Chromosome No. $n = 72$, tetraploid.

West Himalayas (Mehra & Bir, 1957; Bir, 1962).
Eastern Himalayas (Bir, 1960).
South India (Bir, 1965).

Earlier records of distribution:


[FIG: 93]

Synonyms:


A medium sized terrestrial fern. Plant size ranges from 23-47 cm. Rhizome short, condensed, erect, scaly throughout; scales dark brown, 0.5-0.9 cm long, linear-lanceolate, apex long acuminate, hair pointed, margin entire, inner cells thick walled, some what denticulate, marginal cells hyaline thin walled (Fig. 93 e-f)). Fronds pinnate. Stipes 8-12 cm long, stramineous, thick, diameter upto 0.2 cm, scaly, scales as on rhizome except absence of denticulations (Fig. 93 g-h). Rachis scaly; scales same as on rhizome, decreasing in size gradually towards the upper portion. Lamina pinnate, 15-35 cm long, 3-7 cm broad, broadest in the middle, texture subcoriaceous, glabrous; pinnae upto 30 pairs, 2-3 cm long, 1.0-1.5 cm broad, alternate, shortly
petiolate, linear oblong, margin deeply lobed to the costae; lobes 3-5 deeply toothed; acroscopic lobe of the pinnae is large, lower 4-5 pair of pinnae reduced some what (Fig. 93 a). Veins simple or forked, a single veinlet to each tooth (Fig. 93 b). Stomata anomocytic (Fig. 93 d). Upper epidermis having irregular shaped cells with highly sinuous walls (Fig. 93 c). Sori indusiate, linear, swollen, 1-2 in each lobe; indusia pale, margin entire. Sporangia oval, stalked; stalk larger than sporangia, annulate; annulus vertical, 20-21 celled (Fig. 93 i). Spores monolete, dark-yellowish brown, perispore smooth, 20-24 × 30-41 μm (Fig. 93 j).

**Chromosome No.** n = 72, tetraploid (Eastern Himalaya, Bir, 1960).

**Earlier records of distribution:**


**World:** Africa, Bhutan, Burma, Nepal, Taiwan and China.


**Synonyms:**


A small terrestrial fern growing on the rock crevices in shady places. Plant size ranges from 13-20 cm. Rhizome short, erect scaly; scales black, broadly lanceolate, 0.2-0.3 cm long, margin entire (Fig. 94 c-d). Fronds pinnate to bipinnate. Stipes short, 2.5-4 cm long, green, lower half blackish, thin, 2-4 mm in diameter, base scaly; scales as on rhizome, but reduced in size. Rachis green, sparsely scaly. Lamina pinnate in upper portion and bipinnate in the lower portion, 8-11 cm or more long, 1-3.5 cm broad, widest at little above the base, lanceolate, texture herbaceous, glabrous; pinnae 9-12 pairs, lamina apex more or less linear, incised on both the sides, petiolate. Lower 4-5 pairs of pinnae much reduced. Veins simple or forked, free (Fig. 94 a). Stomata anomocytic (Fig. 94 b). Upper epidermis having irregular shaped cells with highly sinuous walls. Sori indusiate; indusia linear, 1-2 mm long, near the costa, persistent. Sporangia oval, stalked; stalk larger than sporangia, annulate; annulus
vertical, 15-16 celled. Spores monolette, dark-brown, perispore, perispore losse, minutely spinulose, 32-37 x 45-48 μm (Fig. 94 e).

**Earlier records of distribution:**

**India:** North western Himalayas: Kashmir, Garhwal, Kumaun. Eastern Himalayas: Sikkim.

**World:** China, Nepal, Pakistan and Tibet.


**Synonyms:**


A large epiphytic fern. Plant size ranges from 52-93 cm in length. Rhizome short, erect, thick, apex scaly; scales brown lanceolate, 1-2 cm long, apex acuminate, margin fimbriate with long hair like projections, possess a glandular cell at the tip in young condition (Fig. 95 e-f). Fronds simple. Stipes short, 2-3 cm long, stramineous, stout, 1.5-2 cm in diameter, glossy. Rachis stramineous, prominently raised on the lower surface, glabrous. Lamina simple, large, length variable, 50-90 cm long, 6-10 cm broad, lanceolate, tapering toward ends, broadest in the middle, texture leathery, subcoriaceous, glabrous, acute, entire (Fig. 95 a). Veins simple or forked once or twice, united at the apices to form a continuous intramarginal vein (Fig. 95 b). Stomata anomocytic (Fig. 95 d). Upper epidermis having irregular shaped cells with highly sinuous walls (Fig. 95 c). Sori crowded, indusiate, 2-3 cm long, extending from the rachis to half or two third of the way to the margin along the side of the vein or veinlets; indusia narrow, linear, persistent. Sporangia stalked, capsule globose (Fig.
Spores monolete, brown, perispore, perispore folded, 23-27 x 34-38 µm (Fig. 95 h-i).

**Chromosome No.** n = 72, tetraplid (cf. Khullar, 1994).

**Earlier records of distribution:**


**World:** Africa, Australia, Bangladesh, Burma, China, Japan, Nepal, Taiwan and Vietnam.


A medium sized lithophytic fern, growing on rock crevices in the shady places. Plant size ranges from 25-40 cm. Rhizome short, erect, scaly; scales dark brown to blackish brown, 4-5 x 0.5-1 mm, linear-lanceolate, margin irregularly fimbriate with small projections (Fig. 96 e). Fronds pinnate compound. Stipes 7-12 cm long, grey to blackish in colour, stiff, thick, 1-2 m in diameter, scaly throughout; scales same as rhizome scales, but smaller in size (Fig. 96 f). Lamina pinnate, 16-25 cm long and 2-4 cm broad, linear oblong, apex acuminate, texture herbaceous, glabrous; pinnae 17-21 pairs, 1.2-2.6 cm long, 0.5-0.7 cm broad, alternate to subopposite, shortly petiolate, apex obtuse, the apices of the incisions blunt, a basiscopic smaller lobe present (Fig. 96 a). Veins open dichotomous, free (Fig. 96 b). Stomata anomocytic (Fig. 96 d). Upper epidermal cells rectangular in shape with highly sinuous walls (Fig. 96 c). Sori indusiate; indusia linear, 0.3-0.5 cm long, elongated, spreading from near base costa, but falling short of margin. Sporangia stalked, annulate; annulus vertical, 20-22 celled (Fig. 96 g). Spores monolete, perispore; perispore folded, reticulate, dark brown, 25-28 x 32-36 µm (Fig. 96 h).

**Earlier records of distribution:**

**India:** Eastern Himalayas: Sikkim.

A small sizes terrestrial fern, growing on rock crevices on shady places. Plant size ranges from 5-20 cm. Rhizome short, erect, covered by persistent stipe bases, apex scaly; scales dark brown, linear-lanceolate, margin fimbriate with few small projections (Fig. 97 e). Fronds pinnate compound. Stipes short 1-5 cm long, dark brown, thin, 0.5-1.5 mm indiameter, glabrous, glossy. Rachis same as stipe. Lamina pinnate, size variable, 4-15 cm long, 1-2 cm broad, linear-lanceolate, texture herbaceous to coriaceous, glabrous; pinnae 12-15 pairs, small, ovate, 0.3-0.5 x 0.2-0.3 cm, alternate, almost sessile, orbicular, base cuneate, apex obtuse, margin finely serrate, basal pinnae distant and reduced, pinnae towards apex shortened (Fig 97 a). Veins simple or forked free (Fig 97 b). Stomata anomocytic (Fig 97 d). Upper epidermal cells with highly sinuous walls (Fig 97 c). Sori indusiate; indusia 1-2 mm long, margin entire. Spores monolette, perisporate; perispore folded, dark brown, 21-29 x 27-41 μm (Fig 97 f).

Chromosome No. n = 36, diploid
n = 72, tetraploid (cf. Khullar, 1994).

Earlier records of distribution:
World: Afganistan, Africa, Australia, Bhutan, Canada, China, Japan, Nepal, New Zealand, Sri Lanka, Taiwan, Tibet and Vietnam.


Type: Athyrium Roth, Rom. Mag. 2: 105, 1799.

5.XXVI.1. Key to the genera of the family Athyriaceae:

1a. Sori generally only on the acroscopic side of the vein, never on both sides of the vein, never bouble (Athyrioid type).................................................. Athyrium
1b. Sori double on both sides of the vein (Diplazioid type)..............Diplazium


5.XXVI.1.1.1. Key to the species of the genus Athyrium:

1a. Basal acroscopic pinnule on each pinna is longer:
   2a. Lamina bipinnate, at least in the basal part:
      3a. Lamina 10-20 cm broad:
         4a. Spores non-perisporeate..........................A. praetermissum
         4b. Spores perisporeate..............................A. distans
      3b. Lamina 2-4 cm broad..................................A. anisopterum
   2b. Lamina tripinnate throughout...........................A. fimbriatum
1b. Basal acroscopic pinnule on each pinna is not longer..............A. attenuatum


Synonyms:
Lastrea sparsa var. membranacea Am. ex Bedd., Suppl. FSI & FBI, 17, 1876.
Nephrodium sparsa var. membranaceum Am. ex Clarke, Trans Linn. Soc. London II Bot. 1: 489, 1880.

A small sized terrestrial fern. Plant size ranges from 18-30 cm. Rhizome thick, short, erect, apex scaly; scales ovate-lanceolate, brown, apex acute. Fronds pinnate compound. Stipes 8-10 cm long, thin, fragile, 1-1.5 mm on diameter, sparsely scaly; scales light-brown, concolourous, 4 x 1 mm, linear-lanceolate, margin entire, apex acuminate. Lamina bipinnate at the basal portion, pinnate in the upper portion, medium sized, 10-12 cm long, 2-4 cm broad, narrowly oblong, glabrous; pinnae 10-16 pairs, 2-3 cm long, 1-1.5 cm broad, alternate, petiolate, broadly lanceolate, margin
irregularly lobed, varying from shallowly obed to \( \frac{1}{2} \) to \( \frac{3}{4} \) to the costa or even becoming pinnate, lobes 3-5 cm long, 0.5-0.4 cm broad, margin crenate dentate, lobes widely obtuse, lowest pinnae of the same size as the above or slightly smaller, in larger fronds the pinnae lobes became pinnules (Fig. 98 a). Veins free, forked, costae glabrous (Fig. 98 b). Stomata polycytic (Fig. 98 d). Upper epidermal cells elongated with slightly wavy walls (Fig. 98 c). Sori indusiate, indusium reniform, thin, persistent. Sporangia globose, stalked, annulate; annulus vertical, 12-14 celled (Fig. 98 e). Spores monoolete, brown, 30-45 x 42-62 \( \mu \)m (Fig. 98 f-g).

**Chromosome No.** \( n = 40 \), diploid sexual, (Bir, 1962).

**Earlier records of distribution:**


**World:** Nepal, Taiwan, Tibet and China.


**Synonyms:**


A medium sized terrestrial fern growing on rock walls on open places. Plant size ranges from 35-50 cm. Rhizome short erect, scaly; scales linear-lanceolate, apex acute (Fig. 99 c). Fronds pinnate compound. Stipes medium sized 5-8 cm long, stramineous, 2 mm in diameter, base densely scaly; scales brown, large 5-10 mm long, lanceolate, margin entire, apex acuminate (Fig. 99 d). Rachis stramineous, dorsally grooved, sparsely scaly; scales as on stipes in reduced forms (Fig. 99 e). Lamina bipinnate, 30-42 cm long, 10-12 cm broad, broadly lanceolate, tapering at
both ends, texture herbaceous, upper surface glabrous. Pinnae 15-18 pairs, 5-6 cm long, 1-1.5 cm broad, alternate, shortly petiolate, lower pinnae not much reduced, higher up on rachis pinnae close together, lanceolate, pinnules 13-15 pairs, 0.5-0.6 cm long, 0.2 cm broad, alternate, sessile (Fig. 99 a). Veins 4-6 pairs in a pinnule, free, forked (Fig. 99 b). Stomata anomocytic. Upper epidermal cells elongated with sinuous walls. Sori indusiate, small, arranged in a single row on either side of the costa, indusia J-shaped, persistent. Sporangia globose, stalked, annulate; annulus vertical, 13-15 celled. Spores monolette, yellowish-brown, perisporate, perispore, folded, exospore smooth, 24-27 x 36-43 μm (Fig. 99 f).

**Chromosome No.** n = 40, diploid sexual, (cf. Khullar, 2000).

**Earlier records of distribution:**


**World:** Afganistan, China, Nepal, Bhutan and Pakistan.

5.XXVI.1.1.1.3. *Athyrium distans* (D. Don) Moore, *Index Fil.* 125, 1859. [FIG: 100; PLATE 18 a]

**Synonyms:**


A large terrestrial fern growing on forest floor and along the water channels. Plant size ranges from 50-64 cm. Rhizome erect, thick, 4-5 m on diameter. Fronds pinnate compound. Stipes very long, 25-30 cm, thin, 1.5-2 mm in diameter, scaly; scales brown to dark brown, 6-11 mm long, 1-2 mm broad, in a tuft at base, narrowly lanceolate, margin entire, apex acute, broadest at the base, thinly herbaceous, delicate (Fig. 100 e-f). Lamina bipinnate in the upper portion of the frond, tripinnate in the lower portion, 25-34 cm long, 20-25 cm broad. Pinnae margin pinnatifid to pinnate,
apices long, narrow, caudate, lowest pinnae slightly shorter than the next pair above; pinnules petiolate, 0.6-3.5 cm long, 0.3-1.0 cm broad, triangular, lanceolate, more or less falcate, asymmetrical about their axes, acroscopic basal lobes markedly longer than the more sloping and decurrent basiscopic ones, apices acute, margin deeply pinatifid lobes into narrow, well separated lobes with the apices of these lobes bearing short, insignificant acute teeth (Fig. 100 a). Veins prominent, forked dichotomously (Fig. 100 b). Stomata polycytic (Fig. 100 d). Upper epidermal cells irregular in shape with highly sinuous walls (Fig. 100 c). Sori indusiate, obliquely placed with the costules of pinnules, linear, more or less 1 mm in length, close to the costules. Sporangia globose, stalked, annulate; annulus vertical, 12-14 celled (Fig. 100 g). Spores monolete, light yellow, exospore smooth, 22-25 x 33-39 μm (Fig. 100 h-i).

**Chromosome No.** n = 40, diploid sexual (Bir, 1962, 1967, 1974).

**Earlier records of distribution:**

**India:** North western Himalayas: Kashmir, Himachal Pradesh. Eastern Himalaya: Sikkim, Meghalaya, and West Bengal-Darjeeling.

**World:** China, Nepal and Japan.


**Synonyms:**


*Araiostegia yaklaensis* Bedd., *Handb. Suppl.* 13-14, 1892.


A large terrestrial fern growing on forest floor or along the water channels. Plant size ranges from 55-100 cm. Rhizome thick, long, creeping, scaly; scales linear lanceolate, entire, acuminate. Fronds pinnate compound. Stipes 15-36 cm long, clusltered together, thick, 3-4 mm in diameter, scaly; scales light brown, concolourous, ovate-lanceolate, margin entire, apex acute (Fig. 101 c). Rachis sparsely scaly; scales
linear-lanceolate, margin entire, apex acuminate (Fig. 101 d). Lamina tri-pinnate, large, 40-64 cm long 18-25 cm broad, deltate, texture herbaceous, glabrous; pinnae 12-16 pairs, 12-18 cm long, 2-4 cm broad, alternate, shortly petiolate, narrowly triangular-lanceolate, lower pinnae largest; pinnules 10-18 pairs, 1.5-2 cm long, 0.5-1.0 cm broad, alternate, shortly stalked, triangular, lanceolate, obliquely inserted, asymmetrical, acrosyn pinnales larger than basiscopic ones, margin lobed with serrate margin (Fig. 101 a). Veins free, forked (Fig. 101 b). Stomata polycytic. Sori curved, J-shaped, indusiate, in a row on either side of the main veinlet of the ultimate lobes; indusia brown, curved, thin, persistent. Sporangia globose, stalked, annulate; annulus vertical, 10-12 celled. Spores monolete, deep brown, perispore; perispore folded, 32-37 x 46-48 μm (Fig. 101 e).


Earlier records of distribution:


World: China, Pakistan and Tibet.


Synonyms:


*Athyrium nigripes* sensu Bedd., *Handb.* 166, 1883 pro parte.


A medium sized terrestrial fern growing on shady forest floor and rock crevices. Plant size ranges from 20-75 cm. Rhizome short, erect, scaly; scales golden brown in colour, long, linear-lanceolate, apex acuminate (Fig. 102 e). Fronds pinnate compound. Stipes 10-35 cm long, stramineous, 1-2 mm in diameter. Lamina
bipinnate, large, 10-40 cm long, 5-10 cm broad, deltate, oblong-ovate, texture firm; pinnae 12-15 pairs, 5-6 cm long, 1-1.5 cm broad, shortly petiolate, elongate acuminate; pinnules 1-1.5 cm long, 0.5-1 cm broad, oblong, basal acroscopic base large, auricled, margin serrate, dorsal groove interrupted at the base of the pinnules and forming a prominent spine or tooth (Fig. 102 a). Veins free, forked (Fig. 102 b). Stomata polycytic (Fig. 102 d). Upper epidermal cells rectangular in shape with more or less smooth walls (Fig. 102 c). Sori indusiate, in two rows close to the costae, hooked; indusia light brown in colour, firm, entire. Sporangia globose, stalked, annulate; annulus vertical, 12 celled (Fig. 102 f). Spores monolete, non-perisporate, exospore smooth, 39-47 x 23-32 μm (Fig. 102 g).

Chromosome No. n = 80, tetraploid, (Manton & Sledge, 1954).

Earlier records of distribution:


World: Burma, Java, Sri Lanka, Tibet, China and Thailand.

Type: Diplazium plantagineum (L.) Sw. in Schrad J. Bot. 1800 (2): 62, 1801.

5.XXVI.1.2.1. Key to the species of the genus Diplazium:

1a. Basal 2-3 pairs of veinlets of adjacent lobes fuse to form an irregular excurrent veinlet, runs to the sinus..........................................................D. esculentum

1b. Basal veinlets of adjacent lobes do not fuse to form an irregular excurrent veinlet..........................................................D. maximum


**Synonyms:**


A medium sized terrestrial fern. Plant size ranges from 80-115 cm long. Rhizome stout, erect, short, stamp like, usually unbranched, scaly; scales elongate-lanceolate, 10-15 x 1.0 mm, dark brown with a broad cordate base, apex acuminate with glandular cell. Fronds large, pinnate compound. Stipes 30-40 cm long, deciduously scaly. Lamina ovate to deltoid-ovate, 50-75 cm long, 50-55 cm broad, pinnate, obliquely erect and with the anterior end spreading; rachis sparsely scaly and bearing a few pale brown small glandular hairs; primary pinnae narrowly elongate-ovate, 25-50 cm long, 10-20 cm broad and the basal ones sub-opposite, but the upper alternate, secondary pinnae shortly petiolate, truncate-subtruncate base with nearly parallel sides in the basal half and gradually tapeed to an acuminate apex, margins narrowly or shortly lobed., texture thin, subcoriaceous glabrous on both surfaces (Fig. 103 a). Main lateral veins bearing 7-10 pairs of simple or rarely forked oblique secondary veins, the basal 3-4 pairs of which unite at an angle to corresponding veinlets of the adjacent main lateral veins, an excurrent veinlets being borne at the point of fusion of each pair and this veinlets uniting with the next anterior veinlet a little distance behind the point at which the latter is fused (Fig. 103 b), vein and veinlets hairy (Fig. 103 e). Stomata polycytic (Fig. 103 d). Upper epidermal cells with sinuous walls (Fig. 103 c). Sori extended nearly the whole length of the secondary veinlets. Sporangia golobose, stalked, annulate; annulus vertical, 14-16 celled (Fig. 103 f). Spores monolete, bilateral, 35-38 x 53-57 μm (Fig. 103 g).

**Chromosome No.** \( n = 41 \), (cf. Khullar, 2000).

**Earlier records of distribution:**

World: Asia, China, Java, Nepal, Pakistan, Philippines, Sri Lanka and Taiwan.


**Synonyms:**


*Diplazium polyplodioides* sensu Bedd., *FSI* t. 163, 1864.

A large sized terestrial fern. Plant size rages from 100-160 cm. Rhizome ascending, thick, apex scaly; scales pale brown, 0.3-1.5 cm long, 0.1 cm broad, linear lanceolate, margin toothed. Fronds pinnate compound. Stipes 60-70 cm long, stramineous to light brown thick, diameter 0.5 cm, scaly at base; scales as on rhizome, but longer, narrowly-lanceolate. Upper portion of the stipes glabrous. Rachis stramineous, glabrous, not muricated. Lamina bipinnatifid to bipinnate, size variable, upto 75 cm long, 36 cm broad, broadly ovate-lanceoleate, texture herbaceous, glabrous; pinnae upto 12 pairs, 20-30 cm long, 10-12 cm broad, deeply lobed to the costa, margin minutely serrulate (Fig. 104 a). Stomata polycytic (Fig. 104 d). Upper epidermal cells irregular in shape with highly sinuous walls (Fig. 104 c). Veins free, simple to forked, in upper lobes veins occasionally forked (Fig. 104 b). Sori indusiate, arranged in two oblique rows, length variable, stretching from costa and almost reaching the margin; indusia linear, thin caducous. Sporangia shortly stalked, annulate; annulus vertical, 13-14 celled (Fig. 104 e). Spores monolete, bilateral, hyaline, exospore psilate, 20-27 x 41-50.5 μm (Fig. 104 f).

**Chromosome No.** n = 41, (cf. Khullar, 2000).

**Earlier records of distribution:**


**World:** Bhutan, China, Nepal, Pakistan and Polynasia.


5.XXVII.1. Key to the genera of the family Dryopteridaceae:

1a. Veins anastomosing; sori irregularly scattered.......................... *Cyrtomium*

1b. Veins free; sori usually in one row on either side of the costae:

2a. Indusia reniform, with a sinus.................................................. *Dryopteris*

2b. Indusia orbicular, without a sinus:

3a. Pinnules strongly auricled, with acute pointed auricles.......... *Polystichum*

3b. Pinnules not auricled............................................................. *Pteridrys*


Type: *Cyrtomium falcatum* (L.) Presl, *Tent. Pterid.* 86, 1836.


Synonyms:


A medium sized terrestrial fern growing on the rock crevices of damp places. Plant size ranges from 30-65 cm. Rhizome short, erect, thick, covered with persistent leaf bases, densely scaly; scales dark brown in colour, concolourous, ovate-lanceolate, 0.5-1 cm long, margin with filamentous projections, apex long acuminate (Fig. 105 e). Fronds pinnate compound. Stipes 10-25 cm long, stramineous, green in young condition, thick, 2-3 mm in diameter, scaly and fibrillose, base densely scaly; scales as on rhizome, fibrils hair like, long, light brown; rachis fibrillose and scaly; scales dark coloured, linear-lanceolate. Lamina pinnate, 18-40 cm long, 7-15 cm broad,
lanceolate, texture thick, markedly coriaceous, lower surface, having light-brown scattered fibrillose microscales (microscopic), upper surface dark green, glossy, glabrous; pinnae 5-10 pairs, large, 5-8 cm long 2-5 cm broad, alternate, shortly petiolate, oblong-lanceolate, falcate on the acroscopic side, basiscopic margin round at base, margin lobes serrate, terminal pinnae strongly auricled on both sides (Fig. 105 a). Stomata polycytic (Fig. 105 d). upper epidermal cells irregular in shape with less sinuous walls (Fig. 105 c). Veins anastomoses to form reticulations, veinlets arching (Fig. 105 b). Sori indusiate, large, round, many, scatterd; indusia light-brown, circular, large, peltate, thin, glabrous. Sporangia oval, stalked, annulate, annulus vertical (Fig. 105 f). Spores monolet, brown, perispore; perispore folded, 39-46 x 45-52 (Fig. 105 g).

**Chromosome No. n = 123, tetraploid, (cf. Khullar, 2000).**

**Earlier records of distribution:**


**World:** Africa, Bhutan, China, Hawaii, Japan, Korea and Taiwan.


Type: *Dryopteris filix-mas* (L.) Schott, *Gen. Fil.* t. 9, 1834.

5.XXVII.1.2.1. Key to the species of the genus *Dryopteris*:

1a. Lamina unipinnate:
   
2a. Sori large..........................................................*D. panda*

2b. Sori small:
   
3a. Stipe scales concolourous, light to mid brown............*D. redactopinnata*

3b. Stipes bicolourous, dark lower half and a light upper half.....*D. wallichiana*

1b. Lamina bipinnate:

4a. Sori small..........................................................*D. barbigera*

4b. Sori large:

5a. Stipes long, 35-50 cm ...........................................*D. marginata*

5b. Stipes short, 5-20 cm ...........................................*D. chrysocoma*

**Synonyms:**


*Lastrea falconeri* (Hook.) Bedd., *FBI* t. 41, 1865.


A medium to large sized terrestrial fern. Plant size ranges from 45-67 cm. Rhizome horizontal, thick, deep brown, scaly; scales hyaline brown. Fronds pinnate compound. Stipes long, 10-12 cm long, brown, stramineous, more in the upper part, thick, 0.2-0.3 cm, very densely scaly and fibrillose; scales pale or russet-brown, concolourous, broadly ovate-lanceolate, large, 1.2-1.5 cm long and 0.4 cm broad, mixed with narrowly lanceolate scales, margin dentate at regular distances, apex long acuminate; rachis densely scaly and fibrillose; scales brown, concolourous, lanceolate, size of the scales diminishing towards the apex of the rachis (Fig. 106 e). Lamina bipinnate, large 35-55 cm long, 15-20 cm broad, ovate-lanceolate, texture thickly herbaceous, both surfaces scaly; scales small, narrow, upper surface sparsely scaly; pinnae many 1-15 cm long, 2.0-2.5 cm broad, subopposite at basal portion and alternate at upper portion, lower 2-3 pairs of pinnae gradually reduced, pinnules 10-20 pairs, 1.2-2.0 cm long, 0.6-0.7 cm broad, sessile, symmetrical, lanceolate, apices acute (Fig. 106 a). Veins 8-9 pairs in each pinnule (Fig. 106 b), costa and costules densely scaly; scales light brown, concolourous, narrow-lanceolate, margin entire (Fig. 106 f-g). Stomata polycytic (Fig. 106 d). Upper epidermal cells elongated with sinuous walls (Fig. 106 c). Sori indusiate, round, submedian, 3-6 pairs in a row on either side of costule; indusia light brown, reniform. Sporangia stalked, annulate; annulus vertical, 14-18 celled (Fig. 106 h). Spores monolete, perispore; perispore undulate, dark brown, 34-36 x 43-45 μm (Fig. 106 i).
Earlier records of distribution:


[FIG: 107]

Synonyms:


A medium sized terrestrial fern. Plant size ranges from 10-70 cm. Rhizome long, decumbent, thick, diameter 0.2-0.3 cm, more or less cylindrical. Fronds pinnate compound. Stipes 3-24 cm long, about 1/2 or 1/3 rd length of the lamina, sparsely scaly, cylindrical; stipe bases bearing a tuft of dense scales; scales pale brown, concolourous, transparent, large, broadly ovate-lanceolate, margins variously filamentous with small teeth like projections, apex acuminate (Fig. 107 d-e). Middle portion of the stipe is sparsely scaly; scales pale, small, narrowly lanceolate, margin fimbriate; rachis stramineous, bearing scattered fimbrial with a few light brown scattered narrow scales. On the upper portion of the rachis only some scattered fimbriallae are found. Lamina bipinnate, the smaller fronds simply pinnate, but pinnatifid, size is much variable, 6-60 cm long, 2-18 cm broad, lanceolate, base slightly truncate, widest in the middle, texture herbaceous, turn yellow on maturity; pinnae numerous, upto 30 pairs, 1.5-10 cm long, 0.5-3.0 cm broad, alternate, very shortly petiolate, basal one or two pairs of pinnae short and distant, lanceolate, pinnules 10-12 pairs, 1.0-2.0 cm long, 0.5 cm broad, opposite to alternate, sessile, lower ones adnate, base decurrent, apex more or less rounded, margin crenate; basal
pinnules are largest (Fig. 107 a). Stomata anomocytic (Fig. 107 c). Veins 5-6 pairs in each pinnules, free, forked (Fig. 107 b); costae and costules sparsely scaly; scales pale concolourous (Fig. 107 f). Sori indusiate, reniform, large, 4-5 pairs in each pinnule; indusia light brown, turning grey at maturity, persistent. Sporangia globose, stalked, annulate; annulus 18-20 celled (Fig. 107 g). Spores monolete, perisporate; perispore thick, folded, loose, dark brown, large, exospore smooth, 35-38 x 45-50 μm (Fig. 107 h).

**Earlier records of distribution:**


**Synonyms:**

*Aspidium marginatum* Wall., List No. 391, 1828 pro parte, nom. nud.


A medium sized terrestrial fern. Plant size ranges from 1-1.3 meter. Rhizome erect, thick, more or less cylindrical with persistant leaf bases. Fronds pinnate compound. Stipes 30-45 cm long, stramineous, sparsely scaly (Fig. 108 d), cylindrical, linear-lanceolate, glossy; rachis stramineous, purple brown, thick. Lamina bipinnate, large, 75 cm or more long, 26-30 cm broad, broadly triangular lanceolate, widely truncate at the base, texture herbaceous; pinnae numerous, upto 12-19 pairs, 25-30 cm long, 4-6 cm broad, alternate, very shortly petiolate, scaly (Fig. 108 e), basal one or two pairs of pinnae short and distant, lanceolate, pinnales 10-15 pairs, 2.0-4.0 cm long, 1.5 cm broad, opposite to alternate, sessile, lower ones adnate, base decurrent, apex more or less rounded, margin crenate; basal pinnules are larger (Fig. 108 a). Stomata anomocytic. Veins 5-6 pairs in each pinnules, free, forked (Fig. 108
b); costae and costules sparsely scaly; scales pale concolourous. Sori indusiate, reniform, medium sized, medial, near the costa, 6-7 pairs in each pinnule; entire frond fertile, indusia light brown, turning grey at maturity, persistent. Sporangia globose, stalked, annulate; annulus 17-19 celled (Fig. 108 f). Spores monolette, perisporate; perispore thick folded, loose, pale brown, large, exospore smooth, 27-32 × 35-40 μm (Fig. 108 g).

**Earlier records of distribution:**


**Synonyms:**


*Lastrea filixmas var. panda* (Clarke) Bedd., *Handb.* 251, 1883.


*Dryopteris filixmas subsp. panda* (Clarke) C. Chr., *Index Fil.* 265, 1906.

A medium sized terrestrial fern. Plant size ranges from 40-75 cm. Rhizome long, erect, thick, scaly; scales deep brown, ovate-lanceolate, margin entire, apex acuminate (Fig. 109 e). Fronds pinnate compound. Stipes 15-25 cm long or more, base dark brown, upper part stramineous, thick 2-3 mm in diameter, stipe base densely scaly; scales golden brown, ovate-lanceolate, higher up in the stipes sparsely scaly; scales pale, concolourous, linear-lanceolate to ovate-lanceolate, margin entire, apex acuminate (Fig. 109 f); rachis stramineous, sparsely scaly, scales very small. Lamina pinnate, 25-50 cm long, 8-17 cm broad, narrowly lanceolate, texture thickly herbaceous, upper surface glabrous, lower surcae scaly along the main veins (Fig. 109 g); pinnae 10-15 pairs, 4-10 long, 2-2.5 cm broad, alternate, margin lobed ½ to 1/3 rd to the costa; lobes 6-7 mm broad, 3-4 mm broad, round, apex harpely toothed, margin
subspinulose, lower pair of pinnae slightly smaller and distant (Fig. 109 a). Veins free, forked, grouped in 4-6 pairs (Fig. 109 b), costa sparsely scaly; scales light brown, concolourous, licear-lanceolate. Stomata polocytic (Fig. 109 d). Upper epidermal cells irregular in shape with highly sinuous walls (Fig. 109 c). Sori indusiate, large, round almost on the main costa, 1-2 per lobe, indusia light-brown, reniform, large, membranaceous, glabrous. Sporangia globose, stalked, annulate; annulus 17-22 celled (Fig. 109 h). Spores monolette, dark-brown, perisporate, perispore folded, 34-39 x 43-50 μm (Fig. 109 i).

Chromosome No. n = 41 (cf. Khullar, 2000).

Earlier records of distribution:

World: China, Korea, Nepal, Pakistan and Tibet.


Synonym:

A medium sized terrestrial fern. Plant size ranges from 32-50 cm. Rhizome palaecous. Fronds pinnate compound. Stipe7-10 cm long, brown, thick, diameter 0.1-0.2 cm, densely scaly; scales (Fig 1C) predominantly narrow, except at the very base of the stipe, ovate-lanceolate, concolourous, brown, mat like in appearance (Fig 1D), large, 1.5-2.0 cm, margin smooth, except the presence of some scattered fimbril like projections, apex acuminate; scales towards the apex of the stipe becomes linear and smaller. In addition to scales some fibril like structures are found on the stipe and rachis (Fig 1GM); rachis scales are like those of the stipe. Lamina bipinnatifid (Fig 1A), 25-40 cm long, 8-12 cm broad, lanceolate, gradually tapering towards the base and apex from mid region, texture thinly herbaceous, both surfaces fairly fibrillosse; fibril light brown, long hair like in appearance, upper surface becoming glabrous towards maturity. Pinnae lanceolate, 7-10 cm long, 1.0-1.5 cm broad, alternate to subalternate at the basal portion, sessile, margin deeply lobed to the costa; lobes 10-20 pairs. Lobes 0.4-0.5 cm long, 0.3 cm broad, oblong, apex truncate, unequally toothed (Fig 1B), lower 4-6 pairs of pinnae gradually reduced but not downward deflexed.
Pinnae hypostomatic, stomata anomocytic (Fig 1KL). Veins in a pinnae lobe 4-6 pairs, mostly forked, costae and costules scaly; scales brown, lanceolate, basal portion with many filamentous projections (Fig. 1DJ). Sori indusiate (Fig.1E), small, reniform, in a single row or either side of costa (Fig 1B); sporangia shortly stalked, annulus 13-celled (Fig 1F); spores monolette, bilateral, yellowish brown, perisporate, 30-32 x 35-45μm, (Fig 1N).

Chromosome No. n = 82, diploid apomict (Gibby, 1985).

Earlier records of distribution:
World: China, Tibet, Taiwan and Pakistan.

5.XXVII.1.2.1.6. *Dryopteris wallichiana* (Spreng.) Hyl., *Bot. Notiser*: 352, 1953;

Synonyms:
*Aspidium paleaceum* Lag. ex Sw., *Syn. Fil.* 52, 1806.
*Dryopteris paleacea* (Lag. ex Sw.) C. Chr., *Amer. Fern J. 1*: 94, 1911.

A large sized terrestrial fern. Plant size more than 1 meter long. Rhizome long, erect, thick, scaly; scales dark coloured (Fig. 111 c). Fronds pinnate compound. Stipe 10-18 cm long, deep-brown, thick, diameter 0.3-0.5 cm, densely scaly below; scales narrow, pale, mixed with black ones, bicolourous and concolourous both type, 1.3 cm long, margin with some scattered fimbrie like projections, apex acuminate (Fig. 111 d); scales towards the apex of the stipe becomes linear and smaller. Rachis very densely scaly, fibrillose (Fig. 111 e). Lamina pinnate, very large more than 1 meter long, 20-25 cm broad, lanceolate, gradually tapering towards the base and apex from mid region, texture tickly coriaceous, lower surface sparsely scaly, upper surfaces glabrous. Pinnae numerous, lanceolate, 12-16 cm long, 1.5-2.0 cm broad, alternate,
subsessile, lobes 10-18 pairs, 1.0-1.2 cm long, 0.5 cm broad, rectangular, apex more or less rounded, sede margins sharply serrate lower 5-6 pairs of pinnae gradually reduced, downwardly deflexed (Fig. 111 a). Pinnae hypostomatic, stomata anomocytic. Veins in a pinnae lobe 4-6 pairs, mostly forked, costae and costules scaly; scales brown, lanceolate, basal portion with many filamentous projections (Fig. 111 b). Sori indusiate, small, reniform, in a single row or either side of costa. Sporangia shortly stalked, annulus 12-14-celled. Spores monolette, bilateral, dark brown, perisporate, perispore granulose, 31-36 x 40-50 μm (Fig. 111 f).

**Chromosome No.** n = 41, diploid sexual (cf. Khullar, 2000).

**Earlier records of distribution:**


**World:** Afganistan, Bhutan, Burma, China, Japan, Java, Nepal, Philippines, Sri Lanka, Taiwan, Vietnam and Pakistan.


5.XXVII.1.4.1. Key to the species of the genus *Polystichum*:

1a. Lamina pinnate:

2a. Stipe scales blackish-brown ........................................... *P. lentum*

2a. Stipe scales light-brown ........................................... *P. nepalense*

1b. Lamina bipinnate:

3a. Stipe scales broad-ovate, colour variable, and 3-types can be distinguished ........................................... *P. piceo-palaeaceum*

3b. Stipe scales linear-lanceolate (never broad), deep brown, one type only ........................................... *P. discretum*


Synonyms:
Polystichum lobatum var. discretum (D.Don) C. Chr., Index Fil. 583, 1906.
Polystichum angulare sensu Bedd., FSI t. 122, 1863.

A medium sized terrestrial fern. Plant size ranges from 48-91 cm. Rhizome short, erect, woody, oblique to the substratum, scaly; scales ovate-lanceolate, apex acute, margin denticulate (Fig. 112 f). Fronds pinnate compound. Stipes 10-34 cm long, stramineous, robust, thick, diameter 0.3-0.4 cm, densely scaly and densely fibrilllose (Fig. 112 e); scales light to deep brown to black, linear-lanceolate, margin with short teeth-like projections, apex aristate (Fig. 112 f-g). Lamina bipinnate, large, 38-57 cm long, 10-16 cm broad, lanceolate, texture sucoriaceous; pinnae many 12-20 pairs, 8-13 cm long, 2-2.5 cm broad, alternate, shortly petiolate, lanceolate, lower pair of pinnae slightly short; pinnules numerous, 1-1.5 cm long, 0.5-0.7 cm broad, variable in shape, ovate-lanceolate to narrowly rhomboidal, alternate, shortly petiolate, apex acutely pointed with prominent teeth, margin serrate-dentate to spinulosely serrate (Fig. 112 a), scaly (Fig. 112 h). Veins in a pinnule 4-5 pairs open dichotomous (Fig. 112 b). Stomata anomocytic (Fig. 112 d). Upper epidermal cells elongated, wall wavy (Fig. 112 c). Sori indusiate, submedial, indusium peltate, pale brown, large. Sporangia stalked, annulate; annulus vertical, 13-14 celled. Spores monolete, deep brown, perisporate, perispore folded, 24-37 x 34-43 μm (Fig. 112 j).

Chromosome No. n = 41 (cf. Khullar, 2000)

Earlier records of distribution:


**Synonyms:**


*Polystichum auriculatum* var. *subpinatum* sensu Bedd., FBI t. 136, 1866.


*Polystichum auriculatum* var. *lentum* (D. Don) Bedd., *Handb.* 204, 1883.


A small terrestrial fern. Plant size ranges from 20-40 cm. Rhizome suberect, densely covered with wiry roots and scales; scales oblique-ovate, margin dentate, concolourous, brown in colour, 2.0-2.5 x 0.5 mm, apex acute (Fig. 113 e-f). Fronds pinnate compound, 20-35 cm long. Stipes 10-15 cm long, slender, scaly; scales are of two types, one is broad ovate-oblique 2 x 0.5 mm and other is linear, membranaceous, 2.5 x 0.5 mm; the previous one bicolourous and the later one concolourous (Fig. 113 g-h). Lamina pinnate, 10-25 x 3.5-5 cm with few reduced basal pinnae, apical portion narrow pinnatifid, bearing proliferating vegetative buds; pinnae oblong 2-3 x 0.5-1 cm, coriaceous, surface scaly; scales linear-ovate, 1-0.5 mm, very small (Fig. 113 a); upper basal margin of the pinnae separating the auricles with acute apex, margin crenate (Fig i-j). Stomata anomocytic (Fig. 113 d). Upper epidermal cells elongated, length is greater than the breadth, margin highly sinuous (Fig. 113 c). Rachis grooved on upper surface, densely covered by scales; scales as on stipes. Veins depressed, lateral veins forked twice or thrice (Fig. 113 b). Sori globose, indusia peltate (Fig. 113 k), thin. Sporangia having stalk larger than the capsule, annulate; annulus vertical, 12-13 celled. Spores monolete, bilateral, 25-32 x 30-35 μm, perispore, and perispore folded, deep to light brown in colour (Fig. 113 l).

**Chromosome No.** n = 41, diploid sexual (cf. Khullar, 2000).
Earlier records of distribution:


World: Bhutan, Burma, China, Nepal, Pakistan, Tibet and Thailand.


Synonyms:

*Aspidium riepalense* Spr., Syst. 4: 97, 1827.

*Polystichum auriculatum* var. *marginatum* (Wall ex Bak. ex Clarke) Bedd., Handb. 204, 1983.


A medium sized terrestrial fern. Plant size ranges from 40-85 cm. Rhizome suberect, densely covered with scales; scales oblique-ovate, margin dentate, apex acute (Fig. 114 e). Fronds pinnate compound. Stipes 10-35 cm long, stramineous, diameter 0.1 cm, scaly and fibrillose; scales pale brown, concolourous, ovate, glossy, margin with short projections, apex long acuminate; rachis sparsely scaly and fibrillose (Fig. 114 f). Lamina pinnate, 30-50 x 4-7 cm, narrowly lanceolate, texture coriaceous, lower surface scaly, upper surface glossy, glabrous; pinnae 20-25 pairs, 2.5-4 cm long, 1.0-1.2 cm broad, close, alternate, shortly petiolate, oblong-ovate, falcate, apex shortly acuminate, margin closely dentate. Veins numerous, free, forked (Fig 114 b). Stomata anomocytic (Fig. 114 d). Upper epidermal cells elongated, longer than the breadth, margin highly sinuous (Fig. 114 c). Rachis grooved dorsally, densely covered by scales; scales as on stipes. Veins depressed, lateral veins forked twice or thrice. Sori many, large, submedial, indusiate; indusia peltate, thin. Sporangia having stalk larger than the capsule, annulate; annulus vertical, 14-16 celled (Fig. 114 g). Spores monolete, bilateral, 28-32 x 32-35 μm, perispore, and perispore folded, deep brown in colour (Fig. 114 h).
Chromosome No. $n = 41$ (cf. Khullar, 2000).

Earlier records of distribution:

**India:** North western Himalayas: Himachal Pradesh, Kumaun. Eastern Himalayas: Sikkim, West Bengal-Darjeeling.

**World:** Bhutan, China, Nepal, Philippines, Tibet and Taiwan.


Synonyms:


A medium sized terrestrial fern growing on shady forest floors. Plant size ranges from 50-64 cm. Rhizome short, erect, thick, woody, densely scaly (Fig. 115 e). Fronds pinnate compound, highly fibrilose and scaly. Stipes 10-30 cm long, light brown, thick, diameter 0.3-0.4 cm, densely scaly and fibrillose; scales are of three types—

i. Dark-brown, bicolourous, lower portion dark brown, upper portion light brown, 1.2-2.0 cm x 0.6-0.7 cm, broadly ovate, apex aristate (Fig. 115 f-g). ii. Light-brown to dark brown, linear-lanceolate, 1.8-2.2 x 0.2-0.3 cm, apex acuminate. iii. Golden brown to light brown, linear-lanceolate, margin fimbriate, 0.3-0.4 cm x 0.1. Rachis densely scaly and fibrillose, scales as on stipes, highly acuminate, margin with short projections. Lamina bipinnate, 30-34 cm long, 10-12 cm broad, lanceolate, texture subcoriaceous; pinnae many, 18-20 pairs, 6-12 cm long, 1-2 cm broad, shortly petiolate, alternate; pinnules numerous, 12-15 pairs, 0.7 cm long, 0.3 cm broad, margin serrate, each tooth ending in a very distinct long spine, auricled, auricles spined or aristate (Fig. 115 a). Veins in pinnule 4-5 pairs, costa and costules scaly, scales light brown, linear, margin fimbriate (Fig. 115 b) Upper epidermal cells elongated (Fig. 115 c). Stomata anisocytic (Fig. 115 d). Sori indusiate, medial, 5-6 pairs in a single row, lower pairs of the pinnae sterile. Sporangia globose, shortly stalked, annulate; anulus 13-15 celled (Fig. 115 i). Spores monolete, brown, perispore, perispore smooth, 32-47 x 36-43 μm (Fig. 115 j).

Chromosome No. $n = 41$ (cf. Khullar, 2000).
Earlier records of distribution:


A medium sized terrestrial fern. Rhizome short, suberect, scaly; scales narrow, adpressed. Fronds pinnate compound. Stipes close, well developed, deeply grooved adaxially. Lamina pinnate, and pinnatifid, herbaceous; pinnae 10-15 pairs, subsessile to shortly stalked, pinnatifid, apex acute; pinnae lobes 10-14, margin broad dentate, apex more or less obtuse, sinus with a lobe-like tooth served by a veinlet. Veins free, forked to simple (Fig. 116 b). Stomata polycytic to anomocytic (Fig. 116 d). Upper epidermal cells rectangular in shape, margin undulated (Fig. 116 c). Sori on the shorter anterior veinlet branch, terminal to subterminal, reniform, indusiate. Sporangia oval, stalked, annulate; annulus vertical, 13-15 celled (Fig. 116 e). Spores ellipsoidal to subspherical, monolete, hyaline yellow, exospore smooth (Fig. 116 f-g).

Synonyms:

*Lastrea spectabilis* sensu Bedd., *FSI* t. 108, 1836.
*Nephrodium spectabile* (Bl.) Hook., *Sp. Fil.* 4: 115, 1862 *pro parte*.

Earlier records of distribution:


World: Bhutan, Burma and China.


5.XXVIII.1. Key to the species of the genus *Tectaria*:

1a. Sori mostly apical on the lamina lobes..........................*T. coadunata*

1b. Sori scattered throughout the lamina surface..........................*T. polymorpha*


Type: *Tectaria trifoliata* (Linn.) Cav., *Descr.* 249, 1802.


**Synonyms:**


*Tectaria macrodonta* (Fee) C. Chr., *Index Fil. Suppl.* III: 181, 1934.

*Neprodium cicutarium* sensu Hook. & Bak., *Syn. Fil.* 299, 1867 *pro parte*.

A medium sized lithophytic fern, size ranges from 29-100 cm. Rhizome short, creeping, 0.5-1 cm in diameter, densely scaly; scales adpressed, free at rhizome apex and stipe base, dark brown, 1 x 0.5 cm, broad-lanceolate, margin with short projections, apex acuminate (Fig. 117 e-f). Fronds pinnate compound, very large. Stipes 9-20 cm long, straw coloured, thick, diameter upto 0.2 cm, glossy; rachis same as stipe. Lamina bipinnate to tripininate, large, 20-80 cm long, 30-35 cm broad, dentate, texture thin, herbaceous to coriaceous, upper syrface of the lamina hairy; hairs bi-celled, clubshaped; pinnae 3-4 pairs, generally 1-3 pairs of pinnae are free and upper rest pinnae are adnate to the rachis, pinnae 10-20 cm long, 12-15 cm broad, alternate, shortly petiolate at base and sessile towards the apex (Fig. 117 a). Veins
anastomosing to form areolae with included veinlets, hairs present on the costa and costules (Fig. 117 b). Stomata polycytic (Fig. 117 d). Upper epidermal cells rectangular, having sinuous walls (Fig. 117 c). Sori small indusiate; indusium kidney shaped. Sporangia oval, stalked, annulate; annulus vertical, 14 celled (Fig. 117 g). Spores brown, monoate, perisporate, perispore folded, 23-30 x 31-42 μm (Fig. 117 h-i).

**Earlier records of distribution:**


**World:** Bhutan, China and Nepal.


**Synonyms:**


A large terrestrial fern growing on moist shady places near the water channels. Plant size ranges from 57-87 cm. Rhizome suerect, scaly; scales linear-lanceolate (Fig. 118 c-d). Fronds pinnate compound. Stipes slender, stramineous, scaly at base; scales linear-lanceolate, brown, margin denticulate, apex acute. Lamina pinnate, herbaceous, 35-52 cm long, 25-34 cm broad; pinnae 3-6 pairs, 3-6 cm broad, entire, terminal pinnae as long as the rest, often confluent with the two below it, oblique at the base, distantly arranged on rachis, hairy above, glabrous beneath; hairs 2 celled, club-shaped, costa and costules raised (Fig. 118 a). Primary veins or costular veins connected transeversely by arched veins with many free included simple or
forked veins in the areoles (Fig. 118 b). Stomata polycytic (Fig. 118 f), upper epidermal cells irregular in shape with sinuous walls (Fig. 118 e). Sori small, round, superficial on veins, scattered all over the leaf surface, indusiate; indusium small, reniform, attached at the base. Sporangia long, stalked, hairy on upper part of the stalk, annulate; annulus 12-14 celled (Fig. 118 g). Spores monolette, deep brown, perispore; perispore folded, hyaline, exospore smooth, 27-30 x 34-40 μm (Fig. 118 i-j).

Earlier records of distribution:


World: Bangladesh, Bhutan, Burma, China, Java, Malay, Nepal, Philippines, Sri Lanka, Taiwan, Thailand and Tibet.


Type: *Elaphoglossum* Schott ex J. Sm., *Gen. Fil. ad Pl.* 14, 1834.


Type: *Elaphoglossum conforme* (Sw.) Schott ex J. Sm., in *Hooker's J. Bot.* 4(27): 148, 1841.


Synonyms:


*Elaphoglossum conforme* sensu Bedd., *Handb.* 416, 1883 *pro parte.*


An epiphytic to lithophytic fern. Plant size ranges from 10-23 cm. Rhizome short, creeping, 2-3 mm in diameter, scaly; scales blackish brown, concolourous, ovate-lanceolate, undulate, acute (Fig. 119 c). Fronds stiff with a cartilaginous
margin, simple, dimorphic. Stipes clutered on rhizome, 3-10 cm long, stramineous, scaly; scales light brown, deciduous, lanceolate, margin with filamentous projections, apex acuminata, scaly, scales as on rhizome (Fig. 119 d). Lamina simple, 7-13 cm long, 1.5-2.5 cm broad, elliptic, acute, entire with a cartilaginous border, texture leathery, coriaceous (Fig. 119 a), lower surface scaly; scales are of two types, stellate and lanceolate type. Veins simple, free, forked (Fig. 119 b). Sori on entire lower surface in scattered manner, exindusiate. Spores monolet, bilateral, dark-brown, 23-25 x 32-35 μm, perisporate, perispore folded (Fig. 119 e).

Earlier records of distribution:


World: Australia, Nepal, Sri Lanka, Taiwan and Thailand.


Type: Nephrolepis Schott, Gen. Fil. 1: t.3, 1834.


Type: Nephrolepis exaltata (Linn.) Schott, Gen. Fil. 1: t.3, 1834.


Synonyms:

Polypodium auriculatum Linn. Sp. Pl. 2: 1089, 1753.


A medium sized terrestrial to lithophytic fern, sometimes grows as epiphyte on tree ferns. Plant size ranges from 30-50 cm. Rhizome 15-40 cm long, erect, more or less thick, many stolons bearing tubers; tubers 0.5-1.5 cm, densely scaly throughout
the surface, rhizome apex scaly (Fig. 120 d-f). Fronds somewhat dimorphic; pinnate compound. Stipes long, 5-25 cm or more in some cases, green when young, becomes brown at maturity, scaly; scales light brown, 0.2-0.5 cm long, concolourous, linear-lanceolate, margi with small glandular projections, deciduous (Fig. 120 g-h); rachis similar to stipe, scaly; base of the scales are broad and upper part narrow lanceolate. Lamina pinnate, 20-70 cm long, 2-7 cm broad, narrowly linear elliptic, not parallel sided, gradually narrowed upwards and downwards from the middle, thin, scaly (Fig. 120 i-j), deep green; pinnae many, 1-3.5 cm long 0.5-0.6 cm broad, alternate, sessile, oblong or linear oblong, parallel sided and narrowed towards pinnae apex, slightly falcate, base asymmetric, an angular growth, more or less triangular in one side; margin serrate to crenate, lower pinnae gradually reduced (Fig. 120 a). Stomata cyclocytic (Fig. 120 c). Upper epidermal cells irregular in shape (Fig. 120 b). Veins free, simple or forked, not reaching to the lamina margin, vein ends globose. Sori idusiate, reniform, submarginal, borne at the tips of vein ends; indusia grayish, lunate to reniform. Sporangia globose, stalked, annulate; annulus 13-14 celled (Fig. 120 k). Spores monolete, planoconvex, perisporate; perispore folded, 20-22 x 36-39 μm, exospore psilate (Fig. 120 l).

Chromosome No. n = 41, diploid (Mehra & Khanna, 1959, North India; Abraham et al. 1962, South India).

Earlier records of distribution:
India: Through out Indian regions.
World: tropics and subtropics of Old World.


5.XXXI.1.1. Key to the species of the genus Oleandra:

1a. Lamina broad; 3-4 cm broad.................................................*O. wallichii*
1b. Lamina narrow; 2-3 cm broad..............................................*O. neriformis*

A medium sized epiphytic fern, grows on tree trunks or dry exposed rocks. Plant size ranges from 22-32 cm. Rhizome long creeping, thin, 0.3-0.4 cm in diameter, densely scaly; scales dark brown to light brown, bicolourous having a dark central region and light coloured margin, linear-lanceolate, acuminate, fimbriate (Fig. 121 c). Fronds simple. Stipes short, 3-6 cm long, stramineous, thin 0.1 cm in diameter, scaly at base; scales as on rhizome, but much broader at base (Fig. 121 d); rachis densely hairy and saly; hairs white, uniseriate 2-7 celled, scales broad, ovate-lanceolate, margin fimbriate. Lamina simple, 19-27 cm long, 2-3 cm broad, elliptic-oblong, base cuneate, papyraceous, hebeaceous, apex suddenly sharp acuminate, both surfaces hairy and scaly (Fig. 121 e), margin faintly undulate with a thick cartilaginous edge (Fig. 121 a). Veins free, forked, up to the margin (Fig. 121 b). Sori indusiate; indusium reniform, close to the rachis. Stomata anomocytic. Upper epidermal cells irregular in shape with sinuous walls. Sporangia round, stalked; stalk larger than capsule, annulate; annulus 13-15 celled. Spores monolette, bilateral dark-brown, 25-27 x 32-38 μm, perispore, exospore minutely spinulose (Fig. 121 f).

**Earlier records of distribution:**


**World:** Sri Lanka.


**Synonym:**

A medium sized epiphytic fern grows on tree trunks and branches. Plant size ranges from 17-42 cm. Rhizome long creeping, thin, 0.2-0.3 cm in diameter, densely scaly; scales dark brown, bicolourous having a dark central region and light coloured margin, linear-lanceolate, apex acuminate, margin fimbriate (Fig. 122 e). Fronds simple. Stipes short, 1.5-4.5 cm distant on rhizome, 5-9 cm long, stramineous, thin 0.1 cm in diameter, scaly at base; scales as on rhizome, but much broader at base (Fig. 122 f); rachis densely hairy and sally; hairs white, uniseriate 2-7 celled; scales broad, ovate-lanceolate, margin fimbriate (Fig. 122 g). Lamina simple, 15-40 cm long, 3.0-4.0 cm broad, elliptic-oblong, base cuneate, papyraceous, herceous, apex suddenly sharp acuminate, both surfaces hairy, lower surface scaly (Fig. 122 h) margin entire (Fig. 122 a). Veins free, forked, up to the margin (Fig. 122 b). Sori indusiate; indusium reniform, close to the rachis. Stomata anomocytic (Fig. 122 d). Upper epidermal cells irregular in shape with sinuous walls (Fig. 122 c). Sporangia round, shortly stalked; stalk with glandular appendages, annulate; annulus 15 celled (Fig. 122 i). Spores monolete, dark-brown, 25-32 x 32-43 μm, perisporate, exospore smooth (Fig. 122 j).

Chromosome No. n = 41, diploid (Mehra & Khanna, 1959; Bir, 1962, Western Himalayas).

Earlier records of distribution:
World: Bhutan, Nepal, China and Tibet.


5.XXXII.1. Key to the genera of the family Davalliaceae:

1a. Indusia tubular, fixed by the base and sides ........................................... Davallia

1b. Indusia not tubular, generally basifixed:

2a. Sori depressed ................................................................. Leucostegia

2b. Sori superficial ............................................................... Araiostegia


5.XXXII.1.1.1. Key to the species of the genus *Araiostegia*:

1a. Margin of the rhizome scale entire............................................. *A. pulchra*

1b. Margin of the rhizome scale toothed......................................... *A. beddomei*


**Synonym:**


A small epiphytic to lithophytic fern. Plant size ranges from 24-45 cm. Rhizome long-creeping, thick, soft, 3-4 mm in diameter, densely scaly; scales, light brown, concolorous, large, broadly lanceolate, margin toothed with small projections, apex acuminate (Fig. 123 c). Fronds pinnate compound, loosely arranged on rhizome, 1-2 cm apart. Stipes 7-10 cm long, 1 mm thick, stramineous, scaly; scales as on rhizome (Fig. 123 d). Lamina broad-lanceolate, 17-35 cm long, 10-20 cm broad, bipinnate to tripinnate, alternate, texture herbaceous, glabrous; pinnae 12-17 pairs, alternate, lowest pair subopposite, lower pair of pinnae almost as long as or slightly smaller than the above pair; pinnules 7-10 pairs, 1-2.5 cm long, 0.5 1 cm broad, alternate, petiolate, margin deeply lobed into unequal sided lobes. (Fig. 123 a). Veins free, forked (Fig. 123 b). Stomata polocytic. Upper epidermal cells rectangular in shape with highly sinuous walls. Sori small, circular, protected by a semicircular, thin indusium attached at the base of the flat basal margin. Sporangia globose, stalked, annulate; annulus 12-13 celled long, paraphysate; paraphyses uniseriately multicellular. Spores monolete, bilateral, light brown, exospore reticulate, 22-25 x 32-39 μm (Fig. 123 e).

**Earlier records of distribution:**


**World:** China, Nepal, Bhutan and Taiwan.

**Synonyms:**


A small epiphytic to lithophytic fern. Plant size ranges from 30-40 cm. Rhizome long-creeping, branched, soft, 3-7 mm thick, densely scaly; scales adpressed, shield-like pseudopeltate, broadly ovate, light brown, 2-3 mm long, 1-1.5 mm broad, margin entire. Fronds pinnate compound, loosely arranged on rhizome, 1-2 cm apart. Stipes 10-15 cm long, 1-2 mm thick. Lamina lanceolate-deltoid, 20-25 cm long, 10-20 cm broad, tripinnate or more pinnate, subopposite to alternate pairs of primary pinnae, which are narrowly deltoid-ovate, having acute apex. The basal most primary pinnae largest, 8-15 x 3-5 cm, others progressively smaller upwards till the apex of the frond is shorter acuminate; secondary pinnae alternate, ovate to elongate-ovate with bluntly rounded apex, shortly stalked to sessile, tertiary pinnae ovate with rounded apex and margin deeply lobed into small strap like lobes having acute apex (Fig. 124 a). Veins free, forked (Fig. 124 b). Stomata polycytic (Fig. 124 d). Upper epidermal cells rectangular in shape with highly sinuous walls (Fig. 124 c). Sori small, circular, protected by a semicircular, thin indusium attached at the base of the flat basal margin. Sporangia globose, stalked, annulate; annulus 14 celled long (Fig. 124 f), paraphysate; paraphyses uniseriately multicellular (Fig. 124 e). Spores monolete, bilateral, 45-48 x 70-75 μm (Fig. 124 g).

**Chromosome No.** n = 40, diploid sexual (cf. Khullar, 2000).

**Earlier records of distribution:**

Central India: Madhya Pradesh-Pachmari. Penninsular India: Karnataka, Tamilnadu, Kerala.

World: Bhutan, Burma, China, Nepal, Sri Lanka and Tibet.


Synonym:


A small epiphytic fern. Plant size ranges from 20-40 cm. Rhizome long creeping, profusely branched, fleshy, cylindrical, 3-5 mm in diameter, densely covered with scales; scales dark brown to blackish brown, peltate, ovate-lanceolate (Fig. 125 c). Fronds scattered on rhizome, pinnately compound. Stipes 5-10 cm long, nearly flat on the adaxial surface but bearing a thin lateral ridge on either side. Lamina deltoid, spreading, 15-30 cm long and as much broad, 3-pinnate with short acute apex and with the rachis and its branches very narrowly and uniformly winged, primary pinnae 10-13 pairs, sub-opposite to alternate; basal pinnae largest, elongated, deltoid, 10-15 x 4-5 cm, with an elongated acute apex and with the basiscopic side slightly broader than acroscopic one, other primary pinnae progressively smaller towards the apex and with the acroscopic side broader than basiscopic one; secondary pinnae alternate, basal basiscopic one of basal pinnae elongate-ovate, 3-5 x 2 cm (Fig. 125 a). Lamina thin, coriaceous and glabrous on both surfaces. Veins free, midvein of the ultimate pinnae slightly raised on both surfaces bearing alternate slender lateral veinlets corresponding to marginal lobes, either forked once or twice (Fig. 125 b). Stomata polycytic. Sori indusiate, occupying the major part of the ultimate lobes, marginal; indusia tubular, brown. Sporangia globose, stalked, annulate; annulus
vertical, 13 celled (Fig. 125 d). Spores monolete, bilateral, pale yellow, 45-50 x 75-82 μm (Fig. 125 e).

**Earlier records of distribution:**


**World:** Burma, Bhutan, China, Japan, Malaya, Nepal and Sri Lanka.


**Type:** *Leucostegia immersa* Wall. ex Presl, *Tent. Pterid.* 95, 1836.


**Synonyms:**


*Acrophorus immersus* sensu Bedd., *FSI*, 11, 1863.

A small epiphytic fern, growing on tre trunks and branch regions. Plant size varies from 25-47 cm. Rhizome long, creeping, moderately thick, 3-4 mm in diameter, densely scaly; scales dark brown to light brown in colour, linear lanceolate to ovate lanceolate, apex acute and glandular, margin with a few projections (Fig. 126 d). Fronds pinnate compound. Stipes 10-15 cm long or more long, stramineous, more or less thick, 0.1-0.2 cm, hairy and scaly in young conditions, stipe scales caducous, scales as on rhizome scales. Lamina 2-3 pinnate, 15-32 cm long, acuminate, herbaceous, pale green in colour, glabrous and hypostomatic; pinnae upto 10 pairs 14-17 x 9-12 cm, obliquely placed on rachis, alternate, ultimate lobes 0.4-1.2 cm x 0.2-0.5 cm, sessile, rhomboidal, margin bluntly toothed (Fig. 126 a). Veins free, open dichotomously forked, costa and costules glabrous (Fig. 126 b). Stomata anomocytic to plocytic (Fig. 126 c). Upper epidermal cells irregular in shape with sinuous walls. Sori indusiate, reniform, green while young, entire, persistent, attached by narrow base. Sporangia oval, having a long stalk, annulate; annulus vertical, made up of 13-
14 cells (Fig. 126 e). Spores monolet, bilateral, light brown to light yellow, 22-28 x 35-48 μm, exospore tuberculate, nonperispore (Fig. 126 f).

**Earlier records of distribution:**


**World:** Indochina, Taiwan, West China and New Guinea.

**5.XXXIII. FAMILY: BLEHNACEAE (Presl) Copeland, Gen. Fil.: 155, 1947.**

**Type:** *Blechnum* Linn., *Sp. Pl.* 2: 1077, 1753.

**5.XXXIII.1. Key to the genera of the family Blechnaceae:**

1a. Sori forming linear continuous cenosori............................................*Blechnum*

1b. Sori discrete...............................................................*Woodwardia*


**Synonyms:**

*Asplenium orientale* (Linn.) Bernh. in *Schrad J. Bot.* 1800 (2): 17, 1801.


A medium sized terrestrial fern with unbranched, erect short, stump like rhizome. Plant size ranges from 40-50 cm. Rhizome thick, densely scaly; scales
elongate-lanceolate, which are 10-12 x 0.5-0.6 mm, gradually narrowed to a long acuminate apex, crowned by a club-shaped large glandular cell and with the margin nearly smooth except for an occasional small tooth like projection of marginal cells here and there (Fig. 127 e). Fronds tufted, spreading, spirally arranged and hypostomatic, 30-45 cm long. Lamina pinnate, pinnae sessile with entire margin, coadunate at base, apex acute, lamina tough and coriaceous, glabrous on both surfaces (Fig. 127 a). Stomata polycytic to anomocytic in nature (Fig. 127 d). Upper epidermal cells irregular in shape, having highly sinuous walls (Fig. 127 c). Venation obscure, midvein protruded on both surfaces, prominently grooved on the upper and bearing many closely placed lateral veins which are simple or forked once, nearly parallel to each other and terminating in the margin of the pinnae (Fig. 127 b). Sori a coenosorus, linear, one on either side of midrib, seated on the vascular commissure between lateral veins, close to the midrib and parallel to it, 1 mm broad, indusiate. Sporangia stalk longer than the capsule, annulate; annulus vertical, 16-18 cells long (Fig. 127 f). Spores bilateral, monolete, subglobose, light-golden brown, 22-29 x 36-42 μm, exospore smooth (Fig. 127 g).

**Chromosome No.** n = 33, 34 (cf. Khullar, 2000).

**Earlier records of distribution:**

**India:** North western Himalayas: Garhwal, Kumaun. Eastern Himalayas: Sikkim. Penninsular India: Karnataka, Tamil Nadu, Kerala.

**World:** Australia, Bangladesh, Burma, China, Hongkong, Taiwan and Thailand.


**Synonyms:**


*Woodwardia radicans* sensu Bedd. *FBI* t. 88, 1865.

A small lithophytic fern. Plant size ranges from 1-1.2 meters long. Rhizome short, ascending, thick, densely scaly; scales golden brown, concolourous, up to 1.2 cm long, lanceolate, apex acuminate, basally attached (Fig. 128 e). Fronds pinnate compound. Stipes 12-20 cm long, brown, thick, 0.2-0.4 cm in diameter, scaly at base, higher up stipe glabrous, scales as on rhizome (Fig. 128 f). Lamina pinnate, large up to 1 meter long, texture succoriaceous, glabrous, pinnae many, 40 cm or more long, 3-5 cm broad, distant, alternate, petiolate, upper pinnae sessile, lanceolate, margin deeply lobed, base unequal, lobes many, 1.2-2.5 cm long, 0.5-0.7 cm broad, ovate-lanceolate, subfalcate, apex acuminate, margin backwardly reflexed, spinulose, serrate, cartilaginous, apex acute (Fig. 128 a). Veins anastomosing to form one costal and 1-2 costular areole, free towards the margin (Fig. 128 b). Stomata polycytic (Fig. 128 d). Upper epidermal cells irregular in shape, walls highly sinuous (Fig. 128 c). Sori indusiate, rectangular or oblong, deeply sunk in a cavity with raised margin in a single row on either side of midvein, close and parallel to the costae, indusia flap like. Sporangia stalked. Spores light brown, monolete, perisporate, perispor e folded, spores 32-35 x 42-47 μm (Fig. 128 g).

**Chromosome No.** n = 34, diploid sexual (cf. Khullar, 2000).

**Earlier records of distribution:**


**World:** Bhutan, California, China, Italy, Japan, Java, Nepal, Pakistan, Philippines, Spain, Taiwan and Vietnam.
B. Ecological studies:

5.B.1. Spatial Distribution:

Development of biodiversity measures is an emerging subject now-a-days and it is realized by scientists and conservationists that not all the areas are available for conservation purpose and efforts need to be concentrated in choosing priority areas or species-rich areas to conserve biodiversity (Humphries et al. 1995). Since the time of Beddome (1863), floristic studies of pteridophytes in India have been made by a number of workers (Bir 1963, 1968; Mehra & Bir, 1964; Baishya & Rao 1982; Nayar and Geevarghese, 1993; Khullar, 1994, 2000; Dixit & Sinha, 2001). But from these studies it is not possible to locate the species-rich areas because of the lack of area-wise distribution maps of pteridophytes.

So, the present work was undertaken with a view to ascertain the species-rich areas through the study of ‘spatial distribution’ of pteridophytes in grid cell manner from Southern part of Sikkim. Identification of pteridophyte-rich zones will help to determine the conservation strategies necessary for pteridophytes of Southern Sikkim. Currie and Paquin, (1987) stated that physical factors not only affect the distribution patterns and abundance of species but, they also play an important role in species-richness. So, in this study, I also tried to correlate environmental features (Rainfall and Temperature) with distribution of species and species-richness.

Due to altitudinal and climatic variations, distribution of pteridophytes varies from place to place (Table: 1). The temperature that a place experiences, varies considerably with changes of altitudes. At places of low altitudes like Melli (420m), Rangpo (480m) and Singtam (488m) and Jorethang (521m), the average annual minimum and maximum temperatures vary between (7°C-10°C to 30°C-35°C) throughout the year. The places of moderate altitudes, like Kewzing (1500m), Namchi (1524m), Gaylshing (1552m), Yangyang (1556m), Gangtok (1677m) and Rumtek (1700m), minimum and maximum temperatures ranges between 5°C to 25°C whereas, at altitudes above 2700m temperatures never rises above 10°C and remains at the freezing point during the winter months (Graph: 3a). Rainfall in this State also varies considerably from place to place due to hill features. The northwestern border of Sikkim experiences comparatively low rainfall (Meteorological Department, Govt. of Sikkim data 2003-2005). Gangtok registers an average of 325 cm rainfall annually,
whereas Uttery (2080 m) in the extreme northwest has average annual rainfall of 121 cm only (Graph: 3b).

So, with the variation of temperature, rainfall and altitude, species-richness also varies (Graph: 3 a, b). Species-richness is the simple count of number of species recorded in a grid cell (6 x 6 km), (Map 18 a, b). From Graph. 3a it was found that species richness increases with altitudes from 1552 m up to an altitude of 3235 m, after which there was a sharp decline in the number of species. Even within this altitudinal range, only some areas like Pelling, Maenum, Rabongla and Gangtok were having higher number of species diversity. But some other areas in this altitudinal ranges like Yang yang, Borong, Uttery and Versey did not have much species diversity; rainfall in these areas were very low (Graph: 3b).

Distribution of fern-allies (Lycopodiaceae, Selaginellaceae and Equisetaceae) shown in Map. 1a & b, 2a suggests that they were distributed mainly in northwestern, central and western parts of South Sikkim. Some species of Selaginella were also found from extreme south and northern parts of the study area. The pattern of distributions of 30 family members of ferns in Southern Sikkim is shown in Map 2b to 17a & b. Extreme north western and northeastern parts of study area were snow bound areas almost throughout the year and are devoid of pteridophytic species. It was found that the areas showing maximum diversity of pteridophytic species were having heavy rainfall (300-425 cm/annum), high humidity and temperature ranging from 5°C to 25°C.

From the study of spatial distribution it is found that among the districts studied, South district is richer in pteridophytic species composition, here 94 pteridophytic species were found, followed by west district harbours 89 species, east district harbours 77 species and north district harbours 58 species.

Altitudinally distribution of pteridophytic species were analysed and found that Upper hill forest zone harbours maximum diversity, containing 120 pteridophytic species, followed by Low and Middle hill forest, containing 38 species and Rododendron-conifer zone forest, containg 33 pteridophytic species. (Graph: 2)

From the analysed result of Similarity Index (SI) it is revealed that South and North districts shows heighest SI (0.725) between them in species composition and East and South district shows lowest SI (0.654). (Table: 3)
5.B.2. Vertical Distribution of Epiphytic pteridophytes on their host trees:

Epiphytic pteridophyte diversity of South Sikkim varies with the change of climatic conditions and altitudinal ranges. In pteridophytes, most of the members of the families of Lycopodiaceae, Vittariaceae, Hymenophyllaceae, Davalliacae, Aspleniaceae and Polypodiaceae are adapted to epiphytic mode of life and they contribute a significant proportion to the pteridophytic flora particularly in Sikkim Himalayas. Though epiphytes comprise about 10% of the total vascular plants of the world (Hietz, 1998) but it is about 20% in Darjeeling and Sikkim Himalayas (Mehra and Bir, 1964).

Apart from traditional systematic classifications, the epiphytic pteridophytes have been classified in several ways by Sands (1926), Holtum (1938), Mehra And Bir (1964), Dhir (1980), Johansson (1974), Page (1979), Cornelisen and Steege (1989) and mainly the nature of habitats and their association have been considered. According to the vertical height sections, host trees are divided into four major regions (Johansson 1974, Cornelisen and Steege 1989), which are- Foot region (I), Upper foot region (II), Branch region (III) and Tree top region (IV) (Fig. 129). Epiphytic pteridophytes grow in different positions on the host trees, known as vertical distribution (Johansson 1974). In India, many workers studied the floristic composition of pteridophytes since the time of Beddome (1883). Many workers like Bir (1985), Bir et al. (1983), Manickam and Ninan (1984), Mehra (1974), King (1966) and Madison (1977) contributed to the understanding of ecology of epiphytes. Workers outside India like Johansson (1974), Cornelisen and Steege (1989), Ingram (1999), Bussmann (1992), Wolf (1993), Hietz (1998), Neider et al. (2000) have worked on the vertical distribution and ecology of vascular epiphytes, but no significant work has been done in India regarding the vertical distribution and diversity of epiphytic pteridophytes with special reference to Sikkim Himalayas. So, this study was undertaken with a view to determine-

a. The composition, vertical distribution and richness of epiphytic pteridophytes of South Sikkim.

b. The specialist species and generalist epiphytic species.

c. The diversity of epiphytic pteridophytes in different altitudinal regions.
d. Whether the vertical distribution and occurrence of epiphytic pteridophytes are related to the types of forest, altitude or to certain other characteristics of trees that serve as host.

This study was also undertaken to identify the epiphytic species rich areas of Southern Sikkim, which could be recommended for in situ conservation for preserving biodiversity. The frequency \( f \) of occurrence of epiphytic pteridophytes was variable along the altitudinal zones (classification considered by Humboldt, 1851). *Artheromeris wallichiana*, *Lepisorus nudus*, *Lepisorus thunbergianus* were found in all the three-altitudinal zones, show a declining frequency of occurrence as one proceeds from low altitude to high altitudes. *Lepisorus excavatus* shows an increasing frequency along the altitudinal gradient. Some species (*Polypodiodes lachnopus*, *Phymatosorus cuspidatus* and *Oleandra wallichii*) show high frequency in the middle hill forest zone and low frequency in the high and low altitudinal zones. Species like *Vittaria linearifolia*, *Vittaria himalayensis*, *Pyrrrosia flocculosa*, *Polypodium argutum*, *Lepisorus kuchensis*, *Lepisorus clathratus*, *Loxogramme carinata*, *Crypsinus griffithiana*, *Araiosperma beddomei*, and *Lycopodium phlegmaria* prefer only the middle hill forest zone. Frequencies of each epiphytic pteridophyte along the altitudinal zones are given in Table: 8.

The low and middle hill forest zone (up to 1500m) had only 20 epiphytic pteridophytic species distributed vertically in the first three regions of the host trees. The tree top region had a single epiphytic pteridophyte (*Lepisorus excavatus*). The species found in low and middle hill forest zone develop some contrivances for storing their available water supply by forming nest like or bracket like structures and thick cuticularised leaves (*Pseudodrynaria coronans*, *Drynaria quercifolia*, *Asplenium nidus*), by inrolling of leaves to prevent desiccation (*Lepisorus nudus*) or by the development of thick woolen hairs for preventing excessive transpiration (*Pyrrosia stigmatosa*).

The host trees found in the low and middle hill forest zone were *Shorea robusta* Gaertn.f., *Schima wallichii* Choisy, *Bauhinia purpurea* Linn, *Cedrela toona* Roxb.ex Rottl., *Pterospermum tetragonum* DC., *Salmalia malabarica* (DC.) Schott & Endl., *Sterculia villosa* Roxb., *Terminalia myricarpa* Heurck & Muell.Arg, *Albizia lebeec*, *Tectona grandis* L. The average heights of the host trees were 30m. Among 21
epiphytic pteridophytes *Pseudodrynaria coronans*, *Microsorium punctatum* and *Lycopodium squarrosum* had restricted distributions, while other species were distributed in two or three vertical regions (Table: 5).

Upper hill forests consisted of host trees such as *Quercus lamelloa* Sm., *Q. pachyphylloa* Kunz, *Q. lineata* Blume, *Magnolia cambelli* Hook.f.& Thoms., *Betula alnoides* Buch.-Ham., *Acer campbelli* Hook.f.& Thoms, *Rhododendron griffithianum* Wight. with an average height of 24 m. This region was the ideal habitat for maximum diversity of epiphytic pteridophytes. Temperature of this region ranged from 5-18°C almost throughout the year, except in winter season; high humidity and heavy rainfall (annually 282 cm avg. of 28 places) prevailed during monsoon, provided ideal growth conditions for epiphytic pteridophytes. I recorded 48 species and one variety of epiphytic pteridophytes from this zone (Table: 6). Among these, only *Oleandra wallichii* was found to be widely distributed in all the four vertical regions of the host trees, while *Nephrolepis cordifolia*, *Lepisorus ussuriensis*, *Polypodiastrium argutum*, *Pseudodrynaria coronans*, *Pyrrosia manii*, *Selaginella involvens* and *Ctenopteris subfalcata* were found to have restricted vertical distributions in any one, either in the foot region or in the upper foot region of the host trees. *Polypodiodes lachnopus* was found to have wide vertical distributions except in the tree top region. *Lepisorus kashyapii* and *Lepisorus excavatus* were found in tree top region in addition to *Oleandra wallichii*.

*Asplenium ensiforme*, *Lepisorus loriiformis*, *Lepisorus loriiformis* var. *steniste*, *Phymatodes griffithiana*, *Vittaria ophiopogonoides*, *Vittaria linearifolia*, *Vittaria taeniophylla*, *Vittaria himalayansis*, and *Vittaria elongata* were found to survive in the month of November and December with fertile leaves. They developed some adaptive features like thick fleshy leaves with highly cuticularised epidermal layer, narrow lanceolate leaves which helped them to withstand the adverse conditions. Here, out of the total 49 species occurring in the upper hill forest zone, 42 species were found in the upper foot region and 33 species in the branch region of the host tree.

*Rhododendron-Conifer* zone forests of Sikkim are situated between 2700-3600m altitudes. Temperature is almost below 10°C throughout the year, except winter, when it is below freezing temperature. This zone consisted of host trees such as *Quercus lineata* Blume, *Acer campbelli* Hook.f. & Thoms, *Betula utilis* D.Don, *Magnolia campbelli* Hook.f. & Thoms, *Rhododendron arboreum* Sm., *R.*
campanulatum Don, Tsuga brunoniana Carr., Abies densa Griff., Cryptomeria japonica D.Don, Pinus spp., Rhododendron setosum D.Don. The average height of the host trees of this region was 18m. This zone harbors only 25 epiphytic pteridophytes. Out of them Oleandra wallichii, Lepisorus excavatus and Arthromeris wallichiana had wide vertical distributions, but being absent in the tree top region. Pleopeltis rostrata, Ctenopteris subfalcata, Hymenophyllum simonsianum and Selaginella involvens were found to have very restricted vertical distributions (Table:7). It was observed that in the Rhododendron-Conifer zone, Rhododendron spp and some conifers did not harbor much epiphytic pteridophytes. Only two pteridophytic species (Lepisoris loriformis var.steniste and Vittaria taineophylla) were found to grow on trunks of Rhododendron spp. having smooth type of bark. Quercus lineata common in this region acted as good host for epiphytes due to its corrosive nature of the bark.

It is found that the upper foot regions of each three altitudinal zones having the maximum diversity of pteridophytes. Species richness, which is the simple count of species, was much more in the upper foot and branch regions than the lower foot and tree top regions. Tree top region of the low and middle hill forest zone was the poorest regarding the species richness. Upper foot regions of the host trees in the upper hill forest areas were having the highest diversity of epiphytic pteridophytes.

5.C. Conservation:

5.C.1. Present status of Pteridophyte diversity in Sikkim State:

The Sikkim State consists five types of forests. The vegetation are generally luxuriant where temperature varies from a min. average of 6° C to a maximum average of 27° C in moderate altitudes, but it is below freezing temperature in high altitudes during winter. Rainfall also varies and average rainfall is 325 cm/annum (Meteorological department, Govt. of Sikkim, Gangtok, 2005). Altitudinally the vegetation of this state is divided into five regions.

1. Low hill forests (Tropical to subtropical type, 300-900m)
2. Middle hill forests (Subtropical type, 900-1500m)
3. Upper hill forests (warm or temperate type, 1500-2700m)
4. Rhododendron-Conifer zone forests (Cold temperate to sub-alpine type, 2700-3600m)
5. Alpine Scrub and Grasslands (3600-4300m or above)
Out of these, first three zones are habitats of pteridophytes in large numbers. Mehra and Bir (1964) reported 362 species of pteridophytes from Darjeeling and Sikkim Himalayas. Maity and Chauhan (2001) partially explored Kanchenjungha Biosphere Reserve and listed 57 species of pteridophytes. According to the department of forestry and wildlife, Govt. of Sikkim, this State harbors over 300 species of ferns and fern-allies including 8 species of tree ferns (Table: 9). The fourth zone Rhododendron-Conifer zone forest harbors a few number of pteridophytic species; whereas the alpine scrub and grasslands having few pteridophyte species. In Sikkim 38 species are listed as endangered species and are on the verge of extinction due to human interferences and natural threats.

More than 40% of the pteridophytic elements of South Sikkim are epiphytes. The epiphytes as are restricted mostly to tropical and subtropical wet forests and by definition growing on trees, they are automatically vanishing with deforestation or with the loss of forest trees. As they are highly sensitive to climatic conditions and often have slow growth, they appear in many cases to be even more vulnerable than other plants. This makes them suitable indicators of changes in local climate.

5.C.2. Threats to pteridophyte diversity:

1. **Indirect effect of increasing tourist pressure:** Increasing tourist pressure and their activities on this attractive small hilly state are disrupting the natural habitats of pteridophytes. According to the data of tourist department, Govt. of Sikkim, tourist activity increased about 20 times from 1980-2005 (Table: 10). As the economy of this state largely depends upon tourism, constructional works like hotels, lodges, roads etc increasing day by day to facilitate tourism, causing depletion of green coverage and loss of biodiversity including pteridophytes (PLATE 20 a, b, c).

Due to increasing pressure of tourists, number of automobiles also increasing throughout the Sikkim. Exhausts of automobile pollute the environment; specially Pb and other heavy metals like Zn, Cd, Cr, Ni etc coming out of exhausts are deposited on the roadside soil and pollute it (Table: 11). It is experimentally proved that over 5 ppm of Pb concentration decrease the percentage of germination of fern spores and arresting the further development of fern gametophytes (Table: 12-13; Plate: 21-22).

*Diploterigium glaucum* (Thunb.) Nakai, the “Welcome fern” of Darjeeling and Sikkim Himalayas which grow along the roadsides was abundant according to previous work, but it is decreasing day-by-day. Present study revealed the decreasing
status of *Diploterygium g/aucom* (Thunb.) Nakai, in different parts of Sikkim, the frequency of occurrence is maximum in North district (44.2) and minimum in East district (12.0). It is probably due to repeated constructional works along the roadsides and deposition of Pb-containing automobile exhausts along the roadside soil, causing decrease in the percentage of spore germination and arresting of further developmental stages of fern gametophytes. (Table: 12 & 13; Plate-21) *Nephrolepis cordifolia* (L.) Pres!, another roadside fern also decreasing due to the same reasons. Ghosh and Ghosh (1997) listed 38 species of pteridophytes under threatened categories from Sikkim. Tree ferns are already listed under endangered categories due to loss of habitats and pollution, they have frequency of occurrence highest in south district \((f=16.3)\) and lowest in north district \((f=7.4)\).

One of the major problems associated with the increasing pressure of tourists in this State is the plastic pollution. Plastics, poly bags were dumped on the mountain slopes and finally obstructing the water channels. Plastics also create major hazard in the soil profile. It is a non-biodegradable product and it lessens the soil binding property and increases landslides. Though the Government of Sikkim banned the use of poly bags, but still it is being used in this State.

2. *Increase of population*: Though the population of Sikkim is very low being 5,40,493 (Census 2001), but the growth rate of population is very high. The population of this State has grown by 32.98% between 1991-2001, against 21.34% for the country as a whole. Population density of Sikkim was 57/ km² in 1991 but in 2001 it increased to 76/ km² (Census, 2001). Urbanization percentage in this state was 9.1% in 1991. It has increased with the increase in population size. The major part of inhabitants is rural people and their major occupation is agriculture. Paddy is one of the major economic crops in this state followed by cardamom cultivation. Cardamom cultivation in the forest floor is one of the major causes for threat of forest floor flora, which includes pteridophytes also, because a large number of pteridophytic species grow on forest floor. So, with the increase of population there was a pressing need for increase of food grains. Therefore, rice cultivable land had to be increased at the cost of forest cover; inspite of afforestation procedure taken by the forest department of Sikkim, 16% land area of this state is used as agricultural land and 37.34% are under forest cover (Department of forestry and wildlife management, 2000). Every day this area of forest cover is decreasing. About 34.67% population of this state is below the
poverty line (Census, 2001) and many of them are depending on the forest products for their livelihood. The forest, agriculture and livestock form such a compact and complex relationship that one is always dependent on the others and maintaining the life of hills; the rural people always feel that the forests are free gifts of nature and consider the forest area as underused. Therefore, human population in this State exploit forests in an accelerated rate for food, fodder, timber, fuel wood and more-agricultural land for their livelihood (Gadgil and Meher-Homji, 1986).

3. Use of pteridophytes as food and fodder: Young twigs of Diplazium esculentum (Retz.) Sw. is sold in the market as green leaf vegetable. Pteridium aquilinum (L.) Kuhn. is extensively used as fodder for cattle in this region. Some species of Dryopteris (D. wallichina, D. redactopinnata) are also extensively collected for fodder. These species of pteridophytes are only exploited; no steps are taken for their regeneration. This extensive exploitation or use causing depletion of the population of these fern genera.

4. Role of Botanists: Botanists themselves are responsible to some extent for depletion in the number of individuals of rare species, because during botanical trips of schools, colleges and universities, there is a craze for collection of rare species by the students. Though collection of rare plants in the field is banned, but it is still going on.

A species just migrated from other areas or a species on the verge of extinction being survived by only one or two individuals, if collected by a botanical excursion team would stop the procedure of plant migration and cause total extinction of the species from that area.

5.D. Floristic analysis:
Phytogeographical analysis of pteridophytic flora of South Sikkim in relation to other phytogeographical regions floristic compositions of India and South-eastern Asian Countries (Table: 14), has revealed the following interesting points:

• Among Indian floristic regions North Western Himalayas shares the maximum percentage of species (76.5%) with south Sikkim.
• Northeastern India (67.9%) and Deccan plateau (45.3%) elements are also well represented.
• Central Indian mountains, which have meager pteridophytic vegetation, share only 26.5% of species.

• Western Ghats (12.5%), Eastern Ghats (8.5%) and Gangetic plain (8.5%) share insignificant representatives.

• Between Southeastern Asian countries Chinese elements share maximum species (67.1%) followed by Nepalese elements (62.5%).

• Tibetan region shares (50.4%) species with South Sikkim.

• Bhutan and Burma represents 54.6% and 43.7% of pteridophytic flora of South Sikkim respectively.