1. An Introduction to Ferns and Fern-Allies: (Part I) — Morphology, Diversity, and Global Distribution

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ABSTRACT

Ferns and fern-allies (pteridophytes) are globally widespread vascular, spore-producing plants, with an estimated 10,000–13,000 species worldwide. India harbors a rich pteridophytic flora, comprising 34 families, 130 genera, and 1156 taxa, including species and subspecies, with major centers of diversity in the Western Ghats, Eastern Himalaya, Northeastern hill ranges, and Andaman–Nicobar Islands. The Indian flora spans primitive fern allies such as Lycopodiaceae and Selaginellaceae to highly evolved leptosporangiate families including Dryopteridaceae, Pteridaceae, Polypodiaceae, and Aspleniaceae. Taxa occupy a wide range of habitats, from aquatic and marshy lowlands to humid tropical forests, montane cloud forests, and high-elevation Himalayan slopes. Specialized lineages include Isoetaceae, Equisetaceae, Psilotaceae, Ophioglossaceae, and Marattiaceae, while tree ferns (Cyatheaceae, Dicksoniaceae) and filmy ferns (Hymenophyllaceae) reflect montane adaptations. Dominant families such as Dryopteridaceae (204 taxa), Pteridaceae (172), Polypodiaceae (130), Woodsiaceae (130), Aspleniaceae (87), and Thelypteridaceae (83) demonstrate remarkable ecological and morphological diversity. Aquatic ferns (Azollaceae, Salviniaceae, Marsileaceae) occupy seasonal and permanent wetlands. This synthesis highlights India as a major center of fern diversity, with high endemism, varied phytogeography, and pressing conservation needs, providing a baseline for further taxonomic, ecological, and conservation studies. In this paper, we discuss ferns and fern allies, covering their morphology, distribution, and diversity, along with important features.

Keywords: Ferns, Fern-Allies, Morphology, Diversity, Distribution

1. INTRODUCTION

Pteridophytes, encompassing ferns and fern-allies, are ancient vascular plants that reproduce by spores and display exceptional morphological and ecological diversity. Globally, they comprise approximately 10,000–13,000 species, ranging from aquatic and terrestrial herbs to epiphytes and tree ferns, with maximum diversity in humid tropical and montane regions. All share a characteristic sporophytic body plan of roots, rhizomes, and fronds, and a life cycle defined by alternation of generations. Primitive fern-allies retain distinctive features such as microphylls, rhizophores, or eusporangiate sporangia, whereas true ferns exhibit advanced characters—especially venation patterns, indumentum, and sori—that are central to taxonomy and identification.

India is a major global centre of pteridophyte diversity, supporting **over** 1,100 taxa across 34 families and 130 genera, with richness concentrated in the Eastern Himalaya, Western Ghats, Northeastern hill ranges, and the Andaman–Nicobar Islands. These regions encompass habitats from wetlands and lowland marshes to cloud forests and high Himalayan slopes. While families such as Dryopteridaceae, Pteridaceae, Polypodiaceae, Woodsiaceae, Aspleniaceae, and Thelypteridaceae show broad ecological amplitude, several lineages—including Isoetaceae, Marattiaceae, filmy ferns, and tree ferns—occupy specialized or relictual niches. This synthesis integrates global and Indian perspectives on taxonomy, morphology, diversity, distribution, reproduction, habitats, and phytogeography, providing a robust framework for research, field identification, and conservation planning.

2. MORPHOLOGY

Ferns and fern-allies, together termed pteridophytes, are flowerless vascular plants with well-developed xylem and phloem but lacking seeds. They reproduce by spores and are therefore known as vascular spore plants, occupying an evolutionary position between non-vascular cryptogams and seed-bearing gymnosperms and angiosperms. In geological history, particularly during the Mesozoic, pteridophytes dominated terrestrial vegetation, with giant club mosses, horsetails, and tree ferns forming extensive forests that later contributed to major coal, petroleum, and natural gas deposits.

Today, apart from about 600 species of tree ferns, most pteridophytes are small herbaceous or shrubby plants, widely distributed across tropical, temperate, alpine, coastal, and dry regions, with roughly 12,000 species recognized worldwide. Traditionally, they are divided into fern-allies, comprising primitive groups such as whisk ferns (*Psilotum*), lycophytes, spike mosses (*Selaginella*), and horsetails (*Equisetum*), and true ferns, which include numerous families and represent the more advanced and diverse evolutionary lineages. (Kholia B. S., 2010 & 2014)

2.1. Fern Allies

1. Clubmosses (Lycopods): Clubmosses are represented by Huperzia, Lycopodium, and Lycopodiella. Growth forms vary—pendulous epiphytes, lithophytes, or creeping terrestrials. Their tiny single-veined microphylls are highly diagnostic. Sporangia may occur in leaf axils or on specialized sporophylls forming terminal cones (*e.g.*, *L. japonicum*, *Lycopodiella cernua*). All produce single-sized spores and are therefore homosporous.
2. Spikemosses (*Selaginella*): Roots arise from the stem base or specialized rhizophores (*e.g.*, *S. biformis*, *S. longipila*). Leaves are usually dimorphic, arranged in definite ranks, and provide key taxonomic characters. *Selaginella* is heterosporous, producing megaspores and microspores within terminal sporophyll spikes. The position of megasporangia, usually near the cone base, helps in identification.
3. Horsetails (*Equisetum*): Horsetails have rough, silica-rich stems used historically for polishing—hence the name *scouring rush*. Their hollow, jointed stems bear whorls of leaves at each node. The creeping rhizome is extensive, and reproductive sporangiophores form compact terminal cones.

2.2. Ferns

True ferns show great variation in size but share a common sporophytic organization comprising roots, stem (rhizome), and leaves (fronds), with the exception of heterosporous aquatic ferns. Roots are fibrous, small, and adventitious, arising along the rhizome except at the growing tip; in epiphytic ferns they are often confined to specific rhizome regions. The stem is a woodless rhizome that may be erect or creeping, ranging from erect caudices in tree ferns and species such as *Diplazium maximum*, to short creeping rhizomes (*Athyrium drepanopterum*, *Pteris wallichiana*) and long creeping types (*Microlepia* spp.), with some taxa producing stolons (*e.g.*, *Nephrolepis cordifolia*). Fronds arise as coiled fiddleheads showing circinate vernation and are frequently protected by scales or hairs during early development. The stipe, which connects the lamina to the rhizome, may be articulated or not and varies in colour, texture, grooves, and indument, providing important diagnostic characters. The lamina may be simple to highly compound, with venation patterns that are free, forked, or reticulate; features such as hydathodes and marginal vein endings are often taxonomically informative. Ferns also show diverse indumentum, including various types of hairs and scales differing in form, colour, and margin structure, all of which are highly diagnostic and essential for species-level identification.

3. REPRODUCTIVE STRUCTURES AND LIFE CYCLE OF PTERIDOPHYTES

3.1. Spore-Producing Organs in Ferns

Sori and Sporangia in Ferns Reproduction in pteridophytes begins with the formation of spores within specialized structures called sporangia, which in ferns are produced in large numbers and arranged in characteristic patterns. The arrangement, position, and form of sporangia (sori) are among the most important diagnostic characters used in fern taxonomy. Sporangia may occur as tassels (*e.g.*, *Botrychium*, *Osmunda*), spikes (*Ophioglossum*), synangia of fused sporangia (*Angiopteris*), or, most commonly, as sori in true ferns.

Sori show great positional variation on the frond. Marginal sori occur at the leaf margin, either in small notches (*Lygodium*), marginal cups or bi-lipped pouches (filmy ferns), or sunken marginal sacs (*Lindsaea*, *Odontosoria*). Submarginal or intramarginal sori, lying close to the margin, are typical of genera such as *Pteris*, *Pteridium*, *Adiantum*, *Aleuritopteris*, and *Onychium*. The most common type, abaxial sori, occur on the lower surface of the lamina and display a wide range of shapes—circular, globose, reniform, linear, J-shaped, cup-shaped, chain-like, or notched—providing valuable characters for identification.

Sori may be indusiate (covered by a membranous indusium) or exindusiate. In some ferns, protection is provided by modified structures such as peltate scales (*Lepisorus*), stellate hairs (*Pyrrosia*), or acicular hairs (*Macrothelypteris*). Many taxa possess a false indusium, formed by the inrolled leaf margin, as seen in *Pteris*, *Pteridium*, *Histiopteris*, and *Cheilanthes*. Indusia vary widely in shape—reniform, circular, linear, funnel-shaped, cup-shaped, or bivalved—and are taxonomically informative.

The relationship of sori to venation is also diagnostic. Sori may occur directly on veins, at vein tips or bifurcations, along one or both sides of veins, on marginal commissures, within areoles, on included veinlets, or along the costa or midrib, patterns that help distinguish major families and genera.

In advanced leptosporangiate ferns, each sporangium is typically stalked and club-shaped, with a thin-walled capsule bearing a specialized annulus and a stomium through which dehiscence occurs. Drying of the annulus generates tension that causes the capsule to split and forcibly release spores. In more primitive ferns and fern allies (*e.g.*, *Osmunda*, *Schizaea*, *Ophioglossum*), the sporangial wall is several cells thick and lacks a well-defined annulus, with dehiscence occurring by simpler longitudinal slits.

Spores are microscopic and are classified mainly as monolete (with a single linear scar) or trilete (with a three-rayed scar). They vary in shape and surface ornamentation—smooth, spiny, verrucose, tuberculate, or ridged—features that are highly useful in palynology, systematics, and species identification.

3.2. Life Cycle of Pteridophytes

Pteridophytes show a distinct alternation of generations with a dominant sporophyte and an independent gametophyte. The sporophyte is the large, visible fern plant that produces haploid spores in sporangia by meiosis; these spores are dispersed by air, aided by their sculptured walls. Under favorable moisture and temperature, spores germinate to form the gametophyte (prothallus), which is small, green, photosynthetic, and usually heart-shaped or ribbon-like, though dark and saprophytic in some primitive groups. The prothallus bears antheridia, producing motile, ciliated sperm, and archegonia, each containing a single egg. Fertilization requires a thin film of water through which the sperm swim to the archegonium; the fertilized egg develops into a zygote that grows into a new sporophyte. In heterosporous ferns, microspores give rise to male gametophytes and megaspores to female gametophytes, with some species showing incipient heterospory and variation in gametophyte structure. Deviations from the typical life cycle include apogamy, where the sporophyte develops without fertilization, and apospory, where the gametophyte arises directly from sporophytic tissue, both involving altered chromosome behavior. In addition to sexual reproduction, many ferns propagate vegetatively through gemmae, bulbils, and rooting buds.

4. DIMORPHISM IN FERNS

Dimorphism in ferns refers to the presence of two morphologically distinct frond types—sterile and fertile—on the same plant. Sterile fronds are primarily photosynthetic and are usually broader, thinner, and more delicate, whereas fertile fronds are specialized for spore production and are often narrower, thickened, or structurally modified to bear sori; in some taxa they may be highly reduced or spike-like. The expression of dimorphism may be influenced by environmental factors such as light, humidity, and nutrient availability, especially in epiphytic ferns where sterile fronds may assist in anchorage or water retention while fertile fronds focus on reproduction. This division of labour enhances spore dispersal efficiency without compromising photosynthetic capacity and facilitates adaptation to diverse habitats, including terrestrial, epiphytic, and lithophytic environments. Pronounced frond dimorphism occurs across several fern families, notably Osmundaceae, Polypodiaceae, Dryopteridaceae, Pteridaceae, Tectariaceae, and Elaphoglossaceae, and is well represented in Indian ferns such as *Osmunda regalis*, *Polystichum squarrosum*, *Adiantum capillus-veneris*, *Microsorum punctatum*, *Bolbitis* spp., *Drynaria* spp., *Lepisorus* spp., *Leptochilus* spp., *Pyrrosia* spp., *Elaphoglossum* spp., and *Tectaria* spp. Overall, frond dimorphism represents an important evolutionary and adaptive strategy in ferns and provides valuable characters for taxonomic, ecological, and evolutionary studies, particularly in fern-rich regions such as the Western Ghats and North-East India.

5. DIVERSITY AND DISTRIBUTION

This paper synthesizes global overviews (museum databases, peer-reviewed studies, and IUCN summaries) with Indian regional checklists and conservation reports, presenting ranges where estimates vary and citing key sources, with a focus on diversity, distribution, and conservation. Globally, fern and fern-ally diversity is estimated at about 10,000–13,000 species, with variation arising from differing taxonomic concepts, inclusion of eusporangiate groups, and ongoing discoveries; diversity peaks in humid tropical and montane regions, particularly in Southeast Asia, Mesoamerica, and Australasia, where epiphytic radiations are prominent. In India, recent conservative estimates indicate roughly 900–1,100 pteridophytic species, with highest richness in Northeast India and the Eastern Himalaya, followed by the Western Ghats and southern hill ranges; ferns occupy a wide range of habitats, dominated by terrestrial forms, with abundant epiphytic and lithophytic taxa in wet montane forests and specialised aquatic species in wetlands and slow-moving waters.

India's fern and fern-ally flora, as represented in the compiled checklist data, comprises a total of 34 families, collectively containing 130 genera and amounting to 1156 taxa when all species, included subspecies, and additional subspecies are considered. This consolidated figure reflects the full spectrum of pteridophytic diversity recorded from India, spanning primitive fern allies such as Lycopodiaceae and Selaginellaceae to highly evolved leptosporangiate ferns including Dryopteridaceae, Pteridaceae, Polypodiaceae, and Aspleniaceae. The total of 1156 taxa highlights India's position as one of the major centres of fern diversity in the Asian tropics, encompassing a wide ecological range from aquatic habitats and lowland marshes to humid tropical forests, cloud-covered montane zones, and high-elevation Himalayan slopes.

India possesses one of the richest assemblages of ferns and fern allies in the tropical and temperate regions of Asia, and the diversity pattern becomes particularly clear when analysed family-wise across the subcontinent. The family Lycopodiaceae in India consists of three genera and 28 species (including two subspecies), occurring largely in montane forests of the Eastern Himalaya and Western Ghats, reflecting a moderate but ecologically significant representation. Selaginellaceae, represented by a single but highly diverse genus Selaginella, contributes 55 species and one subspecies, forming one of the richest fern-ally groups in India and occupying both moist evergreen forests and seasonally dry rocky habitats. Isoetaceae, with only one genus and four species, represents a small but specialised group occurring in wetlands, seasonal pools, and river margins, while Equisetaceae, represented by Equisetum with three species and two subspecies, shows very restricted distribution limited to riverbanks and moist alluvial zones. Psilotaceae is represented by two species of Psilotum, mostly epiphytic and confined to

humid tropical regions, whereas Ophioglossaceae contributes a surprisingly diverse assemblage of 20 species distributed in three genera, which occupy moist grasslands, shaded forest floors, and wetlands; their diversity is globally significant. Marattiaceae, a primitive and relictual family, includes five Indian species confined mainly to the Western Ghats and Northeast, where old-growth evergreen forests support their survival. Osmundaceae, with six species and two subspecies, exhibits a temperate distribution pattern typical of cool and moist Himalayan forests. Similarly, Plagiogyriaceae comprises four species restricted mainly to moist ravines and shaded slopes in the Himalaya, reflecting very narrow ecological requirements, while Dipteridaceae is extremely sparse with only one species of Dipteris found in parts of Northeast India, representing a paleo-tropical lineage.

The family Gleicheniaceae, with two genera and seven species, often occupies open, sunny slopes and forest margins in montane regions, whereas Lygodiaceae, represented by nine climbing species of Lygodium, displays adaptation to disturbed habitats and variable moisture regimes. Schizaeaceae includes three species belonging to two genera, showing limited diversity but specialising in sandy soils and open habitats. The aquatic Marsileaceae, comprising three species of Marsilea, occurs in ponds, wetlands, and rice fields and reflects adaptation to seasonal hydrological fluctuations. Tree ferns of Cyatheaceae are represented by 11 species across high-rainfall montane regions such as the Eastern Himalaya, Western Ghats, and Andaman–Nicobar Islands, while Dicksoniaceae contributes only one species restricted to humid montane forests, representing an ancient Gondwanan lineage. Hymenophyllaceae, the filmy ferns, show high diversity in India with 36 species adapted to extremely humid and shaded habitats such as cloud forests, ravines, and waterfalls. Dennstaedtiaceae includes 27 species in six genera, occurring widely in open forests, grassy slopes, and shrublands, reflecting their ecological versatility. Lindsaeaceae, with 19 species (20 taxa including subspecies) distributed across three genera, is largely confined to moist, shaded tropical forests. One of the most diverse fern families in India, Pteridaceae, comprises 20 genera and 159 species (172 total taxa), displaying remarkable morphological and ecological variation across xeric cliffs, forest floors, riverbanks, and limestone habitats. Vittariaceae, with 16 species across two genera, consists mainly of narrow-leaved, epiphytic ferns of moist tropical forests. The genus Asplenium dominates the family Aspleniaceae in India, contributing 72 species and several subspecific taxa (87 in total), making it one of the most species-rich single genera of Indian ferns, commonly found on shady rock faces and montane cliffs. Thelypteridaceae, with 81 species (83 taxa), forms another major group with high diversity in marshy forests, riverine zones, and montane habitats, reflecting remarkable ecological adaptability. In the second group of families, Woodsiaceae emerges as one of the richest families with 10 genera and 124 species (130 taxa), showing strong representation across temperate and subtropical habitats of the Himalaya and

Northeast. Blechnaceae contributes 11 species across five genera, confined largely to humid upper montane zones, while Dryopteridaceae is the largest fern family in India with 17 genera and 196 species (204 taxa), dominating the fern flora of the Himalaya and Northeastern states and representing extensive evolutionary radiation. Lomariopsidaceae includes 28 species across three genera, mostly epiphytic or lithophytic, distributed in moist evergreen forests. Oleandraceae, with one genus and three species, shows limited distribution on rocky substrates, whereas Nephrolepidaceae comprises nine species across two genera, many of which show adaptation to both natural forests and anthropogenic habitats. Davalliaceae, an important epiphytic family, contains 19 species distributed across four genera, primarily in humid tropical regions. Polypodiaceae, one of the most dominant epiphytic fern families, includes 21 genera and 128 species (130 taxa) and shows remarkable richness in the Eastern Himalaya and Western Ghats. Grammitidaceae includes 12 species in six genera, occupying cloud forests and humid montane habitats where epiphytism is the dominant life form. Among aquatic ferns, Azollaceae is represented by two species (three taxa in total), well known for their ecological and agricultural roles as nitrogen fixers, while Salviniaceae comprises three floating species of Salvinia that inhabit ponds and slow-moving water bodies across India.

Taken together, these families reveal clear patterns in Indian pteridophyte diversity, with exceptionally high richness concentrated in the Eastern Himalaya, followed by the Western Ghats, Northeastern hill ranges, and Andaman–Nicobar Islands. Families such as Dryopteridaceae, Pteridaceae, Polypodiaceae, Woodsiaceae, Aspleniaceae, and Thelypteridaceae dominate the Indian fern flora, while aquatic and relictual families maintain specialised, low-diversity niches. This distribution reflects strong tropical–montane phytogeographical influences, a mixture of ancient Gondwanan lineages and more recent Southeas

6. HOW TO IDENTIFY FERNS AND FERN ALLIES IN THE FIELD

Identifying ferns and fern allies in the field begins with understanding their fundamental morphology, growth forms, and habitat preferences. Unlike flowering plants, ferns do not produce flowers or seeds; instead, they reproduce by spores, which are typically borne on the undersides or margins of their fronds. Field identification therefore relies on careful observation of the frond architecture, venation patterns, soral arrangement, rhizome type, and ecological conditions. The first step is to examine whether the plant is a true fern or a fern ally: true ferns possess fronds with a clear rachis and pinnae, whereas fern allies such as *Selaginella*, *Lycopodium*, *Isoetes*, *Psilotum*, and *Equisetum* display highly distinct vegetative structures that differ from typical fern fronds.

In the field, the overall growth form provides the quickest clue—ferns may be terrestrial, epiphytic, lithophytic, climbing, or aquatic, and each group tends to occupy characteristic ecological niches. Terrestrial ferns usually have an upright or creeping rhizome bearing fronds that may be simple, pinnate, bipinnate or even tripinnate, whereas epiphytic ferns often have wiry or creeping rhizomes on tree trunks with tough, coriaceous fronds (*e.g.*, *Polypodiaceae*). Aquatic ferns such as *Azolla*, *Salvinia*, and *Marsilea* show distinctive floating leaves or clover-like leaflets, making them easy to recognise.

The frond structure is the most essential diagnostic character. Field identification requires noting whether the frond is entire, pinnatifid, pinnate, bipinnate, or highly dissected. The texture (herbaceous, thin-membranous, leathery, or filmy), the shape of the stipe (smooth, scaly, hairy), and the colour or type of scales on the rachis or stipe further narrow down the family or genus. In many genera such as *Dryopteris*, *Polystichum*, or *Asplenium*, distinctive scales, sori patterns, and venation help separate closely related species even in the field.

Venation pattern—whether free, forked, reticulate, or anastomosing—is another major clue. Reticulate venation is common in *Pteris* and *Adiantum*, while free veins are typical in many *Dryopteridaceae*. Marginal false indusia, true indusia, or absence of indusia on sori also help determine genera. For instance, *Pteris* has marginal sori protected by reflexed leaf margins, *Asplenium* has linear sori along the veins, and *Polystichum* has round sori with peltate indusia. Observing the position, shape, and arrangement of sori—whether round, linear, marginal, terminal, scattered, or paired—provides strong taxonomic clues even without microscopes.

Fern allies show entirely different structures. *Selaginella* can be recognised by its small, scale-like leaves arranged in four rows along a slender stem, often forming mats in moist places. *Lycopodium* and *Huperzia* have needle-like or scale-like leaves arranged spirally, and often show upright, club-shaped strobili. *Isoetes* resembles a tuft of quill-like leaves emerging from a corm, always found in marshes or seasonal pools. *Psilotum*, one of the most primitive allies, lacks true leaves and roots, appearing as a green, dichotomously branching twig. *Equisetum* is unmistakeable, with jointed, hollow stems, whorled branches, and cone-like strobili at the tips.

Finally, habitat and altitude are critical components of field identification. Many species inhabit highly specific ecological niches: filmy ferns like *Hymenophyllum* occur only in extremely humid ravines; tree ferns such as *Cyathea* are restricted to high rainfall montane forests; *Selaginella* species may indicate rocky slopes, moist cliffs, or shaded ground; and large *Diplazium* and *Athyrium* often dominate riverbanks and wet valleys. Altitudinal preferences—from lowland evergreen forests to mid-elevation hills and alpine meadows—help separate confusing taxa.

Together, these characters—growth form, frond architecture, venation, indusia types, soral patterns, rhizome traits, and precise habitat—allow reliable field identification of most ferns and fern allies. With repeated observation, these features become intuitive, enabling rapid recognition of families and genera even before consulting taxonomic keys.

Identifying ferns in the field mainly depends on morphological characters that are easily visible without microscopes. The following are the most important features:

7. IMPORTANT FEATURES OF FIVE DOMINANT FERN FAMILIES OF INDIA

Fern identification in the field relies on a combination of vegetative and reproductive characters. Growth habit and habitat (terrestrial, epiphytic, lithophytic, climbing, or aquatic; forest floor, slopes, riverbanks, cliffs, or tree trunks) often provide the first clue to family or genus. The rhizome type—creeping or erect, thick or slender, with characteristic scales or hairs—is diagnostic in groups such as Polypodiaceae, Dryopteridaceae, and Davalliaceae. Frond architecture (simple to highly dissected), texture, and stipe features (colour, scales, hairs) are among the quickest characters for generic separation. Venation pattern (free or reticulate) readily distinguishes genera such as *Pteris*, *Adiantum*, *Asplenium*, *Polystichum*, and *Dryopteris*. The most critical characters are sori, including their shape, position, arrangement, and the presence or absence of an indusium (true or false), which are fundamental for family-level identification. Additional support comes from rachis and stipe characters, overall plant size and form, and distinctive traits such as climbing fronds (*Lygodium*), basket-like sterile fronds (*Drynaria*), filmy fronds (Hymenophyllaceae), clover-like leaves (Marsileaceae), or floating rosettes (Salviniaceae, Azollaceae). Taken together, habitat, frond form, rhizome features, venation, sori and indusium characters, and stipe traits usually allow reliable identification of fern families and genera in the field.

Pteridaceae is one of the most diverse and widespread fern families in India, especially common in dry, semi-arid, rocky, and open habitats. Fronds are usually thin and 1–3-pinnate, often showing xerophytic adaptations. Sori are typically marginal or near vein endings and protected by a false indusium formed by the rolled leaf margin. Members are tolerant of high light and heat and are frequent on hill slopes and rock crevices; major genera include *Pteris*, *Adiantum*, *Cheilanthes*-group ferns, and *Actiniopteris*.

Polypodiaceae is one of the largest families of epiphytic ferns in India, abundant in the Western Ghats and Northeast. Plants have thick, creeping, scaly rhizomes, with fronds that are simple to deeply lobed and usually leathery. Sori are round, exindusiate, and arranged in regular rows. Common genera include *Pyrrosia*, *Lepisorus*, *Microsorum*, *Drynaria*, *Goniophlebium*, and

Selliguea, many of which dominate forest canopies and have ornamental or medicinal value.

Thelypteridaceae is widespread in marshes, riverbanks, moist forests, and swampy lowlands. Fronds are pinnate to bipinnate, soft-textured, and highly variable. Sori are round with a small dome-shaped indusium or sometimes none, and the family is taxonomically complex due to morphological variation. Major genera include *Thelypteris*, *Christella*, *Sphaerostephanos*, and *Amphineuron*, with many species flourishing during the monsoon.

Dryopteridaceae dominates the fern flora of the Himalaya and other cool, high-rainfall regions. Plants have stout, scaly rhizomes and large, robust, pinnate to multipinnate fronds. Sori are round and typically covered by a reniform indusium. Important genera include *Dryopteris*, *Polystichum*, *Arachniodes*, *Ctenitis*, and *Elaphoglossum*, many forming a major component of forest ground flora and some used medicinally.

Aspleniaceae is common in shady, moist montane habitats, particularly on rocks and forested slopes. Fronds are usually simple and narrow to moderately divided, with a slender and elegant appearance. Sori are long, linear, and arranged parallel to veins, protected by a single lateral indusium. The genus *Asplenium* is especially diverse in India and shows marked morphological plasticity across habitats.

8. PRECAUTIONS FOR PTERIDOPHYTE COLLECTION

Sustainable Collection and Field Guidelines for Pteridophytes: Ethical and sustainable collection of pteridophytes is essential in view of increasing horticultural demand and academic use. Live plants should be collected sparingly, with priority given to spore collection and cultivation rather than uprooting wild populations. The development of spore banks and strengthened national and international spore-exchange programmes can significantly reduce pressure on natural habitats. Large-scale herbarium collection, especially by students, should be discouraged in favour of field-based learning using photographs, sketches, and detailed field notes, with physical collection restricted to essential cases only.

Field Guidelines: Prior to fieldwork, necessary permissions must be obtained from forest and protected-area authorities, and researchers should carry identity documents and approval letters; involving local guides familiar with fern-rich sites is strongly recommended. Essential field equipment includes cutting tools, a hand lens, notebook, vasculum or polythene bags, field press, GPS, camera, and tools for recording environmental data. Fresh characters that are often lost on drying should be carefully recorded, including habitat, natural plant size, rhizome characters, stipe features, and lamina traits such as division, venation, sori, and indusia. Large species should be sampled selectively using representative parts, whereas small species may be collected whole, ensuring minimal impact on natural populations.

TABLE 1: Indian Pteridophyte Families and Taxa (As Per Fraser-Jenkins, C.R., 2017)

Family	No. of Genera	No. of Species	Included Subspecies	Additional Subspecies	Total Taxa
Lycopodiaceae	3	28	2	0	28
Selaginellaceae	1	55	1	0	55
Isoetaceae	1	4	0	0	4
Equisetaceae	1	3	1	1	4
Psilotaceae	1	2	0	0	2
Ophioglossaceae	3	20	2	0	20
Marattiaceae	3	5	0	0	5
Osmundaceae	1	6	2	0	6
Plagiogyriaceae	1	4	0	0	4
Dipteridaceae	1	1	0	0	1
Gleicheniaceae	2	7	0	0	7
Lygodiaceae	1	9	0	0	9
Schizaeaceae	2	3	1	0	3
Marsileaceae	1	3	0	0	3
Cyatheaceae	1	11	0	0	11
Dicksoniaceae	1	1	0	0	1
Hymenophyllaceae	2	36	0	0	36
Dennstaedtiaceae	6	27	0	0	27
Lindsaeaceae	3	19	1	1	20
Pteridaceae	20	159	15	13	172
Vittariaceae	2	16	0	0	16
Aspleniaceae	1	72	14	15	87
Thelypteridaceae	1	81	1	2	83
Woodsiaceae	10	124	5	6	130
Blechnaceae	5	11	1	0	11
Dryopteridaceae	17	196	6	8	204
Lomariopsidaceae	3	28	0	0	28
Oleandraceae	1	3	0	0	3
Nephrolepidaceae	2	9	0	0	9
Davalliaceae	4	19	0	0	19
Polypodiaceae	21	128	4	3	130
Grammitidaceae	6	12	0	0	12
Azollaceae	1	2	2	1	3
Salviniaceae	1	3	0	0	3

TABLE 2: Top 5 Dominant Pteridophyte Families (by Total Taxa)

Rank	Family	No. of Genera	No. of Species	Included Subspecies	Additional Subspecies	Total Taxa
1	Dryopteridaceae	17	196	6	8	204
2	Pteridaceae	20	159	15	13	172
3	Woodsiaceae	10	124	5	6	130
4	Polypodiaceae	21	128	4	3	130
5	Aspleniaceae	1	72	14	15	87

TABLE 3: Single-Generic Pteridophyte Families of India

Family	No. of Genera	No. of Species	Included Subspecies	Additional Subspecies	Total Taxa
Selaginellaceae	1	55	1	0	55
Isoetaceae	1	4	0	0	4
Equisetaceae	1	3	1	1	4
Psilotaceae	1	2	0	0	2
Osmundaceae	1	6	2	0	6
Dipteridaceae	1	1	0	0	1
Lygodiaceae	1	9	0	0	9
Marsileaceae	1	3	0	0	3
Cyatheaceae	1	11	0	0	11
Dicksoniaceae	1	1	0	0	1
Aspleniaceae	1	72	14	15	87
Thelypteridaceae	1	81	1	2	83
Oleandraceae	1	3	0	0	3
Azollaceae	1	2	2	1	3
Salviniaceae	1	3	0	0	3

TABLE 4: Families with Highest Generic Diversity (India)

Rank	Family	No. of Genera	No. of Species	Total Taxa
1	Polypodiaceae	21	128	130
2	Pteridaceae	20	159	172
3	Dryopteridaceae	17	196	204
4	Woodsiaceae	10	124	130
5	Dennstaedtiaceae	6	27	27
6	Blechnaceae	5	11	11
7	Davalliaceae	4	19	19
8	Lycopodiaceae	3	28	28
9	Ophioglossaceae	3	20	20
10	Marattiaceae	3	5	5
11	Lindsaeaceae	3	19	20
12	Lomariopsidaceae	3	28	28
13	Nephrolepidaceae	2	9	9
14	Hymenophyllaceae	2	36	36

TABLE 5: Top 5 Contributors families in percentage form

Family	% Contribution
Dryopteridaceae	17.65%
Pteridaceae	14.88%
Woodsiaceae	11.25%
Polypodiaceae	11.25%
Aspleniaceae	7.53%

TABLE 6: Different Plant Parts of Pteridophytes

Plant Part	Structure / Description	Function	Key Features in Pteridophytes
Rhizome	Horizontal or upright stem (creeping, ascending, erect)	Anchoring, storage, production of roots and fronds	May be scaly or hairy; varies from slender (Lindsaea) to thick (Drynaria)
Roots	Adventitious, fibrous roots arising from rhizome	Absorption of water and minerals; anchorage	Often form dense root-mats; may show mycorrhizal associations
Stipe (Petiole)	Leaf stalk connecting rhizome and lamina	Supports the lamina; mechanical strength	May be scaly, hairy, grooved, paleaceous or glabrous
Frond (Leaf)	Green photosynthetic organ (simple, pinnate, bipinnate, etc.)	Photosynthesis; spore-bearing function	Dimorphic or monomorphic; evergreen or deciduous
Rachis	Central axis of a compound frond	Supports pinnae	May have groove, scales, hairs; flexibility varies among taxa
Pinna(e)	Primary divisions of the frond	Photosynthesis	Shape varies widely; margins entire/serrate/dentate
Pinnule(s)	Secondary divisions (in bipinnate fronds)	Photosynthesis	Present in complex fronds like *Dryopteris*, *Athyrium*
Venation	Network of veins (free, forked, anastomosing)	Transport of water and nutrients	Important in taxonomy; *e.g.*, anastomosing in Polypodiaceae
Sorus (plural Sori)	Cluster of sporangia on fronds	Spore production	Position varies—marginal, submarginal, dorsal; taxonomically significant
Indusium	Membrane covering the sorus	Protection of developing sporangia	May be true indusium (cup-/kidney-shaped) or false (rolled margin)
Sporangium	Spore case; capsule-like structure	Produces spores via meiosis	Annulus present in leptosporangiate ferns; large eusporangia in others
Spores	Microscopic reproductive units	Dispersal and germination	Shape, size, ornamentation important for taxonomy
Gametophyte (Prothallus)	Small, green, heart-shaped thallus	Sexual reproduction; bears antheridia & archegonia	Short-lived but independent; requires moisture
Antheridia	Male sex organs on gametophyte	Produces motile sperm	Located on lower surface, near rhizoids
Archegonia	Female sex organs on gametophyte	Houses egg cell	Located near the notch region of the prothallus
Rhizoids (of gametophyte)	Hair-like structures	Anchoring and absorption	Non-vascular, unicellular

9. CONCLUSIONS

Ferns and fern-allies are among the oldest and most structurally diverse vascular plants, combining evolutionary antiquity with remarkable ecological

adaptability. Their wide morphological range, from primitive fern-allies to highly specialized leptosporangiate ferns, has enabled them to occupy diverse habitats worldwide. In India, their exceptional richness—particularly in the Eastern Himalaya, Western Ghats, and Northeast—underscores the country's importance as a global pteridophyte hotspot. A sound understanding of their morphology, distribution, and ecology is fundamental for accurate taxonomy, field identification, and effective conservation planning. Many species act as indicators of habitat quality and contribute ecologically and economically as ornamentals, vegetables, soil stabilizers, bioindicators, and wetland components. In the face of habitat loss, climate change, and increasing anthropogenic pressure, continued documentation, taxonomic refinement, and ecological assessment of pteridophytes are essential for conserving this ancient plant lineage and maintaining ecosystem integrity.

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11.1. Online Resources

1. The Pteridophyte Phylogeny Group (PPG I) Classification (2016). Accessible via https://www.pteridophyte.org
   a) Up-to-date phylogenetic classification.
2. Flora of India – Pteridophytes (BSI). *https://bsi.gov.in*
   a) Regional checklists and species descriptions.
3. Plants of the World Online (POWO) – Kew Gardens. *https://powo.science.kew.org*
4. Accepted names, distribution, and family-level details.