Dindigal Dt.**, Palamalai, Palni Hills, *Manickam* 295 (RHT). **Godavari Dt.**, Ethakonda, *Narayanaswami* 581 (CAL). **Nilgiri Dt.**, Karian Shola, *Subramanyam* 10549 (MH, CAL); Gudallur, *Gamble* 11850 (CAL). **Ramanathapuram Dt.**, Muthaliaruthu, *Nair* 60939 (MH, CAL). **Selam Dt.**, Yercaud, *Azeez* 103703 (CALI), *Ghatak* 456 (CAL). **Tirunelveli Dt.**,

Vayuthamalai, Kuttalum, *Surendran* 5140 (CALI), Thekkumalai, Kuttalum, *Manickam* 33968 (RHT), *Subramanyam* 5016 (MH, CAL); Kannikatti Hills, *Manickam & Mathew* 31721 (RHT).

***Asplenium grevillei* Wall. ex Hook. & Grev.**

Cat. 1036, 1828 *nomen nudum* ex Hook. et Grev. Ic. Fil. t. (1831).

Neottopteris grevillei J. Sm. Jour. Bot. 4: 176 (1841).

Thamnopteris grevillei (Wall. ex Hook. & Grev.) Moore, Ind. Fil. 50 (1857).

Thamnopteris grevillei (Wall.) Beddome, Ferns Br. India 1: 66 (1866), Handb. Ferns Br. India 139, t. 70 (1883); Christens., Ind. Fil. 633 (1906).

Fig. 18 (A-E); Plate 21 (A-D)

Rhizome erect, 0.5-1 cm thick, sparsely covered by small scales at the tip; palea small, ca. 3 x 1 mm, lanceolate, brown, clathrate, apex acuminate, margin entire, base broad, basally attached. Fronds tufted, sterile ones small, upto 27 cm, fertile ones long, upto 48 cm; stipe of sterile fronds short, 10-13 cm, thin, winged; stipe of fertile fronds long, 20-30 cm, similar to sterile ones; lamina simple, entire, ca. 16 x 4 cm, middle portion broad, gradually narrowing towards both ends, ovate or ovate-lanceolate, tip acuminate, margin slightly wavy, subcoriaceous, glabrous on both surfaces, lamina decurrent forming a winged stipe, wings narrow, 3-4 mm on one side just below the lamina, 1-2 mm on one side towards the basal region; costa narrow, distinct along the lower side, not so above, veins distinct on both surfaces, not raised, parallel, oblique, forked once or twice, shows

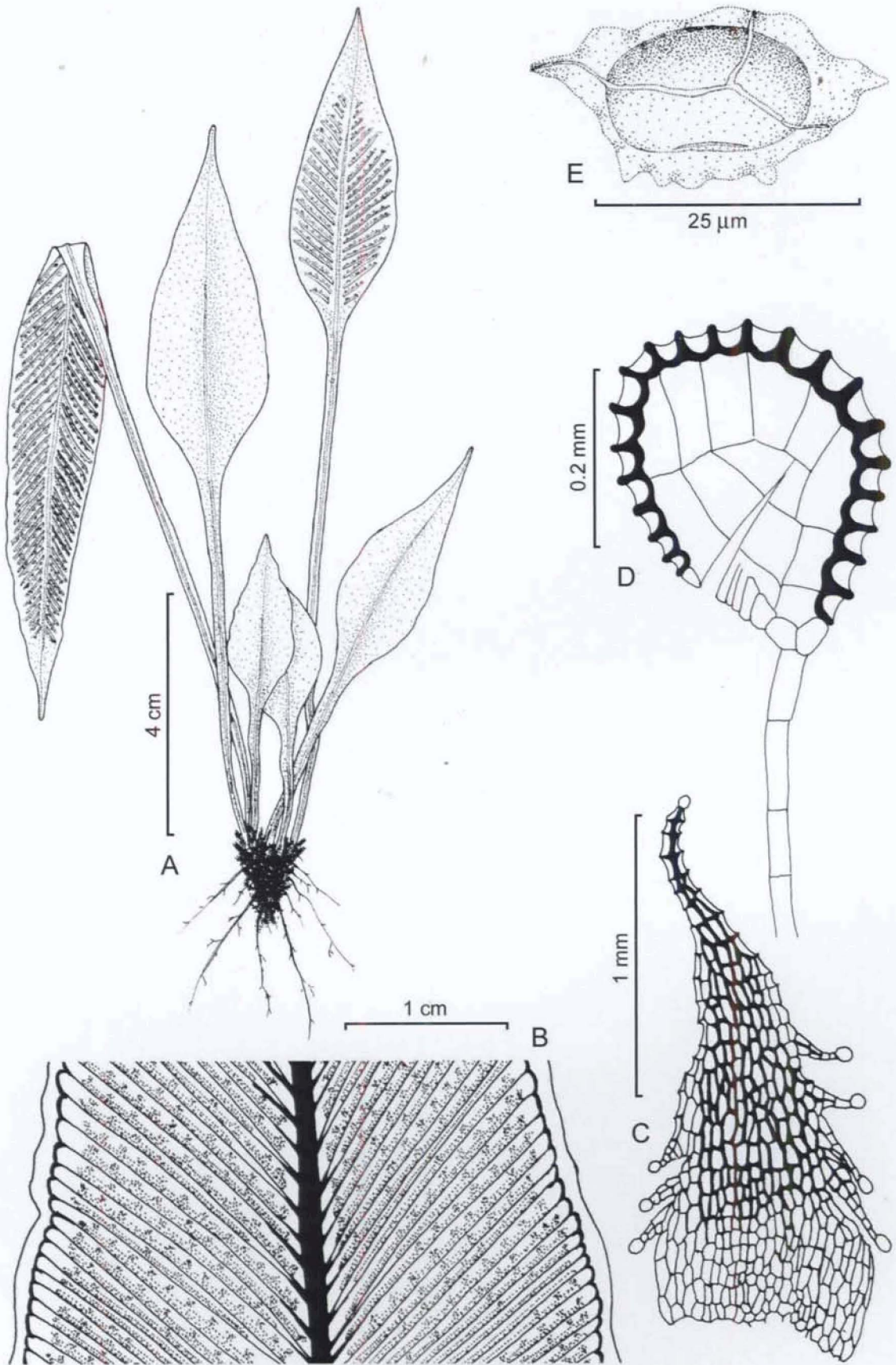


Fig. 18. *Asplenium grevillei* Wall. ex Hook & Grev. A. Habit; B. Part of frond showing venation and position of sori; C. Palea on the rhizome; D. Sporangium; E. Spore.

intramarginal fusion. Sori elongated, 2-3 cm long, oblique, closely arranged, extending from costa to almost margin, sori found all along the lamina except the extreme tips. Spores brownish, 69 x 39 μm , monolete, bilateral, perinate, exine uniformly granulose, perine loose, smooth, forming a broad wing with undulating surface folds. Out of 30 taxa studied, *A. grevillei* Wall. ex Hook. & Grev. possesses the biggest spores. Unacetolysed spores 50 x 30 μm .

Distribution and Ecology: Very rare species. From South India reported only from the Dally forests of Kulathupuzha forest division, Kollam Dt. of Kerala state. No report from other parts of South India. It is seen in a very special habtiat, the '*Myristica* Swamp', epiphytically on the knee roots of *Myristica fatua* at an average elevation of 100 m. Some are seen epilithically also. Also reported from Meghalaya, central and Eastern Himalaya and North-East India. The distribution is also extended to Burma and China.

Cytology: $n = 72$, Tetraploid (Kuriachan, 1978). $n = 36$, Diploid (Ammal & Bhavanandan, 1991).

Note: *A. grevillei* Wall. ex Hook. & Grev. is a very rare fern previously reported only from the North-Eastern frontier region of India Burma and China. Previously this species was reported only once from India (from Khasia Hills) by Gustav Mann (1890). From South India, it was reported for the first time by Nair and Ghosh in 1978 from Dally forests, Kulathupuzha forest division, Kollam Dt. of Kerala state. Recently this taxon was also collected from the same locality by us. we have noticed many populations of



Plate 21. *Asplenium grevillei* Wall. ex Hook. & Grev. A. Habit; B. Fertile frond; C. Part of frond showing sori; D. Rhizome.

this species growing as epiphytes on the knee roots of *Myristica fatua* in swampy localities, commonly known as *Myristica* swamps. Some are grown as epilithic also.

Specimens examined: KERALA: Kollam Dt., Kulathupuzha, Azeez 103708 (CALI), Nair & Ghosh 50659, 52001 (MH).

***Asplenium hindusthanensis* Bir**

Fern Gaz. 14: 309 (1994)

Asplenium unilaterale Lam. var. *rivale* Beddome, Ferns Br. India 153 (1883); Nayar & Kaur, Comp. Beddome Handb. 37 (1974); Nayar & Geevarghese, Fern Fl. Malabar 293 (1993); Azeez *et al.* J. Econ. Tax. Bot. 20(2): 435-455 (1996).

Fig. 19 (A-E); Plate 22 (A-E)

Rhizome long creeping, narrow, 2-3 mm thick, covered by very small scales and woolly hairs; palea small, 0.8 x 0.5 mm, base broad, basally attached, tip narrow, clathrate, margin entire. Fronds 40-53 cm long, somewhat distantly placed, 1.5-2 cm apart; stipe dark brown, glossy, wiry, upto 22 cm long; lamina simply pinnate, 20-30 x 2.5-3.5 cm, nature and colour of the rachis similar to stipe, bears 36-42 pairs of pinnae which are ca. 8 mm apart, rachis grooved above with a narrow green wing on either side of the groove; pinnae subopposite below, alternate above, 2-2.5 x 0.5-0.7 cm, lower ones not reduced, gradually reduced towards the tip into a narrow

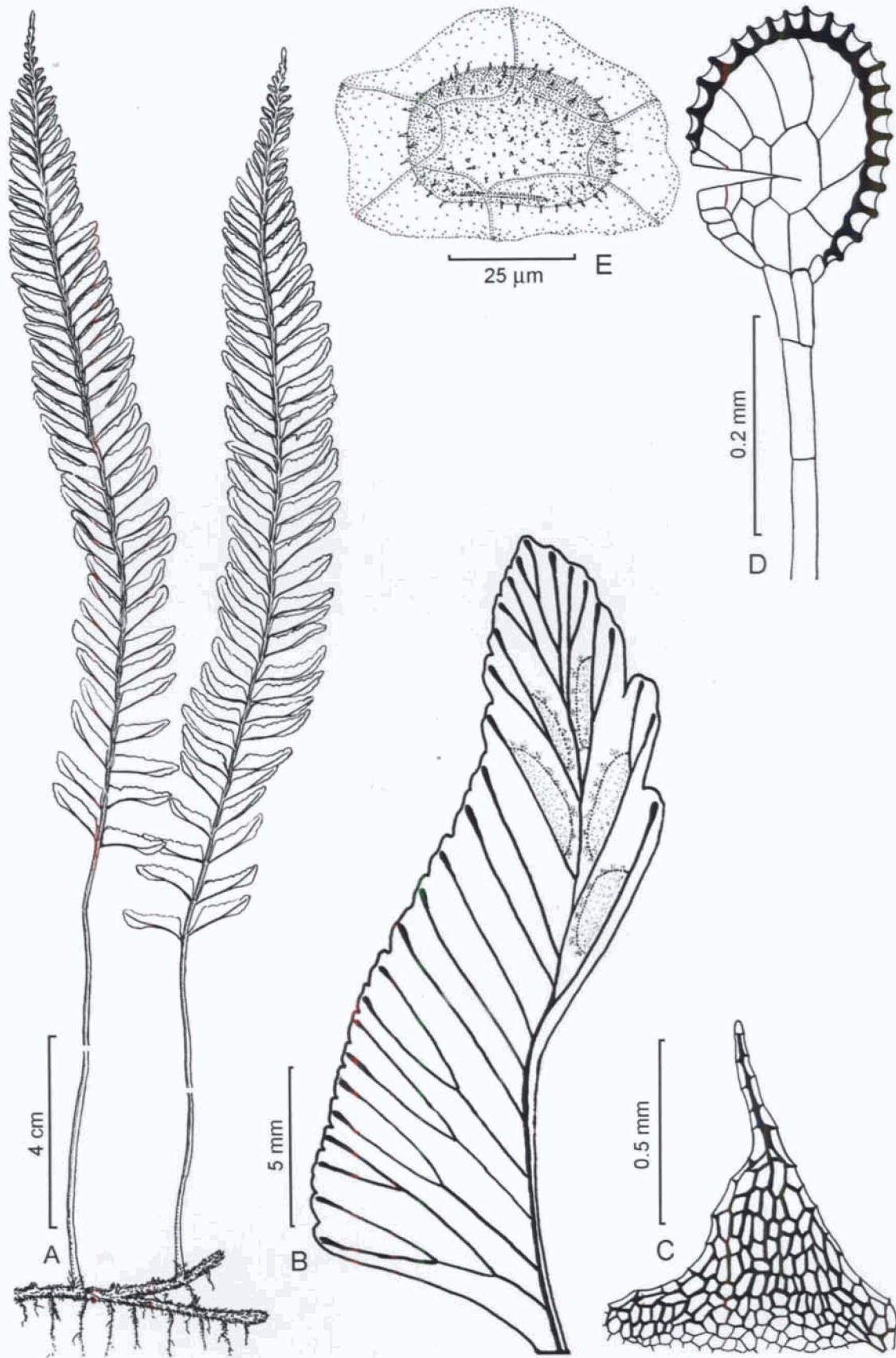


Fig. 19. *Asplenium hindusthanensis* Bir. **A.** Habit; **B.** Pinna showing venation and position of sori; **C.** Palea on the rhizome; **D.** Sporangium; **E.** Spore.

wing, closely and obliquely arranged, more or less parallel to the rachis, ca. two-third region of the basiscopic base excised, margin shallowly crenate, apex blunt, light green, herbaceous, glabrous above and below; costa dark brown, very clear and slightly raised below, veins striated above, simple or forked, acroscopic basal vein forked twice, a few veins are simple and others forked. Sori small, 2-3 mm long, usually confined to the distal half, in some pinnae one or two sori are seen on the proximal half arranged in two close oblique rows on either side of the costa after the excised region, usually 4-8 per pinna. Spores 37 x 28 μm , monolete, bilateral, perinate, exine spinulose, perine loose, margin undulate, wings broad, surface folds anastomosing; unacetolysed spores 34 x 25 μm .

Distribution and Ecology: This is the most widely distributed member among the *Asplenium unilaterale* Lam. complex in South India. Reported from Agasthyamala Hills, Munnar Hills, Chinnar Wild Life Sanctuary, Vellarimala of Kerala Ghats, Palni Hills and Nilgiri Hills of Tamil Nadu. Not reported from other parts of South India, North India and other countries so far. Commonly found growing as terrestrial or epilithic along fully shaded forests between 1500-2300 m.

Cytology: $n = 40$, diploid (Kuriachan, 1968; Irudayaraj & Bir, 1994).

Note: The *Asplenium unilaterale* Lam. var. *rivale* Bedd. is renamed as *A. hindusthanensis* Bir (Bir, 1994), instead of the earlier proposed name *A. rivale* (Bedd.) Bir in edit (Bir, 1989 and Singh and Bir, 1989), because this species

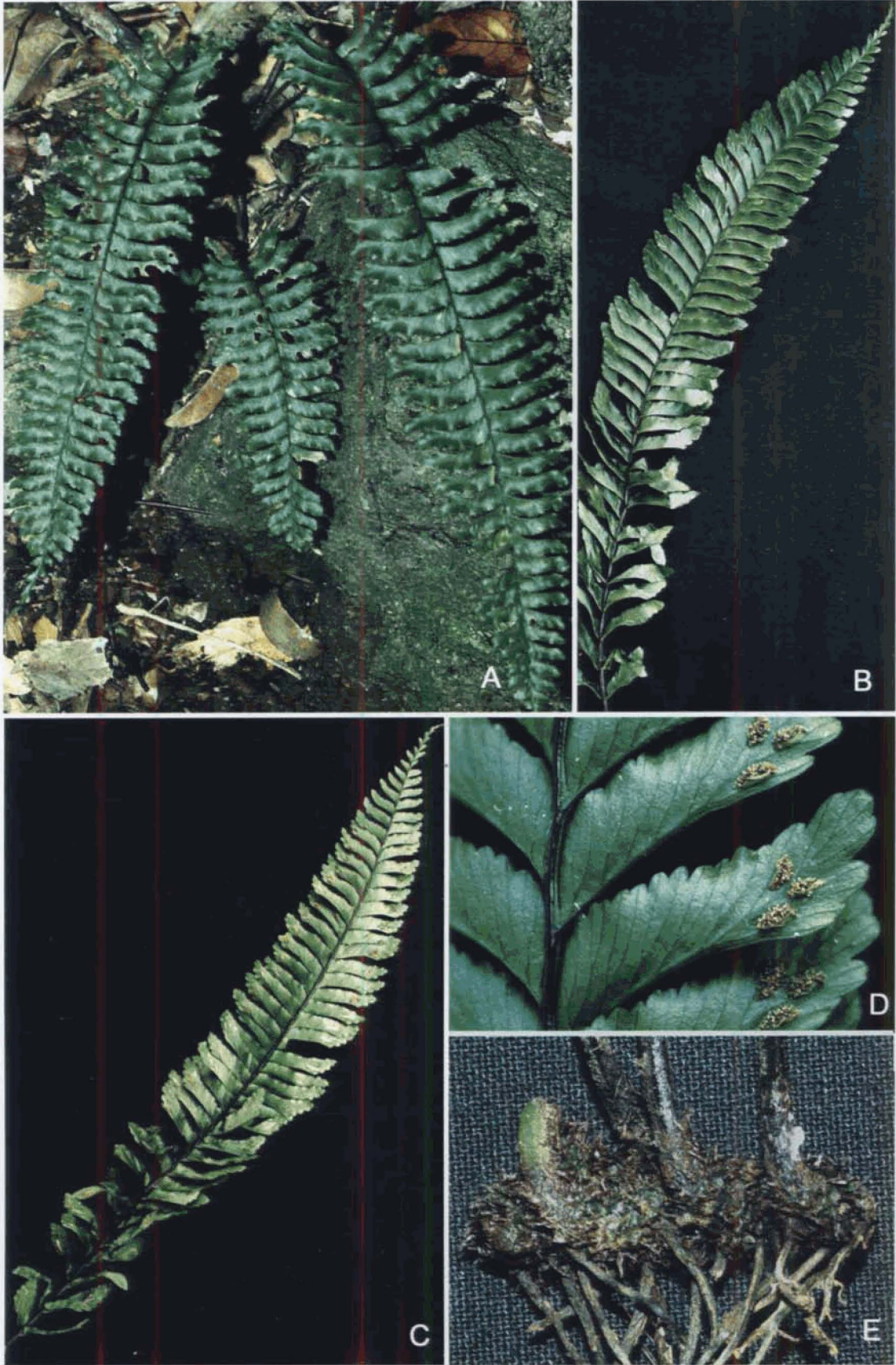


Plate 22. *Asplenium hindusthanensis* Bir A. Habit; B. Frond (dorsal); C. Fertile frond; D. Part of frond showing sori; E. Rhizome.

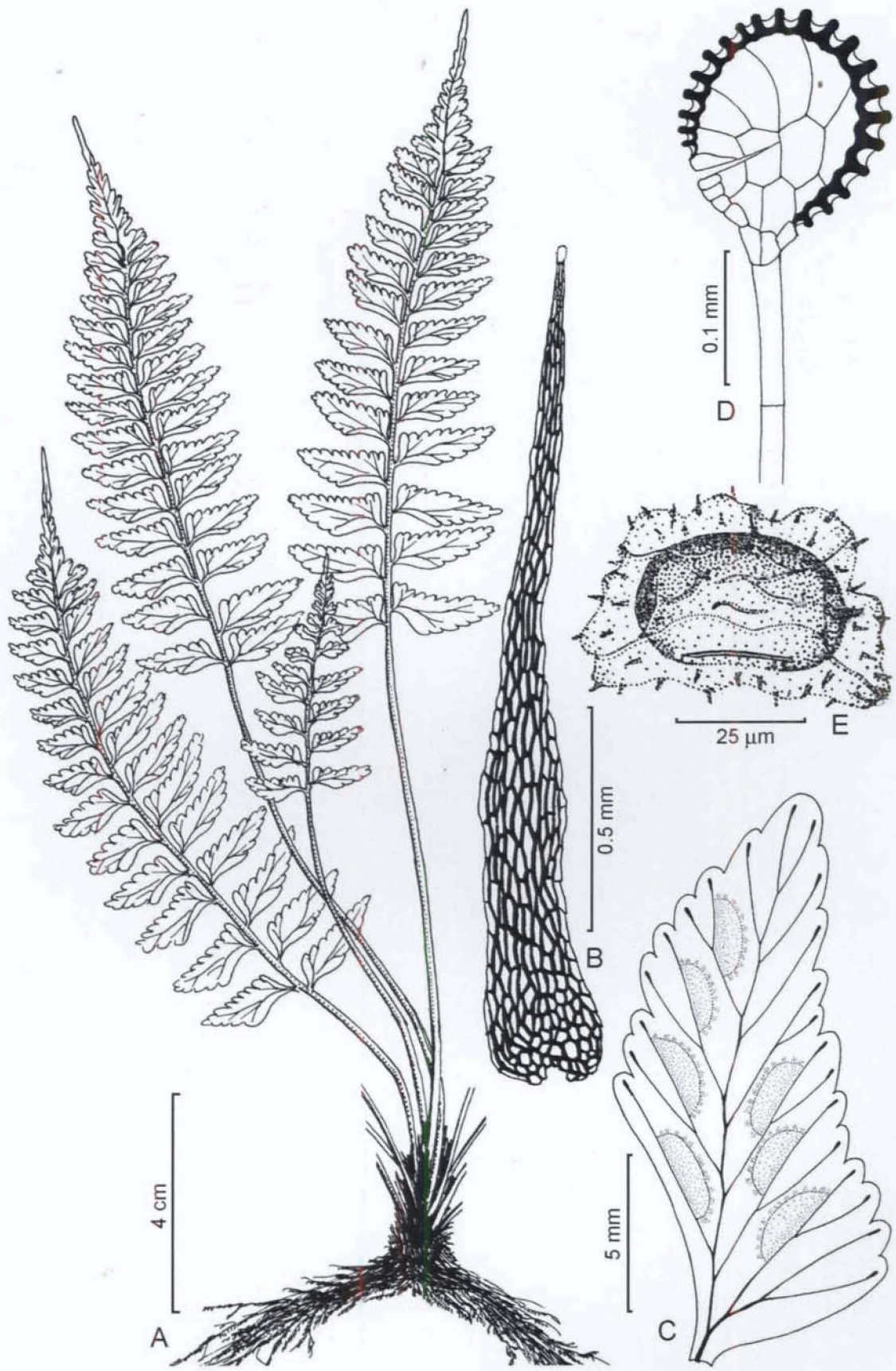
is endemic in the mountains of Peninsular India. This species belong to the *A. unilaterale* complex in India and is characterised by having 30-40 pairs of pinnae. The pinnae are almost parallelogram in shape and have obtuse apices with sori (two or three pairs) almost confined to the apices.

Specimens examined: **KERALA:** Idukki Dt., Gundumala Shola, Azeez 102780 (CALI); Eravikulam National Park, Azeez 102785, 102789 (CALI); Pettimudi, Shetty 26600 (MH); Vellimala, Raju Antony 18684 (TBGT).
Kozhikode Dt., Vellarimala, Satheeshkumar 70394 (CALI).
Thiruvananthapuram Dt., Agasthyamala, Azeez 102764, 102765 (CALI), Madhusoodanan & Nampy 51934 (CALI); on the way to Agasthyarkoodam, Azeez 102756 (CALI); Ollavayal, Chinnar W.L.S., Rajesh 87785 (CALI).
TAMIL NADU: Dindigal Dt., Silver Cascade, Kodaikanal, Azeez 102724 (CALI). Nilgiri Dt., Naduvattom, Shetty 34445 (MH), Ellis 43319 (MH).

Asplenium inequilaterale Willd.

Linn. Sp. Pl. Ed. 4, 5: 322 (1810)

Sledge, Bull. Br. Mus. Nat. Hist. Bot. 3(6): 252 (1965), Bot. J. Linn. Soc. 84: 14 (1982); Nayar & Kaur, Comp. Beddome Handb. 36 (1974); Dixit, Cens. Ind. Pterid. 118 (1984); Manickam, Fern Fl. Palni Hills 107 (1986); Chandra & Kaur, Nom. Guide Beddome F.S.I. & F.B.I. 16 (1987); Singh & Bir, Ind. Fern J. 6(1-2): 272, 279 (1989); Manickam & Irudayaraj, Pterid. Fl. Western Ghats 220, Pl. 168 (1992), Fern Fl. Nilgiris 128 (2003); Azeez *et al.*, J. Econ. Tax. Bot. 20(2) 435-455 (1996).



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Fig. 20. *Asplenium inequilaterale* Willd. A. Habit; B. Palea on the rhizome; C. Pinna showing venation and position of sori; D. Sporangium; E. Spore.

Asplenium trapeziforme sensu Beddome, Ferns S. India 45, t. 134 (1863).

Asplenium lunulatum var. *trapeziforme* Beddome, Handb. Ferns Br. India 148 (1883), p.p. non *A. trapeziforme* Roxb.

Fig. 20 (A-E); Plate 23 (A-E)

Rhizome erect, 0.5-1 cm thick, densely scaly at the apex; palea small, ca. 3 x 0.5 mm, ovate-lanceolate, dark brown, clathrate, apex acuminate, base a little broader, basally attached. Fronds tufted, 22-30 cm; stipe 10-12 cm long, rounded abaxially, grooved above, grey brown to pale brown, glabrous; lamina unipinnate, 15-18 cm x 4.5-5 cm, oblong-lanceolate, nature and colour of the rachis similar to stipe, bears up to 15 pairs of shortly stalked pinnae which are 1-1.5 cm apart; pinnae reduced gradually to the tip of the lamina into a broad lobed apex, basal pinnae not reduced, largest pinna ca. 3 x 1.2 cm, dimediate, acroscopic base truncate and more or less parallel to the rachis, a small portion of the basisopic base excised, apex rounded, both margins inciso-crenate, dark green, herbaceous, glabrous above and below; veins slightly distinct above and below, not raised, acroscopic basal vein forked twice, others forked once. Sori 2-3 mm long, arranged in two regular oblique rows on either side of the costa, sori 5-6 pairs per pinna, formed only on acroscopic veins. Spores 34 x 25 μ m, monolet, bilateral, perinate, exine granulate, perine loose, densely spinulose, margin undulating, supralaesural fold distinct, extending from end to end of the spore; unacetolysed spores 32 x 25 μ m.

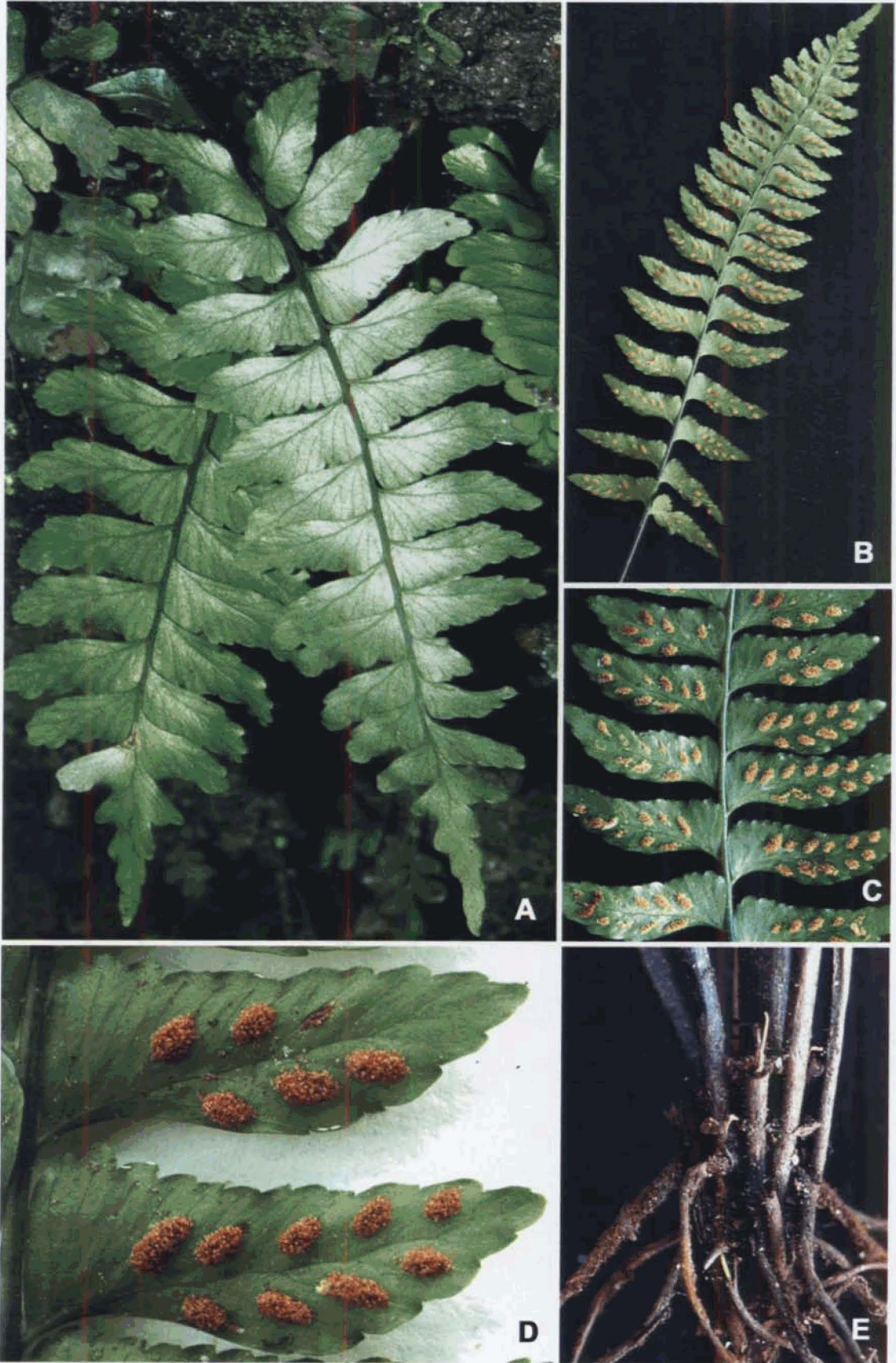


Plate 23. *Asplenium inequilaterale* Willd. A. Habit; B. Fertile frond; C. Part of frond showing sori; D. Pinnae magnified; E. Rhizome.

Distribution and Ecology: It is widely distributed throughout the area of present study. Reported from Agasthyamala Hills and Munnar Hills of Kerala, Nilgiri Hills, Palni Hills, Kolli Hills, Anamalai Hills, Sheveroy Hills, Tirunelveli Hills of Tamil Nadu, Bababudan Hills, Agumbe forests of Karnataka and Vishakapatnam District of Andhra Pradesh. Also reported from Orissa. The distribution is also extended to Sri Lanka, Africa, Ethiopia, Tanzania, South America and Malagasy. Commonly found growing as terrestrial in fully or partially shaded streams and stream banks between 900-2200 m.

Cytology: n = 36, diploid (Kuriachan, 1965; Ghatak, 1977; Irudayaraj, 1990). n = 72, tetraploid (Ghatak, 1977; Irudayaraj & Manickam, 1986, 1987; Manickam & Irudayaraj, 1988).

Specimens examined: **ANDHRA PRADESH:** Vishakapatanam Dt., Galikonda, *Ameer Ahamed* 12890 (SKU), *Rao* 19653 (MH), *Lakshmi* 25141 (SKU); Sunkerimetta R.F., *Balakrishnan* 10926 (MH), *Rao* 23259, 32863 (MH), *Nair* 53166 (MH). **KARNATAKA:** Chickmangalur Dt., Bababudan Hills, *Rajagopal* 552 (MGMC). Shimoga Dt., Agumbe R.F., *Nampy & Pradeep* 48900 (CALI). **KERALA:** Idukki Dt., Gundumala Shola, Munnar, *Azeez* 102781 (CALI), Eravikulam National Park, *Azeez* 102783, 102796 (CALI); Devikulam, *Manickam* 31397 (RHT); Kallar ravine, Munnar, *Manickam* 32222 (RHT). **Palakkad Dt.**, Karapara, *Nair* 69778 (MH, CAL). **Thiruvananthapuram Dt.**, Agasthyamala, *Azeez* 102757, 102761 (CALI), *Madhusoodanan & Nampy* 51921 (CALI), *Henry* 16299 (MH, CAL), *Raju*

Antony 25559 (TBGT); Athirumala, *Azeez* 102766 (CALI). **TAMIL NADU:**
Coimbatore Dt., Valparai- Anamalai Hills, *Manickam & Mathew* 32912 (RHT). **Dindigal Dt.**, Kodaikanal, *Azeez* 102726 (CALI), *Swarupanandan* 918 (CALI), *Manickam* 217, 379, 436 (RHT); Palni Hills, *Manickam* 510, 1473 (RHT); Perumalmalai, Kodaikanal, *Manickam* 31198 (RHT). **Madurai Dt.**, Aruna estate, *Subramanyam* 9480 (MH). **Nilgiri Dt.** Bikkapatimund, *Rao* 40481 (MH); Lamb's rock Shola, *Gamble* 11496 (MH, CAL). **Ramanathapuram Dt.**, Deviar estate, Sethur Hills, *Srinivasan* 3514 (MH). **Selam Dt.**, Sheveroy Hills, *Rao* 26751 (MH); Kakka Shola, Yercaud, *Subramanyam* 6601 (MH), *Ghatak* 26, 81, 128, 249, 495 (CAL); Mancholai, *Sebastine* 5874 (MH); Yercaud Temple Shola, *Manickam* 25759 (RHT); Shevaroy Temple Shola, *Manickam* 33300 (RHT), *Nair* 74217 (MH); Kolli Hills, *Manickam* 33211 (RHT). **Tirunelveli Dt.**, Kothayar, *Manickam* 31059 (RHT); Kalakkad, *Manickam* 31234 (RHT); Kuttalam, *Srinivasan* 99182 (MH); Sengeltheri, *Hooper & Ramaswami* 38603 (CAL); Walayar estate, *Sebastine* 9936 (CAL).

***Asplenium nidus* L.**

Linn. Sp. Pl. 2: 1079 (1753)

Clarke, Trans. Linn. Soc. Lond. 2, Bot., 1: 475 (1880); Hope, J. Bomb. Nat. Hist. Soc. 13: 459 (1901); Duthie, Cat. Pl. Kumaun 224 (1906); Mehra & Bir, Res. Bull. (n.s.) Punjab Univ. 15: 158 (1964); Sledge, Bull. Br. Mus. Nat. Hist. Bot. 3: 242 (1965); Nayar & Kaur, Companion Beddome Handb. 34

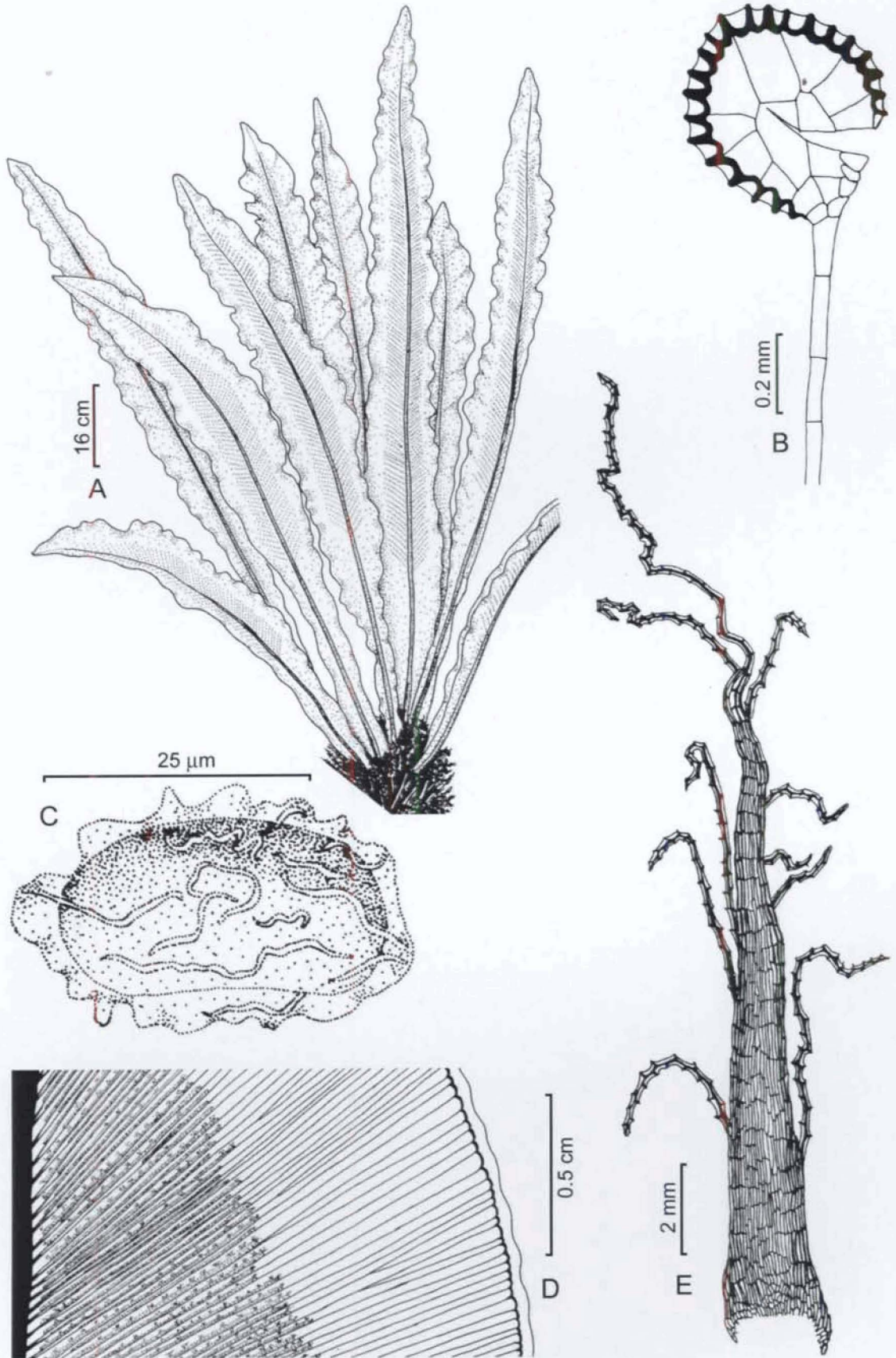


Fig. 21. *Asplenium nidus* L. A. Habit; B. Sporangium; C. Spore; D. Part of frond showing venation and position of sori; E. Palea on the rhizome.

(1974); Ito in Hara, Fl. East Himal. 488 (1966); Dhir, Bibliotheca Pteridologica 1: 113 (1980); Baishya & Rao, Ferns & Fern Allies Meghalaya 115 (1982); Dixit, Cens. Ind. Pterid. 119 (1984); Khullar & Sharma, in Pangtey et Joshi, West Himal. 1: 329 (1987); Jamir & Rao, Ferns Nagaland 284 (1988); Iwatsuki in Ohba et Malla, Himal. Pl. 1: 278 (1988); Pande, Indian Fern J. 7: 171 (1990); Manickam & Irudayaraj, Pterid., Fl. Western Ghats 206, Pl. 153 (1992), Pterid. Fl. Nilgiris 123, Pl. 28 (2003); Bir *et al.*, Pterid. North-East India 67 (1992); Borthakur *et al.*, Illus. Man. Ferns Assam 342, Pl. 165 (2000); Pande & Pande, Fern Fl. Kumaun Himal. 203 (2003).
Thamnopteris nidus (L.) Presl, Epim. Bot. 68 (1849); Beddome, Ferns Br. India t. 197 (1866), Handb. Ferns Br. India 137 (1883); Nayar & Kaur, Companion Beddome Handb. 34 (1974).

Fig. 21 (A-E); Plate 24 (A-E)

Bird's nest fern (Eng.).

Rhizome erect, stout, densely scaly at the apex; scales ca. 2 x 0.2 cm, thin, acuminate, dark brown to black, clathrate, broad, bearing numerous hair-like outgrowths along the margin. Fronds simple, tufted giving a nest habit, ca. 1- 1.5 m long and 14-16 cm broad; stipe not distinct; lamina simple, entire, lanceolate, middle portion broad, gradually narrowed to both ends, texture coriaceous, glabrous above and below, midrib strongly raised on the lower surface, slightly raised and distinct on the upper surface, shining, two- third part dark brown on the upper surface, major part dark brown on the lower surface; veins numerous, parallel, distinct both on upper



Plate 24. *Asplenium nidus* L. A. Habit; B. Fertile frond; C. Part of frond showing sori; D. Sori magnified; E. Rhizome.

and lower surfaces, not raised, usually forked once, reaching the margin, shows intra-marginal fusion. Sori linear, parallel, 4-5 cm long, arranged in close oblique rows on either side of the costa, borne along each veinlet on upper 2/3 part of the lamina, sori arising close to costa, reaching only half way towards the margin. Spores 43 x 35 μ m, monolete, bilateral, perinate, exine brown, granulose, perine loose, forming a narrow wing with anastomosing surface folds. Unacetolysed spores 40 x 30 μ m.

Distribution and Ecology: An extremely rare epiphytic fern, reported only from two localities in South India (Idukki Dt. in Kerala and Tirunelveli Dt. of Tamil Nadu). No recent report elsewhere from South India. But it is widely cultivated in various Botanic Gardens, Nurseries and house gardens. Hence the above report most probably due to escape from cultivation. But this species is widely distributed in North India, like Kumaun Himalaya, North-Eastern Himalaya, Assam, North-West Himalaya. The distribution extended to Admiralty Island, Guam (Marianus Island), Japan, Borneo, Thailand, Malaysia, Taiwan, Sumatra, Madagascar, Philippines, Tropical America, Polynesia, Hawaii and Mauritius. It is epiphytic on partially covered forest trees.

Cytology: n = 72, Tetraploid (Abraham *et al.*, 1962).

Note: The plant is highly variable in size of the frond. Holttum (1974) enumerated five varieties under this species. Dixit (1984) listed two varieties

A. nidus L. var. *acutifolium* Bir and *A. nidus* L. var. *phyllitidis* (D. Don) Bir from India.

Manickam & Irudayaraj (1992, 2003), in their study of the Ferns of South India, reported *A. nidus* L. in the "Pteridophyte Flora of Western Ghats, South India" (p.206, pl. 153) and the "Pteridophyte Flora of Nilgiris, South India" (p.123, pl. 28), but the descriptions clearly show that, both the plants are *A. phyllitidis* D. Don.

A. nidus L. can be distinguished from *A. phyllitidis* D. Don, mainly in the shape, size of fronds and nature of sori. The fronds are usually up to 150 cm x 20 cm in *A. nidus* L., while only 100 cm x 8 cm in *A. phyllitidis* D. Don. The midrib is strongly raised on the lower surface in both, flattened above and dark brown in old fronds in the former, while it is nearly greenish in the latter. The sori are narrow, present on every vein and on both branches of a forked vein in *A. nidus* L., while they are formed only on one of the branches of a forked vein *i.e.*, always have a sterile vein between two adjacent sori. Sori are usually formed on the distal 2/3 part of the frond in the former and are extending from near the midrib half way to the margin, whereas in the latter sori are formed on upper half or upper 1/3 part of the frond and they extend ¾ of the length of the vein.

Economic Importance: The whole plant body is used as a deputation and sedative in philippines (Quisumbing, 1951; May, 1978; Dixit & Vohra, 1984) and also it is antibacterial and used in sore and ulcer (Singh, 1999,2003). It

is widely cultivated in various botanic gardens, nurseries and house gardens because of the beauty of their fronds.

Specimens examined: **KERALA:** Idukki Dt., Pooyamkutti-Manikandanchal, *Bharghavan* 87451 (MH). Kozhikode Dt., IISR Campus (cult.), *Azeez* 102733 (CALI). **TAMIL NADU:** Nilgiri Dt., Ooty Botanic Garden (cult.), *Azeez* 102710 (CALI). Tirunelveli Dt., Way to Walayar estate, *Sebastine* 9948 (MH).

Asplenium nitidum Sw.

Syn. Fil. 84: 280 (1806)

Hook., Sp. Fil. 3: 172 (1860); Beddome, Ferns S. India t. 149 (1863), Handb. Ferns Br. India 157 (1883); Tardieu-Blot. & Ching, Notul. Syst. 5: 148, t. I, f. 1, t. 2, f. 1 (1936); Sledge, Bull. Br. Mus. Nat. Hist. Bot. 3(6): 265 (1965); Nayar & Kaur, Comp. Beddome Handb. 38 (1974); Dixit, Cens. Ind. Pterid. 119 (1984); Chandra & Kaur, Nom. Guide Beddome F.S.I. & F.B.I. 18 (1987); Singh & Bir, Ind. Fen J. 6(1-2): 272 (1989); Manickam & Irudayaraj, Pterid. Fl. Western Ghats 227, Pl. 175 (1992); Nayar & Geevarghese, Fern Fl. Malabar 281, pl. 115 (1993); *Azeez et al.*, J. Econ. Tax. Bot. 20(2): 435-455 (1996).

Asplenium insigne Blume, Enum. Pl. Jav. 2: 188 (1828).

Asplenium spathulinum Kunze, Bot. Zeit. 6: 524 (1848).

Tarachia nitida (Swartz) C. Presl, Abhandl. K. Bohm. e Wiss., Folge 5, 6: 443 (1851).

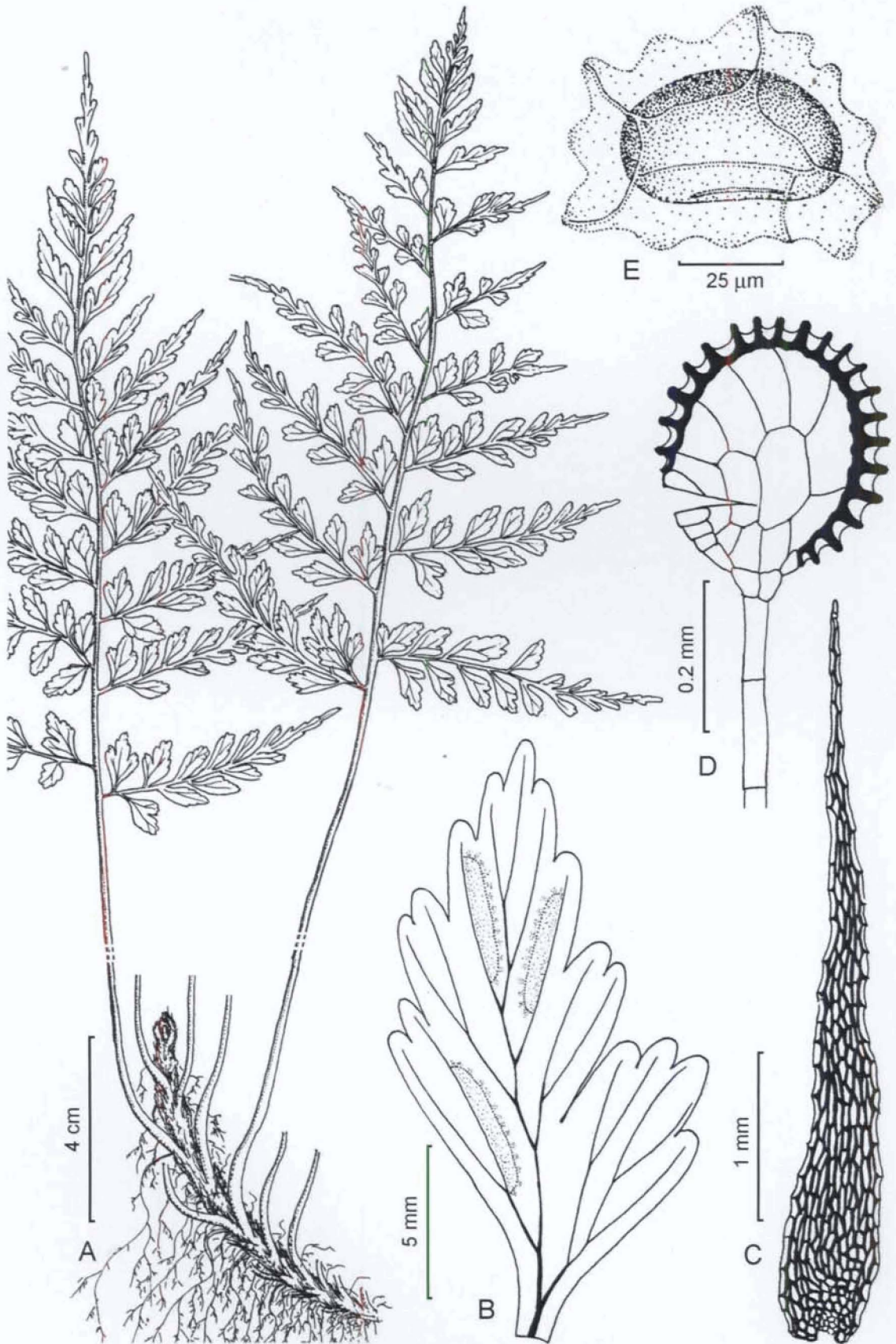


Fig. 22. *Asplenium nitidum* Sw. **A.** Habit; **B.** Pinna showing venation and position of sori; **C.** Palea on the rhizome; **D.** Sporangium; **E.** Spore.

Asplenium glaucophyllum Alderw. van Rosenb., Bull. Tard. Bot. Buitenz., Ser. 2,7 :6 (1912); Holttum, Rev. Fl. Mal. 2: 440 (1954).

Fig. 22 (A-E); Plate 25 (A-E)

Rhizome short creeping up to 0.5 cm thick, clothed by palea all over, densely scaly at the apex; palea small, ca. 4 x 0.6 mm, uniformly dark brown, ovate-lanceolate, clathrate, basally attached, margin entire. Fronds clustered, upto 80 cm long; stipe ca. 36 cm long, stout, dark coloured, glabrous except at the very base, sometimes few sparsely distributed scales present on the stipe; lamina oblong-lanceolate, bipinnate to bipinnate-tripinnatifid, 35-45 x 17-20 cm, colour and nature of the rachis similar to stipe, bears up to 18 pairs of primary pinnae, pinnae alternate or sub-opposite, 10-12 x 3-4 cm, primary pinnae gradually reduced upwards into a lobed wing at the tip; primary pinnae are short stalked, placed ca. 4 cm apart, ovate-lanceolate, bears upto 8 pairs of pinnules; pinnules gradually reduced towards the tip into an obliquely lobed wing like prolongation, acroscopic basal secondary pinnae possess stalked pinnules, other secondary pinnae are pinnatifid, pinnules variable in size and outline, they are more or less triangular with crenate margin, 2-3.5 x 0.5-1 cm and placed ca. 1 cm apart, pinnules light green, texture subcoriaceous, glabrous above and below; veins distinct and striated above, not so below, forked ones or twice. Sori linear, 5 mm long, 3-6 per pinnule and are also seen on the terminal wing like expansion of the primary pinnae. Spores 40 x 25 μ m, monoletic, bilateral, perinate, exine granulate, perine loose, margins

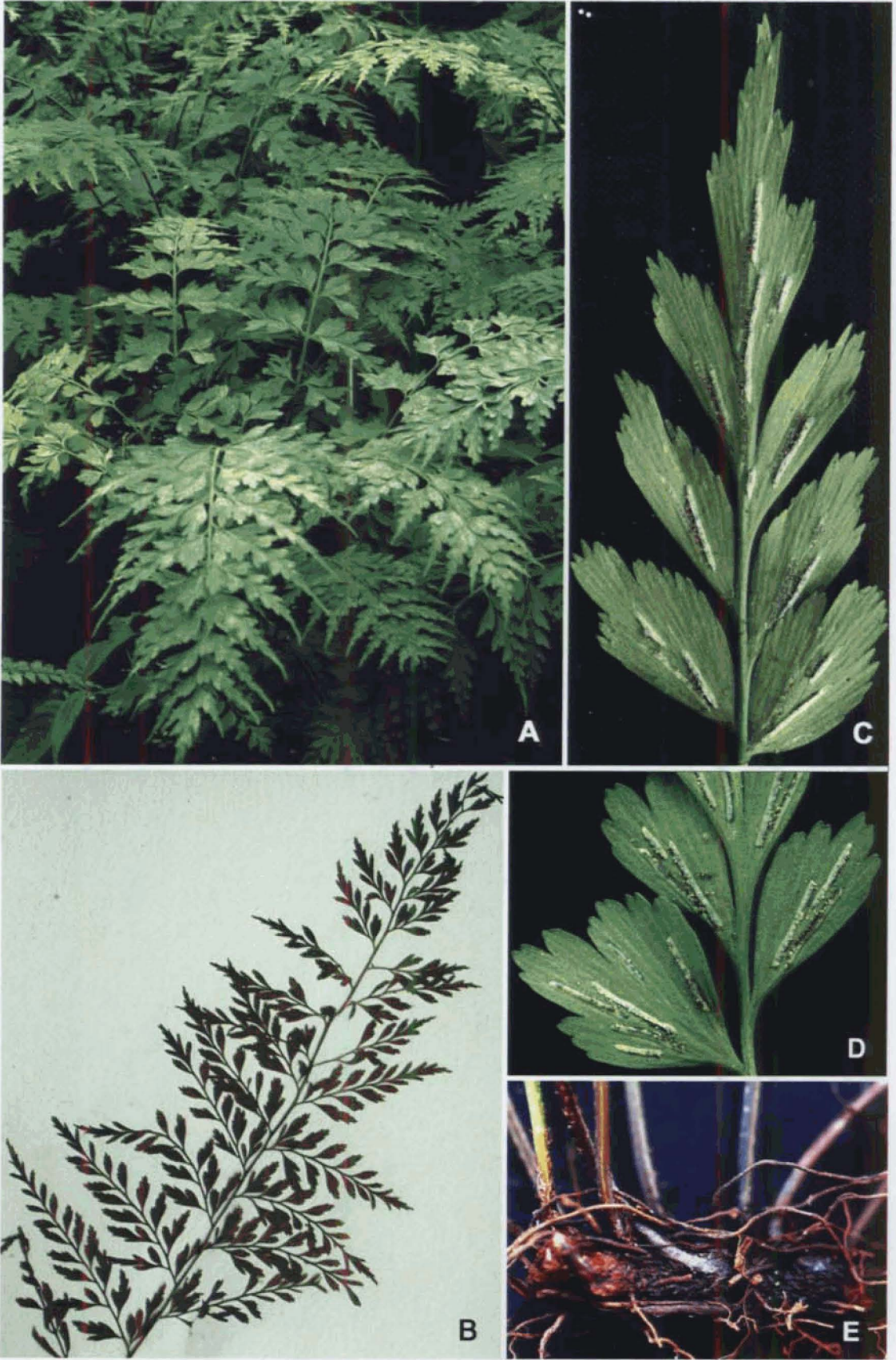


Plate 25. *Asplenium nitidum* Sw. A. Habit; B. Frond; C. Pinna showing sori; D. Pinnules magnified; E. Rhizome.

undulating with anastomosing surface folds, supralaesural fold more or less straight usually extend from end to end of the spore; unacetolysed spores 38 x 24 μm .

Distribution and Ecology: It is a rare species in South India. Reported only from Silent Valley of Kerala and Tirunelveli Hills and Kodaikanal of Tamil Nadu. No report elsewhere from South India. Also reported from Sikkim Himalaya, North-Eastern Himalaya and Assam. The distribution is extended to Sri Lanka, Japan, Malaysia, South Africa, Bhutan, Borneo, Java, Nepal and Sumatra. It is found growing as terrestrial in somewhat fully shaded forests above 1000m.

Specimens examined: **KERALA:** Palakkad Dt., Silent Valley, *Madhusoodanan & Nampy* 45989 (CALI), *Nayar & Madhusoodanan* 21341 A (CALI); Valiyaparthode- Silent Valley, *Nayar* 10057 (CALI); Walakkad - Silent Valley, *Nayar* 10665 (CALI), **TAMIL NADU:** Dindigal Dt., Kodaikanal, *Sauliere* 1000 (CAL).

***Asplenium normale* D. Don**

Prodr. Fl. Nepal, 7 (1825)

Clarke, Trans. Linn. Soc. Lond. II Bot. 1: 477 (1880); Beddome, Handb. Ferns Br. India 144 (1883); Holttum, Rev. Fl. Mala. 2: 436 (1954); Sledge, Bull. Brit. Mus. Nat. Hist. Bot. 3(6): 243 (1965), Bot. J. Linn. Soc. 84: 14 (1982); Dixt, Cens. Ind. Pterid. 120 (1984); Manickam, Fern. Fl. Palni Hills

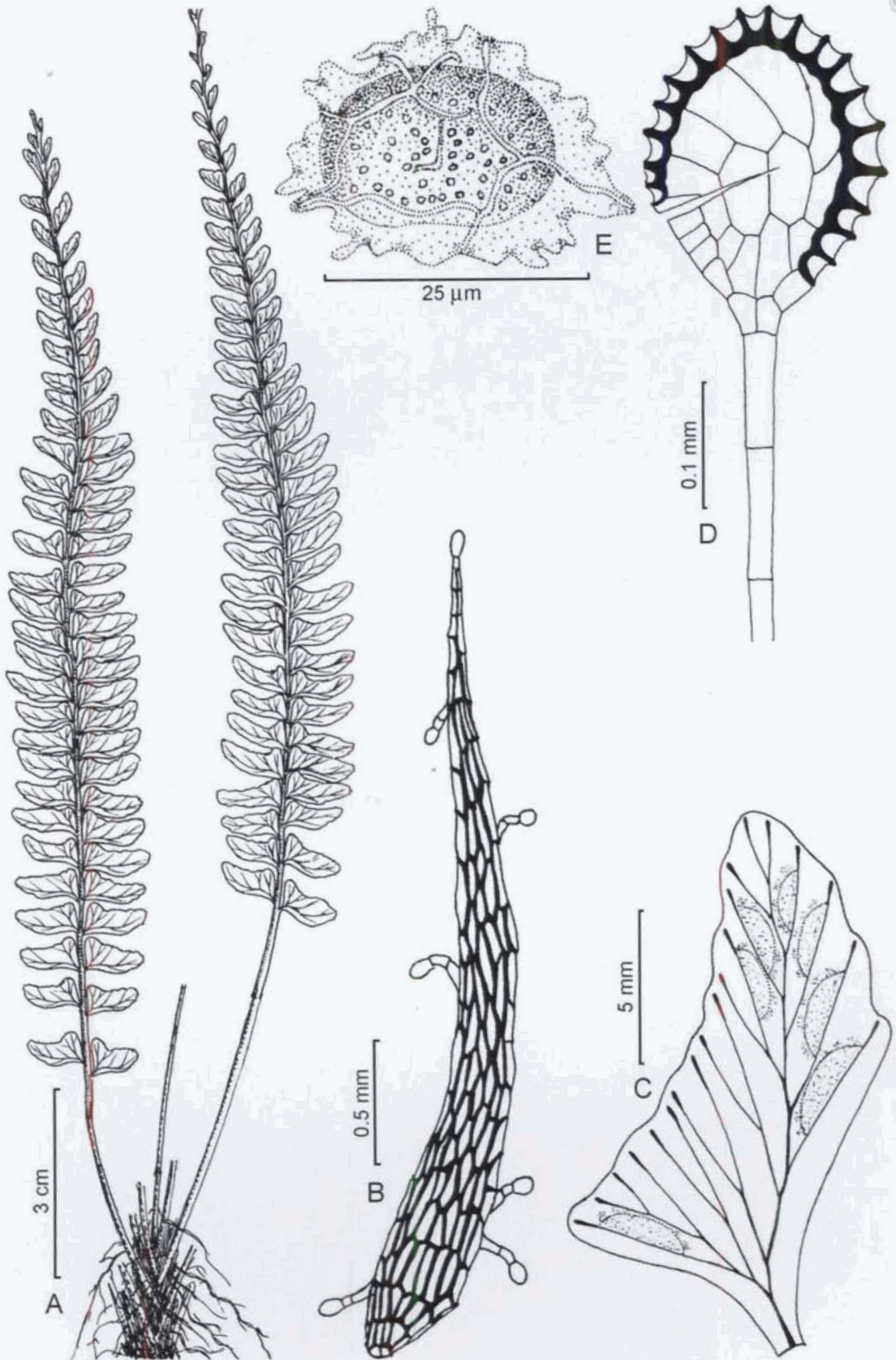


Fig. 23. *Asplenium normale* D. Don. A. Habit; B. Palea on the rhizome; C. Pinna showing venation and position of sori; D. Sporangium; E. Spore.

105 (1986); Chandra & Kaur, Nom. Guide Beddome F.S.I. & F.B.I. 16 (1987); Singh & Bir, Ind. Fern J. 6(1-2): 272, 273, 279, 280 (1989); Manickam & Irudayaraj, Pterid. Fl. Western Ghats 217, Pl. 165 (1992), Pterid. Fl. Nilgiris 128 (2003).

Asplenium minus Bl., Enum. Pl. Jav. 183 (1828).

Asplenium multijugum Wall., Numer. List. 8, n. 207 (1829) nom. nud., Beddome, Ferns S. India t. 133 (1863).

Asplenium opacum Kunze, Linnaea 24: 261 (1851).

Asplenium pavonicum Brackenr., U.S. Expl. Exped. Wilkes 150: t. 20, Fig. 1 (1854).

Asplenium multijugum Wall. ex Mett., Abhandl. Senckenb. Naturforsch. Ges. 3: 179 (1859); Hook., Sp. Fil. 3: 139, t. 188 B. (1860).

Fig. 23 (A-E); Plate 26 (A-F)

Rhizome erect, 1-1.5 cm thick, clothed by paleae all over, densely scaly at the apex; palea small, ca. 3 x 0.4 mm, ovate-lanceolate, dark brown, clathrate, base narrow, margin entire with few shortly stalked glands. Fronds tufted, 50-60 cm long; stipe wiry, dark brown, glossy, glabrous, 20-26 cm long; lamina simply pinnate, oblong-lanceolate, 30-40 x 3-5 cm, colour and nature of the rachis similar to stipe, bears 30-40 pairs of pinnae which are placed 0.5-1 cm apart, pinnae gradually reduced towards the tip into a narrow wing like prolongation; pinnae sessile opposite or alternate, very closely arranged, adjacent pinnae overlap each other, basal 1 or 2 pairs slightly reduced and deflexed, largest pinna 1.5 x 0.5 cm, oblong, acroscopic



Plate 26. *Asplenium normale* D. Don A. Habit; B. Frond; C. Part of frond showing sori; D. Pinnae magnified; E. Bulbils from tip of frond; F. Rhizome.

base truncate, more or less parallel to the rachis, basiscopic base slightly excised, margin sub-entire to wavy, not serrated, tip more or less rounded, dark green texture stiff herbaceous, glabrous above and below; veins obscure on both surfaces, few veins on the acroscopic side forked once or twice, others simple. Sori small, ca. 1-2 mm, usually confined to the distal half of the pinna, aroscopic basal lobe bears 1 or 2 sori; sporangium stalk approximately one and half times longer than the capsule. Spores 40 x 29 μ m, monolete, bilateral, perinate, exine granulose, bears some dark, oval raised areas, perine is smooth, loose forming an undulate wing and wavy surface folds. Unacetolysed spores 38 x 28 μ m.

Distribution and Ecology: This species is not widely distributed in Kerala and Karnataka, noticed only a single gathering from Munnar Hills of Kerala. It is also reported from Kemmangudi region of Karnataka. But it is widely distributed in Tamil Nadu, reported from Kodaikanal, Palni Hills, Yercaud, Kolli Hills, Anamalai Hills, Tirunelveli Hills, etc.. Also reported from Sikkim Himalaya, North-Eastern India & Eastern Himalaya. The distribution is extended to Sri Lanka, Japan, Thailand, Malaysia, Africa, U.S.A, Taiwan, Borneo, Sumatra, Nepal, Madagascar, Bhutan, Australia, Hawaii, Hongkong, Vietnam, Java, Korea, Malagasy and Polynesia. It is commonly found growing as epilithic or terrestrial in fully shaded forest floor between 1000 - 2100 m.

Cytology: n=36, diploid (Kuriachan, 1968). n=72, tetraploid (Bir, 1965; Ghatak, 1977).

Specimens examined: **KARNATAKA:** Chickmangalur Dt., Kemmangudi, *Rajagopal* 558 (MGMC). **KERALA:** Idukki Dt., Gundumala Shola - Munnar, Azeez 102774 (CALI). **TAMIL NADU:** Coimbatore Dt., Valparai-Anamalai Hills, *Mathew*, 31575 (RHT). Dindigal Dt., Kodaikanal, Azeez 102729 (CALI), *Manickam* 152 (RHT), *Gamble* 11494 (MH); Perumal - Palni Hills, *Manickam* 725 (RHT) **Madurai Dt.**, Vellimala, *Subramanyam* 9448 (MH, CAL). **Nilgiri Dt.**, Kotagiri, *Sedgwick* 1604 (CAL); Pakasuramalai, *Sebastine* 3217, 5663 (MH, CAL); Kaikatti, *Vajravelu* 35077 (MH). **Selam Dt.**, Sheveroy Hills - Yercaud, *Manickam* 25761 (RHT), *Ghatak* 21 (CAL), *Rao* 26753 (MH); Kakka Shola - Yercaud, *Manickam* 25864 (RHT), *Nair* 74223 (MH, CAL), *Subramanyam* 6598 (MH, CAL), *Ghatak* 238, 494 (CAL); Kolli Hills, *Manickam* 33233 (MH). **Tirunelveli Dt.**, Kothayar Hills, *Manickam* & *Mathew* 34428 (RHT); Peyar Valley, *Manickam* 32530 (RHT).

Asplenium obscurum Bl.

Enum. Pl. Jav. 2: 181 (1828)

Sledge, Bull. Br. Mus. Nat. Hist. Bot. 3(6): 247 (1965); Dixit, Cens. Ind. Pterid. 120 (1984); *Manickam*, Fern Fl. Palni Hills 104 (1986); Singh & Bir, Ind. Fern J. 6(1-2): 271-273 (1989); *Manickam* & *Irudayaraj*, Pterid. Fl. Western Ghats 210, Pl. 158 (1992), Pterid. Fl. Nilgiris 125 (2003); Azeez *et al.*, J. Econ. Tax. Bot. 20(2): 435-455 (1996); *Pullaiah et. al.*, Pterid. Andhra Pradesh 125, pl. 54 (2003).

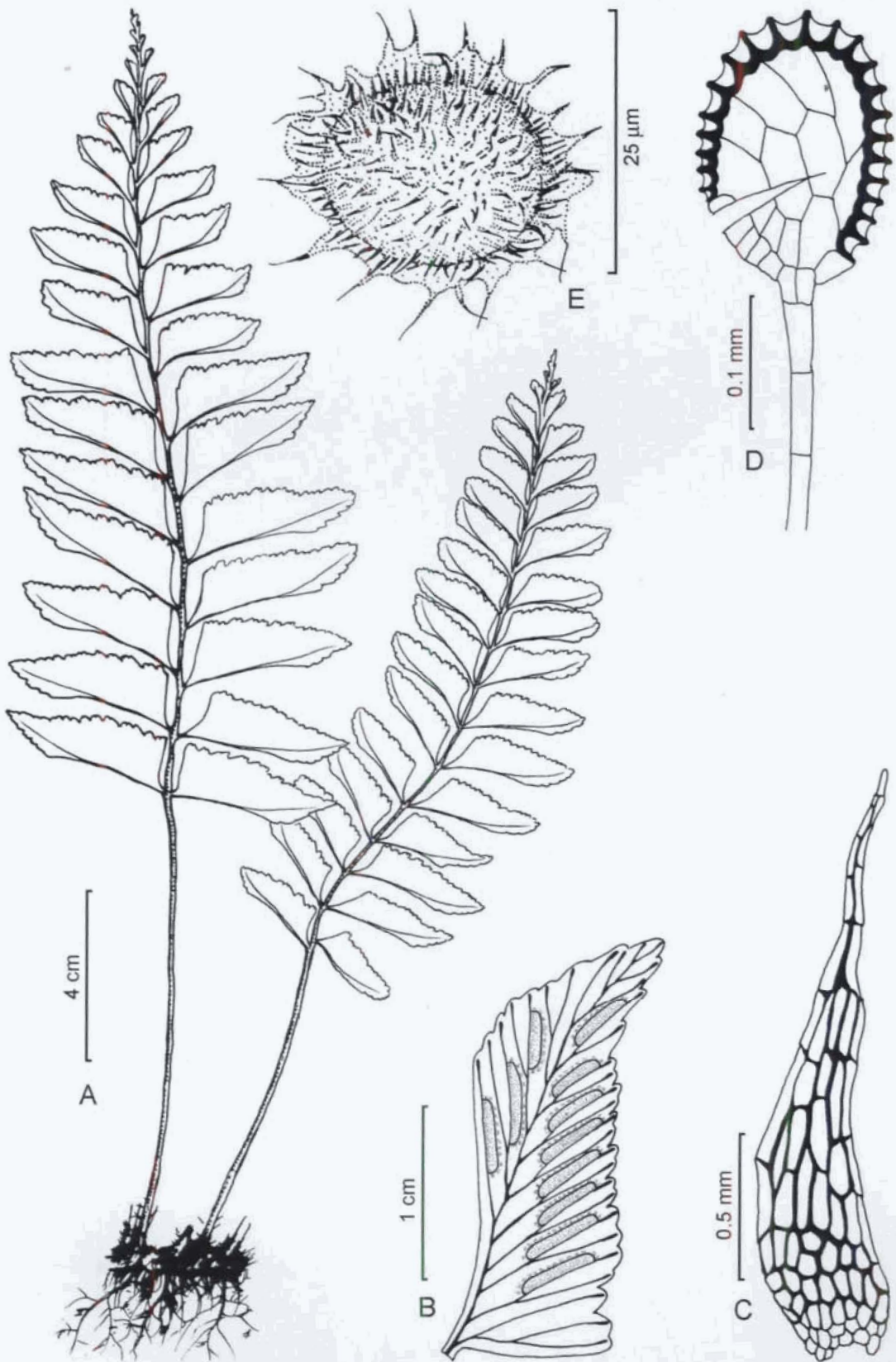


Fig. 24. *Asplenium obscurum* Bl. A. Habit; B. Pinna showing venation and position of sori; C. Palea on the rhizome; D. Sporangium; E. Spore.

Asplenium cristatum Wall., Numer. List. 9, n. 211 (1829) nom. nud., non *A. cristatum* Lam. (1786).

Asplenium erosodentatum Bl., Enum. Pl. Jav. 2: 182 (1828).

Asplenium serriforme Mett., Abhandl. Senckenb. Naturforsch. Ges. 3: 163, t. 4, Fig. 13 (1859) ('serraeforme').

Fig. 24 (A-E); Plate 27 (A-F)

Rhizome short or long creeping, up to 4 mm thick, sparsely covered by scales, densely scaly at the tip; palea small, 2 x 0.4 mm, ovate-lanceolate, clathrate, tip acuminate, margin entire, basally attached. Fronds 35-45 cm, more or less closely arranged, up to 4 mm apart, stipe 14-19 cm long, narrow rounded below, grooved above, green when fresh, some cases light brownish below and greenish above, possess sparsely distributed scales; lamina unipinnate, oblong-lanceolate, 20-27 x 6-8 cm, rachis green above and below, grooved above and have a narrow green wing on either side of the groove, bears 14-22 pairs of shortly stalked pinnae, up to 1.5 cm apart; pinnae 4.5 x 1.2 cm, nearly half to two third part of the basiscopic basal side excised, margin slightly and irregularly lobed, lobes bifid with blunt tip, pinnae not reduced towards the tip into a narrow lobed wing, tip of the pinna more or less blunt, light green, firm, herbaceous, glabrous above and below; veins distinct above and below, not raised, acroscopic basal vein forked twice, others forked once. Sori small, linear, usually confined to acroscopic veins, ca. 3 mm long, produced on either side of the costa. Spores monolete and bilateral, 35 x 29 μ m, monolete, bilateral, perinate, both

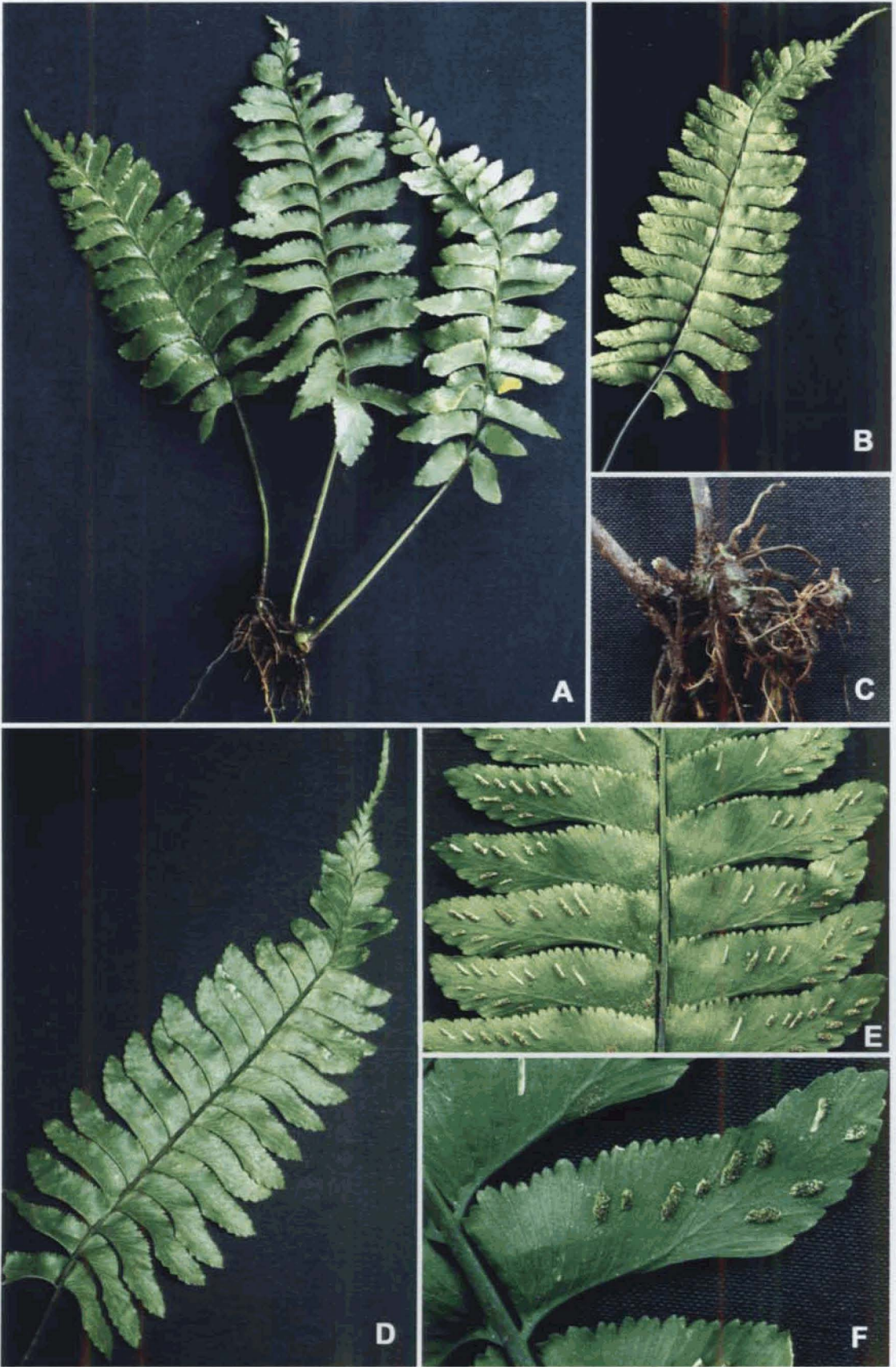


Plate 27. *Asplenium obscurum* Bl. A. Habit; B. Fertile frond; C. Rhizome; D. Frond (dorsal); E. Part of frond showing sori; F. Pinna magnified.

exine and perine are densely clothed with narrow, elongated, sharp, straight or curved spines, making the spores characteristic in the genus. Unacetolysed spores 35 x 27 μ m.

Distribution and Ecology: This is a rare species. Reported from Agasthyamala, Ponmudi Hills, Munnar Hills, Silent Valley region of Kerala, Anamalai Hills, Nilgiri Hills, Kothayar Hills and Kodaikanal of Tamil Nadu. Also reported from Orissa, North-Eastern India, Eastern Himalaya and Western Himalaya. The distribution is extended to Sri Lanka, Africa, Thailand, Myanmar, Taiwan, Tanzania, Nepal, Vietnam, China and Java. Commonly found growing as terrestrial in fully shaded stream banks at an altitude of 1000 - 2000 m.

Cytology: n = 72, diploid apogamous (Abraham *et al.*, 1962; Manickam & Irudayaraj, 1988).

Note: This species superficially resembles *A. excisum* Presl, but they can be easily distinguished from each other by their stipe colour. The stipe is green and not polished in *A. obscurum* Bl., but it is dark brown and glossy in *A. excisum* Presl. Both the taxa differ in the nature of their spores also, in *A. obscurum* Bl. Both exine and perine are clothed with characteristic long, narrow, straight or curved spines, while in *A. excisum* Presl the exine is uniformly granulose and perine is loose and densely spinulose, but the spinules are small.

Specimens examined: **ANDHRA PRADESH:** Vishakapatanam Dt., Galikonda, *Amruthalakshmi* 25171 (CAL). **KERALA:** Idukki Dt., Anamudi Hills, *Mathew & Manickam* 34525 (RHT). Palakkad Dt., Silent Valley, Nair 65459 (MH), 81135 (MH, CAL). Pathanamthitta Dt., Gavi-Moozhiyar road, *Manickam & Mathew* 34301 (RHT). Thiruvananthapuram Dt., Athirumala-Agasthyamala, *Madhusoodanan et al.* 51919 (CALI); Ponmudi Hills, *Manickam* 31330 (RHT). **TAMILNADU:** Coimbatore Dt. Valparai-Anamalai Hills, *Azeez* 102790 (CALI), *Manickam & Mathew* 33078 (RHT); Siruvani, *Vajravelu* 62988 (MH), *Subramanyam* 2456 (CAL). Dindigal Dt., Kodaikanal *Azeez* 103706 (CALI), *Manickam* 580 (RHT). Selam Dt., Pongalkoil Shola, *Mathew & Alphonse* 702 (RHT). Tirunelveli Dt., Kothayar Hills, *Manickam & Mathew* 34803 (RHT); Kannikatti - Ambasamudram, *Manickam* 31771 (RHT).

***Asplenium phyllitidis* D. Don**

Prod. Fl. Nepal 7 (1825)

Holttum, Rev. Fl. Mal. 2: 420 (1954); Nayar & Kaur, Comp. Beddome Handb. 34 (1974); Baishya & Rao, Ferns & Fern Allies Meghalaya 115 (1982); Chandra & Kaur, Nom. Guide Beddome F.S.I. & F.B.I. 15 (1987); Jamir & Rao, Ferns Nagaland 288 (1988); Nayar & Geevarghese, Fern Fl. Malabar 284 (1993); *Azeez et al.* J. Econ. Tax. Bot. 20(2): 435-455 (1996); Borthakur *et al.*, Illus. Man. Ferns Assam 347 (2000).

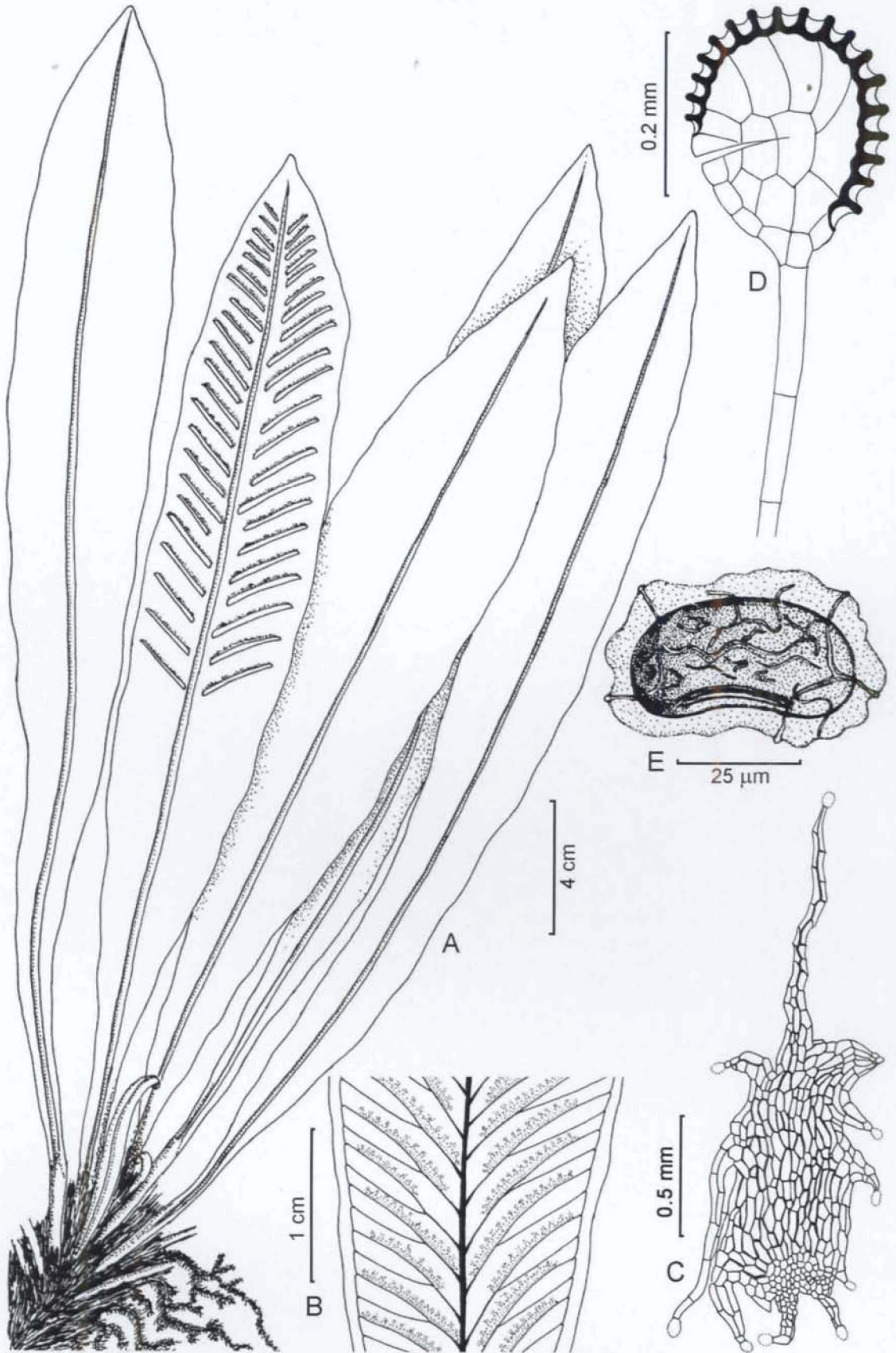


Fig. 25. *Asplenium phyllitidis* D. Don A. Habit; B. Part of frond showing venation and position of sori; C. Palea on the rhizome; D. Sporangium; E. Spore.

Thamnopteris phyllitidis (D. Don) Beddome, Ferns S. India t. 123 (1863); Chandra & Kaur, Nom. Guide Beddome F.S.I & F.B.I. 15 (1987).

Thamnopteris nidus var. *phyllitidis* (D. Don), Beddome, Handb. Ferns. Br. India 139 (1883); Nayar & Kaur, Comp. Beddome Handb. 34 (1974).

Asplenium nidus var. *phyllitidis* (D. Don) Bir, J. Ind. Bot. Soc. 43: 567 (1964).

Asplenium nidus L. sensu Manickam & Irudayaraj, Pterid. Fl. Western Ghats 206, pl. 153 (1992), Pterid. Fl. Nilgiris 123, pl. 28 (2003).

Fig. 25 (A-E); Plate 28 (A-E)

Rhizome erect, ca. 5 cm thick, densely paleaceous all over; palea ca. 15 x 3 mm, clathrate, base broad, basally attached, tip acuminate, gland tipped, margin entire, bears many multicellular gland tipped hairs. Fronds long and simple, tufted giving a nest habit, up to 1 m long and 8-10 cm broad; no distinct stipe; lamina simple and entire elliptic to lanceolate, middle portion broad, gradually narrowing towards tip and base, tip acuminate, margin entire, slightly wavy; dark green, coriaceous, glabrous above and below; midrib prominent and raised below, flattened above; veins usually once forked, shows intramarginal fusion. Sori elongated, linear, 2.5-3 cm long, arranged in close, oblique rows on either side of the costa, usually distributed only in the upper half or upper one-third portion of the frond, produced only on acroscopic veins. Spores 50 x 31 μm , monolete, bilateral, perinate, exine granulose, perine loose forming a narrow folded wing, folds anastomosing; unacetolysed spores 48 x 28 μm .

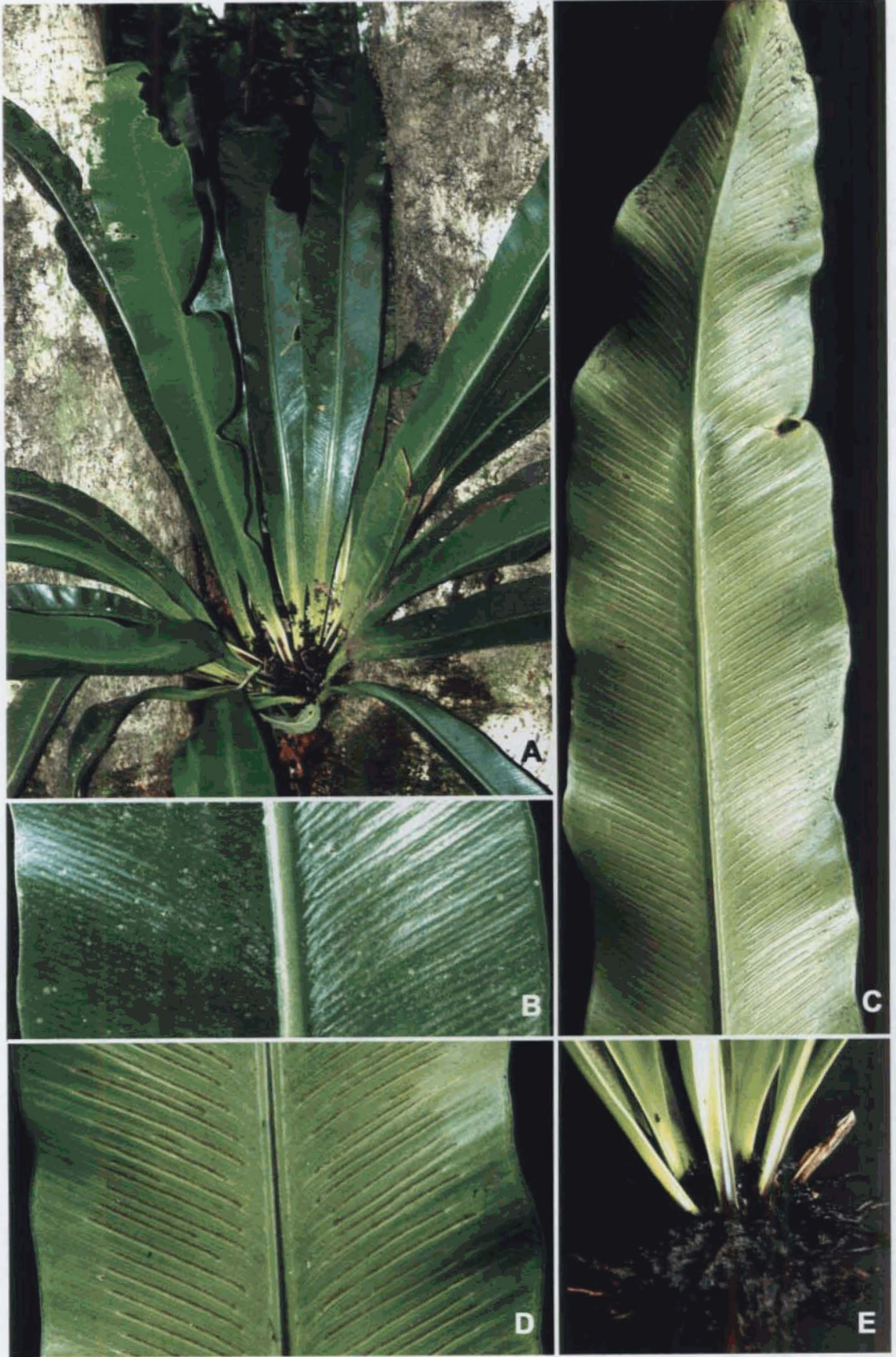


Plate 28. *Asplenium phyllitidis* D. Don A. Habit; B. Part of frond (dorsal); C. Part of frond (ventral); D. Part of frond showing sori; E. Rhizome.

Distribution and Ecology: It is one of the widely distributed species of *Asplenium* L. in the Western Ghats of Kerala, but its distribution is not wide in Tamil Nadu and Karnataka. In Tamil Nadu, it is reported from Anamalai Hills, Tirunelveli Hills & Nilgiri Hills, while only from Nagodi and Kudajadri regions of Shimoga Dt. in Karnataka. No report from other parts of South India. Also reported from North-Eastern Himalaya, Sikkim Himalaya, Assam and Eastern Himalaya. The distribution is extended to Thailand, Malaysia, Admiralty Island, Borneo, Japan, Sumatra, Nepal and Philippines. It is commonly found growing as epiphyte on partially shaded forest trees between 700-2000 m. Rarely seen as epilithic also.

Cytology: No report.

Note: The species is very similar to *A. nidus* L. except for the size, colour and nature of rachis of the frond and nature of formation of sori (See *A. nidus* L.). Beddome (1883) reported that, typical '*Nidus*' has the fronds up to 6 feet long and 5-6 inches wide, and has not been found in the Madras Presidency. Though Manickam & Irudayaraj, in the 'Pteridophyte Flora of the Western Ghats, South India (1992) and Pteridophyte Flora of Nilgiris, South India (2003) identified the smaller plants they collected (fronds only 100 x 10 cm.) as *A. nidus* L., and reported that in their plants the sori never reached the costa. But Sledge (1965) has specified that in *A. nidus* L. the sori extend from the costa.

Specimens examined: **KARNATAKA:** Shimoga Dt., Nagodi - Nettur, Azeez 102735 (CALI); Kudajadri, Rajagopal, 177 (MGMC).**KERALA:**

Ernakulam Dt., Kuttampuzha, *Shetty* 33513 (MH); **Idukki Dt.**, Koonanal Forest - Thekkadi, *Azeez* 102738 (CALI); Vallakadavu, *Azeez* 102743 (CALI); Kuttikanam, *Manickam & Mathew*, 34285 (RHT); Painavu, *Vivekananthan* 50516 (MH); Mangala Devi Temple - Thekkadi, *Vivekananthan* 48867 (MH). **Kannur Dt.**, Begur R.F., *Ramachandran* 62038 (MH); **Kozhikode Dt.**, Vellarimala, *Geevarghese* 29465 (CALI). **Palakkad Dt.**, Silent Valley, *Azeez* 102722 (CALI), *Nayar & Madhusoodanan* 21373 (CALI), *Vajravelu* 26163 (MH), *Geevarghese* 17919 (CALI), *Nayar* 10039 (CALI) *Bharghavan* 65562 (MH); Nelliampathi, *Geervarghese* 4195, 17858 (CALI), *Nayar* 7287 (CALI); *Vajravelu* 44752 (MH); Attapadi, *Nayar* 10606 (CALI); *Parambikulam*, *Nayar* 7394 (CALI); *Karapara*, *Vajravelu* 46125 (MH), *Nair* 56873 (MH); *Kunthipuzha*, *Nair* 64282 (MH). **Pathanamthitta Dt.**, *Plappally*, *Azeez* 102701 (CALI), *Sabarigiri*, *Nayar* 10084 (CALI), *Nair & Ghosh* 5060 (MH); *Sabarimala*, *Nair* 70218 (MH), *Vivekananthan* 45364 (MH), *Manickam & Mathew* 33617 (RHT); *Pamba Hills*, *Manickam & Mathew* 33634 (RHT); *Moozhiyar - Kakki Hills*, *Manickam & Mathew* 33656 (RHT); *Chalakyam*, *Mohanan* 59642 (MH). **Thrissur Dt.**, *Sholayar Forest*, *Azeez*, 102795 (CALI); *Peringalkuthu*, *Nair & Ghosh* 52093 (MH); *Vaazhachal*, *Nair & Ghosh* 51014 (MH); *Mukundapuram - Sholayar*, *Manickam & Mathew* 34715 (RHT). **Thiruvananthapuram Dt.**, *Bonnakad*, *Joseph* 46516 (MH). **Wayanad Dt.**, *Chandanathode - Periya*, *Azeez* 102713 (CALI). TAMIL NADU: **Coimbatore Dt.**, *Karyan Shola - Anamalai*, *Manickam & Mathew* 34621 (RHT), *Mathew* 31533 (RHT); *Valparai - Anamalai Hills*, *Mathew* 31589 (RHT); *Sholayar Top*, *Ramamurthy* 18146 (MH). **Nilgiri Dt.**, *Santhi*

Estate, *Ellis* 34889 (MH). **Tirunelveli Dt.**, Kannikatti Hills -
Ambasamudram, *Manickam & Mathew* 31713 (RHT); Lower Kothayar, *Henry*
48280 (MH).

***Asplenium polydon* G. Forst.**

Prod. Florul. Ins. Austr. 80 (1786)

Sledge, Bot. J. Linn. Soc. 84: 14 (1982); *Manickam & Irudayaraj*, Pterid. Fl.
Western Ghats 218, Pl. 166 (1992); *Azeez et al.*, J. Econ. Tax. Bot. 20(2):
435-455 (1996); *Pullaiah et al.* Pterid. Andhra Pradesh 125, pl.54 (2003).

Asplenium falcatum Lam., Encycl. Metn. Bot. 2: 306 (1786); *Beddome*,
Handb. Ferns Br. India 150 (1883); *Sledge*, Bull. Br. Mus. Nat. Hist. Bot.
3(6): 261 (1965); *Nayar & Kaur*, Comp. *Beddome Handb.* 36 (1974); *Dixit*,
Cens. Ind. Pterid. 117 (1984); *Manickam*, Fern Fl. Palni Hills 98 (1986);
Chandra & Kaur, Nom. Guide *Beddome F.S.I. & F.B.I.* 17 (1987); *Singh &*
Bir, Ind. Fern J. 6(1-2): 278, 279 (1989); *Nayar & Geevarghese*, Fern Fl.
Malabar 276 (1993); *Borthakur et al.*, Illus. Man. Ferns Assam. 340 (2000).

Trichomanes adiantoides L., Sp. Pl. 2: 1098 (1753).

Tarachia falcata (Lam.) C. Presl, Abhandl. K. Bohm. Ges. Wiss. Folge 5, 6:
437 (1851).

Asplenium caudatum *Beddome*, Ferns S. India 48, t. 143 (1863).

Asplenium adiantoides (L.) C. Chr., Ind. Fil. 99 (1905); non *A. adiantoides*
Lam. (1786); *Holttum*, Rev. Fl. Mal. 2: 431 (1954).

Fig. 26 (A-E); Plate 29 (A-D)



Fig. 26. *Asplenium polydon* G. Forst. A. Habit; B. Palea on the rhizome; C. Pinna showing venation and position of sori; D. Sporangium; E. Spore.

Rhizome erect, ca. 1.5 cm thick, densely scaly at the apex; palea ca. 5 x 1 mm, uniformly dark brown, ovate-lanceolate, clathrate, base broad, cordate, margin entire, bears few glands on uniseriate stalk, apex long acuminate and gland tipped. Fronds 30-40 cm long, tufted; stipe 15-20 cm long, grey to dark brown, densely scaly when young, more or less glabrous when mature except at the base; lamina ovate-lanceolate, simply pinnate, 20-23 x 10-18 cm, nature and colour of the rachis similar to stipe which bears 6-10 pairs of lateral pinnae; pinnae shortly stalked, subopposite below, alternate above, placed 2-4 cm apart, the middle pinnae are larger, slightly reduced towards the base and gradual reduction to the tip, apex of the lamina ends in a bilobed or trilobed pinna, largest pinna 8-12 x 2-2.5 cm, the lower base slightly excised, upper base cuneate, acroscopic basal lobe distinct and is serrated, remaining portion of the pinna possess shallow oblique teeth, pinna acuminate and ends in a narrow, entire prolongation, colour light green when fresh, texture subcoriaceous, sparsely distributed lacinate scales present below, glabrous above; veins numerous, crowded, forked 4-5 times, distinct below, raised above, costa grooved and well raised above. Sori linear, many on each pinna, 1-2.5 cm long, sori produced on both acroscopic and basisopic branch of a fork, thus facing opposite to each other, sori irregularly distributed. Spores 37 x 25 μm , monoletic, bilateral, perinate, exine granulate, possesses some highly specialized reticulate patterns, perine loose, smooth, undulating and folded, supralaesural fold distinct, more or less straight and extending from end to end of the spore; unacetolysed spores 36 x 23 μm .



A



B



C



D

Plate 29. *Asplenium polydon* G. Forst. A. Habit; B. Fertile frond; C. Part of frond showing sori; D. Rhizome.

Distribution and Ecology: One of the widely distributed species. Reported throughout Kerala Ghats, Tirunelveli Hills, Sethur Hills of Tamil Nadu. But it is rare on Anamalai Hills, Palni Hills and Nilgiri Hills. No report from Karnataka and a single report from Andhra Pradesh. It is one of the *Asplenium* L. species growing at lower elevations. It is reported from Muhamma region of Alappuzha District (MSL) and Kannothe of Kannur District. Also reported from Assam, Meghalaya and West Bengal. The distribution is extended to Sri Lanka, Malaysia, Philippines, Australia, South Africa, Bangladesh and Polynesia. It is commonly found growing as epilithic along partially exposed roadsides or waysides and rarely on the forest floor between 0-950 m.

Cytology: $n = 72$, Tetraploid (Abraham *et al.*, 1962).

Notes: Morton (1967) shown that *Asplenium falcatum* Lam. and *A. adiantoides* (L.) C. Chr. are both inadmissible names for this species. According to him *A. polydon* G. Forst. is the correct name for this taxon. Formerly it was called as *A. falcatum* Lam., *A. decrescens* Kunze and *A. polydon* G. Forst. are more or less similar in morphology. They can be distinguished by rhizome scales and the mode of arrangement of sori.

Economic Importance: It is used in the treatment of enlarged spleen, incontinence of urine, calculus, jaundice, malaria and is anti-cancerous also (Singh, 2003).

Specimens examined: ANDHRA PRADESH: Chittoor Dt., Papavinasanam Tirumala, *Ameer Ahamed* 13521 (SKU). **KERALA: Alappuzha Dt.,** Muhamma, *Sevichan* 29763 (CALI). **Idukki Dt.,** Tidanadu, *Antony* 1267 (MH); Puyamkutty, *Bharghavan* 87432 (MH); Triveni, *Sharma* 42458 (MH). **Kannur Dt.,** Ezhimala, *Madhusoodanan & Swarupanandan* 29440 (CALI); Kannothe, *Ramachandran* 64014 (MH). **Kollam Dt.,** Palaruvi-Thenmala, *Azeez* 102753 (CALI), *Mohanan* 59530 (MH); Umayar-Mammood, *Nair* 50903 (MH, CAL); Aryankavu Hills, *Manickam* 32308 (RHT). Punaloor, *Nair* 859 (CAL). **Kottayam Dt.,** Meenachil, *Manickam & Mathew* 33490 (RHT). **Malappuram Dt.,** Nilambur, *Madhusoodanan* 29665 (CALI). **Palakkad Dt.,** Kanjirapuzha, *Geevarghese* 4018 (CALI), *Sebastine* 20882 (MH). **Pathanamthitta Dt.,** Moozhiyar, *Azeez* 102749, 102750 (CALI), Sabarigiri, *Nayar* 10083 (CALI); Vennikulam, *Nair* 50850 (MH); Pampa-Ayyappan Temple, *Nair* 50836 (MH, CAL); Konni, *Nair* 911 (CAL), *Nair & Ghosh* 926 (CAL). **Thiruvananthapuram Dt.,** Valvara, *Raju Antony* 18629 (TBGT). **Thrissur Dt.,** Sholayar, *Manickam & Mathew* 34718 (RHT); Chalakkudi, *Nair & Ghosh* 52063 (CAL). **TAMIL NADU: Coimbatore Dt.,** Perumalmudi, *Viswanathan* 970 (MH). **Kanyakumari Dt.,** Kiripara-Nagarcoil, *Nair* 51919 (MH). **Ramanathapuram Dt.,** Nagariar estate, *Srinivasan* 65928 (MH, CAL), 96734 (MH); Sethur Hills, *Makali* 68011 (MH, CAL), *Srinivasan* 63565, 89566 (MH); Attakandy, *Srinivasan* 99285 (MH); Deviar estate, *Srinivasan* 86977, 89569 (MH). **Triunelveli Dt.,** Kannikatti Hills – Ambasamudram, *Manickam* 32318 (RHT), *Sebastine* 8500 (MH).

***Asplenium semivarians* Viane & Reichst.**

Pterid. In the new Millenium; 78-81 (2003)

Asplenium varians Wall. ex Hook. Grev. Ic. Fil. T. 17(1830); Beddome, Ferns S. India 44, t. 129 (1863), Handb. Ferns Br. India 158 (1883); Hope, J. Bombay Nat. Hist. Soc. 13: 667 (1901); Sledge, Bull. Br. Mus. Nat. Hist. Bot. 3: 272 (1965); Nayar & Kaur, Comp. Beddome Handb. 38 (1974); Manickam, Fern Fl. Palni Hills 96 (1986); Chandra & Kaur, Nom. Guide Beddome F.S.I. & F.B.I. 16 (1987); Singh & Bir, Ind. Fern J. 6(1-2): 272, 273, 279 (1989); Manickam & Irudayaraj, Pterid. Fl. Nilgiris 130, Pl. 21 (2003).

Asplenium laciniatum D. Don, Prodr. Fl. Nepal 8 (1825); C. Chr., Ind. Fil. (Rep.) 117 (1973); Singh & Bir, Ind. Fern J. 6(1-2): 271 (1989); Manickam & Irudayaraj, Pterid. Fl. Western Ghats 224, Pl. 172 (1992); Pullaiah *et.al.*, Pterid. Andhra Pradesh 124 (2003).

Fig. 27 (A-E); Plate 30 (A-F)

Rhizome erect, 0.5-1 cm thick, densely scaly at the apex; scales ovate-lanceolate, ca. 5 x 0.5mm, dark brown at the centre, pale brown at the periphery, apex long acuminate. Fronds tufted, 14-16 x 3-5 cm, light green; stipe small, 3-4 cm, pale green adaxially, purplish abaxially, round below, grooved above, scaly at the base; lamina ovate-lanceolate, 10-13 x 3-5 cm, bipinnate, acute, primary pinnae 10-12 pairs, subopposite below, alternate above, 1-1.5 cm apart, apex round, lower 1 or 2 pinnae slightly reduced, lamina progressively narrowed towards tip into slightly and regularly lobed narrow wing, largest pinna 2-2.5 x 0.5-1 cm, pinnae pale green, glabrous

above and below, texture herbaceous; pinnules 3-5 pairs, sessile, alternate, acroscopic basal pinnule larger and distinct from others, shortly stalked, 0.8 x 0.5 cm, distal part of primary pinnae are shallowly lobed without bearing distinct pinnules, apex rounded, base entire, toothed above; veins not distinct above and below, forked once or twice, not reaching the margin. Sori 3-4 mm, one or two in each pinnule, formed even at the terminal wing of lamina and to the extreme tip of the pinnae. Spores monoletate, bilateral, perinate, planoconvex or reniform, 38 x 28 μm , monoletate, bilateral, perinate, exine granulose, but it is provided with few dark oval areas, perine smooth, loose, forming slightly sinuated supralaesural fold. Unacetolysed spores 36 x 28 μm .

Distribution and Ecology: Rare species. Reported from Palaruvi-Thenmala, Munnar Hills and Ichampatty-Chinnar W.L.S. in Kerala, Yercaud, Kodaikanal, Kuttalam, Kalakkad Hills, Sethur Hills, Kolli Hills of Tamil Nadu. No report from other areas of present study. Also reported from Rajasthan, West Bengal, North-Eastern Himalaya, Kumaun Himalaya, Jammu & Kashmir, Nainital, Simla and Uttaranchal. The distribution is also extended to Sri Lanka, Japan, Taiwan, Africa, U.S.A. and Nepal. They are commonly found growing as epilithic or terrestrial in partially or fully shaded places between 1000-2250 m.

Cytology: n=36, diploid (Bir, 1965; Ghatak, 1977; Kuriachan, 1978; Manickam & Irudayaraj, 1988; Irudayaraj *et al.*, 1993; Bir & Irudayaraj, 2001).

Plate 30. *Asplenium semivarians* Viane & Reichst. A. Habit; B. Frond (dorsal); C. Fertile frond; D. Part of frond showing sori; E. Pinna magnified; F. Rhizome.



Handwritten mark, possibly a signature or initials.

1911A

Specimens examined: **ANDHRA PRADESH:** Vishakapatanam Dt., Sunkerimetta, *Balakrishnan* 698 (CAL). **KERALA:** Idukki Dt., Elapara, Nair 40162 (CAL). Kollam Dt., Palaruvi-Thenmala, *Azeez* 102752 (CALI). Thiruvananthapuram Dt., Ichampatty-Chinnar W.L.S., *Rajesh* 87723, 87750 (CALI). **TAMIL NADU:** Coimbatore Dt., Perumalmudi, *Viswanathan* 1053 (MH); Maruthamalai, *Viswanathan* 628, 894 (MH); Kottadi, *Jacob* 302 (MH). Dindigal Dt., Kodaikanal, *Manickam* 31093 (RHT); Palni Hills, *Manickam* 31887 (RHT). Ramanathapuram Dt., Deviar estate - Sethur Hills, *Srinivasan* 63510 (MH, CAL); Mudaliaruthu, *Nair* 60937 (MH, CAL). Selam Dt., Yercaud, *Azeez* 103702 (CALI); Kiliyar falls-Yercaud, *Manickam*, 25782 (RHT), *Nair* 74212 (MH); Balmadies estate, Yercaud, *Subramanyam* 7517 (MH, CAL), *Ghatak* 658 (CAL); Karadu-Yercaud, *Karthikeyan* 26980 (MH); Honey rock - Yercaud, *Ghatak* 6295 (CAL); Kolli Hills, *Manickam & Mathew* 33185, 33226 (RHT). Tirunelveli Dt., Kalakkad, *Manickam* 31257 (RHT), *Joseph* 15289 (MH).

***Asplenium serricula* Fee**

Mem. Fam. Fough. 5: 196 (1852)

Sledge, Bull. Br. Mus. Nat. Hist. Bot. 2: (1965), Bot. J. Linn. Soc. 84: 14 (1982); Nayar & Kaur, Comp. Beddome Handb. 35 (1974); Dixit, Cens. Ind. Pterid. 121 (1984); Manickam, Fern Fl. Palni Hills 102 (1986); Chandra & Kaur, Nom. Guide Beddome F.S.I. & F.B.I. 16 (1987); Singh & Bir, Ind. Fern J. 6(1-2): 272, 279 (1989); Manickam & Irudayaraj, Pterid. Fl. Western Ghats

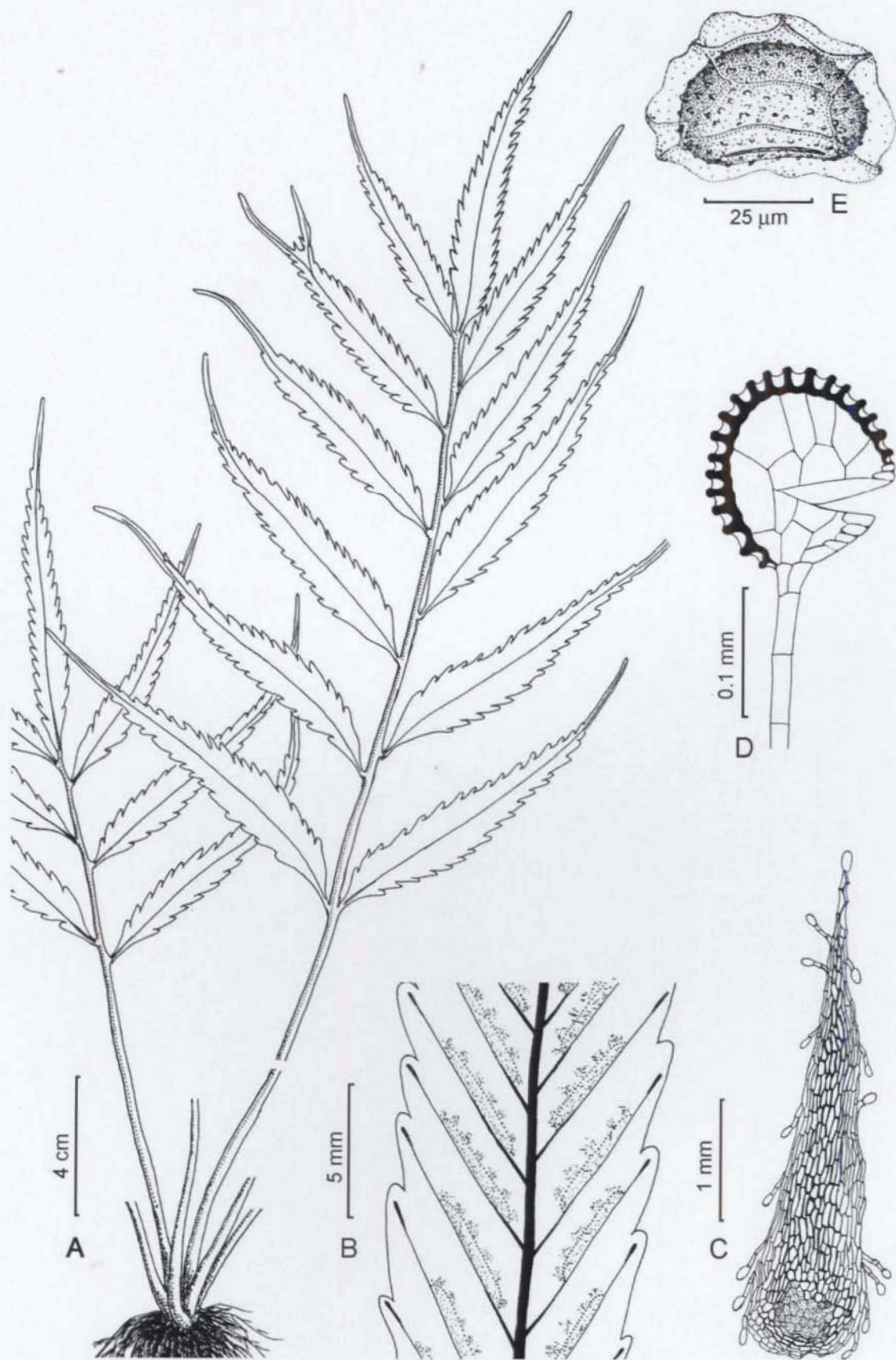


Fig. 28. *Asplenium serricula* Fee A. Habit; B. Pinna showing venation and position of sori; C. Palea on the rhizome; D. Sporangium; E. Spore.

221, Pl. 169 (1992); Nayar & Geevarghese, Fern Fl. Malabar 285, Pl. 116 (1993); Azeez *et al.*, J. Econ. Tax. Bot. 20(2): 435-455 (1996).

Asplenium wightianum Wall., Num. List. no. 2215 (1830) nom. nud., Beddome, Ferns S. India 125, t. 126 (1863), Handb. Ferns Br. India 146, t. 73 (1883).

Asplenium wightianum Wall. ex Hook., Sp. Fil. 3: 105, t. 165 (1860).

Fig. 28 (A-E); Plate 31 (A-E)

Rhizome suberect, ca. 1.5 cm thick, stout, scaly at the apex; palea narrow, 6 x 1 mm, ovate-lanceolate, dark brown and clathrate at the centre, margins pale and thin walled, entire, possess few glands on small uniseriate stalk, gland tipped. Frond tufted, 40-55 cm long, stipe 18-26 cm long, greenish when fresh, scaly at the extreme base, glabrous above; lamina imparipinnate, 24-30 x 12-16 cm, ending in a terminal pinna similar to lateral ones, rachis also greenish, grooved above, round below, bears 3-7 pairs of stalked pinnae, placed 4-5.5 cm apart; pinnae vary in size and number, 6-14 x 1-2 cm, widest at or near the middle, narrowing gradually to the tip, apex long acuminate consist of slightly lobed or unlobed prolongation which is up to 1-3 x 0.1 cm, tip round, occasionally pinna tip shows forking, margin regularly serrated, light green, glabrous above, few small pale brown lacinate scales below, subcoriaceous; veins distinct above and below, costa raised above, venation simple or base forked and tip simple or fully forked. Sori long, linear, 5-13 mm long, arranged in two oblique rows on either side of the costa, arising just above the costa, produced from the extreme base to

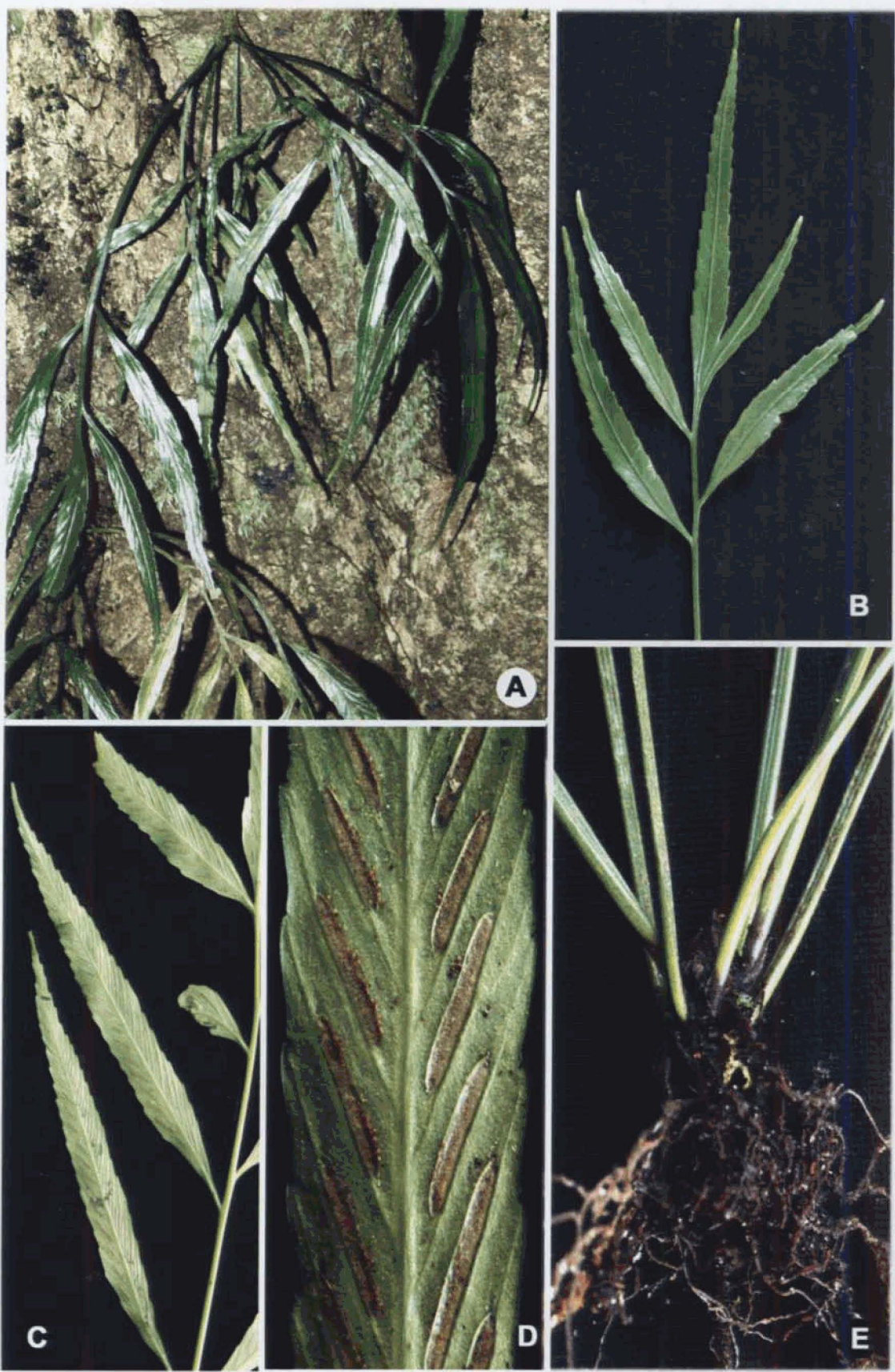


Plate 31. *Asplenium serricula* Fee A. Habit; B. Frond; C. Part of fertile frond; D. Part of pinna showing sori; E. Rhizome.

the tip of pinna, not on the narrow tip region. Spores 40 x 28 µm, monoletate, bilateral, perinate, exine granulose and bears some very small outgrowths which are not pointed, perine also granulose more or less loose, with anastomosing surface folds; unacetolysed spores 40 x 27 µm.

Distribution and Ecology: This species is not widely distributed in South India. Reported only from the Western Ghats of Kerala and Tamil Nadu states. No report elsewhere from India. Also occurs in Sri Lanka, Myanmar, Malaysia, Taiwan and Philippines. Commonly found growing as epiphytes in partially or fully shaded forests between 1000-2000 m.

Cytology: n = 72, tetraploid (Irudayaraj, 1990; Manickam and Irudayaraj, 1988).

Specimens examined: KERALA: Idukki Dt., Kallar coupe-Munnar Hills, *Manickam* 31453 (RHT); Tannikuzhi, *Nair* 70184 (MH); Meenmutty, *Pandurangan* 78051 (MH, CAL). **Palakkad Dt.,** Pulippara, *Satheeshkumar* 10599 (CALI); Silent Valley, *Nayar & Madhusoodanan* 10021 (CALI). **Pathanamthitta Dt.,** Moozhiyar-Sabarigiri, *Nayar & Madhusoodanan* 10081 (CALI). **Thiruvananthapuram Dt.,** Athirumala-Agasthyamala, *Azeez* 102768 (CALI), *Madhusoodanan & Nampy* 51929 (CALI); Kurishumalai-Bonnakad, *Mohanan* 59463 (MH), *Joseph* 46481 (MH); Agasthyamala, *Henry* 16308 (CAL); Ponmudi Hills, *Nair & Ghosh* 51668, 51739 (CAL). **TAMIL NADU: Coimbatore Dt.,** Neerar-Valparai, *Manickam & Mathew* 33088 (RHT); Sholayar Top, *Sebastine* 17268 (MH). **Dindigal Dt.,** Kodaikanal, *Manickam*

287 (RHT). **Madurai Dt.**, Vellimalai, *Shetty* 10315 (MH, CAL). **Ramanathapuram Dt.**, Deviar estate, Sethur Hills, *Srinivasan* 65994 (MH, CAL). **Tirunelveli Dt.**, Kothayar, *Nampy* 45102 (CALI), *Sevichan & Madhusoodanan* 44864 (CALI); Kakachi-Kothayar Hills, *Manickam* 32031 (RHT); Muthukuzhi, *Henry* 60737 (MH, CAL); Muthukuzhivayal, *Henry* 48290 (CAL); Kalakkad Hills, *Manickam* 31251, 31318 (RHT); Walayar estate, *Sebastine* 9940 (MH, CAL); Kannikatti Forest, *Sebastine* 9608 (MH, CAL), *Henry* 68819 (MH, CAL); Naterikal, *Vajravelu* 29231 (MH).

***Asplenium tenerum* G. Forst.**

Prodr. Florul. Ins. Austr. 80 (1786)

Beddome, Handb. Ferns Br. India 147, t. 74 (1883); Holttum, Rev. Fl. Mal. 2: 432 (1954); Sledge, Bull. Br. Mus. Nat. Hist. Bot. 3(6): 253 (1965), Bot. J. Linn. Soc. 84: 14 (1982); Nayar & Kaur, Comp. Beddome Handb. 36 (1974); Dixit, Cens. Ind. Pterid. 121 (1984); Baishya & Rao, Ferns & Fern Allies Meghalaya 116 (1982); Chandra & Kaur, Nom. Guide Beddome F.S.I. & F.B.I. 16, 27 (1987); Jamir & Rao, Ferns Nagaland 290 (1988); Singh & Bir, Ind. Fern J. 6(1-2): 272, 280, 281 (1989); Manickam & Irudayaraj, Pterid. Fl. Western Ghats 222, Pl. 170 (1992); Azeez *et al.* J. Econ. Tax. Bot. 20(2): 435-455 (1996).

Asplenium elongatum Swartz, Syn. Fil. 79 (1806); Hook., Sp. Fil. 3: 117 (1860); Beddome, Ferns S. India 223, t. 224 (1863); Thw., Enum. Pl. Zeyl. 383 (1864).

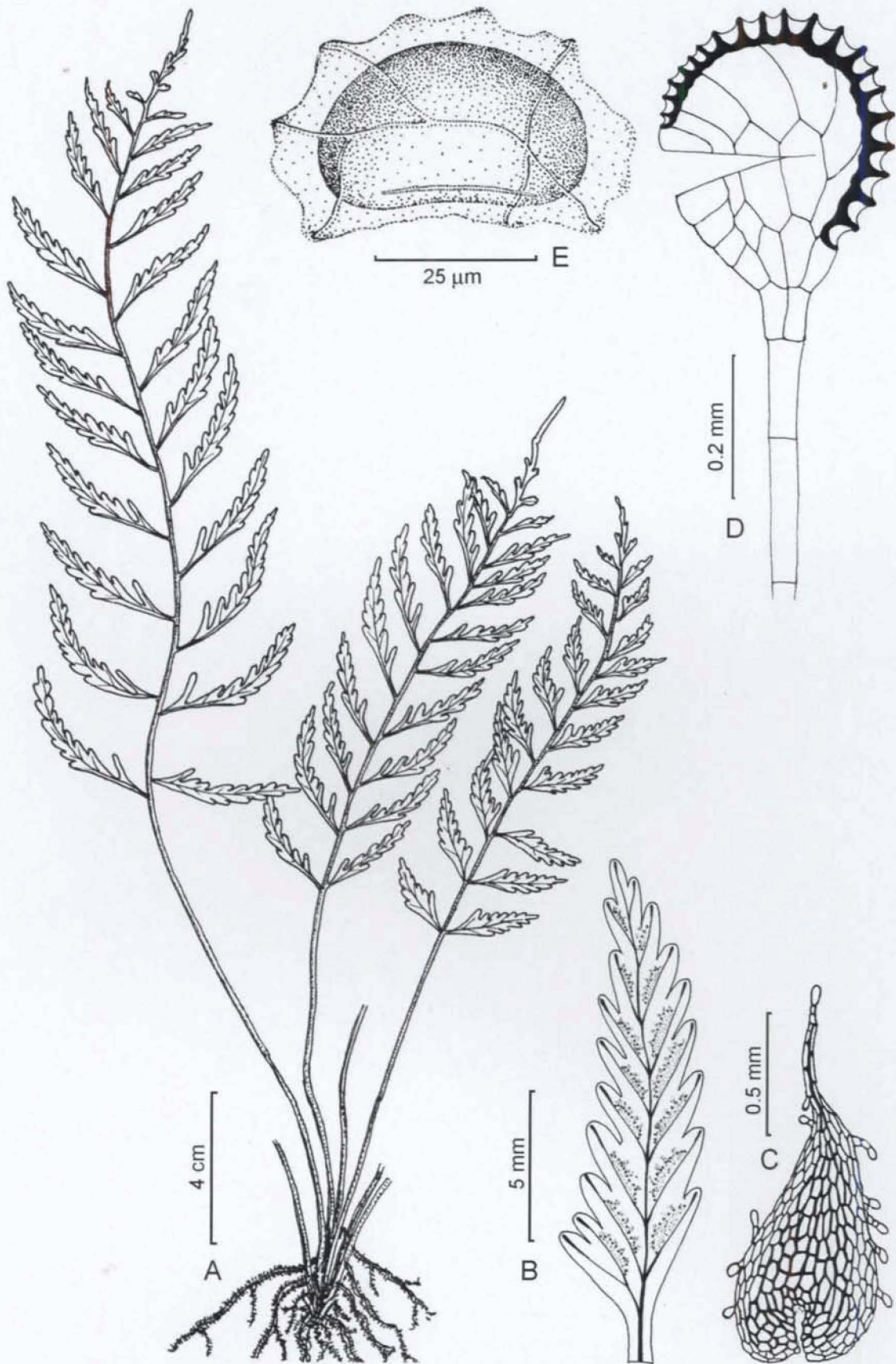


Fig. 29. *Asplenium tenerum* G. Forst. **A.** Habit; **B.** Pinna showing venation and position of sori; **C.** Palea on the rhizome; **D.** Sporangium; **E.** Spore.

Asplenium tenerum var. *terminans* Mett., Abhandl. Senckenb. Naturforsch. Ges. 3: 113 (1859).

Fig. 29 (A-E); Plate 32 (A-F)

Rhizome erect, ca. 1 cm thick, clothed by scales at the apex; palea small, 2 x 1 mm, ovate-lanceolate, clathrate, base round, apex acuminate, basally attached, margin entire with few small glandular hairs. Fronds tufted, 20-35 cm long; stipe 8-10 cm, grey green, glabrous, rounded abaxially, shallowly grooved adaxially, lamina simply pinnate, 15-20 x 5-9 cm, oblong-lanceolate, colour and nature of the rachis similar to stipe, bears up to 12 to 17 pairs of pinnae, basal few well stalked, upper ones sessile or subsessile, pinnae gradually reduced towards the apex into a narrow winged prolongation with simple oblique lobes, basal pinnae not reduced, largest pinna 5 x 0.8 cm, lanceolate, slightly falcate, acroscopic basal lobe bifid, basiscpic base excised for a short distance, margin possesses regular, oblique, blunt teeth, apex usually rounded, texture herbaceous, glabrous above and below; veins distinct below, costa slightly raised above, acroscopic basal vein forked once, remaining ones simple. Sori 4-6 mm long, arranged in two regular oblique rows on either side of the costa, upto 10 pairs per pinnae. Spores 43 x 29 μm , monoletic, bilateral, perinate, exine granulate, perine loose, winged with few anastomosing surface folds; unacetolysed spores 43 x 28 μm .

Distribution & Ecology: This species is not widely distributed in South India. Reported from Agasthyamala, Sholayar forests, Silent Valley,



Plate 32. *Asplenium tenerum* G. Forst. A. Habit; B. Frond (dorsal); C. Fertile frond; D. Part of fertile frond showing sori; E. Pinna magnified; F. Rhizome.

Moozhiyar-Sabarigiri forests, and Munnar Hills of Kerala. This species is rare in Tamil Nadu. Reported only from Anamalai Hills and Tirunelveli Hills. No report elsewhere from South India. Also reported from Eastern Himalaya. The distribution is extended to Sri Lanka, Borneo, Thailand, Malaysia, Taiwan, Japan, Sumatra, Philippines, Java, Marianus Island, New Guinea, Vietnam, Mascareen Islands and Polynesia. Commonly found growing as epilithic in fully shaded streams or stream banks between 700-1300 m.

Cytology: No report.

Notes: *Asplenium tenerum* G. Forst. are morphologically closely related to *A. serricula* Fee. But they can be easily distinguished from each other by the difference in the apex of the frond and nature of veins. In *A. serricula* Fee the frond is imparipinnate with a terminal pinna similar to the lateral ones and the veins reaching the margin, while in *A. tenerum* G. Forst. the frond terminates in a narrow, winged prolongation bearing oblique lobes and the veins which are simple and not bifid except for the acroscopic basal one and not reaching the margin.

Specimens examined: **KERALA:** Idukki Dt., Kallar Coupe-Munnar Hills, Manickam 31453 (CALI); Sivagiri-near Eltheri, Mohanan 72816 (MH, CAL); Vellimala, Raju Antony 18685 (TBGT). Palakkad Dt., Karapara Top – Silent Valley, Nair 69782 (MH, CAL). Pathanamthitta Dt., Anathode-Sabarigiri, Nayar 10117 (CALI); Moozhiyar-Sabarigiri, Nayar 10082 (CALI); Gavi, Manickam & Mathew 34303 (RHT). Thiruvananthapuram Dt., Agasthyamala, Madhusoodanan & Nampy 51920 (CALI); Darbhakulam-

Ponmudi, *Nair & Ghosh* 51682 (CAL). **Thrissur Dt.**, Sholayar forest, Azeez 102793 (CALI).

***Asplenium tenuifolium* D. Don**

Prodr. Fl. Nepal 8 (1825)

Beddome, *Ferns S. India* 44, t. 130 (1863), *Handb. Ferns Br. India* 159, t. 78 (1883); Clarke, *Trans. Linn. Soc. London. II Bot.* 1: 485 (1880); Hope, *J. Bomb. Nat. Hist. Soc.* 13: 667 (1901); Mehra & Bir, *Res. Bull. Punjab Univ. (N.S.)* 15: 158 (1964); Sledge, *Bull. Br. Mus. Nat. Hist. Bot.* 3: 275 (1965); Nayar & Kaur, *Comp. Beddome Handb.* 38 (1974); Dhir, *Ferns N.W. Himal.* 113 (1980); Baishya & Rao, *Ferns & Fern Allies, Meghalaya* 166 (1982); Dixit, *Cens. Ind. Pterid.* 121 (1984); Manickam, *Fern Fl. Palni Hills* 94 (1986); Chandra & Kaur, *Nom. Guide Beddome F.S.I. & F.B.I.* 16 (1987); Jamir & Rao, *Ferns Nagaland* 290 (1988); Singh & Bir, *Ind. Fern J.* 6(1-2): 271, 278, 279 (1989); Manickam & Irudayaraj, *Pterid. Fl. Western Ghats* 223, Pl. 171 (1992), *Pterid. Fl. Nilgiris* 129, Pl. 22 (2003).

Fig. 30 (A-E); Plate 33 (A-E)

Rhizome erect, 0.5-1 cm thick, densely scaly at the apex; palea small, narrow, dark brown, ovate lanceolate, 3.5 x 1 mm. Fronds tufted, light green, 22-34 cm, stipe 5-10 cm, scaly at the base, dark brown, glabrous above, rounded abaxially, flattened adaxially, shallowly grooved and not polished. Lamina 17-24 x 5-7 cm, ovate lanceolate, tripinnate, often gemmiparous at the tip, primary pinnae 7-8 pairs, alternate, 2-3 cm apart, ovate lanceolate, 4-

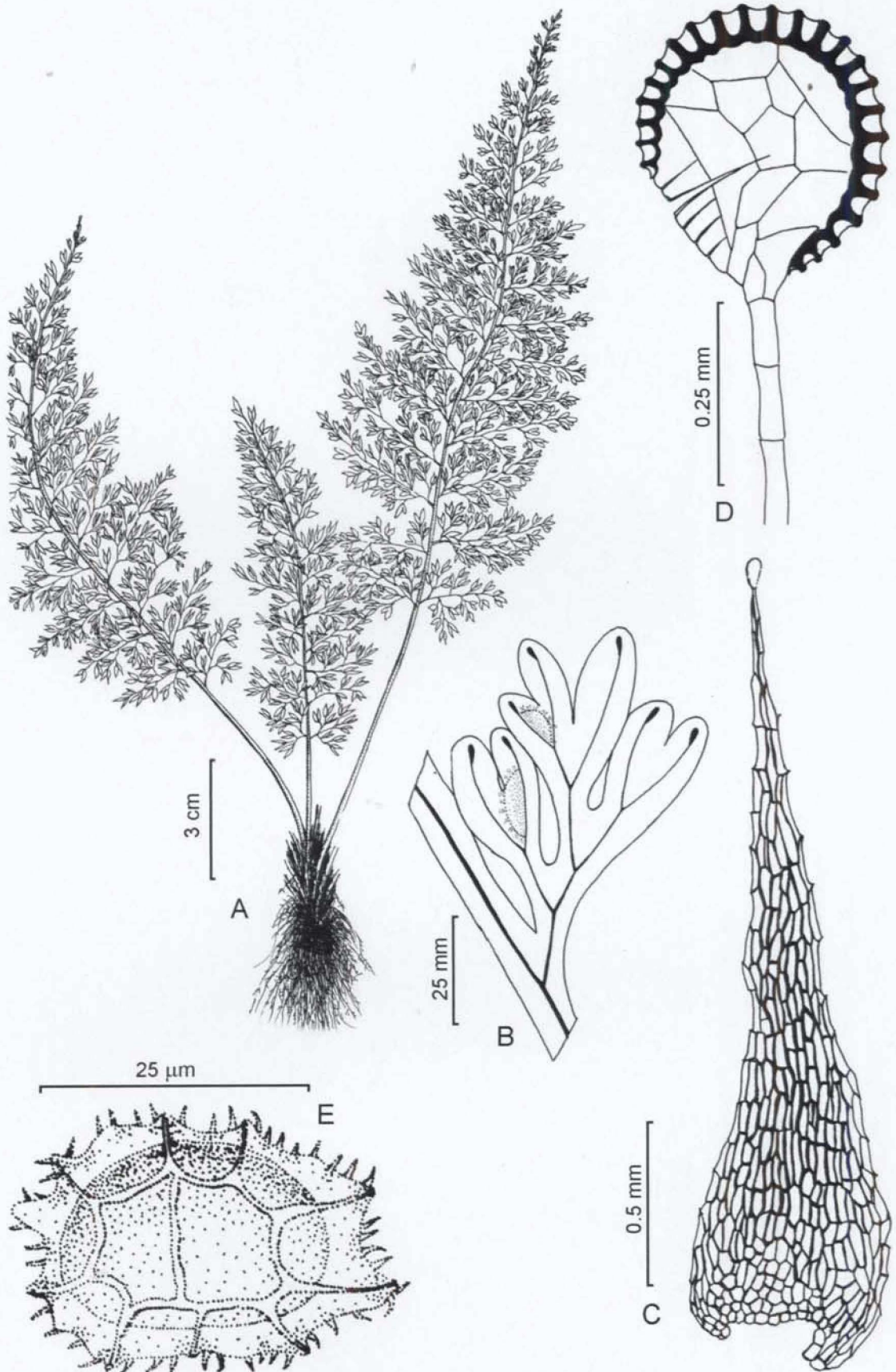


Fig. 30. *Asplenium tenuifolium* D. Don A. Habit; B. Part of pinna showing venation and position of sori; C. Palea on the rhizome; D. Sporangium; E. Spore.

6 x 1-1.5 cm, secondary pinnae 4-5 pairs, alternate, 0.5 cm apart, terminating in a bilobed or trilobed pinnule, pinnae pale green, glabrous above and below, texture thin and herbaceous; veins obscure, one per lobe, forked once or twice, not reaching the margin, vein endings swollen. Sori up to 2 mm long, one or two per pinnule, indusium membranous. Spores 50 x 35 μm , monolete, bilateral, perinate, exine brown, granulate all over, perine loose, spinulose with scattered large oval bare areas, wrinkled in to crowded folds forming a reticulate pattern with no spinules in the lumina. Unacetolysed spores 45 x 35 μm .

Distribution and Ecology: This species is not widely distributed in Kerala, reported only from Munnar Hills of Idukki Dt. and Vellarimala of Kozhikode Dt. But this taxon is distributed more widely in Tamil Nadu, reported from Nilgiri Hills, Palni Hills and Anamalai Hills and is also reported from B.R. Hills of Karnataka. Also reported from Sikkim Himalaya, North-Eastern Himalaya, Arunachal Pradesh and West Bengal. The distribution is extended to Sri Lanka, Bhutan, U.S.A., Taiwan, Nepal, China and Burma. Commonly found growing as epilithic or rarely terrestrial along fully shaded streams or stream banks between 1600-2400 m.

Cytology: $n = 36$, diploid (Bir, 1965; Kuriachan, 1978; Manickam & Irudayaraj, 1988; Irudayaraj & Bir, 1994).

Specimens examined: **KARNATAKA:** Mysore Dt.: B.R. Hills, *Rajagopal* 354 (MGMC). **KERALA:** Idukki Dt., Eravikulam National Park-Munnar,



Plate 33. *Asplenium tenuifolium* D. Don **A.** Habit; **B.** Frond; **C.** Part of frond showing sori; **D.** Bulbils from tip of frond; **E.** Rhizome.

Azeez 102788 (CALI); Naimakad-Munnar Hills, *Manickam* 31400 (RHT); Vagavari-Munnar, *Manickam & Mathew* 34469 (RHT). **Kozhikode Dt.**, Vellarimala, *Satheeshkumar* 70362 (CALI). **TAMIL NADU: Coimbatore Dt.**, Valparai - Anamalai Hills, *Mathew* 31651 (RHT); Thankamalai, *Chandrabose* 65840 (MH). **Dindigal Dt.**, Kodaikanal, *Azeez* 102725(CALI), *Gamble* 11479 (MH), *Manickam* 204, 758, 35567 (RHT), *Manickam & Mathew* 34935 (RHT); Kundalay forest-Palni Hills, *Manickam* 1494 (RHT). **Kanyakumari Dt.**, Mahendragiri Top, *Shetty* 32363 (MH). **Nilgiri Dt.**, Naduvattom, *Azeez* 102706 (CALI), *Shetty* 34436 (MH), *Ellis* 34741 (MH), *Subramanyan* 10588 (MH), *Sharma* 36106 (MH); Kurisumalai, *Ellis* 37779 (MH); T.R. Bazar, *Ellis* 43333 (MH); Lakkadi-Upper Bhavani, *Shetty* 34055 (MH); Avalanchi-Ooty, *Nampy* 48815 (CALI).

***Asplenium trilobatum* Azeez & Madhus. sp. nov.**

Similis ad *Asplenium erectum* Bory ex Willd. sed est dissimile in habens duo distinctae magnae subopposita pinna inferiores edens facies trilobata et non-glandulares paleae.

Fig. 31 (A-E); Plate 34 (A-E)

Rhizome erect, 1.5 cm thick, covered with scales at the tip; scales ovate lanceolate, ca. 2 x 0.5 mm, apex acuminate, margin entire, uniformly dark. Fronds tufted, 32-36 cm long, 3-4 cm wide at the middle; stipe dark, 9-11 x 0.2 cm, glabrous, rounded below, grooved above; lamina

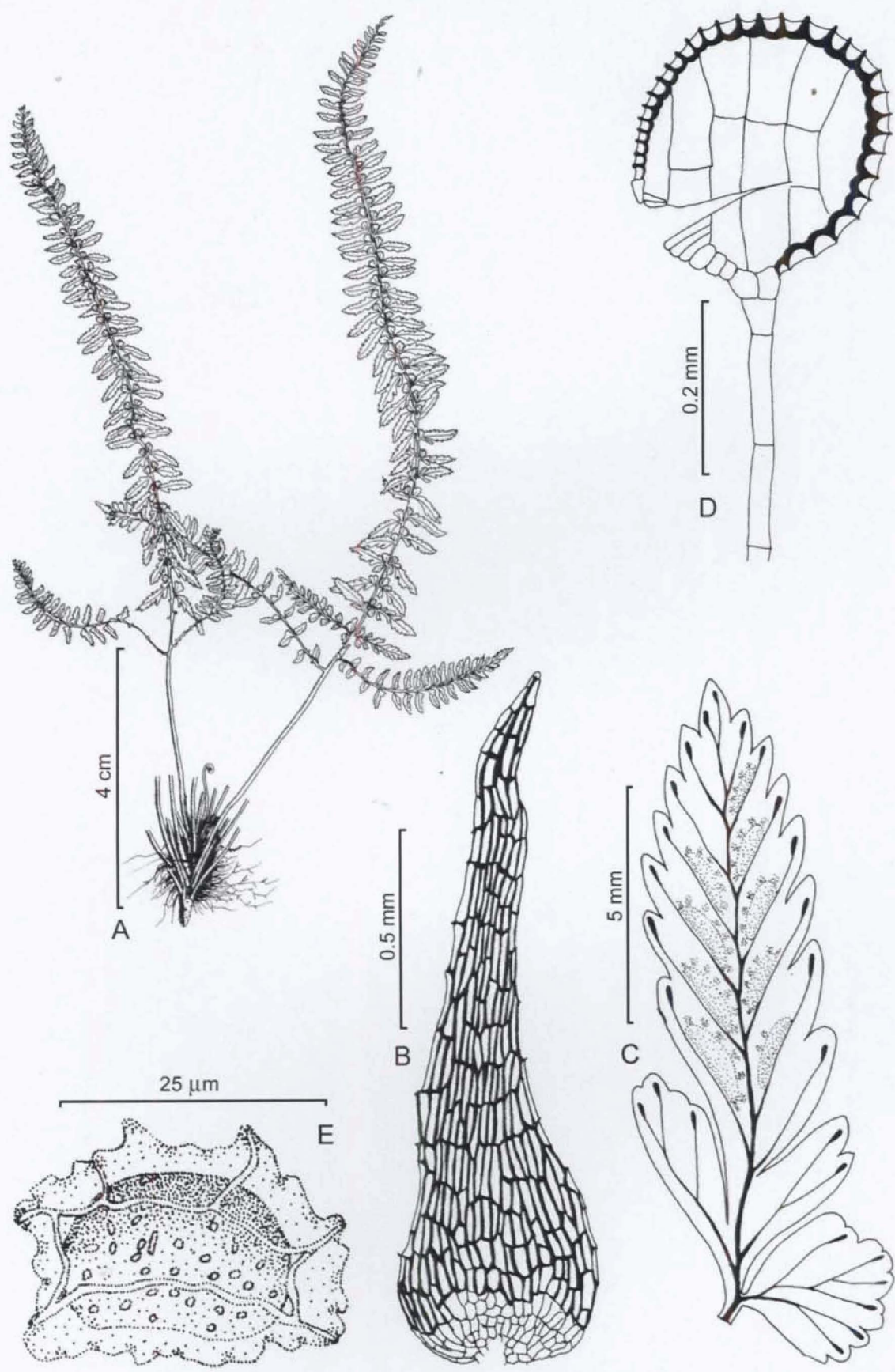
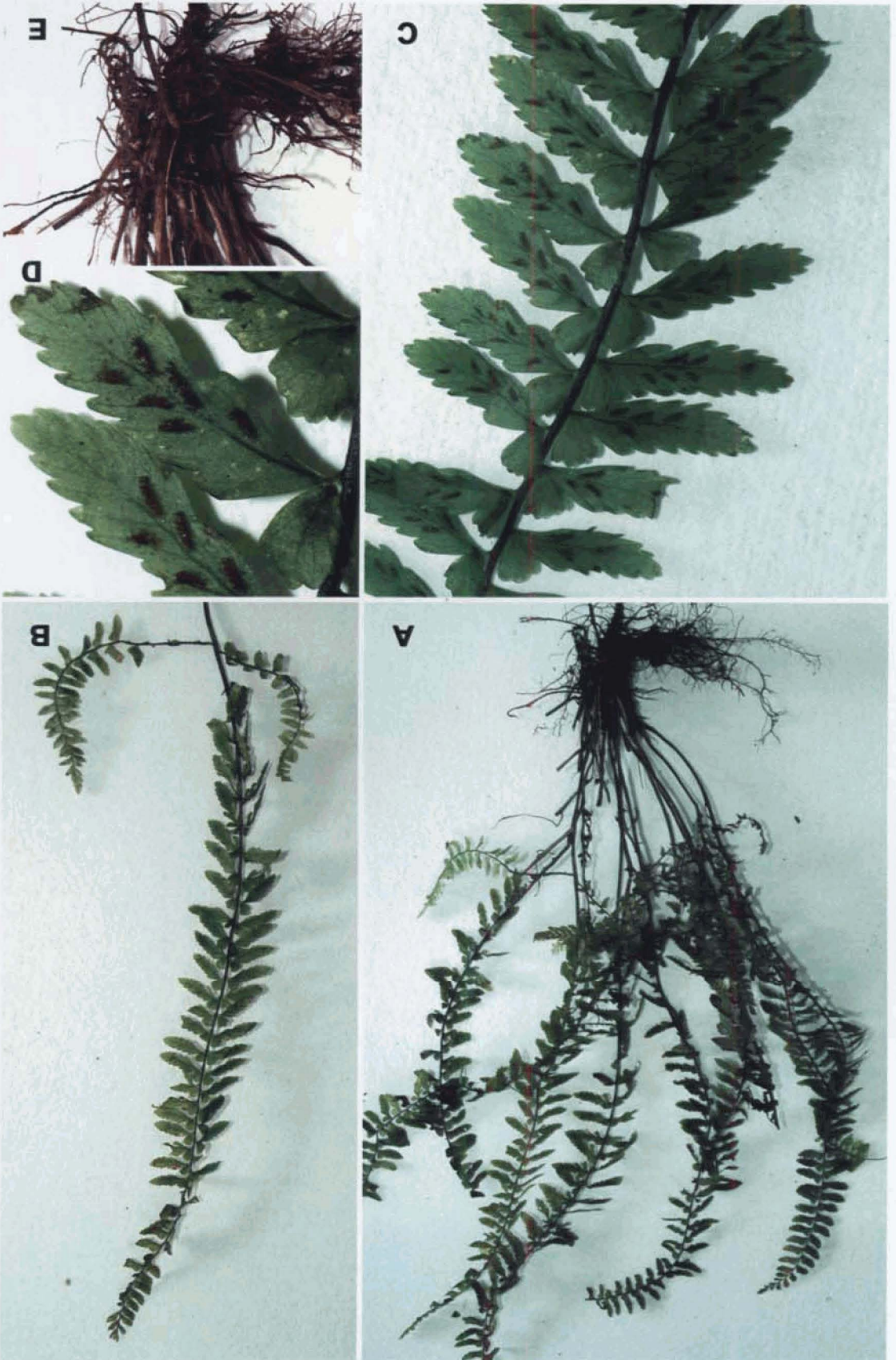


Fig. 31. *Asplenium trilobatum* Azeez & Madhus. sp. nov. A. Habit; B. Palea on the rhizome; C. Pinna showing venation and position of sori; D. Sporangium; E. Spore.

characteristic, 23-26 cm long, bipinnate, pinnae up to 37 pairs, deflexed, alternate, placed 0.5-1 cm apart, very shortly stalked, pinnae gradually reduced towards the tip into a slightly lobed short wing; basal most 1 or 2, rarely 3 or 4 pairs of pinnae highly developed and clearly pinnatifid, lowermost is the biggest one, 8-11 cm long, simply pinnate, upto 15 pairs of pinnules, pinnules gradually reduced towards the tip into a short lobed wing; biggest pinna of the main lamina ca. 2 x 0.5 cm, margin crenate or shallowly incised, basiscopic base slightly excised, acroscopic basal pinnule distinct, 0.5 x 0.3 mm, rest of the part adnate and ending in a pointed tip; veins distinct above and below, not raised, vein endings swollen, reaching the margin; pinnules of lower lateral branches small, 1.3 x 0.3 cm, entire, basiscopic base slightly excised, acroscopic side entire, slightly crenate. Sori small, upto 2 mm, 3-4 pairs per pinna, arranged in two oblique rows on either side of the costa,, not seen on the acroscopic basal pinnule, present on the pinnules of lateral branches also. Spores 30 x 17 μm , plano-convex or reniform, monolete, bilateral, perinate, with a uniformly granulose exine, but bears few dark, oval spots here and there, perine loose, smooth, forming undulating surface folds. Unacetolysed spores 29 x 17 μm .

Distribution and Ecology: Very rare species, not well distributed. It is collected from the forests of Avalanchi-Ooty. No report elsewhere from India. It is found growing in fully shaded forest floors at an elevation of 2300 m.

Plate 34. *Asplenium trilobatum* Azeez & Madhus. sp. nov. A. Habit; B. Entire frond; C. Part of frond showing sori; D. Pinna magnified; E. Rhizome.



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201-4

Note: This taxon is similar to *A. erectum* Bory ex Willd., but differs in fronds having two distinct large sub-opposite lower pinnae giving a trilobed appearance and non-glandular paleae.

Specimens examined: TAMIL NADU: Nilgiri Dt., Avalanchi forest, Azeez 103707 (CALI).

***Asplenium unilaterale* Lam. Complex**

Encycl. Mett. Bot. 2: 305 (1786)

Asplenium unilaterale Lam. is both morphologically and cytologically variable. So Hayata (1927) and Bir (1960, 1963) segregated *A. unilaterale* Lam. to the rank of a subgenus, *Hymenasplenium* (Hayata) Bir. In the present investigation two varieties of *A. unilaterale* Lam. are reported, viz., var. *birii*, and var. *unilaterale*, showing differences in the size of the frond, size, shape, arrangement and nature of margin of the pinnae, etc. Beddome (1883) reported another variety, *A. unilaterale* Lam. var. *rivale* Bedd. from Palni Hills and Anamalai Hills. Dixit (1984) reported this variety as an endemic taxon of South India. Bir (1994) raised this variety to the rank of a species, *A. hindusthanensis* Bir. In the present investigation, this taxon was collected from different localities of South India and followed the treatment of Bir (1994).

Key to varieties of *Asplenium unilaterale* Lam.

- 1a. Rhizome long creeping, Fronds up to 40
cm long, basiscopic base of the pinnae
not excised, tip of the pinna conical.....var. *birii*
- 2a. rhizome short creeping, fronds up to
55cm long, 2/3 part of the basiscopic
base excised, tip of the pinna round..... var. *unilaterale*

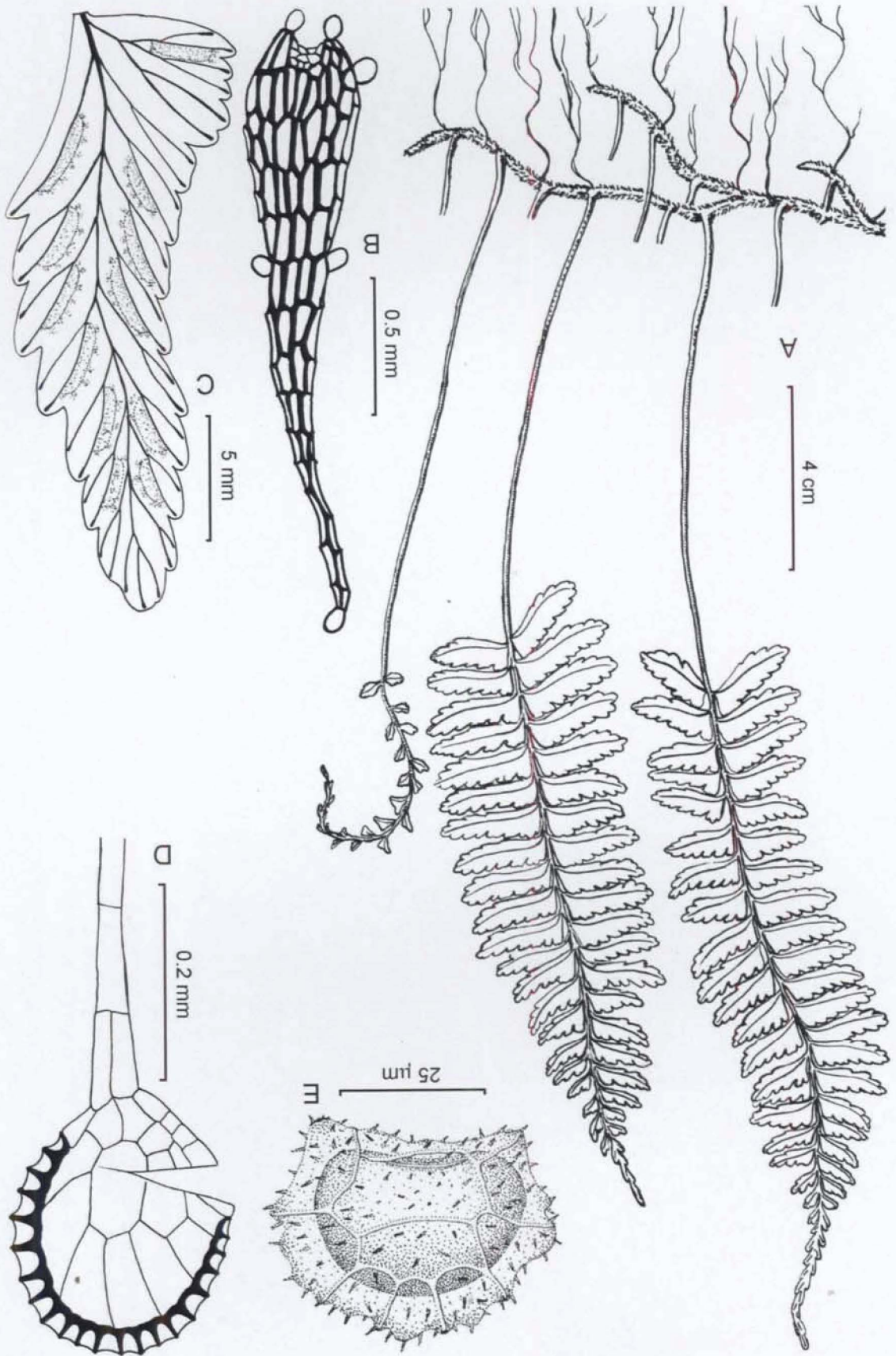
Asplenium unilaterale Lam. var. *birii* Nayar & Geev.

Fern Fl. Malabar 289 (1993)

Fig. 32 (A-E); Plate 35 (A-E)

Rhizome long creeping, ca. 2-3 mm thick, covered by small scales, densely scaly at the apex; palea small, 3 x 0.6 mm, ovate-lanceolate, base broader, basally attached, clathrate, margin entire, bears few sessile glands, narrowed towards the tip, apex gland tipped. Fronds 25-38 cm long; arise in two dorsal rows; stipe 11-14 cm long, dark brown, thin, glabrous except at the very base; lamina unipinnate, 15-20 x 4-5 cm, ovate-lanceolate, colour and nature of the rachis similar to stipe, bears 18-20 alternate, closely set pinnae on either side, rachis grooved above, rounded below; a thin green membranous wing present on either side of the groove hence rachis looks greenish above; pinnae 2-2.5 x 0.5-0.8 cm, sub-sessile, opposite to sub-opposite or alternate, placed 0.5-1 cm apart, middle pinnae are larger,

Fig. 32. *Asplenium unilaterale* Lam. var. *birii* Nayar and Geev. A. Habit; B. Palea on the rhizome; C. Pinna showing venation and position of sori; D. Sporangium; E. Spore.



gradually reduced towards the tip into a regularly and slightly lobed wing, basal 2-3 pairs of pinnae slightly reduced and deflexed, basiscopic base not excised having a narrow lamina below the costa, upper margin and proximal half of the lower margin provided with distinct oblique teeth, pinnae not gradually reduced towards its tip, instead end in a blunt tip, dark green, herbaceous, glabrous above and below; veins distinct below, veins in the acroscopic basal lobes forked thrice, others forked once. Sori linear, small, ca. 4 mm long, arranged in two oblique rows on either side of the costa, usually one (rarely two) sorus on the acroscopic basal lobe arranged parallel to the rachis, sori confined to the acroscopic veins. Spores 36 x 25 μm , monolete, bilateral, perinate, exine granulose, perine loose, densely spinulose, undulating with anastomosing surface folds; unacetolysed spores 31 x 25 μm .

Distribution and Ecology: Rare, reported only from Panthenthode – Silent Valley and Agasthyamala Hills of Kerala state. Not reported from other parts of India. It is found growing in well shaded forest floors near streams between 1000-2000 m.

Cytology: No report

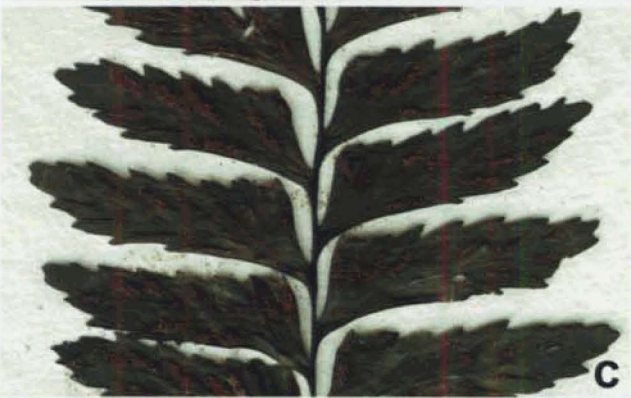
Specimens examined: KERALA: Palakkad Dt., Panthenthode – Silent Valley, *Geevarghese & Madhusoodanan* 29265 (CALI)- ISOTYPE; **Thiruvananthapuram Dt.,** Athirumala-Agasthyamala Hills, *Madhusoodanan & Nampy* 51913 (CALI).



A



B



C



D



E

Plate. 35. *Asplenium unilaterale* Lam. var. *birii* Nayar & Geev. A. Habit; B. Fertile frond; C. Part of frond showing sori; D. Pinnae magnified; E. Rhizome.

Asplenium unilaterale Lam. var. unilaterale

Encycl. Mett. Bot. 2: 305 (1786)

Clarke, Trans. Linn. Soc. II Bot. 1: 481 (1880); Beddome, Handb. Ferns Br. India 152 (1883); Holttum, Rev. Fl. Malaya 2: 438 (1954); Sledge, Bull. Br. Mus. Nat. Hist. Bot. 3: 245 (1965); Nayar and Kaur, Comp. Beddome Handb. 37 (1974); Iwatsuki, Hara Fl. East Himal. (3 Rep.) 195 (1975); Dhir, Ferns N.W. Himal. 109 (1981); Baishya & Rao, Ferns and Fern Allies Meghalaya 116 (1982); Manickam & Irudayaraj, Pterid Fl. Western Ghats 212, Pl. 160 (1992); Nayar and Geevarghese, Fern Fl. Malabar 288 (1993); Azeez *et al.* J. Econ. Tax. Bot. 20(2): 435-455 (1996); Borthakur *et al.*, Illus. Man. Ferns Assam 350, Pl. 169 (2000).

Asplenium resectum Smith, Pl. Ic. 3: t. 72 (1791); Beddome, Ferns S. India 45, t. 132 (1863).

Asplenium trapeziforme Wall. ex Roxb., Calc. J. Nat. Hist. 4: 497 (1844).

Asplenium erythrocaulon Bl., Enum. Pl. Jav. 183 (1828).

Fig. 33 (A-E); Plate 36 (A-D)

Rhizome short creeping, ca. 4 mm thick having sparsely distributed paleae; palea small, 3 x 0.4 mm, ovate-lanceolate, base broad, basally attached, dark brown, clathrate, margin entire with few sessile glands. Fronds 40-55 cm long, closely arranged ca. 5 mm apart; stipe 10-20 cm long, brown, glabrous; lamina unipinnate, oblong-lanceolate, 17-30 x 5-6 cm, colour and nature of the rachis similar to stipe, bears 20-34 pairs of pinnae, rachis rounded abaxially, grooved above having a narrow green wing on

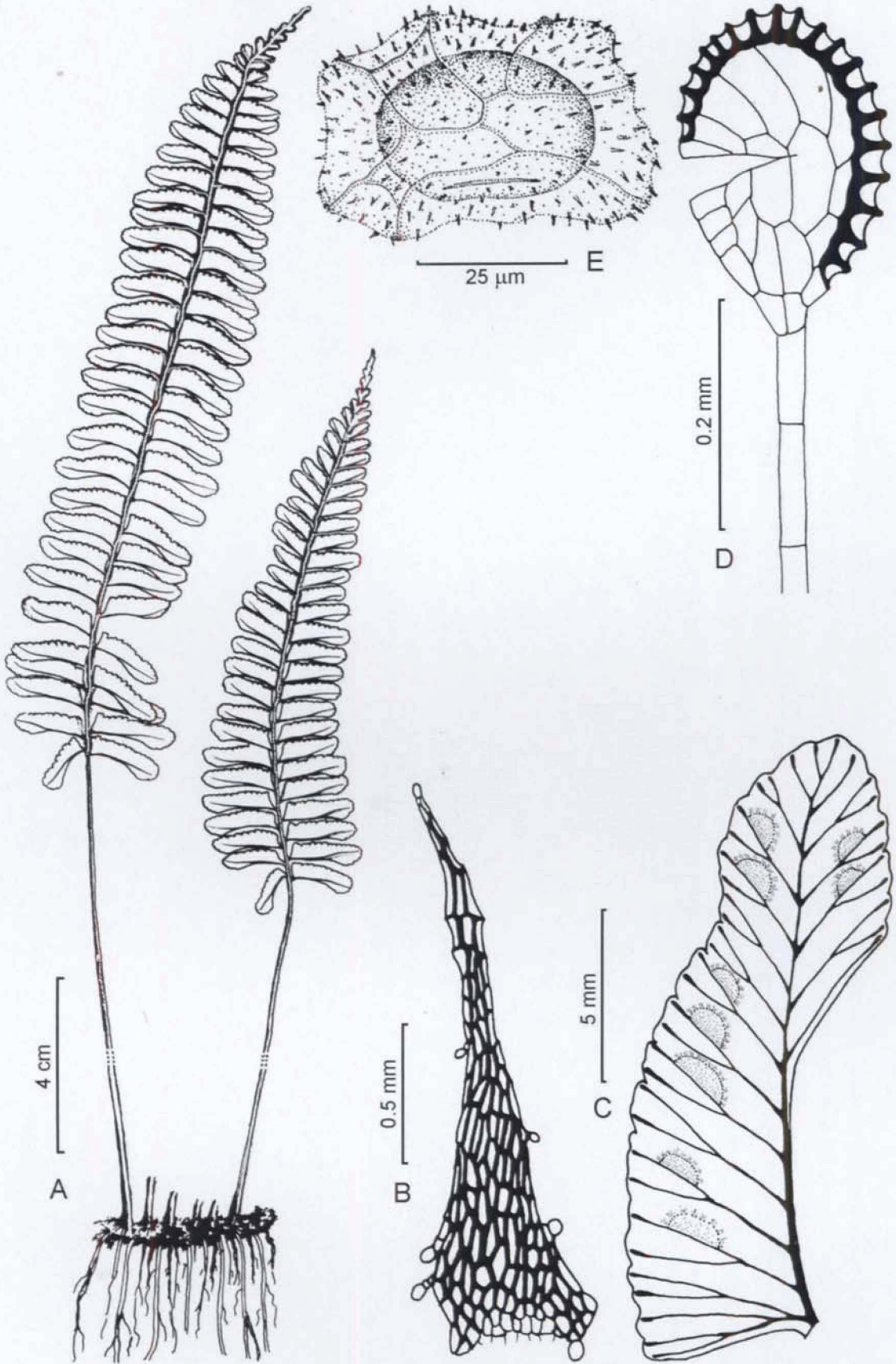


Fig. 33. *Asplenium unilaterale* Lam. var. *unilaterale*. A. Habit; B. Palea on the rhizome; C. Pinna showing venation and position of sori; D. Sporangium; E. Spore.

either side of the groove; pinnae usually sub-opposite or alternate, lowermost one slightly reduced and deflexed, closely arranged, 0.5-1 cm apart, lower ones shortly stalked, upper ones sessile, largest pinna 2-3 x 0.5-0.8 cm, acroscopic base truncate and more or less parallel to the rachis, ca. two-third region of the basisopic base excised, upper margin toothed, teeth arranged in group of two, having blunt tip, apex of the pinna blunt, gradually reduced towards the tip into a lobed wing with blunt apex, light green, herbaceous, glabrous above and below; veins distinct below, acroscopic basal vein forked twice or thrice, others forked only once, continuous to the tip of teeth. Sori small, more or less semicircular, ca. 1 mm long, usually confined to acroscopic veins, produced along the entire length of the pinna. Spores 36 x 25 μm , monolete, bilateral, perinate, exine granulose, perine densely spinulose, broad, loose and surface folds anastomosing; unacetolysed spores 35 x 25 μm .

Distribution and Ecology: This species is widely distributed in Kerala, reported from Agasthyamala, Sholayar Forest, Thekkadi, Munnar Hills, Chinnar Wild Life Sanctuary, Vellarimala Hills, Ponmudi Hills, Silent Valley and Sabarimala Hills of Kerala. Also reported from Kodaikanal, Nilgiri Hills, Tirunelveli Hills, Anamalai Hills of Tamil Nadu and Agumbe Reserve Forest of Karnataka. Also reported from North-Eastern Himalaya, Assam, Orissa, Simla, Kumaun Himalaya, North-West Himalaya, Garhwal, Nital, Almora and Uttaranchal. The distribution is extended to Sri Lanka, Malaysia, Bhutan, Polynesia, Japan, Nepal, Tropical Africa, Philippines, Hawaii,

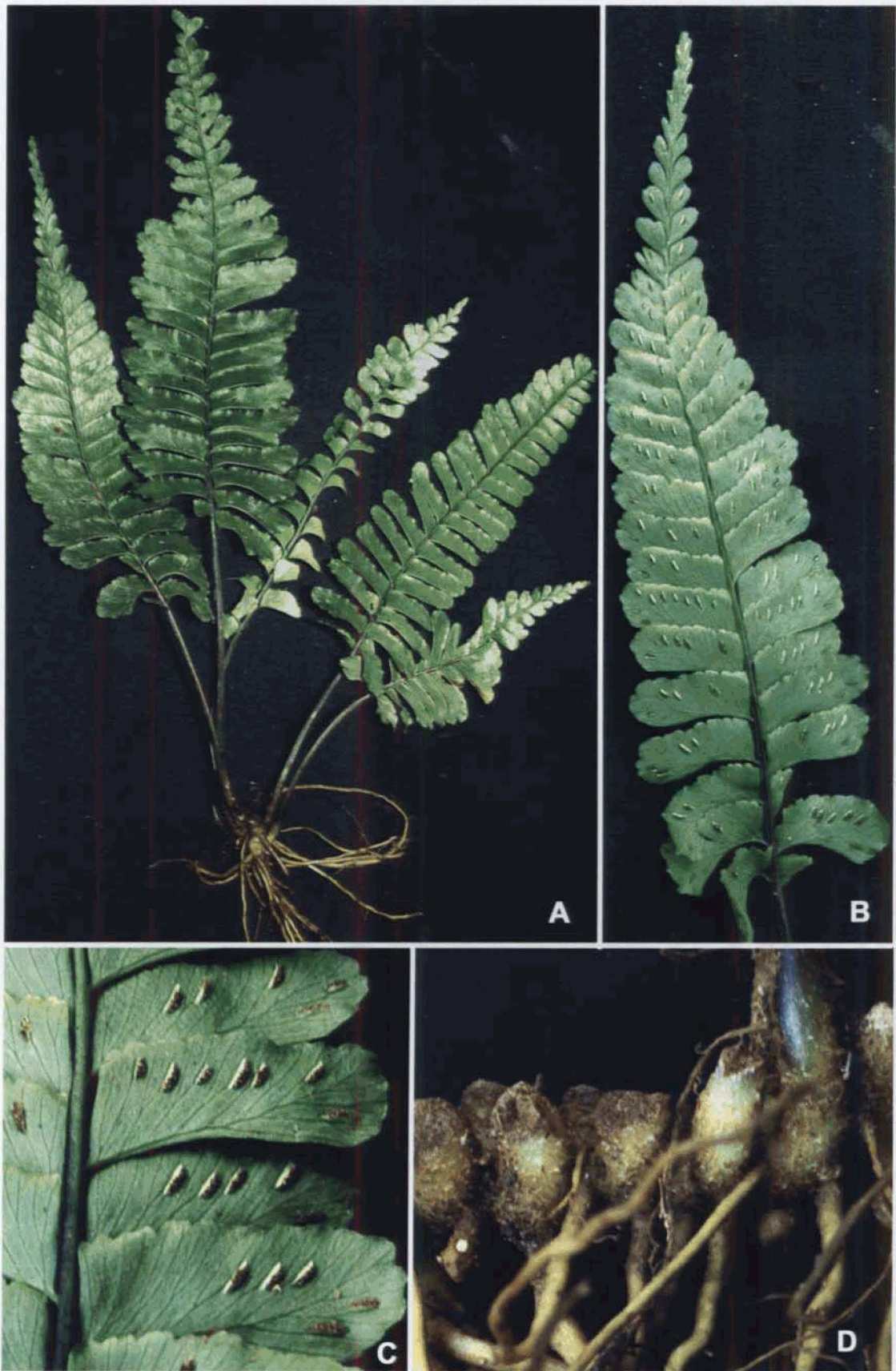


Plate 36. *Asplenium unilaterale* Lam. var. *unilaterale*. A. Habit; B. Fertile frond; C. Part of frond showing sori; D. Rhizome.

Vietnam, Myanmar, Taiwan, Ethiopia and Madagascar. It is commonly found growing in fully shaded forest floors at an elevation of 1200-1800 m.

Cytology: $n = 76$, $2n = \text{ca. } 152$, tetraploid (Kuriachan, 1968). $2n = 116$, triploid hybrid (Kuriachan, 1978). $n = 40$, diploid (Manickam & Irudayaraj, 1988; Irudayaraj, 1990; Ammal & Bhavanandan, 1991).

Specimens examined: **KARNATAKA:** Shimoga Dt., Agumbe Reserve Forest, *Nampy* 48829 (CALI). **KERALA:** Idukki Dt., Thekkady, Azeez 102737 (CALI); Petimudi, *Shetti* 26600 (MH); Vellimala, *Raju Antony* 18684 (TBGT). Kozhikode Dt., Pakranthalam-Kuttiadi, *Nayar & Geevarghese* 11625 (CALI), *Nayar & Madhusoodanan* 11653 (CALI); Vellarimala, *Satheeshkumar* 70378, 70394 (CALI). Palakkad Dt., Silent Valley, *Nair* 65458 (CAL). Pathanamthitta Dt., Pamba to Ayyappan Temple, *Nair* 50834 (CAL). Thiruvananthapuram Dt., Agasthyamala, Azeez 102760 (CALI); Ollavayal-Chinnar W.L.S., *Rajesh* 87785 (CALI); Ponmudi, *Nair & Ghosh* 51728, 52602 (CAL). Thrissur Dt., Sholayar forest, Azeez 102791, 102792 (CALI). **TAMIL NADU:** Coimbatore Dt., Sholayar Dam-Manampalli Road-Anamalai Hills, *Manickam* 34677 (RHT). Dindigal Dt., Kodaikanal, *Fischer* 3073 (CAL), *Sauliers* 1023 (CAL). Nilgiri Dt., Sim's Park-Coonoor, *Madhusoodanan* 21211 (CALI). Tirunelveli Dt., Muthukuzhi, *Henry* 52472 (MH, CAL).

***Asplenium yoshinagae* Makino subsp. *indicum*
(Sledge) Fraser-Jenk.**

Pakistan Syst. 5: 97 (1992)

Asplenium yoshinagae Makino var. *indicum* (Sledge) Ching & S.K. Wu, Fl. Xizangia 1: 182 (1983); Khullar & Sharma in Pangtey & Joshi, West. Himal. 1: 330 (1987); Khullar *et al.* in Pangtey & Joshi, West. Himal., 1: 373 (1987); Pande, Indian Fern J. 7: 173 (1990); Khullar *et al.*, Ferns Ninital 154 (1991); Manickam & Irudayaraj, Pterid. Fl. Nilgiris 127 (2003).

Asplenium indicum Sledge, Bull. Br. Mus. Nat. Hist. Bot. 3: 264 (1965); Nayar & Kaur, Comp. Beddome Handb. 37 (1974); Dhir, Ferns N.W. Himal. 109 (1980); Baishya & Rao, Ferns & Fern Allies Meghalaya 114 (1982); Manickam, Fern Fl. Palni Hills 101 (1986); Chandra & Kaur, Nom. Guide Beddome F.S.I. & F.B.I. 17 (1987); Manickam & Irudayaraj, Pterid. Fl. Western Ghats 215, Pl. 163 (1992); Azeez *et al.*, J. Econ. Tax. Bot. 20(2): 435-455 (1996); Pullaiah *et al.*, Pterid. Andhra Pradesh 123 (2003).

Asplenium planicaule Wall., Numer. List, B, n.189 (1829) nom. nud.

Asplenium falcatum var. *abbreviatum* Kunze, Linnaea 24: 260 (1851).

Asplenium planicaule Wall. ex Mett., Abhandl. Senckenb. Naturforsch.Ges. 3: 201 (1859); non *A. planicaule* Lowe (1958); Hook. Sp. Fil. 3: 163, t. 200 B (1860); Beddome, Ferns S. India 47, t.139 (1863); Hieron., Hedwigia, 61: 33 (1919).

Asplenium laciniatum sensu Beddome, Handb. Ferns Br. India 154 (1883) pro parte; non D. Don.

Fig. 34 (A-E); Plate 37 (A-F)

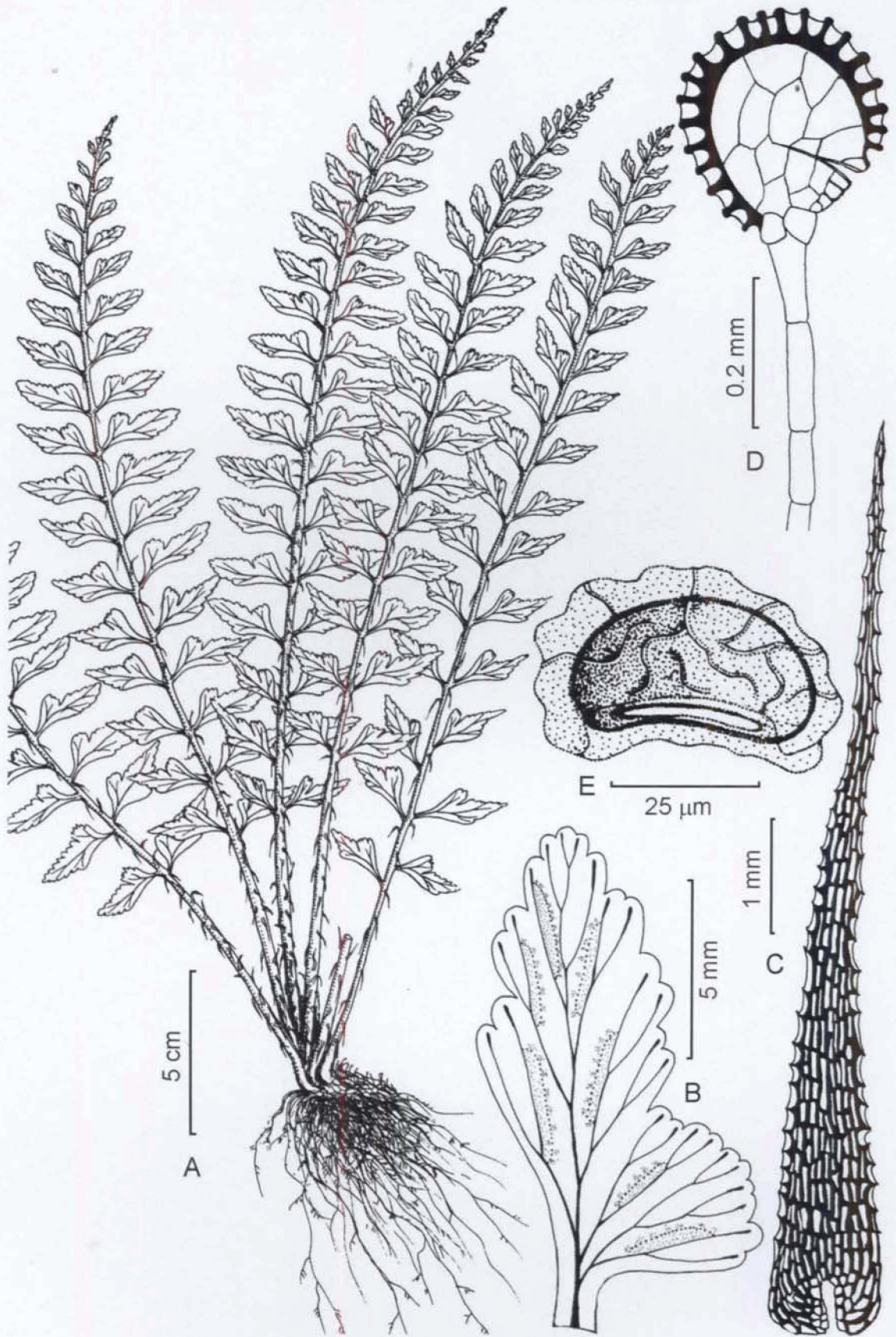


Fig. 34. *Asplenium yoshinagae* Makino subsp. *indicum* (Sledge) Fraser-Jenk. A. Habit; B. Pinna showing venation and position of sori; C. Palea on the rhizome; D. Sporangium; E. Spore.

Rhizome short, erect, ca. 1 cm thick, paleaceous all over; palea narrow, dark brown to black, 5 x 1 mm, linear-lanceolate, clathrate, basally attached, base cordate, tip acute. Fronds unipinnate, 25-35 cm long; both stipe and rachis paleaceous becoming glabrous with age, palea similar to that on the rhizome; stipe 6-8 cm long, brown below and green above when fresh, rounded below, grooved above; lamina unipinnate, oblong-lanceolate, ca. 15 x 3cm, bears up to 20 pairs of shortly-stalked lateral pinnae on green rachis, which are 1-2.5 cm long and nearly 1-1.5 cm broad, dimediate, texture stiff, sub-opposite at the base, alternate above, terminal segments not similar to the lateral ones (not deeply incised), lower pinnae slightly reduced, pinnae pinnatifid, margin irregularly lobed, lobes serrate, basal acroscopic lobe distinct, pinna glabrous above and below; venation forked, vein endings slightly swollen, reaching the margin. Sori linear, 5-8 mm long, restricted to the acroscopic veins. Spores 53 x 31 μm , monolete, bilateral, perinate, exine granulose, perine loose forming a narrow folded wing; unacetolysed spores 50 x 30 μm .

Distribution & Ecology: This is one of the most widely distributed species in South India. Distributed throughout the Western Ghat forests of Kerala, Kolli Hills, Palni Hills, Anamalai Hills of Tamil Nadu, Kudajadri and Koorg regions of Karnataka, Sunkerimetta and Kappakonda forests of Andhra Pradesh. Also reported from Simla Hills, Berinag Hills of West Himalaya, Kumaun Himalaya, North-West Himalaya, Almora, Ninital and Himachal Pradesh. The distribution is extended to Sri Lanka, China, Nepal, Bhutan,

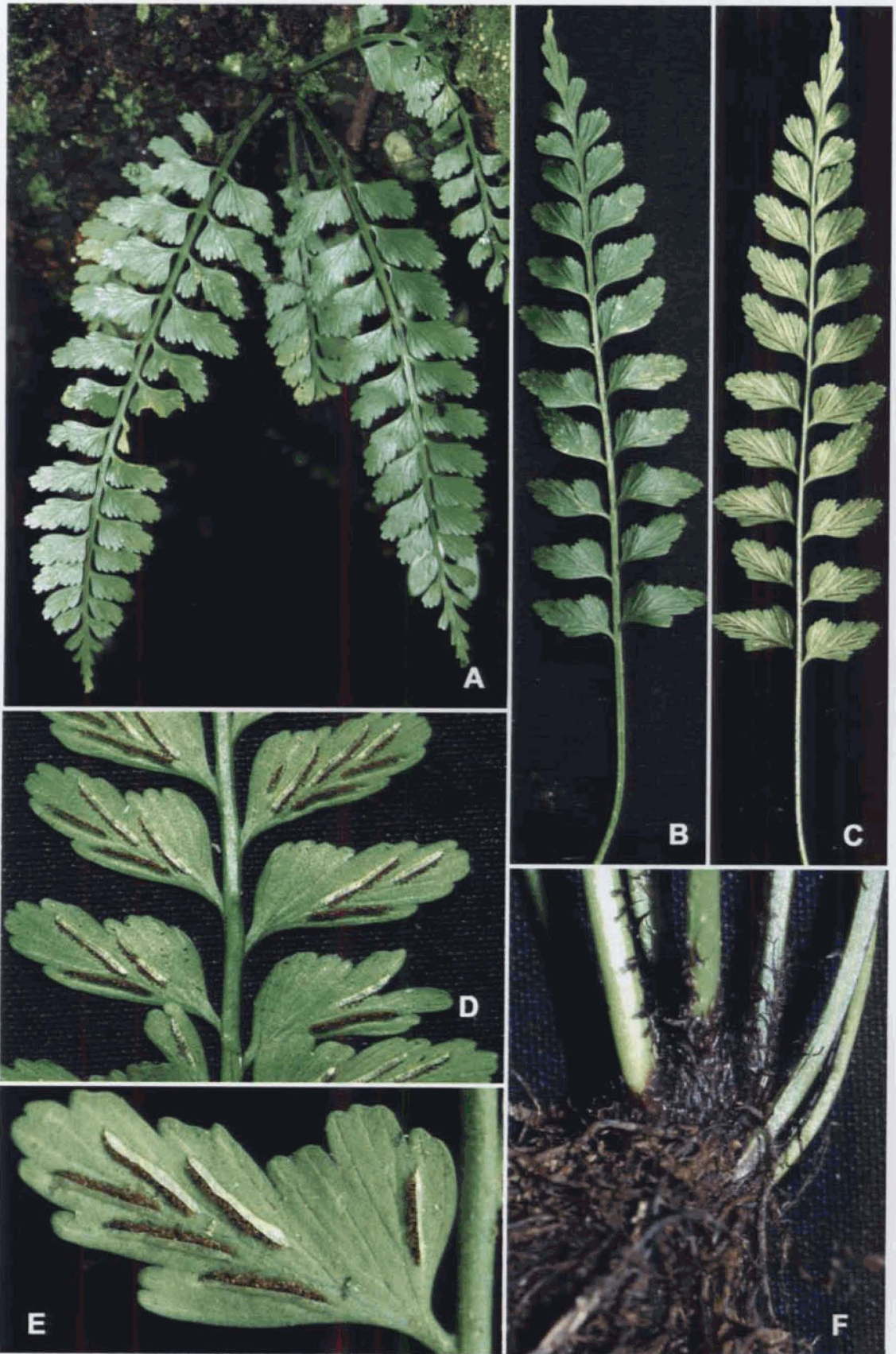


Plate 37. *Asplenium yoshinagae* Makino subsp. *indicum* (Sledge) Fras.-Jenk. A. Habit; B. Frond (dorsal); C. Fertile frond; D. Part of frond showing sori; E. Pinna magnified; F. Rhizome.

Malagasy, Taiwan, Tibet, Myanmar, Thailand, Indo-China, Philippines and Japan. Commonly growing as epilithic or epiphytes in Shola forests especially along stream banks between 700-2300 m.

Cytology: $n = 36$, diploid (Ammal & Bhavanandan, 1991). $2n = 144$, Octoploid (Kuriachan, 1968).

Specimens examined: ANDHRA PRADESH: Vishakapatanam Dt., Sunkerimetta forest, *Balakrishnan* 10937 (MH, CAL); Kappakonda, *Rao* 22626A (MH, CAL). **KARNATAKA: Shimoga Dt.,** Kudajadri, *Rajagopal* 519 (MGMC); Tadiyan dam – Koorg, *Rajagopal* 486 (MGMC). **KERALA: Idukki Dt.,** Eravikulam National Park-Munnar, *Azeez* 102784 (CALI); Vallakadavu, *Azeez* 102742 (CALI); Naimakad-Munnar Hills, *Manickam* 31399 (RHT); Thekkadi Hills, *Manickam & Mathew* 33378 (RHT); Way to Parriaru, *Pandurangan* 78019 (MH, CAL); Umaiyarmala-Devikulam, *Shetty* 26576 (MH); Maddalamkothi, *Mohanan* 72802 (MH, CAL). **Kozhikode Dt.,** Olichuchattam-Anakampoyil, *Azeez* 45929 (CALI); Vellarimala, *Geevarghese* 29478 (CALI), *Satheeshkumar* 70396 (CALI). **Palakkad Dt.,** Silent Valley, *Azeez* 102718 (CALI), *Nayar* 10071, 10177 (CALI), *Geevarghese* 17962 (CALI), *Vohra & Ghosh* 56313, 56339, 56391 (CAL), *Nair* 69592, 64315 (MH, CAL), 81263 (MH); Karapara Top, *Nair* 69774 (MH, CAL); Aruvampara forest, *Nair* 64412 (MH, CAL); Walakkad, *Nayar* 10667 (CALI); Punnamala, *Nayar* 10618 (CALI); Mukkali, *Geevarghese* 4082 (CALI), *Vohra & Ghosh* 58433 (CAL); Parambikulam, *Geevarghese* 17863 (CALI). **Pathanamthitta Dt.,** Kakki-Moozhiyar, *Azeez* 102748 (CALI);

Karimala, *Nayar* 7370 (CALI); Pamba road-Peerumed, *Manickam* 33433 (RHT). **Thiruvananthapuram Dt.**, Attayar-Agasthyamala, *Azeez* 102755 (CALI); Karamanayar-Agasthyamala, *Azeez* 102754 (CALI); Athirumala, *Azeez* 102767 (CALI); Way to Agasthyakoodam, *Azeez* 102758 (CALI); Ponmudi Hills, *Manickam & Mathew* 33786 (RHT), *Nair & Ghosh* 51754 (MH, CAL), 51808, 51855 (CAL); Bonnakad, *Mohanan* 59440 (CAL). **Wayanad Dt.**, Chembra Peak, *Azeez* 102715 (CALI), *Azeez & Madhusoodanan* 45910 (CALI); Sugandhagiri-Vythiri, *Sevichan* 29756 (CALI). **TAMIL NADU: Coimbatore Dt.**, Konalar - Anamalai Hills, *Chandrabose* 69014 (MH). **Dindigal Dt.**, Kodaikanal, *Manickam* 32680 (RHT), *Manickam & Mathew* 32719, 32825 (RHT); Pannaikad-Kodaikanal, *Ramamurthy* 23487 (MH); Manalar-Palni Hills, *Manickam* 31881 (RHT). **Madurai Dt.**, Uthamapalayam, *Manickam* 31488 (RHT). **Nilgiri Dt.**, Naduvattom, *Gamble* 7334 (CAL). **Selam Dt.**, Kolli Hills, *Azeez* 102798 (CALI), *Manickam & Mathew* 33158, 33257 (RHT); Kakka Shola-Yercaud, *Ghatak* 241, 418, 419, 590 (CAL).

Asplenium zenkeranum Kunze

Linnaea 24: 259 (1851)

Beddome, Handb. Ferns Br. Ind. 148 (1883); Sledge, Bull. Br. Mus. Nat. Hist. Bot. 3(6): 254 (1965), Bot. J. Linn. Soc. 84: 14 (1982); Nayar and Kaur, Comp. Beddome Handb. 36 (1974); Dixit, Cens. Ind. Pterid. 122 (1984); Manickam, Fern Fl. Palni Hills 95 (1986); Chandra & Kaur, Nom. Guide

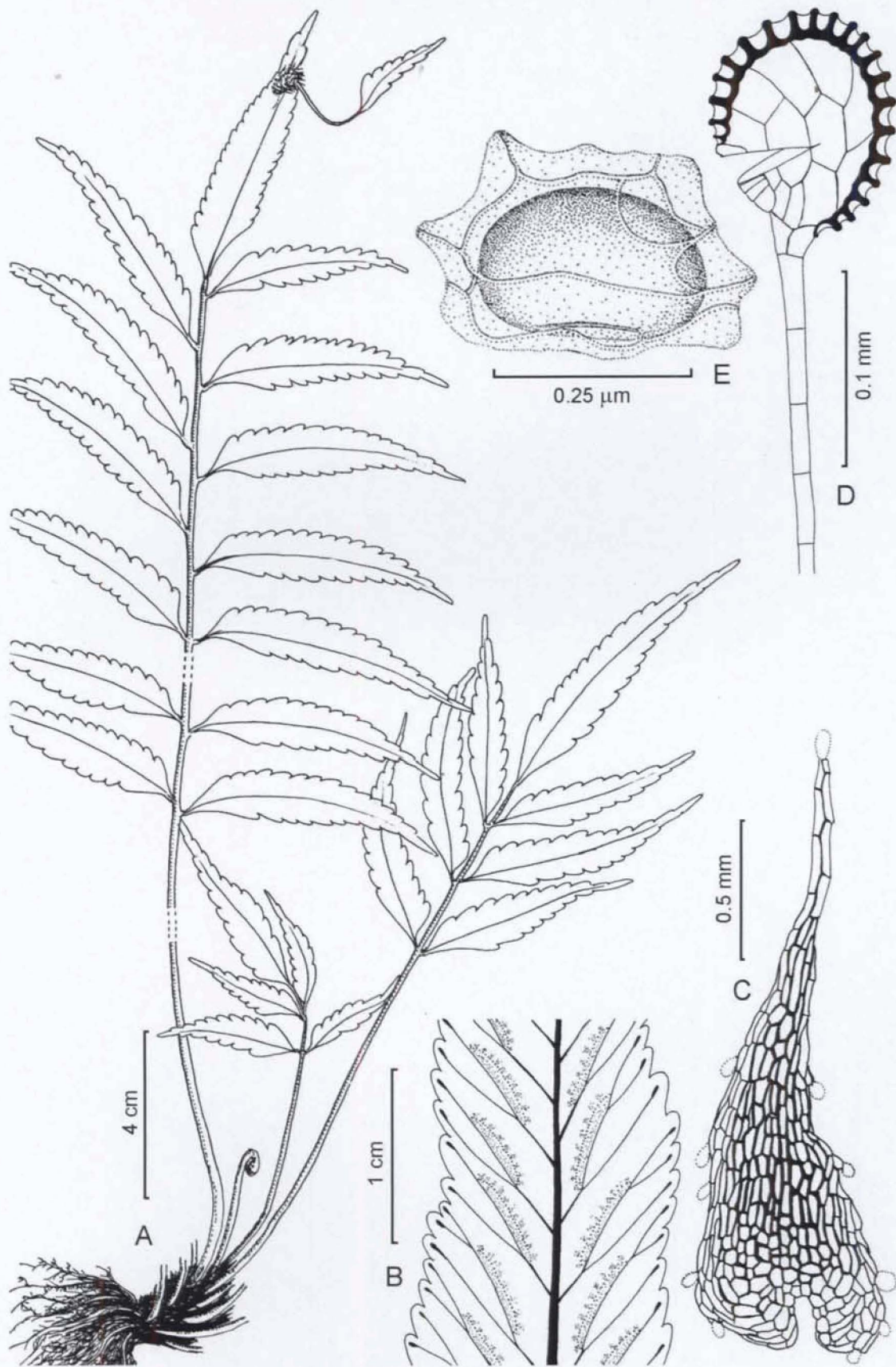


Fig. 35. *Asplenium zenkeranum* Kunze **A.** Habit; **B.** Part of pinna showing venation and position of sori; **C.** Palea on the rhizome; **D.** Sporangium; **E.** Spore.

Beddome F.S.I. & F.B.I. 16 (1987); Singh & Bir, Ind. Fern J. 6(1-2): 273 (1989); Manickam & Irudayaraj, Pterid. Fl. Western Ghats 214. Pl. 162 (1992), Pterid. Fl. Nilgiris 127 (2003); Azeez *et al.*, J. Econ. Tax. Bot. 20(2): 435-455 (1996).

Asplenium persicifolium var. *latifolium* Hook., Sp. Fil. 3: 109 (1860); Thw., Enum. Pl. Zeyl. 383 (1864).

Asplenium persicifolium Smith, Beddome, Ferns S. India 44, t. 128 (1863).

Fig. 35 (A-E); Plate 38 (A-F)

Rhizome suberect, stout, 2-3 cm thick, densely scaly at the apex; palea ovate-lanceolate, 4x1 mm, gland-tipped, dark brown at the centre, clathrate, margin pale, entire, bears few small sessile glands. Fronds tufted, 50-100 cm long; stipe 20-30 cm long, dark brown below, green above when fresh, sparsely covered by small pale brown scales, rounded below, grooved above; lamina oblong-lanceolate, unipinnate, 30-70 cm x 10-23 cm, rachis similar to stipe, bears 10-20 pairs of lateral pinnae, rachis ends in a terminal pinna which is similar to lateral ones and often bears a scaly proliferous bud in the costa, rachis also bears small scales similar to those on the stipe; pinnae are shortly stalked and are placed 2.5-4 cm apart, basal pinnae not reduced, middle pinnae are larger and gradually reduced towards the tip, pinnae vary in their size, 10-16 x 1.5-2.5 cm, acroscopic base rounded, basiscopic base slightly excised, margin crenate, lobes small and oblique having blunt tips, usually the marginal lobes arranged in groups of two, pinnae oblong-lanceolate gradually reduced towards the tip into an entire,



Plate 38. *Asplenium zenkeranum* Kunze A. Habit; B. Part of fertile frond; C. Pinnae showing sori; D. Part of pinna magnified; E. Bulbils from tip of frond; F. Rhizome.

narrow prolongation which is ca. 1.5 cm long, pinnae glabrous above, few small pale brown lacinate scales beneath, dark green, texture firm; veins distinct and slightly raised above, costa well raised above and distinct below, veins once or twice forked. Sori linear, 5-13 mm long, arranged in two regular oblique rows on either side of the costa, not touching the costa and margin, distributed all the length of the pinna except the terminal narrow wing, the size of the sori gradually reduced towards the tip. Spores 46 x 31 μm , monolete, bilateral, perinate, exine smooth, bearing a loose, anastomosing perine, supralaesural fold prominent, straight, extending from end to end of the spore; unacetolysed spores 42 x 29 μm .

Distribution and Ecology: This species is not widely distributed. Reported from Munnar Hills, Wayanad, Vellarimala and Minnampara of Kerala State. It is common in Palni Hills, also reported from Nilgiri Hills, Kothayar Hills, Anamalai Hills, Madurai Hills of Tamil Nadu. No report from other parts of India. Also occurs in Sri Lanka, *i.e.*, this species is confined to Sri Lanka and South India. This species is growing as epilithic on fully shaded forests between 1500-2200 m.

Cytology: No report.

Specimens examined: **KERALA:** Idukki Dt., Gundumala Shola-Munnar, Azeez 102776 (CALI); Eravikulam National Park-Munnar, Azeez 102782 (CALI); Parapayar-Devikulam, *Manickam & Mathew* 34535 (RHT); Aruvicad Forest-Munnar Hills, *Manickam* 32271 (RHT); Munnar Hills, *Manickam*

32299 (RHT); Devikulam-Munnar, *Meebold* 13789 (CAL). **Kozhikode Dt.**, Vellarimala, *Satheeshkumar* 70384 (CALI). **Palakkad Dt.**, Minnampara, *Vajravelu* 48780 (MH, CAL). **Wayanad Dt.**, Chembra Peak, *Azeez et al.* 45909 (CALI). **TAMIL NADU: Coimbatore Dt.**, Valparai - Anamalai Hills, *Manickam & Mathew* 32292 (RHT); Thankamalai, *Chandrbose & Chandrasekharan* 65837 (MH, CAL). **Dindigal Dt.**, Kodaikanal, *Azeez* 102728 (CALI), *Sumathikutty Amma* 9827 (CALI), *Manickam* 345, 395, 32687 (RHT); Palni Hills, *Manickam* 191 (RHT). **Madurai Dt.**, Uthamapalayam Top Station, *Manickam* 31493 (RHT); Vellimalai, *Subramanyam* 9492 (MH, CAL). **Nilgiri Dt.**, Lamb's rock-Coonoor, *Gamble* 11498 (MH, CAL); Kinnakuvai, *Shetty* 34255 (MH). **Tirunelveli Dt.**, Kothayar forest, *Madhusoodanan et al.* 44863 (CALI); Kakachi-Kothayar Hills, *Manickam* 32049 (RHT); Muthukuzhi, *Henry* 52471 (MH, CAL).

STUDIES ON THE ASPLENIACEAE OF SOUTH INDIA



*Thesis submitted to the University of Calicut
in partial fulfilment of the requirements for the degree of*

Doctor of Philosophy

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May, 2007

DISCUSSION

DISCUSSION

The genus *Asplenium* L. is the largest fern genus in the world with cosmopolitan distribution. The genus is usually considered under the family Aspleniaceae along with another genus *Ceterach* Willd., which is not reported so far from South India. The genus *Asplenium* L. is represented by 30 taxa (26 species, two varieties of *A. unilaterale* Lam., one variety of *A. excisum* Presl and one variety of *A. yoshinagae* Makino subsp. *indicum* (Sledge) Fraser-Jenk.) in South India. The members exhibit wide range of habitats; most of the species prefer to grow in exposed or semi-exposed forests where they grow in ravines along streams, on forest floor, on rock (epilithic) or on the branches or trunks of forest trees (epiphytic). Most of the members prefer to grow in between 700-2500m altitude and hence in South India they are distributed chiefly along the Western Ghat mountain ranges, but one species viz., *A. polydon* G. Forst. is reported from the lowland areas like Muhamma (Alapuzha Dt.) and Kannothe (Kannur Dt.). Another species reported from lower elevations (ca. 110 m) is *A. grevillei* Wall. ex Hook. & Grev., which is reported from a single locality of South India, the Dally forests of Kulathupuzha Forest Division, Kollam Dt. of Kerala state, where this species is mainly found growing epiphytically on the knee roots of *Myristica fatua* or a few are epilithic in a very special habitat commonly known as the "Myristica Swamp".

The density and frequency of *Asplenium* L. population varies in South India. Some members are widely distributed in the forests of Western Ghats such as *A. crinicaule* Hance, *A. decrescens* Kunze, *A. formosum* Willd., *A. inequilaterale* Willd., *A. phyllitidis* D. Don and *A. yoshinagae* Makino subsp. *indicum* (Sledge) Fraser-Jenk. at an elevation of more than 700m. *A. aethiopicum* (Burm.f.) Becher., *A. affine* Sw., *A. bipinnatum* (Sledge) Azeez & Madhus., stat. nov., *A. cheilosorum* Kunze ex Mett., *A. erectum* Bory ex Willd., *A. excisum* Presl, *A. hindusthanensis* Bir, *A. normale* D. Don, *A. obscurum* Bl., *A. polydon* G. Forst., *A. semivarians* Viane & Reichst., *A. serricula* Fee, *A. tenerum* G. Forst., *A. tenuifolium* D. Don, *A. unilaterale* Lam. var. *unilaterale*, and *A. zenkaranum* Kunze, are reported from a few localities of South India, whereas *A. auritum* Sw., *A. ensiforme* Wall. ex Hook. & Grev., *A. excisum* Presl var. *serratum* Azeez & Madhus. nov., *A. grevillei* Wall. ex Hook. & Grev., *A. nitidum* Sw., *A. trilobatum* Azeez & Madhus. sp. nov., *A. unilaterale* Lam. var. *birii* Nayar & Geev. are found to be rare and collected only from one or two localities from South India. Among these, some members were distributed widely in the past, but now became rare and localised in one or two localities, due to habitat destruction and anthropogenic activities, that had upset the fragile ecosystem and that resulted in the extinction of a number of ferns in general and asplenioid ferns in particular, and many are at the verge of extinction. *A. nidus* L. was reported earlier from Pooyamkutty region of Idukki Dt. (Bharghavan, 87451 MH) and way to Walayar estate (Sebastine, 9948 MH). In the present investigation this species has not observed anywhere in South India as wild,

but is widely cultivated in gardens as an ornamental plant because of its graceful fronds, arranged in a nest-like pattern. Hence, the above reports of this species are most probably escape from cultivation. The report of *A. nidus* L. from South India by Manickam and Irudayaraj (1992 and 2003) are probably misidentification and the figures and descriptions clearly show that, both plants are *A. phyllitidis* D. Don.

The habit and morphology of *Asplenium* spp. collected from South India vary from small size as in *A. cheilosorum* Kunze ex Mett., *A. formosum* Willd., *A. semivarians* Viane & Reichst., *A. tenerum* G. Forst., *A. tenuifolium* D. Don, etc. 10-30 cm tall, to rather large forms like *A. decrescens* Kunze, *A. nidus* L., *A. phyllitidis* D. Don and *A. zenkeranum* Kunze, in which the fronds are 1-1.5 m long.

The rhizome may be erect (*A. crinicaule* Hance, *A. erectum* Bory ex Willd., *A. formosum* Willd., *A. grevillei* Wall. ex Hook. & Grev., *A. inequilaterale* Willd., *A. nidus* L., *A. normale* D. Don, *A. phyllitidis* D. Don, *A. polydon* G. Forst., *A. semivarians* Viane & Reichst., *A. tenerum* G. Forst., *A. tenuifolium* D. Don, *A. trilobatum* Azeez & Madhus. sp. nov., *A. yoshinagae* Makino subsp. *indicum* (Sledge) Fraser-Jenk.) or suberect (*A. aethiopicum* (Burm.f.) Becher., *A. bipinnatum* (Sledge) Azeez & Madhus., stat. nov. *A. ensiforme* Wall. ex Hook. & Grev., *A. serricula* Fee, *A. zenkeranum* Kunze) or creeping (*A. affine* Sw., *A. cheilosorum* Kunze ex Mett., *A. decrescens* Kunze, *A. excisum* Presl, *A. hindusthanensis* Bir, *A. nitidum* Sw., *A. obscurum* Bl. and *A. unilaterale* Lam. complex).

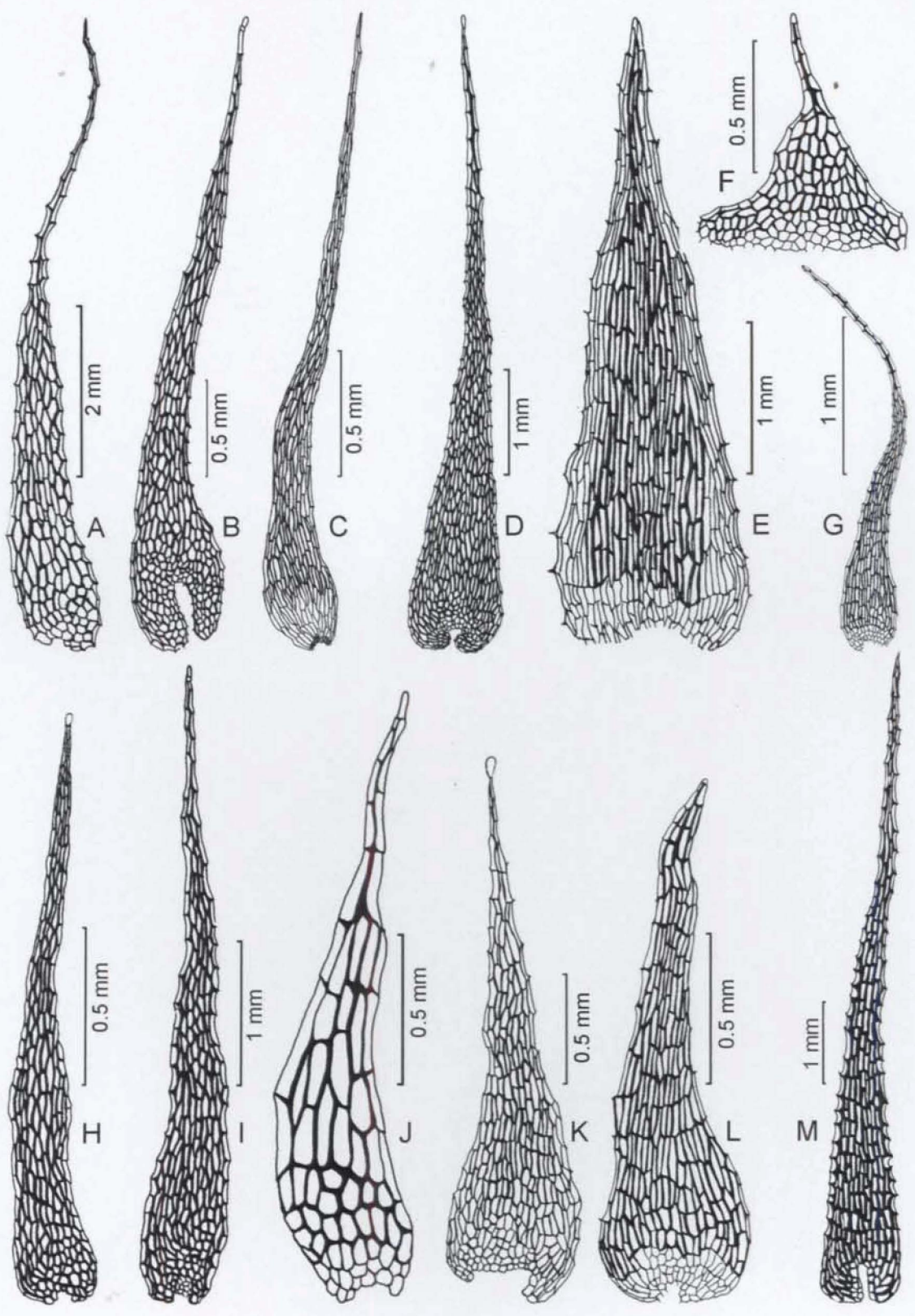


Fig. 36. Paleae of *Asplenium* spp. in South India. A. *A. aethiopicum* (Burm. f.) Becher.; B. *A. affine* Sw.; C. *A. cheilosorum* Kunze ex Mett. D. *A. ensiforme* Wall. ex Hook. & Grev.; E. *A. auritum* Sw. F. *A. hindusthanensis* Bir; G. *A. semivarians* Viane & Reichst.; H. *A. inequilaterale* Willd.; I. *A. nitidum* Sw.; J. *A. obscurum* Bl.; K. *A. tenuifolium* D. Don; L. *A. trilobatum* Azeez & Madhus. sp. nov.; M. *A. yoshinagae* Makino subsp. *indicum* (Sledge) Fraser-Jenk.

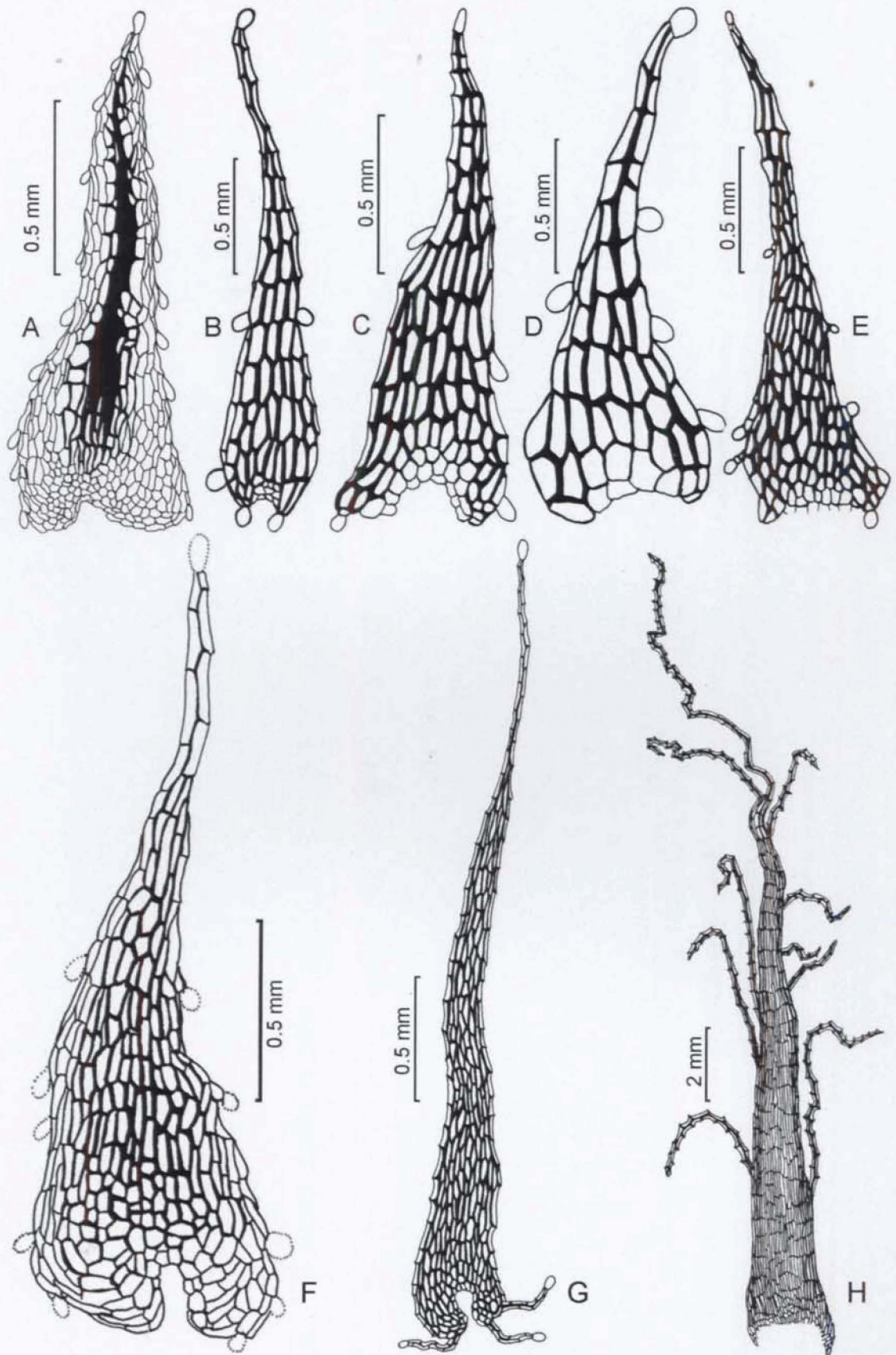


Fig. 37. Paleae of *Asplenium* spp. in South India. A. *A. formosum* Willd.; B. *A. unilaterale* Lam. var. *birii* Nayar & Geev.; C. *A. excisum* Presl; D. *A. excisum* Presl var. *serratum* Azeez & Madhus. nov.; E. *A. unilaterale* Lam. var. *unilaterale*; F. *A. zenkeranum* Kunze; G. *A. crinicaule* Hance; H. *A. nidus* L.

The fronds may be simple (*A. ensiforme* Wall. ex Hook. & Grev., *A. grevillei* Wall. ex Hook. & Grev., *A. nidus* L. and *A. phyllitidis* D. Don), unipinnate (*A. cheilosorum* Kunze ex Mett., *A. crinicaule* Hance, *A. decrescens* Kunze, *A. erectum* Bory ex Willd., *A. excisum* Presl, *A. formosum* Willd., *A. hindusthanensis* Bir, *A. inequilaterale* Willd., *A. normale* D. Don, *A. obscurum* Bl., *A. polydon* G. Forst., *A. serricula* Fee, *A. tenerum* G. Forst., *A. unilaterale* Lam. complex, *A. yoshinagae* Makino subsp. *indicum* (Sledge) Fraser-Jenk. and *A. zenkeranum* Kunze) or bipinnate (or tripinnatifid) in members viz., *A. aethiopicum* (Burm. f.) Becher., *A. affine* Sw., *A. auritum* Sw., *A. bipinnatum* (Sledge) Azeez & Madhus., stat. nov., *A. nitidum* Sw., *A. semivarians* Viane & Reichst., *A. tenuifolium* D. Don, and *A. trilobatum* Azeez & Madhus. sp.nov..

The rhizome in all cases is clothed by paleae which are small, clathrate, ovate-lanceolate or oblong lanceolate and with or without glands. In *A. aethiopicum* (Burm. f.) Becher., *A. affine* Sw., *A. auritum* Sw., *A. cheilosorum* Kunze ex Mett., *A. ensiforme* Wall. ex Hook. & Grev., *A. hindusthanensis* Bir, *A. inequilaterale* Willd., *A. nitidum* Sw., *A. obscurum* Bl., *A. semivarians* Viane & Reichst., *A. tenuifolium* D. Don, *A. trilobatum* Azeez & Madhus. sp. nov. and *A. yoshinagae* Makino subsp. *indicum* (Sledge) Fraser-Jenk., the paleae are without any glands (Fig. 36), whereas in the case of *A. excisum* Presl, *A. formosum* Willd., *A. unilaterale* Lam. and *A. zenkeranum* Kunze, the margin of the palea are provided with some sessile glands (Fig. 37), at the same time in the case of *A. bipinnatum* (Sledge)

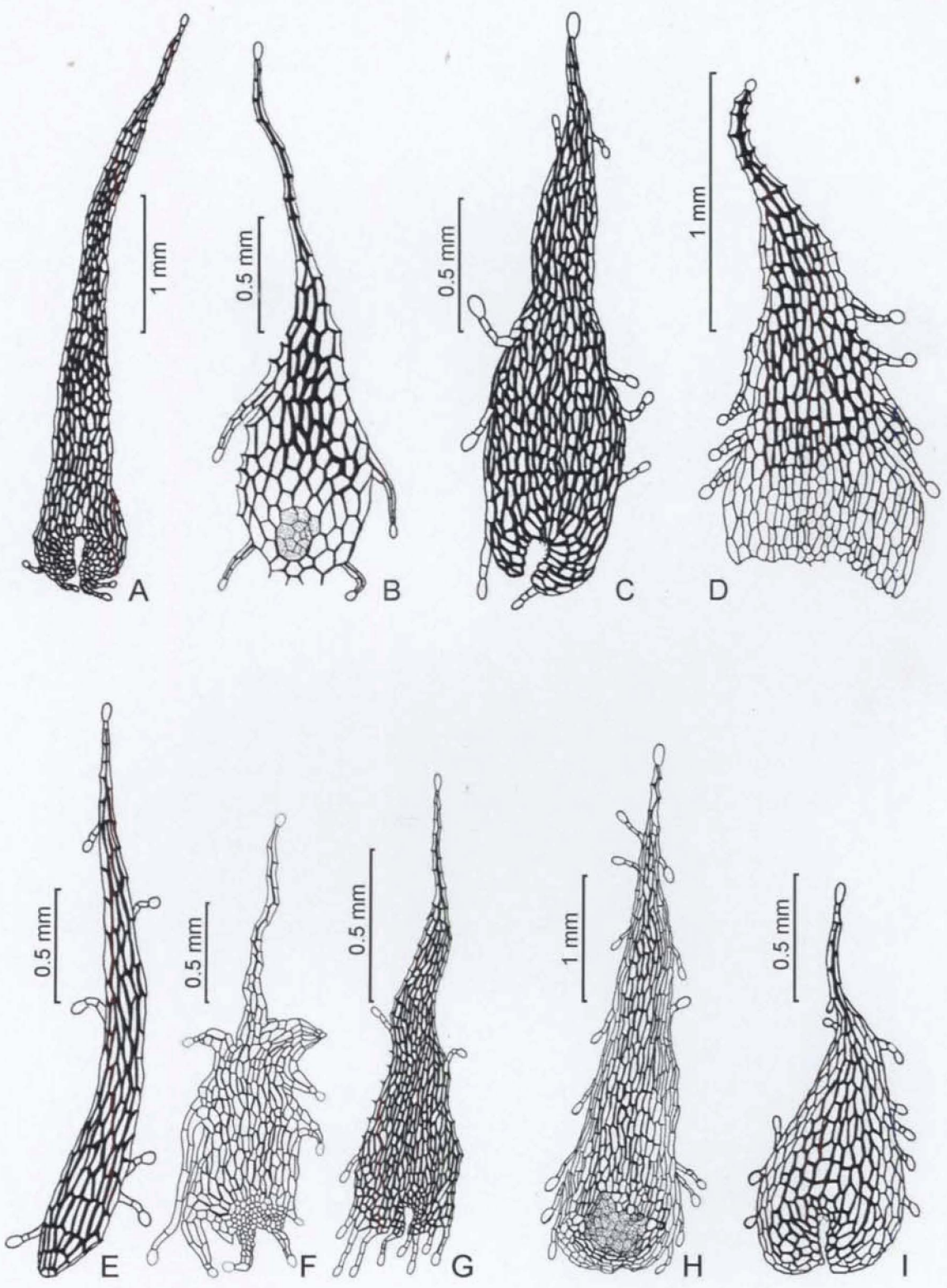


Fig. 38. Paleae of *Asplenium* spp. in South India. A. *A. bipinnatum* (Sledge) Azeez & Madhus., stat. nov.; B. *A. decrescens* Kunze; C. *A. erectum* Bory ex Willd.; D. *A. grevillei* Wall. ex Hook. & Grev.; E. *A. normale* D. Don; F. *A. phyllitidis* D. Don; G. *A. polydon* G. Forst.; H. *A. serricula* Fee; I. *A. tenerum* G. Forst.

Azeez & Madhus., stat. nov., *A. decrescens* Kunze, *A. erectum* Bory ex Willd., *A. grevillei* Wall. ex Hook. & Grev., *A. normale* D. Don, *A. phyllitidis* D. Don, *A. polydon* G. Forst., *A. serricula* Fee, and *A. tenerum* G. Forst., the margin and mainly at the base is provided with small gland-tipped hairs (Fig. 38). In *A. crinicaule* Hance, and *A. nidus* L. the palea are characteristic, in the former the base of the palea provided with long, biseriate gland tipped hairs, while in the latter the paleae are big and are provided with large number of much elongated, biseriate glandless hairs throughout the margin and the palea ends in a long hair (Fig. 37 G&H).

Vasculature of the rhizome is dictyostelic with overlapping leaf gaps in both erect as well as creeping forms. The leaf gaps are very closely arranged in the case of erect rhizome, while in creeping, the leaf gaps are distantly placed (Fig. 2&3) The stipe usually receives two vascular bundles from the main stele and they unite upwards into 'X' shaped configuration usually few centimetres below the first pair of pinnae (Fig. 4&5). Stipe and rachis are normally glabrous, while in the case of *A. aethiopicum* (Burm. f.) Becher., both stipe and rachis are densely scaly, in *A. bipinnatum* (Sledge) Azeez & Madhus., stat. nov., *A. crinicaule* Hance and *A. yoshinagae* Makino subsp. *indicum* (Sledge) Fraser-Jenk. stipe and rachis are sparsely scaly.

Out of 30 taxa of *Asplenium* L. reported from South India, *A. affine* Sw. (Plate 10), *A. normale* D. Don (Plate 26), *A. tenuifolium* D. Don (Plate 33), and *A. zenkeranum* Kunze (Plate 38) show a very specialised mode of vegetative reproduction by means of 'bulbils' which are commonly formed

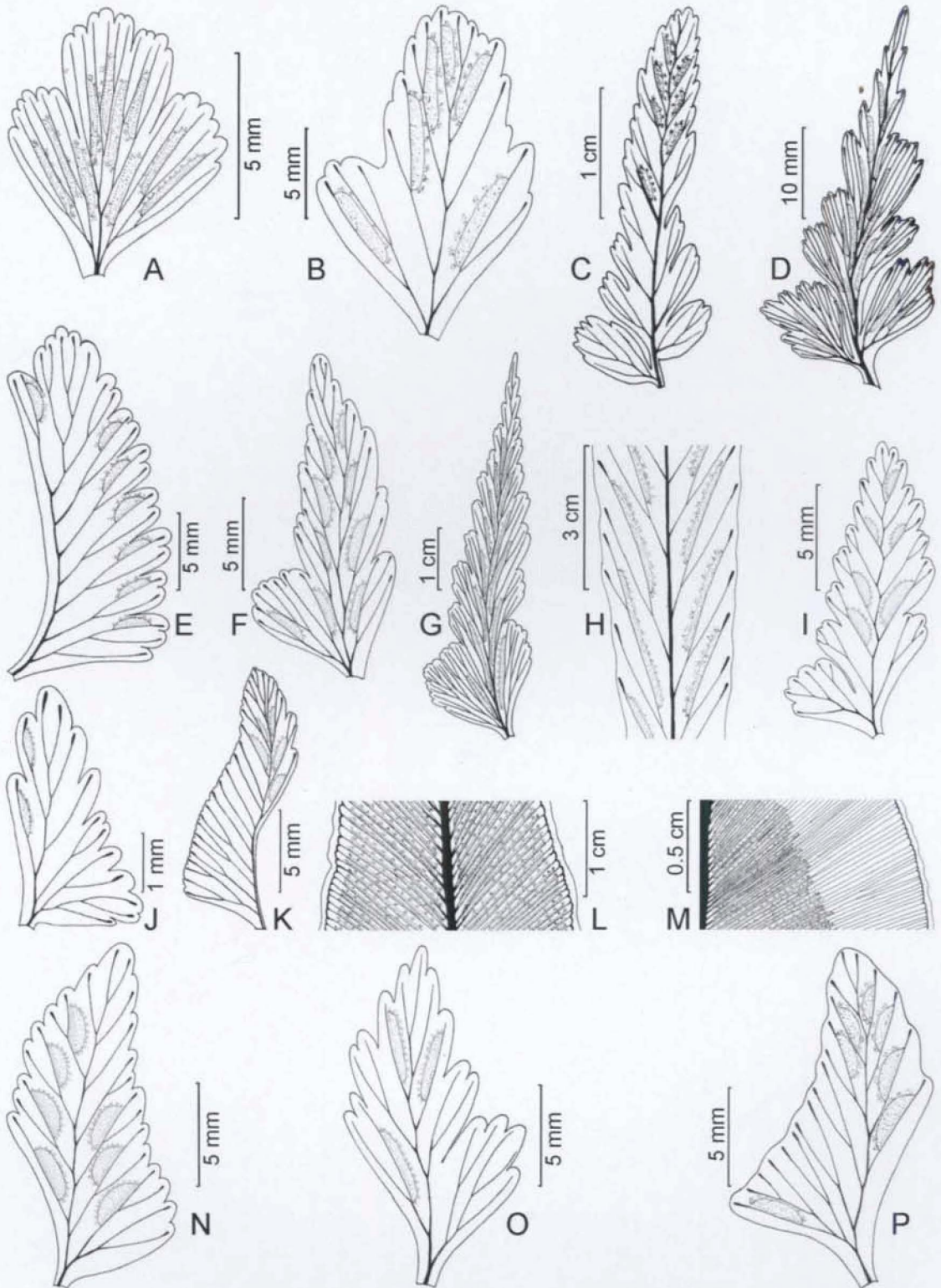


Fig. 39. Fertile pinnae of *Asplenium* spp. in South India: A. *A. aethiopicum* (Burm. f.) Becher.; B. *A. affine* Sw.; C. *A. auritum* Sw.; D. *A. bipinnatum* (Sledge) Azeez & Madhus., stat. nov.; E. *A. cheilosorum* Kunze ex Mett.; F. *A. crinicaule* Hance; G. *A. decrescens* Kunze; H. *A. ensiforme* Wall. ex Hook. & Grev.; I. *A. erectum* Bory ex Willd.; J. *A. formosum* Willd.; K. *A. hindusthanensis* Bir; L. *A. grevillei* Wall. ex Hook. & Grev.; M. *A. nidus* L.; N. *A. inequilaterale* Willd.; O. *A. nitidum* Sw.; P. *A. normale* D. Don

from the tip of the lamina. This feature is very common in *A. tenuifolium* D. Don and *A. zenkeranum* Kunze. Rarely bulbils are also reported in *A. phyllitidis* D. Don.

Sori in *Asplenium* L. are usually linear along the acroscopic veins and are obliquely arranged. The size, shape and position of sori on the lamina may vary in different species. In *A. auritum* Sw., *A. cheilosorum* Kunze ex Mett., *A. excisum* Presl, *A. formosum* Willd., *A. hindusthanensis* Bir, *A. inequilaterale* Willd., *A. obscurum* Bl., *A. semivarians* Viane & Reichst., *A. tenuifolium* D. Don., *A. trilobatum* Azeez & Madhus. sp. nov., and *A. unilaterale* Lam., the sori are oval in shape, 2-3 mm in length (Fig. 39 & 40), while in *A. ensiforme* Wall. ex Hook. & Grev., *A. grevillei* Wall. ex Hook. & Grev., *A. nidus* L., *A. phyllitidis* D. Don and *A. polydon* G. Forst., the sori are long, 1-5 cm in length (Fig. 39 & 40), whereas in *A. aethiopicum* (Burm. f.) Becher., *A. affine* Sw., *A. bipinnatum* (Sledge) Azeez & Madhus., stat. nov., *A. crinicaule* Hance, *A. decrescens* Kunze, *A. erectum* Bory ex Willd., *A. nitidum* Sw., *A. normale* D. Don, *A. serricula* Fee, *A. tenerum* G. Forst., *A. yoshinagae* Makino subsp. *indicum* (Sledge) Fraser-Jenk. and *A. zenkeranum* Kunze, the sori are intermediate and are up to 1cm long (Fig. 39 & 40). The sori are normally formed all along the ventral surface of the sporophylls along the acroscopic veins, but in some members sori formation is characteristic. In *A. cheilosorum* Kunze ex Mett., sori are restricted to the lobes of the acroscopic side of the pinnae and a single sorus on the first lobe of the basispic side near the tip (Fig. 39 E). *A. formosum* Willd. bears 2 or

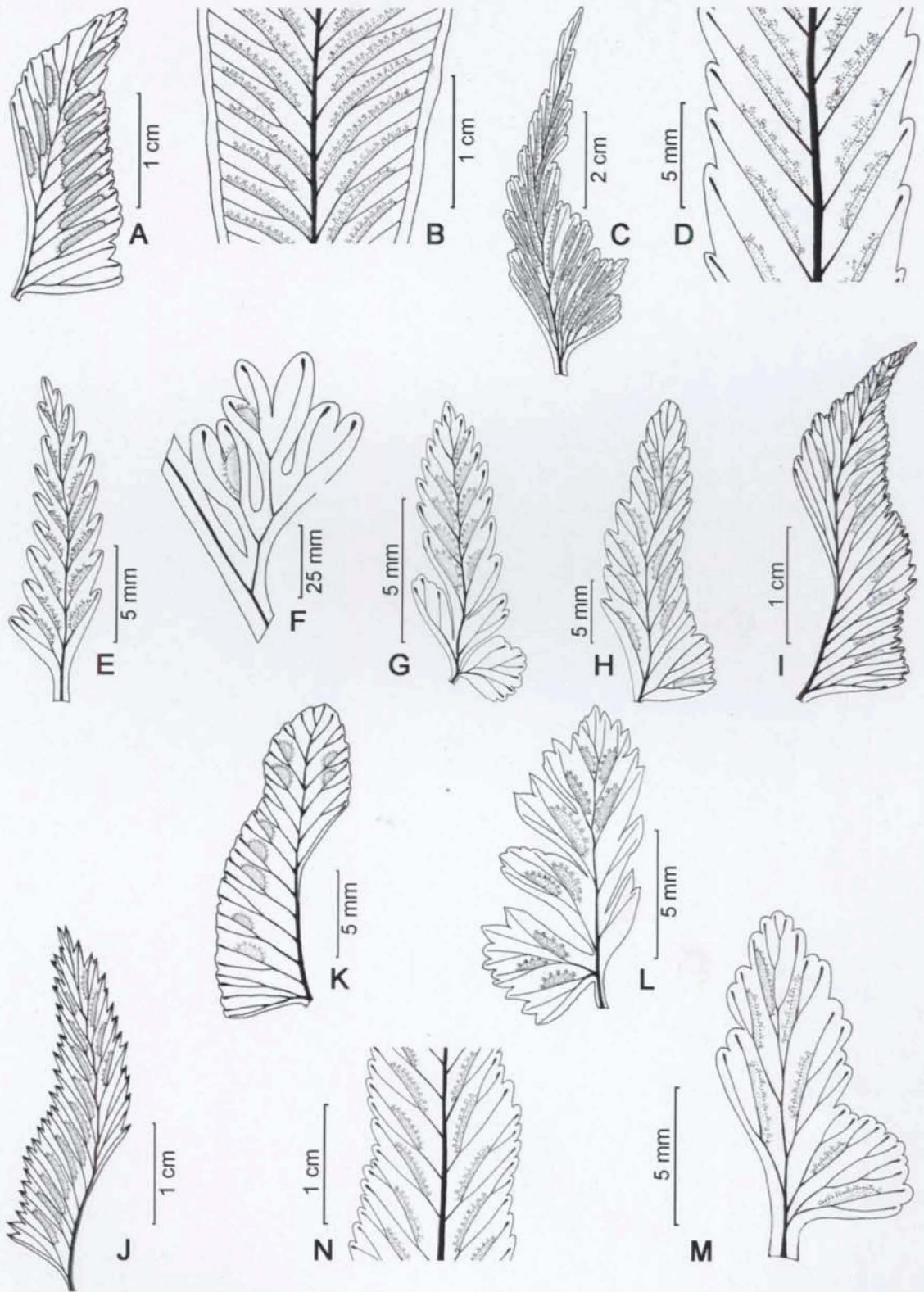


Fig. 40. Fertile pinnae of *Asplenium* spp. in South India. **A.** *A. obscurum* Bl.; **B.** *A. phyllitidis* D. Don; **C.** *A. polydon* G. Forst.; **D.** *A. serricula* Fee; **E.** *A. tenerum* G. Forst.; **F.** *A. tenuifolium* D. Don; **G.** *A. trilobatum* Azeez & Madhus. sp. nov.; **H.** *A. unilaterale* Lam. var. *birii* Nayar & Geev.; **I.** *A. excisum* Presl; **J.** *A. excisum* Presl var. *serratum* Azeez & Madhus. nov.; **K.** *A. unilaterale* Lam. var. *unilaterale*; **L.** *A. semivarians* Viane & Reichst.; **M.** *A. yoshinagae* Makino subsp. *indicum* (Sledge) Fraser - Jenk.;

3 sori per pinna which are restricted to the lower unexcised portion and are more or less parallel to the excised portion of the pinna (Fig. 39 J). In *A. decrescens* Kunze sori are formed on the vein forks near the costa on either side and are seen as two parallel rows close to the costa (Fig. 39 G). In *A. grevillei* Wall. ex Hook. & Grev., the sori are extending from costa to almost margin and are formed all along the lamina except the extreme tip (Fig. 39 L). In *A. hindusthanensis* Bir 2 or 3 pairs of sori present which are confined to the apices (Fig. 39 K). *A. nidus* L. possesses the biggest sori, 4-5 cm long which extend from costa, reaching only half way towards the margin. In this the sori are confined only to the upper $\frac{2}{3}$ part of the lamina in two oblique rows on either side of the costa, and are borne on both branches of a forked vein (Fig. 39 M & Plate 24). In *A. phyllitidis* D. Don, the sori are 2-3 cm long, formed in two oblique rows on either side of the costa and are usually confined to the upper half or distal one-third portion of the lamina (Fig. 40 B & Plate 28). In *A. polydon* G. Forst. sori are formed both on acroscopic and basiscopic branches of a fork in some veins and hence are facing opposite to each other (Fig. 40 C). The sporophylls and vegetative leaves show no difference in their size or other characteristics *i.e.*, heterophylly is not seen in *Asplenium* spp., but in the case of *A. grevillei* Wall. ex Hook. & Grev. the stipe of fertile fronds are 2-3 times longer than the vegetative fronds (Plate 21). The sporangia are similar in most cases with globose to sub-globose capsule consisting of 20-25 annular cells and a uniseriate sporangial stalk usually one and a half time longer than the capsule.

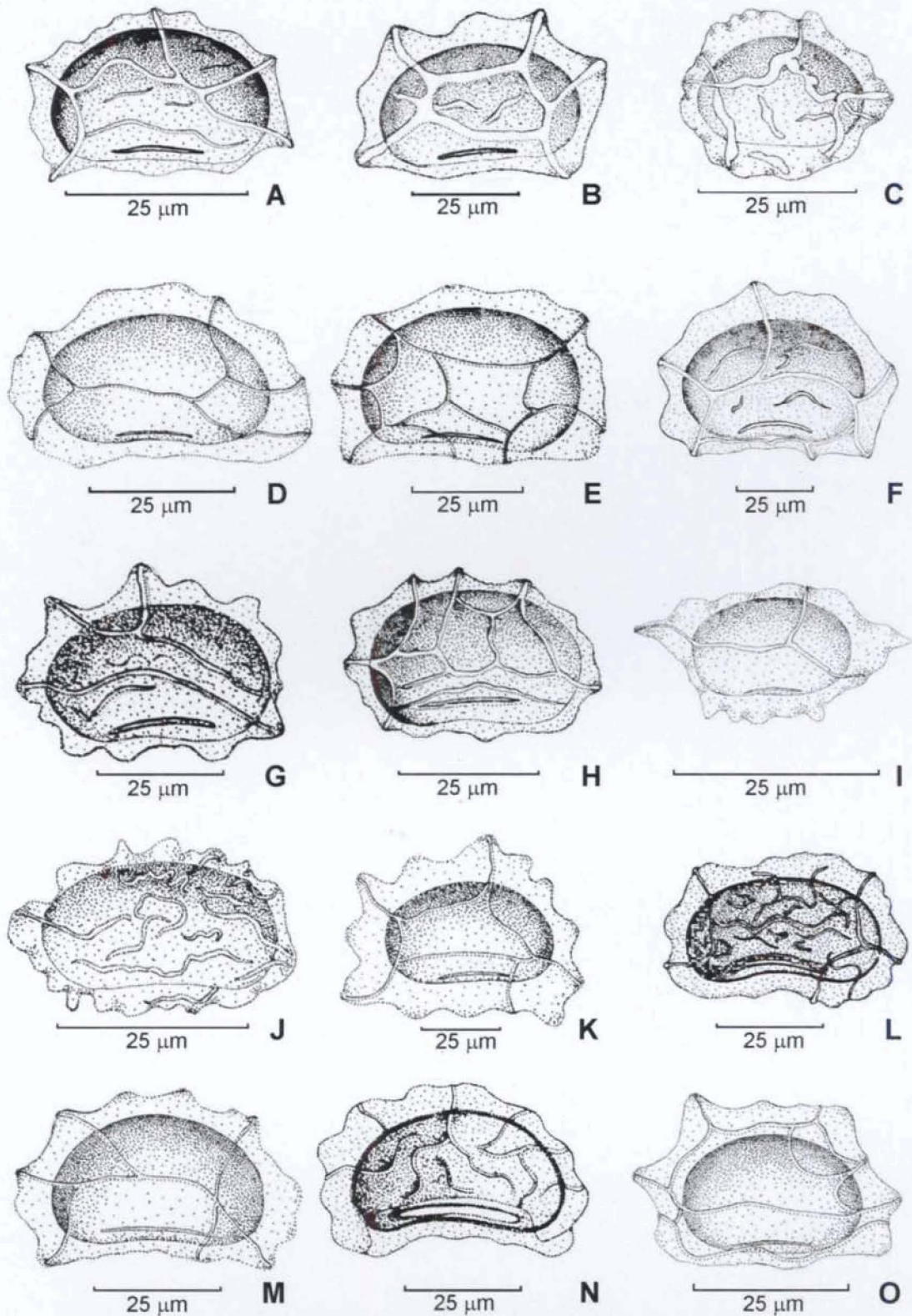


Fig. 41. Spores of *Asplenium* spp. in South India. A. *A. aethiopicum* (Burm. f.) Becher.; B. *A. affine* Sw.; C. *A. auritum* Sw.; D. *A. crinicaule* Hance; E. *A. decrescens* Kunze; F. *A. ensiforme* Wall. ex Hook. & Grev.; G. *A. erectum* Bory ex Willd.; H. *A. formosum* Willd.; I. *A. grevillei* Wall. ex Hook. & Grev.; J. *A. nidus* L.; K. *A. nitidum* Sw.; L. *A. phyllitidis* D. Don; M. *A. tenerum* G. Forst.; N. *A. yoshinagae* Makino subsp. *indicum* (Sledge) Fraser-Jenk.; O. *A. zenkeranum* Kunze

The spores of *Asplenium* L. are monolete, bilateral and perinate. The exine is usually granulose, with or without spines or other ornamentations, while the perine is loose, usually undulating with anastomosing surface folds. Various species show difference in spore size; smallest spores is reported in *A. trilobatum* Azeez & Madhus. sp. nov. (30 x 17 μm) whereas the biggest spores (ca. 2 times bigger than the former) are found in *A. grevillei* Wall. ex Hook. & Grev. (69 x 31 μm). Both exine and perine are non-ornamented in majority of species viz., *A. aethiopicum* (Burm. f.) Becher., *A. affine* Sw., *A. auritum* Sw., *A. crinicaule* Hance, *A. decrescens* Kunze, *A. ensiforme* Wall. ex Hook. & Grev., *A. erectum* Bory ex Willd., *A. formosum* Willd., *A. grevillei* Wall. ex Hook. & Grev., *A. nidus* L., *A. nitidum* Sw., *A. phyllitidis* D. Don, *A. tenerum* G. Forst, *A. yoshinagae* Makino subsp. *indicum* (Sledge) Fraser-Jenk. and *A. zenkeranum* Kunze (Fig. 41), whereas both exine and perine are densely spinulose in *A. cheilosorum* Kunze ex Mett. and *A. obscurum* Bl. (Fig. 42 A&B). The spores of *A. obscurum* Bl. are characteristic in that both exine and perine are clothed with narrow, elongated, sharp, straight or curved spines. In some members exine is ornamented and perine is smooth; in *A. bipinnatum* (Sledge) Azeez & Madhus., stat. nov. the exine is provided with a characteristic band which bears some dark, oval dot like areas (Fig. 42 C), while in *A. polydon* G. Forst. the exine possesses some highly specialized reticulate patterns (Fig. 42 D) which are characteristic in the genus. In the case of *A. normale* D. Don, *A. semivarians* Viane & Reichst. and *A. trilobatum* Azeez & Madhus. sp. nov. both exine and perine are smooth, but the granulose exine is provided with some dark oval areas

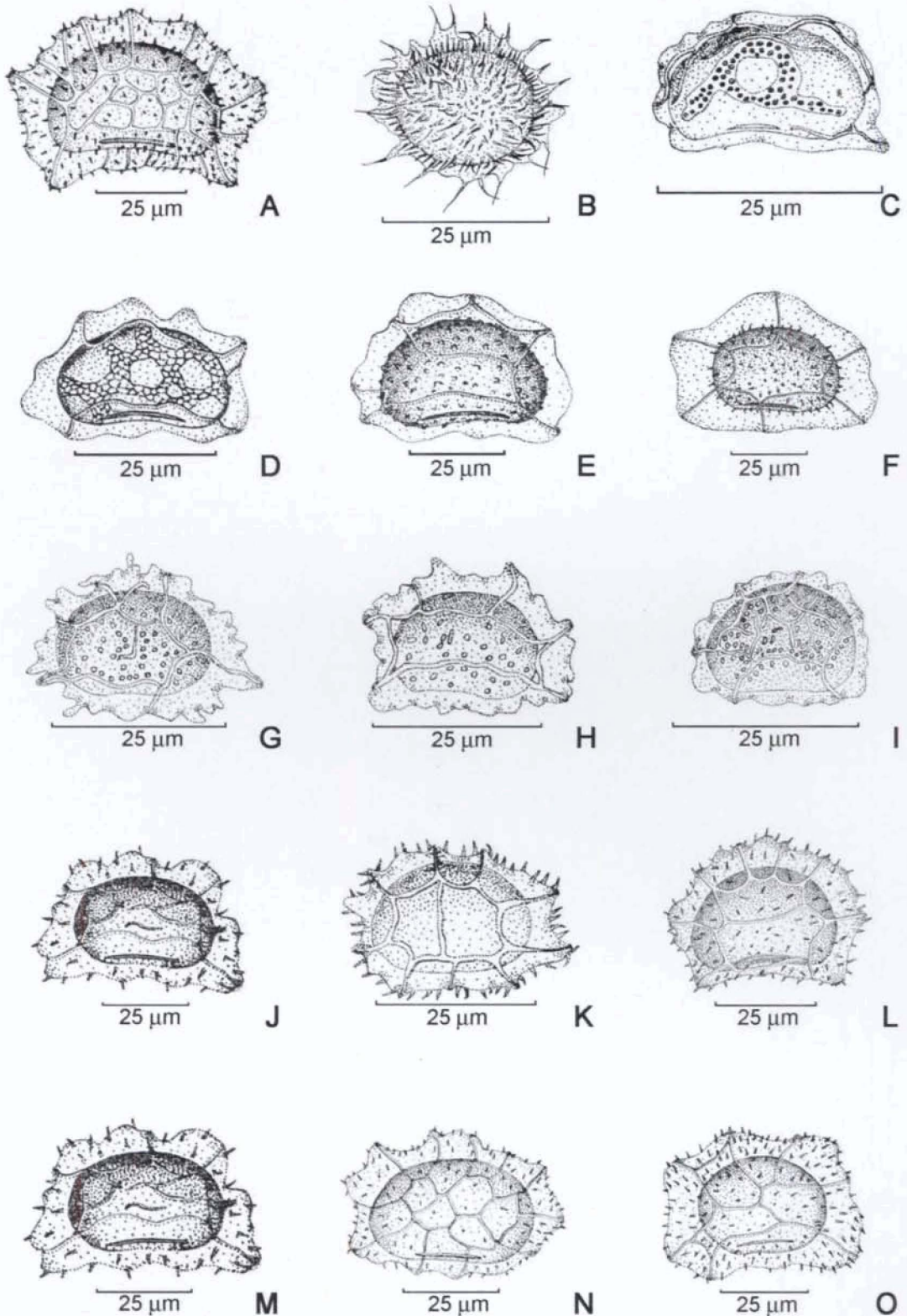


Fig. 42. Spores of *Asplenium* spp. in South India. A. *A. cheilosorum* Kunze ex Mett.; B. *A. obscurum* Bl.; C. *A. bipinnatum* (Sledge) Azeez & Madhus., stat. nov.; D. *A. polydon* G. Forst.; E. *A. serricula* Fee; F. *A. hindusthanensis* Bir; G. *A. normale* D. Don; H. *A. trilobatum* Azeez & Madhus. sp. nov.; I. *A. semivarians* Viane & Reichst.; J. *A. inequilaterale* Willd.; K. *A. tenuifolium* D. Don; L. *A. unilaterale* Lam. var. *birii* Nayar & Geev.; M. *A. excisum* Presl; N. *A. excisum* Presl var. *serratum* Azeez & Madhus. nov.; O. *A. unilaterale* Lam. var. *unilaterale*.

(Fig. 42 G,H&I) whereas in *A. serricula* Fee, the exine bears some raised oval outgrowths (Fig. 42 E). *A. hindusthanensis* Bir, is the only species in which the exine is spinulose and covered with a smooth perine (Fig. 42 F). In members like *A. excisum* Presl, *A. inequilaterale* Willd., *A. tenuifolium* D. Don, *A. unilaterale* Lam. complex, the exine is granulose and non-ornamented, while the perine is spinulose (Fig. 42 J-O), among that, in *A. tenuifolium* D. Don, the spines are seen only along the margin of the perine with no spinules in the lumina (Fig. 42 K).

Cytologically, except *A. unilaterale* Lam. complex, all members are based on the basic chromosome number $x = 36$. The *A. unilaterale* Lam. complex is based upon $x = 40$. Based on the cytological differences Bir (1960, 1963) supported the segregation of *A. unilaterale* Lam. group of species to a subgenus, *Hymenasplenium* (Hayata) Bir.

Out of 30 taxa of *Asplenium* L. studied in South India, 4 taxa are endemic to South India viz., *A. hindusthanensis* Bir, *A. trilobatum* Azeez & Madhus. sp. nov., *A. unilaterale* Lam. var. *birii* Nayar & Geev. and *A. excisum* Presl var. *serratum* Azeez & Madhus. nov., where as 5 species of *Asplenium* L. viz., *A. auritum* Sw., *A. bipinnatum* (Sledge) Azeez & Madhus., stat. nov., *A. decrescens* Kunze, *A. serricula* Fee, and *A. zenkeranum* Kunze the distribution is restricted to South India, in India.

The Aspleniaceae constitute an elegant and successful group of ferns growing in a wide variety of habitats. They show affinities with thelypteroid ferns on one hand and dryopteroid and blechnoid ferns on the other hand.

Their nearest allies among modern ferns are the thelypteroid genera because both groups share some common characters like chromosome number ($x = 36$) except in *A. unilaterale* Lam. ($x = 40$), similar spores and prothalli. Though it is suggested that the Aspleniaceae are not descended from Thelypteridaceae or vice-versa, and they might have originated from a common cyatheoid stock. Nayar and Kaur (1974) suggested that Aspleniaceae are allied to Dryopteridaceae group of ferns and they assigned the same parentage for Dryopteridaceae and Aspleniaceae – Thelypteridaceae group of ferns. The asplenioid ferns also show affinity with blechnoid ferns. The presence and origin of perforations observed in the basal region of the vasculature of *A. ensiforme* Wall. ex Hook. & Grev., resembles *Stenochlaena palustris* (Burm.) Beddome. This is considered as a supporting evidence to the natural affinities of asplenioid and blechnoid ferns by Mehra and Chopra (1951). Pichi Sermolli (1977) suggested close affinity of Aspleniaceae with Athyriaceae and he concluded that the Aspleniaceae are sharply distinct from the rest of the Aspidiales (Thelypteridaceae, Onocleaceae, Woodsiaceae, Athyriaceae, Aspidiaceae, Lomariopsidaceae, Elaphoglossaceae, Nephrolepidaceae, Oleandraceae and Davalliaceae) and cannot be united to any other family of this order. He also suggested that their affinity with other groups of the order Aspidiales is rather remote and their taxonomic position in between Thelypteridaceae and Athyriaceae is rather sound and opined that Aspleniaceae is nearer the former than the latter. Cytology also fully substantiates this view.

The family Aspleniaceae shows more affinity to Thelypteridaceae in the nature of two leaf traces and similar spores and gametophytes. Moreover, both families are based on the same basic chromosome number ($x = 36$). From these morphological, anatomical and cytological similarities, it is apparent that the asplenioid ferns are more closely allied to thelypteroid ferns.

STUDIES ON THE ASPLENIACEAE OF SOUTH INDIA



*Thesis submitted to the University of Calicut
in partial fulfilment of the requirements for the degree of*

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May, 2007

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STUDIES ON THE ASPLENIACEAE OF SOUTH INDIA



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