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Comprehensive Morphotaxonomic Survey and Species Inventory of Ferns and Fern Allies of Nilgiri Hills, Ooty

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Abstract: Fern and their allies were collected from different areas of Udhagamandalam and Coonoor, Tamilnadu, India. The region is encompassed by the lofty and great mountains of Nilgiri hills. Great altitudinal variation, high forest cover, adequate rainfall and due to its varied topography, the region is suitable for sustaining a rich fern flora. Hence, the aim of the present research was to conduct a thorough, systematic survey of the region in order to identify an array of pteridophytes. Specimens were collected during March-October 2020-21 at an altitude of 2700m. A total of 20 species of ferns and their allies were collected belonging to different families. A list of the species along with their nomenclature, synonyms, ecological and distributional notes have been provided so that it will be easy for their identification to the younger generation.

Keywords: *Coonoor, Diversity, Ferns, Pteridophytes, Survey, Udhagamandalam.*

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I. INTRODUCTION

Pteridophytes, or fronds without a leaf gap in the stem stele (Lycophylls), and Monilophytes, or fronds with a leaf gap in the stem stele, are the two lineages that make up the group of seedless but spore-producing plants known as pteridophytes (Euphylls) (Smith *et al*., 2006). Lycophytes comprise three clades; Lycopodiales (homosporous species), Isoetales and Selaginellales (heterosporous species), whereas, Monilophytes include a single clade-conventionally called “ferns”. However, the two lineages have been treated together under various names such as “Pteridophytes” or “Fern and allied plants”. They occupy a unique position between non- seed producing and seed- bearing plants, and are enormously fascinating from their evolutionary and morphological characteristics. They can survive in a wide range of substrates, temperatures, and light regimes due to their vasculature, additionally they are a significant evolutionary step toward closing the functional divergence between vascular plants that bear seeds and non-vascular bryophytes. Ferns are distributed globally, but they have the highest density in the tropical mountains (Salazar *et al*., 2013). There are over 13,600 species of pteridophytes known to exist in the world's flora. (Moran, 2008). An ancient class of vascular plants known as pteridophytes dominated the earth during the Carboniferous epoch, some 300 million years ago. They were the first land plants to have a developed vascular system. Among vascular plants, they come next to the spermatophytes and serves a significant and key role in the plant kingdom's evolutionary history (Benniamin, 2011). There are 1,300 species of ferns (70 families) belonging to 191 genera occurs in different bio-geographical regions of India (Chandra *et al*., 2008) with the main center being the Himalaya, both the eastern and western ghats (Dixit, 2000). According to Fraser-Jenkins *et al*. (2017), India has 1157 Pteridophyte species (including 43 exotic ones), besides nearly 100 sterile hybrids. In Southern India, there are over 400 Pteridophyte species (Singh and Upadhyay, 2010). The Western Ghats are adobe to the majority of South Indian Pteridophytes. Members of the Aspleniaceae, Thelypteridaceae, Selaginellaceae, and Pteridaceae families are mostly found in the Western Ghats (Sumesh *et al*., 2012). In addition to yielding food, herbicides, and ornamentation, ferns were utilized in homeopathic, ayurvedic, and unani medications (Shah and Kumarasamy, 2022, Shah *et.al.*, 2022 & Shah *et. al*., 2023).

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Ferns are sensitive to environmental factors (Abotsi *et al*., 2020), adapting to changes in climatic and edaphic parameters through a variety of strategies (Carvajal-Hernandez *et al*., 2018). Thus, at various spatial scales, fern diversity exhibits distinct patterns along environmental gradients (Weigand *et al*., 2020). Despite many other plant and animal groups, the taxonomic diversity of fern gradients frequently exhibits a hump-shaped unimodal in nature along the elevational gradient. (Khine *et al*., 2019). The combined influence of many meteorological elements, such as temperature, precipitation, and cloud cover, are the primary causes of such unimodal patterns (Acebey *et al*., 2017). In general, fern diversity is higher in temperate and humid environments, but lower in cold, hot, and desert environments (Kluge and Kessler 2006). The emergence of the latitudinal diversity distribution of ferns depends on the elevational range in a location and the macroevolutionary history of particular fern groups. (Wei *et al*., 2018). At differing heights, human activities, environment heterogeneity, soil, and geography all have an impact on fern diversity (Nervo *et al*., 2019). Geometrical limitations, such as the mid-domain and area effects, have been proposed as possible explanation for the hump-shaped patterns (Pouteau *et al*., 2016). Varied fern groupings exhibit different latitudinal and elevational diversity patterns, which is another driver of diversity patterns (Parra *et al*., 2015). The diversity of terrestrial xerophytic ferns, for example, tends to be decline with elevation, but the diversity of epiphytic ferns and terrestrial hygrophytic ferns tends to rise (Schneider *et al*., 2013). Light, moisture, soil, and topography all influence fern diversity at the regional (habitat) level. (Zhang *et al*., 2017). High canopy openness, for instance, might increase illumination but decrease moisture, which would restrict the diversity of ground ferns (Zhan *et al*., 2015). Fern diversity is also influenced by altitude, with slopes having a larger diversity than ridges (Kessler and Lehnert, 2009). The study will provide information and be a valuable resource for identifying fern taxa in this region and for acquainting people with these fern species (Shah and Kumarasamy, 2021 & Shah *et. al*., 2023).

II. MATERIALS AND METHODS

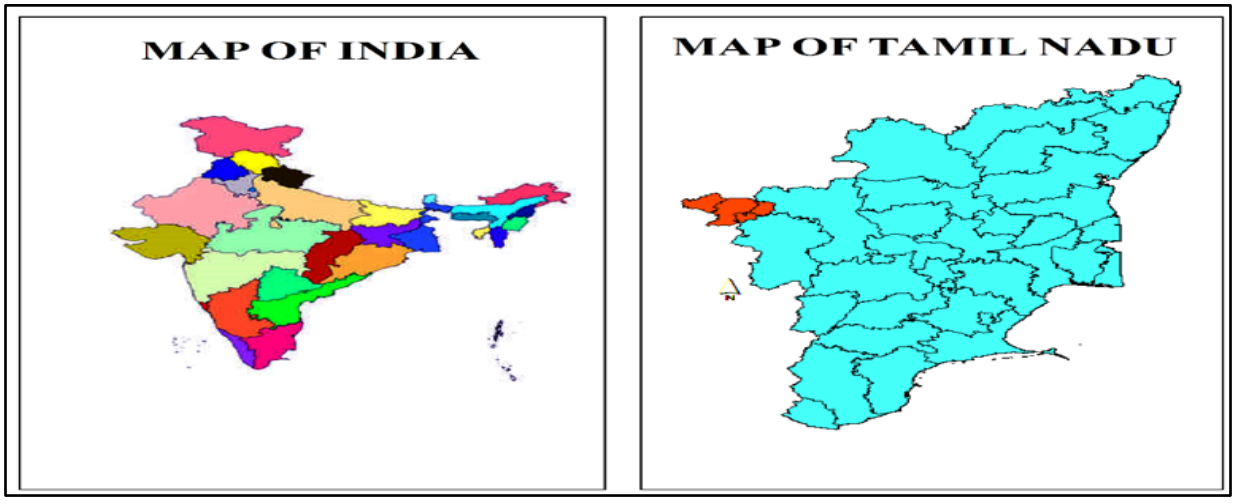
➢ *Collection and Preservation*

To collect ferns and fern allies extensive field trips were conducted in Coonoor and Udhagamandalam from March-October during the year 2020-2021. The subdistricts of the Nilgiris district in Tamil Nadu, India, are Udhagamandalam and Coonoor. They are located at 11° 24' 0" N latitude and 76° 42' 0" E longitude Fig.3.1.1. A wide range of habitats including mountains, sub-alpine and alpine regions, meadows, streams, rivers, dense forests, and plains e.t.c. were looked for fern diversity. Most of the specimens were collected at reproductive stage along with rhizome, as these traits contribute much to fern identification. During the field trips, detailed field notes comprehending habit, habitat, altitude, (using Global Positioning System-eTrex Vista HCx) were recorded on field note books. Besides, morphological characters, patterns of sori distribution and arrangement were also recoded. Specimens were photographed with detailed features, including sori pattern, rhizome features and leaf shapes to assist in later identification.

➢ *Identification*

Identification of plants was accomplished by careful examination of specimens at macroscopic level followed by microscopic studies of hairs, scales and sori. The specimens were studied for numerous characters such as size and structure of whole plant, scale shape, colour; hairs of stipe; lamina; vein arrangement of fronds; frond shape; indusia colour and shape; spore morphology etc. The specimens were identified by using an artificial key provided in various floras, monographs, checklists, books and illustrations such as *An Illustrated West Himalayan Fern Flora* (Khulllar, 1994 & 2000), *Fern Flora of British India* (Beddome, 1976), *Ferns of Northern India* (Clarke, 1880), *The Southern Indian Ferns* (Beddome, 1983), *The Pteridophytic Flora of Eastern India* (Ghosh 2004), *A monograph of Dryopteris* (Fraser-Jenkins, 1989), *A monograph of Pteridophyte Flora of Nilgiris, South India* (Manickam and Irudayaraj, 1992) etc. A complete set of voucher specimens (AU BOT-390-409) was deposited in the department of Botany, Annamalai University Chidambaram.

➢ *Map Showing the Study Area*



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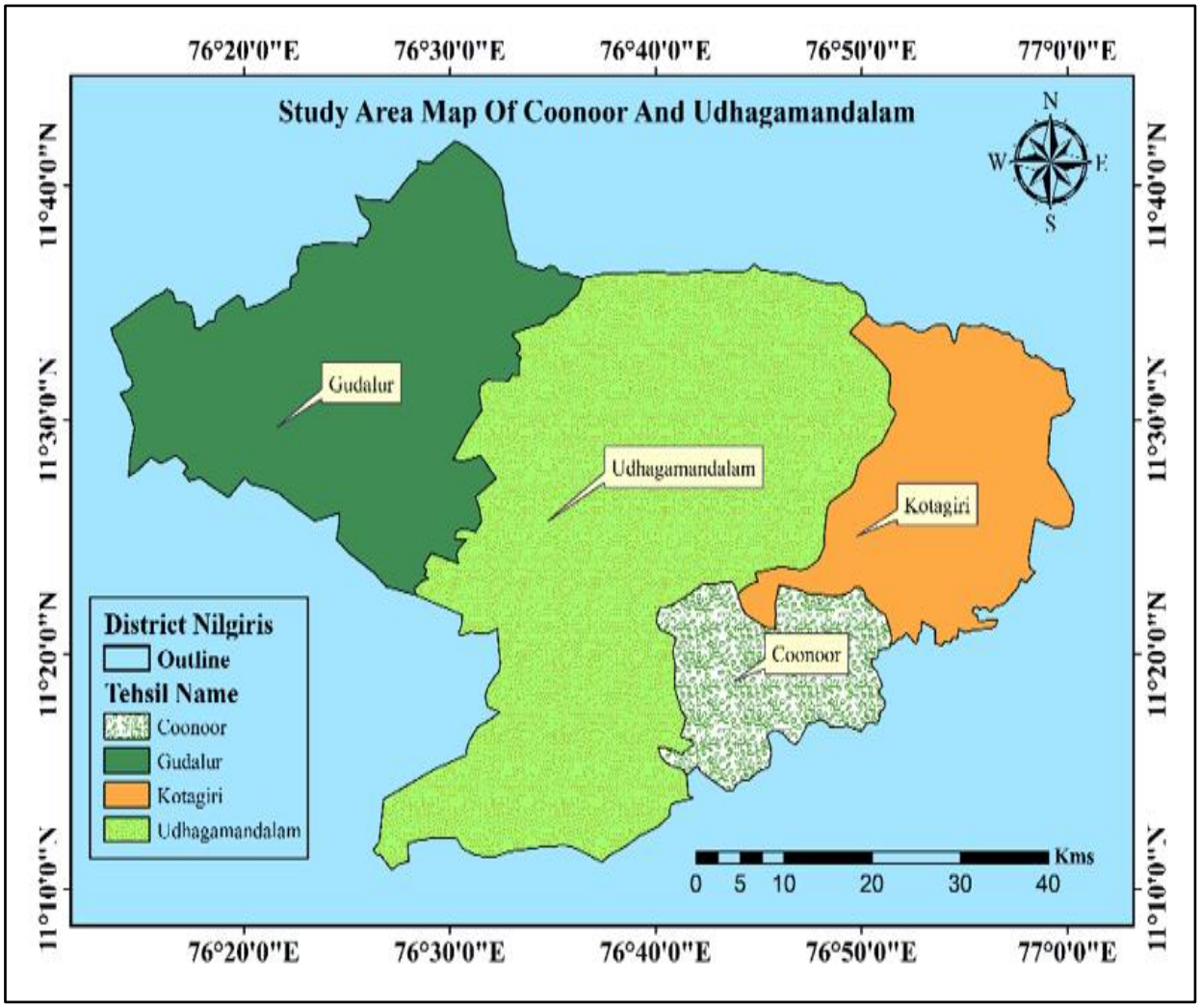

Fig 3 Map Showing the Study Area

III. RESULT AND DISCUSSION

A. *Enumeration of the Species*

➢ *Aspleniaceae*

- *Asplenium Adiantum-Nigrum* L. (Figure 1)
- ✓ **Synonym**: *Asplenium andrewsii, A. chihuahuense, A. sdubiosum.*
- ✓ **Habitat**: Grows on rocky woods, hedge banks, shady walls and rocks at Tiger hill, Coonoor, Fern hill Ooty.
- ✓ **Status**: Frequent
- ✓ **Distribution**: Africa, Afghanistan, Europe, Japan, Iran, Java, Nepal, Taiwan, Turkey, Pakistan, North America.
- ✓ **India**: Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Kerala and Tamil Nadu.

- *Asplenium Hindusthanensis* Bir. (Figure 1)
- ✓ **Synonym:** *Asplenium adiantoides*
- ✓ **Habitat:** Shaded areas, evergreen forest, terrestrial or lithophytic found near Botanical Garden Ooty, Tiger hill and Sims Park (Coonoor).
- ✓ **Status:** Vulnerable
- ✓ **Distribution:** Europe, China, South Africa, Zimbabwe.
- ✓ **India**: Tamil Nadu.

- *Asplenium Nidus* L. (Figure 1)
- ✓ **Synonym:** *Asplenium neohainanense, Neottopteris hainanensis, N. vulgaris, Thamnopteris nidus, Asplenium antiquum, A. musaefolia, Neottopteris rigida, Asplenium australasicum.*
- ✓ **Habit**: Clustered on tree trunks or rocks in rain forest near Botanical Garden Ooty, Fern hill.
- ✓ **Status**: Threatened.
- ✓ **Distribution**: Indonesia, Japan, Malaysia, Myanmar, Sri Lanka, Vietnam, Africa and Australia, Pacific islands, Japan, Taiwan. **India:** Tamil Nadu and Karnataka.

- *Asplenium Scolopendrium* (Fernald) Kartesz & Gandhi. (Figure 1)
- ✓ **Synonym**: *Phyllitis scolopendrium, P. fernaldiana, P. japonica subsp. americana.*
- ✓ **Habitat**: Always find in deep shade and occurs near Botanical Garden Ooty, fern hill, tiger hill.
- ✓ **Status**: Threatened
- ✓ **Distribution**: North America, Mexico, Morgan, Europe, Alabama, Albania, Algeria, Austria, Azores, France, Germany, Hungary, Iran, Iraq, Turkey, Spain.
- ✓ **India**: Tamil Nadu and Kerala.

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- *Asplenium Trichomanes* L. (Figure 2)
- ✓ **Synonym:** *Asplenium melanocaulon, Chamaefilix trichomanes, Asplenium trichomanoides, Trichomanes crenatum, Phylitis rotundifolia, Asplenium minus, A. pusillum, A. densum, A. melaolepis.*
- ✓ **Habitat**: Grows on rocks, in crevices of shady rocks, on banks, cliffs, between boulders in open moist areas. It occurs near Botanical Garden, Fern hill (Ooty) and Sims Park (Coonoor).
- ✓ **Status**: Common
- ✓ **Distribution:** Indonesia, New Zealand, America, Turkey, Pakistan, Iran.
- ✓ **India:** Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Uttar Pradesh, Sikkim, Assam, Meghalaya, Arunachal Pradesh, Manipur, Rajasthan and Tamil Nadu.

- *Asplenium Varians* wall. Ex. Hook. & Grev. (Figure 2)
- ✓ **Synonym:** *Asplenium caespitosum, A. depauperatum, A. laciniatum, A. lankongense, A. parvulum, A. paucijugum, A. ruta.*
- ✓ **Habitat:** Terrestrial inside the forest or stream banks at Tiger hill, Sims Park (Coonoor).
- ✓ **Status:** Rare
- ✓ **Distribution:** Tanzania, Uganda, Zimbabwe, Indonesia, South Africa.
- ✓ **India:** Tamil Nadu, Himachal Pradesh and Uttarakhand.

➢ *Athyriaceae*

- *Athyrium Attenuatum* (Wallich ex C. B. Clarke) Tagawa. (Figure 2)
- ✓ **Synonym:** *Asplenium filix- femina, Athyrium ensiferum, A. filix- femina* var. *attenuatum.*
- ✓ **Habitat:** Meadows on gentle mountain slopes. It occurs at Fern hill Ooty.
- ✓ **Status:** Endangered.
- ✓ **Distribution:** North America, Taiwan, Afghanistan, Bhutan, Nepal, Pakistan.
- ✓ **India:** Tamil Nadu, Kerala, Jammu and Kashmir and Himachal Pradesh.

- *Athyrium Praetermissum* Sledge (Figure 2)
- ✓ **Synonym:** *Athyrium acrocarpum, A. acutipinnatum*
- ✓ **Habitat:** Terrestrial, along fully shaded stream banks. It occurs at Fern hill Ooty.
- ✓ **Status:** Common.
- ✓ **Distribution:** Afghanistan, Brazil, China, Sri Lanka, Java. India: Tamil Nadu, Assam and Kerala.

- *Deparia Allantodioides* Bedd. (Figure 3)
- ✓ **Synonym:** *Asplenium thelypteroid, Athyrium allantodoide, A. thelypteroides, Deparia sikkimensis, Lunathyrium allantodioide, L. mackinnonii, L. sikkimensis.*
- ✓ **Habitat:** On rocky forest floor with higher levels of moisture at Fern hill Ooty.
- ✓ **Status:** Common
- ✓ **Distribution:** Bhutan, China, Nepal, Tibet, Pakistan.
- ✓ **India:** Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh, West Bengal and Tamil Nadu.

- *Deparia Petersenii* Kunze. (Figure 3)
- ✓ **Synonym:** *Asplenium petersenii, Athyrium petersenii, Diplazium petersenii*.
- ✓ **Habitat**: Base of steep mountains, in grassy, open clearings as well as in shady areas at Tiger hill Coonoor.
- ✓ **Status:** Endangered
- ✓ **Distribution:** Sri Lanka, China, South East Asia, Taiwan, Japan, New Guinea, Hawaiian Islands, Thailand, Azores, Madeira, Pakistan, Brazil, New Zealand, Indonesia.
- ✓ **India:** Assam, Kerala and Tamil Nadu.

➢ *Blechnaceae*

- *Blechnum Occidentale* Var. Minor Hooker. (Figure 3)
- ✓ **Synonym:** *Blechnum acuminatum, B. campylotis, B. cartilagineum, B. ciliatum, B. cognatum, B. cunninghamii, B. drepanophyllum, B. extensum, B. falcatum, B. glandulosum, B. mucronatum.*
- ✓ **Habitat:** Rocky and clayey places seasonally dry streams near Tiger hill (Coonoor) and Botanical Garden.
- ✓ **Status:** Endangered
- ✓ **Distribution:** West Indies, America, Jamaica, Mexico, Sri Lanka, Colombia.
- ✓ **India:** Kerala and Tamil Nadu.

- *Blechnum orientale* L. (Figure 3)
- ✓ **Synonym:** *Asplenium orientale, Blechnopsis orientalis, Salpichlaena orientalis, Spicanta orientalis, Blechnum longifolium, Blechnopsis longifolia, Blechnum salicifolium, B. pectinatum, B. elongatum.*
- ✓ **Habitat:** Terrestrial grows on rocks; a few are epiphytes at Tiger hill and Sims Park Coonoor.
- ✓ **Status:** Common
- ✓ **Distribution:** Burma, Japan, Nepal, Northern-Australia, tropical Pacific Islands, Sri Lanka, China, Malaysia, Polynesia.
- ✓ **India:** Kerala and Tamil Nadu.

- *Doodia dives* Kunze (Figure 4)
- ✓ **Synonym:** *Woodwardia dives, Blechnum dives.*
- ✓ **Habitat:** Occasionally found on partially or fully shaded roadsides at Tiger hill (Coonoor).
- ✓ **Status:** Critically Endangered
- ✓ **Distribution:** Australia, New Zealand, Sri Lanka, Java, Indonesia.
- ✓ **India:** Kerala and Tamil Nadu.

➢ *Cyatheaceae*

- *Cyathea Crinita* (Hook) Copel. (Figure 4)
- ✓ **Synonym:** *Alsophila crinita*.
- ✓ **Habitat:** It grows under shaded or open streams and stream sides in evergreen and shola forests at Tiger hill Coonoor.
- ✓ **Status:** Endemic
- ✓ **Distribution:** Sri Lanka.
- ✓ **India:** Tamil Nadu and Kerala.

- *Cyathea Nilgirensis* Holttum Nayar & Kaur (Figure 4)
- ✓ **Synonym:** *Alsophila nilgirensis, Cyathea latibrosa*

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- ✓ **Habitat:** Evergreen forests, shaded stream banks around Botanical Garden Ooty and Sims Park Coonoor.
- ✓ **Status:** Near Threatened
- ✓ **Distribution:** Australia.
- ✓ **India:** Kerala, Karnataka, Andhra Pradesh and Tamil Nadu.

➢ *Cystopteridaceae*

- *Cystopteris Fragilis* L. (Figure 4)
- ✓ **Synonym:** *Aspidium dentatum, A. fragile, A. viridulum, Athyrium dentatum, A. fragile, A. fumarioides, Cyathea anthriscifolia, C. cynapifolia, C. fragilis, Cyclopteris fragilis Cystea fragilis, C. angustata, C. dentata, C. fragilis, Cystopteris acuta, C. baenitzii, C. canariensis, C. dentata, C. dickieana, C. emarginato- denticulata, C. filix- fragilis, C. fragilis* var. *contorta, C. fragilis f. himalayensis, C. fumarioides, C. orientalis, C. polymorpha, C. remotipinnata, C. sikkimensis, C. translucens, C. viridula, Polypodium anthriscifolium, P. cynapifoilum, P. dentatum, P. diaphanum, P. filix- fragile, P. fragile*.
- ✓ **Habitat:** Commonly occurs in open slopes, forest floors and edges of forests at Fern hill Ooty.
- ✓ **Status:** Common
- ✓ **Distribution:** Afghanistan, China, Nepal, Russia, Pakistan, Japan, Iran, Africa, Europe, North America, Taiwan, Korea.
- ✓ **India:** Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Nagaland and Tamil Nadu.

- *Davallia Griffithiana* Hook. (Figure 5)
- ✓ **Synonym:** *Davallia griffithii, D. henryana, D. platylepis, Humata griffithiana, H. henryana, H. platylepis, Leucostegia griffithiana.*
- ✓ **Habitat:** Found in open forests at Sims Park Coonoor and Botanical Garden Ooty.
- ✓ **Status:** Least concern
- ✓ **Distribution:** China, Japan, Taiwan, Bhutan, Myanmar, Laos, Vietnam, New Zealand.
- ✓ **India:** Meghalaya, Manipur, Assam, Kerala and Tamil Nadu.

➢ *Dennstaedtiaceae*

- *Pteridium Aquilinum* (L.) Khun. (Figure 5)
- ✓ **Synonym:** *Pteridium aquilinum* var. *lanuginosum, P. aquilinum subsp. typicum, P. japonicum, P. latiusculum, P. aquilina, P. aquilina* var. *lanuginose, P. capensis, P. lanuginose*.
- ✓ **Habitat:** Commonly occurs in open, sunny slopes, forest floors and edges of forests at Tiger hill, Sims Park Coonoor and Botanical Garden and fern hill Ooty.
- ✓ **Status:** Frequent
- ✓ **Distribution:** Africa, Australia, China, Bhutan, Burma, Europe, Malaya Peninsula, Thailand, Philippines, Vietnam, Taiwan, Nepal, New Zealand, Pakistan, Sri Lanka.
- ✓ **India:**Jammu & Kashmir, Uttarakhand, Himachal Pradesh, Assam, Meghalaya, Tamil Nadu, Kerala, Sikkim, Arunachal Pradesh and Manipur.

- *Pteridium Revolutum* Blume. (Figure 5)
- ✓ **Synonym:** *Pteridium aquilinum* Kuhn
- ✓ **Habitat:** Sunny slopes and open shaded forests at Tiger hill Coonoor.
- ✓ **Status:** Not solved
- ✓ **Distribution:** Gansu, Guangdong, Guangxi, Guizhou, Henan, Hubei. Hunan, Jiangxi, Shaanxi, Sichuan, Taiwan, Xizang, Yunnan, Zhejiang.
- ✓ **India:** Karnataka, Odisha and Tamil Nadu.

➢ *Dryopteridaceae*

- *Arachniodes Aristata* Frost. F. (Figure 5)
- ✓ **Synonym:** *Aspidium aristatum, Byrsopteris aristata, Dryopteris asritata, Lastrea aristata, Nephrodium aristatum, Polypodium aristatum.*
- ✓ **Habitat:** Along fully shaded stream banks at Tiger hill Coonoor.
- ✓ **Status:** Common
- ✓ **Distribution:** Taiwan, China, Japan, Nepal, Korea, Malaysia, Philippines, Australia, Pacific Islands.
- ✓ **India:** Tamil Nadu and Kerala.

IV. CONCLUSION

The diversity of plant species and their relationships with the physical environment were established by the botanical study of a specific area's flora. This paper provides a comprehensive overview of the pteridophytes found in Coonoor and Udhagamandalam. Throughout the course of the investigation, about 20 species of ferns and fern allies were retrieved. The pteridophytes are an essential element of an ecosystem and as the wide range of them live in forests, they serve as excellent indicators of the degree of issues like deforestation and habitat damage. To document the diversity and ecological features of pteridophytes, explorations should increase in the under-explored botanically dense places. To prevent confusions with new and current species, taxonomic reinvestigations should be undertaken in these regions.

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FIGURE

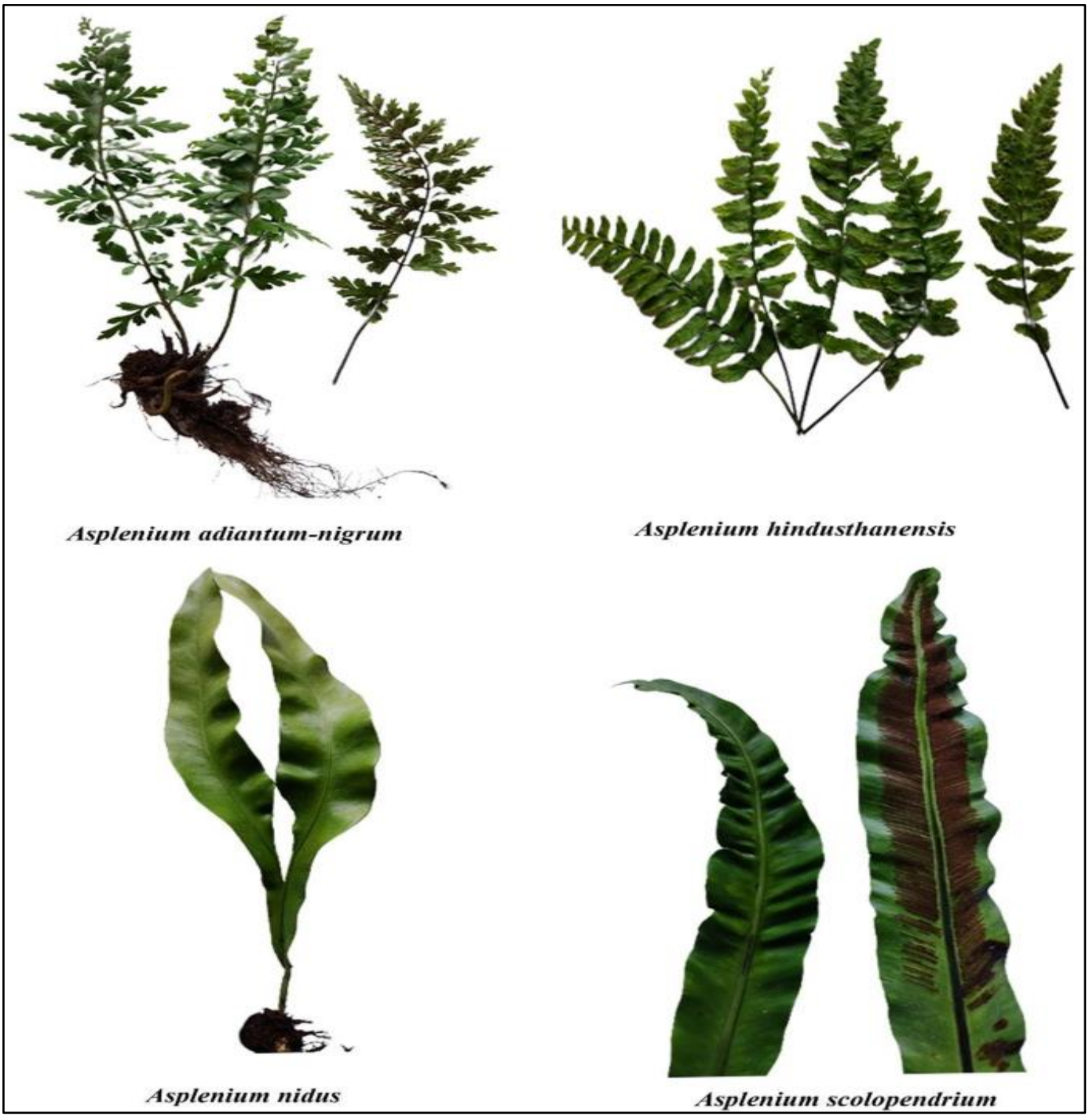

Fig 1 Enumeration of the Different Fern Species

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Fig 2 Enumeration of the Different Fern Species

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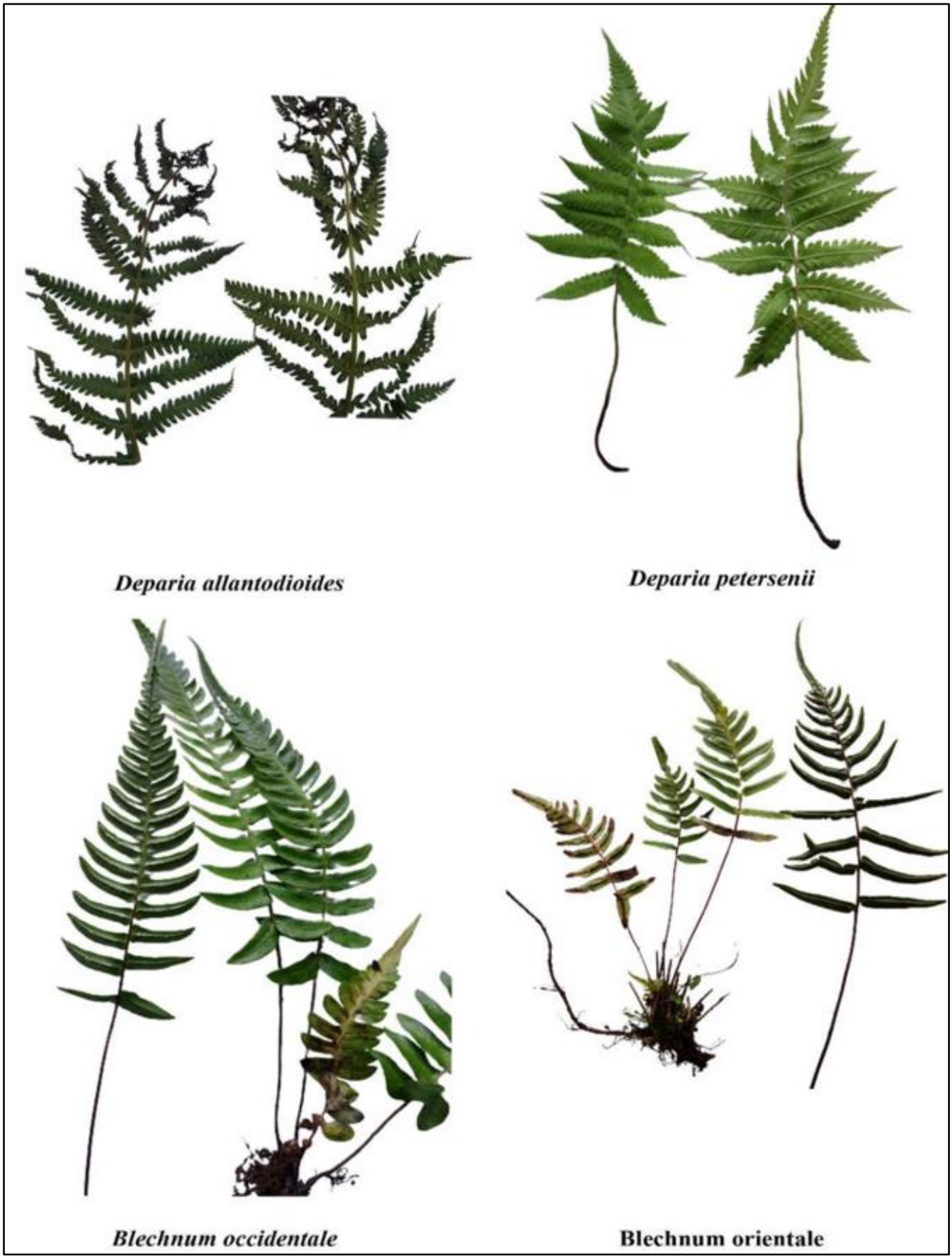

Fig 3 Enumeration of the Different Fern Species

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Fig 4 Enumeration of the Different Fern Species

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Fig 5 Enumeration of the Different Fern Species