REVISIONARY STUDIES ON THE FAMILY SELAGINELLACEAE IN SOUTH INDIA

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CERTIFICATE

This is to certify that the research work presented in the thesis is the bonafide work of Miss. P. Nisha, done under my guidance and supervision. No part of this work has been presented elsewhere for any degree or diploma.

Santhosh Nampy

DECLARATION

I hereby declare that the thesis "**Revisionary studies on the family Selaginellaceae in South India**" submitted by me in partial fulfillment for the Ph. D. degree to the university of Calicut, incorporates the results of the original works done by me. I have not submitted this thesis to any other University for the award of any other degree or diploma.

Nisha. P

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CONTENTS

INTRODUCTION

The Selaginellaceae are an ancient group of fern-allies consisting of an estimated 750 living species. The family is cosmopolitan, having greater diversity in lowland to mid-montane primary tropical rainforests, but also widely distributed in subtropical, temperate, montane and rarely sub-artic regions (Korall *et al.,* 1999). The members are mostly terrestrial herbs with an erect or prostrate main stem and subsidiary branch systems; often with long, dichotomously branched roots, originating from the axil of branches; growing points not protected by scales; leaves ligulate simple with a single vein; sporangia short-stalked, single, near the axil of sporophyll, heterosporous and spores without chlorophyll. Most species are characterised by strongly flattened, frond like branching and dimorphic leaves (Korall, *et al.,* 1999). They also possess other unique features of the epidermis such as iridescence, lens-shaped epidermal cells and presence of chloroplasts (Hebanth & Lee, 1984).

The family is presently regarded as monotypic although Rothmaler (1944) revived the earlier generic names *Lycopodioides* Boehm. and *Didiclis* P. Beauv. for some European species and Kunkel (1963) published *Stachygynandrum myosurus* (Sw.) G. Kunkel, both without sufficient discussion (Jermy, 1990).

Previous systematic studies have identified several major groups within Selaginellaceae but Jermy (1986) recognized only one genus, *viz*., *Selaginella* P.Beauv. with five sub-genera. It is represented by 62 species in India (Dixit, 1992), mostly inhabiting the moist shady forest floors. Since then, two more species were described from India (Madhusoodanan & Nampy, 1994; Antony *et al.,* 2002) taking the total number of species to 67 in India.

In comparison with other taxa of pteridophytes, the family Selaginellaceae has been largely neglected taxonomically in India. Some of the possible reasons for this neglect include the occurrence in inaccessible areas in deep forests, making their collection difficult, its inconspicuous size, similarity in appearance and lack of taxonomic literature. However, the treatments of Spring (1843), Baker (1887), Rosenburgh (1915), Alston (1945), Tryon (1955), Reed (1966) and Dixit (1992) needs special mention in this regard.

Except for a few scattered papers and treatments in regional floras (Panigrahi & Chowdhury, 1962; Mehra & Bir, 1964; Bir & Vasudeva, 1973; Gena *et al.,* 1979; Dixit & Panigrahi, 1983; Dixit, 1983, 1984, 1985; Nair *et al*., 1988; Manickam & Irudayaraj, 1992; Madhusoodanan & Nampy, 1994; Antony *et al.,* (2002), the available works on this genus as a whole in India are those of the enumeration by Alston (1945) and taxonomic revision by Dixit (1992). However, their studies are primarily based on Himalayan ferns and herbarium specimens deposited in various herbaria. Dixit (1992) in his

Selaginellaceae of India admitted that there is the possibility of an increase in number of taxa especially the smaller forms in the near future, provided there is thorough exploration. Reports of Madhusoodanan and Nampy (1994) and Antony *et al.,* (2002) underscores the above statement. Except the above-mentioned treatments, there is no published work on this group confined to South India, the area of present study. In this context a detailed taxonomic study in consultation with type specimens and protologues will be of immense value in sorting out the taxonomic problems. The present work aims the preparation of a taxonomic revision of the family Selaginellaceae in South India based on extensive field and laboratory studies in consultation with type and other authentic collections available in herbaria in India and overseas.

I restrict my work to South India mainly because of the constraints of time as well as to make the work more reliable by concentrating in smaller areas. Such works concentrating in local areas when pooled together can provide an absolute idea about this group.

Ecology and distribution

Species of Selaginellaceae are mostly found in the moist and shady floors of rain forests of tropical and sub-tropical countries. In India, there are no reports of Selaginellaceae from sub-alpine (3500 – 4500 m) and alpine regions (4500 – 5000 m). Most of the members are confined to tropical (0 – 900 m) and sub-tropical forests (900 – 1800 m) and a few to temperate

forests (1800 – 3500 m; Dixit, 1992). In South India most of the species are confined to Western Ghats and Eastern Ghats.

The members are mostly terrestrial, a few occur along banks of river or streams, a few are lithophytes and still others are xerophytes. Xerophytic species are mainly confined to the rocky plateau and dry hilly regions. Terrestrial species are either heliophylous or sciophylous. However, their habitats often overlap. Table 1 shows South Indian species and their habitat preferences.

Table 1

Habitat	Name of Species
Terrestrial Heliophylous	*S. bryopteris* *S. ciliaris* *S. intermedia* *S. involvens* *S. keralensis* *S. monospora* *S. nayarii* *S. repanda* *S. vaginata*
Terrestrial Sciophylous	*S. inaequalifolia* *S. semicordata* *S. wildenovii* *S. brachystachya* *S. coonooriana* *S. proniflora*

Damp regions or stream banks	*S. cataractarum* *S. delicatula* *S. intermedia* *S. miniatospora* *S. proniflora* *S. tenera*
Lithophytic	*S. bryopteris* *S. cataractarum* *S. chrysocaulos* *S. ciliaris* *S. involvens* *S. repanda*
Xerophytic	*S. bryopteris* *S. involvens* *S. wightii*

Endemism

Among the 64 Indian species of Selaginellaceae, 18 are endemic. Of them, 9 are South Indian endemics (Table 2) *S. cataractarum* Alston is reported as endangered by Nayar and Sastry (1987).

Table 2. List of species endemic to South India.

Sl. No.	Name of species	Endemic area
1	*S. camusii*	Kerala (1750 m)
2	*S. cataractarum*	Tamil Nadu (1800 m)
		Kerala (800 m)
3	*S. coonooriana*	Tamil Nadu (800 m)
		Kerala (750 m)
4	*S. dixitii*	Kerala (700 m)
		Tamil Nadu (600 m)
5	*S. ganguliana*	Kerala (40 m)
6	*S. keralensis*	Kerala (900 m)
7	*S. nayarii*	Kerala (900 m)
8	*S. radicata*	Andhra Pradesh (400 m)
		Tamil Nadu (1800m)
9	*S. tenera*	Karnataka (330 m)
		Kerala (300 m)
		Tamil Nadu (333 m)

Morphology

The members are mostly herbs. Some are epiphytic and a few are lithophytic. Many members show xerophytic adaptations also. Most of them prefer shady conditions but a few prefer open sunny habitats but exhibit considerable variation in the habit. Some members like *S. nairii* and *S. keralensis* are only 1.5 cm in size while species like *S. inaequalifolia* and *S. wildenovii* are up to 150 cm in size. Many species like *S. miniatospora* and *S. minutifolia* are erect while *S. delicatula* is sub-erect. *S. inaequalifolia* and *S. monospora* are scandent, while *S. integerrima* is creeping. Species such as *S. involvens* and *S. bryopteris* have a spreading prostrate system

producing erect branches. Species like *S. wildenovii* can reach up to a height of more than one meter.

In the branching pattern also there is much variation within the group. In *S. involvens* and *S. dixitii* the branches are confined to upper half of erect branches. In *S. dixitii* the branching is trichotomous and apical. In species like *S. microdendron* the branches are flabellate. But in most members it is de-compound. Branches may originate from the base as in *S. plumosa* or the lower 1/3rd portion of the stem can be devoid of branches as in *S. uncinata*.

Leaves are either isomorphic or heteromorphic throughout. In some species isomorphic condition is restricted to strobilus alone. Leaves are tetrastichous and most commonly platystichous. Very rarely they are multifarious. The leaves are distributed along the stem and branches and show varying phyllotaxy. Leaves are distantly arranged along main stem but contiguous on branches. They are simple, 1, 2, or 3 nerved. In some species, they are white margined. Among the heterotrichous platystichous group, 3 types of vegetative leaves are present; *viz*., the lateral leaves spreading along lateral sides, the median leaves seen along upper plane which are usually small in size and the axillary leaves seen along the axils of branches.

At the adaxial surface of the leaves and sporophylls is a small, membranous, out growth called the ligule. They become inconspicuous when mature. It is usually inserted by a comparatively stout foot, the

glossopodium in the ligule pit. The shape of the ligules varies considerably from species to species. They are tongue shaped or lobed.

The rhizophores (roots) of *Selaginella*, originate from the angle meristems *i.e*., from the meristems between the shanks. The angle meristems, which are present at every branching of the main shoot, characteristically develop as rhizophores (Cusick, 1954). Rhizophores are confined to the extreme base as in *S. proniflora* and *S. bryopteris* or originate from the basal 1/3rd of main stem nodes as in *S. plumosa* and *S. delicatula*. They are elongate and leafless structures. They are green in *S. plana*, pale green in *S. delicatula* and pinkish brown in *S. tenera* and *S. wildenovii*. In some species like *S. monospora* and *S. inaequalifolia* rhizophores are prominent while in others like *S. cataractarum* and *S. ciliaris* they are delicate and slender.

Webster and Steeves (1963) have conclusively established the rhizophores as roots. They are positively geotropic and give rise to a small tuft of adventitious roots at their tips. These roots bear root hairs and root caps like normal roots.

Vegetative reproduction is common in *S. radicata* and *S. wightii.* Bits of old plants, torn off by wind or rain can form new plants. Sometimes new plantlets may arise from the apex of the mature plants on touching the soil as in *S. radicata*. *S. chrysocaulos* bears certain bud like structures at the tip of some of the vegetative branches which remain at the surface of the ground.In S.chrysorrhizos,on the other hand tubers are developed under

ground,at the ends of filamentous, modified vegetative branches(Bancroft,1914)

Anatomy

Stem anatomy in *Selaginella* has been intensely studied by many scientists in the past decades especially in relation to phylogeny (Mukhopadhyay & Sen, 1986; Gopalakrishnan & Ravi, 1990). The stem has an outer epidermis, thick cortex and central stele. The epidermis is single layered and prosenchymatous with a conspicuous layer of cuticle. Stomata are absent. Cortex consists of thin walled, green, angular parenchyma cells. In the stems of *S. wightii, S.wildenovii, S. plana, S. inaequalifolia* and *S. delicatula* the outer layers of cortex consists of sclerenchyma. In *S. tenera*, the cortex is purely parenchymatous.

In the rhizomes of *S. wightii* the central core of stele is separated from cortex by certain elongated cells – trabeculae. According to Wardlaw (1952) the lacuna is formed by the stretching of the inner layer of cortex. Hence the endodermis at the surface of conjunction gets pulled out and the stele occupies cavity. The trabeculae formed by the lateral stretching of cells also bear casparian strips.

In stem the stele is exert. The number of stele varies from 1 – 5 and rarely more. It is monostelic in *S. wightii* that is always central, laterally flattened and hadrocentric. In *S. inaequalifolia* 2 steles are present, one is ventral and the other is dorsal. In *S. wildenovii* 3 steles are present. One is

at center and the others are aligned dorsal and ventral (Plate1). According to Bower (1930) *Selaginella* exhibits solenostely, distely, polystely and polycycly in different species. The basic structure remains monostelic irrespective of its complexity when mature. But in *Selaginella*, individual internodal strands are in fact formed by the splitting of a single strand and along the region of nodes they unite. So, according to Mukhopadhyay and Sen (1986), the use of the term polystely for the many-stranded tissue in this group is misleading.

The stem of isophyllous group is considered morphologically primitive and anatomically advanced where vessels are the major conducting tissue. In the heterophyllous forms that are morphologically advanced, tracheids and xylem parenchyma are the major conducting tissues (Mukhopadhyay & Sen, 1986). These features might be controlled genetically in these species (Gopalakrishnan & Ravi, 1990). But according to White (1961) occurrence of vessels in pteridophytes is not of phylogenetic value and is associated with ecological adaptations. Mukhopadhyay and Sen (1986) however do not consider the role of ecological factors in the expression of features like the vessels, trabeculae and lacunae in *Selaginella*. According to them, even though members of isophyllous and heterophyllous group grow in association with each other their basic features are not affected.

Wardlaw (1952) had compared the structure and arrangement of vascular system to the size of the sporophyte in *Selaginella* and has shown

a direct correlation between these two parameters. An increase in size of the sporophyte is linked to an increased development of vascular tissue.

The cross section of rhizophores shows an epidermis consisting of a single layer of large, thick walled cells bearing root hairs. The cortex can either be completely of parenchyma or sclerenchyma mixed with parenchyma. In *S. wildenovii*, the outer cortex consists of 3 to 5 layers of sclerenchyma and the inner cortex is multilayered with thin walled parenchymatous cells. In *S. inaequalifolia* cortical cells are thin walled and parenchymatous. Unlike other species, the endodermis is well defined in *S. wildenovii* and *S. tenera*. The cortex in rhizophore is separated from the endodermis by trabeculae (Webster & Steeves, 1963). Inner to the endodermis is one to three layered pericycle. The stele is monarch and exarch. In the isophyllous group trabeculae and lacunae are present where as in the heterophyllous group trabeculae and lacunae are absent (Plate 3 A - E).

In *Selaginella* the leaves have an upper and lower epidermis made of isodiametric cells. The stomata are anomocytic (Plate 3 F). Their distribution varies among species. *S. inaequalifolia, S. tenera* and *S. wightii* are hypostomatic while the median leaves of *S. repanda* and *S. vaginata* are amphistomatic. Mital (1969) conducted an epidermal study on thirty-three species of *Selaginella* and has proposed a key for their identification. The mesophyll is not differentiated in to palisade and spongy. They are green and irregular in shape. The chloroplast has an aggregation of starch

molecules like the pyrenoids. The single vascular bundle is concentric and leaf traces join the main stem. The xylem is surrounded by phloem. External to the phloem is one-layered pericycle.

Selaginella is microphyllous with a single, simple vein. But Wagner *et al*., (1982) reported an average of 13 branching in *S. schaffneri* and tri-nerved condition is noted in *S. griffithii* Spring (Alston, 1945). In these species, the leaf show magaphyllous character. Panigrahi and Dixit (1967) reported bi-nerved condition in *S. involvens* and tri-nerved condition in *S. wildenovii*. But according to Mukharjee and Sen (1981), these are sclerenchymatous bands composed of fibres with warty outgrowths on the outer periclinal surface extending along either side of the midrib on the abaxial epidermis of the lateral leaves. Tracheids and sieve cells are never associated with these sclerotic bands. These bands along with the midrib give a deceptive multi-nerved appearance in *S. involvens, S. intermedia, S. chrysocaulos* and *S. tenera*.

Cytology

The chromosome studies in *Selaginella* has proved the complexity in its basic chromosome number as x = 7, 8, 9, 10, 11 and 12. Denke (1902) reported 2n = 16 in *S. emiliana* (*S.pallescens*) and *S. serpens*. The studies by Heitz (1926) also gave the same chromosome numbers in *S. vogelii*. *S. grandis* has 2n = 16 or 17 and *S. martensii* var. *divericata* is with 2n = 52 to 57. Heitz (1926) reported haploid numbers 8, 10, 11, 26, 27 and 28 in this genus. Manton (1950) reported 2n = 18 with a basic number x = 9 in *S.*

denticulata (L.) Spring, *S. helvetica* (L.) Spring and *S. spinulosa*. All these are diploids (2n = 18) with basic chromosome number 9. Studies by Reese (1951) and Love and Love (1961) in *S. selaginoides* (L.) Link also gave the basic chromosome number 9. The North American species *viz*., *S. bigelovii* Underw., *S. mutica* D.C.Eaton *ex* Underw. and *S. weatherbiana* R.M.Tryon also have the basic number 9 (Tryon, 1955). Thus, most species of *Selaginella* are diploid with chromosome number 2n = 18 and x = 9, or 2n = 20 and x = 10. A few are polyploids with chromosome number 27 where the basic number is 9 (Jermy *et al.*, 1967) and one unidentified species from Kodaikanal is tetraploid with 2n = 36 and x = 9 (Kuriachan, 1963).

Initial cytological works in *Selaginella* gave only one basic chromosome number x = 9. The works by Tschermk – Woes and Dolezal – Janisch (1959) throw light on the chromosomal variation in the species *S. cuspidata* (= *S. pallescens*) with 2n = 22 and x = 11. But Jermy *et al.,* (1967) disagree with them and have stated that *S. cuspidata* (= *S. pallescens*) has 2n = 20.

Cytological studies conducted in the sporangia as well as in the root tips of 8 south Indian species of *Selaginella* have revealed the basic chromosome numbers x = 9 and 10 (Kuriachan, 1963). Polyploids are of natural occurrence in the x = 9 group. *S. crassipes*, *S. wildenovii* and *S. involvens* are with 2n = 18 and *S. gracilis*, *S. plana, S. wallichii* and *S. bryopteris* are with 2n = 20. *S. radicata* is with 2n = 36 and *S. tenera* is

having 2n = 16 and x = 8. *Selaginella* species with the basic chromosome number 7 is so far not reported from India (Mukhopadhyay *et al.,* 1998). Table 4 shows the chromosome numbers reported for species of *Selaginella* from South India (Mukhopadhyay *et al*., 1998).

Table 4

Sl. No.	Name of Species	2n	X
1	*S. braunii*	20	10
2	*S. wallichii*	20	10
3	*S. plana*	20	10
4	*S. crassipes*	18	9
5	*S. involvens*	18	9
6	*S. wildenovii*	18	9

Chromosome number in relation to

1. Evolution

A reduction in basic chromosome number has been treated as a tendency towards advancement as it is evident in the south Indian leptosporangiate ferns (Abraham *et al*., 1962). In *Selaginella* there is a reduction in basic chromosome number from 10 to 9 during the course of evolution (Kuriachan, 1963). There are tetraploids with chromosome number 2n = 36. Meiosis in this group is normal and they form 18 bivalents during metaphase 1 and separate normally during anaphase 1, which suggests allopolyploidy in this group (Kuriachan, 1963). According to Graustein (1930), the high rate of hybridity in this genus has played a key role in the evolution of *Selaginella*. Manton (1950) also is of the opinion that genetic

changes and genetic recombination by inter-specific hybridization are the reasons for evolution.

2. Anatomy

The stem is usually monostelic in Indian *Selaginella*. But multistelar stem even though not common is observed in groups with x = 9 and 10 (Mukhopadhay *et al*., 1998.). Monostelic character is supposed to be primitive. *S. fraipontii* (Leclercq) Schlanker & Leisman, one of the fossil members has monostelic stem. The multistranded condition is derived from the monostelic condition by schizogenous splitting (Gibson & Harvey, 1894.; Mukhopadhay & Sen, 1986).

3. Morphology

The members of the group with x = 9 are all having isophyllous sporophylls. But those with x = 8, 10 and 12 have heterophyllous sporophylls and laminal flap. Cytological studies of non–Indian isophyllous members, *S. selaginoides* (Manton, 1950; Takamiya, 1993) and *S. uliginosa* (Labill.) Spring (Jermy *et al*.,1967) gave 2n = 18. Members with x = 9 existed from carboniferous period and can be considered as the primitive group which got distributed along different zones (Mukhopadhyay *et al.,*1998.). The members of the group with x = 9 exhibits plasticity in morphological and anatomical characters and this group consists both heterophyllous and homophyllous members. According to him, x = 10, 12 etc. evolved from isophyllous x = 9

group which is contrary to the opinion of Jermy *et al*., (1967) and Kuriachan (1963.). Again no isophyllous members belong to x = 10 series.

According to Jermy *et al*., (1967) natural polyploids are common in x = 9 series. The group with x = 10 group is mainly consisting of members of horticulture interest.

Selaginella started its life with a basic chromosome number x = 9 and later other groups with x = 10, 11, 12 etc. originated from it. In the former both hetero and homophyllous members are present while the latter groups bear only heterophyllous members. If the heterophyllous group is treated as advanced, then, the basic chromosome number x = 9 should be treated as primitive since it is associated with isophyllous group. However, there are also members like *S. schlechteri* Hieron. with x = 7 and *S. tenera* with x = 8. They might have formed by reduction in the basic chromosome number during evolution.

Reproduction

Vegetative propagation is prevalent among members of *Selaginella*. The most common method is fragmentation. In *S. radicata* and *S. vaginata* the trailing stem produces new propagules at its tip while in *S. bryopteris* and *S. involvens* the trailing stem produces new erect suckers. In *S. tenera*, gemmae and in *S. chrysocaulos*, tubers are the means of vegetative propagation.

The most common method of reproduction is by spores. Species of isophyllous group bear only tetragonal strobili and those of heterophyllous group bear either tetragonal or bilateral strobili. Only one south Indian species *viz*., *S. wightii* belongs to isophyllous group. The remaining thirty-five South Indian species are heterophyllous. Of them, eighteen are with tetragonal strobili and seventeen are with bilateral strobili. The strobili in all the species studied are terminal but *S. proniflora* possess both terminal and axillary strobili.

The arrangement of sporangia in the strobilus varies within the genus. Hieronymus (1900) used the sporangial arrangement as a key character to describe twenty-six species while Horner and Arnott (1963) have studied the sporangial arrangement in thirty North American species.

The south Indian species show four types of sporangial arrangement within the strobilus. They are 1) strobili with basal megasporangia and apical microsporangia, 2) strobili mostly microspongiate but with a very few basal or middle megasporangia, 3) strobili mostly megasporangiate but with a few apical microsporangia and 4) strobili with both micro and mega sporangia arranged intermixed.

Majority of the south Indian species belong to type one. Species like *S. wightii*, *S. delicatula* and *S. inaequalifolia* fall under this type and have tetragonal strobili. *S. tenera* and *S. ciliaris* with bilateral strobili also belong to type one. *S. nayarii* with bilateral strobili exhibits type two. *S. crassipes* of this group is mostly microsporangiate with middle one or two pairs of

megasporangia attached to smaller sporophylls. In members like *S. radicata, S. nairii* and *S. plana* there is a predominance of megasporangia over microsporangia and they come under type three. During my studies, I could not observe any microsporangia in 90% of strobili in species belonging to type three. In species like *S. vaginata,* the sporophylls with micro and megasporangia are arranged intermixed and exhibits type four arrangements of sporangia.

Among the sporangial arrangement within the strobilus, type one with basal megasporangia and apical microsporangia is considered primitive. The predominance of megasporangia over microsporangia of group three is an advanced feature within *Selaginella* (Horner & Arnott, 1963). The condition where sporophylls with microsporangia and megasporangia are arranged intermixed as in type four is treated intermediate.

The sporophylls of *Selaginella* are mostly fertile but sterile ones also occur in certain species. In the south Indian species with tetragonal strobili, all the sporophylls are fertile. However, in species having bilateral strobili, the sporophylls are either fertile or sterile. In members like *S. crassipes, S. proniflora* and *S. tenera,* all the sporophylls are fertile where as in *S. nairii, S. coonooriana* and *S. minutifolia* only the smaller sporophylls are fertile and the larger sporophylls are sterile.

The margins of the sporophylls also vary between species. In *S. nayarii, S. ciliaris* and *S. proniflora*, the sporophylls are ciliate. In species like *S. tenera, S. keralensis* and *S. vaginata*, the sporophylls are denticulate. The

sporophylls of *S. bryopteris* are entire and that of *S. radicata* are denticulate. In *S. plana* sporophylls have serrate margins. However in *S. wightii* sporophylls are with shortly ciliate margins. The characteristics of sporophylls also can be used as a character in the delimitation of species within *Selaginella*. Dixit (1992) has used the presence of cilia on the sporophylls as a key character for species identification.

A laminal flap is present on the adaxial surface of sporophylls in the heterophyllous group. According to Mukhopadhyay and Sen (1981) this increases the increases the respiratory and photosynthetic area of the leaf. Usually the flap subtends before the vein ending except in *S. tenera* where the vein extends up to the apex of leaf. Another suggestion is that it helps to capture the spores so that both megaspores and microspores can germinate and develop in close proximity (Mukhopadhyay & Sen, 1981.). No laminal flap is associated with the vegetative leaves of any species of *Selaginella*.

In *Selaginella* heterospory is directly linked to nutrition (Webster, 1974). The production of megasporangia is favoured by favourable nutrition. Megasporangia in most cases bear 4 megaspores and are usually unequal in size. The megasporangia dehisce into two unequal halves to liberate megaspores that are tetrahedral, trilete, dry and larger than microspores. Microsporangia bear a large number of microspores that are trilete, tetrahedral, dry and very small in size. Microsporangia dehisce into two equal parts on maturity and the spores are dispersed by wind (Giorgi & Schneller, 1997). The megagametophytes are minute and partly protruding

from the megaspore wall. The microgametophytes developed wholly within the microspore and the wall rupture to release the spermatozoids (Tryon & Tryon, 1981).

Resurrection in xerophytic *Selaginella*

Adaptation to draught takes two extreme forms in *Selaginella*. The members of the first group are characteristic of dry areas and a few along mesophytic heath woodlands. The members of this group belong to *Tetragonostachys* (Jermy, 1986) and have a mat-forming or tufted habit. The leaves are thick, cutinised and taper to a hair point, giving a moss-like appearance as in *S. wightii*.

The so-called ‘resurrection plants’ of *Stachygynandrum* (*sensu* Jermy, 1986) forms the second group. They have creeping or semi-prostrate habit and are also adapted for seasonal draught, but show clustering and curling movements of leaves and stems on dehydration. They regain their original size and form on rehydration (Korall & Kenrick, 2004). They can withstand repeated drying and wetting without showing lesions in the cell membranes. The clustering and curling movement of leaves is purely hygroscopic and is strictly mechanical because their cells on maturity do not carry living protoplasm (Upholf, 1920). The movement is mainly caused by the unequal power of swelling of the different tissues like upper turgescent motor cells, the lower parenchyma and the sclerenchymatous flange, augmented by the peculiarities of pitting on their walls (Chowdhury, 1959).

Daneil and Gaff (1980) has conducted PAGE studies on the soluble proteins of desiccation sensitive *S. kraussiana* (G. Kunze) A. Braun. Changes in the soluble protein composition were found in this species after dehydration. Their work evidenced the possibility of an important role of protein synthesis for survival of dehydration.

S. bryopteris and *S. wightii* occupy a crucial role in xeric ecology. Even after complete desiccation they regain their original form in dampness. *S. involvens, S. repanda, S. radicata*, *S. chrysocaulos* and *S. dixitii* also show 'resurrection' property to some extent.

Economic importance

Ornamentals

Many species of *Selaginella* are grown as ornamentals. *S. wildenovii* and *S. caesia*. are well known for their metallic blue colour when grown in shade, but on getting exposed to direct sunlight their leaves turn pale green. This is due to the presence of particles in the cutin of the epidermis, which reflect certain rays of light. *S. serpens* (Desv. *ex* Poir.) Spring changes its colour throughout the day. In the morning the leaves are bright green, during daytime they become paler and by night they regain their green colour. The leaves of *S. monospora* turn pinkish–green under the exposed conditions in the forest floor. *S. intermedia* is noted for its purple-green colour. *S. dixitii*, *S. plana* and *S. uncinata* are grown as pot plants in India. *S. lepidophylla* (Hook. & Grev.) Spring and *S. pilifera* A. Braun labeled as "resurrection plants" are sold as curiosities in European markets (Dixit, 1992).

Medicine

S. bryopteris, commonly called “sanjivani” is sold as a cooling agent in Indian markets (Dixit, 1982). The extract of the leaves if served with sugar is a cooling and rejuvenating agent. The cytotoxic biflavanoids extracted from *S. delicatula* is effective against various tumour cell lines. Robustaflavone 7, 4’- dimethyl ether and 2”, 3’ – dihydrorobustaflavone 7, 4’, 7” – trimethyl ether can suppress the growth of Raji and Calu – 1 tumor cell lines (Lin *et al.*, 2000). Bioactivity guided fractionation studies of the leaves of *S. wildenovii* afforded three biflavanoids that proved cytotoxic against a panel of human cancer cell lines (Silva *et al.*, 1995). *S. deoderleinii* Hieron. is used in Chinese traditional medicine as bactericide, as an anti-cancerous agent and in the treatment of cardiovascular disease. This plant has got anti-tumor properties and has proved against *HeLa* cells in vitro.

Edible

In spite of an astringent and bitter taste a few species of *Selaginella* are edible. The tender stems of *S. caudata* (Desv.) Spring, *S. fimbriata* Spring and *S. wildenovii* (Desv.) Baker is used as lablab with rice in Java (Dixit, 1992). They are depurative and stomachic.

REVIEW OF LITERATURE

A retrospection of the literature shows that floristic studies in India have given less consideration to vascular cryptogams. The work of Spring (1850) is the first of this kind.In his monograph on *Selaginella*, he

enumerated 42 species from India. Subsequently, Kuntze(1851) listed 5 species of *Selaginella* from Nilgiri hills. Baker (1867, 1883, 1887) had described 29 species of *Selaginella* from India of which eleven were new. Rosenburgh (1915) in his *Handbook to the determination of the fern-allies of the Malayan islands* has provided a good account on Malayan *Selaginella*. He treated 201 species of *Selaginella.*

Alston (1945) has enumerated 58 species of *Selaginella* from the then British India of which only 44 belong to present boundaries of India. Tryon (1955) treated 2 species while Reed (1966) treated 43 species of *Selaginella* from India. Panigrahi and Chowdhury (1962) reported 30 species of *Selaginella* from eastern parts of the country, Mehra and Bir (1964) reported 9 species from Sikkim and Darjeeling and Dixit (1983, 1984, 1985) reported 8 new species from India. Bir and Vasudeva (1973) reported 5 species from Pachmarhi hills, Manickam and Irudayaraj (1992) reported 11 species from Western Ghats. Nair *et al.* (1988) included twenty species of *Selaginella* from Kerala while Dixit (1992) in his revision of Selaginellaceae in India has included 62 species of *Selaginella.* Isolated reports of new species were made by Gena *et al.* (1979), Dixit and Panigrahi (1983), Dixit (1985), Madhusoodhanan and Nampy (1994) and Antony *et al.* (2002). Considering all these works, there is a report of 64 species of *Selaginella* from India and 36 species from South India.

Classification of the genus were given by Spring (1850), Baker (1887), Rosenburgh (1915), Walton and Alston (1938) and Jermy (1986,

1990). Cytological studies on this genus were carried out from time to time. The major works of this kind include Reese (1951), Love and Love (1961) and Kuriachan (1963) on the basic chromosome number, and Jermy *et al.* (1967) regarding polyploidy.

The anatomical works by Wardlaw (1952) and Webster and Steeves (1963) on the rhizophores of *Selaginella* and Bower (1930) on stem are remarkable. Contributions of Dixit (1992), Mukhopadhyay and Sen (1986) and Gopalakrishnan and Ravi (1990) are also worth mentioning. Studies were carried out on the branching by Wagner *et al.* (1982), venation by Alston (1945) and Panigrahi and Dixit (1967) and on false veins by Mukherjee and Sen (1981).

Molecular studies were carried out by Jernstedt and Mansfield (1985) on the secondary metabolites of rhizophores, roots, stems and leaves. This work has shown the closer affinity between rhizophores and stems than between rhizophores and roots. Chao *et al*. (1990) have carried out the structural revision of glycoalkaloids in *Selaginella*. Cladistic analysis based on *rbcL* gene sequencing is also going on in this genus, which can provide a clear picture regarding their evolution (Korall *et al*., 1999).

AREA OF PRESENT STUDY

South India, the area of present study is in shape of an inverted triangle with its apex in the south at Cape Comorin and lies entirely in the tropical zone (Fig.1). It extends from latitudes $8^0$4'N and $15^0$6'N on the West

coast and 19^0N on the East coast and longitudes 74^0 to 85^0E. The study area covers the states of Andhra Pradesh, Goa, Karnataka, Kerala, Tamil Nadu, Pondichery and the Union territory of Mahe, with an area of 6,39,974 sq. km. The two sides of the peninsula are bounded by the Arabian Sea on the west, and the Bay of Bengal on the east. The base of the peninsula i.e., the northern boundary consists of the Vindhya mountains. Between latitudes 21 and 24 north, there is a group of mountains running in a line across the subcontinent namely Vindhya – Satpura line. Along with these regions mention may also be made of the Ajantas and the Aravallis of which the latter is important in the Paleozoic times. South of the Ajantas lies the state of Orissa. The land south of this triple wall of the Vindhyas, Satpuras and Ajantas is called the Deccan, one of the floristic regions of our present study. Deccan is an anglicized form of the Sanskrit term Dakshina or Dakshinapatha. South of these hills were once a belt of impenetrable forests.

The geographical features of Indian peninsula show that it is largely a plateau, which reaches its highest elevation (3000 feet) in the Mysore region and slopes gently towards the East. South India is a region of open valleys and easy slopes in which the rivers flow with slow gradients. In South India one can find rivers that are steep and deep only in Western Ghats.

Along the mountain ranges of peninsula, Western Ghats run almost parallel to the west coast from Cape Comorin to the Tapti Valley. Throughout its length it is broken completely in the Bhorghat, Thalghat and the Palaghat

gaps. Of these Bhorghat was once considered the key to the Deccan. Western Ghats can be divided into two halves *viz*., the southern half and the northern half. The northern half covers the territory between the present Belgum and the Tapti, covering the Deccan traps. The southern half cover Malabar region, another important floristic region of our study area. Anamalais, part of Western Ghats has got peaks rising up to a height of 8,000 feet. The Western Ghats run parallel to the Arabian Sea and form the watershed of the peninsula. Agasthyamalai and its environs, situated at the southern end of the Western Ghats, having an average altitude of 300 – 1500 m, form the most diverse and least known ecosystems in peninsular India (Henry & Subramanyam, 1983).

In the east of peninsula is the Eastern Ghats, simpler in character and extending to an area of 75,000 sq. km. The rivers that drain the interior of the peninsula interrupt the rocky coastline by a series of deltas. The Eastern Ghats are also broken and discontinuous forming a series of detached hills from Balasore of Orissa to the Nilgiris. One of the worth mentioning zone of Eastern Ghats is the Nallamalais that run between Krishna and Pennar of Cuddapah District (Dikshitar, 1981). Even though there is scarcity of rainfall, thick forests abound all over the range. Another important zone is Shevroy Hills that form a detached range in the Salem district. There are no thick forests along Shevroy Hills. Pachamalais, Jivadi hills and Kollimalais are the other hill ranges of Eastern Ghats in Tamil Nadu.

The meeting place of the Western Ghats and Eastern Ghats is represented by a group of hills called Nilgiris. The Nilgiris has abundant rainfall and equally abundant vegetation. Ootacamund, a part of Nilgiri plateau is the queen of hill stations in India. The Nilgiris is interspersed by streams running in shallow channels and contains forest tracts separated by spaces of marsh and bog. The forest territory has its peaks of upto 6,000 feet height. Detached masses of hills like Palani and Salem branch off to the north – eastern sides preserve the structural outlines of the southern parts of South India.

Rivers and river valleys

Only a few types of river systems are observed in South India. The rivers like the Mahanadi, Godavari, Krishna and Kaveri flow in the south – eastward direction and fall into the Bay of Bengal where as the rivers such as Narmada and Tapti that flow westwards to the Arabian Sea. Besides the above mentioned, there are again innumerable small rivers flowing into the Arabian Sea. There are also rivers that drain north - eastward to the Gangetic basin, but the bulk of the drainage of South India is to the Bay of Bengal effected through the large river basins. The river valleys here are all in the adult stage, broad and shallow with low gradients; the bigger rivers have developed deltas. Consequently, there is not much momentum except in times of flood; i.e they are only agents of deposition. In the upper reaches of some of the rivers of the Western Ghats, there are cascades and waterfalls.

One of the important rivers of South India is the Godavari, having a length of 900 miles. Another important river is Kaveri that rises in the hills of Coorg and flows in a south–east direction. The Palar, an important river of Karnataka flows to the Bay of Bengal. The river Vaigai receives much of its drainage from Palani hills.

Climate and rainfall

Generally speaking, peninsular India has got an equable climate. During hot seasons, i.e. the months from March to October, there is high temperature in the land. In the central areas summer remains very hot. On the Malabar Coast the south–west monsoon sets in by the end of May. Having commenced on the west coast it soon sweeps all through the peninsula. By August it almost gets over. Along the Coramandel coast its effect is felt little. The west coast naturally gets heavy rains, its fall being 100 inches and above. The retreating monsoon commences in the latter part of October usually on the Coramandel coast. Usually February is the month when this monsoon abates. Early in March, the south–east wind of the Coramandel Coast establishes itself. To some extent, the rainfall varies from place to place, more due to local conditions and circumstances. The Western Ghats is said to be the foothold of abundant rainfall. It is from the west coast that the Deccan and Mysore plateau are fed with rainfall. The Western Coast of South India receives the heaviest rainfall with more than 220 cm annually, and Andhra Pradesh and Tamil Nadu receives only 100 – 200 cm annually.

Soil

The soils in peninsular India include 1. Lateritic soil, 2. Black soil, 3. Red soil, 4. Alluvial soil, 5. Alkali soil and saline soil and 6. Peaty and other organic soil (Venu *et al*., 1996).

Lateritic soils are reddish or yellow-red and turn black when exposed to sunlight. It occurs in Kerala, Tamil Nadu and Western Ghats in South India and is mainly composed of hydrated oxides of aluminium and iron with minor quantities of manganese and titanium oxides. There is higher content of humus.

Black soil, locally called ‘regur’ is distributed in Tamil Nadu, parts of Karnataka and Andhra Pradesh. Its black colour is mainly due to the presence of superficial iron in the rocks. The red soil is mainly distributed in Karnataka and Andhra Pradesh. This soil is light, friable and porous with a low water holding capacity.

Alluvial soil is the most important soil of India and forms the largest share of agriculture. The main features of this soil is contributed by the silt of various rivers in India. In South India, alluvial soil of Godavari, Krishna and Kaveri valleys are black, sandy and humid. In Kerala, the coastal alluviums are sandy having a low water holding capacity and low nutrient status. The alluviums on the banks of rivers are fertile. Alkali soils with high percentage salt are distributed along many states of North India and in South India they occur along Tamil Nadu. Peaty soils with excessive organic matter accumulated in poorly decomposd state occur along South-eastern Tamil

Nadu and Kerala in addition to Orissa and West Bengal. This soil is coloured due to free aluminium-ferrous compounds. In addition to this, desert soils occur along arid and semi-arid zones. The mountains and hills bear sandy soils.

MATERIALS AND METHODS

MATERIALS

Materials for the present study were gathered from all available sources. As far as possible, fresh specimens, collected from various localities of South India were used except for three species namely *S. brachystachya*, *S. braunii* and *S. minutifolia* where, herbarium specimens were the only available source. Different populations were studied to get a thorough understanding on the variation pattern, if any, exhibited by each species. As much as possible, the ecological and morphological characters were noted from the field itself. Conventional methods were used to prepare the herbarium specimens. Small specimens were pickled in 5% formaldehyde. Live specimens are maintained in the botanical garden of St. Joseph's College, Devagiri.

Type materials received from the Herbarium and Library, Royal Botanic Gardens, Kew, U.K. (K), British Museum (Natural History), London (BM) and Museum National Histoire Naturelle, Laboratoire de Phanerogamie, Paris (P) was referred. Materials deposited at the Central National Herbarium, Kolkatta (CAL), Botanical Survey of India-Southern Circle, Coimbatore (MH), Tropical Botanical Garden and Research Institute, Palode (TBGRI), Sree Krishna Devaraya University, Anantapur (SKU), St. Xavier's College Herbarium, Palayamkottai (XCH) and Calicut University

Herbarium (CALI) were also consulted. Protologues and xeroxcopies of type materials were also obtained from K, P, CAL, TBGRI and XCH. For anatomical studies fresh specimens were used, but for SEM studies of megaspores, dried herbarium samples were used.

METHODS

For morphological studies, materials were observed under Leica MZ 7.5 stereomicroscope. The specimens were identified with the help of types or authentic specimens received from various herbaria and the nomenclature of each specimen was updated with the help of recent literature. Detailed descriptions were prepared using available specimens. Fresh leaves and spikes were mounted on clean glass slides and were observed. In case of herbarium specimens, they were soaked in hot water and observations were made. Illustrations were prepared for all species depicting their habit, lateral leaf, axillary leaf, median leaf, sporophylls, spikes and spores. Most typical specimens of every species were illustrated. Except habit, ligules and spores, all the illustrations were made using the Camera Lucida. S. I. system was followed in each measurement. Cytological observations and etymology were based on the available literature. Ecological notes were prepared based on our own observations and the details recorded from the herbarium sheets. The citations of author's names follow Brummitt and Powell (1992) and the nomenclature is in accordance with the latest Code edited by Mc Neil *et al*. (2006). For the abbreviations of periodicals Lawrence *et al*.'s Botanico-Periodicum-

Huntianum (1968) and for translation of latin description, Botanical Latin by Stern *et al*. (1992) was used. The botanical terminology was based on Lawrence's *An introduction to Plant Taxonomy* (1966).

Anatomy of the rhizophores, stem and ligule were done. Serial sections of the rhizophores, above and at the region of branching were taken. In case of stem, the portion up to apical 1/3 rd was used. Thin hand sections were taken, stained using safranin and Toludine blue and semi-permanent slides were prepared using glycerin. They observed under a Leica *ATC* 2000 microscope and photographs were taken using a Nikon coolpix 4500 camera. The ligules were removed from the leaves and observations were made under a light microscope of magnification x 400. Illustrations were prepared using a Camera Lucida.

The spores of all species were studied under a light microscope of magnification x 400 and illustrations were made using Camera Lucida. Measurements of spores were made with micrometer. SEM studies of megaspores of 13 species of *Selaginella* were carried out. For scanning electron microscopic studies, the untreated spores were fixed on aluminium stubs with double - sided adhesive tape and subjected to sputtering with Au/ Pa alloy using an E – 101 sputtering unit. Photographs were taken with an S – 2400 Hitachi make microscope.

PLAN OF THESIS

The thesis has six chapters. The first chapter begins with a brief introduction. This also discusses the aim and relevance of present work, ecology and distribution, and endemism of the species of *Selaginella* in South India. The details of morphology, anatomy, cytology, reproduction, resurrection in xerophytic *Selaginella* and economic importance of this genus are also explained in this chapter. Review of literature and area of present study are given in detail. A map of study area is provided. Distribution maps of the species are given separately. Details of rivers and river valleys, climate and rainfall as well as the edaphic factors of the study area are also provided.

The second chapter discusses the materials and methods adopted for the present study. This is followed by plan of the thesis. The third chapter deals with plan of thesis. The fourth chapter is about the ligule and its salient features. It is followed by the fifth chapter dealing with spore morphology where SEM studies and light microscopic studies were compared.

The sixth chapter deals with the systematic treatment of the family. It begins with the description of the family Selaginellaceae followed by distribution and notes. The etymology of the genus, history, relevant citation and sub-generic classification follow this. Jermy's (1986) classification is adopted in the present treatment. The genus is divided in to five sub-

genera. This is followed by key to sub-genera. Under each sub-genus, relevant citations, important characters, distribution and key to species were provided. The species coming under each sub-genus is treated in alphabetical sequence. Each species is provided with correct nomenclature, relevant synonyms, type specimen, detailed description, ecology and distribution and notes. For each species, the specimens studied were cited with their places in alphabetical sequence.

Summary is given as the seventh chapter. Doubtful species is treated next. This is followed by a bibliography on literature cited and an index to plant names treated in the thesis.

THE STRUCTURE OF LIGULE AND THEIR TAXONOMIC SIGNIFICANCE

The term ligule is derived from the Latin word ‘ligula’ or ‘lingula’ means a little tongue (Pant *et al*., 2000). In *Selaginella*, it is seen along the adaxial surface of the microphylls and sporophylls (Bilderback & Slone, 1987). It is conspicuous in young vegetative and reproductive leaf. Some of the earlier works include Velenovsky (1905), Geobel (1930) and Verdoorn (1938).It is considered as an absorptive structure by Mc Nab (1887) and Kohlenbach and Geier (1970). Hofmeister (1851) and Harvey & Gibson (1896) reported that the apical cells of ligule appeared to contain granular slime. Lerbs (1974), Sigee (1974) and Horner *et al*. (1975) had shown cytological characteristics of secretory cells for the basal cells of ligules. Sigee (1974, 1975,1976) in a series of papers concluded that the ligule might be vestigial secretory structure. Bilderback (1987) observed some mucilage associated with the ligules of several species of *Selaginella* and concluded that they are specialized for the production and secretion of extracellular mucilage.

Harvey and Gibson (1896) recorded considerable variations in the precise form of ligules of the same plant. Ball (1925) has reported lobed ligules in *Selaginella*. In the present investigation, morphology of the ligules of 8 species of *Selaginella* was studied.

MATERIALS AND METHODS

As far as possible, fresh specimens were used. In the absence of fresh materials, specimens preserved in 20% formalin were used. The specimens were observed under a Leica MZ 7.5 Stereo zoom Microscope (magnification 20 times). The ligules were then separated and mounted on a clean glass slide and observed under the low power of a Compound Microscope (magnification 100 times). Using a Camera Lucida, fitted to the Compound Microscope, illustrations of the ligules were prepared. The ligules were also studied under a Leica ATC 2000 Microscope at a magnification x 400.

OBSERVATION

In the sporophylls, ligules are seen on the stem at the point of attachment of sporophylls. The general structure of ligule shows the basal sheath of cells enclosing glossopodium, the glossopodium and the apical free portion. No vascular traces were observed. The outer sheath is continuous with the epidermis of the leaf and with the epidermis of the stem. The glossopodium represents the sunken part of ligule that is in constant contact with the leaf. The free apical portion is almost parallel with the leaf. Being a part of the leaf, the ligule starts its growth with the ontogeny of the leaf and attains maturity very soon.

Ligules of both vegetative leaves and sporophylls were studied for most species. Since *S. wildenovii* and *S. uncinata* bear sporophylls

occasionally, the ligules of their vegetative leaves alone were included. The characters of ligules of different species studied are the following.

1. ***S. cataractarum*** Alston

Ligules of about 200 vegetative leaves and 50 sporophylls of preserved specimens were observed. Of these, ligules with entire apex were most common among vegetative leaves. Lobed ligules were associated with axillary leaves. The ligules on median leaves were elongated and have rounded apex and on lateral leaves were simple with entire apex. They were entire or lobed in sporophylls. (Fig.2. A - G)

Exsicc. *Nisha* 149 (SJC).

2. ***S. ciliaris*** (Retz.) Spring

About 250 vegetative leaves and 100 sporophylls of fresh specimens were observed. All the leaves possess simple ligules. The apex was slightly curved or straight and acute. (Fig.2. H - J)

Exsicc. Nisha 585 (SJC).

3. ***S. delicatula*** (Desv.) Alston

About 200 vegetative leaves and 500 sporophylls were observed. Of these only 6 ligules were lobed and they were associated with younger sporophylls. All the vegetative leaves bear simple ligules (Fig.2. K - O)

Exsicc. *Nisha* 505 (SJC).

4. ***S. plana*** (Desv. *ex* Poir.) Hieron.

About 500 vegetative leaves and 50 sporophylls of fresh samples were observed. All the ligules were simple with well defined glossopodium (Fig.3. A - D)

Exsicc. *Nisha* 2898 (SJC).

5. ***S. radicata*** (Hook. & Grev.) Spring

About 200 vegetative leaves and 100 sporophylls of preserved specimens were observed. The ligules on median leaves and sporophylls were simple but most of the ligules attached to the lateral and axillary leaves were lobed. The lobes were either entire or irregular with a tendency to get lobed further. Simple ligules were larger in size than the lobed ones (Fig.3. E - G)

Exsicc. *Nisha* 1474 (SJC).

6. ***S. tenera*** (Hook. & Grev.) Spring

About 300 vegetative leaves and 100 sporophylls of fresh samples were analysed. Ligules of sporophylls, axillary leaves and lateral leaves were simple. Most of them have acute apex while others have bifurcated apex, a tendency towards lobed nature (Fig.3. H - K)

Exsicc. *Nisha* 1415 (SJC).

7. ***S. uncinata*** (Desv. *ex* Poir.) Spring

About 100 vegetative leaves of fresh samples were observed. Of these 25% were lobed and the rest were simple with acute apex. The ligules of median and axillary leaves were simple but lobed ligules were present in lateral leaves. Cells of the ligules were elongated (Fig.3. L - N)

Exsicc. *Nisha* 2609 (SJC).

8. ***S. wildenovii*** (Desv. *ex* Poir.) Baker

About 500 vegetative leaves of fresh specimens, including lateral, median and axillary leaves were observed. Unlike other vegetative leaves, almost all the median leaves observed were bearing ligules. The ligules were simple and mostly with acute apex. They show little variation in size. However, 1% was mucronate. The cells of the ligules were all transparent, elongated, polygonal or rectangular (Fig.3. O & P)

Exsicc. *Nisha* 2606 (SJC).

DISCUSSION

Considerable variations occur in the shape of ligules in different species studied. Within a species, its basic shape remains constant both in the vegetative as well as reproductive leaves, but with slight differences. Ligules can be simple or lobed. Most of the ligules were simple with acute

apex. In *S. ciliaris, S. wildenovii* and *S. plana,* the ligules were simple. Lobed ligules were seen in the sporophylls of *S. delicatula*, and the vegetative leaves of *S. uncinata* and *S. radicata*. In *S. cataractarum* both axillary leaves as well as sporophylls bear lobed ligules. However, in comparison with ligules of intact apex, lobed ligules occur rarely. In *S. tenera* ligules were simple but with a tendency towards lobed nature. In all species studied ligules with entire apex were observed. In case of median leaves, ligules were not conspicuous. Despite the fact that there were variations regarding the form or shape of the ligule among different species, that alone cannot be used to key out the species of *Selaginella*.

SPORE MORPHOLOGY AND THEIR TAXONOMIC SIGNIFICANCE

Selaginella, a heterosporous genus of Lycopods, even though commonly described as bisporangiate, can be truly megasporangiate or microsporangiate (Webster, 1974). The arrangement of sporangia in the strobilus varies within the genus. Hieronymus (1900) used the sporangial arrangement to segregate twenty-six species of Selaginella while Horner and Arnott (1963) have grouped thirty North American species based on sporangial arrangement. In the south Indian species, the sporangia contain either microspores or megaspores. Sen *et al*. (1989) have studied the sporoderm structure of mega and microspores of twenty two species of *Selaginella* in India.

The microsporangia are colourless at the early stage of growth and later become white, yellow, orange or red by attaining the colour of the spores. Microspores are non-perinous and are produced in large numbers. They are 18 microns to 58 microns in size and are verrucoid, smooth, reticulate or granulose.

The megasporangia are usually white or pale yellow in colour and usually bear trilete, tertrahedral megaspores of unequal size. The size of megaspores varies from 200 microns to 350 microns and is usually dull white or yellow in colour. They are baculate, reticulate, verrucoid or smooth. Megaspore of *Selaginella* possess three layers *viz.,* - exospore, mesospore

and endospore. In some species there is an additional layer namely perispore (Stainier, 1965). According to Sievers and Buchen (1971) there are only two layers in the sporoderm, a very thick spongy sexine and a thin nexine. SEM works on the torn megaspores of *Selaginella* by Bajpai and Maheswary (1986) has also confirmed this.

MATERIALS AND METHODS

The spore samples for the present study were taken from dried plant specimens deposited at St. Joseph's College Herbarium (SJC). For light microscopic studies the spores were mounted in glycerin jelly and observed under a low power objective (x 100). At least 10 samples were studied for each species. Their size, colour and ornamentations were noted.

For scanning electron microscopic studies the spore samples were fixed with 3% glutaldehyde. The materials were then washed in 0.1 N PB. After that dehydration was carried out with 30%, 50% and 70% alcohol for 15 minutes each. This step was repeated. The material was washed with 90% and 100% alcohol for 30 minutes and this step also was repeated. Critical point drying was carried out with liquid CO_2 using an HCP – 2 Hitachi Critical Point Dryer. The material was fixed on a double - sided adhesive tape and subjected to sputtering with Au/ Pa alloy using an E – 101 sputtering unit. Photographs were taken with an S – 2400 Hitachi make microscope.

OBSERVATIONS

MICROSPORES

The microspores of 36 south Indian species were studied under Light Microscope and there is difference in ornamentation between species. The details of 13 species whose megaspores were studied under SEM are provided here.

The microspores are many in a sporangium but *S. nairii* has only few microspores within the sporangium and none were observed in *S. repanda*.

Selaginella brachystachya (Hook. & Grev.) Spring

Microspores are up to 41 microns in diam., orange – red and reticulate.

Exsicc.: *Santhosh* 29840 (TBGT)..

Selaginella ciliaris (Retz.) Spring

Microspores are up to 58 microns in diam., deep red and reticulate.

Exsicc.: *Nisha* 509 (SJC).

Selaginella crassipes Spring

Microspores are up to 40 microns in diam., orange–yellow and verrucoid.

Exsicc.: *Nisha* 521 (SJC).

Selaginella delicatula (Desv.) Alston

Microspores are up to 31 microns in diam., yellow-orange and verrucoid.

Exsicc.: *Nisha* 505 (SJC).

Selaginella ganguliana Dixit

Microspores are 22 microns in diam., orange-red and papillate.

Exsicc.: *Nisha* 2605 (SJC).

Selaginella monospora Spring

Microspores are 18 microns in diam., orange – red and papillate.

Exsicc.: *Nisha* 558 (SJC).

Selaginella nairii Dixit

Microspores 30 microns in diam., pale yellow and smooth.

Exsicc.: *Nisha* 1493 (SJC).

Selaginella proniflora (Lamk.) Bak.

Microspores are 40 microns in diam., reddish – brown and reticulate.

Exsicc.: *Nisha* 514 (SJC).

Selaginella radicata (Hook. *et* Grev.) Spring

Microspores up to 34 microns in diam., deep red, reticulate and minutely warty.

Exsicc.: *Nisha* 1474 (SJC).

Selaginella repanda (Desv. *ex* Poir.) Spring

Microspores not observed.

Selaginella tenera (Hook. *et* Grev.) Spring

Microspores are up to 18 microns in diam., orange – red, tetrahedral and warty.

Exsicc.: *Nisha* 1404 (SJC).

Selaginella vaginata Spring

Microspores are up to 32 microns in diam., reddish - brown and smooth.

Exsicc.: *Nisha* 1463 (SJC).

Selaginella wightii Hieron.

Microspores are up to 27 microns in diam., orange – red and rugulose.

Exsicc.: *Nisha* 577 (SJC).

Megaspores

Megaspores were studied both under light microscope and scanning electron microscope and there is difference in ornamentation of spores between species. A comparison of megaspores of 13 species of *Selaginella* under light microscope and scanning electron microscope is given.

Selaginella brachystachya (Hook. & Grev.) Spring

Under LM: Megaspore 293 microns in diam., pale yellow, globose and reticulate.

Under SEM: Megaspores globose with a prominent trilete ridge prominently reticulate, numerous fine bead like structures are present on the surface. (Plate 4A)

Exsicc. *Santhosh* 29840 (TBGT).

Selaginella ciliaris (Retz.) Spring

Under LM: Megaspore 222 microns in diam., yellow, globose and smooth.

Under SEM: (x 300) Megaspores sub - globose in proximal view, trilete with stout ridges and reticulate with raised margins. The reticulation is not continuous and are more prominent along proximal face. A depression is present along the distal surface. Minute granules of unequal size are distributed unevenly throughout the surface. The remaining portion of sexine appears smooth under SEM. (Plate 4B)

Exsicc. *Nisha* 509 (SJC).

Selaginella crassipes Spring

Under LM: Megaspore 91 microns in diam., yellow, globose and verrucoid.

Under SEM: Megaspores globose with a prominent trilete ridge, prominently reticulate,many fine bead like granules present on the surface. (Plate 4C)

Exsicc. *Nisha* 521 (SJC).

Selaginella delicatula (Desv.) Alston

Under LM: Megaspore 340 microns in diam., dull white, triangular, and verrucoid.

Under SEM: Megaspores globose with prominent trilete ridge, numerous blunt projections on the sexine. (Plate 5A)

Exsicc. *Nisha* 505 (SJC).

Selaginella ganguliana Dixit

Under LM: Megaspore 256 microns in diam., dull white, globose and reticulate.

Under SEM: Megaspores globose, prominently reticulate. (Plate 5B)

Exsicc. Nisha 2605 (SJC).

Selaginella monospora Spring

Under LM: Megaspore 285 microns in diam., pale yellow, globose and verrucoid.

Under SEM: Megaspores globose with a prominent ridge, warty. (Plate 5C)

Exsicc. Nisha 558 (SJC).

Selaginella nairii Dixit

Under LM: Megaspore 222 microns in diam., pale yellow and smooth.

Under SEM: Megaspores globose with a feeble trilete ridge,smooth except the proximal region with irregular deposition of wall materials. (Plate 6A)

Exsicc.: *Nisha* 1493 (SJC).

Selaginella proniflora (Lamk.) Bak.

Under LM: Megaspore 220 microns in diam., yellow, globose and smooth.

Under SEM: Megaspores sub-globose, trilete and prominently ridged along the proximal region of sexine. Except the ridges proximal region is smooth and the distal region is faintly and distantly granulate. A small depression is present at the proximal region along the zone of attachment of spores to placenta. The spore is paraisopolar. (Plate 6B)

Exsicc.: *Nisha* 514 (SJC).

Selaginella radicata (Hook. & Grev.) Spring

Under LM: Megaspore 271 microns in diam., pale yellow, globose and Reticulate.

Under SEM: Megaspores globose with prominent trilete ridge. Reticulation is prominent throughout. Small depressions are present. The wall materials form closely knit network, giving papillated appearance. (Plate 6C)

Exsicc. *Nisha* 1474 (SJC).

Selaginella repanda (Desv. ex Poir.) Spring

Under LM: Megaspore 233 microns in diam., pale yellow, globose and warty.

Under SEM: Megaspores globose. The small granules are closely packed to form a network like structure. The spores are short baculate and have an apical papilla. (Plate 7A)

Exsicc.: *Nisha* 1496 (SJC).

Selaginella tenera (Hook. et Grev.) Spring

Under LM: Megaspore 367 microns in diam., dull white, globose and warty.

Under SEM: Megaspores sub–circular in proximo–distal view and sub-rugulate. A prominent depression is present at one end and an elevation at the opposite end. Exine is formed in to lumps, which are broader than the depressions and somewhat elongated in outline and slope gently in to the depressions between them. (Plate 7B)

Exsicc.: *Nisha* 1404 (SJC).

Selaginella vaginata Spring

Under LM: Megaspore 211 microns in diam., pale yellow, globose and verrucoid-reticulate. Spores bear caducous hairs.

Under SEM: Megaspores globose with prominent trilete ridge. The spores are feebly reticulate and bear a number of fine caducous hairs. (Plate 7C)

Exsicc.: *Nisha* 1463 (SJC).

Selaginella wightii Hieron.

Under LM: Megaspore 222 microns in diam., pale yellow, globose and reticulate.

Under SEM: (fig: 13.1) Proximal pole of megaspores are globose, trilete, ridged, stout and with a slight depression. Spores are reticulate and paraisopolar. Reticulation is equally prominent along distal and proximal poles, and it is continuous. Small granules are irregularly distributed along the sexine and they are very prominent along the ridged proximal half. These projections along with the concave bays form the reticulate outer surface. Depressed areas face towards center. (Plate 7D)

Exsicc.: *Nisha* 577 (SJC).

Table 5

Shape and ornamentation of megaspores of *Selaginella* under SEM.

Sl. No.	Name of Species	Shape	Ornamentation
1	S. brachystachya	Globose	Reticulate with uniformly distributed beads.
2.	*S. ciliaris*	Sub – globose	Reticulate along proximal pole. A depression along distal pole.
3.	*S. crassipes*	Globose	Reticulate, trilete with granules. Well-developed projections present on each face.
4.	*S. delicatula*	Globose	Verrucoid with blunt projections.
5.	*S. ganguliana*	Globose	Broadly reticulate with an underlying minute network.
6.	*S. monospora*	Globose	Warty.

7.	*S. nairii*	Globose	Smooth, small depressions along the zone of leisura.
8.	*S. proniflora*	Sub-globose	Smooth along distal region, granulate, trilete.
9.	*S. radicata*	Globose	Pitted.
10.	*S. repanda*	Globose	Baculate with prominent apical papilla.
11.	*S. tenera*	Sub-circular	Reticulate with minute granules, trilete.
12.	*S. vaginata*	Globose	Reticulate, caducous hairs present throughout.
13.	*S. wightii*	Sub-circular	Reticulate,small granules irregularly distributed along the sexine.

RESULTS AND DISCUSSION

The microspores are trilete and tetrahedral. They are orange red to brownish red in colour, except in *S. delicatula* and *S. crassipes* where they are yellow-orange. The ornamentations vary in different species. It is reticulate in *S. ciliaris*, *S. brachystachya* and *S. proniflora,* verrucoid in *S. delicatula* and *S. crassipes,* papillate in *S. ganguliana* and *S. monospora*, smooth in *S. vaginata* and *S. nairii* and warty in *S. tenera* and *S. radicata*.

The megaspores are trilete in all the samples analysed. The spores are globose and prominently reticulate in *S. wightii* and *S. crassipes. S. crassipes* bears prominent projections on all faces, which is absent in *S. wightii*. The spores are minutely granulate in *S. proniflora* and reticulate in *S. ciliaris*. In *S. proniflora,* the trilete aperture is much elevated and forms a papillate ridge at the junction.

The spore wall in all cases is made up of sporopollenin units that are discontinuous, porous and reduced in thickness towards inner limit. The ornamentations of sexine observed in these thirteen species of *Selaginella* are specific and thus can be used for species delimitation.

SYSTEMATIC TREATMENT

Selaginellaceae Willk. In Willk. *et* Lange, Prodr. Fl. Hisp. 1 (1): 14. 1861; C.F.Reed, Mem. Sci. Brot. 18: 1 - 287. 1966; Pic. Serm., Webbia 26: 137. 1971; Jermy In Kubitzki, Fam. Gen. Vas. Plants 39 - 45. 1990.

Type genus: ***Selaginella*** P.Beauv., Prodr. Fam. Aetheog. 101. 1805 (*nom*. *cons*.)

Plants usually perennial, terrestrial or occasionally epiphytic, with an erect or prostrate main stem and subsidiary branch systems. The basal portions not differentiated into a distinct rhizome, although some erect species spread by means of creeping basal branches known as sobols, which in turn give rise to further erect branches; growing points not protected by scales. Roots (also termed rhizophores) are dichotomously branched, varying in thickness, arising from the axils of branches, either throughout the length of the main stem, or remain restricted to base. Main stems either long-creeping, often much-branched and of indefinite growth or, short-creeping and then becoming erect; with variously arranged frond-like complanate branch systems (pseudofronds) of finite growth above, further growth arising only from basal branches; sometimes exhibiting a scrambling or climbing habit. Leaves spirally arranged, ligulate, those on basal creeping portions often distantly arranged, either all similar or of two kinds, at least on

the secondary and ultimate branches where they are arranged in four ranks. Strobili terminal on primary or ultimate branches, compact or occasionally more spread out along secondary branches, apex occasionally reverting to become a vegetative shoot; or more rarely, in a lateral position on a primary or secondary branch. Sporophylls leaf-like, spirally arranged or in ranks of four, uniform or, more rarely, dimorphic, subtending sporangia which are on the adaxial surface just above the ligule; sporangia stalked, of two kinds, variously disposed throughout the strobilus, megaspores trilete, usually four in each sporangium, pale buff or white, sporoderm variously patterned, rugose-reticulate, rugose, papillate, tuberculate, granulate, rarely plain on proximal face; microspores trilete, more than 100 in each sporangium, ranging in colour from yellow through orange-brown to red. Sporoderm variously patterned from finely echinulate through papillate to verrucate and sometimes strongly rugose.

Selaginellaceae are represented by a single genus *Selaginella*, with some 750 species distributed mainly in the tropical zones of the world (Jermy, 1990). Heterospory and the presence of vessels in some species, indicate the family is specialised (Tryon & Tryon, 1981). Dixit (1992) recognized 62 species in India. Since then 2 more species were described from South India (Madhusoodanan & Nampy, 1994; Antony *et al*., 2003) making the number 66. Thirty-seven species occur in South India.

There was considerable confusion regarding the authorship of Selaginellaceae. Reed (1965, 1966) attributed the authorship of

Selaginellaceae to Reichenbach (1837), but Reichenbach treated it as a subdivision Selaginelleae of the family Lycopodiaceae without any description. Thus Selaginelleae Reichb. is nomenclaturally invalid and cannot be adopted. Similarly, Selaginellaceae Mett. is also not validly published being the rank of the taxon not in accordance with the accepted sequence. The name Selaginellaceae Milde (1867) is antedated by Selaginellaceae Willk. (1854) and hence cannot be adopted. Though the name Selaginellaceae Willk. is illegitimate as superfluous name for Lycopodiaceae, it is treated as the correct name being conserved (Pichi Sermolli, 1970).

***Selaginella* P. Beauv.**

The name *Selaginella* is derived from the generic name *Selago* given to a genus of Lycopodiaceae and the diminutive latin suffix – ella (Pichi Sermolli, 1971).

The genus *Selaginella* was first established by Palisot de Baeuvois (1805) along with four other genera in his *Prodrome des famille de l' Aetheogamie* to replace *Selaginoides* Dill., which was regarded by him, as well as by several botanists in the past, as a name unsuitable for a genus (Pichi Sermolli, 1971).

The classification of *Selaginella* as a genus dates back to Dillenius (1741) who distinguished four genera *viz*., *Selago*, *Lycopodium*, *Selaginoides* and *Lycopodioides*. Dillenius (1741) recognised thirteen

species of *Lycopodioides,* of which eleven belong to *Selaginella*. Since these names are prior to 1 May 1753, they are invalid. Linnaeus (1753) placed several species of *Selaginella* under the genus Lycopodium. Later Seguier (1754) proposed the genus *Selaginoides* with a single species *Selaginoides foliis spinosis* Ray, but without any binomial. Thus *Selaginoides* Seg. is the oldest name for this genus but it is a *nomen rejiciendum* in favour of *Selaginella* P.Beauv. and on nomenclatural basis both are synonyms.

Browne (1756) proposed the genus *Selago* with four species bearing phrase-names only, without binomial. *Selago* P.Browne is illegitimate being a homonym of *Selago* L. (1754) and it is a taxonomical synonym of *Selaginoides* Seg. and *Selaginella* P.Beauv. The genus *Lycopodium* L. was revised by Boehmer (1760) and he recognized the four genera of Dillenius (*l.c*.) including *Lycopodioides*. The name *Lycopodioides* Boehm. is a *nomen rejiciendum* in favour of *Selaginella*. Moreover *Lycopodioides* is antedated by *Selaginoides* Seg. But his work remained unnoticed and Kuntze (1891) proposed the genus *Lycopodiodes* to replace *Selaginella* and transferred all species of latter known till that time to the former. According to Pichi Sermolli (1971) *Lycopodiodes* Kuntze can be treated as an orthographic variant of *Lycopodioides* Boehm., both names being based on Dillenius's genus.

Adanson (1763) established the genus *Mirmau* citing the monotypic genus *Selaginoides* Dill. as a synonym. So implicitly *Mirmau* Adanson includes the type of *Selaginoides* Dill. and according to Art. 63, *Mirmau* Adanson is a superfluous name for *Selaginoides* and it is illegitimate. It is

also a nomenclatural synonym of *Selaginoides* Seg. and *Selaginella* P.Beauv. Hill (1773) proposed the genus *Trispermium,* which is a superfluous generic name for *Lycopodioides* Dill. and *Lycopodioides* Boehm. Hill (1773) also proposed the genus *Polycocca* to represent *Selaginoides* Seg. and thus it becomes a superfluous name for the latter as well as *Selaginoides* Dill. It is also a nomenclatural synonym of *Selaginella* P.Beauv.

Palisot de Beauvois (1803 – 1805) classified Lycopods based on their spore characters. He proposed six genera, viz., *Planthus*, *Lepidotis*, *Diplostachyum*, *Gymnogynum*, *Selaginella* and *Stachygynandrum*. Of these the last four genera *Diplostachyum*, *Gymnogynum*, *Selaginella* and *Stachygynandrum* belong to present genus *Selaginella*. Sprengel (1817) included *Stachygynandrum* as a sub genus of the genus *Lycopodium* but Brongniart (1837) recognized *Stachygynandrum* as a distinct genus with *Diplostachyum* and *Selaginella* as its synonyms. However, *Selaginella* P.Beauv. being a conserved name *Stachygynandrum* P. Beauv. is only a taxonomic synonym of the former.

While describing the genus *Selaginella,* Palisot de Beauvois (1805) cited *Lycopodium selaginoides* L. as its type. He called this species as *Selaginella spinosa* giving *Lycopodium selaginoides* as its synonym.

The genus *Gymnogynum* P.Beauv. is based on the type *Gymnogynum domingense* P.Beauv. According to Alston (1931, 1952) it is a synonym of *Selaginella plumosa* (L.) C.Presl, based on *Lycopodium plumosum* L. Gymnogynum is usually treated as a taxonomic synonym of

Selaginella. Similarly, *Diplostachyum* P.Beauv. (1805), *Heterophyllium* Hieron. (1912), *Hypopterigiopsis* Sakurai(1943) and *Acopodium* Neck. (1790) are synonyms of *Selaginella* P.Beauv. (Pichi Sermolli, 1971).

According to Pichi Sermolli (1977) the status of *Selaginella* as a natural taxon is not confirmed. According to Rothmaler (1944), the family *Selaginellidae* as an assemblage of three genera *viz*., (1). *Selaginella* P. Beauv. with two sections *viz*., *Selaginella* (Reichb.) Rothm. and *Tetragonostachya* Rothm. (2). *Lycopodioides* Boehm. with sections *Diplostachyum* (Reichb.) Rothm. and *Pleiostele* Rothm. and (3). *Didiclis* P. Beauv. The latter genus consists of two sections: *Stachygynandrum* (Spring) Rothm. and *Heterophyllum* (Hieron.) Rothm. These genera are not separated morphologically. According to Pichi Sermolli (1977) it can be treated as a single taxonomic unit in spite of its large number of species.

Selaginella P.Beauv., Prodr. Fam. Aetheog. 101. 1805 (*nom*. *cons*.).

Selaginoides Seg., Pl. Veron. 3: 51. 1754

Selago Browne, Civ. Nat. Hist. Jamaica 82. 1756 (*non Selago* L., 1753).

Lycopodioides Boehm. In Ludwig, Defin. Gen. Pl. ed. Boehm. 485. 1760.

Mirmau Adanson, Fam. Pl. 2: 491. 1763.

Trispermium Hill, Gen. Nat. Hist. 2 (Hist. Pl.): 112. 1773.

Polycocca Hill, Gen. Nat. Hist. (Hist. Pl.) 2: 116. 1773.

Stachygynandrum P. Beauv. *ex* Mirb. In Lamarck *et* Mirb., Hist. Nat. Veg. 3: 477; 4: 312. 1802.

Didiclis P. Beauv. *ex* Mirb. In Lamarck *et* Mirb., Hist. Nat. Veg. 3: 477; 4: 314. 1802.

Gymnogynum P. Beauv., Prodr. Fam. Aetheog. 103. 1803.

Diplostachym P. Beauv., Prodr. Fam. Aetheog. 104, 107. 1805.

Lycopodioides O. Kuntze, Rev. Gen. Pl. 1: 824. 1891.

Heterophyllium Hieron. *ex* C. Borner, Fl. Deutsch. Volk 110, 285. f. 249. 1912. (*non Heterophyllium* Schimp.) Muell. *ex* Kindb. 1894 ("Heterophyllum").

Hypopterygiopsis Sakurai, Bot. Mag. Tokyo 57: 255. 1943.

Acopodium Necker, Elem. Bot. 3: 335. 1790 (*nom*. *inval*.).

Type: ***Selaginella spinosa*** P. Beauv., Prodr. Fam. Aetheog. 101. 1805 (*nom*. *cons*.). *Selaginella selaginoides* (L.) Link, Fil. Sp. 158. 1841. *Lycopodium selaginoides* L., Sp. Pl. 2: 1101. 1753.

Description as for the family. It is represented by 64 species in India of which 36 species occur in South India.

Sub-generic classification

The sub-generic classification of *Selaginella* were attempted by several authors (Spring, 1850; Baker, 1887; Rosenburgh, 1915; Walton & Alston, 1938; Hieronymus, 1981 and Jermy, 1986). Spring (1850) recognized two sections under the genus *Selaginella viz*., Homophyllae – Foliis homomorphis, polystichis, and Heterophyllae – Foliis dimorphis, tetrastichis.

Baker (1887) recognized four sub-genera *viz*., *Selaginella proper*, *Stachygynandrum*, *Homostachys* and *Heterostachys* under *Selaginella*. In *Selaginella proper*, both ordinary leaves and sporophylls are alike. It is further divided in to plants having their spikes sharply square and plants in which their spikes are not sharply square. In South India, *S. wightii* with sharply square spikes belongs to this sub-genus. In *Stachygynandrum*, vegetative leaves are heteromorphic and sporophylls are isomorphic. There are six series under this sub-genus: 1. *Decumbentes* with dwarf plants. This series has four groups in it *viz*., *Microphylla, Plumosa, Stolonifera* and *Apoda*. 2. *Ascendentes* with plants having ascending and branched stem. This series has four groups *viz., Suberect, Atrovirides, Articulata* and *Radiata*. *Rosulatae* with densely tufted stem that curl up in drought. This series is not further divided. 4. *Sermentosae* with persistent species with elongated stem. This series is not further divided. 5. *Scandentes* having persistent, wide – climbing and continuous stems. This series also is not further divided. 6. *Caulescentes* includes species with persistent erect stem.

This series has two groups viz., *Flabellata* and *Geniculata*. (3). In *Homostachys*, all leaves are heteromorphic. This sub–genus is not further divided. (4). In *Heterostachys*, all leaves are heteromorphic but their spike are resupinating. This group is further divided in to *Bisulcata, Proniflora, Brachystachya* and *Suberosa*.

Hieronymus (1901) followed the classification of Spring (1850) and classified the genus *Selaginella* in two sub-genera *viz., Homeophyllum* and *Heterophyllum*. The sub-genus *Homeophyllum* is further divided in to sections *Cylindrostachyae* and *Tetragonostachyae*. The sub-genus *Heterophyllum* is divided in to sections *Pleiomacrosporangiatae* and O*ligomacrosporangiatae*. *Pleiomacrosporangiatae* is further divided in to two groups: *Monosteliacae* and *Pleiosteliacae*. O*ligomacrosporangiatae* is divided in to two groups: *Continuae* and *Articulatae*.

Rosenburgh (1915) in his *Handbook to the determination of the fern allies of the Malayan Islands* has provided a good account of Malayan Selaginellas. He mostly based morphological and anatomical characters, and classified 201 species of *Selaginella* into three groups *viz*., 1) Heterophyllum (*Subselaginella*) where the leaves are heteromorphous at least along branches and hence branches are conspicuously dorsi-ventral, 2) *Isophyllum* where leaves are isomorphic or nearly so and the branches therefore dorsiventral and 3) *Homeophyllum* where the leaves are isomorphous and the branches rather regularly square or cylindrical. He has further divided *Heterophyllum* to Monostelicae where stems are traversed by

1 or 2 steles and Pleiostelicae where stems are traversed by 3 – 9 steles. Monostelicae members with isomorphic sporophylls and quadrangular spikes were included under *Homoeostachys* and those with heteromorphic sporophylls and flattened spikes under *Heterostachys*.

Walton and Alston (1938) followed Baker (1887) and classified the genus *Selaginella* into 4 sub-genera *viz*., *Euselaginella, Stachygynandrum, Homostachys* and *Heterostachys*. Sub-gen. *Euselaginella* is further divided in to four groups *viz*., *Selaginella, Pygmaea, Uliginosa* and *Rupestris*. Sub-gen. *Stachygynandrum* include six series: *Decumbentes, Ascendentes, Sarmentosae, Caulescentes, Circinatae* and *Articulatae. Homostachys* and *Heterostachys* were not further divided.

Jermy (1986) has classified the genus *Selaginella* in to five sub-genera *viz*., sub-gen. *Selaginella*, sub-gen. *Ericetorum* Jermy, sub-gen. *Tetragonostachys* Jermy, sub-gen. *Stachygynandrum* (P.Beauv.) Baker and sub-gen. *Heterostachys* Baker.

These five sub-genera as recognized by Jermy (1986, 1990) represent natural groups and are world wide in scope. Hence this classification is adopted in the present treatment. (Table 6).

Table 6

South Indian species of *Selaginella* and their sub-generic treatment

Sub-genera	Species
Selaginella	Nil
Ericetorum	Nil
Tetragonostachys	1
Stachygynandrum	18
Heterostachys	17

Key to sub-genera

1a. Leaves isomorphic throughout..……*Tetragonostachys*

1b. Leaves dimorphic at least on branches……..1b

2a. Sporophylls uniform…….....…….
Stachygynandrum

2b. Sporophylls dimorphic…….
…….*Heterostachys*

Of the five sub-genera treated by Jermy, only the sub-genus *Tetragonostachys*, *Stachygynandrum* and *Heterostachys* has got representatives in South India. The sub-genus *Selaginella* and *Ericetorum* are not represented in South India.

1. *Selaginella* sub-gen. ***Selaginella*** Jermy, Fern Gaz. 13: 117 (1986).

Type: ***Selaginella spinosa*** P. Beauv. (= *Selaginella selaginoides* (L.) Link)

Sub-gen. *Homeophyllum* (Spring) Hieron. & Saded. In Engler & Prantl, Nat. Pflanz. 1 (4): 669 (1902) p. p.

The plants of the sub-genus *Selaginella* are erect, producing more and more branches from base on maturity, rooting confined to base. Leaves are isomorphic and arranged spirally. This subgenus has only two species in the world *viz*., *S. selaginoides* (L.) Link, distributed in northern hemisphere and *S. deflexa* Brack. endemic to Hawaiian islands (Jermy, 1986). No south Indian species belongs to this sub-genus.

2. *Selaginella* sub-gen. ***Ericetorum*** Jermy, Fern Gaz. 13: 117 (1986).

Type: ***Selaginella uliginosa*** (Labill.) Spring

Sub-gen. *Homeophyllum* (Spring) Hieron. & Saded. In Engler & Prantl, Nat. Pflanz. 1 (4): 669 (1902) p. p.

The stems of the plants in the sub-genus *Ericetorum* are erect, either unbranched or more compound arising from a creeping solenostelic stem. Their leaves are isomorphic and the sporophylls are tetrastichous. There are only three species in the world, *viz*., *S. uliginosa* (Labill.) Spring and *S. gracillima* (Kuntze) Spring found in Australia and Tasmania and *S. pygmaea* (Kaulf.) Alston found in southern Africa (Jermy, 1986). No south Indian species belongs to this subgenus.

3. *Selaginella* sub-gen. ***Tetragonostachys*** Jermy, Fern Gaz. 13: 118 (1986).

Type: ***Selaginella rupestris*** (L.) Spring

Subgenus *Homeophyllum* (Spring) Hieron, & Sadeb. In Engler & Prantl, Nat. Pflanz. 1(4): 669 (1902) p. p.

Plants are creeping, prostrate and often mat forming, or with short erect branches. Stem is much branched and roots throughout their length. Leaves are monomorphic or slightly dimorphic on prostrate branches, spirally arranged, coriaceous; apex sharp or ending in a hair. Sporophylls tetrastichous. About 50 species in the world (Jermy, 1986). Only one south Indian species, namely *S. wightii* belongs to this group.

Selaginella wightii Hieron., Hedw. 39: 319. 1900; Alston, Proc. Nat. Inst. Sci. 11: 215. 1945; R.D.Dixit, Cens. Ind. Pterid. 18: 1984; N.C.Nair *et al*., J. Econ. & Tax. Bot. 12: 201. 1988; R.D.Dixit, Selaginellaceae India 32. f. 2. 1992; Manickam & Irudayaraj, Pterid. Fl. Western Ghats 34. 1992; R.D.Dixit & Mondal, Ind. Fern J. 10: 167. 1993.

Type: India, *s. l*., *Wight* 15 (CAL!)

Lycopodium bryopteris Wall., Cat. No. 2188. 1829. *non*, L.

L. rupestre (*non* L.) Hook. & Grev. In Hook., Bot. Misc. 11: 373. 1831. p. p.

Selaginella rupestris Spring, Mem. Acad. Brux. 24: 55. 1850. p. p. excl.

syn. L.

Fig. 4 . 11; Plate 9. C.D..

Xerophytic decumbent herbs. Stems 5 - 13 cm long, 2 mm thick, cylindrical, glabrous, green; branched from base, bi or tripinnately branched. Rhizophores 2 - 6 cm long, many, prominent at base but present throughout, wiry, slender, cylindrical. Leaves isomorphic throughout, closely placed on the stem and branches, overlapping at base; lateral leaf 1.8 - 2 x 0.3 mm, linear - subulate, oblique, coriaceous; margins minutely ciliate at base and dentate towards apex, apex long acuminate/ aristate; median leaf inseparable from lateral leaf; axillary leaf 1.1 x 0.3 mm, linear - subulate, slightly oblique, coriaceous; apex acute, margins ciliolate - dentate. Strobilus 4.4 x 0.7 mm, terminal, sessile, solitary. Sporophylls 1.7 - 1.9 x 0.5 - 0.7 mm, isomorphic, spiral, subulate - lanceolate, oblique, base cordate, coriaceous; margins dentate, apex acuminate. Megasporophylls and microsporophylls arranged mixed. Megaspores 4 per sporangium, 326 microns in diam., yellow – orange when fresh and brownish black when dry, globose, tetrahedral, reticulate with irregular blunt processes. Microspores numerous, 27 microns in diam., orange - red, rugulose.

Distribution and ecology: *S. wightii* is endemic to India and Sri Lanka (Dixit, 1992). *S. wightii* is not a true xerophyte but grows along fully exposed, soiled rocks. This species has bright green isomorphic leaves and form a ‘mat’ over the substratum. During dry seasons they become dull brown and round off.

Notes: *S. wightii* closely resembles with *S. indica* but differs from the latter by its glaucous, linear - subulate leaves that are non-glaucous and oblong - linear in *S. indica*.

Specimens examined: ANDHRA PRADESH: Chittoor Dt.: Horsely Hills, 22.09.1993, *Ahmed* 12832 (SKU), 19.10.2004, *Joby* 581 (SJC); Vayalpad, 14.05.1918, *Fischer* 4349 (CAL). Nellore Dt.: Veligusahills, 28.07.1914, *Ramaswami* 1385 (CAL). KERALA: Idukki Dt.: Chinnar, 26.07.1994, *Raju* 22398 (TBGT). TAMIL NADU: Coimbatore Dt.: Kurudimalai, 23.08.1956, *Subramanyam* 614 (MH); Lampton's peak, 23.06.1964, *Ellis* & *Sreemadhavan* 20016 (MH); Thekkumalai, 19.11.1956, *Sebastine* 1357 (CAL, MH); Valparai – Attakatti Road, 07.05.1992, *Manickam* (XCH). Kanyakumari Dt.: Maruthwamalai – Kanyakumari, 07.10.2004, *Nisha* 577 (SJC). Salem Dt.: Shevroy Hills, 08.06.1963, *Ghatak* 444, *Swamy* 1058 (CAL). Tirunelveli Dt.: Courtallum, *Rao* 1979 (CAL); 07.06.1977, *Sarada* 21847, 09.06.1972, *Prithi* 23129 (CALI). Yercaud Dt.: Honey Rock, *Ghatak* 274 (CAL); River Dale, *Ghatak* 91 (CAL).

4. *Selaginella* sub-gen. ***Stachygynandrum*** (P. Beauv.) Baker, J. Bot. Lond. 21: 3. (1883) emend. Jermy, Fern Gaz. 13: 118 (1986).

Type: ***Lycopodium flabellatum*** L. (= *Selaginella flabellate* (L.) Spring).

Sub-gen. *Heterophyllum* Hieron, & Sadeb. In Engler & Prantl, Nat. Pflanz. 1 (4): 673 (1902); Subgen. *Homostachys* Baker, J. Bot. Lond. 21: 4

(1883).

Stems either creeping with prostrate branches or erect with multiple branching; leaves dimorphic at least on the secondary branches, in four distinct rows, median leaves being distinctly smaller; sporophylls uniform or in some cases slightly dimorphic, tetrastichous. Jermy (1986) has elaborated Baker's (1883) concept to include those species which have loose strobili with sporophylls that began to show some dimorphism. This is the largest subgenus consisting of about 600 species, ranging throughout the tropics of all continents (Jermy, 1986). 18 south Indian species belong to this subgenus.

Key to species

1a. Leaves uniform along main stem, heteromorphic along branches …. ……..**2**

1b. Leaves heteromorphic throughout……..…….…….. **3**

2a. Stem erect; rhizomes prominent ……..…..……**4**

2b. Stem scandent/ climbing; rhizomes not prominent……**5**

3a. Stem trailing, procumbent/ decumbent……**6**

3b. Stem erect/ sub-erect……..…..…..……**7**

4a. Aerial shoots trichotomously branched at apex……..……..***S. dixitii***

4b. Aerial shoots not trichotomously branched at apex, pinnate……....**8**

5a. Stem climbing, purple, leaves metallic blue; rhizophores confined to

creeping portion…….. ***S. wildenovii***

5b. Stem scandent, green, leaves dark green; rhizophores extending to upper nodes……..**9**

6a. Median leaf smooth throughout……..……***S. integerrima***

6b. Median leaf ciliate at base, rest dentate……..……...…**10**

7a. Stem sub-erect, delicate; rhizophores along basal 1/3rd; sporophylls entire…… ***S. delicatula***

7b. Stem erect, thick; rhizophores like stilt roots; sporophylls not entire…… ……..…**11**

8a. Branches flabellate; plants xerophytic……..……**12**

8b. Branches deltoid; plants not xerophytic……..…..**13**

9a. Stem simple at base, branched above; rhizophores up to middle; sporophylls serrulate ……..……***S. plana***

9b. Stem branched at base; rhizophores confined to basal 1/3rd; sporophylls entire …..…….. **14**

10a. Megaspores hairy ...……..……..... ***S. vaginata***

10b. Megaspores not hairy ……..……..……....**15**

11a. Sporophylls serrulate……..…. ***S. intermedia***

11b. Sporophylls ciliolate-denticulate……..……..……....**16**

12a. Median leaves long aristate; arista more than half as long as lamina ……..……...…. ***S. bryopteris***

12b. Median leaves acuminate……..…… ***S. involvens***

13a. Branches and stem glabrous; spikes sharply square

……..……..***S. microdendron***

13b. Branches and stem pubescent; spike not sharply square……..……**17**

14a. Branch-lets simple……***S. gracilis***

14b. Branch-lets compound ascending and contiguous with tertiary branches ……..….***S. inaequalifolia***

15a. Stem 50-75 cm high; rhizophores occasionally throughout, branches sub-pyramidal ……***S. radicata***

15b. Stem 5-25 cm high; rhizophores confined to base, branches compound, pinnate……***S. repanda***

16a. Median leaf long aristate, serrate at base..……***S. ganguliana***

16b. Median leaf long cuspidate, ciliate at base……...***S. plumosa***

17a. Stem erect, simple along basal 1/3rd, decompound above ...***S. braunii***

17b. Stem creeping or trailing, copiously branched from base...***S. uncinata***

Selaginella dixitii Madhus. & Nampy, Nord. J. Bot. 14: 5. 527. 1994; Antony *et al.*, J. Econ. & Tax. Bot. 27. 1126. 2003.

Type: India, Kerala, Nelliampathy, *Madhusoodanan* & *Nampy* 48898 (CALI!)

Fig. 5. 35; Plate 16.E.F

Mesophytic prostrate herb with creeping rhizome. Arial stem erect 75 - 100 cm high, 3 mm thick, cylindrical, puberulescent, orange-red; branched

trichotomously at the apex. Rhizophores short, 2 - 4 cm long, confined to the base of erect branches, slender, cylindrical. Leaves isomorphic and distantly placed along main stem, heteromorphic along branches except the strobilus; lateral leaf 3.8 x 2.2 mm, oblong, oblique, membranous; margins smooth, apex sub-acute; median leaf 2.2 x 0.9 mm, ovate, base highly oblique, membranous; margins smooth, apex acuminate; axillary leaf 2.3 x 1 mm, lanceolate, membranous; margins smooth, apex acute. Strobilus 4.8 x 1.1 mm, terminal, sessile, solitary. Sporophylls 1.7 x 0.7 mm, monomorphic, spiral, ovate – lanceolate, membranous; margins smooth, apex acuminate. Megaspores 300 microns in diam., 4 per sporangium, pale yellow when dry, globose, tetrahedral, verrucate. Microspores 27 microns in diam., numerous, orange - red, granulose.

Distribution and ecology: *S. dixitii* is endemic to South India and is rare in the wild. It is often found under cultivation in the botanical gardens.

Notes: *S. dixitii* have their aerial stem trichotomously divided towards the apex. Their leaves are monomorphic along the main stem and dimorphic along branches.

Specimens examined: KERALA: Malappuram Dt.: Botanical Garden, University of Calicut, 21.06.2007, *Nisha* 1501 (SJC). Palakkad Dt.: Nelliampathy, 20.02.1993, *Nampy* 45199 (CAL). Thiruvananthapuram Dt.: TBGRI, 14.07.2007, *Nisha* 1502 (SJC). TAMIL NADU: Nilgiri Dt.: Ootacamund, 12.04.1994, *Antony* 3076 (TBGT).

Selaginella wildenovii (Desv. *ex* Poir.) Baker, Gard. Chron. 783. 950. 1867, Handb. Fern- allies, 93. 1887; Alston, Proc. Nat. Inst. Sci. 11: 224. 1945 (as *S. willdenowii* (Desv.) Baker); R.D.Dixit, Cens. Ind. Pterid. 18. 1984 (as *S. willdenovii* (Desv. *ex* Poir.) Baker); N.C.Nair *et al*., J. Econ. & Tax. Bot. 12: 201. 1988; R.D.Dixit, Selaginellaceae India 40. f. 8. 1992 (as *S. willdenovii* (Desv. *ex* Poir.) Baker); R.D.Dixit & Mondal, Ind. Fern J. 10: 167. 1993.

Type: *Wallich* Cat. No: 122/1

Lycopodium caespitosum Blume, Enum. Pl. Jav. 2: 270. 18. 1828.

Lycopodium wildenovii (Desv.) Hook. & Grev., Ic. Fil. 57. 1831.

Selaginella caespitosa (Blume) Spring, Bull. Acad. Brux. 10: 140. 1843.

Fig.6.11.Plate 9. E.F

Mesophytic trailing or climbing herbs. Stems 30 - 150 cm long, 2 – 4 mm thick, cylindrical, glabrous, sulcate, purple coloured; branched from base, branches decompound. Rhizophores 3 – 20 cm long, produced throughout the straggling portion, cylindrical, purple coloured, dichotomously branched. Leaves dimorphic except along the strobilus and main stem, distant on main stem, contiguous on branches; lateral leaf 3.4 x 1.7 mm, ovate-oblong, oblique towards apex, base entire, membranous; margins smooth, apex sub-acute; median leaf 2.1 x 1 mm, oblong, oblique throughout, membranous; margins smooth, apex sub-acute; axillary leaf 2.7 x 1.9 mm, broadly obovate, membranous; margins smooth, apex sub-acute.

Strobilus 12.7 x 1.3 mm, terminal, sessile, solitary, rarely produced. Sporophylls 1 x 0.9 mm, isomorphic, spiral, broadly ovate, base entire, membranous; margins smooth, apex acute. Megaspores 278 microns in diam., 4 per sporangium, pale brown, globose, tetrahedral, papillate. Microspores not observed.

Distribution and ecology: *S. wildenovii* is reported from India, Burma, Malay Peninsula and Malaysian Islands (Dixit, 1992). Its occurrence in the wild condition in South India is doubtful. This is an ornamental species and is commonly known as 'Peacock fern'.

Notes: *S. wildenovii* is noted for its peculiar branching and beautiful metallic green colour of the foliage. This species grows up to a height of 150 cm and spreads very easily in large areas. Spikes are not common in this species. Reproduction is mainly by vegetative means. This medicinally important species on bioactivity guided fractionation studies of its leaves afforded three biflavanoids that proved cytotoxic against a panel of human cancer cells lines (Silva *et al.*, 1995*).*

Specimens examined: KERALA: Kozhikode Dt.: St. Joseph's College, Botanical Garden, 29.04.2007, *Nisha* 2607; Edakkad, 28.04.2007, *Nisha* 2606 (SJC).

Selaginella integerrima (Hook. *et* Grev.) Spring, Bull. Acad. Brux 10: 138. 1843; Baker, Handb. Fern-allies, 66. 1887; R.D.Dixit, Cens. Ind. Pterid. 14. 1984, Selaginellaceae India 58. f. 18. 1992; R.D.Dixit &

Mondal, Ind. Fern J. 10: 166. 1993.

Type: Sri Lanka, Colombo, *Klein s.n*. Herb. Wight (K).

Lycopodium integerrimum Hook. *et* Grev., Bot. Misc. 2: 396. 1831.

Selaginella ornithopodioides sensu Trimen, J. Linn. Soc. 24; 152. 1887; *sensu* Alston, Proc. Nat. Inst. Sci. India 11: 222. 1945 (*non* (L.) Spring, 1838).

Fig. 7.24.28.A Plate. 8. A. B. C

Mesophytic prostrate herb. of main stem 15 - 35 cm long. Main stem 1 mm in diam., slender, cylindrical, glabrous, green; pinnately branched, branches short and irregular. Rhizophores 4 – 8 cm long, produced throughout, distributed almost throughout the main stem, slender, wiry. Leaves heteromorphic throughout, contiguous along main stem and branches, spreading, ascending; lateral leaf 3.3 x 1.1 mm, oblong - lanceolate, oblique, membranous; margins serrate - serrulate, apex acute - sub-acute; median leaf 2.4 x 1 mm, ovate, oblique, membranous; margins serrate, apex acute; axillary leaf 3 x 1 mm, lanceolate oblique, membranous; margins serrate, apex acuminate.

Distribution and ecology: *S. integerrima* is reported from Sri Lanka (Alston, 1945) and India. It is rare in India and known only from Tamil Nadu. It is found spreading along wet shady soil.

Notes: *S. integerrima* has branched prostrate stem with spreading bright

green leaves and rhizophores throughout. Dixit (1992) and Dixit and Mondal (1993) have stated that they could not examine any specimens of this species from the Indian region and its occurrence in South India needs confirmation. However I have collected this species from Nilgiri district in Tamil Nadu, but all of them were in the vegetative state. It is a new report for India.

Specimens examined: TAMIL NADU: Nilgiri Dt.: Coimbatore – Ootacamund, 17.10.2006, *Nampy* 2622 (SJC); Ootacamund, 11.11.2005, *Nisha* 2620 (SJC).

Selaginella delicatula (Desv.) Alston, J. Bot. 70: 282. 1932; Panigrahi & R.D.Dixit, J. Ind. Bot. Soc. 46: 226. t. 228. 1967; Tagawa, Act. Phytotax. Geobot. 25: 173. 1973; R.D.Dixit, Cens. Ind. Pterid. 12. 1984, Selaginellaceae India 65. f. 29. 1992; R.D.Dixit & Mondal, Ind. Fern J. 10: 165. 1993; R.D.Dixit & B.K.Sinha, Pterid. Andaman & Nicobar Islands 35. 2001; P.C.Pande & H.C.Pande, Phytotax. 3: 69. 2003; S.R.Ghosh *et al.,* Pterid. Fl. Eastern India 3: 114. f. 37. 2004.

Type: Pisang Id., near N. Guinea, *Gaudichaud* 13 (G).

Lycopodium delicatulum Desv. *ex* Poir. Lamark, Encycl. Suppl. 3: 584. 1814.

L. pouzolzianum Gaud., Freyc. Voy. Bot. 1: 287. 1826.

L. crassicaule Hook. & Grev. In Hook., Bot. Misc. 2: 382. 1831.

L. flaccidum Bory, Bel. Voy. Bot. 2: 9. 1833.

Selaginella pouzolziana (Gaud.) Spring, Bull. Acad. Brux. 10: 145. 1843.

S. flaccida (Bory) Spring, Bull. Acad. Brux. 10: 145. 1843.

S. crassicaulis (Hook. & Grev.) Spring, Bull. Acad. Brux 10: 232. 1843.

S. semicordata Spring, Mem. Acad. Brux. 24: 107. 1850.

L. curvatum Dalz. In Hook., Kew J. Bot. 4: 114. 1852, *non* Sw., 1801.

Fig. 8. 35.Plate.16. C. D

Mesophytic sub-erect herbs. Stem 10 – 45 cm high, 1.5 – 2 mm thick, stout, sulcate, glabrous, pale green; pinnately branched. Rhizophores 4 – 8 cm long, confined to base, stout, branched. Leaves dimorphic throughout except strobilus, distantly packed along main stem, contiguous along branches, tetrastichous; lateral leaf 2.8 x 1.3 mm, oblong, base oblique, membranous; margin smooth, very rarely distantly denticulate towards apex, apex acute; axillary leaf 2.4 x 1.2 mm, obovate, oblique, membranous; margin smooth at base, serrulate towards apex, apex acute; median leaf 2 x 0.8 mm, ovate - lanceolate, slightly oblique, membranous; margin smooth, apex acuminate to aristate. Strobilus 16.1 x 1.8 mm, terminal, sessile, solitary. Sporophylls 1.6 x 0.6 or 1.7 x 0.7 mm, monomorphic, spiral, ovate – elliptic, oblique, membranous; margins smooth, apex acute, megasporangia towards base and microsporangia towards apex. Megaspores 4 per

sporangium, 340 microns diam., dull white, trilete, tetrahedral, verrucoid. Microspores numerous, 31 microns diam., yellow-orange, trilete, tetrahedral, verrucoid.

Distribution and ecology: *S. delicatula* is distributed in India, Taiwan, Malaya, (Tagawa, 1973) Philippine Islands, Moluccas, Borneo, Siam, Cambodia and Tonkin (Dixit, 1992). It is common along waysides, earth cuttings, tropical forests and other moist and shady regions between altitudes 70 – 1800 m.

Notes: *S. delicatula* can be easily recognized by its sub-erect habit, compound pinnate branches and pale green colour. The exine of the megaspore is smooth and their sporophylls are entire with acute apex. However, Panigrahi and Dixit (1967) described exine with papillate excrescences and sporophylls with denticulate margins and acuminate apex.

Specimens examined: KERALA: Idukki Dt.: Kalloor, *Nampy* 4, Ashramamkunnu, *Nampy* 6 (SJC). Kannur Dt.: Payyavur, 05.10.1979, *Ansari* 64738 (CAL). Kollam Dt.: Moozhiyar, 19.12.1972, *Nair & Ghosh* 50613 (CAL); Kottarakkara, 22.12.1923, *Kurup* 1069 (CAL); Kulathupuzha, 19.08.1993, *Khan & Antony* 17752 (TBGT); Punalor, 26.12.1972, *Nair* 50876, 27.12.1972, *Nair* 50892 (CAL). Kottayam Dt.: Kaliyarthottam, 11.10.2003, *Joby* 524 (SJC). Kozhikode Dt.: Edakkad, 12.12.2001, *Nisha* 503, 30.12.2001, *Nisha* 504; Puthoor, 30.12.2001, *Nisha* 505 (SJC). Palakkad Dt.: Mukkali forest, 11.10.1979, *Nair* 64515 (MH); Thiruvazhamkunnu, 27.12.1969, *Vajravelu* 33365 (MH). Thrissur Dt.:

Aathirappally, 10.12.1965, *Sebastine* 5037 (MH); Changanassery, 27.08.1985, *Kadavil* 1244 (CAL). Thiruvananthapuram Dt.: Aruvikkara, 29.12.1973, *Nair & Ghosh* 51544 (CAL); Erattumukku, 21.12.1992, *Jabbar* 14797 (TBGT); Kallar, 29.10.1969, *Nair* 40054 (CAL); Ponmudi, 05.01.1974, *Nair & Ghosh* 51726 (CAL); Thenmala, 08.12.1912, *Rao* 698 (CAL).

Selaginella plana (Desv. *ex* Poir.) Hieron. In Engl. & Prantl., Nat. Pfl. 194: 703. 1901; Alderw., Handb. Malayan Fern-allies, 215, 1915; Alston, Proc. Nat. Inst. Sci. 11: 231. 1945; R.D.Dixit, Cens. Ind. Pterid. 15. 1984; N.C.Nair *et al*., J. Econ. & Tax. Bot. 12: 201. 1988; R.D.Dixit, Selaginellaceae India 40. f. 8. 1992; R.D.Dixit & Mondal, Ind. Fern J. 10: 167. 1993.

Lycopodium planum Desv. *ex* Poir. In Lamarck, Encyl. Suppl. 3: 554. 1814.

Fig.9.37. Plate.17. E. F

Mesophytic straggling herbs. Stem 40 - 70 cm long, 1.5 – 2 mm thick, cylindrical, glabrous, sulcate, simple at base, green; branches pinnately compound, originating from a straggling base. Rhizophores 3 – 12 cm long, produced throughout the straggling portion, cylindrical, dichotomously branched. Leaves dimorphic except along the strobilus, distant on main stem, contiguous on branches; lateral leaf 2.8 x 1.5 mm, oblong - lanceolate, oblique throughout, membranous; margins smooth, pellucid margined, apex acute; median leaf 2 x 0.9 mm, ovate, oblique throughout, membranous;

margins smooth, pellucid margined, apex acute – acuminate; axillary leaf 2.7 x 1.5 mm, obovate, membranous; margins smooth, pellucid margined, apex acute. Strobilus 12.7 x 1.3 mm, terminal, sessile, solitary or dichotomously branched. Sporophylls 1.8 x 0.8 mm, isomorphic, spiral, ovate, membranous; margins serrulate, pellucid margined, apex acuminate. Megaspores 292 microns in diam., 4 per sporangium, pale brown, globose, tetrahedral, rugulose. Microspores 49 microns in diam., numerous, deep yellow, verrucoid, papillose.

Distribution and ecology: *S. plana* is reported from India, Trinidad, Brazil, Philippines and many other countries along tropics (Dixit, 1992). This is a garden species in India. It is not reported from wild and often found under cultivation.

Notes: *S. plana* is noted for its bright green leaves and for the beautiful branching pattern. It resembles *S. inaequalifolia* but can be distinguished from the latter by the leafy branches confined mainly to the erect portion. In *S. inaequalifolia* the branches are more spreading and occurs almost throughout the straggling portion. Their spikes considerably long (about 4 cm) and their leaves are pellucid margined.

Specimens examined: KERALA: Malappuram Dt.: Calicut University Botanical Garden, 11.07.1980, *Usha* 29706, 19.09.1980, *Madhu* 29706 (CALI). Kollam Dt.: Kollam, 25.01.1974, *N.C.Nair & Ghosh* 51963 (CAL). Kozhikode Dt.: Edakkad, 28.04.2007, *Nisha* 2898 (SJC).

Selaginella vaginata Spring, Mem. Acad. Brux. 24: 87. 1850; Baker, Handb. Fern-allies 36. 1887; Alston, Proc. Nat. Inst. Sci. 11: 217. 1945; Alston & Bonner, Candollea 194. 1956; R.D.Dixit, Cens. Ind. Pterid. 4: 17. 1984; N.C.Nair *et al*., J. Econ. & Tax. Bot. 12: 202. 1988; R.D.Dixit, Selaginellaceae India 60. f. 25. 1992; R.D.Dixit & Mondal, Ind. Fern J. 10: 167. 1993; P.C.Pande & H.C.Pande, Phytotax. 3: 71. 2003; S.R.Ghosh *et al*., Pterid. Fl. Eastern India 3: 114. f. 36. 2004.

Types: Nelligheries, *Perottet s. n.* (P); 'Gorval' (labelled Khasya in Hb. Kew), *Griffith s. n.* (K!) Bootan, *Griffith s. n.* (K!)

S. imbricata J. Scott., J. Agr. Hort. Soc. Ind. 1: 260. 1868. (excl. syn. Roxb., 1844)

S. thomsonii Hieron., Hedw. 43: 38. 1904.

Fig.10.11. 20. D Plate. 9. A. B

Mesophytic prostrate herbs growing in tufts. Main stem 5 - 15 cm long, filiform, terete, glabrous, green but turn brownish grey when dry; branches short, flabby. Rhizophores 2 – 4 cm long, present throughout, slender. Leaves dimorphic except at the strobilus, closely appressed on the stem, contiguous on branches; lateral leaf 2.3 x 1 mm, ovate - lanceolate, oblique at base, chartaceous; proximal margin ciliolate at base and serrate towards apex, distal margin serrate throughout, apex shortly acuminate;

median leaf 1.5 - 1.7 x 0.7 or 0.8 mm, ovate, slightly oblique, membranous; margins shortly ciliate at base, serrate – serrulate towards apex, apex long acuminate - shortly aristate; axillary leaf 1.8 x 0.9 mm, ovate – lanceolate, oblique throughout, chartaceous; margins ciliate at basal half, serrate towards apex, apex acute. Strobilus 3.8 - 5.3 x 1 - 1.6 mm, terminal, sessile, solitary. Sporophylls 2 - 2.2 x 0.8 or 0.9 mm, isomorphic, spiral, ovate, oblique, scaly, margins serrate, apex acuminate, micro and mega sporophylls arranged intermixed. Megaspores 211 microns in diam., 4 per sporangium, pale yellow, trilete, tetrahedral, verrucoid - reticulate, hairy; hairs caducous. Microspores 32 microns in diam., numerous, reddish - brown, trilete, smooth.

Distribution and ecology: *S. vaginata* is distributed in India, Bhutan and Burma (Alston, 1945). In South India, it is reported from Kerala and Tamil Nadu. It grows on moist soil, or as lithophyte or as epiphyte on trees in mountainous regions at an altitude of 2000 m.

Notes: *S. vaginata* is a trailing species with lax branches. Their megaspores bear crisped hairs. This species resembles *S. radicata* in gross morphology but can be distinguished by its small size (5 – 15 cm against 15 – 35 cm in *S. radicata*). The megaspores are hairy in *S. vaginata* but without hairs in *S. radicata*.

Specimens examined: KERALA: Idukki Dt.: Poongavanam – Sabarimala, 15.12.1981, *Nair* 70213 (CAL). Kannur Dt.: Paithalmala, 14.09.2002, *Nisha* 1463 (SJC). Kollam Dt.: Achankovil, 22.01.2004, *Kumar* 52107 (TBGT).

Kottayam Dt.: Bharananganam, near Pala, 13.08.1984, *Antony* 581, 582 (MH). Palakkad Dt.: Silent Valley, Koomanthodu, 22.04.1980, *Vohra & Ghosh* 56340 (CAL). Pathanamthitta Dt.: Pamba, 01.10.1976, *Vivekanandan* 48370 (CAL, MH). Thrissur Dt.: Sholayar Dam, 19.09.1974, *Nair & Ghosh* 51061 (CAL). TAMIL NADU: Coimbatore Dt.: Sholayar submergible area, 30.07.1963, *Sebastine* 17297 (MH).

Selaginella intermedia (Blume) Spring, Bull. Acad. Brux. 10: 144. 1843; Alston, Proc. Nat. Inst. Sci. 11: 218. 1945; R.D.Dixit, Cens. Ind. Pterid. 14. 1984; N.C.Nair *et al*., J. Econ. & Tax. Bot. 12: 203. 1988; R.D.Dixit, Selaginellaceae India 63. f. 28. 1992; R.D.Dixit & Mondal, Ind. Fern J. 10. 166. 1993.

Type: Java, *s. l. Blume s. n.* (P!)

Lycopodium intermedium Blume, Enum. Pl. Jav. 2: 269. 1830.

L. atroviride Wall. *ex* Hook. & Grev., Icon. Fil. 1: 39. 1831.

Lycopodium furcatum Roxb. *ex* Wall., Cale. J. Nat. Hist. 4: 475. 1844.

Fig.12.15. 28. B Plate. 8. D. E. F

Mesophytic erect herb. Stems up to 70 cm high, 3 mm thick, cylindrical, glabrous, simple at base, purple - green; copiously branched towards apex, branches erecto – patent. Rhizophores 4 - 11 cm long, many, confined to basal1/3rd, thick, cylindrical. Leaves heteromorphic throughout,

distantly placed on the stem and compact along branches, spreading; lateral leaf 5.5 x 2.1 mm, oblong, oblique throughout, membranous; proximal margin dentate, distal margin smooth, apex sub-acute; median leaf 4.2 x 1.8 mm, obovate, oblique at base, membranous; margins dentate, apex aristate; arista 1.6 mm; axillary leaf 3.4 x 1.8 mm, ovate - lanceolate, slightly oblique along basal half, membranous; margins dentate – denticulate, apex sub-acute or obtuse. Strobilus 6.4 x 1.4 mm, terminal, sessile, solitary. Sporophylls 1.9 x 0.6 mm, isomorphic, spiral, ovate - lanceolate, coriaceous; margins distantly dentate, apex acuminate. Megasporophylls and microsporophylls arranged mixed. Megaspores 4 per sporangium, 250 microns in diam., yellow, globose, tetrahedral, verrucoid. Microspores numerous, 16 microns in diam., orange, trilete, with short blunt processes.

Distribution and ecology: *S. intermedia* is distributed in India, Malay Peninsula, Java, Sumatra, Burma, Borneo, Celebes, Annam and Siam (Dixit, 1992). In South India, this species occurs in Kerala and Tamil Nadu. It grows at in shady, moistened forests at altitudes above 800 m.

Notes: *S. intermedia* is noted for its beautiful colouration and branching. The stems are up to 70 cm long with spreading branches, ascending leaves and stout rhizophores.

Specimens examined: KERALA: Idukki Dt.: Aanamalai – Aandiparai Hills, 12.01.1912, *Fischer* 3271 (CAL). Pathanamthitta Dt.: Moozhiyar, 03.09.1985, *Raju & Antony* 1481 (RHK). Thiruvananthapuram Dt.: Agasthyamala, 28.06.05, *Nisha* 2890 (SJC); Chemungi, 08.03.1979,

Mohanan 61702 (CAL), 15.11.1994, *Raju* 22521, 20.12.1993, *Raju* 18644 (TBGT), 05.12.2006, *Nisha* 2887 (SJC); Dharbhakulam forest, 04.01.1974, *Nair* 51687 (CAL); Ponmudi Hills, 06.01.1974, *Nair* & *Ghosh* 51736 (CAL); Pallipara, 06.02.1913, *Rao* 849 (CAL). TAMIL NADU: Kanyakumari Dt.: Kothayar Hills, 20.08.1997, *Manickam* 13594, 15.02.1985, *Manickam* 31996 (XCH). Madurai Dt.: Naterikal – Seugalten, *Hooper* & *Ramaswamy* 38649 (CAL).

Selaginella bryopteris (L.) Baker, J. Bot. 22: 376. 1884, Handb. Fern-allies 87.1887; Alston, Proc. Nat. Inst. Sci. India 11: 221. 1945; Bir & Vasudeva, Plant Sci. 5: 74. 1973; R.D.Dixit, J. Econ. & Tax. Bot. 3: 1982, Cens. Ind. Pterid. 12. 1984, Selaginellaceae India 44. f. 11. 1992; R.D.Dixit & Mondal, Ind. Fern J. 10: 164. 1993; P.C.Pande & H.C.Pande, Phytotax. 3: 69. 2003; Ghosh *et al.*, Pterid. Fl. Eastern Hills 95. 2004.

Lycopodium bryopteris L., Sp. Pl. 2: 1103. 1753.

L. circinale L. *ex* Murray, Syst. Veg. Ed. 13: 794. 1774.

L. imbricatum Roxb., Hort. Beng. 75. 1814 (*nom*. *nud*.)

Selaginella imbricata (Roxb. *ex* Griff.) J. Scott., J. Agr. Hort. Soc. India 1: 260. 1868.

Fig.13. 29. Plate.15. E. F

Xerophytic prostrate herbs. Erect branches 3 – 25 cm high, 2 mm thick, cylindrical, glabrous; simple at basal 2/3rd, copiously branched towards apex; branches flabellate, green but turn straw coloured when dry. Rhizophores 2 - 4 cm long, confined to extreme base of erect branches, produced in tuft, slender, cylindrical. Leaves isomorphic along main stem, dimorphic along ultimate branches, closely packed throughout; lateral leaf 3.8 x 1.6 mm, lanceolate, coriaceous; apex acuminate, margins denticulate, white translucent. Median leaf 0.9 - 3.3 x 0.4 - 0.9 mm, ovate – lanceolate, oblique, coriaceous; margins denticulate, apex aristate; arista 0.9 mm; axillary leaf 2.3 x 1.1 mm, ovate, oblique, coriaceous; margins denticulate, apex acuminate. Strobilus 5.4 x 1.1 mm, terminal, sessile, solitary. Sporophylls 1.7 - 2.8 x 0.7 or 0.8 mm, isomorphic, spiral, ovate, oblique, coriaceous; margin denticulate, apex acuminate or shortly aristate; megasporophylls and microsporophylls arranged intermixed. Megaspores 281 microns in diam., 4 per sporangium, yellow, globose, tetrahedral, verrucoid. Microspores 51 microns in diam., numerous, yellow, wavy in outline, granulose.

Distribution and ecology: *S. bryopteris* is endemic to India. In South India it is collected only from Tamil Nadu and Andhra Pradesh. In dry conditions the plant gets rounded off and when wet, it regains its original form and size. They usually grow on rocks exposed to direct sunlight.

Notes: *S. bryopteris* has creeping prostrate stems and erect branches. The plants I collected were mostly in the vegetative stage and only a few

specimens were fertile. *S. bryopteris* closely resembles *S. involvens* but can be distinguished from the latter by its short aerial branches ranging from 3 to 25 cm and by aristate median leaves. The lateral leaves and the median leaves along the main stem and branches exhibit morphological variation. *S. bryopteris* is sold in Indian markets under the name 'sanjiwani'. It has cooling effect; restore energy, vitality and agility (Dixit, 1982).

Specimens examined: ANDHRA PRADESH: Kurnool Dt.: Ahobilam, 24.11.2001, *Amruthalakshmi* 25124 (CAL), 06.11.2006, *Nisha* 1494 (SJC); Erramalai Hills, 03.07.1983, *Raju* 1522 (SKU); Tandrapadu, 02.09.1993, *Ahmed* 12821 (SKU). Rangareddy Dt.: Koudapur, 11.05.1990, *Muhamed* 10321 (SKU). TAMIL NADU: Nilgiri Dt.: Ootacamund, 07.11.2006, *Nisha* 1497 (SJC).

Selaginella involvens (Sw.) Spring, Bull. Acad. Brux. 10: 136. 1843; Alston, Proc. Nat. Inst. Sci. 11: 220. 1945; Tagawa, Sci. Rep. Tohoku Univ. Ser. 4. 29: 311. 1963; R.D.Dixit, Cens. Ind. Pterid. 14. 1984, Selaginellaceae India 46. f. 12. 1992; R.D.Dixit & Mondal, Ind. Fern J. 10: 166. 1993; P.C.Pande & H.C.Pande, Phytotax. 3: 69. 2003; S.R.Ghosh *et al.*, Pterid. Fl. Eastern India 3: 95. f. 27. 2004.

Type: Japan, *Thunburg* in Herb. Swartz.!

Lycopodium involvens Sw., Syn. Fil. 182. 1806.

L. circinale (*non* L.) D. Don, Prodr. Fl. Nepal 18: 1825.

Selaginella caulescens (Wall.) Spring, Bull. Acad. Brux. 10: 137. 1843.

S. pennula Spring, Mem. Acad. Belg., 24 (2): 160. 1850.

Fig.14.15. Plate.10. A. B

Xerophytic, prostrate herbs with ascending branches. 10 – 45 cm high, 2 - 4 mm thick, cylindrical, glabrous, lower half simple, green; branched towards upper half; branches flabellate, curl up when dry and resume its original form when wet. Rhizophores 2 - 6 cm long, many, spreading, confined to prostrate system, slender, cylindrical. Leaves isomorphic along the base of the main stem and spike, dimorphic along upper portion of main stem and branches, closely placed throughout; lateral leaf 1.9 - 2 x 1 - 1.2 mm, ovate - lanceolate, oblique, coriaceous; margins denticulate, apex acuminate; median leaf 1.3 x 0.7 mm, ovate – lanceolate, oblique, coriaceous; margins dentate – denticulate, smooth along basal half, apex acuminate; axillary leaf 1.9 x 1.3 mm, broadly ovate at base, lanceolate along upper half, oblique, coriaceous; margins denticulate along upper half, smooth towards base, apex acuminate. Strobilus 6.4 x 1 mm, terminal, sessile, solitary. Sporophylls 1 or 1.1 x 0.5 or 0.6 mm, isomorphic, spiral, ovate, oblique, coriaceous; margin denticulate, apex acute. Megaspores 305 microns in diam., 4 per sporangium, yellow, globose, tetrahedral and warty with transparent wing like perispore. Microspores 50 microns in diam., numerous, usually clustered together, orange – yellow, warty with transparent delicate perispore.

Distribution and ecology: *S. involvens* occurs in India, China, Nepal, Bhutan, Burma, Sri Lanka, and Malaysian Islands (Dixit, 1992). In South India, this species is distributed in Kerala and Tamil Nadu. It is found growing on large, exposed boulders in streams.

Notes: *S. involvens* curl up when dried and regain its original form when wet. Because of this resurrection habit, it is also sold in Indian markets for *S. bryopteris* as 'sanjivani'. But *S. bryopteris* is smaller than *S. involvens* and the median leaves of the former are aristate. Moreover, the megaspores of *S. involvens* are with transparent wing like perispore. Most of the specimens collected are not bearing strobili.

Specimens examined: KERALA: Cannanore Dt.: Tirunelli Reserve forest, 04.03.1979, *Ramachandran* 62063 (MH). Idukki Dt.: Muthuvankudi, 13.10.1989, *Bhargavan* 90920 (MH); Neriamangalam - Munnar, 06.01.1973, *Nair* & *Ghosh* 50713 (CAL); Pulayanmala, 16.12.1982, *Mohan* 76131 (MH). Kottayam Dt.: Kurisumalai, 31.08.1985, *Manickam* 33586 (XCH); Vagamon, 30.10.2004, *Nisha* 1413 (SJC). Palakkad Dt.: Silent Valley, Koomanthodu, 22.04.1980, *Vohra* 56321 (CAL); Kunthipuzha, 23.04.1980, *Ghosh* 56353 (CAL), *Nair* 67265 (MH). Pathanamthitta Dt.: Vandiperiyar – Kakki, 25.08.1985, *Mathew & Manickam* 33396 (XCH). Wayanad Dt.: Banasuramala, *Nampy* 45 (SJC). TAMIL NADU: Coimbatore Dt.: Akkamalai forest, 22.05.1992, *Manickam* 2109 (XCH); Periyakallur River, 03.05.1992, *Manickam* 1848 (XCH); Valparai – Nirar Dam, 03.05.1992, *Manickam* 1786 (XCH). Kamrajar Dt.: Devathanam – Daviyar Estate, 28.12.1992, *Manickam*

2973, 28.12.1992, *Manickam* 2966 (XCH). Kanyakumari Dt.: Kakkulam, 16.02.1985, *Manickam* 32024; Mahendragiri estate roadside, 19.07.1992, *Manickam* 2587 (XCH). Palani Dt.: Kodaikanal, 14.10.1919, *Jacob* 16094 (MH), *Rao* 3 (CAL), 23.11.2005, *Nisha* 1471, 24.11.2005, *Nisha* 1475 (SJC). Nellai Dt.: Sengaltheri – Natrikel, 29.06.1992, *Manickam* 2426 (XCH). Tirunelveli Dt.: Kothayar, 19.09.2003, *Nisha* 567 (SJC).

Selaginella microdendron Baker, J. Bot. 23: 116. 1885; Manickam & Irudayaraj, Pterid. Fl. Western Ghats 36. 1992.

Fig.16.17 Plate.11. A. B

Mesophytic prostrate herb. Erect branches up to 30 cm high, 1.5 mm thick, cylindrical, glabrous, green; simple along basal 1/4th, copiously branched towards upper half, deltoid aerial branches are attached to a single point at base. Rhizophores of 1 – 3 cm long, confined to base, in tuft, slender, cylindrical. Leaves isomorphic along extreme base, heteromorphic on other parts, closely placed; lateral leaf 3.2 x 1.9 mm, ovate - lanceolate, oblique, membranous; margins ciliate at base, serrate towards apex, apex acute; median leaf 2.4 x 1.4 mm, broadly ovate, oblique, membranous; margins ciliate at base, serrate towards apex, apex acuminate; axillary leaf 3.1 x 1.7 mm, ovate, oblique, membranous; margins ciliate along base, serrate towards apex, apex acuminate. Strobilus 14.6 x 1.8 mm, terminal, sessile, solitary. Sporophylls 2.4 x 1.1 mm, monomorphic, spiral, ovate,

membranous; margin ciliate along base, serrate towards apex, apex acuminate. Megaspores 309 microns in diam., 4 per sporangium, yellowish-brown, globose, tetrahedral, ridged with few small warts. Microspores 19 microns in diam., numerous, reddish-brown, globose, tetrahedral, granulose.

Distribution and ecology: In South India *S. microdendron* is so far not reported from wild.

Notes: This species is noted for its peculiar branching giving a monopodial appearance and for closely arranged leaves on the main stem and branches.

Specimens examined: KERALA: Thiruvananthapuram Dt.: Palode, Botanical Gardens, TBGRI, *Nisha* 2628 (SJC). TAMIL NADU: *s. l. anonymous* 31811 (XCH).

Selaginella gracilis Moore, Gard. Chron. 1886; Baker, Handb. Fern-allies 90. 1887.

Type: Madras, *Wight* 2187 (E, dupl. K!)

Fig.18.24 Plate.13. C. D

Sciophytic scandent herb. Erect branches 20 - 45 cm long, up to 4 mm thick, cylindrical, grooved, puberulent, sarmentose, green. Rhizophores 6 - 20 cm long, confined to basal 1/3rd, stout, cylindrical. Leaves dimorphic except the strobilus, distant along the main stem, contiguous on branches;

lateral leaf 3.1 x 1.4 mm, ovate, base obtuse or attenuate, membranous; margins entire, apex acute; median leaf 1.9 x 0.6 mm, elliptic - oblong, oblique throughout, base keeled with an extending flap along proximal side, membranous; margins entire, apex acute; axillary leaf 2.3 x 1 mm, ovate - lanceolate, slightly oblique, base with an extending flap on either side, membranous; margins entire, apex acute. Strobilus 3. 8 x 0.9 mm, terminal, sessile, solitary. Sporophylls 1.6 x 0.8 mm, isomorphic, spiral, ovate, oblique, membranous; margins entire, apex acute. Megaspores 100 microns in diam., 4 per sporangium, dull yellow, trilete, tetrahedral, warty. Microspores not observed.

Distribution and ecology: It is not found in the wild.

Notes: *S. gracilis* resembles *S. wallichi* Spring and *S. inaequalifolia* but is a prostrate plant with erect branches about 20 – 45 cm high where as the other 2 species are trailing plants with stems about 20 – 150 cm long.

Specimens examined: KERALA: Thiruvananthapuram Dt.: Kerala University Bot. Gard., 07. 12. 2006, *Nisha* 2889 (SJC).

Selaginella inaequalifolia (Hook. & Grev.) Spring, Bull. Acad. Brux.10: 145. 1843; Baker, Handb. Fern-allies 91. 1887; Alston, Proc. Nat. Inst. Sci. 11: 223. 1945; R.D.Dixit, Cens. Ind. Pterid. 13. 1984; N.C.Nair *et al.,* J. Econ. & Tax. Bot. 12: 204. 1988; R.D.Dixit, Selaginellaceae India 66. f. 30. 1992; Manickam & Irudayaraj, Pterid. Fl. Western Ghats 37.

1992; R.D.Dixit & Mondal, Ind. Fern J. 10: 165. 1993; S.R.Ghosh *et al.,* Pterid. Fl. Eastern India 3. 117. f. 38. 2004.

Type: Madras, *Wight* 2187 (E, dupl. K!)

Lycopodium inaequalifolium Hook. & Grev. In Hook., Bot. Misc. 2: 391. 1831.

Selaginella inaequalifolia Baker, Gard. Chron. 783. 1867.

Fig. 19. a. 24. 49.C. D Plate.13.E. F

Sciophytic scandent herb. Erect branches 20 - 150 cm high, up to 4 mm thick, cylindrical, grooved, puberulent, sarmentose, stolons like branches originate from base, green. Rhizophores 6 - 20 cm long, originating from stem opposite to branches, confined to basal 1/3rd, stout, cylindrical. Leaves dimorphic except the strobilus, distant along the main stem, contiguous on branches; lateral leaf 4 x 2.4 mm, ovate, oblique, base obtuse or attenuate, membranous; apex acute, margins smooth; median leaf 3.6 x 1.3 mm, elliptic - oblong, oblique throughout, imbricate, base keeled with an extending flap along proximal side, membranous; margins smooth, apex acuminate; axillary leaf 5.3 x 2 mm, oblong - lanceolate, slightly oblique, base attenuate, membranous; margins smooth, apex acute. Strobilus 18.3 x 1.8 mm, terminal, sessile, solitary. Sporophylls 1.9 - 2.3 x 1 - 1.4 mm, isomorphic, spiral, ovate, oblique, base auricled, membranous; margins smooth, apex acuminate, megasporophylls towards base and microsporophylls towards apex. Megaspores 366 microns in diam., 4 per sporangium, dull yellow, trilete, tetrahedral, warty. Microspores 29 microns in

diam., numerous, reddish - brown, warty.

Distribution and ecology: *S. inaequalifolia* is so far known only from Burma (Alston 1945) and India. In South India, it is distributed in Kerala and Tamil Nadu. It occurs in high altitudes and usually grows as a straggler along shady forest floor.

Notes: *S. inaequalifolia* is one of the largest species occurring in South India. It is dark green in colour with conspicuous strobilii about 3 cm long. The stem appears glabrous to naked eye, but is puberulent when observed under microscope. The leaf base extends as sheath and spread as wing like structure along the stem. But in main stem the leaves are distantly arranged and the base of the lateral leaves are mainly confined to the grooves on the stem.

Specimens examined: KERALA: Idukki Dt.: Meemutti, 27.09.1981, *Mohanan & Ramanujam* 72131 (MH); Valara, 26.01.1982, *Ramamurthi* 72997 (CAL), 19.03.1982, *Rajan* 73075, 02.12.1993, *Khan* 18630 (TBGT). Kollam Dt.: Palaruvi, 18. 09. 2006, *Sanoj* 1429 (SJC); Umayar – Mammood, 05.09.1977, *N.C.Nair* 50885 (CAL), 27.01.1974, *N.C.Nair* 51988 (MH). Pathanamthitta Dt.: Anathodu, 25.08.1985, *Antony* 1305 (RHK); Gavi – Kochupamba, 17.06.2006, *Azeez* & *Sanoj* 1424 (SJC). Thiruvananthapuram Dt.: Chemunjii, 07.12.2006, *Nisha* 2889 (SJC); Dharbhakulam, 04.01.1974, *N.C.Nair & Ghosh* 51691 (CAL); Kallar, 10.10.2004, *Nisha* 556, 591, 10. 08. 2005, *Nisha* 1406 (SJC); Pallippara, 06.02.1913, *Rao* 848; Ponmudi, 29.07.1978, *Mohanan* 56963 (CAL), 05.01.1974, *N.C.Nair* 51720, 51729

(CAL). TAMIL NADU: Kanyakumari Dt.: Kalaviarumalai – Balamore, 29.08.1976, *Henry* 48128 (CAL). Tirunelveli Dt.: Ambasamuthram, *Manickam* 32464 (XCH); Kakachi, 08.05.1958, *Sebastine* 5831 (CAL), 15.10.1957, *Sebastine* 1666 (MH); Kannikatty, 08.04.1985, *Manickam* 32340 (XCH), 10.11.1959, *Sebastine* 9612 (MH); Kothayar, 19.09.2003, *Nisha* 568 (SJC); Thenkasi, 04.10.1985, *Manickam* 33975 (XCH); way to Walayar estate, 24.02.1960, *Sebastine* 9933 (CAL), 24.02.1960, *Sebastine* 550 (MH).

Selaginella radicata (Hook. & Grev.) Spring, Mem. Acad. Brux. 24: 114. 1850; Alston, Proc. Nat. Inst. Sci. India 11: 216. 1945; Alston & Bonner, Candollea 15: 195. 1956; Bir & Vasudeva, Pt. Sci. 5: 75. 1973; N.C.Nair *et al.,* J. Econ. & Tax. Bot. 12: 204. 1988 (as *S. radiata*, excl. Panigrahi & R.D.Dixit, Proc. Nat. Inst. Sci. India 34: 203. 1968); R.D.Dixit, Cens. Ind. Pterid. 16. 1984, Selaginellaceae India 56. f. 21. 1992; Manickam & Irudayaraj, Pterid. Fl. Western Ghats 36. 1992; R.D.Dixit & Mondal, Ind. Fern J. 10: 167. 1993; P.C.Pande & H.C.Pande, Phytotax. 3: 70. 2003.

Types: Courtallum and Dindygall, *Wight s. n*. (BM, E, K!, W)

Lycopodium radicatum Hook. & Grev. In Hook., Bot. Misc. 11: 397. 1831.

L. radicans Bory, Bel. Voy. Bot. 11: 11. 1833, *non* Schrank 1789.

S. praelonga (Hook. & Grev.) Spring, Bull. Acad. Brux. 10. 142. 1843.

S. radicata var. *praelonga* (Hook. & Grev.) Spring, Mem. Acad. Brux. 24: 114. 1880.

Fig.19. b. 20.A. 22 Plate.14. E. F

Mesophytic decumbent herbs. Stem 15 – 35 cm long, 1.5 – 2 mm thick, cylindrical, glabrous, pale green when young straw coloured when dry; branched from base, branches erecto – patent, compound. Rhizophores 1 - 8 cm long, a few, confined mainly to basal 1/3, feebly present along upper portions, slender, cylindrical; stem apex when touches soil develop rhizophores. Leaves heteromorphic except along the strobilus, compact on the stem and branches, pale green, curl from opposite sides covering the stem on getting dried. Lateral leaf 3 x 1.7 mm, ovate - lanceolate, oblique, membranous; margins ciliate at basal half, irregularly denticulate towards apex, apex acute; median leaf 1.7 x 1.4 mm, broadly ovate, oblique, membranous; margins ciliate along lower half and dentate along upper half, apex acuminate; axillary leaf 1.9 x 0.9 mm, ovate - lanceolate, oblique at base, membranous; margins ciliate at base and dentate – denticulate towards apex, apex acute. Strobilus 5.4 x 0.9 mm, terminal, sessile, solitary. Sporophylls 1.7 x 0.8 mm, isomorphic, spiral, ovate, oblique, membranous; margins ciliolate - dentate at base, denticulate towards apex, apex acuminate; megasporophylls toward base and microsporophylls toward apex; megasporophylls are more in number than microsporophylls. Megaspores 4 per sporangium, 271 microns in diam., pale yellow, globose, tetrahedral, reticulate. Microspores many, 34 microns in diam., deep red,

reticulate with small warts.

Distribution and ecology: *S. radicata* is endemic to South India. Panigrahi and Dixit (1968) had described it as a new record for eastern India, but their description and illustration does not matches with the type. Hence its occurrence in eastern India is doubtful. It occurs in wet earth cuttings. It is easily distinguished in the field by the curling nature of its lateral leaves from opposite sides, covering the stem when dry.

Notes: The leaves of *S. radicata* are pale green, heterophyllous and membranous even though coriaceous in appearance. The plant develops roots almost throughout its body and the apex on touching the soil develops a tuft of roots. On getting detached from the mother plant the fragments bearing roots give rise to a new plant.

Specimens examined: KERALA: Palakkad Dt.: Nelliampathy, 28.07.1991, *Madhusoodanan & Pradeep* 44818 (CALI). TAMIL NADU: Coimbatore Dt.: Valparai, 21.12.1992, *Nampy* 48877 (CALI). Madurai Dt.: Kodaikanal, 28.06.1984, *Manickam* 31095 (XCH), 23. 11. 2005, *Nisha* 1470, 1474 (SJC), 4.10.1913, *Saulieres* 39, 1037 (CAL); Palamali – Thalayar, 29.06.1984, *Manickam* 31128 (XCH); Palani Hills, 16.01.1985, *Manickam* 31835 (XCH); Way to Kumali, *Subramanyam* 8976 (MH). Nilgiri Dt.: *s.l*., *Gamble* 21389 (CAL); Adderlley – Kallar, 06.12.1971, *Radhakrishnan* 30172 (MH); Coonoor, Kolikari road, 22.11.1991, *Manickam* 810, 04.01.1992, *Manickam* 1067 (XCH). Salem Dt.: Kolli Hills, Solakkadu, 04.07.1985, *Manickam & Mathew* 33184 (XCH).

Selaginella repanda (Desv. *ex* Poir.) Spring In Gaudich., Voy. Bonite Bot. 1: 329, 1846; Alston, Proc. Nat. Inst. Sci. Ind. 11: 217. 1945; Panigrahi & R.D.Dixit, Pro. Nat. Inst. Sci. India 34: 231. 1968; Tagawa, Act. Phytotax. Geobot. 15: 174. 1973; Baishya & R.R.Rao, Ferns & Fern-allies Meghalaya India 28. 1982; R.D.Dixit, Cens. Ind. Pterid. 16. 1984, Selaginellaceae India 62. f. 27. 1992; R.D.Dixit & Mondal, Ind. Fern J. 10: 167. 1993; Mukhop. & Goswami, Ind. Fern J. 13: 23. 1996; P.C.Pande & H.C.Pande, Phytotax. 3: 70. 2003; S.R.Ghosh *et al.*, Pterid. Fl. Eastern India. 3. 100. f. 28. 2004.

Type: Philippines, *s. l*.,Herb. *Desvaux s.n.* (P).

Lycopodium repandum Desv. *ex* Poir. In Lamarck, Encycl. Suppl. 3: 558. 1814.

L. barbatum Kaulf., Enum. Fil. 18. 1824.

L. tetragonostachyum Wall. *ex* Hook. & Grev. In Hook., Bot. Misc. 2: 389. 1831.

L. tetragonostachyum var. *major* Hook. & Grev. In Hook., Bot. Misc. 2: 389. 1831.

Fig. 21. 22 Plate.12. A. B

Mesophytic sub-erect herbs of stem 5 – 25 cm high, 1 or 2 mm thick, cylindrical, glabrous, branched from base, branches erecto–patent and

compound. Rhizophores 3 - 5 cm long, a few in number, confined to base, slender, cylindrical and branched dichotomously. Leaves heteromorphic except the strobilus and base of the main stem, compact on the stem and branches, pale green; lateral leaf 3.1 x 1.5mm, ovate - lanceolate, oblique, membranous; margins ciliate at basal half, dentate towards apex, apex acute; median leaf 2 x 1.1 mm, broadly ovate, oblique, membranous; margins ciliate along lower half and dentate along upper half, pellucid, apex acuminate; axillary leaf 2 x 1 mm, ovate - lanceolate, membranous; margins ciliate at base and dentate towards apex, pellucid, apex acute. Strobilus 7.1 x 2.4 mm, terminal, sessile, solitary. Sporophylls 1.6 x 0.9 mm, isomorphic, spiral, ovate, oblique, membranous; margins dentate, apex acuminate. Megaspores 233 microns in diam., 4 per sporangium, pale yellow, globose, tetrahedral, warty. Microspores not observed.

Distribution and ecology: *S. repanda* is confined to India, Nepal, Burma, China and many other Asian countries (R.D.Dixit, 1992). It is one of the common species in South India. Even though they prefer shady and wet soils of earth cuttings, they also show xerophytic adaptation and curl on drying, but regain their original form when wet.

Notes: *S. repanda* are dark green with leaves of coriaceous appearance even though membranous in texture. The sporophylls are acuminate and ovate. This species is close to *S. radicata* (Hook. & Grev.) Spring, but can be identified from the latter by the small size, spreading but compactly placed vegetative leaves and by the warty megaspores.

Specimens examined: ANDHRA PRADESH: Adilabad Dt.: Wankidi RF, 15.08.1989, *Prasanna* 9484 (SKU). Anantapur Dt.: Talakona, 07.11.2006, *Nisha* 1496 (SJC). Chittoor Dt.: Tirumala 24.01.1994, *Ahmed* 13519 (SKU). East Godavari Dt.: Gunlabrahmeswaram, 27.10.1964, *Ellis* 22229 (MH); Near Tadepalli, 16.10.1986, *Rao* & *Narasimhan* 84365 (CAL, MH); Upper Ahobilam, 29.09.1984, *Pullaih* & *Raju* 2728 ; 05.09.1993, *Ahmed* 12824 (SKU); Way to Kakur from Maredumilli, 21.09.1980, *Rao* 67595 (CAL, MH). North Arcot Dt.: Way to Pudur, 05.12.1958, *Subramanyam* 7501 (CAL). KERALA: Pathanamthitta Dt.: Muzhiyar - Kakki road, 03.09.1985, *Manickam & Mathew* 33654, 33686 (XCH). TAMIL NADU: Coimbatore Dt.: Akkamalai forest, 27.05.1993, *Manickam* 3449 (XCH); Kuridimalai, 24.09.1956, *Subramanyam* 831 (CAL, MH); Periyakallur river, 03.05.1992, *Manickam* 1851 (XCH). Salem Dt.: Shevroy Hills, 04.09.1964, *Ghatak* 771 (CAL).

Selaginella ganguliana R.D.Dixit, Bull. Bot. Surv. India 26. 104. t. 105. 1984, Cens. Ind. Pterid. 13. 1984, Selaginellaceae India 57. f. 22. 1992; R.D.Dixit & Mondal, Ind. Fern J. 10: 165. 1993.

Type: India, Kerala, Thiruvananthapuram Dt.: Aruvikkara, *Nair* 51560 (CAL!)

Fig. 23. 24 Plate.13. A. B

Mesophytic erect herbs. Stems 5 - 15 cm high, 1 – 1.5 mm thick, cylindrical, glabrous, green; copiously branched. Rhizophores 1 - 4 cm long, produced in tufts, confined to basal 1/3, slender, cylindrical, dichotomously

branched at base. Leaves heteromorphic except the strobilus, distantly packed on main stem and compact along branches; lateral leaf 2.8 x 1.5mm, ovate - lanceolate, oblique, membranous; proximal margin serrate at base, serrulate towards apex, distal margin serrulate, apex acute; median leaf 2.6 x 1.1 mm, ovate, oblique, membranous; margins dentate – denticulate, apex aristate, arista 1.1 mm; axillary leaf 1.7 x 0.9 mm, ovate - lanceolate, oblique at base, membranous; margins dentate, apex acute. Strobilus 6.1 x 1.6 mm, terminal, sessile, solitary. Sporophylls 2 x 0.7 mm, isomorphic, spiral, ovate, oblique, membranous; margins dentate - denticulate, apex aristate, arista 0.8 mm. Megaspores 256 microns in diam., 4 per sporangium, dull white, globose, tetrahedral, reticulate. Microspores 22 microns in diam., numerous, orange-red, trilete, tetrahedral, papillate.

Distribution and ecology: *S. ganguliana* is endemic to Kerala and is one of the common species in the state. It is found growing along shaded vertical earth cuttings at an altitude between 40 – 910 m.

Notes: *S. ganguliana* shows colour variation. It is light brown to fluorescent green or bright green. It shows copious branching towards upper half and the rhizophores are confined to basal 1/3rd.

Specimens examined: KERALA, Idukki Dt.: Munnar, 12.09.2005, *Nisha* 2618 (SJC). Kozhikode Dt.: Edakkad, 28.07.2007, *Nisha* 1500, 08.08.2007, *Nisha* 2605 (SJC). Malappuram Dt.: Manjeri, 31.10.2004, *Nisha* 2613 (SJC). Palakkad Dt.: Cherunelly, 10.12.2002, *Joby & Sibichen* 549 (SJC). Thiruvananthapuram Dt.: Aruvikkara, 07.10.2004, *Nisha* 557, 1403,

08.10.2004, *Nisha* 583 (SJC); Bonaccord, 02.01.1996, *Antony*, 26841 (TBGT); Ponmudi, 06.10.2004, *Nisha* 579, 584 (SJC). Wayanad Dt.: Kalpetta, 11.08.2005, *Nisha* 2614 (SJC).

Selaginella plumosa Baker, J. Bot. 144. 1883, Handb. Fern-allies 50. 1887;R.D.Dixit & Mondal, Ind. Fern J. 10: 167. 1993; P.C.Pande & H.C.Pande, Phytotax. 3: 70. 2003.

Fig. 25. 37 Plate.14. A. B

Mesophytic erect herbs. Stems up to 18 cm high, stout, cylindrical, glabrous, green throughout and turn brownish when dry; branched from base but copiously branched from middle towards apex. Rhizophores 3 or 4 cm long, few in number, confined to basal nodes, slender, cylindrical and dichotomously branched. Leaves dimorphic except the strobilus, contiguous on main stem and branches; lateral leaf 3.1 x 1.2 mm, oblong - lanceolate, oblique throughout, coriaceous; margins ciliolate - serrate along base, serrate towards apex, apex acute; median leaf 1.5 x 0.8 mm, ovate, imbricate, keeled, oblique throughout, coriaceous; margins ciliate at base, serrate towards apex, apex acuminate; axillary leaf 1.8 x 0.7 mm, lanceolate, slightly oblique, coriaceous; margins serrate along upper half, ciliate along basal half, apex acute. Strobilus 6.8 x 1.4 mm, terminal, sessile, tetragonal, either solitary or dichotomously or trichotomously branched. Sporophylls 1.5 or 1.6 x 0.6 mm, isomorphic, spiral, ovate-lanceolate, oblique, scaly; margins

serrate - serrulate, apex acuminate, micro and mega sporophylls arranged intermixed. Megaspores 182 microns in diam., 4 per sporangium, pale yellow, globose, tetrahedral, smooth. Microspores 24 microns in diam., numerous, reddish - brown, rugulose-reticulate.

Distribution and ecology: Baker (1887) reported this species from Eastern Himalayas and mountains of Indian Peninsula and Ceylon. The present collection is from the sandy soils of Muthanga of Wayanad district of Kerala.

Notes: *S. plumosa* is generally rough in texture and branched profusely from middle towards apex. Their spikes are terminal on the branches and are either simple or branched dichotomously or trichotomously.

Specimens examined: ANDHRA PRADESH: Cuddapah Dt.: Balapalle, 10.11.1962, *Ellis* 15001 (CAL). KERALA: Wayanad Dt.: Muthanga, 29.11.2002, *Nisha* 542 (SJC).

Selaginella braunii Baker, Gard. Chron. 1120. 1867, Handb. Fern-allies 96. 1887; Alston, Proc. Nat. Inst. Sci. 11: 229.1945; R.D.Dixit, Cens. Ind. Pterid. 11. 1984, Selaginellaceae India 38. f. 6. 1992.

Type: West China, *s. l*. *Blakiston s. n*. (K!)

Selaginella pubescens, A. Br., *non* Spring Ann. Sci. Nat. 4: 13. 76. 1860.

S. hieronymi Alderw., Bull. Tard. Bot. Brit. 2: 1. 18. 1912.

Fig. 29. Plate.15. C. D

Mesophytic erect herb. Main stem 30 – 45 cm high, 1.5 - 2 mm thick, cylindrical, pubescent, pale brown; simple along basal 1/3, flexuously pinnately branched towards apex. Rhizophores 2 – 3 cm long, confined to base. Leaves heteromorphic throughout, distant along main stem, contiguous along branches; lateral leaf 6 x 2.1 mm, ovate-rhomboid, oblique, membranous; margins entire, apex acute; median leaf 2.8 x 0.8 mm, oblong, membranous; margins entire, apex cuspidate; axillary leaf 3.6 x 1.8 mm, ovate, slightly oblique, apex sub-acute, margins smooth, membranous. Strobilus 5 - 7 x 1 or 2 mm, terminal, sessile, solitary. Sporophylls isomorphic, spiral, oblique, membranous; margins minutely denticulate, acuminate; number of megasporangia outweighs the number of microsporangia. Megaspores 450 microns in diam., 4 per sporangium, pale yellow when dry, globose, tetrahedral, reticulate. Microspores 41 microns in diam., numerous, orange - red, reticulate.

Distribution and ecology: *S. braunii* is reported from China (Baker, 1887) and India. It is a pot plant, prefer moistend habitat.

Notes: *S. braunii* is one of the largest terrestrial species in South India with pale brown stem, which is flexuously branched towards upper half. It is an ornamental plant and so far not reported from wild.

Specimens examined: KERALA: Thiruvananthapuram Dt.: *s. l*. 15.01.1961, *Abraham* 1001 (KUBH). TAMIL NADU: Madurai Dt.: Yercaud, 24.03.1962,

Ghatak 96 (CAL).

Selaginella uncinata (Desv. *ex* Poir.) Spring, Bull. Acad. Brux 10: 141. 1843; Baker, Handb. Fern-allies, 48. 1887; R.D.Dixit, Selaginellaceae India 54. f. 19. 1992.

Fig.11. 26. Plate.12. E. F

Mesophytic sub-erect herbs. Branches up to 18 cm long, up to 1 mm thick, cylindrical, glabrous, simple at base but copiously branched from middle towards apex, green throughout. Rhizophores 1 – 3 cm long, a few in number, confined to base, slender, cylindrical and dichotomously branched. Leaves dimorphic except the strobilus and main stem, distant on main stem and contiguous on branches; lateral leaf 1.7 x 0.9 mm, oblong - lanceolate, base entire, membranous; margins serrate troughout, apex sub-acute; median leaf 1.9 x 0.7 mm, ovate-lanceolate, imbricate, keeled, base entire, membranous; margins serrulate, apex acuminate; axillary leaf 1.7 x 1 mm, obovate, membranous; margins serrate - serrulate, apex sub-acute. Strobilus 6.8 x 1.4 mm, terminal, sessile, solitary. Sporophylls 1 x 0.9 mm, isomorphic, spiral, broadly ovate, oblique, membranous; margins serrate-serrulate, apex acute. Megaspores not observed. Microspores 30 microns in diam., numerous, pale yellow, trilete, tetrahedral with spiny projections.

Distribution and Ecology: *S. uncinata* is reported from India and China (Dixit, 1992). It is a pot plant in India and grows well in wet soil

Notes: *S. uncinata* is noted for its feathery branching and beautiful, pale green foliage.

Specimens examined: KERALA, Kozhikode Dt.: Edakkad, 29.11.2006, *Nisha* 2608, 30.01.2007, *Nisha* 2713 (SJC).

5. ***Selaginella*** Sub-gen. ***Heterostachys*** Baker, J. Bot., Lond. 21: 4 (1883).

Lectotype: ***Selaginella heterostachys*** Baker

Synonym: subgen. *Heterophyllum* (Spring) Hieron. & Saded. In Engler & Prantl, Nat. Pflanz. 1 (4): 673. 1902

Stems creeping and branched. Rhizophores originate from the branch axils. Leaves resemble that of sub-gen. *Stachygynandrum*. Sporophylls are dimorphic and tetrastichous. This group has 60 species in the world (Jermy, 1986). In South India 17 species belong to this subgenus.

Key to species

1a. Plants persistent……..……..**2**

1b. Plants fugacious……**3**

2a. Stem decumbent, branched along upper half; smaller sporophylls long aristate……..…..***S. brachystachya***

2b. Stem procumbent, branched from base; smaller sporophylls acute… ……***S. monospora***

3a. Stems strong, erect……..……....**4**

3b. Stem weak, descending……..……..**5**

4a. Plants small up to 7 cm long; sporophylls ciliate……..**6**

4b. Plants more than 7 cm long; sporophylls dentate…….....**7**

5a. Sporophylls ciliate……..……..**8**

5b. Sporophylls not ciliate……..…..**9**

6a. Sporophylls aristate……..**10**

6b. Sporophylls sub-acute to acuminate……..……..…**11**

7a. Stem stoloniferous……..…… ***S. chrysocaulos***

7b. Stem not stoloniferous……..**12**

8a. Lateral leaf ciliate…….…. ***S. proniflora***

8b. Lateral leaf denticulate……..**13**

9a. Stem very rarely branched; rhizophores in bunch at base … ……..

……..***S. keralensis***

9b. Stem pinnate or bipinnate; rhizophores thread like, not in bunch ……**14**

10a. Median leaf shortly cuspidate……..……..……**15**

10b. Median leaf aristate……..…….. ***S. crassipes***

11a. Lateral leaf smooth……..……***S. nairii***

11b. Lateral leaf ciliolate-dentate……..……..……...***S. minutifolia***

12a. Rhizophores confined to basal half, gemmae like structures at the end of branches …… ***S. tenera***

12b. Rhizophores at base only, no gemmae-like structures present……. ……***S. miniatospora***

13a. Rhizophores produced throughout; stem prostrate, not sulcate……..**16**

13b. Rhizophores up to ½ of the plant; stem erect, sulcate…….***S. camusii***

14a. Stem decumbent; smaller sporophylls long ciliate…..…***S. coonooriana***

14b. Stem procumbent; smaller sporophylls dentate……***S. cataractarum***

15a. Sporophylls ciliate, megaspore verrucoid……..... ***S. chrysorhizos***

15b. Sporophylls serrate, megaspore smooth……..……..***S. lakkidiana***

16a. Megaspores warty, spikes resupinate; median leaf acuminate ……. …….. ***S. nayarii***

16b. Megaspores reticulate, spikes not resupinate; median leaf aristate …. ……. ***S.ciliaris***

Selaginella brachystachya (Hook. *et* Grev.) Spring, Bull. Acad. Brux. 10: 232. 1843; Baker, Handb. Fern-allies 113. 1887 (*p. p*.); Alston, Proc. Nat. Inst. Sci. 11: 229.1945; R.D.Dixit, Cens. Ind. Pterid. 11. 1984; Manickam & Irudayaraj, Pterid. Fl. Western Ghats 41. 1992.

Type: Ceylon, *s. l*. *Lindley* 1829 (K).

Lycopodium brachystachyum Hook. *et* Grev. In Hook., Bot. Misc. 3: 107. 1833.

Selaginella brachystachya var. *denticulata* Spring In Mem. Acad. Brux. 24: 256. 1850.

S. stolonifera (*non* Spring) Ferguson, Ceylon Ferns 63. 1880.

Fig. 27. 29. Plate.15. A. B

Mesophytic decumbent herb. Stem 30 - 35 cm long, 1.5 – 2 mm thick, cylindrical, glabrous, green; branches pinnate. Rhizophores 6 – 10 cm long, produced throughout except apex, originating from axils of branches or sub – axillary, slender, cylindrical. Leaves heteromorphic throughout, distant along main stem and branches; lateral leaf 6 x 2.1 mm, oblong - lanceolate, oblique, membranous; margins smooth, apex sub-acute; median leaf 2.8 x 0.8 mm, ovate, oblique, membranous; margins smooth, apex aristate; arista 1.6 mm long; axillary leaf 3.6 x 1.8 mm, ovate, slightly oblique, membranous; margins smooth, apex sub-acute. Strobilus 8.9 x 2.8 mm, terminal, sessile, solitary. Sporophylls 1.7 - 1.9 x 0.5 - 0.7 mm, dimorphic, spiral, oblique, membranous; margins smooth; larger sporophylls ovate – lanceolate, apex acuminate; smaller sporophylls ovate, apex aristate; arista 1 mm long. In strobilus, the number of megasporangia are more than the number of microsporangia. Megaspores 293 microns in diam., 4 per sporangium, pale yellow when dry, globose, tetrahedral, reticulate. Microspores 41 microns in diam., numerous, orange - red, reticulate.

Distribution and ecology: *S. brachystachya* is known to occur in Sri Lanka (Alston, 1945) and India. It is rare in South India collected only from

Anamalais, Palani hills and Kannikatty hills of altitudes 1200 – 2000 m. The species prefers shady moistend habitat.

Notes: *S. brachystachya* is one of the largest species in South India having bright green, dimorphic leaves. It closely resembles *S. monospora* but differs in having smooth leaves and aristate smaller sporophylls against leaves and acute smaller sporophylls in *S. monospora*.

Specimens examined: KERALA: Idukki Dt.: Anamalai Hills, 15.06.1985, *Manickam & Mathew* 33136, 06.03.1986, *Manickam & Mathew* 34471 (XCH); Munnar, 08.10.1994, *Santhosh* 29840 (TBGT). TAMIL NADU: Tirunelveli Dt.: Kannikatty hills, 09.04.1985, *Manickam* 32376 (XCH). Madurai Dt.: Palani Hills, 13.05.1985, *Manickam & Mathew* 32881 (XCH).

Selaginella monospora Spring, Mem. Acad. Sci. Belg. 24: 135. 1850; Alston, Proc. Nat. Inst. Sci. 11: 228. 1945; Baishya & R.R.Rao, Ferns & Fern-allies Meghalaya 27. 1982; R.D.Dixit, Cens. Ind. Pterid. 4: 14. 1984, Selaginellaceae India 92. f. 56. 1992; R.D.Dixit & Mondal, Ind. Fern J. 10: 166. 1993; S.R.Ghosh *et al.,* Pterid. Fl. Eastern India 3: 127. f. 46. 2004.

Type: Gorval, *Griffith* 195 (K!)

S. gorvalensis Spring, Mem. Acad. Sci. Belg. 24: 286. 1850.

S. plumosa var. *monospora* (Spring) Baker, J. Bot. 21: 145. 1883.

S. microclada Baker, J. Bot. 22: 246. 1884.

S. semicordata sensu Burkill, Rec. Bot. Surv. India. 10: 228. 1925 (*non* Spring, 1850).

Fig.17. 28.D. 30 Plate.11. E. F

Mesophytic decumbent herbs of erect branches up to 60 cm high, main stem 2 mm thick, cylindrical, glabrous, dark green but turns 'brown' on drying; branched pinnately. Rhizophores 6 – 10 cm long, produced throughout except apex, originating from axils opposite to branches, stout, cylindrical. Leaves heteromorphic throughout, distant along main stem and branches, spreading; lateral leaf 3.7 x 1.25 mm, oblong - lanceolate, oblique, membranous; margins denticulate, apex sub-acute; median leaf 2.6 x 1.1 mm, ovate, oblique, base sub-cordate, membranous; margins denticulate, apex aristate; arista 1.1 mm long; axillary leaf 3.3 x 1.25 mm, oblong-lanceolate, slightly oblique, membranous; margins smooth, apex sub-acute. Strobilus 4.9 x 3.3 mm, terminal, sessile, solitary. Sporophylls 3.3 x 0.9 mm, dimorphic, spiral, oblique, membranous; larger sporophylls oblong – lanceolate, margins smooth, apex acute; smaller sporophylls ovate, margins denticulate, aristate; arista 1.9 mm long. Megaspores 285 microns in diam., 4 per sporangium, pale yellow when dry, globose, tetrahedral, verrucoid. Microspores 18 microns in diam., numerous, orange - red, papillate.

Distribution and ecology: *S. monospora* is reported from India, Burma, China, Indo–China, Tonkin and Annam (Dixit, 1992). In South India, this species occurs in Kerala and Tamil Nadu. This terrestrial species prefers wet, shady habitats.

Notes: It is one of the largest terrestrial species in South India with erect branches up to 60 cm. It bears long, cylindrical rhizophores throughout and dimorphic, bright green, spreading leaves.

Specimens examined: KERALA: Thrissur Dt.: Sholayar, 18.09.1974, *Nair & Ghosh* 51059 (CAL). TAMIL NADU: Coimbatore Dt.: Indira Gandhi National Park, 21.01.2004, *Nisha* 558 (SJC). Kanyakumari Dt.: Nagercoil, Kiripara, 07.10.1974, *Nair* & *Ghosh* 52613 (CAL).

Selaginella chrysocaulos (Hook. *et* Grev.) Spring, Bull. Acad. Brux. 10: 232. 1843; Baker, Handb. Fern-allies, 117. 1887 (*p. p.*); Alston, Proc. Nat. Inst. Sci. India 11: 225. 1945; Panigrahi & R.D.Dixit, Proc. Nat. Acad. Sci. 46: 103. t. 1. f. 2. 1966; R.D.Dixit, Cens. Ind. Pterid. 12. 1984, Selaginellaceae India 95. f. 58. 1992; R.D.Dixit & Mondal, Ind. Fern J. 10. 164. 1993; P.C.Pande & H.C.Pande, Phytotax. 3: 69. 2003; S.R.Ghosh *et al.*, Pterid. Fl. Eastern India.3. 106. f. 31. 2004.

Type: Mountains of Penang, *Wallich* list no. 127 (E!)

Lycopodium chrysocaulos Hook. *et* Grev. In Hook., Bot. Misc. 2: 401. 1831.

S. hypnoides Spring, Mem. Acad. Brux. 24 (2): 101. 1850.

S. semicordata sensu Strachey, Gaz. North-West Prov. 10: 66. 1882.

S. philippina var. *khasiansis* Baker, J. Bot. 22. 298. 1884.

S. rosenstockii Hieron., Hedwigia 43: 22. 1904.

Fig.31. 44 Plate.18. C. D. E. F

Mesophytic erect herb. Main stem 10 – 25 cm high, 1 – 1.5 mm thick, slender, cylindrical, tufted, straw coloured, branched from base; branches erecto – patent, compound. Rhizophores up to 3 cm long, confined to base, slender, cylindrical, branched dichotomously. Leaves heteromorphic throughout, distantly arranged on the stem and compact along branches, pale green - green; lateral leaf 1.5 x 0.8 mm, ovate - lanceolate, membranous; margins denticulate, apex acute; median leaf 0.9 x 0.4 mm, ovate, membranous; margins denticulate, apex acute-acuminate; axillary leaf 1.4 x 0.6 mm, ovate, membranous; margins smooth, apex acute. Strobilus 5 x 2.7 mm, terminal, sessile, solitary. Sporophylls 0.7 - 1.2 x 0.3 or 0.4 mm, dimorphic, spiral, membranous; larger sporophylls oblong – lanceolate, margins denticulate, apex acute-acuminate; smaller sporophylls ovate, margins dentate-denticulate, apex acuminate. Megaspores 183 microns in diam., 4 per sporangium, pale yellow, globose, tetrahedral, verrucoid. Microspores 21 microns in diam., numerous, deep red, warty.

Distribution and ecology: *S. chrysocaulos* is reported from Nepal, Bhutan and India (Dixit, 1992). It grows along exposed earth cuttings.

Notes: *S. chrysocaulos* has heterophyllous, membranous leaves. The branch apices bear bud-like structures that develop into new plants (Bancroft, 1914).

Specimens examined: KARNATAKA: Kolloor Dt.: Muppani forest, *Nisha* 1455 (SJC). KERALA: Kasaragod Dt.: Ranipuram, *Joby* 575 (SJC).

Selaginella proniflora (Lam.) Baker, J. Bot. 22: 156. 1885; Handb. Fern-allies 108. 1887; Alston, Proc. Nat. Inst. Sci. 11: 226. 1945; Baishya & R.R.Rao, Ferns and Fern-allies Meghalaya India 28. 1982; R.D.Dixit, Cens. Ind. Pterid. 16. 1984, Selaginellaceae India 83. f. 46. 1992; R.D.Dixit & Mondal, Ind. Fern J. 10: 167. 1993.

Type: India Orientalis, *s. l*., *Sonnerat s.n*. (P)

Lycopodium proniflorum Lam., Encycl. 3: 652. 1789.

Selaginella dalzelli Baker, J. Bot. 23: 249. 1885.

Lycopodium caespitosum Dalz. In Hook., J. 4: 114. 1852 (*non* Blume 1830).

Fig. 22. 32 Plate.14. C. D

Mesophytic decumbent herb. Stem 5 - 20 cm long, slender, cylindrical, glabrous, pale-green; branched from base. Rhizophores 0.5 – 2.5 cm long, few, confined to base, cylindrical, dichotomously branched. Leaves dimorphic throughout, arranged in four rows, distant along the stem, contiguous on branches; lateral leaf 2.9 x 0.9 mm, oblong - lanceolate, oblique at base, membranous; proximal margin ciliate along basal half, upper half serrate, distal margin smooth at base, apex acute; median leaf 1.6 x 0.8 mm, ovate, membranous; margins distantly ciliate along basal half, serrate towards apex, pellucid margined, apex aristate; arista 0.4 mm;

axillary leaf 1.6 x 0.8 mm, elliptic - oblong, oblique, membranous; margins ciliate along basal half, serrulate along upper half, apex acute. Strobilus terminal and axillary, terminal spike 5 x 2 mm, axillary spike 2.8 x 0.8 mm, sessile, solitary. Sporophylls dimorphic; larger sporophylls 0.9 x 0.5 mm, ovate, oblique, membranous; margins serrate, pellucid, apex acuminate; smaller sporophylls 0.7 x 0.4 mm, ovate, oblique, membranous; margins ciliate - ciliolate towards base, serrate towards apex, apex acuminate. Megaspores 220 microns in diam., 4 per sporangium, dull yellow, globose, trilete, tetrahedral, reticulate. Microspores 40 microns in diam., numerous, reddish - brown, reticulate.

Distribution and ecology: *S. proniflora* is reported from India, Sri Lanka and Malay region to North and East Australia (Dixit, 1992). In South India it is reported from Karnataka and Kerala. It is a terrestrial species that grows near springs or other water sources.

Notes: *S. proniflora* have cilia both in vegetative and reproductive leaves. This is the only south Indian species that have axillary spikes.

Specimens examined: KARNATAKA: Uduppi Dt.: Kolloor, 12.10.2005, *Nisha* 2612 (SJC). KERALA: Kozhikode Dt.: Vayalada, 01.01.2002, *Nisha* 510, 514 (SJC).

Selaginella keralensis R.D.Dixit, Bull. Bot. Surv. India 27: 123. f. 1. 1985, Selaginellaceae India 63. f. 48. 1992; R.D.Dixit & Mondal, Ind. Fern J.

10: 166. 1993.

Type: Kerala, Kuttikanam, *Nair* 40195 (BSA).

Fig.15. 33 Plate.10. C. D

Prostrate herb. Stems 3 – 6 cm long, up to 1 mm thick, slender, cylindrical, glabrous, green; branched from base. Rhizophores in tufts confined to base, slender, cylindrical, 1 or 2 cm long. Leaves dimorphic throughout, dark green, distant along main stem, closely placed along branches; lateral leaf 1.8 x 1 mm, ovate - lanceolate, oblique, membranous; margins dentate at basal proximal half, denticulate to smooth towards apex, smooth along distal half, apex acute; median leaf 1 x 0.4 mm, ovate - elliptic, oblique, membranous; margins dentate, apex acute; axillary leaf 1.9 x 0.9 mm, ovate - elliptic, slightly oblique, membranous; margins dentate, apex acute. Strobilus 6.4 x 2.7 mm, terminal, solitary. Sporophylls dimorphic; larger sporophylls 1.6 x 0.6 mm, sterile, ovate – lanceolate, oblique, membranous; margins dentate, bear serrate laminal flap along the adaxial side, apex sub – acute; smaller sporophylls 1.1 x 0.5 mm, fertile, ovate, oblique, membranous; margins smooth at base, rest dentate, apex acute; Megaspores 167 microns in diam., 4 per sporangium, pale yellow, trilete, tetrahedral, smooth. Microspores not observed.

Distribution and ecology: *S. keralensis* is endemic to Kerala and hitherto reported only from its type locality, Kuttikanam. However, we have collected this species from Talakona of Anantapur district in Andhra Pradesh. It grows

on moist rocks at an altitude of 850 m.

Notes: Dixit (1985) described *S. keralensis* as simple to sometimes branched, stem 1.5 - 3 cm long, which is stramineous on drying. But in our specimens from Talakona differs in having copious branching, 3 – 6 cm long stem which is dark green even after drying. Their leaves and the sporophylls are dentate or serrate.

Specimens examined: Andhra Pradesh: Anantapur Dt.: Talakona, 07.11.2006, *Nisha* 1499 (SJC).

Selaginella crassipes Spring, Mem. Acad. Sci. Brux. 24: 243. 1850; Baker, Handb. Fern-allies 117. 1887; Alston, Proc. Nat. Inst. Sci. India 11: 226. 1945; N.C.Nair *et al*., J. Econ. & Tax. Bot. 12: 205. 1988.

Type: Ceylon, *s. l*., Walker *s.n*. (K).

S. fergusonii Heiron, Hedw. 43: 59. 1904.

Fig. 34. 35 Plate.16. A. B

Mesophytic erect herb. Stem 8 - 13 cm high, slender, up to 1 mm thick, cylindrical, glabrous, branched from base, yellowish green. Rhizophores 2 - 4 cm long, confined to basal 1/3rd, slender, repeatedly dichotomously branched. Leaves heteromorphic throughout, distantly arranged on the main stem, contiguous on branches, tetrastichous; lateral leaf 2.2 x 1.6 mm, ovate - elliptic, oblique, membranous; margin serrulate,

apex acute; axillary leaf 2 x 1.5 mm, ovate-lanceolate, oblique, base auricled, membranous; margin serrate, apex acute; median leaf 1.3 x 0.6 mm, ovate, membranous; margins serrate, apex aristate; arista 0.4 mm long. Strobilus 5.6 x 1.6 mm, terminal, sessile, solitary. Sporophylls dimorphic, spiral, membranous. Larger sporophylls 1.2 x 0.6 mm, ovate–elliptic, oblique, white margined, proximal margin ciliate along basal half, serrulate along upper half, apex acute, all microsporangiate. Smaller sporophylls 0.9 x 0.4 mm, ovate, oblique, margins ciliate towards basal half, serrate towards upper half, apex aristate; all microsporangiate or one or two megasporangiate at middle. Megaspores 4 per sporangium, 191 microns in diam., yellow, globose, tetrahedral, verrucoid. Microspores numerous, 40 microns in diam., yellow - orange, trilete, verrucoid.

Distribution and ecology: *S. crassipes* is endemic to India and Sri Lanka (Baker, 1887; Nair, 1988). In India, it is known only from Kerala. It is distributed in moist, shady waysides and prefers altitudes between 400 – 1500 m.

Notes: Nair (1988) has reported this species first time from Kerala. But I could not find these specimens cited by Nair (1988) from CAL. *S. crassipes* can be easily recognized by its ovate, serrulate lateral leaves and ciliate sporophylls.

Specimens examined: KERALA: Kottayam Dt.: Kaliyarthottam, 21.07.2002, *Joby* 520, *Nisha* 523, 25.07.2002, *Nisha* 521, 01.11.2004, *Joby* 597 (SJC).

Selaginella nairii R.D.Dixit, Bull. Bot. Surv. India 26: 106. t. 2. 1984, Cens. Ind. Pterid. 15. 1984, Selaginellaceae India 81. f. 48. 1992.

Type: India, Orissa, Jeypore, *Nair* 40637 (CAL!) (Holotype).

Fig. 36. 37 Plate. 17. A. B

Prostrate herb. Stem 3 - 7 cm long, slender, up to 1 mm thick, cylindrical, glabrous, pale green but stramineous on drying; branched from base, branches pinnate. Rhizophores a few, confined to base, slender, cylindrical, 1 – 3 cm long, dichotomously branched towards tip. Leaves dimorphic throughout, distantly placed on the stem and branches; lateral leaf 1.3 – 1.9 x 0.8 - 1.2 mm, ovate - elliptic, equal or vaguely oblique at base, membranous; margins smooth at base, denticulate towards apex, apex sub–acute; median leaf 0.6 - 0.8 x 0.4 mm, elliptic, oblique throughout, membranous; margins denticulate, apex acute; axillary leaf 1.5 - 1.9 x 0.9 - 1.3 mm, ovate, slightly oblique, membranous; margins smooth at base and denticulate towards apex, apex acute. Strobilus 2.8 x 2.6 mm, terminal, solitary. Sporophylls dimorphic, larger sporophylls 1.4 or 1.5 x 0.7 mm, sterile, ovate – oblong, oblique, membranous; margins ciliate along basal half, dentate at apex, bear ciliated flap along the adaxial side, apex acute; smaller sporophylls 0.9 x 0.6 or 0.7 mm, fertile, 3 or 4 pairs in number, ovate, oblique, membranous; margins ciliate throughout, dentate at apex, apex acute. Megasporangia more in number than microsporangia. Megaspores

222 microns in diam., 4 per sporangium, pale yellow, trilete, tetrahedral, smooth. Microspores 30 microns in diam., few within a sporangium, pale yellow, smooth.

Distribution and ecology: *S. nairii* grows on moist rocks at an altitude of 850 m. It is endemic to India and known only from Orissa and Andhra Pradesh.

Notes: *S. nairii* is closely allied to *S. minutifolia* Spring in having slender stem, which grows up to 7 cm, smooth lateral and axillary leaves that are denticulate towards apex and smaller median leaves. However, the present collections from Talakona differ from protologue description in some aspects: the leaves are membranous and the sporophylls are ciliate with dentate apical portion in our specimens but it is described chartaceous and 'ciliate throughout. Of all the specimens collected, (about 25 specimens) we got only one microsporangium. The number of microspores within the sporangium was also least.

Specimens examined: Orissa: Jeypore Dt.: Jeypore, 17.09.1990, *Nair* 40637 (CAL). Andhra Pradesh, Ananthapur Dt.: Talakona, 7.11.2006, *Nisha* 1493 (SJC).

Selaginella minutifolia Spring, Mem. Acad. Brux. 24: 239. 1850; Alston, Proc. Nat. Inst. Sci. India 11: 228. 1945; R.D.Dixit, Selaginellaceae India 81. f. 42. 1992.

Type: Burma, Mergui, *Griffith s. n.* (K)

Fig.17. 38 Plate.11. C. D

Mesophytic erect herb. Main stem 8 - 13 cm high, 1 – 1.5 mm thick, cylindrical, glabrous, branched from base, yellowish-green. Rhizophores 2 - 4 cm long, confined to basal 1/3rd, slender, repeatedly dichotomously branched. Leaves heteromorphic throughout, distantly placed along main stem, contiguous along the branches; lateral leaf 2.2 x 1.1 mm, ovate - elliptic, oblique, membranous; margin dentate, apex sub-acute; axillary leaf 2.2 x 1 mm, ovate-elliptic, membranous; margin dentate, apex acute; median leaf 0.9 x 0.4 mm, ovate-oblong, membranous; margins dentate – denticulate, apex acuminate. Strobilus 12.9 x 8.6 mm, terminal, sessile, solitary. Sporophylls 1.3 – 2.1 x 0.7 - 1 mm, dimorphic, spiral, membranous; larger sporophylls ovate–oblong, oblique, margin dentate, laminal flap dentate, apex acute; smaller sporophylls ovate–oblong, oblique, margins long ciliate, apex acuminate. Megaspores 4 per sporangium, 183 microns diam., yellow, globose, tetrahedral, papillate. Microspores numerous, 21 microns diam., yellow-orange, trilete, papillate.

Distribution and ecology: *S. minutifolia* is distributed in Burma, Malaya (Alston, 1945) and India. They grow in shady moist forest floors.

Notes: *S. minutifolia* closely resembles *S. ciliaris*. But *S. ciliaris* is a prostrate species with profuse branches and rhizophores produced almost throughout the stem while *S. minutifolia* is erect with distant branches and rhizophores

confined to basal 1/3rd.

Specimens examined: KERALA: Idukki Dt.: Kuttikanam, 02.01.1971, *Nair* 818 (CAL).

Selaginella tenera (Hook. et Grev.) Spring, Bull. Acad. Brux. 10: 232 1843; Baker, Handb. Fern-allies 118. 1887; Alston, Proc. Nat. Inst. Sci. India 11: 227. 1945; R.D.Dixit, Cens. Ind. Pterid. 17. 1984, Selaginellaceae India 87. f. 50. 1992.

Type: Tamil Nadu, Courtallum, *Wight s.n*. (CAL!)

Lycopodium tenerum Hook. & Grev. In Hook., Bot. Misc. 2: 400. 1831.

L. debile Bory, Bel. Voy. Bot. 2: 8. t. 1. f.1. 1834.

Selaginella debilis (Bory) Spring, Bull. Acad. Brux. 10: 143. 1843.

Fig. 22. 39 Plate.12. C. D

Mesophytic erect herb. Stem 10 - 30 cm high, stout, 1.5 – 2 cm thick, strong, cylindrical, glabrous, reddish – brown, straw coloured when dry; profusely branched towards apex. Rhizophores 2 – 6 cm long, confined to basal half, thick and strong, repeatedly dichotomously branched towards base. Leaves dimorphic, tetrastichous; lateral leaf 2.7 x 1.4 mm, obovate - lanceolate, oblique, membranous; proximal margin irregularly serrate along lower half, serrulate along upper half, distal margin smooth, apex acute; median leaf 1.2 x 0.3 mm, lanceolate, oblique, membranous; margin serrate, apex aristate; arista 0.4 mm. Strobilus 7.5 x 2.5 mm, terminal, sessile,

solitary, un-branched. Sporophylls dimorphic, all fertile; larger sporophylls 1.4 – 1.6 x 0.5 – 0.7 mm, ovate – elliptic, oblique, membranous; margins distantly serrulate along proximal and basal distal half, smooth along upper distal half, apex acute; smaller sporophylls 0.9 – 1.2 x 0.4 – 0.6 mm, broadly ovate, oblique, membranous; margin serrulate, apex aristate; arista 0.4 mm; bear microsporangia towards tip and megasporangia towards base. Megaspores 4 per sporangium, 367 microns in diam., dull white, globose – tetrahedral, warty. Microspores numerous, 18 microns in diam., orange – red, tetrahedral, warty.

Distribution and ecology: *S. tenera* is distributed in India and Sri Lanka (Dixit, 1992). It is a common species along wet shaddy regions and forest floors.

Notes: *S. tenera* can easily be identified by its erect habit, reddish brown stem, dimorphic sporophylls and the 'gemmae' like structure at the branch tips. The number of gemmae is high when vegetative growth is minimum and vice – a –versa.

Specimens examined: ANDHRA PRADESH: Prakasham Dt.: Nallamalais, *Joby* 599 (SJC). KARNATAKA: Dakshin Kannad Dt.: Shirady Ghats, *Nisha* 1449 (SJC). Shimoga Dt.: Kargal forest, *Nisha* 1457 (SJC). KERALA: Idukki Dt.: Kaliyar, *Nampy* 318 (SJC); Koonanal forest, *Sanoj* 1427 (SJC); Rajakumari, *Aboobacker* 598 (SJC). Kollam Dt.: Palaruvi, *Nisha* 1430 (SJC). Kottayam Dt.: Kaliyarthottam, *Joby* 525 (SJC). Kollam Dt.: Umayar, *Nair* 50889 (CAL); Moozhiyar, *Nair* (CAL). Kozhikode Dt.: Vayalada, *Nisha* 507,

512, 515 (SJC). Malappuram Dt.: Aadyanpara, *Nisha* 1480 (SJC). Palakkad Dt.: Cherunelly, *Joby & Sibichen* 548 (SJC). Pathanamthitta Dt.: Moozhiyar power House, *Nisha* 1421 (SJC); Pamba – Ayyappan temple, *Nair* 50800 (CAL). Thiruvananthapuram Dt.: Kallar, *Nisha* 1404 (SJC); Nedumangad, *Manickam & Mathew* 33741 (XCH); Ponmudi, *Nisha* 1401 (SJC). Wayanad Dt.: Pookode lake, *Nampy* 1 (SJC); Wayanad pass, *Nisha* 1466 (SJC). TAMIL NADU: Kanyakumari Dt.: Palmore forest, *Manickam* 33939 (XCH). Nilgiri Dt.: Nadukani Ghats, *Nisha* 1415, 1416 (SJC). Tirunelveli Dt.: Courtallam – Thenmala, *Nisha* 1467 (SJC); Kalakkad Hills, Sengaltheri – Netrikkal path, *Manickam & Mathew*, 34142, 34157, 34159 (XCH); Kannikatti, *Sebastine* 9624 (CAL); Kothayar, *Nisha* 569 (SJC); Valayar estate, *Sebastine* 9938 (CAL).

Selaginella miniatospora (Dalz.) Baker, J. Bot. 23: 249. 1885, Handb. Fern-allies 115. 1887; Alston, Proc. Nat. Inst. Sci. 11: 227. 1945; R.D.Dixit, Cens. Ind. Pterid. 14. 1984, Selaginellaceae India 99. f. 61. 1992; R.D.Dixit & Mondal, Ind. Fern J. 10: 166. 1993; P.C.Pande & H.C.Pande, Phytotax. 3: 70. 2003.

Type: Bombay, Miki, *Dalzell* 538 (K!)

Lycopodium miniatosporum Dalz. In Hook., J. Bot. 4: 114. 1852.

Fig. 17. 28. C. 40

Mesophytic erect herb. Stem 12 - 20 cm high, slender, 1 mm thick,

cylindrical, glabrous, green; branched from base, dichotomously branched towards apex of each branchlets. Rhizophores 2 - 6 cm long, confined to basal 1/3rd, slender, cylindrical, repeatedly branched. Leaves heteromorphic throughout, distant along main stem and branches; lateral leaf 2.3 x 1.3 mm, oblong - obovate, oblique, membranous; margins denticulate along proximal side and smooth along distal side, apex sub-acute; median leaf 0.9 x 0.3 mm, ovate, oblique, membranous; margins serrate, apex aristate; arista half as long as the lamina; axillary leaf 2 x 1.3 mm, ovate, apex sub-acute, margins distantly minutely denticulate, membranous. Strobilus 4.6 x 2.8 mm, terminal, sessile, solitary or branched. Sporophylls dimorphic, all fertile; larger sporophylls 1.4 x 0.5 mm, oblong – elliptic, oblique, membranous; margins serrate, apex acute; smaller sporophylls 0.9 x 0.5 mm, broadly ovate, oblique, membranous; margins serrate, apex aristate; arista 0.4 mm. Megaspores 206 microns in diam., 4 per sporangium, yellow, globose, tetrahedral, papillate. Microspores 23 microns in diam., numerous, trilete, tetrahedral, orange-red, verrucoid.

Distribution and ecology: *S. miniatospora* is distributed in Goa, Karnataka, Kerala and Maharashtra. It is a new record for Kerala and is also collected from Goa. It occurs on wet rock boulders and along moist lateritic earth cuttings.

Specimens examined: GOA: Ponda Dt.: Bandla Sanctuary, 28.09.2002, *Nampy & Joby* 526 (SJC). KERALA. Kozhikode Dt.: Wayanad pass, 15.12.2005, *Nisha* 1443 (SJC).

Selaginella camusii Raju *et al.*, Nord. J. Bot. 22: 337. 2002.

Type: India, Kerala, Agasthyamala, *Raju* 25581 (TBGT!)

Fig. 29. 41

Mesophytic erect herb. Stem 5 - 9 cm high, slender, smooth, glabrous pale green; branched from base, branches bipinnate. Rhizophores 0.5 – 2 cm long, few, confined to basal 1/3rd, thin, wiry and cylindrical. Leaves dimorphic throughout, ascending, arranged lax; lateral leaf 2.6 x 1.6 mm, ovate or ovate-oblong, oblique, base entire, membranous; margins denticulate, apex acute or sub-acute; median leaf 1.3 x 0.8 mm, ovate, oblique throughout, membranous; margins denticulate, apex acute; axillary leaf 2.6 x 1.4 mm, ovate - oblong, oblique, base entire, membranous; margins denticulate, apex acute. Strobilus 6.4 x 3.3 mm, terminal, sessile. Sporophylls dimorphic, all fertile; larger sporophylls 1.7 - 2.6 x 0.8 mm, ovate - oblong, oblique, keeled, membranous; margins dentate to denticulate, ciliated laminal flap attached to the adaxial side, apex acute; smaller sporophylls 0.9 x 0.5 mm, oblique, keeled, membranous; margins ciliate, cilia 0.4 mm long, apex acute. Megaspores 270 microns in diam., 4 per sporangium, dull white, globose, tetrahedral, tuberculate - reticulate. Microspores 25 microns in diam., numerous, pale yellow, trilete, tetrahedral, reticulate.

Distribution and ecology: *S. camusii* is endemic to Kerala. It is a terrestrial species that grows in shaded shola forests at an altitude of 1750 m.

Notes: It closely resembles *S. nayarii* Dixit in having flexuous cilia in the sporophylls. But *S. camusii* has rhizophores confined to base where in *S. nayarii* rhizophores are present throughout. The megaspores bear tubercles apart from being reticulate.

Specimen examined: KERALA: Thiruvananthapuram Dt.: Agasthyamala, *Raju* 25581 (CALI!).

Selaginella coonooriana R.D.Dixit, Bull. Bot. Surv. India 25: 223. f. 1. 1983, Cens. Ind. Pterid. 17: 1984, Selaginellaceae India 88. f. 51. 1992; R.D.Dixit & Mondal, Ind. Fern J. 10. 165. 1993.

Type: TAMIL NADU: Nilgiri, coonoor hills, *August* 1893. *s.l*. *s.n*. (MH).

Fig. 35. 42 Plate.19. E. F

Mesophytic prostrate herb. Stems 3 - 6 cm long, 1 mm thick, cylindrical, glabrous, green; branched from base. Rhizophores 1 - 3 cm long, slender, confined to base. Leaves heteromorphic throughout, distantly placed on the stem than on the branches; lateral leaf 2.8 x 1.6 mm, ovate – lanceolate, oblique, membranous; margins minutely denticulate, apex acute; median leaf 1.3 x 0.9 mm, ovate, slightly oblique, membranous; margins minutely denticulate, apex acute; axillary leaf 2.9 x 1.7 mm, ovate - lanceolate, oblique, membranous; margin minutely denticulate, apex acute. Strobilus 3.2 x 2.6 mm, terminal, sessile. Sporophylls dimorphic, spiral, few in number, all fertile; larger sporophylls 1.8 x 0.9 mm, ovate – lanceolate,

oblique, membranous; margins dentate, laminal flap ciliate-ciliolate, apex acute; smaller sporophylls 1.2 x 0.8 mm, usually four to six in number, ovate, oblique, membranous; margins ciliate, apex acuminate. Megasporangia and microsporangia arranged scattered. Megaspores 361 microns in diam., 4 per sporangium, pale yellow, globose, tetrahedral, warty. Microspores 29 microns in diam., numerous, orange - red, verrucoid.

Distribution and ecology: *S. coonooriana* is endemic to South India. We have collected this species from Ootacamund in Nilgiri district. It grows on wet, shady earth cuttings.

Notes: In *S. coonooriana*, the cilia of the smaller sporophylls are elongated up to 0. 3 mm. Dixit (1983) has described the larger sporophylls as sterile with dentate margins. However, in our specimens larger sporophylls are fertile with ciliate sporangial flap. Similarly Dixit (1983) described the lateral leaves and axillary leaves minutely denticulate on proximal margin and smooth on distal margin, but in some leaves both the margins are smooth.

Specimens examined: TAMIL NADU: Nilgiri Dt.: Ootacamund, *Nisha* 149 (SJC).

Selaginella cataractarum Alston, Proc. Nat. Inst. Sci. India 11: 228. 1945; R.D.Dixit, Cens. Ind. Pterid. 12. 1984; M.P.Nayar & Sastry, Red Data Book Ind. Plants 1: 367. 1987 (as *S. cataractrum*); R.D.Dixit, Selaginellaceae India 89. f. 52. 1992 (as *S. cataractrum*), R.D.Dixit & Mondal, Ind. Fern J. 10: 164. 1993 (as *S. cataractum*).

Type: South India, Silver Cascade, *Munch s.n*. (BM)

Selaginella agastyamalayana Raju *et al*.,. Fern Gaz. 18 (1): 27-29, 2006.

Fig. 43. 44. Plate.18. A. B

Mesophytic prostrate herb. Stem 1.5 to 5 cm long, slender, smooth, glabrous; pale green, branches bipinnate towards base. Rhizophores 0.5 – 2 cm long, produced throughout the stem, wiry, cylindrical. Leaves dimorphic throughout, descending or at right angles to the stem, arranged lax; lateral leaf 2 x 1.6 mm, broadly ovate, slightly oblique, base entire, membranous; margins dentate – denticulate, apex sub-obtuse; median leaf 1 x 0.5 mm, ovate - lanceolate, oblique throughout, base rounded, membranous; margins dentate – denticulate, apex long acuminate; axillary leaf 1.7 x 1.3 mm, ovate, oblique, base entire, membranous; apex sub-obtuse, margins distantly dentate. Strobilus 2.7 x 1.7 mm, terminal, sessile. Sporophylls 1.2 or 1.3 x 0.6 - 0.9 mm, dimorphic, spiral, ovate, oblique, membranous; margins dentate, apex acute – sub-acute; micro and mega sporophylls arranged intermixed and lax, all fertile, few in number. Megaspores 175 microns in diam., 4 per sporangium, yellow, globose, tetrahedral, papillate. Microspores 26 microns in diam., numerous, reddish- brown, papillate.

Distribution and ecology: *S. cataractarum* is endemic to South India and collected only from a few places in Kerala and Tamil Nadu. It grows on shady, moss covered rocks near trickling water. Nayar and Sastry (1987) have described this species as endangered.

Notes: The specimens from Vazhukkanpara and Silver Cascade show some differences. The plants are only upto 5 cms height with distantly placed leaves. According to Alston (1945) and Dixit (1992), the rhizophores are confined only to the base. However in our specimens, the spores are granulose and the rhizophores are distributed throughout the plant. Moreover the median leaves are acuminate and sporophylls are acute in our specimens. *Selaginella agastyamalayana* Raju *et al*., is treated as the synonym of *S. cataractarum* since most of the characteristic features of the former match with the latter.

Specimens examined: KERALA: Thiruvananthapuram Dt.: Agasthyamala, Vazhukkanpara, 07.02.06, *Sanoj* 1498 (SJC). TAMIL NADU: Nilgiri Dt.: Kodaikanal, Silver Cascade, 24.11.05, *Nisha* 1491 (SJC).

Selaginella chrysorrhizos Spring, Mem. Acad. Sci. Belg. 24: 251. 1850; Baker, Fern-allies 117. 1867; Alston, Proc. Nat. Inst. Sci. 11: 226. 1945; R.D.Dixit, Cens. Ind. Pterid. 12. 1984; Selaginellaceae India 77. f. 40. 1992; Ghosh *et al*., Pterid. Fl. Eastern India 3. 102. f. 29. 2004.

Type: *s. l*., Griffith 141 (K!)

Fig. 44. 45 Plate.19. A. B

Mesophytic erect herb. Main stem 8 - 12 cm high, 1 – 1.5 mm thick, cylindrical, tufted, branches pinnate, erecto-patent, green. Rhizophores 3 – 5 cm long, confined to base, 1 – 1.5 mm thick, slender, cylindrical. Leaves

heteromorphic throughout, distant along main stem and contiguous along branches; lateral leaf 2.1 x 0.9 mm, oblong - lanceolate, oblique, membranous; margins denticulate, apex acute; median leaf 1.3 x 0.4 mm, ovate - lanceolate, oblique, membranous; apex cuspidate, margins denticulate; axillary leaf 2.3 x 1.1 mm, oblong - lanceolate, oblique, membranous; margins denticulate, apex acute. Strobilus 3.1 x 2.5 mm, terminal, sessile, solitary. Sporophylls 1.1 – 1.6 x 0.5 - 0.7 mm, dimorphic, spiral, membranous; larger sporophylls ovate – lanceolate, margins serrate, apex acuminate; laminal flap ciliate, smaller sporophylls ovate, margins ciliate, apex acuminate - aristate. Megaspores 183 microns in diam., 4 per sporangium, pale yellow, globose, tetrahedral, verrucoid. Microspores 21 microns in diam., numerous, deep red, warty.

Distribution and ecology: *S. chrysorrhizos* is reported from Nepal, Burma and India (Alston, 1945). It is 'rare' in South India and is collected only from Kerala. It grows on moist, vertical earth cuttings.

Notes: *S. chrysorrhizos* closely resembles *S. crassipes* but the larger sporophylls are ciliate along proximal region in the latter but is serrate in the former.

Specimens examined: KERALA: Pathanamthitta Dt.: Maccankunnu, *Mathew* 29849 (TBGT). Thiruvananthapuram Dt.: Bonaccord,12. 11. 1998, *Antony* 29863 (TBGT).

Selaginella lakkidiana Nampy *et* Nisha sp. nov.

Type: India, Kerala, Wayanad, Lakkidi, *Nampy 3* (CALI, SJC)

Fig.15. 46 Plate.10. E. F

Mesophytic erect herb. Main stem up to 15 cm high, 1 – 1.5 mm thick, sulcate, glabrous, reddish – brown towards base, stramineous green towards apex; branched from base and copiously branched towards apex. Rhizophores 2 – 4 cm long, confined to basal 1/3, slender, cylindrical, dichotomously branched. Leaves dimorphic throughout, appressed on the stem, contiguous on branches; lateral leaf 1.8 x 0.8 mm, ovate - lanceolate, oblique throughout, membranous; margins serrate along proximal side, entire along distal side, apex acute; median leaf 1.4 x 0.6 mm, elliptic, oblique throughout, membranous; margins serrate, apex cuspidate; axillary leaf 1.7 x 1 mm, ovate – lanceolate, slightly oblique, membranous; margins serrate, extreme base entire, apex acute. Strobilus 1.5 - 2 x 0.9 - 1 mm, terminal, sessile, solitary. Sporophylls 0.8 or 0.9 x 0.4 or 0.5 mm, dimorphic, spiral, ovate, membranous; margins serrate, apex acuminate, micro and mega sporophylls arranged intermixed; larger sporophylls oblique, keeled; smaller sporophylls slightly oblique, feebly keeled. Megaspores 118 microns in diam., 4 per sporangium, yellow, globose, tetrahedral, smooth. Microspores 48 microns in diam., numerous, reddish- brown, pitted.

Distribution and ecology: *S. lakkidiana* is hitherto known only from type locality. It grows on vertical earth cuttings along the margins of wet

evergreen forest at 700 m altitude.

Notes: *S. lakkidiana* is similar to *S. chrysorrhizos* in gross morphology, but the sporophylls bear ciliated laminar flap in the latter where as it is serrated in *S. lakkidiana.* The megaspores are smooth in *S. lakkidiana* while it is verrucoid in *S. chrysorrhizos.*

Selaginella nayarii R.D.Dixit, Bull. Bot. Surv. India 27. 123. f. 2. 1985, Selaginellaceae India 74. f. 37. 1992; R.D.Dixit & Mondal, Ind. Fern J. 10: 167. 1993.

Type: India, Kerala, idukki Dt.: kuttikanam, *Nair* 818 (BSA).

Fig. 37. 47 Plate.17. C. D

Mesophytic prostrate herb. Stem 3 - 7 cm long, slender, up to 1 mm thick, cylindrical, glabrous, green; branched. Rhizophores 1 - 3 cm long, slender, produced throughout except apical erect portion. Leaves heteromorphic throughout, distantly placed; lateral leaf 2.3 x 0.9 mm, ovate-lanceolate, oblique, membranous; proximal margin minutely serrate, distal margin smooth, apex acute; median leaf 1.3 x 0.5 mm, ovate, oblique, membranous; margins smooth or distantly denticulate, apex acuminate; axillary leaf 1.7 x 0.8 mm, ovate - lanceolate, oblique, membranous; proximal margin distantly denticulate, distal margin smooth, apex acute. Strobilus 7.7 x 3.7 mm, terminal, sessile, solitary. Sporophylls dimorphic; larger sporophylls 2.3 x 0.9 mm, ovate – lanceolate, oblique, membranous;

margins dentate, apex acute, ciliated laminal flap present along adaxial surface; smaller sporophylls 1.3 x 0.6 mm, ovate, oblique, membranous; margins ciliate; cilia 0.4 mm, apex acuminate. Megasporophylls along the ventral side, few in number; microsporophylls along both the planes, more in number. Megaspores 211 microns in diam., 4 per sporangium, pale yellow, globose, tetrahedral, warty. Microspores 39 microns in diam., numerous, deep red, trilete, tetrahedral, reticulate.

Distribution and ecology: *S. nayarii* is endemic to Kerala. It grows along moist earth cuttings.

Notes: *S. nayarii* is pale green when fresh and straw coloured when dried. This species is noted for its flexuous cilia on the sporophylls. The cilia of the smaller sporophylls are up to 0.4 mm long and are even visible to naked eye.

Specimens examined: KERALA: Idukki Dt.: Munnar, 16.10.2003, *Nisha* 2611 (SJC).

Selaginella ciliaris (Retz.) Spring, Bull. Acad. Brux. 10: 231. 1843; Alston, Proc. Nat. Inst. Sci. India 11: 227. 1945; Panigrahi & R.D.Dixit, Proc. Nat. Inst. Sci. India 34: 194. 1968; Bir & Vasudeva, Plant Sci. 5: 74. 1973; Tagawa, Acta Phytotax. Geobot. 15: 178. 1973; Baishya & R.R.Rao, Ferns & Fern-allies Meghalaya India 26. 1982; R.D.Dixit, Cens. Indian Pterid. 12. 1984; N.C.Nair *et al*., J. Econ. & Tax. Bot. 12:

204. 1988; R.D.Dixit, Selaginellaceae India 79. f. 41. 1992; R.D.Dixit & Mondal, Ind. Fern J. 10. 164. 1993; R.D.Dixit & Sinha, Pterid. Andaman & Nicobar Islands 34. 2001; P.C.Pande & H.C.Pande, Phytotax. 3: 69. 2003; S.R.Ghosh *et al.,* Pterid. Fl. Eastern India 3. 122. f. 42. 2004.

Type: Ceylon, *s. l*., *Koenig s. n*. (Fragment, K!)

Lycopodium ciliare Retz., Obs. 5: 32. 1789.

L. depressum Sw., Schrad. J. Bot. 1800. 2: 119. 1801.

L. belangeri Bory In Belanger, Voy. Bot. 2: 12. 1834.

Selaginella exigua Spring, Mem. Acad. Brux. 24: 238. 1850.

S. tenera (*non* Spring) V.Naray. & H.J.Carter, Mem. As. Soc. Beng. 7: 290. 1922.

Fig. 44. 48. 49. A. B Plate.19. C. D

Mesophytic prostrate herbs. Stems 1.5 – 15 cm long, 0.5 – 1 mm thick, cylindrical, glabrous, branched throughout. Rhizophores 1 - 4 cm long, many, distributed throughout except apex or mainly confined to basal 1/4th, slender, cylindrical, branched profusely. Leaves heteromorphic throughout, distantly palced on the main stem and compact along branches, green; lateral leaf 2.1 x 1.1 mm, ovate - oblong, oblique, base entire, membranous; margins shortly ciliate along proximal basal half, irregularly dentate to denticulate towards apex, denticulate along distal margin, apex acute;

median leaf 1.8 x 0.9 mm, obovate, base entire, membranous; margins denticulate except base, apex aristate; arista 0.6 mm; axillary leaf 1.9 x 0.9 mm, ovate - lanceolate, base oblique, membranous; margins dentate at base, smooth or distantly and irregularly denticulate towards apex, apex acute. Strobilus 9 x 3.7 mm, terminal, sessile, solitary or branched. Sporophylls dimorphic, spiral; larger sporophyll 2.3 x 0.9 mm, oblong-lanceolate, oblique, membranous; proximal half dentate, distal half smooth at base, denticulate towards apex, laminal flap along the adaxial side, margins ciliate-dentate, apex acute; smaller sporophyll 1.5 x 1 mm, ovate - triangular, oblique, membranous; margins ciliate, apex acuminate. Megaspores 4 per sporangium, 214 microns in diam., pale yellow, globose, tetrahedral, reticulate. Microspores numerous within the sporangium, 58 microns in diam., deep red, reticulate.

Distribution and ecology: *S. ciliaris* is distributed in India, Burma, China, Philippine Islands and Sri Lanka (Dixit, 1992). It is a common species in South India occurring at altitudes of 60 - 1500 m. *S. ciliaris* grows in all types of soil and remains pale green in shade and dark green in bright light.

Notes: It is a profusely branched, prostrate species that bears rhizophores throughout. The lateral leaves are ciliate along proximal basal half and their smaller sporophylls are possessing long cilia. The specimens labeled as *S. kurzii* Baker deposited at CAL herbarium with collection numbers *Nair* 40699, *Ghosh* 57949 and *Lestie* 52 are *S. ciliaris*.

Specimens examined: ANDHRA PRADESH: Anantapur Dt.: Thalakona,

07.11.2006, *Nisha* 1495 (SJC). KARNATAKA: Kolloor Dt.: Muppani forest, 02.12.2005, *Nisha* 1440 (SJC). KERALA: Kollam Dt.: Kottarakkara, 30.12.1972, *Nair* 50926 (CAL). Kozhikode Dt.: Devagiri, 31.12.2001, *Nisha* 509 (SJC); Vilangad, 27.09.2003, *Nisha* 572 (SJC). Malappuram Dt.: Aadyanpara, 19.09.2004, *Nisha* 582 (SJC). Pathanamthitta Dt.: Gavi, 20.10.2005, *Sanoj* 1434 (SJC); Punalur paper mill area, 28.12.1972, *Nair* 50905 (CAL). Wayanad Dt.: Cherambady, 08.10.2005, *Nisha* 1458 (SJC). TAMIL NADU: Tirunelveli Dt.: Thenmala, 08.10.2004, *Nisha* 585, 1407 (SJC). Trichirappally Dt.: Trichi, 17.02.1959, *Subramanyam* 7781 (MH).

SUMMARY

The present work is a revisionary study on the family Selaginellaceae in South India. The family is represented by about 700 species world over (Jermy, 1986), 64 species in India (Dixit, 1988) and 36 in South India. Of these 18 species are endemic and *S. cataractarum* is endangered. The members are mostly herbs and they are terrestrial, lithophytic or epiphytic and prefer moistened habitat.

Anatomy of stems, rhizophores and leaves of seven species were discussed. The basic structure of stem in *Selaginella* is monostelic with exarch xylem even though it divides to form polystelic condition on maturity. The rhizophores and the stem of isophyllous group bear trabeculae. The structure of rhizophores of ten species studied were same with a single stele. The leaves are ligulate, microphyllous and possess single un-branched vein, but reports of occurrence of multiple veins are also there. However, in the south Indian species single veined condition exists. Most of the works we referred for anatomy were discussing the role of anatomy in phylogeny. Evidences are there to prove that the morphologically advanced species with heteromorphic leaves is anatomically primitive over the morphologically primitive group with isophyllous leaves.

For the cytological works I referred available literatures which states that *Selaginella* shows considerable chromosomal variations of basic

numbers as x = 7, 8, 9, 10, 11 and 12. Cytological studies conducted in the sporangia as well as in root tips of 8 south Indian species of *Selaginella* have revealed that the basic chromosome numbers are x = 9 and 10.

Selaginella reproduces vegetatively by fragmentation or gemmae formation, but strobilus, bearing spores are the main reproductive body. The arrangement of micro and megasporangia in the strobilus are of four types among south Indian species. SEM of megaspores of thirteen species was carried out and the results show variation between species. Some are smooth, reticulate, rugulose or warty. The microspores are also rugulose, pitted or warty. They are usually yellow to deep red. The results of the observation of spores are helpful in classification. The ligules of eight south Indian species were studied and it was found that they are either simple or branched. They shed off when the leaves mature.

Many species of this genus show resurrection property. They regain their original form and size when soaked in water. A few are edible like *S. wildenovii*. The extract of the leaves of *S. bryopteris*, commonly called “sanjivani”, if served with sugar is a cooling and rejuvenating agent. *S. delicatula* and *S. wildenovii* is cytotoxic against a panel of human cancer cells lines. *S. wildenovii* (the peacock fern)*, S. monospora, S. dixitii*, *S. plana* and *S. uncinata* are ornamental.

In this present work I followed the classification of Jermy (1986) and classified the south Indian species of *Selaginella* in to five sub-genera.

However the sub-genus *Selaginella* and sub-genus *Ericetorum* of Jermy has no representatives in South India.

The sub-genus *Tetragonostachys* has only one representative in South India namely *S*. *wightii.* The members are creeping, prostrate and mat forming or with short erect branches. Stems are branched with roots throughout the body.

The sub-genus *Stachygynandrum* has 18 species having their stems creeping with prostrate branches or erect with multiple branching. Leaves are dimorphic along vegetative part and the sporophylls are uniform. However in this group some members have prominent rhizome giving out ascending branches. Such rhizomes or main stems bear isomorphic leaves. In those species where the rhizomes are rudimentary or absent all the vegetative leaves are heteromorphic. In this sub-genus some species are scandent like *S. wildenovii* and *S. plana* and some are erect like *S*. *bryopteris* and *S. involvens*. Of these *S. bryopteris* and *S. involvens* are xerophytic and exhibits resurrection property. In species like *S. delicatula* the stem is sub-erect.

The sub-genus *Heterostachys* has 17 species in South India. In this sub-genus the stems are creeping and branched. Rhizophores occur along the branch axils with the leaves being dimorphic. Sporophylls are arranged tetrastichously. This sub-genus includes small species like *S. minutifolia*. Some members are fugacious and some are persistent. Some are erect and still others are weak stemmed trailers. Many have ciliated sporophylls and lateral leaves, still others have dentate or entire leaves.

Members of this sub-genus exhibits little difference from its closely allied species. So distinction of species of this group is a tough task. There are 4 new records for South India and one species is newly described.

In conclusion the genus *Selaginella* represented by 36 species in South India can be classified in to 5sub-genera The classification will become more reliable if cytological, anatomical, cladistic and molecular works were also adopted since the evolutionary trends that are considered morphologically advanced are not going hand in hand with anatomy and cytology. Because of the constraints that usually go with a Ph. D work this present attempt is mainly restricted to check the stability of nomenclature and reconcilability of taxa.

DOUBTFUL SPECIES

1. *Selaginella semicordata* (Wall. *ex* Hook. *et* Grev.) Spring

Sealginella semicordata (Wall. *ex* Hook. *et* Grev.) Spring, Mart. Fl. Bras. 1(2): 122. 1840.

Lycopodium semicordatum Wall. *ex* Hook. *et* Grev. In Hook., Bot. Misc. 2: 396.1831.

Selaginella burghallii Roxb., Sim. Cat. 61. 1858 (*nom. nud*.).

Type: Mountains near Sylhet, ***Wall. Cat. No.* 126/3 E)!**

Nair *et al*. (J. Econ. Tax. Bot. 12: 204. 1988) reported this species from Kerala based on the specimens *Nair* 698, 50613 and 52054. However our critical examination has revealed that all these specimens belong to *S. delicatula* (Desv. ex Poir.) Alston. We also could not able to collect the specimens from anywhere in south India. Hence the report of *S. semicordata* from Kerala is doubtful.

2. *Selaginella subdiaphana* (Wall.) Spring

Selaginella subdiaphana (Wall.) Spring, Bull. Ac. Brux. 10: 232. 1843.

Lycopodium subdiaphanum Wall. Cat. No. 136 (1829) *nom. nud*. Hook. & Grev. In Hook., Bot. Misc. 11: 401. 1831.

Selaginella glauca Spring, Mem. Ac. Brux. 24: 252. 1850.

S. schlagintweitii Hieron., Hedwigia 43: 62. 1904.

Type: Assam, ***Merck* 549 (K). *Wall. Cat. No.* 126/3 (CAL)!**

Dixit (1992) reported this species from Kerala. However even after extensive floristic survey, we could not able to collect this species from south India. Further the specimen studied and cited by Dixit *viz*., *Nair* 40229 at CAL was not able to locate. Hence the occurrence of *S. subdiaphana* (Wall.) Spring in south India is doubtful.

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Acopodium

Didiclis

Diplostachyum

Gymnogynum

Heterophyllium

Heterostachys

Homostachys

Hypopterigiopsis

L. flabellatum L.

L. selaginoides

L. wildenovii (Desv.) Hook. & Grev.

L. bryopteris Wall.

L. caespitosum Blume

L. integerrimum Hook. *et* Grev.

L. rupestre (*non* L.) Hook. & Grev.

Lepidotis

Lycopodiodes

Lycopodioides

Lycopodium

Mirmau

Planthus

Polycocca

S. caespitosa (Blume) Spring

S. bigelovii

S. brachystachya

S. braunii

S. bryopteris

S. caesia

S. camusii

S. cataractarum

S. caudate

S. chrysocaulos

S. chrysorhizos

S. ciliaris

S. coonooriana

S. crassipes

S. cuspidata

S. cuspidata = *S. pallescens*

S. delicatula

S. denticulate

S. deoderleinii

S. dixitii

S. dixitii Madhus. & Nampy

S. emiliana

S. fimbriata

S. flabellate (L.) Spring

S. fraipontii

S. ganguliana

S. gracilis

S. grandis

S. griffithii

S. helvetica

S. inaequalifolia

S. integerrima

S. integerrima (Hook. *et* Grev.) Spring

S. intermedia

S. involvens

S. keralensis

S. kraussiana

S. lakkidiana

S. lepidophylla

S. martensii var. divericata

S. microdendron

S. miniatospora

S. minutifolia

S. monospora

S. mutica

S. nairii

S. nayarii

S. ornithopodioides sensu Trimen

S. pilifera

S. plana

S. plumosa

S. proniflora

S. radicata

S. repanda

S. rupestris Spring

S. schffneri

S. schlechteri

S. selaginoides

S. selaginoides

S. semicordata

S. serpens

S. serpens

S. spinosa

S. spinulosa

S. tenera

S. uliginosa

S. uncinata

S. vaginata

S. vogelii

S. wallichii

S. weatherbiana

S. wightii Hieron.

S. wildenovii

S. wildenovii (Desv. *ex* Poir.) Baker

Selaginella P. Beauv.

Selaginella proper

Selaginellaceae

Selaginellidae

Selaginoides

Stachygynandrum myosurus

Tetragonostachya

Trispermium

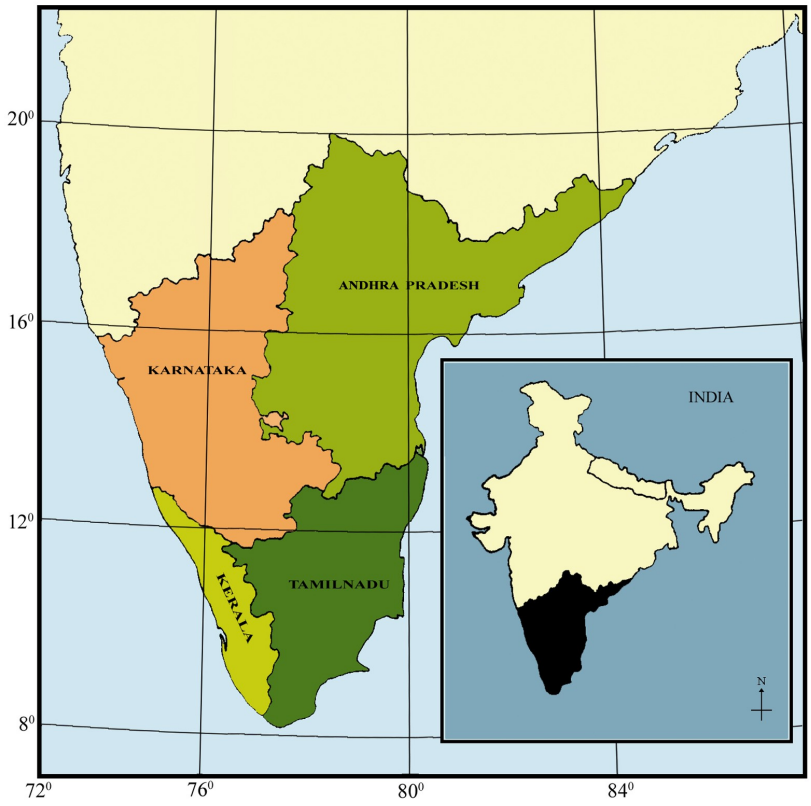


Fig. 01. Map of South India

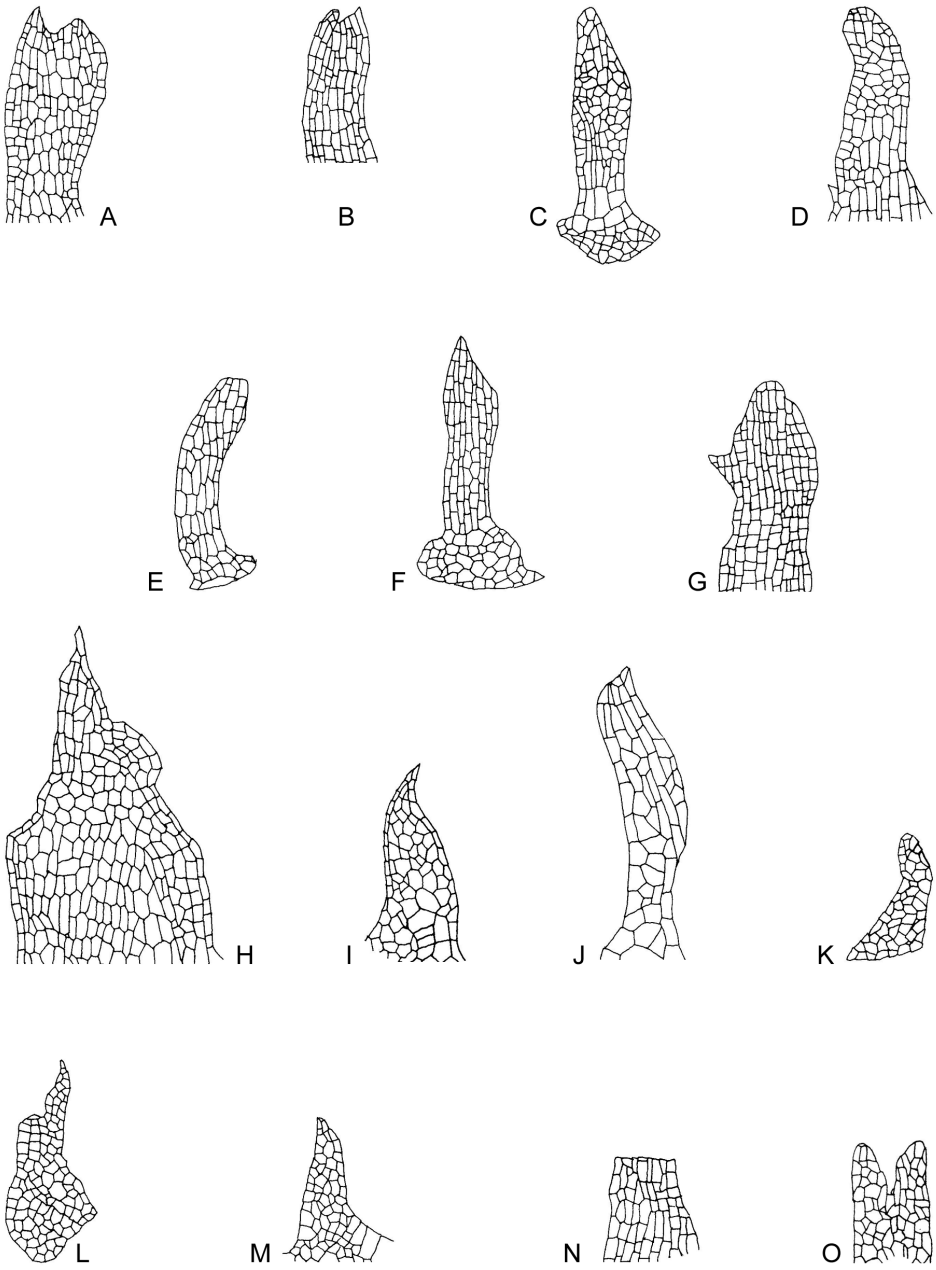


Fig. 2. Ligules. A - G. *Selaginella cataractarum* Alston, **H - J. *Selaginella ciliaris*** (Retz.) Spring, **K - O. *Selaginella delicatula*** (Desv.) Alston

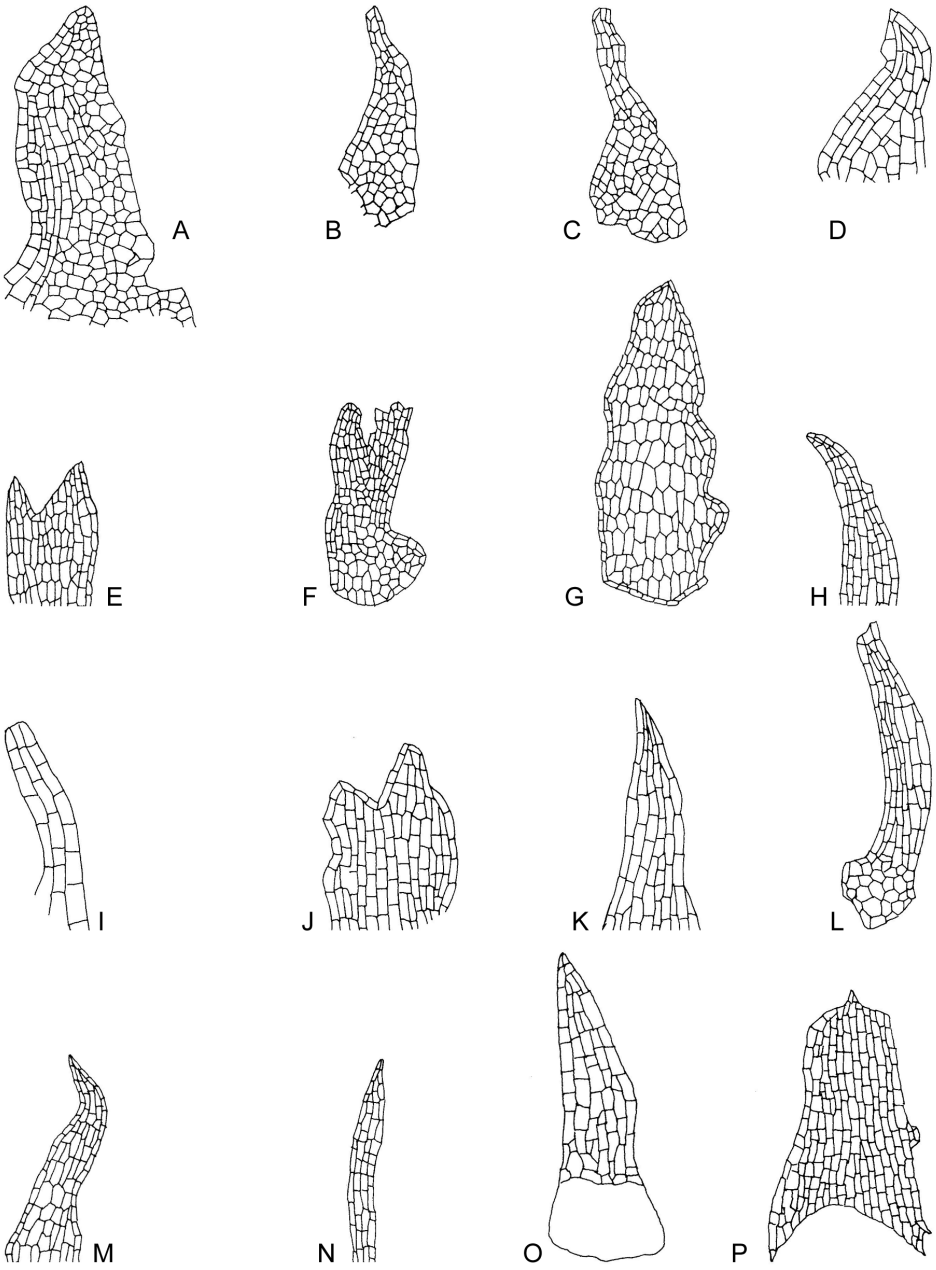


Fig. 3. Ligules. A - D. *Selaginella plana* (Desv. ex Poir.) Hieron., **E - G. *Selaginella radicata*** (Hook. & Grev.) Spring, **H - K. *Selaginella tenera*** (Hook. & Grev.) Spring, **L - N. *Selaginella uncinata*** (Desv. ex Poir.) Spring, **O & P. *Selaginella wildenovii*** (Desv. ex Poir.) Baker

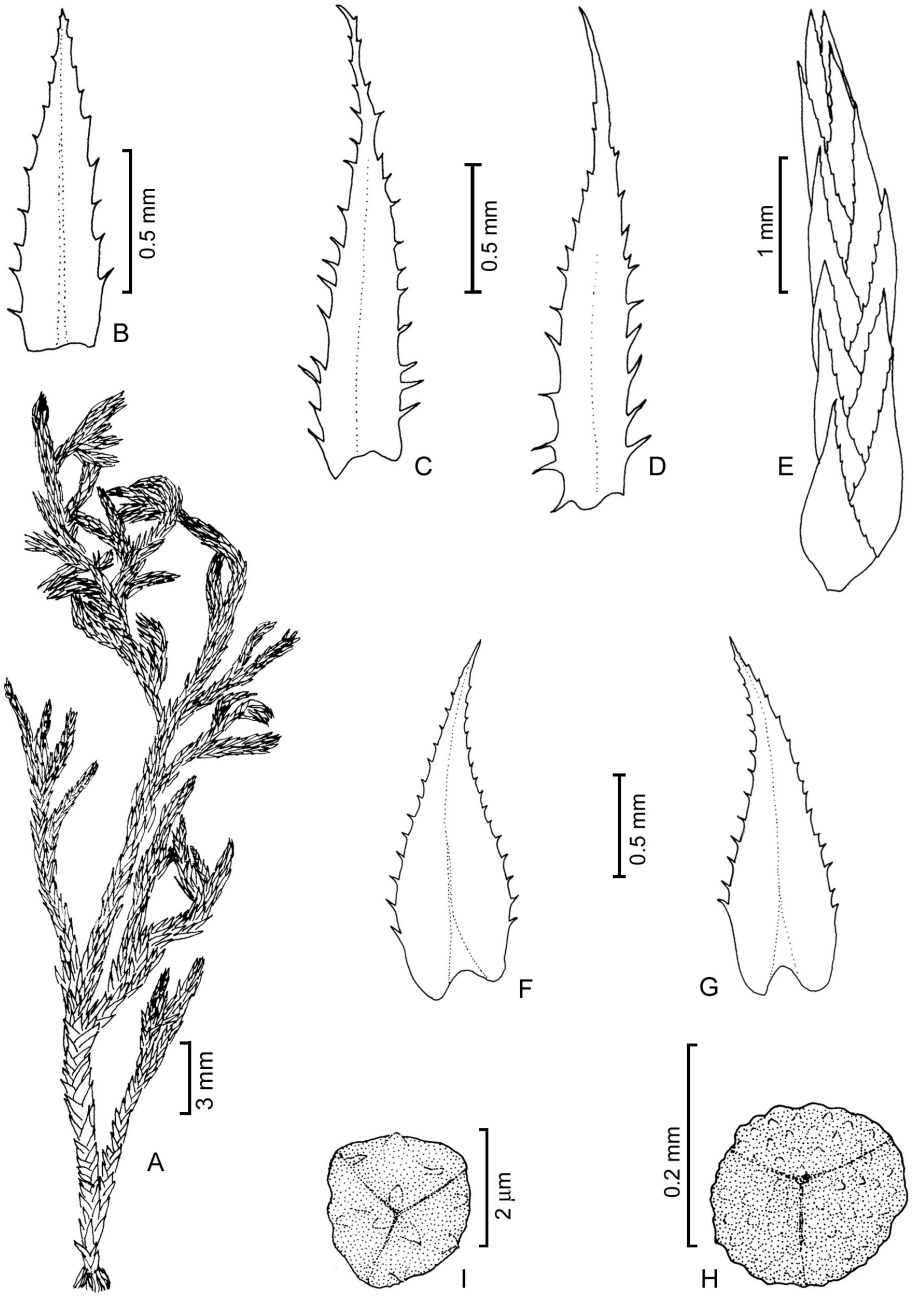


Fig. 4. *Selaginella wightii* Hieron.: **A**. Habit; **B**. & **C**. Lateral leaves; **D**. Axillary leaves; **E**.. Strobilus; **F**. & **G**. Sporophylls; **H**. Megaspore; **I**. Microspore (from *Nisha* 577, SJC).

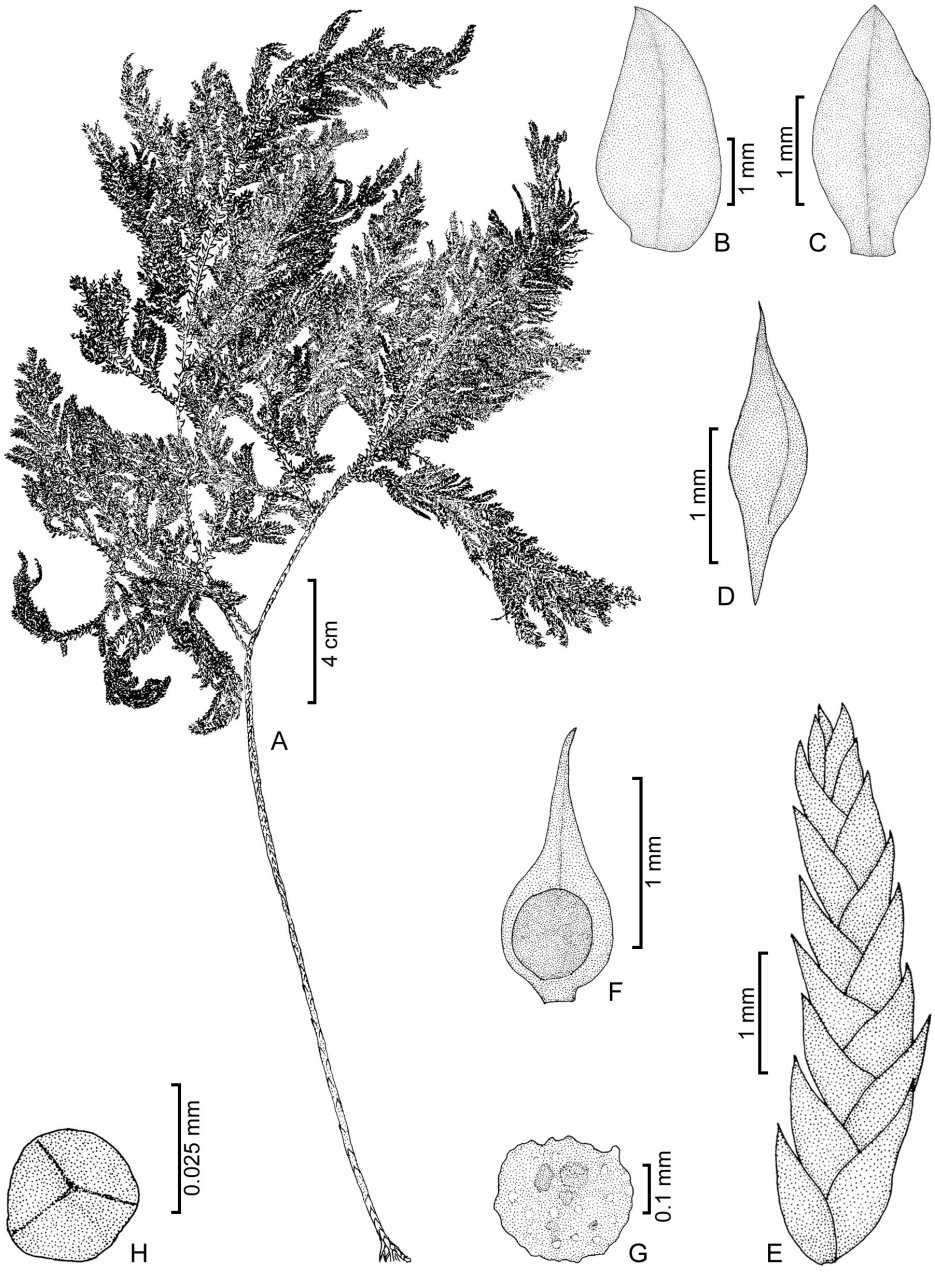


Fig. 5. *Selaginella dixitii* Madhusoodanan & Nampy: **A**. Habit; **B**. Lateral leaf; **C**. Axillary leaf; **D**. Median leaf; **E**. Strobilus; **F**. Sporophyll; **G**. Megaspore; **H**. Microspore (from *Nisha* 1501, SJC).

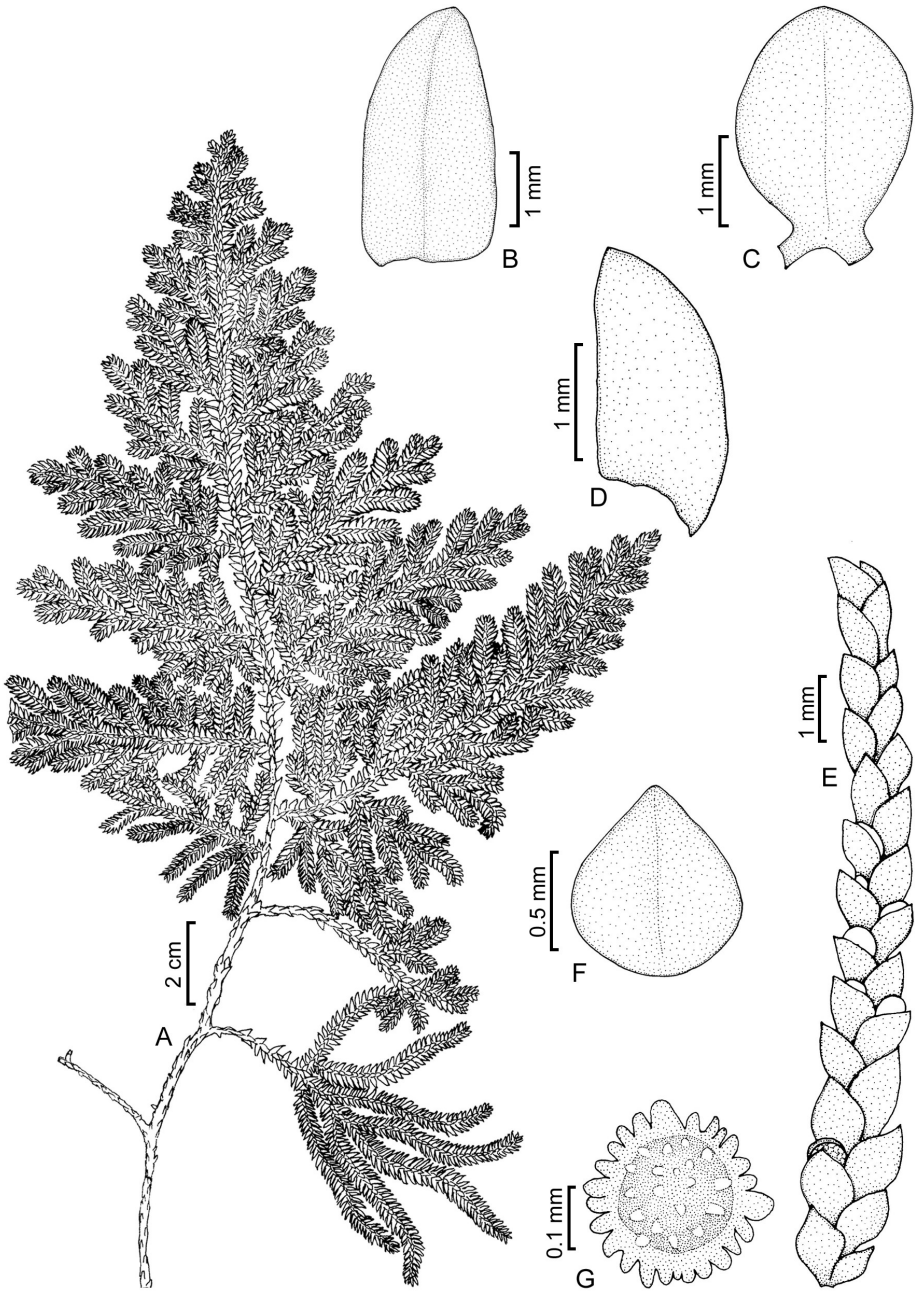


Fig: 6. *Selaginella wildenovii* (Desv. *ex* Poir.) Baker: **A**. Habit; **B**. Lateral leaf; **C**. Axillary leaf; **D**. Median leaf; **E**. Strobilus; **F**. Larger sporophyll; **G**. Megaspore (from *Nisha* 2606, SJC).

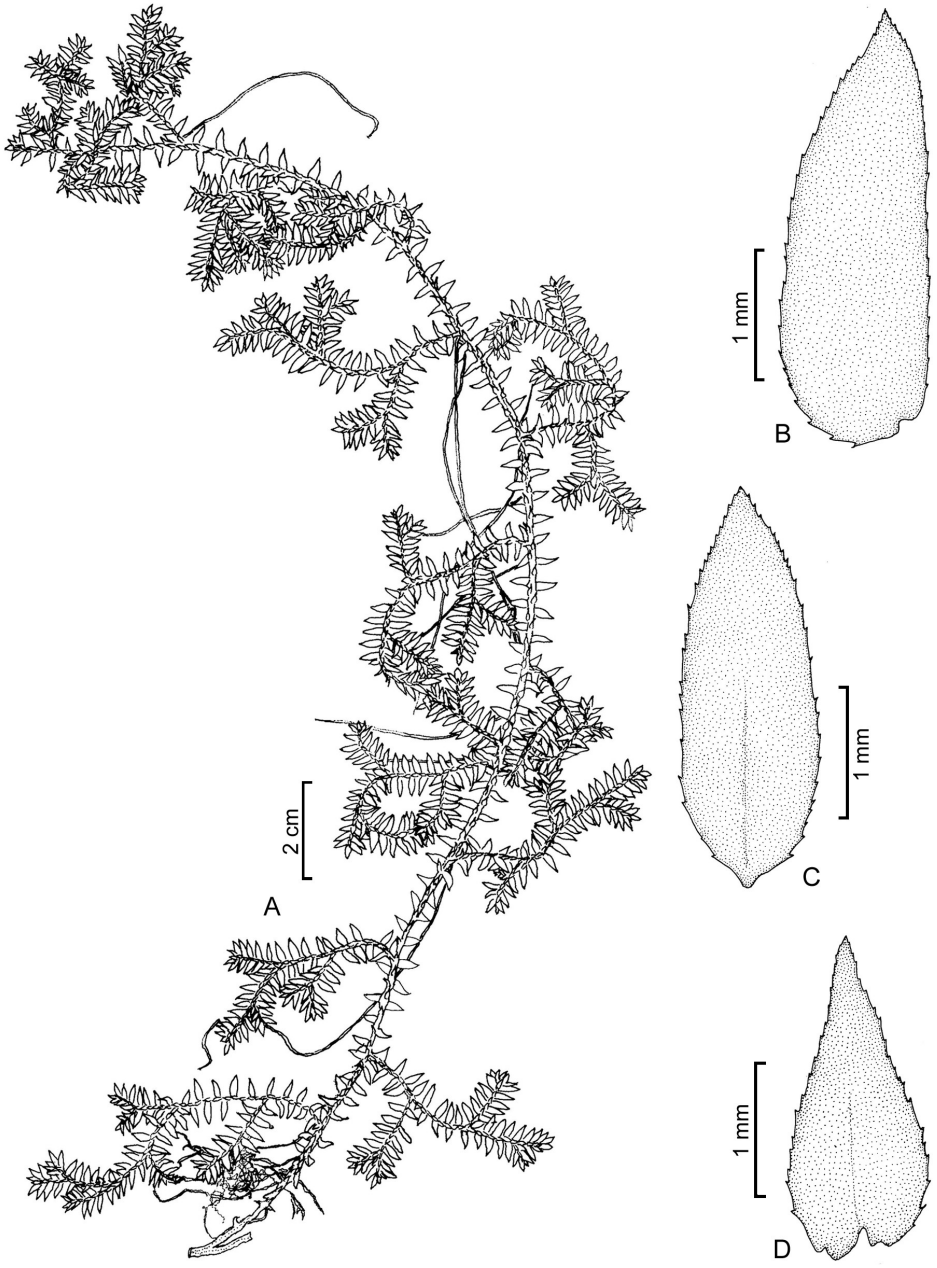


Fig. 7. *Selaginella integerrima* (Hook. *et* Grev.) Spring: **A**. Habit; **B**. Lateral leaf; **C**. Axillary leaf; **D**. Median leaf (from *Nisha* 2620, SJC).

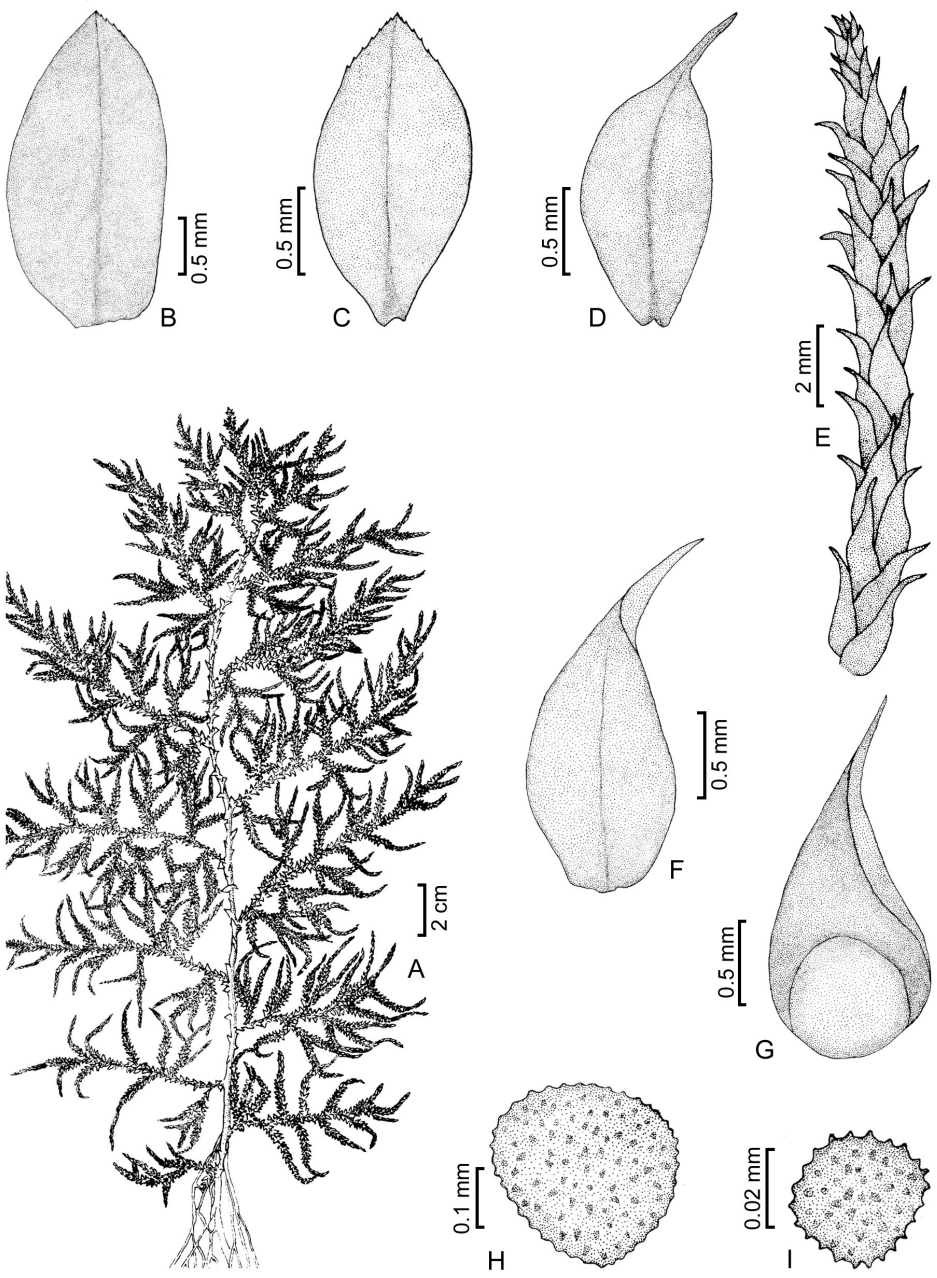


Fig. 8. *Selaginella delicatula* (Desv.) Alston: **A**. Habit; **B**. Lateral leaf; **C**. Axillary leaf; **D**. Median leaf; **E**. Strobilus; **F**. & **G**. Sporophyll; **H**. Megaspore; **I**. Microspore (from *Nisha* 505, SJC).

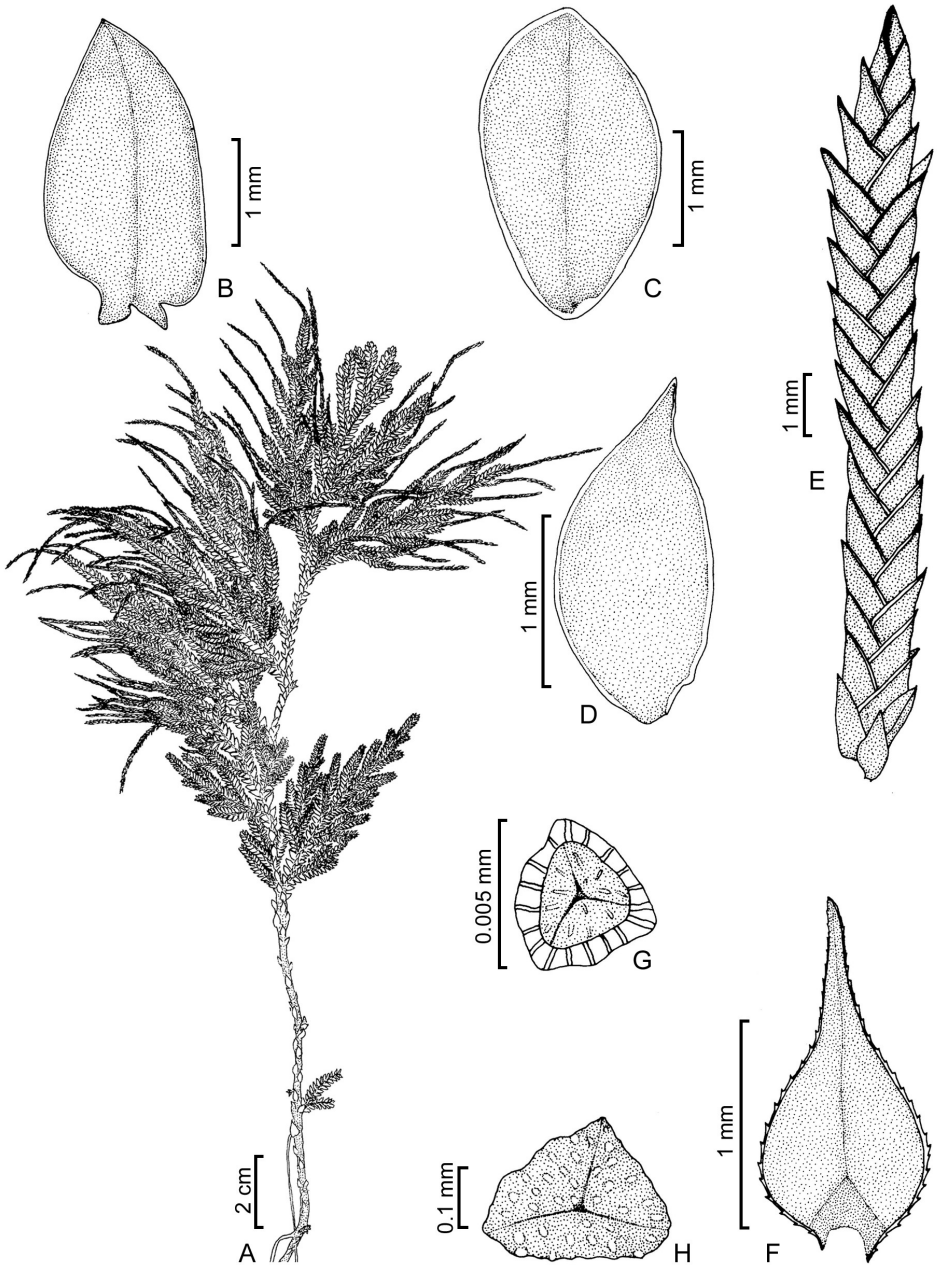


Fig. 9. *Selaginella plana* (Desv. *ex* Poir.) Hieron: A. Habit; B. Lateral leaf; C. Axillary leaf; D. Median leaf; E. Strobilus F. Sporophyll; G. Megaspore; H. Microspore (from *Nisha* 2898, SJC).

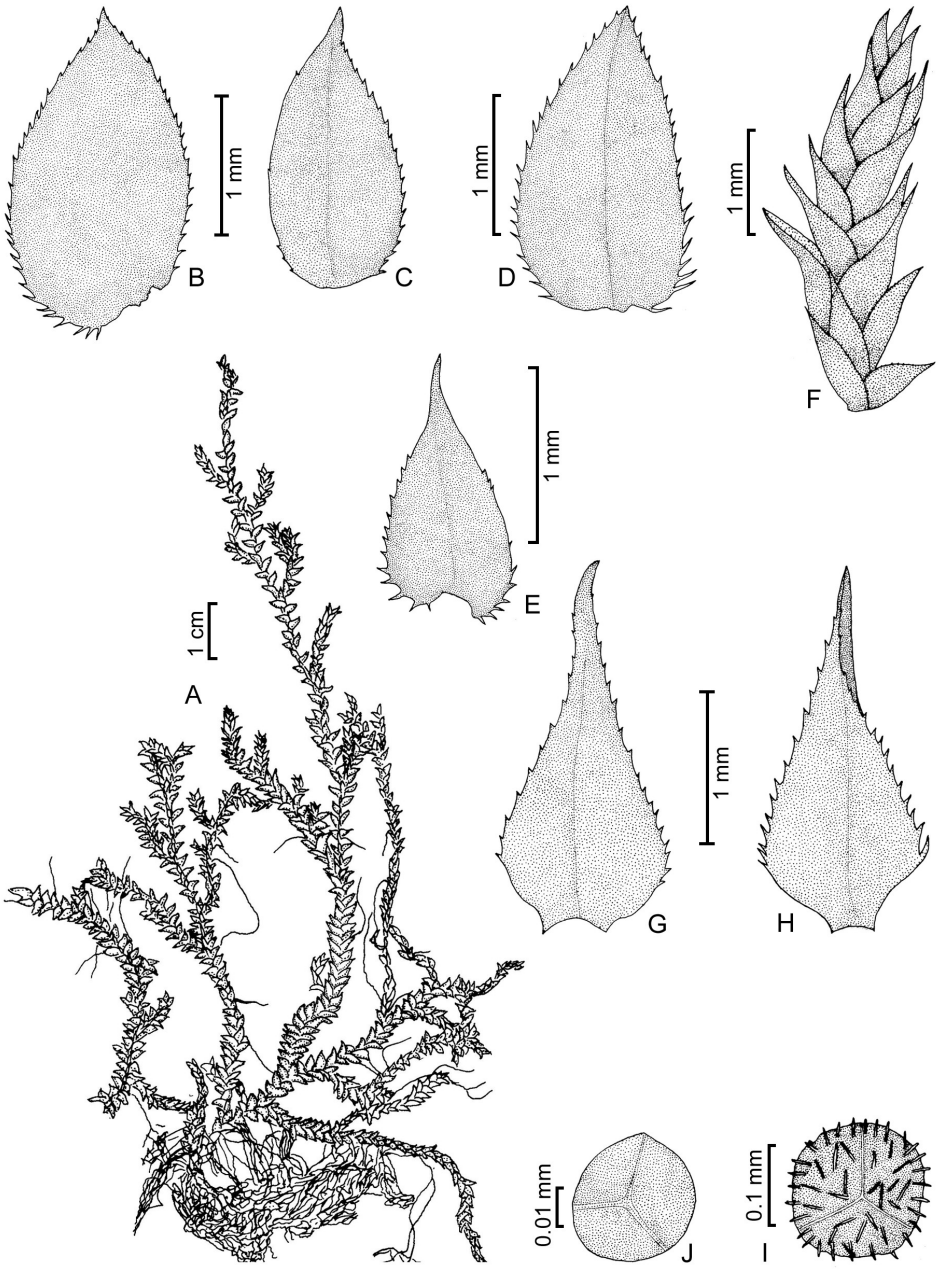
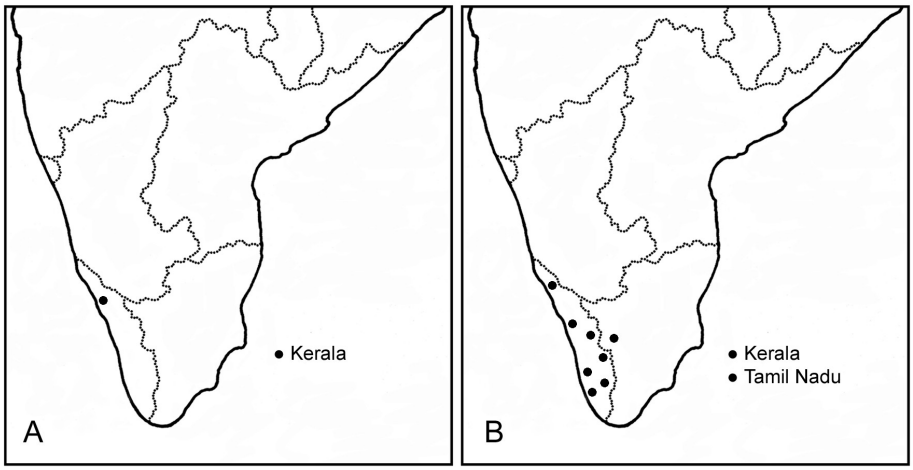
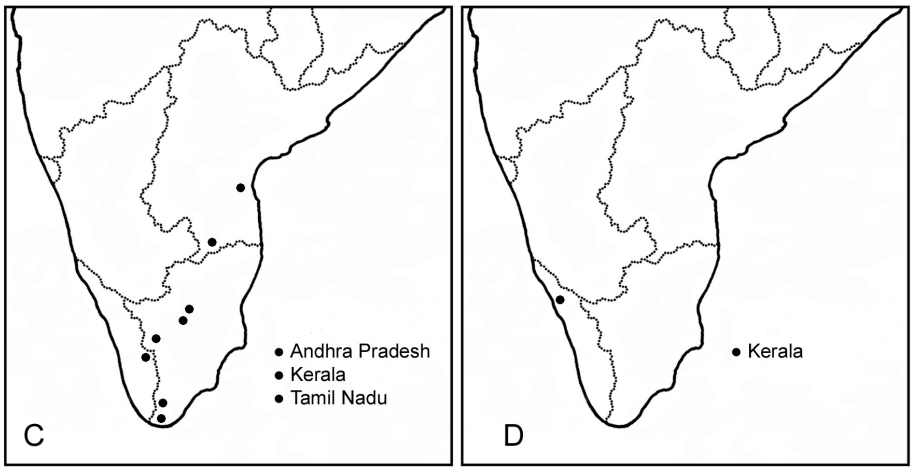


Fig. 10. *Selaginella vaginata* Spring: **A**. Habit; **B**. & **C**. Lateral leaves; **D**. Axillary leaf; **E**. Median leaf; **F**. Strobilus; **G**. & **H**. Sporophylls; **I**. Megaspore; **J**. Microspore (from *Nisha* 1463 SJC).



S. uncinata ***S. vaginata***



S. wightii ***S. wildenovii***

Fig. 11. Distribution maps of species of *Selaginella*

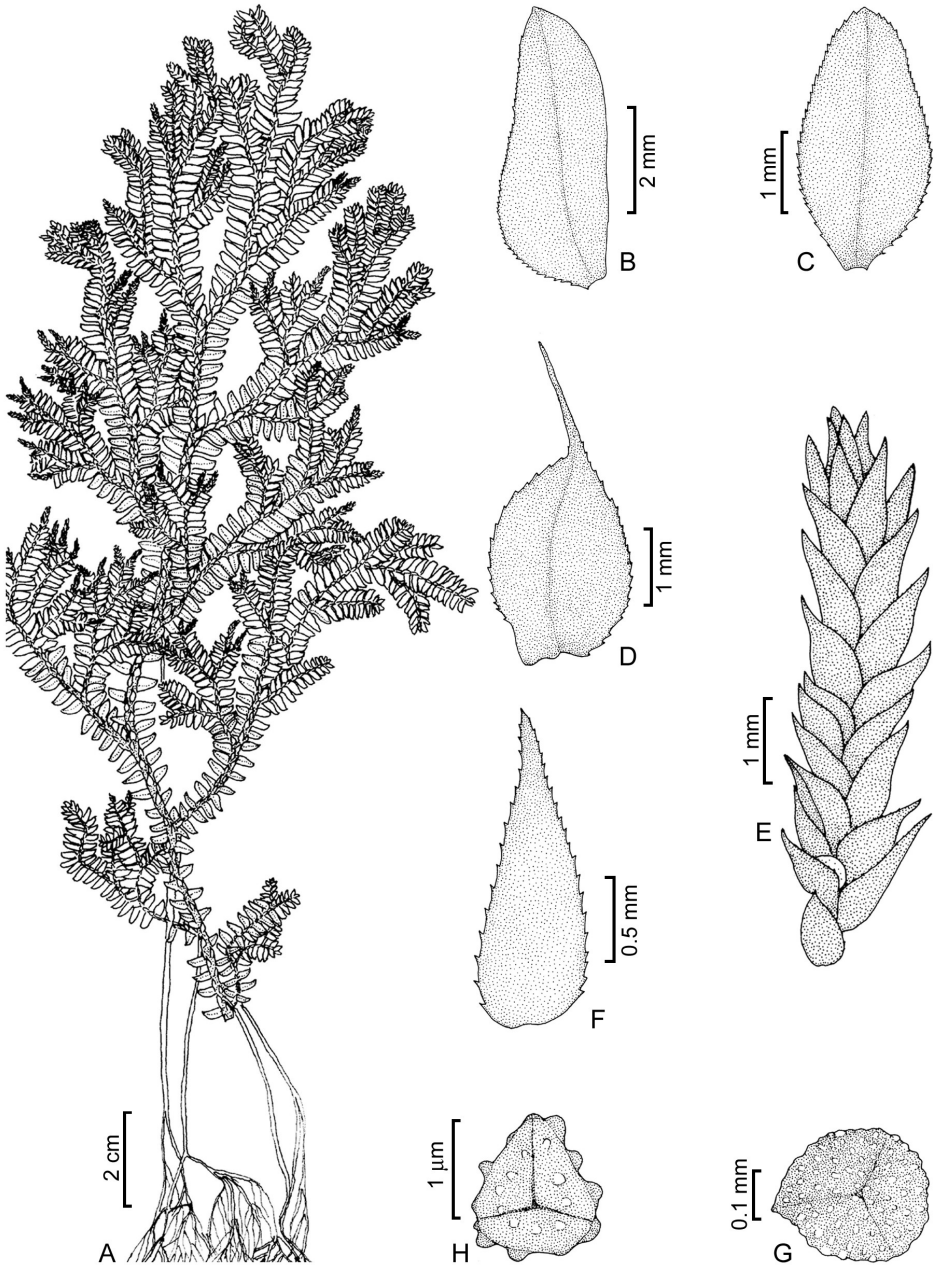


Fig. 12. *Selaginella intermedia* (Blume) Spring: **A**. Habit; **B**. Lateral leaf; **C**. Axillary leaf; **D**.Median leaf; **E**. Strobilus **F**. Sporophyll; **G**. Megaspore; **H**. Microspore. (from *Nisha* 2887, SJC).

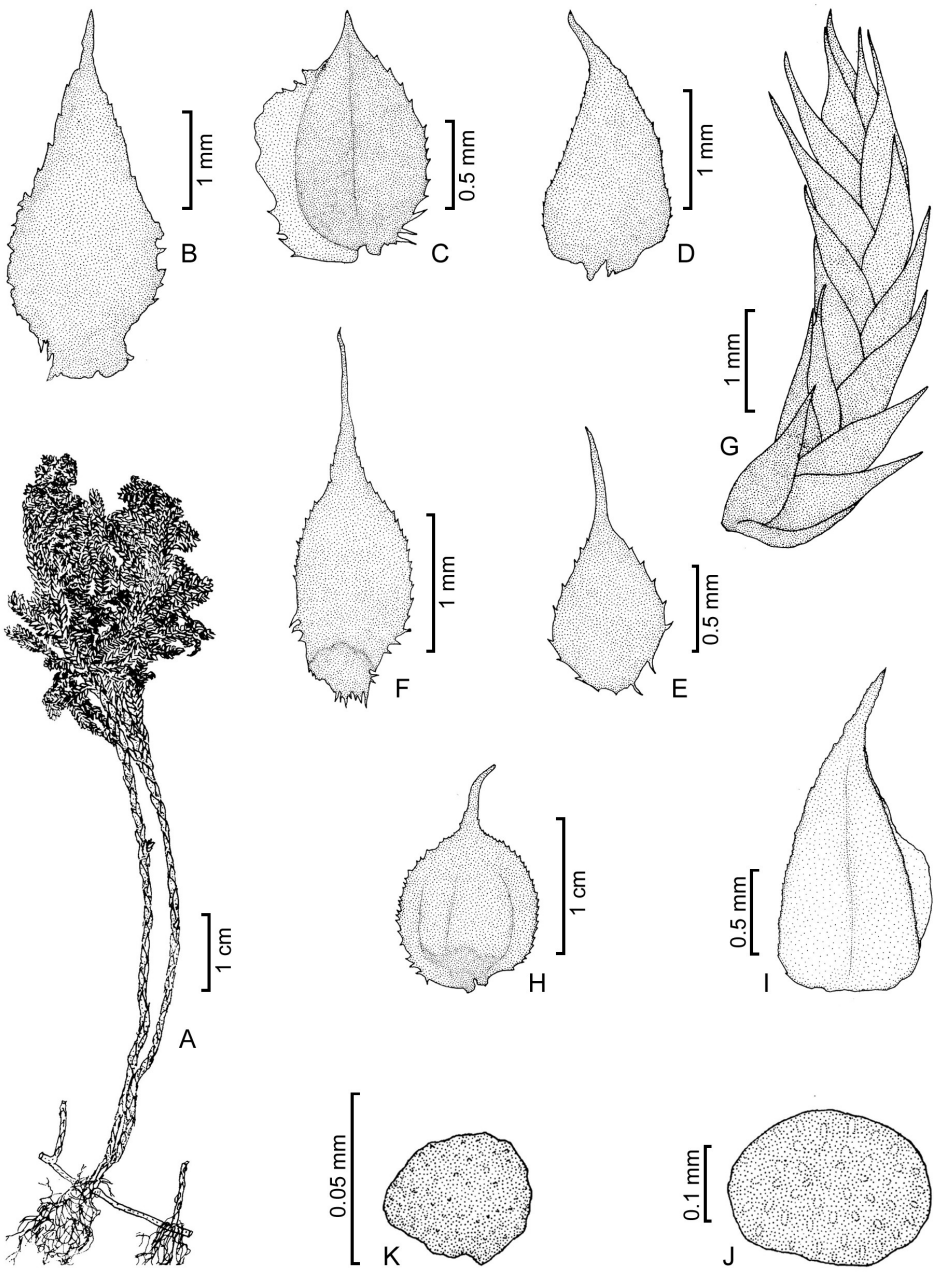


Fig. 13. *Selaginella bryopteris* (L.) Baker, **A**. Habit; **B**. & **C**. Lateral leaf; **D**. Axillary leaf; **E**. & **F**. Median leaf; **G**. Strobilus; **H**. & **I**. Sporophylls; **J**. Megaspore; **K** Microspore. (from *Nisha* 1497, SJC).

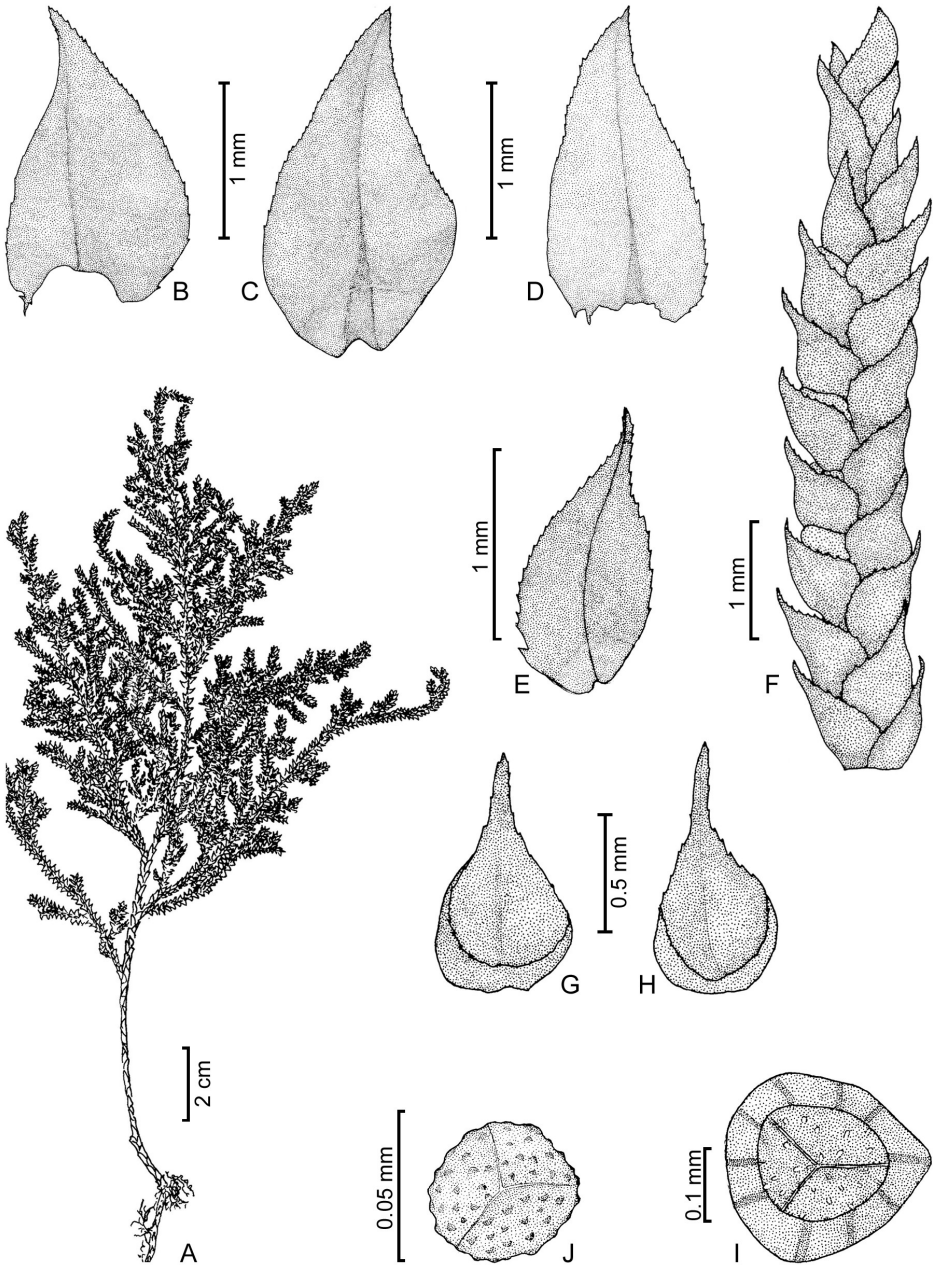
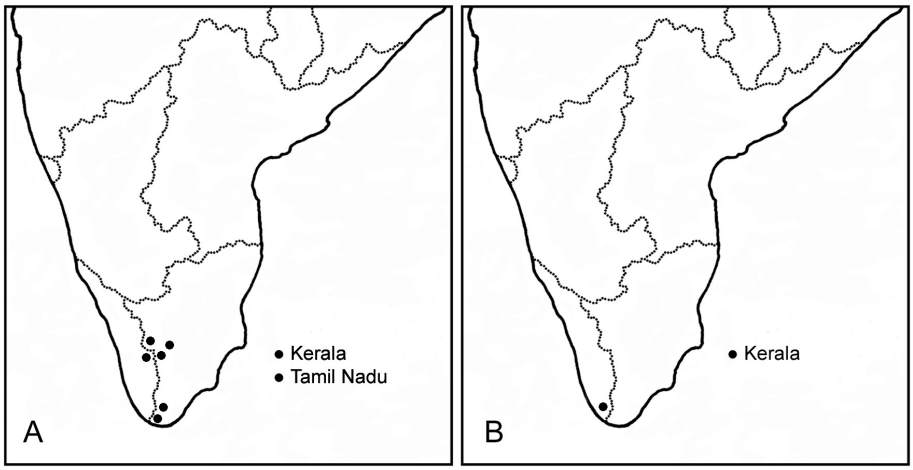
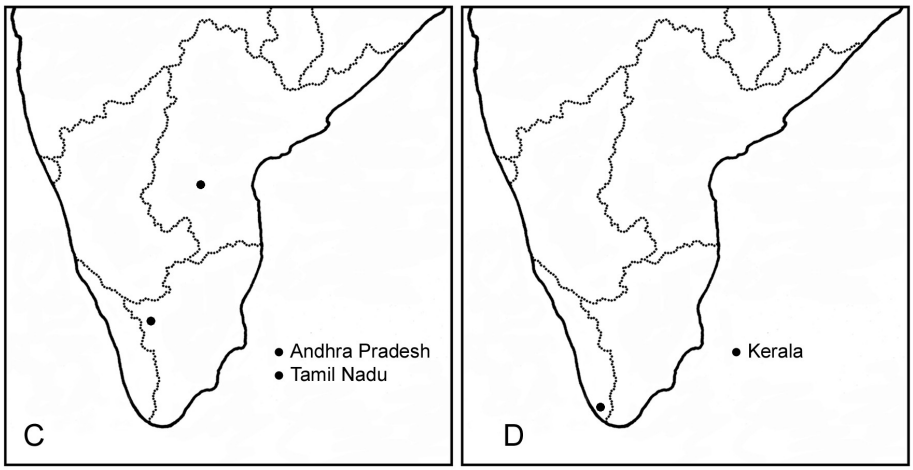


Fig. 14. *Selaginella involvens* (Sw.) Spring: **A**. Habit; **B.** & **C.** Lateral leaf; **D**. Axillary leaf; **E**. Median leaves; **F**. Strobilus; **G**. & **H**. Sporophylls; **I**. Megaspore; **J**. Microspore (from *Nisha* 567, SJC).



S. brachystachya ***S. braunii***



S. bryopteris ***S. camusii***

Fig. 15. Distribution maps of species of *Selaginella*

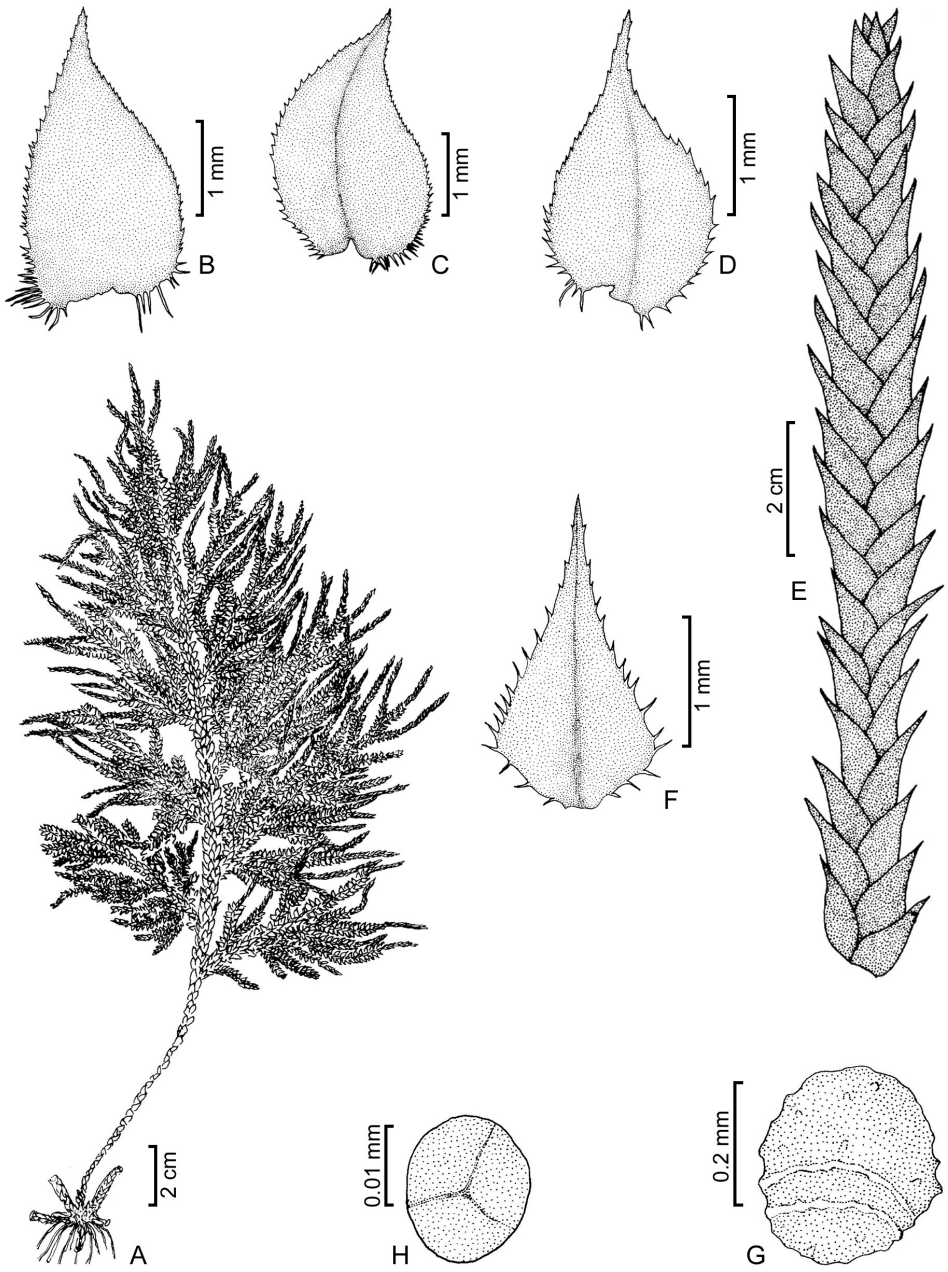
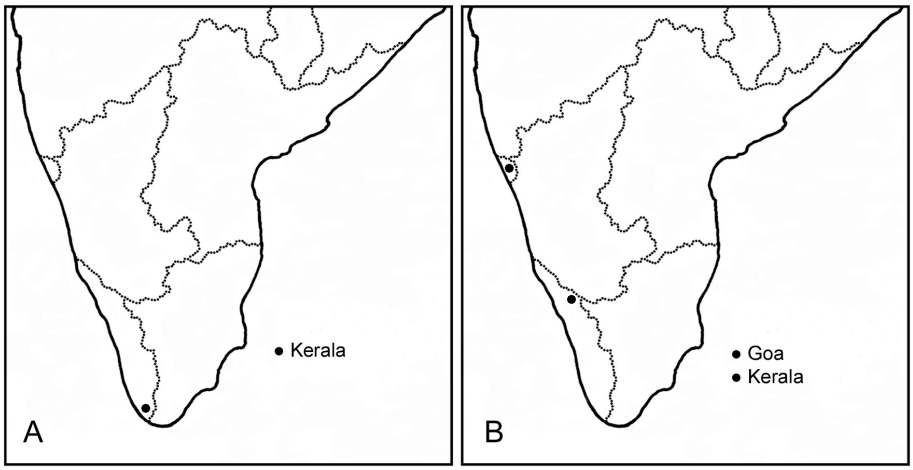
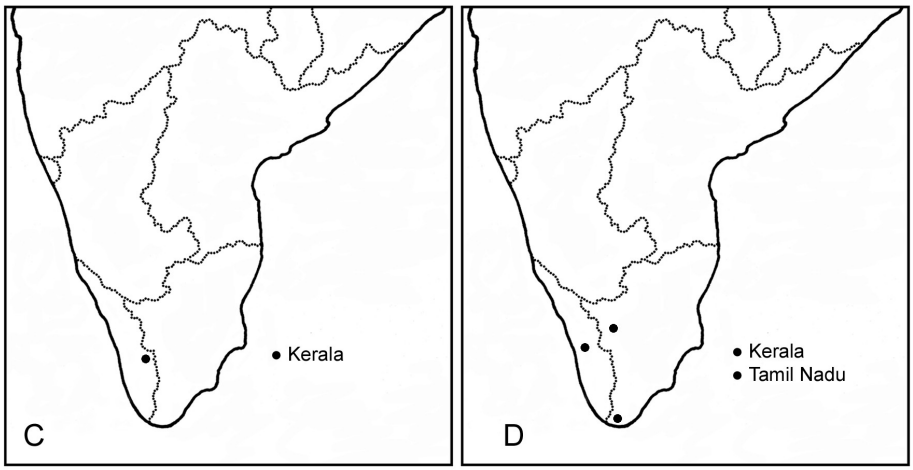


Fig. 16. *Selaginella microdendron* Baker: **A**. Habit; **B**. Lateral leaf; **C**. Median leaf; **D**. Axillary leaf; **E**. Strobilus; **F**. Sporophyll; **G**. Megaspore; **H**. Microspore (from *Nisha* 2628, SJC).



S. microdendron ***S. miniatospora***



S. minutifolia ***S. monospora***

Fig. 17. Distribution maps of species of *Selaginella*

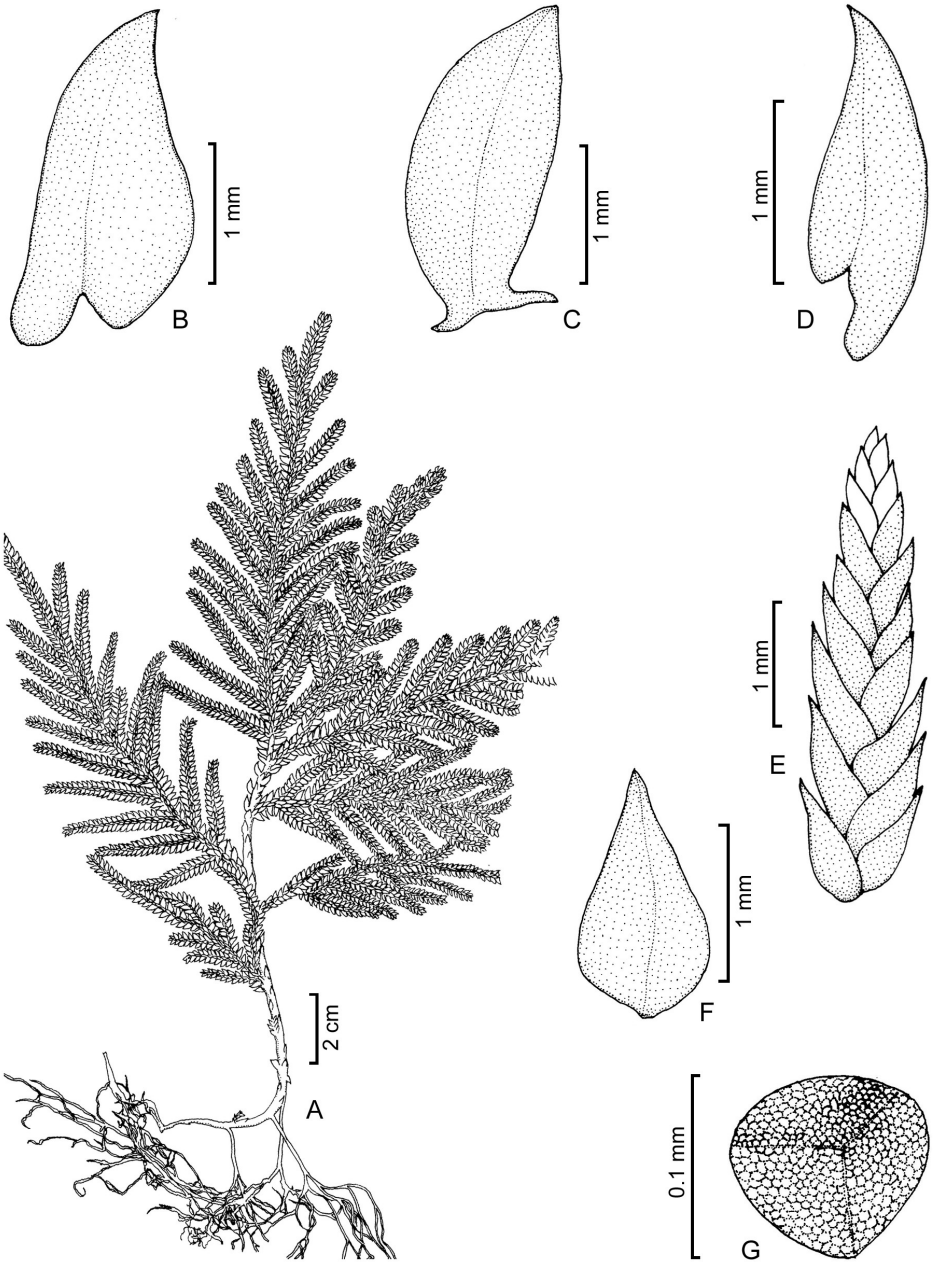


Fig. 18. *Selaginella gracilis* Moore: **A**. Habit; **B**. Lateral leaf; **C**. Axillary leaf; **D**. Median leaf; **E**. Strobilus; **F**. Sporophyll; **G**. Megaspore (from *Nisha* 2889, SJC).

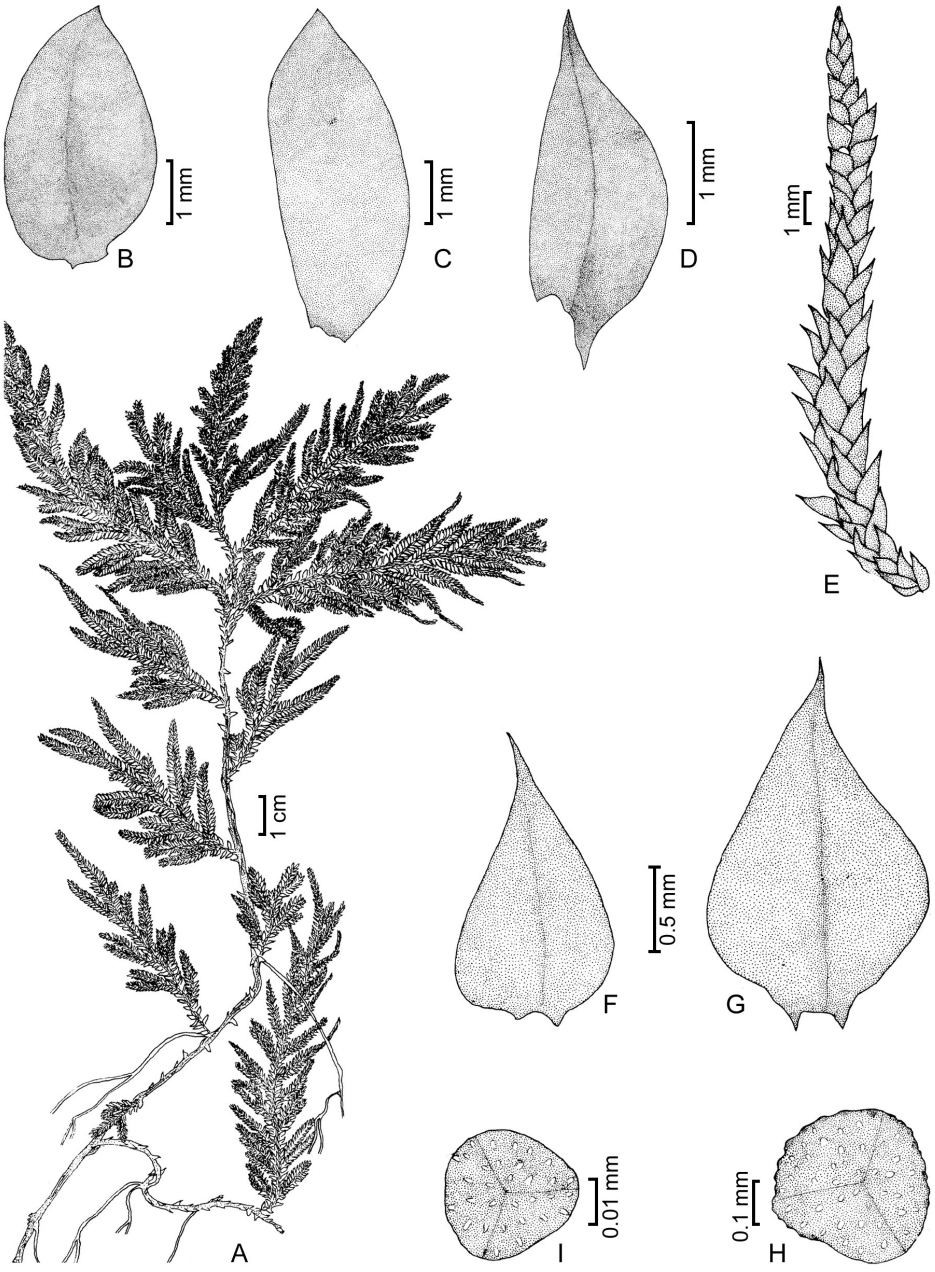


Fig. 19.a *Selaginella inaequalifolia* (Hook. & Grev.) Spring: **A**. Habit; **B**. Lateral leaf; **C**. Axillary leaf; **D**. Median leaf; **E**. Strobilus; **F.** & **G.** Sporophyll; **H**. Megaspore; **I**. Microspore (from *Nisha* 1406, SJC).

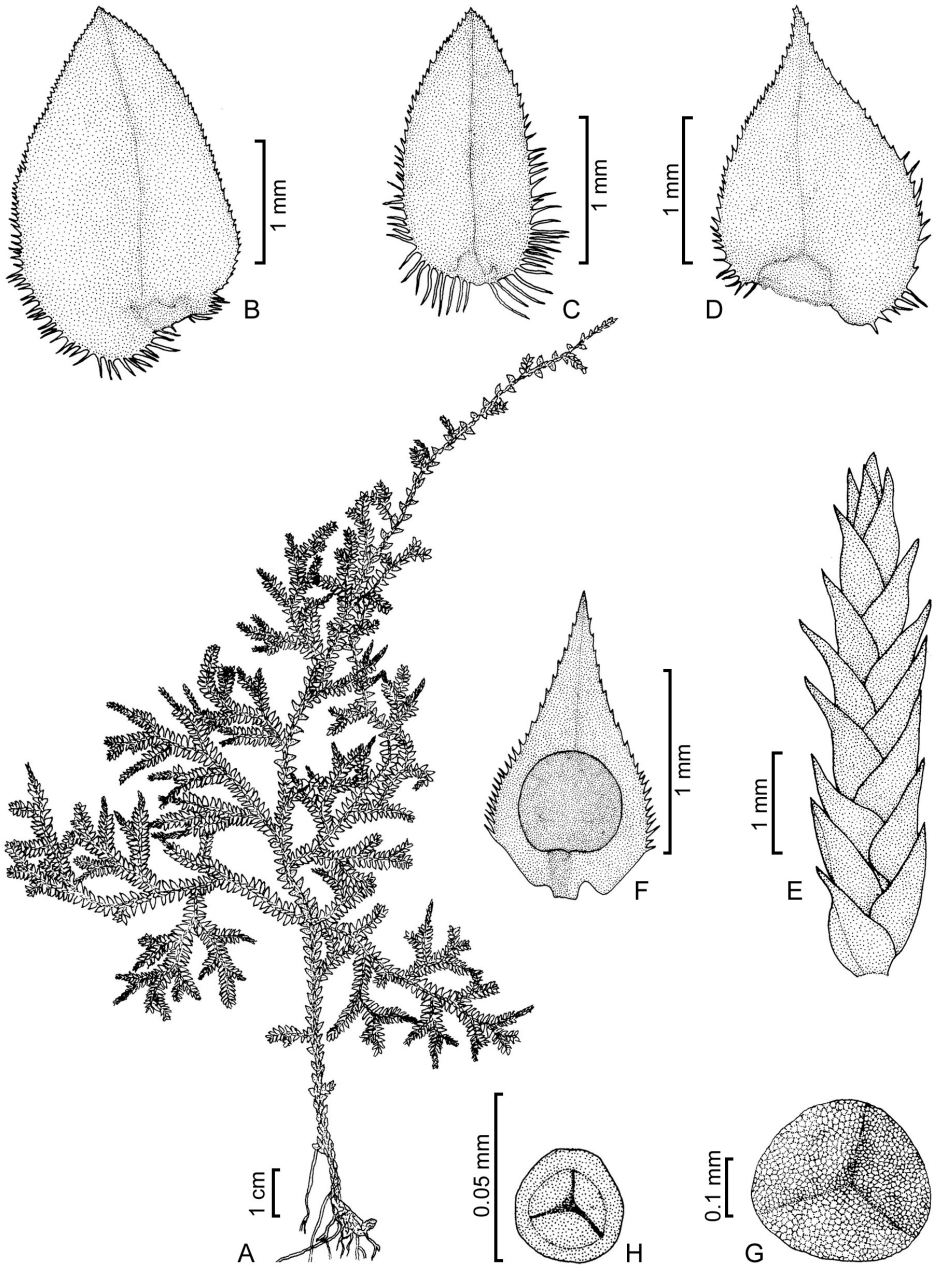


Fig. 19 b. *Selaginella radicata* (Hook. & Grev.) Spring: **A**. Habit; **B**. Lateral leaf; **C**. Axillary leaf; **D**. Median leaf; **E**. Strobilus; **F**. Sporophyll; **G**. Megaspore; **H**. Microspore (from *Nisha* 1470, SJC).

Fig. 20. Scanned images of types of *Selaginella* species:**A.** *Selaginella radicata* (Hook. & Grev.) Spring*;* **B.** *Selaginella rupestris* (L.) Spring*;* **C.** *Selaginella subdiaphana* (Wall. *ex* Hook. *et* Grev.) Spring*;* **D.** *Selaginella vaginata* Spring

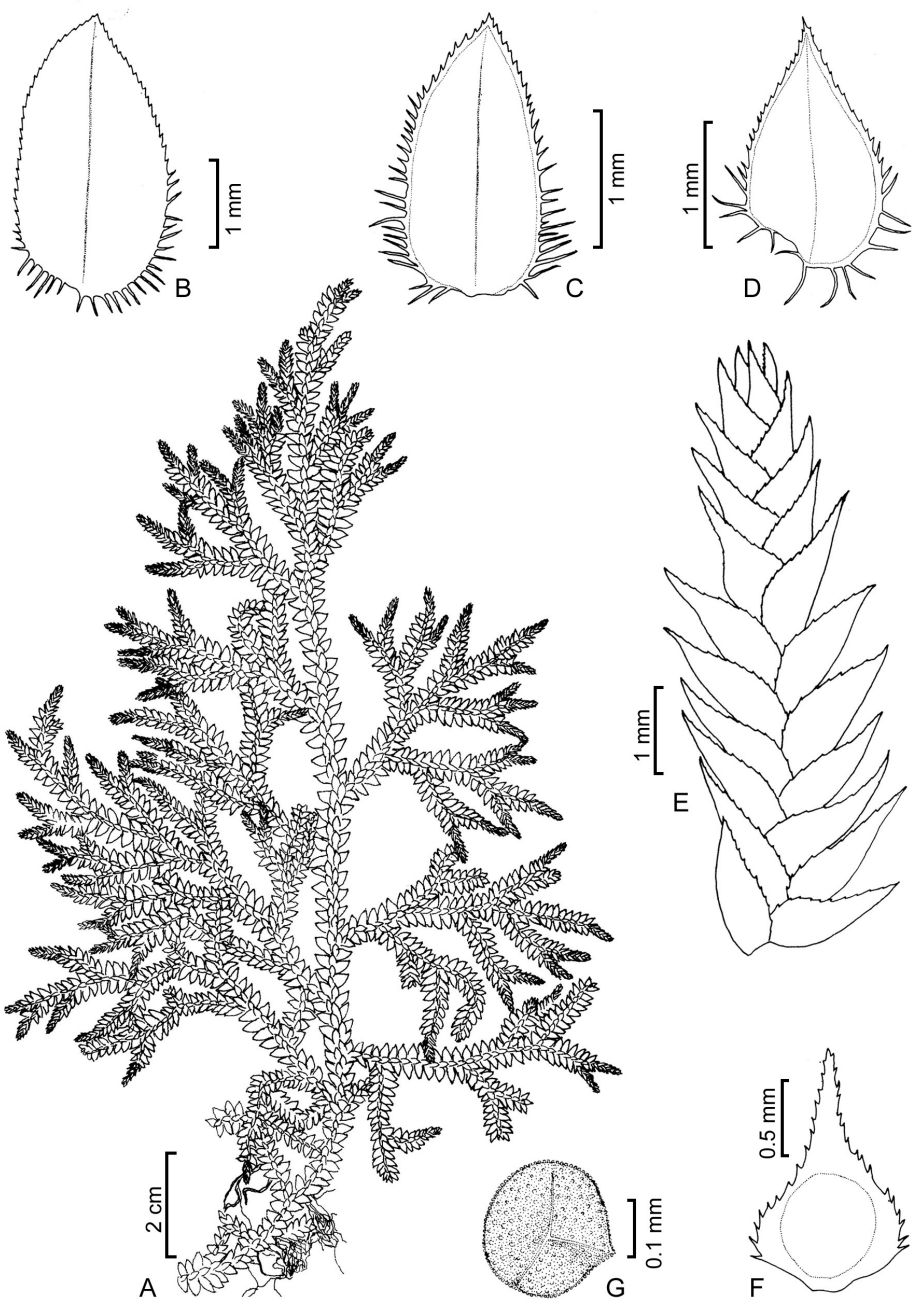
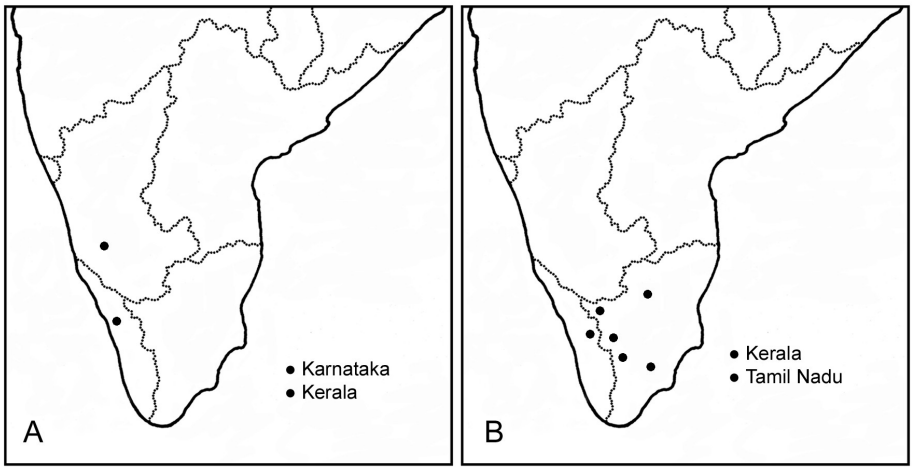
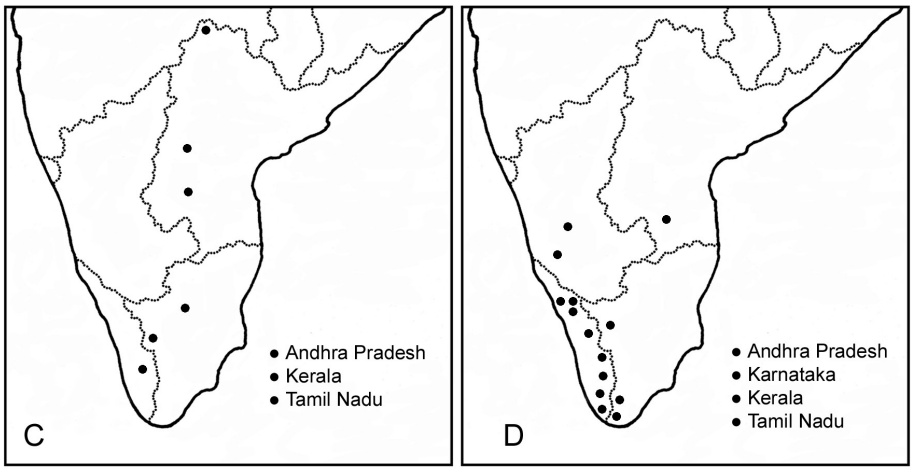


Fig. 21. *Selaginella repanda* (Desv. *ex* Poir.) Spring: **A**. Habit; **B**. Lateral leaf; **C**. Median leaf; **D**. Axillary leaf; **E**. Strobilus; **F**. Sporophyll; **G**. Megaspore; **H**. Microspore (from *Nisha* 1496, SJC).



S. proniflora ***S. radicata***



S. repanda ***S. tenera***

Fig. 22. Distribution maps of species of *Selaginella*

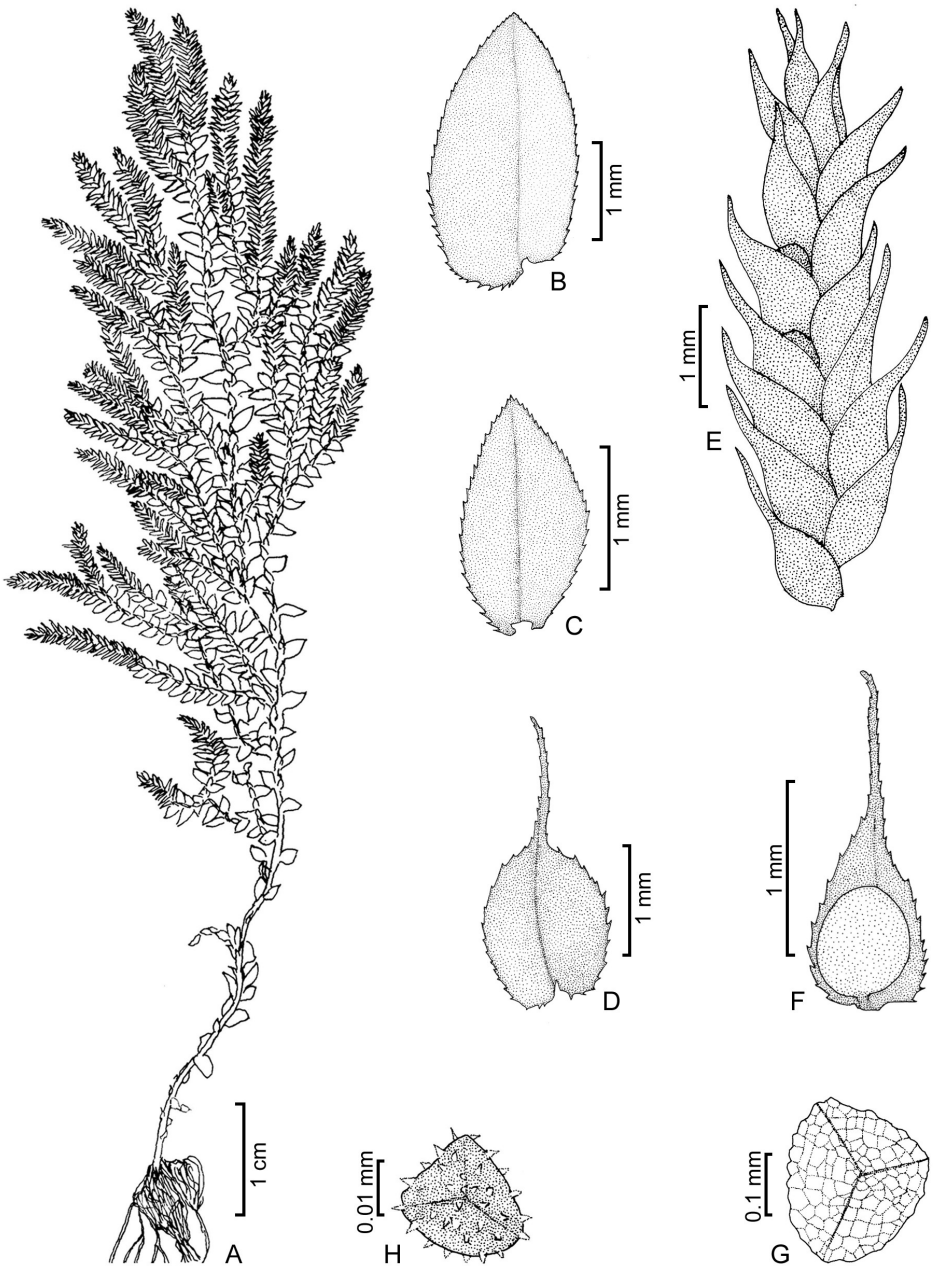
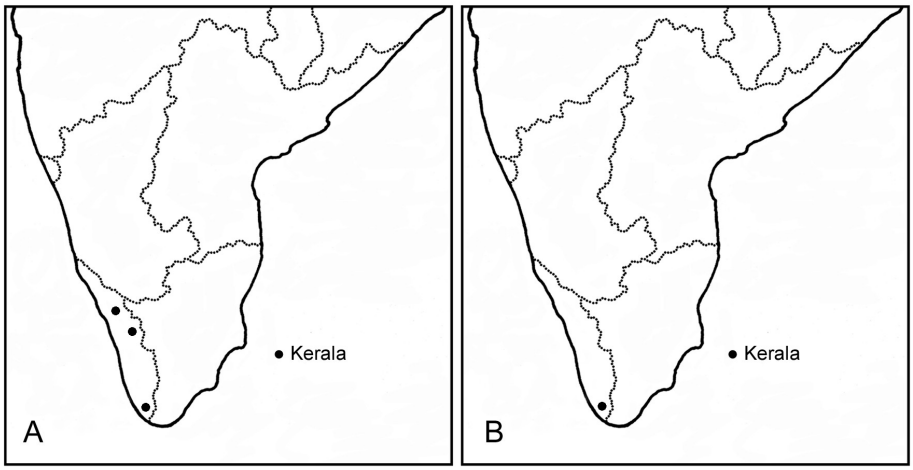
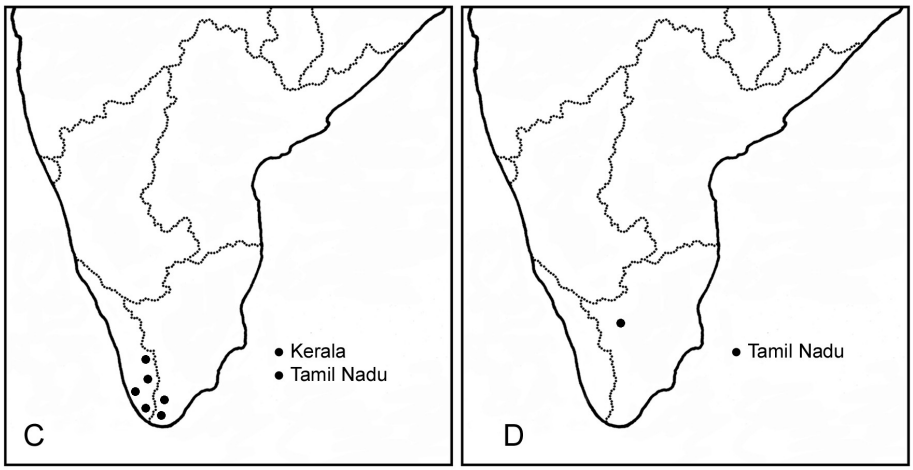


Fig. 23. *Selaginella ganguliana* R.D.Dixit: **A**. Habit; **B**. Lateral leaf; **C**. Axillary leaf; **D**. Median leaf; **E**. Strobilus **F**. Sporophyll; **G**. Megaspore; **H**. Microspore. (from Nisha 2614 SJC).



S. ganguliana ***S. gracilis***



S. inaequalifolia ***S. integerrima***

Fig. 24. Distribution maps of species of *Selaginella*

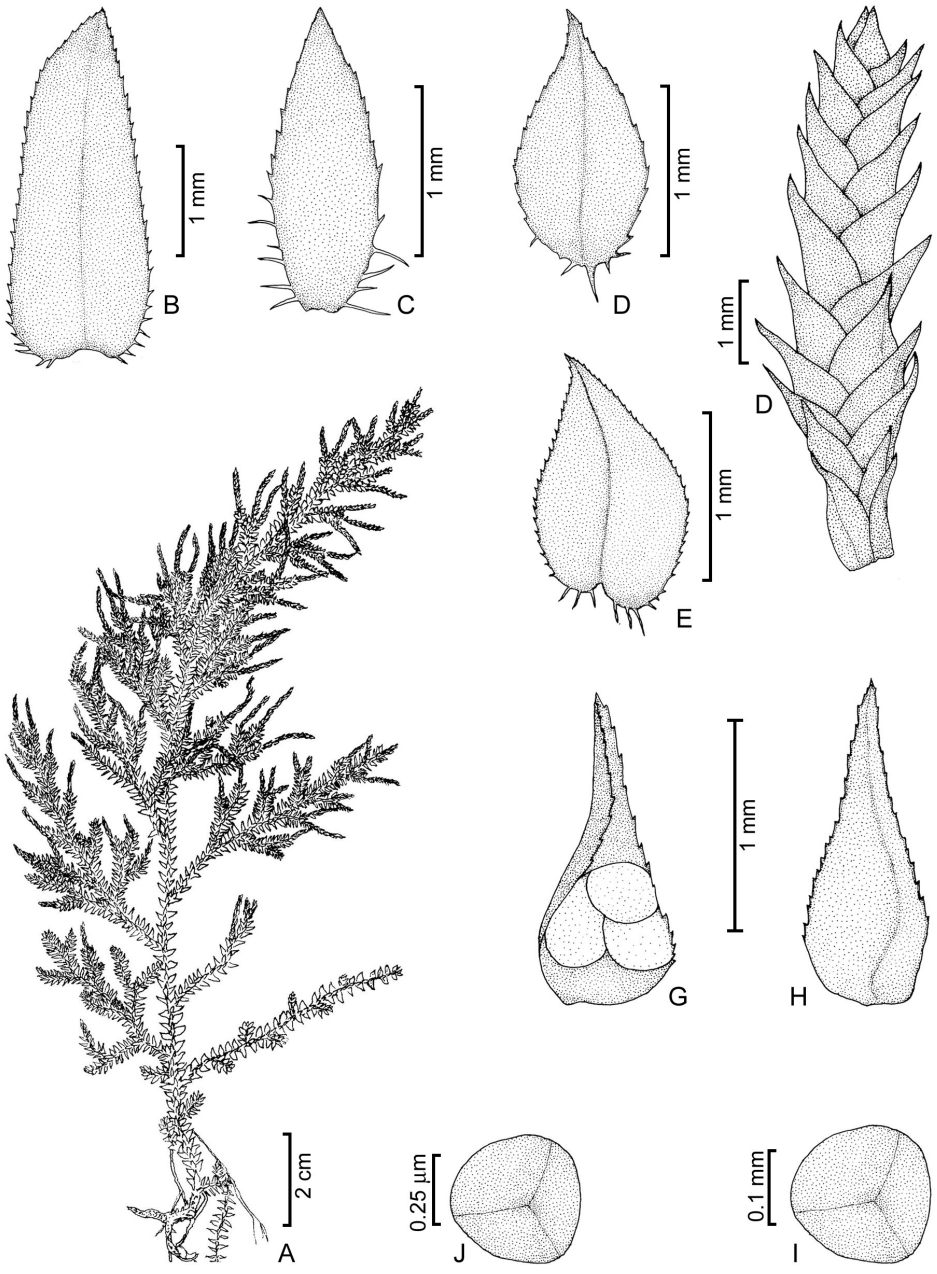


Fig. 25. *Selaginella plumosa* Baker: **A**. Habit; **B**. Lateral leaf; **C**. Axillary leaf; **D**. & **E**. Median leaves; **F**. Strobilus; **G**. & **H**. Sporophylls; **I**. Megaspore; **J**. Microspore (from *Nisha* 542, SJC).

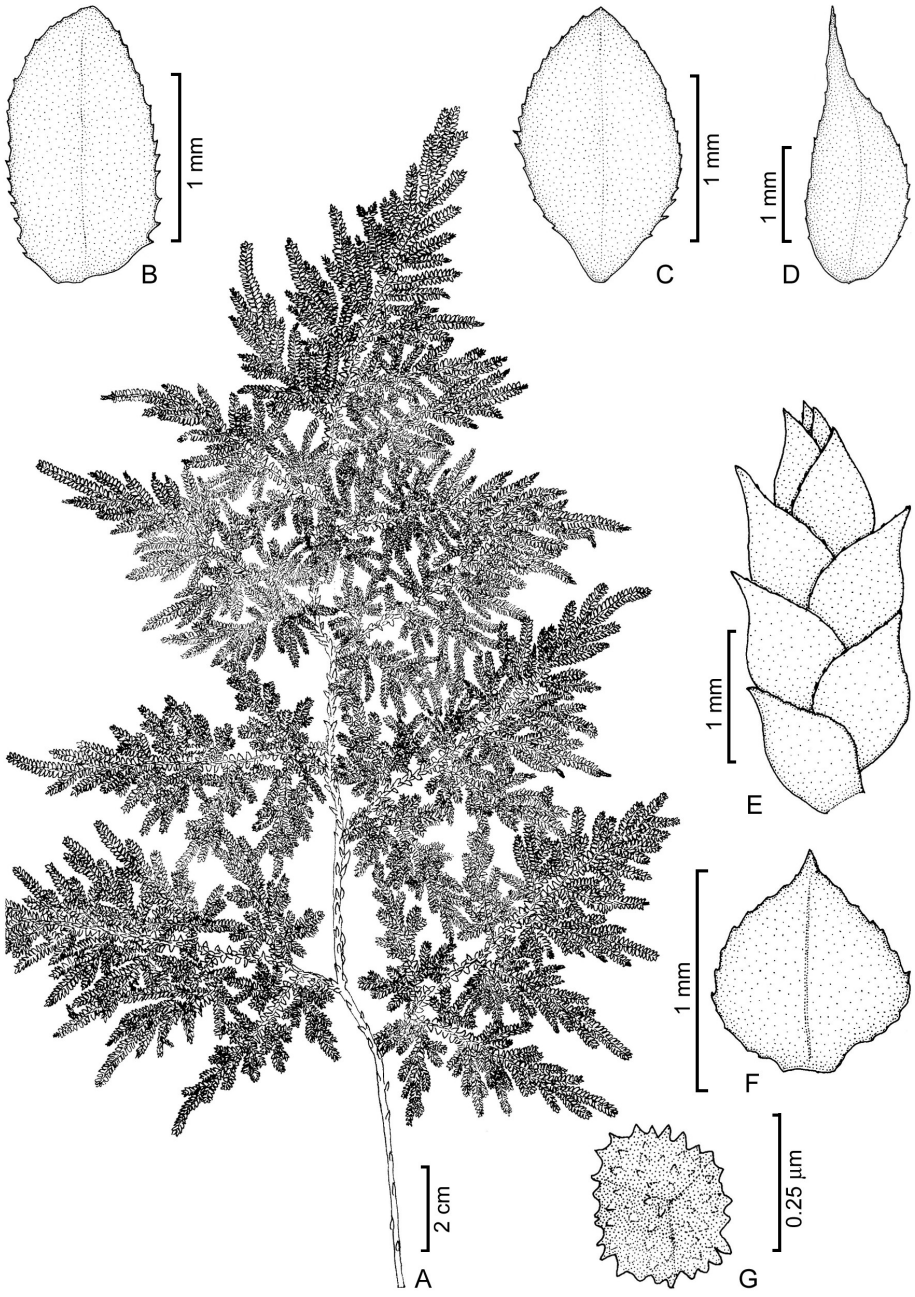


Fig: 26. *Selaginella uncinata* (Desv. *ex* Poir.) Spring: **A**. Habit; **B**. Lateral leaf; **C**. Axillary leaf; **D**. Median leaf; **E**. Strobilus; **F**. Sporophyll; **G**. Megaspore (from *Nisha* 2609, SJC).

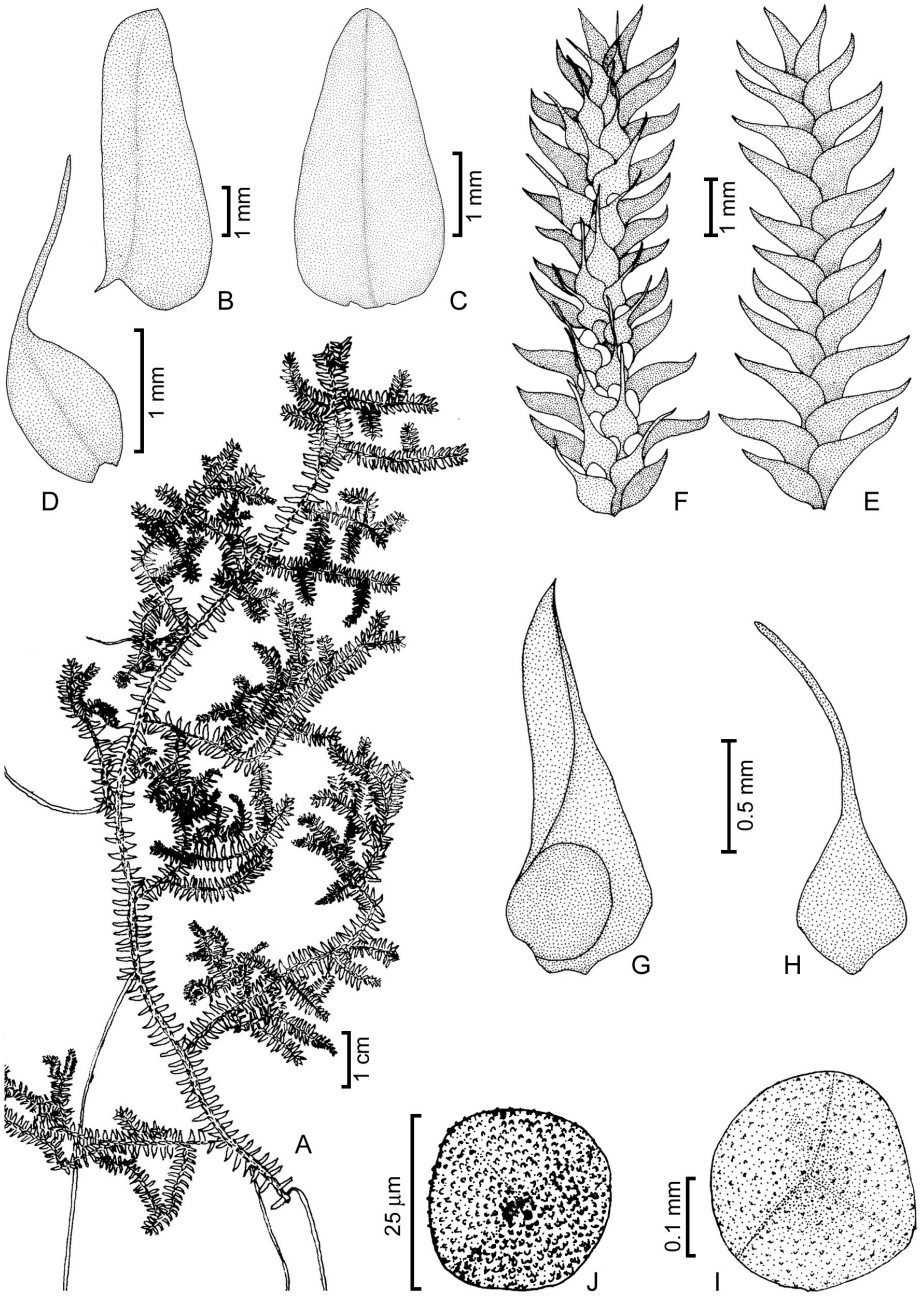


Fig: 27. *Selaginella brachystachya* (Hook. & Grev.) Spring: **A**. Habit; B. Lateral leaf; **C**. Axillary leaf; **D**. Median leaf; **E**. Strobilus – dorsal view; **F**. Strobilus – ventral view; **G**. Larger sporophyll; **H**. Smaller sporophyll; **I**. Megaspore; **J**. Microspore (from *Santhosh* 29840, TBGT).

Fig. 28. Scanned images of types of *Selaginella* species: **A.** *Selaginella integerrima* (Hook. *et* Grev.) Spring*;* **B.** *Selaginella intermedia* (Blume) Spring*;* **C.** *Selaginella miniatospora* (Dalz.) Baker; **D.** *Selaginella monospora* Spring

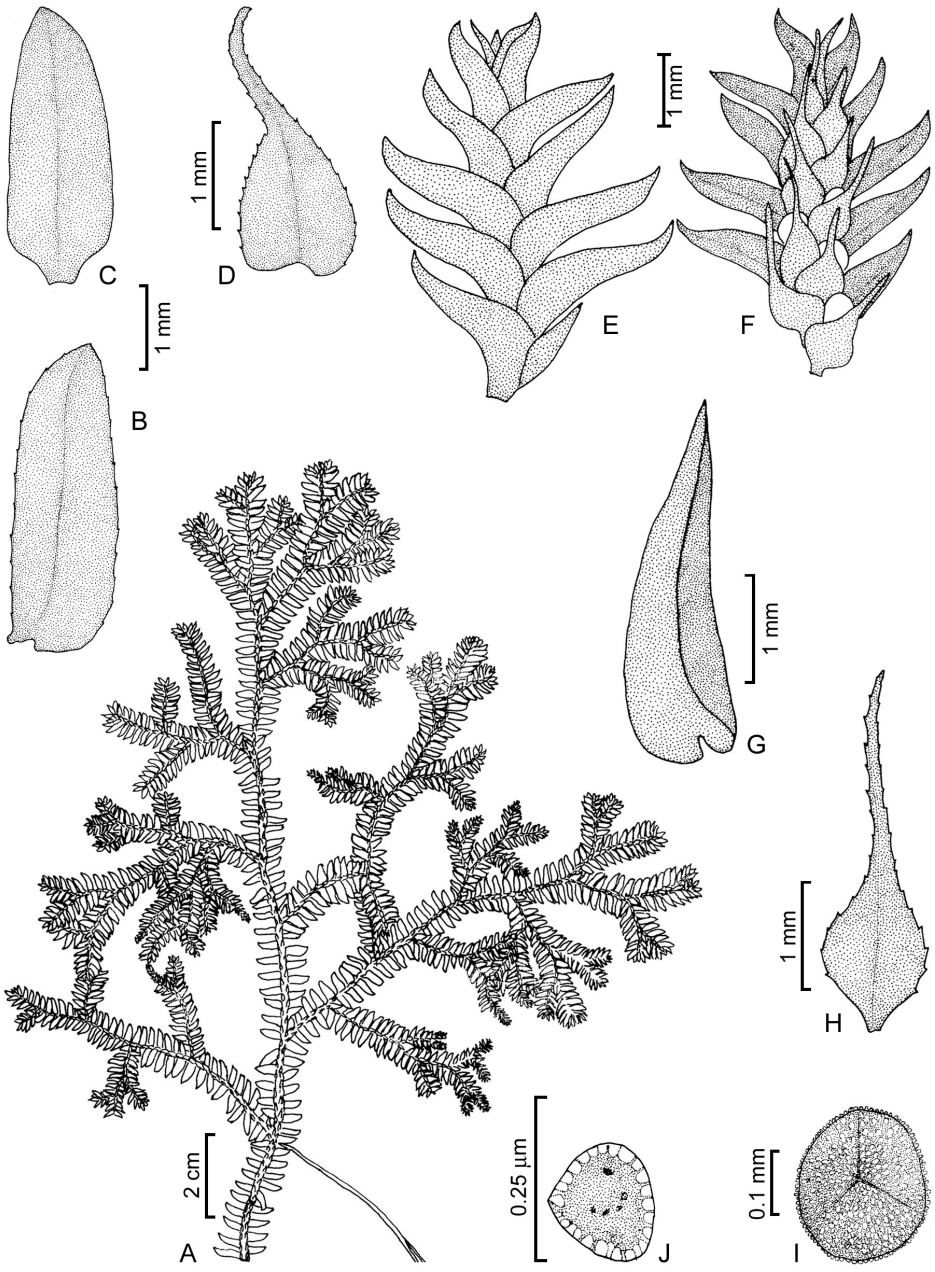


Fig. 30. *Selaginella monospora* Spring: **A**. Habit; **B**. Lateral leaf; **C**. Median leaf; **D**. Axillary leaf; **E**. Strobilus – dorsal view; **F**. Strobilus – ventral view; **G**. Larger sporophyll; **H**. Smaller sporophyll; **I**. Megaspore; **J**. Microspore (from *Nisha* 558, CAL).

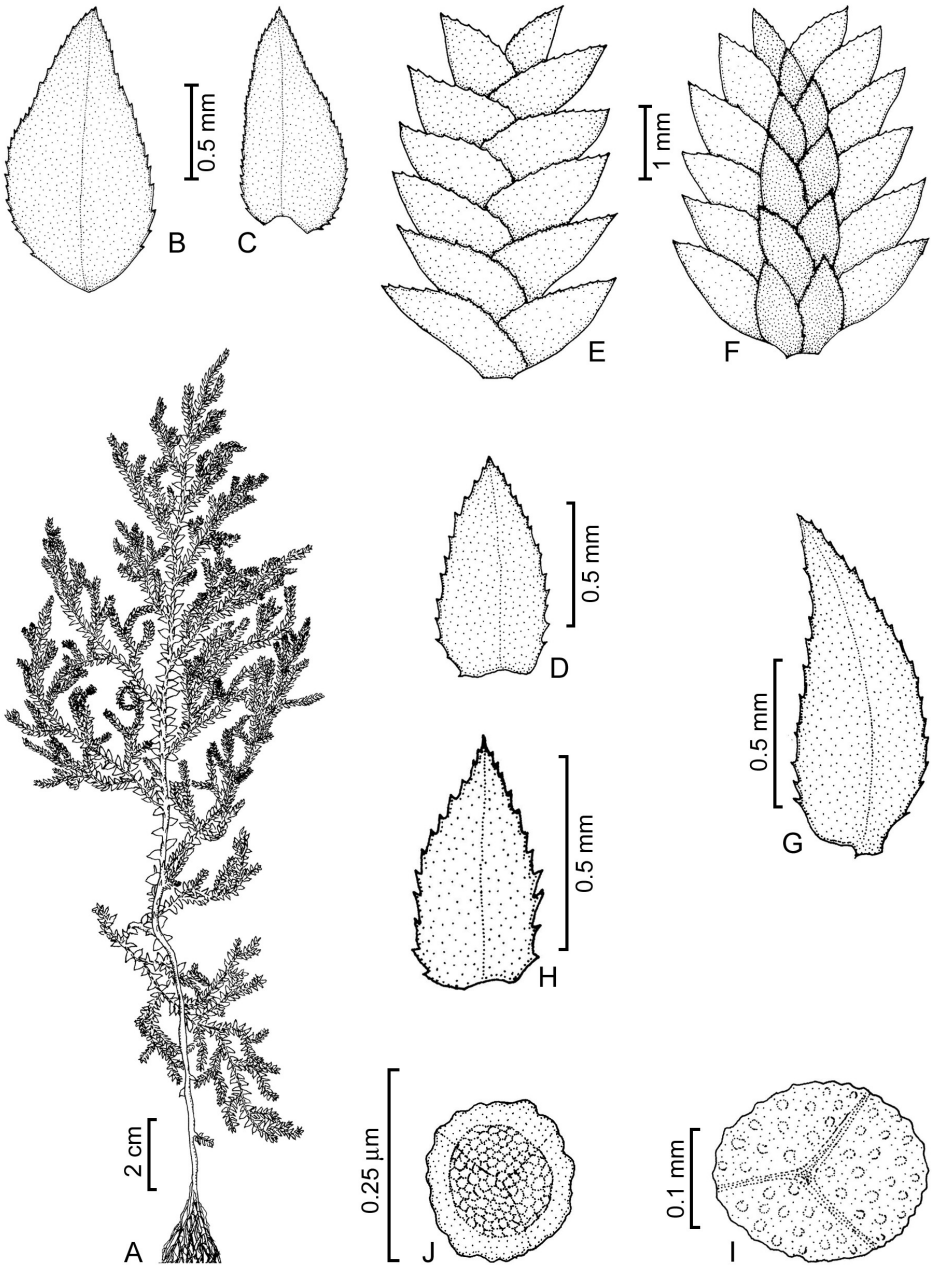


Fig. 31. *Selaginella chrysocaulos* (Hook. et Grev.) Spring: **A**. Habit; **B.** Lateral leaf; **C.** Axillary leaf; **D**. Median leaf; **E**. Strobilus – dorsal view; **F**. Strobilus – ventral view; **G.** Larger sporophyll; **H**. Smaller sporophyll; **I.** Megaspore; **J**. Microspore (from *Nisha* 1455, SJC).

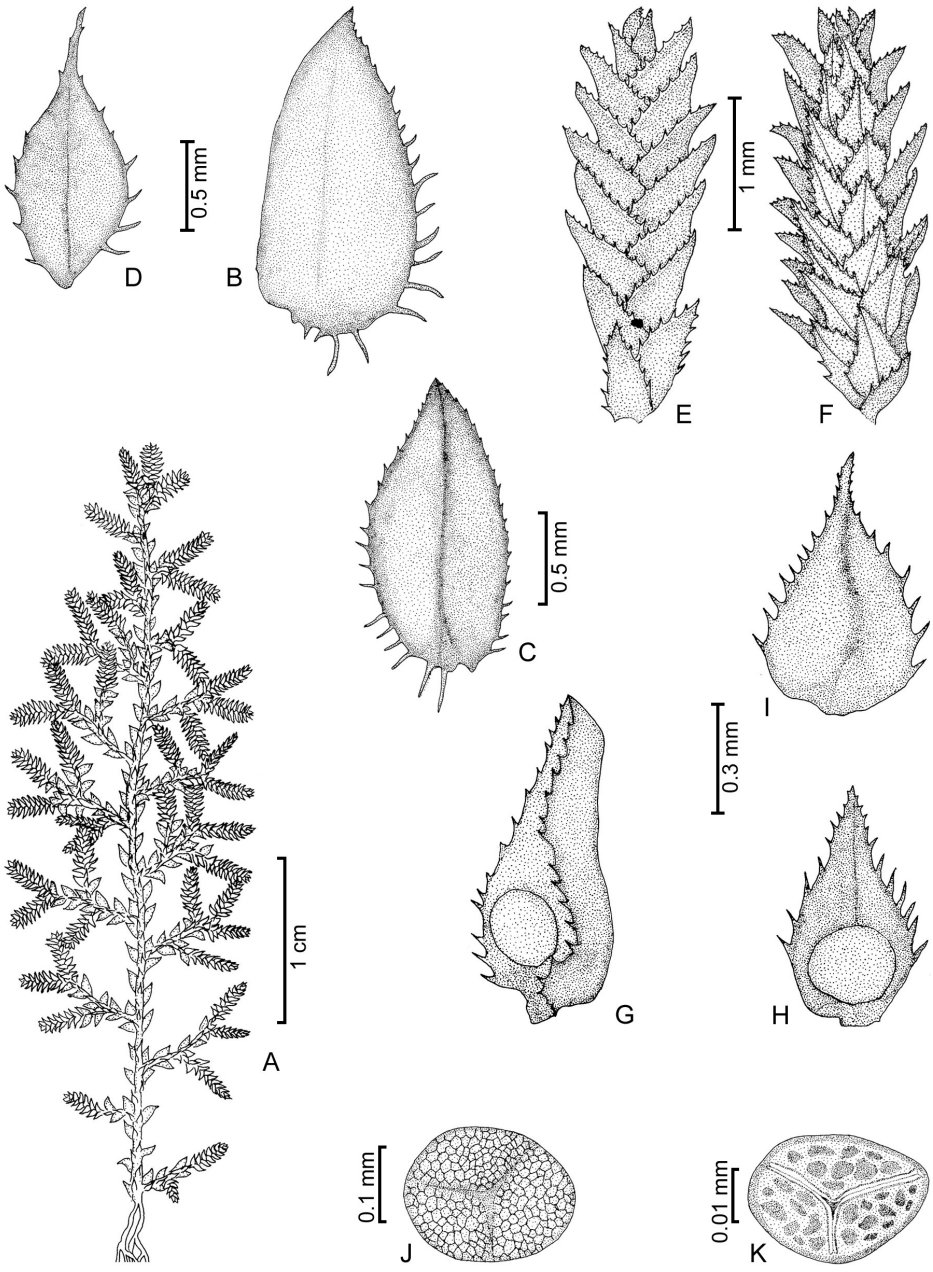


Fig. 32. *Selaginella proniflora* (Lam.) Baker, **A**. Habit; **B**. Lateral leaf; **C**.Axillary leaf; **D**. Median leaf; **E**. Strobilus – dorsal view; **F**. Strobilus – ventral view; **G**. Larger sporophyll; **H**. & **I**. Smaller sporophyll; **J**. Megaspore; **K**. Microspore (from *Nisha* 2612, SJC).

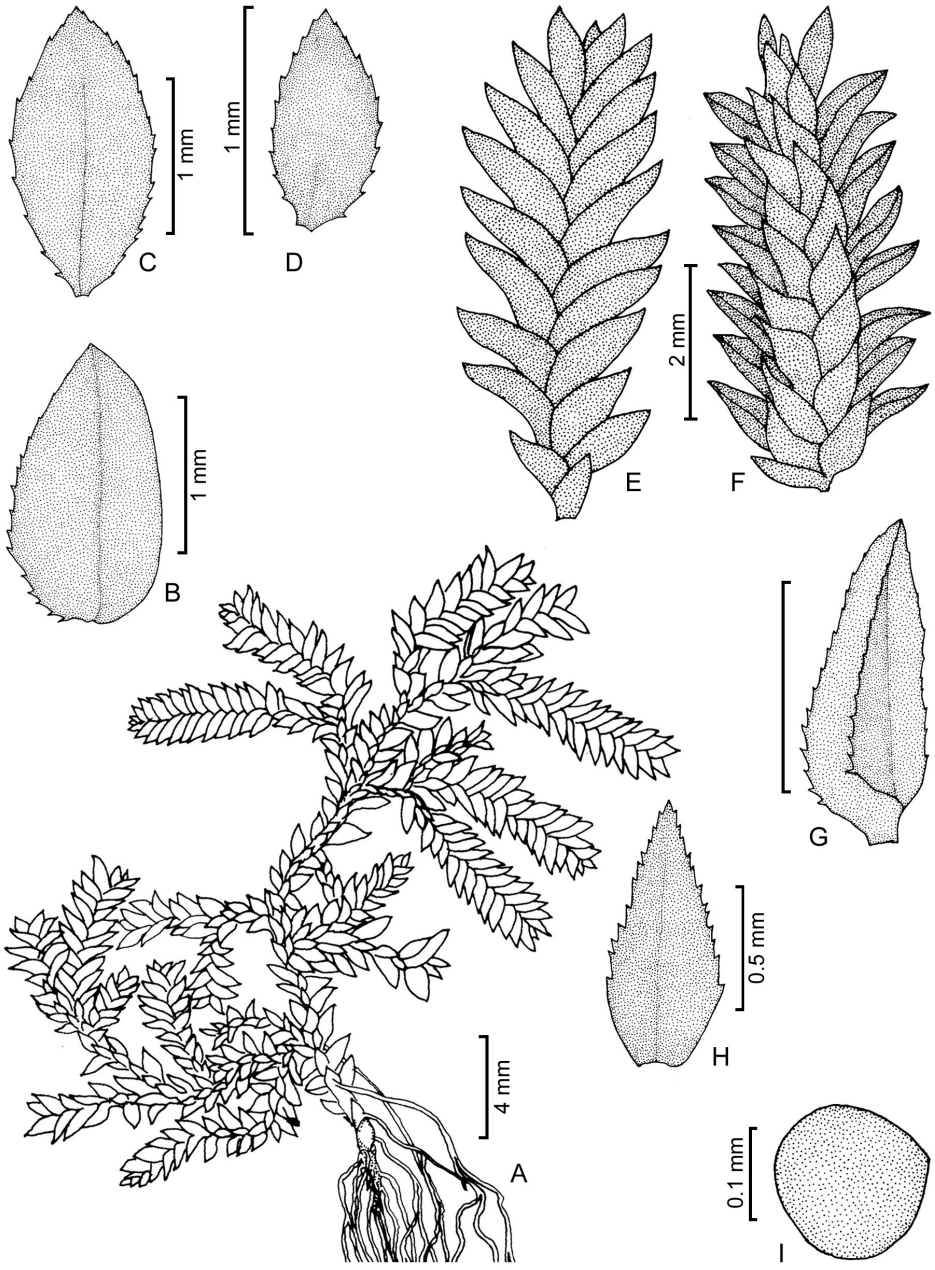


Fig. 33. *Selaginella keralensis* R.D.Dixit, **A**. Habit; **B**. Lateral leaf; **C**. Axillary leaf; **D**. Median leaf; **E**. Strobilus – dorsal view; **F**. Strobilus – ventral view; **G**. Larger sporophyll; **H**. Smaller sporophyll; **I**. Megaspore (from *Nisha* 1499, SJC).

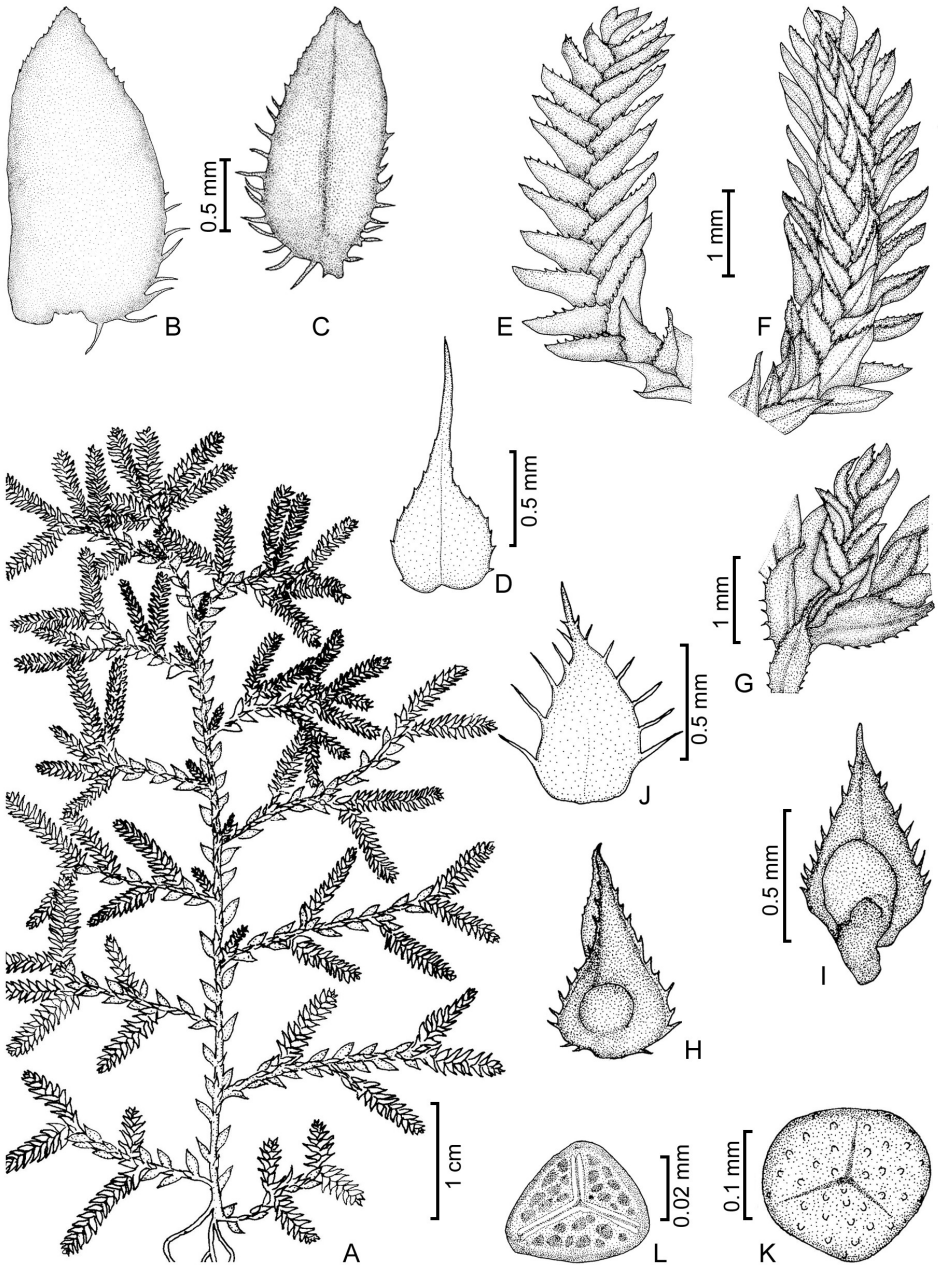


Fig. 34. *Selaginella crassipes* Spring: **A**. Habit; **B.** Lateral leaf; **C.** Axillary leaf; **D**. Median leaf; **E**. Strobilus – dorsal view; **F**. Strobilus – ventral view; **G**. Axillary strobilus; **H. & I.** Larger sporophyll; **J**. Smaller sporophyll; **K**. Megaspore; **L**. Microspore (from *Nisha* 521, SJC).

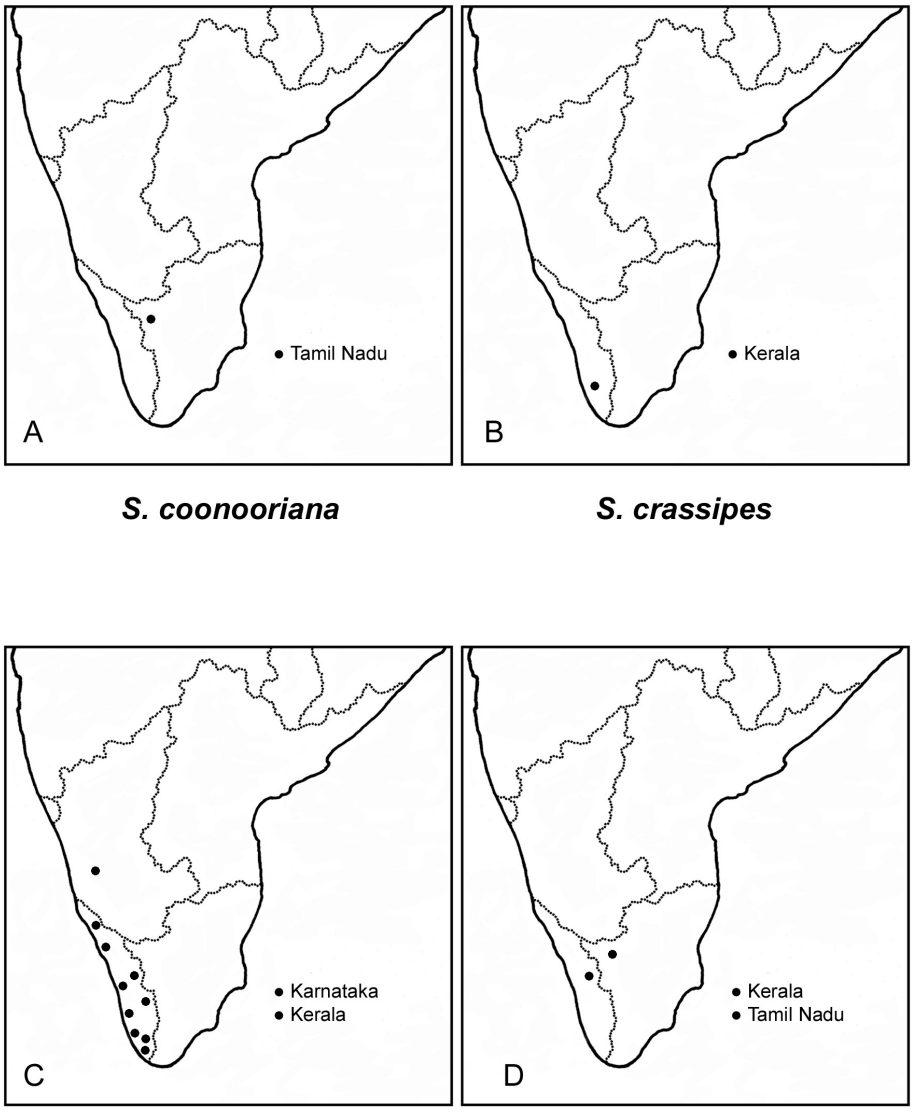


Fig. 35. Distribution maps of species of *Selaginella*

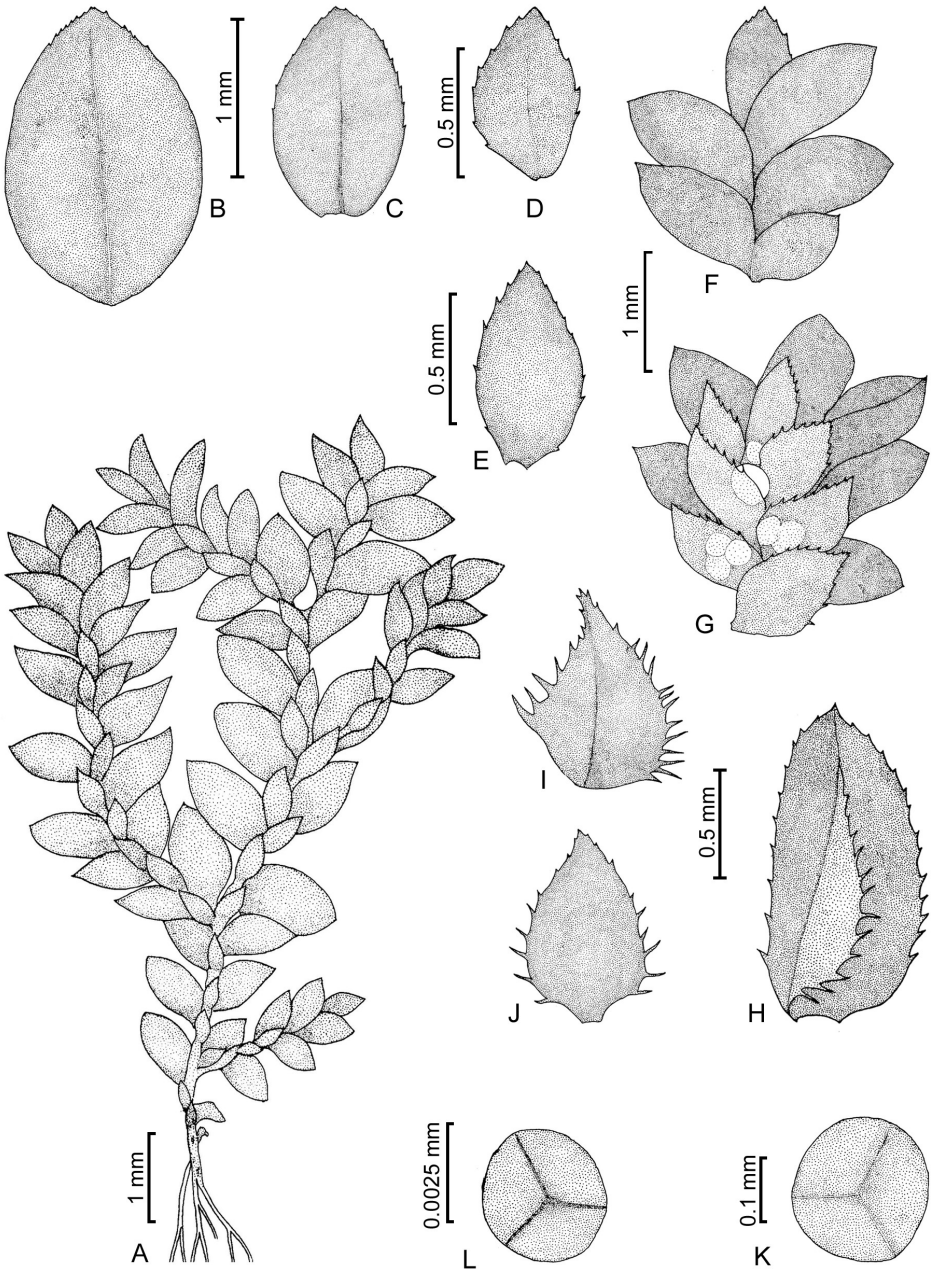
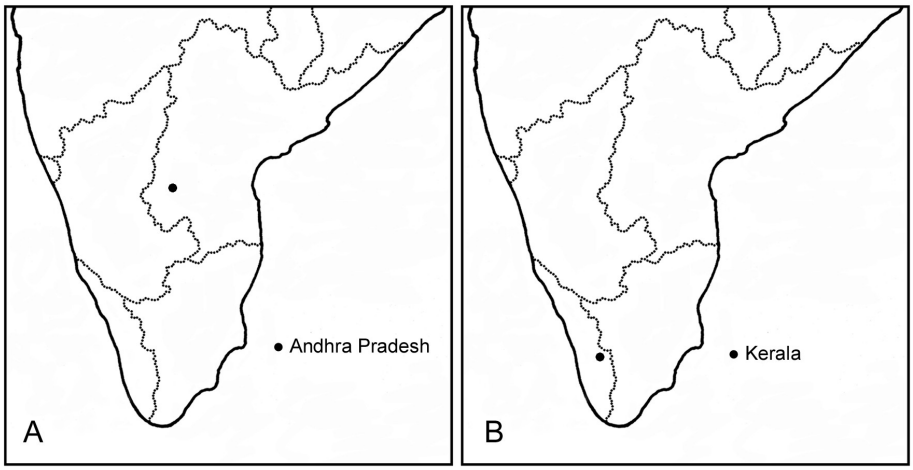
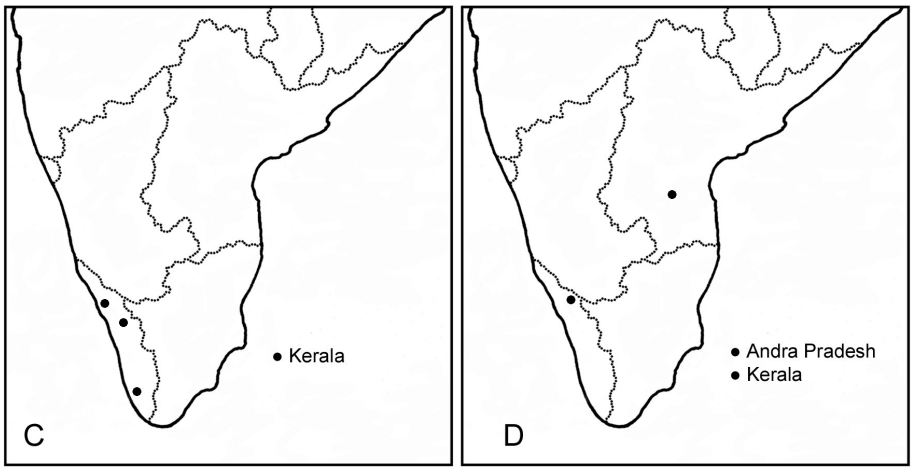


Fig. 36. *Selaginella nairii* R.D.Dixit: **A**. Habit; **B**. Lateral leaf; **C**. Axillary leaf; **D**. & **E**. Median leaf; **F**. Strobilus – dorsal view; **G**. Strobilus – ventral view; **H**. Larger sporophyll; **I**. & **J**. Smaller sporophyll; **K**. Megaspore; **L**. Microspore (from *Nisha* 1493, SJC).



S. nairii ***S. nayarii***



S. plana ***S. plumosa***

Fig. 37. Distribution maps of species of *Selaginella*

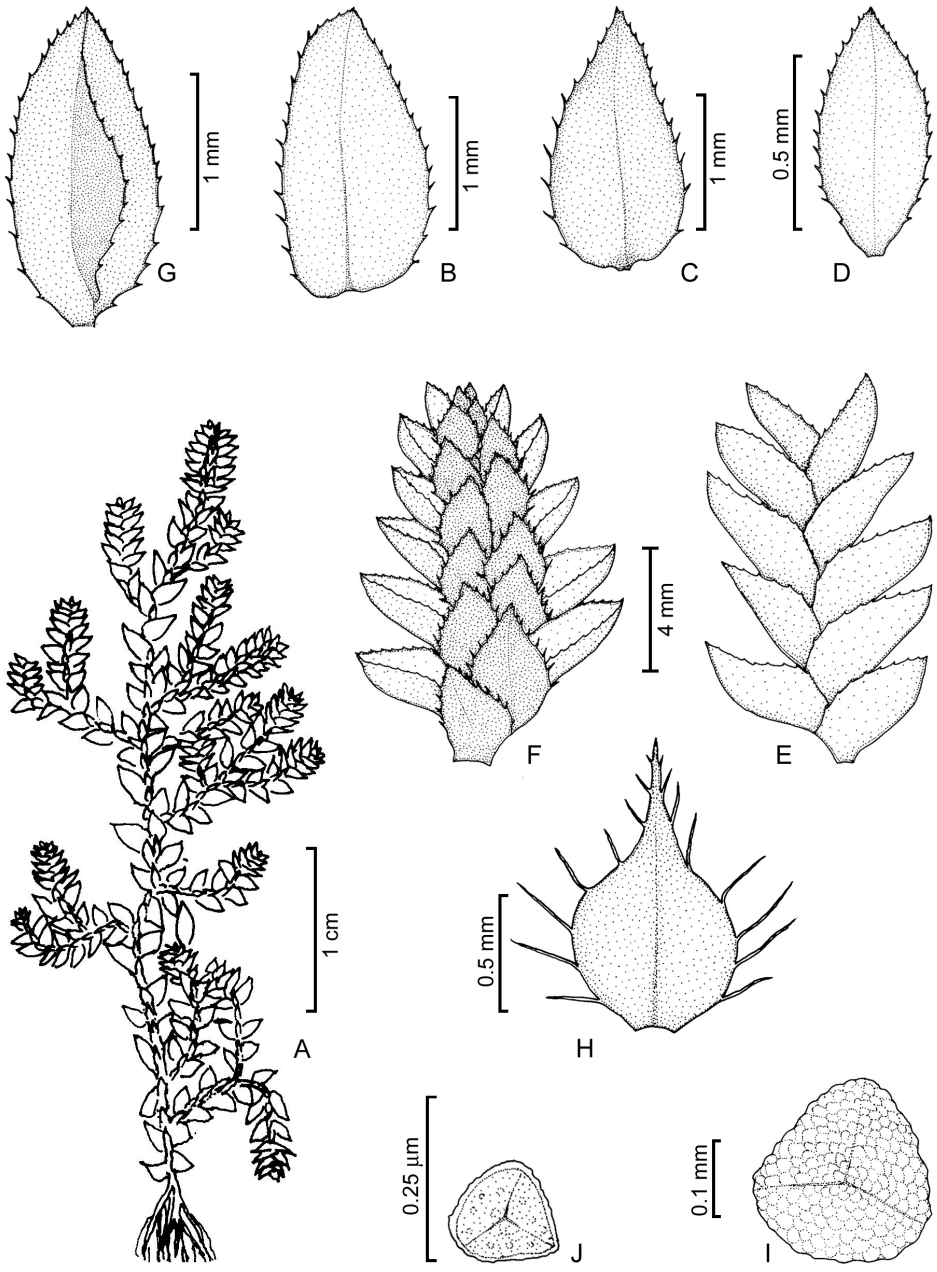


Fig. 38. *Selaginella minutifolia* Spring: **A**. Habit; **B**. Lateral leaf; **C**. Axillary leaf; **D**. Median leaf; **E**. Strobilus – dorsal view; **F**. Strobilus – ventral view; **G**. Larger sporophyll; **H**. Smaller sporophyll; **I**. Megaspore; **J**. Microspore. (from *Nair* 818, CAL).

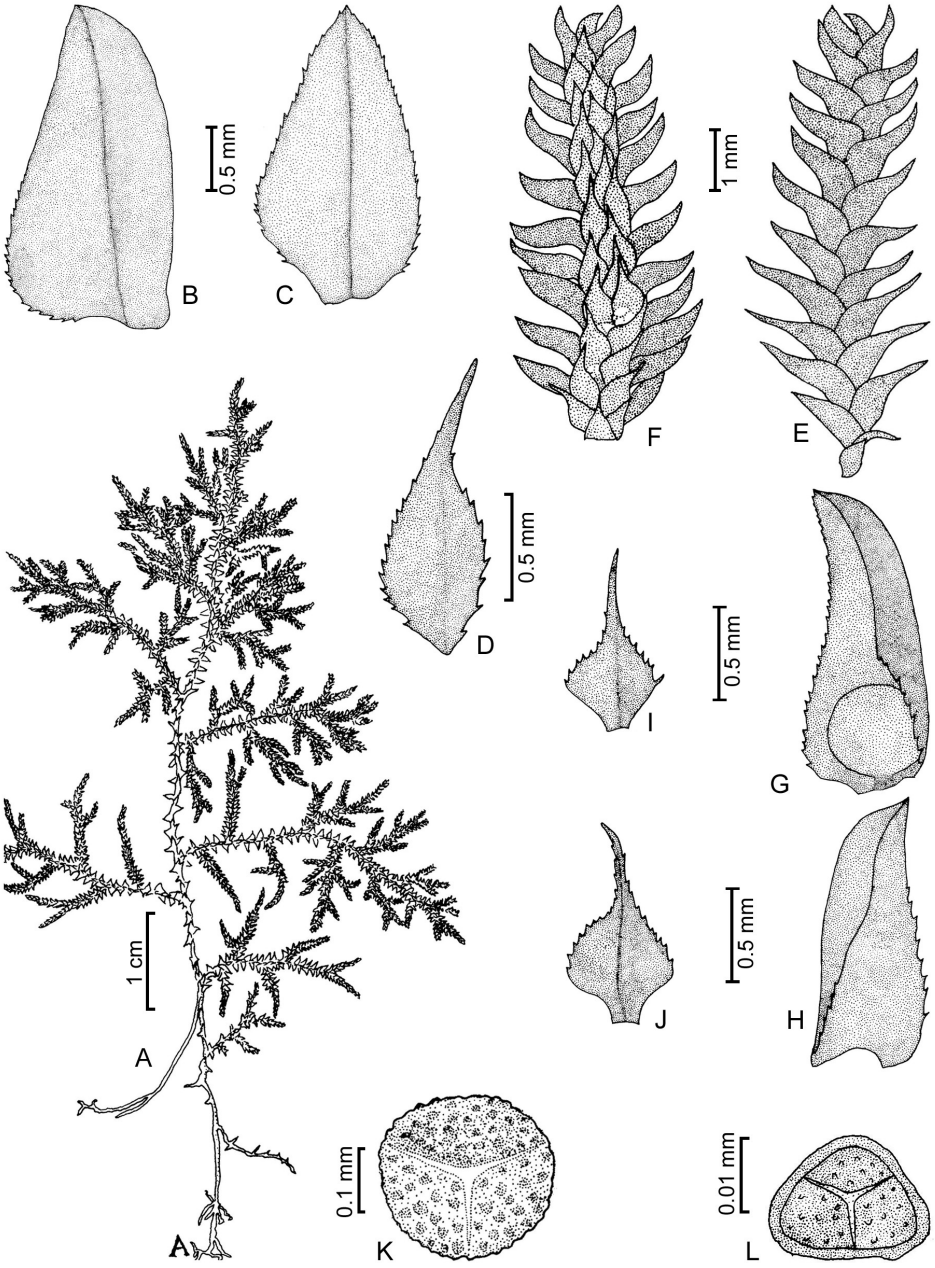


Fig. 39. *Selaginella tenera* (Hook. & Grev.) Spring: **A**. Habit; **B**. Lateral leaf; **C**. Axillary leaf; **D**. Median leaf;**E**. Strobilus – dorsal view; **F**. Strobilus – ventral view; **G**. & **H**. Larger sporophyll; I. & **J**. Smaller sporophyll; **K**. Megaspore; **L**. Microspore. (from Nisha 569 SJC).

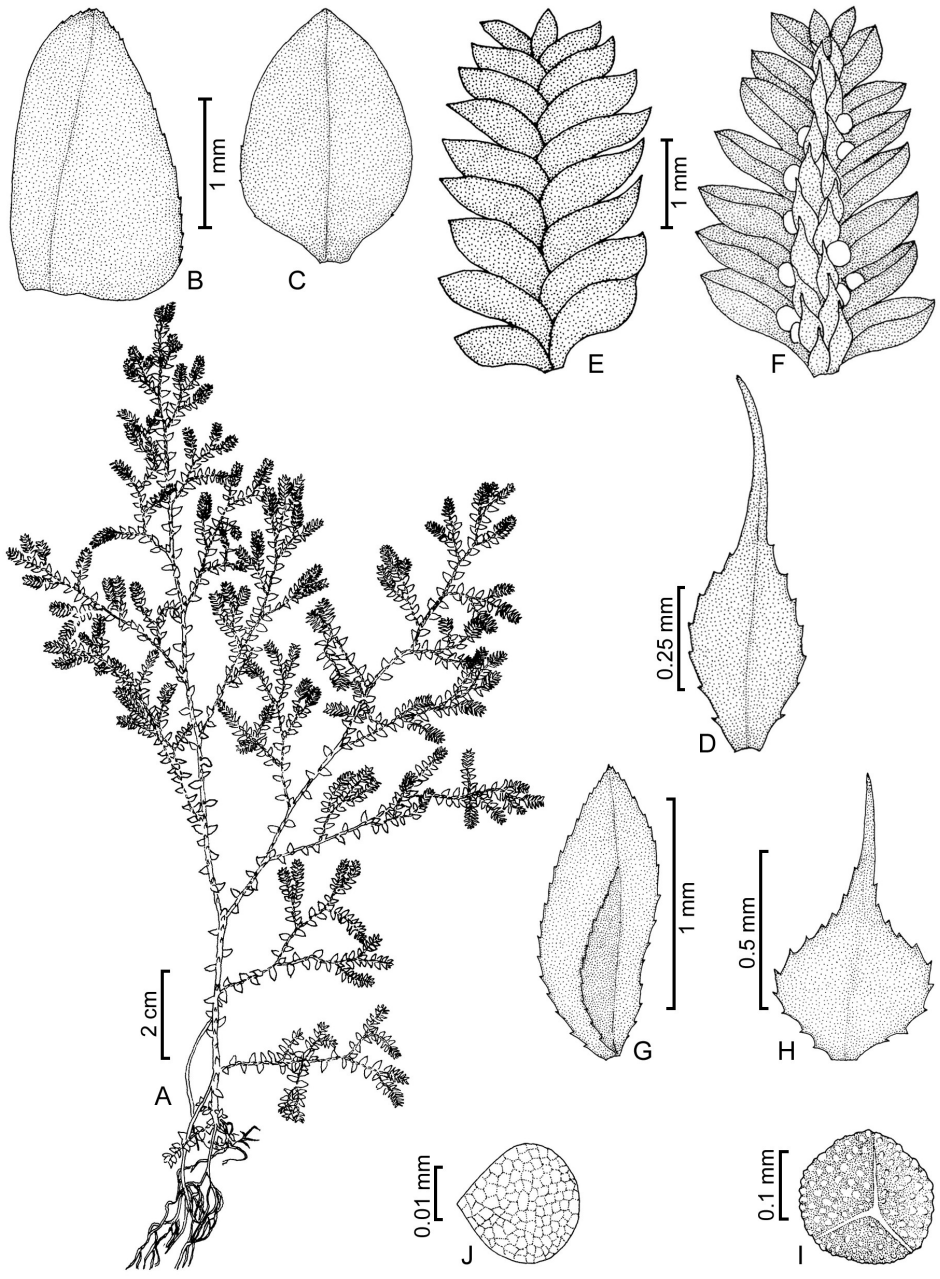


Fig. 40. *Selaginella miniatospora* (Dalz.) Baker: **A**. Habit; **B**. Lateral leaf; **C**. Axillary leaf; **D**. Median leaf; **E**. Strobilus – dorsal view; **F**. Strobilus – ventral view; **G**. Larger sporophyll; **H**. Smaller sporophyll; **I**. Megaspore; **J**. Microspore (from *Nisha* 1443, SJC).

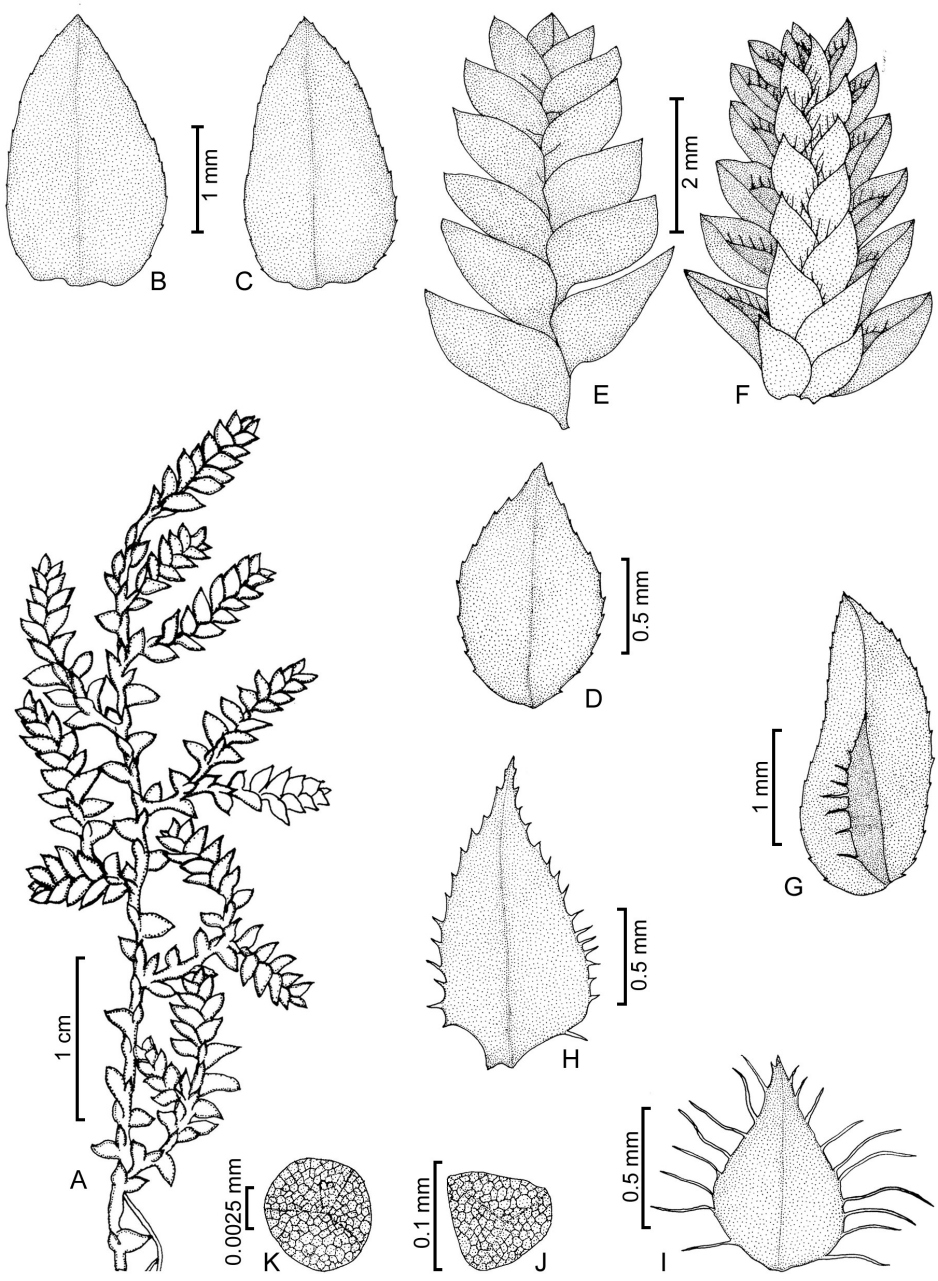


Fig. 41. ***Selaginella camusii*** Raju *et al.*, **A**. Habit; **B**. Lateral leaf; **C**. Axillary leaf; **D**. Median leaf; **E**. Strobilus – dorsal view; **F**. Strobilus – ventral view; **G**. & **H**. Larger sporophyll; **I**. Smaller sporophyll; **J**. Megaspore; **K**. Microspore. (from *Raju* 25581, CALI).

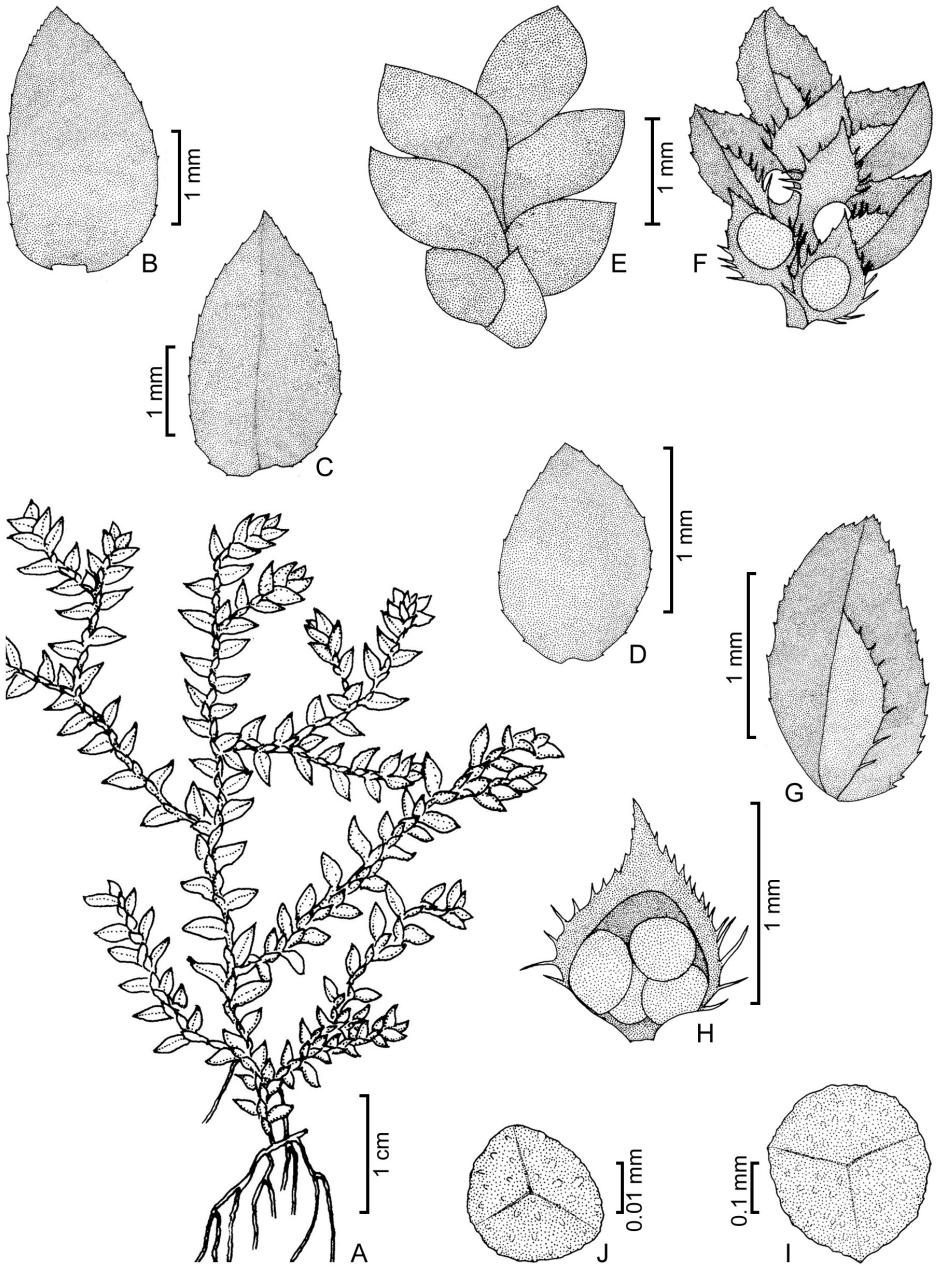


Fig. 42. *Selaginella coonooriana* R.D.Dixit: **A**. Habit; **B**. Lateral leaf; **C**. Axillary leaf; **D**. Median leaf; **E**. Strobilus – dorsal view; **F**. Strobilus – ventral view; **G**. Larger sporophyll; **H**. Smaller sporophyll; **I.** Megaspore; **J**. Microspore (from *Nisha* 149, SJC).

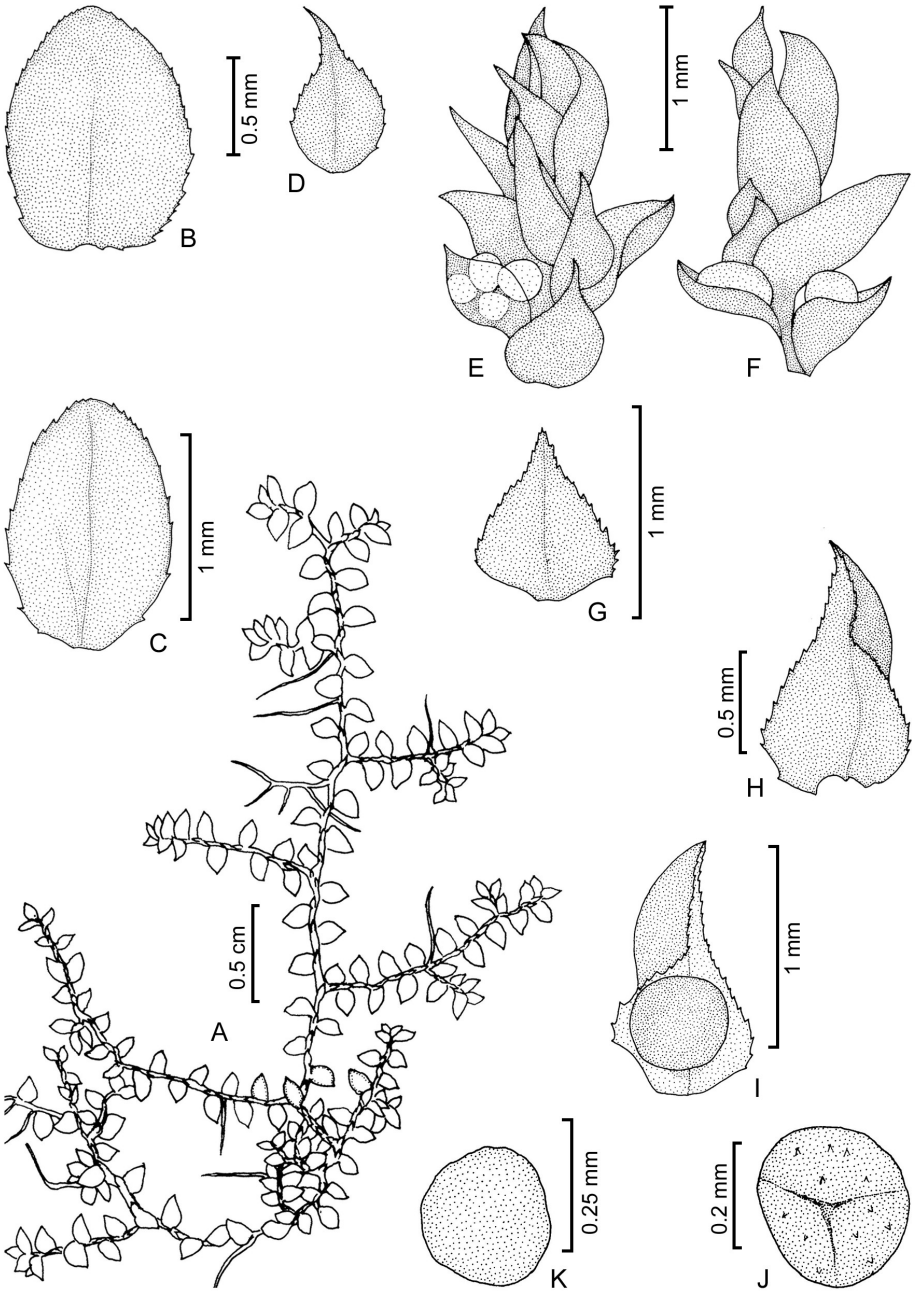
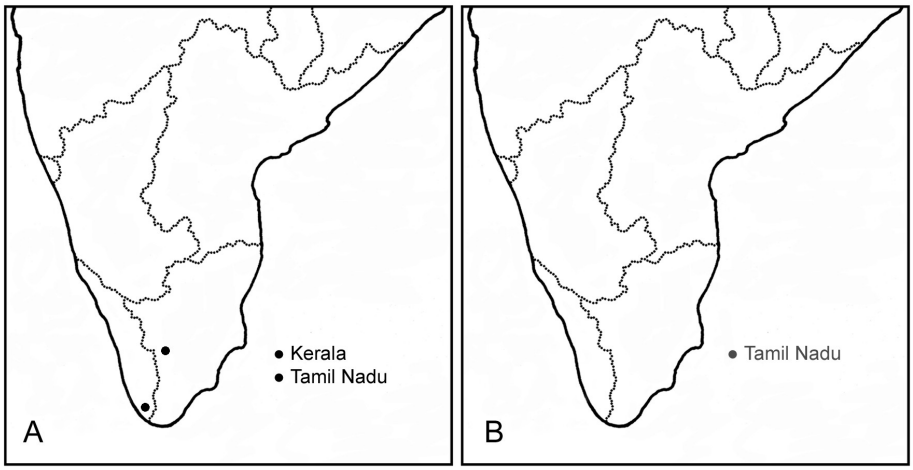
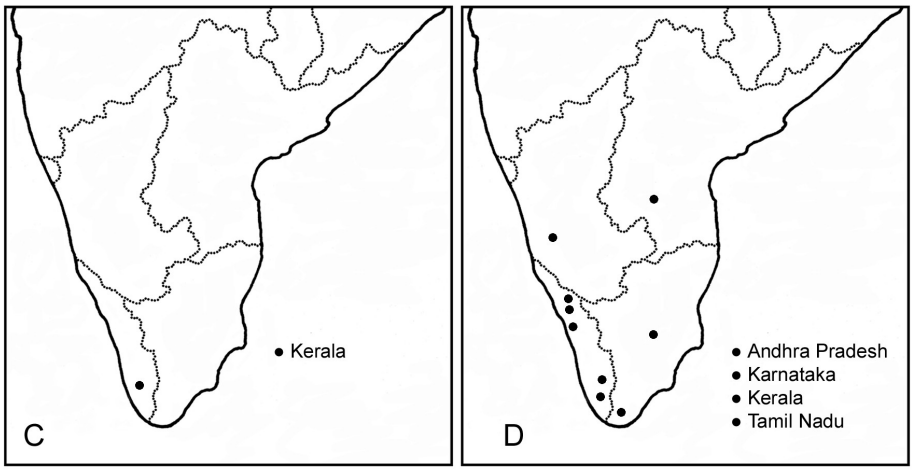


Fig. 43. ***Selaginella cataractarum*** Alston: **A.** Habit; **B.** Lateral leaf; **C.** Axillary leaf; **D.** Median leaf; **E.** Strobilus – dorsal view; **F.** Strobilus – ventral view; **G, H. & I.** Larger sporophyll; **J**. Megaspore; **K.** Microspore (from *Sanoj* 1498, SJC).



S. cataractarum ***S. chrysocaulos***



S. chrysorhizos ***S. ciliaris***

Fig. 44. Distribution maps of species of *Selaginella*

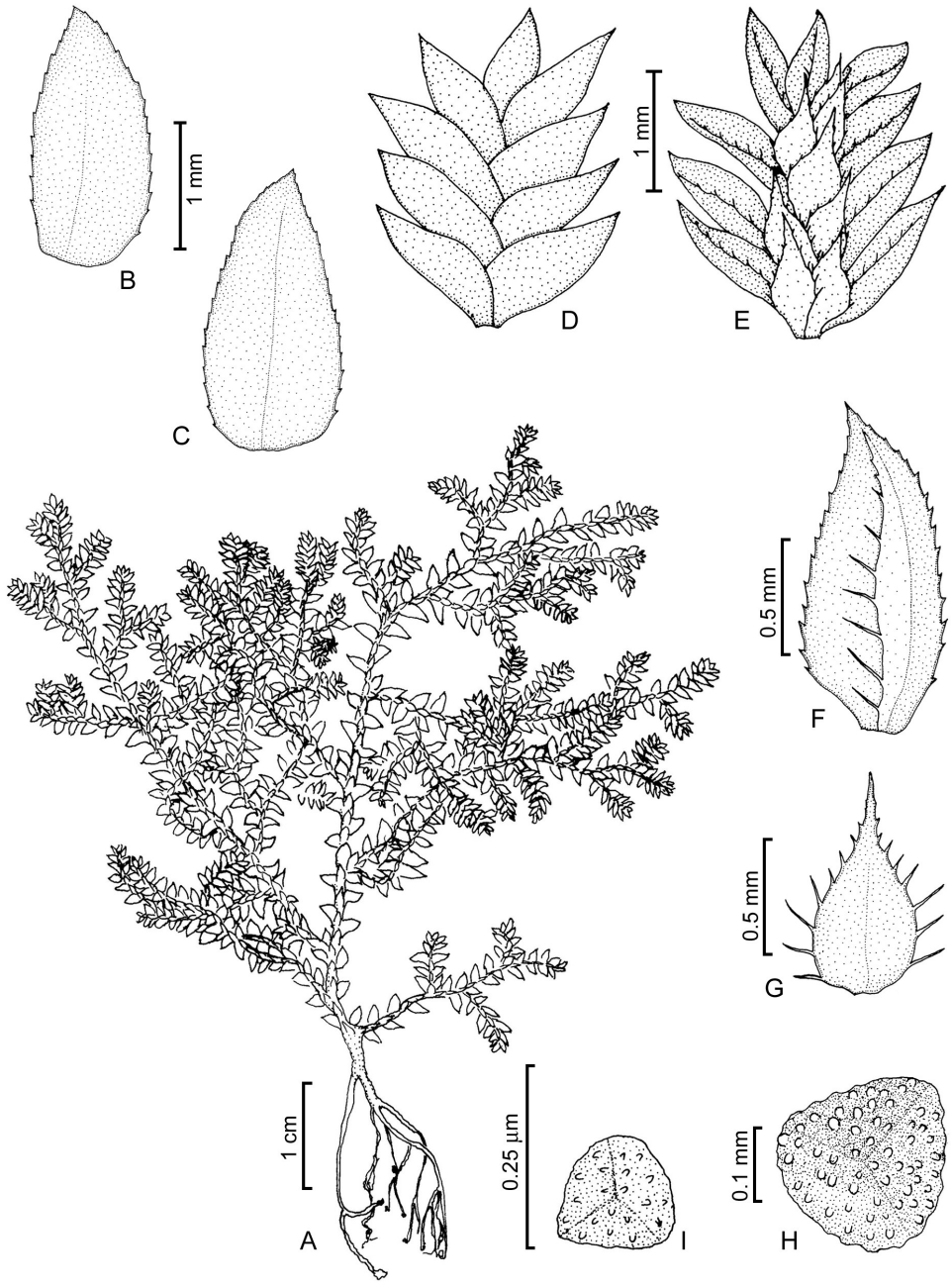


Fig. 45. *Selaginella chrysorrhizos* Spring: **A**. Habit; **B**. Lateral leaf; **C**. Median leaf; **D**. Axillary leaf; **E**. Strobilus – dorsal view; **F**. Strobilus – ventral view; **G**. Larger sporophyll; **H**. Smaller sporophyll; **I**. Megaspore; **J**. Microspore (from *Antony* 29863, TBGT).

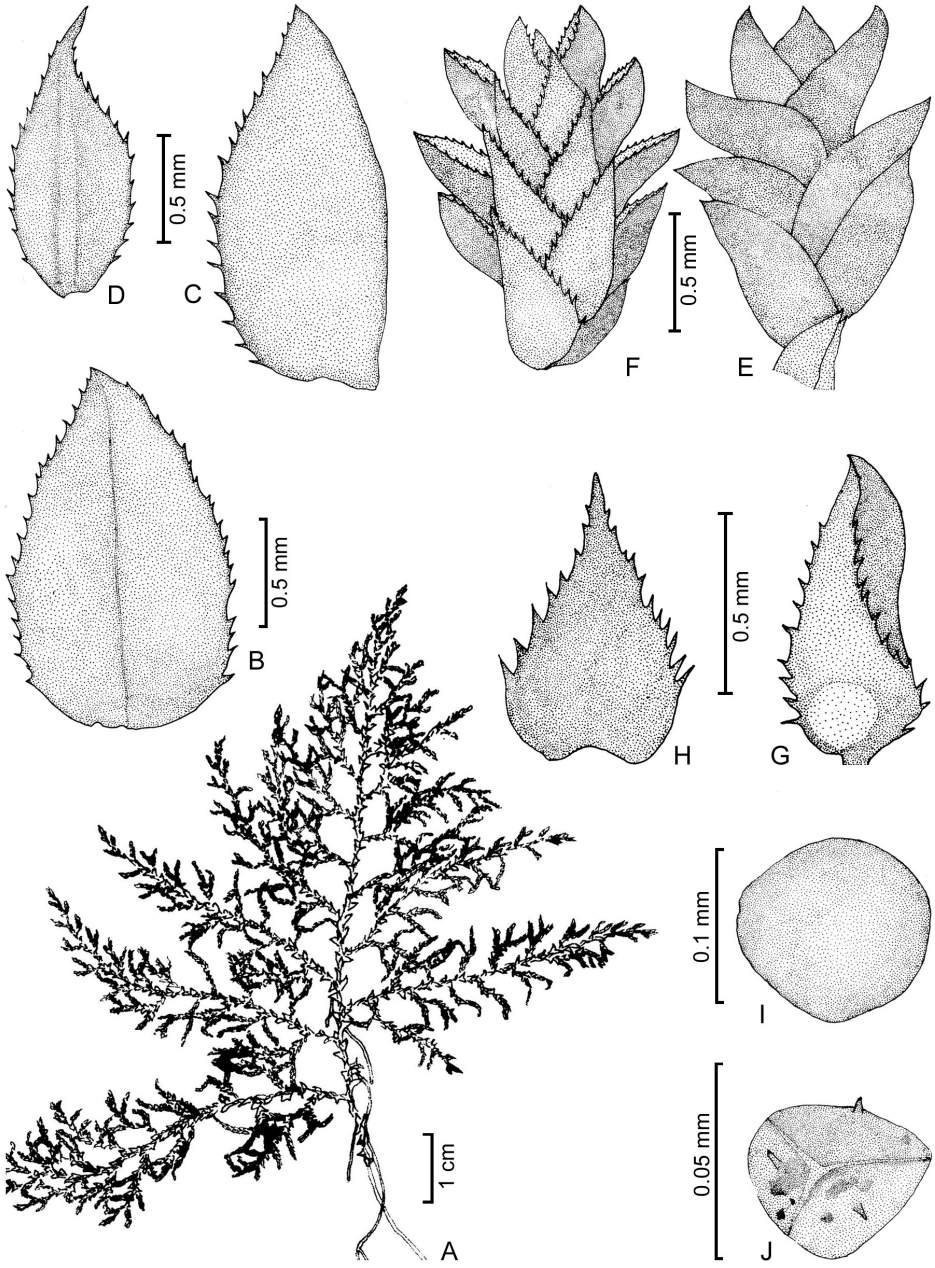


Fig. 46. *Selaginella lakkidiana* Nampy & Nisha: **A**. Habit; **B**. Lateral leaf; **C**. Median leaf; **D**. Axillary leaf; **E.** Strobilus – dorsal view; **F**. Strobilus – ventral view; **G**. Larger sporophyll; **H**. Smaller sporophyll; **I**. Megaspore; **J**. Microspore. (from *Nampy* 3, SJC).

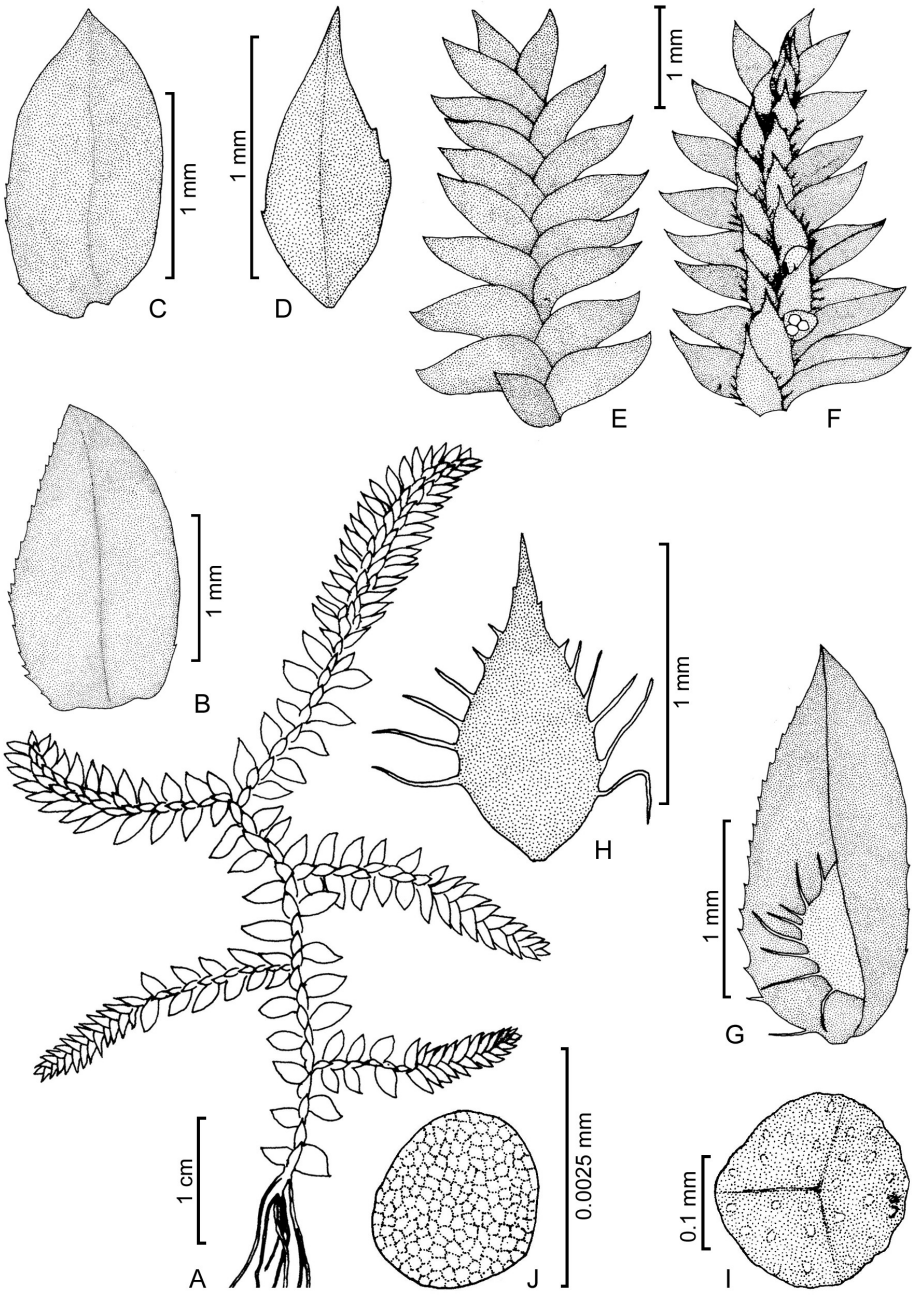


Fig:47. *Selaginella nayarii* R.D.Dixit: **A**. Habit; **B**. Lateral leaf; **C**. Median leaf; **D**. Axillary leaf; **E**. Strobilus – dorsal view; **F**. Strobilus – ventral view; **G**. Larger sporophyll; **H**. Smaller sporophyll; **I**. Megaspore; **J**. Microspore (from *Nisha* 2611, SJC).

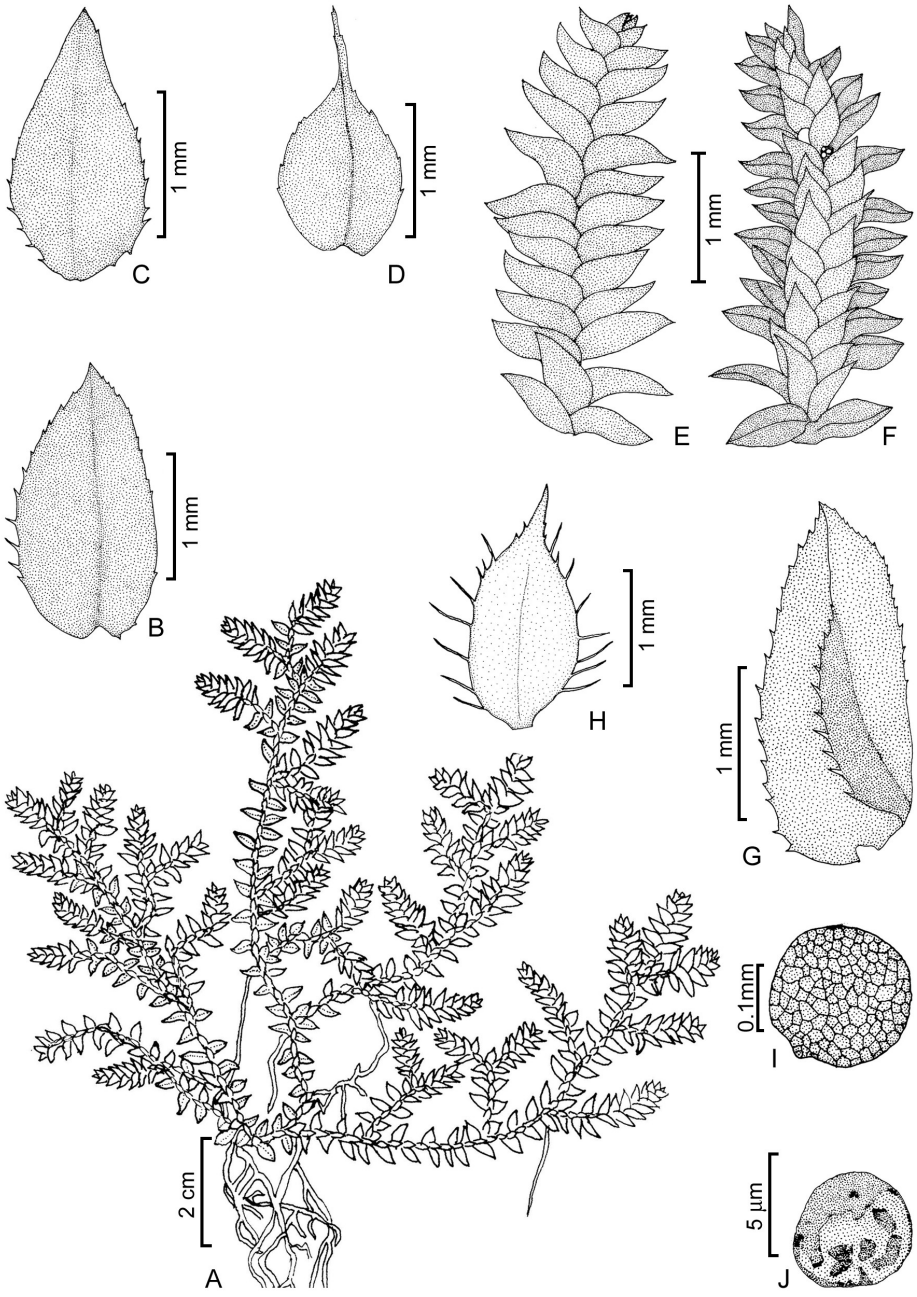


Fig. 48. *Selaginella ciliaris* (Retz.) Spring: **A**. Habit; **B**. Lateral leaf; **C**. Axillary leaf; **D**. Median leaf; **E.** Strobilus – dorsal view; **F**. Strobilus – ventral view; **G**. Larger sporophyll; **H**. Smaller sporophyll; **I**. Megaspore; **J**. Microspore (from *Nisha* 509, SJC).

Fig. 49. Scanned images of types of *Selaginella* species: **A. & B.** *Selaginella ciliaris* (Retz.) Spring; **C. & D.** *Selaginella inaequalifolia* (Hook. & Grev.) Spring

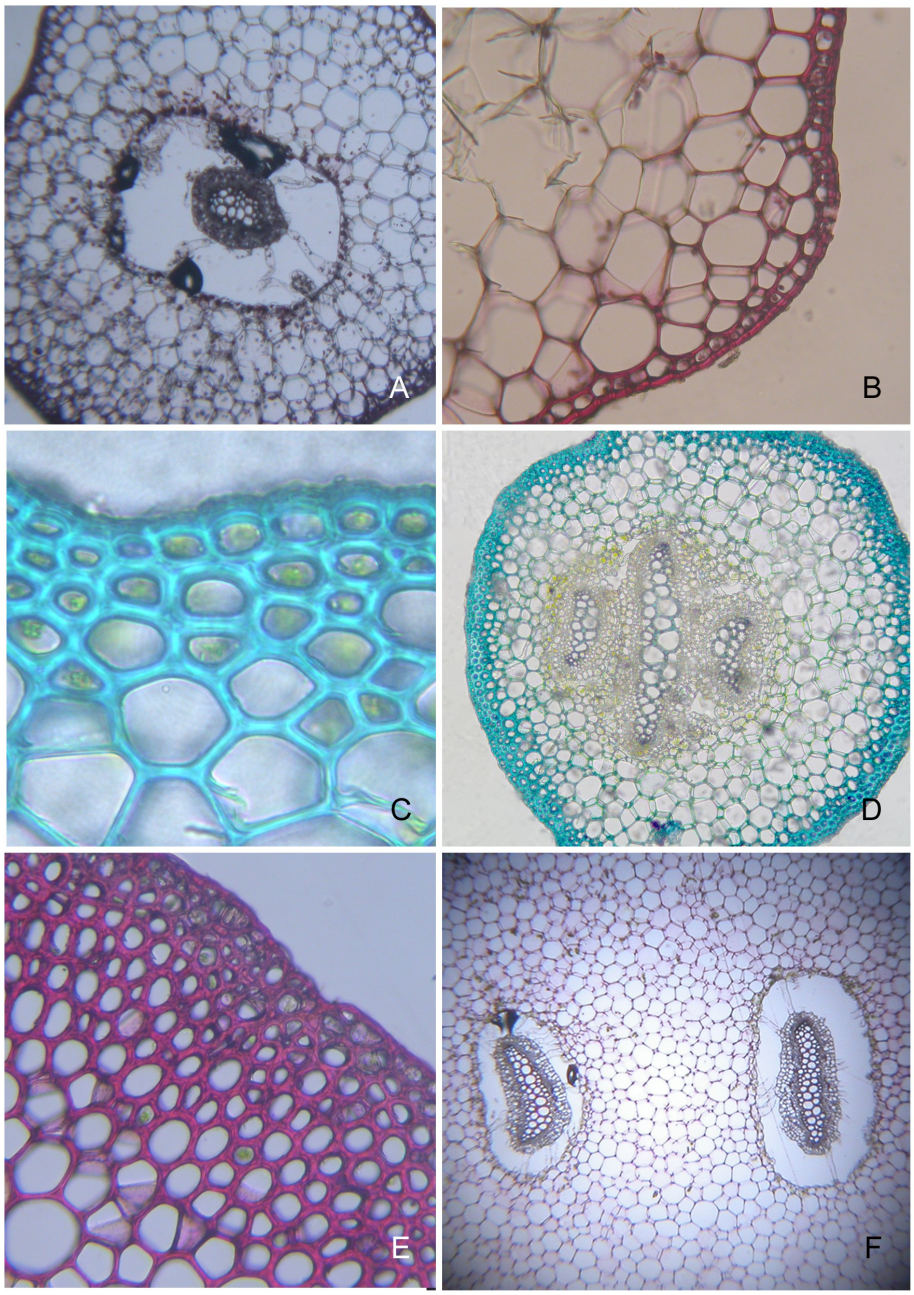


Plate 1. *Selaginella* stem T.S. **A & B**. *Selaginella tenera* (Hook. *et* Grev.) Spring*;* **C & D.** *Selaginella wildenovii* (Desv. *ex* Poir.) Baker; **E.** *Selaginella inaequalifolia* (Hook. & Grev.) Spring*;* **F.** *Selaginella plana* (Desv. *ex* Poir.) Hieron.

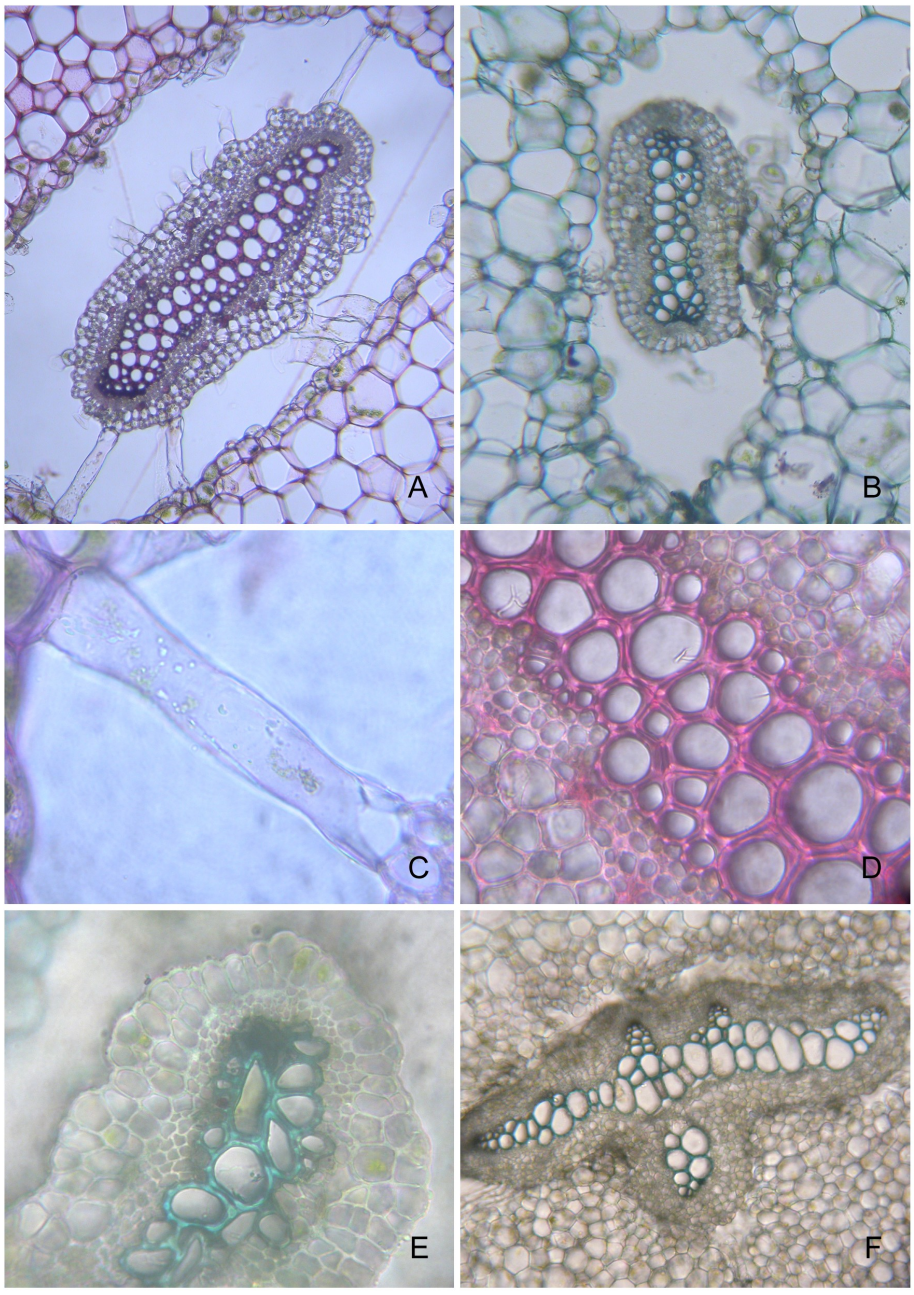


Plate 2. *Selaginella* stem T.S. *Selaginella plana* (Desv. *ex* Poir.) Hieron. **A & B** . Stele enlarged; **C.** Trabeculae*;* **D.** *Selaginella wildenovii* (Desv. *ex* Poir.) Baker, Stele enlarged; **E & F.** *Selaginella inaequalifolia* (Hook. & Grev.) Spring*;* Stele enlarged**.**

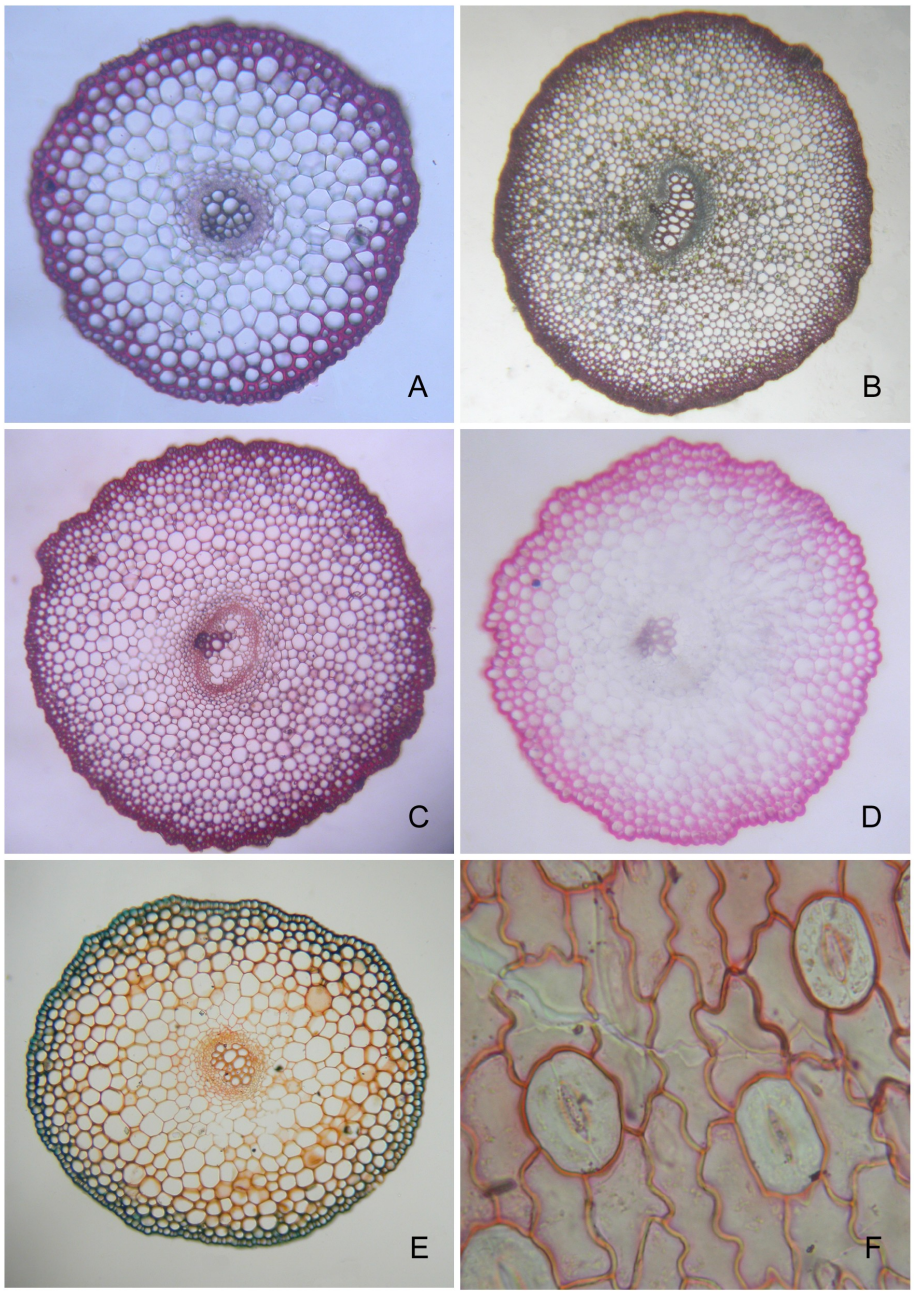
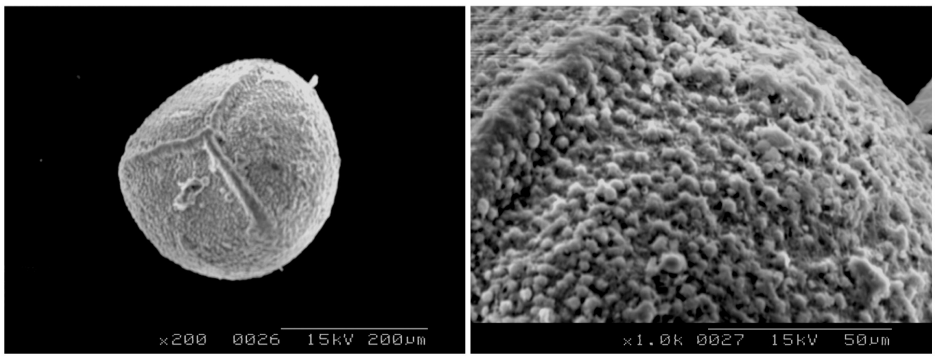
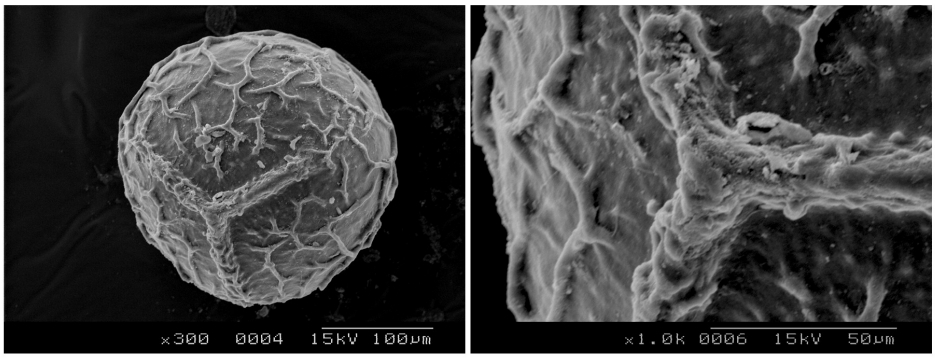


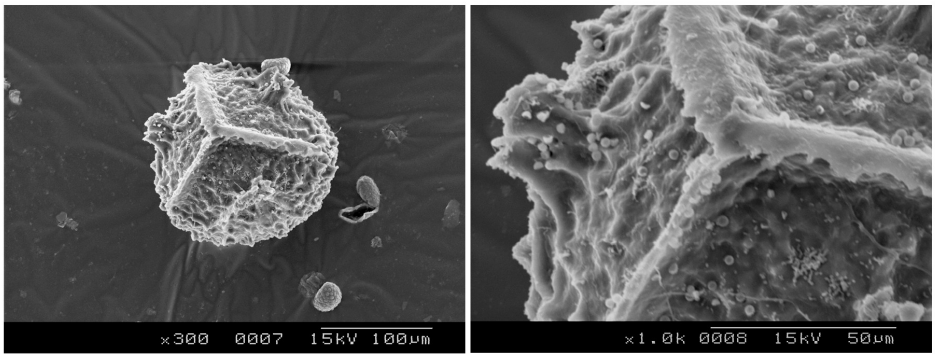
Plate 3. *Selaginella* root T.S. **A.** *Selaginella delicatula* (Desv.) Alston**; B.** *Selaginella inaequalifolia* (Hook. & Grev.) Spring*;* **C.** *Selaginella plana* (Desv. *ex* Poir.) Hieron.*;* **D.** *Selaginella radicata* (Hook. & Grev.) Spring; **E.** *Selaginella tenera* (Hook. *et* Grev.) Spring; **F.** Stomata.



A. *Selaginella brachystachya* (Hook. & Grev.) Spring

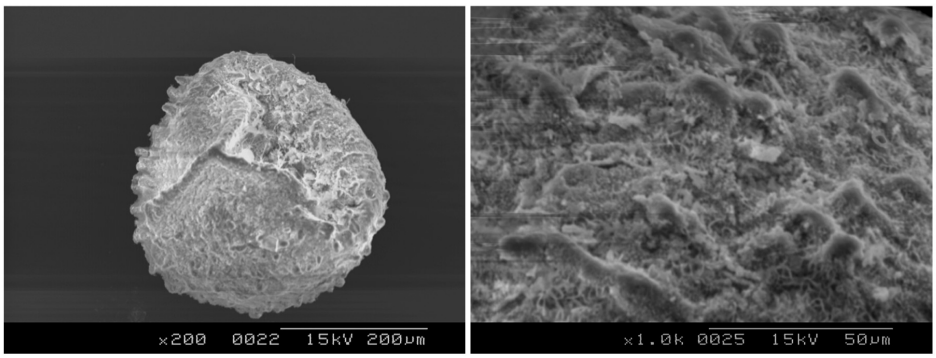


B. *Selaginella ciliaris* (Retz.) Spring

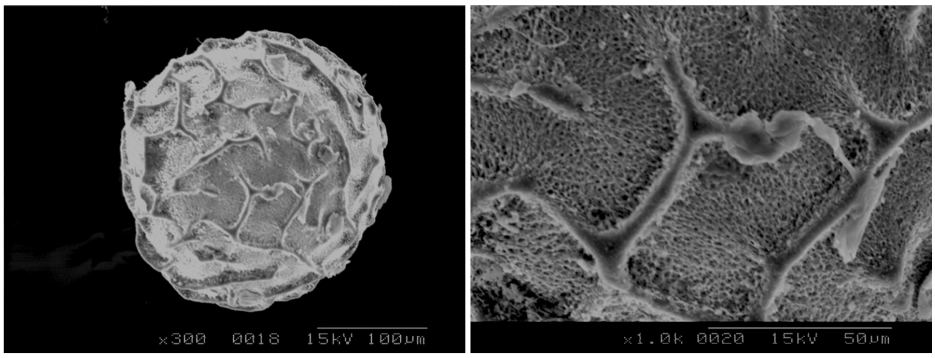


C. *Selaginella crassipes* Spring

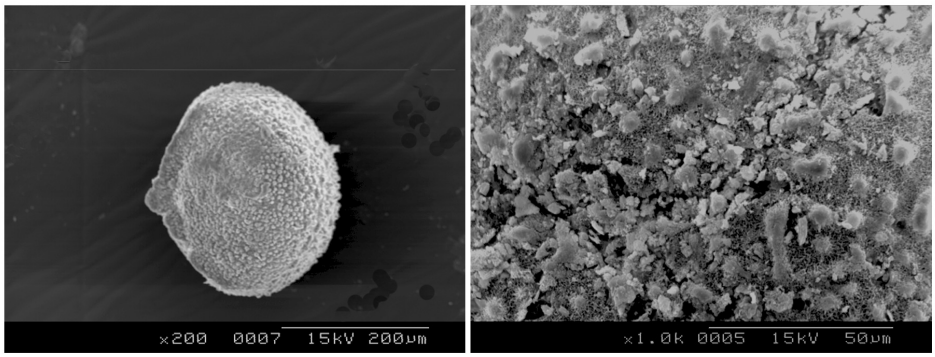
Plate 4. Scanning Electron Micrographs of Megaspores of *Selaginella* species



A. *Selaginella delicatula* (Desv.) Alston

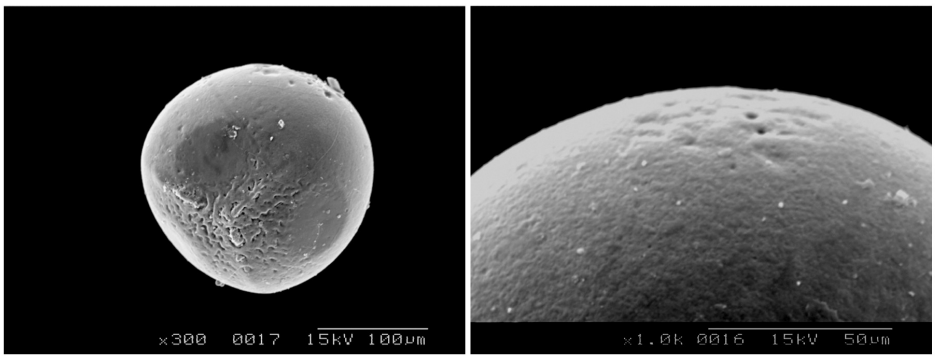


B. *Selaginella ganguliana* Dixit

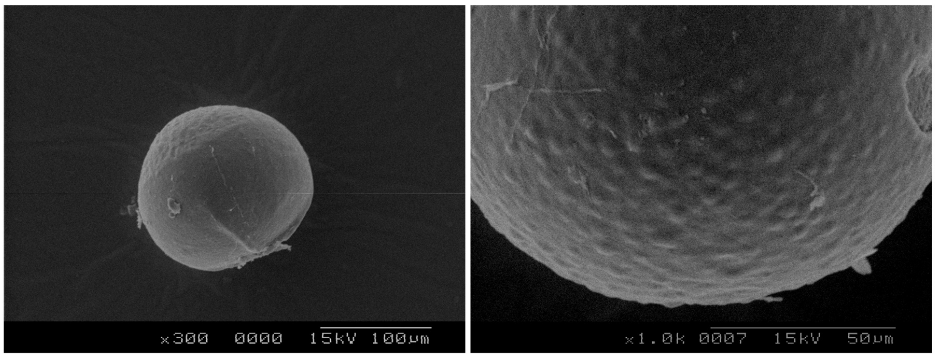


C. *Selaginella monospora* Spring

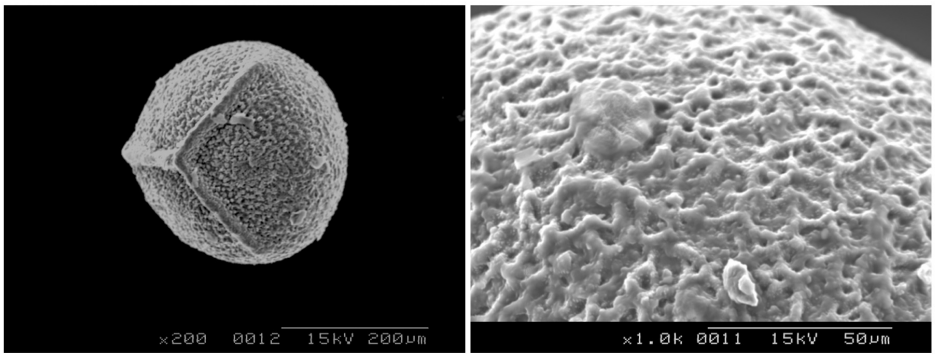
Plate 5. Scanning Electron Micrographs of Megaspores of *Selaginella* species



A. *Selaginella nairii* Dixit

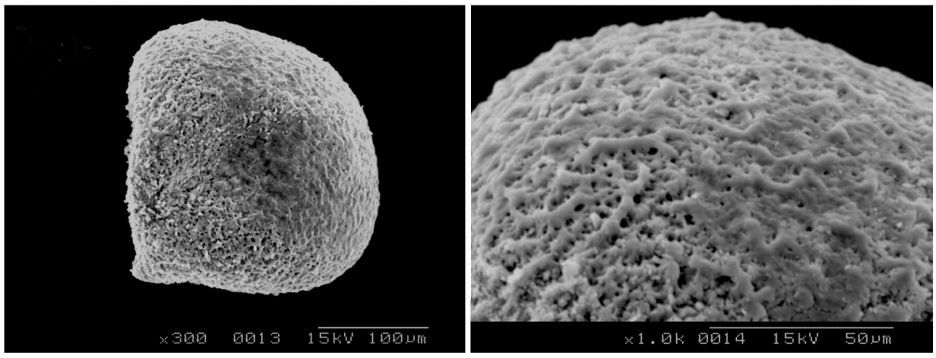


B. *Selaginella proniflora* (Lam.) Baker

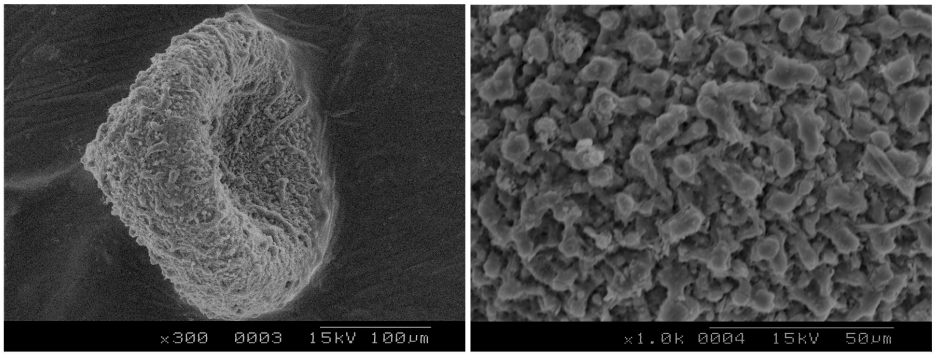


C. *Selaginella radicata* (Hook. & Grev.) Spring

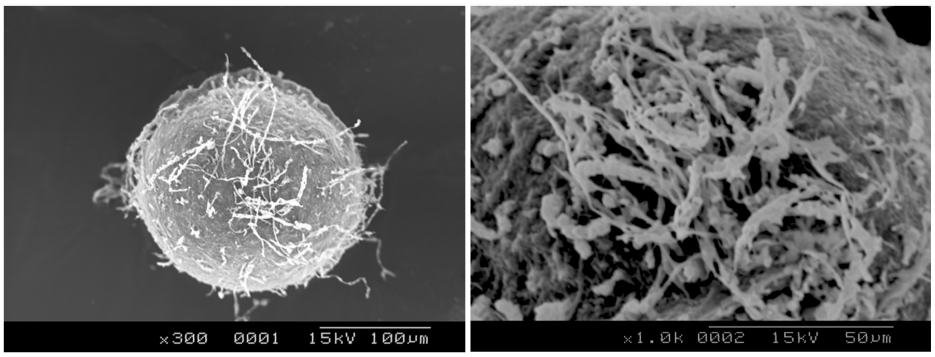
Plate 6. Scanning Electron Micrographs of Megaspores of *Selaginella* species



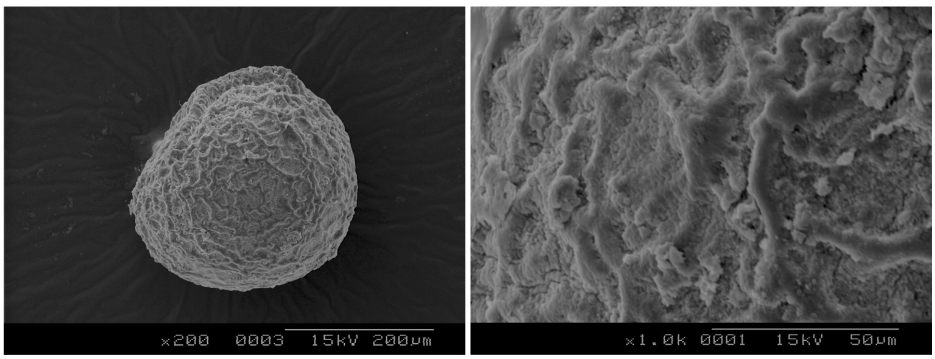
A. *Selaginella repanda* (Desv. ex Poir.) Spring



B. *Selaginella tenera* (Hook. & Grev.) Spring



C. *Selaginella vaginata* Spring



D. *Selaginella wightii* Hieron.

Plate 7. Scanning Electron Micrographs of Megaspores of *Selaginella* species

Plate 8. A, B & C. *Selaginella integerrima* (Hook. *et* Grev.) Spring; **D, E & F.** *Selaginella intermedia* (Blume) Spring

Plate 9. A & B. *Selaginella vaginata* Spring; **C & D.** *Selaginella wightii* Hieron.; **E & F.** *Selaginella wildenovii* (Desv. *ex* Poir.) Baker

Plate 10. A & B. *Selaginella involvens* (Sw.) Spring; **C & D.** *Selaginella keralensis* Dixit; **E & F.** *Selaginella lakkidiana* Nampy & Nisha

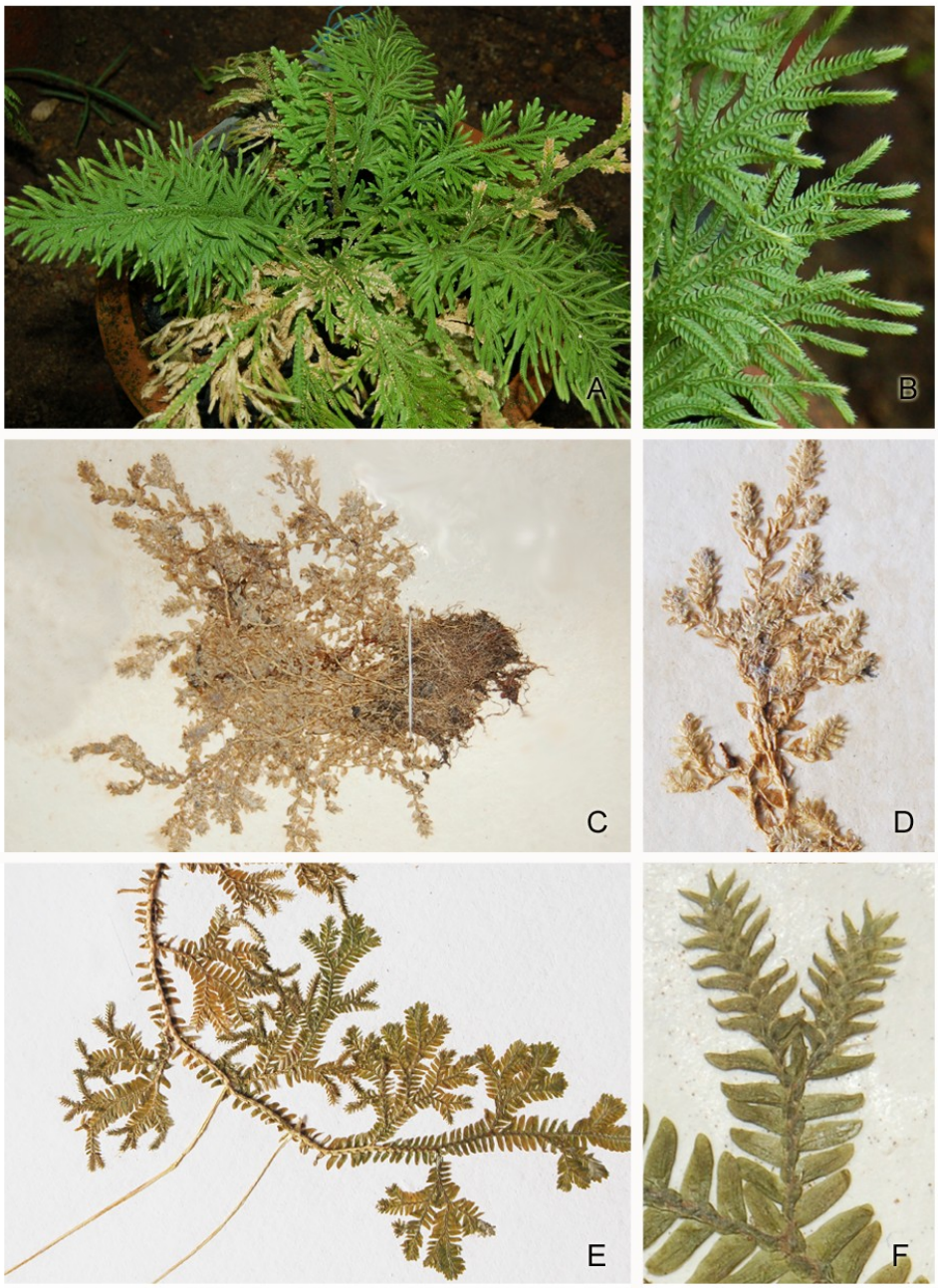


Plate 11. A & B. *Selaginella microdendron* Baker; **C & D.** *Selaginella minutifolia* Spring; **E & F.** *Selaginella monospora* Spring

Plate 12. A & B. *Selaginella repanda* (Desv. ex Poir.) Spring; **C & D**. *Selaginella tenera* (Hook. & Grev.) Spring; **E & F.** *Selaginella uncinata* (Desv. ex Poir.) Spring

Plate. 13. A & B. *Selaginella ganguliana* Dixit; **C & D.** *Selaginella gracilis* Moore; **E & F.** *Selaginella inaequalifolia* (Hook. & Grev.) Spring

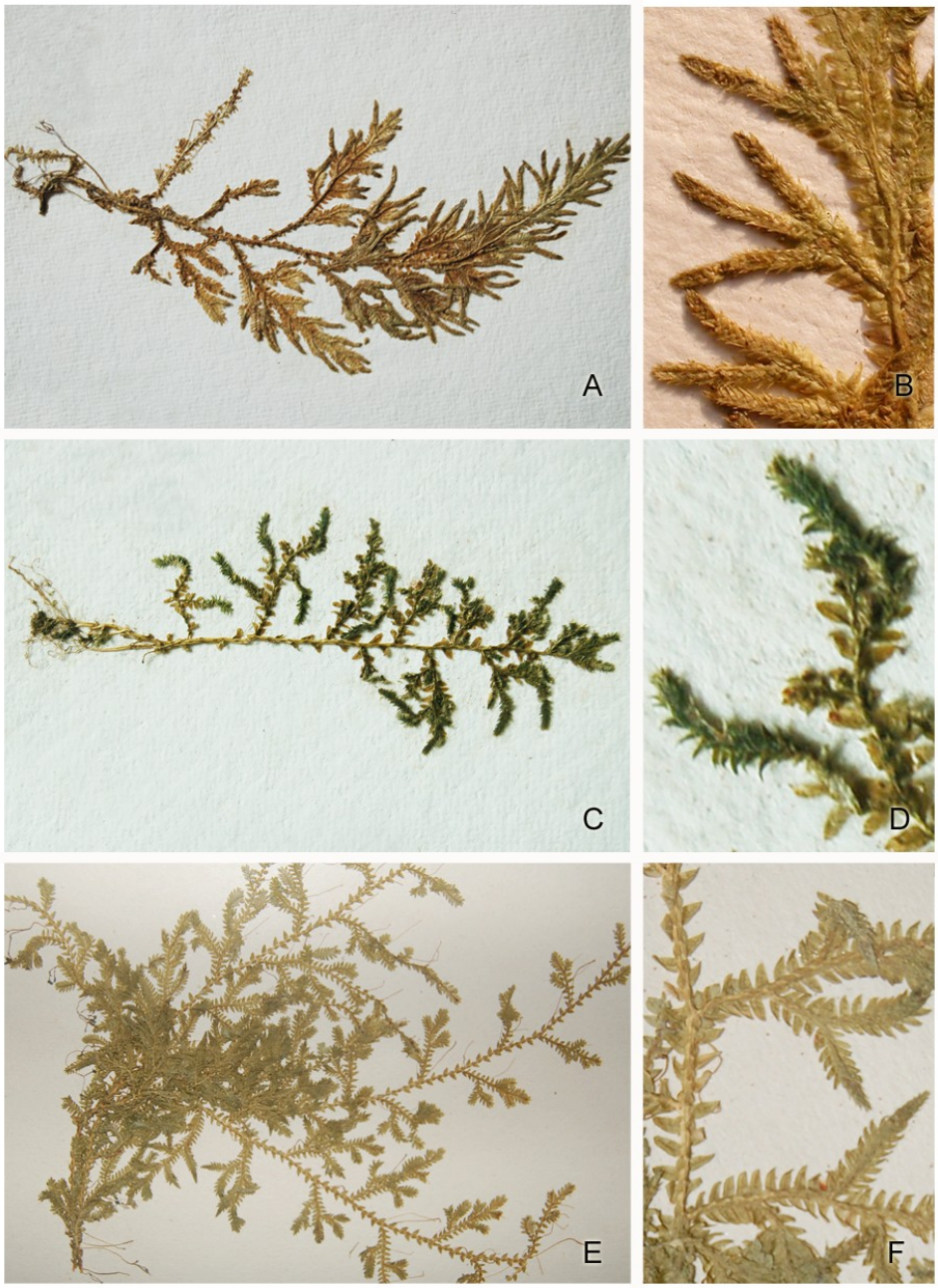


Plate 14. A & B. *Selaginella plumosa* Baker; **C & D.** *Selaginella proniflora* (Lam.) Baker; **E & F.** *Selaginella radicata* (Hook. & Grev.) Spring

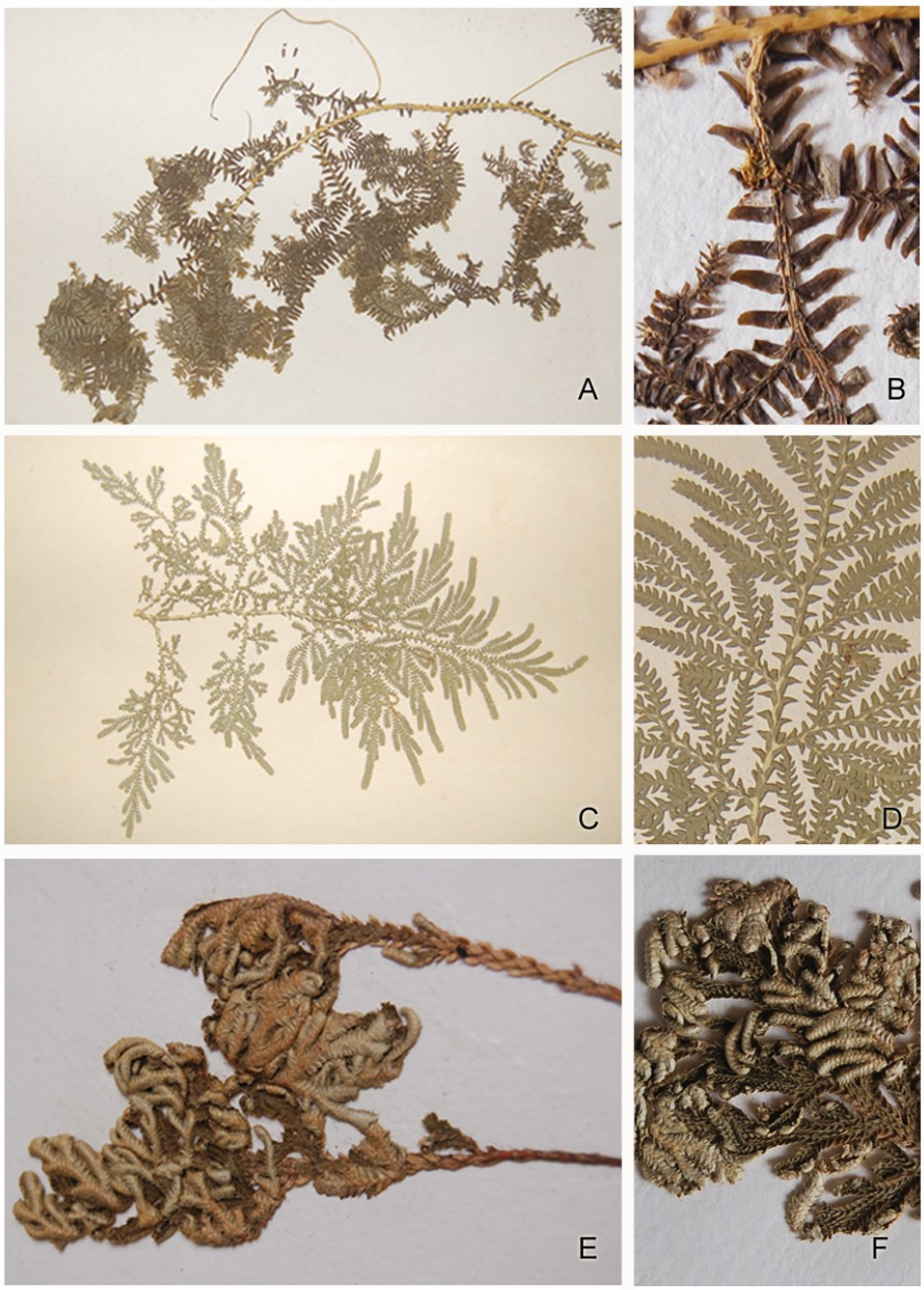


Plate. 15. A & B. *Selaginella brachystachya* (Hook. & Grev.) Spring; **C & D.** *Selaginella braunii* Baker; **E & F.** *Selaginella bryopteris* (L.) Baker

Plate. 16. A & B. *Selaginella crassipes* Spring; **C & D.** *Selaginella delicatula* (Desv.) Alston; **E & F.** *Selaginella dixitii* Madhusoodanan & Nampy

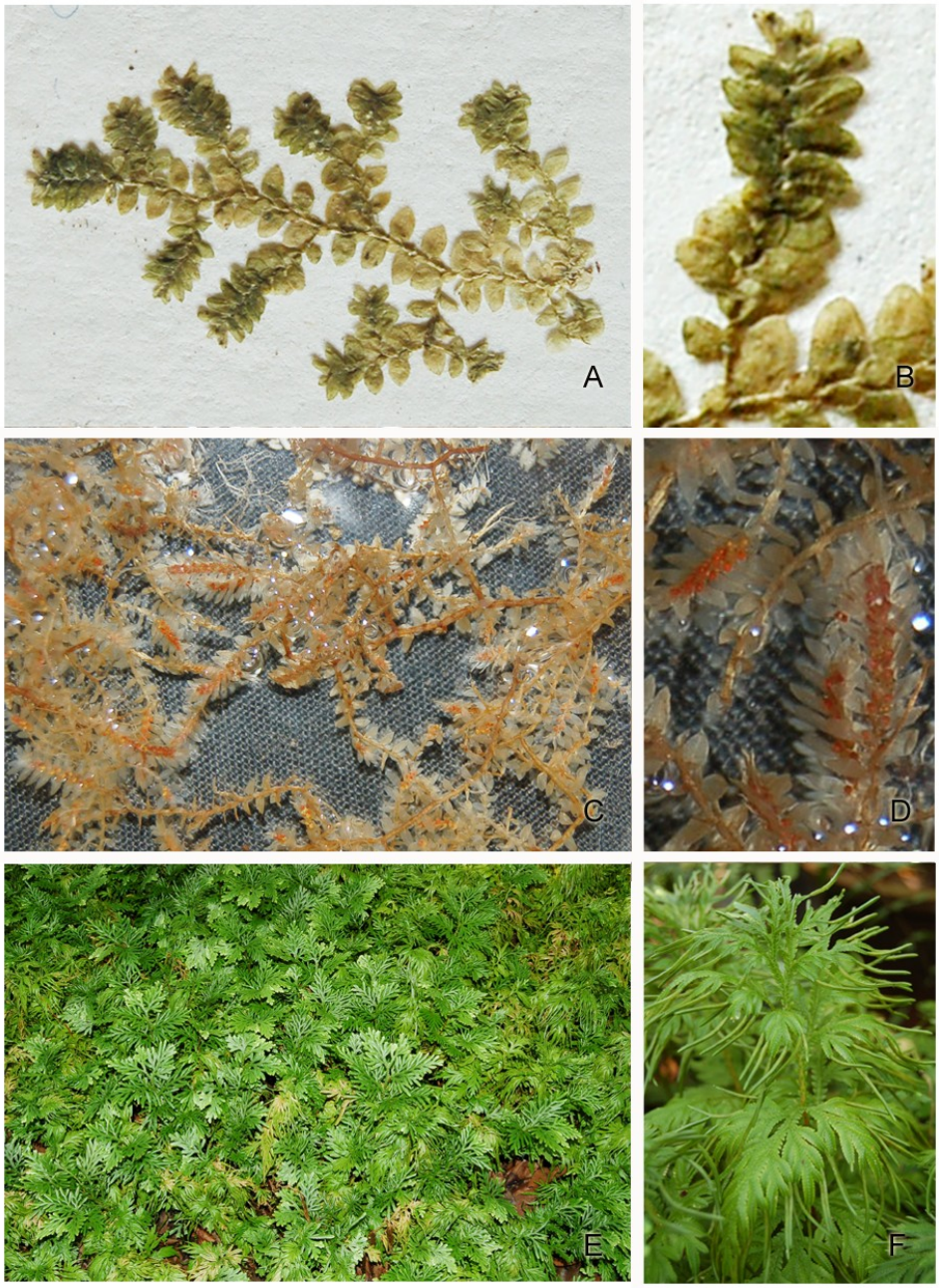


Plate 17. A & B. *Selaginella nairii* Dixit; **C & D.** *Selaginella nayarii* Dixit; **E & F.** *Selaginella plana* (Desv. *ex* Poir.) Hieron.

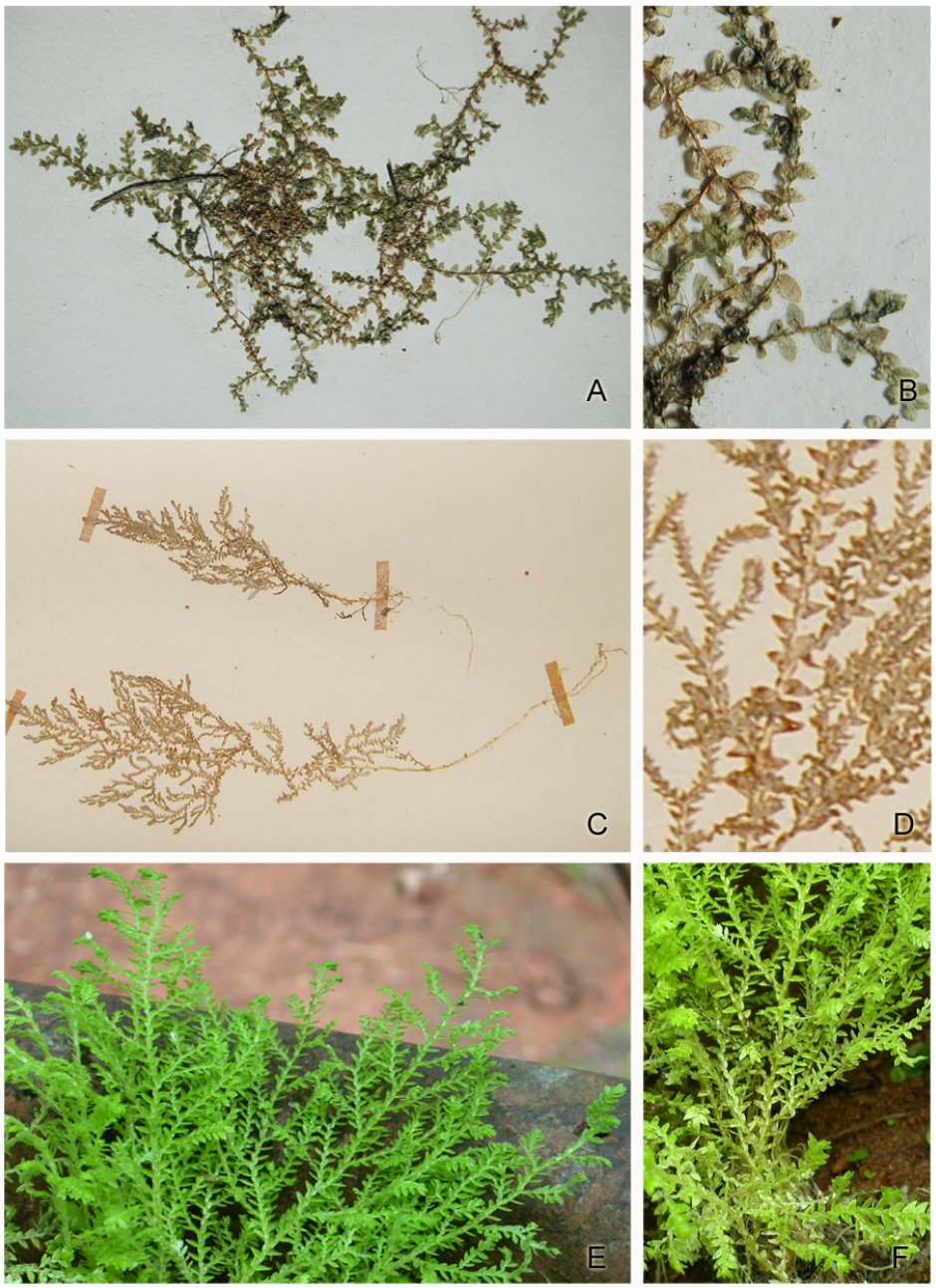


Plate. 18. A & B. *Selaginella cataractarum* Alston; **C, D, E & F**.*Selaginella chrysocaulos* (Hook. et Grev.) Spring

Plate. 19. A & B. *Selaginella chrysorrhizos* Spring; **C & D.** *Selaginella ciliaris* (Retz.) Spring; **E & F.** *Selaginella coonooriana* Dixit