

**Studies on Lycophytes and Ferns as influenced by Palghat
Gap of Southern Western Ghats - an Ecological,
Molecular and Taxonomic Approach**

*Thesis submitted to the
UNIVERSITY OF CALICUT
in partial fulfilment for the requirements for the award of the degree of*

Doctor of Philosophy in Botany

by

THULASI R.

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Under the guidance of

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This is to certify that the thesis entitled “**Studies on Lycophytes and Ferns as influenced by Palghat Gap of Southern Western Ghats - an Ecological, Molecular and Taxonomic Approach**” is a research work carried out by Ms. Thulasi, R., Research Scholar, P.G. & Research Department of Botany under the supervision and guidance of Dr. Rajesh K. P., Assistant Professor of Botany of this College and Prof. (Dr.) Maya C. Nair, Principal, Govt. Arts and Science College, Tholanur, Palakkad (Research Guide, Government Victoria College, Palakkad) during the period of 2018 - 2024.

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Research Guide

Prof. (Dr.) Maya C. Nair, M.Sc., Ph.D.
Professor & Principal

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(Prof. (Dr.) Maya C. Nair)
Research Co-Guide

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DECLARATION

I hereby declare that the work presented in the thesis entitled “**Studies on Lycophytes and Ferns as influenced by Palghat Gap of Southern Western Ghats - an Ecological, Molecular and Taxonomic Approach**” is based on the original work done by me under the guidance of Dr. K.P. Rajesh and Prof. (Dr.) Maya C. Nair and has not been included in any other thesis submitted previously for the award of any degree. The contents of the thesis are undergone plagiarism check using ITHENTICATE software at C.H.M.K. Library, University of Calicut, and the similarity index was found within the permissible limit. I also declare that the thesis is free from AI generated contents.

(Ms. Thulasi R.)

(Dr. K.P. Rajesh)

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ABSTRACT

Palghat Gap is the most ancient and widest discontinuity in the continuous stretch of Western Ghats. There are many hypotheses regarding the origin of Palghat Gap and also about the influential effect of Palghat Gap on the distribution of plants and animals.

Pteridophytes are one of the ancient groups of vascular plants with a long evolutionary history. So, here in the present research, an attempt has been made to unveil the influence of Palghat Gap, if any, on the distribution of pteridophytes along the gap region through different aspects-taxonomical, molecular and ecological.

The study area was explored during the period 2018 to 2023 and recorded each taxon with its ecological parameters and spatial attributes. After critical analysis three taxa were recognised with some ambiguity in their morphological features. These ambiguous taxa were further analysed by its spore morphological traits through scanning electron microscopy and molecular divergence analysis using three gene regions - *rbcL*, *trnL-F* and *atpB*. Geospatial analysis for endemic/narrowly distributed taxa and IUCN red listed taxa were analysed. Then the ecological similarity between different habitats and micro-habitats along altitudinal gradients were studied with reference to the presence of ferns and lycophytes. Finally, ecological niche modelling of one selected endemic taxon, *Elaphoglossum beddomei*, was carried out to know the trend of future climate change and its effect on the existence of the evergreen elements in the Western Ghats.

During the study, a total of 191 taxa belonging to 65 genera and 27 families were recorded from the Palghat Gap and Gap influenced areas. In the entire study area, the dominant genus is *Asplenium* and the family are Pteridaceae. *Asplenium* is the dominant genus in the South of the Gap, both *Asplenium* and *Thelypteris* in the North, and *Pteris* is the dominant genus within the Gap areas. Among the collected taxa, 20 are endemics (South India-Sri Lanka) or narrowly distributed. A total of 17 species were found to be listed under the IUCN categories. The endemic/narrowly distributed taxa and IUCN red listed taxa were distributed between 100-2300 m altitudes. Any disturbances to their habitat in these altitudinal classes may severely affect their existence.

The population diversification studies of three ambiguous taxa, *Angiopteris*

spp., *Actiniopteris radiata* and *Mickelopteris cordata*, were carried out using spore morphological and molecular analysis. The spore analysis of populations of these showed some population diversification along the Palghat Gap area. Molecular level analysis showed slight variations between the populations. So, it warrants a further detailed analysis using more gene regions and more taxa for getting clarity on the influence of the Palghat Gap.

The major habitat types in the Palghat Gap and Gap influenced areas are; dry deciduous forests, moist deciduous forests, semi-evergreen forests, evergreen forests, shola forests and montane open grasslands. This habitat gradient is influenced by altitude and topography of the area. The highest number of taxa were recorded from evergreen forest, which offers the most suitable ecological parameters for the majority of the fern species. The terrestrial micro-habitats contain more taxa compared to other micro-habitats found in the study area. The altitude wise distribution showed the maximum number of taxa in the middle altitudinal zone. The Sorensen similarity index analysis of habitats showed maximum similarity between evergreen and shola vegetations, and least between dry deciduous forests and wetlands; moist deciduous forests and wetlands. The altitudinal classes 1600-1700 and 1700-1800 showed maximum similarity. Geo-spatial analysis of the study area, Land use-land cover and NDVI, showed the expansion of deciduous forests even to higher altitudes and corresponding altitudinal changes in the distribution of semi-evergreen and evergreen forests, with a consequent decrease in the montane grassland ecosystems.

Ecological niche modelling (ENM) of *Elaphoglossum beddomei* in current as well as the future climatic regimes (2041-2071) showed a decline in the potential habitat for it in future time periods. ENM analysis showed that the distribution of *E. beddomei* is limited by precipitation in Southern Western Ghats. The declining potential habitat of *E. beddomei* in future climatic regimes can be interpreted as the declining of evergreen forests in Southern Western Ghats of India.

The overall analysis showed that Palghat Gap acts as a barrier for distribution of ferns and lycophytes as well. It was inferred that, the climatic and edaphic factors operating in the Gap region influence the genetic make-up and it may trigger the genetic changes in species.

Keywords: Palghat Gap, Lycophytes and Ferns, Taxonomy, Ecology, Molecular study, Western Ghats

സംഗ്രഹം

പശ്ചിമഘട്ടത്തിലെ താരതമ്യേന വലിപ്പം കൂടിയതും, ആദ്യമായി രൂപപ്പെട്ടതെന്നും കരുതപ്പെടുന്ന പാലക്കാട് ചുരത്തിലെ കാലാവസ്ഥാ ഘടകങ്ങൾ സ്വാധീനം ചെലുത്തുന്ന മേഖലകളിലെ പന്നൽ സസ്യ വിഭാഗങ്ങളുടെ (ലൈക്കോഫൈറ്റുകളും ഫേണുകളും) പഠനമാണ് ഈ ഗവേഷണത്തിന് ആധാരം. പാരിസ്ഥിതിക ഘടകങ്ങൾ ഈ സസ്യ വിഭാഗത്തിന്റെ വിതരണത്തിലും രൂപഘടനയിലും മോളികുലാർ തലത്തിലും ചെലുത്തുന്ന സ്വാധീനം പഠന വിധേയമാക്കിയിട്ടുണ്ട്. 2018 മുതൽ 2023 വരെയുള്ള കാലയളവിൽ ചുരത്തിന്റെ സ്വാധീനം നേരിടുന്ന മേഖലകൾ സ്ഥിരമായി പഠന വിധേയമാക്കിയതിന്റെ ഫലമായി 27 സസ്യ കുടുംബങ്ങളിലെ 65 ജനസുകളിൽ ഉൾപ്പെട്ട 191 സ്പീഷീസുകൾ കണ്ടെത്തി. ഇവയിൽ ബാഹ്യ പ്രത്യേകതകളിൽ ഉള്ള വ്യത്യാസങ്ങൾ കണക്കിലെടുത്ത് തിരഞ്ഞെടുത്ത മൂന്നു ജനസുകളിലെ നാല് സ്പീഷീസുകളെ (*Angiopteris helferiana*, *A. crassipes*, *Actiniopteris radiata*, *Mickelopteris cordata*) ചുരത്തിലെ കാലാവസ്ഥാ ഘടകങ്ങളുടെ സസ്യങ്ങളിൽ ഉള്ള ആഴത്തിലുള്ള സ്വാധീനം മനസ്സിലാക്കുന്നതിനായി അവയുടെ രേണുക്കളുടെ ബാഹ്യാവരണത്തിന്റെ പ്രത്യേകതകളും മോളികുലാർ തലത്തിലെ വിശദാംശങ്ങളും പഠന വിധേയമാക്കിയിട്ടുണ്ട്.

കൂടാതെ, സ്ഥാനീയ സ്പീഷീസുകളുടേയും IUCN പട്ടികയിൽ ഉൾപ്പെട്ടിട്ടുള്ള പന്നൽ വർഗ സസ്യങ്ങളുടേയും ജിയോസ്‌പേഷിയൽ പഠനവും, ഈ സസ്യ വിഭാഗത്തിന്റെ വ്യത്യസ്ത ആവാസ വ്യവസ്ഥകളിലേയും, സൂക്ഷ്മ ആവാസ വ്യവസ്ഥകളിലേയും, ഉയര വ്യത്യാസങ്ങൾ ഉള്ള പ്രദേശങ്ങളിലേയും വിതരണ രീതിയിലുള്ള വ്യതിയാനങ്ങളും പഠനത്തിന്റെ ഭാഗമായി രേഖപ്പെടുത്തിയിട്ടുണ്ട്.

കാലാവസ്ഥാ വ്യതിയാനം, സ്ഥാനീയ സസ്യങ്ങളുടെ നിലനില്പിനെ ഏതു തരത്തിൽ സ്വാധീനിക്കുന്നു എന്നറിയുന്നതിനായി 'എലഫ്ലോസ്സം ബെഡോമി' എന്ന സ്പീഷീസിന്റെ നിലവിലേയും 2040-2070 വർഷങ്ങളിലേയും കാലാവസ്ഥാ ഘടകങ്ങളുടെ അടിസ്ഥാനത്തിൽ 'ഇക്കോളജിക്കൽ നിഷ് മോഡലിംഗ്' സംവിധാനത്തിലൂടെ വിശകലനം ചെയ്തപ്പോൾ ഭാവിയിൽ ഈ സസ്യത്തിന്റെ അനുകൂല ആവാസ വ്യവസ്ഥകളിൽ കുറവ് വരുമെന്ന് കണ്ടെത്തുകയും അത് ഈ സസ്യത്തിന്റേയും സമാന സ്വഭാവങ്ങളുള്ള മറ്റ് സ്പീഷീസുകളുടേയും ഭാവിയിലെ നിലനില്പിനെ ബാധിക്കുമെന്നും തിരിച്ചറിഞ്ഞിട്ടുണ്ട്.

പ്രാഥമികമായി നടത്തിയ ഈ പഠനത്തിൽ നിന്നും ലൈക്കോഹൈറ്റുകളുടേയും ഫേണുകളുടേയും സുഗമമായ വിതരണത്തിന് പാലക്കാട് ചുരം ഒരു പരിധി വരെ തടസ്സമാകുന്നുണ്ടെന്നും ചുരത്തിലെ കാലാവസ്ഥയും മറ്റു ഘടകങ്ങളും ഇവയുടെ ജനിതക ഘടനയെ സ്വാധീനിക്കുകയും പുതിയ സ്പീഷീസുകൾ രൂപപ്പെടാനുള്ള പ്രക്രിയയെ ത്വരിതപ്പെടുത്തുകയും ചെയ്യുന്നുണ്ടെന്നുള്ള ഉദ്കാശ്യ നൽകുന്നു.

സൂചകപദങ്ങൾ: പാലക്കാട് ചുരം, ലൈക്കോഹൈറ്റുകളും ഫേണുകളും, വർഗ്ഗീകരണം, പാരിസ്ഥിതികപഠനം, മോളികുലാർപഠനം, പശ്ചിമഘട്ടം

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ABBREVIATIONS

µm	: Micrometer
AUC	: Area Under Curve
BM	: The Natural History Museum, London (Acronym)
BSI	: Botanical Survey of India
CAL	: Central National Herbarium, Howrah (Acronym)
CALI	: Calicut University Herbarium (Acronym)
CHELSA	: Climatologies at high resolution for the Earth's land surface areas
CMIP6	: Coupled Model Intercomparison Project Phase-6
CR	: Critically Endangered
DDF	: Dry Deciduous Forest
DEM	: Digital Elevation Model
DH	: Disturbed habitats
E	: Royal Botanic Garden, Edinburgh (Acronym)
EG	: Evergreen Forest
EN	: Endangered
ENM	: Ecological Niche Modelling
EP	: Epiphytes
ESMs	: Earth System Models
GL	: Grassland
HD	: Hydrophytes
KFRI	: Kerala Forest Research Institute Herbarium, Thrissur
K	: Royal Botanic Garden Herbarium, Kew
LC	: Least Concern

LT	: Lithophytes
LULC	: Land Use Land Cover
m	: Metre
MC	: Mud cliffs
MDF	: Moist Deciduous Forest
MH	: Madras Herbarium, Botanical Survey of India
mm	: millimetre
NDVI	: Normalised Difference Vegetation Index
NG	: North of the Gap
NP	: National Park
NT	: Near Threatened
PAST	: PAlaeontological STatistics
PCR	: Polymerase Chain Reaction
PL	: Plantation
PS	: Psammophytes
RC	: Rock cliffs
RCP	: Representative Concentration Pathway
RET	: Rare, Endangered and Threatened
RH	: Rheophytes
RP	: Riparian
SDM	: Species Distribution Modelling
SEG	: Semi Evergreen Forest
SEM	: Scanning Electron Microscope
SF	: Shola Forest
SG	: South of the Gap

SI	: Sorensen's Similarity Index
ssp	: Shared Socio-economic Pathways
TR	: Terrestrial
TSS	: True Skill Statistics
VU	: Vulnerable
WG	: Within the Gap
WL	: Wet land
WLS	: Wildlife Sanctuary
XCH	: St. Xavier's College Herbarium, Palayamkottai
XR	: Xerophytes
ZGC	: Zamorins Guruvayurappan College
Δ^*	: Taxonomic Distinctness

PREFACE

Allopatric speciation is a natural phenomenon where one geographical barrier acts as the reason for speciation. Palghat Gap, the prominent ancient discontinuity of Western Ghats acts as a geographical barrier in free movement or distribution of some species of animals, birds, amphibians and angiosperms across the Gap. Pteridophytes are the ancient group of plants and in this study, an attempt has been made to analyse the influential effect of Palghat Gap on distribution of lycophytes and ferns across the Gap. The observations and results of the study have been summarised in this thesis under different chapters.

The first chapter includes the brief outline of the general account of pteridophytes, evolution, classification systems, ecology, geospatial mapping, molecular studies, spore morphological studies, relevance of the current study and objectives of present study. Following it, in the second chapter, an exhaustive review on the available knowledge base in pteridology, specifically in the field of taxonomy, ecology, molecular studies, geospatial studies and spore morphological studies has been summarised. The third chapter describes the study area and detailed methodologies adopted in taxonomic studies, ecological, molecular, geospatial analysis and spore morphological studies using SEM to fulfil the objectives of the thesis. The fourth chapter describes the outcomes of the study and the chapter is divided into 5 sections, *viz.*, Systematic treatment, Spore morphological studies, Molecular analysis, Geospatial analysis and Ecological studies. Systematic treatment includes a dichotomous key to the families, genera and species recorded from the study area and taxonomic account of each species recorded. The accepted name as per Fraser-Jenkins *et al.* (2017, 2018 & 2021) is used for each taxon and the synonyms for the species are limited to the most relevant works carried out in Southern India, especially Southern Western Ghats. The specimens examined are given for each species and most of the collected taxa are supported by photo plates. In addition to the freshly documented taxa, the taxa described from the current study area in previous literature such as Nayar and Geevarghese (1992), Nair *et al.* (1988,

1992a, 1992b, 1994) were also included in each family, based on herbarium studies. The spore morphological analysis includes the SEM analysis of selected ambiguous taxa along with description. The molecular part describes the molecular analysis of selected taxa using 3 gene regions - *rbcL*, *trnL-F* and *atpB*. The geospatial mapping part includes the mapping of study area in different aspects, land use-land cover analysis, NDVI analysis and mapping of collected endemic and IUCN categorised taxa. The ecological analysis part contains quantitative comparison of species distribution based on vegetation and altitude gradients, along with the ecological niche modelling analysis of one endemic species - *Elaphoglossum beddomei* - in 2 climatic regimes. These sections contain photographs, graphs, maps and tables as support documents for the observations made during the study.

The fifth chapter concludes with the salient findings made during the study followed by the recommendations suggested for protecting the biodiversity of the area. A detailed bibliography has also been provided at the end of the thesis.

1. INTRODUCTION

Evolution is a continuous process and the present-day Earth is the result of this continuous evolutionary process. The continents reached their current locations by drastic movements that occurred billions of years ago (Wegener, 1912). As per continental drift theory, continents were broken and float in the ocean for many years and this is a continuous process with each continent moving slowly to reduce their entropy and to attain their maximum equilibrium (Meinhold and Şengors, 2019). Western Ghats-the cradle of evolution-is believed to be formed by such a collision of plates. Due to the position of Western Ghats, near to the equator, it has a very high degree of diversity and also allows continuous evolution due to the accumulation of genetic diversities. This is because of the climatic stability and evolutionary age of Western Ghats (Gopal *et al.*, 2023).

Palghat Gap, one of the prominent ancient discontinuities in the continuous stretch of Western Ghats, has originated through such an evolutionary process. It is estimated that this Gap originated around 500 million years ago, in the Palaeozoic Era in the Phanerozoic Eon of Earth's evolutionary scenario (Soman *et al.*, 1990). One of the hypotheses about the origin of Palghat Gap is that it was a remnant plateau landform representing the plantation surface of the Jurassic age. Similarly, the imagery analysis evidenced that there was an easterly flowing palaeo stream-Proto-Amaravathi- which dried up in post-Mio-Pliocene times due to change in climatic patterns. The North-South stretching of the Western Ghats and the continental crust elevation related to Deccan trap volcanism (Subramanian and Muraleedharan, 1985) are believed to be the reasons for the Palghat Gap formation. All the population divergences are believed to have occurred in the Pleistocene due to the climatic fluctuations experienced in the Pleistocene (Sukumar *et al.*, 1993). Based on microscopic as well as mesoscopic analysis, Palghat Gap is treated as a ductile shear zone and assumed that the present gap topography is the product of shearing and erosion (D'Cruz *et al.*, 2000). Further, geological studies pointed out that the Peninsular India in its ancient period was part of Madagascar. Later in the

geological time scale it got separated from Madagascar as evidenced by the comparative lithological structure of Western Ghats and Eastern part of Madagascar. The Ranotsara Gap in Madagascar is believed to be the continuation of Palghat Gap in southern Western Ghats (Gunnell and Harbor, 2008).

In tune with the movement of continents, evolution occurred in living organisms too. The first land plants with vasculature-the primitive pteridophytes- originated around 400 mya, in the Silurian period of Palaeozoic Era and they are the first land plants, which 'stand up' on their stem. The conductive tissues in plants, xylem and phloem, evolved in pteridophytes to adapt to the dry habitats. In earlier times they lacked leaves, appearing as green sticks emerging from soil, and afterwards, leaves evolved to adapt in various environmental conditions. They diversified drastically and distributed long distances through their minute powdery spores and flourished all over the land, forming the major vegetation in the Carboniferous period (Kenrick and Crane, 1997).

In the middle Devonian period of the Palaeozoic Era, Gymnosperms evolved and in the Cretaceous, flowering plants diverged. The colonisation of flowering plants marginalised the pteridophytes and the change in climatic conditions favoured the flowering plant diversification, diminishing the pteridophytes. Contrary to the earlier assumptions, and based on molecular data, it is assumed that most of the modern ferns are products of secondary radiations, and opportunists that diversified taking the advantages of microhabitats were formed, after the dominance of Angiosperms (Schneider *et al.*, 2004). Due to the presence of diversified topography, variable climatic conditions and geographical positions, pteridophytes still form a part of major flora next to Angiosperms. Now in the Anthropocene epoch, these living fossils are extremely shrinking to some pockets and becoming the second largest group of plants, next to Angiosperms, but we usually ignore these ones as waste plants.

There is sufficient fossil evidence for pteridophytes that can be traced back to Silurian to Tertiary periods. The ancient group Psilophytales contains the families Rhyniaceae, Zosterophyllaceae and Psilophytaceae. Apart from Psilophytales, other

fossil groups like *Schizopodium*, *Cladoxylon*, *Asteroxylon*, *Aneurophyton*, *Eospermatopteris*, etc. are some of the ancestral stalks of extant ferns. Similarly, lycophytes can also be traced back to some fossil members. Many species of *Selaginella* and *Lycopodium* were traced in fossils of Carboniferous, and also the interesting genus *Isoetes* have its ancestral stalk in Carboniferous and Tertiary (Grauvogel-Stamm and Lugardon, 2001).

Pteridophytes are considered as the connecting link between bryophytes and phanerogams and have some peculiar features other than these two groups. The main plant body is sporophytic, which is gametophytic in bryophytes. This group is characterised by independent gametophytic and sporophytic stages in their life cycle, which is absent in all other plant groups. Pteridophytes show a wide range of diversity from herbaceous to large tree forms and majority of them are herbs and shrubs. Tree forms like *Cyathea* are perennial and live for long. There are scrambling and climbing forms in which scrambling forms form thickets in open areas and they have spreading and branching rhizomes and rachis as *Dicranopteris* spp., *Gleichenia* spp., etc. The climbing forms like *Lygodium* spp., *Stenochlaena* sp., etc climbed on large trees and exist in a variety of habitats from hydrophytic to xerophytic and also in different climatic conditions as well as in variable ecosystems. But no pteridophytes could be documented from marine habitats, except the one halophytic *Acrostichum* and no parasitic forms so far reported.

Pteridophyta-are broadly divided into two in the mid time period of classification; as ferns and fern allies. In this classification, ferns include the Polypodiopsida and fern allies include the most primitive members such as Psilotopsida, Lycopsida and Sphenopsida. Later in the molecular era, molecular analysis of ferns and fern allies revealed fern allies as a polyphyletic group, Psilotopsida as sister group to Ophioglossaceae and Sphenopsida closer to Polypodiopsida, than to Lycopsida (Manhart, 1995). The term 'fern allies' was suggested for rejection (Christenhusz and Chase, 2014) and this made rearrangements to the group with Psilotopsida, Equisetopsida and Polypodiopsida as ferns and Lycopsida considered as a separate clade. Of late, the group nomenclature has changed to Lycophytes and Ferns.

Over these years, taxonomists attempted to classify the pteridophytes into different groups based on different criteria. The first such recorded attempt was done by Linnaeus (1753 & 1754) where he classified pteridophytes based on the shape and position of sori and recognized 174 species in 16 genera under Cryptogamae. Following this, there were many attempts to classify this plant group and these pioneer attempts were purely artificial in nature. After the publication of Darwin's evolutionary theory in 1859, the evolutionary thoughts intruded in classification of organisms and influenced the fern classification too. Later many taxonomists attempted classification of pteridophytes based on the evolutionary trends observed in this plant group and first such classification was proposed by Diels (1898-1900), followed by Bower (1923-1928), Copeland (1929), Christensen (1906), Holttum (1947), Copeland (1947), Reimers (1954) who included fossil taxa also in classification, and Pichi-Sermolli (1958). Of late, the advances in cytological studies also influenced fern classification (Manton, 1950, 1954 & 1958; Manton and Sledge, 1954). Ploidy of this group of plants is highly variable from diploids to large numbers of polyploids and hence, the genetic load is high in pteridophytes. The reasons for variation in ploidy are the usual apospory, apogamy and also due to the higher efficiency in producing natural hybrids. This high variation in ploidy leads to the formation of species complexes in pteridophytes showing high degree of variations.

Later, with the emergence of the molecular data, molecular phylogenetic analysis took systematics to a new dimension. Many hypotheses regarding the divergence of pteridophytes were proposed by various authors based on molecular studies (Pryer *et al.*, 1995 & 2004; Wikström and Pryer, 2005; Schuettpelz and Pryer, 2008). With the advent of molecular profiling, the earlier concepts on the phylogeny of pteridophytes underwent a revolution. The 16S ribosomal plastid DNA sequence analysis showed that Psilotaceae are closer to Ophioglossaceae. Similarly, Equisetaceae showed more relation to Polypodiales, than to Lycopodiales (Manhart, 1995). Just as phylogenetic studies, gene level molecular studies also got geared with pteridophytes. The barcoding studies in cheilanthoid ferns lead to divergence of two new genera, *Gaga* (Li *et al.*, 2012) and *Baja* (George *et al.*, 2019). Similarly, the

whole genome studies of *Azolla filiculoides* and *Salvinia cucullata* provided deep insights on land plant evolution and cyanobacteria symbiosis (Li *et al.*, 2018). RNA editing studies in pteridophytes are also progressing to analyse the rate of evolution in the fern plastome (Fauskee *et al.*, 2021).

Apart from the molecular studies, analysis of micro-morphological characters such as spore morphology and spore ornamentation are also used to delineate the species. Spore ornamentation is one of the key characteristics for identification and classification of pteridophytes. Spores are one of the major ways for reproduction in pteridophytes and on germination, produce an independent gametophyte. The minute powdery spores have different ornamentations on their exospore. These characters are unique, and more static and less affected by environmental factors for a species or variety. So, spore ornamentation and other features are used for phylogenetic as well as taxonomic studies in pteridophytes (Gamal, 2012). Normally pteridophytes showed variations in accordance with the environment and in tune with hybrid formation. But the spore traits are not influenced by ecosystem traits and hence, the differences in spore traits can be taken as an indicator for species identity and species divergence (Adeonipekun *et al.*, 2021).

Usually spores of pteridophytes germinate in environments with high humidity and moderate temperatures in tropical and sub-tropical montane forests (Bhattarai *et al.*, 2004). However, many of the taxa are adapted to extreme conditions of temperatures and water availability, which help them to adapt from hot to cold, low altitude to high altitude and xeric to aquatic habitats (Rathinasabapathi, 2006). This reflects their diverse strategies for survival in response to environmental disturbances. This is mainly because of high photosynthetic capacity in low light intensities, anti-herbivore defence, tolerance to low nutrient conditions, long dispersal ability through spores and non-dependence on biotic vectors for reproduction (Sharpe *et al.*, 2010).

Ferns are major plant lineages with higher diversity and abundance in humid tropical and subtropical regions (Bhattarai *et al.*, 2004; Salazar *et al.*, 2015). But

some ferns colonise in disturbed and unstable exposed areas and are tolerant to a range of ecological and environmental parameters (Hemp, 2001). Some taxa colonise highly disturbed regions like landslide areas, flood plains, lava flows, etc. (Walker *et al.*, 1996). This is mainly because of the wide dispersibility of spores of pteridophytes and are able to flourish vegetatively from adjacent areas. So, these ferns which can colonise in such disturbed conditions can grow under low nutrient, drought and high light conditions. *Dicranopteris*, *Gleichenia*, *Pteridium*, *Cyathea*, *Hypolepis*, *Nephrolepis*, *Blechnum*, *Odontosoria*, *Polystichum*, *Lygodium*, *Lycopodiella*, many species of *Asplenium*, *Acrostichum*, *Pityrogramma*, etc. are seen in disturbed habitats. Among these, scrambling ferns (*Gleichenia*, *Dicranopteris*) and climbing ferns like *Lygodium* are common in such disturbed regions, especially in slopes and landslide affected areas. Walker (1994) stated that fern thickets improve the seed germination of tree species and promote forest formation especially in forest fire prone areas. Climbing ferns are common in forest margins and tree fall gaps, and they climb into the canopy, forming narrow, tall thickets (Mehltreter, 2006).

After establishing, these ferns compete for light and nutrients. The most common fern in disturbed habitats, *Pteridium aquilinum*, have allelopathic effects and toxic chemicals which prevent herbivory (Gliessman and Muller, 1978). They grow in different eco-geographical zones; sea level to highest mountains (Dixit, 2000). Earthquake or rain triggered land-slide affected areas are also invaded by ferns. Extreme flooding damages ferns and provides conditions for colonisation of fern species which can grow in flood condition, like *Adiantum capillus-veneris* dominated small, isolated and frequently flooded rock walls. Likewise *Marsilea* is another genus in flood areas and *Azolla pinnata* grows very well in polluted water (Robinson *et al.*, 2010). *Lycopodium*, *Pteridium aquilinum*, etc. recover quickly from rhizomes after fire damage. Many of them have spores, which germinate best in alkaline pH following fire (Gliessman, 1978) and tree ferns regenerate from their apical bud, which is protected in their fibrous trunks (Ough and Murphy, 2004). But as the disturbances increase, the diversity and species richness get adversely affected (Walker *et al.*, 2010). Apart from this widely growing species, many of the

pteridophytes are highly specific for critical eco-climatic conditions, such as the endemic taxa like *Elaphoglossum beddomei*, *E. nilgiricum*, Hymenophyllaceae members, etc. (Fraser-Jenkins *et al.*, 2017, 2018 & 2021). Due to its specific ecological preferences, they function as ecological indicators in changing climate. So, the disturbances to the micro-habitat conditions may adversely affect the existence of many taxa in this plant group and hence, studying the distribution of this plant group may help to analyse the ecosystem health and may assist in developing suitable conservation strategies to protect a fragile ecosystem.

Ecological niche modelling is a recently developed technique to analyse the distribution of species in potential habitats from known geographical locations. There are many advantages for this technique and this could predict the extent of occurrence of a species under study and can locate new populations. So, use of niche modelling of pteridophytes will be helpful in predicting the future changes in climate and how the climate change may affect the ferns and other organisms' distribution and existence in future climatic regimes. Hence, suitable conservation measures can be developed to reduce the rate of degradation of critical habitats such as evergreen forests in Peninsular India along with protecting the micro habitats of taxa that serve as ecological indicators.

Pteridophytes have ecological specifications to grow and establish in varied habitats ranging from most xeric to moist, and to the ice-covered temperate zones. Hence, distribution analyses will provide data on the climatic and environmental conditions of the specific location where they thrive and for the conservation of one taxon, we should know the habitat preferences of that specific species.

Pteridophytes are distributed in temperate and tropical regions (Qian *et al.*, 2022), and in the tropical regions the rate of speciation is more, as compared with temperate zones (Smith *et al.*, 2014). In India, there are two major centres of diversity for pteridophytes; North-Eastern India and the Western Ghats. About 12,000 species of Pteridophytes occur in the world, of which, more than 1,200 species of ferns and lycophytes are likely to occur in India where they are mainly distributed in the Eastern Himalayas and Western Ghats of Southern India.

The Western Ghats are one of the important centres of plant diversity and the region is remarkable with a variety of vegetation types, climatic zones and endemism. The Western Ghats range starts near the border of Gujarat and Maharashtra, south of Tapti River, and runs approximately 1,600 km through the six states of Gujarat, Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala ending at Kanyakumari, the southern tip of India (Nair, 1991). Western Ghats are one of the oldest mountain stretches and thousands of years older, believed to have formed as a result of continental drift and collision of continents as proposed by Wegener (1921). The Western Ghats harbours different environmental conditions leading to the formation of myriads of habitats, from drier to moist environmental conditions and dry deciduous to evergreen and shola forests. The pattern of distribution of habitats is similar to usual habitat distribution in mountain regions- from moist deciduous or dry deciduous to semi-evergreen, then to evergreen, montane grasslands and shola forests. The mountain ranges are characterised by high degrees of endemism, and are also under uncontrolled destruction. Hence these ranges are considered as one of the hottest biodiversity hotspots in the world by Conservation International (2023). UNESCO declared it as a world heritage site in 2012 (UNESCO World Heritage Centre, 2023).

The Western Ghats are not a continuous mountain stretch and are with discontinuities at three different regions. The Palghat Gap is a prominent discontinuity in the Western Ghats. Apart from this, two other gaps also break the Western Ghats- most northerly the Goa Gap and at the south the Sengottai Gap. Among these, Palghat Gap is the largest and oldest Gap and is almost 32 km wide. The wet southwest monsoons as well as winds from the Bay of Bengal cross the Western Ghats through the opening. So Palghat Gap plays a pivotal role in the species distribution pattern in the southern Western Ghats. Palghat Gap, strongly influences the climatic conditions of Southern India, and thereby the floristic composition of this region. Gap region has strong altitudinal gradation, with about 170 m within the Gap and about 2000 m on both sides (Nair, 1991).

The Palghat Gap separated the Western Ghats into two parts- Northern part, the Nilgiris stretch and Southern part, the Anamalai hills. The research reports authenticate the hypothesis that, the Palghat Gap plays a role as geographic barrier in the speciation of animals like Asian elephant (Vidya *et al.*, 2005), Nilgiri tahr (Joshi *et al.*, 2018), amphibians (Gopalan *et al.*, 2014; Vijayakumar *et al.*, 2016), birds (Robin *et al.*, 2010) and plants like *Eurya nitida* (Bahulikar *et al.*, 2004), *Gaultheria fragrantissima* (Apte *et al.*, 2006) and *Kingiodendron pinnatum* (Nair *et al.*, 2019). Pteridophytes are altitude, climatic and habitat specific and the Palghat Gap along with adjacent regions offer a gradient of climatic and habitat conditions. It also makes a discontinuity in the pteridophyte populations, specific for high altitudes as southern and northern populations. There is no such influential analysis of Palghat Gap on pteridophytes and other lower plant groups till date. So, the present study aims to reveal the influence of Palghat Gap, if any, on the distribution of lycophytes and ferns.

Aim

The present research is being planned to conduct ecological, taxonomic and molecular studies on the Lycophytes and Ferns of Palghat Gap and adjacent regions of the Western Ghats. The investigation also focuses on the influence of Palghat Gap features on the distribution patterns of the pteridophyte population across the gap region.

Objectives

- Exploration and collection of ferns and lycophytes in different seasons across the Gap influenced regions
- Identification of species in consultation with types and protologue
- Preparation of taxonomic accounts
- Photo-documentation of Pteridophyte taxa of the area and their habitats

- Study of the ecology and diversity of the Pteridophytes of the Gap influenced region.
- Preparation of herbarium specimens
- SEM analysis of spores of selected taxa to evaluate variability between populations across the gap.
- Molecular studies on selected ambiguous taxa and variable populations across the gap.
- Geo-spatial mapping of endemic as well as threatened lycophytes and ferns collected from the Palghat Gap and Gap influenced areas.
- Ecological Niche Modelling studies of a selected endemic fern to analyse the future trends in habitats of Palghat Gap influenced areas.

Relevance of the study

The Indian sub-continent with the diversified topography, variable climatic conditions and strategic geographic position, has a rich diversity of pteridophytes. The taxonomic re-examination of many species in its wild habitats showed taxonomic re-arrangements of the species. The recent literature stated that '*Angiopteris evecta*' does not occur in South India; the specimens mentioned under this name from South India belong to two different species *viz.*, *A. crassipes* and *A. helferiana* (Fraser-Jenkins, 2008). It also points out the crucial need for detailed explorations as it happens to the widely distributed species of South India. However, cautious search in the different habitats and documentation only could show the occurrence of other two species, not much known. So, there is the need for advanced techniques to clarify the ambiguous positions of some taxa.

The recent works, especially on the ecological aspects, put forward by Mehlreter *et al.* (2010) also reveals the gaps in our understanding of this group in the Indian context and especially in the Western Ghats. The Indian region is blessed with the rich diversity of about 1054 Pteridophytes (Hassler, 2024). The Western Ghats of Kerala, is rich with more than 300 Pteridophytes. It is evident from the fact

that it is necessary to re-document the floristic wealth of Western Ghats from an evolutionary point of view.

Pteridophytes, except a very few species, are easily vulnerable to anthropogenic activities due to their susceptibility and lack of adaptiveness to the slightest environmental changes. Extensive deforestation leads to the disappearance of pteridophytes at that particular habitat. They play an important role ecologically in the forest ecosystem as an vital part of biogeochemical cycling.

Lycophytes and ferns are good indicators of climatic changes, and can be used to analyse the environmental fluctuations of the specific habitats where they exist. Similarly, the DNA sequence analysis of ferns, the second dominant plant group, to decipher the mystery of plant evolution is going on in different parts of the world. Here, the study of the Pteridophyte flora across the Palghat Gap would reveal the influence of Gap on the distribution of pteridophyte populations in southern Western Ghats and may also help in the study of evolutionary process and trends taking place in southern Western Ghats' pteridophytes. The collected and identified herbarium specimens will also serve as future reference materials. The results of this study may also help in developing new conservation strategies for threatened and endangered taxa by analysing their distribution patterns and tendencies in Western Ghats.

II. REVIEW OF LITERATURE

II.1. Classical accounts on Pteridophytes

The floristic analysis of Pteridophytes is a well-established research area across the world as well as in India. Hooker and Greville (1827-1831), Hooker (1844-1864), Hooker and Baker (1865-1868) studied on British fern flora and Moore (1857) worked on Isoetaceae members. Later Copeland (1929) studied ferns of Sumatra, and Christensen (1932) on ferns of Madagascar. Then, Copeland (1933, 1937 & 1938) studied the filmy ferns and Clausen (1938) on Ophioglossaceae. The fern flora of Nepal was studied by Ratzada and Vaid (1952). And the fern flora of Malaysia was studied by Holttum (1954). Likewise, Hennipman (1977) did work on the revision of *Bolbitis*. Later, Holttum and Hennipman (1978) documented the *Lomariopsis* group in Malaysia. Following this, the fern flora of the Mediterranean region was studied by Pichi-Sermolli (1979). Kuo (1985) documented Taiwanese pteridophytes. The fern diversity of Malaysia and New Zealand was done by Parris (1996). Many revisionary works, like on *Pyrrosia* (Hovenkamp, 1986), *Microsorium* (Bosman, 1991), Microsoroid ferns (Nooteboom, 1997), *Lomariopsis* of neotropics (Moran, 2000), filmy ferns (Ebihara *et al.*, 2006) and *Ascogrammitis* (Sundue, 2010), were also carried out in different parts of the world.

In India, the detailed pteridological research begins in the Britishers era. The classical work of Van Rheede (1678-1703), '*Hortus Malabaricus*' is the first reference on South Indian Pteridophytes. The volume 12 of this epic literature includes illustrations and descriptions of 18 Pteridophytes (Manilal, 2003). R.H. Beddome conducted extensive floristic studies in India and his major contributions include, *Ferns of South India* (1863-1864), *The ferns of British India* (1865-1870), *Supplement to the ferns of Southern India and British India* (1876), *Handbook to the ferns of British India Ceylon and Malay Peninsula* (1883) and *Supplement to the ferns of British India, Ceylon and Malay Peninsula* (1892). Later, Alston (1945) recorded 58 species of *Selaginella*. Similarly, Holttum (1947, 1949, 1971 & 1973)

also made valuable contributions to Indian Pteridology. Holttum (1976) documented the Thelypteridaceae of Hassan district of Karnataka.

Bir worked on cytological aspects of ferns of Kodaikanal (1965), Simla (1963), and Bir and Vasudeva worked on floristic studies of Kodaikanal Hills (1971) and Pachmarhi Hills of Central India (1972). He also conducted works on floristic studies of Garhwal Himalaya (Bir *et al.*, 1983), North-Eastern India (Bir *et al.*, 1991) and revisionary works on Polypodiaceae (Bir *et al.*, 1983), *Diplazium polypodioides* complex (Bir and Irudayaraj, 1992) and Asplenioid fern (Bir, 1998).

Nayar and his team (1959, 1970 & 1974) made valuable contributions to Indian Pteridology, especially on South Indian Ferns. Nayar worked on pteridophytes in different aspects, giving detailed account on many groups, like - *Pseudodrynaria* (1954), *Loxogramme* (1963), *Drymoglossum* (1957), *Bolbitis* (1960), *Adiantum* (1961a and 1962), *Microsorium* (1961b), *Pyrrosia* (1961c), *Cheilanthes* (1963), *Actiniopteris* (1962), *Pityrogramma* (1964) and *Peranema* (1966). Then, Nayar and Srivastava (1962) documented 31 species of ferns from the Great Andamans as a preliminary study. Nayar and Kaur (1974) published the book *Companion to Beddome's Handbook to the ferns of British India*, and proposed classification schemes for ferns (1970, 1974 & 1976). Ghosh and Ghosh (1983) reported a new taxon of *Pteris* as *P. silent-valliensis* - from Kerala. Similarly, Nayar and Geevarghese (1993) and Madhusoodanan and Jyothi (1993) reported new species of *Pellaea* as *P. malabarica* from Silent Valley National Park. The *Fern flora of Malabar* by Nayar and Geevarghese (1993) serves as a good reference resource for ferns of Malabar part of the Western Ghats, which described 166 species of ferns in Malabar region.

Nair and Bhargavan (1981) reviewed pteridological studies of Peninsular India and this summarises references to many old literatures on Pteridophytes of South India. During the same period, *A Dictionary of the Pteridophytes of India* (Dixit and Vohra, 1984) and *Lycopodiaceae of India* (Dixit, 1988), got published and are regarded as significant contributions to Indian pteridology. Following this, Nair *et al.* (1988, 1992a, 1992b & 1994) had given a detailed account of ferns and

fern-allies of Kerala, with about 250 taxa.

Dixit (1984) published the work *A census of Indian Pteridophytes* which includes 219 taxa. *A dictionary of the Pteridophytes of India* was presented by Dixit and Vohra (1984). Monographs on Lycopodiaceae (1988) and Selaginellaceae (1992) of India were also prepared by Dixit. Theuerkauf (1994) did an analysis on conservation of Indian pteridophytes and concluded that half of the South Indian pteridophytes are under threat. An update on ferns of India was brought by Chandra (2000) with details on synonyms and distribution of taxa.

Fraser-Jenkins studied the pteridophytes, especially in the Indian subcontinent, in detail. He published monographs of *Dryopteris* (1986) and *Polystichum* (1991). He also gave an account on 'new species syndrome' in Indian pteridology (1997). Fraser-Jenkins (2008) brought out a comprehensive work summarising the advances in the taxonomic concepts in the Indian context. After that, Fraser-Jenkins and Dulawat (2009) revised the Cheilanthoid ferns of India. Later, Fraser-Jenkins (2012) and Ebihara *et al.* (2012) listed rare and threatened pteridophytes of Asia, which includes 337 Indian taxa. The breakthrough work on Indian pteridology, *An annotated checklist of Indian pteridophyte* was published in three volumes by Fraser-Jenkins *et al.* (2017, 2018 & 2021). It contains an updated nomenclature of each taxon in India.

Goswami *et al.* (2006) studied pteridophytes from lower Gondwana formations of river Coalfield, Orissa and their distribution and diversity in Permian. Then, Chandra *et al.* (2008) documented the rare, threatened pteridophytes of India. They concluded that around 43% of pteridophytes in India are rare or threatened.

Manickam and his team (1984, 1986 & 1988) also made valuable contributions to almost all aspects of pteridology, including taxonomy, anatomy, conservation, ecology, cytology, phytochemistry and morphology of South Indian ferns. Manickam and Nainan (1984) studied the ecology of fern flora of Palani Hills. Manickam (1986) published the fern flora of Palni Hills. Manickam and Irudayaraj (1988) studied the cytology of ferns of the Western Ghats, with the cytological information of about 200 ferns of South India. Also published the *Pteridophyte flora*

of *Western Ghats, South India* (1992), provided illustrations and descriptions of 255 pteridophyte taxa from those parts of the Western Ghats of South India, which lies south of Palghat Gap. Manickam and Rajkumar (1999) described the polymorphism in 100 south Indian Pteridophytes. Irudayaraj and Ganapathi (2000) rediscovered *Elaphoglossum commutatum* from Kothayar hills of Tamil Nadu. The detailed account on the taxonomy and distribution of ferns from the Nilgiris was done by Manickam and Irudayaraj (2003). Benjamin and Manickam (2007) studied the ethnomedicinally important pteridophytes used by the ethnic populations in the Western Ghats. Benniamin *et al.* (2008) described a new species - *Polystichum manickamianum* - from the Agastyamala hills of Tamil Nadu.

Madhusoodanan and Kumar (1986) reported *Schizaea digitata* from Thiruvananthapuram - a new record to South India. The rare and endangered ferns and fern allies of Western Ghats of Kerala is listed by Madhusoodanan (1991) and also discussed their conservation in this work. Later, Madhusoodanan and Sevichan (1991) studied the genus *Adiantum* in Kerala. Madhusoodanan and Leena studied different genera of Thelypteridaceae, such as *Pronephrum* (1991), *Sphaerostephanos* (1994) and also the family Thelypteridaceae (1992). Madhusoodanan and Jyothi (1993) gave a detailed account on Chelanthoid ferns. Nampy and Madhusoodanan (1992) gave a detailed account of Polypodiaceae of South India. Madhusoodanan and Nampy (1994a & b) described *Selaginella dixitii* and *Phymatosorus malabaricus* from Palakkad of Kerala as a new record. The ecological studies of Lomariopsid ferns of Kerala were conducted by Majeed *et al.* (1994). Leena and Madusoodanan (1996) gave an account on *Macrothelypteris* in South India. Azeez (2007) and Azeez *et al.* (1996) studied the spleenworts-*Asplenium*, of Kerala. Rajesh *et al.* (1997) reported the rare taxon *Arthropteris palisotii* from the Periyar Tiger Reserve in Idukki district of Kerala. Nampy and Madhusoodanan (1998) published the revision of Polypodiaceae of South India and provided a detailed account of 33 species. Leena and Madhusoodanan (1998) documented the pteridophyte diversity of Wayanad district of Kerala, and recorded 119 taxa. Hameed *et al.* (2003) presented a detailed account on the 28 taxa of filmy ferns of south India. Hameed and Madhusoodanan (2003) described a new species,

Trichomanes vamana, from the Athirapilly of Thrissur of Kerala. Easa (2003) enumerated more than 337 pteridophytes of Kerala. Raju and Mohanan (2010) reported the occurrence of *Polystichum manickamianum* from the Cheminji hills of Thiruvananthapuram, as a new record for Kerala state. The revisionary work of the genus *Pteris* in South India was done by Sreenivas (2011) and Sreenivas *et al.* (2013). Niranjana *et al.* (2013) documented the pteridophyte diversity of Malabar Wildlife Sanctuary in Kozhikode district of Kerala. Varma and Madhusoodanan (2013 a & b) gave an account on the phenetics and molecular systematic studies of filmy ferns of South India. Madhusoodanan (2015) documented 283 species of fern and fern allies in the *Hand book on the fern and fern allies of Kerala*. Vijisha and Rajesh (2016) documented the 69 species of pteridophytes of Aralam Wildlife sanctuary, Kerala. Huang *et al.* (2019) presented a detailed review on edible pteridophytes in Asia, enlisting 172 taxa, including *Diplazium esculentum* and *Blechnopsis orientalis* widely used in India. An update on the pteridophytes of Western Ghats was made by Benniamin and Sundari (2020). Jash and De (2020) presented an account of *Ophioglossum* in West Bengal, which include *O. costatum*, *O. gramineum*, *O. parvifolium*, *O. petiolatum*, *O. reticulatum* and with comments on the doubtful occurrence of *O. pendulum*. Patil *et al.* (2020) recorded *Tectaria multicaudata* (C.B.Clarke) Ching, from the Panhala fort of Kolhapur District in Maharashtra state. It was earlier known in India only from the north eastern states. Rajput *et al.* (2021) published a check-list of pteridophytes of Gujarat state, which includes 50 species under 23 genera and 14 families. The threat status of *Cyrtomium micropterum* in India was assessed by Bhagathsingh and Benniamin (2021) based on the IUCN guidelines. Similarly, Benniamin *et al.* (2021) listed 18 threatened pteridophyte species of the Western Ghats of Karnataka. Benniamin *et al.* (2023) documented 63 species of pteridophytes from Bhadra Tiger Reserve of Karnataka state. The intraspecific variations of pteridophytes from the Western Ghats were discussed by Benniamin *et al.* (2024), where 46 species were analysed and concluded that the morphological variations in pteridophytes are due to genetic diversity within the species, and not merely due to the ecological diversity of habitats.

Recently additions to pteridophyte floras of different regions were happening all over India - such as addition to Karnataka (Jesubalan *et al.*, 2020; Bhagathsingh *et al.*, 2020; Jesubalan *et al.*, 2024), Maharashtra (Patil *et al.*, 2020), Himachal Pradesh (Singh *et al.*, 2022), Jammu and Kashmir (Khoja *et al.*, 2022), Arunachal Pradesh (Soni *et al.*, 2023). The pteridophyte floristic survey of Bhadra Tiger Reserve, Karnataka by Benniamin *et al.* (2023) was also presented recently.

II.2. Classification of Pteridophytes-Artificial to Phylogenetic

Like all organisms, the first attempt of classifying pteridophytes was done by Linnaeus (1753 & 1754) based on the shape and position of sori on leaves. He placed ferns in Cryptogamae and recognized 174 species in 16 genera. It was an artificial system, many species with dissimilarities grouped together. Later on the first natural system of classification of pteridophytes by Smith (1793), he grouped ferns based on features of indusium and, mainly focused on ontogeny and inducial rupture method. Swartz (1806) in *Synopsis Filicum* gave an elaborate system of Smith's classification, based on characters of sori and indusium as done in J.E. Smith (1793), he recognised 720 species under 38 genera. Presl (1836, 1845 & 1852) and John Smith (1842) independently classified the ferns based on soral characters, petiole anatomy and venation, then arranged ferns in 176 genera and 138 genera respectively.

The concept of evolution by Darwin (1859) has influenced the fern classification also. The first classification of ferns based on Darwinian evolution was proposed by Diels (1898-1900). Christensen (1906) grouped ferns under 147 genera. Bower (1923-1928), in the three volumes of *The Ferns*, classified ferns into 12 families and based on anatomy, development and morphological features recognized 6 evolutionary lineages in Polypodiaceae. Copeland (1929) arranged East Asian genera in a phyletic sequence. Holttum (1947) presented a revised classification of Polypodiaceae and also revised classification scheme proposed by Christensen (1938). Following this, Copeland (1947) takes microscopic characters like scales, hairs, etc. for classification. Based on evolutionary trends Holttum (1949) also proposed a classification of pteridophytes. Reimers (1954) and Pichi-Sermolli

(1958) considered fossil taxa also in classification.

The cytological studies on ferns were carried out by Manton (1950, 1954 & 1958) as well as Manton and Sledge (1954). Later, cytological information was also used to solve the problems in classification of ferns. Mehra and Kannan (1959) recognized phyletic fern lineages using their chromosome numbers. Wagner (1969) described the non-evolutionary and phenetic system of fern classification.

The emergence of molecular studies also got reflected in fern classifications. Hasebe *et al.* (1994) developed a primer for *rbcL* for ferns for phylogenetic analysis. And showed that Grammitidaceae are to be placed in Polypodiaceae, and also that Davalliaceae have more similarity to Polypodiaceae. Smith (1995) summarised non-molecular characters of fern relationships. Then the first cladistic analysis by using morphological characters along with *rbcL* data was put forward by Pryer *et al.* (1995). Manhart (1995) used plastid 16S rDNA for delineating fern allies. Based on an expanded morpho-molecular analysis, Pryer *et al.* (2004) concluded that Psilotaceae, the primitive group considered under fern allies, belongs to the fern clade. Based on molecular evidence, Schneider *et al.* (2004) pointed out that most of the extant leptosporangiate ferns are diversified after the dominance of angiosperms in the Cretaceous period. A comprehensive phylogenetic classification of ferns, was proposed by Smith *et al.* (2006). Schuettpelz and Pryer (2007) used the data of *atpA* sequences to the criteria for fern classification. Later researchers studied a number of groups in detail, such as Cyatheaceae (Korall *et al.*, 2006 & 2007), Salviniiales (Nagalingam *et al.*, 2008) and Marattiaceae (Christenhusz *et al.*, 2008). Based on the additional data, Smith *et al.* (2008) expanded their classification. Schneider *et al.* (2009) recognized 4 major clades such as Equisetidae, Ophioglossidae, Marattiidae and Polypodiidae. After the detailed studies by Christenhusz *et al.* (2011), Christenhusz and Schneider (2011), placed Equisetaceae as sister to all ferns than to Marattiidae. Following this, first combined phylogenetic analysis by Pteridophyte Phylogeny Group was published in 2016 where 11916 species of 337 genera under 41 families, 14 orders and 2 classes were included (PPG1).

II.3. Cytological approaches in Pteridophytes

The first attempt to cytology and use of this to interpret evolution in pteridophytes was depicted by Manton (1950) in her book entitled *Problems of cytology and evolution in Pteridophyta*. It said that evolution reflects changes in ploidy and reproductive systems. Later, Manton and Sledge (1954) revised Copeland's families based on cytology. The cytological evaluation of the fern genus *Pteris* by Walker (1962), showed that 34% are obligate apogamous, 55% are polyploids and 33% diploids. One of the old genera *Pteris* has high evolution capacity through formation of hybrids. The percentage of ploidy is an indicator of rate of evolution in ferns; which is faster in tropical regions than in temperate regions.

Abraham and Ninan (1954) reported the highest chromosome number in *Ophioglossum reticulatum* and also showed parallelism between Ophioglossaceae and Schizaeaceae. This high polyploidy in *Ophioglossum* is interpreted based on the oldest history of Peninsular India. Ninan (1958) studies the cytology and phylogeny of the pteridophytes, especially the *Ophioglossum*, *Botrychium* and *Helmithostachys*, and concluded that the high percentage of polyploids in South Indian races of *Ophioglossum* might be due to the oldest geological age of Peninsular India. The chromosome evolution in the genus *Ophioglossum* was analysed by Khandelwal (1990). Faseena and Thoppil (2007) elucidated one high polyploid chromosome complement of *O. nudicaule*. Abraham *et al.* (1962), Irudayaraj *et al.* (1993), Irudayaraj and Bir (1994), Irudayaraj and Manickam (1995) are major contributions in cytology of pteridophytes of Southern India. Cytology of ferns of Nilgiris was done by Bir and Irudayaraj (2001) and that of Kolli Hills of Eastern Ghats was done by Vijayakanth *et al.* (2018), where 66 taxa were analysed cytologically. The chromosome number of *Ophioglossum trilokinathii* was reported by Yadav and Meena (2023) as $n = 120$. Amirtham *et al.* (2023) re-investigated the cytology of *Christella hispidula* of both diploid ($n=36$) and tetraploid ($n=72$) from Meghamalai hills of Tamil Nadu.

II.4. Pteridophytes and spore morphology

Morphological analysis of spore ornamentation in pteridophytes is a key character to distinguish many species. Tryon (1990) analysed spore morphological characters in an evolutionary perspective and as an ecological differentiation level. In this work he concluded that; primitive families have trilete spores with a thin conforming perispore and monolete spores with a complex perispore are characteristic of derived families. The ecological adaptations in pteridophytes also reflect in surface contours; as epiphytic species have more contours than terrestrial and epilithic species. Tryon and Lugardon (1990) studied surface, wall structure and diversity based on the spore morphology of 232 genera belonging to 35 families. Spore morphological analysis compared with phylogenetic analysis based on two chloroplast non-coding regions *trnL-F* and *rps4-trnS*, showed that perispore morphology has a relation to the phylogeny of *Elaphoglossum* (Moran *et al.*, 2007). The palynological analysis of Cyatheaceae revealed that perispore features are homogenous with the genus and exospore features are heterogeneous, so it can be used for illustrating the evolutionary trends within the group (Marquez *et al.*, 2010 a & b). Combined light microscopy and SEM analysis of some fossil taxa showed that the spore analysis of fossils gives information about the ancient environment in that region and also gives information on climate (Grímsson *et al.*, 2011). The spore morphological analysis of Kolli Hills of Tamil Nadu showed that 43 species are most primitive with trilete spores and 12 advanced species with monolete spores with visible perine (Vijayakanth and Satish, 2016). Chao and Huang (2018) used spore morphology along with leaf characters to reconstruct the phylogenetic tree and also for infrageneric classification of the genus *Pteris*. Spore ornamentation of ancestral lineage of microsoroid ferns showed verrucate and also this ornamentation helps to distinguish certain microsoroid clades (Chen *et al.*, 2021).

II.5. Ecological studies

Knowing the ecology helps to understand how these ecosystems exist and how it extends. Ecological studies are thus important for the conservation of

ecosystems. Fern ecological studies were very rare before 2000; but limited to works of R. E. Holttum, A. F. Dyer and C. N. Page, etc. Holttum worked on the ferns of the Malay peninsula and gave a detailed description on the habit, habitat and associated species in his renowned work *Ferns of Malay* (1954). Later, Dyer and his team worked on soil spore banks and its implications for gametophyte establishment (Lindsay and Dyer, 1990). They also studied the soil spore bank in temperate zones (Dyer and Lindsay, 1992) and proposed the soil spore banks as a resource for conservation (Dyer and Lindsay, 1996). Similarly, the phenology of gametophyte development (Lindsay and Dyer, 1996) was also studied by the team. Page along with Dyer worked on the conservation approaches of pteridophytes (Page *et al.*, 1992) as well reviewed the ecological aspects of fern evolution (Page, 2002).

The fern ecology was out-shooted between 2000 and 2010 (Mehltreter, 2014) and different aspects of ecological traits were analysed during this period. Epiphytic forms are very common among pteridophytes. But all epiphytes do not grow in all hosts and there is a selectivity of the host plants. The epiphytic host preference is a result of species-specific interactions between the epiphyte and the host. Host characters are important in the establishment of epiphytes on it. The major characteristics of hosts which influence the epiphytic community are the water holding capacity and architecture of bark (Callaway *et al.*, 2002). The habitat ecological studies of the genus *Trichomanes* showed that dwarfism of the plant increases when hygrophilous condition increases (Dubuisson *et al.*, 2003). Endemicity in pteridophytes is lower as compared to seed plants. It may be due to high dispersibility. The study of diversity and distribution of ferns in Sub-Saharan Africa, Madagascar and some islands of South Atlantic show this high dispersal ability of fern spores (Aldasoro *et al.*, 2004). Elevational patterns of diversity of pteridophytes shows that mid-elevations offer highest richness because of the highest humidity and moderate temperature. Towards both ends, highest and lowest altitudes, the richness decreases because of the limiting patterns (Kluge and Kessler, 2006). The fern species richness follows a latitudinal gradient and high richness in tropics, and the high endemism is observed in high elevations. Likewise, different continents contain more similar fern communities due to the ability of spores to

disperse in a long distance (Kessler, 2010). Sharpe and Mehltreter (2010) observed that the documentation of phenological features of ferns can give a better understanding of population structure, seasonal pattern and biomass turn over in a particular habitat. Ferns take part in many ecosystem services, like nutrient cycling in an ecosystem (Richardson and Walker, 2010) and restoration of a destructed ecosystem (Walker and Sharpe, 2010).

Apart from the moist environments, many ferns are adapted to xeric environments by developing particular drought tolerance mechanisms like in higher plants (Hietz, 2010). Diversification of pteridophytes and the rise of most extant fern lineages occurred in the Cretaceous period. The wetter Angiospermic forests promote the diversification of ferns, especially the epiphytic forms (Watkins Jr. and Cardelús, 2012). The fern composition in interior forest and forest edges are drastically different. So, it can be used as an indicator of the restoration efforts along the habitat quality along the forest edges (Silva *et al.*, 2018). The analysis of functional diversity, pointed out that the maximum functional diversity in intermediate elevations and habitat degradation inversely affect the species richness of fern flora (Carvajal *et al.*, 2018). The interesting stories of the fern-insect and fern-fungi interactions were discussed by Mehltreter (2010 & 2022).

In India, Manickam and Ninan (1984) studied the ecological aspects of ferns of Palani Hills of Western Ghats. Chandra *et al.* (2008) summarises the threatened status of Indian pteridophytes, and concluded 414 species of pteridophytes as threatened. Fraser-Jenkins (2008) analysed the endemics and pseudo-endemics in Indian pteridophytes based on their distribution pattern. He stated that in India only 47 endemics are present. Chowdhary *et al.*, (2016) studied the diversity, utilisation and ecological characteristics of pteridophytes in tea gardens of West Bengal, and recorded 44 species belonging to 17 families. The distribution pattern of pteridophytes along elevation, geographical area, annual temperature, rainfall, soil moisture, soil pH in Himachal Pradesh was analysed and showed that the species richness is negatively correlated with annual temperature (Kumari *et al.*, 2018). Similarly, the species richness of ferns along the altitudinal gradient in Kolli Hills

showed the characteristic hump-shaped curve (Sureshkumar *et al.*, 2020). The fern diversity assessment of Rajamala of Eravikulam National Park (Arjun *et al.*, 2021) and epiphytic pteridophyte flora of Darjeeling region (Rai *et al.*, 2022) were also reported. Thulasi *et al.* (2022) studied the distribution of pteridophytes along the altitudinal gradient of Palghat Gap influenced area. The effect of ecological variations in the chemical constituents of three species of *Asplenium* from Iraq was studied by Ismail *et al.* (2022). Banik *et al.* (2023) focused on the habitat distributional mapping of threatened species *Gymnosphaera gigantea* for its conservation and re-introduction in suitable areas. Bagathsingh and Benniamin (2023) studied the relation between elevation and richness in Biligiri Rangaswamy Temple Tiger Reserve, Karnataka and concluded the relation was in unimodal pattern.

II.6. Geo-spatial studies on Pteridophytes

The geo-spatial studies of organisms are used to study different aspects of their distribution and other characters. Schafer (2001) studied the distribution of pteridophytes of Faial Islands. Price *et al.* (2007) mapped the plant species in Hawaiian Islands. In India many GIS based studies on the increasing threat of forest fires in different areas were conducted (Krishnan and Reddy, 2012; Saranya *et al.*, 2014; Manaswini and Reddy, 2015; Satish and Reddy, 2015). These kinds of studies mainly focused on the influence of fire on species adaptability, ecological damage assessment and planning for forest fire management for effective conservation of resources. Geri *et al.* (2013) using the herbarium data, mapped patterns of fern species richness, and concluded that the distance to water bodies was the only significant topographical variable which controls the species diversity. Qayum *et al.* (2014), mapped the antimalarial plants used in traditional knowledge systems for their spatial analysis. Biswas *et al.* (2017) developed a web GIS based mapping and identification of medicinal plants in Agra. The GIS studies on pteridophytes are very low, compared to other groups. Edwin-Wosu *et al.* (2022) studied the richness and diversity of cryptogamic flora in different habitats and distribution rate in the area through GIS tools. Takeshige *et al.* (2022) analysed the fern thickets and vine-laden

forests in degraded forest areas for studying the recovery of lost vegetation in the landscape of Bornean Logged-over tropical secondary rainforests.

II.7. Molecular studies in Pteridophytes

The recent advances in molecular biology are now used to solve the phylogenetic problems of many plant groups, including pteridophytes. The molecular phylogeny analysis of various groups of pteridophytes were studied by Professor Kathleen M. Pryer and her team from the mid-90's onwards. They proposed the phylogenetic classification of pteridophytes by forming a group, the Pteridophyte Phylogeny Group (PPG I). First cladistics analysis of extant ferns based on both morphological as well as *rbcL* sequences was carried out by Pryer *et al.* (1995). Phylogenetic tree based on *rbcL* sequence analysis concluded that; Polypodiaceae, Grammitidaceae and Pleurosoriopsis are monophyletic, *Davallia* is related to Polypodiaceae, *Tectaria* is closer to Oleandraceae than Dryopteridaceae, Dryopteridaceae are polyphyletic, heterosporous water ferns forms a monophyletic group which may emerged much before tree ferns. The *rbcL* sequence analysis revealed two monophyletic groups of Hymenophyllaceae (Pryer *et al.*, 2001). Also, the origin of the genus *Trichomanes* was analyzed by using *rbcL* data by Dubuisson *et al.* (2003). The whole genome studies suggested *Chara* as the ancestor of land plants (Pryer *et al.*, 2004). Using the *atpI* intron distribution pattern it was shown that the Leptosporangiate and Marattioid ferns are monophyletic. These groups together form a sister group to horse-tails (Wikstnöm and Pryer, 2005). By analyzing *rbcL* and *atpB* plastid genome sequences *Cystodium* was recommended to shift from Dicksoniaceae to Polypod clade (Korall *et al.*, 2006). Metzgar *et al.* (2007) showed divergence time of the fern genus *Azolla* using six plastid genes. In an elaborated study using the plastid genes - *rbcL*, *atpB* and *atpA*, Schuettpelez and Pryer (2007) elucidated the phylogeny of 400 leptosporangiate ferns. It was found that *atpA*, another plastid gene, provides support for relationships among ferns (Schuettpelez *et al.*, 2007). The paraphyly of *Osmunda* was confirmed by Metzgar *et al.* (2008) using seven plastid genes. Rothfels *et al.* (2008) blended morphological characters with molecular features to resolve the evolutionary convergence in xeric adaptations of ferns. Hennequin *et al.* (2008) used gene level studies (*rbcL* along

with *rsp4*) to analyse the divergence time and epiphytism in Hymenophyllaceae. It revealed that the ancestors of filmy ferns were terrestrial and the epiphytism evolved during the Cretaceous period along with the emergence of Angiosperms. Later Schuettpelz *et al.* (2008) suggested a new nuclear gene region to address the species level questions across ferns-the gap Cp-encoding a glyceraldehyde-3- phosphate dehydrogenase. Smith *et al.* (2008) presented a fern classification incorporating details of molecular data. The burst of fern diversification occurred in Cenozoic by the evolution of epiphytism to adapt to new situations offered by the appearance of angiosperms (Schuettpelz and Pryer, 2009). The molecular studies in plants to address the taxonomic puzzles is sometimes not very useful due to lack of a universal marker gene as in animals, like *cox 1*. In plants usually multiple genes were used for this. Another study showed developmental juvenilization in evolution of leaf form in Marsileaceae ferns (Pryer and Hearn, 2009). Classification based on Morphological characters is in most cases are same as molecular classification. But sometimes due to the apomorphic characters, the morphological classification deviated from molecular classification in ferns (Schneider *et al.*, 2009). Molecular analysis was used to demonstrate the evolution of tree habit in ferns. It was said that deceleration in molecular evolution results in long lived ferns which culminated in the tree ferns (Korall *et al.*, 2010). The DNA barcoding of ferns was used to correct the ambiguity in identification of horticultural ferns; as in the case of two Cheilantheid ferns, *Cheilanthes distans* but was marketed as *Cheilanthes wrightii* (Pryer *et al.*, 2010).

The plastome analysis of ferns revealed a series of inversions, which resulted in branches in fern phylogeny and also underwent frequent RNA editing which is rare in seed plants. It was predicted that the plastome of ferns are evolving faster than seed plants (Wolf *et al.*, 2011). Plastid phylogeny suggested that asexuality in ferns limits evolutionary potential to some extent (Beck *et al.*, 2011). Li *et al.* (2011) evaluated different plastid genes for their feasibility as DNA barcodes. They suggested *matK* sequence data for universal primer development, and *rbcL* and *matK* as two efficient barcode regions for fern identification.

Molecular phylogenetic studies of cheilantheid ferns using four DNA

regions such as *matK*, *rbcL*, *trnG-R* and *gapCp* resulted in creation of a new genus *Gaga* (Li *et al.*, 2012). Along with molecular data, spore morphological studies also supported the segregation of this new genus. Molecular analysis based on plastid genes - *matK*, *rbcL* and *trnG-R*, also resulted in separation of Cystopteridaceae from Woodsiaceae (Rothfels *et al.*, 2013).

Usually, ferns are identified on the basis of characteristics of sporophytes. In the absence of a sporophytic phase it may be difficult to identify even at the family level. Leon *et al.* (2013) used DNA sequence data of *rbcL* and *trnG-R* along with morphological characters to identify a cryptic fern population of *Pityrogramma trifoliata* in Western Andes of Peru. Rothfels *et al.* (2013) used transcriptome data for designing primers for molecular phylogenetic studies. Kim *et al.* (2014) studied the evolution of the chloroplast genome in early diverged leptosporangiate ferns. Apart from molecular phylogenetic studies, biogeographic analysis using plastid genes of scaly tree ferns in Galapagos and Cocos islands tried to trace the origin of endemic tree ferns in these islands (Kao *et al.*, 2015). Li *et al.* (2014) demonstrated the origin of phototropins in vascular plants from liverworts and hornworts by horizontal gene transfer and duplication events. Rothfels *et al.* (2015) inferred fern evolutionary history from low-copy number genes. Deep hybridisation between two genera was also unveiled using the molecular approach (Rothfels *et al.*, 2015). Wolf *et al.* (2015) made some preliminary attempts to solve the mystery of genome space in ferns and revealed that several genome regions are consistent across ferns; some regions appear to be similar to phanerogams. Many morphotypes, cytotypes and flavonoid chemotypes are present in the genus *Pentagramma*. Schuettpelz *et al.* (2015) used phylogenetic analysis along with spore characteristics for delimitation of this genus and proposed a new species as *P. glanduloviscida*.

Homosporous ferns are considered as the extreme inbreeders. But the genetic analysis by Haufler *et al.* (2016) showed that they are regularly outcrossed, and possess many physiological and genetic mechanisms for outcrossing. A fast resolution using PacBio single molecule sequencing of hybrid polyploid complexes was developed by Rothfels *et al.* (2016). For recently diverged species, single locus

sequence-based DNA barcoding is inefficient for identification. So, Liu *et al.* (2017) proved that multi-locus data can be used for such recently originated species identification. A phylogenetic analysis using four plastid markers of the genus *Adiantum* showed convergent evolution in architecture of leaf blade (Huiet *et al.*, 2018). Studies on the whole genome of *Azolla filiculoides* and *Salvinia cucullata* provided deep insights on the land plant evolution as well as cyanobacteria symbiosis (Li *et al.*, 2018). The whole chloroplast genome of *Dryopteris fragrans* was sequenced by Gao *et al.* (2018). Evolution of farina in notholaenoid ferns was confirmed by low-copy number nuclear sequences (Kao *et al.*, 2019). George *et al.* (2019) using plastid markers segregated a new genus, as *Baja* from *Cheilanthes*. Kao *et al.* (2020) studied the infraspecific diversification of *Notholaena standleyi*, using a combined approach based on plastid as well as nuclear markers, ploidy and chemical composition. Fauskee *et al.* (2021) commented that the RNA editing studies were also found promising in analysing the rate of evolution of fern plastomes. Fan *et al.* (2021) analysed the chloroplast genome of three ferns for identifying the species. Then the whole chloroplast genome of *Sphaeropteris lepifera* (Hu *et al.*, 2023) and *Christella dentata* (Xu *et al.*, 2023) were sequenced and analysed. Some recent analyses proposed major changes in classical taxa; splitting into many. Zhou and Zhang (2023) divided the Selaginellaceae into 7 sub-families and 19 genera based on molecular, morphological and geographical features. Similarly, for Ophioglossaceae several attempts were made to divide into several genera, such as Nishida (1952) - 8 genera, Sun *et al.* (2001) added *Mankyua*, PPG I (2016) 10 genera and Zhang *et al.* (2020) 10 genera with a new phylogenetic tree.

The molecular studies of pteridophytes in India is in its nascent stage. Fraser-Jenkins (2009) but has different views on the use of molecular data for pteridophyte taxonomy. The molecular analysis of many taxa gave surprising results, mostly controversial, in the pteridophytes classification. It may be due to the low sampling while considering the extent of diversity and evolutionary history of this group. So, it is necessary to combine both classical as well as molecular taxonomy for the classification in pteridophytes (Fraser-Jenkins, 2009). The presentation as the

smallest terrestrial pteridophyte *Ophioglossum malviae* from Gujarat, India (Patel and Reddy, 2018) is noteworthy as in integrating morphological SEM of spores and molecular characters. They used 3 chloroplast DNA (cpDNA) regions - *trnL-F*, *rbcL* and *psbA-trnH* - to distinguish the species. Later some other species from India were also described following the morpho-molecular approach. Goswami *et al.* (2020) described a new species, *Ophioglossum chaloneri* from Jharkhand based on morphological, palynological, cytological and molecular details. Mohanta *et al.* (2020) studied the relationship between gene loss in the plastome and its evolution. They concluded that the chloroplast genes were lost from algae to angiosperms. The report of *Ophioglossum trilokinathii* by Yadav *et al.* (2021) from Rajasthan was also based on the molecular analyses. By using the morphological and *rbcL* analysis Patil *et al.* (2021) confirmed the occurrence of *Christensenia aesculifolia* in the North-Eastern states of India. Marimuthu *et al.* (2022) in their book summarised different aspects of fern research, such as biotechnology, propagation, medicinal uses and environmental regulations of ferns. In which, Janakiraman *et al.* (2022) reviewed the status of molecular phylogeny of pteridophytes; Kumar *et al.* (2022) reviewed the importance of plastogenomic studies in ferns; Morajkar *et al.* (2022) reviewed the molecular markers in pteridophytes; and Youngstrom *et al.* (2022) discussed about the *WOX* gene family in ferns by using the model species as *Ceratopteris richardii* under the biotechnology section. Narayani *et al.* (2024) reported the molecular taxonomic studies of south Indian *Selaginella* based on *rbcL* gene region. Darshetkar *et al.* (2024) reported the whole chloroplast genome of *Tectaria coadunata*, the first of its kind from India.

II.8. Palghat Gap

According to the geological time scale, now the Earth is in the Meghalayan age, a recent addition to the geological time scale (Walker *et al.*, 2018). Palghat Gap, an ancient prominent discontinuity in the continuous stretch of the Western Ghats, is a result of a geological evolutionary process. Different concepts exist on the origin of Palghat Gap. It is estimated that it was formed around 500 Ma ago (Soman *et al.*, 1990). The most accepted one is; Palghat Gap is a remnant plateau

landform representing plantation surface of the Jurassic age. The data from LANDSAT imagery evidenced there was an easterly flowing paleo stream, Proto-Amaravathi, which dried up in post-Mio-Pliocene times due to changes in climatic patterns. The North-South stretching of the Western Ghats and the continental crust elevation related to Deccan trap volcanism are believed to be the reasons for the formation of Palghat Gap (Subramanian and Muraleedharan, 1985). All the population divergences are believed to have occurred in the Pleistocene due to the climatic fluctuations experienced in that age (Sukumar *et al.*, 1993). The rocks of the Gap are characterised by three groups of folds formed during two deformations. Shear indicators suggest ductile dextral shearing. And at the same time the kinematic analysis of structural elements supports shearing in a North-South compressional field. Based on microscopic as well as mesoscopic analysis, Palghat Gap is treated as a ductile shear zone. The present gap topography is the product of shearing and erosion (D'Cruz *et al.*, 2000). Further geological studies pointed that the Peninsular India in its ancient period was a part of Madagascar, and later separated from it. It can be evidenced by comparing the lithological structure of the Western Ghats and Eastern part of Madagascar. The Ranotsara Gap in Madagascar is believed to be the continuation of Palghat Gap in southern Western Ghats (Gunnell and David, 2008).

Because of its wideness some have assumed its strong influence in the species divergence as a barrier in allopatric speciation. Entomological studies by Ambrose and Livingstone (1978, 1979 and 1984) in the scrub jungles of Palghat Gap pointed out peculiar behavioural patterns in the members of Reduviidae in this area, as adaptive modifications to live in such an ecological condition.

Based on mtDNA studies, it is assumed that the populations of Asian elephants on either side of the Palghat Gap are two distinct haplotypes (Vidya *et al.*, 2005). It is also assumed that the Palghat Gap acted as a barrier in the gene flow of some birds like white-bellied shortwing (Robin *et al.*, 2010), animals, such as lion-tailed macaque (Ram *et al.*, 2015), and some fish species (Sidharthan *et al.*, 2020).

Robin *et al.* (2010) showed that divergence of *Brachypterynx major*, an endemic bird species of the Western Ghats, as due to the effect of Palghat Gap and paleo- climatic conditions in the Western Ghats. Radhakrishna *et al.* (2014) commented that the distribution of populations of Grey Slender Loris, *Loris lydekkerinus*, in the Western Ghats as defined by the gaps; one south of Ariankavu pass, second between Ariankavu pass and Palghat Gap and third north to the Palghat Gap. Gopalan *et al.* (2014) also distinguished two haplotypes of Wayanad bush frog, *Pseudophilautus wynadensis*, as demarcated by the Palghat Gap. Vijayakumar *et al.* (2016) also commented on the influence of the Palghat Gap on the allopatric speciation of bush frogs, *Raorchestes* lineages, *Pseudophilautus* lineages, etc. Demarcation of subpopulations as influenced by the Gap is also suspected in Nilgiri Tahr (*Nilgiritragus hylocrius*), an endemic mammal of the Western Ghats (Joshi *et al.*, 2018).

Influence of the Gap in divergence is suspected for some plants also; such as *Eurya nitida* (Bahulikar *et al.*, 2004) and *Gaultheria fragrantissima* (Apte *et al.*, 2006). Nair *et al.* (2019) confirmed the occurrence of two distinct populations of *Kingiodendron pinnatum* on North and South of the Palghat Gap. However, no such difference was found in the case of *Syzygium travancoricum* (Ray *et al.*, 2018).

Gap influenced distribution pattern is evident in the case of some animals and angiospermic plants. However, no such studies were found for lycophytes and ferns. So here in this current study we are trying to analyse the influence of the Palghat gap on the distribution of lycophytes and ferns using taxonomic, ecological and molecular parameters.

III. MATERIALS AND METHODS

III.1. Study Area

The present investigation on the diversity of ferns and lycophytes has been concentrated in the Palghat Gap region of southern Western Ghats along with the Gap influenced areas - from North, the Nilgiris to South the Anamalai and Palni Hills (Fig. 3.1). The study area extends to the states of Kerala and Tamil Nadu and include protected forest areas of Karimpuzha Wildlife Sanctuary (WLS), Peechi-Vazhani WLS, Chimmony WLS, Silent Valley National Park (NP), Pambadum Shola NP, Parambikulam Tiger Reserve in Kerala and Kodaikanal WLS, Mukurthi NP, Anamalai Tiger Reserve in Tamil Nadu. The study area covers different altitudinal ranges from near sea level to hill ranges with about 2500 m height. Due to this altitudinal gradation, documentation could be done with a variety of habitats and vegetation types within the Gap influenced area.

III.1.1. Topography

The altitude of the Gap region is almost 100 m above sea level and it forms a corridor-like passage by breaking the continuity of the Western Ghats. The topographic features like mountains and valleys of the Gap influenced area come under different subunits (Nair, 1991), such as the Nilgiris (up to 2637 m), the Palghat Hills (up to 1664 m), the Nelliampathies (up to 1572 m), the Anamalais (up to 2695 m) and the High Ranges (above 600 m).

The Nilgiris, a high steep plateau, is the northern border of the study area. It extends up to Bhavani basin in South and the southern edge of Nilgiris meets the Attappady plateau. Silent Valley NP and Attappady forests are the extreme southwest corner and these are the major catchment areas of river Chaliyar. Most of the parts of Nilgiris come under Tamil Nadu and only South-West regions and western slopes are in Kerala.

Near to the Nilgiris is the Palghat Hills and this forms the northern margin of the Palghat Gap. It starts from the Walayar-Madukkarai region as steep edges in the South. Towards North it forms a chain of ridges as the Palamala- Elival - Muthikulam Hills, and it continues with Attappady Plateau up to the base of the Nilgiris. North-Eastern edge of Palghat Hills is at the Varadimala-Bolampatti Hills.

The Nelliampathy and the Anamalai hills border the South of Palghat Gap. Nelliampathy hills starts from South of Palghat Gap and extends to the Parambikulam Tiger Reserve. Western region of Nelliampathy hills descends and merges with mid-lands of Thrissur. North-Western edge extends up to Bharathapuzha through the spur hills of Pattikkad, Vadakkanchery and Vazhani. Anamalais starts from the eastern border of Parambikulam which is near the south-eastern edge of the Palghat Gap. Anamalais extends south-east and merges with the High Range Hills and the north-eastern region merges with lower and upper Palani, Kodaikanal Hills of Tamil Nadu.

III.1.2. River and Drainage system

Silent Valley and Attappady forests are the major contributors of Chaliyar River. Bhavani and its tributaries originate from Siruvani, Silent Valley and Attappady plateau. The Attapadi Hills, western part of Palghat Hills (Silent Valley National Park), is the drainage of major tributaries of Bharathapuzha including Kunthi River, Nellipuzha and Kanjirapuzha. Other major tributaries of Bharathapuzha - Gayathripuzha originated from Anamalai hills and Kalpathippuzha from the Chenthamarakkulam of the North Walayar Hills. Bolampatty hill, located east of Palghat Gap is the catchment area of Noyyal River. Water from Nelliampathy Hills flows through Puzhakal and Karuvannur river systems to the Arabian Sea. Chalakudy river originates from Parambikulam basin and flows towards south-west. Palni hills and Anamalais are drained through Amaravathi River to Bay of Bengal. Anamalais and High Range Hills get drained through river Periyar (Nair, 1991).

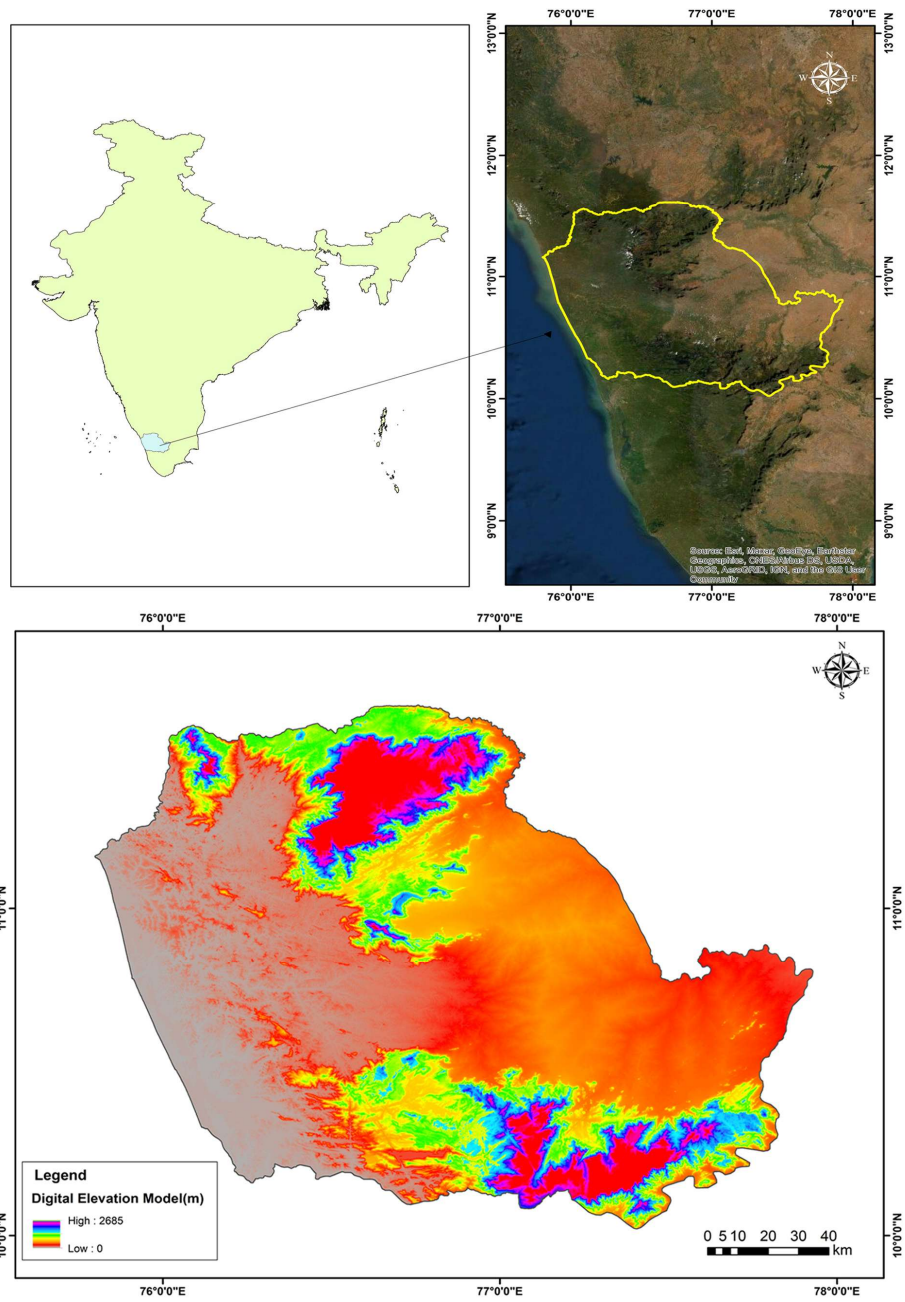


Fig.3.1. Palghat Gap and Gap influenced areas explored during the current study

III.1.3. Soil and Climate

The major soil types in the study area are; alluvial soil, laterite soil, hill soil, black soil and forest soil. It receives south-west monsoon during the months of June to September and the north-east monsoon from October to early December. The months from December to February are the winter season and March to May is the summer season.

III.1.4. Forest types

The Palghat Gap region is remarkable with a variety of vegetation types, climatic zones and endemism. Major forest types found in the study area are Southern Tropical Wet-Evergreen Forest, Southern Tropical Semi-Evergreen Forest, South Indian Moist Deciduous Forest, Tropical dry deciduous forest, tropical thorny forest, tropical riparian evergreen forest and Montane Subtropical Forests. This diversity in forest types reflects the diversified distribution of flora in the Gap influenced region of the southern Western Ghats.

Forest divisions coming under the study area are; Nilambur South division of Malappuram district and the Karimpuzha Wildlife Sanctuary falls under this division. Three forest divisions of Palakkad district; Mannarkkad, Palakkad and Nemmara divisions. Northern part of Gap - influenced regions is within the Mannarkkad division, comprising three ranges, such as Agali, Attappadi and Mannarkkad. The most renowned National Park - Silent Valley - is under Attappadi range of Mannarkkad division. And the Nilambur South Division. The gap regions occupied under Palakkad division, is divided into Olavakkode, Ottappalam and Walayar ranges. Southern parts of the gap-influenced areas are included in Nemmara division, with three ranges - Alathur, Kollengode and Nelliampathy. Parambikulam Tiger Reserve comes under this division. As lies in the vicinity of the Palghat Gap, the forest divisions of Thrissur district - Thrissur, Chalakudy and Vazhachal as well as Munnar division of Idukki district were also explored for the present study (Plate 3.1 - 3.9).

III.2. Methodology adopted - Taxonomic studies

The current research was carried out to evaluate the influence of Palghat Gap on distribution of pteridophytes. Extensive field studies were conducted within the Gap and southern as well as northern regions of the Gap during 2018-2022. Sufficient samples were collected along with photo documentation. Identification of each collected specimen was done following the standard methods. Taxonomic accounts of each taxon, along with up-to-date nomenclature were also prepared. The herbarium voucher specimens were prepared and deposited in the herbarium of the Zamorin's Guruvayurappan College (ZGC).

III.2.1. Exploration and Collection of samples

Survey and collection of lycophytes and ferns in all possible regions of the study area were conducted between 2018 and 2023. During the survey, the details of habitat, habit, associated species, interaction if any and other ecological data were recorded for each species located. The distributional patterns including latitude, longitude and altitude were noted in the field itself using GPS status android app. Three to six specimens in its reproductive stage were collected for further observations in the laboratory and for herbarium. Throughout the field study, the specimens were collected as whole plants along with rhizomes. In case of large plants, a part of frond along with some parts of rhizome were collected. The actual size and those characters that may be lost during the processing were noted in the field-book for further studies.

III.2.2. Photo Documentation

Photographs of each specimen were taken in its natural habitat using a Nikon D3200 camera. Detailed photographs of rhizome, frond, rachis, etc. were also taken after bringing the specimens to the laboratory. Micromorphological observations were made under Olympus Zoom Stereo microscope and Leica compound microscope. Photomicrographs were taken using the Magnus camera attached to the microscope.

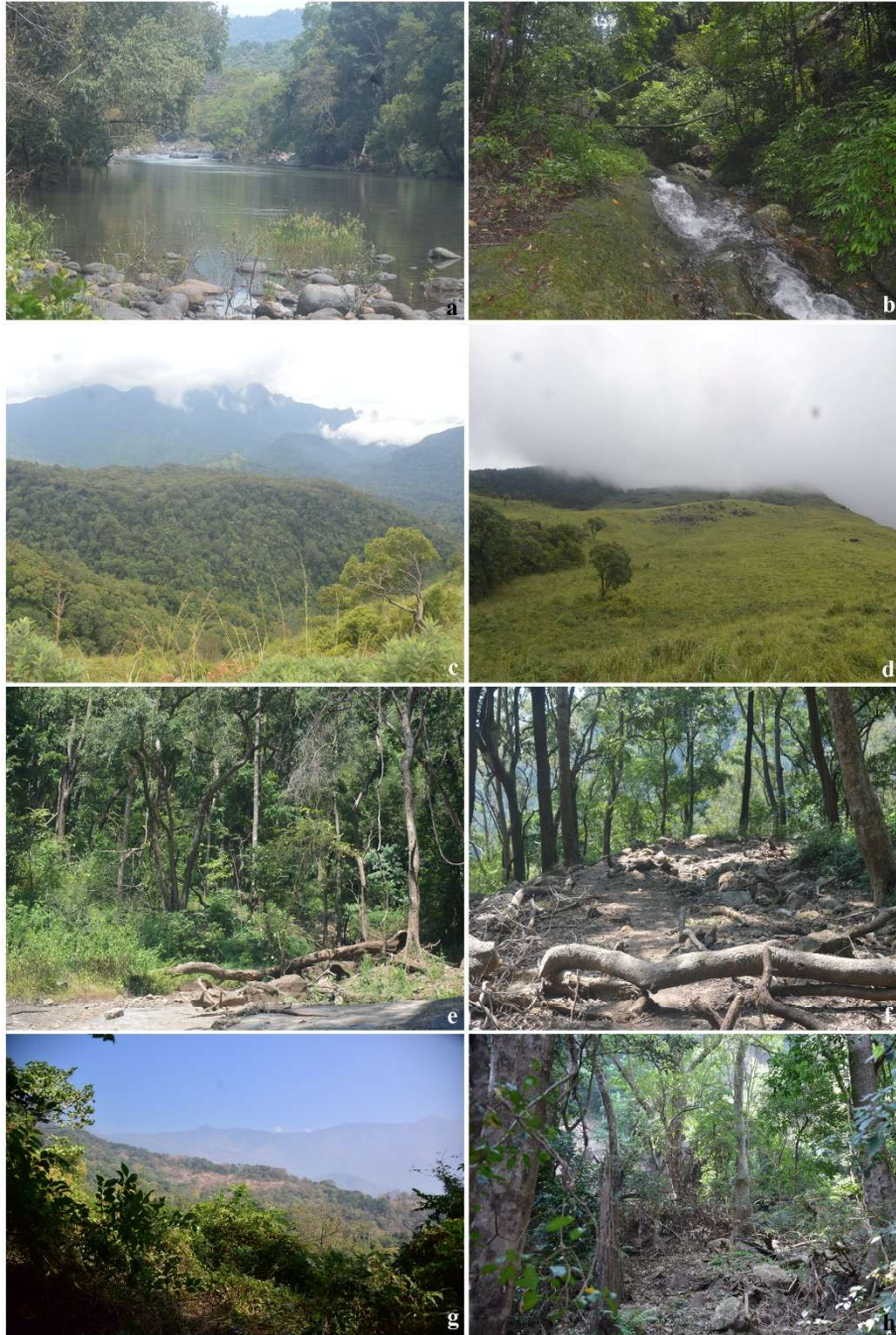


Plate 3.1: a. Riparian vegetation in Bhavani range; b-c. Evergreen vegetation in Bhavani range; d. Grassland in Bhavani range; e. Semi-evergreen vegetation in Dhoni; f-h. Moist deciduous vegetation in Dhoni

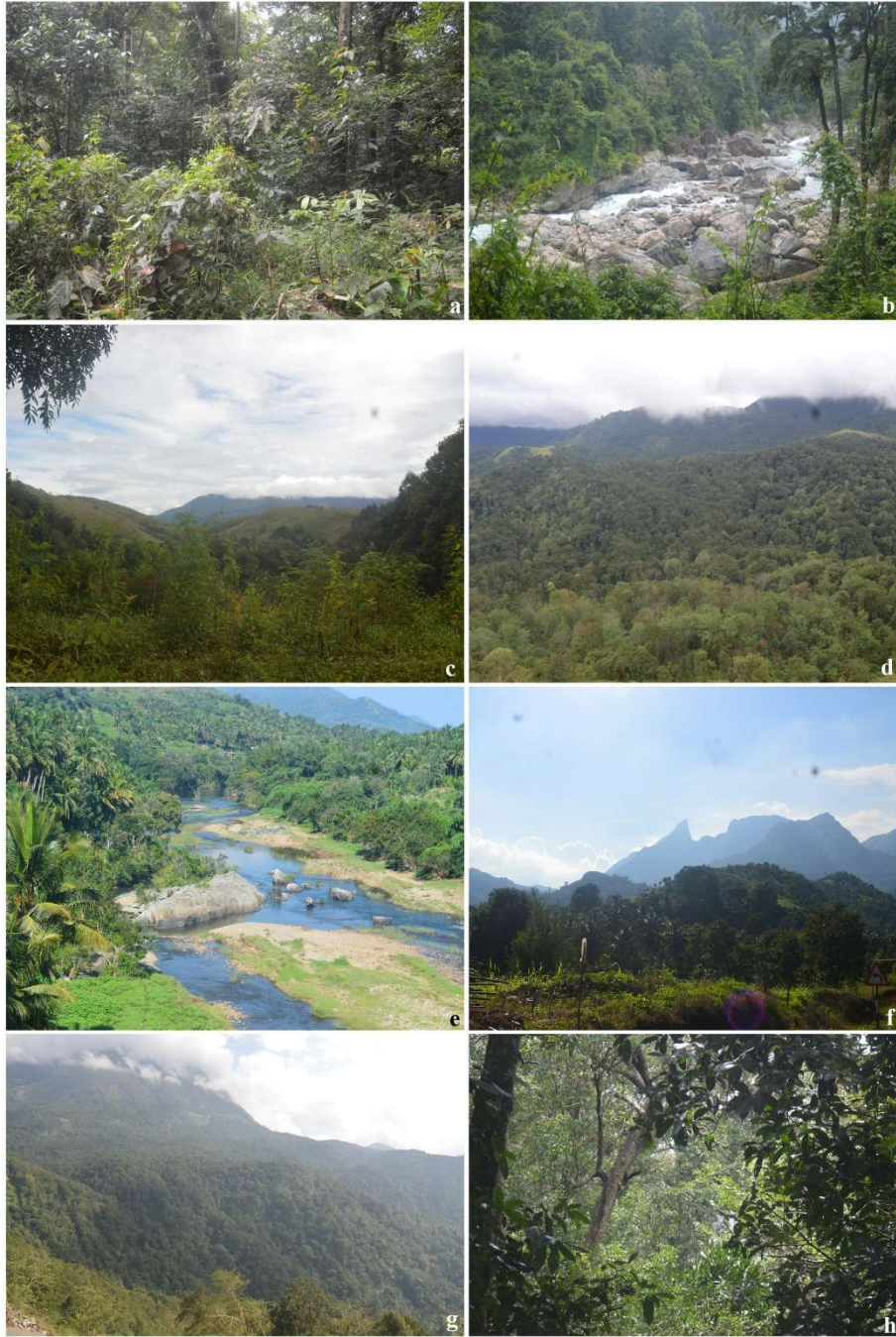


Plate 3.2: a-b. Semi-evergreen vegetation in Karimbuzha Wildlife Sanctuary; c. Grassland in Ommala, Agali; d. Semi-evergreen in Ommala, Agali; e. Vegetation along Bhavani river side in Attappadi; f. Dry vegetation in Attappadi; g-h. Evergreen vegetation in Siruvani, Mannarkkad.



Plate 3.3: a. Riparian vegetation along Kunthi River in Silent Valley National Park; b. Shola evergreen vegetation in Poochippara, Silent Valley National Park; c. Evergreen vegetation Silent Valley National Park



Plate 3.4: a. Shola and Montane grassland vegetation at Sispara of Silent Valley National Park ; b. Grassland vegetation of Silent Valley National Park; c-d. Grassland vegetation of Anginda of Silent Valley National Park.

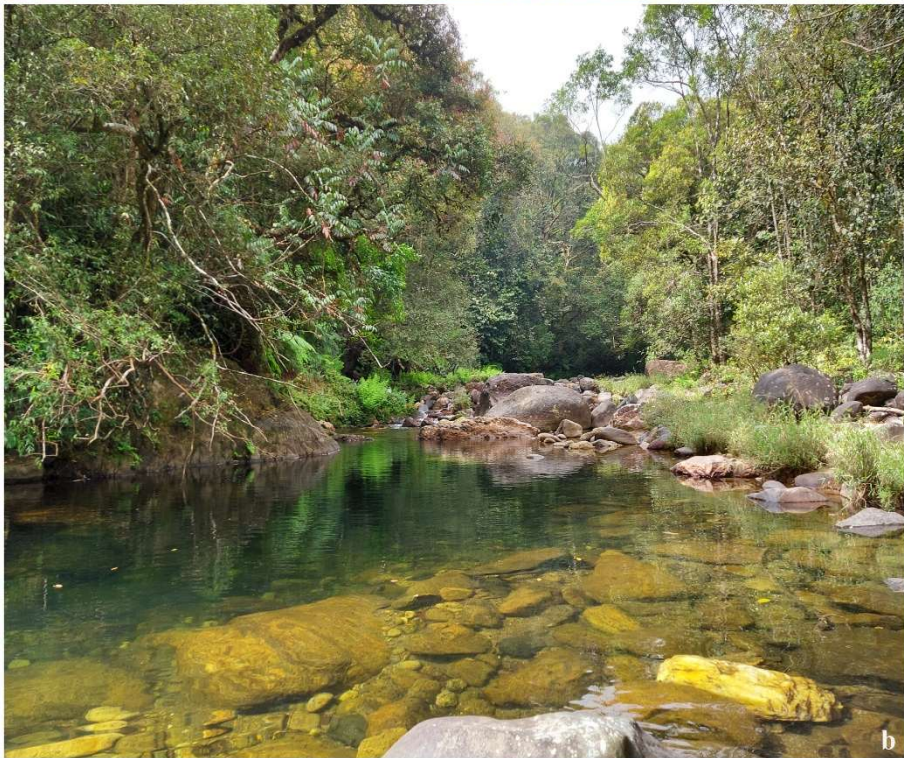


Plate 3.5: a. Evergreen vegetation in Silent Valley National Park; b. Riparian vegetation of Walakkad, Silent Valley National Park



Plate 3.6: a. Hillock vegetation in Walayar; b-d. Dry deciduous vegetation in Walayar region; e. Deciduous vegetation in Walayar; f. Riparian vegetation in Walayar region; g. Southern border of Palghat Gap from the foothills of Nelliampathi; h. Northern border of Palghat Gap from Walayar region.

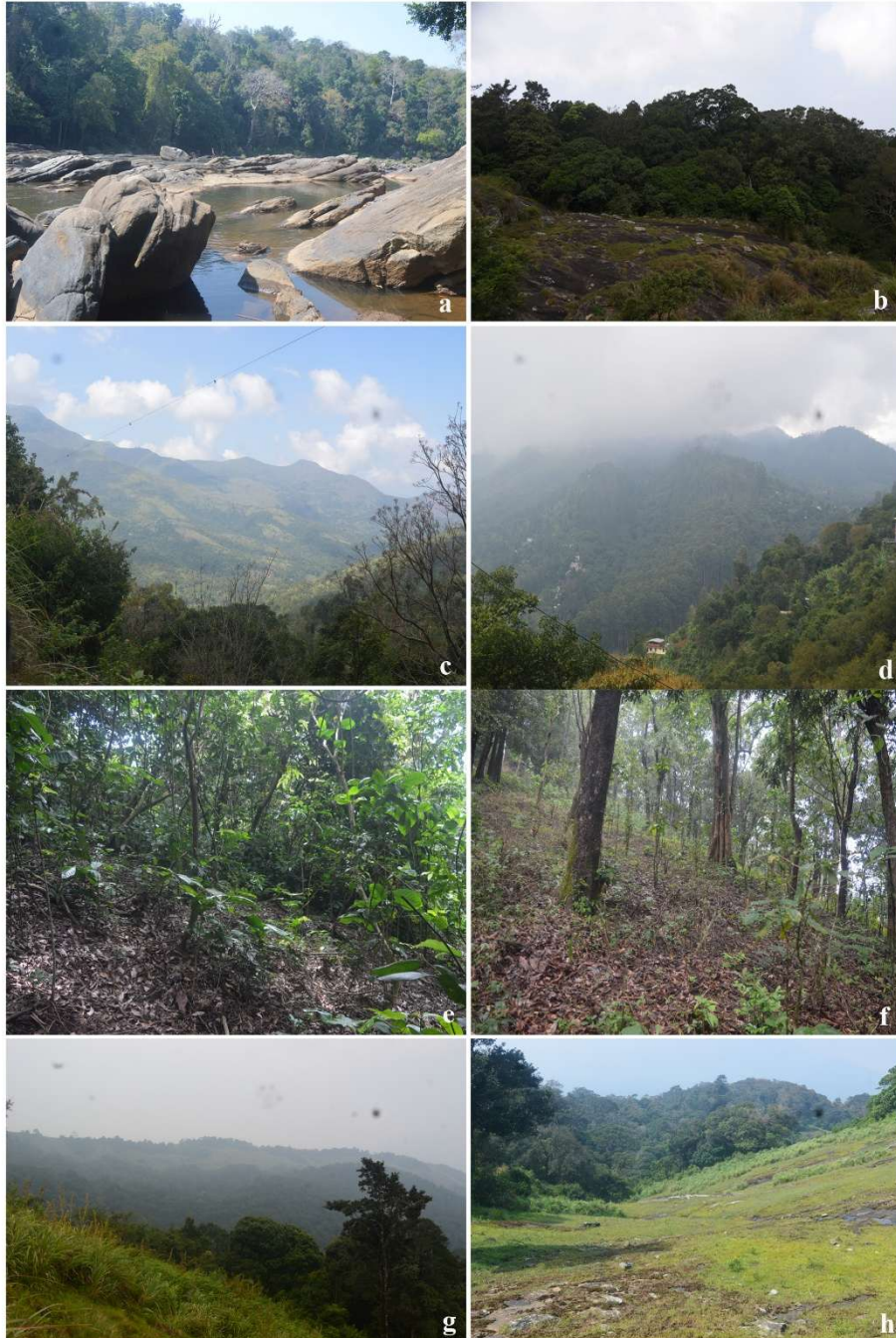


Plate 3.7: a. Riparian vegetation along Chalakkudi river, Athirappilly; b. Evergreen vegetation of Manpara, Nelliampathy; c-d. Vegetation of upper Palni hills, Kodaikanal; e-f. Moist Deciduous vegetation of Cheriya-govindamala, Nelliampathy; g. Grassland and shola vegetation in Cheriya-govindamala, Nelliampathy; h. Grassland vegetation of Maattumala, Nelliampathy.



Plate 3.8: a-b. Vegetation in Peechi Wildlife Sanctuary; c-d. Evergreen vegetation of Pambadum shola National park; e. Grassland and Shola vegetation of Pambadum shola National park.



Plate 3.9: a-b. Grassland and shola vegetation of Mathikettan Shola National Park; c-d. Tea plantations and associated vegetation of Munnar hills.

III.2.3. Preparation of Herbarium

The specimens were processed following standard herbarium preparation protocol (Bridson and Forman, 1994). After the collection trip, the collected plant specimens were brought to the laboratory and pressed in between blotters without folding. In case of larger specimens it was folded like ‘V’, ‘N’ or ‘W’ shapes, or otherwise cut into pieces and pressed separately by giving sub-numbers of collection number. These specimens kept between blotters were bound tightly in between wooden herbarium presses. The blotters were changed regularly for proper drying of specimens. The properly dried specimens were pasted, labelled and deposited in the Zamorin’s Guruvayurappan College Herbarium (ZGC), Kozhikode, Kerala.

III.2.4. Identification of Specimens and Preparation of Taxonomic Account

All collected specimens were identified by using pertinent literature such as Manickam and Irudayaraj (1992), Nayar and Geevarghese (1993), Nampy and Madhusoodhanan (1998), Hameed *et al.* (2003), Nisha (2008), Sreenivas (2011), Sreenivas *et al.* (2013), Azeez (2007); Azeez *et al.* (2008) and Fraser-Jenkins *et al.* (2017, 2018 and 2021). The fresh materials were examined in all possible situations, otherwise dried samples were used for analysis. The external characters were studied using stereo microscopes (Olympus SZ). Internal features were analysed using compound microscopes (Olympus CX21iLED and Leica). Taxonomic accounts of the species were prepared including the details such as habit, features of rhizome, scales, fertile and sterile fronds and sori.

III.2.5. Herbarium consultation

Authentic specimens in various herbaria were also consulted for confirming the identity of specimens. The major herbaria such as St. Xavier’s College (XCH), Palayamkottai, Central National Herbarium (CAL), Howrah, Calicut University Herbarium (CALI), Botanical Survey of India, Southern Regional Centre (MH), Coimbatore and Kerala Forest Research Institute Herbarium (KFRI), Thrissur were visited. Digital Herbaria such as Royal Botanic Garden, Kew (K); The Natural History Museum, London (BM), Royal Botanic Garden, Edinburg (E), etc. were also consulted online.

Classification adopted

The Pteridophyte Phylogeny Group I (PPG I, 2016), classification system was followed in this study.

III.3. Population diversification analysis

For assessing the influence of Palghat Gap on the distribution of lycophytes and ferns, the micro-morphological features, spore ornamentation, as well as molecular analysis of populations of selected pteridophyte taxa were attempted.

The taxa were selected based on the morphological variations observed during field survey, its extent of distribution and the habitat they preferred. Based on these criteria, four taxa were selected, viz., *Angiopteris helferiana*, *A. crassipes*, *Mickelopteris cordata* and *Actiniopteris radiata* for population diversification analysis across the Palghat Gap.

III.4. Spore Morphological Analysis

Spore morphology of each population was studied by scanning electron microscopy (SEM). The spore samples, in all available conditions, were collected and after proper drying of spores, it was stored in 90% ethanol. Scanning Electron Microscopic analysis was done at the Sophisticated Test and Instrumentation Facility Centre of Cochin University of Science and Technology (CUSAT), Ernakulam, Kerala. The stored samples were taken in separate buttons, after gold coating the images were taken at 15 kV. The structure of spores was identified by referring to standard literature (Tryon and Lugardon, 1990).

III.5. Molecular Diversification Analysis

The molecular analysis was carried out for the selected pteridophyte taxa. The samples for molecular analysis were collected and stored in 4°C as well as in packets along with Silica Gel blue. Based on literature (Lehtonen *et al.*, 2020) and trial and error method, selected three gene regions - *rbcL*, *trnL-F* and *atpB* - for the analysis. Amplified each gene region of the collected materials of each population using respective forward and reverse primers (Table 3.1). The PCR products were sequenced based on Sanger's sequencing method. The resulting high-quality sequences were selected and carried out further molecular analysis.

III.5.1. Selection of Ambiguous taxa

Taxa which showed variable traits in external morphology were selected for molecular characterization to analyse the influence of Palghat Gap on the distribution of ferns and lycophytes. The ambiguous taxa were selected based on morphological variations and distribution parameters. Accordingly, four taxa were selected, viz., *Angiopteris helferiana*, *A. crassipes*, *Mickelopteris cordata* and *Actiniopteris radiata*. *Angiopteris* spp. showed some morphological variations and is distributed along the altitudinal ranges from about 400 to 2400 m. *Mickelopteris cordata* also showed morphological variations and distributed in almost all areas in the study area, from lower to higher altitudes. *Actiniopteris radiata*, which preferred xerophytic habitat and are distributed at 200-900 m altitudinal range. Samples of each ambiguous taxa were collected from both North as well as South of the Palghat Gap. DNA was extracted from each sample and the plastid genes - *trnL-F*, *rbcL* and *atpB* were sequenced.

III.5.2. DNA Isolation protocol

Total cellular DNA was isolated from silica-dried plant material using NucleoSpin[®] Plant II Kit (Macherey-Nagel). The quality of the DNA was confirmed by Agarose Gel electrophoresis.

Table 3.1: The primer sequences used for sequencing respective gene regions of each population.

Primer Name Primer	Primer Sequence 5' -> 3'	Length
<i>rbcL</i> -F	ATGTCACCACAAACAGAGACTAAAGC	26
<i>rbcL</i> -R	TCAGGACTCCACTTACTAGCTTCACG	26
<i>trnL-F</i> -F	GGCAGCCCCCARATTCAGGGRAACC	25
<i>trnL-F</i> -R	ATTTGAACTGGTGACACGAG	20
<i>ATPB672</i> -F	TTGATACGGGAGCYCCTCTWAGTGT	25
<i>ATPB1592</i> -R	TGTAACGYTGyAAAGTTTGCTTAA	24

III.5.3. PCR amplification

PCR was done in 20 µl reaction volume containing 1 µl DNA (10-50 ng), 1 µl each of Forward and Reverse primers (10 picomoles µl⁻¹) and 10 µl Emerald Amp GT PCR master mix (Takara). The cycling conditions used are as follows: initial denaturation at 94°C for 2 min, followed by 30 cycles of denaturation at 94°C for 30 seconds, annealing at 50°C/53°C/55°C/ 58°C for 40 seconds, extension at 72°C for 1.5 min and a final extension for 10 min at 72°C

III.5.4. Cleaning up of PCR product

ExoSAP-IT treatments were done for cleaning up of the PCR products. Five microliters of PCR product were mixed with 0.5µl of ExoSAP-IT and incubated at 37°C for 15 minutes followed by enzyme inactivation at 85°C for 5 minutes.

III.5.5. Sequencing using BigDye Terminator v3.1

Sequencing reaction was done in a PCR thermal cycler (GeneAmp PCR System 9700, Applied Biosystems) using the BigDye Terminator v3.1 Cycle sequencing Kit (Applied Biosystems, USA) following manufacturer's protocol.

III.5.6. Quality Analysis of Sequence

The sequence quality was checked using Sequence Scanner Software v1 (Applied Biosystems). Sequence alignment and required editing of the obtained sequences were carried out using Geneious Pro v5.1.

III.5.7. Sequence alignment and Phylogenetic analysis

- The available sequences of the 3 marker genes - *atpB*, *rbcL* and *trnL-F* - of the selected ambiguous taxa and outgroup taxa were downloaded from NCBI GenBank.
- The details of downloaded sequence data (species, accession number, geographical location and authors) were stored in an MS Excel file for future reference.

- Then, combined the sequence data of each gene with the available or downloaded sequence data of that particular gene region using Notepad++ software.
- After compilation, the combined data sets were aligned in MEGA X, for each gene separately. The noisy 3' and 5' ends were trimmed.
- After trimming the final data saved as NEXUS file format for further analysis.
- Then the aligned sequence data in different NEXUS files were combined into one file using Notepad++ software. After that the command in the beginning part of the combined file was changed by giving number of taxa in the command “DIMENSIONS NTAX= (No. of taxa)” and total sequence count in “NCHAR=(Total sequence count)”.
- Also removed the accession number of GenBank data and checked the order of taxa in each marker sequence data, whether the order of the sequence is same for each marker region. Then saved the combined NEXUS file.
- The combined NEXUS file then opened in MrBayes software. Run the data using suitable commands

The resulted tree was saved as; ‘File name’.nex.con.tre

- The .tre file was opened in FigTree software. The node values in Bayesian tree represents the probability percentage. And saved the resulted tree as .JPEG or .PNG file format.

III.6. Geospatial Mapping and NDVI analysis

Distribution mapping of lycophytes and ferns were carried out using ArcGIS 10.2 software. The geographical coordinates of each collected species were recorded during field exploration. For distribution mapping, study area maps were prepared using Google Earth pro. After which, the coordinates of each species were mapped in the outline map of the study area. The Digital Elevation Model of the study area

was generated using the DEM image data downloaded from USGS Earth explorer (Earth Explorer (usgs.gov)) and maps of the study area in different aspects such as contour map, slope map, aspect map and hydrology map using ArcGIS 10.2 software were generated.

The comparison of vegetation change for the last 10 years (2011 to 2021) was analysed using the land use land cover and Normalised Difference Vegetation Index (NDVI) maps of the two time periods, 2011 and 2021. Similarly, the narrowly distributed or endemic taxa and IUCN red listed taxa were mapped based on their altitudinal distribution in the study area.

III.7. Ecological studies

The ecological analysis of lycophytes and ferns of the study area were done using Sorensen's Similarity Index (SI) (Sorensen, 1948) and the diversity index-Taxonomic distinctness (Δ^*) (Clarke and Warwick, 1999). Taxonomic singularity of each forest zone was also analyzed based on generic distribution in different forest types. Along with this, statistical analysis and Ecological Niche Modelling (ENM) were also conducted to predict the distribution of ferns and lycophytes in the current study area.

III.7.1. Sorensen's Similarity Index (SI)

Sorensen's Similarity Index (SI) was calculated for comparing and analysing the similarity between the communities across the Palghat Gap region. Here similarity of distribution of ferns and lycophytes in different localities along the Palghat Gap as well as along altitudinal gradients were analysed using SI. This is calculated based on species number and using the following formula (Sorensen, 1948);

$$SI = 2c/(a+b)$$

Here, c is the species common to the sampling localities, (a+b) is the total number of species in sampling areas. SI value laid between 0 and 1; 0 indicates no similarity between the comparing communities and in contrast, 1 indicates a perfect

similarity or identical species composition in comparing communities.

III.7.2. Taxonomic distinctness (Δ^*)

Taxonomic distinctness (Δ^*) (Clarke and Warwick, 1999) was also calculated for the study area. This measures the average distance between species composition between community samples. Taxonomic distinctness is calculated using the formula;

$$\Delta^* = [\sum \sum_{i < j} \omega_{ij}] / [m(m-1)/2]$$

Here, m is the number of species in the particular sample and ω_{ij} is the weight given to the taxonomic relationship between species i and j (Clarke and Warwick, 1999).

III.7.3. Collection of data and calculation

During the field studies, incidence data (presence/ absence) for each pteridophyte species were recorded in a 1 x 1 m quadrat in all possible situations. The entire study area is divided into different altitudinal classes of 100 m difference. The presence/ absence data in each altitudinal class were compiled with Microsoft Office Excel, in a binary format and scored 1 for presence and 0 for absence. SI and Δ^* were analysed in PAST 4.13 (PALaeontological STatistics) (Hammer *et al.*, 2001) software by importing the incidence binary data file.

III.7.4. Ecological Niche Modelling (ENM)

Ecological Niche Modelling (ENM) of selected endemic and endangered taxon was carried out for evaluating their distribution in current as well as future (2041-2070) climatic conditions.

III.7.4.1. Occurrence data

Distribution data of the selected taxon *Elaphoglossum beddomei* Sledge was tabulated from the available literature (Fraser-Jenkins *et al.*, 2021; Hassler, 1994-2024; Manickam and Irudayaraj 1992; Nayar and Geevarghese, 1993), herbaria (CALI, KFRI, MH, ZGC) and field observations. It is an endemic fern with simple fronds, crowded on the short creeping (0.5cm thick) rhizome and growing in the

evergreen and shola forests of the Western Ghats of Peninsular India as epiphytes or lithophytes. It is sparsely distributed in the Western Ghats of the Peninsular Indian states of Kerala, Tamil Nadu and Karnataka. GPS data points were obtained from the field observations during 2018-2021 (Table 3.2). Position coordinates, latitude and longitude, were recorded using a mobile based geopositioning application. Co-located or nearby locations (Phillips *et al.*, 2017), within 2 km, were avoided for better results, totalling 31 records of *E. beddomei*, including four primary collection records (Table 3. 2).

III.7.4.2. Environmental Data

High resolution climatic data of 19 bioclimatic variables for two time periods - 2011-2040 (current) and 2041-2070 - from the CHELSA (Climatologies at high resolution for the Earth's land surface areas) CMIP6 by Karger *et al.* (2017) were selected, as environmental predictors. Two scenarios of future climate were selected as ssp126 and ssp585 representing seasonality, annual trends in climate and limiting environmental factors (Qi *et al.*, 2004). The Shared Socioeconomic Pathways (ssp) derive the emission scenarios under different climate policies. ssp126 stands for ssp1-RCP2.6 climate as simulated by the GCMs. Here RCP is the Representative Concentration Pathway, which is a greenhouse gas emission trajectory by the IPCC. ssp126, RCP2.6 is the lowest in the representative concentration pathways; it assumes a decreased emission of greenhouse gases after 2100. Conversely, ssp585, ssp5-RCP8.5 climate as simulated by GCMs, represents a more pessimistic scenario of future gas emission. RCP8.5 represents the concentration of carbon which delivers global warming at an average of 8.5 Watts/sq. metre across the earth (Karger *et al.*, 2021). We eliminated the highly correlated variables – both positively and negatively correlated – with a Pearson correlation coefficient > 0.75 , for avoiding over prediction and confounding effects in the model (Elith *et al.*, 2011; Merow *et al.*, 2013; Bose *et al.*, 2016).

III.7.4.3. Background points

The first and most crucial step in species distribution modelling is the choice of background points, or landscape selection, which should represent a broad array

of possible habitats for the species (Sreekumar and Nameer, 2021 & 2022). So, in this study, the background has been selected within the evergreen and shola forest vegetation of southern Western Ghats - representing a potential habitat for *E. beddomei* - from the vegetation map of Indian Institute of Remote Sensing Biodiversity Information System, Government of India (Roy *et al.*, 2016)

III.7.4.4. MaxEnt Modelling

MaxEnt version 3.4.1 (Phillips and Dudik, 2008) was used to perform the species distribution model of *E. beddomei*. The model that showed highest values for True Skill Statistics (TSS) and overall accuracy, calculated using R package ENMTools (Chaitanya and Meiri, 2021), and Area Under the receiver operating characteristic Curve (AUC) for analysis. The initial model was created using MaxEnt based on the regularisation multiplier value (rm value = 3) as calculated by the ENM evaluation tool. Then, based on jackknife analysis in the MaxEnt output, we calculated the contribution permutation importance of each variable and discarded the lowest valued variable (Zurell *et al.*, 2020) and again ran MaxEnt to get the best model with highest AUC, TSS and overall accuracy. The MaxEnt settings were given as 10 folds of cross validation, number of background points of 10,000 and iterations of 5,000. The output file format was set as complementary log-log (c-loglog).

III.7.4.5. Future distribution prediction of *E. beddomei*

The current study predicted the distribution of *E. beddomei* in future climatic regimes (2041 - 2070) under different climate change scenarios – such as ssp (shared socio-economic pathway) 126 and ssp 585 for 2041-2070. Here we used five Earth System Models (ESMs) under CMIP6 (Coupled Model Intercomparison Project Phase-6) - including GFDL-ESM4, UKESM 1-OLL, MPI-ESM 1-2HR, IPSLL-CM6A LR and MRI-ESM 2-0. Then calculated the average of these ESMs.

III.7.4.6. Evaluation of MaxEnt models

Evaluation of the MaxEnt models based on the Area Under the receiver operating characteristic Curve (AUC), which plots sensitivity against 1-specificity.

It ranges from 0 to 1, the value near to one indicates the best prediction. We also considered TSS (true skill statistics), which is “sensitivity + specificity - 1”, and the overall accuracy for model performance, using R package ENM Tools.

III.7.4.7. Habitat loss and gain in future simulations

The present study also mapped suitable and unsuitable habitats of *E. beddomei* by considering the threshold value of maximum test sensitivity plus specificity c-loglog threshold (Max SSS) (Liu *et al.*, 2013) on the predicted probabilities, using the Raster reclassification tool in Q-GIS v. 3.61. Then we used the raster calculator tool of Q-GIS v. 3.61 to calculate changes in suitable habitats of *E. beddomei*, as the difference between the current binary map and future binary maps in different conditions in future climatic regimes. Based on the prediction of potential habitats, we calculated the habitat loss and gain in the future time periods, by comparing the predicted suitable area under two climatic scenarios - ssp126 and ssp585 - of 2041-2070 and the prediction in the current time period. From this calculation we obtained the gain of suitable habitat, loss of suitable habitat and unchanged habitats of *E. beddomei* in future climatic conditions.

Table 3.2: Coordinates of the representative populations of *Elaphoglossum beddomei* Sledge.

Location	Longitude	Latitude
Kerala, Kannur, Aralam	75.79892	11.9318
Kerala, Kannur, Aralam	75.79906	11.93185
Karnataka, Avalahalli	75.768	12.8352
Kerala, Kozhikode, Anakkampoyil	76.10148	11.4848
Kerala, Wayanad, Chethalayam	76.26457	11.7757
Kerala, Wayanad	76.28122	11.75864
Kerala, Palakkad, Silent Valley, Walakkad	76.41199	11.3365
Kerala, Palakkad, Silent Valley, Walakkad	76.41489	11.17787
Kerala, Palakkad, Kunthi River bank	76.41925	11.14611
Kerala, Palakkad, CheriyaWalakkad	76.42235	11.16793

Location	Longitude	Latitude
Kerala, Palakkad, Sispara	76.42337	11.18101
Kerala, Palakkad, Poochippara	76.42587	11.10987
Kerala, Palakkad, Walakkad	76.42591	11.1854
Kerala, Palakkad, Silent Valley, Padavayal	76.43122	11.1145
Kerala, Palakkad, Silent Valley	76.43126	11.16408
Kerala, Palakkad, Bank of Kunthipuzha	76.43779	11.10231
Kerala, Palakkad, Padavayal	76.4541	11.12823
Kerala, Palakkad, Bank of Kunthipuzha	76.46775	11.11702
Kerala, Palakkad, Attappadi	76.48347	11.14219
Kerala, Palakkad, Nelliampathy	76.67446	10.424
Kerala, Ernakulam, Edamalakudy	77.00684	10.1999
Kerala, Idukki, Munnar	77.08052	10.15169
Kerala, Thiruvananthapuram, Ponmudi	77.14154	8.7543
Kerala, Thiruvananthapuram, Bonaccord	77.17934	8.68351
Kerala, Thiruvananthapuram, Agasthyamalai hills	77.17999	8.765838
Kerala, Idukki, Periyar Tiger Reserve	77.19455	9.596457
Kerala, Kollam, Shenduruny	77.21764	8.858973
Kerala, Pathanamthitta, Ranni	77.21829	9.32648
Kerala, Idukki, Mathikettan Shola	77.24573	9.985709
Kerala, Idukki, Mathikettan Shola National Park	77.2463	9.9846
Tamil Nadu, Tirunelveli hills	77.27199	8.74751

IV. RESULTS AND DISCUSSION

IV.1. Diversity of Ferns and Lycophytes

Classification is important for the easy identification of taxa. Many attempts were made earlier to classify pteridophytes, based on different parameters. During the pioneer stages of identification and classification, morphological characters, specifically, reproductive features were used for grouping the taxa (Linnaeus, 1753 & 1754; Smith, J.E., 1793; Smith, J., 1842). Later developments in electron microscopic analysis and cytological studies made advancements in the classification of Pteridophytes (Mehra and Kannan, 1959; Wagner, 1969). Recently, the emergence of molecular techniques made the classification more evolutionary, incorporating data at genetic level (Hasebe *et al.*, 1994; Pryer *et al.*, 1995 & 2004; Schneider *et al.*, 2004; PPG 1, 2016). Though in the field, taxa could be identified only by using the morphological characters, the comprehensive treatment of the taxa must be based on all available data incorporating the concept of evolution. Hence, in the present documentation, the classification by PPG 1 (2016) is being followed.

Exploration and documentations of ferns and lycophytes across Palghat Gap zone resulted in documenting 191 taxa coming under 65 genera and 27 families. Following is the key for the identification of families of pteridophytes recorded in and around Palghat Gap.

Key for identification of Families of Lycophytes and Ferns across Palghat Gap

1. Leaves with unbranched veins; young leaves without circination 2
1. Leaves with branched veins and veinlets; young leaves with circination 5
2. Plants heterosporous 3
2. Plants homosporous 4
3. Plants aquatic or semi aquatic; stem corm-like; leaves acicular..... **Isoetaceae**
3. Plants not aquatic or semi aquatic; stem not corm-like; leaves not acicular **Selaginellaceae**
4. Stem jointed, hollow, grooved; leaves scale like around nodes **Equisetaceae**
4. Stem not jointed, hollow or grooved; leaves thick or needle-like **Lycopodiaceae**

5.	Plants heterosporous	6
5.	Plants homosporous	7
6.	Plants rooted at bottom; leaves tetra-foliate	Marsileaceae
6.	Plants free floating; leaves simple	Salviniaceae
7.	Fronds thin, filmy; indusium cupular or bivalvate	Hymenophyllaceae
7.	Fronds not thin or filmy; indusium not cupular or bivalvate, sometimes absent	8
8.	Leaf solitary or few, sporangia on a spike	Ophioglossaceae
8.	Leaves many, sporangia not on a spike	9
9.	Rhizome hairy; creeping	10
9.	Rhizome scaly or devoid of scales and hairs; creeping, erect or sub-erect	12
10.	Fronds of indefinite growth	11
10.	Fronds of definite growth	Dennstaedtiaceae
11.	Sori on finger-like strobili along the sporophyll margin	Lygodiaceae
11.	Sori forms rosettes adaxially on sporophylls	Gleicheniaceae
12.	Sporophylls monomorphic	13
12.	Sporophylls dimorphic	14
13.	Sori marginal or sub-marginal; sporangia without annulus	Marattiaceae
13.	Sori various; sporangia with annulus	15
14.	Sporangia on panicle, panicle borne near the base of frond	Anemiaceae
14.	Sporangia on terminal panicle; panicle borne above the base of frond	Osmundaceae
15.	Plants arborescent	Cyatheaceae
15.	Plants otherwise	16
16.	Sori marginal or acrostichoid; veins anastomosing	17
16.	Sori not marginal	18
17.	Indusia true	Lindsaeaceae
17.	Indusia false or ex-indusiate	Pteridaceae
18.	Sori parallel to costa; indusiate	Blechnaceae
18.	Sori not parallel to costa	19
19.	Rhizome scales appressed and lanceolate	20
19.	Rhizome scales otherwise	21
20.	Rhizome erect, fronds pinnately lobed, sori marginal	Nephrolepidaceae
20.	Rhizome creeping, fronds entire, sori along costa	Oleandraceae
21.	Sori rounded, linear or 'J'-shaped	22

- 21. Sori acrostichoid or circular **23**
- 22. Sori linear, slanting, along one side of the vein; scales clathrate ... **Aspleniaceae**
- 22. Sori rounded at vein endings or J-shaped; scales not clathrate **Woodsiaceae**
- 23. Plants epiphytic or lithophytic; not terrestrial **24**
- 23. Plants usually terrestrial or lithophytic; rarely epiphytic **25**
- 24. Veins anastomosing; aereoles with free, included veinlets **Polypodiaceae**
- 24. Veins not anastomosing; aereoles absent **Davalliaceae**
- 25. Sporophylls dimorphic or monomorphic; rhizome densely scaly
..... **Dryopteridaceae**
- 25. Sporophylls usually monomorphic; rhizome not densely scaly **26**
- 26. Included veinlets present **Tectariaceae**
- 26. Included veinlets absent **Thelypteridaceae**

Lycopodiales

Lycopodiaceae P. Beauv. ex Mirb. Hist. Nat. Vég. 4: 293. 1802.

Key to genera

- 1. Plants epiphytic; stem short, suberect or pendulous ***Huperzia***
- 1. Plants terrestrial; stem wide creeping **2**
- 2. Strobili sessile at the tips of branchlets ***Lycopodiella***
- 2. Strobili peduncled at the tips of branchlets ***Lycopodium***

Huperzia Bernh. in Schrader, J. Bot. 1800(2): 126. 1801.

Key to species

- 1. Sporophylls forming distinct strobili or cone **2**
- 1. Sporophylls not aggregated to distinct strobili or cones..... **3**
- 2. Leaves thin, firm, margin not revolute ***H. phlegmaria***
- 2. Leaves coriaceous, margin revolute ***H. phyllantha***
- 3. Leaves obtuse; sporangia on unreduced sporophylls ***H. hamiltonii***
- 3. Leaves acuminate; sporangia on reduced sporophylls..... ***H. squarrosa***

Huperzia hamiltonii (Spreng.) Trevis., Atti Soc. Ital. Sci. Nat. 17: 248. 1874;
Manickam & Irud., Pterid. Fl. W. Ghats S. India, 27. Pl. 6. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 10. 2017.

Lycopodium hamiltonii Spreng. var. *petiolatum* C.B. Clarke, Trans. Linn. Soc. Lond., 2 Bot., 1: 590, 593. 1880.

Huperzia hamiltonii (Spreng.) T. Sen & U. Sen, Fern Gaz. 11(6): 419. 1978-isonym.

Phlegmariurus hamiltonii (Spreng.) L.B. Zhang, Fl. Reipubl. Pop. Sin. 6(3): 42. 2004.

Stem pendulous, 25-30 x 2-5 cm with leaves; iso-dichotomously branched; leaves numerous, arranged spirally, adnate, spreading, 2-4 x 0.4-0.5 cm, elliptic, apex obtuse, margin entire; coriaceous, green, glabrous. Sporophylls not formed into a definite cone like structure, not distinct from vegetative leaves; sporangia borne in the axils of sporophylls towards the distal most part of the branches, 0.2-0.4 x 0.1-0.3 cm, reniform, yellowish-brown, dehisced vertically, outer edge formed into two distinct flaps; spores numerous, light yellow, trilete.

Distribution: Small epiphytic or epilithic in evergreen and shola forests along stream sides or road sides, between 900-1200 m. Found growing along Kunthipuzha trek path, Parathode, Poochippara of Silent Valley National Park; Govinda Mala, Nelliampathy. (Plate 4.1: Fig. a-e).

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Kunthipuzha Trek path, 11° 5' 45.276" N, 76° 26' 51.18" E, 916 m, 22 October 2019, Thulasi, 14511 (ZGC); Parathodu, 11° 5' 51" N, 76° 26' 48.84" E, 920 m, 23 October 2019, Thulasi, 14527 (ZGC); Kollengode range, Cheriya Govinda Mala, 10° 30' 27.864" N, 76° 41' 45.924" E, 990 m, 11 March 2020, Thulasi & Maya, 15045 (ZGC).

Huperzia phlegmaria (L.) Rothm., Feddes Repert. Spec. Nov. Regni Veg. 54: 62. 1944; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 24. Pl. 3. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 14. 2017.

Lycopodium phlegmaria L., Sp. Pl. 2: 1101. 1753.

Huperzia phlegmaria (L.) Panigrahi, Higher Plants Indian Subcont, add. ser. Indian J. Forest. 7, 4: 109. 1993.

Stem pendulous, 45-50 x 3-4 cm with leaves, iso-dichotomously branched. Leaves numerous, 1-5 mm apart, sessile or subsessile, ovate lanceolate, 1.5-2 x 0.5-1 cm, acuminate, entire, broadly base cuneate, midrib slightly distinct above and below, dark green, sub coriaceous, glabrous. Strobili terminal, 9-10 x 0.2-0.5 cm, slender, forked; sporophylls opposite decussate, appressed, adnate; spreading at basal part, deltoid, thin, apex subacute, entire margin; sporangia on axils of sporophylls, reniform, yellowish; spores trilete, grey. (Plate 4.1: Fig. f-k.)

Distribution: Epiphyte on shola and evergreen forests, between 900-1200 m. Observed from Valiapaarathode and Poochippara of Silent Valley National Park.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Valiyaparathodu, 11° 6' 49.32" N, 76° 25' 51.6" E, 910 m, 27 December 2019, Thulasi, 14637 (ZGC); on the way from Poochippara to Walakkad, 11° 8' 0.96" N, 76° 24' 42.84" E, 1140 m, 28 December 2019, Thulasi, 14667 (ZGC).

Huperzia phyllantha (Hook. & Arn.) Holub, Folia Geobot. Phytotax. 20(1): 75. 1985; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 25. Pl. 4. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 15. 2017.

Lycopodium phyllanthum Hook. & Arn., Bot. Beechey Voy. 102. 1832.

Huperzia phyllantha (Hook. & Arn.) Panigrahi, Higher Plants Indian Subcont., add. ser. *Indian J. Forest.* 7, 4: 109. 1993-isonym.

Stem pendulous, 40-45 x 4-5 cm with leaves, forked once or two times. Leaves spreading, arranged in six vertical rows, three leaves in a whorl, successive whorl alternate to the previous whorl, 1.5-2 cm apart, sessile, 2-3 x 0.8-1 cm, ovate, entire, acute, broadly cuneate base, mid rib slightly raised below, grooved above; leaves yellowish green, glabrous, stiff coriaceous. Strobili terminal on ultimate branches, 8-10 x 0.3-0.5 cm thick, stiff; sporophylls in 4 rows, alternate, opposite decussate, sessile, triangular, entire, acute, base incurved and encloses sporangium, coriaceous; sporangia at the axils of sporophylls, reniform, 2-3 x 1.5-2 mm, light yellow; spores trilete, grey. (Plate 4.2: Fig. a-f.)

Distribution: Epiphytic in evergreen forests, along stream sides, between 900-1600 m. Recorded from Mathikettan Shola National Park and Silent Valley National Park.

Specimen/s examined: Kerala: Idukki District, Mathikettan Shola National Park, Choondal, 9° 59' 4.56" N, 77° 14' 46.68" E, 1500 m, 2 August 2019, Thulasi, 14375 (ZGC); Mathikettan, 9° 58' 47.28" N, 77° 14' 12.84" E, 1400 m, 8 August 2019, Thulasi, 14403 (ZGC); Palakkad District, Silent Valley National Park, Kunthipuzha trek path, 11° 5' 45.6" N, 76° 26' 57.84" E, 950 m, 22 October 2019, Thulasi, 14498 (ZGC); Parathodu, 11° 5' 33" N, 76° 26' 44.52" E, 1020 m, 23 October 2019, Thulasi, 14521 (ZGC).

Huperzia squarrosa (G.Forst.) Trevis., Atti Soc. Crittog. Ital. 17: 247. 1875; Manickam & Irud., Pterid. Fl. W. Ghats S. India 26. Pl. 5. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 19. 2017.

Lycopodium squarrosum G.Forst., Fl. Ins. Austr 86. 1786.

Huperzia squarrosa (G.Forst.) Rothm., Feddes Rep. Spec. Nov. Regn. Veg. 54(1): 62. 1944-isonym.

Stem pendulous, 45-50 x 2-3 cm wide including leaves, forked; leaves crowded, arranged in spiral, adnate, 12-15 x 2-3 mm, oblanceolate, towards the tip progressively narrowed, acuminate, entire, dark green, stiff, glabrous. Sporophylls at distal part of the branches, smaller than vegetative leaves, lanceolate, acuminate; sporangia one, on axil of each sporophyll, reniform, yellowish; spores trilete, white. (Plate 4.2: Fig. g-m.)

Distribution: Epiphytic in evergreen forest, between 1000-1200 m. Found growing at Poochippara to Walakkad way.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, on the way from Poochippara to Walakkad, 11° 6' 38.16" N, 76° 25' 20.64" E, 1070 m, 28 December 2019, Thulasi, 14659 (ZGC).



Plate 4.1: a-e. *Huperzia hamiltonii* (Spreng.) Trevis. a. Habitat b. Habit c. Vegetative leaf d-e. Sporophylls. f-k *Huperzia phlegmaria* (L.) Rothm. f. Habitat g. Habit h. Strobili i. Rhizome j. Sporangium k. Strobilus enlarged.



Plate 4.2: a-f. *Huperzia phyllantha* (Hook. & Arn.) Holub. a. Habitat b. Habit c. Plantlets formed through apospory d. Strobili e. Sporophyll f. Sporangium. g-m. *Huperzia squarrosa* (G.Forst.) Trevis. g. Habitat h. Habit i. Vegetative leaf j. Rhizome k. Strobilus l. Sporophyll m. Sporangium.

Lycopodiella Holub, Preslia 36: 20, 22. 1964.

Lycopodiella cernua (L.) Pic.Serm., Webbia 23(1): 166. 1968; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 31. Pl. 10. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 21. 2017.

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

Lycopodium cernuum var. *sikkimense* (Müll.Hal.) C.B.Clarke, Trans. Linn. Soc. Lond., 2 Bot., 1: 592. 1880.

Lycopodiella cernua var. *sikkimensis* (Müll.Hal.) Panigrahi & Sarn.Singh, Ferns Fern-Allies Arunachal Pradesh 1: 54. 2005.

Stem erect, 120-125 x 0.3-0.5 cm, terete, with branched roots at base; branches above the unbranched main stem up to 70 x 20 cm, branches sub opposite, decussate, 10-15 x 9-10 cm, forked in to 2 to 3 times, tertiary branches 4-5 x 3-4 cm. Leaves less in main stem, dense in rest of the parts, spreading, adnate, linear, 3-5 x 0.3-0.5 mm, entire, acuminate, pale green, stiff, texture herbaceous. Strobili terminal, pedunculate, pendant, cylindrical, 10 x 3 mm; sporophylls pale green, thin, ovate, acuminate, 1-2 x 0.6-0.8 mm, base peltate, fimbriate margin; sporangia reniform, light brown; spores trilete, pale green. (Plate 4.3: Fig. a-g.; Plate 4.80: Fig. a.)

Distribution: Common species in fully exposed roadsides or cuttings, between 400-2000 m. Observed at Poochippara, Parathode, Walakkad, Sispara of Silent Valley National Park; Mulli; Neriamangalam; Munnar; Meesappulimala; Ooty.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Parathodu, 11° 5' 51" N, 76° 26' 48.84" E, 920 m, 23 October 2019, Thulasi, 14528 (ZGC); on the way from Poochippara to Walakkad, 11° 8' 0.96" N, 76° 24' 42.84" E, 1140 m, 28 December 2019, Thulasi, 14659 (ZGC); Walakkad, 11° 12' 3.096" N, 76° 26' 47.688" E, 2150 m, 29 December 2019, Thulasi, 14945 (ZGC). Tamil Nadu: Nilgiri District, Ooty, 11° 13' 28.56" N, 76° 44' 13.92" E, 570 m, 22 November 2021, Thulasi, 15005 (ZGC).

Lycopodium L. Sp. Pl. 2: 1100. 1753.

Lycopodium wightianum Grev. & Hook., Enum. Fil. 85. 1833; Manickam & Irud., Pterid. Fl. W. Ghats S. India 29. Pl. 11. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 26. 2017.

Stem prostrate, 2-3 mm thick, terete, roots on abaxial side; branches alternate, bent at the base, erect, bearing secondary branches at 2-4 cm intervals, erect, tertiary branches forked. Leaves dense on ultimate branchlets, less in other parts, appressed, opposite decussate, adnate, 2-3 x 0.5-1 mm, subulate, slightly falcate, entire, acuminate, glabrous, light green, coriaceous. Strobili on ultimate bracelets, pedunculate, peduncles up to 6 cm long, forked, with ovate-lanceolate sparsely, spreading, thinner leaves; strobili cylindrical, 2-3 x 0.5-1 cm; sporophylls ovate, 3-4 x 2-3 mm, acuminate, thinner, transparent towards margins, margin wavy, opaque at centre, base with narrow, tail like projection, subbasally attached; sporangia reniform, pale brown; spores globose, trilete, light green. (Plate 4.3: Fig. h-l.; Plate 4.80: Fig. b.)

Distribution: Rare in the current study area. Terrestrial, along dry fully exposed roadsides, between 2200-2500 m. Found growing at Bankitapal.

Specimen/s examined: Tamil Nadu: Nilgiri District, Ooty, 11° 13' 24.96" N, 76° 32' 1.68" E, 2371 m, 27 February 2022, Maya, 15025 (ZGC).

Selaginellales

Selaginellaceae Willk., Anleit. Stud. Bot. 2: 163. 1854.

Selaginella P.Beauv., Prodr. Fam. Aethéogam. 101. 1805, *nom. cons.*

Key to species

1. Leaves monomorphic, spirally arranged.....***S. wightii***
1. Leaves dimorphic, arranged in 4-rows **2**
2. Stem prostrate, rooting throughout ***S. radicata***
2. Stem erect, rooting at base **3**
3. Leaves uniform at the main stem base ***S. involvens***



Plate 4.3: a-g. *Lycopodiella cernua* (L.) Pic.Serm. a. Habitat b. Habit c. Vegetative leaf d. Strobili e. V.S. of strobilus f. Strobilus enlarged g. Sporophyll with sporangia. h-l. *Lycopodium wightianum* Grev. & Hook. h. Habit i. Prostrate stem j-k. Strobili l. Sporophyll with sporangia.

3.	Leaves dimorphic throughout	4
4.	Lateral leaves towards the base of the stem continuous, spreading	5
4.	Lateral leaves distant towards the base of the stem	6
5.	Sporophylls uniform	<i>S. intermedia</i>
5.	Sporophyll dimorphic	7
6.	Vegetative leaves and sporophylls entire	<i>S. delicatula</i>
6.	Vegetative leaves and sporophylls otherwise	8
7.	Rhizophore confined to basal half, gemmae-like structures at branch tips	<i>S. tenera</i>
7.	Rhizophore at base only, gemmae-like structures absent	<i>S. miniatospora</i>
8.	Rhizophores confined to the basal part	9
8.	Rhizophores throughout, except the terminal part	<i>S. ciliaris</i>
9.	Lateral leaves margin denticulate	<i>S. chrysorrhizos</i>
9.	Lateral leaves margin serrulate	<i>S. crassipes</i>

Selaginella chrysorrhizos Spring, Mem. Acad. Sci. Belg. 24: 251. 1850; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 30. 2017.

Stem erect, 10-13 x 1-1.5 cm, tufted, cylindrical, pinnate branches, green. Rhizophores 4-5 cm long, slender, cylindrical. Leaves heteromorphic, distantly placed in main stem and contiguous in branches, lateral leaves 1.8-2 x 0.7-0.9 mm, oblong-lanceolate, oblique, membranous; margin denticulate, apex acute; median leaves 1-1.5x0.1-0.5 mm, ovate-lanceolate, apex cuspidate, margin denticulate; axillary leaves 2.3 x 1 mm, oblong-lanceolate, margin denticulate, apex acute. Strobili terminal, 2-3 x 1.5-2.5 mm, sessile, solitary. Sporophylls 1-1.5 x 0.1-0.6 mm, dimorphic, spirally arranged, membranous; megasporophylls ovate lanceolate, apex acuminate, margin serrate; microsporophylls ovate, margin ciliate, apex acuminate-aristate. Megaspores four per sporangium, light yellow, globose, tetrahedral; microspores numerous, dark red. (Plate 4.4: Fig. a-g.; Plate 4.80: Fig. e.)

Distribution: Terrestrial, grows in mud cliffs between 20 to 1600 m. Found growing at Meenvallam; Mathikettan Shola National Park; Rayiranallur mala; Arikampara, Silent Valley National Park; Cheriya Govinda mala, Nellyampathy; Malakkappara, Athirappilly; Thudukki, Bhavani.



Plate 4.4: a-g. *Selaginella chrysorrhizos* Spring a. Habitat b. Habit c. Strobili d. Median leaf e. Stem with rhizophors f. Lateral leaf g. Axillary leaf. h-o. *Selaginella ciliaris* (Retz.) Spring h. Habitat i. Habit j. Strobili k. Lateral leaf l. Axillary leaf m. Median leaf n. Megasporophyll with sporangium o. Microsporophyll with sporangium.

Specimen/s examined: Kerala: Palakkad District, Mannarkkad, Meenvallam, 10° 55' 24.6" N, 76° 33' 51.84" E, 81 m, 11 September 2018, Thulasi, 14217 (ZGC); Walayar, Akamalavaram, 10° 52' 7.32" N, 76° 42' 43.2" E 10° 52' 7.32" N, 76° 42' 43.2" E, 212 m, 1 December 2018, Thulasi & Maya, 14409 (ZGC); Ottappalam, Rayiranallur mala, 10° 52' 14.16" N, 76° 9' 16.92" E, 33 m, 16 September 2019, Thulasi, 14545 (ZGC); Silent Valley National Park, Arikampara, 11° 4' 51.6" N, 76° 26' 36.6" E, 1070 m, 24 October 2019, Thulasi, 14736 (ZGC); Kollengode, Cheriya Govinda mala, 10° 30' 38.16" N, 76° 41' 42" E, 987 m, 4 November 2020, Thulasi & Maya, 14803 (ZGC); Bhavani, Thudukki, 11° 8' 15.72" N, 76° 29' 59.64" E, 1500 m, 2 October 2021, Thulasi, 14917 (ZGC); Thrissur district, Vazhachal, 10° 17' 47.76" N, 76° 47' 38.76" E, 930 m, 14 November 2021, Thulasi, 14840 (ZGC); Idukki district, Mathikettan Shola National Park, 9° 58' 47.28" N, 77° 14' 12.84" E, 1400 m, 1 August 2019, Thulasi, 14387 (ZGC).

Selaginella ciliaris (Retz.) Spring, Bull. Acad. Roy. Sci. Bruxelles 10(1): 231. 1843; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 31. 2017.

Lycopodium ciliare Retz., Observ. Bot. 5: 32. 1789.

Stem prostrate, 1.5-12 x 0.1-0.3 cm, cylindrical, throughout branched. Rhizophores 3-3.5 cm long, throughout except the terminal part, slender, cylindrical. Leaves heteromorphic, distantly distributed on main stem, closely distributed in branches, green; lateral leaves 1.8-2 x 0.8-1 mm, ovate oblong, base entire, membranous, margin ciliate along proximal basal part, apex acute; median leaves 1.8-1.9 x 1-1.2 mm, obovate, membranous, base entire, denticulate margin except base, apex aristate; axillary leaves 1.9-2 x 1-1.2 mm, ovate-lanceolate, oblique base; margin dentate at base, apex acute. Cones 9x3.5 mm, sessile, terminal, solitary. Sporophylls spiral, dimorphic; megasporophylls 2.3x1 mm, oblong lanceolate, membranous, denticulate towards apex, margin dentate, apex acute; micro-sporophylls 1.5-1.8 x 1-1.3 mm, ovate-triangular, margin ciliate, acuminate apex. Megaspores 4 per sporangium, light yellow, globose, tetrahedral; microspores numerous in one sporangium, dark red in colour. (Plate 4.4: Fig. h-o.; Plate 4.80: Fig. d.)

Distribution: Terrestrial, grown in wet or water-logged soil as well as in rock

crevices, between 100 to 200 m. Found growing at Dhoni; Nellyampathy.

Specimen/s examined: Kerala: Palakkad District, Olavakkode range, Dhoni, 10° 51' 34.2" N, 76° 37' 21.72" E, 120 m, 13 September 2018, Thulasi & Maya 14235 (ZGC); Kollengode range, Cheriya Govinda Mala, 10° 30' 38.16" N, 76° 41' 42" E, 987 m, 3 November 2020, Thulasi & Maya, 15046 (ZGC).

Selaginella crassipes Spring, Mém. Acad. Roy. Sci. Belgique 24(2): 243. 1850; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 32. 2017.

Stem erect, 13-15 cm, slender, cylindrical, glabrous, yellowish green. Rhizophores 4.5-5 cm long, confined to basal parts, slender, dichotomously, repeatedly branched. Leaves heteromorphic; lateral leaves 1.8-2 x 1.4-1.6 mm, ovate-elliptic, margin serrulate, apex acute; axillary leaves 1.8-2 x 1.3-1.5 mm ovate-lanceolate, base auricled, serrate margin, acute apex; median leaves 1-1.2 x 0.3-0.5 mm, ovate, margin serrate, aristate apex. Strobili terminal, solitary, sessile. Sporophylls dimorphic, spirally arranged; megasporophylls ovate-elliptic, 1-1.2x0.3-0.5 mm, margin serrulate upper half, ciliate along basal half; microsporophylls ovate, margin ciliate in basal part, serrate in upper half, apex aristate; one or two megasporangiate at middle, all others are microsporangiate. Megaspores four per sporangium, tetrahedral, globose, yellow; microspores numerous, yellow-orange. (Plate 4.5: Fig. a-h.; Plate 4.80: Fig. c.)

Distribution: Terrestrial in shaded road sides, between 400-1300 m. Endemic to Southern India and Sri Lanka. Found growing at Kummattamthode, Silent Valley National Park; Karimala, Parambikulam Tiger Reserve; Mattumala, Nellyampathy; Ommala, Attappadi.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Kummattanthodu, 11° 5' 48.84" N, 76° 27' 19.8" E, 1030 m, 22 October 2019, Thulasi, 14483 (ZGC); Parambikulam Tiger Reserve, Karimala, 10° 28' 58.8" N, 76° 50' 56.4" E, 530 m, 5 December 2019, Thulasi, 14582 (ZGC); Kollengode range, Maattumala, 10° 32' 4.2" N, 76° 43' 18.12" E, 1300 m, 4 November 2020, Thulasi & Maya, 14831 (ZGC); Agali range, Ommala, 11° 3' 35.64" N, 76° 36'

39.96" E, 730 m, 14 November 2021, Thulasi, 14935 (ZGC).

Selaginella delicatula (Desv. ex Poir.) Alston, J. Bot. 70: 282. 1932; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 40. Pl. 19. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 32. 2017.

Lycopodium delicatulum Desv. ex Poir., Lam. Encycl. suppl. 3: 554, no. 99. 1814.

Stem erect or suberect, roots at the base, stramineous, 5-6 mm thickness sparsely with leaves. Plants 40-45 cm height, many lateral branches, leaves scattered on main stem, arranged in four rows in lateral branches; lateral leaves 2.3-2.5 x 1.3-1.5 mm, ovate, entire, obtuse; median leaves ovate, 2-2.2 x 1-1.2 mm, aristate, entire; axillary leaf 2.3-2.6 x 1-1.4 mm, oblique, obovate, margin serrulate towards apex, apex acute. Strobili on ultimate branches, quadrangular, sporophylls uniform, ovate, acuminate, entire; megaspores pale brown; microspores green. (Plate 4.5: Fig. i-q.; Plate 4.80: Fig. i.)

Distribution: Very common species. Seen in low to high altitude areas, between 0 to 1200 m. Found growing at many locations in the current study area.

Specimen/s examined: Kerala: Palakkad District, Olavakkode range, Dhoni, 10° 51' 34.2" N, 76° 37' 21.72" E, 120 m, 13 September 2018, Thulasi & Maya, 14225 (ZGC); Mannarkkad, Arakurussy, 10° 59' 41.28" N, 76° 26' 48.84" E, 54 m, 17 October 2018, Thulasi, 14249 (ZGC); Ovalakkode, Dhoni, 10° 51' 30.996" N, 76° 37' 19.92" E, 133 m, 20 November 2018, Thulasi & Maya, 14271 (ZGC); Mannarkkad, Virgin Valley, 11° 2' 42.72" N, 76° 26' 33" E, 79 m, 24 November 2018, 14283 (ZGC); Walayar, Akamalavaram, 10° 52' 5.16" N, 76° 42' 41.04" E, 212 m, 16 September 2019, Thulasi & Maya, 14318 (ZGC); Agali, Siruvani, 10° 58' 55.56" N, 76° 36' 1.8" E, 700 m, 20 September 2019, Thulasi, 14410 (ZGC); Ottappalam, Rayiranallur mala, 10° 52' 14.16" N, 76° 9' 16.92" E, 33 m, 02 October 2019, Thulasi, 14415 (ZGC); Thirumittakkode, 10° 46' 54.84" N, 76° 10' 58.8" E, 17 m, 2 October 2019, Thulasi, 14440 (ZGC); Silent Valley National Park, Parathod, 11° 5' 51" N, 76° 26' 48.84" E, 920 m, 23 October 2019, Thulasi, 14526 (ZGC); Parambikulam Tiger Reserve, Karimala, 10° 28' 42.96" N, 76° 50' 55.32" E,



Plate 4.5: a-h. *Selaginella crassipes* Spring a. Habitat b. Habit c. Strobili d. Axillary leaf e. Lateral leaf f. Median leaf g. Megasporophyll with megasporangium h. Microsporophyll with microsporangium. i-q. *Selaginella delicatula* (Desv. ex Poir.) Alston i. Habitat j. Habit k. Rhizophores l. Median leaf m. Lateral leaf m. Axillary leaf o. Strobilus p. Microsporophyll with microsporangium q. Megasporophyll with megasporangium.

600 m, 5 December 2019, Thulasi, 14596 (ZGC); Nelliampathy, Vazhakkundu, 10° 31' 6.7332" N, 76° 42' 52.398" E, 910 m, 15 January 2020, Thulasi & Maya, 14769 (ZGC); Olavakkode, Dhoni, 10° 52' 22.44" N, 76° 37' 3" E, 350 m, 18 January 2020, Thulasi & Maya, 14780 (ZGC); Nelliampathy, Kesavan para, 10° 31' 27.336" N, 76° 40' 4.008" E, 940 m, 12 December 2021, Thulasi, 14956 (ZGC); Ottappalam, Nhangattiri, 10° 47' 14.136" N, 76° 10' 51.924" E, 25 m, 17 May 2022, Thulasi, 15033 (ZGC); Malappuram district, Pulamanthol, 10° 53' 56.4" N, 76° 11' 28.68" E, 11 m, 15 November 2018, Thulasi, 14264 (ZGC); Karimpuzha Wildlife sanctuary, Panappuzha, 11° 17' 23.388" N, 76° 21' 10.836" E, 64 m, 4 September 2021, Thulasi, 14869 (ZGC).

Selaginella intermedia (Blume) Spring, Bull. Acad. Roy. Sci. Bruxelles 10(1): 144. 1843; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 39. Pl. 17. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 36. 2017.

Lycopodium intermedium Blume, Enum. Pl. Javae 2: 269, no. 20. 1830.

Stem erect or suberect, 2-3 mm thick without leaves; rhizophores on basal 1/3rd part of the main stem as stilt roots; distal 2/3rd part of the main stem dichotomously branched; leaves dimorphic entire, lateral leaves oblong-lanceolate, 5-6 x 2-3 mm, unequal base, apex obtuse, margin ciliolate at the basisopic part, rest is entire; median leaves ovate, aristate apex with denticulate margin; axillary leaves 3.5-3.6 x 1.7-2 mm, ovate-lanceolate, slightly oblique in the base; margin dentate-denticulate, apex obtuse. Cones 1.5-1.6 x 0.4-0.5 cm, sporophylls uniform, ovate, acuminate, denticulate margin; microspores yellowish brown, trilete; megaspore globose, yellow, tetrahedral. (Plate 4.6: Fig. a-f.)

Distribution: Terrestrial along shaded stream banks or roadsides between 1000 to 2000 m. Pampadum Shola National Park; Mathikettan Shola National Park; Malakkappara, Athirappilly.

Specimen/s examined: Kerala: Idukki District, Pampadum Shola National Park, Kuttikkad, 10° 7' 35.4" N, 77° 15' 29.88" E 1900 m, 30 July 2019, Thulasi, 14340 (ZGC); Thrissur District, Vazhachal, Malakkappara, 10° 17' 47.76" N, 76° 47' 38.76" E, 930 m, 14 February 2021, Thulasi, 14854 (ZGC).

Selaginella involvens (Sw.) Spring, Bull. Acad. Roy. Sci. Bruxelles 10(1): 136. 1843; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 35. Pl. 12. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 36. 2017.

Lycopodium involvens Sw., Syn. Fil. 182, no. 50. 1806.

Stem erect, rooting at the base, 1-2 mm thick, 18-20 cm long without branches, stramineous; quadripinnate; lateral branches 7-8 pairs, alternate, ascending, bearing secondary and tertiary branches; leaves in main stem uniform, scattered, broadly ovate, acute, entire; leaves on distal part of main stem and on lateral branches dimorphic; lateral leaves ovate lanceolate, acute, entire; dark green to pale green; strobili terminal on ultimate branches, quadrangular, sporophylls uniform, ovate, acuminate, entire; microspores reddish. (Plate 4.6: Fig. g-l.)

Distribution: Terrestrial or lithophyte along shaded stream banks or roadsides. Between 1000 to 2000 m. Pampadum Shola National Park; Mathikettan Shola National Park; Silent Valley National Park; Maattumala, Nelliampathy.

Specimen/s examined: Kerala: Idukki District, Pampadum Shola National Park, Kuttikkad, 10° 7' 33.6" N, 77° 15' 22.68" E, 1892 m, 30 July 2019, Thulasi, 14355 (ZGC); Mathikettan Shola National Park, 9° 58' 47.28" N, 77° 14' 9.6" E, 1400 m, 1 August 2019, Thulasi, 14376 (ZGC); Palakkad District, Silent Valley National Park, 11° 5' 48.84" N, 76° 27' 19.8" E, 1030 m, 22 October 2019, Thulasi, 14463 (ZGC); Arikampara, 11° 4' 45.12" N, 76° 26' 50.64" E, 1090 m, 24 October 2019, Thulasi, 14546 (ZGC); Nelliampathy, Maattumala, 10° 32' 2.4" N, 76° 43' 18.12" E, 1300 m, 4 November 2020, Thulasi & Maya, 14812 (ZGC).

Selaginella miniatospora (Daiz.) Baker, J. Bot. 23: 249. 1885; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 38. 2017.

Stem erect, 12-20 x 1-1.5 cm, glabrous, branched from base, green. Rhizophores 2-6 cm long, slender, cylindrical, arise from 1/3rd of basal part. Leaves heteromorphic, distantly placed in main stem and branches, lateral leaves 2.3-2.5 x 0.9-1.3 mm, oblong-ovate, oblique, membranous; margin denticulate in proximal side, smooth in distal part, apex sub-acute; median leaves 1-1.4x0.1-0.4 mm, ovate, apex aristate,



Plate 4.6: a-f. *Selaginella intermedia* (Blume) Spring a. Habitat b. Habit c. Strobili d. Lateral leaf e. Median leaf f. Axillary leaf. g-l. *Selaginella involvens* (Sw.) Spring g. Habitat h. Habit i. Root j. Lateral leaf k. Median leaf l. Axillary leaf.

margin serrate; axillary leaves 2-2.1 x 1-1.3 mm, ovate, margin distantly minutely denticulate, apex sub-acute. Strobili terminal, 3-4.6 x 2.5-2.8 mm, sessile, solitary or branched. Sporophylls dimorphic, larger 1-1.5 x 0.1-0.6 mm, oblong-elliptic, margin serrate, apex acute, membranous; smaller 0.9-1 x 0.4-0.5 mm, broadly ovate, margin serrate, apex aristate. Megaspores four per sporangium, yellow, globose, tetrahedral, papillate; microspores numerous, trilete, orange-red. (Plate 4.7: Fig. a-i.; Plate 4.80: Fig. f.)

Distribution: Terrestrial or on wet rocky surfaces along shaded lateritic mud cliffs, between 800-1500 m. Found growing at Nelliampathy.

Specimen/s examined: Kerala: Palakkad District, Nelliampathy, Maattumala, 10° 32' 4.2" N, 76° 43' 18.12" E, 1300 m, 4 November 2020, Thulasi & Maya, 14834 (ZGC).

Selaginella radicata (Hook. & Grev.) Spring, Mém. Acad. Roy. Sci. Belgique 24(2): 14. 1850; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 44. 2017.

Lycopodium praelongum Hook. & Grev., Enum. Filic. J. Bot. (Hook.) Kew Misc.3:107.1833.

Stem decumbent, 30-32 x 0.2-0.4 cm, cylindrical, pale green, branched from base. Rhizophores are about 7 cm long, confined at the basal part, rarely in the upper part, slender, cylindrical. Leaves heteromorphic, except in strobili, compact on stem and branches; lateral leaves ovate-lanceolate, margin ciliate at base, denticulate in upper part, apex acute, 3-4 x 1.5-1.7 mm; axillary leaves ovate-lanceolate, 1.9-2 x 1-1.2 mm, margin ciliate at base, denticulate at apex, acute apex; median leaves 1.8-2 x 1-1.3 mm, ovate, margin ciliate in lower part, dentate in upper part, acuminate at apex; axillary leaves 2-2.2 x 0.8-1 mm, ovate-lanceolate, base oblique, margin dentate at apex, ciliate at base; apex acuminate. Cone terminal, solitary, sessile. Sporophylls isomorphic, spirally arranged, ovate, margin ciliate in basal part, denticulate in upper part, acuminate apex; megasporophylls at basal part and microsporophylls at upper part; megaspores 4 in one sporangium, globose, pale yellow, tetrahedral; microspores numerous, dark red. (Plate 4.7: Fig. j-q.)

Distribution: Terrestrial, on wet mud cliffs, between 900 to 1000 m. Endemic to Southern India. Found growing at Cheriya Govinda Mala, Nelliampathy; Parambikulam Tiger Reserve

Specimen/s examined: Kerala: Palakkad District, Nelliampathy, Cheriya Govinda Mala, 10° 30' 38.16" N, 76° 41' 42" E, 987 m, 3 November 2020, Thulasi & Maya, 14802 (ZGC).

Selaginella tenera (Hook. & Grev.) Spring, Bull. Acad. Roy. Sci. Bruxelles 10(1): 232. 1843; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 41. Pl. 20. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 47. 2017.

Lycopodioides tenera (Hook. & Grev.) Kuntze, Revis. Gen. Pl. 2: 827. 1891.

Stem erect, rooting at the base, 3.5-3.7 mm thick without leaves, green to reddish pink colour in fresh, stramineous to pink in dry; entire plant is 30-32 cm height, with primary alternate branches, they branched several times. Leaves dimorphic, continuous on main stem and on primary axis, spreading and dense on the other branches; lateral leaves 3.5-3.6 x 2-2.2 mm, oblong-ovate, sub-acute, acroscopic margin denticulate, on rest entire, base unequal; median leaves ovate, 1-1.3 x 0.5-0.8 mm, aristate, arista less than half the length of the leaf, margins dentate; axillary leaves ovate, 0.9-1.2 x 0.4-0.5 mm, apex aristate. Cones dorsiventral; sporophylls dimorphic, megasporangia on lateral sporophylls, others with microsporangia; megaspore globose, off white, tetrahedral; microspores red in colour, tetrahedral. (Plate 4.8: Fig. a-g.; Plate 4.80: Fig. g.)

Distribution: Terrestrial on shaded forest floor or road sides, between 100 to 2000 m. Found growing at many locations in the entire study area.

Specimen/s examined: Kerala: Palakkad District, Mannarkkad, Meenvallam, 10° 55' 24.96" N, 76° 33' 51.84" E, 85 m, 11 September 2018, Thulasi, 14206 (ZGC); Olavakkode, Dhoni, 10° 51' 34.2" N, 76° 37' 21.72" E, 120 m, 13 September 2018, Thulasi & Maya, 14226 (ZGC); Mannarkkad, Virgin Valley, 11° 2' 42.72" N, 76° 26' 33" E, 79 m, 24 November 2018, Thulasi, 14284 (ZGC); Nelliampathy, Manpara, 10° 33' 27.72" N, 76° 44' 40.38" E, 1065 m, 1 December 2018, Thulasi &



Plate 4.7: a-i. *Selaginella miniatospora* (Daiz.) Baker a. Habitat b. Habit c. Root d. Strobili e. Lateral leaf f. Axillary leaf g. Median leaf h. Microsporophyll i. Megasporophyll with megasporangium. j-q. *Selaginella radicata* (Hook. & Grev.) Spring j. Habitat k. Habit. l. Prostrate stem m. Stem bearing strobili n. Strobilus o. Lateral leaf p. Axillary leaf q. Median leaf.

Maya, 14298 (ZGC); Silent Valley National Park, Kummattanthodu, 11° 5' 33.36" N, 76° 26' 44.16" E, 1020 m, 22 October 2019, Thulasi, 14448 (ZGC); Parambikulam Tiger Reserve, Karimala, 10° 30' 42.84" N, 76° 52' 49.44" E, 5 December 2019, Thulasi, 14580 (ZGC); Parambikulam TR, Vengolimala, 10° 23' 45.24" N, 76° 46' 30.36" E, 600 m, 6 December 2019, Thulasi, 14611 (ZGC); Nelliampathy, Cheriya Govinda mala, 10° 30' 38.16" N, 76° 41' 42" E, 987 m, 3 November 2020, Thulasi & Maya, 14801 (ZGC); Agali, Ommala, 11° 3' 35.964" N, 76° 36' 40.284" E, 730 m, 14 November 2021, Thulasi, 14929 (ZGC); Idukki District, Mathikettan Shola National Park, 9° 58' 47.28" N, 77° 14' 12.84" E, 1400 m, 1 August 2019, Thulasi, 14361 (ZGC); Malappuram District, Pulamanthol, 10° 53' 56.4" N, 76° 11' 28.68" E, 11 m, 15 November 2018, Thulasi, 14263 (ZGC).

Selaginella wightii Hieron, *Hedwigia* 39: 319. 1900; Manickam & Irud., *Pterid. Fl. W. Ghats S. India*, 34. Pl. 11. 1992; Fraser-Jenkins *et al.*, *Anno. Checklist Indian Pterid.*, 50. 2017.

Stem decumbent, cylindrical, glabrous, 12-13 x 0.1-0.2 cm thick, green; bi- or tri pinnately branched from base; Rhizophores many, cylindrical, 2-7 cm long, prominent at base, present throughout, slender, wiry. Leaves dense, isomorphic, arranged spirally, linear, greenish, 1.8-2 x 0.1-0.2 mm, apex long acuminate, membranous margin, ciliate border. Strobili borne at ultimate branches, slightly distinct from sterile branches, quadrangular, 5-6 x 0.5-1 mm, sporophyll uniform, arranged spirally, ovate, apex acuminate, margin dentate, base cordate. Micro and megasporangia on the same spike, spherical, 1-1.2 mm diameter. Megaspore yellowish brown, globose; microspore yellowish orange, trilete, with prominent ridges. (Plate 4.8: Fig. h-k.; Plate 4.80: Fig. h.)

Distribution: Xerophytic. Grows in open rock crevices with dry condition, between the altitudes 350-1500 m. Found growing at Maanpaara, Nelliampathy; Chinnar.

Specimen/s examined: Kerala: Palakkad District, Nelliampathy, Manpara, 10° 33' 30.6" N, 76° 45' 36.72" E, 1265 m, 1 December 2018, Thulasi & Maya, 14297 (ZGC); Idukki District, Chinnar, 10° 17' 11.76" N, 77° 10' 5.88" E, 933 m, 8 January 2020, Thulasi, 14743 (ZGC).

Isoetales

Isoetaceae Dumort., Anal. Fam. Pl. 67. 1829 (as "Isoetineae").

Isoetes L., Sp. Pl. 2: 1100. 1753.

Isoetes coromandelina L.f., Suppl. Pl. Cyst. Veg. ed. II, 447. 1781; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 34. Pl. 23. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 55. 2017.

Corm subterranean, obconical to hemispheroid, fleshy, 4.8-5 x 4.8-5 mm, bearing fibrous roots. Leaf tufted, erect, grasslike, linear, 10-35 x 0.2-0.5 mm, thin and wide at base, tapered towards apex, dark green, herbaceous, glabrous. Sporangia at the base of sporophylls, 1-1.8 x 0.8-1 cm, heterosporangiate; megasporangia reniform, connected by a ligule at apex, sporangial wall membranous, transparent, inner wall has horizontal trabeculae, with membranous ligule; microsporangia same as megasporangia, rare; megaspore granular, triangular, trilete whitish; microspores whitish, monolete. (Plate 4.9: Fig. a-d.; Plate 4.80: Fig. j.)

Distribution: Rare species in the current study area; terrestrial on exposed marshy or water-logged areas. Found growing at Viruthi, Vengappara of Kollengode range.

Specimen/s examined: Kerala: Palakkad District, Nenmara, Kollengode, Vengappara, 10° 34' 54.048" N, 76° 42' 43.488" E, 108 m., 28 July 2018, Thulasi and Maya, 14205 (ZGC).

Psilotopsida

Ophioglossales

Ophioglossaceae (R. Br.) C.A. Agardh, Aphor. Bot. 8: 113 (1822).
("Ophioglosseae")

Key to Genera

1. Veins anastomosing; sterile leaf simple *Ophioglossum*
1. Veins free; sterile leaf dissected 2
2. Spike bi- to tri pinnatifid *Botrychium*
2. Spike simple *Helminthostachys*



Plate 4.8: a-g. *Selaginella tenera* (Hook. & Grev.) Spring a. Habitat b. Rhizophore c. Habit d. Strobili e. Lateral leaf f. Axillary leaf g. Median leaf. h-k. *Selaginella wightii* Hieron h. Habitat i. Habit enlarged j. Vegetative leaf k. Sporophyll

Ophioglossum L., Sp. Pl. 2: 1062 (1753).

Ophioglossum costatum R. Br., Prod. Fl. Nov. Holl. 163. 1810; Nayar & Geev., Fern Fl. Malabar 74. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 74. 2017.

Rhizome globose, tuberous, unbranched, 1-1.5 x 1.5-2.3 cm, with unbranched roots. Fronds 3-4 at a time, simple, clustered; stipe 1-4.5 cm x 1.4-3 mm, green, soft, fleshy. Sterile fronds 4-8 x 2-3 cm, ovate- lanceolate, apex acute or obtuse, base cuneate, margin entire, lamina thick, glabrous, fleshy, midrib raised abaxially, having oblique veins, costal areoles, free-ending veinlets; marginal secondary areoles form irregular intramarginal vein. Fertile frond stalked, 5-18 cm x 1.6-3.4 mm, spore- bearing segment 3-7 x 0.2-0.4 cm wide, dorsiventral, apex acute. (Plate 4.9: Fig. e-j.)

Distribution: Terrestrial herbs distributed in exposed marshy areas within the Gap region. Found growing at Viruthy, Vengappara of Kollengode range

Notes: The population of *O. costatum* growing at Viruthy, Vengappara of Kollengode range, showed a wide range of variations in shapes of rhizome and sterile fronds. Some plants were with branched fertile fronds. Recently, a new taxon, *O. madhusoodananii* Sojan *et al.* (2022) was proposed based on collections from the same locality. An examination of the protologue of *O. madhusoodananii* gives the impression that it is not much different from *O. costatum*, but is with some natural variations. However, it is not confirmed here as the type specimens of *O. madhusoodananii* were not examined. Khan *et al.* (2023) also treated it as a cytotype of *O. costatum*, and suggested for synonymising.

Specimen/s examined: Kerala: Palakkad District, Nenmara, Kollengode, Vengappara, 10° 34' 54.048" N, 76° 42' 43.488" E, 108 m., 28 July 2018, Thulasi & Maya, 14203 (ZGC).

Botrychium Sw., Schrd. J. Bot. 1800 (2): 8, 110 (1801).

Key to species

1. Fertile spike originated from the rachis a little above the base
.....**B. lanuginosum**
1. Fertile spike originated from the middle of the rachis**B. daucifolium**

Botrychium daucifolium Wall. ex Hook. & Grev., Ic. Fil. t. 161. 1829; Bedd. Handb. Ferns Br. India, 469, t. 294. 1883; Manickam, Fern Fl. Palni Hills, 8. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 54. Pl. 32. 1992; Nayar & Geev., Fern Fl. Malabar 68. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 67. 2017.

Sceptridium daucifolium (Wall. ex Hook. & Grev.) Lyon, Bot. Gaz. 40: 457. 1905.

Rhizome erect, cylindrical, 2-3 x 0.5-1 cm, glabrous, bearing thick fleshy glabrous roots. Fronds variable in size, common stalk up to 35 cm long, 1.5 cm thick, ensheathed at the base by base of withered stalk, terete, sparsely pubescent, branching into a fertile or a sterile segment. Sterile stalk 7-8 cm long, forked twice, resulting in three branches each bearing bipinnatifid, transversely broad angulate-ovate blade; entire lamina 17-18 x 21-22 cm, middle branch larger, basal pinnae of each branch stalked, angulate-ovate, upper pinnae 5 pairs, decurrent, oblong-lanceolate, lobed more than half way to the costa; lobes 3-4 x 1.5-2 cm, ovate-oblong, irregularly serrate, apex acute, costa and costules narrowly winged above, veins slightly distinct, lamina dark green; herbaceous, pinnules sparsely hairy beneath, glabrous above. Fertile spike arise a little above the middle region of the stipe, 16-18 x 4.5-5 cm thick, tripinnate, ultimate segment bearing two compact rows of spherical sporangia, dehiscing by a median slit; spores many, trilete, globose, pale yellow. (Plate 4.10: Fig. a-e.; Plate 4.87: Fig. a.)

Distribution: Grows as isolated plants on shaded moist forest floor, at altitudes above 900 m. Found growing at both North (Silent Valley National Park) as well as South (Nelliampathy hills, Mathikettan Shola National Park) of Palghat Gap in the

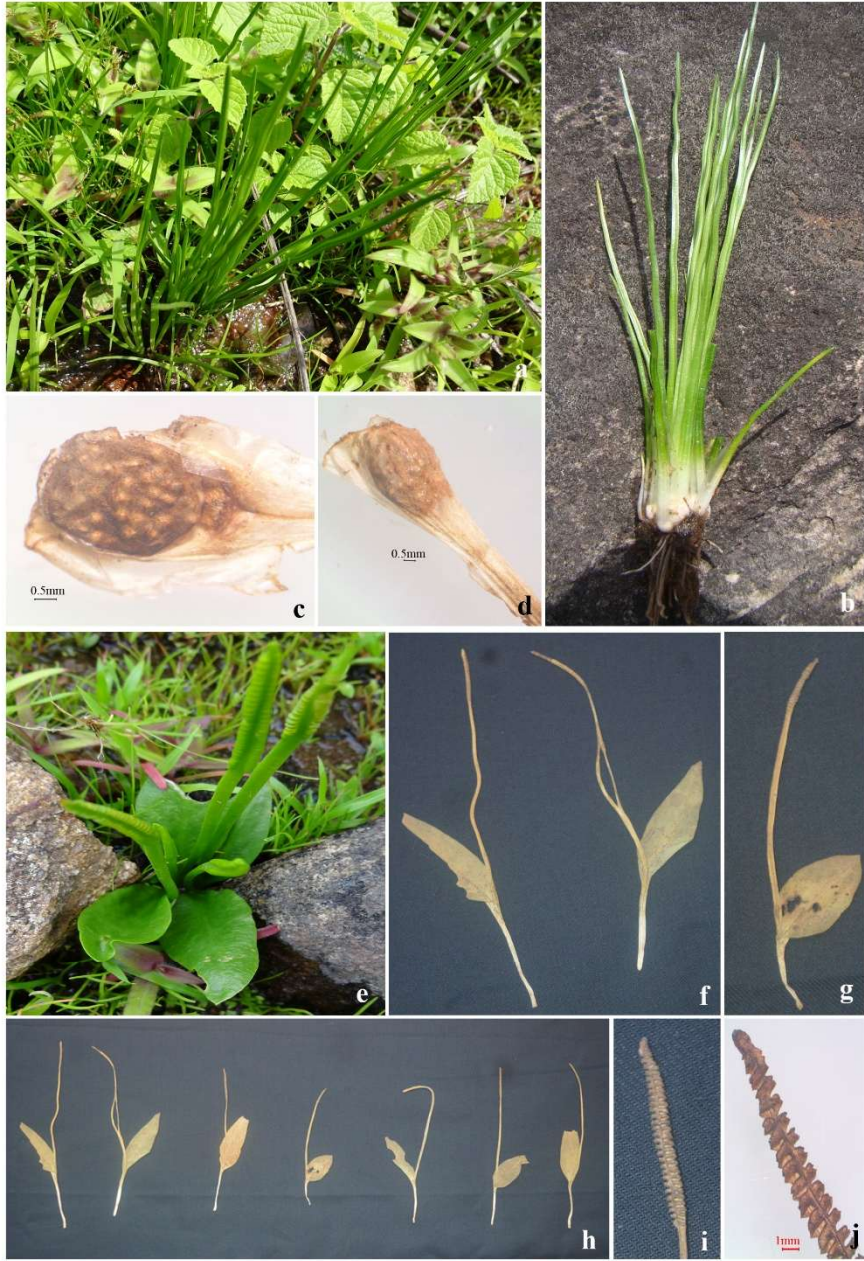


Plate 4.9: a- d. *Isoetes coromandelina* L.f. a. Habitat b. Habit c-d. Megasporangium. e-j. *Ophioglossum costatum* R. Br. e. Habitat f-h Morphological variation in habit i-j. Sporophore.

present investigation. Rare.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Valiyaparathodu-Madrithodu, 11° 6' 49.32" N, 76° 25' 51.6" E, 910 m, 27 December 2019, Thulasi, 14634 (ZGC); Walakkad, 11° 12' 5.04" N, 76° 26' 41.28" E, 2114 m, 3 January 2022, Thulasi, 14996 (ZGC); Idukki District, Pambadum Shola National Park, Kuttikkad, 10° 7' 33.6" N, 77° 15' 22.68" E, 1892 m, 30 July 2019, Thulasi, 14353 (ZGC); Mathikettan Shola National Park, 9° 58' 47.28" N, 77° 14' 12.84" E, 1400 m, 1 August 2019, Thulasi, 14366 (ZGC); Choondal, 9° 59' 4.56" N, 77° 14' 46.68" E, 1500 m, 2 August 2019, Thulasi, 14393 (ZGC).

Botrychium lanuginosum Wall. ex. Hook. & Grev., Icon. Fil. 1(4): t. 79. 1828; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 534. Pl. 31. 1992; Nayar & Geev., Fern Fl. Malabar 69. 1993; Fraser-Jenkins *et al.*, Annot. Checklist of Indian Pterido, 68. 2017.

Rhizome erect, 10-15 mm thick, having few large irregular dark-brown stipule like remnants of old leaf base. Frond solitary, 15-30 cm long, 5-10 cm thick. Lamina spreading, 10-20 x 15-25 cm, 3-4 pinnate; primary pinnae 3-5 pairs, subopposite, basal pinnules deltoid-ovate to ovate-deltoid, 8-15 x 6-12 cm, secondary pinnae 4-6 pairs, basal most secondary pinnae being on basisopic side and largest, distinctly stalked, obliquely-deltoid ovate; tertiary pinnae 1-5 pairs, lobes sessile, adnate at base; margin toothed. Fertile spike formed from adaxial side of rachis, long or longer than sterile frond, 308 cm long, anterior region pinnately divided, sporangia globose, yellowish when mature; spores triangular, yellowish.

Distribution: Terrestrial along fully or partially espoused roadsides. Between 900-2400 m.

Notes: During the present study this species could not be recorded. Added here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Kerala: Palakkad District, Valiyaparathodu, Nair & Bhargavan, 69526 (MH); Idukki district, Kulamavu, Mohanan, 79971 (MH).

Helminthostachys Kaulf. Enum. Fil. 28. 1824.

Helminthostachys zeylanica (L.) Hook., Gen. Fil. t. 47. 1840; Bedd., Handb. Ferns Br. India, 467. T. 292. 1883; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 55. Pl. 33. 1992; Nayar & Geev., Fern Fl. Malabar 71. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 73. 2017.

Osmunda zeylanica L., Sp. Pl. 2: 1063. 1753.

Rhizome short creeping, 1-1.8 cm in diameter, tuberous, terete with 2.8-3 mm thick fleshy roots arranged in two alternate rows on the abaxial side; adaxial side with single row of closely arranged stipe scars; apex covered by oblong, 10-11 x 7-7.5 mm, pale brown entire, round scales; stipe solitary, produced annually from the same rhizome, 33-35 x 0.4-0.6 cm, pale brown at the base, greenish above, terete, glabrous. Lamina more or less orbicular in outline, divided, each branch shortly stalked; lateral branch bears an accessory leaf at the basal region, forked equally about 4 cm above from the base; the accessory branches of lateral branches pendent, middle branch bears a pair of opposite basal leaves and then it forks equally 1.5-2 cm above from the base; ultimate segments 15-17 x 3-5 cm, oblong lanceolate, apex acute base cuneate, margin irregularly wavy with narrow, pale brown, membranous border; costa slightly raised and rounded below, shallowly grooved above, narrowly winged above and below with sharp edges; veins distinct, forked once or twice, free, parallel, 1-2 mm apart, reaching the margin; lamina pale green, glabrous above and below, texture herbaceous. Fertile branch solitary, arising from the base of the sterile lamina with 10-12 x 0.1-0.2 cm stalk, and 6-7 x 0.7-0.9 cm spike; sporangia in small crested clusters forming a loose spike; sporangia in group of four, green, each group with a small sterile lobe at the apex; spores trilete, pale yellow. (Plate 4.10: Fig. f-j.)

Distribution: Observed from only one locality, Nilambur. Terrestrial, near forest edge and inside teak forest. Now considered as rare, once flourished species in laterite soil areas.

Specimen/s examined: Kerala: Malappuram District, Nilambur, 11° 17' 57.48" N, 76° 15' 2.52" E, 30 m, 6 June 2019, Thulasi, 14326 (ZGC).

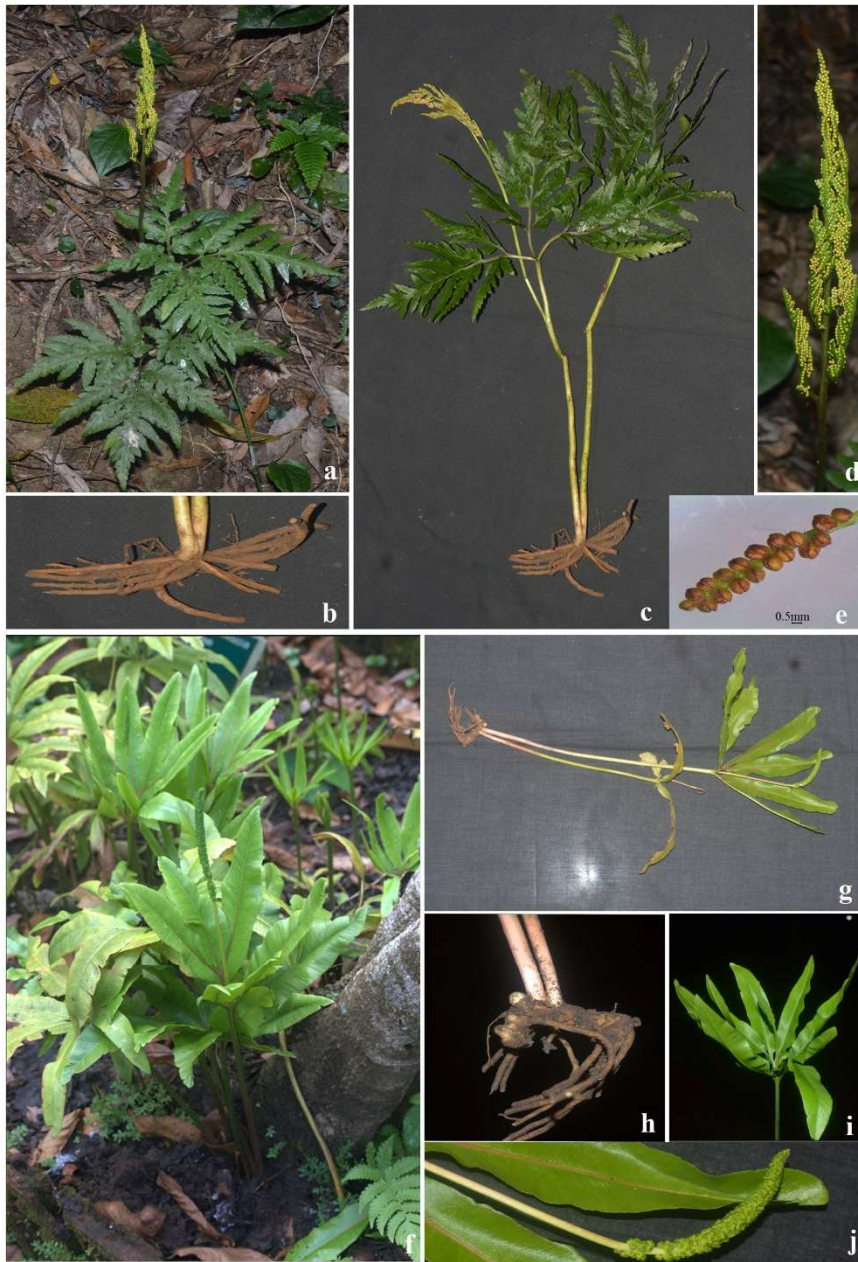


Plate 4.10: a-e. *Botrychium daucifolium* Wall. ex Hook. & Grev. a. Habitat b. Rhizome c. Habit d. Fertile spike e. Sporangia. f-j. *Helminthostachys zeylanica* (L.) Hook. f. Habitat g. Habit h. Rhizome i. Plant with fertile spike j. Fertile spike.

Equisetopsida C. Agardh

Equisetales DC. ex Bercht. & J. Presl

Equisetaceae Michx. ex DC., Michx. ex DC., Essai Propr. Méd. Pl. 49. 1804.

Equisetum L., Sp. Pl. 2: 1061. 1753.

Equisetum ramosissimum Desf., Fl. Atlant. 2: 398-399. 1799; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 44. Pl. 24. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 63. 2017.

Rhizome long creeping, 15-35 cm x 0.3-0.6 mm, subterranean, branched, dark brown, terete with ridges and furrows, with nodes and internodes, bearing fibrous roots and aerial stem, inter nodal length 3.5-3.7 cm, each node bear 0.4-0.5 cm cylindrical sheath. Aerial stem 100-108 x 1-1.3 cm, with nodes and internodes; inter nodal region tubular, surface with many ridges and furrows, nodal region concolorous with inter nodal part, the upper edge of the nodal sheath is dark brown; lateral branches 1-5, borne around the node, erect or pendent, 29-30 x 0.2-0.3 cm, similar to the main stem; leaves scale like, borne on the upper edge of the nodal sheath, 6-8 x 1-2 mm, narrowed, dark and opaque with a thin membranous border at the basal half; aerial stem pale green, glabrous, coriaceous. Cones born at the tip of main stem, 1.5-1.7 x 0.5-0.7 cm; sporangia borne on underside of closely fitted, peltate sporophylls with sporangiophore; spores homosporous, green, globose with elaters. (Plate 4.11: Fig. a-f.; Plate 4.80: Fig. k.).

Distribution: Found growing at Valiyaparathodu and Thudukki of Silent Valley National Park, 900-1500 m altitude. A rare, narrowly distributed species.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Valiyaparathodu-Madrithodu, 11° 6' 49.32" N, 76° 25' 51.6" E, 910 m, 27 December 2019, Thulasi, 14640 (ZGC); Bhavani, Thudukki, 11° 4' 3.36" N, 76° 32' 7.8" E, 520 m, 2 October 2021, Thulasi, 14883 (ZGC).

Marattiopsida**Marattiales** Link**Marattiaceae** Kaulf. Enum. Fil. 31. 1824 (as Marattiae).**Key to Genera**

1. Sporangia fused to form synangia ***Marattia***
1. Sporangia separate from one another, closely arranged in sori ***Angiopteris***

Angiopteris Hoffm., Commentat. Soc. Regiae Sci. Gott. 12 (Cl. Phys.):
29.1796.

The ambiguity on the species of *Angiopteris* in India, and elsewhere, is still existing on a large scale, and was discussed at length in the recent years. Among which the most common and widely reported name was *A. evecta* (G.Forst.) Hoffm. Critical analysis by Fraser-Jenkins (2008, pp. 22-26.) doubted its occurrence in India, but reported the presence of two other species, *A. indica* Desv. and *A. helferiana* C.Presl. These two were distinguished mainly based on the nature of sori being marginal or submarginal (Fraser-Jenkins, 2008). Based on the digital images of fragments of pinnules present at Museum National d'Histoire Naturelle, Paris (P), Mazumdar (2015) designated a lectotype for *A. indica*. However, it was later corrected by Fraser-Jenkins *et al.* (2016) and sinking the name *A. indica* Desv. under *A. evecta* (G.Forst.) Hoffm. At present in India three species of *Angiopteris* are known to occur, viz., *A. crassipes* Wall. ex C.Presl, *A. evecta* (G.Forst.) Hoffm and *A. helferiana* C.Presl. The Southern Indian plants, reported by earlier workers (Beddome, 1863; Manickam and Irudayaraj, 1992; Nayar and Geevarghese, 1993; Nair *et al.*, 1988, etc) as '*Angiopteris evecta* (G.Forst.) Hoffm.' belong to *A. helferiana* or *A. crassipes* (Fraser-Jenkins *et al.*, 2016).

Key to species

1. Sori marginal ***A. crassipes***
1. Sori sub-marginal ***A. helferiana***

Angiopteris crassipes Wall. ex C.Presl, Suppl. Tent. Pterid. 23. 1845; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 84. 2017.

Angiopteris evecta auct. Ind., Manickam & Irud., Pterid. Fl. W. Ghats S. India, 56. Pl. 34. 1992, non (G. Forst.) Hoff., Comm. Soc. Reg. Gott. 12: 29, t. 5. 1796.

Rhizome erect, cylindrical, 24-25 cm in diameter, apex densely covered by dark brown hairs. Stipes 166-170 x 4-5 cm, stipular at the base, abaxially rounded, adaxially flattened bearing whitish linear streaks all over, glabrous. Lamina deltoid, 245-247 x 161-165 cm, bipinnate; pinnae 16-18 pairs, sub-opposite with 2-3 cm long stalk, 15-16 cm apart, oblong-lanceolate, 65-66 x 24-25 cm with a terminal pinnule similar to the lateral ones, base truncate; pinnules 25-26 pairs, sub-opposite, shortly stalked, 2.5-2.8 cm apart, oblong lanceolate, 14-15 x 2-2.5 cm, apex acuminate, base sub-truncate or broadly cuneate, margin serrate in the distal part of the pinnae, crenate in the rest, costa slightly raised and rounded above and below; veins distinct and slightly raised above and below, simple or forked ones, free, reaching the margin; pinnae dark green, glabrous except the occurrence of small, pale brown, soft, laciniate scales on the costa below; texture herbaceous. Sori marginal, ellipsoid; sporangia 6-8 pairs in two rows, compact, free; spores trilete, globose, brown. (Plate 4.11: Fig. g-l).

Distribution: Found growing on the way to Walakkad, from Poochippara; and Naadukaani.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Kunthipuzha trek path, 11° 5' 45.6" N, 76° 26' 57.84" E, 950 m, 22 October 2019, Thulasi, 14500 (ZGC); Nelliampathy, Maattumala, 10° 32' 4.2" N, 76° 43' 18.12" E, 1300 m, 4 November 2020, Thulasi & Maya, 14830 (ZGC); Idukki District, Neriamangalam, 10° 2' 38.76" N, 76° 50' 30.84" E, 500 m, 06 March 2022, Thulasi, 15029 (ZGC). Tamil Nadu: Nadukaani, 11° 28' 51.6" N, 76° 32' 39.12" E, 1800 m, 28 December 2021, Thulasi, 14965 (ZGC).

Angiopteris helferiana C.Presl, Suppl. Tent. Pterid. 22. 1845; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 86. 2017.

Angiopteris evecta auct. Ind., Manickam & Irud., Pterid. Fl. W. Ghats S. India, 56. Pl. 34. 1992, non (G.Forst.) Hoff., Comm. Soc. Reg. Gott. 12: 29, t. 5. 1796.



Plate 4.11: a-f. *Equisetum ramosissimum* Desf. a. Habitat b. Habit c. Rhizome d. Node with nodal sheath e. Nodal sheath f. Strobilus. g-l. *Angiopteris crassipes* Wall. ex C.Presl g. Habitat h. Habit i. Pinna - adaxial side j. Pinna - abaxial side k. Sporophyll with sporangia l. Marginal sori.

Rhizome erect, cylindrical, 24-25 cm in diameter, apex densely covered by dark brown hairs. Stipes 164-170 x 4-5 cm, stipular at the base, abaxially rounded, adaxially flattened bearing whitish linear streaks all over, glabrous. Lamina deltoid, 245-250 x 160-165 cm, bipinnate; pinnae 15-20 pairs, sub-opposite with 2-3 cm long stalk, 15-16 cm apart, oblong-lanceolate, 65-66 x 24-25 cm with a terminal pinnae similar to the lateral ones, base truncate; pinnules 25-26 pairs, sub-opposite, shortly stalked, 2.5-2.8 cm apart, oblong lanceolate, 10-20 x 2-6 cm, apex acuminate, base cuneate, margin serrate in the distal part of the pinnae, crenate in the rest, costa slightly raised and rounded above and below; veins distinct and slightly raised above and below, simple or forked ones, free, reaching the margin; false veins present; pinnae dark green, glabrous except the occurrence of small, pale brown, soft, lacinate scales on the costa below; texture herbaceous. Sori 2-3 mm from the margin, sub marginal, ellipsoid; sporangia 7-13 pairs in two rows, compact, free; spores trilete, globose, brown. (Plate 4.12: Fig. a-h.).

Distribution: Found growing along the way to Walakkad, Poochippara; Malakkappara; Nelliampathy.

Specimen/s examined: Kerala: Palakkad District, Bhavani, Thudukki, 11° 8' 15.72" N, 76° 29' 59.64" E, 1500 m, 2 October 2021, Thulasi, 14908 (ZGC); Idukki District, Neriamangalam, 10° 2' 15" N, 77° 0' 20.88" E, 1000 m, 06 March 2022, Thulasi, 15029 (ZGC). Tamil Nadu: Nadukaani, 11° 28' 51.6" N, 76° 32' 39.12" E, 1800 m, 28 December 2021, Thulasi, 14965 (ZGC).

Marattia Sw., Nov. Gen. Spec. Prodr. Fl. Ind. Occ. 128. 1788.

Marattia fraxinea Sm., Pl. Icon. Ined. 2: t. 48. 1790; Bedd., Ferns S. India 460, t. 78. 1864; Bedd., Handb. Ferns Br. India, 460, t. 286. 1883; Manickam, Fern Fl. Palani Hills, 16. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 57. Pl. 35. 1992; Nayar & Geev., Fern Fl. Malabar 81. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 88. 2017.

Rhizome erect, large, fleshy, 25-45 x 25-35 cm, having dense, spirally arranged leaf bases; stipular flaps either side of leaf base, thick at the bottom, thin towards the

margin, covered by reddish, soft, appressed hairs and scales. Stipe 128-130 x 2-3, young stipes covered by scales and hairs, muricate, green above, purple below, having whitish linear streaks. Lamina bipinnate, deltoid, 122-123 x 150-152 cm, pinnae up to 16 pairs, subopposite, base dark coloured and swollen, lanceolate with a terminal pinnule, pinnules 20 pairs, subopposite, shortly stalked, apex acuminate, unequally cuneate base, margin serrate; costa slightly raised below, veins well distinguished below, slightly above, simple or forked once, free, reaching margin, pinnae dark green above, pale green below, glabrous except in rachis and rachules; thick texture. Sori submarginal, ellipsoid, 3-4 x 1-2 mm wide; sporangia on two rows, fused adjacently, dehisced by longitudinal slit; spores monoete round, brown. (Plate 4.12: Fig. i-p.).

Distribution: Terrestrial, grows along fully shaded trek paths and streams, between 2000-2200 m. Rare in the current study area. Found growing at Silent Valley National Park, North to Palghat Gap.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Walakkad to Sispara trek path, 11° 12' 5.04" N, 76° 26' 41.28" E, 2114 m, 2 January 2022, Thulasi, 14995 (ZGC).

Polypodiopsida

Osmundales

Osmundaceae Berchtold et. J. S. Presl, Prirozen. Rostl. 1: 272.1820,

Osmunda L., Sp. Pl. 2: 1063. 1753.

Osmunda acuta (Burm.f.) Fraser-Jenk., Indian Fern J. 36(1-2): 28. 2019 & Indian J. Forest. 43(1): 65. 2021.

Polypodium acutum Burm. f., Fl. Indica 232. 1768.

Osmunda regalis L., Sp. Pl. 2: 1065.1753; Bedd., Ferns S. India t. 76. 1864; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 59. Pl. 36. 1992; Nayar & Geev., Fern Fl. Malabar 84. 1993.

Osmunda hilsenbergii Grev. & Hook., Hooker Bot. Misc. 3: 230. 1833; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 93. 2017.

Rhizome epigeal, erect or sub erect, elongated, 4-8 cm x 0.2-0.7 m, dichotomously branched, bearing persistent leaf bases, and clothed by a thick dense felt of black slender highly branched roots, devoid of scales and hairs. Fronds crowded, obliquely erect, 42-55 cm long, the basal region laterally expanded, sub cylindrical upwards, pale greenish when fresh, adaxially grooved, abaxially rounded, bearing a few elongated slender tortuous uniseriate occasionally branched thin-walled non-glandular brownish hairs on the basal region. Lamina ovate, 35-100 x 25-30 cm, bipinnate, obliquely erect, rachis similar to stem, bearing several sub opposite pairs of loosely placed primary pinnae, the basal one pair slightly shorter than those above, 6-8 pairs of alternate lateral pinnae; secondary rachis adaxially grooved. Secondary pinnae narrowly oblong to oblong lanceolate, 5-7.5 cm x 7-13 mm, stalked or sessile, loosely placed, margins curved upwards to an acute apex and crenate with the edge cartilaginous; herbaceous to sub coriaceous, thin, naked, glabrous when mature. Veins free and pinnate, with midrib raised upper and lower surface, alternate lateral veins slightly raised and forked with branches parallel extending up to the margin and merging with the cartilaginous part of the sinus. Fertile fronds similar to sterile fronds with only the pinnae of the anterior region of the frond bearing sporangia. Fertile pinnae devoid of lamina but bearing sporangia unprotected greenish when young, dark brown at maturity, pear shaped, short massive stalk and with ill-differentiated annulus. Spores trilete, globose, pale yellowish brown, sub verrucate. (Plate 4.13: Fig. a-f.; Plate 4.87: Fig. b.).

Distribution: Found growing at the flood basin of Kunthi River of Silent Valley NP and Mukurthi NP above 1000 m.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, way to Poochippara, 11° 3' 57.96" N, 76° 32' 10.68" E, 550 m, 26 December 2019, Thulasi, 14621 (ZGC); way to Walakkad, 11° 6' 38.16" N, 76° 25' 20.64" E, 1070 m, 28 December 2019, Thulasi, 14660 (ZGC); Walakkad, 11° 12' 2.88" N, 76° 26' 47.4" E, 2150 m, 2 January 2022, Thulasi, 15004 (ZGC). Tamil Nadu: Mukurthi National Park, Bankitapal, 11° 24' 23.4" N, 76° 44' 47.4" E, 2430 m, 27 February 2022, Maya, 15021 (ZGC).



Plate 4.12: a-h. *Angiopteris helferiana* C.Presl a. Habitat b-c Front d. Pinna - adaxial side e. Pinna - abaxial side f-g. Fertile pinnules with sori h. Sub marginal sorus. i-p. *Marattia fraxinea* Sm. i. Habita j. Frond k. Swollen base of stipe l. Pinna - abaxial side m. Pinna - adaxial side n-o. Pinnules with sori p. Sorus.

Hymenophyllales

Hymenophyllaceae Mart., Consp. Regn. Veg.: 3. 1835.

Key to Genera

1. Indusia valvate; receptacle not extruded *Hymenophyllum*
1. Indusia cupular; receptacle long, extruded *Trichomanes*

Hymenophyllum J. Smith., Mem. Acad. Sc. Turin 5: 418. 1793.

Hymenophyllum exsertum Wall. ex Hook., Sp. Fil. 1: 109, t. 38 A. 1844; Bedd., Ferns S. India 3. pl. 9. 1863; Nayar & Geev., Fern Fl. Malabar 360. 1993; Hameed *et al.*, Filmy Ferns of South India 150. 2003; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 93. 2017.

Rhizome wide-creeping, profusely branched, pale black, 20-35 cm long, 0.3-0.4 mm thick bearing wiry roots and dark brown, thick walled, 2-3 celled hairs 1-2 mm long. Fronds 14-15 cm long, distantly placed; stipes 1-5 cm long, wingless, dark brown, with brown hairs only at the upper portion just below the lamina; lamina oblong-lanceolate or ovate-lanceolate, 7-8 x 3-4 cm, bipinnatifid, round apex, broadly cuneate at base with narrowly winged rachis; mid-rib distinct, bearing fragile, deciduous, multicellular hairs, 0.5-0.6 cm long; pinnae 7-13 pairs, sometimes lowest pinnae slightly reduced, ovate-oblong, round to moderately acute apex, 2.3-2.5 x 0.7-1 cm; pinnules 2-5 in pairs, simple or forked; ultimate segment oblong, 3-4 mm, entire, apex sub-acute; lamina cells polygonal nearly pentagonal or hexagonal, cell walls rather thick, coarsely pitted; costa and veins distinct, slightly raised above and below, costa nearly zigzag or somewhat wavy, bearing alternate lateral veins. No distinction between sterile and fertile fronds. Sori acroscopic, axillary, usually restricted to the anterior half of frond; indusia 1-2 mm wide, bilabiate, free, more or less up to the base; lips irregular, receptacles included. Sporangia spherical longer than broader, small stalked; annulus broad; spores approximately 52 µm in diameter, hemispherical, perineless, exine papillate, green. (Plate 4.13: Fig. g-n.; Plate 4.80: Fig. l.; Plate 4.87: Fig. d.).

Distribution: Growing as erect or pendulous, epiphytic or lithophytic; forms extensive mats on basal region of tree trunks or rocks along the banks of partially or fully shaded streams between altitudes of 700-2500 m. Found growing at Silent Valley National Park, Parambikulam TR and Nelliampathy.

Specimen/s examined: Kerala: Palakkad District, Nelliampathy, Maanpara, 10° 33' 30.6" N, 76° 45' 36.72" E, 1265 m, 1 December 2018, Thulasi & Maya, 14295 (ZGC); Silent Valley National Park, Arikampara, 11° 4' 51.6" N, 76° 26' 36.6" E, 1070 m, 24 October 2019, Thulasi, 14539 (ZGC); Parambikulam TR, Karimala, 10° 25' 15.24" N, 76° 46' 1.2" E, 670 m, 5 December 2019, Thulasi, 14599 (ZGC); Valiyaparathodu-Madrithodu, 11° 6' 52.2" N, 76° 25' 52.32" E, 910 m, 27 December 2019, Thulasi, 14731 (ZGC); Nelliampathy, Cheriya Govinda Mala, 10° 30' 27.72" N, 76° 41' 45.6" E, 990 m, 3 November 2020, Thulasi & Maya, 14788 (ZGC); Walakkad, 11° 12' 3.96" N, 76° 26' 31.92" E, 2065 m, 2 January 2022, Thulasi, 14991 (ZGC).

Trichomanes L. Sp. Pl. 2: 1097. 1753.

Key to species

1. Rhizome erect or sub-erect, stout *T. obscurum*
1. Rhizome creeping, slender 2
2. Fronds simple 6
2. Fronds bi- or tri pinnatifid 3
3. Submarginal false veinlets present 4
3. Submarginal false veinlets absent 5
4. Submarginal false veinlets continuous, striae absent *T. intramarginale*
4. Submarginal false veinlets interrupts, oblique striae present *T. bilabiatum*
5. Fronds semi circular to orbicular *T. minutum*
5. Fronds otherwise *T. campanulatum*
6. Fronds ovate to oblong-lanceolate, margin crenate with single or paired or sometimes stellate hairs *T. exiguum*
6. Fronds ovate to obovate 7
7. Margin entire, glabrous *T. bimarginatum*
7. Margin lobed, club shaped hairs are present *T. schmidianum*

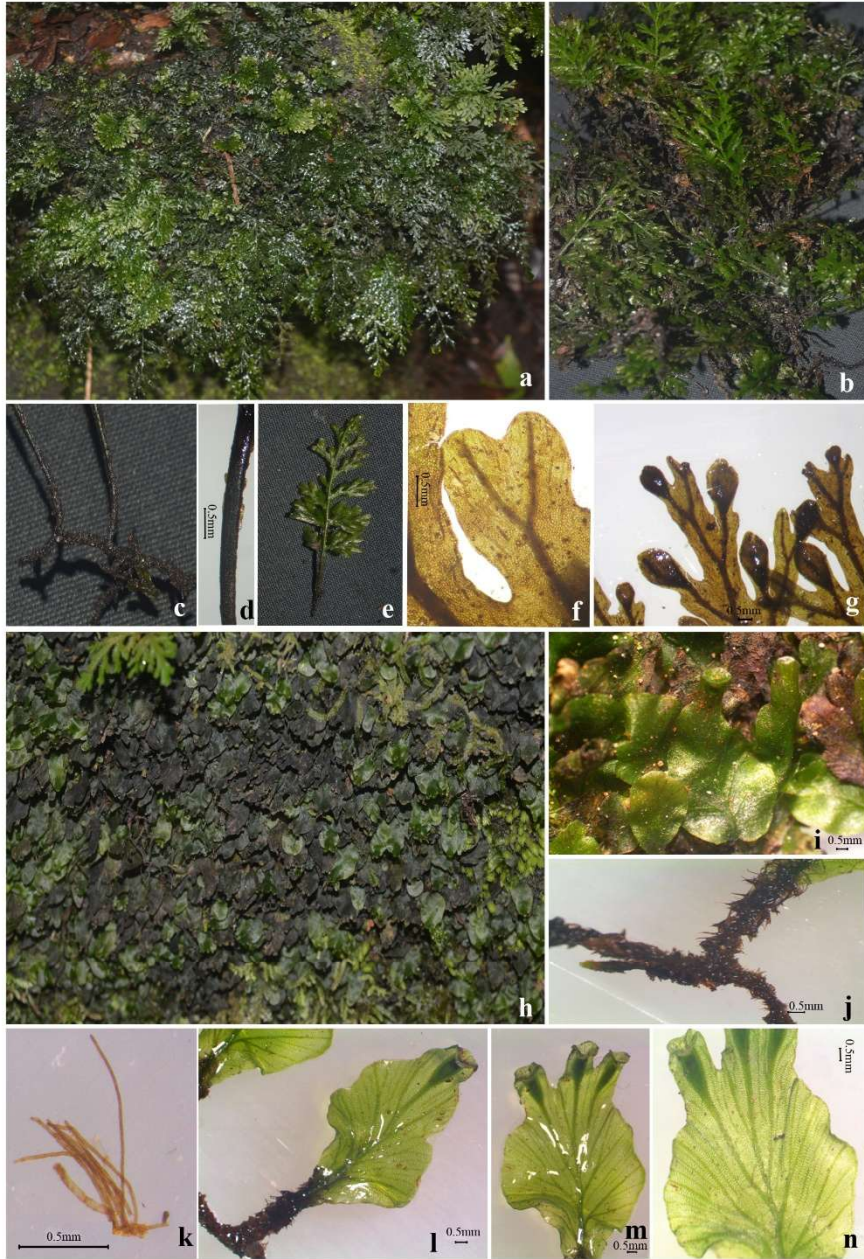


Plate 4.14: a-g. *Trichomanes bilabiatum* Nees & Blume a. Habitat b. Habit c. Rhizome d. Stipe e. Frond f. Veination g. Sori. h-n. *Trichomanes bimarginatum* (Bosch.) Bosch h. Habitat i. Habit j. Rhizome k. Rhizome hairs l. Fertile frond m-n. Sori.



Plate 4.13: a-f. *Osmunda acuta* (Burm.f.) Fraser-Jenk. a. Habitat b. Frond c. Vegetative pinna d-e. Fertile pinna f. Fertile pinnule. g-n. *Hymenophyllum exsertum* Wall. ex Hook. g. Habitat h. Habit i. Fertile frond j-k. Rhizome l-n. Sorus.

Trichomanes bilabiatum Nees & Blume, Nov. Act. Acad. Caes. Leop.-Carol. Nat. Cur. 11: 123. 1823; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 136. 2017.

Crepidomanes bilabiatum (Nees & Blume) Copel., Philipp. J. Sci. 67(1): 59. 1938; Hameed *et al.*, Filmy Ferns of South India 63. 2003.

Rhizome long-creeping, 15-25 cm, filiform, 0.8-0.9 mm thick with dense black unicellular hairs. Fronds distant, 1.5-2.5 cm apart, usually erect but pendent in some large plants; stipes filiform, narrowly winged except at its extreme basal part; laminae glabrous, dark green, bipinnatifid to tripinnatifid, narrowly ovate to narrowly elliptical, 14-15 cm long; rachis winged moderately, wings slightly wavy; pinnae oblique, deltoid or oblong 3.5-3.8 x 1.5-1.8 cm broad, pinnatifid or bipinnatifid; pinnules linear, rounded, entire, 1-2 mm broad. Submarginal false veinlets interrupted, irregular especially in segments; striae oblique, numerous. Lamina cells are oblong, nearly isodiametric. Sori 4-8, confined to the upper part of the pinnae; indusia short, bilipped, involucre obtuse; receptacles exerted. Sporangia spherical, small stalked, green; annulus oblique. (Plate 4.14: Fig. a-g).

Distribution: Epiphytic in evergreen forests. Found growing at Walakkad and Sispara of Silent Valley National Park.

Specimen/s examined: Kerala: Palakkad District, Nelliampathy, Maanpara, 10° 33' 30.6" N, 76° 45' 36.72" E, 1265 m, 1 December 2018, Thulasi & Maya, 14294 (ZGC); Silent Valley National Park, Kummattanthodu, 11° 5' 33.36" N, 76° 26' 44.16" E, 1020 m, 22 October 2019, Thulasi, 14452 (ZGC); Valiyaparathodu-Madrithodu, 11° 6' 52.2" N, 76° 25' 52.32" E, 910 m, 27 December 2019, 14734 (ZGC); Nelliampathy, Maattumala, 10° 32' 4.2" N, 76° 43' 18.12" E, 1300 m, 4 November 2020, Thulasi & Maya, 14811 (ZGC); Bhavani, Thudukki, 11° 8' 3.84" N, 76° 30' 28.08" E, 1300 m, 2 October 2021, Thulasi, 14893 (ZGC); Idukki District, Pampadum Shola National Park, Kuttikkad, 10° 7' 33.6" N, 77° 15' 22.68" E, 1892 m, 30 July 2019, Thulasi & Manju, 14348 (ZGC).

Trichomanes bimarginatum (Bosch.) Bosch, Nederl. Kruidk. Arch. 5(2): 143-144. 1861; Nayar & Geev., Fern Fl. Malabar 361. 1993; Hameed *et al.*, Filmy Ferns of

South India, 181. 2003; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 136. 2017.

Microgonium bimarginatum Bosch, Verh. Konigk. Akad. Wetensch. Amsterdam (Hym. Javan.) 9(4): 7. 1861.

Trichomanes neilgherrense Bedd., Ferns S. India 2. 6. 1863; Bedd., Ferns Br. India. 303. 1869.

Trichomanes muscoides Bedd., Handb. Ferns Br. India, 38. 1883.

Didymoglossum bimarginatum (Bosch) Ebihara & K.Iwats., Blumea 51(2): 236. 2006.

Rhizome filiform, long-creeping, 20-30 cm x 0.1-0.3 mm, branched, covered by dark brown hairs. Fronds simple, scattered on rhizome with a gap of 1 cm; stipes about 7-8 x 0.1-0.2 mm wide, covered by reddish brown, unbranched hairs; lamina 0.5-2 cm x 2-7 mm broad, simple, ovate to obovate, apex obtuse or bifid; base cuneate, margin glabrous entire, submarginal false veins continuous, a single layer of colourless cells separated false veins from margin. Lateral veins from zig-zagged costa and connecting the submarginal false veinlets or not; costa having small hairs mostly on the lower side. Fertile and sterile fronds look alike. Sori 1 or 2 at the terminal part of veins; indusia tubular, 1-2.5 x 1-1.2 mm broad; receptacle long exerted. Sporangia sessile, spherical. Spore spherical, trilete, chlorophyllous. (Plate 4.14: Fig. h-n.).

Distribution: Grown in evergreen forests, on tree trunks or rocks in shaded stream sides of the altitude range 900 to 1000 m.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Valiyaparathodu-Madrithodu, 11° 6' 52.2" N, 76° 25' 52.32" E, 910 m, 27 December 2019, Thulasi, 14730 (ZGC).

Trichomanes campanulatum Roxb., Griffith, Calcutta J. Nat. Hist. 4: 518. 1844; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 139. 2017.



Plate 4.15: a-e. *Trichomanes campanulatum* Roxb. a. Habitat b. Rhizome c. Hairs d. Veination e. Young sori. f-l. *Trichomanes exiguum* (Bedd.) Baker f. Habitat g. Habit h. Fertile frond i. Rhizome j. Hairs on the frond margin k. Veination l. Sorus.

Crepidomanes campanulatum (Roxb.) Panigrahi & Sarn.Singh, Ferns Fern-Allies Arunachal Pradesh 1: 333. 2005.

Trichomanes campanulatum Roxb., Wall., Num. List n. 2199. 1829.

Trichomanes plicatum (Bosch) Bedd., Ferns Brit. India pl. 258. 1868.

Crepidomanes plicatum (Bosch) R.C. Chnig., in Chien & Chun, Fl. Republic Pop. Sin. 2: 171. 1959; Hameed *et al.*, Filmy Ferns of South India 92. 2003.

Rhizome long-creeping, 20-35 cm long, much branched, subfiliform, 1-2 mm in diameter, with short black hairs showing ramifications at the apex. Fronds irregularly spaced, 1-2 cm apart; stipes 2-3 cm long, narrowly winged from the base, bearing short hairs along the margins; laminae narrowly oblong to ovate, with lowest pinnae usually reduced, bipinnatifid to tri-pinnatifid, apex acute or rounded, base broadly cuneate; rachis manifestly winged, wings plane, entire. Primary pinnae alternate, 6-7 pairs, secondary pinnae forked once or twice; ultimate segments linear, plicate when dry. Midrib distinct above and below, pinnate, veins end just below the apex of segments; striae numerous, scattered, but no submarginal false veinlets. Lamina cells pentagonal or hexagonal. Sori many, borne on acroscopic basal segments of pinnae; indusium bi-lipped, obconical, base narrowly winged, with bluntly triangular involucral valves; receptacles exserted; sporangia spherical, green, slightly longer than broader. (Plate 4.15: Fig. a-e.).

Distribution: Epiphytic or epilithic in evergreen forests. Found growing at Valiyaparathodu of Silent Valley National Park.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Valiyaparathodu-Madrithodu, 11° 6' 52.2" N, 76° 25' 52.32" E, 910 m, 27 December 2019, Thulasi, 14732 (ZGC).

Trichomanes exiguum (Bedd.) Baker, Syn. Fil. 464. 1874; Bedd., Handb. Ferns Brit. India 37. 1883; Hameed *et al.*, Filmy Ferns of South India 173. 2003; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 141. 2017.

Hymenophyllum exiguum Bedd., Handb. Ferns Brit. India, t. 275. 1868.

Didymoglossum exiguum (Bedd.) Copel., Philipp. J. Sci. 67: 78. 1938.

Rhizome very slender, wide-creeping, 10-25 cm long, 0.2-0.3 mm thick, bears very short, unicellular hairs. Fronds simple, 1-1.5 x 0.4-0.5 cm broad, short stiped, spaced at short intervals on rhizome, variable in shape, ovate to oblong-lanceolate, round or moderately acute apex, cuneate or obtuse at base; margin crenate with single or paired or sometimes stellate hairs, fertile fronds long, narrow, sterile fronds broader and short. Venation pinnate, costa giving off numerous arching false veins. Sori single, apical; indusia half submerged; mouth prominently bilabiate with rounded, entire, thickened, reddish-margined lips; receptacles exerted. Sporangia spherical, green, sessile. (Plate 4.15: Fig. f-l.).

Distribution: Often intermingled with mosses. Found growing at Valiyaparathodu, Walakkad of Silent Valley National Park.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Valiyaparathodu-Madrithodu, 11° 6' 52.2" N, 76° 25' 52.32" E, 910 m, 27 December 2019, Thulasi, 14733 (ZGC).

Trichomanes intramarginale Hook. & Grev., Icon. Fil. 2(11): t. 211. 1831; Bedd., Ferns S. India t. 208. 1864; Bedd., Ferns Br. India, 41. 1883; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 156. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 143. 2017.

Crepidomanes intramarginale (C.Presl) C.Presl, Abh. Königl. Böhm. Ges. Wiss. 5(6) (Epim. Bot.): 258. 1851.

Crepidomanes indicum C. A. Hameed & Madhus., Sida 18: 520. 1998; Hameed *et al.*, Filmy Ferns S. India 258. 2003.

Rhizome filiform, long-creeping, 10-15 cm long, profusely branched, less than 0.25 mm thick, bearing thick walled, dark brown, unicellular rhizoids. Fronds scattered on rhizomes at intervals of 2-4 mm; stipes 3-5 mm long, covered with profuse hairs like those of rhizomes; lamina irregularly pinnatifid, 2-7 mm long, thin, membranaceous, pinnae 2 or 3-lobed, segments 0.7-0.8 mm wide, margin entire,



Plate 4.15: a-e. *Trichomanes campanulatum* Roxb. a. Habitat b. Rhizome c. Hairs d. Veination e. Young sori. f-l. *Trichomanes exiguum* (Bedd.) Baker f. Habitat g. Habit h. Fertile frond i. Rhizome j. Hairs on the frond margin k. Veination l. Sorus.

single cell-thick, shallowly emarginated apex; lamina segments each with a single vein ending at the apex, arising alternately from the midrib, clothed with spars, clavate dark brown trichomes; submarginal false veinlets thin and continuous, separated from the margin by a single row of comparatively broad, marginal cells; striae absent. Sori 2-8, embedded at the apices of distal segments; indusia usually cup-shaped, sometimes lunar-shaped; receptacle filiform, included. Sporangia subsessile, spherical, green. (Plate 4.16: Fig. a-f.).

Distribution: Epiphytic on the trunks of large trees in the dense evergreen riparian forests. Found growing at Peechi-Vazhani Wildlife Sanctuary and Meenvallam.

Notes: The indusia of recorded specimens are of two types, both cup-shaped and lunar-shaped.

Specimen/s examined: Kerala: Palakkad District, Mannarkkad, Meenvallam, 10° 55' 24.96" N, 76° 33' 51.84" E, 85 m, 11 September 2018, Thulasi, 14215 (ZGC).

Trichomanes minutum Blume, Enum. Pl. Javae 2: 223. 1828; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 146. 2017.

Trichomanes proliferum Blume, Enum. Pl. Jav. 224. 1828; Bedd., Handb. Ferns Br. India 39. 1883; Manickam, Fern Fl. Palani Hills, 6. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 150. Pl. 115. 1992.

Gonocormus prolifer (Blume) Prantl, Unters. Morph. Gefäßskrypt. 1. Hymenoph. 51. 1875; Nayar & Geev., Fern Fl. Malabar 363. 1993.

Crepidomanes proliferum (Blume) Bostock, Fl. Australia 48: 706. 1998; Hameed *et al.*, Filmy Ferns of South India 109. 2003.

Crepidomanes parvulum (Poir.) Nivart, Senterre & Dubuisson, Phytotaxa 523(1): 123. 2021.

Rhizome slender, 10-16 cm long, 0.22-0.25 mm broad, long-creeping, filiform, profusely branched, covered with brown unicellular hairs. Fronds scattered, irregularly spaced, proliferating into 2-3 part-fronds, either from rachis or stipe;

stipes slender, scattered 1.5- 2 cm long, terete, wingless, glabrescent; laminae ovate, oblong, deltoid or lanceolate, 4-4.5 x 1-1.2 cm broad, pinnately compound with pinnate to flabellate pinnae in alternate arrangement; ultimate segment linear, round to moderately acute at the apex. Midrib not much distinct, bearing lateral veins, the basal ones of which fork toward the pinnules; false veins absent. Lamina cells elongated rectangular, cell wall irregularly thickened, wavy. Fertile fronds similar to sterile ones. Sori 4-12, terminal on the basal pinnules; indusia tubular, immersed, broadly winged, mouth truncate without distinct lips. Receptacles exerted when mature. Sporangia spherical, biconvex, short-stalked. Spores trilete, tetrahedral, chlorophyllous, perineless, densely spinulose. (Plate 4.16: Fig. g-j.).

Distribution: Forms dense mat on rocks in the streams of densely shaded areas of evergreen forests. Found growing at Poochippara, Valiyaparathodu, Walakkad of Silent Valley National Park.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Valiyaparathodu-Madrithodu, 11° 6' 52.2" N, 76° 25' 52.32" E, 910 m, 27 December 2019, Thulasi, 14729 (ZGC).

Trichomanes obscurum Blume, Enum. Pl. Jav. 227. 1828; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 148. Pl. 113. 1992.

Selenodesmium obscurum (Blume) Copel., Philipp. J. Sci. 67(1): 81. 1938; Nayar & Geev., Fern Fl. Malabar 363. 1993.

Cephalomanes obscurum (Blume) K.Iwats., J. Fac. Sci. Univ. Tokyo, 3, 13(5): 547. 1985; Hameed *et al.*, Filmy Ferns of South India 42. 2003; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 148. 2017.

Abrodictyum obscurum (Blume) Ebihara & K.Iwats., Blumea 51(2): 244. 2006.

Rhizome short, stout, epigeal, erect to suberect, sometimes very shortly creeping, 1-2 cm high, bearing many wiry roots and clothed by simple, stiff, dark or reddish-brown, 0.5-2 mm long hairs. Fronds clustered, spirally arranged; stipes terete, 15-17 x 0.1-0.2 cm broad, rigid brown or purplish brown when fresh, black when dry

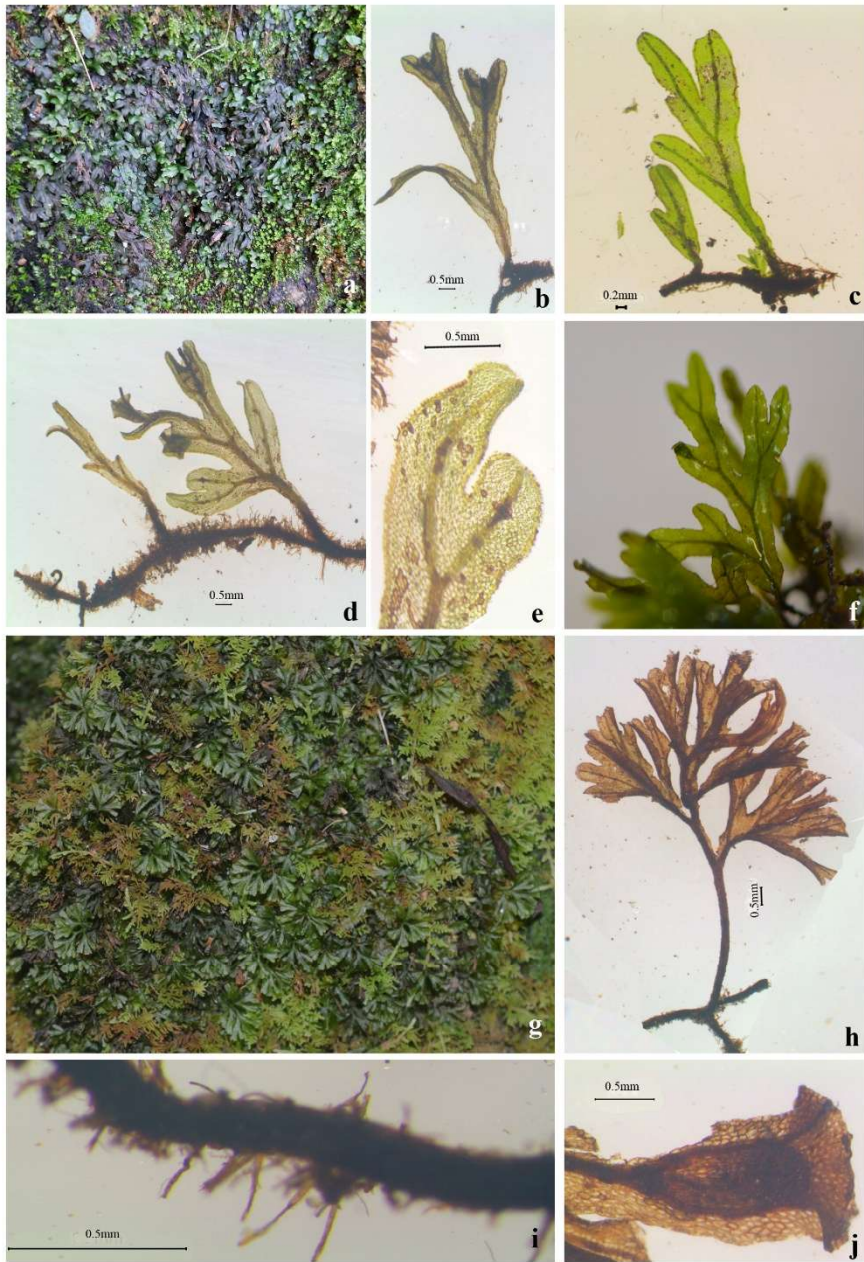


Plate 4.16: a-f. *Trichomanes intramarginale* Hook. & Grev. a. Habitat b-d Habit e. Veinaition f. Young sorus. g-j. *Trichomanes minutum* Blume g. Habitat h. Habit i. Rhizome j. Sorus.

bearing long, deciduous hairs at the base; young leaves circinate coiled; lamina ovate or subdeltoid, broadly cuneate or sub-truncate at the base, 20 x 10 cm, tri-pinnatifid; basal pinnae reduced in some fronds, primary pinnae 18-20 pairs, ovate-deltoid, opposite at the base but alternate towards the middle, acute at the apex, base cuneate, largest pinnae 7x2 cm, more or less oblique to the rachis; secondary pinnae 8-10 pairs, alternate lanceolate, 3x1 cm, the acroscopic basal ones close to the main rachis, overlapping it on the lower surface; pinnules alternate on secondary pinnae, sessile, large, lower pinnules deeply dissected, upper pinnule less deeply dissected; ultimate segment narrow, acute at the apex. Veins obscure at both surfaces, pinnate, diverging into the pinnules, forks to the segments. Fertile fronds similar to the sterile ones; sori restricted to the basal acroscopic segments of pinnules, dark brown, hang downwards when mature; indusia cup-shaped, narrowly winged, 1.8- 2 x 0.8-1 mm; involucre mouth truncate, lips absent; receptacles highly protruded, slightly curved. Sporangia basipetal, semicircular to flabelliform, short stalked; annulus oblique, uninterrupted. Spores globose-trilete, greenish. (Plate 4.17: Fig. a-f.; Plate 4.86: Fig. e.; Plate 4.87: Fig. c.).

Distribution: Terrestrial on wet ground or inhabiting densely shaded cave-like recesses in dense evergreen forests at high altitudes. Found growing at Poochippara, Walakkad, Sispara of Silent Valley National Park

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Valiyaparathodu-Madrithodu, 11° 6' 52.2" N, 76° 25' 52.32" E, 910 m, 27 December 2019, Thulasi, 14646 (ZGC); Walakkad to Sispara trek path, 11° 12' 6.48" N, 76° 26' 24.36" E, 2000 m, 29 December 2019, Thulasi, 14694 (ZGC); Sispara, 11° 12' 3.96" N, 76° 26' 31.74" E, 2065 m, 2 January 2022, Thulasi, 14986 (ZGC).

Trichomanes schmidianum Zenker ex Taschner, Dissert. Trichom. 34, t. 1, f. 1, 3, 5. 1843; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 154. Pl. 118. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 149. 2017.

Vandenboschia schmidiana (Zenker ex Taschner) Copel., Philipp. J. Sci. 67(1): 53. 1938; Nayar & Geev., Fern Fl. Malabar 365. 1993.

Crepidomanes schmidianum (Zenker ex Taschner) K.Iwats., J. Fac. Sci. Univ. Tokyo III. 73: 19, Pl. 4. 1985; Hameed *et al.*, Filmy Ferns of South India 127. 2003.

Rhizome long creeping, slender, 10-15 cm long, 1.5-2 mm thick, filiform, black, profusely branched, dark reddish-brown short rhizoids mixed with short brown hairs. Fronds scattered; stipe 1-1.5 cm long, erect, dorsiventral, base having many rhizoids, young part having 2-3 celled short club-shaped hairs. Lamina broadly ovate, 3-5 x 2-3 cm, apex blunt, downward narrowed, base decurrent, margin deeply lobed; lobes elongate, strap-like, forked 2 or 3 times, ultimate lobes 3-4 x 1.5-2 mm; lamina thin membranaceous, having short club shaped hairs. Fertile fronds similar to sterile ones; sori in one row along the sides of rachis, restricted to basal lobe, terminal, narrowly oblique to rachis, 1.5-2 x 0.5-1 mm; spores commonly develop into prothalli within the sporangium.

Distribution: Grows in montane evergreen forests as lithophytes along shaded stream sides, between 700 to 1500 m.

Notes: During the present study this species could not be recorded. Added here based on the previous report (Nayar and Geevarghese, 1993; Hameed *et al.*, 2003) from the current study area.

Specimen/s examined: Tamil Nadu: Avalanchi, Ooty, Abdul Hameed, 51938 (CALI). Kerala: Palakkad District, Silent Valley National Park, Poovanchola, S. Stephan, 007669 (MH).

Gleicheniales

Gleicheniaceae (R. Brown) Presl., Rel. Haenk. 1(1): 70. 1825.
(Gleicheniae).

Dicranopteris Bernhardt., Schrader's Neues J. Bot. 1(2): 38. 1805.

Key to species

1. Primary branches forked several times; stipules clasping the rachis
..... ***D. taiwanensis***
1. Primary branches forked 2 or 3 times; stipules lobed to auricled, leafy ultimate branches ***D. linearis***

Dicranopteris linearis (Burm.f.) Underw., Bull. Torrey Bot. Club 34(5): 250. 1907; Nayar & Geev., Fern Fl. Malabar 367. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 101. 2017.

Polypodium lineare Burm.f., Fl. Ind. 235, t. 67, f.2. 1768. *non* Thunb., 1784.

Gleichenia linearis (Burm.f.) C.B. Clarke, Trans. Linn. Soc. London, Bot. 1: 428. 1880.

Dicranopteris linearis var. *brevis* Manickam & Irud., Pterid. Fl. W. Ghats S. India, 158. Pl. 121. 1992.

Dicranopteris linearis var. *tenuis* Manickam & Irudarajay, Pterid. Fl. West. Ghats, S. India 159. 1992.

Dicranopteris linearis var. *inaequiloba* B.K. Nayar & Geev., Fern Fl. Malabar 372. 1993.

Rhizome long creeping, 40-100 cm long, slender, branched, epigeal, 3-6 mm thick, hard, dark-brown, hairy. Stipe scattered, 56-60 x 0.2-0.25 cm, brown, glabrous. Lamina 35-40 x 55-60 cm, primary branches 2-3 pairs, 15-16 cm apart, forked 1-2 times; unequal secondary branches, accessory branches at the fork, stipules lobed to auricled, leafy ultimate branches 18-20 x 3-4 cm, oblanceolate, acuminate pinnatifid, leaf segments 1.6-2 x 0.2-0.4 cm, oblong, slightly narrowed towards apex, veins forked 2-3 times; pinnae pale green, glabrous. Sori submedian on veinlets, spores pale green, round. (Plate 4.17: Fig. g-k.; Plate 4.81: Fig. a.).

Distribution: Terrestrial, common in fully exposed land cuttings, form thickets; between 700-2400 m.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Kummattanthodu, 11° 5' 33.36" N, 76° 26' 44.16" E, 1020 m, 22 October 2019, Thulasi, 14446 (ZGC); Poochippara, 11° 8' 0.96" N, 76° 24' 42.84" E, 1140 m, 28 December 2019, Thulasi, 14674 (ZGC); Agali, Ommala, 11° 3' 35.64" N, 76° 36' 39.96" E, 730 m, 14 November 2021, Thulasi, 14936 (ZGC); Idukki District, Neriambangalam, 10° 3' 29.88" N, 76° 48' 11.88" E, 350 m, 06 March 2022, Thulasi,

15026 (ZGC). Tamil Nadu: Ooty, 11° 14' 40.2" N, 76° 42' 7.56" E, 650 m, 21 November 2021, Thulasi, 14946 (ZGC); Mukkurthi National Park, Bankitapal, 11° 24' 23.4" N, 76° 44' 47.4" E, 2430 m, 27 February 2022, Maya, 15019 (ZGC).

Dicranopteris taiwanensis Ching & P.S.Chiu in Chien & Chun, Fl. Reipubl. Pop. Sin. 2: 346. 1959; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 102. 2017.

Dicranopteris linearis var. *sebastiana* Panigrahi & R.D.Dixit, Bull. Bot. Surv. India 13(1 & 2): 162-163. 1971; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 157. Pl. 120. 1992. *Dicranopteris linearis* var. *demota* Holttum, Reinwardtia 4: 275. 1957; Nayar & Geev., Fern Fl. Malabar 371. 1993.

Rhizome long creeping, 40-110 cm long, 0.5-1 cm thick, with wiry roots in the lower side, covered by brown hairs. Stipe scattered, 10-11 cm apart, 155-160 x 0.5-0.6 cm, terete, dark brown, hairy at base, glabrous above. Lamina 125-130 cm long, primary branches forked 3-4 times; stipules clasping the rachis, 1-1.1 x 1-1.1 cm, ovate, entire; accessory branches from the fork; leafy branch 17-18 x 3-4 cm, lanceolate, acuminate, pinnatifid, 1-3 mm to costa, segments oblong, 1.8-2 x 0.4-0.5 cm, entire, apex notched, sinus wide at apex, veins distinct above and below, forked 3-4 times, free, reaching the margin; pale green, glabrous; chartaceous texture; sori submedian on the acroscopic veinlet, round, pale brownish green.

Distribution: Terrestrial, thicket forms in open areas of land cuttings. Between 300-800 m.

Notes: During the present study this species could not be recorded. Included here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Kerala: Palakkad District, Silent Valley, Walakkad, Nayar and Party, 10672 (CALI); Palakkad, Nair & Bhargavan, 67480 (MH). Tamil Nadu: Nilgiris, Vivekanandan, 42970 (MH).



Plate 4.17: a-f. *Trichomanes obscurum* Blume a. Habitat b. Frond c. Rhizome d. Veination e. Hair f. Fertile frond with sori. g-k. *Dicranopteris linearis* (Burm.f.) Underw. g. Habitat h. Frond i. Rhizome hairs j. Bifurcation of stem with bud k. Young sprophyll with sori.

Schizaeales

Lygodiaceae C. Presl, Suppl. Tent. Pterid. 98. 1845.

Lygodium Sw. in Schrader, J. Bot. 1800(2): 7, 106. 1801, *nom. cons.*

Lygodium flexuosum (L.) Sw., Schrader J. Bot. 1800(2): 106. 1801; Bedd., Handb. Ferns Br. India. 457, 283. 1883; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 61. Pl. 38. 1992; Nayar & Geev., Fern Fl. Malabar 92. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 107. 2017.

Rhizome short creeping, 5-6 cm long, 0.5-0.7 cm thick, densely covered by long, dark brown, multicellular, uniseriate, tubular hairs all over. Stipes closely arranged, 45-50 cm x 3-4 mm, dark brown and densely hairy at the base, stramineous and glabrous above, abaxially rounded, adaxially flattened; fronds oblong-lanceolate; about 80 cm wide, tripinnate; primary pinnae alternate, 13-15 cm apart with 2-3 mm long common stalk forked once and bearing a dormant bud on the forking axis; each forked branch bears two to three pairs simple or forked pinnules alternatively; pinnules about 10-12 x 2.5-3 cm, oblong-lanceolate, simple or forked or auriculated pinnules; margin regularly or irregularly serrulate in sterile pinnule; costa raised above and below; veins distinct above and below, forked thrice or twice, free, reaching the margin; axis of the main branches and costa sparsely pubescent; pinnae pale green, texture herbaceous. Sporangia arranged adaxially on finger-like spikes along the margin of the pinnules; sporangia about 5 pairs, alternate; indusiate; spores yellowish brown, hemispherical. (Plate 4.18: Fig. a-f.).

Distribution: Terrestrial climber along partially or fully shaded road sides between 10- 950 m altitude.

Specimen/s examined: Kerala: Palakkad District, Olavakkodek, Dhoni, 10° 51' 34.2" N, 76° 37' 21.72" E, 120 m, 13 September 2018, Thulasi & Maya, 14234 (ZGC); Mannarkkad, Mothikkal, 10° 57' 27" N, 76° 25' 41.16" E, 53 m, 18 September 2018, Thulasi, 14237 (ZGC); Arakurussy, 10° 59' 41.28" N, 76° 26' 48.84" E, 54 m, 17 October 2018, Thulasi, 14254 (ZGC); Virgin Valley, 11° 2' 42.72" N, 76° 26' 33" E, 79 m, 24 November 2018, Thulasi, 14288 (ZGC);

Elivalmala, 10° 52' 26.04" N, 76° 38' 10.68" E, 300 m, 1 July 2019, Thulasi, 14746 (ZGC); Walayar, Chacolas, 10° 51' 16.2" N, 76° 45' 5.76" E, 270 m, 31 August 2019, Thulasi, 14405 (ZGC); Ottappalam, Rayiranallurmala, 10° 52' 14.16" N, 76° 9' 16.92" E, 33 m, 16 September 2019, Thulasi, 14412 (ZGC); Akamalavaram, 10° 52' 7.392" N, 76° 42' 43.38" E, 212 m, 02 January 2020, Thulasi, 14739 (ZGC); Malappuram District, Pulamanthol, 10° 53' 56.4" N, 76° 11' 28.68" E, 11 m, 15 November, 2018, Thulasi, 14269 (ZGC); Thrissur District, Athirappilly, Malakkappara, 10° 17' 47.76" N, 76° 47' 38.76" E, 930 m, 14 February 2021, Thulasi, 14839 (ZGC); Peechi, 10° 32' 17.88" N, 76° 25' 2.64" E, 160 m, 9 July 2021, Thulasi, 14862 (ZGC).

Anemiaceae Link., Fil. Spec. 23, 1841

Anemia Sw., Syn. Fil. 6, 155. 1806.

Anemia schimperiana C. Presl subsp. *wightiana* (Gardner) Fraser-Jenk., Taxon. Revis. Three Hundred Indian Subcont. Pterid. 32. 2008; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 112. 2017.

Anemia wightiana Gardner, Calcutta J. Nat. Hist. 7: 10. 1847; Bedd., Ferns S. India 22, 66. 1864; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 64. Pl. 40. 1992; Nayyar & Geev., Fern Fl. Malabar 86. 1993.

Rhizome erect or suberect, 6-10 cm long, 2-3 cm thick, densely clothed with 5-6 mm long, thin, soft, multicellular, woolly, deciduous hairs all over. Stipes tufted, 26-30 x 0.2-0.4 cm in fertile fronds, 17-20 x 0.3-0.4 cm in sterile fronds, abaxially rounded, adaxially grooved with revolute margin, stramineous, densely covered by hairs; rachis similar to stipes; fronds monomorphic, ternately divided, two lateral branches fertile, terminal sterile, sterile branch 22-25 x 11-14 cm, bipinnate, apex acuminate, base broadly cuneate, pinnae about eight pairs, slightly ascending, opposite or subopposite, shortly stalked, largest pinna 9-10 x 5-6 cm, oblong lanceolate, apex acute, base sub-truncate, pinnules 8 pairs, adnate, basal pairs ovate, others oblong, 2.4-2.5 x 0.7-0.8 cm, apex rounded, margin sub-crenate, basiscopic base decurrent, connecting the acroscopic base of adjacent pinnules. Costa raised

and slightly rounded above, flattened below; veins slightly distinct below, raised and well distinct above, free, reaching the margin. Pinnae dark green; short unicellular, stiff hairs densely distributed on costa, costules and veins, above and below; texture thick herbaceous; fertile branches two, much contracted, borne below the sterile lamina, 7-10 x 0.9-1 cm with 3-4 cm long stalk, sporangia borne on the surface of the lobes. Spore triangular, pale yellow. (Plate 4.18: Fig. g-m.).

Distribution: Terrestrial, grows on fully shaded land cuttings at 1000 to 1500 m. Found growing along sides of Kunthi River, Silent Valley National Park.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Kunthipuzha trek path, 11° 5' 45.6" N, 76° 26' 57.84" E, 950 m, 22 October 2019, Thulasi, 14497 (ZGC); Parathodu, 11° 5' 33" N, 76° 26' 44.52" E, 1020 m, 23 October 2019, Thulasi, 14522 (ZGC); Poochippara, 11° 8' 0.96" N, 76° 24' 42.84" E, 1140 m, 28 December 2019, Thulasi, 14670 (ZGC); Nelliampathy, Maattumala, 10° 32' 4.2" N, 76° 43' 18.12" E, 1300 m, 4 November 2020, Thulasi & Maya, 14814 (ZGC).

Salviniales

Marsileaceae Mirb., Hist. Nat. Vég. 5: 126. 1802 (as "Marsileae").

Marsilea L., Sp. Pl. 2: 1099. 1753.

Marsilea minuta L., Mant. Pl. 2: 308. 1771; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 342. Pl. 259. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 116. 2017.

Rhizome long creeping, 30-60 cm long, branched, subterranean, 1.7-2 mm thick, green in aquatic condition, pale or dark brown in terrestrials, covered by 4-5 x 0.2-0.25 mm, whitish, soft, slender hairs all over; roots borne usually on nodes. Stipes scattered, 1-1.2 cm apart, 15-16 x 0.1-0.2 cm, usually green, glabrous or with few hairs. Leaves four, sessile, arranged at the tip of the stipe in clover leaf model, obovate or wedge-shaped, base cuneate, margin entire; veins distinct above and below, flabellately branched, connected occasionally by lateral veins; leaves pale or

dark green, glabrous; texture thin, soft herbaceous. Sporocarps borne at the nodes in clusters. (Plate 4.19: Fig. a-e.).

Distribution: Hydrophytic; seen in wetlands. Found growing in paddy fields and wetlands of the study area.

Specimen/s examined: Kerala: Palakkad District, Ottappalam, Thirumittakkode, 10° 46' 54.84" N, 76° 10' 58.8" E, 17 m, 2 October 2019, Thulasi, 14442 (ZGC); Nhangattiri, 10° 47' 14.136" N, 76° 10' 51.924" E, 25 m, 17 May 2022, Thulasi, 15036 (ZGC).

Salviniaceae Dumortier., Anal. Fam. Pl. 67. 1829.

Key to Genera

1. Rhizome with nodes and internodes; submerged leaves modified into root-like organ*Salvinia*
1. Rhizome zig-zagged; submerged leaves absent*Azolla*

Azolla Lam. in Lamarck et Poiret, Encycl. Meth. Bot. 1:343. 1783.

Azolla pinnata R. Br., Prodr. Fl. Nov. Holl. 167. 1810, subsp. *asiatica* R.M.K.Saunders & K.Fowler, Bot. J. Linn. Soc. 109(3): 349. 1992; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 345. Pl. 261. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 301. 2021.

Plant aquatic, free floating, whole plant 0.7-1.2 cm wide, 1.2-1.5 cm length; stem horizontal, profusely branched, zig-zag, bearing roots, covered by long hairs; young leaves not in circinate vernation. Leaves alternate, arise from the dorsal lobe, aerial, rectangular, 1-2 x 0.75-0.8 mm, sessile, margin entire with a narrow whitish transparent membranaceous border, grey-green, thick, enclosing large mucilage filled cavities that harbour blue-green algae; veins indistinct; ventral lobes submerged, broadly ovate, 0.8-1 x 0.8-1 mm, base cuneate, margin entire, veins distinct, anastomosing, lobes thin membranaceous, transparent, brownish, glabrous. (Plate 4.19: Fig. f-k.).

Distribution: Free floating, aquatic plants, at plains.

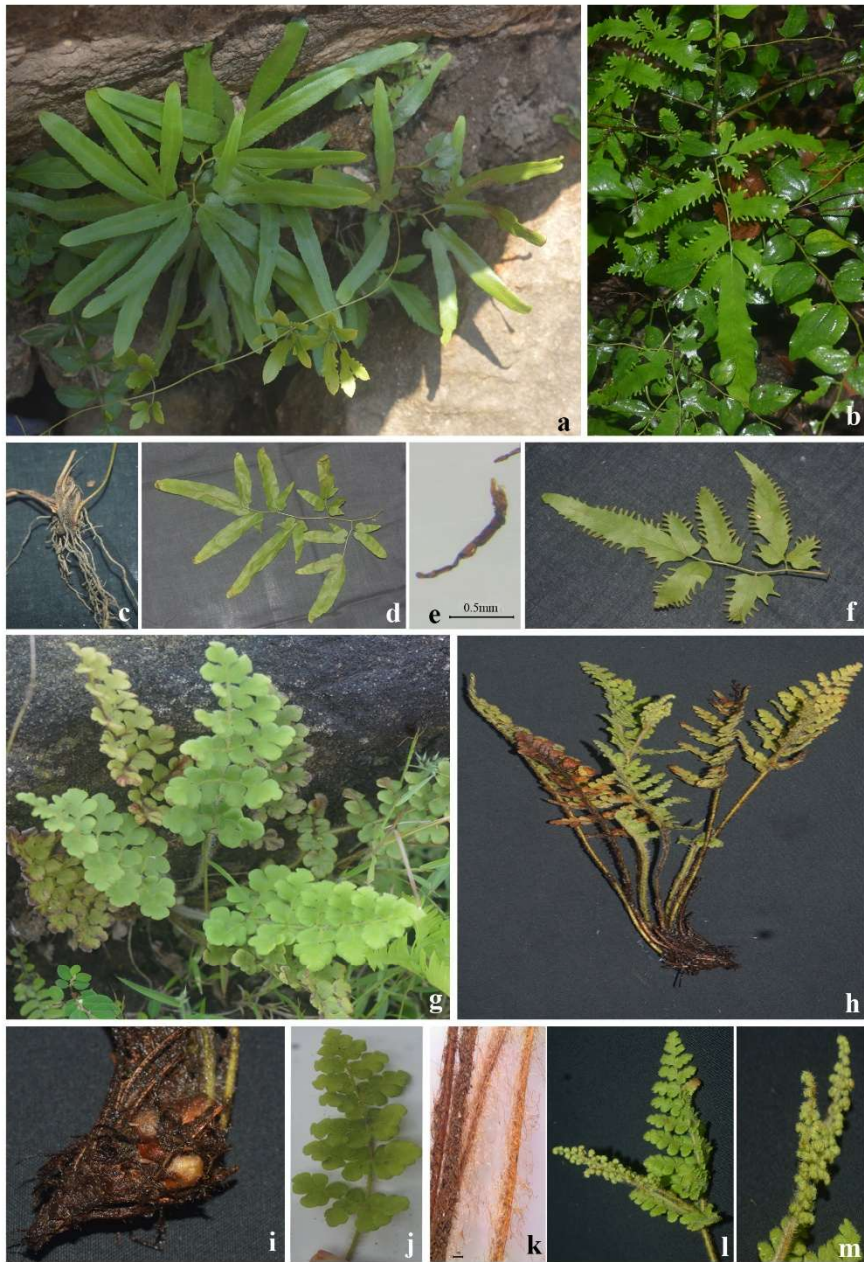


Plate 4.18: a-f. *Lygodium flexuosum* (L.) Sw. a-b. Habitat c. Rhizome d. Vegetative leaf e. Rhizome hair f. Fertile frond with sori. g-m. *Anemia schimperiana* C.Presl subsp. *wightiana* (Gardner) Fraser-Jenk. g. Habitat h. Habit i. Rhizome j. Vegetative frond k. Hairs l-m. Fertile frond.

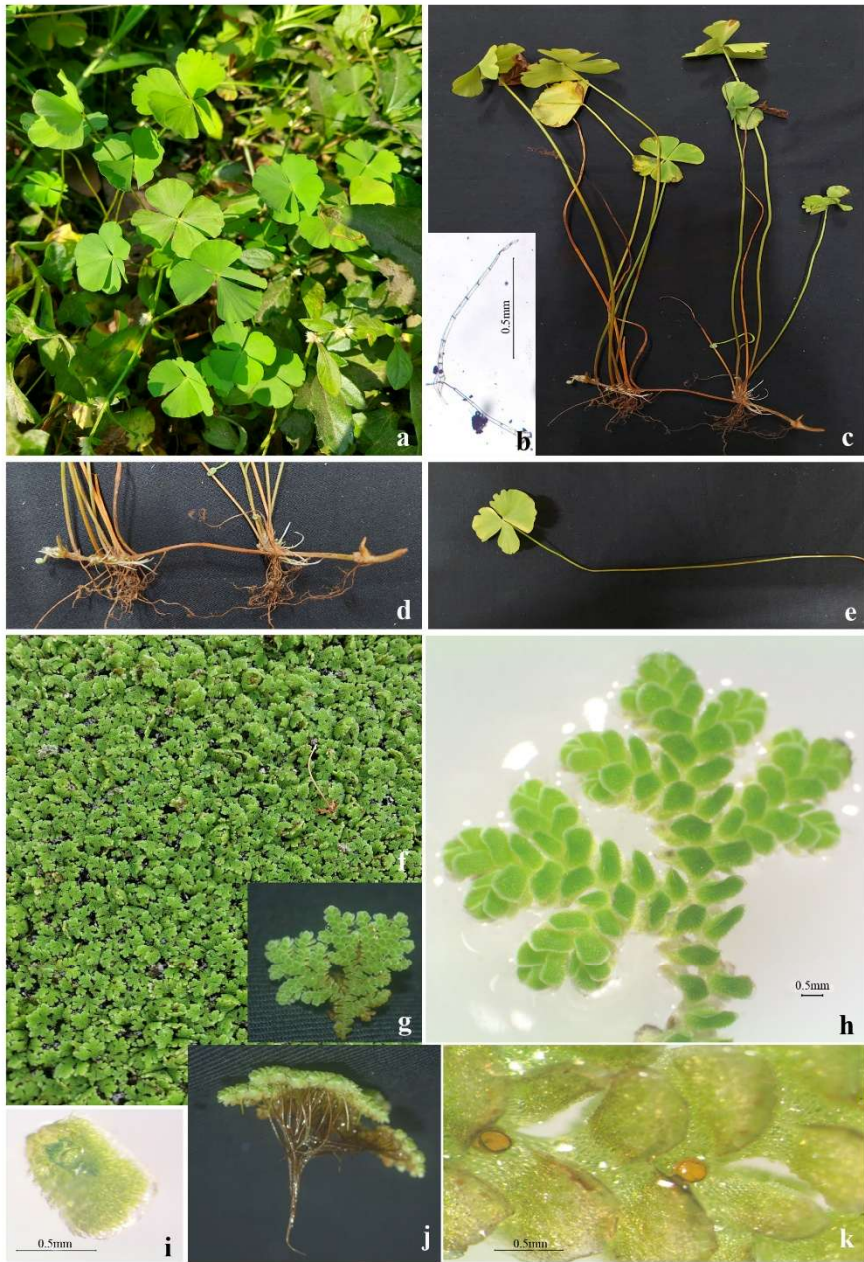


Plate 4.19: a- e. *Marsilea minuta* L. a. Habitat b. Rhizome hairs c. Habit d. Rhizome e. Frond. f-k. *Azolla pinnata* R. Br. f. Habitat g-h. Habit i. Leaf j. Root k. Sori under the axil of fronds.

Specimen/s examined: Kerala: Palakkad District, Ottappalam, Mattaya, 10° 46' 44.76" N, 76° 10' 10.56" E, 40 m, 17 May 2022, Thulasi, 15048 (ZGC); Nhangattiri, 10° 47' 4.92" N, 76° 10' 53.04" E, 12 m, 17 May 2022, Thulasi, 15038 (ZGC).

Salvinia Seguir., Fl. Veron. 3: 52. 1754.

Salvinia × *molesta* Mitch., Br. Fern Gaz. 10: 251. 1973; Madhusoodanan, Proc. Int. Symp. Syst. Pterid. Beijing. 61. 1989; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 344. Pl. 260. 1992.

Plants aquatic, free floating. Stem spongy, terete, 8-12 cm long, 2-3 mm thick, brown, branched with nodes and internodes. Normal leaves at the nodes in two opposite pairs, erect, floating, sessile, obovate, 1.8-2 x 2.3-2.5 cm, entire, pale green, lower surface glabrous, upper surface with dense 'egg beater' hairs with stiff, erect common stalk, and branched into four, septate hooked branches; veins slightly distinct below, anastomosing to form parallel, elongated areoles; texture herbaceous; normal leaves spongy due to the presence of hairs; submerged leaves modified into 4.6-5 cm long, root-like filiform structure, densely covered by brown, septate hairs. Sporocarps borne in clusters on submerged leaves, about 10 in numbers, ovoid, 1-2 mm diameter, sessile, densely hairy; microsporangia borne on the branched receptacle in cluster in micro sporocarps; megasporangia borne in mega sporocarps. (Plate 4.20: Fig. a-h.).

Distribution: Common, free floating, fresh water weed. Up to 900 m

Specimen/s examined: Kerala: Palakkad District, Ottappalam, Nhangattiri, 10° 47' 4.92" N, 76° 10' 53.04" E, 12 m, 17 May 2022, Thulasi, 15037 (ZGC).

Cyatheales

Cyatheaceae Kaulf., Wesen Farnkr. 119. 1827.

Note: The classification of Cyatheaceae has undergone a lot of changes in recent years. PPG 1 (2016) recognised three genera, viz., *Alsophila*, *Cyathea* and *Sphaeropteris*. Later (Dong and Zuo, 2018; Loiseau *et al.*, 2020) *Gymnosphaera* was also recognised in the family. However, in order to avoid nomenclatural

confusions, the single genus concept as by Fraser-Jenkins *et al.* (2017) is followed here.

Cyathea Sm., Mém. Acad. Roy. Sci., Turin 5: 416. 1793.

Key to species

1. Sori forming 'V'-shaped pattern on each fertile lobe *C. gigantea*
1. Sori not forming 'V'-shaped pattern on each fertile lobe 2
2. Fronds bearing 1 or 2 small stipule like pinnae at leaf base *C. spinulosa*
2. Fronds does not bearing any stipule like pinnae at leaf base 3
3. Abaxial surface of the lamina with hairs *C. nilgirensis*
3. Abaxial surface of the lamina without hairs *C. crinita*

Cyathea crinita (Hook.) Copel., Philipp. J. Sci., C, 4: 40. 1909; Bedd. Handb., 7. 1974; Manickam, Fern Fl. Palni Hills, 70. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 163. Pl. 127. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 123. 2017.

Alsophila crinita Hook., Ic. Pl. 7: t. 671. 1844.

Sphaeropteris crinita (Hook.) R.M.Tryon, Contr. Gray Herb. 200: 21. 1970.

Trunk 4.5-5 m height, 10-12 cm in diameter, with leaf bases; densely scaly in the apex, linear lanceolate, uniformly golden yellow, apex acuminate, margin with ascending setae. Stipes about 1 m long, dark brown, rounded abaxially, slightly grooved adaxially, base swollen obconical, brown, glossy, densely spiny on abaxial and lateral surface of stipe and rachis; densely soft, slender, yellow hairy on the adaxial surface of primary and secondary rachis and stipes, along with few scales. Lamina bipinnate, 200-203 x 100-105 cm, oblong-lanceolate, base sub-truncate, apex acute; pinna 18-20 pairs, alternate, stalked, oblong-lanceolate, acuminate; pinnules 23- 25 pairs, basal 3 or 4 opposite, next 5 to 8 sub-opposite, others alternate, sessile, oblong-lanceolate, acuminate, sub-truncate base, margin lobed up to costa, lobes alternate, margin crenate-serrate, costa little raised, rounded above and below; veins slightly distinct above, more distinct below; lamina pale green, chartaceous; yellow, small, ciliate scales densely on abaxial and adaxial surface of

costa and costules. Sori on above the fork, spherical, exindusiate; spores trilete, triangular, pale yellow. (Plate 4.20: Fig. i-m.).

Distribution: Terrestrial along stream and trek path sides between 1000-1200 m.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Walakkad, 11° 10' 30" N, 76° 24' 37.8" E, 1170 m, 2 January 2022, Thulasi, 14979 (ZGC); Idukki District, Kolukkumala, 10° 3' 33.84" N, 77° 12' 43.56" E, 1716 m, 8 April 2023, Thulasi, 15049 (ZGC).

Cyathea gigantea (Wall. ex Hook.) Holttum, Gard. Bull. Straights Settlem. 8(4): 318. 1935; Bedd. Handb. 7. 1974; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 162. Pl. 126. 1992; Nayar & Geev., Fern Fl. Malabar 153. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 123. 2017.

Alsophila gigantea Wall. ex Hook., Sp. Fil. 1: 53. 1844.

Polypodium giganteum Wall., List 64 n. 321. 1828, non Desv. 1827.

Gymnosphaera gigantea (Wall. ex Hook.) J.Sm., Lond. J. Bot. 1: 667. 1842.

Trunk about 8.5-9 cm in diameter, 1.8-2 m in height, with persistent swollen stipe bases, covered by scales, with crown of fronds at the apex; scales mixture of narrow, oblong, 4-5 x 1.5-2 mm, lanceolate scales, 9-10 x 1-2 mm, uniformly dark brown, glossy, long acuminate, entire. Stipes tufted, 73- 74 x 1-2 cm, chestnut brown, glossy, abaxially rounded, adaxially grooved, densely scaly at the base, glabrous above. Lamina bipinnate, deltoid 158-160 x 100-105 cm, primary pinnae 12-13 pairs, spreading, alternate, distinctly stalked, 19-20 cm apart, oblong-lanceolate, 47-50 x 17-20 cm, apex acuminate, base truncate; secondary pinnae about 20 pairs, catadromous, spreading, alternate, 1.8-2 cm apart, shortly stalked, oblong-lanceolate, 10-11 x 1.5-1.7 cm, apex acuminate, base truncate, margin usually lobed 2-5 mm to costa, rarely crenate; lobes 10-12 pairs oblong or broadly deltoid, 2-3 x 3-4 mm, apex rounded, margin crenate; costa and costule well distinct below, slightly distinct above; veins of adjacent lobes reaching the side of sinus independently; lamina dark green when fresh; herbaceous; pale brown, acicular hairs distributed on

the adaxial side of secondary rachis and costa along with some pale brown thin scales; intervenal area glabrous above and below. Sori median on the veins, 3-5, spherical, 1-1.5 mm in diameter, forming two zig zag rows submarginally, exindusiate, numerous sporangia, compact; paraphyses intermingled with sporangia; spores triangular, light brown. (Plate 4.21: Fig. a-e.; Plate 4.81: Fig. b.).

Distribution: Terrestrial, along shaded stream sides, between 100-1200 m.

Specimen/s examined: Kerala: Palakkad District, Mannarkkad, Siruvani, 10° 58' 43.32" N, 76° 36' 43.92" E, 830 m, 20 September 2019, Thulasi, 14431 (ZGC); Silent Valley National Park, Kummattanthodu, 11° 5' 33.36" N, 76° 26' 44.16" E, 1020 m, 22 October 2019, 14457 (ZGC); Kunthipuzha trek path, 11° 5' 45.6" N, 76° 26' 57.84" E, 950 m, 22 October 2019, Thulasi, 14501 (ZGC); Parathodu, 11° 5' 51" N, 76° 26' 48.84" E, 920 m, 23 October 2019, Thulasi, 14536 (ZGC); Sirandri to Poochippara, 11° 3' 57.96" N, 76° 32' 10.68" E, 550 m, 26 December 2019, Thulasi, 14632 (ZGC); Valiyaparathodu-Madrithodu, 11° 6' 49.32" N, 76° 25' 51.6" E, 910 m, 27 December 2019, Thulasi, 14638 (ZGC); Thrissur District, Athirappilly, 10° 17' 47.76" N, 76° 47' 38.76" E, 930 m, 14 February 2021, Thulasi, 14852 (ZGC). Tamil Nadu: Kodaikanal, 10° 13' 20.64" N, 77° 26' 39.12" E, 2300 m, 18 November 2019, Thulasi, 14570 (ZGC).

Cyathea nilgirensis Holttum, Kew Bull. 19: 468. 1965; Bedd. Handb. 6. 1974; Manickam, Fern Fl. Palni Hills, 68. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 160. Pl. 123. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 125. 2017.

Alsophila nilgirensis (Holttum) R.M.Tryon, Contr. Gray Herb. 200: 32. 1970.

Cyathea schmidiana (Kunze) N.C.Nair, Indian Forester 94: 170. 1968.

Cyathea nilgirensis var. *lobata* Manickam & Irudajaray, Pterid. Fl. W. Ghats S. India, 161. 1992.

Cyathea walkerae auct. Nayar & Geev., Fern Fl. Malabar 156. 1993, *non* Hook., Ic. Pl. t. 667. 1844.



Plate 4.20: a-h. *Salvinia* × *molesta* Mitch. a. Habitat. b-c. Habit d. Normal leaf e. Submerged leaves f. Rhizome g-h Sporocarps. i-m. *Cyathea crinita* (Hook.) Copel. i. Habitat j. Abaxial side of the frond k. Scale l. Fertile pinnule with sori m. Adaxial side of the frond.

Trunk 1.5- 2 m height, 9-13 cm in diameter, fronds at the top, forms crown; scales densely covering in young parts, 8-10 x 1.5-2.5 mm, lanceolate, dark brown at the centre, at periphery orange colour, apex pointed, fimbriate margin. Stipes 100-101 x 1.5-2 cm, base swollen, bearing bullate, small. Light brown appressed hairs. Lamina bipinnate, oblong-lanceolate, 190-200 x 90-100 cm, acute; 10-12 pairs of pinnae, alternate, petiolate, 15-16 cm apart, 48-50 x 18-20 cm, oblong-lanceolate, acuminate, truncate base few basal pairs slightly reduced; pinnules acuminate, 10-12 x 2-2.5 cm, truncate or sub truncate base, pinnatifid margin up to costa; veins distinct below, slightly above, almost all veins forked ones, free, reaching the margin; pinna pale green below, dark green above; herbaceous texture; ovate, appressed brown, lanceolate scales distributed on lower surface of costa throughout. Sori at the vein forks, ex-indusiate, paraphyses mixed with sporangia; spore trilete. (Plate 4.21: Fig. f-m.; Plate 4.87: Fig. e.).

Distribution: Terrestrial on shaded trek paths and streams between 900-2300 m.

Notes: Endemic to Southern India.

Specimen/s examined: Kerala: Idukki District, Pampadum Shola National Park, Kuttikkad, 10° 7' 35.4" N, 77° 15' 29.88" E, 1900 m, 30 July 2019, Thulasi, 14341 (ZGC); Palakkad District, Silent Valley National Park, Valiyaparathodu-Madrithodu, 11° 6' 49.32" N, 76° 25' 51.6" E, 910 m, 27 December 2019, 14643 (ZGC); Poochippara to Walakkad trek path, 11° 8' 0.96" N, 76° 24' 42.84" E, 1140 m, 28 December 2019, Thulasi, 14678 (ZGC); Sispara to Angida trek path, 11° 11' 20.04" N, 76° 27' 35.64" E, 2280 m, 30 December 2019, Thulasi, 14714 (ZGC).

Cyathea spinulosa Wall. ex Hook., Sp. Fil. 1: 25, t. 12 C. 1844; Nayar & Geev., Fern Fl. Malabar 154. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 126. 2017.

Alsophila spinulosa (Wall. ex. Hook.) R. M. Tryon; Contr. Gray Herb. 200. 32. 1970.

Rhizome trunk like, 9-10 m x 9-15 cm, covered by clinging roots and persistent leaf bases, young parts covered by scales; scale 35-40 x 3-4 mm. Frond crowded, each

bearin an adaxial vegetative bud at the base; stipe 50-75 x 1.5-2 cm, dark purplish brown, shining, shallowly grooved on adaxial side, abaxial side having woody spines, one lateral row of whitish linear lenticels on either side. Lamina ovate-oblong, 12-15 pairs of primary pinnae; larger one ovate-oblong, 50-75 x 15-25 cm; secondary pinnae 25-30 pairs, narrowly oblong, 10-12 x 1.5-2 cm, subsessile, margin pinnatisect. Midrib of secondary pinnae raised on both surfaces, having dense acicular hairs on upper side and pale small bullate scales on the lower surface. Sori restricted to lateral veinlets in basal half of the lobes, protected by thin membranous indusium; spores triangular, brown.

Distribution: Terrestrial along the partially shaded river sides, between 800-1500 m.

Notes: During the present study this species could not be recorded. It is included here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Kerala: Palakkad District, Panthanthode, Nayar and Party, 10076 (CALI); Silent Valley National Park, N.C. Nair, 64436 (MH).

Polypodiales

Lindsaeaceae C.Presl ex M.R.Schomb., Reis. Brit.-Guiana 3: 883, 1048. 1849 ("1848").

Key to Genera

- 1. Sori along margins *Lindsaea*
- 1. Sori solitary at the apex of each segment *Odontosoria*

Lindsaea Dryand. ex Sm., Mém. Acad. Roy. Sci., Turin 5: 413, t. 9, f. 4. 1793.

Key to species

- 1. Fronds bipinnate or triforked *L. heterophylla*
- 1. Fronds simply pinnate 2
- 2. Pinnules dimidiate, subtriangular; veins free *L. odorata*
- 2. Pinnules not dimidiate, oblanceolate; veins anastomosing *L. ensifolia*

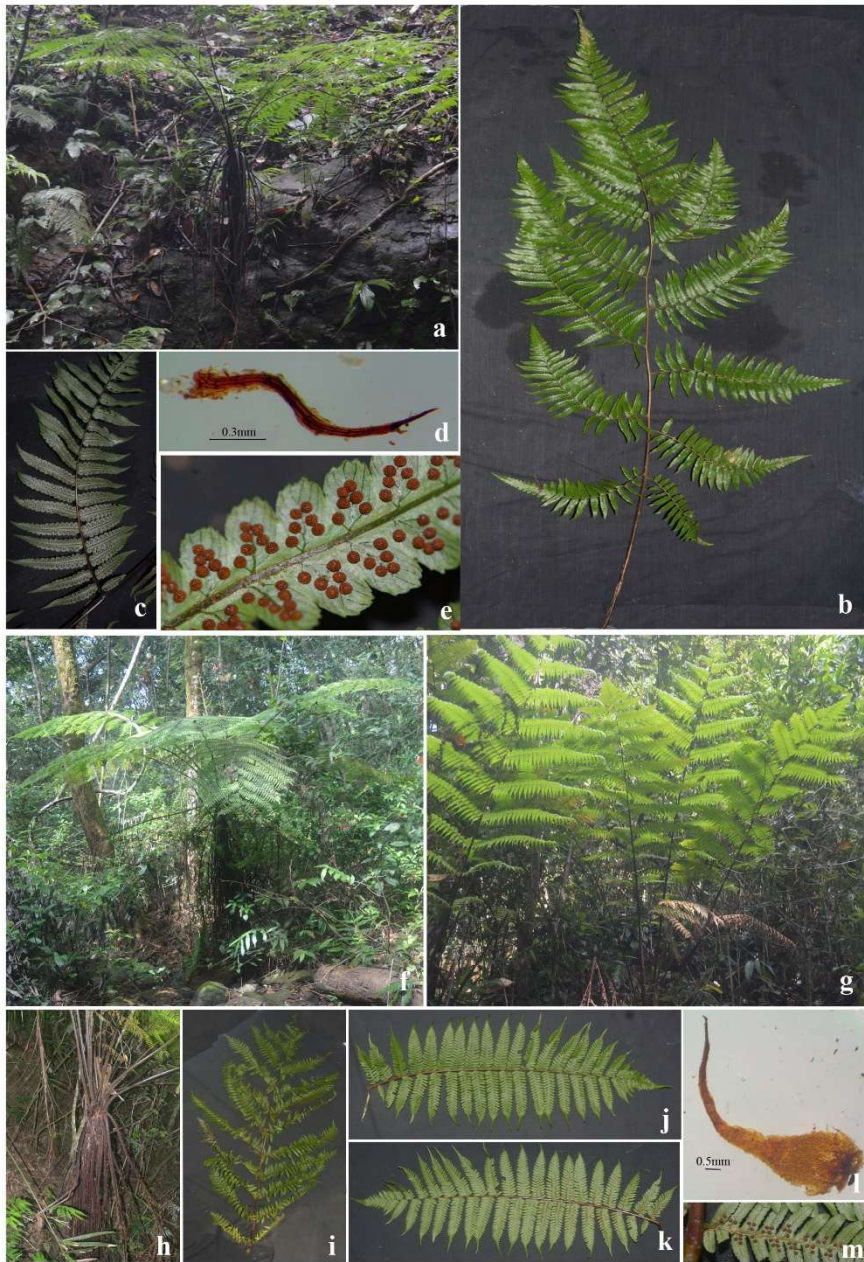


Plate 4.21: a-e. *Cyathea gigantea* (Wall. ex Hook.) Holttum a. Habitat b. Frond c. Pinna d. Scale e. Sori. f-m. *Cyathea nilgirensis* Holttum f-g. Habitat h. Trunk i. Frond j. Pinna - adaxial side k. Pinna - abaxial side l. Scale m. Sori.

Lindsaea ensifolia Sw., Schrader, J. Bot. 1800(2): 77. 1801; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 125. 1992; Nayar & Geev., Fern Fl. Malabar 172. 98. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 182. 2017.

Lindsaea ensifolia var. *gigantea* B.K.Nayar & Geev., Fern Fl. Malabar 173. 1993.

Rhizome creeping, 10-16 cm long, 2- 3 mm thick, branched, densely covered by scales all over; scales ovate lanceolate, 1-2 x 0.7-0.75 mm, uniformly pale brown. Stipes scattered, 28-29 x 0.1-0.2 cm, more or less tetragonal with a shallow groove on all sides except on below, dark or purplish brown below, stramineous above, glossy and glabrous all over. Lamina obovate, 18-20 x 14-15 cm, simply pinnate with a terminal pinna similar to lateral pinna or with a forked pinna; pinnae 1-6 pairs, sub-opposite or alternate, shortly stalked; largest pinna 18-19 x 1.8- 2 cm, usually ovate or lanceolate, margin entire in fertile pinna, finely serrate or wavy or entire in sterile ones; costa raised and rounded below, flattened, shallowly grooved above, veins slightly distinct above and below, copiously anastomosing to form a series of narrow areoles without any free included veinlets; texture herbaceous. Sori linear continuous, all along the margin except at the very base, indusiate; indusia membranaceous, pale brown, glabrous with wavy margin; spores pale brown, triangular. (Plate 4.22: Fig. a-g.; Plate 4.81: Fig. c.).

Distribution: Terrestrial, commonly seen in well-shaded to exposed areas. Found growing at Madhrithod and Poochippara of Silent Valley National Park, altitude above 700 m.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Sairandri to Poochippara trek path, 11° 3' 57.96" N, 76° 32' 10.68" E, 550 m, 26 December 2019, Thulasi, 14622 (ZGC); Walakkad to Sispara trek path, 11° 12' 6.48" N, 76° 26' 24.36" E, 2000 m, 29 December 2019, Thulasi, 14693 (ZGC); Agali, Ommala, 11° 3' 35.64" N, 76° 36' 39.96" E, 730 m, 14 November 2021, Thulasi, 14920 (ZGC).

Lindsaea heterophylla Dryand., Trans. Linn. Soc. Lond. 3: 41, t. 8, f. 1. 1797; Bedd., Ferns. S. India, 70, t. 206. 1864; Handb. Ferns Br. India, 77. 1883; Manickam

& Irud., Pterid. Fl. West. Ghats, S. India 129. Pl. 101. 1992; Nayar & Geev., Fern Fl. Malabar 175. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 184. 2017.

Rhizome short creeping, 4-8 cm long, 2-5 mm thick, branched, densely covered by scales; scales narrowly triangular, 2-2.5 x 0.2-0.3 mm, 3-5 seriate at base, uniseriate above, uniformly dark brown. Stipes scattered, 40-42 x 0.2-0.3 cm, castaneous below, pale brown above, tetragonal, glabrous and glossy. Lamina deltoid or ovate, 30-35 x 12-14 cm, bipinnate, pinnae 13-15 x 4-5 cm, imparipinnate, apex acuminate, basal pairs bear 1-3 branches on the basal acroscopic side; pinnules 8- 10 pairs, alternate, shortly stalked, lanceolate, apex acuminate, base cuneate, oblique or not, margin usually entire, no distinct midrib; veins slightly distinct below, indistinct above, forked, free, ending sub-marginally in sterile pinnules, reaching the base of the sori in fertile ones; pinnules dark green, glabrous; texture herbaceous. Sori submarginal, continuous along the margin, except in the cuneate base; indusia pale green, papery, margin crenate; spores, triangular, brown. (Plate 4.22: Fig. h-m.; Plate 4.81: Fig. d.).

Distribution: Terrestrial, on land-cuttings, in moist, well-shaded localities, above 700 m. Found growing at Silent Valley National Park.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Valiyaparathodu-Madrithodu, 11° 7' 9.84" N, 76° 25' 48.36" E, 960 m, 27 December 2019, Thulasi, 14655 (ZGC); Poochippara to Walakkad trek path, 11° 8' 0.96" N, 76° 24' 42.84" E, 1140 m, 28 December 2019, Thulasi, 14677 (ZGC); Walakkad to Sispara trek path, 11° 12' 6.48" N, 76° 26' 24.36" E, 2000 m, 29 December 2019, Thulasi, 14695 (ZGC).

Lindsaea odorata Roxb. in Griffith, Calcutta J. Nat. Hist. 4: 511. 1844; Manickam, Fern Fl. Palni Hills, 33. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 125. Pl. 97. 1992; Nayar & Geev., Fern Fl. Malabar 177. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 187. 2017.

Osmolindsaea odorata (Roxb.) Lehtonen & Christenh., Bot. J. Linn. Soc. 163(3): 335. 2010.

Rhizome slender, hypogeal, branched, 6-9 cm long, 2-3 mm thick, densely covered by hairlike scales all over; scales lanceolate 1-2 x 0.2-0.25 mm, dark brown. Stipes scattered, 0.5-1 cm apart, 12-15 cm x, 1-2 mm thick, purple brown, glossy, glabrous, rounded below, grooved above. Lamina linear-lanceolate, 30-32 x 3-3.7 cm, simply pinnate; pinnae 30-35 pairs, alternate, few pairs of pinnae slightly reduced, pinnae of distal part also gradually reduced to acuminate apex; largest pinna dimidiate, narrowly triangular, apex acute, base truncate and parallel to rachis, lower margin entire, upper margin shallowly lobed; veins not distinct above and below; texture herbaceous. Sori along the margin of each lobe; indusia papery, spores triangular, pale green, granulose. (Plate 4.23: Fig. a-f).

Distribution: Terrestrial, lithophytic, along shaded river banks. Found growing in rock crevices of Sispara, Anginda of Silent Valley National Park, about the altitude of 800-2200 m.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Anginda, 11° 11' 17.88" N, 76° 27' 36.72" E, 2300 m, 30 December 2019, Thulasi, 14713 (ZGC); Walakkad to Sispara trek path, 11° 12' 5.76" N, 76° 26' 42.36" E, 2120 m, 2 January 2022, Thulasi, 15000 (ZGC). Tamil Nadu: Ooty, 11° 26' 39.48" N, 76° 37' 24.24" E, 2200 m, 28 December 2021, Thulasi, 14973 (ZGC).

Odontosoria Fée, Mém. Fam. Foug. 5 Gen. Fil.: 325. 1852.

Odontosoria chinensis (L.) J.Sm., Bot. Voy. Herald 430. 1857; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 121. Pl. 95 & 96. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 192. 2017.

Trichomanes chinense L., Sp. Pl. 2: 1099. 1753.

Sphenomeris chinensis (L.) Maxon, J. Washingt. Acad. Sci. 3(5): 144. 1913; Nayar & Geev., Fern Fl. Malabar 179. 1993.

Rhizome short creeping, 5-10 cm long, 0.4-0.5 cm thick, branched irregularly,

bearing roots in the abaxial surface, fronds arranged on adaxial surface as two alternate rows, covered by hair like scales all over, scales up to 3 mm, pale brown, multicellular, uniseriate throughout or biseriate at the base. Stipes scattered, 3-5 cm apart, 35-37 x 0.3-0.4 cm, shallowly grooved, pale brown to stramineous, scaly at base, glabrous above. Lamina lanceolate, 44-45 x 14-15 cm, cuneate, acuminate, about one-third of the distal part of the lamina progressively narrowed, tripinnatifid; primary pinnae 10-12 pairs, ascending, basal one or two pairs subopposite, others alternate, distinctly stalked, 8-10 x 4-5 cm, ovate lanceolate, straight, acuminate, acroscopic base truncate, basiscopic base cuneate; secondary pinnae about eight pairs per primary pinna, ascending, anadromous, shortly stalked, alternate, 2.5-3 x 0.5-1 cm, obliquely ovate, acute; tertiary pinnae about three pairs, anadromous, alternate, shortly stalked, apex rounded in outline, 0.5-1 x 0.2-0.5 cm, deeply dissected into 2-4 lobes, lobes obconical alternate, 4-5 x 1-2 mm, sessile, entire, apex truncate; veins obscure above and below, forked, free; lamina pale green, glabrous above and below; texture herbaceous. Sori sub marginal at the vein end of each lobe. (Plate 4.23: Fig. g-l.; Plate 4.81: Fig. e.).

Distribution: Terrestrial on land cuttings, in well-shaded parts, above 700 m. Found growing at Sairandhri, Poochippara and Walakkad of Silent Valley National Park.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Kummattanthodu, 11° 5' 48.84" N, 76° 27' 19.8" E, 1030 m, 22 October 2019, Thulasi, 14490 (ZGC); Sairandhri to Poochippara trek path, 11° 3' 57.96" N, 76° 32' 10.68" E, 550 m, 26 December 2019, Thulasi 14626 (ZGC); Valiyaparathodu-Madrithodu, 11° 6' 49.32" N, 76° 25' 51.6" E, 910 m, 27 December 2019, Thulasi, 14636 (ZGC); Sispara to Anginda trek path, 11° 11' 20.04" N, 76° 27' 35.64" E, 2280 m, 30 December 2019, Thulasi, 14721 (ZGC). Tamil Nadu: Ooty, 11° 13' 28.704" N, 76° 44' 13.92" E, 570 m, 21 November 2021, Thulasi, 14944 (ZGC); Nadukani, 11° 28' 1.056" N, 76° 32' 59.856" E, 1900 m, 29 December 2021, Thulasi, 14969 (ZGC); Mukurthi National Park, Bankitapal, 11° 13' 25.176" N, 76° 32' 1.968" E, 2371 m, 27 February 2022, Maya, 15012 (ZGC).



Plate 4.22: a-g. *Lindsaea ensifolia* Sw. a. Habitat b. Habit c. Frond - adaxial side d. Frond - abaxial side e. Scale f. Rhizome g. Sori. h-m. *Lindsaea heterophylla* Dryand. h. Habit i. Rhizome j. Frond k. Sporophyll l. Sori m. Scale.



Plate 4.23: a-f. *Lindsaea odorata* Roxb. a. Habitat b. Habit c. Rhizome d. Scale e. Sporophyll f. Vegetative frond. g-l. *Odontosoria chinensis* (L.) J.Sm. g. Habitat h. Habit i. Rhizome j. Frond k. Scale l. Sori.

Dennstaedtiaceae Lotsy, Vortr. Bot. Stammesgesch. 2: 655. 1909.

Key to Genera

1. Sori along the margins of the pinnule *Pteridium*
1. Sori not along margins, but dispersed on lamina at vein endings 2
2. Sori orbicular *Hypolepis*
2. Sori pouch-shaped *Microlepia*

Hypolepis Bernh., Neues J. Bot. 1(2): 34. 1805.

Hypolepis polypodioides (Blume) Hook., Sp. Fil. 2: 63. 1852; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 159. 2017.

Hypolepis punctata (Thunb.) Mett. ex Kuhn, Fil. Afr. 120. 1868; Nayar & Geev., Fern Fl. Malabar 168. 1993.

Rhizome creeping, 3-5 mm thick, covered by brown shaggy dense hairs; hairs 3-7 mm long, uniseriate. Frond distantly placed, large; stipe 100-175 x 1-1.5 cm, erect, adaxially grooved, abaxially rounded, brown in mature; lateral vegetative buds present in the adaxial surface of stipe. Lamina variable in size, 50-170 x 100-150 cm, deltoid, spreading, pale green, 3-4 pinnate; primary pinnae smaller towards apex, basal 1 or 2 pairs opposite, distal ones alternate, larger one deltoid-ovate, 80-85 x 10-25 cm, oblique to rachis; ultimate pinnae sessile, 6-10 x 3-4 mm, elongate-oblong, apex rounded, variously lobed, margin crenate, lamina glabrous. Fertile fronds similar to sterile, slightly reduced; sori circular, solitary per ultimate lobe; spore plano convex, yellowish.

Distribution: Terrestrial on shaded to open land, between 800 to 1200 m.

Notes: During the present study this species could not be recorded. It is added here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Kerala: Palakkad District, Attappadi, Panthenthode, B. K. Nayar & Party, 10067 (CALI); Cherunelly- Nelliampathi, B.K. Nayar, Geevarghese & S. Pankajam, 7355 (CALI); Silent Valley, Geevarghese, 4115

(CALI); Silent Valley, Geevarghese, 17904 (CALI). Tamil Nadu: Salem, Nair & Bhargavan, 74228 (MH).

Microlepia C.Presl, Tent. Pterid. 124, t. 4, f. 21-23. 1836.

Key to species

1. Rachis of pinnae bearing soft spreading hairs all over *M. speluncae*
1. Rachis of pinnae bearing stiff strigose hairs on its upper surface **2**
2. Lamina deltoid, ultimate pinnae margin lobed into prominent rounded teeth *M. nepalensis*
2. Lamina deltoid-ovate, ultimate pinnae margin sub-entire *M. rhomboidea*

Microlepia speluncae (L.) T.Moore, Index Fil. 93. 1857; Bedd., Handb. Ferns Br. India. 67. 1883; Manickam, Fern Fl. Palni Hills. 52. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 119. Pl. 93 & 94. 1992; Nayar & Geev., Fern Fl. Malabar 164. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 171. 2017.

Polypodium speluncae L., Sp. Pl. 2: 1093. 1753.

Rhizome long creeping, branched, 50-120 cm long, 2-2.5 cm thick, densely covered by pale brown, multicellular, uniseriate, tubular hairs all over. Stipes scattered 90-95 x 0.5-1 cm, greyish green below, pale brown above, rounded below, grooved above, hairy at the base, glabrous above. Lamina broadly deltoid ovate, 98-100 x 148-150 tri-pinnatifid, primary pinnae 8-10 pairs, ascending, 13-15 cm apart at the base, distinctly stalked, sub opposite at the base, alternate above, acroscopic base truncate, basisopic base cuneate, secondary pinna 16-20 pairs, slightly ascending, anadromous, subopposite, shortly stalked, 8-10 x 2-3 cm, lanceolate, acroscopic base truncate, basisopic base cuneate; tertiary pinna 10-12 pairs, anadromous, sessile, alternate, 0.8-1 cm apart, oblong, asymmetrical, oblique, apex subacute, margin lobed up to costule; basal acroscopic lobe is largest one, 6-7 x 3-4 mm, apex subacute, margin sub entire or crenate, veins slightly distinct, forked once, free, not reaching the margin; lamina pubescent, dark green, soft herbaceous in texture. Sori sub marginal, on the basal acroscopic vein end of each lobe, indusia cup-shaped, hairy; spores trilete. (Plate 4.24: Fig. a-f.).

Distribution: Very common. Terrestrial along the river banks or stream banks.
Altitude

ranges from below 100 to 1800 m. Found growing at Poochippara, Walakkad, Valiyaparathodu of Silent Valley National Park and Karuvarakkundu, Perinthelmana.

Specimen/s examined: Kerala: Palakkad District, Mannarkkad, Meenvallam, 10° 55' 24.96" N, 76° 33' 51.84" E, 85 m, 11 September 2018, Thulasi, 14211 (ZGC); Mannarkkad, 11° 2' 27.996" N, 76° 26' 41.496" E, 76 m, 17 October 2018, Thulasi, 14261 (ZGC); Parambikulam Tiger Reserve, Vengolimala, 10° 21' 56.52" N, 76° 45' 36.36" E, 830 m, 6 December 2019, Thulasi, 14605 (ZGC); Silent Valley National Park, Sairandri to Poochippara trek path, 11° 3' 57.96" N, 76° 32' 10.68" E, 550 m, 26 December 2019, Thulasi, 14631 (ZGC); Poochippara to Walakkad trek path, 11° 8' 0.96" N, 76° 24' 42.84" E, 1140 m, 28 December 2019, Thulasi, 14673 (ZGC); Walakkad to Sispara trek path, 11° 12' 6.48" N, 76° 26' 24.36" E, 2000 m, 29 December 2019, Thulasi, 14699 (ZGC); Walakkad to Atti chekpost trek path, 11° 10' 40.08" N, 76° 24' 53.28" E, 1150 m, 31 December 2019, Thulasi, 14727 (ZGC); Olavakkode, Elival mala, 10° 52' 26.04" N, 76° 38' 10.68" E, 300 m, 7 July 2019, Thulasi, 14752 (ZGC); Bhavani, Thudukki, 11° 8' 4.128" N, 76° 30' 28.404" E, 1300 m, 2 October 2019, Thulasi, 14782 (ZGC); Nelliampathy, Cheriya Govinda mala, 10° 30' 27.72" N, 76° 41' 45.6" E, 990 m, 3 November 2019, Thulasi & Maya, 14890 (ZGC); Malappuram District, Karimpuzha Wildlife Sanctuary, Panappuzha, 11° 18' 24.876" N, 76° 26' 37.644" E, 310 m, 4 September 2019, Thulasi, 14873 (ZGC); Idukki District, Pampadum Shola National Park, 10° 7' 33.6" N, 77° 15' 22.68" E, 1892 m, 30 July 2019, Thulasi, 14349 (ZGC); Mathikettan Shola National Park, 9° 58' 47.28" N, 77° 14' 12.84" E, 1400 m, 1 August 2019, Thulasi, 14358 (ZGC).

Microlepidia nepalensis (Spreng.) Fraser-Jenk., Kandel & Pariyar, Ferns Fern-Allies Nepal 172. 2015; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 167. 2017.

Microlepidia hancei Prantl, Arbeit. Königl. Bot. Gart. Breslau 1. 35. 1892; Nayar & Geev., Fern Fl. Malabar 161. 1993.

Microlepia manohara B.K.Nayar & Madhus., Fern Gaz. 12(6): 335. 1984; Nayar & Geev., Fern Fl. Malabar 163. 1993.

Rhizome creeping, 1-1.5 cm thick, hairy; hairs hyaline, 5-10 celled, acicular, terminated by swollen glandular cell. Frond with stipe, stipe 85-120 cm x 6-10 mm, green, having uniseriate acicular hairs. Lamina deltoid-ovate, 80-110 x 60-70 cm, tri-pinnate to tetra-pinnatifid; middle ones 40-50 x 12-17 cm, narrowly ovate, apex acuminate; secondary pinnae 5-10 x 1.5-2 cm, basal acroscopic one larger; tertiary pinnae sessile, sub-rhomboidal, 9-10 x 4-5 mm; margin sub-crenate. Sorus submarginal, indusiate, indusium glabrous; spore triangular, pale brown.

Distribution: Terrestrial on well drained flat grounds, between 700-1200 m.

Notes: During the present study this species could not be recorded. Included here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Kerala: Palakkad District, Silent Valley, near dam site, 20 March 1981, B.K. Nayar & Party, 10042 (CALI)

Microlepia rhomboidea (Hook.) C.Presl ex Prantl, Arbeit. Königl. Bot. Gart. Breslau 1: 31. 1892; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 168. 2017.

Microlepia trapeziformis (Roxb.) Kuhn, Grup. Chaetopt. Polyp. 437, 1882; Nayar & Geev., Fern Fl. Malabar 163. 1993.

Rhizome 18-20 mm thick, covered by hairs; hairs uniseriate, multicellular, 4-6 mm long, hyaline, terminated by ovate glandular cell. Frond loosely arranged, stipe 65-85 cm x 5-10 mm, hairy in young, glabrous when matured. Lamina deltoid-ovate, 65-90 x 40-55 cm, obliquely spreading, 3-pinnate-4-pinnatifid; primary pinnae alternate, deltoid-ovate, 30-45 x 10-15 cm, apex acuminate; secondary pinnae 5-10 x 2-3 cm; tertiary pinnae sessile, 6-12 pairs, sub-rhomboidal, 8-12 x 5-8 mm, apex rounded, base truncate, margin deeply dissected, 3-4 pairs; lamina thin and sub-coriaceous. Sorus submarginal, one per lobe; spores triangular, hyaline to pale brown.

Distribution: Terrestrial on partially shaded areas, between 700 to 1200 m.

Notes: During the present study this species could not be recorded. It is included here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Tamil Nadu: Nilgiris District, Nilgiris, G. King, 59030 (MH). Kerala: Palakkad District, Silent Valley, 15 September 1978, Geevarghese 17951 (CALI).

Pteridium Gled. ex Scop., Fl. Carniol. 169. 1760, nom. cons.

Pteridium aquilinum (L.) Kuhn subsp. *wightianum* (Wall. ex J.Agardh) W.C.Shieh, Quart. J. Chin. Forest. 6(4): 98. 1973.

Pteridium aquilinum (L.) Kuhn, Kersten, Reisen Ost-Afr. 3(3): 11. 1879; Bedd., Handb. Ferns Br. India. 31. 1883; Manickam, Fern Fl. Palni Hills, 47. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 109. 86. 1992; Nayar & Geev., Fern Fl. Malabar 169. 1993.

Pteridium revolutum (Blume) Nakai, Bot. Mag., Tokyo 39: 109. 1925; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 177. 2017.

Rhizome long creeping, subterranean, 60-130 cm long, 0.8-1.2 cm thick, covered by brown, long, uniseriate, multicellular hairs. Stipes scattered, dark brown, at base hairy, stramineous, glabrous above, abaxially rounded, adaxially grooved. Lamina deltoid, acute, cuneate, tripinnatifid at base, bipinnatifid at apex; primary pinna 7-8 pairs, opposite, with long petiole; secondary pinna 10-12 pairs, at base sub-opposite, above alternate, catadromous, subsessile; pinnules about 20 pairs, alternate, sessile, 3-3.5 x 0.8-1 cm, basal some are smaller than above ones, acute, truncate, margin lobed to costule; lobes deltoid, oblique, acute, entire, membranous; costa and costule grooved above, veins and veinlets slightly raised below; veins forked, free; soft, whitish hairs on sec.rachis, costa, costule and lower surface of pinnule, upper surface glabrous; lamina green, coriaceous. Sori linear, submarginal, covered by brown soft, fimbriate, reflexed margin above and thin fimbriate margin below.

(Plate 4.24: Fig. g-l.; Plate 4.81: Fig. f.).

Distribution: Terrestrial, very common species in cleared areas and road sides of the study area at altitude between 600-2000 m.

Notes: Fraser-Jenkins *et al.* (2017) treated this as *Pteridium revolutum* (Blume) Nakai, as distinct from *P. aquilinum* (L.) Kuhn. However, Zhou *et al.* (2014) treated it as a subspecies of *P. aquilinum* (L.) Kuhn.

Specimen/s examined: Kerala: Palakkad District, Nelliampathy, Manpara, 10° 33' 27.72" N, 76° 44' 40.2" E, 1065 m, 1 December 2018, Thulasi, 14313 (ZGC); Mannarkkad, Siruvani, 10° 58' 55.704" N, 76° 36' 1.98" E, 700 m, 20 September 2019, Thulasi, 14425 (ZGC); Silent Valley National Park, Arikampara, 11° 4' 51.6" N, 76° 26' 36.924" E, 1070 m, 24 October 2019, Thulasi, 14544 (ZGC); Parambikulam Tiger Reserve, Kariyanjola, 10° 24' 47.16" N, 76° 47' 3.84" E, 630 m, 7 December 2019, Thulasi, 14620 (ZGC); Nelliampathy, Vazhakkundu, 10° 31' 6.6" N, 76° 42' 52.2" E, 910 m, 15 January 2020, Thulasi & Maya, 14767 (ZGC); Cheriya Govinda mala, 10° 30' 27.72" N, 76° 41' 45.6" E, 990 m, 3 November 2020, Thulasi, Maya, 14791 (ZGC); Idukki District, Pampadum Shola National Park, Kuttikkad, 10° 7' 33.6" N, 77° 15' 22.68" E, 1892 m, 30 July 2019, Thulasi & Manju, 14356 (ZGC).

Pteridaceae E. D. M. Kirchn., Schul.-Bot. 109. 1831.

Key to Genera

1. Lamina simple, entire 2
1. Lamina pinnate to decompound, if simple, deeply lobed 4
2. Lamina linear; sori marginal *Vittaria*
2. Lamina elliptic, cordate or deltoid; sori not marginal 3
3. Lamina elliptic; sori along the veins *Antrophyum*
3. Lamina cordate or deltoid; sori all over the abaxial surface *Mickelopteris*
4. Lamina fan shaped, dichotomously divided *Actiniopteris*
4. Lamina otherwise 5
5. Plants aquatic; fronds dimorphic *Ceratopteris*
5. Plants terrestrial or lithophytic; fronds not dimorphic 6



Plate 4.24: a-f. *Microlepia speluncae* (L.) T.Moore a. Habitat b. Rhizome c. Frond d. Habit e. Multicellular hairs f. Sori. g-l. *Pteridium aquilinum* (L.) Kuhn subsp. *wightianum* (Wall. ex J.Agardh) W.C.Shieh g. Habitat h. Habit i. Rhizome j. Rhizome hairs k. Frond l. Sori.

- 6. Lamina with white or yellow farina on the abaxial surface of fronds 7
- 6. Lamina not with white or yellow farina on abaxial surface of fronds 8
- 7. Sori acrostichoid type, covers the entire abaxial surface of the sporophyll
..... ***Pityrogramma***
- 7. Sori not acrostichoid type, marginal or submarginal, protected by reflexed
margins of lamina ***Aleuritopteris***
- 8. Lamina simple, palmately lobed ***Doryopteris***
- 8. Lamina unipinnate to decompose 9
- 9. Stipe glossy, lamina linear lanceolate to deltoid ovate 10
- 9. Stipe not glossy, lamina sub-triangular to deltoid 11
- 10. Pinnules stalked, fan shaped, ovate or dimidiate ***Adiantum***
- 10. Pinnules sessile or sub-sessile, ovate or oblong ***Oeosporangium***
- 11. Leaflets hairy ***Pellaea***
- 11. Leaflets not hairy ***Pteris***

Actiniopteris Link, Fil. Spec. 79. 1841.

Actiniopteris radiata (J.Koenig ex Sw.) Link, Fil. Spec. 80. 1841; Bedd., Handb. 47. 1974; Manickam, Fern Fl. Palni Hills, 27. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 81. Pl. 58. 1992; Nayar & Geev., Fern Fl. Malabar 97. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 198. 2017.

Asplenium radiatum J.Koenig ex Sw., J. Bot. (Schrader) 1800(2): 50. 1801.

Rhizome suberect, subglobose, 3-5 cm long, 1-2 cm thick, densely covered by scales; scales lanceolate, 6-7 x 1-2 mm, dark at the centre, pale brown at the periphery, apex acuminate, pointed, margin entire. Stipes numerous, tufted, 15-16 cm long in fertile fronds, 10-11 cm long in sterile ones, abaxially deeply grooved, adaxially rounded, edges reflexed, pale brown at the base, pale green above; pale brown, soft, thin, transparent scales distributed on the stipes all over. Lamina flabellate, semicircular or wedge shaped, 3.7-4 x 5.8-6 cm, repeatedly, dichotomously divided up to six times; segments rachiform, 1-2 mm wide, apex acute, margin entire; veins not distinct in mature frond, slightly distinct in young ones; costa and veins indistinct; lamina pale green, coriaceous in texture; soft, pale brown, scales distributed in young lamina, sparsely in older ones. Sporangia in

intramarginal grooves throughout, protected by reflexed margins; spores trilete. (Plate 4.25: Fig. a-f.).

Distribution: Occurs in dry and rocky surfaces. Terrestrial. Seen in 200-900 m altitudinal range. Found growing at Akamalavaram, Walayar; Chinnar Wildlife Sanctuary; Lower Palni Hills, way to Kodaikanal.

Notes: This species shows variations in the size of plants and segmentation of lamina.

Specimen/s examined: Kerala: Palakkad District, Walayar, Akamalavaram, 10° 52' 7.32" N, 76° 42' 43.2" E, 212 m, 02 January 2020, Thulasi & Maya, 14324 (ZGC); Idukki District, Chinnar Wildlife Sanctuary, 10° 17' 11.76" N, 77° 10' 5.88" E, 933 m, 7 January 2020, Thulasi & Maya, 14740 (ZGC). Tamil Nadu: Kodaikanal, 10° 14' 6.36" N, 77° 29' 35.88" E, 2100 m, 20 November 2019, Thulasi, 14573 (ZGC); Ooty, 11° 11' 22.56" N, 76° 42' 36" E, 480 m, 21 November 2021, Thulasi, 14939 (ZGC).

Adiantum L., Sp. Pl. 2: 1094. 1753.

Key to species

- | | | |
|----|-----------------------------------------------------------------------------------------------|-----------------------|
| 1. | Fronds simple pinnate | 2 |
| 1. | Fronds branched | 5 |
| 2. | Stipe glabrous | 3 |
| 2. | Stipe hairy | 4 |
| 3. | Rhizome scales uniformly thickened | <i>A. incisum</i> |
| 3. | Rhizome scale differentially thickened | <i>A. philippense</i> |
| 4. | Pinnae densely hairy all over | <i>A. caudatum</i> |
| 4. | Pinnae glabrous | <i>A. zollingeri</i> |
| 5. | Fronds dichotomously branched | <i>A. hispidulum</i> |
| 5. | Fronds pinnately branched | 6 |
| 6. | Rhizome long creeping, 0.4-0.5 cm thick, scales lanceolate, lamina bipinnate ..
..... | <i>A. latifolium</i> |
| 6. | Rhizome short creeping, 1.5-2 cm thick, scales ovate-lanceolate, lamina .
tripinnate | <i>A. raddianum</i> |

Adiantum caudatum L., Mant. Pl. Altera 308. 1771; Bedd., Handb. Ferns Br. India, 83. 1883; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 96. Pl. 71. 1992; Nayar & Geev., Fern Fl. Malabar 136. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 201. 2017.

Adiantum lomesam B. K. Nayar & Geev., Fern Fl. Malabar 140. 1993.

Rhizome erect, 2.5-3.5 cm long, 1.8-2 cm thick, densely scaly all over; scales lanceolate, 2-3 x 0.2-0.3 mm, centre dark brown, pale towards margin, opaque, apex acuminate, entire. Stipes numerous, tufted, 9-10 x 0.1-0.2 cm thick, dark brown, below rounded, above grooved, covered densely by long, multicellular, pale, uniseriate hairs; fronds proliferate; lamina oblong-lanceolate, 20-25 x 2-3 cm, narrowed towards both ends, long wiry, acuminate apex, pinnate simply; pinnae 15-20 pairs, alternate, sessile, basal some pairs reduced; largest pinna 1-1.5 x 0.4-0.5 cm, dimidiate, basispic half excised, truncate acroscopic base, upper margin lobed, rounded apex, pale green, herbaceous; veins obscure, dichotomously branched; long, hairs minutely in intervenal areas on both sides. Sori marginal, reniform, indusiate; indusia pubescent; spores triangular, yellowish brown.

Distribution: Terrestrial along fully exposed areas, especially dry areas. Between 100-300 m.

Notes: During the present study this species is not recorded. It is added here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Kerala: Idukki district, Nair & Bhargavan, 70172 (MH); Palakkad district, Walayar, Vajravelu, 19046 (MH); Silent Valley, B.K.Nayar and P.V Madhusoodhanan, 21384 (CALI); Kanjirappuzha, Geevarghese, 4068 (CALI); Bengali Peak, B. K. Nayar, 7390 (CALI); Chullippara-Muthukurisi, K. Swarupananthan, 29317 (CALI).

Adiantum hispidulum Sw. in Schrader, J. Bot. 1800(2): 82. 1801; Bedd., Handb. Ferns Br. India, 86. 1883; Manickam, Fern Fl. Palni Hills, 37. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 99. Pl. 75. 1992; Nayar & Geev., Fern Fl.

Malabar 144. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 204. 2017.

Rhizome short creeping, 20-30 cm long, branched, densely covered by scales; scales stiff, 2-3 x 1-2 mm, ovate-lanceolate, apex acuminate, margin entire, uniformly dark brown, stipes compact, 32- 33 x 0.2-0.3 cm, black, polished, triangular with flattened side below, grooved on the lateral sides, scaly at the base, pale brown, appressed hairs distributed densely on the grooves, rarely in the rest. Lamina obovate, 26-27 x 16-17 cm, bipartite pedately divided tripinnate, basal dichotomy equal or unequal, each primary branch forked to form an outer branch which forks once or twice and an inner branch which does not forks, innermost being longest, outermost branch being shortest; rachis and petiole of pinnules densely covered by light brown appressed hairs; ultimate branches pinnate, oblong, acute, basal three to five pairs of pinnules patent, upper pair ascending and overlapping with the adjacent edges, pinnules 34-35 pairs, 1-2 pinnules usually borne on stalk of the ordinary and secondary branches, alternate, shortly stalked, largest pinnule 1-1.7 x 0.3-0.5 cm, dimidiate, inner edges obliquely truncate, outer edge rounded, upper and lower edges parallel, outer and upper margin of the sterile pinnules deeply dentate, crenate in the fertile part of the pinnules; veins distinct above, dichotomously branched, reaching the margin, pinnae dull green, glabrous above, lower intervenal area with dense, appressed light brown hairs; firm coriaceous texture. Sori on crescent shaped, reflexed flap of the outer and upper edges, with numerous long hairs on the upper surface; spores triangular, brown. (Plate 4.25: Fig. g-l.; Plate 4.81: Fig. h.).

Distribution: Terrestrial, in fully or partially shaded land cuttings. Altitudinal range between 900-1400 m. Found growing along the way to Kunthipuzha, Parathode, road sides of the way from Mukkali to Sairandhri of Silent Valley National Park.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Kunthipuzha trek path, 11° 5' 45.6" N, 76° 26' 57.84" E, 950 m, 22 October 2019, Thulasi, 14507 (ZGC); Parathod, 11° 5' 51" N, 76° 26' 48.84" E, 920 m, 23 October 2019, Thulasi, 14530 (ZGC). Tamil Nadu: Ooty, 11° 14' 40.2" N, 76° 42' 7.56" E, 650 m, 21 November 2021, Thulasi, 14947 (ZGC); Mukurthi National Park, Bankitapal, 11° 15' 41.04" N, 76° 30' 49.68" E, 2220 m, 27 February 2022, Maya, 15015 (ZGC).



Plate 4.25: a-f. *Actiniopteris radiata* (J.Koenig ex Sw.) Link a. Habitat b. Habit c. Rhizome d. Scale e. Lamina of vegetative frond f. Lamina of sporophyll with sori. g-l. *Adiantum hispidulum* Sw. in Schrader g. Habitat h. Habit i. Frond j. Rhizome k. Scale l. Sori.

Adiantum incisum Forssk., Fl. Aegypt.-Arab. 187. 1775, non C.Presl. 1825; Manickam, Fern Fl. Palni Hills, 36. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 97. Pl. 72. 1992; Nayar & Geev., Fern Fl. Malabar 139. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 206. 2017.

Adiantum caudatum auct. Bedd., Ferns S. India t.2. 1864; Handb. Ferns Br. India, 83. t. 44. 1883, *non* L., Sp. Pl. 2: 1753.

Rhizome erect, 2-4 cm long, 1-2 cm thick, densely scaly all over; scales lanceolate, 2-2.5 x 0.25-0.5 cm, uniformly pale brown, acuminate, entire; stipes numerous, tufted, 7-8 x 0.1-0.15 cm, dark brown, glossy, abaxially rounded, adaxially grooved, sparsely covered by long, soft, slender, pale brown, multicellular hairs. Lamina oblong-lanceolate, slender, 35-40 x 4-5 cm, not proliferate, simple pinnate; pinnae 20-25 pairs, sessile to subsessile, basal few pairs slightly reduced, deflexed, subopposite, distal most pairs progressively reduced, rest of the pinnae alternate, 1-5 cm apart; largest pinna 2-2.5 x 1-1.5 cm, dimidiate, lower margin perpendicular to rachis, upper margin deeply lobed, upper base truncate and parallel to rachis, apex rounded; veins slightly distinct above and below, repeatedly forked, flabellate, free, reaching the margin; pinnae pale green, glabrous; texture herbaceous. Sori marginal, oblong or reniform, 1.5-2 x 0.5-1 mm; indusia dark brown, entire, glabrous; spores triangular, pale brown.

Distribution: Along fully exposed wet rocks along roadsides, especially dry areas. Between 400-1000 m.

Notes: This species is included here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Kerala: Palakkad, Walayar, Vajravelu, 19046 (MH); Silent Valley, B. K. Nayar and P.V Madhusoodhanan, 21384 (CALI); Dhoni hills, P.V Madhusoodhanan, 21286 (CALI); Kanjirapuzha, Geevarghese, 4068 (CALI); Kanjirapuzha, Santhosh Nampy, 43787 (CALI); Nelliampathy, Cherunelly, B. K. Nayar, Geevarghese, 7312 (CALI); Nelliampathy, P. V. Madhu & A. K. Pradeep, 44822 (CALI).

Adiantum latifolium Lam., Encycl. Méth. Bot. 1(1): 43. 1783; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 103. Pl. 80. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 206. 2017.

Rhizome long creeping, 25-40 cm long, rarely branched, 0.4-0.5 cm thick, densely scaly; scales lanceolate, about 2.2-2.3 x 0.3-0.5 mm, uniformly pale brown, apex acuminate, margin sparsely fimbriate. Stipes arranged in two alternate rows, up to 1 cm apart, about 25 x 0.2 cm, abaxially rounded, adaxially grooved, black, stiff, glossy, glabrous below, gradually become pubescent above. Lamina broadly ovate, 21-22 x 19-20 cm, bipinnate, apex acute, base broadly cuneate; primary pinnae one or two half pairs, alternate, 3.5-4 cm apart, slightly ascending; distinctly stalked; pinna oblong-lanceolate, acute; pinnules 10-12 pairs, basal two pairs reduced, anadromous, patent, alternate, shortly stalked; pinnules oblong, straight or slightly falcate, one-third of the lower base excised, upper base truncate, apex acute, rarely rounded, upper margin and non-excised lower margin of sterile pinnules serrulate; veins slightly distinct both sides, forked, reaching the margin; pinnae dark green, glabrous on both sides; long, narrow, pale brown hairs and scales densely distributed on the costa and rachis; herbaceous. Sori oblong or reniform, distributed all along the upper margin and non-excised part of the lower margin, 4-5 x 1-1.5 mm, dark brown reflexed margin form pale brown, thin fimbriate indusium, protect the basal and lower side of the sori; spore abortive. (Plate 4.26: Fig. a-g.; Plate 4.81: Fig. i.).

Distribution: Terrestrial, along river banks, canals and road sides, seen in altitudinal range of up to 500 m.

Specimen/s examined: Kerala: Palakkad District, Ottappalam, Thirumittakode, 10° 46' 54.84" N, 76° 10' 58.8" E, 17 m, 2 October 2019, Thulasi, 14444 (ZGC); Nhangattiri, 10° 47' 14.136" N, 76° 10' 51.924" E, 25 m, 17 May 2022, Thulasi, 15031 (ZGC); Thrissur District, 10° 32' 17.88" N, 76° 25' 2.64" E, 160 m, 9 July 2021, Thulasi, 14866 (ZGC).

Adiantum philippense L., Sp. Pl. 2: 1094. 1753; Bedd., Ferns S. India t.1. 1864; Handb. Ferns Br. India, 82. 1883; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 208. 2017.

Adiantum lunulatum Burm.f., Fl. Indica 235. 1768, non Houtt. 1783; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 98. Pl. 73. 1992; Nayar & Geev., Fern Fl. Malabar 142. 1993.

Rhizome erect or suberect, 2.5-3 cm long, 2-2.5 cm thick, scales ovate-lanceolate, 2-3 x 1-0.5 mm, apex acuminate, margin entire, pale brown at the periphery, dark at the centre. Stipes tufted, wiry, numerous, 24-25 x 0.3-0.4 mm, dark brown, scaly at the base, glabrous above. Lamina lanceolate, 34-35 x 7.8-8 cm, simple pinnate; pinnae 10-17 pairs, alternate, 2.5-3 x 4.8-5 cm apart, distinctly stalked, pinnae fan-shaped, dimidiate, the lower edge nearly in line or oblique with the petiole, upper edge rounded, lobed, acroscopic base truncate, margin entire or sub-crenate in sterile pinnae; veins distinct above and below, dichotomously, flabellately branched, free, reaching the margin; pinnae pale green, glabrous both sides, herbaceous texture. Sori continuous along the edge of the lobe, crescent-shaped, 1-2 mm wide, spores triangular, brown. (Plate 4.26: Fig. h-m.).

Distribution: Very common species. Terrestrial, seen along fully or partially exposed land cuttings between below 10 m to 1200 m.

Specimen/s examined: Kerala: Palakkad District, Mannarkkad, Meenvallam, 10° 55' 24.6" N, 76° 33' 51.84" E, 81 m, 11 September 2018, Thulasi, 14216 (ZGC); Olavakkode, Dhoni, 10° 51' 34.2" N, 76° 37' 21.72" E, 120 m, 13 September 2018, Thulasi & Maya, 14223 (ZGC); Mannarkkad, Arakurussy, 10° 59' 41.28" N, 76° 26' 48.84" E, 54 m, 17 October 2018, Thulasi, 14252 (ZGC); Mannarkkad, 11° 2' 27.996" N, 76° 26' 41.496" E, 76 m, 17 October 2018, Thulasi, 14259 (ZGC); Olavakkode, Dhoni, 10° 51' 30.96" N, 76° 37' 19.92" E, 133 m, 20 November 2018, Thulasi & Maya, 14279 (ZGC); Virgin Valley, 11° 2' 42.72" N, 76° 26' 33" E, 79 m, 24 November 2018, Thulasi, 14289 (ZGC); Nelliampathy, Manpara, 10° 33' 27.72" N, 76° 44' 40.2" E, 1065 m, 1 December 2018, Thulasi & Maya, 14317 (ZGC); Siruvani, 10° 58' 43.32" N, 76° 36' 43.92" E, 830 m, 20 September 2019, Thulasi, 14407 (ZGC); Ottappalam, Rayiranallurmala, 10° 52' 14.16" N, 76° 9' 16.92" E, 33 m, 16 September 2019, Thulasi, 14429 (ZGC); Thirumittakkode, 10° 46' 54.84" N, 76° 10' 58.8" E, 17 m, 2 October 2019, Thulasi, 14439 (ZGC); Silent Valley

National Park, 11° 5' 48.84" N, 76° 27' 19.8" E, 1030 m, 22 October 2019, Thulasi, 14465 (ZGC); Parathod, 11° 5' 51" N, 76° 26' 48.84" E, 920 m, 23 October 2019, Thulasi, 14525 (ZGC); Parambikulam Tiger Reserve, 10° 25' 12.72" N, 76° 45' 57.6" E, 700 m, 7 December, 2019 Thulasi, 14615 (ZGC); Nhangattiri, 10° 47' 14.136" N, 76° 10' 51.924" E, 25 m, 17 May 2022, Thulasi, 15032 (ZGC); Malappuram District, 10° 53' 56.4" N, 76° 11' 28.68" E, 11 m, 15 November 2018, Thulasi, 14268 (ZGC); Thrissur District, Athirappilly, 10° 17' 47.76" N, 76° 47' 38.76" E, 930 m, 14 February 2021, Thulasi, 14838 (ZGC); Peechi, 10° 32' 18.06" N, 76° 25' 2.712" E, 160 m, 10 July 2021, Thulasi, 14858 (ZGC).

Adiantum raddianum C.Presl, Tent. Pterid. 158. 1836, *nom. nov.* for *A. cuneatum* Langsd. & Fisch, 1810, *non* G.Forst. 1786; Manickam, Fern Fl. Palni Hills, 40. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 211. Pl. 78. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 204. 2017.

Adiantum venustum *auct.* Nayar & Geev., Fern Fl. Malabar 146. 1993, *non* D.Don, Prodr. Fl. Nepal. 17. 1824.

Rhizome short creeping, 15-25 cm long, 1-1.5 cm thick, scales ovate-lanceolate, 2-2.5 x 0.2-0.25 mm, uniformly pale brown, apex acuminate, margin entire. Stipes compact, 19-20 x 0.1-0.2 cm, dark brown, terete or shallowly grooved above, glabrous, glossy above, scaly at the base. Lamina deltoid ovate, 17-18 x 11-12 cm, usually tripinnate, very rarely quadripinnate; primary, secondary and tertiary pinnae alternate and anadromous. Pinnules obovate, ob-triangular, 0.5-1 x 0.5-1 cm, base narrowly cuneate, margin rounded regularly, deeply bilobed or trilobed, primary lobes sometimes lobed again, margin serrulate when sterile; veins distinct, repeatedly, dichotomously, flabellately, branched, free, reaching the sinuses between the ultimate serrature, 3-6 veins converging, thin herbaceous texture. Sori 3-8 to each pinnule, obreniform; indusium translucent, pale brown, entire. (Plate 4.27: Fig. a-f.; Plate 4.81: Fig. g.).

Distribution: Common in areas of 600-1600 m altitude. Terrestrial, seen in fully or partially exposed roadsides and land cuttings. Found growing at Nelliampathy, Silent Valley National Park, Siruvani, Pampadum Shola National Park, Munnar.



Plate 4.26: a-g. *Adiantum latifolium* Lam. a. Habitat b. Habit c. Scale d. Rhizome e. Frond - Adaxial surface f. Frond - Abaxial surface g. Sori. h-m. *Adiantum philippense* L. h. Habitat i. Habit j. Rhizome k. Scale l-m. Sporophyll - l. Adaxial surface m. Abaxial surface.

Notes: The specimen described by Nayar and Geevarghese (1993) under the name *A. venustum* was re-identified as *A. raddianum* by Kurup (2003).

Specimen/s examined: Kerala: Palakkad District, Nelliampathy, Manpara, 10° 33' 27.72" N, 76° 44' 40.2" E, 1065 m, 1 December 2018, Thulasi & Maya, 14316 (ZGC); Silent Valley National Park, Kummattanthodu, 11° 5' 33.36" N, 76° 26' 44.16" E, 1020 m, 22 October 2019, Thulasi, 14445 (ZGC); Parambikulam Tiger Reserve, Kariyanjola, 10° 25' 10.92" N, 76° 46' 46.2" E, 700 m, 7 December 2019, Thulasi, 14618 (ZGC); Vazhakkundu, 10° 31' 6.6" N, 76° 42' 52.2" E, 910 m, 15 January 2020, Thulasi, 14765 (ZGC); Cheriya Govinda mala, 10° 30' 38.16" N, 76° 41' 42" E, 987 m, 3 November 2020, Thulasi & Maya, 14808 (ZGC); Maattumala, 10° 32' 4.236" N, 76° 43' 18.444" E, 1300 m, 4 November 2020, Thulasi & Maya, 14826 (ZGC); Agali, Ommala, 11° 3' 35.64" N, 76° 36' 39.96" E, 730 m, 14 November 2021, Thulasi, 14921 (ZGC); Thrissur District, Malakkappara, 10° 17' 47.76" N, 76° 47' 38.76" E, 930 m, 14 February 2021, Thulasi, 14842 (ZGC). Tamil Nadu: 10° 13' 20.64" N, 77° 26' 39.12" E, 2300 m, 18 November 2019, Thulasi, 14569 (ZGC); Ooty, 11° 14' 40.272" N, 76° 42' 7.596" E, 650 m, 21 November 2021, Thulasi, 14948 (ZGC); Ooty, 11° 26' 39.48" N, 76° 37' 24.24" E, 2200 m, 29 October 2021, Thulasi, 14972 (ZGC). Palakkad, Silent Valley Dam site, Nayar and team, 10198 (CALI).

Adiantum zollingeri Mett. ex Kuhn, Ann. Mus. Bot. Lugd.-Bat. 4: 280. 1869; Manickam. Fern Fl. Palni Hills, 37. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 99. Pl. 74. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 215. 2017.

Adiantum nagnam B.K.Nayar & Gev., Fern Fl. Malabar 143. 1993.

Rhizome erect, 2-4 cm long, 2-2.5 cm thick, densely scaly all over; scales 3-4 x 0.5-1 mm, lanceolate, dark at the centre, pale brown at the periphery, acuminate, entire, stipes tufted, 11.7-12 x 0.4-0.5 cm, dark brown, terete, scaly at the very base, densely hairy on the adaxial surface. Lamina oblong-lanceolate, 29-30 x 3-4 cm, simply pinnate, acuminate; pinnae 10-12 pairs, basal few pairs deflexed, others patent; subopposite below, alternate above, 0.5-1 cm apart, sessile, semi deltoid, lower half completely excised, lower margin perpendicular to the rachis, upper base

truncate, apex acute, upper margin lobed on r-third to halfway to the lower margin; lobes oblong with truncate apex; veins slightly distinct above and below, dichotomously branched, free, reaching the margin; pinnae pale green, glabrous both sides, texture herbaceous; short, dark brown stiff hairs densely distributed on the adaxial side of the rachis, sori marginal on each lobe, oblong or reniform, protected by reflexed margin, densely hairy above; spore triangular, brown, exine spinulose. (Plate 4.27: Fig. g-l.; Plate 4.81: Fig. j.).

Distribution: Terrestrial or lithophytic, along dry and fully exposed road sides, rock crevices.

Specimen/s examined: Kerala: Palakkad District, Olavakkode, Dhoni, 10° 51' 34.2" N, 76° 37' 21.72" E, 120 m, 13 September 2018, Thulasi & Maya, 14227 (ZGC); Ottappalam, Ananganmala, 10° 46' 28.02" N, 76° 22' 33.6" E, 180 m, 13 October 2018, Thulasi & Maya, 14245 (ZGC); Bhavani, Thudukki, 11° 8' 4.272" N, 76° 30' 31.68" E, 1260 m, 2 October 2021, Thulasi, 14886 (ZGC). Tamil Nadu: Ooty, 11° 11' 58.884" N, 76° 43' 16.824" E, 490 m, 21 November 2021, Thulasi, 14941 (ZGC).

Aleuritopteris Fée, Mém. Fam. Foug. 5 Gen. Fil.: 153. 1852.

Key to species

1. Lamina ovate; indusial margin sub-entire*A. bullosa*
1. Lamina ovate-lanceolate; indusial margin deeply incised*A. bicolor*

Aleuritopteris bicolor (Roxb.) Fraser-Jenk., Fern Gaz. 18(5): 223. 2009; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 221. 2017.

Pteris bicolor Roxb., Calcutta J. Nat. Hist. 4: 507. 1844.

Cheilanthes farinosa (Forsk.) Kaulf., Enum Fil. 212.1824; Bedd., Ferns S. India, t. 191. 1864; Handb. Ferns Br. India, 92. 1883; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 83. Pl. 63. 1992; Nayar & Geev., Fern Fl. Malabar 120. 1993.

Cheilanthes bullosa Bedd., Ferns South. India, t. 192. 1863.

Rhizome erect, 2-5 cm long, 1.8-2 cm thick, scaly all over; scales lanceolate, 4-5 x



Plate 4.27: a-f. *Adiantum raddianum* C.Presl a. Habitat b. Habit c. Scale d. Rhizome e. Sori f. Spotophyll. g-l. *Adiantum zollingeri* Mett. ex Kuhn g. Habitat h. Habit i. Rhizome j. Sori k. Scale l. Sporophyll.

1-2 mm, reddish-brown, centre dark, apex acuminate, margin entire. Stipes tufted, 14.5-15 x 0.2-0.3 cm wide, purplish brown, terete, sparsely scaly at base, glossy. Lamina bipinnatifid, ovate-lanceolate, 29-30 x 8-10 cm, apex acuminate, base cordate; pinnae 8-10 pairs, opposite, sessile; largest pinna 7.7-8 x 2.8-3 cm, ovate-lanceolate, acroscopic base truncate, basispic base cuneate; pinnules 7-8 pairs per pinna, alternate, 2.8-3 x 0.8-1 cm, oblanceolate, apex rounded, margins crenate; costa obscure, pinnae dark green, glabrous above, lower surface covered by silvery waxy powder, texture sub-coriaceous; veins obscure above, slightly distinct below, forked, free, reaching the margin. Sori submarginal, protected by false indusium; indusia pale brown; spores spherical, dark brown. (Plate 4.28: Fig. a-f.; Plate 4.81: Fig. k.).

Distribution: Terrestrial along partially or fully exposed areas. Between 300-2300 m.

Specimen/s examined: Kerala: Idukki District, Mathikettan Shola National Park, Choondal, 9° 59' 4.56" N, 77° 14' 46.68" E, 1500 m, 2 August 2019, Thulasi & Manju, 14394 (ZGC); Palakkad District, Mannarkkad, Siruvani, 10° 58' 55.56" N, 76° 36' 1.8" E, 700 m, 20 September 2019, Thulasi, 14416 (ZGC); Silent Valley National Park, Kummattanthodu, 11° 5' 48.84" N, 76° 27' 19.8" E, 1030 m, 22 October 2019, Thulasi, 14466 (ZGC); Poochippara to Walakkad trek path, 11° 6' 38.16" N, 76° 25' 20.64" E, 1070 m, 28 December 2019, Thulasi, 14665 (ZGC); Parambikulam Tiger Reserve, Karimala, 10° 30' 42.84" N, 76° 52' 49.44" E, 360 m, 5 December 2019, Thulasi, 14578 (ZGC); Nelliampathy, Vazhakkundu, 10° 31' 6.7332" N, 76° 42' 52.38" E, 910 m, 15 January 2020, Thulasi & Maya, 14772 (ZGC); Cheriya Govinda mala, 10° 30' 38.2608" N, 76° 41' 42.18" E, 987 m, 3 November 2020, Thulasi & Maya, 14795 (ZGC); Maattumala, 10° 32' 4.2" N, 76° 43' 18.12" E, 1300 m, 4 November 2020, Thulasi & Maya, 14818 (ZGC). Tamil Nadu: Ooty, 11° 17' 9.78" N, 76° 38' 47.436" E, 1750 m, 23 November 2021, Thulasi, 14951 (ZGC); Mukurthi National Park, Bankitapal, 11° 13' 24.96" N, 76° 32' 1.68" E, 2371 m, 27 February 2022, Maya, 15024 (ZGC).

Aleuritopteris bulbosa (Kunze) Ching, Hong Kong Naturalist 10(3-4): 202. 1941 [as "*bulbosa*"]; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 222. 2017.

Cheilanthes bulbosa Kunze, Linnaea 24: 274-275. 1851; Manickam, Fern Fl. Palni Hills, 28. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 88. Pl. 64. 1992.

Rhizome erect, 3-4 cm long, 2-3 cm thick, scaly all over; scales lanceolate, 3-4 x 1-2 mm wide, dark at centre, periphery pale, apex acuminate, margin entire. Stipes tufted, 28-30 x 0.22-0.25 cm thick, dark brown, terete, scaly at base, glabrous above. Lamina bipinnatifid, ovate, 20-25 x 8-10 cm, acuminate; pinnae slightly ascending, opposite, sessile; largest pinna 5.5-6 x 2.5-3 cm, oblong-lanceolate, acuminate, acroscopic base truncate, basiscopic base cuneate, pinnules 10-12 pairs, alternate, adnate, oblong, 2.5-3 x 0.3-0.5 cm, basiscopic pinnules slightly larger than others, apex subacute, margin crenate, pinnae dark green, above glabrous, below covered by silvery waxy powder; costa and costules marked by deep furrow above, interveinal area bullate; sori submarginal, false indusiate, false indusium sub-entire; spores ovoid, dark brown. (Plate 4.28: Fig. g-m.; Plate 4.81: Fig. l.).

Distribution: Terrestrial along partially shaded trek paths and stream sides. Between 800-2100 m.

Specimen/s examined: Tamil Nadu: Kodaikanal, 10° 14' 30.12" N, 77° 29' 17.16" E, 2075 m, 18 November 2019, Thulasi, 14556 (ZGC); Ooty, 11° 28' 16.32" N, 76° 24' 41.04" E, 870 m, 29 December 2021, Thulasi, 14961 (ZGC); Kerala: Palakkad District, Silent Valley National Park, Walakkad to Sispara trek path, 11° 12' 6.48" N, 76° 26' 24.36" E, 2000 m, 29 December 2019, Thulasi, 14692 (ZGC).

Antrophyum Kaulf., Enum. Fil. 197, 282. 1824.

Key to species

1. Fronds sessile or sub-sessile; scales narrowly oblong *A. reticulatum*
1. Fronds distinctly stipitate; scales lanceolate *A. plantagineum*

Antrophyum plantagineum Kaulf., Enum. Fil. 197. Sept. 1824, *nom. cons.*, non D. Don Dec. 1824; Bedd., Handb. Ferns Br. India, 403. 1883; Manickam, Fern Fl.



Plate 4.28: a-f. *Aleuripteris bicolor* (Roxb.) Fraser-Jenk. a. Habitat b. Habit c-d. Frond e. Rhizome f. Scale. g-m. *Aleuripteris bullosa* (Kunze) Ching g. Habitat h. Habit i. Rhizome j-k. Frond l. Scale m. Sori.

Palni Hills, 45. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 107. Pl. 85. 1992; Nayar & Geev., Fern Fl. Malabar 148. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 323. 2017.

Rhizome short creeping, 2-4 cm long, 3-4 mm thick, densely covered by scales all over; scales lanceolate, 3-4 x 0.22-0.25 mm, dark brown to black, acuminate, margin conspicuously toothed. Fronds closely arranged, simple, entire, 14.5-15 x 3-3.5 cm, with 4.8-5 x 0.1-0.2 cm flattened stipe, with densely scaly at the base; fronds falcate-elliptic, usually widened above the half, margin entire, apex acute or obtuse, base cuneate; midrib slightly distinct at the base; veins distinct in sterile fronds, conspicuously raised in fertile fronds, anastomosing without any included veinlets; texture sub-coriaceous, plicate above, fertile fronds slightly thicker than sterile ones, dark green, glabrous above and below. Sori borne along the longitudinal groove along the netted veins, soral grooves raised on the upper surface; paraphyses club-shaped; spores trilete, tetrahedral, yellowish-green. (Plate 4.29: Fig. a-e.; Plate 4.82: Fig. a.).

Distribution: Epiphytes or lithophytes, along fully shaded areas. Found growing at Silent Valley National Park, Mathikettan shola National Park.

Specimen/s examined: Kerala: Idukki District, Mathikettan Shola National Park, 9° 58' 47.28" N, 77° 14' 12.84" E, 1400 m, 1 August 2019, Thulasi & Manju, 14363 (ZGC); Malappuram District, Karimpuzha Wildlife Sanctuary, Paanappuzha, 11° 18' 29.844" N, 76° 26' 55.536" E, 350 m, 4 September 2021, Thulasi, 14875 (ZGC); Palakkad District, Bhavani, Thudukki, 11° 8' 4.128" N, 76° 30' 28.404" E, 2 October 2021, Thulasi, 14895 (ZGC).

Antrophyum reticulatum (G.Forst.) Kaulf., Enum. Fil. 198. 1824; Nayar & Geev., Fern Fl. Malabar 149. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 323. 2017.

Rhizome short creeping, 3-4 cm long, 2-3 mm thick, unbranched, covered by sales; scales narrowly oblong, 4-5 x 0.5-0.75 mm, apex with ovate yellowish gland, margin prominently toothed. Fronds tufted, erect, dorsoventrally compressed

inconspicuous stipe; lamina simple, 15-25 x 1.5-2.5 cm, narrowly oblanceolate, apex acuminate, base decurrent, above and below glabrous; veins slightly distinct, basal midrib region splitting into 6-10 slender veins forming a network of narrow areoles; texture coriaceous. Sori elongated along reticulated veins, located in shallow groove; sporangia mixed with paraphyses; spores 45 x 55 μ in size.

Distribution: Epiphytic along shaded locations, between 750 -1000 m.

Notes: During the present study this species could not be recorded. Here added based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Kerala: Palakkad district, Silent Valley, Kummattanthodu, Nayar and Party, 10028 (CALI); Bhargavan, 65517 (MH).

Ceratopteris Brongn., Bull. Sci. Soc. Philom. Paris 1821: 186. 1822.

Ceratopteris thalictroides (L.) Brongn., Bull. Sci. Soc. Philom. Paris 8: 186. 1821; Bedd., Ferns Br. India, t.75. 1864; Manickam, Fern Fl. Palni Hills, 31. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 91. Pl. 67. 1992; Nayar & Geev., Fern Fl. Malabar 89. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 225. 2017.

Rhizome erect or subrect, 1-2 cm long, 0.5-0.7 cm thick, bearing thick, fibrous, long roots on abaxial side, apex covered with scales; scales soft, uniformly pale brown, 1-2 x 3-4 mm, ovate, acute, entire, comprising small, curved cells all over. Fronds arranged in rosettes; stipes 18-20 x 1-2 cm, terete, fleshy, pale green, densely ridged all over with few scattered scales. Lamina dimorphic; sterile lamina bipinnatifid, ovate, 30-32 x 19-20 cm acute; primary pinnae about five pairs, slightly ascending, alternate, 7-8 cm apart, distinctly stalked, secondary pinnae 3-4 pairs, alternate, shortly stalked, broadly deltoid, 3.5-4 x 3.5-4 cm, pinnatifid 2-3 mm to the costa, ultimate lobes linear, oblong or variously shaped, 1.5-2 x 0.5-1 cm, apex acute, margin entire; veins slightly distinct above and below, anastomosing, elongated areoles of 0.5-1 x 1-2 mm, lamina glabrous above and below, pale green, texture soft

herbaceous. Fertile lamina ovate, 38-40 x 22-23 cm, tripinnate, ultimate segment needle like, 5-6 x 0.1-0.2 cm, acute, margin reflexed, completely covering the lower surface, on which two rows of larger sporangia are borne; spores trilete, triangular-globose, pale green. (Plate 4.29: Fig. f-h).

Distribution: Aquatic or semi-aquatic plants. Seen in fully exposed paddy fields, canals, marshy areas and ponds between 15 to 100 m.

Specimen/s examined: Kerala: Palakkad District, Mannarkkad, Arakurussy, 10° 59' 41.28" N, 76° 26' 48.84" E, 54 m, 17 October 2018, Thulasi, 14250 (ZGC); Virgin Valley, 11° 2' 42.72" N, 76° 26' 33" E, 79 m, 24 November 2018, Thulasi & Jisha, 14290 (ZGC); Ottappalam, Nhangattiri, 10° 47' 14.136" N, 76° 10' 51.924" E, 25 m, 17 May 2022, Thulasi, 15044 (ZGC); Thrissur District, Peechi, 10° 32' 17.88" N, 76° 25' 2.64" E, 160 m, 10 November 2021, Thulasi, 14864 (ZGC).

Doryopteris J. Sm. Hooker J. Bot. 3: 404. 1841, *nom. cons.*

Doryopteris concolor (Langsd. & Fisch.) Kuhn, Reis. Ost-Afrika 3(3): 19. 1879; Bedd., Handb. Ferns Br. India, 100. 1883; Manickam, Fern Fl. Palni Hills, 30. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 83. Pl. 59. 1992; Nayar & Geev., Fern Fl. Malabar 124. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 245. 2017.

Rhizome erect or suberect, 2-2.5 cm long, 1.8-2 cm thick, covered by scales; scales lanceolate, 3-3.5 x 1-2 mm, pale brown, opaque at the centre, transparent at the periphery, apex acuminate, margin entire. Stipes tufted, 23-25 cm x 2-2.5 mm, dark brown to blackish, shallowly grooved above, rounded below, densely scaly at the base. Lamina simple, cordiform, ternate, pedate, 7-8 x 15-16 cm; primary lobes broad lanceolate, pinnatifid or bipinnatifid, lateral lobes longer than the middle ones, terminal segments 10-12 pairs, ovate lanceolate, obtuse, sinuses; costa distinct, dark purplish, polished, raised above and below, pale brown and grooved above; veins indistinct; pinnae dark green, glabrous above and below. Sori marginal, continuous, 1-2 mm wide, concolored with lamina surface; spores trilete, globose, pale brown. (Plate 4.30: Fig. a-g.; Plate 4.82: Fig. b.).

Distribution: Common. Seen in exposed dry terrestrial habitats, from 300- 900 m. Found growing at Vazhakkundu, Nellyampathy; Mathikettan shola National Park; Silent Valley National Park; Palni Hills.

Specimen/s examined: Kerala: Palakkad District, Nellyampathy, Manpara, 10° 33' 27.972" N, 76° 44' 40.38" E, 1065 m, 1 December 2018, Thulasi & Maya, 14306 (ZGC); Vazhakkundu, 10° 31' 6.708" N, 76° 42' 52.38" E, 910 m, 15 January 2020, Thulasi & Maya, 14776 (ZGC); Cheriya Govinda mala, 10° 30' 27.72" N, 76° 41' 45.6" E, 990 m, 3 November 2020, Thulasi & Maya, 14786 (ZGC). Tamil Nadu: Kodaikanal, 10° 15' 15.12" N, 77° 31' 32.16" E, 1650 m, 18 November 2019, Thulasi, 14566 (ZGC);

Oeosporangium Vis., Atti Real Ist. Sci. Veneto, 3, 12: 656. 1867.

Key to species

1. Basal pairs of pinnae reduced to auricles *O. elegans*
1. Basal pairs of pinnae not reduced *O. tenuifolium*

Oeosporangium elegans (Poir.) Fraser-Jenk. & Pariyar in Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 256. 2017.

Pteris elegans Poir., Lamarck, Encycl. Meth. Bot. 5: 718. 1804, *non* Sw., 1817, *nec al.*, *nec Cheilanthes elegans* Desv., 1811.

Cheilanthes opposita Kaulf., Enum. Fil. 211. 1824.

Cheilanthes mysurensis Wall. ex Hook., Sp. Fil. 2: 94, t. 100A. 1852; Manickam, Fern Fl. Palni Hills, 29. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 89. Pl. 65. 1992.

Rhizome erect, 2-3.5 cm long, 2-3 cm thick, scaly at apex; scales linear-lanceolate, 2-3 x 0.5-0.6 mm wide, uniformly dark brown, margin entire, apex acuminate. Stipes tufted, 5-6 x 2-2.5 mm thick, glossy, brittle, scaly at base, rounded below, flattened above, narrowly winged at both edges. Lamina linear-lanceolate, 28-30 x 3.8-4 cm wide, narrowed towards both tips, bipinnatifid; pinnae about 15-20 pairs,



Plate 4.29: a-e. *Antrophyum plantagineum* Kaulf. a. Habitat b. Habit c. Rhizome d. Scale e. Sporophylls with sori. f-h. *Ceratopteris thalictroides* (L.) Brongn. f. Habitat g. Habit h. Sporophyll.

opposite, basal few pairs reduced and forms deflexed auricle; largest pinna 2-2.5 x 1-1.5 cm wide, ovate, sessile, apex acute, base truncate; pinnules 6-7 pairs, alternate, oblong, adnate to costa, apex rounded, lobed margin, lobes halfway to costule; lobe apex truncate, margin entire, dark green, glabrous, texture herbaceous; veins obscure on both sides, forked repeatedly, free, not reaching the margin. Sori semicircular, on margins of each lobe, protected by reflexed margin; spores globose, brown. (Plate 4.30: Fig. h-n.; Plate 4.82: Fig. c.).

Distribution: Terrestrial and lithophytic on exposed dry localities. Between 80-1100 m.

Specimen/s examined: Kerala: Palakkad District, Nelliampathy, Manpara, 10° 33' 27.72" N, 76° 44' 40.38" E, 1065 m, 1 December 2018, Thulasi & Maya, 14304 (ZGC); Parambikulam Tiger Reserve, Vengolimala, 10° 21' 47.88" N, 76° 45' 28.44" E, 1100 m, 6 December 2019, Thulasi, 14614 (ZGC); Idukki District, Chinnar, 10° 17' 11.76" N, 77° 10' 5.88" E, 933 m, 7 January 2020, Thulasi & Maya, 14742 (ZGC). Tamil Nadu: Ooty, 11° 17' 9.78" N, 76° 38' 47.436" E, 1750 m, 21 November 2021, Thulasi, 14949 (ZGC).

Oeosporangium tenuifolium (Burm.f.) Fraser-Jenk. & Pariyar in Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 261. 2017.

Trichomanes tenuifolium Burm.f., Fl.Ind.237. 1768.

Cheilanthes tenuifolia (Burm.f.) Sw., Syn. Fil. 129, 332. 1806; Bedd., Handb. Ferns Br. India. 92. 1883; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 90. Pl. 66. 1992; Nayar & Geev., Fern Fl. Malabar 122. 1993.

Rhizome short creeping, around 3.5 cm long, 0.8-1 cm thick, densely scaly at the apex; scales lanceolate, 2-2.5 x 0.2-0.25 mm, uniformly pale brown, acuminate, entire. Stipes crowded, 38-40 x 0.1-0.2 cm, dark brown, rounded below, grooved above, glabrous, glossy. Lamina ovate-lanceolate, 25-30 x 8-10 cm, quadripinnate below, tripinnate at middle, bipinnate above, apex acuminate, base cuneate; primary pinnae 5-6 pairs, opposite, distinctly stalked, obliquely ovate-lanceolate, 7-8 x 4.5-5 cm, secondary pinnae larger on the basiscopic side, about five pairs; tertiary pinnae



Plate 4.30: a-g. *Doryopteris concolor* (Langsd. & Fisch.) Kuhn a. Habitat b. Habit c. Rhizome d. Vegetative frond e. Scale f. Sporophyll g. Sori h-n. *Oeosporangium elegans* (Poir.) Fraser-Jenk. & Pariyar. h. Habitat i. Habit j. Frond k. Rhizome l. Scale m. Abaxial surface of sporophyll n. Sori.

1-1.2 x 0.4-0.5 cm, pinnatifid up to the midrib; ultimate lobes ovate, subacute, entire or shallowly lobed; veins slightly distinct; forked once, free; pinnae dark green, glabrous above and below; texture thin herbaceous. Sori marginal on each ultimate lobe; protected by ultimate margin; spores globose, dark brown, exine granulose. (Plate 4.31: Fig. a-g.).

Distribution: Terrestrial herb. Common. Distributed from low to high altitudes, up to 1000 m.

Specimen/s examined: Kerala: Palakkad District, Olavakkode, Dhoni, 10° 51' 34.2" N, 76° 37' 21.72" E, 120 m, 13 September 2018, Thulasi & Maya, 14230 (ZGC); Ottappalam, Ananganmala, 10° 46' 28.02" N, 76° 22' 33.6" E, 180 m, 13 October 2018, Thulasi & Maya, 14243 (ZGC); Mannarkkad, Arakurussy, 10° 59' 41.28" N, 76° 26' 48.84" E, 54 m, 17 October 2018, Thulasi, 14255 (ZGC); Nelliampathy, Manpara, 10° 33' 27.72" N, 76° 44' 40.2" E, 1065 m, 1 December 2018, Thulasi & Maya, 14305 (ZGC); Thrissur District, Peechi, 10° 32' 18.06" N, 76° 25' 2.712" E, 160 m, 11 July 2021, Thulasi, 14860 (ZGC).

Mickelopteris Fraser-Jenk., Anno. Checklist Indian Pterid., 1: 246. 2017.

Mickelopteris cordata (Roxb. ex Hook. & Grev.) Fraser-Jenk. in Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 247. 2017.

Hemionitis cordifolia Wall. ex Roxb. in Griffith, Calcutta J. Nat. Hist. 4: 500. 1844.

Hemionitis cordata Roxb. ex Hook. & Grev., Icon. Fil. t. 64. 1828; Bedd., Handb. Ferns Br. India, 413. T. 245. 1883.

Hemionitis arifolia (Burm.f.) Moore, Ind. Fil., 114. 1859; Manickam, Fern Fl. Palni Hills, 34. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 93. Pl. 68. 1992; Nayar & Geev., Fern Fl. Malabar 125. 1993.

Parahemionitis cordata (Roxb. ex Hook. & Grev.) Fraser-Jenk., New Sp. Syndr. Indian Pteridol. 187. 1997.

Rhizome erect when young, about 3 cm long, short creeping when mature, 2.5-3 cm thick, densely covered by scales; scales ovate-lanceolate, 3-3.5 x 0.5-1 mm, dark at the centre, whitish at the periphery and entire, about one third of the scale toward the distal part is completely whitish without median dark band. Stipes compact, numerous, dark brown, polished, brittle, 30-35 cm long in fertile fronds, 20-25 cm long in sterile ones, 1-2 mm thick, terete, densely scaly all over when young, less when mature. Lamina simple, dimorphic, cordiform, 8.5-9 x 5.5-6 cm, fertile ones 6.8-7 x 9-10 cm, deltoid, trilobed, entire; costa raised below, grooved above, densely scaly below; veins obscure below and above, closely anastomosing, lamina pale green, chartaceous; long, soft, pale brown scales distributed all over the lower surface of the sterile lamina, very rare in fertile lamina. Sori continuous along the veins filling the entire surface of the lamina when mature, intermixed with hairs and scales; spores trilete, spherical, brown. (Plate 4.31: Fig. h-n.; Plate 4.82: Fig. d.).

Distribution: Common species. Distributed from low altitude to 1500 m, in fully exposed dry areas.

Notes: Show high variation in leaf shape from nearly ovate to deltoid or sagittate.

Specimen/s examined: Kerala: Palakkad District, Mannarkkad, Mothikkal, 10° 57' 27" N, 76° 25' 41.16" E, 53 m, 18 September 2018, Thulasi & Jisha, 14239 (ZGC); Ottappalam, Ananganmala, 10° 46' 28.02" N, 76° 22' 33.6" E, 180 m, 13 October 2018, Thulasi & Maya, 14246 (ZGC); Thirumittakode, 10° 46' 54.984" N, 76° 10' 58.98" E, 17 m, 2 October 2019, Thulasi, 14323 (ZGC); Walayar, Akamalavaram, 10° 52' 5.16" N, 76° 42' 41.04" E, 212 m, 02 January 2020, Thulasi & Maya, 1444 (ZGC); Idukki District, Mathikettan Shola National Park, 9° 58' 47.28" N, 77° 14' 12.84" E, 1400 m, 1 August 2019, Thulasi & Manju, 14372 (ZGC).

Pellaea Link, Fil. Spec. 59. 1841, *nom. cons.*

Key to species

1. Rhizome erect or suberect; scale apex acuminate; frond tripinnate ... *P. boivinii*
1. Rhizome short creeping; scale apex acute; frond simple or bipinnate
.....*P. longipilosa*

Pellaea boivinii Hook., Sp. Fil. 2: 147, t. 118 A. 1858; Bedd., Handb. Ferns Br. India, 102. t. 53. 1883; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 85. Pl. 61. 1992; Nayar & Geev., Fern Fl. Malabar 127. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 271. 2017.

Rhizome erect or suberect, 5-7 cm long, 1-1.5 cm thick, densely scaly at the apex; scales lanceolate, 5-5.5 x 1-2 mm, uniformly pale brown, transparent, apex acuminate, margin slightly toothed. Stipes tufted, numerous, 29-30 cm x 2-3 mm, black, stiff, brittle, terete, glossy and glabrous; lamina sub-triangular, 23-25 x 14-15 cm, tripinnate, primary pinnae 5- 6 pairs, subopposite, stalked 2-2.5 cm, ovate, 9-10 x 5-6 cm, secondary pinnae 5-6 pairs, opposite or subopposite, stalked 0.8- 1 cm; pinnules deltoid-ovate, 1.8-2 x 0.7-0.8 cm, shortly stalked, apex rounded, margin entire, base cordate; costa indistinct and grooved above, distinct, black and glabrous below; costule obscure both sides; pinnules green and pale green below, glabrous both above and below; adaxial of the rachis of the entire lamina and stalk of the pinnules densely covered by pale brown, short, stiff, unicellular, tubular hairs; texture coriaceous. Sori along the margin, protected by thin membranous, glabrous, entire, reflexed margin; spores trilete, triangular, brown. (Plate 4.32: Fig. a-e.).

Distribution: Rare species. Lithophytes, on dry fully exposed regions between 1100-1500 m. Found growing at Poochippara, Valiyaparathode of Silent Valley National Park.

Specimen/s examined: Kerala: Idukki District, Mathikettan Shola National Park, 9° 58' 47.28" N, 77° 14' 12.84" E, 1400 m, 1 August 2019, Thulasi & Manju, 14382 (ZGC); Palakkad District, Silent Valley National Park, Sairandhri to Poochippara trek Path, 11° 8' 0.96" N, 76° 24' 42.84" E, 1140 m, 28 December 2019, Thulasi, 14679 (ZGC); Walakkad to Sispara trek path, 11° 12' 6.48" N, 76° 26' 24.36" E, 2000 m, 29 December 2019, Thulasi, 14697 (ZGC).

Pellaea longipilosa Bonap., Notes Ptéridol. 15: 33-34. 1924; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 272. 2017.

Pellaea malabarica Geev. ex Madhus. & Jyothi, Indian Fern J. 9: 39.1993.



Plate 4.31: a-g. *Oeosporangium tenuifolium* (Burm.f.) Fraser-Jenk. & Pariyar a. Habitat b. Habit c. Vegetative leaf d. Rhizome e. Scale f. Sporophyll g. Pinnule with sori. h-n. *Mickelopteris cordata* (Roxb. ex Hook. & Grev.) Fraser-Jenk. h. Habitat i. Habit j. Rhizome k. Vegetative leaf l. Scale m. Sporophyll n. Sori.

Pellaea malabarica B.K.Nayar & Geev., Fern Fl. Malabar 129. 1993.

Rhizome short creeping, 4-8 cm x 5-8 mm, densely scaly; scale reddish brown, 4-5 x 0.3-0.4 mm, margin entire, apex acute. Frond tufted, erect, simple or bi-pinnate, stipe 15-25 cm x 1-2 mm, dark reddish brown, hair all over. Lamina narrowly ovate-lanceolate, 15-20 x 3-5 cm, lateral pinnae 6-18 pairs, subopposite, larger simple one short stalked, others sessile, 20-35 x 5-10 mm, oblong, margin crenate; lateral veins oblique, forked, ending to margin. Fertile pinnae faintly narrower, sori marginal, indusiate; spores triangular, brown.

Distribution: Terrestrial on exposed dry areas between boulders, between 800 to 1200 m.

Notes: During the present study this species was not recorded. It is included here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Kerala: Palakkad District, Silent Valley, Sabu, SV11123 (CALI); Thrissur District, Sholayar, Nair & Ghosh, 51047 (MH).

Pityrogramma Link., Handb. Erken. Gewäsche 3: 19. 1833.

Key to species

1. Abaxial surface of pinnae covered by white powder *P. calomelanos*
1. Abaxial surface of pinnae covered by yellow powder 2
2. Scales acuminate at apex *P. austroamericana*
2. Scales tapered at apex with club-shaped gland tipped *P. chrysophylla*

Pityrogramma austroamericana Domin, Spisy Vyd. Přírod. Fak. Karlovy Univ. 88: 7. 1928; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 272. 2017.

Pityrogramma calomelanos var. *aureoflava* (Hook.) Weath. ex. Bailey, Man. Cult. P. 64. 1924; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 95. Pl. 70. 1992.

Rhizome erect, about 6-8 cm long, 3.5-4 cm thick, scaly; scales lanceolate, 5-6 x 0.5-1 mm, long acuminate, light brown. Stipes tufted, 9-10 cm long, base scaly,

glossy above, grooved. Fronds 20-30 x 6-10 cm, bipinnate; lamina ovate, pinnae lanceolate, 4-7 x 1-2 cm, acuminate, narrowly towards apex, pinnules lanceolate, 5-8 x 2-3 cm, apex acute, margins serrate, basal pinnules reduced to auricle, glabrous above, covered by yellow powder below. Sori acrostichoid; spore trilete, globose, dark brown. (Plate 4.32: Fig. f-l.).

Distribution: Terrestrial along exposed land cuttings, road sides and mud cliffs. Between 500-1600 m.

Specimen/s examined: Tamil Nadu: Ooty, 11° 13' 28.704" N, 76° 44' 13.92" E, 570 m, 21 November 2021, Thulasi, 14943 (ZGC); Kerala: Idukki District, Neriamangalam, 10° 6' 51.156" N, 77° 3' 31.68" E, 1540 m, 06 March 2022, Thulasi, 15028 (ZGC).

Pityrogramma calomelanos (L.) Link, Handb. Erken. Gewäsche 3: 20. 1833 (as "*calomelas*"); Manickam, Fern Fl. Palni Hills, 33. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 94. Pl. 69. 1992; Nayar & Geev., Fern Fl. Malabar 99. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 273. 2017.

Acrostichum calomelanos L., Sp. Pl. 2: 1072. 1753.

Rhizome erect, about 5-7 cm long, 2.5-3 cm thick, densely scaly at the apex; scales lanceolate, uniformly yellowish-brown, apex long acuminate, margin entire; stipes tufted, 18-20 x 0.2-0.25 cm, dark brown, scaly at the very base, glabrous and glossy above, abaxially rounded, adaxially grooved. Lamina lanceolate, 18-20 x 7.5-8 cm, bipinnate, apex acute, base broadly cuneate; pinnae 10-12 pairs, progressively reduced towards apex, opposite or subopposite, 1.5-2 cm apart, shortly stalked, ovate-lanceolate, 6.7-7 x 1.5-2 cm, apex acuminate, acroscopic base truncate, basisopic base decurrent; pinnules 8-10 pairs, ovate, 0.8-1 x 0.4-0.5 cm, adnate with the costa, apex acute, margin entire; veins obscure, forked once or twice, reaching the margin; pinnae dark green, glabrous and glossy above, covered by silver coloured waxy powder below; thin herbaceous texture. Sori along veins, covered by entire surface in mature lamina. Spores trilete, globose, brown. (Plate 4.33: Fig. a-g.; Plate 4.82: Fig. e.).

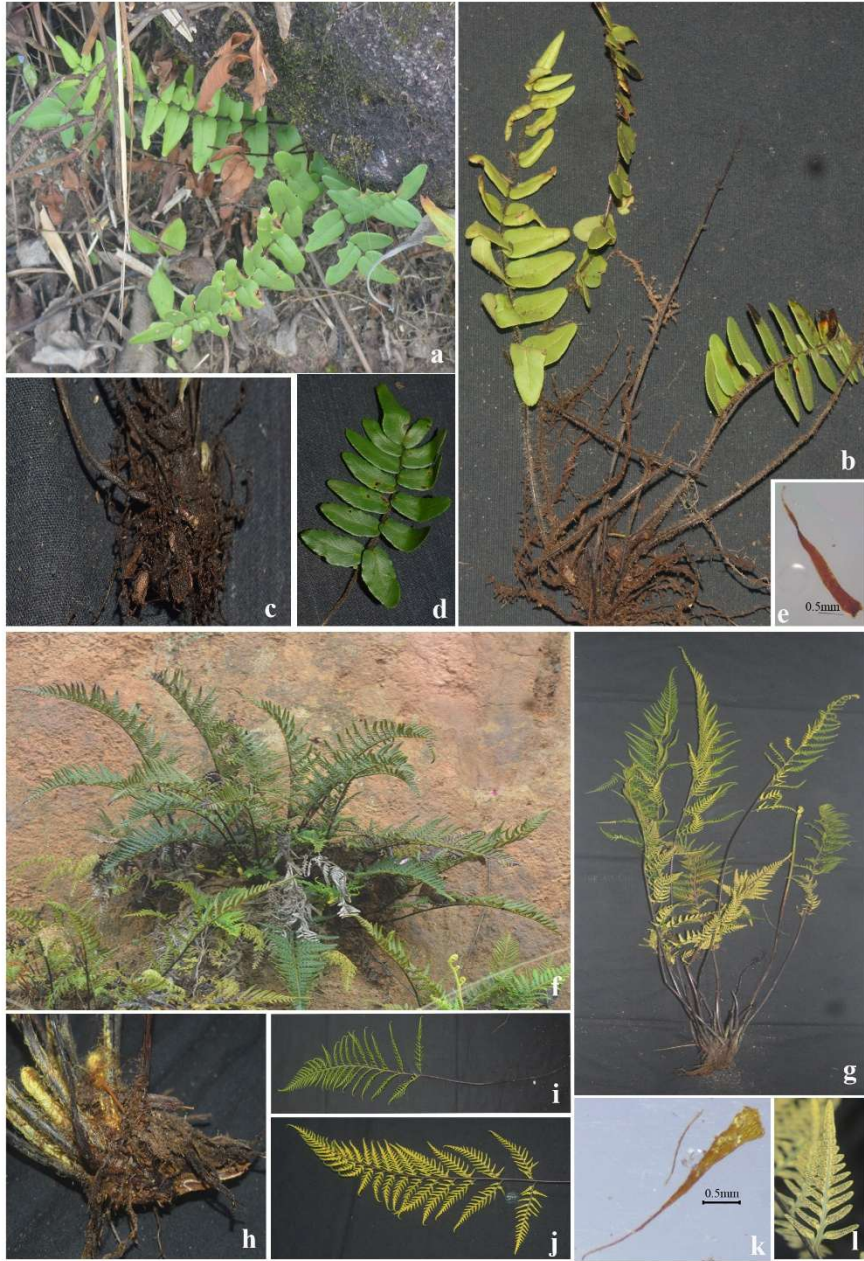


Plate 4.32: a-e. *Pellaea boivinii* Hook. a. Habitat b. Habit c. Rhizome d. Frond e. Scale. f-l. *Pityrogramma austroamericana* Domin f. Habitat g. Habit h. Rhizome i-j. Frond - i. Adaxial surface j. Abaxial surface k. Scale l. Sori.

Distribution: Common species. Terrestrial or lithophytic, along road sides in fully exposed areas. Seen as pioneer species in landslide areas. Common in low altitudes to 1800 m.

Notes: Showed high variation in plant size, leaf shape etc.

Specimen/s examined: Kerala: Palakkad District, Ottappalam, Ananganmala, 10° 46' 28.02" N, 76° 22' 33.6" E, 180 m, 13 October 2018, Thulasi & Maya, 14244 (ZGC); Nelliampathy, Manpara, 10° 33' 27.72" N, 76° 44' 40.38" E, 1065 m, 1 December 2018, Thulasi & Maya, 14315 (ZGC); Mannarkkad, Siruvani, 10° 58' 32.16" N, 76° 37' 16.68" E, 830 m, 20 September 2019, Thulasi, 14438 (ZGC); Silent Valley National Park, Kummattanthodu, 11° 5' 33.36" N, 76° 26' 44.16" E, 1020 m, 22 October 2019, Thulasi, 14447 (ZGC); Parambikulam Tiger Reserve, Karimal, 10° 28' 42.96" N, 76° 50' 55.32" E, 600 m, 5 December 2019, Thulasi, 14594 (ZGC).

Pityrogramma chrysophylla (Sw.) Link, Handb. Erken. Gew. 3: 19 (1833); Nayar & Geev., Fern Fl. Malabar 100. 1993.

Rhizome erect, about 4-7 cm long, 3-5 x 3-5 cm, covered by scale; scale 3-5 x 0.5-0.75 mm, tapered, apex club-shaped gland tipped. Frond spreading, 10-40 cm long. Lamina broadly lanceolate, 15-45 x 10-15 cm, rachis having sub-opposite primary pinnae, narrowly ovate, 5-10 x 1.0-2.5 cm, basispic base decurrent, apex acute, margin entire. Lamina subcoriaceous, abaxial surface having dense golden yellowish farina; veins not distinct, forked once, ending at margin. Sori abaxially on the sporophyll; spores triangular, brown.

Distribution: Forms dense populations at open or shaded localities, between 700 to 2000 m.

Notes: This species is included here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen examined: Kerala: Palakkad district, Silent Valley, Nayar and Party, 10044 (CALI); Thrissur district, Sholayar, N.C. Nair & S.R. Ghosh, 51062 (MH).

Pteris L., Sp. Pl. 2: 1073. 1753.

Key to species

1. Fronds simple pinnate 2
1. Fronds bipinnate or ternately divided and bipinnate 7
2. Rhizome short creeping 3
2. Rhizome erect or suberect 4
3. Terminal pinnae longer than lateral pinnae *P. ensiformis*
3. Terminal pinnae same as lateral pinnae *P. multiaurita*
4. Basal pinnae progressively reduced *P. vittata*
4. Basal pinnae not reduced 5
5. Sori protected by reflexed margin *P. scabripes*
5. Sori protected by indusium 6
6. Scale uniformly dark brown; pinnae margin spinulose serrate
..... *P. cretica* subsp. *cretica*
6. Scale not uniformly brown; pinnae margin entire with translucent pale brown
membrane border *P. cretica* subsp. *laeta*
7. Fronds ternately divided and bipinnate *P. pellucens*
7. Fronds bipinnate 8
8. Basal veins anastomosing *P. biaurita*
8. Basal veins not anastomosing 9
9. Scale apex acuminate *P. argyrea*
9. Scale apex not acuminate 10
10. Sori restricted to middle of the lobes' margin *P. blumeana*
10. Sori along the full length of the lobes' margin *P. mertensioides*

Pteris argyrea T.Moore, Gard. Chron. 1859: 671. 1859; Fraser-Jenkins *et al.*,
Anno. Checklist Indian Pterid., 323. 2017.

Pteris quadriaurita var. *argentea* Hort. ex Bedd., Handb. Ferns Brit. India 111.
1883; Manickam, Fern Fl. Palni Hills, 23.1986; Manickam & Irud., Pterid. Fl. W.
Ghats S. India, 78. Pl. 54. 1992; Nayar & Geev., Fern Fl. Malabar 114. 1993;
Manickam & Irudayaraj, Pterido. Fl. Nilgiris, 87. 2003; Sreenivas *et al.*, Indian Fern
J. 30: 268. 2013.

Rhizome erect, 4.5-6.5 cm long, 1.5-4 cm thick, scaly at the apex; scales lanceolate, 4-4.2 x 0.5- 0.6 mm, pale brown at the periphery, dark at the centre, apex acuminate, margins fimbriate. Stipes tufted, numerous, 20-85 x 2-5 cm thick, pale brown and scaly at the base, stramineous and glossy above. Lamina 15-70 x 15-34 cm, broadly or narrowly deltoid, bipinnate; pinnae up to nine pairs, opposite, subopposite, alternate, oblong-lanceolate, 21-22 x 4-5 cm, apex acuminate, base broadly cuneate, margin lobed, 4/5th to the costa; lobes 2.5-3 x 0.4-0.6 cm, oblong lanceolate, entire, apex rounded, veins pinnate, 12-14 pairs, distinct both above and below; adaxially green with white stripes along the midrib, pale green abaxially; Spore triangular, brown. (Plate 4.33: Fig. h-l.).

Distribution: Seen in fully shaded or partially shaded stream banks or forest floor, between 600-2100 m.

Specimen/s examined: Kerala: Palakkad District, Mannarkkad, Meenvallam, 10° 55' 24.96" N, 76° 33' 51.84" E, 85 m, 11 September 2018, Thulasi, 14210 (ZGC); Arakurussy, 10° 59' 41.28" N, 76° 26' 48.84" E, 54 m, 17 October 2018, Thulasi, 14253 (ZGC); Virgin Valley, 11° 2' 42.72" N, 76° 26' 33" E, 79 m, 24 November 2018, Thulasi, 14292 (ZGC); Olavakkode, Dhoni, 10° 51' 34.2" N, 76° 37' 21.72" E, 120 m, 13 September 2018, Thulasi & Maya, 14236 (ZGC); Nelliampathy, Manpara, 10° 33' 27.72" N, 76° 44' 40.2" E, 1065 m, 1 December 2018, Thulasi & Maya, 14302 (ZGC); Vazhakundu, 10° 31' 6.6" N, 76° 42' 52.2" E, 910 m, 15 January 2020, Thulasi & Maya, 14763 (ZGC); Maattumala, 10° 32' 4.2" N, 76° 43' 18.12" E, 1300 m, 4 November 2020, Thulasi, 14819 (ZGC); Parambikulam Tiger Reserve, Karimala, 10° 25' 15.24" N, 76° 46' 1.2" E, 670 m, 5 December 2019, Thulasi, 14604 (ZGC); Silent Valley National Park, Poochippara to Walakkad trek path, 11° 6' 38.16" N, 76° 25' 20.64" E, 1070 m, 28 December 2019, Thulasi, 14662 (ZGC); Walakkad to Sispara trek path, 11° 12' 6.48" N, 76° 26' 24.36" E, 2000 m, 29 December 2019, Thulasi, 14707 (ZGC); Bhavani, Thudukki, 11° 8' 9.24" N, 76° 30' 18.792" E, 1380 m, 2 October 2021, Thulasi, 14905 (ZGC); Walayar, Aduppukootti mala, 10° 57' 10.8" N, 76° 48' 46.8" E, 456 m, 12 January 2020, Thulasi, 14758 (ZGC); Ottappalam, Nhangattiri, 10° 47' 13.92" N, 76° 10' 51.6" E, 25 m, 17 May



Plate 4.33: a-g. *Pityrogramma calomelanos* (L.) Link a. Habitat b. Habit c. Rhizome d. Frond e. Scale f. Sporophyll g. Sorus. h-l. *Pteris argyraea* T.Moore h. Habitat i. Rhizome j. Frond k. Habit l. Scale.

2022, Thulasi, 15041 (ZGC); Malappuram District, Pulamanthol, 10° 53' 56.4" N, 76° 11' 28.68" E, 11 m, 15 November 2018, Thulasi, 14266 (ZGC); Karimbuzh Wildlife Sanctuary, Paanappuzha, 11° 18' 24.84" N, 76° 26' 37.32" E, 310 m, 4 September 2021, Thulasi, 14870 (ZGC); Idukki District, Mathikettan Shola National Park, Choondal, 9° 59' 4.56" N, 77° 14' 46.68" E, 1500 m, 2 August 2019, Thulasi & Manju, 14392 (ZGC); Thrissur District, 10° 32' 17.88" N, 76° 25' 2.64" E, 160 m, 10 July 2021, Thulasi, 14865 (ZGC).

Pteris biaurita L., Sp. Pl. 2: 1076. 1753; Manickam, Fern Fl. Palni Hills. 21, 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 73. Pl. 49. 1992; Nayar & Geev., Fern Fl. Malabar 104. 1993; Manickam & Irudayaraj, Pterido. Fl. Nilgiris, 86. 2003; Sreenivas *et al.*, Indian Fern J. 30: 268. 2013; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 323. 2017.

Rhizome erect or suberect, 2.8-6 cm long, 2.6- 3 cm in diameter, densely scaly at the apex, scales lanceolate, 2-3 x 0.7-0.75 mm, pale brown, translucent at periphery, dark brown and opaque at the centre, apex acuminate, margin hairy. Stipes tufted, numerous, 20-61 cm x 2-4 mm, pale brown at the base, stramineous above, adaxially rounded, abaxially grooved, scaly at the base, glabrous above. Lamina lanceolate, bipinnate, 20-30 x 12-25 cm, green to pale green, coriaceous. Pinnae 10-12 pairs with one or two accessory branches on the basal basiscopic side of the basal most pair, subopposite, lanceolate, shortly stalked, apex acuminate, base broadly cuneate, margin lobed; lobes oblong, slightly falcate, 3-3.5 x 0.5-1 cm, apex rounded, margin entire; veins distinct below and above, basal veins of the adjacent costules forming an arc along costa with five to seven excurrent veins passing to the sinus base, other veins forked once and reaching the margin. Sori along the margin except at the base of the sinus and at the apex of the lobes, spores triangular, dark brown. (Plate 4.34: Fig. a-f.; Plate 4.82: Fig. f.).

Distribution: Terrestrial, along roadsides between the altitude 50-2000 m. A common species.

Specimen/s examined: Kerala: Palakkad District, Nelliampathy, Manpara, 10° 33' 27.72" N, 76° 44' 40.2" E, 1065 m, 1 December 2018, Thulasi & Maya, 14301

(ZGC); Vazhakkundu, 10° 31' 6.6" N, 76° 42' 52.2" E, 910 m, 15 January 2020, Thulasi, 14761 (ZGC); Mannarkkad, Siruvani, 10° 58' 55.56" N, 76° 36' 1.8" E, 700 m, 20 September 2019, Thulasi, 14421 (ZGC); Silent Valley National Park, Kummattanthodu, 11° 5' 48.84" N, 76° 27' 19.8" E, 1030 m, 22 October 2019, Thulasi, 14468 (ZGC); Parambikulam Tiger Reserve, Karimala, 10° 28' 42.96" N, 76° 50' 55.32" E, 600 m, 5 December 2019, Thulasi, 14590 (ZGC); Olavakkode, Elival Mala, 10° 52' 26.04" N, 76° 38' 10.68" E, 300 m, 8 January 2020, Thulasi, 14747 (ZGC); Agali, Ommala, 11° 3' 35.964" N, 76° 36' 40.284" E, 730 m. 14 November 2021, Thulasi, 14933 (ZGC); Idukki District, Pambadum Shola National Park, Pothukandam, 10° 7' 32.16" N, 77° 15' 16.92" E, 1800 m, 29 July 2019, Thulasi & Manju, 14327 (ZGC); Kuttikkad, 10° 7' 35.4" N, 77° 15' 29.88" E, 1900 m, 30 July 2019, Thulasi, 14334 (ZGC); Mathikettan Shola National Park, Choodal, 9° 59' 4.56" N, 77° 14' 46.68" E, 1500 m, 2 August 2019, Thulasi, 14401(ZGC). Tamil Nadu: Kodaikanal, 10° 15' 15.12" N, 77° 31' 32.16" E, 1650 m, 18 November 2019, Thulasi, 14567 (ZGC).

Pteris blumeana J.Agardh, Recens. Spec. Gen. Pterid. 22. 1839; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 68. 2017.

Pteris aspericaulis Wall., List No. 107, 1828; Nayar & Geev., Fern Fl. Malabar 102. 1993.

Pteris asperula J. Sm., Hook. J. Bot. 3: 405, 1841; Nayar & Geev., Fern Fl. Malabar 103. 1993.

Rhizome erect, unbranched, 2-3 x 2-2.5 cm, covered by scales; scale 3-4 x 0.5-0.6 mm, tip with club-shaped cell, dark-brown with hyaline margin, margin with many uniseriate multicellular elongated shaggy marginal hairs. Frond tufted, spreading, stipe 15-35 cm x 2-4 mm, reddish, glabrous. Lamina pinnate, elongate-ovate, 30-35 x 10-15 cm, rachis copper-red; pinnae 3-5, obliquely spreading, subopposite, terminal pinna slightly longer, basal pinnae short stalked, upper ones sessile, lateral pinnae ovate-oblong, base cuneate, apex acute, margin deeply pinnatifid; lobes oblong, 2-2.5 x 0.5-0.6 cm, apex obtuse. Lamina thin coriaceous, glabrous. Sori restricted to margin of the middle of the lobes; spores triangular, brown.

Distribution: Terrestrial on partially shaded localities, between 500 to 1000 m.

Notes: This species is included here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Kerala: Palakkad district, Parambikulam, Varghese, 17885 (CALI).

Pteris cretica L. subsp. *laeta* (Wall. ex Ettingsh.) Fraser-Jenk., Taxon. Revis. Three Hundred Indian Subcont. Pterid. 100. 2008; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 285. 2017. pteris cre

Pteris laeta Wall. ex Ettingsh., Farnkr. Jetztw. 96, t. 57, f. 8-11, t. 58, f. 4, 12.: 75. 1864 (1865).

Pteris pellucida Presl, Rel. Haenk, 1: 55. 1825; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 69. Pl. 44. 1992; Sreenivas *et al.*, Indian Fern J. 30: 268. 2013.

Pteris venulosa Bl., Enum. Pl. Jav. 209. 1828; Nayar & Geev., Fern Fl. Malabar 115. 1993.

Rhizome erect, 5-10 cm long, 2.5-3 cm thick, scaly at apex; scales lanceolate, 3-4 x 0.4-0.5 mm wide, dark at centre, pale at periphery, gland tipped, margins with multicellular glandular outgrowths. Stipes 44.5-45 cm x 3-4 mm thick, rounded below, grooved above, glabrous, glossy. Lamina broadly obovate, 34-35 x 24-25 cm, simply pinnate, apex ternate; pinnae spreading, basispic base of terminal pinnae adnate to rachis; largest pinna 23.5-25 x 3.8-4 cm, elliptic, narrowing towards apex, decurrent at base, entire margin with pale brown translucent membranous border; costa raised and grooved above, rounded below; veins perpendicular to costa, forked, free, reaching the margin; pinnae light green, glabrous, coriaceous. Sori linear, marginal, indusiate; indusia dark brown, entire, glabrous; spores trilete, triangular, brown. (Plate 4.34: Fig. g-l.; Plate 4.82: Fig. h.).

Distribution: Terrestrial along fully shaded trek paths and forest floors. Between 80-1600 m.



Plate 4.34: a- f. *Pteris biaurita* L. a. Habitat b. Habit c. Rhizome d. Frond e. Scale f. Sori. g-l. *Pteris cretica* L. Subsp. *laeta* (Wall. ex Ettingsh.) Fraser-Jenk. g. Habitat h. Habit i. Rhizome j. Frond k. Sori l. Scale.

Specimen/s examined: Kerala: Palakkad District, Mannarkkad, Meenvallam, 10° 55' 24.6" N, 76° 33' 51.84" E, 81 m, 11 September 2018, Thulasi & Jisha, 14219 (ZGC); Arakurussy, 10° 59' 41.28" N, 76° 26' 48.84" E, 54 m, 17 October 2018, Thulasi, 14248 (ZGC); Virgin Valley, 11° 2' 42.72" N, 76° 26' 33" E, 79 m, 24 November 2018, Thulasi, 14282 (ZGC); Silent Valley National Park, Kummattanthodu, 11° 5' 48.84" N, 76° 27' 19.8" E, 1030 m, 22 October 2019, Thulasi, 14484 (ZGC); Olavakkode, Dhoni, 10° 51' 34.2" N, 76° 37' 21.72" E, 120 m, 13 September 2018, Thulasi & Maya, 14221 (ZGC); Elival mala, 10° 52' 26.04" N, 76° 38' 10.68" E, 300 m, 8 January 2020, Thulasi, 14751 (ZGC); Nelliampathy, Vazhakkundu, 10° 31' 6.6" N, 76° 42' 52.2" E, 910 m, 15 January 2020, Thulasi & Maya, 14766 (ZGC); Cheriya Govinda mala, 10° 30' 27.72" N, 76° 41' 45.6" E, 990 m, 3 November 2020, Thulasi & Maya, 14784 (ZGC); Bhavani, Thudukki, 11° 8' 15.72" N, 76° 29' 59.64" E, 1500 m, 2 October 2021, Thulasi, 14918 (ZGC); Malappuram District, Pulamanthol, 10° 53' 56.4" N, 76° 11' 28.68" E, 11 m, 15 November 2018, Thulasi, 14265 (ZGC).

Pteris cretica L. subsp. *cretica* Fraser-Jenk., *et al.*, Anno. Checklist Indian Pterid., 283. 2017.

Pteris cretica L., Mantissa Pl. 1: 130. 1767; Bedd., Handb. Ferns Brit. India 106. 1883; Manickam, Fern Fl. Palni Hills. 20, 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 71. Pl. 45. 1992; Nayar & Geev., Fern Fl. Malabar 105. 1993; Sreenivas *et al.*, Indian Fern J. 30: 268. 2013.

Rhizome erect, 5.5-8.5 cm long, 1.8-2 cm thick, scaly at apex; scales ovate lanceolate, 3-4 x 4-5 mm, dark brown, acuminate apex, entire margin. Stipes tufted, 49-50 cm x 2-3 mm thick, rounded below, grooved above, glabrous, glossy. Lamina ovate, 28.5-30 x 18.5-20 cm, simply pinnate with bipartite pinnules shorter than lateral ones; pinnae 6-7 pairs, basal one pair forked at their base, stalked, others simple, sessile; largest sterile pinna 14-15 x, 1-2 cm, lanceolate, apex acuminate, base broadly cuneate, margin spinulose serrate; fertile pinnae with entire margins; costa raised on both sides, veins parallel, simple or forked, free, reaching the margin; pinna dark green, glabrous, coriaceous. Sori linear along the margins; spores triangular, dark brown.

Distribution: Terrestrial along shaded trek paths, stream sides. Between 1000-2300 m.

Notes: This species is included here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Kerala: Palakkad District, Panthanthodu, Nayar and party, 10614 (CALI); N.C. Nair, 56644 (MH).

Pteris ensiformis Burm.f., Fl. Indica 230. 1768; Bedd., Handb. Ferns Brit. India 107. 1883; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 71. 1992; Nayar & Geev., Fern Fl. Malabar 108. 1993; Sreenivas *et al.*, Indian Fern J. 30: 268. 2013; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 286. 2017.

Rhizome short creeping, 3-6 cm long, 3-4 mm thick, scaly; scales 2-3 x 0.4-0.5 mm, brown, lanceolate, acuminate apex, margin entire. Stipes 10-15 x 2-3 cm, quadrangular, grooved above, glabrous, base scaly. Lamina simply pinnate, dimorphic, 18.8-20 x 10-15 cm, ovate or deltoid, membranous. Pinnae 3-5 pairs, terminal one larger than lateral ones; lateral pinnae 9- 10 x 4-5 mm wide in fertile fronds, in sterile fronds 8.5-9 cm x 2-3 mm wide; opposite, lanceolate-ensiformis, apex acute, margins crenate, pinnae adnate to rachis, lower pinnae deeply lobed, glabrous. Costa grooved on both sides, glabrous. Veins free, forked. Sori long, submarginal, false indusiate, white; sporangia intermixed with paraphyses. Spores triangular, brown. (Plate 4.35: Fig. a-g.).

Distribution: Terrestrial along shaded areas. Between 30-500 m.

Specimen/s examined: Kerala: Palakkad District, Ottappalam, Thirumittakkode, 10° 46' 54.984" N, 76° 10' 58.8" E, 17 m, 2 October 2019, Thulasi, 14443 (ZGC); Nhangattiri, 10° 47' 14.136" N, 76° 10' 51.924" E, 25 m, 17 May 2022, Thulasi, 15034 (ZGC).

Pteris pellucens J. Agardh, Recens. Spec. Gen. Pterid. 43. 1839; Sreenivas *et al.*, Indian Fern J. 30: 268. 2013; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 297. 2017.

Pteris longipes D. Don, Prod. Fl. Nepal, 15. 1825; Bedd., Handb. Ferns Brit. India 115. 1883; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 72. Pl. 47 & 48. 1992; Nayar & Geev., Fern Fl. Malabar 109. 1993.

Rhizome erect, 2.5-5 cm long, 1-2 cm thick, scaly at apex; scales ovate-lanceolate, 4-5 x 0.3-0.5 mm wide, dark brown, acuminate apex, margins entire. Stipes numerous, tufted, 25-50 cm x 4-5 mm, rounded below, grooved above, scaly at base, glabrous above. Lamina ternately divided, ovate, 44-45 x 23-25 cm, each branch bipinnatifid, median branch longer than lateral branches, ovate, some basal pinnae slightly reduced; lateral branches ovate, oblique. Pinnae 15-16 pairs in median branch, opposite, 8-9 pairs in lateral branches, alternate, oblong-lanceolate, 12-15 x 3-5 cm, long caudate apex acuminate, subsessile, base sub-truncate, margins lobed, lobes 0.4-0.5 mm to costa, 18-20 pairs, oblong, 0.5-1 x 0.3-0.5 cm, apex subacute, margins serrate in sterile ones, entire in fertile; costa raised on both sides, rounded below, grooved above; veins slightly distinct, forked once, free, reaching the margin; a spinule at junction of rachis and costa, pinnae green, thin herbaceous. Sori along the margin, except at tips and base of lobes, indusiate; indusia pale green, margins entire, glabrous; spores trilete, triangular, brown. (Plate 4.35: Fig. h-m.; Plate 4.82: Fig. g.).

Distribution: Terrestrial along shaded forest floors. Between 900-1200 m.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Kummattanthodu, 11° 5' 48.84" N, 76° 27' 19.8" E, 1030 m, 22 October 2019, Thulasi, 14496 (ZGC); Valyaparathodu-Madhrithodu, 11° 7' 9.84" N, 76° 25' 48.36" E, 960 m, 27 December 2019, Thulasi, 14651 (ZGC); Nelliampathy, Cheriya Govinda mala, 10° 30' 27.72" N, 76° 41' 45.6" E, 990 m, 3 November 2020, Thulasi & Maya, 14781 (ZGC).

Pteris mertensioides Willd., Linnaeus Sp. Pl., ed. 4, 5: 394. 1810; Nayar & Geev., Fern Fl. Malabar 110. 1993; Sreenivas *et al.*, Indian Fern J. 30: 268. 2013; Fraser-Jenkins *et al.*, Annot. Checklist of Indian Pterido, 294. 2017.

Rhizome short, erect, 3-4 x 4-8 cm, densely scaly; scales 15-20 x 0.4-0.5 mm,

narrowed to prolonged uniseriate apex, crowned by a short non-glandular cell. Frond tufted, spreading. Lamina spreading, ovate-oblong, 50-70 x 25-30 cm, simple pinnate, terminal pinna large; lateral pinnae elongate-oblong, 20-25 x 3-4.5 cm, margin deeply lobed; lobes 20-30 x 3-4 mm, apex round, base dilated, glabrous. Sorus along the margin of lobes; spores triangular, brown.

Distribution: Terrestrial on fully shaded forest floor, between 700-1200 m.

Notes: This species is included here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Kerala: Thrissur, Vazhachal, Nair & Ghosh, 51015 (MH).

Pteris multiaurita J.Agardh., Recens. Spec. Gen. Pterid. 12. 1839; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 69. 1992; Sreenivas *et al.*, Indian Fern J. 30: 268. 2013; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 295. 2017.

Rhizome short creeping, 3.5-7.5 cm long, 0.5-1 cm thick, scaly at apex; scales lanceolate, 3-4 x 0.7-0.75 mm, translucent at periphery, centre dark, acuminate apex, ciliate margin. Stipes tufted, 18-20 x 1-2 mm, glossy, base scaly, rounded below, grooved above. Lamina 24-25 x 19-20 cm, ovate, simply pinnate; pinnae 9-10 pairs, sessile, opposite, spreading; basal pair bipartite at base, not reduced; largest pinna 8.8-10 x 0.8-1 cm wide, oblong-lanceolate, acuminate apex, cuneate base, in distal part margin serrate, basal part entire margin; costa slightly raised, forked; above spinules present on costa; pinnae sub membranaceous texture, light green, glabrous. (Plate 4.36: Fig. a-f.).

Distribution: Terrestrial on shaded forest floors. Between 900-1000 m.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Valiyaparathodu-Madhrithodu, 11° 7' 9.84" N, 76° 25' 48.36" E, 960 m, 27 December 2019, Thulasi, 14656 (ZGC).

Pteris scabripes Wall. ex J.Agardh., Recens. Spec. Gen. Pterid. 11.1839; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 71. 1992; Sreenivas *et al.*, Indian Fern J. 30: 268. 2013; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 300. 2017.



Plate 4.35: a-g. *Pteris ensiformis* Burm.f. a. Habitat b. Habit c. Vegetative frond d. Rhizome e. Sporophyll f. Scale g. Sorus. h-m. *Pteris pellucens* J.Agardh h. Habitat i. Scale j. Habit k. Rhizome l. Frond m. Sori.

Pteris silent-valliensis S. R. Ghosh & R. K. Ghosh, J. Bombay Nat. Hist. Soc. 79(2): 385. 1983 ("1982").

Rhizome erect, 1.8-5 cm long, 2.5-3 cm thick, scaly at apex; scales 4-5 x 0.4-0.5 mm, ovate-lanceolate, uniformly dark brown, gland tipped, margins with glandular hairs. Stipes numerous, tufted, 30-50 cm x 3-5 mm, rounded below, grooved above, scaly at base, glabrous above. Lamina 25-35 x 15-30 cm, obovate, simply pinnate; pinnae 4-5 pairs, opposite, stalked, linear lanceolate, 18-20 x 1-2 cm, acroscopic base excised, base narrowly cuneate, apex acuminate, margin serrate at apex, entire in rest; costa raised and grooved adaxially, raised and rounded abaxially, pinnae dark green, glabrous, subcoriaceous texture; veins obscure, parallel, forked, free, reaching the margin. Sori along the margin, except base and apex, protected by reflexed margin; spores triangular, dark brown. (Plate 4.36: Fig. g-1).

Distribution: Terrestrial along shaded road sides. Between 900-2100 m.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Valiyaparathodu-Madhrithodu, 11° 7' 9.84" N, 76° 25' 48.36" E, 960 m, 27 December 2019, Thulasi, 14647 (ZGC); Walakkad to Sispara trek path, 11° 12' 5.4" N, 76° 26' 24" E, 2013 m, 2 January 2022, Thulasi, 14982 (ZGC); Bhavani, Thudukki, 11° 8' 4.2" N, 76° 30' 31.68" E, 1260 m, 2 October 2021, Thulasi, 14889 (ZGC).

Pteris vittata L., Sp. Pl. 2: 1074. 1753; Manickam, Fern Fl. Palni Hills. 21, 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 68. Pl. 42. 1992; Nayar & Geev., Fern Fl. Malabar 116. 1993; Sreenivas *et al.* Indian Fern J. 30: 268. 2013; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 307. 2017.

Rhizome suberect, 3.5-6 cm long, 4.6-5 cm thick, scaly at apex; scales ovate-lanceolate, 6-7 x 7-8 mm, thin membranaceous, apex acuminate, margins entire. Stipes tufted, 18-20 cm x 7-8 mm, rounded below, grooved above, pale brown, scaly at base. Lamina lanceolate, 90-95 x 30-34 cm, simply pinnate; pinnae 34-35 pairs, opposite, 1-2 cm apart, sessile, linear-lanceolate, 15-20 x 0.5-0.8 cm, apex acuminate, base broadly cuneate, margins serrate in distal part, entire in rest; basal

some pairs progressively reduced to deflexed auricles; veins obscure, simple, forked; pinnae light green, glabrous, texture herbaceous; sori along margin, up to base and apex; spore triangular, yellowish brown. (Plate 4.37: Fig. a-f.).

Distribution: Lithophytic and terrestrial along partially shaded regions. Between low altitude to 1000 m.

Specimen/s examined: Kerala: Palakkad District, Ottappalam, Nhnagattiri, 10° 47' 13.92" N, 76° 10' 51.6" E, 25 m, 10 May 2022, Thulasi, 15050 (ZGC).

Vittaria Sm., Mém. Acad. Roy. Sci., Turin 5: 413, t. 9, f. 5. 1793.

Vittaria elongata Sw., Syn. Fil. 109, 302. 1806; Bedd., Handb. Ferns Br. India, 238. 1883; Manickam, Fern Fl. Palni Hills, 45. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 107. Pl. 84. 1992; Nayar & Geev., Fern Fl. Malabar 151. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 326. 2017.

Rhizome short creeping, about 6-15 cm long, 3-4 mm thick, branched, scaly all over; scales lanceolate, 4-5 x 0.2- 0.3 mm, uniformly dark brown, uniformly thickened, margins sparsely dentate, apex long acuminate, gland tipped. Fronds simple, 48-50 x 0.8-1 cm, linear-lanceolate, narrowing towards both ends, basal 0.5-1 cm stipe, apex acuminate, margins entire, midrib distinct, slightly raised below, not raised above; veins obscure on both sides, oblique; dark green, texture chartaceous, flexuose. Sori marginal, 1-2 mm wide, groove extrorse in young, erect in mature, sporangia intermixed with paraphyses, paraphyses have terminal cells twice as long; spores monoletate, ellipsoid, yellowish green. (Plate 4.37: Fig. g-m.; Plate 4.82: Fig. i.).

Distribution: Epiphytic on shaded areas. Between 100-1600 m.

Notes: Two populations from north to the Palghat Gap, Karimpuzha WLS and Meenvallam, have bifurcated lamina. It is unusual in *Vittaria*.

Specimen/s examined: Kerala: Idukki District, Mathikettan Shola National Park, 9° 58' 47.28" N, 77° 14' 12.84" E, 1400 m, 1 August 2019, Thulasi, 14367 (ZGC); Choondal, 9° 59' 4.56" N, 77° 14' 46.68" E, 1500 m, 2 August 2019, Thulasi &

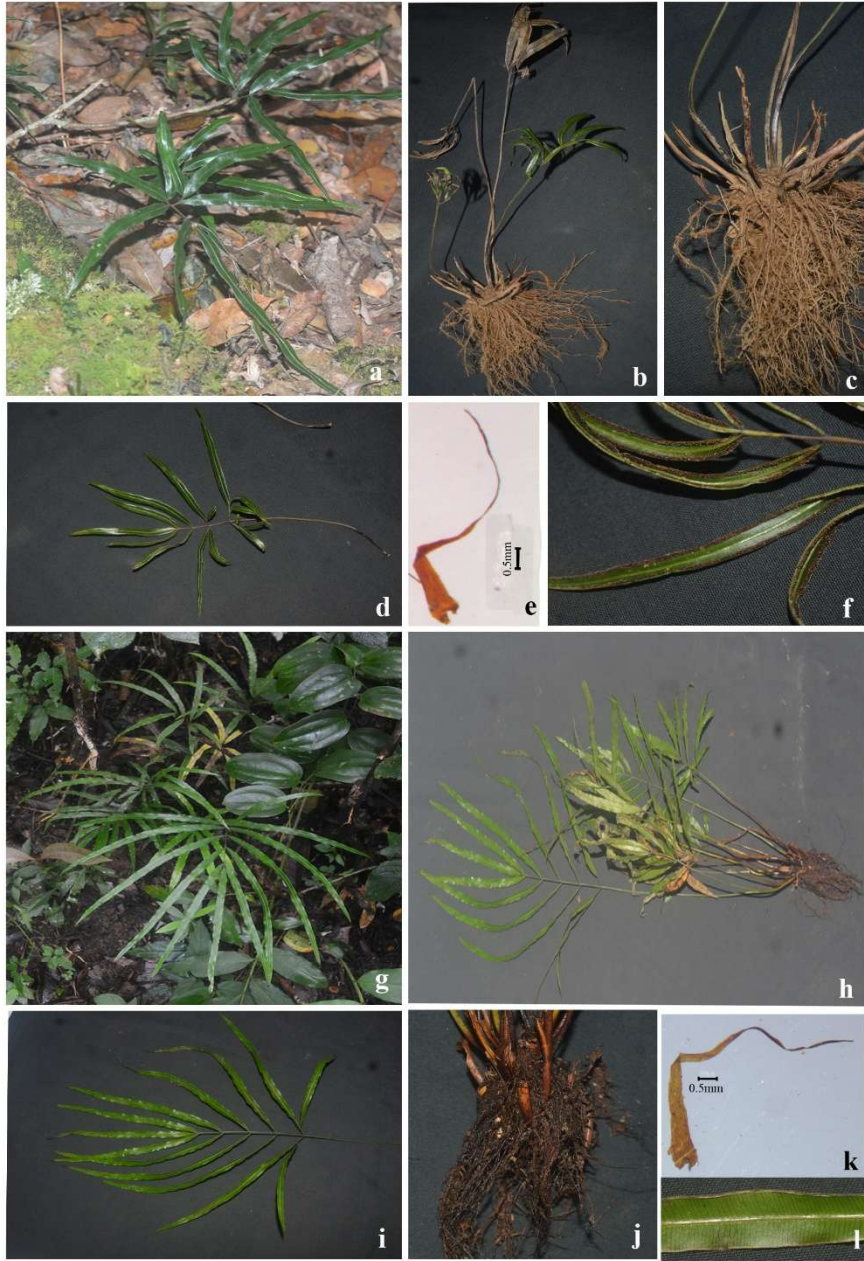


Plate 4.36: a-f. *Pteris multiaurita* J.Agardh. a. Habitat b. Habit c. Rhizome d. Frond e. Scale f. Sori. g-l. *Pteris scabripes* Wall. ex J.Agardh. g. Habitat h. Habit i. Frond j. Rhizome k. Scale l. Sorus.



Plate 4.37: a-f. *Pteris vittata* L. a. Habitat b. Habit c. Frond d. Rhizome e. Scale f. Sorus. g-m. *Vittaria elongata* Sw. g. Habitat h-i. Habit j. Rhizome k. Scale l. Frond m. Sorus.

Manju, 14398 (ZGC); Palakkad District, Silent Valley National Park, Arikampara, 11° 4' 51.6" N, 76° 26' 36.6" E, 1070 m, 24 October 2019, Thulasi, 14543 (ZGC); Valiyaparathodu-Madhrithodu, 11° 6' 49.32" N, 76° 25' 51.6" E, 910 m, 27 December 2019, Thulasi, 14634 (ZGC); Parambikulam Tiger Reserve, 10° 25' 12.72" N, 76° 45' 57.6" E, 700 m, 7 December 2019, Thulasi, 14616 (ZGC); Bhavani, Thudukki, 11° 8' 4.2" N, 76° 30' 31.68" E, 1260 m, 2 October 2021, Thulasi, 14885 (ZGC); Malappuram District, Karimpuzha Wildlife Sanctuary, Paanappuzha, 11° 18' 24.84" N, 76° 26' 37.32" E, 310 m, 4 September 2021, Thulasi, 14871 (ZGC).

Aspleniaceae Newman, Hist. Brit. Ferns 6. 1840.

Asplenium L., Sp. Pl. 2: 1078. 1753.

Key to species

1. Fronds simple *A. phyllitidis*
1. Fronds not simple 2
2. Fronds simple pinnate 3
2. Fronds bipinnate to quadripinnate 17
3. Fronds decrescent *A. formosum*
3. Fronds not decrescent 4
4. Rhizome short or long creeping 5
4. Rhizome erect or suberect 6
5. Fronds sub-coriaceous; margin of pinnae irregularly lobed; sori close to the costa *A. decrescens*
5. Fronds herbaceous; margin of pinnae serrate or regularly lobed; sori not close to costa 7
6. Stipe and rachis densely scaly 8
6. Stipe and rachis glabrous 16
7. Stipe green, not glossy *A. obscurum*
7. Stipe black and glossy 9
8. Fronds large, 50-60 x 20-30 cm, gemmiparous *A. zenkerianum*
8. Fronds less than 50-60 x 20-30 cm, not gemmiparous 10
9. Upper margin of pinnae cut to one third; sori restricted to lobes 11
9. Upper margin of pinnae not cut to one third; sori on distal half 12

10. Margin of pinnae deeply, irregularly lobed
 *A. laciniatum* subsp. *fraser-jenkinsii*
10. Margin of pinnae crenate or shallowly lobed *A. crinicaule*
11. Scales ovate or elongate-lanceolate *A. hondoense*
11. Scales lanceolate 13
12. Rhizome scales without sessile glands *A. emarginatodentatum*
12. Rhizome scales with sessile glands 14
13. Scales pale brown; lamina oblong-lanceolate *A. cheilosorum*
13. Scales dark brown; lamina elongate-deltoid *A. nitidum*
14. Fronds with membranous wings on either side of the groove *A. excisum*
14. Fronds without membranous wings 15
15. Lamina oblong-lanceolate, simple, terminal pinna same as lateral pinnae,
 uniformly serrate margin *A. serricula*
15. Lamina ovate-lanceolate, simple, terminal pinnae gradually reduced, lobed
 margins, margins serrate *A. falcatum*
16. Stipe dark brown to black *A. normale*
16. Stipe green *A. inaequilaterale*
17. Fronds tri- to quadripinnatifid; pinnules membranous *A. tenuifolium*
17. Fronds bipinnate; pinnule not membranous 18
18. Stipe and rachis glabrous; frond texture firm *A. andreisii*
18. Stipe and rachis scaly; frond texture not firm 19
19. Pinnae densely scaly abaxially *A. aethiopicum*
19. Pinnae not densely scaly abaxially *A. mysorensis*

Asplenium aethiopicum (Burm.f.) Bech., Candollea 6: 22. 1935; Manickam, Fern Fl. Palni Hills, 97. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 228. Pl. 176. 1992; Azeez *et al.*, Spleenworts S. India. 113. 2008; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 307. 2017.

Trichomanes aethiopicum Burm. f., Fl.Ind. 32 (err.28). 1768.

Rhizome erect, about 4-6 cm long, 0.5-1 cm thick, covered by scales; scales linear-lanceolate, brown, clathrate, tip pointed, base broad, basally attached, margins slightly toothed. Fronds 48-50 cm long; stipe 20-22 cm long, purplish black, adaxially grooved, abaxially rounded. Lamina bi or tripinnatifid, ovate lanceolate, 27-30 x 8-10 cm, primary pinnae about 20 to 25 pairs, alternate, oblong-lanceolate,

4-5 cm long, petiole short, gradually reduced towards tip, forming a lobed wing, subopposite below, alternate above, pinnules 6-8 pairs, stalked, 3-4 x 0.5-0.6 cm, split into 2 or 3 with serrate margin, stipe and stalks of pinnae with small scales similar to rhizome scales; texture sub-coriaceous; veins distinct below, not in above, forked. Sori linear, along acroscopic veins, about 5 mm. Spore monolete, reniform, brown. (Plate 4.38: Fig. a-g.; Plate 4.82: Fig. j.).

Distribution: Terrestrial, lithophytic or epiphytic along shaded roadsides and stream sides. Between 800 to 2300 m.

Specimen/s examined: Kerala: Idukki District, Pambadum Shola National Park, Pothukandam, 10° 7' 32.16" N, 77° 15' 16.92" E, 1800 m, 29 July 2019, Thulasi, 14328 (ZGC); Kuttikkad, 10° 7' 33.6" N, 77° 15' 22.68" E, 1892 m, 30 July 2019, Thulasi, 14351 (ZGC); Mathikettan Shola National Park, Choondal, 9° 59' 4.56" N, 77° 14' 46.68" E, 1500 m, 2 August 2019, Thulasi, 14402 (ZGC); Palakkad District, Silent Valley National Park, Poochippara to Walakkad trek path, 11° 8' 0.96" N, 76° 24' 42.84" E, 1140 m, 28 December 2019, Thulasi, 14684 (ZGC); Anginda, 11° 11' 17.88" N, 76° 27' 36.72" E, 2300 m, 30 December 2019, Thulasi, 14711 (ZGC); Nelliampathy, Cheriya Govinda mala, 10° 30' 27.72" N, 76° 41' 45.6" E, 990 m, 3 November 2020, Thulasi & Maya, 14793 (ZGC). Tamil Nadu: Kodaikanal, 10° 14' 30.12" N, 77° 29' 17.16" E, 2075 m, 18 November 2019, Thulasi, 14557 (ZGC); Ooty, 11° 17' 9.6" N, 76° 38' 47.4" E, 1750 m, 25 November 2021, Thulasi, 14953 (ZGC); Nadukaani, 11° 28' 16.32" N, 76° 24' 41.04" E, 870 m, 29 December 2021, Thulasi, 14960 (ZGC).

Asplenium andreisii Fraser-Jenk. in Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 339. 2017.

Asplenium auritum sensu Bedd., Handb. Ferns Brit. India 149. 1883; Manickam, Fern Fl. Palni Hills, 99. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 227, Pl. 174. 1992, *non* Sw., Schrad, Journ. Bot. 1800 (2): 52. 1801; Azeez *et al.*, Spleenworts S. India. 120. 2008

Rhizome erect or suberect, 2-3 cm long, 0.50-1 cm thick, scaly at the apex; scales 4-5 x 0.5-1 mm wide, pale brown, lanceolate. Fronds tufted, 33-35 cm long, stipes 14-15 cm x 1-2 mm, lamina ovate-lanceolate, 28-30 x 10-12 cm, simply pinnate or bipinnatifid, base wider, progressively narrowed towards apex, acuminate. Pinnae 14-15 pairs, spreading, alternate, stalked; largest pinna 7.6-8 x 2-2.5 cm, lanceolate, apex caudate, acuminate, acroscopic base truncate, basispic base cuneate, pinnules 7-8 pairs, anadromous, alternate, basal some pairs sessile, others adnate, acroscopic basal pinnule larger than others, 1-2 x 0.6-0.7 cm wide, oblong, apex rounded, acroscopic base truncate, basispic base cuneate, decurrent in distal pairs, margins crenate; costa flattened and narrowly winged, veins slightly raised above, forked once or twice, free, not reaching margin; pinnae light green, glabrous, texture coriaceous. Sori linear along the veins in 2 rows, indusiate; indusia entire, light brown; spores globose, dark brown. (Plate 4.38: Fig. h-n.; Plate 4.82: Fig. k.).

Distribution: Epiphytic on shaded forests. Between 1400-2000 m.

Specimen/s examined: Kerala: Idukki District, Pampadum Shola National Park, Kuttikkad, 10° 7' 35.4" N, 77° 15' 29.88" E, 1900 m, 30 July 2019, Thulasi & Manju, 14345 (ZGC); Mathikettan Shola National Park, Choondal, 9° 59' 4.56" N, 77° 14' 46.68" E, 1500 m, 2 August 2019, Thulasi & Manju, 14386 (ZGC).

Asplenium cheilosorum Kunze ex Mett., Abhandl. Senckenb. Naturf. Ges. 3: 177, t. 5, f. 12-13. 1859; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 210, Pl. 211. 1992; Azeez *et al.*, Spleenworts S. India. 126. 2008; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 343. 2017.

Hymenasplenium cheilosorum (Kunze ex Mett.) Tagawa, Acta Phytotax. Geobot. 7(2): 84. 1938.

Rhizome short creeping, about 6-7 cm long, 4-5 mm thick, scaly at apex; scales lanceolate, 2-3 x 0.2-0.25 mm, long acuminate, pale brown, entire. Stipes crowded, 20-21 cm x 2-3 mm, slender, rounded below, grooved above, glabrous, glossy. Lamina oblong lanceolate, 40-45 x 5-6 cm, simply pinnate, 1/4th to 1/3rd distal part progressively narrowed and ended in a long caudate, apex acuminate, base truncate. Pinnae 40-42 pairs, spreading, basal few stalked, others sessile; largest pinna 4-5

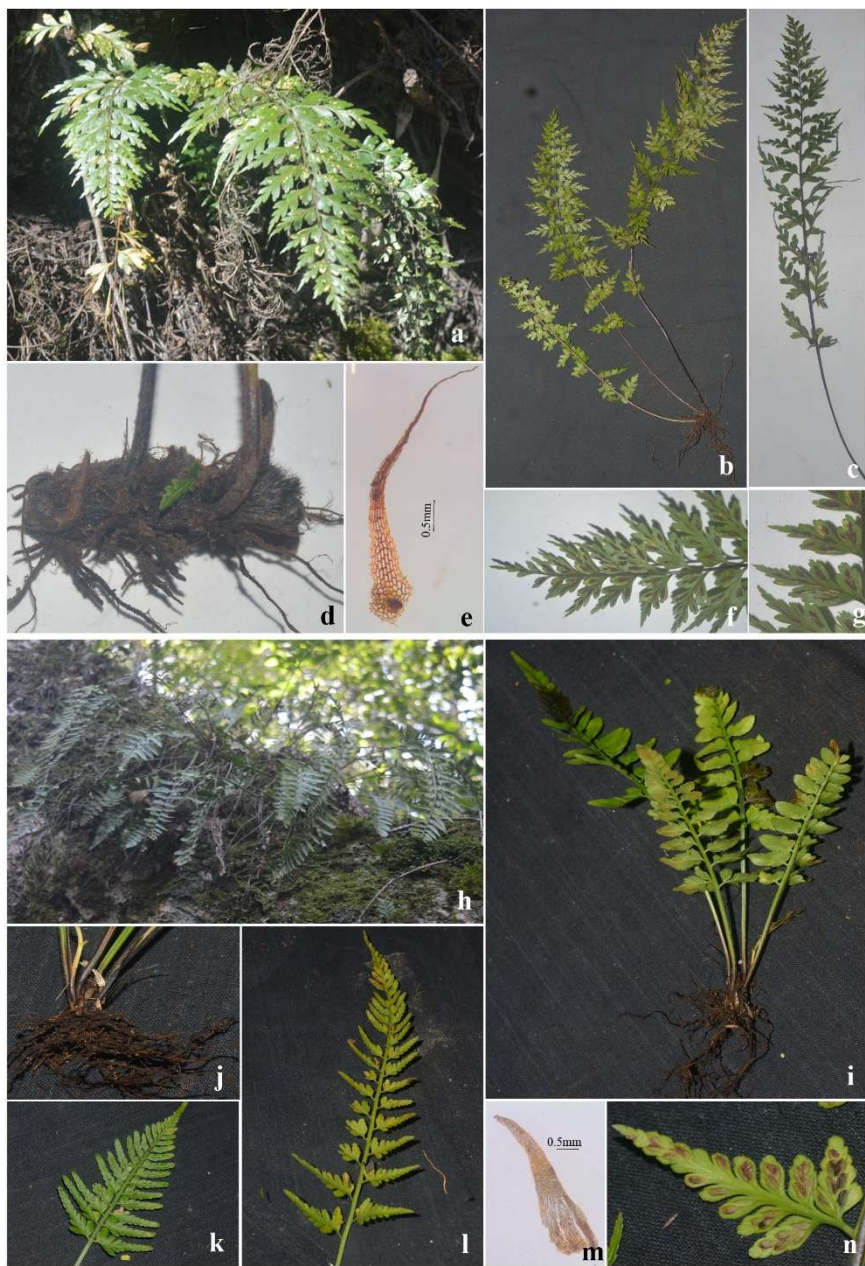


Plate 4.38: a-g. *Asplenium aethiopicum* (Burm.f.) Bech. a. Habitat b. Habit c. Frond d. Rhizome e. Scale f. Sporophyll g. Sori. h-n. *Asplenium andreisii* Fraser-Jenk. h. Habitat i. Habit j. Rhizome k. Frond l. Sporophyll m. Scale n. Pinnule with sori.

x 1-2 cm, oblong, slightly falcate, lower half slightly excised to the apex of the pinna, acroscopic base truncate, upper margin deeply incised, lower margin entire, apex subacute. Veins slightly distinct above and below, free, forked, reaching the margin, pinna dark green, glabrous, texture thin membranous. Sori in lobes only, linear, submarginal, along the veins, indusiate; indusia entire, light brown; spores mostly abortive, brown. (Plate 4.39: Fig. a-g.; Plate 4.82: Fig. 1.).

Distribution: Lithophytic in shaded stream sides. Between 500-2100 m.

Specimen/s examined: Kerala: Idukki District, Mathikettan Shola National Park, Choondal, 9° 59' 4.56" N, 77° 14' 46.68" E, 1500 m, 2 August 2019, Thulasi & Manju, 14390 (ZGC); Palakkad District, Silent Valley National Park, Parathod, 11° 5' 33" N, 76° 26' 44.52" E, 1020 m, 23 October 2019, Thulasi, 14516 (ZGC); Sairandri to Poochippara trek path, 11° 3' 57.96" N, 76° 32' 10.68" E, 550 m, 26 December 2019, Thulasi, 14623 (ZGC); Poochippara to Walakkad trek path, 11° 6' 38.16" N, 76° 25' 20.64" E, 1070 m, 28 December 2019, Thulasi, 14663 (ZGC); Walakkad to Sispara trek path, 11° 12' 6.48" N, 76° 26' 24.36" E, 2000 m, 29 December 2019, Thulasi, 14705 (ZGC); Parambikulam Tiger Reserve, Karimala, 10° 28' 42.96" N, 76° 50' 55.32" E, 600 m, 5 December 2019, Thulasi, 14592 (ZGC).

Asplenium crinicaule Hance, Ann. Sci. Nat., 5, 5: 254-255. 1866; Bedd., Handb. Ferns Br. India, 150. 1883; Manickam, Fern Fl. Palni Hills, 103. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 216, Pl. 164. 1992; Azeez *et al.*, Spleenworts S. India. 129. 2008; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 343. 2017.

Rhizome erect, 5-6 cm long, 1.5-2 cm thick, scaly all over; scales lanceolate, 6-8 x 0.6-0.7 mm wide, dark brown uniformly, apex hair pointed gland tipped, margins entire with few filamentous glandular, multicellular hairs. Stipes tufted, 5-6 cm x 1-2 mm, dark brown, rounded below, grooved above, young stipes covered densely by dark brown, linear, hair-like, branched scales. Lamina oblong-lanceolate, 20-21 x 4-5 cm, narrowed towards both ends, simply pinnate, acuminate, pinnae 18-20 pairs, subsessile, subopposite, basal few pairs slightly reduced; largest pinna 1-2 x 0.5-1 cm, ovate-lanceolate, subacute, base truncate acroscopic, basisopic base auriculate,



Plate 4.39: a-g. *Asplenium cheilosorum* Kunze ex Mett. a. Habitat b. Habit c. Frond d. Sporophyll e. Rhizome f. Scale g. Sori. h-m. *Asplenium crinicaule* Hance h. Habitat i. Habit j. Scale k. Rhizome l. Sporophyll m. Sori.

slightly excised, margin crenate; veins obscure on both sides, forked, free, not reaching margin, pinnae light green, scales distributed on rachis, texture coriaceous. Sori linear, along acroscopic veinlet, not reaching costule or margin, indusiate, indusia entire, rigid; spores reniform, dark brown. (Plate 4.39: Fig. h-n.).

Distribution: Lithophytic or epiphytic in fully shaded forests. Between 900-1200 m.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Kummattanthodu, 11° 5' 48.84" N, 76° 27' 19.8" E, 1030 m, 22 October 2019, Thulasi, 14462 (ZGC).

Asplenium decrescens Kunze, *Linnaea*, 24: 261.1851; *Bedd.*, *Handb.* 36. 1974; Manickam, *Fern Fl. Palni Hills* 100. 1986; Manickam & Irud., *Pterid. Fl. W. Ghats S. India*, 210, Pl. 157. 1992; Manickam & Irud., *Pterid. Fl. Nilgiris* 125. 2003; Azeez *et al.*, *Spleenworts S. India*. 132. 2008; Fraser-Jenkins *et al.*, *Anno. Checklist Indian Pterid.*, 346. 2017.

Rhizome long creeping, 5-6 cm long, 7-8 mm thick, covered by scales, densely scaly at apex; scales small, 1-2 x 0.3-0.5 mm, brittle, dark brown, ovate-lanceolate, clathrate, margin entire, with few glands, apex acuminate, gland tipped. Fronds 40-70 cm long, 1-1.5 cm apart; stipes 28-30 cm long, pale to dark brown, adaxially grooved, scaly first, almost glabrous later, except at the base; lamina unipinnate, 20-40 x 10-14 cm, oblong-lanceolate, colour of rachis similar to that of stipe, pinnae 12-25 pairs, shortly stalked, falcate, subopposite below, alternate above, lower most pinna slightly reduced, tip of the lamina ends in a lobed prolongation, pinnae 6-8 x 1-2 cm, basiscopic slightly excised, acroscopic base truncate, both edges deeply lobed, lobes oblique and sharply toothed, pale green, chartaceous, sparsely scaly both sides; veins many, forked 4-5 times, distinct abaxially, raised adaxially. Sori linear, 0.8-1 cm, on the vein forks near the costa; spores reniform, brown. (Plate 4.40: Fig. a-g.; Plate 4.87: Fig. f.).

Distribution: Found growing at Walakkad of Silent Valley National Park

Specimen/s examined: Kerala: Idukki District, Mathikettan Shola National Park, Choondal, 9° 59' 4.56" N, 77° 14' 46.68" E, 1500 m, 2 August 2019, Thulasi &

Manju, 14396 (ZGC); Palakkad District, Sairandri to Poochippara trek path, 11° 3' 57.96" N, 76° 32' 10.68" E, 550 m, 26 December 2019, Thulasi, 14624 (ZGC); Sispara to Anginda, 11° 11' 20.04" N, 76° 27' 35.64" E, 2280 m, 30 December 2019, Thulasi, 14719 (ZGC); Walakkad to Sispara, 11° 12' 7.884" N, 76° 26' 30.192" E, 2050 m, 3 January 2022, Thulasi, 14998 (ZGC).

Asplenium emarginatodentatum Zenker ex Kunze, Linnaea 24: 263-264. 1851; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 347. 2017.

Asplenium unilaterale Lam. var. *rivale* Bedd., Ferns Br. India 153. 1883, *non* Spruce, 1867.

Asplenium rivale (Bedd.) Bir in Bir & Sago, Perspect. Pl. Sci. India 1-22. 1989, *non* Spruce ex Baker, 1867.

Asplenium hindusthanensis Bir., Fern Gaz. 14: 309. 1994; Azeez *et al.*, Spleenworts S. India. 154. 2008

Asplenium rivulare Fraser-Jenk., Taiwania 53(2): 190. 2008, *nom. nov.* for *A. rivale* (Bedd.) Bir.

Hymenasplenium rivulare (Fraser-Jenk.) Viane & S.Y. Dong, Fl. China 2-3: 308. 2013.

Rhizome long creeping, 4-7 cm long, 2-3 mm thick, covered by scales and hairs; scales 0.8- 0.9 x 0.4-0.5 mm, basally attached, tip narrow, margins entire. Stipes scattered, wiry, brown, glossy, 20-22 cm x 1-2 mm. Fronds 40-50 cm long, lamina simple pinnate, about 20-30 x 2-4 cm, grooved above with green narrow wings, on either side of groove; pinnae subopposite below, alternate above, about 2-3 x 1-1.5 cm, lower not reduced, gradually reduced towards tip, basiscopic 2/3rd excised, margins shallowly crenate, apex blunt, light green, herbaceous, glabrous above and below; costa raised below; veins simple or forked. Sori linear, on distal half, along veins, 1-2 mm long, 4-6 per pinnae, indusiate; spores monoletate, reniform, brown. (Plate 4.40: Fig. h-n).

Distribution: Terrestrial and lithophytic in shaded forests. Between 1000-1100 m.

Notes: Fraser-Jenkins (2012) treats this Southern Indian endemic as Near Threatened (NT).

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Walakkad to Sispara, 11° 10' 30.648" N, 76° 24' 30.636" E, 1054 m, 4 January 2022, Thulasi, 14981 (ZGC).

Asplenium excisum C.Presl, Epim. Bot. 74. 1849; Azeez *et al.*, Spleenworts (*Asplenium* L.-Pteridophyta) of South India. 141. 2008; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 349. 2017.

Asplenium unilaterale Lam. var. *majus* (C.Chr.) Sledge, Bull. Brit. Mus. (Nat. Hist.), Bot. 3: 246. 1965; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 213, Pl. 161.1992.

Asplenium excisum var. *serratum* Azeez & Madhus., Spleenworts S. India 145, fig. 16 A-E, t. 19 A-F. 2008.

Hymenasplenium excisum (C.Presl) S.Linds., Thai Forest Bull., Bot. 37: 69. 2009.

Rhizome short creeping, about 6-7 cm long, 4-5 mm thick, covered by scales, dark brown, ovate lanceolate, clathrate, basally attached, margins entire with few sessile glands. Fronds 55- 60 cm, stipe 20-25 cm, glossy, blackish brown, rounded below, grooved above, membranous wing on either side of the groove; lamina unipinnate, oblong-lanceolate, 32-44 x 9-11 cm; bears 24-35 pairs of pinnae, 0.6-1 cm apart; pinnae 5-6 x 1-1.5 cm, 1/3rd of the basisopic base excised, margin slightly lobed, lobes bifid, blunt tipped, falcate, apex acuminate, lower pinnae not reduced, pinnae gradually reduced towards the tip, light green, herbaceous, glabrous adaxially and abaxially, veins distinct above and below, costa raised slightly below, brownish, veins forked once and basisopic veins forked twice or thrice. Sori 0.5-0.6 mm long, more sori concentrated at distal half, on the either side of the costa, protected by a pair of similar flap-like indusia. Spores reniform, brown. (Plate 4.41: Fig. a-g.; Plate 4.83: Fig. a.).



Plate 4.40: a-g. *Asplenium decrescens* Kunze a. Habitat b. Habit c. Frond d. Sporophyll e. Rhizome f. Scale g. Sori. h-m. *Asplenium emarginatodentatum* Zenker ex Kunze h. Habitat i. Habit j. Rhizome k. Scale l. Sori. m. Sporophyll

Distribution: Terrestrial or lithophytic. Found growing at Kunthipuzha and Walakkad of Silent Valley National Park.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Walakkad to Sispara, 11° 12' 6.48" N, 76° 26' 24.36" E, 2000 m, 29 December 2019, Thulasi, 14706 (ZGC); Bhavani, Thudukki-Chindakki, 11° 8' 15.72" N, 76° 29' 59.64" E, 1500 m, 2 October 2021, Thulasi, 14909 (ZGC). Tamil Nadu: Ooty, 11° 28' 16.32" N, 76° 24' 41.04" E, 870 m, 29 December 2021, Thulasi, 14962 (ZGC).

Asplenium falcatum Lam., *Encycl. Méth. Bot.* 2(1): 306. 1786; Bedd., *Handb. Ferns Br. India* 150. 1883; Nayar & Geev., *Fern Fl. Malabar* 276. 1993.

Rhizome erect, 2-4 cm long, 0.5-1 cm thick, densely scaly at apex, scale 4-5 x 1-2 mm, dark brown, ovate-lanceolate, base broad, cordate, margin entire, with few glands, apex acuminate, gland tipped. Fronds 35-45 cm long, tufted; stipe 18-27 cm, dark brown, scaly in young, glabrous in mature; lamina ovate lanceolate, simple pinnate, 20-25 x 10-20 cm, bear 6-10 pairs of pinnae; pinnae shortly stalked, subopposite below, alternate above, middle pinnae larger, slightly reduced towards base, gradually reduced towards tip, lower base slightly excised, upper base cuneate, acroscopic basal lobe serrate, rest of the margin with shallow teeth, acuminate at ends, veins numerous, forked 4-5 times, distinct below, costa grooved and well raised above; sub-coriaceous. Sori linear, many on each pinnae; spore monolet, reniform, brown. (Plate 4.41: Fig. h-n.).

Distribution: Epilithic along shaded forest paths, between 300-1000 m. Found growing at Karimpuzha Wildlife Sanctuary.

Specimen/s examined: Kerala: Malappuram District, Karimpuzha Wildlife Sanctuary, Paanappuzha, 11° 18' 29.52" N, 76° 26' 55.32" E, 350 m, 6 September 2023, Thulasi, 15153 (ZGC).

Asplenium formosum Willd., *Linn. Sp. Pl.* ed. 4, 5: 329. 1810; Bedd., *Handb. Fern Br. India* 152. 1883; Manickam & Irud., *Pterid. Fl. W. Ghats S. India*, 208, Pl.155. 1992; Manickam & Irud., *Pterid. Fl. Nilgiris* 124. 2003; Nayar & Geev., *Fern Fl. Malabar* 278. 1993; Azeez *et al.*, *Spleenworts S. India*. 148. 2008; Fraser-Jenkins *et al.*, *Anno. Checklist Indian Pterid.*, 355. 2017.

Rhizome erect, 3-4 cm long, 5-10 mm thick, apex densely scaly, scales small, 2-2.5 x 0.5-0.7 mm, ovate lanceolate, centre dark brown, margin light brown, base broad, basally attached, gland tipped, unicellular sessile glands present along the margins. Fronds tufted, 20-32 cm long; stipes 2-4 cm long, dark brown, glossy; lamina unipinnate, 30-40 sessile lateral pinnae, green, 1-1.5 x 0.3-0.5 cm, pinnae gradually reduced to both ends, half of the basiscopic base cutaway, upper margin and lower margin's distal part incised deeply, lobes mostly bifid, tip rounded, few basal pairs reduced to auricles, lamina gradually reduced to the tip by regularly lobed wing, herbaceous, glabrous, rachis grooved adaxially with a green wing on either side; veins obscure, simple, except some acroscopic basal ones, they are forked once, reaching the margin, ends swollen. Sori small, 1-2 mm long, 2-3 per pinna, in the lower un-excised part of the pinna, sori parallel to the un-excised portion. Spores ellipsoid, pale brown. (Plate 4.42: Fig. a-g.).

Distribution: Common species. Growing as epilithic, epiphytic or terrestrial along river banks and mud cliffs or rock cliffs between 600-1800 m.

Specimen/s examined: Kerala: Palakkad District, Mannarkkad, Meenvallam, 10° 55' 24.96" N, 76° 33' 51.84" E, 85 m, 11 September 2018, Thulasi, 14202 (ZGC); Siruvani, 10° 58' 55.56" N, 76° 36' 1.8" E, 700 m, 20 September 2019, Thulasi, 14422 (ZGC); Nelliampathy, Manpara, 10° 33' 27.72" N, 76° 44' 40.38" E, 1065 m, 1 December 2018, Thulasi & Maya, 14309 (ZGC); Vazhakkundu, 10° 31' 6.708" N, 76° 42' 52.38" E, 910 m, 15 January 2020, Thulasi & Maya, 14773 (ZGC); Cheriya Govinda mala, 10° 30' 27.864" N, 76° 41' 45.924" E, 990 m, 3 November 2020, Thulasi & Maya, 14785 (ZGC); Maattumala, 10° 32' 4.236" N, 76° 43' 18.444" E, 1300 m, 4 November 2020, Thulasi & Maya, 14828 (ZGC); Silent Valley National Park, Kummattanthodu, 11° 5' 48.84" N, 76° 27' 19.8" E, 1030 m, 22 October 2019, Thulasi, 14461 (ZGC); Kunthipuzha trek path, 11° 5' 45.672" N, 76° 26' 57.912" E, 950 m, 22 October 2019, Thulasi, 14499 (ZGC); Poochippara to Walakkad, 11° 6' 38.16" N, 76° 25' 20.64" E, 1070 m, 28 December 2019, Thulasi, 14661 (ZGC); Parambikulam Tiger Reserve, Karimala, 10° 30' 42.84" N, 76° 52' 49.44" E, 360 m, 5 December 2019, Thulasi, 14577 (ZGC); Karimala, 10° 28' 42.96" N, 76° 50'



Plate 4.41: a-g. *Asplenium excisum* C.Presl a. Habitat b. Habit c. Frond d. Rhizome e. Sporophyll f. Scale g. Sori. h-n. *Asplenium falcatum* Lam. h. Habitat i. Habit j. Frond k. Rhizome l. Sporophyll m. Scale n. Sori.

55.32" E, 600 m, 5 December 2019, Thulasi, 14589 (ZGC); Olavakkode, Dhoni, 10° 52' 9.12" N, 76° 37' 23.16" E, 350 m, 18 January 2020, Thulasi & Maya, 14778 (ZGC); Idukki District, Mathikettan Shola National Park, 9° 58' 47.28" N, 77° 14' 12.84" E, 1400 m, 1 August 2019, Thulasi & Manju, 14362 (ZGC).

Asplenium hondoense N.Murak. & Hatan., J. Fac. Sci. Univ. Tokyo, 3 Bot., 14: 191, t. 5. 1988; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 3. 357. 2017.

Asplenium unilaterale var. *birii* B.K.Nayar & Geev., Fern Fl. Malabar 289. 1993; Azeez *et al.*, Spleenworts S. India. 196. 2008

Rhizome slender, creeping, sparsely branched, 10-15 cm x 3-4 mm, scaly; scales ovate, reddish brown, 2-3 x 0.4-0.5 mm, base broad auricled, apex narrow, biseriate. Frond 1-2 cm apart; stipe 15-20 cm x 1-1.5 mm. Lamina narrowly oblong, 15-20 x 5-7 cm, apical region 3-4 cm long narrow pinnatifid acuminate. Lateral pinnae 15-20 pairs, opposite, basal pairs slightly deflexed; larger pinna 3.5-4 x 0.8-1 cm, oblong, subfalcate, entire, margin serrate; lamina thin herbaceous, glabrescent on both sides. Sori on acroscopic branch of lateral veins, 4-6 mm long, indusiate; spores planoconvex, light brown.

Distribution: Terrestrial on shaded forest floor, between 800 to 1200 m.

Notes: This species is included here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Kerala: Palakkad District, Silent valley, Panthanthode, Geevarghese and P.V. Madhu, 29265 (CALI); Karapara, N.C. Nair, 69824 (MH).

Asplenium inaequilaterale Bory ex Willd., Sp. Pl., ed. 4, 5(1): 322. 1810; Manickam, Fern Fl. Palni Hills, 107. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 210, Pl. 220. 1992; Azeez *et al.*, Spleenworts S. India. 157. 2008; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 357. 2017.

Rhizome erect or suberect, 2-4 cm long, 1-2 cm thick, scaly at apex; scales ovate-lanceolate, 3-4 x 0.4-0.5 mm wide, dark brown at centre, periphery pale brown, apex acuminate, margin entire. Stipes tufted, 22-25 x 0.3-0.4 cm, pale brown, rounded

below, grooved above, glabrous. Lamina oblong, 10-30 x 5-10 cm, terminal pinnae lobed, subacuminate, like the lateral pinnae; simple pinnate; pinnae 20-22 pairs, reduced gradually in distal part, basal ones not reduced; pinnae alternate, shortly stalked, trapezoid-lanceolate, 4-5 x 1-2 cm, oblique, acroscopic base truncate, acroscopic base parallel to rachis, basal basisopic part obliquely excised, apex subacute, margin serrate; costules 10-12 pairs, acroscopic basal costule forked, simple in distal part, free, not reaching margin; pinnae dark green, glabrous, texture herbaceous. Sori 10-12 pairs, median, on veins; spores reniform, brown. (Plate 4.42: Fig. h-n.).

Distribution: Terrestrial on shaded mud cliffs and stream sides. Between 1100-1900 m.

Specimen/s examined: Kerala: Idukki District, Pampadum Shola National Park, Kuttikkad, 10° 7' 35.4" N, 77° 15' 29.88" E, 1900 m, 30 July 2019, Thulasi & Manju, 14344 (ZGC); Palakkad District, Parambikulam Tiger Reserve, Vengolimala, 10° 21' 47.88" N, 76° 45' 28.44" E, 1100 m, 6 December 2019, Thulasi, 14613 (ZGC).

Asplenium laciniatum D.Don subsp. *fraser-jenkinsii* Reichst. ex Pangtey & Khullar, in Fraser-Jenkins *et al.*, Indian Fern J. 27(1-2): 185, t. 5-7. 2011 ("2010"); Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid. 360. 2017.

Asplenium semivariense Viane & Reichst., Pterid. in the new Millenium 78. 2003; Azeez *et al.*, Spleenworts S. India. 180. 2008

Rhizome erect, 0.6-1.2 cm thick, scaly at apex; scales lanceolate, 4-5 x 0.3-0.5 mm, centre dark brown, periphery pale brown, apex acuminate. Fronds tufted, 15-16 x 4-5 cm, stipe 3-4 cm, round below, grooved above, scaly at base, lamina ovate-lanceolate, 10-14 x 3-6 cm, bipinnate, apex acute; primary pinnae 10-12 pairs, sub-opposite below, alternate above, apex round, basal some pinnae slightly reduced; largest pinna 2-2.7 x 0.5-1 cm, pale green, glabrous, herbaceous; pinnules 3-5 pairs, sessile, alternate, acroscopic basal pinnule larger, distal part of primary pinna lobed, apex rounded, base entire; veins not distinct, forked. Sori 3-5 mm, 1-2 in each



Plate 4.42: a-g. *Asplenium formosum* Willd. a. Habitat b. Habit c. Rhizome d. Frond e. Scale f. Sporophyll g. Sori. h-m. *Asplenium inaequilaterale* Bory ex Willd. h. Habitat i. Habit j. Rhizome k. Young sori l. Scale m. Mature sori.

pinnule, linear. Spore monolete, reniform, brown. (Plate 4.43: Fig. a-f.; Plate 4.83: Fig. e.).

Distribution: Epilithic or terrestrial on shaded areas between 1000-1800 m. Found growing at Kodaikanal.

Specimen/s examined: Tamil Nadu: Kodaikanal, 10° 14' 30.12" N, 77° 29' 17.16" E, 2075 m, 19 November 2023, Thulasi, 15151 (ZGC).

Asplenium mysorensense Roth, Nov. Pl. Sp. 395. 1821; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 364. 2017.

Asplenium falcatum var. *bipinnatum* Sledge, Bull. Brit. Mus. (Nat. Hist.) Bot. 3: 262. 1965.

Asplenium polyodon var. *bipinnatum* (Sledge) Sledge, Bot. J. Linn. Soc. 84(1): 6. 1982; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 210, Pl. 219. 1992.

Asplenium bipinnatum (Sledge) Philcox, Rev. Handb. Fl. Ceylon 15a: 24. 2006.

Asplenium bipinnatum (Sledge) Azeez & Madhus. in Azeez *et al.*, Spleenworts S. India 122, fig. 9A-E, t. 12 A-E. 2008.

Rhizome suberect, 4-6 cm long, 2-3 cm thick, scaly all over; scales linear-lanceolate, 9-10 x 1-2 mm, uniformly dark brown, apex long acuminate, margin entire. Stipes tufted, 28-30 x 0.5-1 cm, dark brown, rounded below, grooved above, scaly at very base, above glabrous. Lamina lanceolate, 48-50 x 10-20 cm, acuminate, bipinnate, broadly cuneate; primary pinnae 10-12 pairs, slightly ascending, subopposite, basal pinnae not reduced; largest pinna 10-12 x 4-5 cm, lanceolate, apex acuminate, base cuneate, 1/3rd to half of distal part shallowly lobed without pinnules in primary pinnae; pinnules 5-6 pairs, anadromous, sessile, alternate, obovate, 2-3 x 1-1.5 cm, base cuneate, apex rounded and irregularly incised; veins adaxially marked by striations, slightly distinct abaxially, copious, forked, free, parallel, reaching the margin; pinnae pale green, glabrous on both sides, texture sub-coriaceous; some soft, linear hairs are present. Sori numerous, linear, along veins, indusiate; indusia pale brown, entire; spores reniform, brown. (Plate 4.43: Fig. g-l.; Plate 4.83: Fig. d.).

Distribution: Terrestrial or lithophytic in shaded roadsides, forest floors. Between 300-2000 m.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Kummattanthodu, 11° 5' 48.84" N, 76° 27' 19.8" E, 1030 m, 22 October 2019, Thulasi, 14464 (ZGC); Walakkad to Sispara, 11° 12' 6.48" N, 76° 26' 24.36" E, 2000 m, 29 December 2019, Thulasi, 14703 (ZGC); Malappuram District, Karimpuzha Wildlife Sanctuary, Paanappuzha, 11° 18' 29.52" N, 76° 26' 55.32" E, 350 m, 4 September 2021, Thulasi, 14879 (ZGC).

Asplenium nitidum Sw., Syn. Fil. 84, 280. 1806; Nayar & Geev., Fern Fl. Malabar 281. 1993; Azeez *et al.*, Spleenworts S. India. 164. 2008; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 3. 367. 2017.

Rhizome short creeping, 5-10 cm long, 9-10 mm thick, branched, persistent leaf base is present, scaly; scale dark-brown, 3-4 x 0.4-0.5 mm, margin smooth, apex gradually narrowed. Fronds spirally arranged; stipe 30-50 cm x 3-4 mm, erect, black, nearly glabrous. Lamina spreading, elongate-deltoid, 45-50 x 20-25 cm, bipinnate; primary pinnae gradually smaller and less dissected upwards till the apex of the frond; apex pinnatifid, acuminate, pinnae sub-opposite, basal pairs largest, 10-20 x 3-5 cm, deltoid-lanceolate; secondary pinnae 6-15 pairs, alternate, basal one largest, 3-3.5 x 1.5-2 cm, deltoid-lanceolate, deeply pinnatifid, subdimidiate-oblong, apex acute, margin lobed; texture sub-coriaceous, glabrous; sori few in ultimate pinnae, restricted to 1-2 basal veins, indusiate; spores plano convex, light brown.

Distribution: Terrestrial on fully shaded areas, between 900 to 1500 m.

Notes: This species is included here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen examined: Kerala: Palakkad District, Valiyaparathodu, Silent Valley, Nayar, 10057 (CALI); Walakkad, Nayar, 10665 (CALI).



Plate 4.43: a-f. *Asplenium laciniatum* D.Don. subsp. *fraser-jenkinsii* Reichst. ex Pangtey & Khullar a. Habitat b. Habit c. Rhizome d. Frond e. Scale f. Sporophyll with sori. g-l. *Asplenium mysorense* Roth g. Habitat h. Scale i. Rhizome j. Frond k. Sporophyll l. Sori.

Asplenium normale D.Don, Prodr. Fl. Nepal. 7. 1824; Bedd., Handb. Ferns Br. India, 144. 1883; Manickam, Fern Fl. Palni Hills, 105. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 217. Pl. 165. 1992; Azeez *et al.*, Spleenworts S. India. 164. 2008; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 368. 2017.

Rhizome erect, 2-3 cm long, 1.8-2 cm thick, scaly at apex; scales ovate-lanceolate, dark brown, edges pale, apex acute, gland tipped, margins entire, with few glandular hairs. Stipes tufted, about 15-20 x 0.2-0.5 cm thick, wiry, dark purple, abaxially rounded, shallowly grooved adaxially, glabrous, polished. Lamina oblong-lanceolate, 34-35 x 4-5 cm, simple pinnate, acute, base truncate; pinnae dark green, glabrous, texture stiff herbaceous, 32-35 pairs, sessile, subopposite, overlapping, basal pairs not reduced, 5 distal pairs progressively reduced; largest pinna 1-2 x 0.5-1 cm, oblong, basispic base slightly excised, apex rounded, acroscopic base truncate, slightly auricled, margin crenate; veins distinct on both sides, forked, free, not reaching the margin. Sori terminal, along veinlets, indusiate; indusia entire, light brown; spores reniform, dark brown. (Plate 4.44: Fig. a-f.).

Distribution: Terrestrial or lithophytic or sometimes epiphytic in shaded forests and trek paths. Between 1800-2000 m.

Specimen/s examined: Kerala: Idukki District, Pampadum Shola National Park, Kuttikkad, 10° 7' 35.4" N, 77° 15' 29.88" E, 1900 m, 30 July 2019, Thulasi & Manju, 14342 (ZGC).

Asplenium obscurum Blume, Enum. Pl. Javae 2: 181-182. 1828; Manickam, Fern Fl. Palni Hills, 104. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 210. Pl. 158. 1992; Azeez *et al.*, Spleenworts S. India. 170. 2008; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 369. 2017.

Hymenasplenium obscurum (Blume) Tagawa, Acta Phytotax. Geobot. 7(2): 83. 1938.

Asplenium unilaterale var. *bivalvatum* B.K.Nayar & Geev., Fern Fl. Malabar: 292. 1993.



Plate 4.44: a-f. *Asplenium normale* D.Don a. Habitat b. Habit c. Rhizome d. Scale e. Sporophyll f. Young sori. g-m. *Asplenium obscurum* Blume g. Habitat h. Habit i. Rhizome j. Scale k. Sori l. Frond m. Sporophyll

Hymenasplenium bivalvatum (B.K.Nayar & Geev.) Viane, Fl. China 2-3: 316. 2013.

Rhizome short creeping, 3-6 cm long, 5-8 mm thick, scaly at apex; scales ovate-lanceolate, 2-3 x 0.8-1 mm, pale brown uniformly, apex acuminate, entire. Stipes scattered, 27-28 x 0.5-0.8 cm, scaly at base, glabrous above, abaxially rounded, adaxially grooved. Lamina oblong-lanceolate, 38-40 x 6-7 cm, simple pinnate, base truncate, apex acuminate; pinnae 23-25 pairs, patent, subopposite, shortly stalked, basal pairs not reduced; largest pinna 3-4 x 0.8-1 cm, oblong-lanceolate, dimidiate, falcate, base truncate acroscopic, apex acuminate, basal half excised half to 2/3rd part, margin serrate in non excised part; veins forked once, free; pinnae dark green, glabrous, herbaceous. Sori on subbasal part of acroscopic veinlets, indusiate; indusia entire, light brown; spores ellipsoid, brownish green. (Plate 4.44: Fig. g-m.; Plate 4.83: Fig. b.).

Distribution: Lithophytic or terrestrial in shaded forests. Between 1200-1500 m.

Specimen/s examined: Kerala: Idukki District, Mathikettan Shola National Park, 9° 58' 47.28" N, 77° 14' 12.84" E, 1400 m, 1 August 2019, Thulasi & Manju, 14359 (ZGC); Palakkad District, Nelliampathy, Maattumala, 10° 32' 4.236" N, 76° 43' 18.444" E, 1300 m, 4 November 2020, Thulasi & Maya, 14833 (ZGC).

Asplenium phyllitidis D.Don, Prodr. Fl. Nepal. 7. 1824; Holttum, Rev. Fl. Mal. 2:420. 1954; Nayar & Kaur, Comp. Bedd. Handb. 34.1974; Chandra & Kaur, Nom. Guide Bedd. F.S.I. & F.B.I. 15.1987; Nayar & Geev., Fern Fl. Malabar. 284. 1993; Azeez *et al.*, Spleenworts S. India. 171. 2008; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 373. 2017.

Asplenium nidus auct., Manickam & Irudayaraj, 206. Pl. 153. 1992, *non* L., Sp. Pl. 2: 1079. 1753.

Rhizome erect, short, 3-5 cm long, 4-5 cm thick, stout unbranched; devoid of persistent leaf base. Scales dense, black, lanceolate, 18-20 x 3-4 mm, apex narrowed acuminate hair-like, with a swollen glandular hair at tip, margins with gland tipped hairs. Fronds crowded, obliquely erect, long, simple, 0.95-1 m x 10-12 cm, lanceolate, tip acuminate, margins entire, dark green, coriaceous, glabrous; midrib



Plate 4.45: a-g. *Asplenium phyllitidis* D. Don a. Habitat b. Habit c. Frond d. Rhizome e. Scale f. Sporophyll g. Sori. h-m. *Asplenium tenuifolium* D. Don. h. Habitat i. Habit j. Scale k. Rhizome l. Sporophyll m. Sori.

raised below, flattened above, veins forked. Sori linear, 2-3 cm long, arranged as oblique rows on either side of the costa, on acroscopic veins. Spores monoete, reniform, brown. (Plate 4.45: Fig. a-g.; Plate 4.83: Fig. c.).

Distribution: Epiphytic, as individual plants on large trees, between 700-2000 m. Found growing at Silent Valley National Park, Nelliampathy and Parambikulam Tiger Reserve.

Notes: A lot of confusion existed on the identity of *A. phyllitidis* D. Don and *A. nidus* L. in India, which was discussed in detail by Fraser-Jenkins *et al.* (2017) by comparing with *A. nidoides* Fraser-Jenk. & Kandel.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Kummattanthodu, 11° 5' 48.84" N, 76° 27' 19.8" E, 1030 m, 22 October 2019, Thulasi, 14474 (ZGC); Parathod, 11° 5' 33" N, 76° 26' 44.52" E, 1020 m, 23 October 2019, Thulasi, 14520 (ZGC); Arikampara, 11° 4' 45.12" N, 76° 26' 50.64" E, 1090 m, 24 October 2019, Thulasi, 14547 (ZGC); Parambikulam Tiger Reserve, Karimala, 10° 28' 42.96" N, 76° 50' 55.32" E, 600 m, 5 December 2019, Thulasi, 14591 (ZGC); Nelliampathy, Cheriya Govinda mala, 10° 30' 38.232" N, 76° 41' 42" E, 987 m, 3 November 2021, Thulasi & Maya, 14805 (ZGC); Maattumal, 10° 32' 4.236" N, 76° 43' 18.444" E, 1300 m, 4 November 2021, Thulasi & Maya, 14823 (ZGC); Thrissur District, Athirappilly, Malakkappara, 10° 17' 47.76" N, 76° 47' 38.76" E, 930 m, 14 February 2021, Thulasi, 14848 (ZGC).

Asplenium serricula Fée, Mém. Fam. Foug. 5 Gen. Fil.: 196. 1852; Nayar & Geev., Fern Fl. Malabar 285. 1993; Azeez *et al.*, Spleenworts S. India. 183. 2008; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 3. 381. 2017.

Rhizome short, erect, unbranched, 2-4 cm long, 6-12 mm thick, scaly; scale narrow, elongated, dark-brown, pseudo peltate, 6-8 x 2-2.5 mm, having broad marginal band of thin-walled cells, apex acuminate, margin with marginal hairs. Frond tufted; stipe 15-18 cm. Lamina 20-35 x 10-20 cm, oblong-lanceolate, simple pinnate with terminal pinna similar to lateral ones; lateral pinna 3-10 pairs, alternate to sub-opposite, petiolate, 10-15 cm x 8-12 mm, base narrowly cuneate, apex acuminate,

margin serrate, basal margin entire; lamina soft, thick, coriaceous. Sori on acroscopic side of basal vein, indusiate; spores plano convex, pale reddish-brown.

Distribution: Epiphytic on basal region of tree trunk in shady humid areas, between 900 to 1500 m.

Notes: This species could not be recorded during the present study. It is included here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Kerala: Idukki District, Nair & Bhargavan, 70184 (MH); Palakkad district, Silent Valley, Kummattanthode, Nayar & team, 10021 (CALI).

Asplenium tenuifolium D. Don. Prodr. Fl. Nepal 8. 1825; Bedd., Ferns S. India 44, 130. 1864; Handb. Ferns Br. India, 159, 78. 1883; Manickam, Fern Fl. Palni Hills, 94. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 223. Pl. 171. 1992; Azeez *et al.*, Spleenworts S. India. 189. 2008; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 385. 2017.

Rhizome erect, 2-3 cm long, 0.5-1.5 cm thick, scaly at the apex; scales ovate-lanceolate, 3.5-5 x 1-1.5 mm, dark brown, apex long acuminate, margins toothed. Stipes tufted, about 8-19 cm long, 1-3 mm thick, base scaly, glabrous above, abaxially rounded, adaxially flat, light green, shallowly grooved. Lamina ovate-lanceolate, 11-35 x 4-16 cm, tripinnate, pinnae up to 20 pairs, alternate; pinnae ovate-lanceolate, 7-8 x 2-3 cm, apex acuminate; secondary pinnae about 8 pairs, alternate, terminated in a trilobed pinnule, ovate, oblique, anadromous, basal secondary pinna acroscopic, overlapping the main rachis; pinnule alternate, 3-4 x 0.5-1 mm, obovate, stalked 2-3 mm, bilobed or trilobed, base narrowly cuneate; apex of the lob subacute; veins obscure, one per lobe, not reaching the margin; pale green, glabrous on both sides, thin herbaceous. Sori 1.8-2 mm long, indusium membranous; spores monoletе, reniform, brown. (Plate 4.45: Fig. h-n.).

Distribution: Epilithic or terrestrial along fully shaded steam banks, between 900 to 2400 m. Valiyaparathodu, Silent Valley National Park.



Plate 4.46: a-g. *Asplenium zenkerianum* Kunze a. Habitat b. Habit c. Habit d. Rhizome e. Leaf bulb f. Scale g. Sori. h-m. *Thelypteris arbuscula* (Willd.) K.Iwats. h. Habitat i-j. Sporophyll k. Reduced basal pinnules l. Scale m. Sori.

Specimen/s examined: Kerala: Idukki District, Pampadum Shola National Park, Kuttikkad, 10° 7' 35.4" N, 77° 15' 29.88" E, 1900 m, 30 July 2019, Thulasi, 14338 (ZGC); Mathikettan Shola National Park, Choondal, 9° 59' 4.56" N, 77° 14' 46.68" E, 1500 m, 2 August 2019, Thulasi & Manju, 14395 (ZGC); Palakkad District, Silent Valley National Park, Valiyaparathodu-Madhrithodu, 11° 7' 9.84" N, 76° 25' 48.36" E, 960 m, 27 December 2019, Thulasi, 14649 (ZGC).

Asplenium zenkerianum Kunze, Linnaea 24: 259. 1851; Bedd., Handb. Ferns Br. India, 148. 1883; Manickam, Fern Fl. Palni Hills, 95. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 214. Pl. 162. 1992; Nayar & Geev., Fern Fl. Malabar 295. 1993; Azeez *et al.*, Spleenworts S. India. 205. 2008; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 393. 2017.

Asplenium persicifolium Bedd., Ferns South. India, 44, t. 128. 1863.

Rhizome short creeping, about 10-15 cm long, 4-5 cm thick, scaly at apex; scales ovate, 7-8 x 1-1.5 mm, dark brown, periphery pale, apex acute, gland tipped, margins fimbriate. Stipes crowded, 28-30 x 1-1.2 cm, dark brown below, rounded, green above, grooved, covered by brown fimbriate scales, rachis similar to stipe. Lamina oblong-lanceolate, 50-60 x 20-30 cm wide, base broadly cuneate, apex acuminate, simple pinnate, imparipinnate; terminal pinnae with rooted vegetative buds, lateral pinnae rarely have proliferating buds; pinnae about 15 pairs, spreading, stalked shortly, basal few pairs opposite, next few subopposite, rest alternate, 3-4 cm apart, largest pinna 10-20 x 3-4 cm, oblong-lanceolate, towards distal part abruptly narrowed, apex acuminate, acroscopic base rounded, basisopic base cuneate, margins serrate towards distal part, crenate in rest; costa raised above and below, forked, free, not reaching margin; pinnae green, glabrous, chartaceous. Sori linear, along basal acroscopic veinlet, indusiate; indusia yellowish-green, entire, glabrous; spores ellipsoid, brown. (Plate 4.46: Fig. a-g.; Plate 4.83: Fig. f.).

Distribution: Lithophytic on fully shaded stream sides, forest floor. Between 1300-1900 m.

Specimen/s examined: Kerala: Idukki District, Pampadum Shola National Park,

Pothukandam, 10° 7' 32.34" N, 77° 15' 16.92" E, 1800 m, 29 July 2019, Thulasi & Manju, 14329 (ZGC); Kuttikkad, 10° 7' 33.6" N, 77° 15' 22.968" E, 1892 m, 30 July 2019, Thulasi & Manju, 14350 (ZGC); Mathikettan Shola National Park, 9° 58' 47.28" N, 77° 14' 12.84" E, 1400 m, 1 August 2019, Thulasi & Manju, 14370 (ZGC).

Thelypteridaceae Ching ex Pic.Serm., *Webbia* 24: 709. 1970.

The taxonomy and nomenclature of the family Thelypteridaceae had undergone a lot of changes over the past. The PPG 1 (2016) system recognised 30 genera, under 2 sub-families. In recent years, Fawcett and Smith (2021) recognised 45 genera in the family. However, in order to avoid nomenclatural confusions, the single genus concept as by Fraser-Jenkins *et al.* (2017) is followed here.

Thelypteris Schmidel, in Keller, *Icon. Pl.*, ed. 3, 45. t. 11, 13. 1763, *nom. cons.*

Key to species

- | | | |
|----|---------------------------------------------------------------------|-----------------------|
| 1. | Veins free | 2 |
| 1. | Veins anastomosing | 7 |
| 2. | Fronds bipinnate or tripinnate; veins not reaching the margin | 3 |
| 2. | Fronds simply pinnate; veins reaching the margin | 4 |
| 3. | Fronds bipinnate; lamina ovate lanceolate | <i>T. flaccida</i> |
| 3. | Fronds tripinnate; lamina deltoid | 5 |
| 4. | Sori exindusiate | <i>T. mollisima</i> |
| 4. | Sori indusiate | 6 |
| 5. | Stipe and rachis verrucose | <i>T. ornata</i> |
| 5. | Stipe and rachis smooth | <i>T. torresiana</i> |
| 6. | Basal pairs of pinnae abruptly reduced to tubercles | <i>T. ochthodes</i> |
| 6. | Basal pairs of pinnae not reduced or progressively reduced | <i>T. calcarata</i> |
| 7. | Pinnae lobed 1/4th way to costa | 8 |
| 7. | Pinnae lobed 1/3rd to ½ way to the costa | 9 |
| 8. | Rhizome creeping | 10 |
| 8. | Rhizome erect | <i>T. articulatum</i> |
| 9. | Basal pinnae not reduced always | <i>T. interruptus</i> |

9.	Basal pinnae reduced or not	11
10.	Fronds trifoliate	<i>T. triphyllum</i>
10.	Fronds having many lateral pinnae	<i>T. thwaitesii</i>
11.	Pinnae glandular beneath	12
11.	Pinnae eglandular beneath	13
12.	Glands and sori distributed in pinna lobes	<i>T. terminans</i>
12.	Glands and sori distributed in unlobed and lobed parts	14
13.	Basal pinnae progressively reduced or unreduced	15
13.	Basal pinnae reduced abruptly	<i>T. truncata</i>
14.	Basal pinnae progressively reduced	<i>T. arbuscula</i>
14.	Basal pinnae abruptly reduced	<i>T. subtruncatus</i>
15.	Rhizome erect	<i>T. hispidula</i>
15.	Rhizome creeping	16
16.	Basal pinnae unreduced	<i>T. parasitica</i>
16.	Basal pinnae progressively reduced	<i>T. dentata</i>

Thelypteris arbuscula (Willd.) K.Iwats., Acta. Phytotax. Geobot. 21(5/6): 170. 1965; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 412. 2017.

Aspidium arbuscula Willd., Sp. Pl., ed. 4, 5: 233. 1810.

Sphaerostephanos arbuscula (Willd.) Holttum, J. S. African Bot. 40(2): 165. 1974; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 192. Pl. 145. 1992; Nayar & Geev., Fern Fl. Malabar 338. 1993.

Rhizome erect, arborescent, massive, 13-15 cm thick, apex densely scaly; scales dark brown, lanceolate, 6-8 x 1-2 mm, margin entire, apex acuminate. Fronds tufted, stipes numerous, 70-74 cm x 3-4 mm, pale green, scaly at base, abaxially rounded, adaxially grooved. Lamina elliptic, 50-54 x 10-14 cm, pinnae 34-35 pairs, 8-10 basal pairs reduced, basal reduced pinnae 3-3.5 x 1-1.5 cm, ovate-deltoid, auricled on acroscopic base, apex acute, margin entire or crenate; veins forked; largest pinnae 8-9 x 0.8-1 cm, linear-lanceolate, short stalked, subopposite at basal part, margin shallowly lobed. Sori median on the veins, 3-4 pairs, indusia hairy; spores bilateral, light brown. (Plate 4.46: Fig. h-m.).



Plate 4.47: a-g. *Thelypteris calcarata* (Blume) Ching a. Habitat b. Habit c. Frond d. Rhizome e. Scale f. Sporophyll g. Sori. h-m. *Thelypteris dentata* (Forssk.) E.P.St.John h. Habitat i. Rhizome j. Scale k. Sori l. Habit m. Frond.

Distribution: Terrestrial on partially or fully shaded stream banks, between 700 to 1300 m. Found growing at Parathode and Valiyaparathodu of Silent Valley National Park.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Parathod, 11° 5' 51" N, 76° 26' 48.84" E, 920 m, 23 October 2019, Thulasi, 14529 (ZGC); Valiyaparathodu-Madhrithodu, 11° 6' 52.2" N, 76° 25' 52.32" E, 910 m, 27 December 2019, Thulasi, 14644 (ZGC); Palakkad, Anavai, N.C. Nair, 56814 (MH).

Thelypteris articulata (Houlston & T.Moore) Tagawa & K.Iwats., Acta. Phytotax. Geobot. 26: 169. 1975; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 416. 2017.

Nephrodium articulatum Houlston & T.Moore, Gard. Mag. Bot. 3: 293. 1851.

Pronephrium articulatum (Houlston & T.Moore) Holttum, Blumea 20(1): 116. 1972; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 186. Pl. 141. 1992; Nayar & Geev., Fern Fl. Malabar 323. 1993.

Rhizome erect, short, unbranched, 3-4 cm thick, scaly; scale pseudo-peltate, elongate-ovate, yellowish brown, 5-8 x 3-4 mm, base rounded, apex with cub-shaped glandular cell. Frond tufted; stipe 45-65 cm long, erect, quadrangular, black, pneumatophore absent, hairy. Lamina obliquely erect, elongate-oblong, 60-100 x 25-45 cm, short pinnatifid apex, broader, having 2-3 pairs of short pinnae like basal lobes; lateral pinnae 18-25, alternate, sessile, prominent swollen black gland-like aerophore present at abaxial base, oblong, 15-20 x 2-3.5 cm, apex acuminate, margin entire, base broadly cuneate to sub-truncate; lamina thin, coriaceous. Veins pinnate, 9-13 unbranched lateral veinlets. Fertile fronds smaller than sterile fronds, 10-15 x 1.2-2 cm. Sori small, circular, indusium reniform; spore plano-convex, dark brown.

Distribution: Terrestrial in humid shaded localities near water bodies, between 700-1500 m.

Notes: This species could not be recorded during the present study. It is included here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Kerala: Palakkad district, Silent Valley, 20 December 1977, Nayar & Madhusoodhanan, 21380 (CALI); Nayar & Geevarghese, 29267 (CALI).

Thelypteris calcarata (Blume) Ching, Bull. Fan Mem. Inst. Biol., Bot., 6(5): 288. 1936; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 419. 2017.

Aspidium calcaratum Blume, Enum. Pl. Javae 2: 159.1828.

Trigonospora calcarata (Blume) Holttum in Nayar & Kaur, Comp. to Bedd. Handb. Ferns Brit. India 203. 1974.

Thelypteris calcarata (Blume) Ching, Bull. Fan Mem. Inst. Biol. Bot. 6: 288. 1936.

Trigonospora caudipinna Ching, Bull. Fan Mem. Inst. Biol., Bot., 6(5): 288-289. 1936; *auct.* Manickam & Irud., Pterid. Fl. W. Ghats S. India, 182. Pl. 138. 1992; Nayar & Geev., Fern Fl. Malabar 344. 1993.

Rhizome erect or sub erect, 5-12 cm long, 1-2.5 cm thick, with black wiry roots, apex scaly; scales ovate, 2-2.2 x 1-1.2 mm, brown uniformly, acute apex, entire margin with acicular hairs both surface and along margin. Stipes 23-25 cm long in fertile one, 15-17 cm long in sterile ones; thin, acicular, soft hairs sparsely at basal part, densely above. Lamina simple pinnate, 22-25 x 6- 8 cm, ovate, caudate apex, pinnae 15-22 pairs, sessile, sub-opposite at basal part, gradually alternate in distal part; basal 2 or 3 pinnae reduced, basal most pairs deflexed, pinnae oblong-ovate, apex acuminate, base truncate, margin lobed; 18-20 pairs of lobes, oblong, falcate, slightly oblique, rounded apex; costa raised both sides, flattened above, rounded abaxially, costules and veins not distinct above, slightly below; veins 6-7 pairs, free, reaching the margin, basal acroscopic reaching the sinus base, whereas basiscopic vein reaching the side of sinus, in terminal lobes veins are forked. Sori 4 pairs, brown, round, indusia covered by acicular hairs; spores triangular, brown. (Plate 4.47: Fig. a-g.).

Distribution: Epilithic in fast flowing streams (rheophytic), between the altitudinal ranges 900-1100 m.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park,

Kummattanthodu, 11° 5' 45.6" N, 76° 26' 57.84" E, 950 m, 22 October 2019, Thulasi, 14504 (ZGC); Parathod, 11° 5' 33" N, 76° 26' 44.52" E, 1020 m, 23 October 2019, Thulasi, 14518 (ZGC).

Thelypteris dentata (Forssk.) E.P.St.John, Amer. Fern J. 26(2): 44. 1936; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 428. 2017.

Polypodium dentatum Forssk., Fl. Aegypt.-Arab. 185. 1775.

Christella dentata (Forssk.) Brownsey & Jermy, Brit. Fern Gaz. 10(6): 338. 1973; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 199. Pl. 149. 1992; Nayar & Geev., Fern Fl. Malabar 299. 1993.

Rhizome short creeping, more than 10 cm long, 0.5-0.7 cm thick, sparsely scaly; scales lanceolate, 8-9 x 1-1.5 mm, pale brown, apex acuminate, margin entire, hairy; stipes 1-2 cm apart, 70-75 cm long, pale to dark brown, scaly at the base, glabrous above. Lamina 88-90 x 20-23 cm, oblong-lanceolate; pinnae up to 20 pairs, up to 10 pairs progressively reduced basal pinnae, unreduced pinnae alternate, reduced pinnae opposite or sub-opposite, largest pinna 18-20 x 1-2 cm, apex acuminate, base cuneate, basal pinnae sub-sessile, upper pinnae sessile, margin lobed about halfway to the costa, lobes 3-3.5 mm wide; veins 7-8 pairs, free, basal veins anastomosing to form an excurrent vein reaching the base of sinus; long, slender, unicellular, acicular hairs distributed on rachis and upper surface of costa; sori median on veins, up to 6 pairs, indusia with short hairs; spores reniform, brown. (Plate 4.47: Fig. h-m.; Plate 4.83: Fig. g.).

Distribution: Very common, along roadsides and river banks from below 10-2400 m.

Specimen/s examined: Kerala: Palakkad District, Mannarkkad, Meenvallam, 10° 55' 24.96" N, 76° 33' 51.84" E, 85 m, 11 September 2018, Thulasi, 14212 (ZGC); Virgin Valley, 11° 2' 42.72" N, 76° 26' 33" E, 79 m, 24 November 2018, Thulasi, 14291 (ZGC); Olavakkode, Dhoni, 10° 51' 34.2" N, 76° 37' 21.72" E, 120 m, 13 September 2018, Thulasi, 14232 (ZGC); Walayar, Chacolas, 10° 51' 22.68" N, 76° 44' 29.04" E, 195 m, 31 August 2019, Thulasi & Aswani, 14404 (ZGC); Silent



Plate 4.48: a-d. *Thelypteris flaccida* (Blume) Ching a. Habit b. Rhizome c. Scale d. Frond. e-k. *Thelypteris mollissima* (Fisch. ex Kunze) Thapa e. Habitat f. Habit g. Frond h. Rhizome i. Scale j. Sori k. Sporophyll.

Valley National Park, Kummattanthodu, 11° 5' 48.84" N, 76° 27' 19.8" E, 1030 m, 22 October 2019, Thulasi, 14486 (ZGC); Valyaparathodu-Madhrithodu, 11° 6' 52.2" N, 76° 25' 52.32" E, 910 m, 27 December 2019, Thulasi, 14648 (ZGC); Nelliampathy, Maattumala, 10° 32' 7.44" N, 76° 43' 10.56" E, 1335 m, 13 November 2019, Thulasi & Maya, 14554 (ZGC); Parambikulam Tiger Reserve, Karimala, 10° 30' 42.84" N, 76° 52' 49.44" E, 360 m, 5 December 2019, Thulasi, 14574 (ZGC); Olavakkode, Elivalmala, 10° 52' 26.04" N, 76° 38' 10.68" E, 300 m, 8 January 2020, Thulasi, 14745 (ZGC); Walayar, Aduppukootimala, 10.877, 76.813, 242 m, 12 January 2020, Thulasi & Aswani, 14755 (ZGC); Agali, Ommala, 11° 3' 35.64" N, 76° 36' 39.96" E, 730 m, 14 November 2021, Thulasi, 14923 (ZGC); Ottappalam, Nhanagattiri, 10° 47' 14.136" N, 76° 10' 51.924" E, 25 m, 17 May 2022, Thulasi, 15039 (ZGC); Idukki District, Pambadum Shola National Park, Kuttikkad, 10° 7' 33.6" N, 77° 15' 22.68" E, 1892 m, 30 July 2019, Thulasi & Manju, 14352 (ZGC); Chinnar Wildlife Sanctuary, 10° 17' 11.76" N, 77° 10' 5.88" E, 933 m, 7 January 2020, Thulasi & Maya, 14743 (ZGC); Thrissur District, Peechi, 10° 32' 18.06" N, 76° 25' 2.712" E, 160 m, 10 July 2021, Thulasi, 14861 (ZGC).

Thelypteris flaccida (Blume) Ching, Bull. Fan Mem. Inst. Biol., Bot., 6(5): 336-338. 1936; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 434. 2017.

Aspidium flaccidum Blume, Enum. Pl. Javae 2: 161. 1828.

Metathelypteris flaccida (Blume) Ching, Acta. Phytotax. Sin. 8(4): 306. 1936; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 169. Pl. 129. 1992.

Rhizome erect, 5-7 cm long, 3-4 cm thick, scaly at apex; scales ovate lanceolate, 4-5 x 0.8-1 mm, uniformly brown, apex acuminate, 0.25-0.26 mm long hairs distributed along margin and other parts. Stipes tufted, 15-16 x 2-3 cm, slender, pale green, below rounded, adaxial surface with two lateral grooves, base scaly. Lamina ovate-lanceolate, 20-40 x 8-16 cm, bipinnate, acute; pinnae 10-20 pairs, sessile, opposite or sub-opposite, lanceolate, 10-12 x 2-2.5 cm, base truncate, apex acuminate, costa raised above and below; pinnules sessile, adnate, 12-15 pairs, alternate or subopposite, largest pinnule 1-1.5 x 0.5-0.6 cm, margin lobed halfway to the costa; lobes 6-7 pairs, 2-2.5 x 1-1.26 mm, entire, oblique, rounded; veins pinnate, free, not

reaching margin; rachis and costa covered by long hairs on upper surface, sparsely on lower surface; texture soft herbaceous. Sori rounded, indusia hairy. spores monolete, globose, dark brown. (Plate 4.48: Fig. a-d.).

Distribution: Terrestrial along shaded stream sides, between 800 -1800 m. Found growing at Atti, Malappuram.

Specimen/s examined: Kerala: Malappuram, Atti, 11° 10' 40.08" N, 76° 24' 53.28" E, 1150 m, 31 December 2019, Thulasi, 14708 (ZGC).

Thelypteris hispidula (Decne.) C.F.Reed, Phytologia 17(4): 283. 1968; Nayar & Geev., Fern Fl. Malabar 305. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 3. 440. 2017.

Aspidium hispidulum Decne., Nouv. Ann. Mus. Hist. Nat. 3: 346. 1834.

Christella hispidula (Decne.) Holttum, Kew Bull. 31(2): 312. 1976; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 199. Pl. 150. 1992.

Rhizome erect, unbranched, 5-10 cm x 10-20 mm, scaly; scales dark brown, lanceolate, 8-10 x 0.75-1 mm, apex acuminate. Frond tufted; stipe 20-60 cm x 3-4 mm, densely scaly at base. Lamina ovate-oblong, 60-80 x 20-30 cm, apex pinnatifid; rachis hairy, hairs short, shaggy, pale brown, acicular; lateral pinnae 20-30 pairs, sub-opposite, larger pinna 10-15 x 1.5-1.8 cm, apex acuminate, margin serrate, 1-2 pairs of basal pinnae slightly reduced. Partially fertile fronds are frequent, sori on basal united veinlets; spore concavo-convex, dark brown.

Distribution: Terrestrial in partially or fully shaded locations, between 700-1300 m.

Notes: This species is included here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Kerala, Palakkad District, Panthanthodu, N.C. Nair, 56645 (MH).

Thelypteris interrupta (Willd.) K.Iwats., J. Jap. Bot. 38(10): 314. 1963; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 3. 444. 2017.

Pteris interrupta Willd., Phytographia 1: 13, t. 10, f. 1. 1794.

Cyclosorus interruptus (Willd.) H.Itô, Bot. Mag., Tokyo 51: 714. 1937; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 187. Pl. 142. 1992; Nayar & Geev., Fern Fl. Malabar 309. 1993.

Rhizome long creeping, more than 10 cm long, 0.6-1 cm thick, branched, scaly; scale dark brown, elongate-ovate, 3-4 x 1-2 mm, apex acute. Frond scattered on rhizome, spirally arranged; stipe erect, 30-50 cm x 3-5 mm. Lamina elongate-ovate, 30-55 x 15-25 cm, erect, simply pinnate; pinnae obliquely spreading, larger one short petiolate, others sessile, 20-25 pairs, subopposite, 10-15 cm x 10-13 mm, narrowly oblong, base truncate, apex acute, margin lobed, lobes sub-deltoid; lamina thick coriaceous, glabrous; venation pinnate. Fertile frond similar to sterile ones; sori circular, sub-median, on ultimate veinlets; spores plano-convex, dark brown.

Distribution: Terrestrial in exposed swampy areas, between 100 to 700 m.

Notes: This species is included here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Kerala: Palakkad District, Kaikatty, Nayar and Pankajam, 7327 (CALI). Tamil Nadu: Subramanyan, 3480 (MH).

Thelypteris mollissima (Fisch. ex Kunze) Thapa, Pterid. Nepal 95. 2002; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 457. 2017.

Gymnogramma mollissima Fisch. ex Kunze, Linnaea 23: 255, 310. 1850.

Stegnogramma pozoii auct., Manickam & Irud., Pterid. Fl. W. Ghats S. India, 248. Pl. 173. 1992, *non* (Lagasca) K. Iwats., Acta Phytotaxa Geobot. 19: 124. 1963.

Leptogramma mollissima (Fisch. ex Kunze) Ching, Sinensia 7: 102, t. 9. 1936.

Rhizome short creeping, 6-8 cm long, 2-3 cm thick, apex scaly; scales broad-ovate, uniformly pale brown, entire margin, apex acuminate, short hairs on the surface and margin. Stipes 14-35 x 2-3 cm, adaxially grooved, abaxially round, short and long soft, acicular, unicellular cells all over above. Lamina elliptic lanceolate, 23-25 x 6-7



Plate 4.49: a-f. *Thelypteris parasitica* (L.) Tardieu a. Habitat b. Habit c. Rhizome d. Scale e-f. Frond. g-m. *Thelypteris terminans* (J.Sm. ex Hook.) Tagawa & K.Iwats. a. Habitat b. Habit c. Rhizome j. Scale k. Sporophyll l-m. Sori.

cm, distal part lobed, subacute, pinnae about 8-15 pairs, basal few pairs reduced progressively, sub-opposite; basal pinnae sessile, others adnate to rachis, apex acuminate, margin lobed in basal pinnae, shallowly lobed and become crenate towards the distal part; pinna lobes 14-15 pairs, oblong, apex rounded; costa raised above and below; veins unbranched, free, reaching the margin, short sinus membrane only in few basal pinnae, intra venal and veins of both sides covered by soft, acicula, unicellular hairs; pinnae pale green, herbaceous. Sori linear, 3-3.5 mm, on the basal part of basal acroscopic and basispic veins, ex-indusiate, sporangia having firm, erect, acicular hairs. Spores reniform, brown. (Plate 4.48: Fig. e-k.; Plate 4.87: Fig. h.).

Distribution: Terrestrial, along shaded roadsides and stream sides in rock crevices. Between 1500 to 2400 m.

Specimen/s examined: Tamil Nadu: Ooty, 11° 13' 24.96" N, 76° 32' 1.68" E, 2371 m, 27 February 2022, Maya, 15010 (ZGC). Kerala: Silent Valley National Park, Anginda, 11° 11' 17.88" N, 76° 27' 36.72" E, 2300 m, 30 December 2019, Thulasi, 14712 (ZGC).

Thelypteris ochthodes (Kunze) Ching, Bull. Fan Mem. Inst. Biol., Bot., 6(5): 300-301. 1936; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 463. 2017.

Aspidium ochthodes Kunze, Linnaea 24: 282-283. 1851.

Pseudocyclosorus ochthodes (Kunze) Holttum in Nayar & Kaur, Comp. Beddome's Handb. 204. 1974; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 176. Pl. 134. 1992; Nayar & Geev., Fern Fl. Malabar 334. 1993.

Rhizome short creeping or suberect, more than 5 cm long, 5-6 cm thick; scales broadly ovate, 3-4 x 4-5 mm, uniformly pale brown, apex acuminate, margin entire with few uniseriate outgrowths. Frond erect; stipe 100-105 x 0.8-1 cm, glabrous, adaxially grooved, abaxially rounded, 3-4 pairs of 2-3 mm long dark brown aerophores present along each side of the stipe. Lamina ovate or lanceolate, 110-115 x 35-38 cm, apex acuminate; pinnae 30-35 pairs, sessile, sub opposite or alternate, 8-10 basal pairs of pinnae abruptly reduced to tubercles; larger pinnae 19-20 x 1-1.5

cm, linear lanceolate, apex acuminate, base truncate, margin lobed, costa distinctly raised and rounded below, dark green above, pale green below; texture subcoriaceous. Sori supramedian on each vein, indusiate; spores biconvex, yellowish green.

Distribution: Terrestrial along partially or fully exposed stream banks, roadsides; between 1000 to 2400 m.

Notes: This species is included here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Kerala: Palakkad, Valiyaparathodu, Silent Valley, Nayar and Party, 10060 (CALI). Tamil Nadu: Nilgiris, Vajravelu, 38300 (MH).

Thelypteris ornata (J.Sm.) Ching, Bull. Fan Mem. Inst. Biol., Bot., 6: 346. 1936; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 467. 2017.

Polypodium ornatum Wall. ex Bedd., Ferns S. India 56, t. 171. 1864, *non* Klotzsch. 1847.

Macrothelypteris ornata (J.Sm.) Ching, Act. Phytotax. Sin. 8(4): 309. 1963; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 171. Pl. 131. 1992; Nayar & Geev., Fern Fl. Malabar 312. 1993.

Rhizome creeping, more than 30 cm long, 3-4 cm thick, densely clothed by scales; scales 1.8-2 cm x 2-2.5 mm, uniformly yellowish brown, apex long acuminate, margin entire, long, stiff, acicular hairs sparsely distributed all over. Stipes tufted, swollen at the base, rounded below, grooved above, densely covered by scales all over in young parts, verrucose due to the persistent bases of scales in mature parts. Lamina 128-130 x 128-130 cm, ovate with acuminate apex, tripinnate, about 10 pairs of 67-70 x 24-25 cm, lanceolate, subopposite, secondary pinnae up to 30 pairs, 18-20 x 4-5 cm, oblong lanceolate, 2-3 cm apart, apex acuminate, base truncate; tertiary pinnae up to 25 pairs, opposite or alternate; lobes up to 8 pairs, 1-2 x 0.5-1 mm, oblong, oblique, apex subacute or rounded, veins obscure, forked twice; abaxial side of primary and secondary rachis verrucose, densely strigose adaxially; long,

stiff, acicular hairs distributed on adaxial and abaxial side of the costule and veins; pinnae dark green, herbaceous.

Distribution: Terrestrial on partially shaded land cuttings, seen between 900-1900 m.

Notes: This species is included here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Nayar and Party, 10043 (CALI). N.C. Nair, 56669 (MH).

Thelypteris parasitica (L.) Tardieu, Notul. Syst., Paris 7: 75. 1938; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 472. 2017.

Polypodium parasiticum L., Sp. Pl. 2: 1090. 1753.

Thelypteris parasitica (L.) Fosberg, Occas. Pap. Bernice P. Bishop Mus. 23(2): 30. 1962, *isonym*.

Thelypteris parasitica (L.) K.Iwats., Mem. Coll. Sci. Univ. Kyoto, B, Biol. 31: 172. 1965, *isonym*.

Christella parasitica (L.) H.Lév., Fl. Kouy-Tchéou 475. 1915; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 195. Pl. 147. 1992; Nayar & Geev., Fern Fl. Malabar 307. 1993.

Rhizome long creeping, 8-15 cm long, rarely erect, 0.5-1 cm thick; scales linear-lanceolate 9-10 x 1-1.5 mm, apex acuminate, margin entire. Stipes 2-2.5 cm apart, 43-45 x 4-5 cm, grey-green, scaly at the base, covered by hairs at the top, rest glabrous. Lamina deltoid, broadly ovate or cordate, 29-30 x 14-15 cm; rachis covered by hairs; pinnae up to 13-20 pairs, opposite at the base, alternate in distal part; pinnae 10-11 x 1-1.3 cm, linear-lanceolate, sessile, base truncate or very broadly cuneate, apex acuminate, margin lobed, lobes up to 20 pairs, oblique, basal acroscopic lobe slightly larger than others; costa densely covered by hairs above and below; veins up to 8 pairs, basal veins of opposite lobes joining to form an excurrent

vein passing to the base of the sinus; upper and lower surface of costules, veins and interveinal space covered by glandular hairs; elongated orange coloured glandular hairs on lower surface of costules and veins; pinnae pale green. Sori median on the veins, up to 5 pairs, indusia densely hairy. Spores reniform, brown. (Plate 4.49: Fig. a-f.; Plate 4.83: Fig. h.).

Distribution: Very common

Specimen/s examined: INDIA, Idukki District, Mathikettan Shola National Park, 9° 58' 47.28" N, 77° 14' 12.84" E, 1400 m, 1 August 2018, Thulasi & Manju, 14381 (ZGC); Palakkad District, Mannarkkad, Siruvani, 10° 58' 55.56" N, 76° 36' 1.8" E, 700 m, 20 September 2019, Thulasi, 14424 (ZGC); Ottappalam, Nhangattiri, 10° 47' 14.136" N, 76° 10' 51.924" E, 25 m, 17 May 2022, Thulasi, 15040 (ZGC).

Thelypteris subtruncata (Bory) Panigrahi, Phytologia 31: 371. 1975; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 489. 2017.

Polypodium subtruncatum Bory in Bélanger, Voy. Bot. 2: 32. 1833.

Sphaerostephanos subtruncatus (Bory) Holttum in Holttum & Chandra, Kew Bull. 26: 80. 1971; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 194. Pl. 146. 1992; Nayar & Geev., Fern Fl. Malabar 340. 1993.

Rhizome erect, 10-20 cm long, 4-5 cm thick, densely scaly at apex; scales ovate-lanceolate, 4-5 x 1-2 mm, pale brown, apex acuminate, margin entire, minute acicular hairs distributed all over the and the margin. Fronds tufted; stipe 55-60 cm long, adaxially and laterally grooved, abaxially flattened. Lamina oblong-lanceolate, 100-105 x 35-40 cm, simply pinnate, basal pinnae abruptly reduced; pinnae 44-45 pairs, basal 10 pairs abruptly reduced; reduced pinnae ovate-lanceolate, auricled on acroscopic side, margin crenate or entire, veins forked free or anastomosing; largest pinnae 18-20 x 2-2.3 cm, oblong-linear-lanceolate, sessile, opposite or subopposite, base broadly cuneate, apex acuminate, margin lobed halfway to the costa; lobes 30-35 pairs, oblong, 4-5 x 3-4 mm, slightly oblique and falcate, apex subacute; veins slightly distinct above and below, 8-10 pairs; texture herbaceous. Sori median on veins, 8-10 pairs, rounded, indusia glabrous; spores reniform, brown.

Distribution: Terrestrial along partially shaded stream sides, between 400-900 m.

Notes: This species is included here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Kerala: Palakkad district, Nayar, 2031 (CALI).

Thelypteris terminans (J.Sm. ex Hook.) Tagawa & K.Iwats., Acta. Phytotax. Geobot. 26: 169. 1975; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 491. 2017.

Aspidium terminans Wall., Numer. List no. 386. 1829, *nom. nud.*

Amphineuron terminans (J.Sm. ex Hook.) Holttum, Amer. Fern J. 63: 82. 1973; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 189. Pl. 143. 1992; Nayar & Geev., Fern Fl. Malabar 298. 1993.

Amblovenatum terminans (Wall. ex Hook.) J.P.Roux, Strelitzia 23: 201. 2009.

Thelypteris terminans (J.Sm. ex Hook.) Panigrahi, Phytologia 30: 410. 1975.

Rhizome wide creeping, 8-13 cm long, 0.8-0.9 cm thick, densely scaly at the apex; scales linear lanceolate, 8-8.5 x 1.5-2 mm, dark brown, thickened uniformly, apex acuminate, short acicular hairs distributed all over. Stipes 4-5 mm apart, 85-88 cm long, tetragonal with shallow groove on both sides, dark brown, scaly at the base, glabrous above. Lamina 66-70 x 55-56 cm, broadly deltoid, simple pinnate; pinnae about 25 pairs, ascending, alternate above, opposite at base, subsessile, some basal pairs reduced to tubercles, pinnae linear lanceolate, apex acuminate, base attenuate or cuneate oblique, margin lobed one-third to half to the costa, lobed subacute or rounded or deltoid with acute apex; costa distinctly raised and rounded below, slightly raised and grooved above; costules and veins slightly distinct above and slightly raised below; one and a half pairs of basal veins from adjacent lobes joining to form an excurrent vein reaching the base of very short sinus membrane; herbaceous; thin, short acicular hairs distributed on lower surface and long acicular hairs on upper surface of costa and rachis, upper inter-venal area glabrous, spherical yellowish glands distributed on the lower surface of veins. Sori up to 10 pairs,

supramedian, on margin of lobes, indusia glabrous, glandular sporangium. Spores monolete, globose, brown. (Plate 4.49: Fig. g-m.).

Distribution: Common, along roadsides and forest edges between 100-1000 m.

Specimen/s examined: Kerala: Palakkad District, Mannarkkad, 11° 2' 27.996" N, 76° 26' 41.28" E, 76 m, 17 October 2018, Thulasi, 14260 (ZGC); Siruvani, 10° 58' 55.704" N, 76° 36' 1.98" E, 700 m, 20 September 2019, Thulasi, 14418 (ZGC); Nelliampathy, Manpara, 10° 33' 27.72" N, 76° 44' 40.38" E, 1065 m, 1 December 2018, Thulasi & Maya, 14312 (ZGC); Silent Valley National Park, Kummattanthodu, 11° 5' 48.84" N, 76° 27' 19.8" E, 1030 m, 22 October 2019, Thulasi, 14475 (ZGC); Parambikulam Tiger Reserve, Vengolimala, 10° 21' 56.52" N, 76° 45' 36.36" E, 830 m, 6 December 2019, Thulasi, 14606 (ZGC); Bhavani, Thudukki, 11° 8' 4.128" N, 76° 30' 28.404" E, 1300 m, 2 October 2021, Thulasi, 14891 (ZGC); Malappuram District, Karimpuzha Wildlife Sanctuary, Paanappuzha, 11° 18' 8.748" N, 76° 25' 30.432" E, 250 m, 4 September 2021, Thulasi, 14881 (ZGC).

Thelypteris × *thwaitesii* (Hook.) C.F.Reed, *Phytologia* 17: 319. 1968; Fraser-Jenkins *et al.*, *Anno. Checklist Indian Pterid.*, 504. 2017.

Meniscium thwaitesii Hook., *Fil. Exot.* t. 83. 1859.

Pronephrium thwaitesii (Hook.) Holttum, *Blumea* 20(1): 122. 1972; Nayar & Geev., *Fern Fl. Malabar* 326. 1993.

Rhizome long creeping, 8-12 cm long, branched, 3-4 mm thick, covered by hairs and scales; scales lanceolate, dark-brown, 5-7 x 0.9-1 mm, base cordate, apex acuminate with a swollen subglobose hyaline glandular cell; margin bear straight acicular hairs. Frond dimorphic; stipe erect, smooth, 1.5-2.5 mm thick, sterile stipe 20-30 cm long, fertile ones 30-45 cm long. Lamina simple pinnate, spreading in sterile fronds, deltoid-ovate, 12-20 x 5-10 cm; lateral pinnae 6-14 pairs, sub-opposite; apical region elongated, oblong-lanceolate, 5-8 x 1-2 cm, base broadly cuneate, margin deeply pinnatifid, lobes narrowly falcate. Fertile frond longer than sterile fronds, pinnae slightly contracted and less dissected, larger basal fertile

pinnae 4-7 x 0.8-1 cm, narrowly lanceolate; sori elongated along the confluent lateral veinlets; spore commonly abortive, plano-convex, light brown.

Distribution: Terrestrial along river sides of partially shaded areas, between 1000 to 1500 m.

Notes: This species is included here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Nayar & Geevarghese, 10669 (CALI).

Thelypteris torresiana (Gaudich.) Alston, Lilloa 30: 111. 1960; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 492. 2017.

Polystichum torresianum Gaudich. in Freycenet, Voy. Uranie, Bot. 8: 333. 1828.

Macrothelypteris torresiana (Gaudich.) Ching, Acta. Phytotax. Sin. 8(4): 310. 1963; Manickam & Irud., Pterid. Fl. W. Ghats S. India 172. 1992; Nayar & Geev., Fern Fl. Malabar 317. 1993.

Rhizome short creeping, 4-6 cm long, 8-10 mm thick, densely scaly; scales linear lanceolate, 10-12 x 1-1.5 mm, uniformly pale brown, apex acuminate, gland tipped, margin entire with acicular hairs. Stipes 65-67 x 1-1.2 cm, abaxially rounded, adaxially grooved, dark brown, scaly at base. Lamina broadly ovate to deltoid, 80-100 x 50-60 cm, bipinnate, primary pinnae 12-15 pairs, apex acuminate; largest pinnae 40-45 x 15-16 cm, lanceolate, apex acuminate; secondary pinnae, 18-20 pairs, 8-10 x 2-3 cm; tertiary pinnae 18-20 pairs, oblong, apex sub-acute, margin lobed halfway to the costule, lobes 5-6 pairs, oblique with rounded apex; veins distinct, free, forked twice or thrice; long hairs distributed on abaxial surface of secondary rachis and costa; pinnae pale green; texture herbaceous. Sori on the basal acroscopic veinlets; indusia minute, fugacious, hairy; spore reniform, brown. (Plate 4.50: Fig. a-e.).

Distribution: Terrestrial on shaded stream and road sides, between 80-900 m. Found growing at Mannarkkad and Walayar.



Plate 4.50: a-e. *Thelypteris torresiana* (Gaudich.) Alston a. Habitat b. Habit c. Rhizome d. Scale e. Sporophyll with sori. f-l. *Athyrium cumingianum* (C.Presl) Ching f. Habitat g. Habit h. Frond i. Rhizome j. Scale k-l. Sori.

Specimen/s examined: Kerala: Palakkad District, Mannarkkad, Agali, Ommala, 11° 3' 35.964" N, 76° 36' 40.284" E, 730 m, 14 November 2021, Thulasi, 14925 (ZGC); Meenvallam, 10° 55' 25.68" N, 76° 34' 23.88" E, 100 m, 11 September 2022, Thulasi, 15054 (ZGC).

Thelypteris triphylla (Sw.) K.Iwats., Mem. Coll. Sci. Kyoto Imp. Univ., B, 31(3): 190. 1965; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 493. 2017.

Pronephrium triphyllum (Sw.) Holttum, Blumea 20(1): 122. 1972; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 140. Pl. 183. 1992; Nayar & Geev., Fern Fl. Malabar 329. 1993.

Rhizome long creeping, more than 10 cm long, 0.3-0.4 mm thick, densely scaly; scales lanceolate, 4-5 x 1-1.5 mm, uniformly dark brown, apex acuminate, margin entire with short, wightish, unicellular, acicular hairs. Frond not tufted; stipe 2-3 cm apart, 35-40 x 0.2-0.3 cm, slightly longer in fertile fronds, trigonal, grooved above, scaly at base, sparsely scaly at the base, densely covered by short, wightish, unicellular, acicular hairs. Lamina ovate, base cuneate, 15-20 x 10-15 cm, trifoliate; leaves lanceolate or oblanceolate, 15-20 x 2-3 cm, median leaf longer than lateral leaves, distinctly stalked, erect; lateral leaves 4-5 x 1-2 cm, apex acuminate, base asymmetric, sub-truncate, margin wavy, pinnae dark green, texture herbaceous. Sori oblong to elliptic to crescent shaped, on the veins between the costules, nonindusiate; spores reniform or plano-convex, dark brown.

Distribution: Terrestrial on partially espoused areas along stream sides, between 1000 to 1200 m.

Notes: This species is included here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Kerala: Palakkad District, Attappady, Panthanthode, Nayar & Team, 10602 (CALI).

Thelypteris truncata (Poir.) K.Iwats., Mem. Coll. Sci. Kyoto Imp. Univ., B, 31(1): 33. 1964; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 494. 2017.

Pneumatopteris truncata (Poir.) Holttum, Blumea 21(2): 314. 1973; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 152, Pl. 202. 1992.

Pneumatopteris truncata (Poir.) Holttum, Blumea 21(2): 314. 1973; Nayar & Geev., Fern Fl. Malabar 320. 1993.

Rhizome short, erect, 15-25 x 5-7 cm, scaly; scales ovate-lanceolate, light brown, 6-8 x 1.5-2 mm, base cordate, apex acuminate, margin with uniseriate hairs. Fronds tufted, spirally arranged; stipe erect, 135-140 x 0.8-1 cm, adaxially grooved, bear 8-9 pairs of small auricle-like reduced pinnae. Lamina elongate-oblong, 135-140 x 30-60 cm, simply pinnate, hairy all over; lateral pinnae 30-45 pairs, sessile, base having swollen aerophore; larger pinnae 15-25 x 2-3 cm, oblong-lanceolate, base cuneate, apex acuminate, margin lobed, lobes rectangular; lamina sub-coriaceous, glabrous; venation pinnate, midrib raised on both sides, 8-12 lateral veinlets. Fertile frond similar to sterile; sori small, circular, on the ultimate veinlet; spores plano-convex, golden-brown.

Distribution: Terrestrial in densely shaded evergreen forest floors. Between 700 to 1500 m.

Notes: This species is included here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Kerala: Palakkad District, Silent Valley dam site, Geevarghese and Nayar, 29264 (CALI); Thathengalam N.C. Nair, 56752 (MH).

Woodsiaceae Herter, Revista Sudamer. Bot. 9: 14. 1949.

Key to Genera

1. Sori hooked, circular or reniform *Athyrium*
1. Sori linear 2
2. Stipe, rachis and veins with multicellular hairs *Deparia*
2. Stipe, rachis and veins without multicellular hairs *Diplazium*

Athyrium Roth, Tent. Fl. Germ. 3: 31, 58. 1799, *nom. cons.*

Key to species

1. Sori circular, indusia fugacious *A. cumingianum*
1. Sori elongate, indusia persistent 2
2. Fronds narrowed below *A. hohenackerianum*
2. Fronds not clearly narrowed below *A. solenopteris*

Athyrium cumingianum (C.Presl) Ching in Christensen, Index Fil. Suppl. 3: 40. 1934; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 19. 2018.

Anisocampium cumingianum C.Presl, Abhandl. Kön. Böhm. Ges. Wiss., 5, 6: 418-419. 1851 ("1849"); Manickam & Irud., Pterid. Fl. W. Ghats S. India, 231. Pl. 179. 1992.

Rhizome short creeping, 2-3 cm long, 1-1.5 cm thick, covered by scales all over; scales lanceolate, 4-5 mm long, acuminate, pale brown, entire, soft, membranaceous. Stipe scattered, rounded below, grooved above, pale green, scaly at base, glabrous above. Lamina ovate-lanceolate, simply pinnate, imparipinnate, 28-30 x 20-23 cm; pinnae up to 10 pairs, alternate, stalked shortly, 5-6 cm apart; largest pinna 10-12 cm long, 3.5-4 cm wide, oblong-lanceolate, narrowed slightly at base, suddenly narrowed distally, acuminate apex, broadly cuneate base, deeply serrated margin, lobes 0.7-1 x 0.6-0.9 cm, oblique, apex acute; smaller lobes entire, in larger ones margin serrate; costa not raised, flattened in both sides; midrib and veins not clearly distinct in both sides, veins simple, pinnae dark or light green, glabrous, herbaceous. Sori median on all veins, looks random, round, indusiate; indusia small, light brown, fimbriate; spores ellipsoid, brown. (Plate 4.50: Fig. f-1).

Distribution: Terrestrial, along partially exposed roadside, trek paths and shaded forest floor. Between 100-400 m.

Specimen/s examined: Kerala: Palakkad District, Olavakkode, Dhoni, 10° 51' 34.2" N, 76° 37' 21.72" E, 120 m, 13 September 2018, Thulasi & Maya, 14222 (ZGC); Silent Valley National Park, Kummattanthodu, 11° 5' 33.36" N, 76° 26' 44.16" E, 1020 m, 22 October 2019, Thulasi, 14449 (ZGC); Parambikulam Tiger Reserve,

Karimala, 10° 23' 45.24" N, 76° 46' 30.36" E, 600 m, 6 December 2019, Thulasi, 14610 (ZGC); Bhavani, Thudukki, 11° 8' 7.26" N, 76° 30' 19.62" E, 1370 m, 2 October 2021, Thulasi, 14904 (ZGC); Thrissur District, Peechi, 10° 32' 17.88" N, 76° 25' 2.64" E, 160 m, 10 July 2021, Thulasi, 14863 (ZGC); Malappuram District, Karimpuzha Wildlife Sanctuary, Paanappuzha, 11° 18' 24.876" N, 76° 26' 37.644" E, 310 m, 4 September 2021, Thulasi, 14874 (ZGC).

Athyrium hohenackerianum (Kunze) T.Moore, Index Fil. 49. 1857; Bedd., Ferns S. India 50. t. 150. 1864; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 231. Pl. 233 1992; Nayar & Geev., Fern Fl. Malabar 187. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 36. 2018.

Asplenium hohenackerianum Kunze, Bot. Zeitung (Berlin) 771. 1849.

Allantodia hohenackeriana (Kunze) Kunze, Farnkr. 2: 63, t. 126. 1850.

Rhizome erect, 2-4 cm long, 1-2 cm thick, scaly at apex; scales linear-lanceolate, 4-5 x 0.4-0.5 mm, apex pointed. Stipes tufted, 5-6 x 0.2-0.3 cm, brown, densely scaly below, sparsely above. Lamina lanceolate, simply pinnate, narrowed towards both sides from middle; pinnae about 20 pairs, some basal pinnae shortly stalked, opposite, others sessile, alternate, slightly ascending; largest pinna oblong, subacute apex, basispic base cuneate, acroscopic base truncate; margin irregularly dentate; lobes 6 pairs, deltoid, basal acroscopic lobe larger than basispic lobe, acute apex, serrate margin; veins slightly distinct, simple, reaching the margin; pinnae light green, glabrous; filiform scales distributed sparsely on rachis; herbaceous. Sori median on veins, hooked, indusiate; indusia light brown, entire; spores ellipsoid, brown. (Plate 4.51: Fig. a-f.; Plate 4.83: Fig. i.).

Distribution: Terrestrial or lithophytic, along shaded roadsides.

Specimen/s examined: Kerala: Palakkad District, Olavakkode, Dhoni, 10° 51' 34.2" N, 76° 37' 21.72" E, 120 m, 13 September 2018, Thulasi, 14220 (ZGC); Mannarkkad, Virgin Valley, 11° 2' 42.72" N, 76° 26' 33" E, 79 m, 24 November 2018, Thulasi, 14287 (ZGC); Malappuram District, Pulamanthol, 10° 53' 56.4" N, 76° 11' 28.68" E, 11 m, 15 November 2018, Thulasi, 14267 (ZGC); Karimpuzha



Plate 4.51: a-f. *Athyrium hohenackerianum* (Kunze) T.Moore a. Habitat b. Habit c. Rhizome d. Scale e. Sporophyll f. Sori. g-l. *Athyrium solenopteris* (Kunze) T.Moore g. Habitat h. Frond i. Sporophyll j. Rhizome k. Scale l. Sori.

Wildlife sanctuary, Paanappuzha, 11° 18' 29.844" N, 76° 26' 55.536" E, 350 m, 4 September 2021, Thulasi, 14878 (ZGC); Thrissur District, Peechi, 10° 32' 18.06" N, 76° 25' 2.712" E, 160 m, 10 July 2021, Thulasi, 14856 (ZGC).

Athyrium solenopteris (Kunze) T.Moore, Index Fil. 43. 1857 & 187. 1860; Bedd., Handb. Fern Br. India, 166. 1883; Manickam, Fern Fl. Palni Hills, 111. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 236. Pl. 182. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 52. 2018.

Allantodia solenopteris Kunze, Linnaea 24: 266. 1851.

Athyrium pectinatum Bedd., Ferns South. India, 51 t. 156. 1863, p.p., *non* Wall. ex Mett., Abh. Senckenb. Naturf. Ges. (*Asplenium*) 197. 1859.

Athyrium selenopteris (Kunze) Bedd., Handb. Ferns Brit. India: 166. 1883, *orth. var.*

Rhizome erect, 3-6 cm long, 5-6 cm thick, densely covered by scales all over; scales lanceolate, 8-10 x 0.5-1 mm. Stipes tufted, 23-25 x 0.3-0.5 cm, light brown, rounded below, grooved above, scaly at base, glabrous above. Lamina ovate, 38-40 x 18-20 cm, bipinnate, apex acuminate, base broadly cuneate; pinnae 12-15 pairs, subopposite below, alternate above, shortly stalked, basal some pairs reduced; largest pinna 15-16 x, 5-6 cm, oblong-lanceolate, apex acuminate, base cuneate, pinnules about 12 pairs, subopposite, apex subacute, margins lobed, light green, glabrous, herbaceous; lobes about 7 pairs per pinnule, oblong, tip sub-acute, margins serrate; veins slightly distinct, simple or forked sometimes, free up to margin. Sori in 2 rows, hooked, indusiate; indusium yellowish, margin incised; spores reniform, brown. (Plate 4.51: Fig. g-l.; Plate 4.83: Fig. j).

Distribution: Terrestrial along shaded stream sides, roadsides and forest floor, between 800-2000 m.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Kummattanthodu, 11° 5' 48.84" N, 76° 27' 19.8" E 11° 5' 48.84" N, 76° 27' 19.8" E, 1030 m, 22 October 2019, Thulasi, 14470 (ZGC); Parambikulam Tiger Reserve, Karimala, 10° 25' 15.24" N, 76° 46' 1.2" E, 670 m, 5 December 2019, Thulasi,

14600 (ZGC). Tamil Nadu: Ooty, 11° 17' 9.78" N, 76° 38' 47.436" E, 1750 m, 22 November 2021, Thulasi, 14950 (ZGC); Bankitapal, 11° 28' 1.056" N, 76° 32' 59.856" E, 1900 m, 28 December 2021, Maya, 14967 (ZGC).

Deparia Hook. & Grev., Icon. Fil. 2(8): t. 154. 1829-1830.

Deparia japonica subsp. *petersenii* (Kunze) Fraser-Jenk., Anno. Checklist Indian Pterid., 178. 2018.

Asplenium petersenii Kunze, Analecta Pteridogr. 24. 1837.

Deparia petersenii (Kunze) M. Kato subsp. *sledgei* Fraser-Jenk., Taxon. Revis. Three Hundred Indian Subcont. Pterid. 248. 2008.

Deparia petersenii (Kunze) M. Kato, Bot. Mag. Tokyo, 96. 1977; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 239. Pl. 186. 1992.

Diplazium japonicum (Thunb.) Bedd., Suppl. Ferns S. Brit. Ind. 12, t. 292. 1876; Nayar & Geev., Fern Fl. Malabar 198. 1993.

Rhizome long creeping, 6-10 cm long, 0.5-0.7 cm thick, branched randomly, densely scaly all over; scales lanceolate, 8-9 x 1-1.5 mm wide, light brown, thin-walled cells, apex acuminate, margin entire. Stipes scattered, 2-3 cm apart, 33-35 x 0.4-0.5 cm, rounded below, grooved above, base dark brown, above light brown, densely scaly at base, sparsely above. Lamina lanceolate, 40-43 x 18-20 cm, simply pinnate; pinnae about 10 pairs, alternate, sessile, basal pinnae not reduced, distally reduced, terminated with a caudate apex; largest pinna 14-15 x 2.5-3 cm, oblong-lanceolate, apex acuminate, base broadly cuneate, margins deeply lobed, incisocrenate in the distal pairs; lobes oblong, slightly oblique, apex subacute, margins serrate at apex, entire in rest, mid rib slightly raised on both sides, abaxially rounded, adaxially grooved, veins minutely distinct on both surface, simple, free, reaching the margin; stipe, midrib and veins covered by thin hairs; pinnae pale green, herbaceous. Sori median, on veins, linear, indusiate; indusia with fimbriate margin; spores monoletate, globose, brown. (Plate 4.52: Fig. a-f.; Plate 4.83: Fig. k.).



Plate 4.51: a-f. *Athyrium hohenackerianum* (Kunze) T.Moore a. Habitat b. Habit c. Rhizome d. Scale e. Sporophyll f. Sori. g-l. *Athyrium solenopteris* (Kunze) T.Moore g. Habitat h. Frond i. Sporophyll j. Rhizome k. Scale l. Sori.

Distribution: Terrestrial along shaded roadsides, trek paths and stream banks. Between 1000-2400 m.

Specimen/s examined: Tamil Nadu: Kodaikanal, 10° 15' 23.04" N, 77° 31' 43.68" E, 1550 m, 18 November 2019, Thulasi, 14562 (ZGC).

Diplazium Sw., Schrader, J. Bot. 1800(2): 4, 61. 1801.

Key to species

1. Veins anastomosing *D. esculentum*
1. Veins free 2
2. Fronds simple pinnate *D. sylvaticum*
2. Fronds bi- or tripinnate 3
3. Rhizome creeping *D. leptophyllum*
3. Rhizome erect or sub erect 4
4. Stipe muricate 5
4. Stipe smooth 6
5. Scales linear-lanceolate; lamina lanceolate *D. polypodioides*
5. Scale lanceolate; lamina elongate-ovate *D. manickamii*
6. Terminal part of the pinnae serrate less than 1/3rd of the length .. *D. latifolium*
6. Terminal part of pinnae form long serrate apices more than 1/3rd of the length *D. travancoricum*

Diplazium esculentum (Retz.) Sw. in Schrader, J. Bot. 1801(2): 312. 1803; Bedd., Handb. Fern Br. India, 192. 1883; Manickam, Fern Fl. Palni Hills, 114. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 241. Pl. 187. 1992; Nayar & Geev., Fern Fl. Malabar 195. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 112. 2018.

Hemionitis esculenta Retz., Obs. Bot. 6: 38. 1791.

Rhizome erect or suberect, 5-12 cm long, 4-5 cm thick, apex densely scaly; scales linear-lanceolate, 7-8 x 1-2 mm, apex acuminate, margins with simple bipartite teeth. Stipes tufted, 62-65 x 0.8-1 cm, dark brown at base, pale brown above, sparsely scaly at base, glabrous above; purplish band present throughout the stipe and rachis. Lamina deltoid, 106-110 x 55-60 cm, base truncate, apex acuminate,

bipinnate at base, simple pinnate towards apex, pinnae about 7 pairs, basal few pairs subopposite, others alternate, 18-19 cm apart, with about 3-5 cm long stalk, narrowly deltoid, apex acuminate, base truncate; pinnules 14-15 pairs, alternate, few basal pairs sessile, 2-3 cm apart, oblong-lanceolate, 10-11 x 1.5-2 cm, apex acuminate, base truncate, margins serrate at apex, lobed in the rest; lobes broadly deltoid, oblique, margin serrate, apex toothed; costa slightly raised in both sides, adaxially shallowly grooved, flattened abaxially, with a narrow wing on both sides; veins pinnate, in unlobed part of adjacent apart, joining to form irregular excurrent vein, which reaching the base of sinus. Pinnae dark green, glabrous, herbaceous. Sori linear, along veins, indusiate; indusia with wavy margin, pale brown. Spore reniform, brown. (Plate 4.52: Fig. g-l.; Plate 4.83: Fig. l.).

Distribution: Terrestrial along stream sides, river sides and also in marshy areas. Between low altitudes to 1300 m.

Specimen/s examined: Kerala: Palakkad District, Olavakkode, Dhoni, 10° 51' 34.2" N, 76° 37' 21.72" E, 120 m, 13 September 2018, Thulasi & Maya, 14231 (ZGC); Mannarkkad, Arakurussy, 10° 59' 41.28" N, 76° 26' 48.84" E, 54 m, 17 October 2018, Thulasi, 14247 (ZGC); Mannarkkad, 11° 2' 27.996" N, 76° 26' 41.496" E, 76 m, 17 October 2018, 14256 (ZGC); Virgin Valley, 11° 2' 42.72" N, 76° 26' 33" E, 79 m, 24 November 2018, Thulasi, 14285 (ZGC); Walayar, Akamalavaram, 10° 52' 5.16" N, 76° 42' 41.04" E, 212 m, 02 January 2020, Thulasi, 14321 (ZGC); Olavakkode, Elivalmala, 10° 52' 26.148" N, 76° 38' 10.968" E, 300 m, 8 January 2019, Thulasi, 14725 (ZGC); Nelliampathy, Cheriya Govinda mala, 10° 30' 38.232" N, 76° 41' 42" E, 987 m, 3 November 2020, Thulasi & Maya, 14799 (ZGC); Bhavani, Thudukki, 11° 8' 4.272" N, 76° 30' 31.68" E, 1260 m, 2 October 2021, Thulasi, 14884 (ZGC); Thrissur District, Athirappilly, Malakkappara, 10° 17' 47.832" N, 76° 47' 38.76" E, 930 m, 14 February 2021, Thulasi, 14836 (ZGC).

Diplazium latifolium T.Moore, Index Fil. 141. 1859; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 122. 2018.

Asplenium latifolium D.Don, Prodr. Fl. Nepal. 8. 1824, non Bory 1803.

Diplazium dilatatum auct. Manickam & Irud., Pterid. Fl. W. Ghats S. India, 248. Pl. 193. 1992, *non* Blume, Enum. Pl. Javae 2: 194. 1828.

Rhizome erect, 7-12 cm long, 4-5 cm thick, covered densely by scales at apex; scales ovate-lanceolate, 6-7 x 1-2 mm, dark brown uniformly, acuminate apex, margin bipartately toothed. Stipes tufted, 25-30 x 1-1.5 cm, sparsely scaly at the base, rest glabrous, rounded below, grooved above. Lamina ovate, 40-45 x 30-34 cm, bipinnatifid; primary pinnae about 5 pairs, alternate, 6-8 cm apart, ovate-lanceolate, 30-35 x 10-15 cm; secondary pinnae 10-12 pairs per primary pinna, subopposite, 3-4 cm apart, shortly stalked, oblong-lanceolate, 7-8 x, 2-3 cm, apex acuminate, base truncate, margins lobed; lobes 7-8 pairs, oblong, 1.5-1.8 x 1-1.2 cm, apex rounded, margins entire; costa raised slightly above and below, veins and costules distinct below, slightly above; veins pinnate, about 5 pairs, forked once, reaching the margin; pinnae dark green above, light green below, glabrous, herbaceous. Sori submedian, along veins, indusiate; indusia entire, pale brown; spores reniform, brown. (Plate 4.53: Fig. a-e.).

Distribution: Terrestrial along shaded stream sides and trek paths. Between 1100-1300 m.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Sispara, 11° 10' 40.08" N, 76° 24' 53.28" E, 1150 m, 30 December 2019, Thulasi, 14744 (ZGC).

Diplazium leptophyllum Christ in C.Chr., Index Fil. Suppl.: 103. 1916; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 124. 2018.

Diplazium leptophyllum Baker ex Christ, Bull. Acad. Int. Géogr. Bot., Mans 11: 245. 1902, nom. nud.

Asplenium leptophyllum Baker, Bull. Misc. Inform. Kew 1906: 10. 1906, *non* Sw., 1791, *non* Lag., D. García & Clemente, 1802, *nec* Fee, 1857.

Diplazium cognatum (Mett. ex Hieron.) Sledge, Bull. Brit. Mus. Nat. Hist., Bot., 2: 308, t. 31, f. 18. 1962; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 246. Pl. 191. 1992.

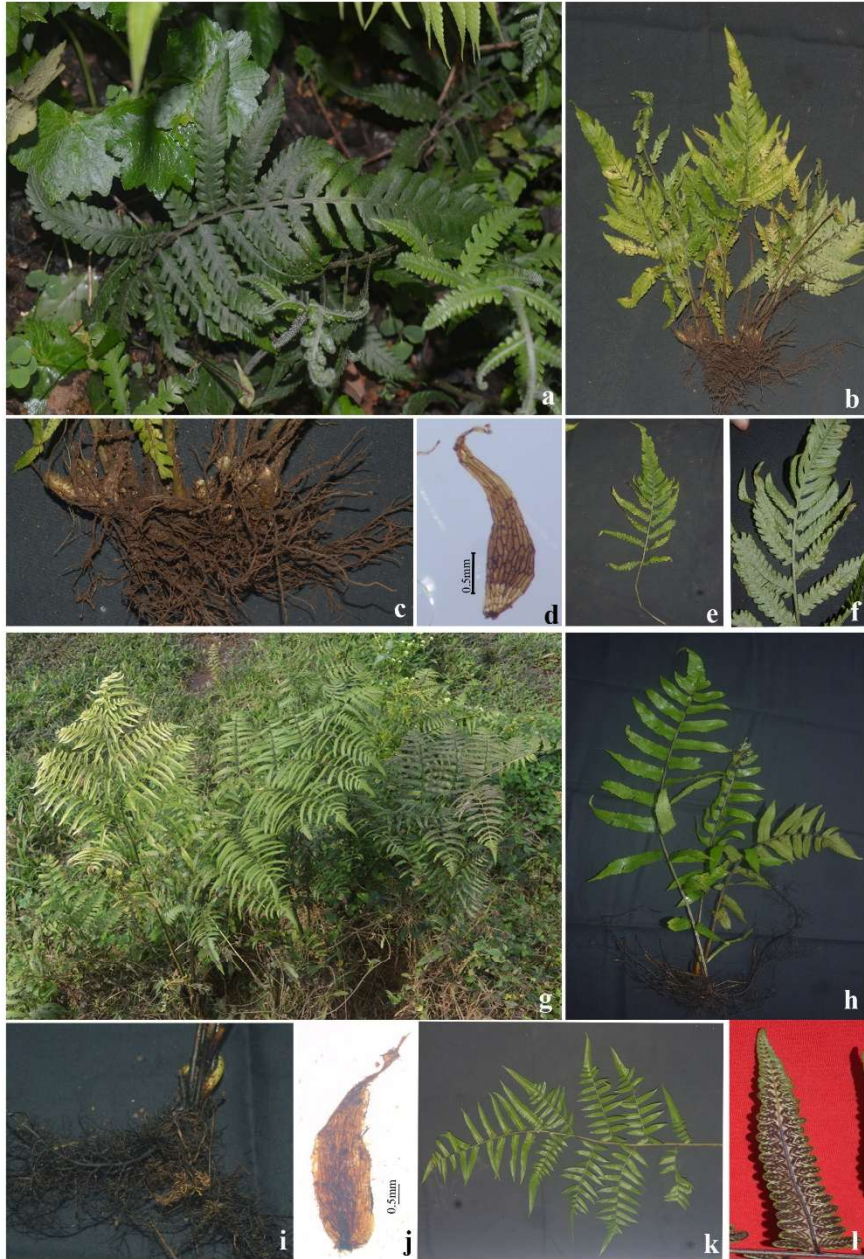


Plate 4.52: a-f. *Deparia japonica* subsp. *petersenii* (Kunze) Fraser-Jenk. a. Habitat b. Habit c. Rhizome d. Scale e. Frond f. Sori. g-l. *Diplazium esculentum* (Retz.) Sw. g. Habitat h. Habit i. Rhizome j. Scale k. Frond l. Sori.

Athyrium cognatum Mett. ex Hieron., Hedwigia 59: 321. 1917.

Rhizome suberect, 6-10 cm long, 1-2 cm thick, apex densely covered by scales; scales lanceolate, 8-10 x 1-2 mm, dark brown uniformly, apex acuminate, margins entire. Stipes compact, 74-75 x 1-2 cm, rounded below, grooved above, pale brown, sparsely scaly at base, glabrous above. Lamina deltoid, 80-85 x 70-72 cm, apex acute, base broadly cuneate, tripinnatifid below, bipinnatifid above; primary pinnae 6-7 pairs, alternate, oblong-lanceolate, 9-10 x 3-4 cm, 1-1.4 cm, long stalked, apex acuminate, base broadly cuneate, margins pinnatifid; lobes about 8 pairs, subopposite, oblong, 2-2.5 x 1-1.5 cm, slightly falcate, apex rounded, margins serrate; costa flattened; veins pinnate, about 6 pairs, forked, free; pinnae light green, glabrous both sides, herbaceous. Sori linear, along veins, about 7 pairs per lobe, indusiate; spores reniform, brown. (Plate 4.53: Fig. f-k).

Distribution: Terrestrial along shaded trek paths and forest floors. Between 1000 - 1500 m.

Notes: Known from China, Sri Lanka, Myanmar, Northern Thailand and India. In India from Mizoram, Kerala and Tamil Nadu. Fraser-Jenkins (2012) considers it as Critically Endangered (CR) for India.

Specimen/s examined: Kerala: Idukki District, Mathikettan Shola National Park, Check post, 9° 58' 47.28" N, 77° 14' 12.84" E, 1400 m, 1 August 2019, Thulasi, 14357 (ZGC).

Diplazium polypodioides Blume, Enum. Pl. Javae 2: 194-195. 1828; Bedd., Ferns S. India 54, t. 163. 1864; Ferns Br. India, t. 293. 1868; Handb. Ferns Br. India, 184. 1883; Manickam, Fern Fl. Palni Hills, 118. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 250. Pl. 195. 1992; Nayar & Geev., Fern Fl. Malabar 201. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 131. 2018.

Rhizome erect, 30-100 cm long, 15-16 cm thick, apex densely scaly; scales linear-lanceolate, 13-15 x 1-2 mm, tip pointed, margins with forked teeth. Stipes tufted, 135-140 x 2-2.5 cm, dark at base, pale brown above, sparsely scaly at base, muricate all over. Lamina lanceolate, 138-140 x 76-80 cm, bipinnatifid; primary pinnae about



Plate 4.53: a-e. *Diplazium latifolium* T.Moore a. Habit b. Scale c. Sporophyll d. Sori e. Frond f-k. *Diplazium leptophyllum* Christ. f. Habitat g. Habit h. Scale i. Rhizome j. Sporophyll k. Sori.

10 pairs, stalked, alternate, apex acuminate, base truncate; about 25 pairs of secondary pinnae in the largest basal primary pinna, basal some pairs stalked, others sessile, basal some are subopposite, others alternate, oblong-lanceolate, apex acuminate, base truncate, margin serrate at apex, lobed; lobes oblong, 8-9 x 3-4 mm, margin serrate, apex rounded; costa slightly raised above, below flattened with narrow membranous wing on either side, not raised below; veins and costules slightly raised in both sides, about 8 pairs of veins, basal basisopic vein forked, others simple, reaching the margin. Pinnae dark green, glabrous on both sides, except some small scales below the costules and costa. Sori linear, along veins, indusiate; indusia thin, pale brown membranous, margins fimbriate. Spores reniform, brown. (Plate 4.54: Fig. a-e.; Plate 4.84: Fig. a.).

Distribution: Terrestrial, along shaded stream sides, river sides, etc. Between 900-1700 m.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Poochippara to Walakkad trek path, 11° 6' 38.16" N, 76° 25' 20.64" E, 1070 m, 28 December 2019, Thulasi, 14664 (ZGC); Walakkad to Sispara trek path, 11° 12' 6.48" N, 76° 26' 24.36" E, 2000 m, 29 December 2019, Thulasi, 14696 (ZGC).

Diplazium sylvaticum (Bory) Sw., Syn. Fil. 92. 1806; Bedd., Handb. Fern Br. India, 177. 1883; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 243. Pl. 188 & 189. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 142. 2018.

Callipteris sylvatica Bory, Voy. Mers Afr. 1: 282. 1804.

Rhizome erect, 5-7 cm long, 4-5 cm thick, scaly at apex; scales ovate-lanceolate, uniformly dark, long acuminate, base sinuate, margins shortly toothed. Stipes tufted, 45-50 x 1-1.2 cm, grooved above, rounded below, dark at the base, sparsely scaly. Lamina ovate, 53-55 x 20-25 cm wide, simple pinnate; pinnae about 20 pairs, alternate, ascending; largest pinna 28-30 x 3-5 cm, linear-lanceolate, lower pairs slightly reduced, terminal pinna shallowly lobed at base, serrate in the remaining part, apex acuminate, apex margin serrate, remaining part entire; broadly cuneate at base; costa raised below, not in above, veins distinct below, slightly above, forked,

free, reaching the margin; pinnae green, glabrous, herbaceous. Sori along the basal veinlet of one veinlet pair; spores brown, reniform. (Plate 4.54: Fig. f-1.).

Distribution: Terrestrial along shaded stream sides. Between 500-1100 m.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Sirandhri to Poochippara trek path, 11° 3' 57.96" N, 76° 32' 10.68" E, 550 m, 26 December 2019, Thulasi, 14629 (ZGC); Poochippara to Walakkad trek path, 11° 6' 38.16" N, 76° 25' 20.64" E, 1070 m, 28 December 2019, Thulasi, 14666 (ZGC).

Diplazium travancoricum Bedd., Handb. Ferns Brit. India 188. 1883; Manickam, Fern Fl. Palni Hills, 117. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, Pl. 194. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 145. 2018.

Rhizome erect, 7-14 cm long, 6-10 cm thick, apex densely scaly; scales linear-lanceolate, 18-20 x 2-2.5 mm, pointed, margins toothed. Stipes tufted, 73-75 x 1-1.3 cm, dark brown, scaly at base, glabrous above. Lamina ovate-lanceolate, 124-125 x 42-45 cm, bipinnate, apex simply pinnate; pinnae about 12 pairs, alternate, ascending, stalked, lanceolate, 28-30 x 12-15 cm, apex acuminate with serrate margins, base truncate; some basal pairs of pinna have about 8 pairs of pinnules basally, distal part shallowly lobed, narrowed at apex; margins of distal 2 or 3 pairs of pinnae unlobed, basal 1-3 pairs slightly reduced, few basal pairs sessile, others adnate, alternate, oblong-lanceolate, suddenly narrowed towards apex and form acuminate apex, base sub-truncate margins entire; costules distinct on both sides, forked about 4 times, free, reaching margin; pinna dark green, herbaceous, almost glabrous, few small scales abaxially on costules and costa. Sori linear, along costa or costule, not reaching the margin, indusiate; indusia pale brown, thin, margins incised. Spores reniform, brown. (Plate 4.55: Fig. a-f.).

Distribution: Terrestrial along shaded stream sides and trek paths. Between 900-1700 m.

Notes: This is known from Sri Lanka and Southern India (Kerala and Tamil Nadu). Fraser-Jenkins (2012) considers it as Near Threatened for India.

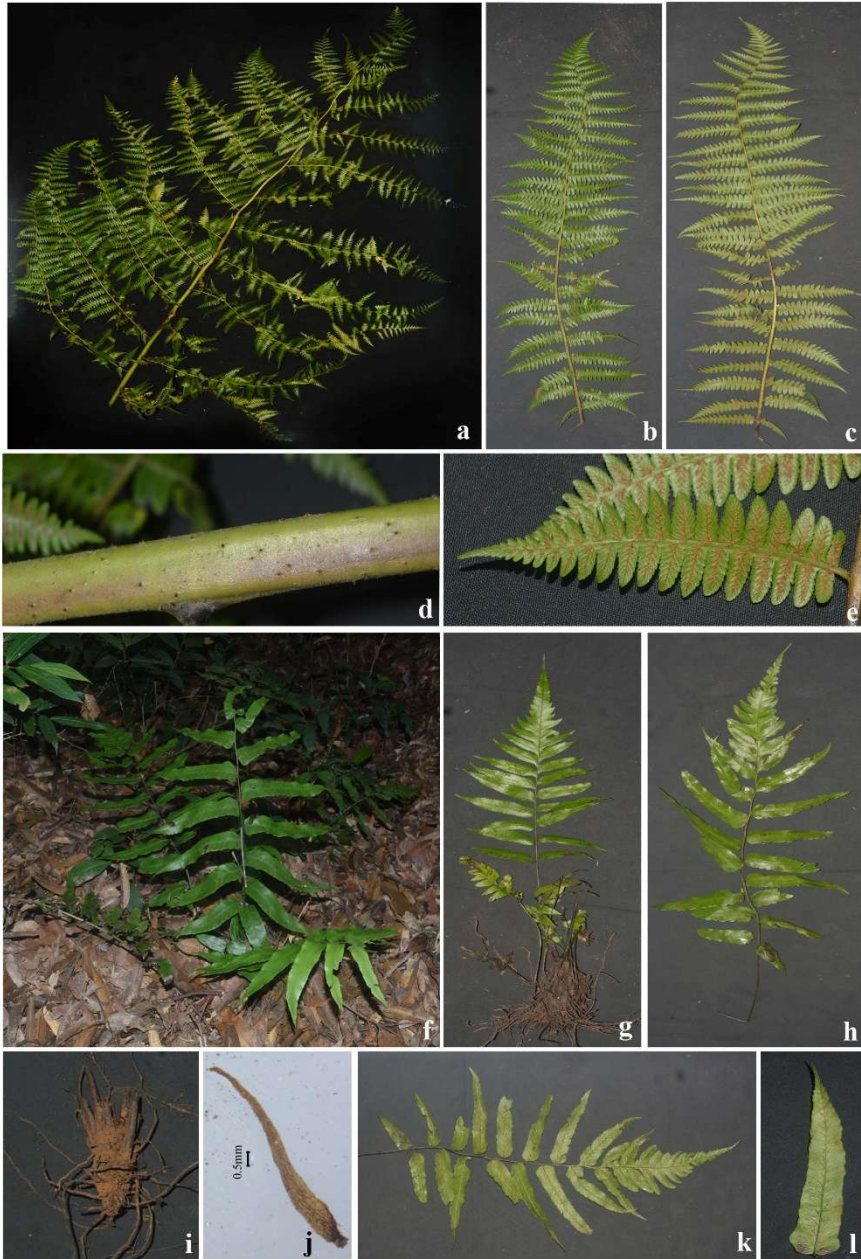


Plate 4.54: a-e. *Diplazium polypodioides* Blume a. Frond b-c. Pinna - b. Adaxial surface c. Abaxial surface d. Rachis e. Sori. f-l. *Diplazium sylvaticum* (Bory) Sw. f. Habitat g. Habit h. Frond i. Rhizome j. Scale k. Sporophyll l. Sori.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Valiyaparathodu-Madhrithodu, 11° 6' 49.32" N, 76° 25' 51.6" E, 910 m, 27 December 2019, Thulasi, 14641 (ZGC); Walakkad to Sispara trek path, 11° 11' 18.528" N, 76° 25' 21.72" E, 1614 m, 2 January 2022, Thulasi, 14984 (ZGC).

Diplazium manickamii Fraser-Jenk. & Kholia in Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 2. 126. 2018.

Diplazium australe auct. Nayar & Geev., Fern Fl. Malabar 192. 1993, *non* (R. Br.) Wakef., Vict. Nat. 58, 142. 1942.

Rhizome erect or sub-erect, more than 6 cm long, 3-5 cm thick, covered by scales; scales dark-brown, lanceolate, 10-18 x 1.5-2.0 mm, apex acuminate. Frond with the stipe obliquely erect, 30-35 cm x 5-8 mm, adaxially grooved, abaxially rounded. Lamina elongate-ovate, 55-75 x 30-50 cm, bipinnate to tri-pinnatifid, apex short pinnatifid acute; primary pinnae loosely placed, 20-15 x 8-10 cm, ovate-lanceolate, apex pinnatifid; secondary pinnae basal one slightly reduced, sub-opposite to alternate, sessile, elongate-oblong, 5-6 x 1.2-1.5 cm, apex acute or short acuminate, base truncate, margin deeply lobed, serrate; lamina soft herbaceous, both surfaces glabrous. Sorus close to midrib of lobes, restricted to acroscopic side, indusium glabrous; spores plano convex, pale brown.

Distribution: Terrestrial on humid shaded areas of evergreen forest, between 800 to 1500 m.

Notes: This species is included here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Tamil Nadu: Coimbatore, Joseph, 15593 (MH).

Blechnaceae Newman, Hist. Brit. Ferns, ed. 2, 8. 1844.

Key to Genera

1. Rhizome erect or suberect *Blechnum*
1. Rhizome long creeping or climbing *Stenochlaena*

Blechnum L., Sp. Pl. 2: 1077. 1753.

Key to species

1. Lamina dimorphic *B. melanocaulon* subsp. *pallens*
1. Lamina monomorphic..... 2
2. Stipe with tubercles *B. orientale*
2. Stipe without tubercles *B. occidentale*

Blechnum melanocaulon (Brack.) T.C. Chambers & P.A. Farrant **subsp. *pallens***
T.C.Chambers & P.A.Farrant, Blumea 46(2): 321. 2001; Fraser-Jenkins *et al.*, Anno.
Checklist Indian Pterid., 180. 2018.

Lomaria melanocaulon Brack., U.S. Expl. Exped., Filic. 16: 122. 1854.

Lomaria elongata Blume, Enum. Pl. Javae 2: 201. 1828; Bedd., Ferns S. India t. 28,
28A, 1864.

Blechnum colensoi (Hook. f.) Wakef., Vict. Natur., 72: 1956; Manickam & Irud.,
Pterid. Fl. W. Ghats S. India, 299. Pl. 231. 1992.

Austroblechnum melanocaulon (Brack.) Gasper & V.A.O.Dittrich, Phytotaxa
275(3): 203. 2016.

Rhizome erect or suberect, 8-16 cm long, 4-5 cm thick, apex scaly; scales ovate-lanceolate, 2-3 x 0.8-1 mm, dark brown, acuminate, entire. Stipes arranged in spirals, 13-15 x 0.5-0.8 cm, dark brown at base, pale brown above, with deep groove, sparsely scaly at base, glabrous above. Lamina dimorphic, sterile lamina lanceolate, 50-70 x 15-25 cm wide, apex acuminate, base cuneate, pinnatifid, terminal pinna larger; pinnae about 12 pairs, alternate, ascending, some basal most pairs reduced to tubercles, above this some pairs become semicircular lobes; largest pinna 11-13 x 2-3 cm, oblong-lanceolate, slightly narrow at subbasal regions, narrowed towards acuminate apex; margins entire; costa not raised above and grooved, slightly raised and rounded below; coriaceous. Fertile fronds with longer stipe, lamina about 18-20 x 6-10 cm, lanceolate, about 8 pairs, compressed, ascending, basal 3 pairs suddenly reduced as sterile fronds, terminal one larger than lateral

ones, pinna oblong, apex acuminate, decurrent basiscopic base; sori on the lower side of the pinnae, linear, protected by reflexed margin; spores monoletate, reniform, brown. (Plate 4.55: Fig. g-n.; Plate 4.84: Fig. b.).

Distribution: Terrestrial along fully shaded land cuttings, stream sides and trek paths. Between 1200-2400 m.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Walakkad to Sispara trek path, 11° 10' 52.68" N, 76° 25' 0.48" E, 1270 m, 29 December 2019, Thulasi, 14687 (ZGC). Tamil Nadu: Mukurthi National Park, Bankitapal, 11° 13' 24.96" N, 76° 32' 1.68" E, 2371 m, 27 February 2022, Maya, 15014 (ZGC).

Blechnum occidentale L., Sp. Pl. 2: 1077. 1753 (as "*B. orientale*", transposed, corrected in ed. 2: 1534. 1763); Manickam & Irud., Pterid. Fl. W. Ghats S. India, 300. Pl. 230. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 178. 2018.

Rhizome suberect, 4-8 cm long, 4-5 cm thick, densely scaly at apex; scales lanceolate, 5-6 x 1-2 mm, uniformly pale brown, acuminate apex, entire margin. Stipes tufted, 43-45 cm long, dark brown at base, pale brown above, scaly at base, glabrous above. Lamina falcate-lanceolate, 28-30 x 17-18 cm, apex acuminate, base truncate; pinnae 18-20 pairs, spreading, falcate, basal pairs sessile, others adnate, sub-opposite, 2-3 cm apart; pinna oblong-lanceolate, apex acuminate, base truncate, apparently entire margin; costa deeply grooved, not raised above, raised and rounded below; veins not distinct on both sides, forked, free, reaching the margin, dark green, glabrous, coriaceous. Sori linear along midrib, not reaching base and apex, parallel, 1-2 mm wide, indusiate; indusia pale brown, serrate margin; spores reniform, brown. (Plate 4.56: Fig. a-g.; Plate 4.87: Fig. g.; Plate 4.84: Fig. c.).

Distribution: Terrestrial along shaded roadsides, land cuttings or mud cliffs. Between 300 to 1000 m.

Specimen/s examined: Kerala: Thrissur District, Athirappilly, Malakkappara, 10° 17' 47.76" N, 76° 47' 38.76" E, 930 m, 14 February 2021, Thulasi, 14845 (ZGC); Palakkad District, Agali, Ommala, 11° 3' 35.64" N, 76° 36' 39.96" E, 730 m, 14

November 2021, Thulasi, 14931 (ZGC); Malappuram District, Karuvarakindu, Atti, 11° 9' 44.82" N, 76° 23' 26.88" E, 350 m, 5 January 2022, Thulasi, 15006 (ZGC).

Blechnum orientale L., Sp. Pl. 2: 1077, 1753 (as "*B. occidentale*", transposed, corrected in ed. 2: 1534. 1763); Bedd., Ferns S. India t. 29, 1864 & Handb. Fern Br. India, 132, t. 86. 1883; Manickam, Fern Fl. Palni Hills, 144. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 299. Pl. 229. 1992; Nayar & Geev., Fern Fl. Malabar 349. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 180. 2018.

Blechnum orientale var. *grande* B.K.Nayar & Geev., Fern Fl. Malabar 353. 1993.

Blechnopsis orientalis (L.) C.Presl, Abh. Königl. Böhm. Ges. Wiss. 5(6) (Epim. Bot.): 117. 1851.

Rhizome erect, 6-16 cm long, 10-12 cm thick, densely covered by scales all over; scales linear-lanceolate, 14-15x 2-3 mm, uniformly brown, apex acuminate, glossy, margins entire. Stipes tufted, 115-120 cm long, dark brown at base, pale brown above, scaly at base, glabrous above, about 15 pairs of small tubercles present along the stipe. Lamina linear-lanceolate, 20-170 x 13-50 cm, apex acute, base sub-truncate; pinnae 10-56 pairs, spreading, sessile, alternate, basal few slightly reduced; largest pinna 35-37 x 2-3 cm wide, oblong-linear-lanceolate, base cuneate, oblique, apex long acuminate, margins entire; midrib slightly raised above and below, grooved above, rounded below; veins slightly distinct, simple, parallel, perpendicular to midrib, pinnae pale green, glabrous, coriaceous. Sori linear on either side of the midrib, parallel, dark brown, continuous, indusiate; indusia dark brown; spores spherical, brown. (Plate 4.56: Fig. h-n.; Plate 4.84: Fig. d.).

Distribution: Terrestrial along land cuttings, trek paths and stream sides. Between the altitudinal ranges 700-2200 m.

Specimen/s examined: Kerala: Palakkad District, Mannarkkad, Siruvani, 10° 58' 43.32" N, 76° 36' 43.92" E, 830 m, 20 September 2019, Thulasi, 14427 (ZGC); Silent Valley National Park, Kummattanthodu, 11° 5' 48.84" N, 76° 27' 19.8" E, 1030 m, 22 October 2019, Thulasi, 14489 (ZGC); Parathod, 11° 5' 33" N, 76° 26' 44.52" E, 1020 m, 23 October 2019, Thulasi, 14517 (ZGC); Valiyaparathodu-



Plate 4.55: a-f. *Diplazium travancoricum* Bedd. a. Habitat b. Scale c. Habit d. Rhizome e. Frond f. Sori. g-n. *Blechnum melanocaulon* (Brack.) T.C. Chambers & P.A. Farrant subsp. *pallens* T.C.Chambers & P.A.Farrant g. Habitat h. Habit i. Scale j. Rhizome k. Frond l-m. Sporophyll n. Sori.



Plate 4.56: a-g: *Blechnum occidentale* L. a. Habitat b. Habit c. Rhizome d. Sporophyll e. Sori f. Frond g. Scale. h-n, *Blechnum orientale* L. h. Habitat i. Habit j. Frond k. Rhizome l. Sporophyll m. Sori n. Scale.

Madhrithodu, 11° 7' 9.84" N, 76° 25' 48.36" E, 960 m, 27 December 2019, Thulasi, 14652 (ZGC); Poochippara to Walakkad trek path, 11° 8' 0.96" N, 76° 24' 42.84" E, 1140 m, 28 December 2019, Thulasi, 14675 (ZGC); Walakkad to Sispara, 11° 12' 6.48" N, 76° 26' 43.8" E, 2130 m, 2 January 2022, Thulasi, 15002 (ZGC); Nelliampathy, Maattumala, 10° 32' 12.84" N, 76° 43' 10.2" E, 1312 m, 13 November 2019, Thulasi & Maya, 14550 (ZGC); Bhavani, Thudukki, 11° 8' 15.828" N, 76° 29' 59.784" E, 1500 m, 2 October 2021, Thulasi, 14919 (ZGC); Agali, Ommala, 11° 3' 35.64" N, 76° 36' 39.96" E, 730 m, 14 November 2021, Thulasi, 14932 (ZGC); Thrissur District, Athirappilly, Malakkappara, 10° 17' 47.76" N, 76° 47' 38.76" E, 930 m, 14 February 2021, Thulasi, 14844 (ZGC).

Stenochlaena J. Sm., Hooker J. Bot. 4: 149. 1841.

Stenochlaena palustris (Burm.f.) Bedd., Suppl. Ferns Brit. Ind. 26, t. 201. 1876; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 299. Pl. 232. 1992; Nayar & Geev., Fern Fl. Malabar 355. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 180. 2018.

Polypodium palustre Burm. f., Fl. Ind. 234. 1768.

Rhizome long creeping, scandent, 15-20 m long, 1-1.5 cm thick, with few scales, climbing by palmately arranged, hairy, long roots on lower side, younger roots protected by scales; scales ovate, pale brown, apex acuminate. Fronds scattered, dimorphic; sterile fronds 18-20 cm x 6-8 mm, stipe glabrous; lamina oblong-lanceolate, 70-75 x 34-40 cm, slightly narrowed towards apex; pinnae about 20 pairs, shortly stalked, spreading, alternate, 4-5 cm apart; largest pinna 21-23x 3-4 cm, lanceolate, apex acuminate, base cuneate, margins finely serrated with hard, pale brown, sclerotic border; midrib slightly raised and grooved above and below; coriaceous. Fertile frond originate at distal part of the plant, more or less same as sterile one, pinnae much contracted; sori on lower surface, all over, protected by reflexed margin; spores monoletate, reniform, pale green. (Plate 4.57: Fig. a-d.).

Distribution: Climber in shaded roadsides, stream sides and interior forests, and in marshy areas. Seen at an altitude up to 800 m.

Specimen/s examined: Kerala: Palakkad District, Mannarkkad, Mothikkal, 10° 57' 27" N, 76° 25' 41.16" E, 53 m, 18 September 2018, Thulasi & Jisha, 14238 (ZGC); Siruvani, 10° 58' 55.56" N, 76° 36' 1.8" E, 700 m, 20 September 2019, Thulasi, 14420 (ZGC); Walayar, Aduppukootimala, 10° 57' 10.8" N, 76° 50' 2.4" E, 452 m, 1 December 2019, Thulasi & Aswani, 14756 (ZGC).

Dryopteridaceae Herter, Revista Sudamer. Bot. 9: 15. 1949, *nom. cons.*

Key to Genera

- 1. Sori acrostichoid 2
- 1. Sori usually round..... 3
- 2. Lamina simple *Elaphoglossum*
- 2. Lamina pinnately compound *Bolbitis*
- 3. Adaxial surface of stipe not grooved; short septate hairs present all over the frond, distinct from scale *Dryopsis*
- 3. Adaxial surface of the stipe grooved; hairs present only in upper surface, not distinct from scales 4
- 4. Indusia peltate 5
- 4. Indusia reniform..... 6
- 5. Lamina bipinnately compound; veins free *Polystichum*
- 5. Lamina simple pinnate; veins anastomosing *Cyrtomium*
- 6. Fronds coriaceous with sharp teeth on pinnules *Arachniodes*
- 6. Fronds not coriaceous without sharp teeth on pinnules *Dryopteris*

Arachniodes Blume, Enum. Pl. Javae 2: 241-242. 1828.

Key to species

- 1. Rhizome creeping *A. palmipes*
- 1. Rhizome erect *A. sledgei*

Arachniodes palmipes (Kunze) Fraser-Jenk., Taxon. Revis. Three Hundred Indian Subcont. Pterid. 329. 2008; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 203. 2018.

Aspidium palmipes Kunze, Linnaea 24: 287. 1851.

Arachniodes aristata auct. Manickam, Fern Fl. Palni Hills, 134. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 274. Pl. 210. 1992, *non* (Forst.f.) Tindale, Contr. N.S. Wales Nation. Herb. 3: 89. 1961

Rhizome long creeping, more than 10 cm long, 0.5-1 cm thick, covered densely by scales; scales oblong-linear-lanceolate, 8-10 x 0.8-1 mm wide; stipes scattered, 1-2 cm apart, 43-45 x 0.4-0.5 cm, pale brown, scaly at below, above sparsely. Lamina ovate-lanceolate, 45-46 x 25-27 cm, at base tripinnate, above bipinnatifid, apex acuminate, base broadly cuneate; primary pinnae about 8 pairs, alternate, ascending slightly, stalked 1-1.5 cm, basal pinnae 22-24 x 20-21 cm, deltoid, apex acuminate, base truncate, having about 4 pairs of secondary pinnae, remaining of the primary pinnae lanceolate, 20-22 x 5-6 cm, apex acuminate, basiscopic pinnae cuneate, acroscopic base truncate; secondary pinnae about 15 pairs, shortly stalked, alternate, 5-6 x 2-2.5 cm, lanceolate, base broadly cuneate; pinnules sessile, oblong-ovate, 1-2 x 1-1.5 cm, shallowly lobed margin, base truncate acroscopic, basiscopic base cuneate; apex of pinnules and lobes having stiff long spinules; indistinct veins above and below, pinnae dark green; coriaceous; rachis, costa and costules having sparsely distributed pale brown scales on both surfaces. Sori on the basal acroscopic veinlet, indusium reniform. Spores abortive, brown. (Plate 4.57: Fig. e-i).

Distribution: Terrestrial, along fully shaded roadsides, mud cliffs, etc. Between 1500-1800 m.

Specimen/s examined: Tamil Nadu: Kodaikanal, 10° 15' 15.12" N, 77° 31' 32.16" E, 1650 m, 18 November 2019, Thulasi, 14568 (ZGC).

Arachniodes sledgei Fraser-Jenk., Taxon. Revis. Three Hundred Indian Subcont. Pterid. 323-324. 2008; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 205. 2018.

Arachniodes tripinnata auct. Manickam & Irud., Pterid. Fl. W. Ghats S. India, 273. Pl. 210. 1992, *non* (Goldm.) Sledge, Bull. British Mus. Nat. Hist. (Bot.) 5: 41. 1973.

Arachniodes coniifolia sensu Nayar & Geev., Fern Fl. Malabar 204. 1993, *non*

(T.Moore) Ching, Acta Bot. Sin. 10: 257. 1962.

Rhizome erect, 7-16 cm long, 7-8 cm thick, densely scaly; scales linear-lanceolate, 1-2 x 2-3 mm, reddish brown. Stipes tufted, 75-76 x 0.7-0.8 cm, light brown, glossy. Lamina broadly ovate, 65-70 x 55-60 cm, tripinnatifid, apex acuminate, base broadly cuneate; primary pinnae about 8 pairs, ascending, slightly falcate, stalked, broadly ovate, 38-40 x 24-25 cm, oblique at base; secondary pinnae about 8 pairs in the largest primary pinnae, stalked, tertiary pinna about 10 pairs per secondary pinna, oblong, 3.5-4 x 1-1.5 cm wide, apex acuminate for primary and secondary pinnae, acute in tertiary pinnae; base truncate acroscopic, base cuneate basiscopic; pinnules about 6 pairs, rounded apex with a spinule, margins serrate, basiscopic base decurrent; indistinct veins in both sides, all veins reaching the margin except the sori bearing ones, pinnae dark green, glabrous, glossy, coriaceous. Sori on acroscopic basal vein, indusiate; indusia reniform, fugacious, dark brown; spores ellipsoid, brown. (Plate 4.58: Fig. a-g.; Plate 4.88: Fig. b.; Plate 4.84: Fig. e.).

Distribution: Terrestrial along roadsides, trek paths and mud cliffs. Between 500-2100 m.

Specimen/s examined: Kerala: Palakkad District, Nellyampathy, Manpara, 10° 33' 27.72" N, 76° 44' 40.38" E, 1065 m, 1 December 2018, Thulasi, 14308 (ZGC); Maattumala, 10° 32' 31.56" N, 76° 41' 57.84" E, 1132 m, 13 November 2019, Thulasi, 14555 (ZGC); Cheriya Govinda mala, 10° 30' 38.232" N, 76° 41' 42" E, 987 m, 3 November 2020, Thulasi & Maya, 14804 (ZGC); Mannarkkad, Siruvani, 10° 58' 55.704" N, 76° 36' 1.8" E, 700 m, 20 September 2019, Thulasi, 14419 (ZGC); Silent Valley National Park, Kummattanthodu, 11° 5' 33.36" N, 76° 26' 44.16" E, 1020 m, 22 October 2019, Thulasi, 14459 (ZGC); Kunthipuzha trek path, 11° 5' 45.672" N, 76° 26' 57.912" E, 950 m, 22 October 2019, Thulasi, 14502 (ZGC); Parathodu, 11° 5' 51" N, 76° 26' 48.84" E, 920 m, 23 October 2019, Thulasi, 14534 (ZGC); Sairandhri to Poochippara, 11° 3' 57.96" N, 76° 32' 10.68" E, 550 m, 26 December 2019, Thulasi, 14627 (ZGC); Idukki District, Pambadum Shola National Park, Kuttikkad, 10° 7' 33.6" N, 77° 15' 22.968" E, 1892 m, 30 July 2019, Thulasi, 14354 (ZGC); Thrissur District, Athirappilly-Malakkappara, 10° 17' 47.76" N, 76°



Plate 4.57: a-d. *Stenochlaena palustris* (Burm.f.) Beddome a. Habitat b. Rhizome c. Scale d. Frond. e-i. *Arachniodes palmipes* (Kunze) Fraser-Jenk. g. Habitat h. Habit g. Rhizome h. Frond i. Scale.

47' 38.76" E, 930 m, 14 February 2021, Thulasi, 14843 (ZGC). Tamil Nadu: Kodaikanal, 10° 15' 23.04" N, 77° 31' 43.68" E, 1550 m, 18 November 2019, Thulasi, 14563 (ZGC).

Bolbitis Schott, Gen. Fil. 3, t. 13. 1834.

Key to species

- 1. Veins free 2
- 1. Veins anastomosing 3
- 2. Sterile pinnae crenate *B. appendiculata*
- 2. Sterile pinnae lobed *B. asplenifolia*
- 3. Rhizome suberect..... *B. angustipinna*
- 3. Rhizome short creeping 4
- 4. Terminal sterile pinnae with long flagella *B. beddomei*
- 4. Terminal sterile pinnae without long flagella *B. semicordata*

Bolbitis angustipinna (Hayata) Ito, J. Jap. Bot. 14. 443. 1938; Nayar & Geev., Fern Fl. Malabar 230. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 4. 2021.

Rhizome suberect, about 4-8 cm long, 10-15 mm thick, scaly; scales ovate-lanceolate, 4-6 x 1-2 mm, having semicircular overlapping basal auricles, margin with deflexed uniseriate gland-tipped marginal hairs. Fronds tufted, 2-3 dorsal rows on rhizome. Stipe of sterile frond 25-45 x 0.3-0.4 cm; sterile lamina spreading, ovate, 50-80 x 30-40 cm, having terminal pinna similar to lateral pinnae with subterminal vegetative bud; lateral pinnae alternate, largest basal pinnae oblong-lanceolate, 15-20 x 2.5-4 cm, apex acuminate with serration, base broadly cuneate, margin lobed or widely serrate or sub-undulate. Lamina coriaceous, glabrous, veins anastomosing. Fertile frond stipe 35-60 cm long, lamina 20-35 cm; sori acrostichoid; spore plano-convex, dark brown.

Distribution: Terrestrial along fully or partially exposed roadsides. Between 900 - 1000 m.

Notes: This species is included here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Kerala: Palakkad district, Silent Valley Dam site, Nayar and Party, 10183 (CALI); Mukkali slopes, Bhargavan, 65736 (MH).

Bolbitis appendiculata (Willd.) K. Iwatz., Acta Phytotax. Geobot. 18: 48. 1959; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 291. Pl. 224. 1992; Nayar & Geev., Fern Fl. Malabar 233. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 6. 2021.

Acrostichum appendiculatum Willd., Sp. Pl. 5: 114. 1810.

Rhizome short creeping, 5-10 cm long, 1-1.5 cm thick, apex scaly; scales ovate-lanceolate, 1-2 x 0.5-1 mm, uniformly pale brown, apex acuminate, margins fimbriate, base sinuate. Stipes in 2 alternate closely arranged rows, 4-5 mm apart, 24-25 x 0.2-0.25 cm, dark green, rounded below, grooved above, sparsely scaly at base. Sterile lamina lanceolate, simple pinnate, subbasal region widest, apex acuminate, base truncate, apex having small, rooting vegetative buds; pinnae about 25 pairs, some basal pinnae slightly reduced, opposite at base, alternate or subopposite above, some basal pinnae stalked, others sessile; largest pinna 8-9 x 1-1.2 cm, oblong, apex acute, basispic base narrowly cuneate, acroscopic base subtruncate, margins crenate or lobed; lobes about 15 pairs, deltoid, ascending, acroscopic basal lobe larger and auricled, apex subacute, margins entire; pointed, long bristles coming from base of each sinus; costa slightly raised and rounded on both sides, veins obscure, about 15 pairs, forked about 5 times, free, reaching the margins, basispic basal veinlets reaching the sinus; pinnae dark green, glabrous, texture firm herbaceous; fertile fronds have longer stipe, 30-32 cm long, longer than sterile fronds, oblong-lanceolate, 24-25 x 4-5 cm, about 20 pairs, fertile pinnae oblong, 2-2.5 x 0.5-0.7 cm, apex rounded, base sub truncate, margins crenate; sori acrostichoid, covering lower surface; spores spherical, brown. (Plate 4.58: Fig. h-m.; Plate 4.88: Fig. c.; Plate 4.84: Fig. f.).

Distribution: Lithophytic or terrestrial in fully shaded forests and stream sides. Between 90-2300 m.

Specimen/s examined: Kerala: Palakkad District, Mannarkkad, Meenvallam, 10°



Plate 4.58: a-g. *Arachniodes sledgei* Fraser-Jenk. a. Habitat b. Habit c. Rhizome d. Sporophyll - enlarged protion e. Scale f. Sori g. Frond. h-m. *Bolbitis appendiculata* (Willd.) K. Iwatz. h. Habitat i. Habit j. Scale k. Rhizome l. Frond m. Sporophyll.

55' 24.96" N, 76° 33' 51.84" E, 85 m, 11 September 2018, Thulasi & Jisha, 14208 (ZGC); Nelliampathy, Manpara, 10° 33' 27.72" N, 76° 44' 40.38" E, 1065 m, 1 December 2018, Thulasi & Maya, 14307 (ZGC); Cheriya Govinda mala, 10° 30' 38.232" N, 76° 41' 42" E, 987 m, 3 November 2020, Thulasi & Maya, 14806 (ZGC); Silent Valley National Park, Kummattanthodu, 11° 5' 33.36" N, 76° 26' 44.16" E, 1020 m, 22 October 2019, Thulasi, 14458 (ZGC); Kunthipuzha trek path, 11° 5' 45.276" N, 76° 26' 51.18" E, 916 m, 22 October 2019, Thulasi, 14509 (ZGC); Arikampara, 11° 4' 51.6" N, 76° 26' 36.6" E, 1070 m, 24 October 2019, Thulasi, 14540 (ZGC); Valiyaparathodu-Madhrithodu, 11° 7' 9.84" N, 76° 25' 48.36" E, 960 m, 27 December 2019, Thulasi, 14654 (ZGC); Walakkad to Sispara trek path, 11° 12' 6.48" N, 76° 26' 24.36" E, 2000 m, 29 December 2019, Thulasi, 14702 (ZGC); Sispara to Anginda trek path, 11° 11' 20.04" N, 76° 27' 35.64" E, 2280 m, 30 December 2019, Thulasi, 14718 (ZGC); Parambikulam Tiger Reserve, Karimala, 10° 25' 15.24" N, 76° 46' 1.2" E, 670 m, 5 December 2019, Thulasi, 14603 (ZGC); Bhavani, Thudukki-chindakki, 11° 8' 7.08" N, 76° 30' 19.44" E, 1370 m, 2 October 2021, Thulasi, 14899 (ZGC).

Bolbitis aspleniifolia (Bory) K.Iwats., Acta. Phytotax. Geobot. 18: 49. 1959 (as “*asplenifolia*”); Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 7. 2021.

Acrostichum aspleniifolium Bory, Bél. Voy. Indes Or., Bot. 2: 21, t. 3. 1833.

Bolbitis appendiculata var. *asplenifolia* (Bory) Sledge, Bot. J. Linn. Soc. 84: 19. 1982; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 293. Pl. 225. 1992; Nayar & Geev., Fern Fl. Malabar 237. 1993.

Rhizome short creeping, 5-12 cm long, 4-5 mm thick, scaly at apex; scales lanceolate, uniformly dark brown, 1-2 x 0.5-0.7 mm, gland tipped, acuminate, margin wavy. Fronds simple pinnate, dimorphic; stipes crowded, 12-15 cm x 1-2 mm in sterile fronds, double the length in fertile fronds, dark green, rounded below, grooved above, rarely scaly throughout; sterile lamina lanceolate, proliferate, 25-30 x 6-8 cm, subbasal region widest, distal 1/3rd progressively narrowed; pinnae about 35 pairs, sessile, patent, opposite at base, alternate at apex; basal few pairs reduced and deflexed; largest pinna 3.5-4 x 0.5-1 cm, oblong, dimidiate, apex acute,

acroscopic base truncate, overlapping the rachis, upper margin and un-excised part of lower margin lobed; acroscopic basal lobes larger, acute apex, margins entire, costa and veins slightly distinct on both sides, veins pinnate in basal acroscopic lobes, forked in rest about 5 times, acroscopic basal veinlets reaching the base of sinus and bearing 1-2 mm long bristle, densely scaly below; pinnae dark green, texture herbaceous. Fertile fronds with longer stipe, longer than sterile ones, 22-24 x 0.5-1 cm, oblong-lanceolate, about 25 pairs, subopposite, arranged closely above, widely below, basal some pairs deflexed, oblong, apex rounded, margins crenate; sori acrostichoid, spores monolete, spherical, brown. (Plate 4.59: Fig. a-e.).

Distribution: Lithophytic or terrestrial in fully shaded forest floors, stream sides. Between 600-1400 m.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Kummattanthodu, 11° 5' 48.84" N, 76° 27' 19.8" E, 1030 m, 22 October 2019, Thulasi, 14491 (ZGC); Parambikulam Tiger Reserve, Karimala, 10° 25' 15.24" N, 76° 46' 1.2" E, 670 m, 5 December 2019, Thulasi, 14602 (ZGC); Nelliampathy, Maattumala, 10° 32' 4.2" N, 76° 43' 18.12" E, 1300 m, 4 November 2020, Thulasi & Maya, 14824 (ZGC); Bhavani, Thudukki-Chindakki, 11° 8' 7.08" N, 76° 30' 19.44" E, 1370 m, 2 October 2021, Thulasi, 14898 (ZGC).

Bolbitis beddomei Fraser-Jenk. & Gandhi, Indian Fern J. 32: 185. 2015, *nom. nov.* for *Acrostichum proliferum* Hook.; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 8. 2021.

Acrostichum proliferum Hook., Hooker's Icon. Pl. 7: t. 681-682. 1844, *nom. illeg., nec* Blume, 1828; *nor* Bory, 1833.

Bolbitis × *prolifera* (Bory) C. Chr. & Tardieu-Blot in Tardieu-Blot & C. Chr., Not. Syst. 7: 102. 1938; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 295. Pl. 226. 1992.

Bolbitis subcrenatoides Fraser-Jenk., Taxon. Revis. Indian Subcontinental Pteridophytes 346, 2008.

Rhizome short creeping, 4-8 cm long, 7-8 mm thick, scaly all over; scales appressed, ovate-lanceolate, 2-4 x 0.5-1 mm, blackish, apex acuminate, sub entire margin with few out growths. Stipes 64-65 x 4-5 mm, below rounded, above grooved, scaly at base, sparsely above; rachis narrowly winged; sterile lamina ovate, 45-50 x 16-20 cm, widest at base, narrowed towards apex, simple pinnate; pinnae about 10 pairs, subsessile, basal some pairs subopposite, rest alternate; terminal pinna varied, more or less similar to lateral ones, with long flagella which is simple or shallowly lobed, terminal pinnae sub-terminally proliferate; lateral pinnae 10-13 x 8-12 cm, elliptic, acuminate apex, base unequal; margins much varied, from entire to shallowly lobed; midrib raised on both sides, veins obscure below; pinnae pale green, glabrous on both sides, texture herbaceous to chartaceous. Fertile fronds have longer stipes, 25-30 x 10-12 cm, oblong-lanceolate, pinnae about 8 pairs, alternate, 5-6 x 0.2-0.3 cm, sessile, spreading, margin entire or shallowly lobed, terminal one similar to lateral ones; sori acrostichoid; spores abortive, brown. (Plate 4.59: Fig. f-j.; Plate 4.84: Fig. g.).

Distribution: Lithophytic on shaded forest floors, stream sides. Between 300-1600 m.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Kummattanthodu, 11° 5' 48.84" N, 76° 27' 19.8" E, 1030 m, 22 October 2019, Thulasi, 14478 (ZGC); Parathodu, 11° 5' 33" N, 76° 26' 44.52" E, 1020 m, 23 October 2019, Thulasi, 14515 (ZGC); Parambikulam Tiger Reserve, Karimala, 10° 28' 42.96" N, 76° 50' 55.32" E, 600 m, 5 December 2019, Thulasi, 14598 (ZGC); Bhavani, Thudukki-chindakki, 11° 8' 15.72" N, 76° 29' 59.64" E, 1500 m, 2 October 2021, Thulasi, 14910 (ZGC); Malappuram District, Karimbuzha Wildlife sanctuary, Paanappuzha, 11° 18' 29.844" N, 76° 26' 55.536" E, 350 m, 4 September 2021, Thulasi, 14876 (ZGC).

Bolbitis semicordata (Baker) Ching in C. Chr., Nat. Bot. Gard. Ind. Fil., Suppl. 3: 50. 1934; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 296. 1992; Nayar & Geev., Fern Fl. Malabar 239. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 17. 2021.

Acrostichum semicordatum Baker in Hook. & Baker, Syn. Fil. 422. 1868.

Rhizome short creeping, 1-2 cm long, 4-5 mm thick, scaly at apex; scales lanceolate, 3-4 x 1-2 mm, uniformly dark brown, apex acuminate, margins entire. Stipes crowded, arranged in 2 rows, 10-12 cm x 1-2 mm in sterile fronds, flattened below, grooved above, laterally narrowly winged, sparsely scaly throughout. Lamina simple pinnate, narrowly deltoid, 10-12 x 7-8 cm, progressively narrowed from base to apex, terminal pinna slightly different from lateral ones; pinnae about 6 pairs, subopposite at base, alternate above, sessile, oblong-lanceolate, 4-5 x 1-2 cm, slightly convex, margins sub entire; veins slightly distinct on both sides, anastomosing, forms 2 series of larger areoles along costa, without included veinlets; pinnae glabrous, dark green, herbaceous; fertile fronds have stipes 28-30 x 0.2-0.4 cm, pinnules much reduced, about 8 pairs, alternate, apex rounded; sori acrostichoid; spores abortive, light brown. (Plate 4.60: Fig. a-f.).

Distribution: Lithophytic along shaded stream sides, trek paths, road sides and forest floors. Between 60 -1900 m.

Specimen/s examined: Kerala: Palakkad District, Mannarkkad, Meenvallam, 10° 55' 24.96" N, 76° 33' 51.84" E, 85 m, 11 September 2018, Thulasi & Jisha, 14209 (ZGC); Olavakkode, Dhoni, 10° 51' 34.2" N, 76° 37' 21.72" E, 120 m, 13 September 2018, Thulasi & Maya, 14224 (ZGC); Elival mala, 10° 52' 26.04" N, 76° 38' 10.68" E, 300 m, 8 January 2020, Thulasi, 14750 (ZGC); Nelliampathy, Manpara, 10° 33' 27.72" N, 76° 44' 40.2" E, 1065 m, 1 December 2018, Thulasi & Maya, 14311 (ZGC); Cheriya Govinda mala, 10° 30' 27.72" N, 76° 41' 45.6" E, 990 m, 3 November 2020, Thulasi & Maya, 14783 (ZGC); Maattumala, 10° 32' 4.2" N, 76° 43' 18.12" E, 1300 m, 4 November 2020, Thulasi & Maya, 14829 (ZGC); Kesavanpaara, 10° 31' 27.336" N, 76° 40' 4.008" E, 940 m, 12 December 2021, Thulasi, 14957 (ZGC); Silent Valley National Park, Kummattanthodu, 11° 5' 48.84" N, 76° 27' 19.8" E, 1030 m, 22 October 2019, Thulasi, 14488 (ZGC); Kunthipuzha trek path, 11° 5' 45.24" N, 76° 26' 51" E, 916 m, 22 October 2019, Thulasi, 14510 (ZGC); Valiyaparathodu-Madhritodu, 11° 7' 9.84" N, 76° 25' 48.36" E, 960 m, 27 December 2019, Thulasi, 14653 (ZGC); Walakkad to Atti check post trek path, 11°



Plate 4.59: a-e. *Bolbitis asplenifolia* (Bory) K.Iwats. a. Habitat b. Habit c. Rhizome d. Scale e. Sporophyll. f-j. *Bolbitis beddomei* Fraser-Jenk. & Gandhi f. Habitat g. Scale h. Vegetative leaf i. Sporophyll j. Habit.

10° 40.08" N, 76° 24' 53.28" E, 1150 m, 31 December 2019, Thulasi, 14722 (ZGC); Parambikulam Tiger Reserve, Karimala, 10° 30' 42.84" N, 76° 52' 49.44" E, 360 m, 5 December 2019, Thulasi, 14575 (ZGC); Walayar, Akamalavaram, 10° 52' 7.32" N, 76° 42' 43.2" E, 212 m, 02 January 2020, Thulasi & Maya, 14735 (ZGC); Bhavani, Thudukki-Chindakki, 11° 8' 9.24" N, 76° 30' 18.792" E, 1380 m, 2 October 2021, Thulasi, 14907 (ZGC); Idukki District, Mathikettan Shola National Park, 9° 58' 47.28" N, 77° 14' 12.84" E, 1400 m, 1 August 2019, Thulasi & Manju, 14365 (ZGC); Thrissur District, Peechi, 10° 32' 17.88" N, 76° 25' 2.64" E, 160 m, 10 July 2021, Thulasi, 14868 (ZGC); Malappuram District, Karimpuzha Wildlife sanctuary, Paanappuzha, 11° 18' 8.64" N, 76° 25' 30.36" E, 250 m, 4 September 2021, Thulasi, 14880 (ZGC).

Cyrtomium C.Presl, Tent. Pterid. 86, t. 2(26). 1836.

Key to species

1. Pinnae 4-6 pairs, margins irregularly incised *C. caryotideum*
 1. Pinnae up to 12 pairs, margins serrate *C. micropterum*

Cyrtomium caryotideum (Wall. ex Hook. & Grev.) C.Presl, Tent. Pterid. 86, t. 2, f. 26. 1836; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 212. 2018.

Aspidium caryotideum Wall. ex Hook. & Grev., Icon. Filic. t. 69. 1828.

Phanerophlebia caryotideum (Wall. ex Hook. & Grev.) Copel., Gen. Fil. 111. 1947; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 270. Pl. 208. 1992.

Rhizome suberect, 7-12 cm long, 5-6 cm thick, scaly at apex; scales varies in size, from smallest 4-5 x 1-2 mm, lanceolate, to larger ones with 1-2 x, 0.2-0.3 cm, falcate-lanceolate, edges with thread-like branches. Stipes 20-30 cm x 4-5 mm, base scaly, glabrous above and grooved adaxially. Lamina pinnate, ovate-elliptic, 15-40 x 15-22 cm, base rounded or sub-truncate, terminal pinnule lobed, 4-6 later pairs of pinnules, petiolate, ovate-falcate or elliptic -falcate, 13-18 x 3.5-4 cm, base cuneate, margin irregularly incised, lobes serrate, apex acute; terminal pinnule trilobed, sinus up to halfway to the base, lobes unequal. Veins forming deep arches, costular areoles with included single free vein, parallel to the costule, other areoles with 2-3

included veins, texture coriaceous, pinnae glabrous. Sori on veinlet juncture, at the end of free veins, indusiate; indusia orbicular, peltate; spore ellipsoid, brown. (Plate 4.60: Fig. g-m.).

Distribution: Terrestrial on forest floors. Between 1700-1900 m.

Specimen/s examined: Kerala: Idukki District, Pampadum Shola National Park, Pothukandam, 10° 7' 32.34" N, 77° 15' 16.92" E, 1800 m, 30 July 2019, Thulasi & Manju, 14335 (ZGC).

Cyrtomium micropterum (Kunze) Ching, Icon. Fil. Sin. 3: t. 127. 1935; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 215. 2018.

Aspidium anomophyllum f. *micropterum* Kunze, Linnaea 24: 278. 1851.

Phanerophlebia caryotideae var. *micropteris* (Kunze) Tardieu, Fl. Madagascar. Comor. 5(1): 326. 1958; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 272. Pl. 209. 1992.

Rhizome erect, 6-8 cm long, about 3-4 cm thick, covered by scales; scales ovate-lanceolate, 8-10 x 4-5 mm wide, dark brown, periphery light brown, apex acuminate, margin ciliate. Stipes tufted, up to 18-20 x 0.3-0.5 cm, rounded below, grooved above, covered by soft scales. Lamina oblong, up to 40-45 x 10-12 cm, simple pinnate, with simple or bilobed or trilobed terminal pinna; pinnae up to 12 pairs, stalked shortly, subopposite; largest pinna 4-5 x 2-2.5 cm, ovate-lanceolate, apex acuminate, falcate, acroscopic base truncate, basispic base cuneate, acroscopic base auricled, margins finely serrate; veins slightly distinct adaxially, obscure abaxially, copiously anastomosing, and forms areoles; areoles elongated, ascending, 6-8 x 1-2 mm, apex acute, areoles enclose 1 or 2 included veinlets; pinnae pale green, glabrous on both sides, texture coriaceous; petiole base with linear, soft, brown scales; sori numerous, median on included veinlets, indusiate; indusia small, reniform, fimbriate; spore monoete, spherical-ellipsoid, brown. (Plate 4.61: Fig. a-e).

Distribution: Terrestrial in forest floor. Between 2300-2400 m.

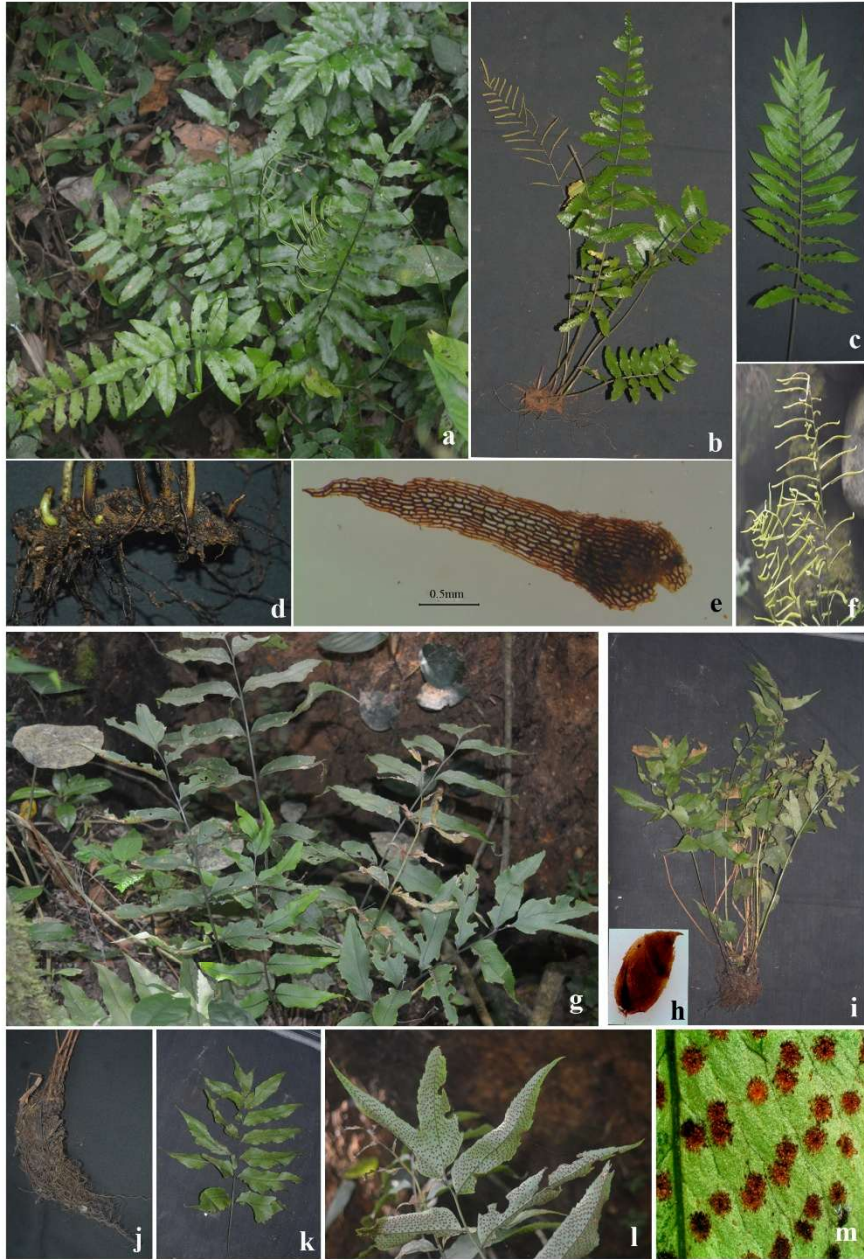


Plate 4.60: a-f. *Bolbitis semicordata* (Baker) Ching a. Habitat b. Habit c. Frond d. Rhizome e. Scale f. Sporophyll. g-m. *Cyrtomium caryotideum* (Wall. ex Hook. & Grev.) C.Presl g. Habitat h. Scale i. Habit j. Rhizome k. Frond l. Sporophyll m. Sori.

Specimen/s examined: Tamil Nadu: Mukurthi National Park, Bankitapal, 11° 13' 24.96" N, 76° 32' 1.68" E, 2371 m, 27 February 2022, Maya, 15011 (ZGC).

Dryopsis Holttum & P.J.Edwards, Kew Bull. 41: 179. 1986.

Dryopsis scabrosa (Kunze) Holttum & P.J.Edwards, Kew Bull. 41(1): 199. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 261, 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 224. 2018.

Aspidium scabrosum Kunze, Linnaea 24: 286. 1851.

Polypodium nigrocarpum Bedd., Ferns S. India 56. t. 169. 1864, *non* 1828.

Dryopteris scabrosa (Kunze) Kuntze, Revis. Gen. Pl. 2: 813. 1891.

Ctenitis scabrosa (Kunze) Ching, Bull. Fan Mem. Inst. Biol., Bot., 8: 292. 1938; Manickam, Fern Fl. Palni Hills, 124. 1986.

Rhizome suberect, 6-12 cm long, 4-5 cm thick, scaly at apex; scales lanceolate, 14-15 x 4-5 mm, pale brown uniformly, acuminate apex, entire margin. Tufted stipes, 14-15 cm x 6-7 mm thick, below flat, above grooved, brown, scaly at base. Lamina deltoid, 68-70 x 72-75 cm, tripinnate, acuminate apex, truncate base; primary pinnae about 5 pairs, basal some pairs subopposite, others alternate, stalked, oblong-lanceolate, 27-30 x 12-15 cm, acuminate apex, truncate base; secondary pinnae about 15 pairs in larger primary pinna, stalked shortly, 16-20 x 5-6 cm, oblong-lanceolate, acuminate apex, truncate base; pinnules about 20 pairs per secondary pinnae, adnate, oblong, 3-4 x 2-3 cm, broadly cuneate base, rounded apex, crenate margin or lobbed; lobes about 9 pairs, oblong, 5-6 x 3-4 mm, rounded apex; veins free, about 4 pairs, simple, not reaching the margin, pinnae pale green, soft herbaceous texture, soft, short, appressed hairs, densely distributed on upper surface of rachis, costa and rachules. Sori median, on basal acroscopic vein, orbicular, indusiate; spores monolete, ellipsoid. (Plate 4.61: Fig. f-k).

Distribution: Terrestrial on partially or fully shaded roadsides. Between 900-1000 m.

Notes: Zhang *et al.* (2012) treated *Dryopsis* and other satellite genera under *Dryopteris*. Fraser-Jenkins *et al.* (2018) however kept it separate.

Specimen/s examined: Tamil Nadu: Ooty, 11° 26' 39.48" N, 76° 37' 24.24" E, 2200 m, Thulasi, 14853 (ZGC).

Dryopteris Adans., Fam. Pl. 2: 20, 551. 1763 (as "*Druopteris*"), *nom. cons.*

Key to species

- 1. Lamina simple pinnate 2
- 1. Lamina bipinnate or bipinnatifid 4
- 2. Pinnae lobed to costa *D. odontoloma*
- 2. Pinnae lobed 1/3rd to costa 3
- 3. Pinnae lobes rounded, scales pale brown *D. hirtipes*
- 3. Pinnae lobes more rectangular, scales blackish brown *D. atrata*
- 4. Fronds dimorphic *D. cochleata*
- 4. Fronds monomorphic 5
- 5. Pinnae lobes entire or crenate *D. sparsa*
- 5. Pinnae lobes serrate *D. juxtaposita*

Dryopteris atrata (Kunze) Ching, Sinensia 3(12): 326. 1933; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 231. 2018.

Aspidium atratum Kunze, Linnaea 24: 279-280. 1851 [*non sensu* Wall. (1828), *nom. nud.*]

Rhizome erect, 9-15 cm long, 8-12 cm thick, densely scaly; scales lanceolate, dark brown, 2-3 x 0.5-1 cm, apex acuminate, margin entire. Stipes tufted, 30-50 x 0.5-0.6 cm, stramineous, base densely scaly; lamina broadly lanceolate, 30-40 x 15-18 cm, simple pinnate, base not narrowed; pinnae 20-22 pairs, spreading, lanceolate, largest pinna 8-12 x 1.2-1.7 cm, base truncate, sessile, margin lobed, lobes more rectangular, apex acuminate; herbaceous; lateral veins simple. Sori on the middle of veinlet, each side of costa, rounded; indusia reniform, fugacious; spores reniform, brown. (Plate 4.62: Fig. a-e.; Plate 4.84: Fig. h.).



Plate 4.61: a-e. *Cyrtomium micropterum* (Kunze) Ching a. Habit b. Rhizome c. Scale d. Sporophyll with sori e. Frond. f-k. *Dryopsis scabrosa* (Kunze) Holttum & P.J.Edwards f. Habitat g. Habit h. Rhizome i. Scale j. Frond k. Sori

Distribution: Terrestrial along shaded stream sides, road sides, trek paths, etc. Between 1000-2100 m. Found growing at Kodaikanal, Tamil Nadu.

Specimen/s examined: Tamil Nadu: Kodaikanal, 10° 15' 23.4" N, 77° 31' 46.2" E, 1500 m, 18 November 2019, Thulasi, 14558 (ZGC).

Dryopteris cochleata (D.Don) C.Chr., Index Fil. 258. 1905; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 279. Pl. 215. 1992; Nayar & Geev., Fern Fl. Malabar 207. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 236. 2018.

Nephrodium cochleatum D. Don, Prodr. Fl. Nepal. 6. 1825.

Rhizome suberect or erect, 7-12 cm long, 2.5-3 cm thick, scaly all over, scales lanceolate, 9-10 x 2.3-2.5 mm, thin, pale brown, membranaceous, apex long acuminate, margins with tooth-like outgrowths. Stipes 30-32 x 0.5-1 cm, scaly below, glabrous and glossy above, fronds dimorphic; lamina lanceolate, bipinnate; sterile lamina 38-40 x 19-20 cm, fertile lamina much reduced, 26-30 x 10-12 cm, pinnae about 10 pairs, ascending, shortly stalked, subopposite; sterile pinna large 10-13 x 4-5 cm wide, oblong lanceolate, apex acute, base truncate; fertile pinna 10-12 x 3-3.8 cm, pinnules about 15 pairs, alternate, isodromous, oblong, 1-2 x 1-1.5 cm, apex obtuse, margins lobed, lobes oblong, 3-4 x 2-3 mm, apex rounded, margins serrulate; costa raised, rounded below, shallowly grooved brownish adaxially; veins distinct below, indistinct above, ending in a pellucid gland; pinnae pale green, long, texture stiff sub-coriaceous, appressed hairy on costa, costules and veins. Fertile pinnules 1.5-2 x 0.5-0.8 cm, oblong, acute, lobes about 8 pairs, deltoid, apex acute; sori one per lobe, reniform, indusiate; indusia reniform; spores reniform-ellipsoid, dark brown. (Plate 4.62: Fig. f-l.; Plate 4.84: Fig. i.).

Distribution: Terrestrial along fully exposed roadsides, rock crevices, etc. Between 700-2400 m.

Specimen/s examined: Kerala: Palakkad, Silent Valley National Park, Kummattanthodu, 11° 5' 33.36" N, 76° 26' 44.16" E, 1020 m, 22 October 2019, Thulasi, 14456 (ZGC); Nelliampathy, Vazhakkundu, 10° 31' 6.6" N, 76° 42' 52.2" E, 910 m, 15 January 2020, Thulasi & Maya, 14759 (ZGC); Maattumala, 10° 32'

4.236" N, 76° 43' 18.444" E, 1300 m, 4 November 2020, Thulasi & Maya, 14817 (ZGC); Bhavani, Thudukki-Chindakki, 11° 8' 15.828" N, 76° 29' 59.64" E, 1500 m, 2 October 2021, Thulasi, 14911 (ZGC); Agali, Ommala, 11° 3' 35.64" N, 76° 36' 39.96" E, 730 m, 14 November 2021, Thulasi, 14924 (ZGC). Tamil Nadu: Mukurthi National Park, Bankitapal, 11° 13' 24.96" N, 76° 32' 1.68" E, 2371 m, 27 February 2022, Maya, 15008 (ZGC).

Dryopteris hirtipes (Blume) Kuntze, Revis. Gen. Pl. 2: 813. 1891; Manickam, Fern Fl. Palni Hills, 135. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 277. Pl. 213. 1992; Nayar & Geev., Fern Fl. Malabar 209. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 245. 2018.

Aspidium hirtipes Blume, Enum. Pl. Javae 2: 148. 1828.

Rhizome erect, 7-12 cm long, 8-10 cm thick, densely scaly; scales linear-lanceolate, 1-2 x 0.25-0.5 cm, uniformly pale brown, apex acuminate, margins entire. Stipes tufted, 48-50 x 0.5-0.6 cm, grey-brown, scaly at base, sparsely above. Lamina oblong-lanceolate, 75-80 x 35-40 cm, apex acute, base cuneate, simple pinnate with caudate apex; pinnae about 20-25 pairs, spreading, subsessile, subopposite; largest pinna 23-25 x 2-3 cm, oblong-lanceolate, distal half progressively narrow towards apex, base broadly cuneate, apex acuminate, margins lobed; lobes deltoid, apex subacute, margins entire or crenulate; costa distinctly raised and rounded below, grooved above; costules and veins slightly distinct above, distinct below; veins about 6-7 pairs, pinnate; pinnae dark green above, light green below; rachis, costa sparsely scaly, interveinal area glabrous; texture herbaceous. Sori median on the veins, indusiate, indusia brown, glabrous, spores reniform, brown. (Plate 4.63: Fig. a-g.; Plate 4.84: Fig. j.).

Distribution: Terrestrial along shaded stream sides, road sides, trek paths, etc. Between 500-2100 m.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Sairandhri to Poochippara trek path, 11° 3' 58.14" N, 76° 32' 10.68" E, 550 m, 26 December 2019, Thulasi, 14628 (ZGC); Walakkad to Sispara trek path, 11° 12'



Plate 4.62: a-e. *Dryopteris atrata* (Kunze) Ching a. Habitat b. Scale c. Sori d. Frond e. Pinnule of sporophyll with sori. f-l. *Dryopteris cochleata* (D.Don) C.Chr. f. Habitat g. Habit h. Frond j. Rhizome k. Sporophyll l. Sori

6.84" N, 76° 26' 23.28" E, 2000 m, 29 December 2019, Thulasi, 14689 (ZGC); Bhavani, Thudukki-Chindakki, 11° 8' 15.828" N, 76° 29' 59.784" E, 1500 m, 2 October 2021, Thulasi, 14914 (ZGC).

Dryopteris juxtaposita Christ, Bull. Acad. Int. Géogr. Bot., Mans 17: 138. 1907.; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 283. Pl. 218. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 275. 2018.

Rhizome sub-erect, massive, 7-10 cm long, 6-7 cm thick, densely scaly all over; scales uniformly pale brown, ovate-acuminate, entire. Stipes tufted, base dark brown, above stramineous, abaxially rounded, adaxially grooved, scale scars sparsely distributed above. Lamina deltoid-elongate to oblong, 60-70 x 20-30 cm, pinnate; pinnae alternate, pinnatifid, 20-25 pairs, sessile, apex acuminate; largest pinna 20-30 x 3-5 cm, oblong-lanceolate, apex obtuse, base caudate, margins lobed up to costa; lobes 10-20 pairs, margin sharply serrate; costa grooved above, rounded below; veins distinct; pinnae dark green, sub-coriaceous, fimbriate to ciliate, soft scales on rachis. Sori on acroscopic veins, submedian, reniform, indusia persistent, dark brown, glabrous. Spores reniform, brown. (Plate 4.63: Fig. h-m.; Plate 4.84: Fig. k.).

Distribution: Terrestrial along shaded road sides between 1900-2200 m. Found growing at Ooty.

Specimen/s examined: Tamil Nadu: Ooty, Doddabetta, 11° 26' 39.48" N, 76° 37' 24.24" E, 2200 m, 29 December 2021, Thulasi, 15057 (ZGC).

Dryopteris odontoloma (T.Moore ex Bedd.) C.Chr., Act. Hort. Gothob. 1(2): 59-60. 1924; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 292. 2018.

Lastrea odontoloma T.Moore ex Bedd., Ferns S. India 39. t. 114. 1863.

Lastrea filix-mas var. *odontoloma* (T.Moore ex Bedd.) Bedd., Suppl. Ferns S. Brit.

India 17. 1876 (*non sensu* Bedd., 1876).

Dryopteris juxtaposita sensu Manickam, Fern Fl. Palni Hills, 139. 1986, *non* Christ., Bull. Acad. Int. Géogr. Bot. 17(212): 138. 1907.

Rhizome suberect, 6-10 cm long, 7-9 cm thick, scaly all over. Scales lanceolate, 6-7 x 2-3 mm, pale to dark brown, apex acute, margins entire, tip toothed. Stipes tufted, pale brown, scaly at base, glabrous above with persistent scale bases. Lamina ovate-lanceolate, acute, bipinnate; pinnae about 8-10 pairs, basal ones slightly reduced, subopposite, subsessile, oblong lanceolate, falcate, apex acute or acuminate, base cuneate; pinnules adnate to costa, apex round, margins serrate, costa raised and rounded adaxially, flattened abaxially, veins slightly distinct above, forked; pinnae glabrous, texture herbaceous. Sori median on veins, 3 pairs per pinnule, indusiate, indusia pale brown; spores ellipsoid to reniform, brown. (Plate 4.64: Fig. a-g).

Distribution: Terrestrial along shaded road sides, between 1000-2500 m.

Specimen/s examined: Tamil Nadu: Ooty, Doddabetta, 11° 26' 39.624" N, 76° 37' 24.24" E, 2200 m, 29 December 2021, Thulasi, 15056 (ZGC).

Dryopteris sparsa (D.Don) Kuntze subsp. *rectipinnula* Fraser-Jenk., Tax. Revis. Three Hundred Indian Subcont. Pterid. 320-321. 2008; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 263. 2018.

Dryopteris sparsa (D.Don) Kuntze, Rev. Gen. Pl. 2: 813. 1891; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 281. Pl. 216. 1992; Nayar & Geev., Fern Fl. Malabar 210. 1993.

Nephrodium sparsum D.Don, Prodr. Fl. Nepal. 6. 1825.

Rhizome erect, 6-8 cm long, 4-5 cm thick, scaly at apex; scales ovate-lanceolate, 7-8 x 3-4 mm wide, pale brown, glossy above. Lamina ovate-lanceolate, 45-50 x 10-15 cm, bipinnatifid, apex acuminate, base cuneate; primary pinnae about 7-8 pairs, falcate, ascending, basal part subopposite, above opposite, stalked; largest pinna 16-18 x 4-5 cm, ovate-lanceolate, apex acuminate, base cuneate, sub opposite or alternate, anadromous below, isodromous above, few basal pairs stalked, others sessile, ovate-lanceolate, 5-6 x 2-3 cm, apex acute, basiscopic base broadly cuneate, acroscopic base truncate, margins lobed; lobes oblong, 1-1.5 x 0.3-0.5 cm, apex acute, margins toothed; rachules narrowly winged on either side, shallowly grooved above; veins indistinct above, slightly distinct below, about 5 pairs, forked, not



Plate 4.63: a-g. *Dryopteris hirtipes* (Blume) Kuntze a. Habitat b. Habit c. Frond d. Rhizome e. Scale f-g. Sori. h-m. *Dryopteris juxtaposita* Christ h. Habitat i. Habit j. Sporophyll k. Rhizome l. Scale m. Sporophyll pinna with sori.

reaching the margin; pinnae dark green, texture herbaceous. Sori median on veinlets, indusiate; indusia reniform, glabrous; spores reniform, dark brown. (Plate 4.64: Fig. h-n.).

Distribution: Terrestrial along shaded stream sides, roadsides, trek paths, etc. Between 500-2100 m.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Kummattanthodu, 11° 5' 48.84" N, 76° 27' 19.8" E, 1030 m, 22 October 2019, Thulasi, 14493 (ZGC); Sairandhri to Poochippara trek path, 11° 3' 58.14" N, 76° 32' 10.68" E, 550 m, 26 December 2019, Thulasi, 14630 (ZGC); Poochippara to Walakkad trek path, 11° 8' 0.96" N, 76° 24' 42.84" E, 1140 m, 28 December 2019, Thulasi, 14680 (ZGC); Walakkad to Sispara trek path, 11° 12' 2.52" N, 76° 26' 36.852" E, 2100 m, 4 January 2022, Thulasi, 14994 (ZGC); Bhavani, Thudukki-Chindakki, 11° 8' 4.128" N, 76° 30' 28.08" E, 1300 m, 2 October 2021, Thulasi, 14894 (ZGC); Nelliampathy, Maattumala, 10° 32' 7.44" N, 76° 43' 10.56" E, 1335 m, 13 November 2019, Thulasi & Maya, 14553 (ZGC). Tamil Nadu: Nadukaani, 11° 28' 51.708" N, 76° 32' 39.336" E, 1800 m, 28 December 2021, Thulasi, 14963 (ZGC).

Elaphoglossum Schott ex J.Sm., Hooker J. Bot. 4: 148. 1841, nom. Cons.

Key to species

1. Fronds glabrous or with some scales; scales uniformly dark brown, apex acuminate with gland tipped *E. beddomei*
1. Fronds hairy; scales pale brown, edge dark brown, apex acuminate without gland tipped *E. nilgircum*

Elaphoglossum beddomei Sledge, Bull. British Mus. Nat. Hist. Bot. 4: 88. 1967; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 288. Pl. 221. 1992; Nayar & Geev., Fern Fl. Malabar 246. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 29. 2021.

Elaphoglossum stigmatolepis sensu Bedd., Ferns South. India 67. t. 199. 1864.

Rhizome short creeping, 6-15 cm long, 0.3-0.5 cm thick, scaly all over; scales lanceolate, 4-5 x 0.5-1 mm, uniformly dark brown, acuminate, gland tipped, fimbriate at base. Stipes crowded, 8-10 cm x 23-25 mm, tetragonal, deeply grooved, pale brown, sparsely hairy in young, glabrous in mature. Lamina simple, elliptic, 33-35 x 3-4 cm, narrowed towards base and apex, base narrowly cuneate, apex acute, margins entire with cartilaginous border; mid rib distinctly raised on both sides, shallowly grooved above, veins slightly distinct below, simple or forked; lamina pale green, texture coriaceous; minute fimbriate, brown scales on both surfaces; fertile fronds with longer stipes, otherwise similar to sterile fronds, but slightly compressed; sori acrostichoid; spores reniform, brown. (Plate 4.65: Fig. a-e.; Plate 4.88: Fig. d.).

Distribution: Epiphytic or lithophytic in fully shaded forest areas. Between 900-2200 m.

Specimen/s examined: Kerala: Idukki, Mathikettan Shola National Park, Choondal, 9° 59' 4.56" N, 77° 14' 46.68" E, 1500 m, 2 August 2019, Thulasi & Manju, 14388 (ZGC); Palakkad District, Silent Valley National Park, Valiyaparathodu-Madhrithodu, 11° 6' 49.32" N, 76° 25' 51.6" E, 910 m, 27 December 2019, Thulasi, 14635 (ZGC); Poochippara to Walakkad trek path, 11° 8' 0.96" N, 76° 24' 42.84" E, 1140 m, 28 December 2019, Thulasi, 14685 (ZGC); Walakkad to Sispara trek path, 11° 12' 6.48" N, 76° 26' 24.36" E, 2000 m, 29 December 2019, Thulasi, 14700 (ZGC); 11° 12' 6.84" N, 76° 26' 28.104" E, 2030 m, 3 January 2022, Thulasi, 14987 (ZGC); 11° 12' 6.66" N, 76° 26' 44.088" E, 2130 m, 4 January 2022, Thulasi, 15003 (ZGC).

Elaphoglossum nilgircum Krajina ex Sledge, Bull. British Mus. Nat. Hist. Bot. 4: 94. 1967; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 290. Pl. 223. 1992; Nayar & Geev., Fern Fl. Malabar 247. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 31. 2021.

Rhizome short creeping, 5-9 cm long, 1-2.5 mm thick, densely covered by scales; scales lanceolate, 4-5 x 0.5-1 mm, pale brown, edges dark brown, apex acuminate, margins with dark brown 0.8-1 mm long teeth. Fronds crowded, lanceolate, 25-30 x



Plate 4.64: a-g. *Dryopteris odontoloma* (T.Moore ex Bedd.) C.Chr. a. Habitat b. Habit c. Rhizome d. Frond e. Scale f. Sori g. Sporophyll h-n. *Dryopteris sparsa* (D.Don) Kuntze subsp. *rectipinnula* Fraser-Jenk. h. Habitat i. Habit j. Frond k. Rhizome l. Scale m. Sporophyll pinnae n. Sori.

2.5-3 cm; stipes 4-5 x 0.2-0.4 cm, scaly at base; basal half and distal part of frond gradually narrowed, apex acute, base decurrent, margins entire, without cartilaginous border; veins indistinct above and below, simple or forked, not reaching the margins; fronds dark green, scales toothed, densely covered on both surfaces of younger fronds, abaxially in mature fronds. Fertile fronds with longer stipes; sori acrostichoid; spores reniform-ellipsoid, dark brown. (Plate 4.65: Fig. f-j).

Distribution: Epiphytic or lithophytic in fully shaded forests. Between 900-1100 m.

Specimen/s examined: Kerala: Palakkad, Silent Valley National Park, Kunthipuzha trek path, 11° 5' 45.672" N, 76° 26' 57.84" E, 950 m, 22 October 2019, Thulasi, 14505 (ZGC).

Polystichum Roth, Tent. Fl. Germ. 3: 31, 69. 1799, *nom. cons.*

Key to species

1. Fronds simple pinnate *P. harpophyllum*
1. Fronds bipinnate or sub-tripinnate 2
2. Fronds sub-tripinnate *P. anomalum* subsp. *travancoricum*
2. Fronds bipinnate 3
3. Lamina lanceolate, not proliferating at apex *P. squarossum*
3. Lamina deltoid, proliferating buds present at apex *P. subinerme*

Polystichum anomalum (Hook. & Arn.) J.Sm., Ferns Brit. For. 151. 1866. subsp. *travancoricum* (Bedd.) Fraser-Jenk., Anno. Checklist Indian Pterid., 2. 311. 2018.

Polystichum aculeatum var. *travancoricum* Bedd., Handb. Ferns Brit. India, 209. 1883.

Polystichum travancoricum (Bedd.) B.K.Nayar & S.Kaur, Comp. Bedome's Handb. 49. 1973; Nayar & Geev., Fern Fl. Malabar 216. 1993.

Rhizome erect or sub-erect, about 6-8 cm long, 2-3 cm thick, scaly; scales two types, larger scales 15-20 x 3-4 mm, elongate-ovate, smaller scales 5-15 x 8-10 mm,

narrowly lanceolate, margin has hairlike out-growths. Fronds obliquely spreading, having sub-apical vegetative bud on ventral side of rachis; stipe 30-40 cm long, green. Lamina broadly ovate, 40-55 x 20-25 cm, sub-tripinnate, apex acuminate; primary pinnae 20-25 pairs, larger one elongate-lanceolate, 14-15 x 3-4 cm, apex acuminate and serrate; secondary pinnae with scaly rachis, 12-15 pairs, larger middle pinnae 12-15 x 6-8 mm, sub-falcate, basispic base narrowly cuneate, acroscopic base truncate. Lamina coriaceous, upper surface glabrous, basal surface scaly. Sori on the apex of acroscopic branch, exindusiate; spores plano-convex, dark brown.

Distribution: Terrestrial on humid shady areas, between 900 to 1800 m.

Notes: This species is included here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Kerala: Palakkad District, Silent Valley, Walakkad, Nayar & Geevarghese, 10660 (CALI).

Polystichum harpophyllum (Zenker ex Kunze) Sledge, Bot. J. Linn. Soc. 84(1): 7. 1982; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 265. Pl. 203. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 319. 2018.

Polypodium harpophyllum Zenker ex Kunze, Linnaea 24: 256. 1891.

Rhizome erect, 7-14 cm long, 4-5 cm thick, scaly at apex; scales oblong-lanceolate, 6-7 x 1-2 mm, apex acuminate, pale brown, margins with thread like outgrowths. Stipes tufted, 50-65 x 1-1.5 cm, rounded below, grooved above, densely scaly below. Lamina simple pinnate, oblong-lanceolate, 50-70 x 10-15 cm, apex acuminate, base truncate; pinnae about 14-15 pairs, alternate, sessile, 2-3 cm apart, largest pinna 7-8 x 1-1.5 cm, oblong lanceolate, apex acuminate, falcate, acroscopic base truncate and auricled, basispic base narrowly cuneate, margins deeply serrate; costa slightly raised and rounded below, shallowly grooved above, not raised; veins slightly distinct abaxially, indistinct adaxially, pinnate, halfway to margin, simple or forked twice, the first basal acroscopic veinlets traverse up to the half way to margin of the pinnae and whether it have sorus or not, it ends



Plate 4.65: a-e. *Elaphoglossum beddomei* Sledge a. Habitat b. Rhizome c. Scale d. Sporophyll e. Habit. f-j. *Elaphoglossum nilgircum* Krajina ex Sledge f. Habit g & i. Frond - g. Adaxial surface i. Abaxial surface h. Rhizome j. Scale.

submedianly, others traverse close to the margin and end sub-marginally; pinnae dark green, glabrous on both sides, sub-coriaceous texture; long, narrow, pale brown scales and hairs distributed sparsely on rachis. Sori at end of each acroscopic basal veinlet, submedian or marginal, round, ex-indusiate; spores spherical, brown. (Plate 4.66: Fig. a-f.; Plate 4.84: Fig. 1.).

Distribution: Terrestrial along fully shaded stream sides or trek paths. Between 1000-2300 m.

Specimen/s examined: Kerala: Idukki District, Pampadum Shola National Park, Kuttikkad, 10° 7' 35.4" N, 77° 15' 29.88" E, 1900 m, 30 July 2019, Thulasi & Manju, 14346 (ZGC); Mathikettan Shola National Park, 9° 58' 47.28" N, 77° 14' 12.84" E, 1400 m, 1 August 2019, Thulasi & Manju, 14380 (ZGC); Palakkad District, Silent Valley National Park, Walakkad to Sispara trek path, 11° 10' 30.648" N, 76° 24' 30.6" E, 1054 m, 4 January 2022, Thulasi, 14980 (ZGC). Tamil Nadu: Mukurthi National Park, Bankitapal, 11° 15' 41.04" N, 76° 30' 49.716" E, 2220 m, 27 February 2022, Maya, 15018 (ZGC).

Polystichum squarrosum (D.Don) Fée, Mém. Fam. Foug. 5 Gen. Fil.: 278. 1852; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 268. Pl. 207. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 343. 2018.

Aspidium squarrosum D.Don, Prodr. Fl. Nepal. 4. 1825.

Rhizome erect or suberect, 5-12 cm long, 7-8 cm thick, scaly; scales elliptic lanceolate, acuminate, 1-2 x 0.2-0.5 cm, edges toothed, dark brown. Stipes tufted, 30-40 x 7-8 mm, covered by brown, filiform scales at base, upward by large scales, deeply grooved above. Lamina bipinnate, acute, lanceolate, acuminate, 50-60 x 20-30 cm, base sub truncate; pinnae about 28-30 pairs, subopposite, sessile, largest one 10-20 x 3-4 cm wide, oblong-lanceolate, base sub truncate, apex acuminate; pinnules ovate, 1.8-2 x 0.5-1 cm, basispic margin excised at base, incised 1/3rd to the costule; basal basispic lobes larger than the next above, ovate-elliptic, sub entire. Veins about 4-5 pairs, reaching the margins, obscure below, slightly above. Pinnae dark green, texture coriaceous; rachis and costa with long branched hairs and

scales on both sides, pinnules glabrous on both sides. Sori in 2 submarginal rows, indusiate; indusium glabrous. Spores reniform, brown. (Plate 4.66: Fig. g-m.; Plate 4.85: Fig. a.; Plate 4.88: Fig. e.).

Distribution: Terrestrial in fully shaded forest floors. Between 1800-2300 m.

Specimen/s examined: Tamil Nadu: Ooty, 11° 28' 51.708" N, 76° 32' 39.336" E, 1800 m, 29 December 2021, Thulasi, 14959 (ZGC); Doddabetta, 11° 28' 1.056" N, 76° 32' 59.856" E, 1900 m, 29 December 2021, Thulasi, 14971 (ZGC); Mukurthi National Park, 11° 15' 41.04" N, 76° 30' 49.716" E, 2220 m, 27 February 2022, Maya, 15016 (ZGC).

Polystichum subinerme (Kunze) Fraser-Jenk. in Bhardwaja & Gena, Aspects Pl. Sci. 13: 265. 1991; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 266. Pl. 204. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 345. 2018.

Aspidium subinerme Kunze, Linnaea 24: 290. 1851.

Polystichum kunthianum B.K.Nayar & Geev., Fern Fl. Malabar 214. 1993.

Rhizome erect or suberect, 7-15 cm, 5-6 cm thick, densely scaly; scales lanceolate, 14-15 x 1-2 mm, yellowish-brown, apex acuminate, margins with short outgrowths below, long above. Stipes tufted, 38-40 x 1-1.5 cm thick, dark brown, shallowly grooved above, lateral sides having deep grooves, densely scaly below, sparsely above. Lamina bipinnate, 35-40 x 26-30 cm, deltoid, apex acute, base truncate; pinnae about 10 pairs, subopposite, spreading, stalked shortly; basal most pair is the largest one, 15-17 x 5-6 cm, oblong-lanceolate, apex acute, base truncate; pinnules about 15 pairs in largest pinnae, alternate, spreading, shortly stalked, largest pinnule 2-3 x 1-1.5 cm wide, ovate, apex acute, acroscopic base truncate, basisopic base narrowly cuneate, margins crenate in distal part, shallowly lobed on upper margin, deeply lobed on acroscopic or basisopic lobes, free from adjacent lobe; lobes broadly deltoid, apex subacute, margins entire; costa flattened above and below; veins slightly distinct below, indistinct above, repeatedly forked, free, not reaching the margin, rachis and costa covered by soft, long, pale brown scales; long, soft, septate hairs on veins and costules below; upper surface and interveinal lower



Plate 4.66: a-f. *Polystichum harpophyllum* (Zenker ex Kunze) Sledge a. Habitat b. Habit c. Frond d. Rhizome e. Scale f. Sporophyll with sori. g-m. *Polystichum squarrosum* (D.Don) Fée g. Habitat h. Habit i. Frond j. Rhizome k. Scale l. Sporophyll m. Sori.

surface glabrous; pinnae dark green, texture thick coriaceous. Sori median on veinlets, orbicular, indusiate; indusia orbicular, dark brown. Spores ellipsoid, brown. (Plate 4.67: Fig. a-g.; Plate 4.88: Fig. f.).

Distribution: Terrestrial on shaded trek paths, stream sides, etc. Between 1100-2400 m.

Notes: Fraser-Jenkins (2012) treats this endemic taxon as Endangered (EN).

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Sispara, 11° 10' 40.08" N, 76° 24' 53.28" E, 1150 m, 30 December 2019, Thulasi, 14724 (ZGC); Walakkad to Sispara trek path, 11° 12' 2.52" N, 76° 26' 36.852" E, 2100 m, 4 January 2022, Thulasi, 14992 (ZGC). Tamil Nadu: Mukurthi National Park, Bankitapal, 11° 13' 25.176" N, 76° 32' 1.968" E, 2371 m, 27 February 2022, Maya, 15023 (ZGC).

Nephrolepidaceae Pic. Serm., *Webbia* 29(1): 8-11. 1975.

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

Key to species

1. Rhizome creeping ***N. undulata***
1. Rhizome erect or suberect **2**
2. Roots with tubers; sori middle to margin and midrib ***N. cordifolia***
2. Roots without tubers; sori marginal or submarginal **3**
3. Sori marginal ***N. brownii***
3. Sori sub marginal ***N. hirsutula***

Nephrolepis brownii (Desv.) Hovenkamp & Miyam., *Blumea* 50(2): 293. 2005; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 45. 2021.

Nephrodium brownii Desv., Mem. Soc. Linn. Paris 6, 2: 252. 1827.

Nephrolepis multiflora (Roxb.) Jarret in Morton, Contrib. U.S. Nat. Herb. 38: 309. 1974; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 299. Pl. 109. 1992.

Rhizome erect or suberect, 5-6 cm long, woody, 1.5-2 cm thick with stipes, scales

all over; scales appressed, 2-3 x 0.5-1 mm, ovate-lanceolate, dark brown at centre, pale at periphery, apex acute, margins fimbriate. Stipes tufted, 60-65 x 0.5-0.6 cm, rounded below, grooved above, minutely scaly adaxially. Lamina oblong-lanceolate, 75-80 x 13-15 cm wide, simple pinnate, pinnae up to 25 pairs, subopposite, sessile, spreading; basal some pairs reduced and deflexed; largest pinna 8-10 x 1-1.5 cm, oblong-lanceolate, acute, base cuneate, unequal, margins serrate; midrib slightly raised on both sides; veins well distinct in younger fronds, forked, free, parallel, not reaching the margin, veins ended in a hydathode. Lamina light green, herbaceous; linear, fimbriate scales along with hairs distributed slightly all over the lamina. Sori submarginal, at vein endings, reniform, indusiate, indusia brown, glabrous; spores reniform, brown. (Plate 4.67: Fig. h-m.; Plate 4.85: Fig. b.).

Distribution: Terrestrial along fully exposed or partially exposed road sides, trek paths and stream sides, up to 1500 m.

Specimen/s examined: Kerala: Palakkad District, Mannarkkad, Meenvallam, 10° 55' 24.96" N, 76° 33' 51.84" E, 85 m, 9 November 2018, Thulasi & Jisha, 14214 (ZGC); Siruvani, 10° 58' 43.32" N, 76° 36' 43.92" E, 830 m, 20 September 2019, Thulasi, 14432 (ZGC); Olavakkode, Dhoni, 10° 51' 34.2" N, 76° 37' 21.72" E, 120 m, 13 September 2018, Thulasi & Maya, 14229 (ZGC); Walayar, Akamalavaram, 10° 52' 5.16" N, 76° 42' 41.04" E, 212, 02 January 2020, Thulasi & Maya, 14320 (ZGC); Aduppukootti mala, 10° 55' 4.8" N, 76° 44' 49.2" E, 484 m, 8 January 2020, Thulasi & Aswani, 14754 (ZGC); Nelliampathy, Maattumala, 10° 32' 4.236" N, 76° 43' 18.12" E, 1300 m, 4 November 2020, Thulasi & Maya, 14815 (ZGC); Agali, Ommala, 11° 3' 35.64" N, 76° 36' 39.96" E, 730 m, 14 November 2021, Thulasi, 14926 (ZGC); Idukki District, Mathikettan Shola National Park, 9° 58' 47.28" N, 77° 14' 12.84" E, 1400 m, 1 August 2019, Thulasi, 14379 (ZGC); Thrissur District, Athirappilly-Malakkappara, 10° 17' 47.796" N, 76° 47' 38.796" E, 930 m, 14 February 2021, Thulasi, 14847 (ZGC). Tamil Nadu: Ooty-Mulli road side, 11° 11' 58.56" N, 76° 43' 16.68" E, 490 m, 21 November 2021, Thulasi, 14942 (ZGC).

Nephrolepis cordifolia (L.) C.Presl, Tent. Pterid. 79. 1836, *nom. et type cons.*; Nayar & Geev., Fern Fl. Malabar 251. 1993; Fraser-Jenkins *et al.*, Anno. Checklist



Plate 4.67: a-g. *Polystichum subinerme* (Kunze) Fraser-Jenk. a. Habitat b. Habit c. Frond d. Bulbil on the frond e. Scale f. Pinnule of sporophyll g. Sori. h-m. *Nephrolepis brownii* (Desv.) Hovenkamp & Miyam. h. Habitat i. Habit j. Scale k. Rhizome l. Frond m. Sori.

Indian Pterid., 46. 2021.

Polypodium cordifolium L., Sp. Pl. 2: 1089. 1753.

Nephrolepis auriculata (L.) Trimen, J. Linn. Soc. Bot. 24: 152. 1887; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 140. Pl. 108. 1992.

Rhizome erect, 3-5 cm long, 1.5-2 cm thick, scaly all over; scales lanceolate, 4-5 x 0.8-1 mm, uniformly light brown, acuminate, margins fimbriate; rhizome has long wiry roots with spherical, fleshy, 1 cm diameter, scaly tubers. Stipes tufted, 18-20 x 0.4-0.5 cm, scaly below, glabrous above. Lamina linear-lanceolate, 63-65 x 5-6 cm, narrowed towards base and apex. Pinnae 25-30 pairs, alternate, spreading, sessile; pinnae apex subacute, base unequal, cordate, acroscopic base auricled, overlapping the rachis and nearby pinna, margins crenate; midrib and veins distinct on both sides; veins forked once, free, not reaching margin, end having hydathode, pinnae pale green, glabrous on both surfaces, herbaceous; linear, brown, soft hairs minutely spread all over the rachis. Sori submarginal, 2 rows, up to 10 pairs, on acroscopic veinlets, reniform, indusiate; indusia reniform, dark brown at base, pale brown in edges, entire, glabrous; spores reniform, brown. (Plate 4.68: Fig. a-f.; Plate 4.85: Fig. c.).

Distribution: Epiphytic or lithophytic along shaded roadsides, trek paths and stream sides. Between 500 to 1700 m.

Specimen/s examined: Kerala: Palakkad District, Mannarkkad, Virgin Valley, 11° 2' 42.72" N, 76° 26' 33" E, 79 m, 24 November 2018, Thulasi & Jisha, 14286 (ZGC); Silent Valley National Park, Kummattanthodu, 11° 5' 33.36" N, 76° 26' 44.16" E, 1020 m, 22 October 2019, Thulasi, 14450 (ZGC); Kunthipuzha trek path, 11° 5' 45.6" N, 76° 26' 57.84" E, 950 m, 22 October 2019, Thulasi, 14506 (ZGC); Parambikulam Tiger Reserve, Karimala, 10° 28' 42.96" N, 76° 50' 55.32" E, 600 m, 5 December 2019, Thulasi, 14593 (ZGC); Idukki District, Mathikettan Shola National Park, Choondal, 9° 59' 4.56" N, 77° 14' 46.68" E, 1500 m, 2 August 2019, Thulasi, 14384 (ZGC); Thrissur District, Peechi, 10° 32' 17.88" N, 76° 25' 2.64" E, 160 m, 11 July 2021, Thulasi, 14867 (ZGC).

Nephrolepis hirsutula (Forst.) Presl, Tent. Pterid. 79, 1836; Nayar & Geev., Fern Fl. Malabar 257. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 3. 49. 2021.

Rhizome un-branched, 5-10 cm x 4-6 mm, stolons many, 2-3 mm thick, greenish to brownish, branched, having small plantlets, scaly; scales peltate, dark-brown to blackish, elongate-ovate, 3-4 x 0.9-1 mm, abruptly narrowed to a uniseriate multicellular apex, tipped by elongated thin-walled acicular cell, margin having profuse, uniseriate, multicellular, thin-walled, slender, shaggy, elongated hairs. Frond not tufted, each associated at base with 2-3 stolons, erect, stipe hard, 15-25 cm long, brownish, grooved adaxially. Lamina narrowly elongate-elliptic, 40-90 x 10-15 cm, hairy, hairs short, slender. Lateral pinnae many, sub-opposite or alternate, reduced towards both ends, larger one 5-8 cm x 10-15 mm. Elongate, sub-falcate, margin minutely and irregularly crenate, base broad, acroscopic base being truncate, form short triangular auricle; texture thick coriaceous. Midrib conspicuous on both surfaces, lateral veins oblique to mid-rib. Fertile pinnae similar to sterile ones. Sorus sub-marginal; spores plano-convex, dark brown.

Distribution: Terrestrial on partially espoused areas, between 300-1000 m.

Notes: This species is included here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Kerala: Palakkad District, Mukkali, Geevarghese and Nayar, 4002 (CALI).

Nephrolepis undulata (Afzel. ex Sw.) J.Sm., Curtis Bot. Mag. 72 (Companion): 35(bis.). 1846; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 51. 2021.

Aspidium undulatum Afzel. ex Sw., J. Bot. (Schrader) 1800(2): 32. 1801.

Nephrolepis delicatula (Decne. in Jacquem.) Pichi-Sermoli, Webbia, 23: 181. 1968; Nayar & Geev., Fern Fl. Malabar 253. 1993.

Rhizome unbranched, 1-3 cm long, 1.5-2 mm thick, with many stolons, sparsely scaly, having tubers, 6-10 mm long, densely scaly; scales uniformly pale brown,

ovate, 2.5-3 x 0.5-1 mm, apex acuminate, with an acicular cell at tip, margins smooth, with few glandular hairs. Fronds spreading, pendant, crowded, stipes 8-10 cm x 1-2 mm, sparsely scaly, grooved above, rounded below. Lamina narrowly elongate-elliptic, 40-45 x 4-5 cm; simple pinnate, lateral pinnae alternate, many, closely placed, auriculated, sessile, basal pairs reduced; larger pinna 20-25 x 6-7 mm, apex acute, subfalcate, acroscopic base prominently auricled, basisopic base cuneate, margins serrate, light green, texture thin membranous, glabrous; veins obscure, midrib slightly raised below, veins oblique, subopposite, free, forked. Fertile pinnae have more prominent dentate margin. Sori on tips of acroscopic branch of lateral vein, indusiate; indusia curved; spores plano convex, brown. (Plate 4.68: Fig. g-m.; Plate 4.85: Fig. d.).

Distribution: Lithophytic or epiphytic on shaded forests. Between 110 -1700 m.

Specimen/s examined: Kerala: Palakkad District, Nelliampathy, Kesavan Para, 10° 31' 27.12" N, 76° 40' 3.72" E, 940 m, 12 December 2021, Thulasi, 15058 (ZGC). Tamil Nadu: Mulli, 11° 11' 58.884" N, 76° 43' 16.68" E, 490 m, 21 November 2021, Thulasi, 15059 (ZGC).

Tectariaceae Panigrahi, J. Orissa Bot. Soc. 8: 41. 1986.

Tectaria Cav., Anales Hist. Nat. 1: 115. 1799.

Key to species

1. Lamina simple pinnate ***T. wightii***
1. Lamina bipinnate or bipinnatifid **2**
2. Included veinlets absent ***T. coadunata***
2. Included veinlets present ***T. paradoxa***

Tectaria coadunata (J.Sm.) C.Chr., Contrib. U. S. Natl. Herb. 26(6): 331. 1931; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 260. Pl. 200. 1992; Nayar & Geev., Fern Fl. Malabar 219. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 365. 2018.

Sagenia coadunata J.Sm., Hooker J. Bot. 4: 184. 1842 (as "*coadunatum*").

Tectaria periya B.K.Nayar & Geev., Bull. Bot. Surv. India 28(1-4): 136. 1986 (publ. 1988); Nayar & Geev., Fern Fl. Malabar 225. 1993.

Rhizome short creeping, 5-7 cm long, 2-3 cm thick, scaly at apex; scales ovate-lanceolate, 6-8 x 1-2 mm, brown, apex acuminate, margins sparsely ciliated. Stipes scattered, 46-50 x 1-1.5 cm, rounded below, grooved above, greyish brown, glossy, glabrous. Lamina ovate, 25-30 x 36-40 cm, apex acute, base cordate, bipinnatifid, primary pinnae 3-5 pairs in the basal part, distal part with 3-5 fused primary pinnae, apex caudate; primary pinnae subopposite, basal pair largest, petiole 0.5-1 cm long, 23-25 x 16-17 cm, obliquely ovate, cuneate broadly, acuminate; secondary pinnae adnate, about 5 pairs, alternate, basal most basicopic pinnae of primary pinnae are the largest, 7-8 cm long, oblong-lanceolate, acute, margins crenate in distal pairs, lobed in basal; lobes oblong, ascending, rounded, margins entire or sub crenate; veins distinct below, less distinct above, anastomosing, forms series of elongated areoles along costa and costules, areoles free from included veinlets, rarely with included veinlets; lamina light green, thin, soft herbaceous; with multicellular, long, soft, brown hairs on all over except the lower part of main rachis. Sori borne at the ends of veinlets, in 2 rows along the costules, orbicular, indusiate; indusia glabrous, dark brown; spores reniform, pale brown. (Plate 4.69: Fig. a-f.; Plate 4.85: Fig. e.).

Distribution: Terrestrial along the shaded roadsides, trek paths and stream sides. Between 80 to 2400 m.

Specimen/s examined: Kerala: Palakkad District, Mannarkkad, Meenvallam, 10° 55' 25.176" N, 76° 33' 51.9984" E, 85 m, 11 September 2018, Thulasi & Jisha, 14201 (ZGC); Siruvani, 10° 58' 32.16" N, 76° 37' 16.68" E, 830 m, 20 September 2019, Thulasi, 14437 (ZGC); Olavakkode, Dhoni, 10° 51' 34.2" N, 76° 37' 21.72" E, 120 m, 13 September 2018, Thulasi & Maya, 14228 (ZGC); Elivalmala, 10° 52' 26.04" N, 76° 38' 10.68" E, 300 m, 8 January 2020, Thulasi, 14749 (ZGC); Silent Valley National Park, Kummattanthodu, 11° 5' 48.84" N, 76° 27' 19.8" E, 1030 m, 22 October 2019, Thulasi, 14477 (ZGC); Parathodu, 11° 5' 33" N, 76° 26' 44.52" E, 1020 m, 23 October 2019, Thulasi, 14514 (ZGC); Walakkad to Sispara trek path, 11° 12' 6.48" N, 76° 26' 24.36" E, 2000 m, 29 December 2019, Thulasi, 14698



Plate 4.68: a-f. *Nephrolepis cordifolia* (L.) C.Presl a. Habitat b. Habit c. Rhizome d. Bulbils on rhizome e. Scale f. Sori. g-m. *Nephrolepis undulata* (Afzel. ex Sw.) J.Sm. g. Habitat h. Habit i. Rhizome j-k. Sporophyll l. Scale m. Sori.

(ZGC); Sispara to Anginda trek path, 11° 11' 20.04" N, 76° 27' 35.64" E, 2280 m, 30 December 2019, Thulasi, 14715 (ZGC); Nelliampathy, Maattumala, 10° 32' 12.84" N, 76° 43' 10.2" E, 1312 m, 13 November 2019, Thulasi, 14551 (ZGC); Vazhakkundu, 10° 31' 6.6" N, 76° 42' 52.2" E, 910 m, 15 January 2020, Thulasi & Maya, 14774 (ZGC); Cheriya Govinda mala, 10° 30' 38.16" N, 76° 41' 42" E, 987 m, 3 November 2020, Thulasi & Maya, 14809 (ZGC); Parambikulam Tiger Reserve, Karimala, 10° 28' 42.96" N, 76° 50' 55.32" E, 600 m, 5 December 2019, Thulasi, 14595 (ZGC); Walayar, Akamalavaram, 10° 52' 7.32" N, 76° 42' 43.2" E, 212 m, 02 January 2020, Thulasi & Maya, 14737 (ZGC); Bhavani, Thudukki-Chindakki, 11° 8' 4.272" N, 76° 30' 31.68" E, 1260 m, 2 October 2021, Thulasi, 14887 (ZGC); Agali, Ommala, 11° 3' 35.64" N, 76° 36' 39.96" E, 730 m, 14 November 2021, 14927 (ZGC); Malappuram District, Karimpuzha Wildlife sanctuary, 11° 18' 24.84" N, 76° 26' 37.32" E, 310 m, 4 September 2021, Thulasi, 14872 (ZGC).

Tectaria paradoxa (Fée) Sledge, Kew Bull. 27(3): 413-415. 1972; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 256. Pl. 198. 1992; Nayar & Geev., Fern Fl. Malabar 224. 1993; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 378. 2018.

Aspidium paradoxum Fée, Mém. Foug. 5 (Gen. Fil.): 293. 1852.

Rhizome erect, 6-8 cm long, 2-3 cm thick, scaly at apex; scales lanceolate, 7-8 x 1.5-2 mm, margins fimbriate. Stipes tufted, 50-52 cm long, brown, scaly at base, less scaly or glabrous at distal part. Lamina lanceolate, 60-65 x 26-30 cm, base bipinnatifid, distally simple pinnatifid, apex acute, base cuneate; pinnae about 9 pairs, subopposite, ascending; largest one is the basal most one, about 4 pairs of secondary pinnae on either side; largest simple pinnae oblong-lanceolate, apex acuminate, base cuneate with 2 largest pinnule free from adjacent pinnules, margins lobed; lobes oblong, apex acute, base cuneate; costa rounded and raised below, grooved above; veins minutely distinct below, not distinct above, about 9 pairs, forked, free, reaching submarginal ending with a dot; pinnae light green or greyish green; herbaceous; brown, soft, short hairs on rachis, costa, costules and veins, inter-venal area glabrous. Sori submarginal, on veins, reniform, indusiate; indusia persistent, brown, glabrous, margin entire; spores ellipsoid, pale brown. (Plate 4.69: Fig. g-m.; Plate 4.85: Fig. f.).

Distribution: Terrestrial along shaded roadsides, trek paths, etc. Between 600 to 1300 m.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Kummattanthodu, 11° 5' 33.36" N, 76° 26' 44.16" E, 1020 m, 22 October 2019, Thulasi, 14455 (ZGC); Poochippara to Walakkad trek path, 11° 8' 0.96" N, 76° 24' 42.84" E, 1140 m, 28 December 2019, Thulasi, 14681 (ZGC); Agali, Ommala, 11° 3' 35.64" N, 76° 36' 39.96" E, 730 m, 14 November 2021, Thulasi, 14938 (ZGC); Thrissur District, Athirapally-Malakkappara roadside, 10° 17' 47.76" N, 76° 47' 38.76" E, 930 m, 14 February 2021, Thulasi, 14850 (ZGC).

Tectaria wightii (C.B.Clarke) Ching, *Sinensia* 2: 28, t. 10. 1931; Manickam & Irud., *Pterid. Fl. W. Ghats S. India*, 258. Pl. 199. 1992; Fraser-Jenkins *et al.*, *Anno. Checklist Indian Pterid.*, 365. 2018.

Nephrodium wightii C.B.Clarke, *Trans. Linn. Soc. London, Bot.* 1: 538. 1880.

Tectaria macrocarpa (Bedd.) B.K.Nayar & Geev., *Bull. Bot. Surv. India* 28: 134. 1988; Nayar & Geev., *Fern Fl. Malabar* 222. 1993

Aspidium polymorphum var. *macrocarpum* Bedd., *Ferns S. India* 40, t. 117. 1864, *nom. nud.*

Rhizome short creeping, 7-13 cm long, 1.5-2 cm thick, scaly at apex; scales lanceolate, 4-5 x 0.5-1 mm, dark brown, edges pale, margin with projecting cells. Stipes clustered, 50-55 x 0.6-0.8 cm, base dark brown and scaly, above grey brown and glabrous. Lamina ovate, 48-50 x 23-25 cm, simple pinnate, terminal pinna same as lateral ones, apex acuminate, base cuneate, pinnae about 6 pairs, lanceolate, ascending, suddenly narrowed towards the apex, apex acuminate, base cuneate, margins entire, midrib slightly raised and rounded abaxially, not raised and slightly grooved adaxially; veins raised and distinct abaxially, copiously anastomosing, forms areolas of various shapes, with one included veinlet; pinnae pale green, glabrous, herbaceous; fertile pinnae smaller than sterile ones, numerous sori abaxially on the veins in 2 rows; sori round, ex-indusiate; spores ellipsoid, pale brown. (Plate 4.70: Fig. a-g.; Plate 4.88: Fig. a.).



Plate 4.69: a-f. *Tectaria coadunata* (J.Sm.) C.Chr. a. Habitat b. Habit c. Rhizome d. Scale e. Frond f. Sori. g-m. *Tectaria paradoxa* (Fée) Sledge g. Habitat h. Habit i. Frond j. Rhizome k. Scale l. Sporophyll m. Sori.

Distribution: Terrestrial along shaded land cuttings, stream sides and forest floor. Between 80 to 2300 m.

Specimen/s examined: Kerala: Palakkad District, Mannarkkad, Siruvani, 10° 58' 55.56" N, 76° 36' 1.8" E, 700 m, 20 September 2019, Thulasi, 14414 (ZGC); Silent Valley National Park, Kummattanthodu, 11° 5' 48.84" N, 76° 27' 19.8" E, 1030 m, 22 October 2019, Thulasi, 14476 (ZGC); Sairandhri to Poochippara, 11° 3' 57.96" N, 76° 32' 10.68" E, 550 m, 26 December 2019, Thulasi, 14625 (ZGC); Sispara to Anginda trek path, 11° 11' 20.04" N, 76° 27' 35.64" E, 2280 m, 30 December 2019, Thulasi, 14720 (ZGC); Agali, Ommala, 11° 3' 35.64" N, 76° 36' 39.96" E, 730 m, 14 November 2019, Thulasi, 14922 (ZGC); Thrissur District, Athirappilly-Malakkappara roadside, 10° 17' 47.76" N, 76° 47' 38.76" E, 930 m, 14 February 2021, Thulasi, 14851 (ZGC).

Oleandraceae Ching ex Pic.Serm., *Webbia* 20. 2: 745. 1965.

Oleandra Cav., *Anales Hist. Nat.* 1(2): 115. 1799.

Oleandra musifolia (Bl.) Presl, *Epim. Bot.* 42. 1849; Nayar & Geev., *Fern Fl. Malabar* 258. 1993; Fraser-Jenkins *et al.*, *Anno. Checklist Indian Pterid.*, 3. 35. 2021.

Rhizome long creeping, more than 40 cm long, branched, 3-4 mm thick, dorsiventrally compressed, bearing scattered thick wiry roots; scale peltate, narrowly ovate, 5-8 x 0.8-1 mm, dark brown around the centre, lighter towards margin, base broadly lobed, tip gradually narrowed, margin nearly smooth with slender elongated uniseriate hairs. Frond scattered, stipe 8-15 x 0.7-1 mm, dorsally grooved. Lamina simple, erect, elongate-elliptic, 20-30 x 2.5-3.5 cm, margin entire or undulate with cartilaginous edge, base narrowly broad or cuneate, apex acute; lamina thin coriaceous, yellowish-brown when dry. Venation free, spreading lateral veins, forked at extreme base. Fertile fronds similar to sterile fronds, having irregular rows of sori either side close to mid-rib; sori indusiate, indusium semi-circular. Spore bilateral, pale brown.

Distribution: Epiphytic on shady areas, between 800 to 1800 m.

Notes: This species is included here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen examined: Kerala: Palakkad District, Silent Valley, Punnamala adivaram, Nayar and Party, 10659 (CALI); Valiyaparathodu, M.C. Nair, 64376 (MH). Tamil Nadu: Coimbatore, Sebastian, 17276 (MH).

Davalliaceae M. R. Schomb., Reis. Brit.-Guinea 2: 883. 1848.

Key to Genera

- 1. Indusia attached except at the very tip ***Davallia***
- 1. Indusia attached at base only ***Katoella***

Davallia Sm., Mem. Acad. Roy. Sci. Turin 5: 414, t. 9, f. 6. 1793.

Note: Tsutsumi *et al.* (2016) treated members of Davalliaceae under a single genus *Davallia* with seven sections. However, it was not well accepted by many. Multi-generic treatment as followed by Fraser-Jenkins *et al.* (2021) is followed here.

Davallia trichomanoides Blume, Enum. Pl. Javae 2: 238. 1828; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 180. 2021.

Davallia bullata sensu Bedd., Ferns S. India 6, t. 17. 1864; Manickam & Irud., Pterid. Fl. W. Ghats S. India 132. Pl. 103. 1992; Nayar & Geev., Fern Fl. Malabar 263. 1993, *non* Wall. ex Hook., Sp. Fil. 1: 169, f. 50 B, 1864.

Rhizome long creeping, more than 20 cm long, branched, slender, 0.4-0.5 cm thick, covered by scales; scales ovate-lanceolate, spreading, attached by centre, 4-5 x 1-1.8 mm wide, periphery yellowish-brown, centre dark brown, distal part abruptly acuminate, margin ciliate, long cilia perpendicular to the margin, longer than the width of the scale in narrow region. Stipes scattered, 10-11 x 0.2-0.3 cm, 1-2 cm apart, brown, rounded abaxially, flattened adaxially, glabrous, either side with narrow wings up to costa and rachis. Lamina deltoid, 17-20 x 16-20 cm, base wide and cuneate, apex acute, below tri pinnatifid, above bipinnatifid, primary pinnae about 12 pairs, spreading, basal pairs subopposite, others alternate, small stalked, 2-

3 cm apart, basal most pair largest, then progressively reduced; basal largest primary pinna 12-13 x 7-8 cm, deltoid narrowly, apex acuminate; secondary pinnae about 12 pairs in the largest basal pinna, stalked, basal pairs subopposite, others alternate, about 1 cm apart, largest secondary pinna ovate, 4-5 x 2.5-3 cm, acute, acroscopic base truncate, basiscopic base cuneate; tertiary pinnae about 6 pairs, basal pairs subopposite, others alternate, largest pinna ovate, 1-5 x 0.8-1 cm, acute, basiscopic base cuneate, acroscopic base truncate, green when fresh, brown when dry, margins lobed; lobes sessile, elliptic, entire, acute, costa and costule winged; veins distinct, glabrous all over, free; coriaceous. Sori submarginal, at the vein ends; elongated, indusiate; indusium attached except at the very tip. Spores reniform, brown. (Plate 4.70: Fig. h-n.; Plate 4.85: Fig. g.).

Distribution: Epiphytic in evergreen forests. Between 500 to 2400 m.

Specimen/s examined: Kerala: Idukki District, Mathikettan Shola National Park, 9° 58' 47.28" N, 77° 14' 12.84" E, 1400 m, 1 August 2019, Thulasi & Manju, 14377 (ZGC); Palakkad District, Silent Valley National Park, Kummattanthodu, 11° 5' 48.84" N, 76° 27' 19.8" E, 1030 m, 22 October 2019, Thulasi, 14487 (ZGC); Kunthipuzha trek path, 11° 5' 45.24" N, 76° 26' 51" E, 916 m, 22 October 2019, Thulasi, 14513 (ZGC); Parathodu, 11° 5' 51" N, 76° 26' 48.84" E, 920 m, 24 October 2019, Thulasi, 14537 (ZGC); Parambikulam Tiger Reserve, Karimala, 10° 28' 58.8" N, 76° 50' 56.4" E, 530 m, 5 December 2019, Thulasi, 14585 (ZGC); Bhavani, Thudukki-Chindakki, 11° 8' 7.08" N, 76° 30' 19.44" E, 1370 m, 2 October 2021, Thulasi, 14902 (ZGC).

Katoella Fraser-Jenk. in Fraser-Jenkins *et al.*, Ferns Fern-Allies Nepal 1: 33. 2015.

Katoella pulchra (Don D.) Fraser-Jenk., Kandel & Pariyar, Fern Fern-allies Nepal 1. 34, 2015; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 74. 2021.

Davallia pulchra D.Don, Prodr. Fl. Nepal. 2. 1825.

Araiostegia pulchra (D.Don) Copel., Philipp. J. Sci. 34(3): 241. 1927; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 132. Pl. 104. 1992; Nayar & Geev., Fern Fl. Malabar 263. 1993.

Davallodes pulchra (D.Don) M.Kato & Tsutsumi, Acta Phytotax. Geobot. 59(1): 13. 2008.

Rhizome creeping, about 7-10 cm long, 7-8 mm thick, branched, covered by scales; scales ovate, uniformly yellowish-brown and a dark spot just above the base, membranous, translucent, apex obtuse, margins entire. Stipes about 2 cm apart, about 17-19 x 0.3-0.4 cm, stramineous, rounded below, grooved above, base scaly, upper part glabrous. Lamina ovate, 40-45 x 20-22 cm, narrowing towards apex, apex acute, base narrowly cuneate, tripinnatifid; primary pinnae about 12 pairs, stalked, ascending, base subopposite, above alternate, obliquely ovate-lanceolate, 20-22 x 10-12 cm, apex acuminate, base cuneate; secondary pinnae in the basal pairs of primary pinnae about 12 pairs, unequal in basal part, shortly stalked, alternate, apex acute, ovate; tertiary pinnae about 10 pairs, alternate, ovate, stalked, 1.5-2 x 0.6-1 cm, apex acute; pinnules about 4 per tertiary pinna, adnate, alternate, apex bifid, apex acute, base cuneate, margin deeply lobed; veins minutely distinct above and below, forked according to lobes, free, not reaching the margins; lamina light green, glabrous; chartaceous; rachis, rachules and rachilets shortly winged. Sori in the apical forking points, indusiate; indusia attached at base only, glabrous; spores reniform, brown. (Plate 4.71: Fig. a-f.; Plate 4.85: Fig. h.).

Distribution: Epiphytic in evergreen forests. Between 900 to 1500 m.

Specimen/s examined: Kerala: Idukki District, Mathikettan Shola National Park, 9° 58' 47.28" N, 77° 14' 12.84" E, 1400 m, 1 August 2019, Thulasi, 14371 (ZGC). Tamil Nadu: Mukurthi National Park, Bankitapal, 11° 13' 24.96" N, 76° 32' 1.68" E, 2371 m, 27 February 2022, Maya, 15013 (ZGC).

Polypodiaceae Bercht. & J.Presl, Delic. Prag. 159. 1822.

Note: The classification of Polypodiaceae, especially at the subfamily levels, has undergone tremendous changes. Based on the morpho-molecular features Wei and Zhang (2022) suggested nine subfamilies; and also many changes in generic delimitation. Most of which are yet to be widely accepted. The treatment followed in Fraser-Jenkins *et al.* (2021) is adopted here.

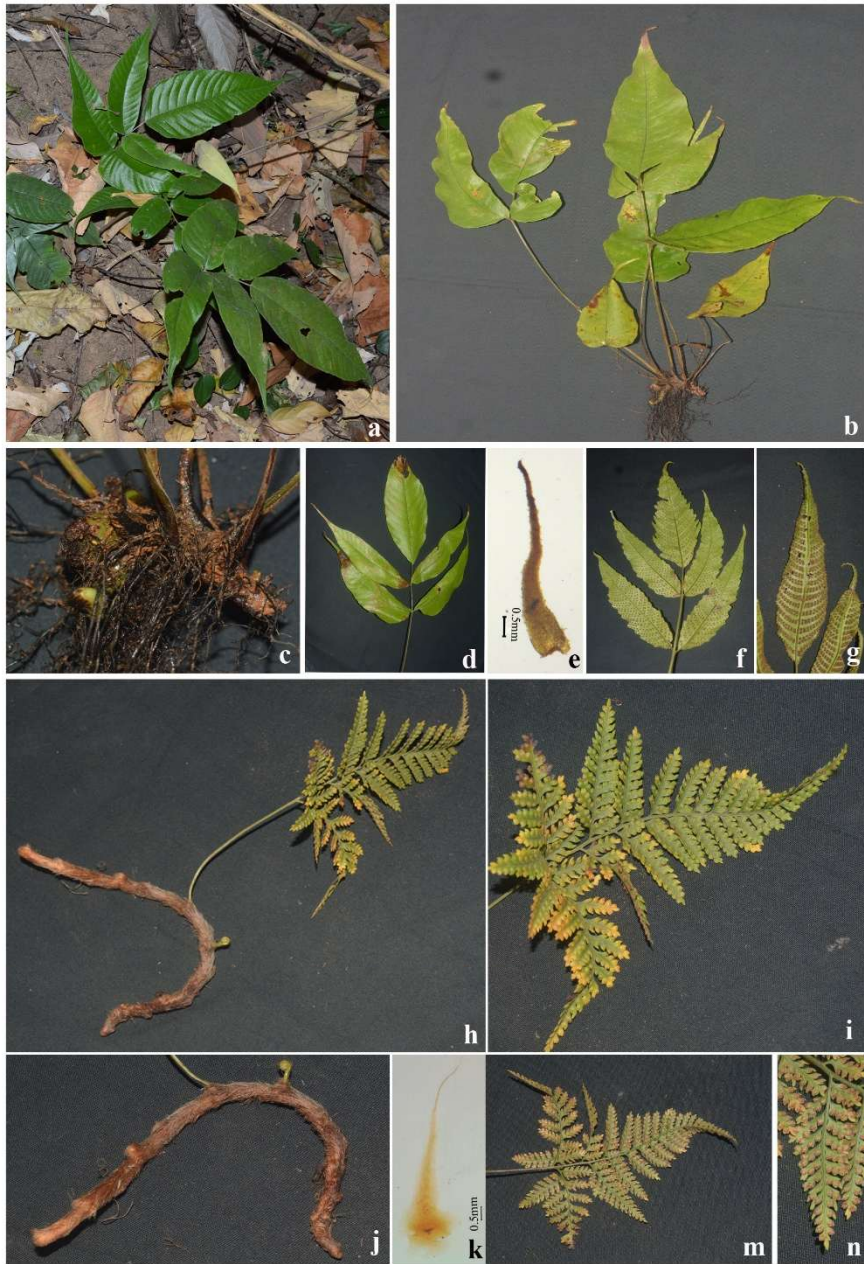


Plate 4.70: a-g. *Tectaria wightii* (C.B.Clarke) Ching a. Habitat b. Habit c. Rhizome d. Frond e. Scale f. Sporophyll g. Sori. h-n. *Davallia trichomanoides* Blume h. Habit i. Sporophyll j. Rhizome k. Scale m. Abaxial surface of sporophyll n. Sori.

Key to Genera

1. Fronds pinnately lobed 2
1. Fronds entire 3
2. Nest leaves present *Drynaria*
2. Nest leaves absent *Selliguea*
3. Fronds densely covered with stellate hairs *Pyrrrosia*
3. Fronds usually glabrous, rarely scaly or with simple hairs 4
4. Fronds dimorphic, sori acrostichoides *Leptochilus*
4. Fronds not dimorphic, sori not acrostichoides 5
5. Sori linear *Loxogramme*
5. Sori rounded 6
6. Sori on either side of midrib, in a single row 7
6. Sori numerous, all over on the abaxial surface *Microsorium*
7. Lamina glabrous *Lepisorum*
7. Lamina sparsely or densely scaly all over *Oreogrammitis*

Drynaria (Bory) J.Sm., Hooker J.Bot. 4: 60. 1841. *nom. cons.*

Drynaria quercifolia (L.) J.Sm., Hooker J. Bot. 3: 398. 1841; Bedd., Ferns S. India 63 t. 186, 1864 & Handb. Fern Br. India 341, t. 191. 1883; Manickam, Fern Fl. Palni Hills 149, 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 312. Pl. 238. 1992; Nayar & Geev., Fern Fl. Malabar 382. 1993; Nampy & Madhus., Fern Fl. S. India Tax. Rev. Polypodioid Ferns 45. 1998; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 104. 2021.

Polypodium quercifolium L., Sp. Pl. 2: 1087. 1753.

Aglaomorpha quercifolia (L.) Hovenkamp & S.Linds., Gard. Bull. Singapore 69(1): 152. 2017.

Rhizome short creeping, more than 15 cm long, 4-5 cm thick, densely scaly; scales linear-lanceolate, 10-12 x 1-2 mm, uniformly pale brown, apex long acuminate, margins dentate-ciliate; nest leaves ovate, 22-24 x 15-17 cm, apex acute, margins shallowly lobed, midrib and veins raised on both surface, secondary and tertiary veins slightly raised on both surface, veins interconnected; stipes 20-22 x 0.6-1 cm, grey-brown, rounded below, grooved above, narrowly winged either side, glabrous.

Lamina oblong, 75-80 x 48-50 cm, pinnately lobed, ended by a terminal pinnule same as lateral ones, base decurrent; lobes 10-12 pairs, basal pairs reduced; largest lob 23-25 x 4-5 cm, oblong-lanceolate, apex acute, margins entire, base decurrent; costa and veins raised abaxially and adaxially, interconnected by veinlets, areoles free from included veinlets; pinnae green, glabrous, coriaceous. Sori on the juncture of veins, 2 rows along primary veins, orbicular, ex-indusiate; spores reniform, brown. (Plate 4.71: Fig. g-m.).

Distribution: Most common species, epiphytic or lithophytic, and also on walls. From low altitude to 1400 m.

Specimen/s examined: Kerala: Palakkad District, Mannarkkad, Meenvallam, 10° 55' 24.96" N, 76° 33' 51.84" E, 85 m, 11 September 2018, Thulasi & Jisha, 14213 (ZGC); Virgin Valley, 11° 2' 42.72" N, 76° 26' 33" E, 79 m, 24 November 2018, Thulasi, 14293 (ZGC); Olavakkode, Dhoni, 10° 51' 34.2" N, 76° 37' 21.72" E, 120 m, 13 September 2018, Thulasi & Maya, 14233 (ZGC); Parambikulam Tiger Reserve, Karimala, 10° 25' 10.92" N, 76° 46' 46.2" E, 700 m, 7 December 2019, Thulasi, 14619 (ZGC); Walayar, Akamalavaram, 10° 52' 7.32" N, 76° 42' 43.2" E, 212 m, 02 January 2020, Thulasi & Maya, 14738 (ZGC); Nelliampathy, Cheriya Govinda mala, 10° 30' 38.232" N, 76° 41' 42" E, 987 m, 3 November 2020, Thulasi & Maya, 14798 (ZGC); Maattumala, 10° 32' 4.2" N, 76° 43' 18.12" E, 1300 m, 4 November 2020, Thulasi & Maya, 14821 (ZGC); Ottappalam, Nhangattiri, 10° 47' 13.92" N, 76° 10' 51.6" E, 25 m, 17 May 2022, Thulasi, 15035 (ZGC); Thrissur District, Peechi, 10° 32' 17.88" N, 76° 25' 2.64" E, 160 m, 10 July 2021, Thulasi, 14857 (ZGC).

Lepisorus (J.Sm.) Ching, Bull. Fan Mem. Inst. Biol. 4(3): 47, 56-58. 1933,
nom. cons.

Key to species

1. Rhizome short creeping; 2-4 cm long, scale apex acuminate, margin dentate; lamina elliptic-lanceolate *L. contortus*
1. Rhizome long creeping; 4-9 cm long, scale apex acute, margin entire; lamina linear-lanceolate *L. nudus*

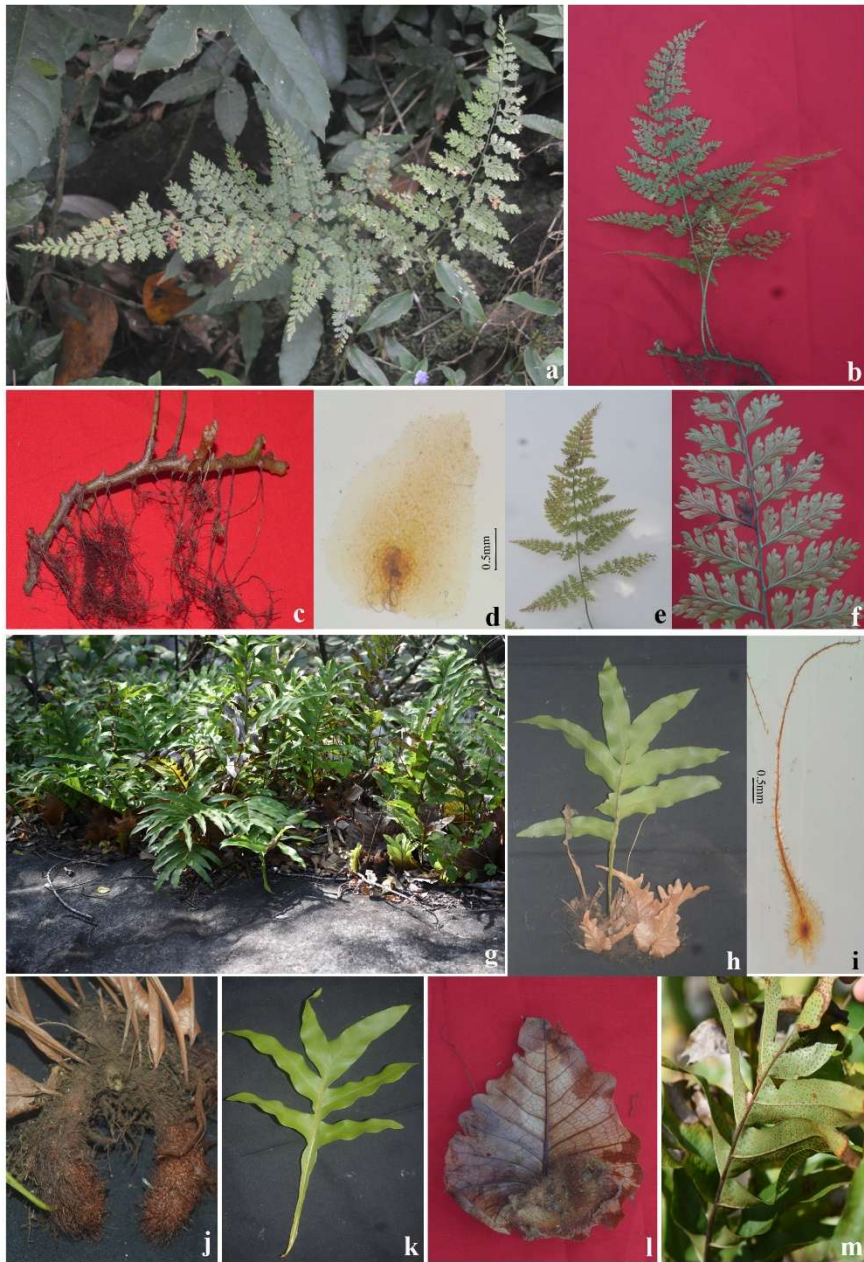


Plate 4.71: a-f. *Katoella pulchra* (D. Don) Fraser-Jenk. a. Habitat b. Habit c. Rhizome d. Scale e. Sporophyll f. Sori. g-m. *Drynaria quercifolia* (L.) J.Sm. g. Habitat h. Habit i. Scale j. Rhizome k. Frond l. Nest leaf m. Sori.

Lepisorus contortus (Christ) Ching, Bull. Fan Mem. Inst. Biol. 4(3): 90-91. 1933; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 121. 2021.

Polypodium lineare var. *contortum* Christ, Nuov. Giorn. Bot. Ital. n. s. 4: 98. 1897.

Lepisorus amaurolepidus (Sledge) Bir & Trikhan in Vasudeva, J. Bomb. Nat. Hist. Soc. 68: 192. 1971; Handb. Fern Br. India 341. t.191. 1883; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 312. Pl. 253. 1992; Nayar & Geev., Fern Fl. Malabar 387. 1993; Nampy & Madhus., Fern Fl. S. India Taxo. Rev. Polypodioid Ferns 52. 1998.

Rhizome short creeping, 2-4 cm long, 2-3 mm thick, densely scaly; scales peltate, 1-2 x 0.8-1 mm, bicolorous distinctly, dark brown at centre with thick walled cells, light brown at periphery with thin walled cells, apex acuminate, margins dentate. Stipes crowded, about 5 mm apart, 1-2 cm x 0.1-0.2 mm, rounded below, grooved above, scaly at base, glabrous above. Lamina simple, elliptic-lanceolate, 20-22 x 1-2 cm, middle part wider than both ends, base cuneate and decurrent, apex acute, margins entire; mid rib raised and rounded above and below, veins indistinct, anastomosing; both sides of lamina dark green, herbaceous to chartaceous. Sori superficial, one per areole, in 2 rows, median, usually in distal half, hemispherical, about 4 mm diameter; spores planoconvex, light brown. (Plate 4.72: Fig. a-f.; Plate 4.85: Fig. i.).

Distribution: Epiphytic or lithophytic in shaded areas. Between 500-2100 m.

Specimen/s examined: Kerala: Idukki District, Pampadum Shola National Park, Kuttikkad, 10° 7' 35.4" N, 77° 15' 29.88" E, 1900 m, 30 July 2019, Thulasi, 14336 (ZGC); Palakkad District, Parambikulam Tiger Reserve, Karimala, 10° 28' 58.8" N, 76° 50' 56.4" E, 530 m, 5 December 2019, Thulasi, 14586 (ZGC); Silent Valley National Park, Poochippara to Walakkad trek path, 11° 6' 38.16" N, 76° 25' 20.64" E, 1070 m, 28 December 2019, Thulasi, 14657 (ZGC); Sispara to Anginda trek path, 11° 11' 20.04" N, 76° 27' 35.64" E, 2280 m, 30 December 2019, Thulasi, 14716 (ZGC); Bhavani, Thudukki-Chindakki, 11° 8' 4.272" N, 76° 30' 31.68" E, 1260 m, 2 October 2021, Thulasi, 14888 (ZGC). Tamil Nadu: Kodaikanal, 10° 15' 23.04" N,

77° 31' 43.68" E, 1550 m, 18 November 2019, Thulasi, 14561 (ZGC).

Lepisorus nudus (Hook.) Ching, Bull. Fan. Mem. Inst. Biol. 4: 83. 1933; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 332. Pl. 252. 1992; Nayar & Geev., Fern Fl. Malabar 388. 1993; Nampy & Madhus., Fern Fl. S. India Taxo. Rev. Polypodioid Ferns 54. 1998; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 134. 2021.

Pleopeltis nuda Hook., Exot. Fl. 1, t. 63. 1823.

Rhizome long creeping, 4-9 cm long, 2-3 mm thick, branched, densely scaly; scales appressed, ovate-lanceolate, 3-4 x 1-2 mm, periphery pale brown, centre dark brown, attached subbasal, apex acute, margins entire. Stipes scattered, 1-2 cm apart, 1-10 x 0.1-0.15 cm, reddish brown, rounded below, grooved above, base scaly, glabrous above. Lamina simple, linear-lanceolate, 4-35 x 2-4 cm, wide in the mid-part, gradually narrowed towards both ends, apex acuminate, base decurrent, margins entire; midrib slightly raised and flattened on both sides, veins indistinct on both surfaces; lamina dark green above, greyish-green below, glabrous, chartaceous to sub coriaceous. Sori superficial, hemispherical, arranged in the distal half of the frond in 2 rows, between margin and midrib, conspicuous, about 5 mm diameter; spores reniform, brown. (Plate 4.72: Fig. g-m.).

Distribution: Epiphytic or lithophytic in fully shaded areas. Between 100-1900 m.

Specimen/s examined: Kerala: Palakkad District, Olavakkode, Dhoni, 10° 51' 30.96" N, 76° 37' 19.92" E, 133 m, 20 November 2018, Thulasi & Maya, 14273 (ZGC); Nelliampathy, Manpara, 10° 33' 30.6" N, 76° 45' 36.72" E, 1265 m, 1 December 2018, Thulasi & Maya, 14296 (ZGC); Vazhakkundu, 10° 31' 6.708" N, 76° 42' 52.2" E, 910 m, 15 January 2020, Thulasi & Maya, 14770 (ZGC); Cheriya Govinda mala, 10° 30' 27.864" N, 76° 41' 45.924" E, 990 m, 3 November 2020, Thulasi & Maya, 14789 (ZGC); Mannarkkad, Siruvani, 10° 58' 32.16" N, 76° 37' 16.68" E, 830 m, 20 September 2019, Thulasi, 14436 (ZGC); Silent Valley National Park, Kummattanthodu, 11° 5' 48.84" N, 76° 27' 19.8" E, 1030 m, 22 October 2019, Thulasi, 14469 (ZGC); Arikampara, 11° 4' 45.12" N, 76° 26' 50.64" E, 1090 m, 24 October 2019, Thulasi, 14548 (ZGC); Poochippara to Walakkad, 11° 8' 0.96" N, 76°



Plate 4.72: a-f. *Lepisorus contortus* (Christ) Ching a. Habitat b. Habit c. Rhizome d. Scale e-f. Sporophyll with sori. g-m. *Lepisorus nudus* (Hook.) Ching g. Habitat h. Habit i. Rhizome j. Frond k. Scale l. Sporophylls m. Sori.

24' 42.84" E, 1140 m, 28 December 2019, Thulasi, 14686 (ZGC); Agali, Ommala, 11° 3' 35.964" N, 76° 36' 39.96" E, 730 m, 14 November 2021, Thulasi, 14934 (ZGC); Idukki District, Pampadum Shola National Park, Pothukandam, 10° 7' 32.34" N, 77° 15' 16.92" E, 1800 m, 29 July 2019, Thulasi, 14331 (ZGC); Mathikettan Shola National Park, 9° 58' 47.28" N, 77° 14' 12.84" E, 1400 m, 1 August 2019, Thulasi, 14360 (ZGC); Choondal, 9° 59' 4.56" N, 77° 14' 46.68" E, 1500 m, 2 August 2019, Thulasi, 14385 (ZGC).

Leptochilus Kaulf., Enum. Fil. Chamisso 147. 1824.

Key to species

1. Fronds monomorphic *L. pteropus* subsp. *minor*
1. Fronds dimorphic 2
2. Rhizome long, 10-20 cm long, climber; scales dark brown *L. axillaris*
2. Rhizome short, 4-10 cm long, not climber; scales pale brown 3
3. Sterile fronds ovate-lanceolate with acuminate or acute apex, herbaceous
..... *L. decurrens*
3. Sterile fronds lanceolate with blunt or rounded apex, subcoriaceous
..... *L. thwaitesianus*

Leptochilus axillaris (Cav.) Kaulf., Enum. Fil. Chamisso 147, t. 1, f.10. 1824; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 318. Pl. 233. 1992; Fraser-Jenk. *et al.*, Anno. Checklist Indian Pterid., 154. 2021.

Acrostichum axillare Cav., Anal. Hist. Nat. 1: 101. 1799.

Nistarika bahupunctika B.K.Nayar, Madhus & Molly, Fern Gaz. 13(1): 33. 1985; Nayar & Geev., Fern Fl. Malabar 404. 1993

Leptochilus bahupunctika (B.K.Nayar, Madhus & Molly) S. Nampy in Nampy & Madhus., Fern Fl. S. India Taxon. Revis. Polypodioid Ferns 59. 1998.

Rhizome slender, short creeping, 10-20 cm long, 2-3 mm thick, climber, green in fresh, black in dry, apex scaly; scales 1-2 x 0.2-0.5 mm, margin toothed, dark brown. Stipes 0.5-1 cm apart, 4-5 cm long in sterile fronds, 20-25 cm long in fertile fronds; sterile lamina elliptic lanceolate, 22-25 x 2.5-3 cm, apex acuminate,



Plate 4.73: a-e: *Leptochilus axillaris* (Cav.) Kaulf. a. Habitat b. Habit c. Rhizome d. Frond e. Scale. f-k. *Leptochilus decurrens* Bl. f. Habitat g. Rhizome h. Scale i. Habit j. Frond k. Sporophyll.

gradually decurrent base; fertile frond 26-30 x 0.3-0.5 cm; acrostichoides sori. Spores reniform, brown. (Plate 4.73: Fig. a-e.).

Distribution: Climber, epiphytic or lithophytic in evergreen forests. Between 400-2100 m.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Kummattanthodu, 11° 5' 48.84" N, 76° 27' 19.8" E, 1030 m, 22 October 2019, Thulasi, 14471 (ZGC); Poochippara to Walakkad trek path, 11° 8' 0.96" N, 76° 24' 42.84" E, 1140 m 28 December 2019, Thulasi, 14683 (ZGC); Walakkad to Sispara trek path, 11° 12' 6.48" N, 76° 26' 24.36" E, 2000 m, 29 December 2019, Thulasi, 14704 (ZGC); Parambikulam Tiger Reserve, Karimala, 10° 28' 58.8" N, 76° 50' 56.4" E, 530 m, 5 December 2019, Thulasi, 14583 (ZGC).

Leptochilus decurrens Bl., Enum. Pl. Jav. 206. 1828; Manickam, Fern Fl. Palni Hills, 147. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 307. Pl. 234. 1992; Nayar & Geev., Fern Fl. Malabar 389. 1993; Nampy & Madhus., Fern Fl. S. India Taxo. Rev. Polypodioid Ferns 61. 1998; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 155. 2021.

Leptochilus metallicus (Bedd.) C.Chr., Index Filic. 386. 1906; Nayar & Geev., Fern Fl. Malabar 392. 1993.

Rhizome creeping, 4-8 cm long, 4-5 mm thick, scaly; scales ovate-lanceolate, 1.5-2 x 0.7-1 mm, uniformly pale brown. Stipes 4.5-5 cm apart, 16-20 cm x 25-30 mm in sterile fronds, rounded below, grooved above, glabrous; lamina ovate-lanceolate, 42-45 x 10-12 cm, apex acuminate, base abruptly decurrent. Fertile fronds 20-22 x 1-1.5 cm, with about 35-37 cm long stipes; spores reniform, brown. (Plate 4.73: Fig. f-k.; Plate 4.88: Fig. g.).

Distribution: Terrestrial or epiphytic along shaded stream sides. Between 900-2200 m.

Specimen/s examined: Kerala: Idukki District, Pampadum Shola National Park, Pothukandam, 10° 7' 32.16" N, 77° 15' 16.92" E, 1800 m, 29 July 2019, Thulasi, 14330 (ZGC); Mathikettan Shola National Park, Choondal, 9° 59' 4.56" N, 77° 14'



Plate 4.74: a-e. *Leptochilus pteropus* subsp. *minor* (Bedd.) Fraser-Jenk. a. Habitat b. Habit c. Rhizome d. Scale e. Young sporophyll. f-j. *Loxogramme involuta* (D.Don) C.Presl f. Habitat g. Habit h. Rhizome i. Scale j. Sori.

46.68" E, 1500 m, 2 August 2019, Thulasi, 14391 (ZGC); Palakkad District, Silent Valley National Park, Kummattanthodu, 11° 5' 33.36" N, 76° 26' 44.16" E, 1020 m, 22 October 2019, Thulasi, 14453 (ZGC); Arikampara, 11° 4' 51.6" N, 76° 26' 36.6" E, 1070 m, 24 October 2019, Thulasi, 14541 (ZGC); Valiyaparathodu-Madhrithodu, 11° 6' 52.2" N, 76° 25' 52.32" E, 910 m, 27 December 2019, Thulasi, 14645 (ZGC); Walakkad to Sispara tek path, 11° 12' 6.84" N, 76° 26' 23.28" E, 2000 m, 29 December 2019, 14690 (ZGC); Walakkad, 11° 12' 2.52" N, 76° 26' 36.852" E, 2100 m, 2 January 2022, Thulasi, 14993 (ZGC); Nelliampathy, Cheriya Govinda mala, 10° 30' 27.72" N, 76° 41' 45.6" E, 990 m, 3 November 2020, Thulasi & Maya, 14787 (ZGC); Bhavani, Thudukki-Chindakki, 11° 8' 7.26" N, 76° 30' 19.44" E, 1370 m, 2 October 2021, Thulasi, 14901 (ZGC).

Leptochilus pteropus subsp. *minor* (Bedd.) Fraser-Jenk. in Fraser-Jenkins *et al.*, Indian J. Forestry 42(4): 311-312. 2020 (“2019”); Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 172. 2021.

Pleopeltis pteropus var. *minor* Bedd., Handb. Ferns Brit. India, 361. 1833.

Kaulinia pteropus (Blume) B.K.Nayar, Taxon 13: 67. 1964; Nayar & Geev., Fern Fl. Malabar 385. 1993.

Kaulinia pteropus var. *minor* (Bedd.) B.K.Nayar & Kaur, Comp. to Bedd. Handb. Ferns Brit. India 87. 1974.

Microsorium pteropus (Bl.) Copel., Univ. Cali. Publ. Bot. 16: 112. 1929; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 326. Pl. 247. 1992; Nampy & Madhus., Fern Fl. S. India Taxo. Rev. Polypodioid Ferns 80. 1998.

Rhizome long creeping, 4-8 cm long, 4-5 mm thick, scaly; scales lanceolate, 4-5 x, 0.7-0.9 mm, light brown, apex long acuminate, margins entire. Fronds scattered, lanceolate, 14-15 x 2.5-3 cm, apex acute, base decurrent, margin entire wavy; midrib raised and rounded abaxially, flattened adaxially; veins distinct on both sides, copiously anastomosing, forms 2 rows of large areoles parallel to midrib and in addition to small areolas which are inside the larger ones; lamina green, thin, form, herbaceous; in lower side of the midrib thin, dark brown, short, linear scales are

distributed, lower surface of frond having short erect stiff trichomes, adaxial surface glabrous. Sori in 2 rows, parallel to midrib; spores reniform, brown. (Plate 4.74: Fig. a-e.).

Distribution: Lithophytic on rocks in running water, in shaded streams. Between 100-200 m.

Specimen/s examined: Kerala: Palakkad District, Mannarkkad, Meenvallam, 10° 55' 25.86" N, 76° 34' 23.88" E, 101 m, 11 September 2022, Thulasi, 15060 (ZGC).

Leptochilus thwaitesianus Fee, Mem. Fam. Foug. 10. 7. Pl. 24, 1865; Nayar & Geev., Fern Fl. Malabar 393. 1993; Nampy & Madhus., Fern Fl. S. India Taxo. Rev. Polypodioid Ferns 70. 1998; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 174. 2021.

Rhizome creeping, 5-10 cm long, 3-4 mm thick, dark brown, sparsely scaly; scales ovate-lanceolate, 3-4 x 0.8-1 mm, pale brown at base, dark brown above, apex acuminate, margin entire with small outgrowths. Fronds scattered; stipe 40-45 x 0.2-0.25 cm in sterile fronds, 10-12 x 0.2-0.25 cm in fertile fronds, grey-brown in dry, abaxially rounded, adaxially grooved, glabrous. Sterile lamina lanceolate, 18-20 x 5-6 cm, base widest, progressively narrowed upwards, apex rounded, base decurrent, margin entire, wavy; midrib raised below; veins distinct, copiously, irregularly anastomosing; lamina dark green, glabrous, texture sub coriaceous. Fertile fronds 20-25 x 1-1.2 cm, oblong, margin entire, base cuneate; sori acrostichoid, all over the lower surface; spores plano-convex, brown.

Distribution: Lithophytic in shaded forests, between 800 to 1400 m.

Notes: This species is included here based on the previous report by Nayar and Geevarghese (1993) from the current study area.

Specimen/s examined: Kerala; Malappuram District, Nilambur, Madhusoodanan 29669 (CALI); Palakkad District, Nelliampathy, Varghese, 17838 (CALI).

Loxogramme (Bl.) Presl., Tent. Pterid. 214, t. 9, fig.8. 1836.

Key to species

1. Scales lanceolate, base yellowish-brown, remaining part pale brown; sori oblique to costa *L. involuta*
1. Scales lanceolate, uniformly brown; sori parallel to costa *L. parallela*

Loxogramme involuta (D.Don) C. Presl, Tent. Pterid. 215. 1836; Bedd., Ferns S. India 17 t. 50, 1864 & Handb. Fern Br. India 393. pl. 228. 1883; Manickam, Fern Fl. Palni Hills, 150. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 314. Pl. 239. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 185. 2021.

Grammitis involuta D.Don, Prodr. Fl. Nepal. 14. 1825.

Rhizome long creeping, 8-12 cm long, 4-5 mm thick, scaly; scales lanceolate, base yellowish-brown, remaining part pale brown, apex acuminate, margins entire. Fronds scattered, 1-2 cm apart, stipes 2-3 cm x 4-5 mm, flattened, winged, scaly at base, linear lanceolate, entire, lamina 40-45 x 2-3 cm, apex acuminate, margins entire, base decurrent; midrib slightly raised and flattened; veins indistinct; lamina succulent, yellowish-green, glabrous, brittle, upper surface smooth. Sori linear, oblique, 3-4 x 1-2 mm, parallel, in distal part, not reaching the margin, ex-indusiate; spores monoletate, reniform, light brown. (Plate 4.74: Fig. f-j.; Plate 4.85: Fig. j.).

Distribution: Epiphytic or lithophytic in shaded forests. Between 1300-2000 m.

Specimen/s examined: Kerala: Idukki District, Pampadum Shola National Park, Kuttikkad, 10° 7' 35.4" N, 77° 15' 29.88" E, 1900 m, 30 July 2019, Thulasi, 14337 (ZGC); Mathikettan Shola National Park, 9° 58' 47.28" N, 77° 14' 12.84" E, 1400 m, 1 August 2019, Thulasi, 14373 (ZGC).

Loxogramme parallela Copel. in Perkins, Fragm. Fl. Philipp. 3: 182. 1905; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 315. Pl. 240. 1992; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 186. 2021.

Rhizome long creeping, 8-12 cm long, 4-5 mm thick, scaly; scales lanceolate 7-8 x

0.2-0.4 mm, uniformly brown, apex long acuminate, margin slightly toothed. Stipes scattered, 1-2 cm apart, 2-3 x 0.1-0.2 cm, pale brown, winged, rounded above and below, scaly at base, glabrous above. Lamina linear-lanceolate, 20-24 x 2-5 cm, apex acuminate, base narrowly cuneate, margins entire; midrib slightly raised on both sides, veins indistinct, yellowish-green, glabrous on both sides, coriaceous. Sori about 10 pairs, oblong, 10-12 x 1-2 mm, basal few pairs parallel to midrib, rest oblique; spores spherical, light brown. (Plate 4.75: Fig. a-f.).

Distribution: Rarely found in current study area, epiphytic in shola forests. Between 2300-2400 m.

Specimen/s examined: Kerala: Palakkad District, Silent Valley National Park, Anginda, 11° 11' 17.88" N, 76° 27' 36.72" E, 2300 m, 30 December 2019, Thulasi, 14710 (ZGC).

Microsorium Link, Hort. Berol. 2: 110.1833.

Key to species

1. Sori in 2 rows along two sides of costa, in cavity **2**
1. Sori numerous, randomly distributed on abaxial surface, not in a cavity **3**
2. Scales sub circular, shield like, black; lamina oblong-deltoid
..... *M. cuspidatum* subsp. *beddomei*
2. Scales deltoid, dark brown at centre, pale at periphery; lamina ovate
..... *M. membranifolium*
3. Rhizome long creeping, 8-15 cm long; scales ovate, apex acute, yellowish-brown, c-shaped spot at centre, periphery pale brown, margin wavy
..... *M. membranaceum*
3. Rhizome short creeping, 4-8 cm long; scales broadly ovate, apex acuminate, uniformly dark brown, margin toothed *M. punctatum*

Microsorium cuspidatum (D.Don) Tagawa. subsp. *beddomei* (S.R.Ghosh) Fraser-Jenk. In Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 3: 194. 2021.

Polypodium cuspidatum D.Don, Prodr. Fl. Nepal. 2.1824 [non C.Presl. 1825].

Microsorium cuspidatum (D.Don) Tagawa in H. Hara, Fl. E. Himal. 495. 1966; Nayar & Geev., Fern Fl. Malabar 397. 1993.



Plate 4.74: a-e. *Leptochilus pteropus* subsp. *minor* (Bedd.) Fraser-Jenk. a. Habitat b. Habit c. Rhizome d. Scale e. Young sporophyll. f-j. *Loxogramme involuta* (D.Don) C.Presl f. Habitat g. Habit h. Rhizome i. Scale j. Sori.

Phymatosorus beddomei S.R. Ghosh, Jour. Econ. Tax. Bot. 6: 433-434. 1985; Nampy & Madhus., Fern Fl. S. India Taxo. Rev. Polypodioid Ferns 95. 1998.

Phymatosorus cuspidatus subsp. *beddomei* (S.R.Ghosh) Fraser-Jenk.; Taxon. Revis. Indian Subcontinental Pteridophytes 55. 2008.

Microsorium beddomei (S.R.Ghosh) Mazumdar, Bull. Bot. Surv. India 61: 30. 2019.

Rhizome long creeping, 10-20 cm long, branched, 1.5-2 cm thick, scaly; scales adpressed, clathrate, subcircular, shield-like, black, pseudo peltate, 5-8 x 4-5 mm, apex terminated by a branched club-shaped glandular cell. Fronds not crowded; stipe 50-60 cm x 4-5 mm, greenish-brown, glabrous. Lamina coriaceous, glabrous, oblong-deltoid, 35-50 x 25-30 cm, deeply pinnatisect; midrib prominent; 7-9 pairs of sub-opposite pinnae like lobes and terminated by a lobe similar to lateral lobes, elongate-lanceolate, narrowed towards base, 20-35 x 1-2 cm, apex long acuminate, margin smooth entire or slightly undulate. Fertile fronds similar to sterile ones; sori in one row on either side of midrib of lobes; spores concavo-convex, yellowish brown. (Plate 4.75: Fig. g-l.; Plate 4.86: Fig. a.).

Distribution: Epiphytic on tree trunks in shaded localities, between 700 to 1500 m.

Specimen/s examined: Kerala: Thrissur District, Athirappilly-Malakkappara roadside, 10° 17' 47.796" N, 76° 47' 38.796" E, 930 m, 14 February 2021, Thulasi, 14849 (ZGC).

Microsorium membranaceum (D. Don) Ching, Bull. Fan. Mem. Inst. Biol. 4: 309. 1933; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 327. Pl. 248. 1992; Nayar & Geev., Fern Fl. Malabar 401. 1993; Nampy & Madhus., Fern Fl. S. India Taxo. Rev. Polypodioid Ferns 78. 1998; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 199. 2021.

Polypodium membranaceum D.Don, Prodr. Fl. Nepal. 2. 1825.

Bosmania membranacea (D.Don) Testo, Syst. Bot. 44(4): 8. 2019.

Rhizome long creeping, 8-15 cm long, 4-5 mm thick, sparsely scaly; scales ovate, 1-

1.5 x 1-2 mm, apex acute, base rounded, yellowish-brown 'c' shaped spot at centre, periphery pale brown, margins wavy. Stipes 1-6 cm x 3-5 mm. Fronds elliptic, in single row adaxially on rhizome, about 0.5-1 cm apart, fronds entire 62-65 x 5-6 cm, apex acute, base decurrent, margin entire; midrib raised below and rounded, above shallowly grooved; veins distinct on both sides, copiously anastomosing, form large areoles, enclosing small areoles with included veinlets; pinnae pale green, glabrous, membranaceous. Sori numerous, randomly distributed abaxially, orbicular; spores reniform, yellow. (Plate 4.76: Fig. a-g.; Plate 4.85: Fig. k.).

Distribution: Epiphytic on fully shaded shola forests. Between 100-1500 m.

Specimen/s examined: Kerala: Palakkad District, Nelliampathy, Manpara, 10° 33' 27.72" N, 76° 44' 40.38" E, 1065 m, 1 December 2018, Thulasi & Maya, 14310 (ZGC); Cheriya Govinda mala, 10° 30' 27.864" N, 76° 41' 45.6" E, 990 m, 3 November 2020, Thulasi & Maya, 14792 (ZGC); Silent Valley National Park, Kummattanthodu, 11° 5' 48.84" N, 76° 27' 19.8" E, 1030 m, 22 October 2019, Thulasi, 14492 (ZGC); Bhavani, Thudukki-Chindakki, 11° 8' 7.26" N, 76° 30' 19.62" E, 1370 m, 2 October 2021, Thulasi, 14896 (ZGC); Idukki District, Mathikettan Shola National Park, 9° 58' 47.28" N, 77° 14' 12.84" E, 1400 m, 1 August 2019, Thulasi & manju, 14369 (ZGC).

Microsorium membranifolium (R.Br.) Ching, Bull. Fan Mem. Inst. Biol., 10(5): 239. 1941; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 201. 2021.

Polypodium membranifolium R.Br., Prodr. Fl. Nov. Holland. 147. 1810.

Phymatosorus nigrescens (Blume) Pic.Serm., Webbia 28(2): 459. 1973; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 317. Pl. 242. 1992; Nayar & Geev., Fern Fl. Malabar 402. 1993; Nampy & Madhus., Fern Fl. S. India Taxo. Rev. Polypodioid Ferns 99. 1998.

Microsorium malabaricum B.K.Nayar & Geev., Fern Fl. Malabar: 399. 1993.

Phymatosorus malabaricus Geev. ex S.Nampy & Madhus., Fern Gaz. 14: 233. 1994.

Rhizome creeping, 10-20 cm long, terete, 2-3 cm thick, green, fleshy, scaly at apex;



Plate 4.75: a-f. *Loxogramme parallela* Copel. a. Habit b. Frond c. Rhizome d. Scale e. Sporophyll f. Sori. g-l. *Microsorium cuspidatum* (D.Don) Tagawa subsp. *beddomei* (S.R.Ghosh) Fraser-Jenk. g. Habitat h. Habit i. Scale j. Rhizome k. Sporophyll l. Sori.

scales deltoid, 4-5 x 4-5 mm, dark brown at centre, pale brown at periphery, apex acute, margin have few outgrowths. Stipes scattered, about 0.8-1 cm apart, 57-60 x 1-1.5 cm, shallowly grooved above, glabrous, brown, glossy. Lamina 95-100 x 56-60 cm, ovate, apex acute, base cuneate, pinnatifid, about 2-10 mm to the midrib; pinnae about 10-12 pairs, alternate, oblong-lanceolate, 40-50 x 2-3 cm, basiscopic base abruptly decurrent, margins entire; costa distinctly raised above, rounded on both sides, copiously anastomosing, forms 2 rows of larger areoles along midrib, larger and small areoles have included veinlets; pinnae dark green, glabrous, herbaceous. Sori up to 25 pairs, submedian, prominent, 1 per large areole, extruded above; spores monolete, reniform, yellowish-green. (Plate 4.76: Fig. h-k.; Plate 4.85: Fig. l.).

Distribution: Epiphytic or lithophytic in fully shaded road sides, stream sides and trek paths. Between 500-1500 m.

Specimen/s examined: Kerala: Idukki District, Mathikettan Shola National Park, 9° 58' 47.28" N, 77° 14' 12.84" E, 1400 m, 1 August 2019, Thulasi & Manju, 14383 (ZGC); Palakkad District, Mannarkkad, Siruvani, 10° 58' 43.428" N, 76° 36' 43.92" E, 830 m, 20 September 2019, Thulasi, 14430 (ZGC); Parambikulam Tiger Reserve, Karimala, 10° 28' 42.96" N, 76° 50' 55.32" E, 600 m, 5 December 2019, Thulasi, 14587 (ZGC).

Microsorium punctatum (L.) Copel., Univ. Calif. Publ. Bot. 16: 111. 1929; Manickam, Fern Fl. Palni Hills, 154. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 328. Pl. 249. 1992; Nayar & Geev., Fern Fl. Malabar 403. 1993; Nampy & Madhus., Fern Fl. S. India Taxo. Rev. Polypodioid Ferns 83. 1998; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 202. 2021.

Acrostichum punctatum L., Sp. Pl. ed. II, 2: 1524. 1763.

Rhizome short creeping, 4-8 cm long, 1-2 cm thick, scaly at apex; scales broadly ovate, 4-5 x 1-1.7 mm, dark brown, apex acuminate, margins sparsely toothed. Fronds arranged closely in 2 rows, fronds entire 85-90 x 8-10 cm, lanceolate, apex acute, margins entire, base decurrent, without a distinct stipe, light brown at base,

midrib rounded below, grooved above; veins slightly distinct on both sides, copiously anastomosing, form large areoles, smaller areoles inside the larger ones with included veinlets; pinnae dark green, glabrous on both surfaces, coriaceous texture. Sori numerous, all over the lower side of the fertile frond, orbicular, with club-shaped paraphyses; spores monolete, reniform, yellowish-green. (Plate 4.77: Fig. a-f.).

Distribution: Epiphytic or lithophytic in shaded forests. Between 500-1500 m.

Specimen/s examined: Kerala: Idukki District, Mathikettan Shola National Park, 9° 58' 47.28" N, 77° 14' 12.84" E, 1400 m, 1 August 2019, Thulasi, 14368 (ZGC); Palakkad District, Mannarkkad, Siruvani, 10° 58' 55.56" N, 76° 36' 1.8" E, 700 m, 20 September 2019, Thulasi, 14413 (ZGC); Silent Valley National Park, Kummattanthodu, 11° 5' 48.84" N, 76° 27' 19.8" E, 1030 m, 22 October 2019, Thulasi, 14472 (ZGC); Valiyaparathodu-Madhrithodu, 11° 6' 49.32" N, 76° 25' 51.6" E, 910 m, 27 December 2019, Thulasi, 14642 (ZGC); Parambikulam Tiger Reserve, Karimala, 10° 25' 15.24" N, 76° 46' 1.2" E, 670 m, 5 December 2019, Thulasi, 14608 (ZGC); Thrissur District, Athirappilly-Malakkappara roadside, 10° 17' 47.76" N, 76° 47' 38.76" E, 930 m, 14 February 2021, Thulasi, 14841 (ZGC).

Oreogrammitis Copel., Phillipp. J. Sci., C, 12; 64. 1917.

Oreogrammitis attenuata (Kunze) Parris, Gard. Bull. Singapore. 58(2): 256. 2007; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 293. 2021.

Grammitis attenuata Kunze, Linnaea 24: 251. 1851; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 336. Pl. 254. 1992; Nayar & Geev., Fern Fl. Malabar 349. 1993; Nampy & Madhus., Fern Fl. S. India Taxo. Rev. Polypodioid Ferns 20. 1998.

Rhizome short creeping, 2-5 cm long, 2-3 mm thick, apex densely scaly; scales ovate-lanceolate, 1-2 x 0.5-0.8 mm, uniformly dark brown, apex acute, margins entire. Stipe tufted, 1-2 x 0.1-0.2 cm, terete, dark brown, covered by stiff, short, brown hairs. Lamina simple, linear to oblong-elliptic, 5-6 x 1-1.5 cm, apex acute, margins entire; midrib raised and rounded above, veins immersed, once forked, free,



Plate 4.76: a-g. *Microsorium membranaceum* (D. Don) Ching a. Habitat b. Habit c. Rhizome d. Sporophyll e. Scale f-g. Sori. h-k. *Microsorium membranifolium* (R.Br.) Ching h. Habitat i. Habit j. Rhizome k. Sori.

lamina dark green, chartaceous to sub coriaceous; densely hairy on the upper surface of the frond, hairs glossy, dark brown, unicellular, slender, 0.8-1 mm long, non-soral region of abaxial surface glabrous. Sori oblong 2-3 x 1-1.5 mm, 2 rows on either side of midrib, on acroscopic veinlet, in young stage protected by paraphyses; paraphyses slender, 1 mm long, brown, arranged around the sorus. Sorus oblong to round, arranged in two rows on either side of midrib. Spores abortive, brown. (Plate 4.77: Fig. g-l.; Plate 4.88: Fig. h.).

Distribution: Epiphytic or lithophytic along stream sides, deeply shaded trek paths in shola and evergreen forests. Between 1300-2100 m.

Specimen/s examined: Kerala: Palakkad District, Bhavani, Perumalmedu, 11° 8' 7.08" N, 76° 30' 19.44" E, 1370 m, 2 October 2021, Thulasi, 14903 (ZGC); Silent Valley National Park, Walakkad to Sispara trek path, 11° 12' 3.96" N, 76° 26' 31.74" E, 2065 m, 3 January 2022, Thulasi, 14985 (ZGC).

Pyrrosia Mirbel in Lamarck et Mirbel, Hist. Nat. Veg. 5: 91. 1802.

Key to species

1. Fronds dimorphic *P. heterophylla*
1. Fronds monomorphic 2
2. Rhizome short creeping, 4-6 cm long; scales brown, margin fimbriate; fronds elliptic or lanceolate *P. porosa*
2. Rhizome long creeping, 10-15 cm long; scales pale brown, margin entire; fronds linear-lanceolate *P. lanceolata*

Pyrrosia heterophylla (L.) M.G.Price, Kalikasan, Philipp. J. Bot. 3: 177. 1974; Nampy & Madhus., Fern Fl. S. India Taxo. Rev. Polypodioid Ferns 113. 1998; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 260. 2021.

Acrostichum heterophyllum L., Sp. Pl. 2: 1067. 1753.

Drymoglossum heterophyllum (L.) Trimen, J. Linn. Soc., Bot. 24: 152. 1887; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 310. Pl. 237. 1992; Nayar & Geev., Fern Fl. Malabar 380. 1993.

Rhizome long creeping, 20-30 cm long, about 0.8-1 mm thick, slender, scaly; scales

ovate, 1-1.5 x 0.5-1 mm, peltate, acuminate apex, brown. Fronds simple, dimorphic; stipes scattered, 4-5 mm long, base scaly; sterile fronds 4.5-5 x 2-3 cm, obovate, glabrous, entire margin, base cuneate, coriaceous texture; veins indistinct, anastomosing; fertile frond longer than sterile fronds, 6-7 x 0.2-0.4 cm, linear, base cuneate, stipes 1-2 cm long. Sori acrostichoid, on lower surface; spores monoletate, reniform, brown. (Plate 4.78: Fig. a-g.; Plate 4.86: Fig. b.).

Distribution: Epiphytic on shaded plantations, roadsides. Between 800-1400 m.

Specimen/s examined: Kerala: Palakkad District, Nelliampathy, Vazhakundu, 10° 31' 6.6" N, 76° 42' 52.2" E, 910 m, 15 January 2020, Thulasi & Maya, 14762 (ZGC); Cheriya Govinda mala, 10° 30' 38.16" N, 76° 41' 42" E, 987 m, 3 November 2019, Thulasi & Maya, 14796 (ZGC); Maattumala, 10° 32' 4.236" N, 76° 43' 18.12" E, 1300 m, 4 November 2020, Thulasi & Maya, 14827 (ZGC).

Pyrrrosia lanceolata (L.) Fawcett, Amer. Middl. Nat. 12: 245. 1930 (*Pyrrrosia lanceolatus*); Manickam, Fern Fl. Palni Hills, 150. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 322. Pl. 245. 1992; Nayar & Geev., Fern Fl. Malabar 408. 1993; Nampy & Madhus., Fern Fl. S. India Taxo. Rev. Polypodioid Ferns 116. 1998; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 261. 2021.

Acrostichum lanceolatum L., Sp. Pl. 2: 1067. 1753.

Rhizome long creeping, more than 15 cm long, 1-2 mm thick, slender, scaly; scales lanceolate, 4-5 x 1-2 mm, uniformly pale brown with reddish brown spot at subbasal zone, apex acuminate, base rounded, margins entire. Stipes scattered, 2-2.5 cm x 1-2 mm, flattened, winged along the margins, pale brown, scaly at base, remaining part covered by stellate hairs. Fronds simple, linear-lanceolate or elliptic, 14-16 x 1-2 cm, apex acute, base decurrent up to winged portion, margins entire; midrib grooved above, veins indistinct, dark green above, brownish below; abaxial surface of the frond covered by stellate hairs, upper surface glabrous, texture coriaceous. Sori irregularly in distal part, orbicular, dark brown, naked; spores reniform, brown. (Plate 4.78: Fig. h-n.).

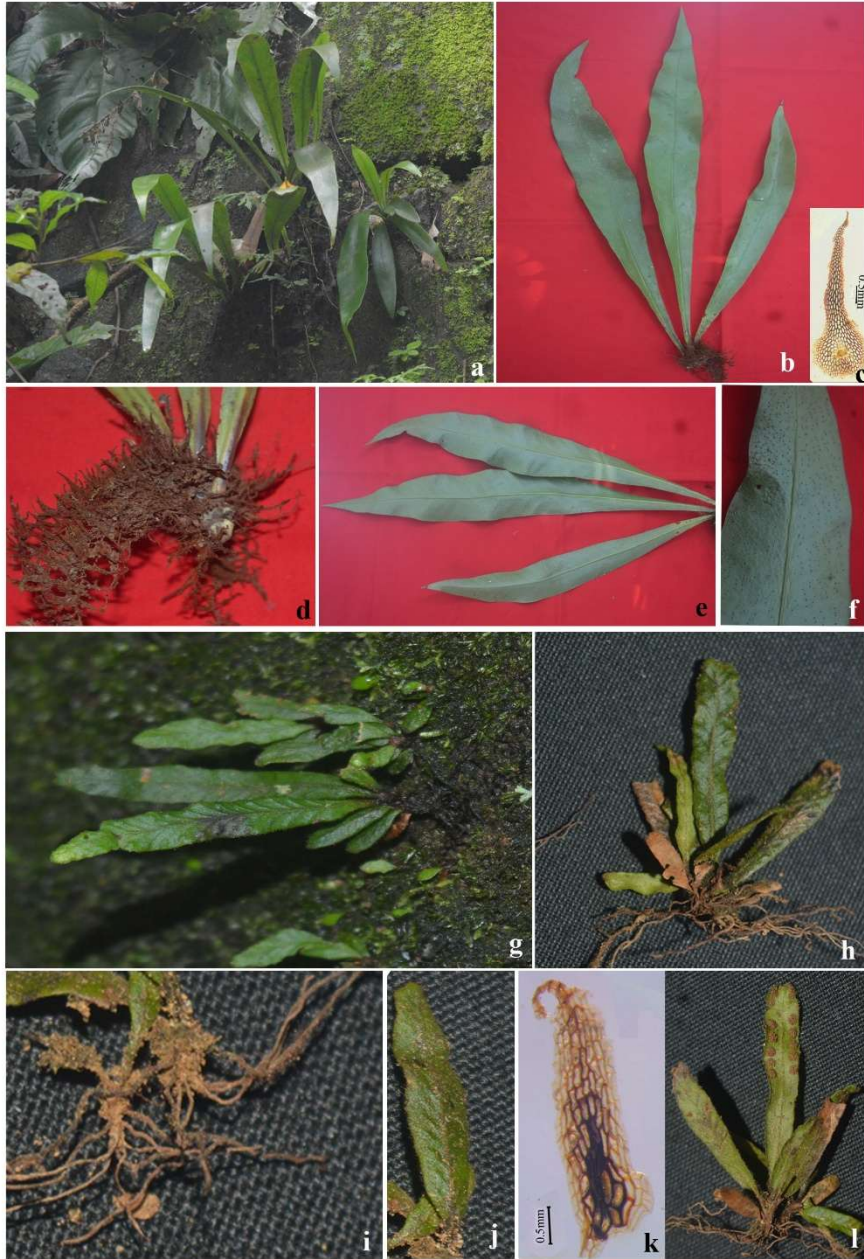


Plate 4.77: a-f. *Microsorium punctatum* (L.) Copel. a. Habitat b. Habit c. Scale d. Rhizome e. Frond - Abaxial surface f. Sori. g-l. *Oreogrammitis attenuata* (Kunze) Parris g. Habitat h. Habit i. Rhizome j. Frond k. Scale l. Sporophyll with sori.

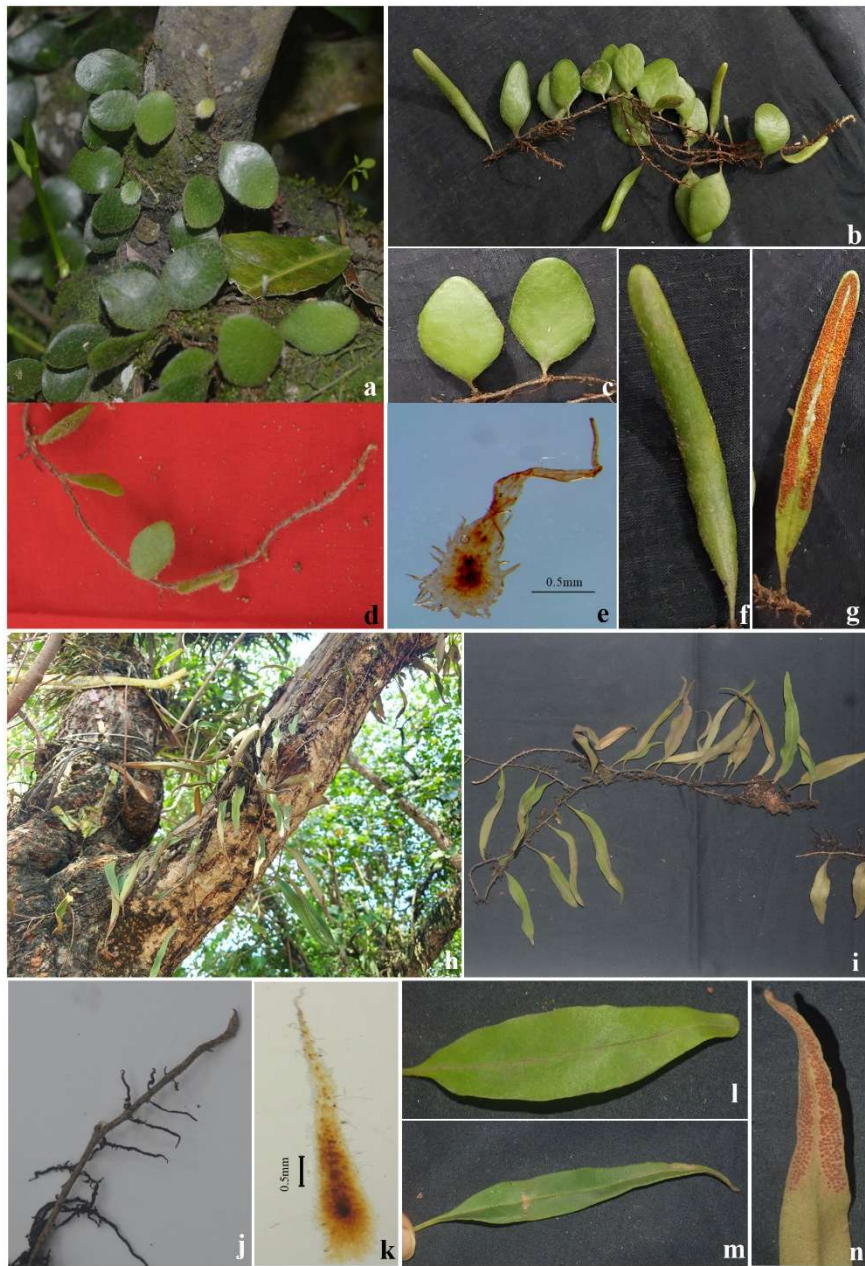


Plate 4.78: a-g. *Pyrrrosia heterophylla* (L.) M.G.Price a. Habitat b. Habit c. Fronds d. Rhizome e. Scale f. Sporophyll g. Sori. h-n. *Pyrrrosia lanceolata* (L.) Farewell h. Habitat i. Habit j. Rhizome k. Scale l. Frond m. Sporophyll n. Sori.

Distribution: Epiphytic or lithophytic in fully or partially shaded places. Between 0-2000 m.

Specimen/s examined: Kerala: Palakkad District, Nelliampathy, Manpara, 10° 33' 27.72" N, 76° 44' 40.2" E, 1065 m, 1 December 2018, Thulasi & Maya, 14300 (ZGC); Silent Valley National Park, Kummattanthodu, 11° 5' 33.36" N, 76° 26' 44.16" E, 1020 m, 22 October 2019, Thulasi, 14325 (ZGC); Parambikulam Tiger Reserve, Karimala, 10° 28' 58.8" N, 76° 50' 56.4" E, 530 m, 5 December 2019, Thulasi, 14454 (ZGC); Walayar, Akamalavaram, 10° 52' 7.32" N, 76° 42' 43.2" E, 212 m, 02 January 2020, Thulasi & Maya, 14581 (ZGC); Idukki District, Pampadum Shola National Park, Pothukandam, 10° 7' 32.34" N, 77° 15' 16.92" E, 1800 m, 29 July 2019, Thulasi & Manju, 14332 (ZGC); Kuttikkad, 10° 7' 35.4" N, 77° 15' 29.88" E, 1900 m, 30 July 2019, Thulasi & Manju, 14339 (ZGC).

Pyrrisia porosa (C.Presl) Hovenkamp, *Blumea* 30(1): 208. 1984; Manickam & Irud., *Pterid. Fl. W. Ghats S. India*, 323. Pl. 246. 1992; Nayar & Geev., *Fern Fl. Malabar* 265. 1993; Nampy & Madhus., *Fern Fl. S. India Taxo. Rev. Polypodioid Ferns* 119. 1998; Fraser-Jenkins *et al.*, *Anno. Checklist Indian Pterid.*, 265. 2021.

Niphobolus porosus C.Presl, *Tent. Pterid.* 202. 1836.

Rhizome short creeping, about 10 cm long, 4-5 mm thick, scaly; scales appressed, lanceolate, 5-6 x 1-1.5 mm, sub-basally attached, brown, apex acuminate, base cuneate or rounded, margins fimbriate. Fronds scattered, simple, monomorphic, elliptic or lanceolate, 32-35 x 2-3 cm wide, widest at almost middle part, narrowed towards both ends, margins entire; midrib slightly raised above, indistinct below; veins immersed, primary veins parallel, secondary veins connect primary veins, forms rectangular areoles; fronds adaxially green, abaxially pale brown and densely covered with stellate, brown, stalked hairs, texture thick coriaceous. Sori numerous, 3-5 in large areoles, distal half of the frond orbicular, protected by stellate hairs; spores reniform, brown. (Plate 4.79: Fig. a-f.; Plate 4.86: Fig. c.).

Distribution: Lithophytic or epiphytic along road sides, stream sides and trek paths. Between 500-2500 m.

Specimen/s examined: Kerala: Palakkad District, Nelliampathy, Manpara, 10° 33' 27.72" N, 76° 44' 40.2" E, 1065 m, 1 December 2018, Thulasi & Maya, 14303 (ZGC); Cheriya Govinda mala, 10° 30' 27.864" N, 76° 41' 45.924" E, 990 m, 3 November 2019, Thulasi & Maya, 14790 (ZGC); Silent Valley National Park, Parathodu, 11° 5' 51" N, 76° 26' 48.84" E, 920 m, 23 October 2019, Thulasi, 14531 (ZGC); Parambikulam Tiger Reserve, Karimala, 10° 28' 58.8" N, 76° 50' 56.4" E, 530 m, 5 December 2019, Thulasi, 14584 (ZGC); Bhavani, Perumalmedu, 11° 8' 7.26" N, 76° 30' 19.62" E, 1370 m, 2 October 2021, Thulasi, 14897 (ZGC); Idukki District, Pampadum Shola National Park, Kuttikkad, 10° 7' 35.4" N, 77° 15' 29.88" E, 1900 m, 30 July 2019, Thulasi, 14333 (ZGC); Mathikettan Shola National Park, 9° 58' 47.28" N, 77° 14' 12.84" E, 1400 m, 1 August 2019, Thulasi, 14374 (ZGC); Choondal, 9° 59' 4.56" N, 77° 14' 46.68" E, 1500 m, 2 August 2019, Thulasi & Manju, 14389 (ZGC). Tamil Nadu: Kodaikanal, 10° 15' 23.04" N, 77° 31' 43.68" E, 1550 m, 18 November 2019, Thulasi, 14564 (ZGC).

Selliguea Bory, Dict. Class. Hist.Nat. 6: 587. 1924.

Selliguea montana (Sledge) Hovenkamp in Shaffer-Fehre & Dassanayake, Revis. Handb. Fl. Ceylon 15B: 344. 2006; Fraser-Jenkins *et al.*, Anno. Checklist Indian Pterid., 121. 2021.

Crypsinus montanus Sledge, Bull. British Mus. Nat. Hist. Bot. 2(5): 145. 1960; Manickam, Fern Fl. Palni Hills 152. 1986; Manickam & Irud., Pterid. Fl. W. Ghats S. India, 318. Pl. 243. 1992; Nayar & Geev., Fern Fl. Malabar 377. 1993.

Phymatopteris montana (Sledge) Pic.Ser., Webbia 28: 463. 1973; Nampy & Madhus., Fern Fl. S. India Taxo. Rev. Polypodioid Ferns 90. 1998.

Rhizome long creeping, more than 10 cm long, 4-5 mm thick, densely scaly; scales ovate-lanceolate, 3-4 x 1-2 mm, base widest, narrowed abruptly towards apex and become acuminate, yellowish-brown, with a dark brown spot at centre of basal part, margins slightly dentate. Stipes scattered, about 1- 2 cm apart, 10-12 x 0.1-0.3 cm, reddish-brown, rounded below, grooved above, scaly at base, glabrous above. Lamina broadly ovate, 10-15 x 8-13 cm wide, apex acute, base broadly cuneate, 2-3

mm to the midrib pinnatifid; pinnae about 5 pairs, opposite, slightly ascending, oblong-lanceolate, about 8-10 cm long, 2 cm wide, apex acuminate, basiscopic base decurrent, and joining the acroscopic base of adjacent pinna, margins broadly notched; midrib raised and rounded below, not raised and flattened adaxially; about 10-15 pairs of major veins, slightly distinct above, anastomosing, form areoles with forked included veinlets; pinnae dark green, glabrous on both sides, herbaceous. Sori median, one per areole, orbicular, prominent, naked; spores reniform, brown. (Plate 4.79: Fig. g-m.; Plate 4.86: Fig. d.).

Distribution: Lithophytic or epiphytic on fully shaded areas. Between 1000-1600 m.

Specimen/s examined: Kerala: Idukki District, Mathikettan Shola National Park, Choondal, 9° 59' 4.56" N, 77° 14' 46.68" E, 1500 m, 2 August 2019, Thulasi & Manju, 14400 (ZGC); Palakkad District, Silent Valley National Park, Arikampara, 11° 4' 45.12" N, 76° 26' 50.64" E, 1090 m, 24 October 2019, Thulasi, 14549 (ZGC).

IV.2. Diversity of Ferns and Lycophytes- an analysis

The floristic studies on pteridophytes in the Palghat Gap and Gap influenced regions are less, as compared to the angiosperms. During the period of Britishers, Col. R.H. Beddome studied the fern flora of British India, especially Southern India. Later, Nair *et al.* (1988, 1992a, 1992b & 1994) studied fern allies and ferns of Kerala and documented 150 species. These floristic works were more concentrated on Southern districts of Kerala than central and Northern districts. Manickam and Irudayaraj (1992) recorded 243 taxa from the area lying south to the Palghat Gap, including parts of Kerala and Tamil Nadu. After that, Nayar and Gheevarghese (1993) documented the fern flora of Malabar area accounting the ferns of northern districts of Kerala and recorded a total of 168 taxa from this region.

There are many studies on animals which analysed the influence of Palghat Gap on the species distribution and speciation, such as Asiatic Elephant (Vidya *et al.*, 2005), Lion-tailed macaque (Ram *et al.*, 2015), Nilgiri tahr (Joshi *et al.*, 2018), some frogs (Gopalan *et al.*, 2014; Vijayakumar *et al.*, 2016), snakes (Mallik *et al.*, 2021) and fishes (Sidharthan *et al.*, 2020). Studies on plants are however, limited to some angiosperm plant species (Bahulikar *et al.*, 2004; Apte *et al.*, 2006; Nair *et al.*, 2019), where results showed that the Palghat Gap acts as a barrier in species distribution or free movement of populations. These studies elucidated that the Gap influences the distribution of these taxa and leads to the evolution in different lineages. It was in this backdrop, the current research has been undertaken to analyse the influence of Palghat Gap, if any, on the distribution of lycophytes and ferns in the Southern Western Ghats, through different dimensions utilising ecological, taxonomical, micro morphological and molecular parameters.

Due to the extent of variations of geographical regimes and the habitat diversity, the Palghat Gap and Gap influenced areas are inhabited by varieties of pteridophytes. In this study, based on the field explorations from 2018 to 2023, a total of 158 taxa belonging to 63 genera and 26 families were recorded. Along with the field observations, for a comprehensive analysis, data on 33 species earlier reported from the parts of the current study area by earlier workers (Nayar and



Plate 4.79: a-f. *Pyrrhosia porosa* (C.Presl) Hovenkamp a. Habitat b. Habit c. Young sporophyll d. Scale e. Rhizome f. Sori. g-m. *Selligaea montana* (Sledge) Hovenkamp g. Habitat h. Habit i. Rhizome j. Frond k. Scale l. Sporophyll m. Sori.

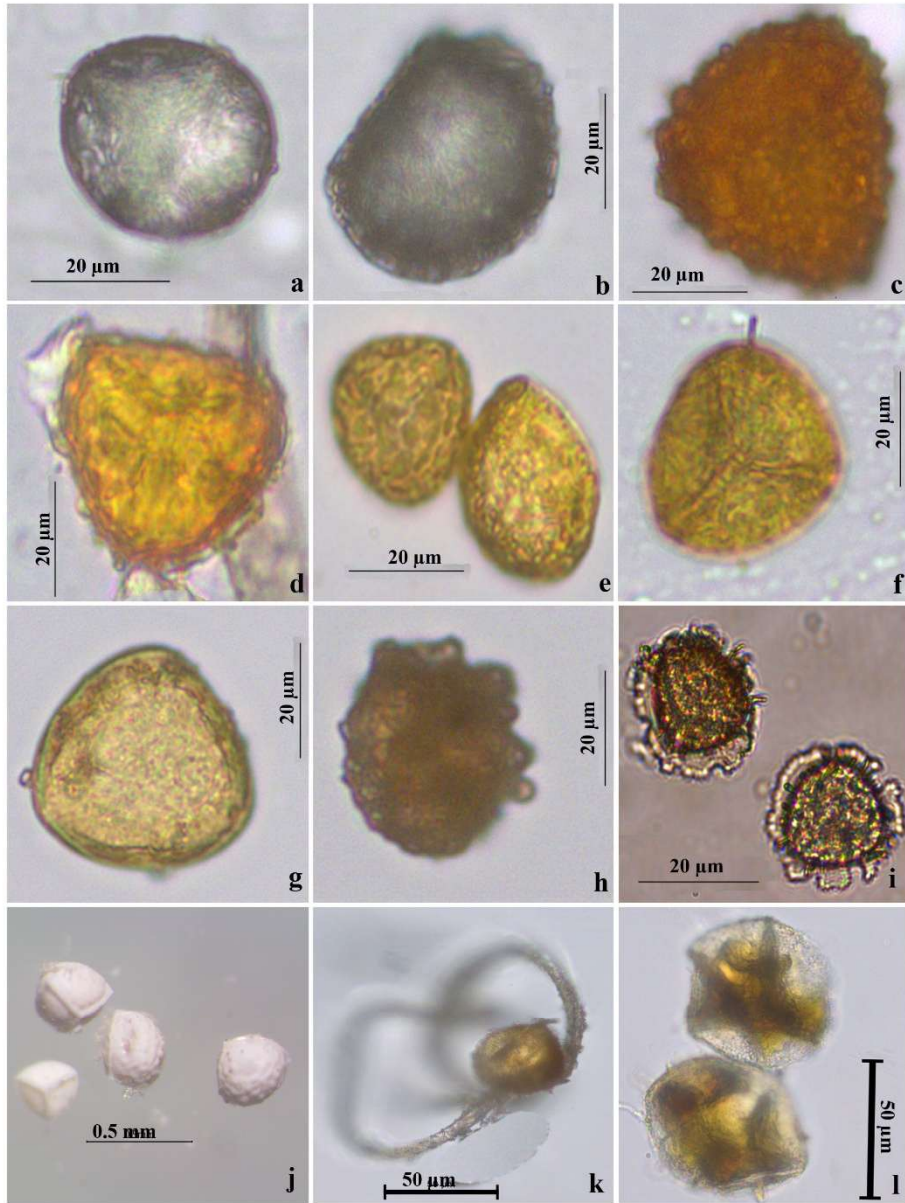


Plate 4.80: Light Microscopic photographs of spores of some taxa collected from the Palghat Gap influenced area a. *Lycopodiella cernua* (L.) Pic.Serm.; b. *Lycopodium wightianum* Grev. & Hook.; c. Microspore of *Selaginella crassipes* Spring; d. Microspore of *Selaginella ciliaris* (Retz.) Spring; e. Microspore of *Selaginella chrysorrhizos* Spring; f. Microspore of *Selaginella miniatospora* (Daiz.) Baker; g. Microspore of *Selaginella tenera* (Hook. & Grev.) Spring; h. Microspore of *Selaginella wightii* Hieron; i. Microspore of *Selaginella delicatula* (Desv. ex Poir.) Alston; j. Megaspore of *Isoetes coromandelina* L.f.; k. *Equisetum ramosissimum* Desf.; l. *Hymenophyllum exsertum* Wall. ex Hook.

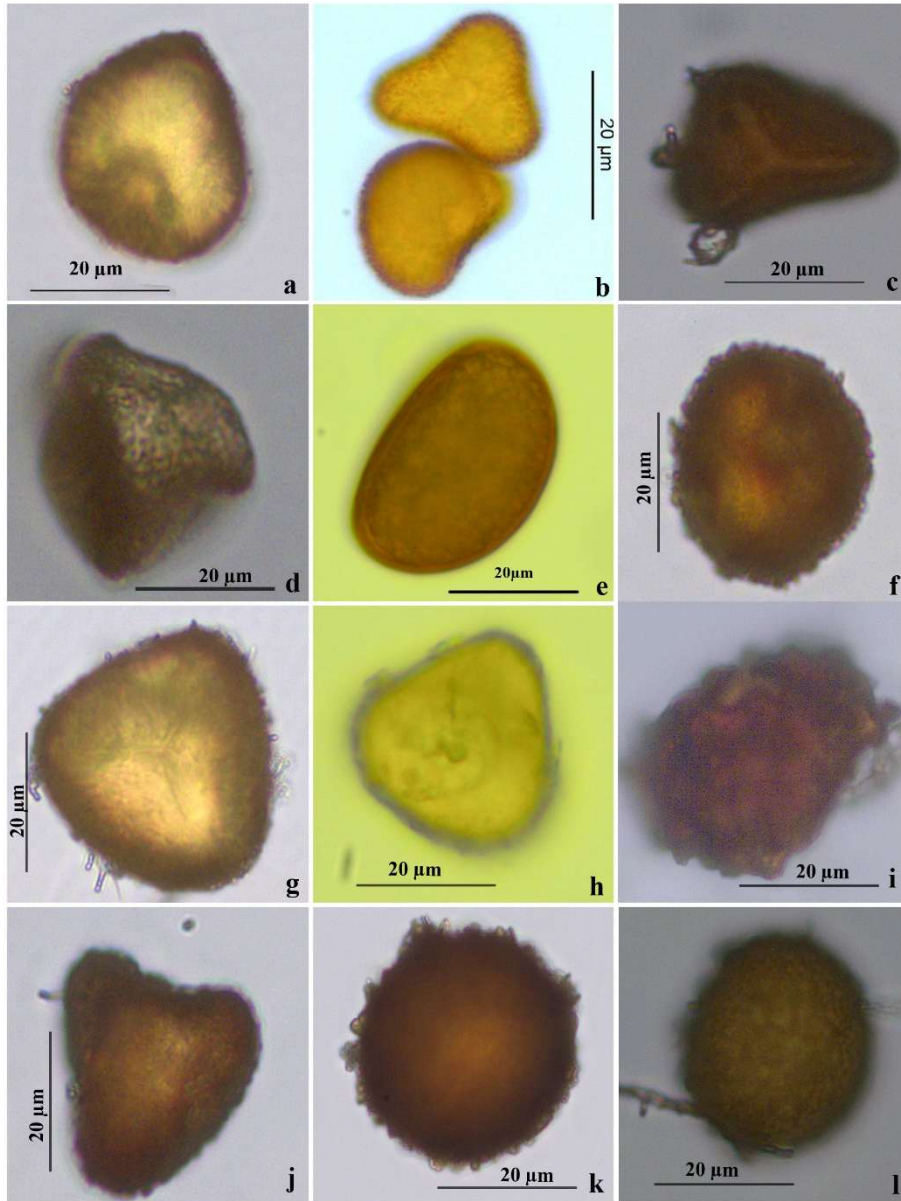


Plate 4.81: Light Microscopic photographs of spores of some taxa collected from the Palghat Gap influenced area a. *Dicranopteris linearis* (Burm.f.) Underw.; b. *Cyathea gigantea* (Wall. ex Hook.) Holttum; c. *Lindsaea ensifolia* Sw.; d. *Lindsaea heterophylla* Dryand.; e. *Odontosoria chinensis* (L.) J.Sm.; f. *Pteridium aquilinum* (L.) Kuhn subsp. *wightianum* (Wall. ex J.Agardh) W.C.Shieh; g. *Adiantum raddianum* C.Presl; h. *Adiantum hispidulum* Sw.; i. *Adiantum latifolium* Lam.; j. *Adiantum zollingeri* Mett. ex Kuhn; k. *Aleuriteopteris bicolor* (Roxb.) Fraser-Jenk.; l. *Aleuriteopteris bullosa* (Kunze) Ching.

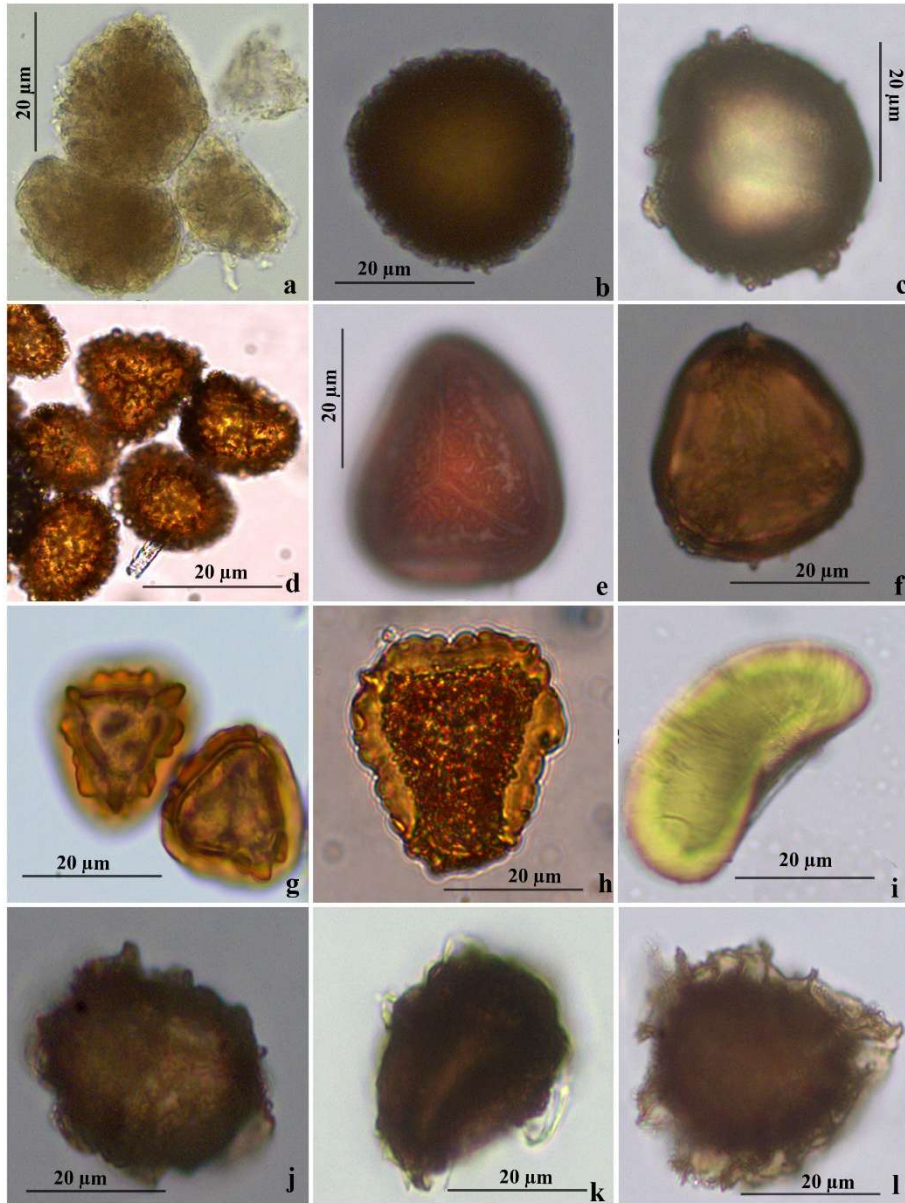


Plate 4.82: Light Microscopic photographs of spores of some taxa collected from the Palghat Gap influenced area a. *Antrophyum plantagineum* Kaulf.; b. *Doryopteris concolor* (Langsd. & Fisch.) Kuhn; c. *Oeosporangium elegans* (Poir.) Fraser-Jenk. & Pariyar; d. *Mickelopteris cordata* (Roxb. ex Hook. & Grev.) Fraser-Jenk.; e. *Pityrogramma calomelanos* (L.) Link; f. *Pteris biaurita* L.; g. *Pteris pellucens* J.Agardh; h. *Pteris cretica* L. Subsp. *laeta* (Wall. ex Ettingsh.) Fraser-Jenk.; i. *Vittaria elongata* Sw.; j. *Asplenium aethiopicum* (Burm.f.) Bech.; k. *Asplenium andreisii* Fraser-Jenk.; l. *Asplenium cheilosorum* Kunze ex Mett.

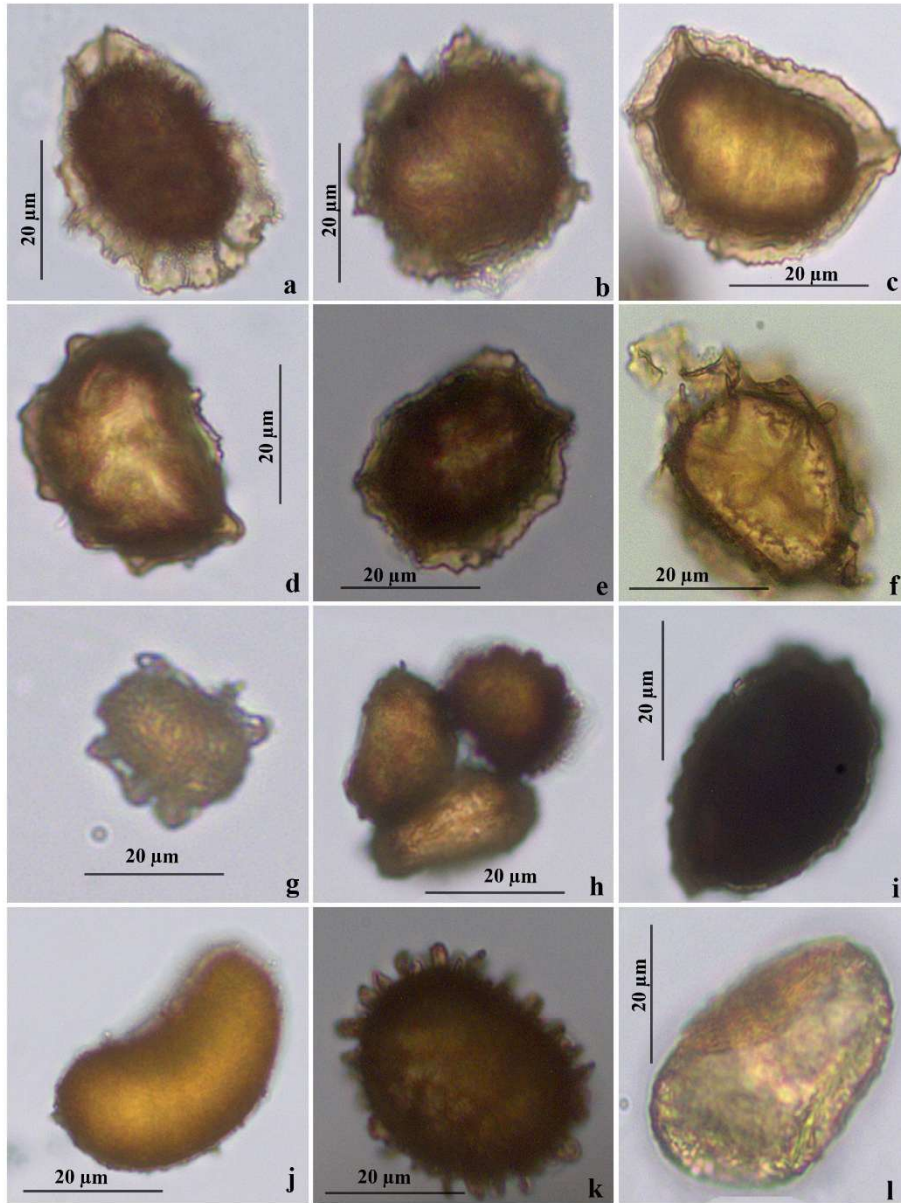


Plate 4.83: Light Microscopic photographs of spores of some taxa collected from the Palghat Gap influenced area a. *Asplenium excisum* C.Presl; b. *Asplenium obscurum* Blume; c. *Asplenium phyllitidis* D.Don; d. *Asplenium mysorensense* Roth; e. *Asplenium laciniatum* D.Don. Subsp. *fraser-jenkinsii* Reichst. ex Pangtey & Khullar; f. *Asplenium zenkerianum* Kunze; g. *Thelypteris dentata* (Forssk.) E.P.St.John; h. *Thelypteris parasitica* (L.) Tardieu; i. *Athyrium hohenackerianum* (Kunze) T.Moore; j. *Athyrium solenopteris* (Kunze) T.Moore; k. *Deparia japonica* subsp. *petersenii* (Kunze) Fraser-Jenk.; l. *Diplazium esculentum* (Retz.) Sw.

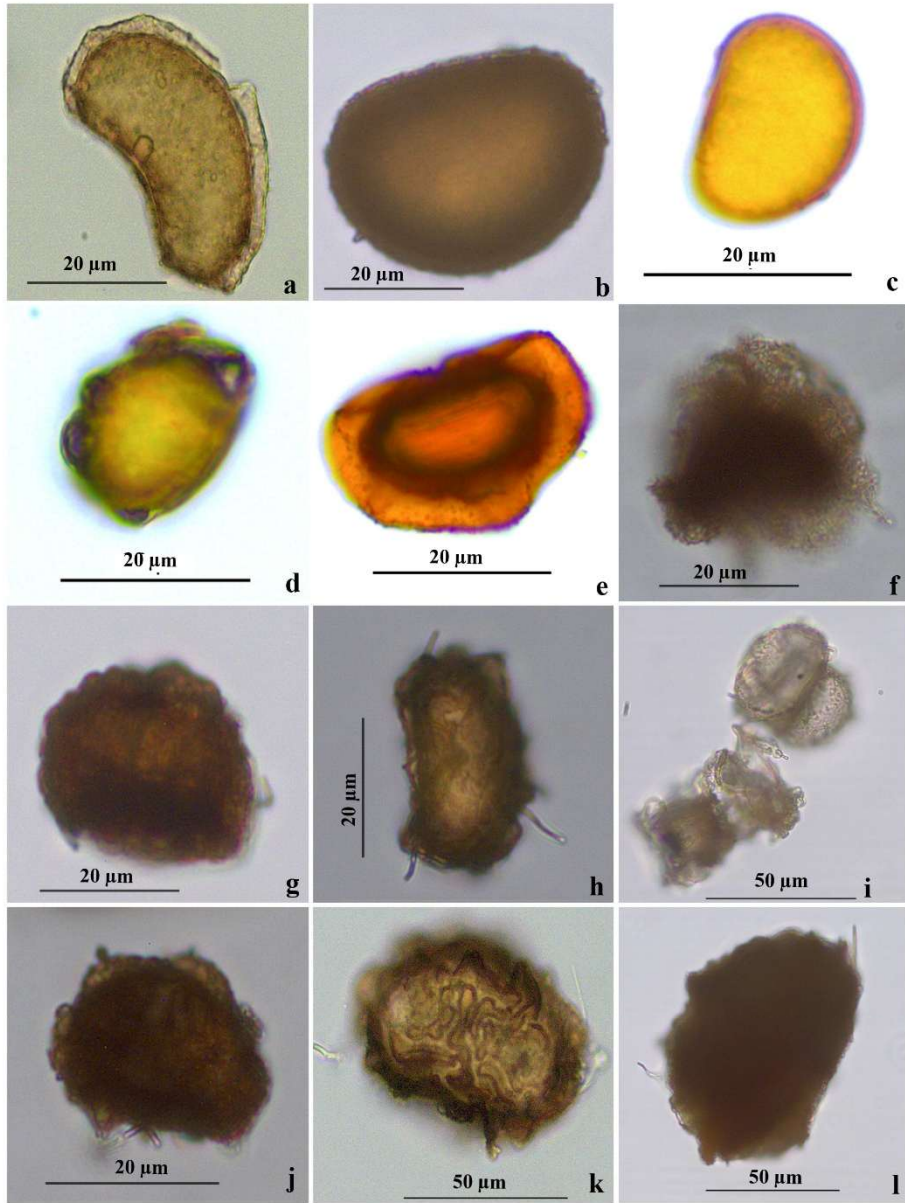


Plate 4.84: Light Microscopic photographs of spores of some taxa collected from the Palghat Gap influenced area a. *Diplazium polypodioides* Blume; b. *Blechnum melanocaulon* (Brack.) T.C. Chambers & P.A. Farrant subsp. *pallens* T.C.Chambers & P.A.Farrant; c. *Blechnum occidentale* L.; d. *Blechnum orientale* L.; e. *Arachniodes sledgei* Fraser-Jenk.; f. *Bolbitis appendiculata* (Willd.) K. Iwatz.; g. *Bolbitis beddomei* Fraser-Jenk. & Gandhi; h. *Dryopteris atrata* (Kunze) Ching; i. *Dryopteris cochleata* (D.Don) C.Chr.; j. *Dryopteris hirtipes* (Blume) Kuntze; k. *Dryopteris juxtaposita* Christ.; l. *Polystichum harpophyllum* (Zenker ex Kunze) Sledge

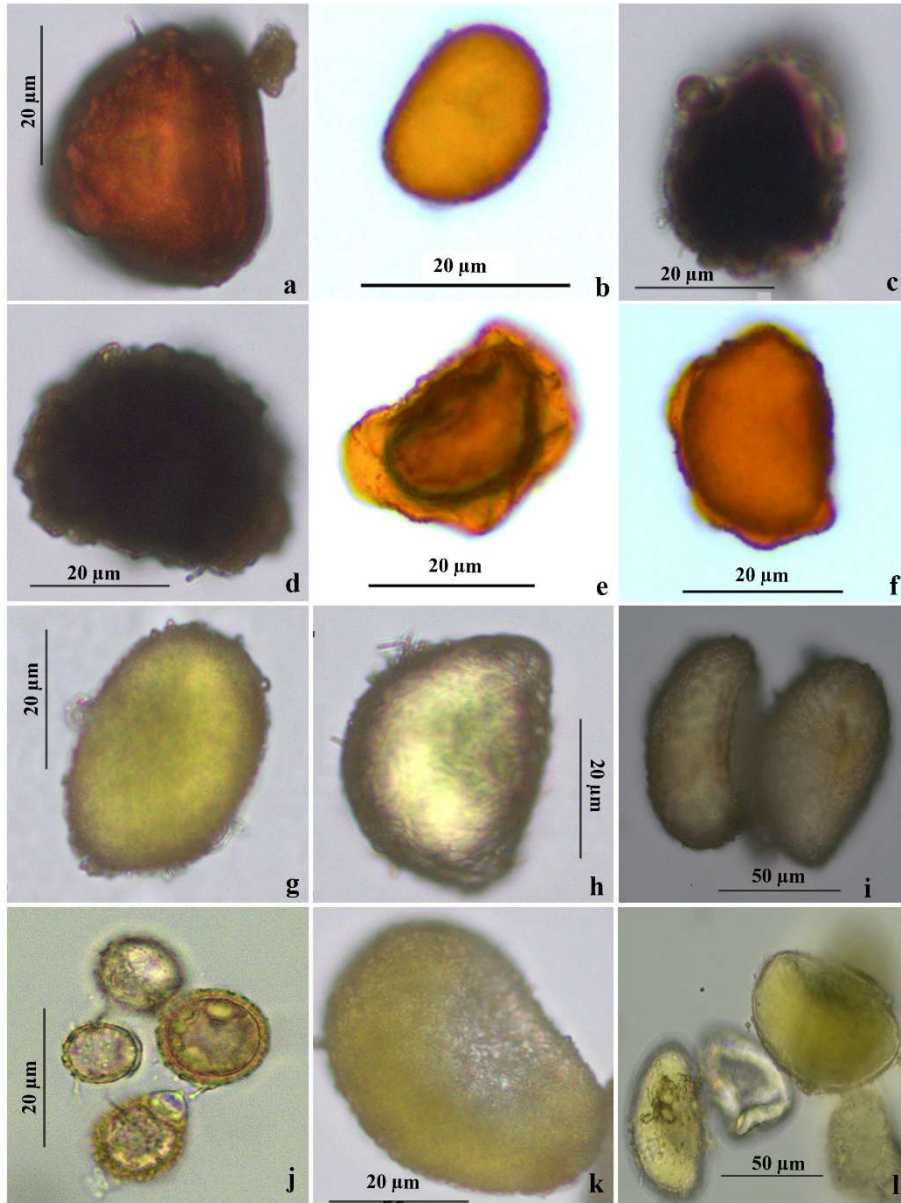


Plate 4.85: Light Microscopic photographs of spores of some taxa collected from the Palghat Gap influenced area a. *Polystichum squarrosum* (D.Don) Fée; b. *Nephrolepis brownii* (Desv.) Hovenkamp & Miyam.; c. *Nephrolepis cordifolia* (L.) C.Presl; d. *Nephrolepis undulata* (Afzel. ex Sw.) J.Sm.; e. *Tectaria coadunata* (J.Sm.) C.Chr.; f. *Tectaria paradoxa* (Fée) Sledge; g. *Davallia trichomanoides* Blume; h. *Katoella pulchra* (D. Don) Fraser-Jenk.; i. *Lepisorus contortus* (Christ) Ching; j. *Loxogramme involuta* (D.Don) C.Presl; k. *Microsorium membranaceum* (D.Don) Ching; l. *Microsorium membranifolium* (R.Br.) Ching

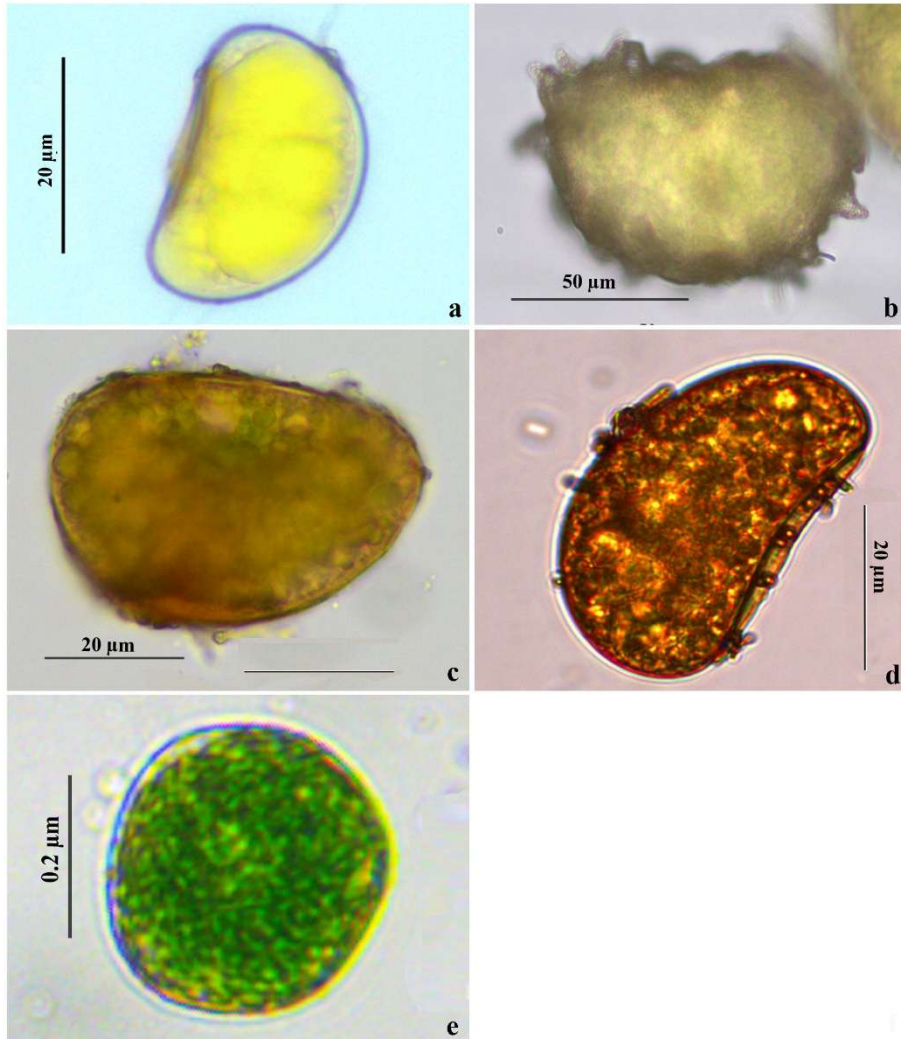


Plate 4.86: Light Microscopic photographs of spores of some taxa collected from the Palghat Gap influenced area a. *Microsorium cuspidatum* (D.Don) Tagawa subsp. *beddomei* (S.R.Ghosh) Fraser-Jenk.; b. *Pyrrosia heterophylla* (L.) M.G.Price; c. *Pyrrosia porosa* (C.Presl) Hovenkamp; d. *Selliguea montana* (Sledge) Hovenkamp; e. *Trichomanes obscurum* Blume

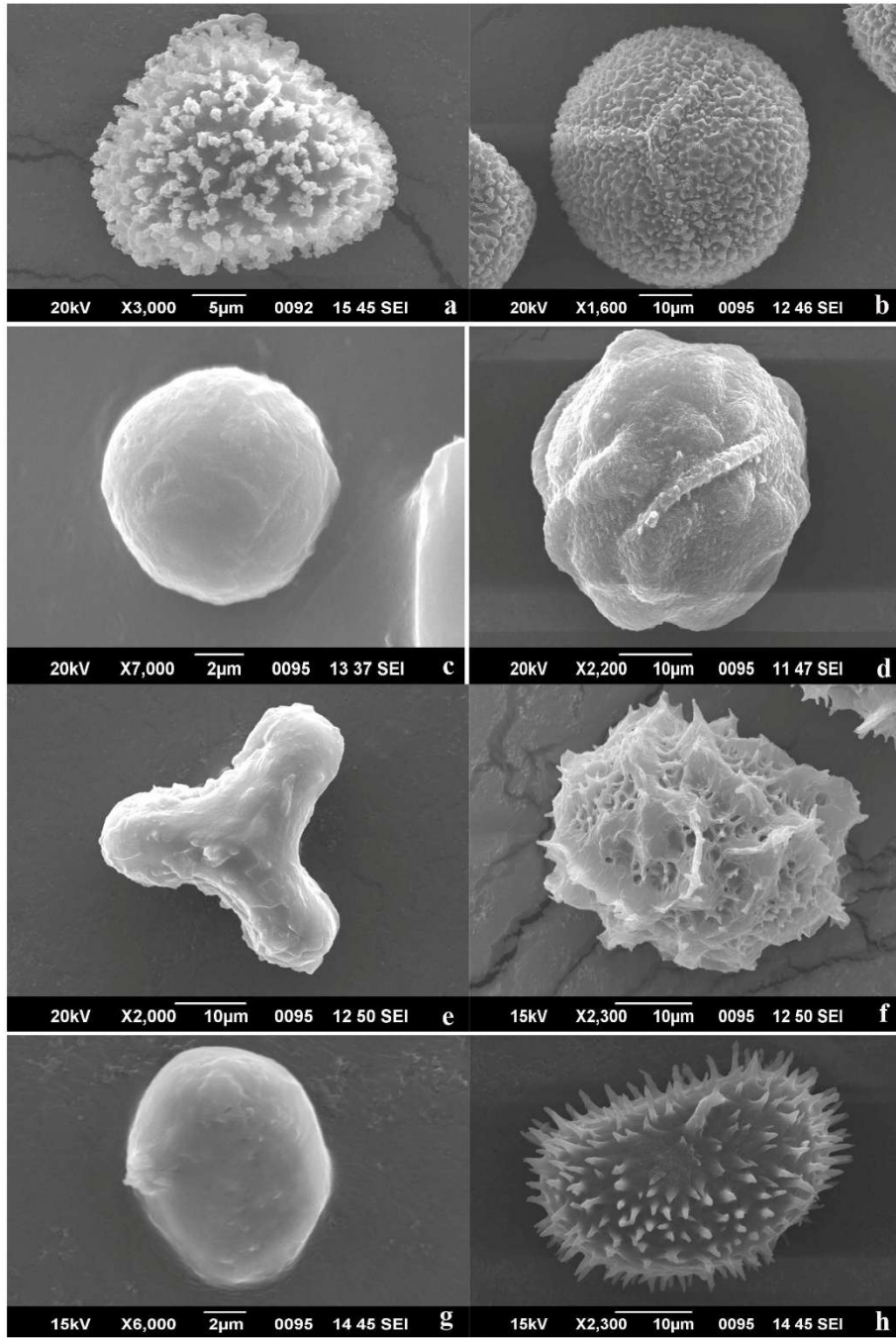


Plate 4.87: Scanning Electron Micrographs of spores of some taxa collected from the Palghat Gap influenced area a. *Botrychium daucifolium* Wall. & Hook. et Grev.; b. *Osmunda acuta* (Burm.f.) Fraser-Jenk.; c. *Trichomanes obscurum* Blume; d. *Hymenophyllum exsertum* Wall. ex Hook.; e. *Cyathea nilgirensis* Holttum; f. *Asplenium decrescens* Kunze; g. *Blechnum occidentale* L.; h. *Thelypteris mollissima* (Fisch. ex Kunze) Thapa

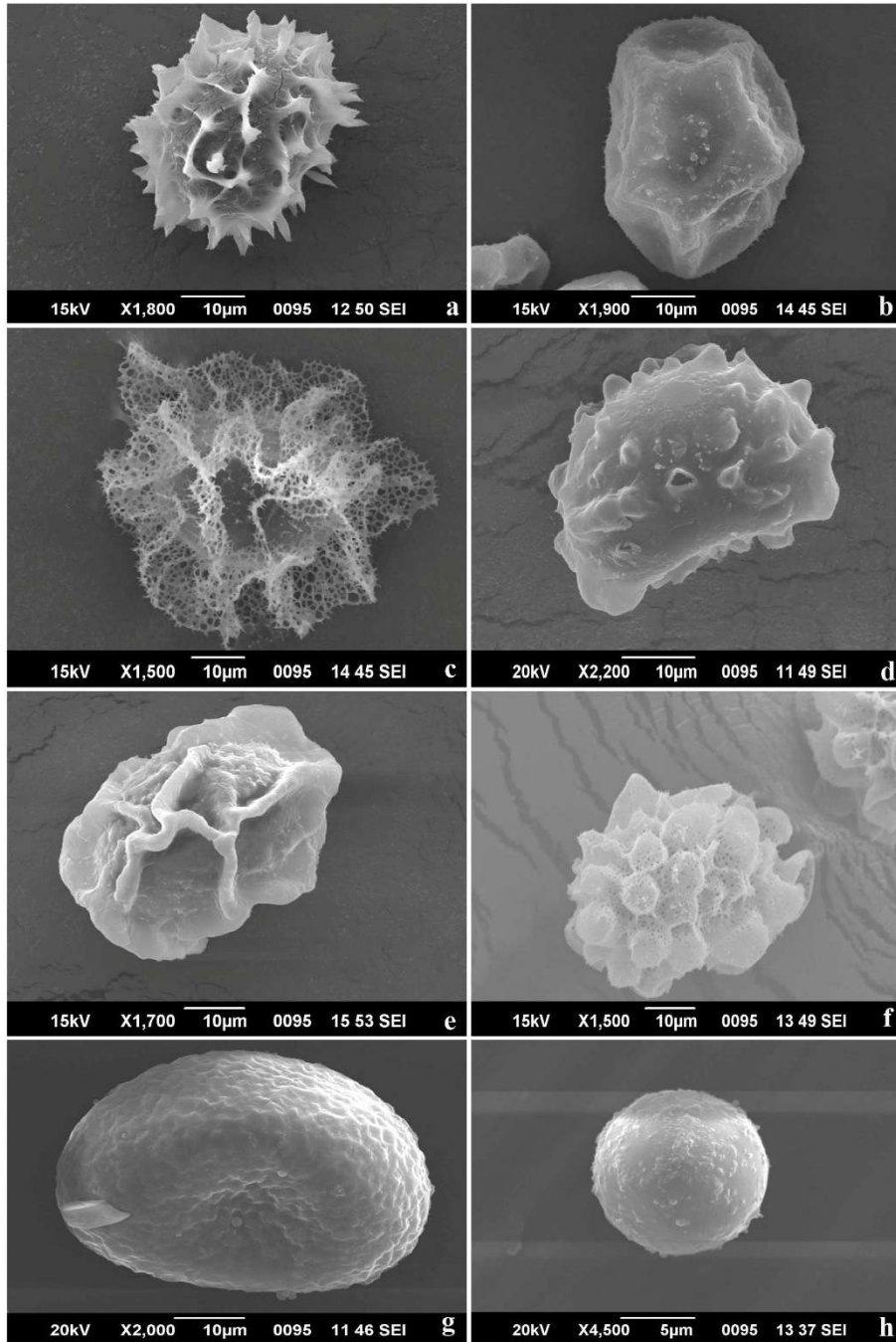


Plate 4.88: Scanning Electron Micrographs of spores of some taxa collected from the Palghat Gap influenced area a. *Tectaria wightii* (C.B.Clarke) Ching; b. *Arachniodes sledgei* Fraser-Jenk.; c. *Bolbitis appendiculata* (Willd.) K. Iwatz; d. *Elaphoglossum beddomei* Sledge; e. *Polystichum squarrosum* (D.Don) Fée; f. *Polystichum subinerme* (Kunze) Fraser-Jenk.; g. *Leptochilus decurrens* Bl.; h. *Oreogrammitis attenuata* (Kunze) Parris.

Geevarghese, 1993; Nair *et al.*, 1988, 1992a, 1993b & 1994) were also included based on herbarium data. So, a total of 191 taxa in 65 genera and 27 families were included for analysis. The genus *Asplenium* with 20 taxa formed the dominant one, and Pteridaceae with 34 taxa are the dominant family in the entire study area (Fig. 4.1). The analysis showed that 177 species belong to 62 genera and 26 families were from the North of the Gap (Fig. 4.2) and similarly, 122 species belong to 56 genera and 25 families were from South of the Gap (Fig. 4.3). The Gap region showed the presence of 23 species under 18 genera and 10 families (Fig. 4.4).

Pteridaceae are the dominant family in the entire study area, with 33 species in North of the Gap, 27 species in South and 8 species in areas within the Gap (Fig. 4.2, 4.3, 4.4 & 4.5). *Asplenium* is the dominant genus in South of the Gap with 10 species, and in North *Asplenium* as well as *Thelypteris* with 17 species represented more. The genus *Pteris* forms the dominant one within the Gap area with representation of 5 taxa (Fig. 4.2, 4.3, 4.4 & 4.5).

While comparing the species distribution along the Palghat Gap region, based on field observations as well as previous reports, three taxa *viz.*, *Cyrtomium caryotidium*, *Diplazium leptophyllum* and *Isoetes coromandelina*, were recorded only from south of the Gap. The taxa *C. caryotidium* and *D. leptophyllum* were found growing at Pampadum Shola National Park and Mathikettan Shola National Park respectively. Among which *D. leptophyllum* is a critically endangered (CR) species in India (Fraser-Jenkins, 2012). Similarly, *Isoetes coromandeliana* was recorded from the southern border of Palghat Gap, from the foothills of Nelliampathy. This taxon was recorded in the 2017-2018 period, before the flood in 2018, and after, the habitat of *I. coromandeliana* was visited frequently in every season, but could not record its existence again. During the frequent visits after the flood of 2018, it was found that the habitat for this species was disturbed by constructions, quarrying and dumping of waste materials. The disturbances to the potential habitat of *I. coromandeliana* might have adversely affected the survival of this taxon in this area. In the current study area, *I. coromandeliana* is a rare taxon, so it is necessitated that the public must be made aware of, along with governing

bodies, on the importance of preserving such habitats of rare taxa. The floods in consecutive years (2018 and 2019) with associated landslides and mudslides followed by habitat destruction also might have adversely affected the species in the study area.

Two taxa mentioned by Beddome (1864) from the Palghat region, *Belvisia spicata* and *Schizaea dichotoma* also could not be located in the present exploration. *B. spicata* (= *Lepisorus spicatus* (L.f.) Li Wang) could not be recorded from Southern India, since then. *S. dichotoma* was treated as at 'high risk' (Chandra *et al.*, 2008) and endangered for India (Fraser-Jenkins, 2012).

Among the species recorded, 21 taxa were narrowly distributed or endemic to Southern India and Sri Lanka biogeographic region, and 17 taxa belong to IUCN red list categories. Among the endemic species, 7 are under IUCN red list, such as, Endangered (EN) (*Elaphoglossum nilgircum*), Vulnerable (VU) (*Bolbitis semicordata*) and Near Threatened (NT) (*Asplenium emarginatodentatum*, *Diplazium travancoricum*, *Selaginella miniatospora* and *Elaphoglossum beddomei*) (Fraser-Jenkins *et al.*, 2018; Hessler 2024; IUCN, 2024). During the present study, North of the Gap was found to harbour 14 endemics and 13 taxa under IUCN Red List categories. From the South to the Gap areas, 15 endemics and 7 IUCN Red Listed species and within the Gap region, one endemic species - *Bolbitis semicordata*- which is categorised as Vulnerable (VU) were documented. Among these endemic species, 9 were recorded from both South and North of the Gap, and one endemic species, *Bolbitis semicordata* is distributed throughout the study area (Fig. 4.6). Altitudinal distribution analysis of the endemic/ narrowly distributed and red listed elements showed the maximum number of taxa in the mid altitudinal classes than the highest and lowest altitudinal classes (Fig. 4.7).

Among the 33 taxa included based on previous literature and herbarium data, *Polystichum anomalum* subsp. *travancoricum* mentioned in 'Fern Flora of Malabar' (Nayar and Geevarghese, 1992) is very much similar to *P. subinerme*. Similarly, the specimens of *P. kunthianum* described by Nayar and Gheevarghese (1992) and synonymised under *P. subinerme* by Fraser-Jenkins *et al.* (2018) seems to be distinct

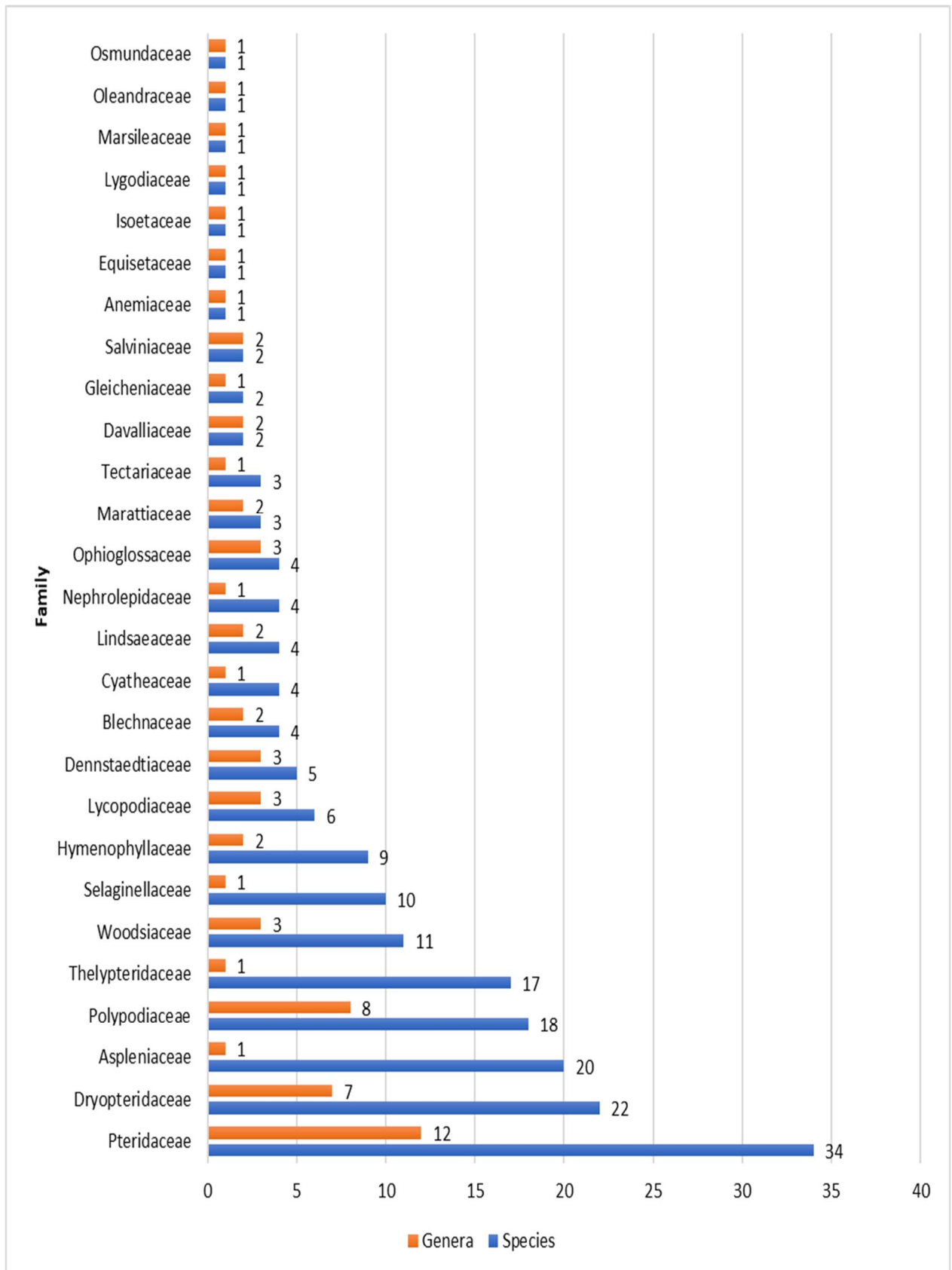


Fig. 4.1. Proportion of species and genera along Palghat Gap influenced areas

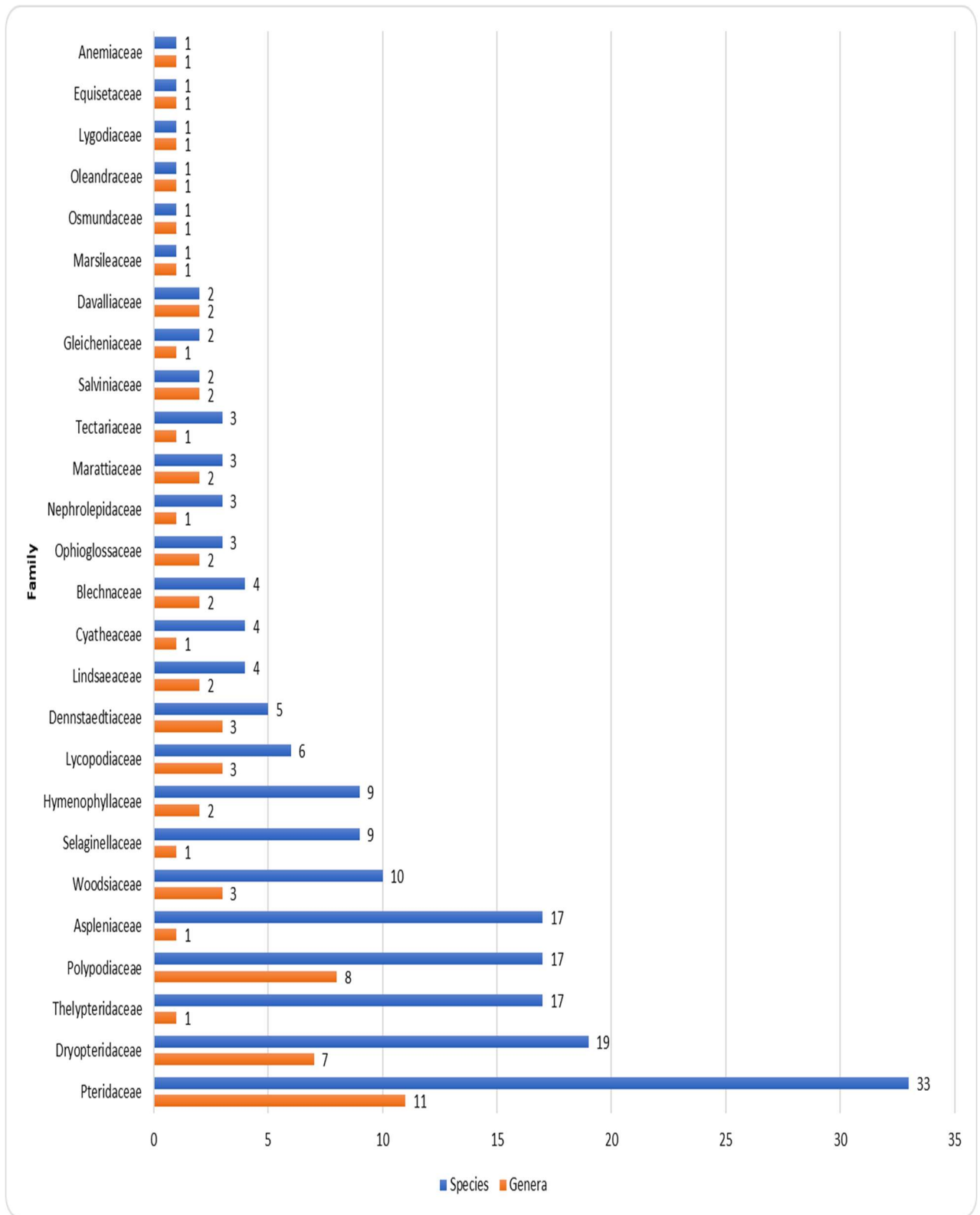


Fig. 4.2. Proportion of species and genera in North of the Palghat Gap

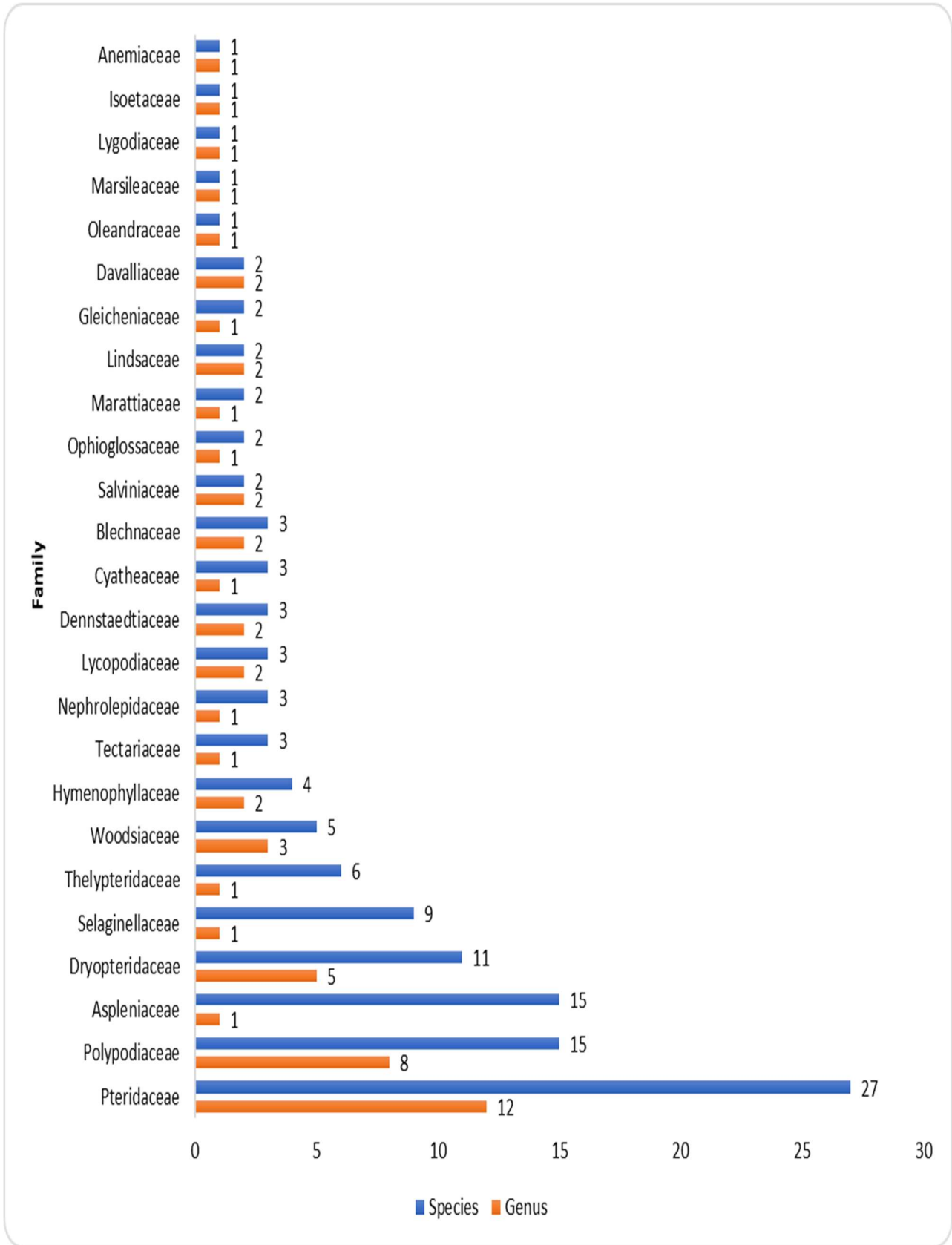


Fig. 4.3. Proportion of species and genera in South of the Palghat Gap

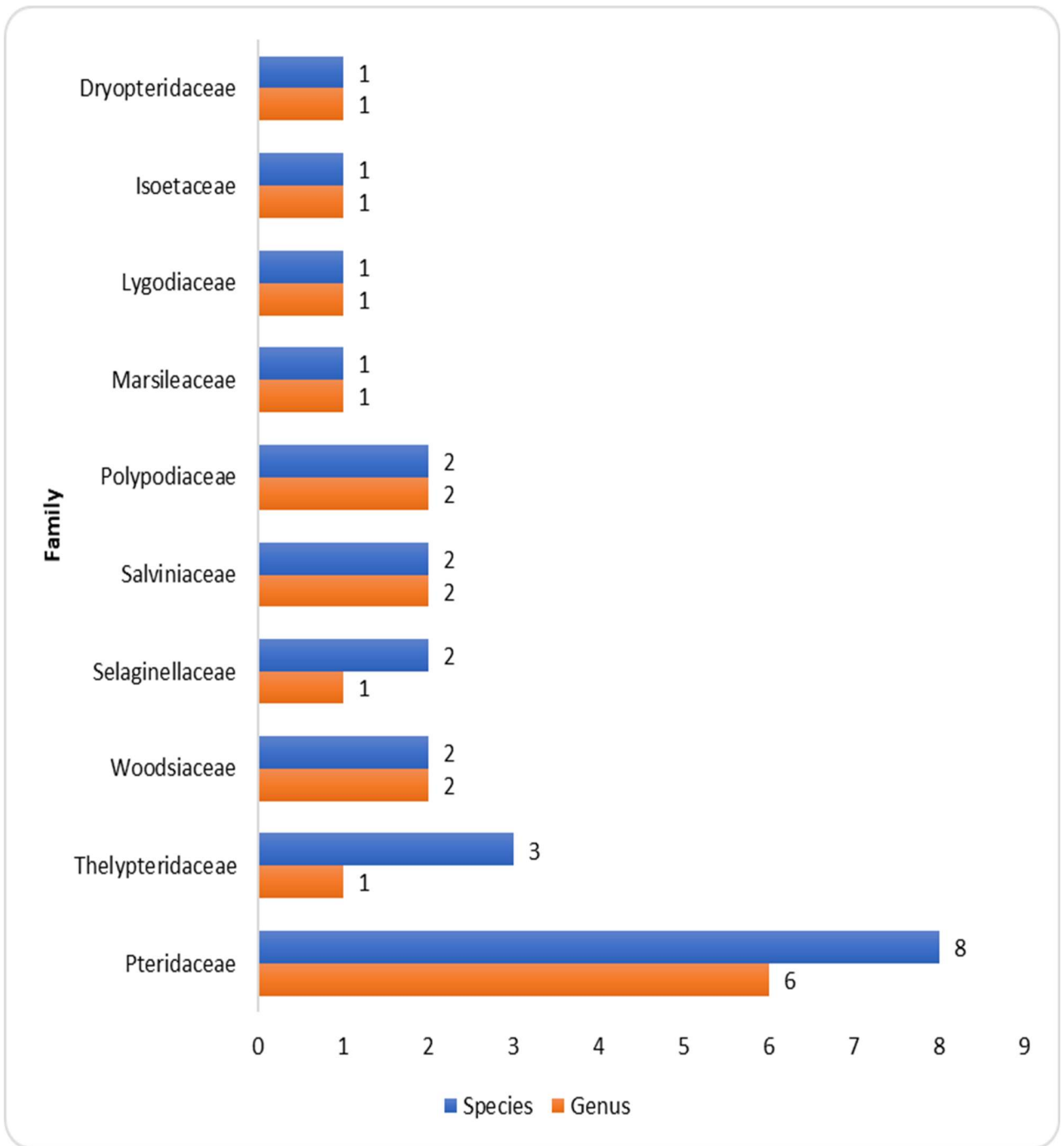


Fig. 4.4. Proportion of species and genera in areas within the Palghat Gap

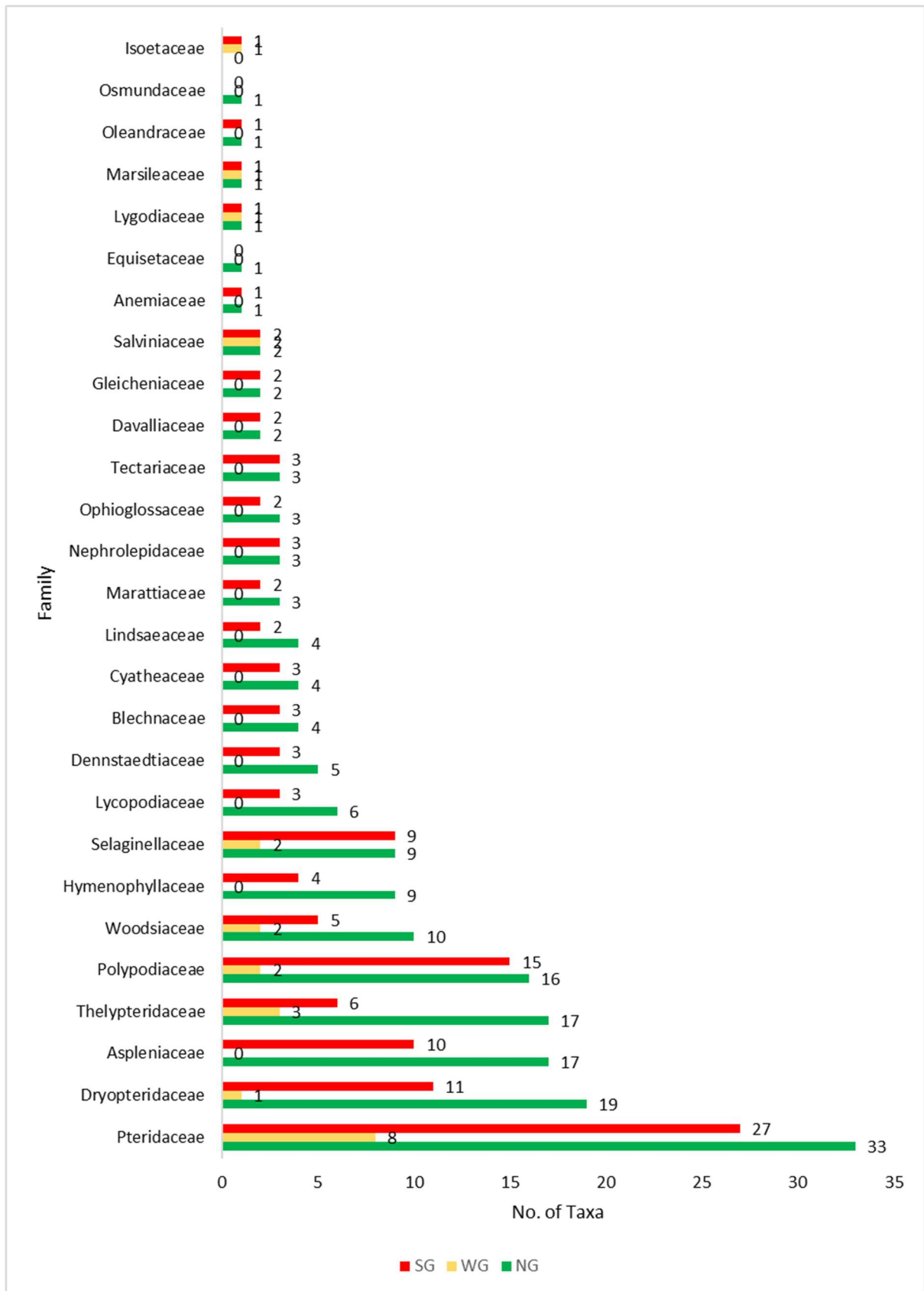


Fig. 4.5. Distribution of taxa in different families (NG- North of the Gap; WG- within the Gap; SG- South of the Gap)

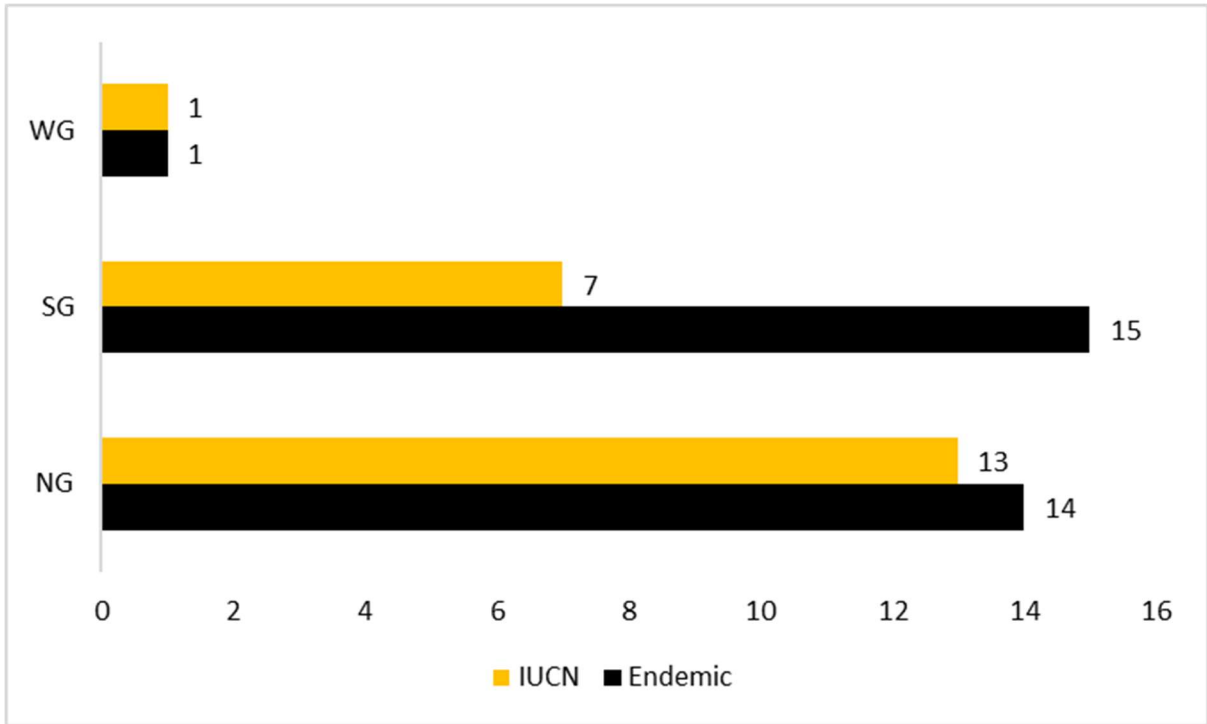


Fig. 4.6. Proportion of Endemic/narrowly distributed and IUCN Red listed taxa in North, South and within the Gap. (NG- North of the Gap; WG- within the Gap; SG- South of the Gap).

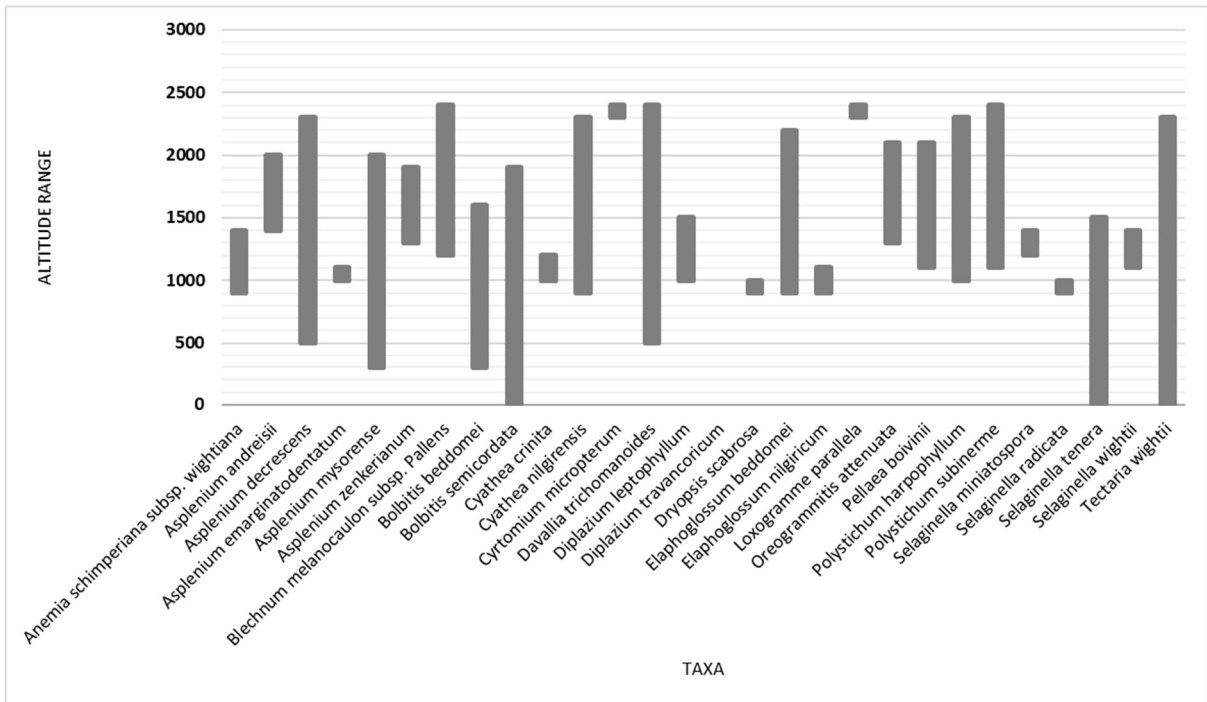


Fig. 4.7. Altitudinal distribution of Endemic/narrowly distributed and IUCN Red listed taxa

from the latter. Hence, these taxa demand further studies to reveal their taxonomic identity.

It is also significant to note that, despite repeated explorations, 33 taxa recorded in the current study area approximately 30 years ago could not be relocated. The climate change, habitat modification, increased rates of natural calamities like flood, landslides, mud slips, severe drought as a consequence of El Nino and increase in rates of pollution might have been contributing to the risk of survival of these ancient land plants.

IV.3. Spore Morphology of variable populations of selected taxa

Spore morphology in general and ornamentation in particular, is one of the stable traits, which is least affected by changes in climatic and ecological parameters. So, in many studies spore ornamentation (in non-flowering plants) or pollen morphology (in flowering plants) were used for delineation of different taxa (Joujeh *et al.*, 2019). While documenting lycophytes and ferns in Gap region, it was found that some of the taxa exhibited morpho-variants across the Gap. In the present investigation, populations of four taxa with morphological variations were selected, such as *Angiopteris helferiana*, *A. crassipes*, *Mickelopteris cordata* and *Actiniopteris radiata*, with differential ecological preferences and distribution ranges. These taxa exhibited some morphological differences between different populations growing in the study area. *Angiopteris* spp. are seen in an altitude between 500 to 2000 m of evergreen forests, whereas, *Actiniopteris radiata* prefers a drier habitat of the altitude between 200 to 900 m. *Mickelopteris cordata* also prefers dry and shady habitat and is distributed throughout the study area from around 20 to 2000 m altitudes.

IV.3.1. Spore morphological studies of different populations of *Angiopteris crassipes* Wall. ex C.Presl and *A. helferiana* C.Presl

Earlier it was assumed that the species of *Angiopteris* present in Southern India as *A. evecta* (Manickam and Irudayaraj 1992; Nayar and Geevarghese, 1992). Fraser-Jenkins *et al.* (2017) figured out that the South Indian *Angiopteris* populations constitute two species, *viz.*, *A. helferiana* and *A. crassipes*. It was concluded that *A. evecta* is distributed in the North-Eastern part of India, and not in Southern Indian states. During the current explorations in the study area, two morphologically distinct populations of *Angiopteris* spp. could be observed; one with marginal sori and the another with sub-marginal sori. The spores of these distinct populations were subjected for SEM analysis.

Angiopteris crassipes Wall. ex C.Presl

Spores in monads, globose, 24-25 μm x 22-23 μm ; proximal pole with trilete aperture, the arms $\frac{1}{2}$ to $\frac{3}{4}$ the radius, ornamentation tuberculate with more inter

tubercular spaces than in distal pole; distal pole with higher concentration of closely packed tubercles which are prominent and free, showing intermittent lateral fusion (Plate 4.89: Fig. a-b).

Angiopteris helferiana C.Presl

Spores in monads, globose, 24-25 μm x 22-23 μm ; proximal pole with trilete aperture, the arms $\frac{1}{2}$ to $\frac{3}{4}$ the radius, faintly tuberculate; distal pole faintly tuberculate, tubercles not prominent and with more fusion in short ridges (Plate 4.89: Fig. c-d).

The spore morphological analysis of populations of marginal and submarginal soried *Angiopteris* from the present study area showed distinct spore ornamentation patterns (Table 4.1). *A. crassipes* spores have an ornamentation of highly tuberculate, where tubercles are prominent and less fused in short ridges. Whereas in *A. helferiana*, the surface is low tuberculate, tubercles are not prominent and more fused in short ridges (Plate 4.89). The differences in spore ornamentation between the populations confirms the presence of two distinct species of *Angiopteris* in the South Indian populations; *A. helferiana* and *A. crassipes*.

Table 4.1. Spore morphological features of *Angiopteris* spp. from the study area

Spore characters	<i>Angiopteris crassipes</i>	<i>Angiopteris helferiana</i>
Spore nature and shape	Monads, globose	Monads, globose
Size	24-25 μm x 22-23 μm	24-25 μm x 22-23 μm
Proximal pole	Trilete aperture, the arms $\frac{1}{2}$ to $\frac{3}{4}$ the radius	Spores with trilete aperture, the arms $\frac{1}{2}$ to $\frac{3}{4}$ the radius
Distal pole and Ornamentation	Tuberculate with more inter tubercular spaces than in distal pole. Higher concentration of closely packed tubercles which are prominent and free, showing intermittent lateral fusion.	Faintly tuberculate, tubercles not prominent and with more fusion in short ridges

IV.3.2. Spore morphological studies of different populations of *Mickelopteris cordata* (Hook. & Grev.) Fraser-Jenk.

Populations of *Mickelopteris cordata* from North, South and within the Gap region showed spore morphological variations.

Population of *Mickelopteris cordata* from North of the Gap

Spores in monads, globose, 35-53 μm x 35-50 μm , trilete, proximal view with trilete aperture, the arms $3/4^{\text{th}}$ to radius, distal view with surface having two forms, cristate and tuberculate to echinate. Cristate spores have long thin cristae, the baculae or rodlets formed by perispore between two compact strata are not prominent. Echinate spores are also observed and the spines in echinate form are prominent (Plate 4.90: Fig. a-h).

Population of *Mickelopteris cordata* from the Gap

Spores in monads, globose, 35-53 μm x 35-50 μm , trilete, proximal view with trilete aperture, the arms $3/4^{\text{th}}$ to radius, distal view with surface cristate. Cristae are thicker, the baculae or rodlets formed by perispore between two compact strata are not observed (Plate 4.91: Fig. a-b).

Population of *Mickelopteris cordata* from South of the Gap

Spores in monads, globose, 35-53 μm x 35-50 μm , trilete, proximal view with trilete aperture, the arms $3/4^{\text{th}}$ to radius, distal view with surface having two forms, cristate and tuberculate to echinate. Cristate spores have long thinner cristae, the baculae or rodlets formed by perispore between two compact strata are prominent. Echinate spores were also observed and the spines in echinate forms are not prominent (Plate 4.91: Fig. c-f).

The spore morphological analysis of populations of *M. cordata*, across Palghat Gap region showed variations (Table 4.2). The surface ornamentation pattern of the proximal pole of the spores showed differences between the populations collected from north, south and within the Gap zone. Populations from north of the Gap showed prominent rugulae (Plate 4.90: Fig. a-h), whereas the same

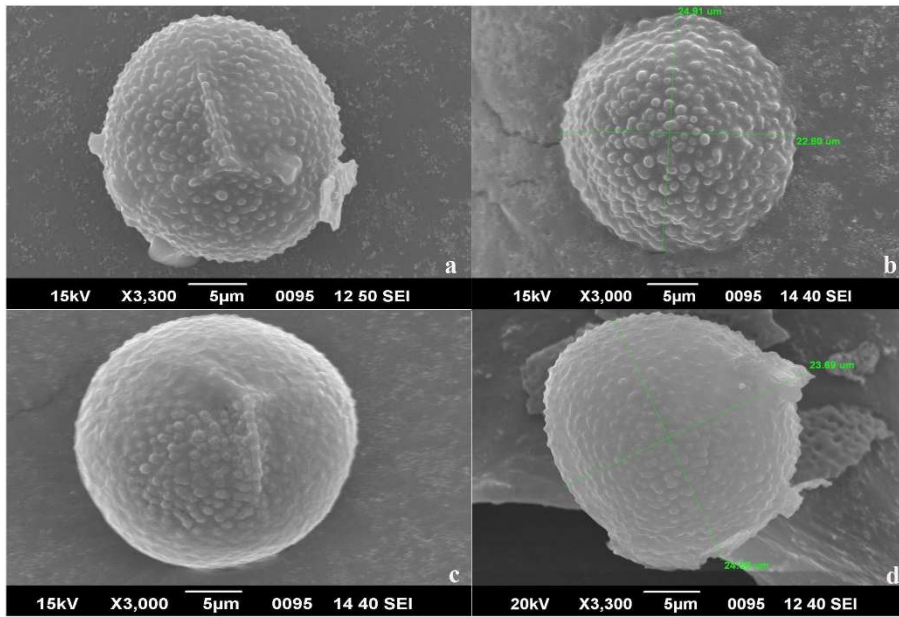


Plate 4.89: a-b. Scanning Electron Micrograph of spores a-b. *Angiopteris crassipes* a. proximal pole; b. distal pole. c-d. *Angiopteris helferiana* c. proximal pole; d. distal pole.

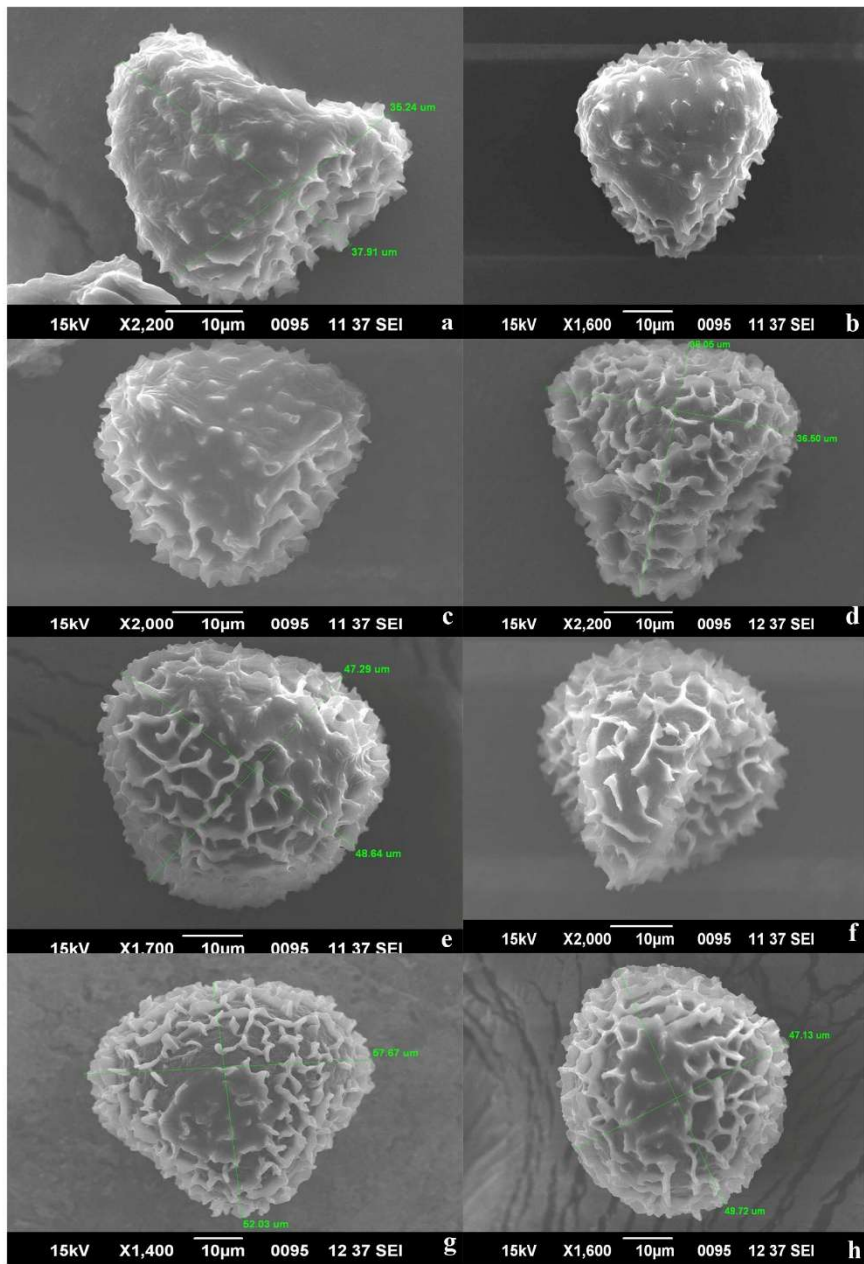


Plate 4.90: Scanning Electron Micrograph of *Mickelopteris cordata* spores collected from North of the Palghat Gap; a-c. Proximal pole: d-h. Distal pole

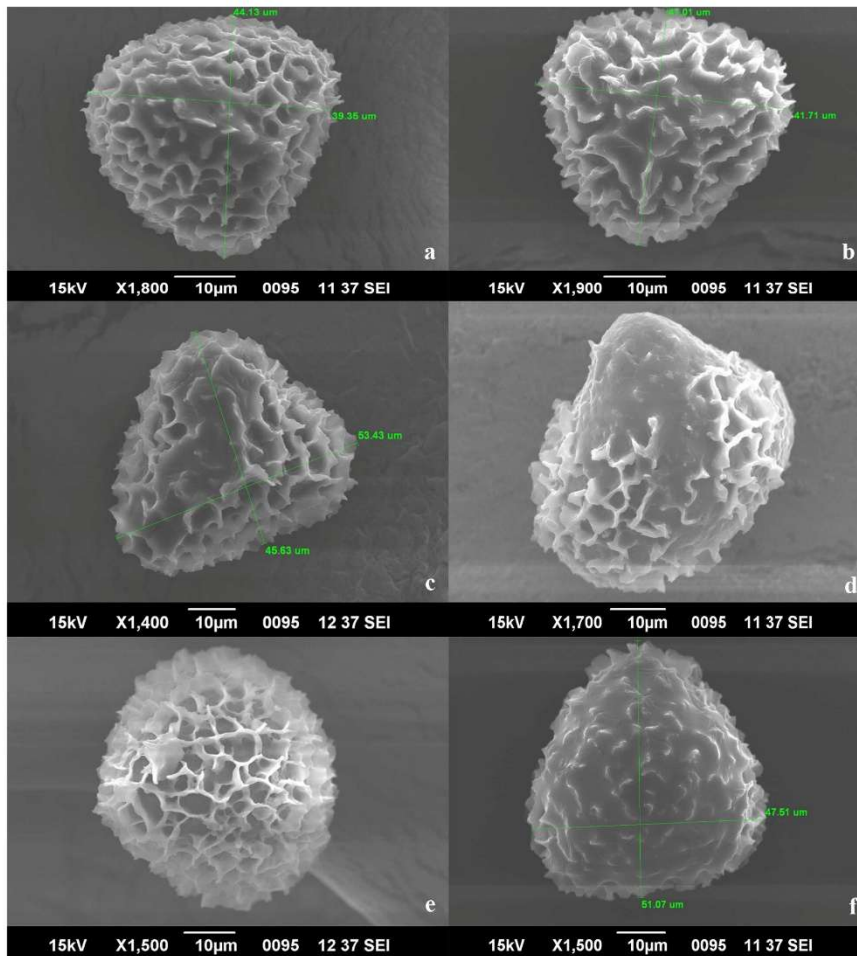


Plate 4.91: Scanning Electron Micrograph of spores a-b. *Mickelopteris cordata* spore collected from within the Palghat Gap; a. Proximal pole b. Distal pole: c-f; *Mickelopteris cordata* spore collected from South of the Palghat Gap; c&d. Proximal pole e&f. Distal pole.

from South of the Gap have partially or poorly developed rugulae (Plate 4.91: Fig. c-f). The proximal pole of the spores collected from within the Gap also showed well developed rugulae. The populations from North and South of the Gap contain two types of spores-cristate and tuberculate to echinate. The cristate spores of North of the Gap have thin cristae and baculae are not prominent. But the cristate spores from the South of the Gap have long thinner cristae and are with prominent baculae. The cristate spores collected from within the Gap have thicker cristae and baculae are absent. Populations collected from South of the Gap have two forms of spore surface- cristate and tuberculate to echinate. Cristate spores have long thin cristae, the baculae or rodlets formed by perispore between two compact strata are not prominent. Echinate spores are also observed. So, here the spores of populations along the Gap showed some variations based on the distribution along the Gap.

Table 4.2. Spore morphological features of *Mickelopteris cordata* from the study area

Spore character	North of the Gap	within the Gap	South of the Gap
Spore nature and shape	Monads, globose	Monads, globose	Monads, globose
Size	35-53 μm x 35-50 μm , trilete	35-53 μm x 35-50 μm , trilete	35-53 μm x 35-50 μm , trilete
Proximal pole	Trilete aperture, the arms 3/4 th to radius	Trilete aperture, the arms 3/4 th to radius	Trilete aperture, the arms 3/4 th to radius
Distal pole and Ornamentation	Distal view with surface having 2 forms, cristate and tuberculate to echinate. Cristate spores have long thin cristae, the baculae or rodlets formed by perispore between two compact strata are not prominent. Echinate spores are also observed. The spines in echinate form are prominent	Distal view with surface cristate. Cristae are thicker, the baculae or rodlets formed by perispore between two compact strata are not observed	Distal view with surface having 2 forms, cristate and tuberculate to echinate. Cristate spores have long thinner cristae, the baculae or rodlets formed by perispore between two compact strata are prominent. Echinate spores were also observed. The spines in echinate form are not prominent

IV.3.3. Spore morphological studies of different populations of *Actiniopteris radiata* (J. Koenig ex Sw.) Link

The populations examined from North and South of the Gap showed slight variation.

Population of *Actiniopteris radiata* from North of the Gap

Spores in monads, globose with a prominent equatorial flange with parallel ridges, 46-47 μm x 52-53 μm , trilete, proximal view with trilete aperture, the arms $\frac{3}{4}$ th radius, extending nearly to the equatorial flange, distal view with surface having less tubercles, distal face coarsely rugulate (Plate 4.92: Fig. a-b).

Population of *Actiniopteris radiata* from South of the Gap

Spores in monads, globose with a prominent equatorial flange with parallel ridges, 44-45 μm x 47-48 μm , trilete, proximal view with trilete aperture, the arms $\frac{3}{4}$ th radius, extending nearly to the equatorial flange, distal view with surface having more tubercles, distal face rugulate (Plate 4.92: Fig. c-d).

The spore morphological analysis of populations of *A. radiata*, across Palghat Gap region showed variations (Table 4.3). The surface ornamentation pattern of the distal pole of the spores showed differences between the populations collected from north and south of the Gap zone. Spores of the populations collected from north of the Gap showed distal surface with less tubercles and are coarsely rugulate. Whereas, the spores of the populations collected from south of the gap have distal view more tuberculate and distal face rugulate.

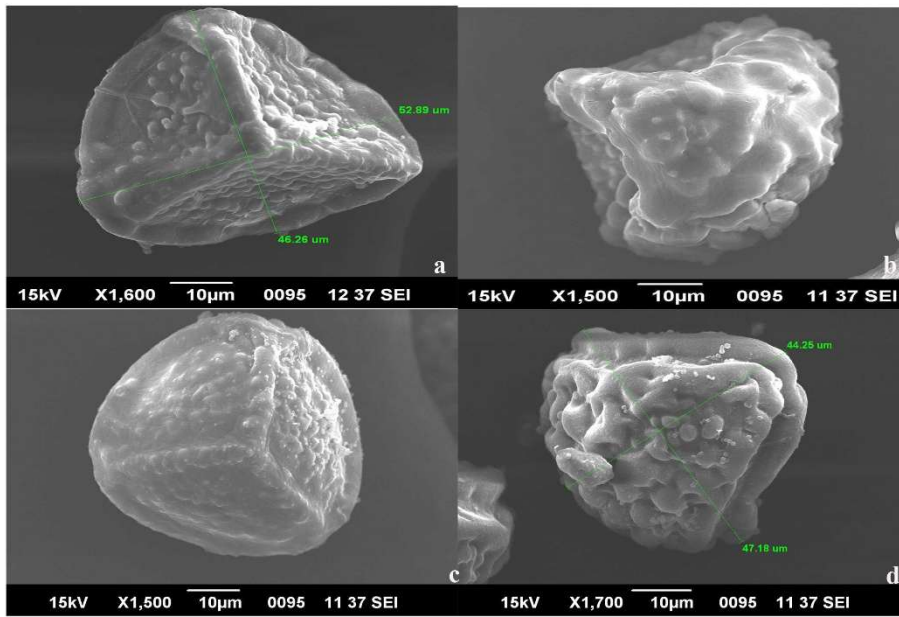


Plate 4.92: a-b. Scanning Electron Micrograph of spores a-b. *Actiniopteris radiata* spore collected from North of the Palghat Gap; a. Proximal pole; b. Distal pole; c-d. *Actiniopteris radiata* spore collected from South of the Palghat Gap; c. Proximal pole; d. Distal pole.

Table 4.3. Spore morphological features of *Actiniopteris radiata* from the study area

Spore character	North of the Gap	South of the Gap
Spore nature and shape	Monads, globose with a prominent equatorial flange with parallel ridges	Spores in monads, globose with a prominent equatorial flange with parallel ridges
Size	46-47 μm x 52-53 μm , trilete	44-45 μm x 47-48 μm , trilete
Proximal pole	Trilete aperture, the arms $\frac{3}{4}$ th radius, extending nearly to the equatorial flange	Trilete aperture, the arms $\frac{3}{4}$ th radius, extending nearly to the equatorial flange
Distal pole and Ornamentation	Distal view with surface having less tubercles, distal face coarsely regulate	Distal view with surface having more tuberculate, distal face rugulate

Spore morphological analysis

The spore morphological study of different populations of *Angiopteris* spp., *Actiniopteris radiata* and *Mickelopteris cordata* provided some indications of population diversification. The spore ornamentations of different taxa were taken as one of the differentiating characteristics by many taxonomists (Goswami, 2007; Olejnik *et al.*, 2018). Wang *et al.* (2015) studied the relationship between two varieties of *Adiantum* using molecular characters and ornamentation features of spores, and described a new species. Shah *et al.* (2021) used the spore morphological analysis to solve the identification problem in Dryopteridaceae and concluded that the spore ornamentation and perispore characters have a significant value in species level delimitation. There are studies of sympatric speciation in some angiosperms like *Howea* spp. by reproductive isolation in variable flowering period (Osborne *et al.*, 2019). Here, in current study also, some variations in spore ornamentations were observed between different populations of selected taxa. So, it may be an indication of chances of population diversification across the Palghat Gap region.

IV.4. Molecular Diversification analysis of selected ferns across Palghat Gap

Population diversification of a species begins at the molecular level, and any minor change in the genetic makeup of an organism reflects in its morphology. Here, in the present research, four ambiguous taxa were selected for analysis at molecular level to check whether the Palghat Gap features have any influence in their molecular level diversification.

IV.4.1. *Angiopteris crassipes* Wall. ex C.Presl and *A. helferiana* C.Presl

During the exploration different populations of two species of *Angiopteris*; *A. crassipes* and *A. helferiana* - were recorded from southern and northern lips of Palghat Gap. The molecular diversification analysis of these populations of *Angiopteris* spp., were carried out to find out the degree of variations exhibited by the populations. Table 4.4 shows the details of *Angiopteris* populations collected across the Palghat Gap region and Table 4.5 depicts the accessions retrieved from GenBank. The results obtained are summarised in Fig. 4.8. Here the sequence data segregates into 4 clades. The sequences of *A. wangii*, *A. madagascariensis*, *A. hawaii*, *A. lygodifolia*, *A. hakauensis*, *A. helferiana*, *A. fakiensis*, *A. dianyuocola*, *A. caudiformis*, *A. cartilaginea* and *A. acutidentata* forms a clade. The sequences of the populations collected from the Gap influenced areas of southern Western Ghats form a clade, except the AG27 population, which forms a separate clade. The sequences of *A. takinensis*, *A. tamdaoensis*, *A. chingii*, *A. bipinnata* and *A. evecta* grouped together in a separate clade, and *A. angustifolia* forms a separate clade. Here, *Marattia fraxinea* (MOG) has been selected as the outgroup taxon (Fig. 4.8). The results showed that the southern Western Ghats populations of *Angiopteris* are entirely different from the populations of other regions in the world. The southern Western Ghats populations form a unique germplasm as compared with other populations. The clustering of these populations is irrespective of its distribution along the Palghat Gap and morphological variations. Interestingly, these populations are not grouped with the accessions of *A. helferiana* and *A. evecta* from other parts of India and China. As per Fraser-Jenkins *et al.* (2018), the Southern Indian populations of *Angiopteris* include two species; *A. helferiana* and *A. crassipes*. The

morphological analysis showed characteristic differences between the populations of *A. helferiana* and *A. crassipes*. The delineating features of these two species at morpho level are the soral arrangements and venation pattern. But the preliminary studies did not show any distinct clustering with regard to morphological parameters or its distribution across the Palghat Gap. Similarly, the GenBank sequences of *A. helferiana* and *A. evecta* did not group with the Western Ghats populations. Here, in the current analysis, the selected genes; *rbcL*, *trnL-F* and *atpB*, might not have much differences in sequences between the two species. So, further molecular analysis of *Angiopteris* populations of the southern Western Ghats using other more delineating genes is necessary.

Table 4.4: Details of *Angiopteris* spp. populations collected from the study area

1	AM	North	Marginal
2	ASM	North	Sub-marginal
3	AG1	South	Sub-marginal
4	AG2	South	Sub-marginal
5	AG3	South	Sub-marginal
6	AG4	South	Sub-marginal
7	AG5	North	Sub-marginal
8	AG6	North	Marginal
9	AG7	North	Marginal
10	AG8	South	Marginal
11	AG9	North	Marginal
12	AG10	North	Sub-marginal
13	AG11	North	Sub-marginal
14	AG12	North	Sub-marginal
15	AG13	North	Sub-marginal
16	AG14	North	Sub-marginal
17	AG15	South	Marginal
18	AG19	North	Sub-marginal
19	AG22	South	Sub-marginal
20	AG23	North	Sub-marginal
21	AG24	North	Sub-marginal
22	AG27	South	Sub-marginal

Table 4.5: GenBank accessions of three gene regions of *Angiopteris* species used in molecular studies

Sl. No.	Species	Accession number	Gene	Origin of the population
1	<i>Angiopteris acutidentata</i>	DQ838052	<i>rbcL</i>	China
2	<i>Angiopteris acutidentata</i>	DQ838082	<i>trnL-F</i>	China
3	<i>Angiopteris angustifolia</i>	EU221678	<i>atpB</i>	Finland
4	<i>Angiopteris angustifolia</i>	EU221738	<i>rbcL</i>	Unknown
5	<i>Angiopteris angustifolia</i>	EU221806	<i>trnL-F</i>	Unknown
6	<i>Angiopteris bipinnata</i>	MT855995	<i>atpB</i>	China
7	<i>Angiopteris bipinnata</i>	MT856009	<i>rbcL</i>	China
8	<i>Angiopteris bipinnata</i>	MT856037	<i>trnL-F</i>	China
9	<i>Angiopteris boninensis</i>	AB574692	<i>rbcL</i>	Japan
10	<i>Angiopteris cartilaginea</i>	DQ838060	<i>rbcL</i>	China
11	<i>Angiopteris cartilaginea</i>	DQ838077	<i>trnL-F</i>	China
12	<i>Angiopteris caudatiformis</i>	DQ838056	<i>rbcL</i>	China
13	<i>Angiopteris caudatiformis</i>	DQ838087	<i>trnL-F</i>	China
14	<i>Angiopteris caudipinna</i>	DQ838053	<i>rbcL</i>	China
15	<i>Angiopteris chingii</i>	MT855996	<i>atpB</i>	China
16	<i>Angiopteris chingii</i>	MT856010	<i>rbcL</i>	China
17	<i>Angiopteris chingii</i>	MT856038	<i>trnL-F</i>	China
18	<i>Angiopteris dianyuocola</i>	MT855997	<i>atpB</i>	China
19	<i>Angiopteris dianyuocola</i>	MT856011	<i>rbcL</i>	China
20	<i>Angiopteris dianyuocola</i>	MT856039	<i>trnL-F</i>	China
21	<i>Angiopteris evecata</i>	EF463485	<i>atpB</i>	USA
22	<i>Angiopteris evecata</i>	EU439092	<i>rbcL</i>	Hawai
23	<i>Angiopteris evecata</i>	AY344778	<i>trnL-F</i>	USA
24	<i>Angiopteris fokiensis</i>	AB574693	<i>rbcL</i>	Japan
25	<i>Angiopteris fokiensis</i>	DQ838078	<i>trnL-F</i>	China
26	<i>Angiopteris hainanensis</i>	DQ838061	<i>rbcL</i>	China
27	<i>Angiopteris helferiana</i>	DQ838050	<i>rbcL</i>	China
28	<i>Angiopteris helferiana</i>	KT286856	<i>trnL-F</i>	Assam, India
29	<i>Angiopteris hokouensis</i>	MT855998	<i>atpB</i>	China
30	<i>Angiopteris hokouensis</i>	MT856012	<i>rbcL</i>	China
31	<i>Angiopteris hokouensis</i>	MT856040	<i>trnL-F</i>	China

32	<i>Angiopteris howii</i>	DQ838054	<i>rbcL</i>	China
33	<i>Angiopteris howii</i>	DQ838081	<i>trnL-F</i>	China
34	<i>Angiopteris lygodiifolia</i>	AF313543	<i>atpB</i>	USA
35	<i>Angiopteris lygodiifolia</i>	AB574694	<i>rbcL</i>	Japan
36	<i>Angiopteris madagascariensis</i>	KF992420	<i>rbcL</i>	Mascarene Islands
37	<i>Angiopteris madagascariensis</i>	AY651836	<i>trnL-F</i>	Germany
38	<i>Angiopteris marchionica</i>	MT215969	<i>rbcL</i>	Marquesan
39	<i>Angiopteris omeiensis</i>	DQ838057	<i>rbcL</i>	China
40	<i>Angiopteris omeiensis</i>	DQ838079	<i>trnL-F</i>	China
41	<i>Angiopteris palmiformis</i>	LC484369	<i>rbcL</i>	Japan
42	<i>Angiopteris tamdaoensis</i>	MT855994	<i>atpB</i>	China
43	<i>Angiopteris tamdaoensis</i>	MT856008	<i>rbcL</i>	China
44	<i>Angiopteris tamdaoensis</i>	MT856036	<i>trnL-F</i>	China
45	<i>Angiopteris tonkinensis</i>	MT855993	<i>atpB</i>	China
46	<i>Angiopteris tonkinensis</i>	MT856007	<i>rbcL</i>	China
47	<i>Angiopteris tonkinensis</i>	MT856035	<i>trnL-F</i>	China
48	<i>Angiopteris wangii</i>	DQ838051	<i>rbcL</i>	China
49	<i>Angiopteris wangii</i>	DQ838085	<i>trnL-F</i>	China

IV.4.2. *Actiniopteris radiata* (J. Koenig ex Sw.) Link

During the exploration, four different populations of *A. radiata* across the Palghat Gap region were recorded. This taxon exhibited minimal distribution across the Gap and it showed variations, especially the size and dissection of the fronds and these accessions were subjected to molecular analysis. Table 4.6 showed the details of populations collected from the Palghat Gap influenced areas and accessions from GenBank. The results summarised in Figure 4.9 showed that accessions of *A. radiata* formed distinct groups as northern and southern populations. The populations - AR1 and AR2 - collected from North of the Palghat Gap form a clade, whereas the populations - AR3 and AR4 - collected from South of the Gap form a different clade (Fig. 4.9). For the analysis, sequences of *A. radiata*, *A. dimorpha*, *A. semiflabellata* and *A. australis* were downloaded from the GenBank. *A. dimorpha*, *A. semiflabellata* and *A. australis* formed the outgroup clade.

The molecular studies on *A. radiata* showed distinct clusters of South and North populations. The GenBank sequences of *A. radiata* are also included in the same clade of the sampled populations. All other species of *Actiniopteris*, viz., *A. dimorpha*, *A. semiflabellata* and *A. australis*, formed a distinct outgroup clade (Fig. 4.9). This showed that Palghat Gap has some influence in the populations of *A. radiata*. To confirm this trend and precise interpretation on the influence of Palghat Gap, more populations need to be analysed.

Table 4.6: Details of *Actiniopteris radiata* populations used in the molecular analysis

S. No.	Species	Code/ Accession number	Gene	Origin of the population
1	<i>Actiniopteris radiata</i>	AR1	<i>rbcL+trnL-F+atpB</i>	North of the Palghat Gap
2	<i>Actiniopteris radiata</i>	AR2	<i>rbcL+trnL-F+atpB</i>	North of the Palghat Gap
3	<i>Actiniopteris radiata</i>	AR3	<i>rbcL+trnL-F+atpB</i>	South of the Palghat Gap
4	<i>Actiniopteris radiata</i>	AR4	<i>rbcL+trnL-F+atpB</i>	South of the Palghat Gap
5	<i>Actiniopteris australis</i>	JX144887	<i>rbcL</i>	London
6	<i>Actiniopteris dimorpha</i>	EF452009	<i>atpB</i>	USA
7	<i>Actiniopteris dimorpha</i>	KM008014	<i>trnL-F</i>	China
8	<i>Actiniopteris dimorpha</i>	EF452130	<i>rbcL</i>	USA
9	<i>Actiniopteris radiata</i>	MT727043	<i>rbcL</i>	India
10	<i>Actiniopteris semiflabellata</i>	KM007674	<i>atpB</i>	China
11	<i>Actiniopteris semiflabellata</i>	KM008015	<i>trnL-F</i>	China
12	<i>Actiniopteris semiflabellata</i>	KM008127	<i>rbcL</i>	China

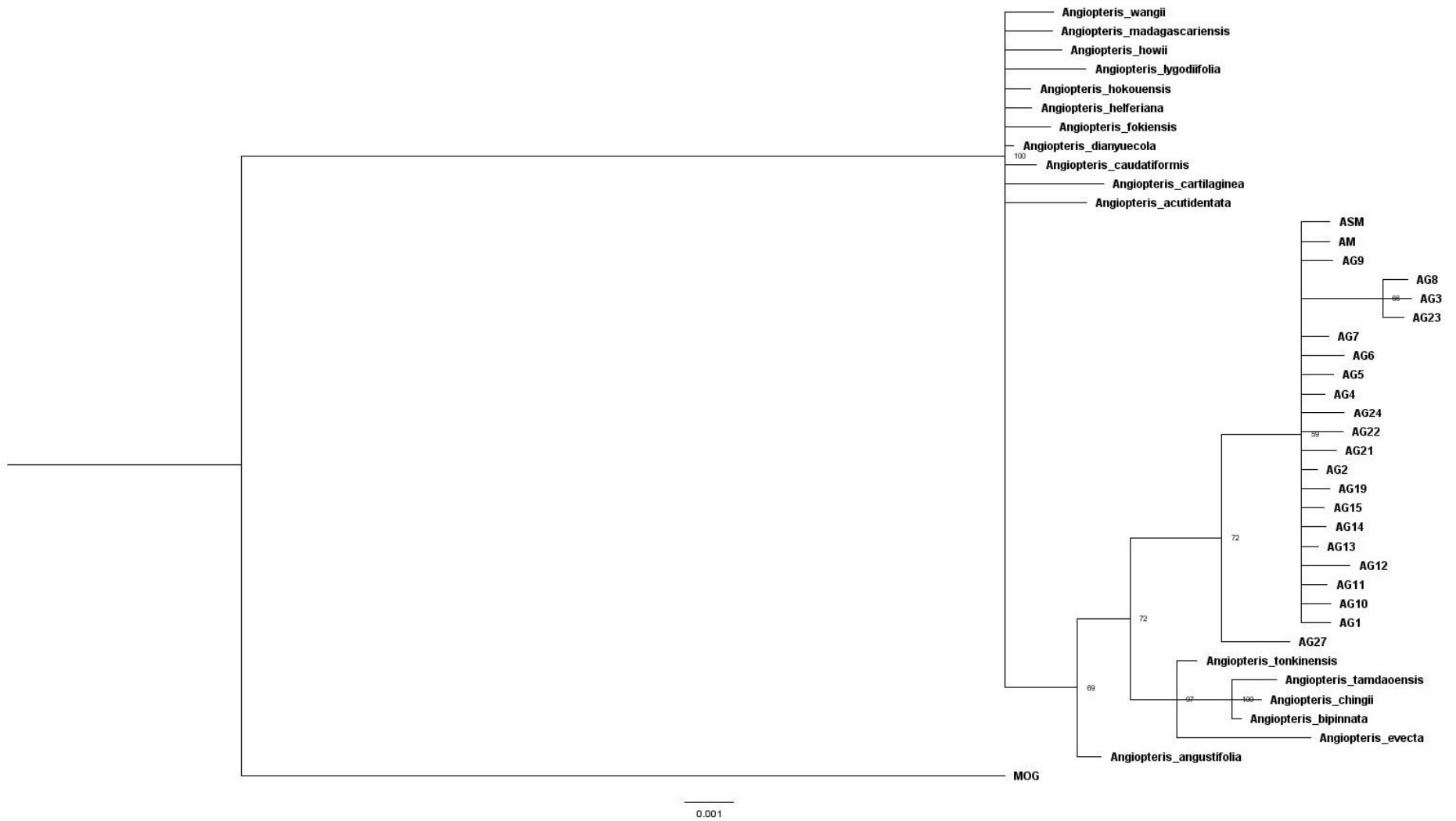


Fig. 4.8. Dendrogram of *Angiopteris* populations developed by combining the 3 gene regions - *rbcL*, *trnL-F*, *atpB*

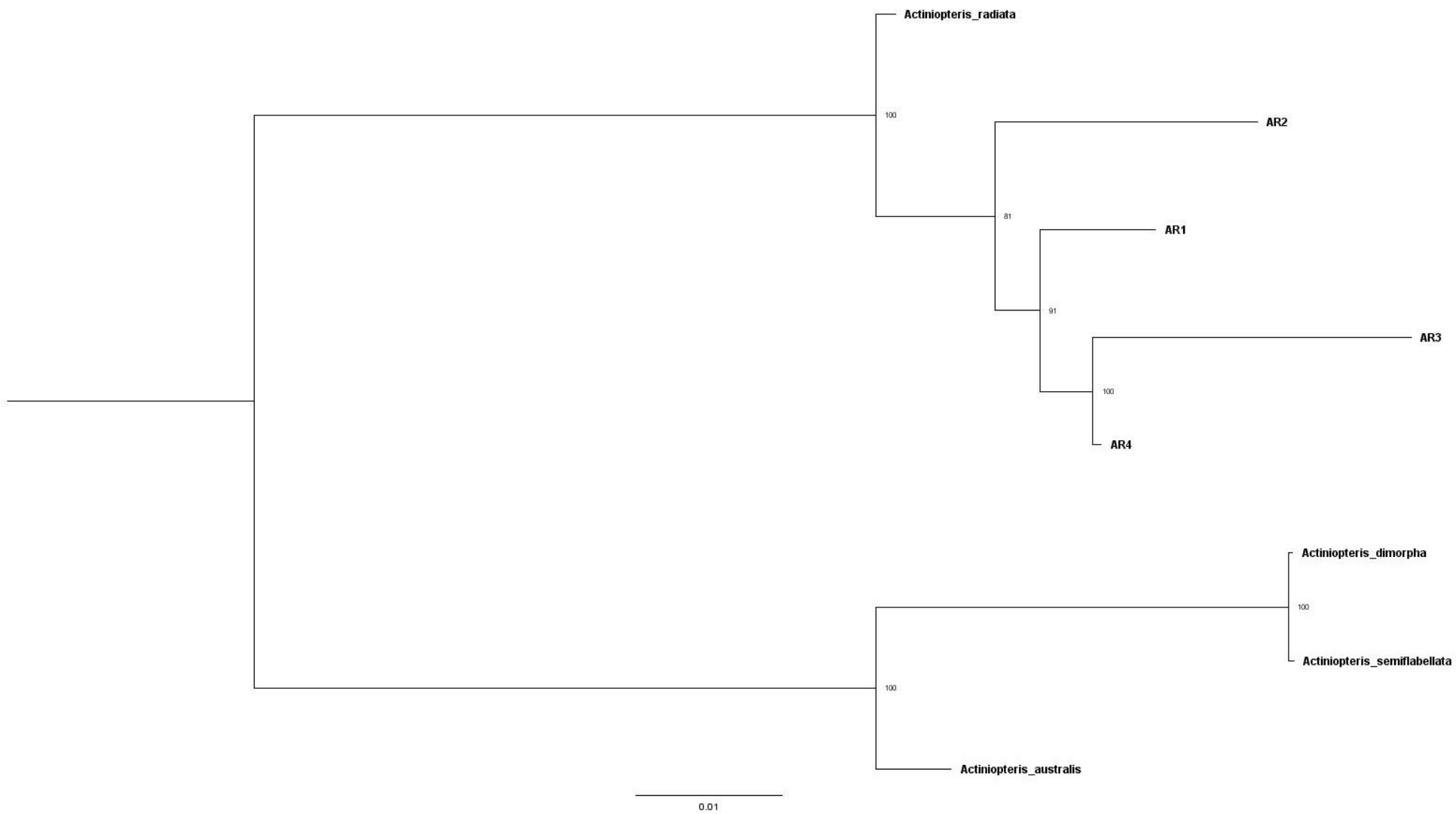


Fig. 4.9. Dendrogram of *Actiniopteris radiata* populations developed by combining the 3 gene regions - *rbcL*, *trnL-F*, *atpB*

IV.4.3. *Mickelopteris cordata* (Hook. & Grev.) Fraser-Jenk.

The field studies across the Palghat Gap showed some morphological variations in the frond shape and size of different populations of *M. cordata*. This species has a continuous distribution across the Palghat Gap region from North, within the Gap and South of the Gap, as well as from low altitude to high altitudes. Table 4.7 summarises the details of populations collected from the study area. The results of the molecular analysis are summarised in Figure 4.10. Here, *Actiniopteris radiata* is taken as the outgroup for the analysis. In the case of *M. cordata*, the GenBank accessions for the gene regions selected in the molecular analysis is negligible. The molecular analysis of different populations of *M. cordata* (Fig. 4.10) collected from the North of the Gap, South of the Gap and within Gap, showed segregation, irrespective of their geographical distribution and morphological variations.

In this taxon, the populations were collected throughout the study area, from Northern part to Southern part through the Gap areas. As morphological variations are more pronounced in *M. cordata* populations, further molecular analysis based on other marker genes are necessary to make conclusive inferences on the effect of Gap.

The results of the molecular analysis of *Actiniopteris radiata* exhibited a sharp cladding between northern and southern populations. This may be due to the separation of these populations by the wider Palghat Gap. But the analysis conducted for the other three taxa, viz., *Angiopteris helferiana*, *A. crassipes* and *Mickalopteris cordata*, are not conclusive to interpret that the Gap features influence the populations on either ends to evolve separately into segregate taxa. In this case, the selected gene regions - *rbcL*, *trnL-F* and *atpB* - might not be having much nucleotide insertion or deletions by evolution or these three gene regions in these two taxa might be slow evolving. So, the chances for variations in sequences between different suspected populations might be absent or negligible. Therefore, some other gene regions which may be fast evolving or genes that can accumulate nucleotide indels might be a solution for proper interpretation.

Compared to angiosperms, the rate of evolutionary process is slow in ferns (Smith, 1972) and they possess a long evolutionary history also. The molecular

databased divergence analysis by Schneider *et al.* (2004) stated that the present day pteridophytes diversified in the Cretaceous period, after angiosperm diversification, and they got ecologically adapted in an angiosperm dominant ecosystem. Similar conclusions were also given by Schuettpelz and Pryer (2009) regarding the radiation of leptosporangiate ferns. Waltkins and Cardelus (2012) also concluded the diversification and epiphytic adaptation of ferns in the Cretaceous period. Benniamin *et al.* (2024) after analysing 46 species of pteridophytes in Western Ghats concluded that the intraspecific variations among the pteridophytes are not merely due to the ecological diversity of habitats, but it has the base of genetic diversity within the species itself. So, the slow rate of evolution combined with lesser linkage of genetic makeup with morphological traits warrants studies on more genes in pteridophytes to make reasonable interpretations on evolution. Thus, it demands a detailed molecular level investigation to decipher the influence of Palghat Gap on the pteridophyte distribution and their evolution in the Western Ghats.

Table 4.7: Details of *Mickelopteris cordata* populations collected from the study area

Sl. No.	Code	Origin of the population
1.	PC2	North of the Palghat Gap
2.	PC3	North of the Palghat Gap
3.	PC4	North of the Palghat Gap
4.	PC10	South of the Palghat Gap
5.	PC12	North of the Palghat Gap
6.	PC13	North of the Palghat Gap
7.	PC14	South of the Palghat Gap
8.	PC15	South of the Palghat Gap
9.	PC17	North of the Palghat Gap
10.	PC19	South of the Palghat Gap
11.	PC20	Within the Gap
12.	PC21	Within the Gap
13.	PC22	Within the Gap

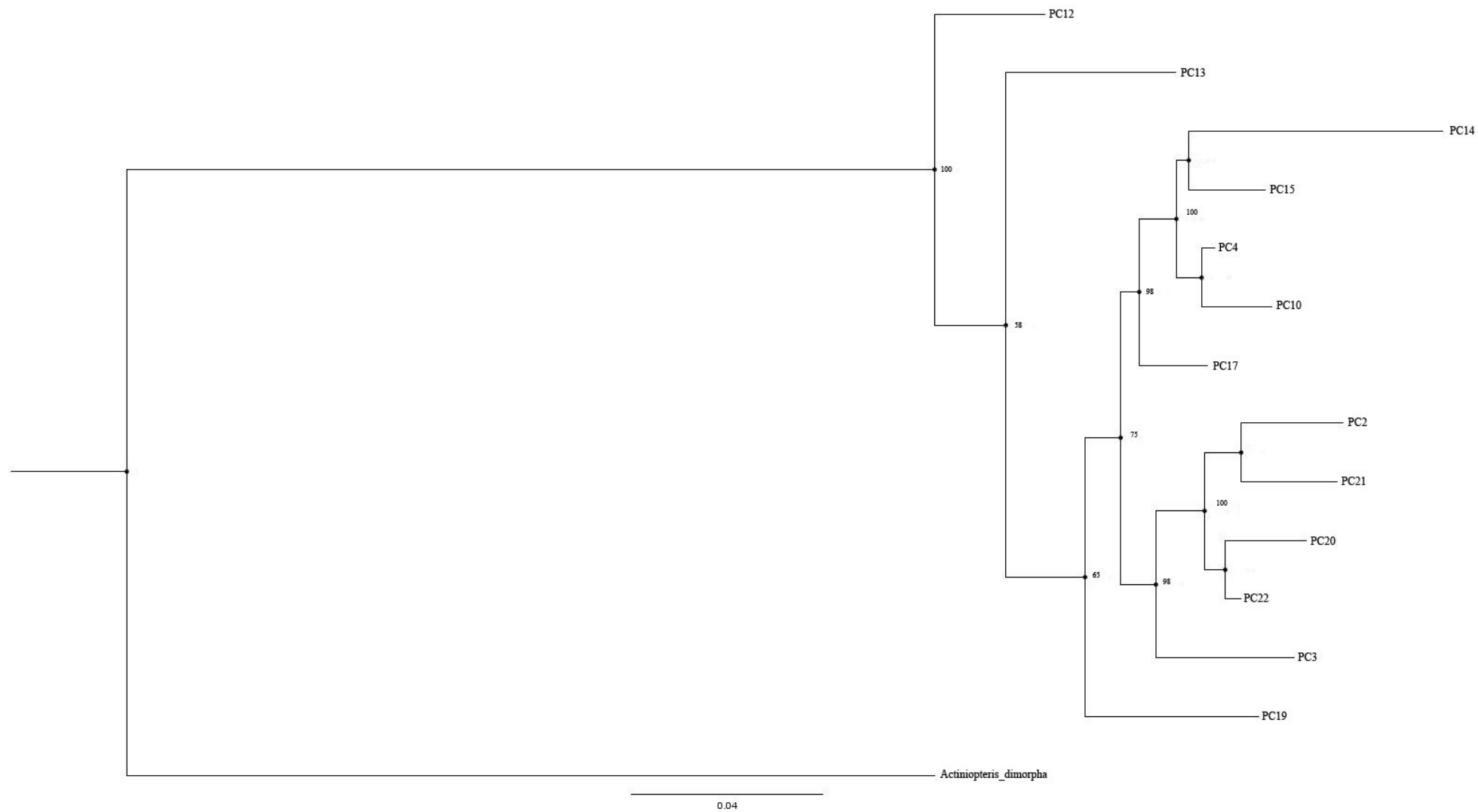


Fig. 4.10. Dendrogram of *Mickelopterus cordata* populations developed by combining the 3 gene regions - *rbcL*, *trnL-F*, *atpB*.

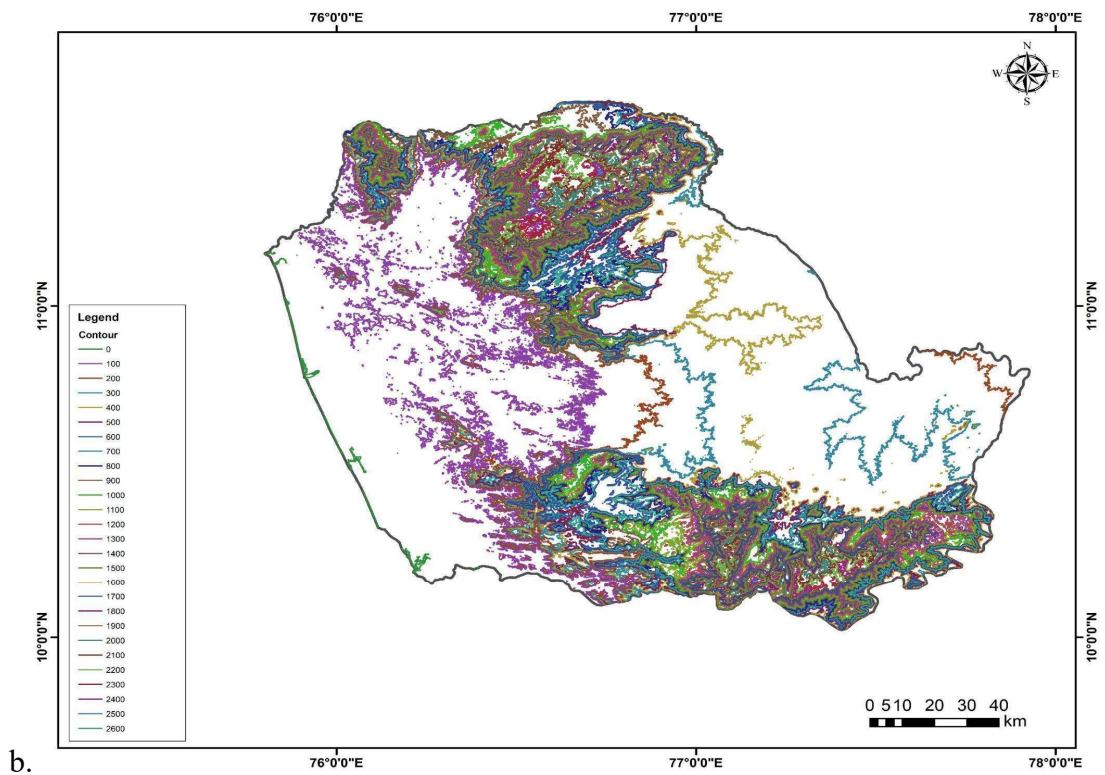
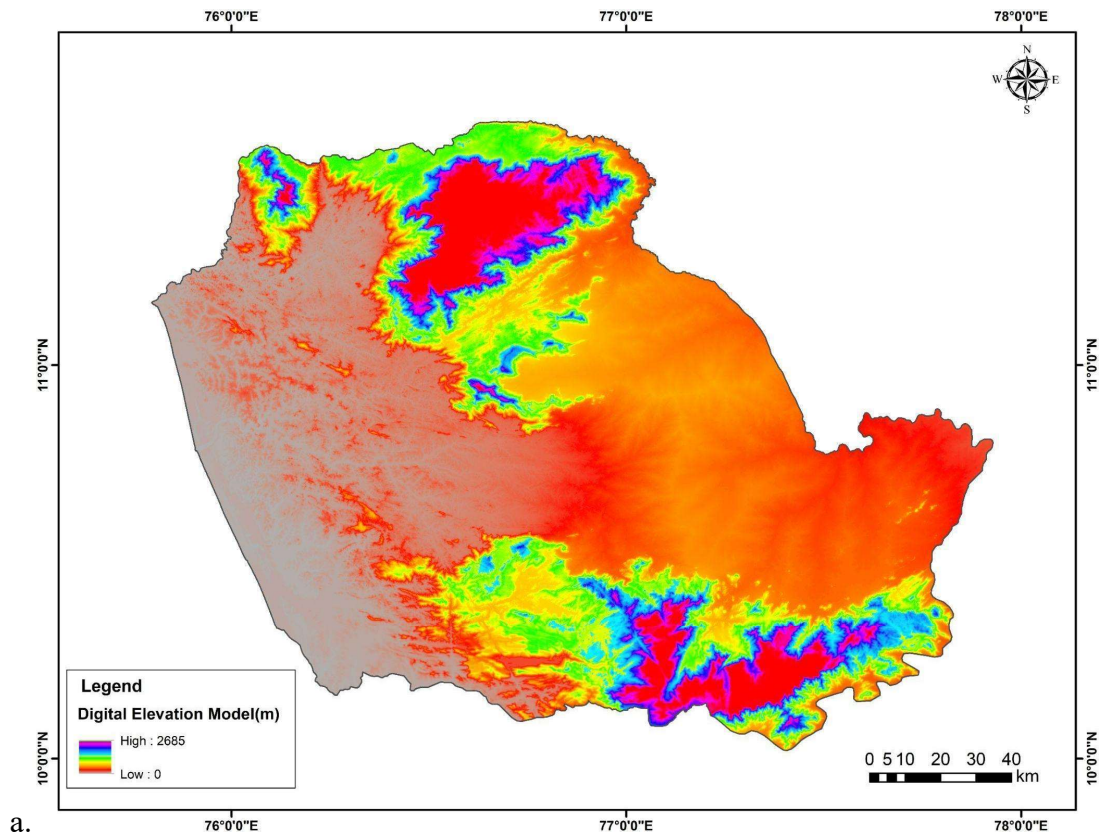


Fig. 4.11: a. DEM image of Palghat Gap and Gap influenced area b. Contour map of Palghat Gap and Gap influenced area

IV. 5. Geospatial Distribution Mapping of selected Lycophytes and Ferns across the Gap

The significance of regional vegetation mapping relies on the fact that it assists in implementing conservation measures and management of natural resources. As part of the present research, the distribution mapping of lycophytes and ferns recorded from the Gap influenced regions along with IUCN Red listed and narrowly distributed, endemic taxa were done using GIS tools. Digital Elevation Model, created using the DEM images downloaded from USGS Earth explorer, showed the elevation range of the entire study area was ranging from 0 to above 2000 m (Fig. 4.11.a). Based on the elevation model, a contour map with an interval of 100 m was prepared (Fig. 4.11.b). From the contour map, slope map (Fig. 4.12.a) and aspect map (Fig. 4.12.b) were developed. The hydrology map of the study area (Fig. 4.13) showed streams in first order to fifth order. There are four fifth order streams which are flowing westward and one fifth order river that drains eastward (Fig. 4.13).

IV.5.1. Land use land cover (LULC) Classification

Land use land cover (LULC) analysis between two time periods; 2002 and 2021- provided data on the changes in the land use as well as the land cover between these time periods. It showed 11 different categories of land use patterns in the Gap and Gap influenced areas such as Evergreen Forest, Deciduous Forest, Mixed Forest, Shrublands, Grasslands intermixed with shrubs and small trees, Grasslands, Wetlands, Croplands/Natural vegetation, Urban and Built-Up lands, Barren areas and Water bodies (Table 4.8). The major land use form in the study area is crop lands/natural vegetation. Demarcation between evergreen, shola and semi-evergreen was difficult due to their similarity. So these three vegetations together are included under a broader category, Evergreen Forest category. Among the different forest covers, evergreen forest (16.529%) forms the major forest type, followed by grasslands intermixed with shrubs and small trees (29.843%), grasslands (2.785%) and deciduous forests (1.034%). Though typical Savannah vegetation is present in African countries, almost similar vegetation type, with scattered tree growth in the

vast grassy areas are referred to as ‘mesic savannas’ in the Asian region (Ratnam *et al.*, 2016, 2019). These may be the transitional area between evergreen or shola forest and grasslands or transformed by fire and possess scattered trees amidst grassland. These types are referred to in this work as ‘Savannas’ (after Ratnam *et al.*, 2016, 2019). The analysis showed that the evergreen, deciduous and mixed forest areas increased to some extent in 2021, than in 2002. Similarly, the barren area, grasslands, savanna and shrub lands showed a reduction in area by 2021 (Fig.4.14; Table 4.8). This reduction might be due to increase in urbanisation along with increase in built up area. These results are in tune with earlier reports (Lahiri and Roy, 2022) stating that occupancy of grasslands showed a small decrease over the decades by overgrazing and utilising grasslands for other purposes. Croplands/Natural vegetation (47.396%) in the study area includes crop lands, plantations and natural vegetation. The plantations include both private and Government owned ones. Critical evaluation of area coverage of different land use forms revealed that the increase in evergreen, deciduous and mixed forests may be due to increased forest management practices by way of social forestry and agroforestry activities by Forest Department and other agencies involved in greening the planet action. Also, many of the private plantations are now under the Forest Department since the lease period is over and now are left undisturbed for the natural regeneration and restoration of the forest.

The urbanisation has increased manifold and this might have reduced the suitable habitats for the pteridophyte taxa that prefer undisturbed habitats. This in turn might have also increased suitability for survival of pteridophytes that grow in disturbed as well as polluted habitats like *Pteris vittata*. The decline in the wetland ecosystems constitute another factor for population reduction of wetland specific pteridophytes such as species of *Isoetes*. Madhusoodanan *et al.*, (1993) discussed the detailed ecology and taxonomy of aquatic pteridophytes of Kerala. And pointed out that the decline in the wetlands by climate change might be adversely affect the aquatic pteridophytes flora of Kerala. Kokkal *et al.* (2008) provided data on decrease in wetland ecosystems across the state of Kerala which seems to be supportive for the present finding of reduction in wetlands around the Gap influenced areas.

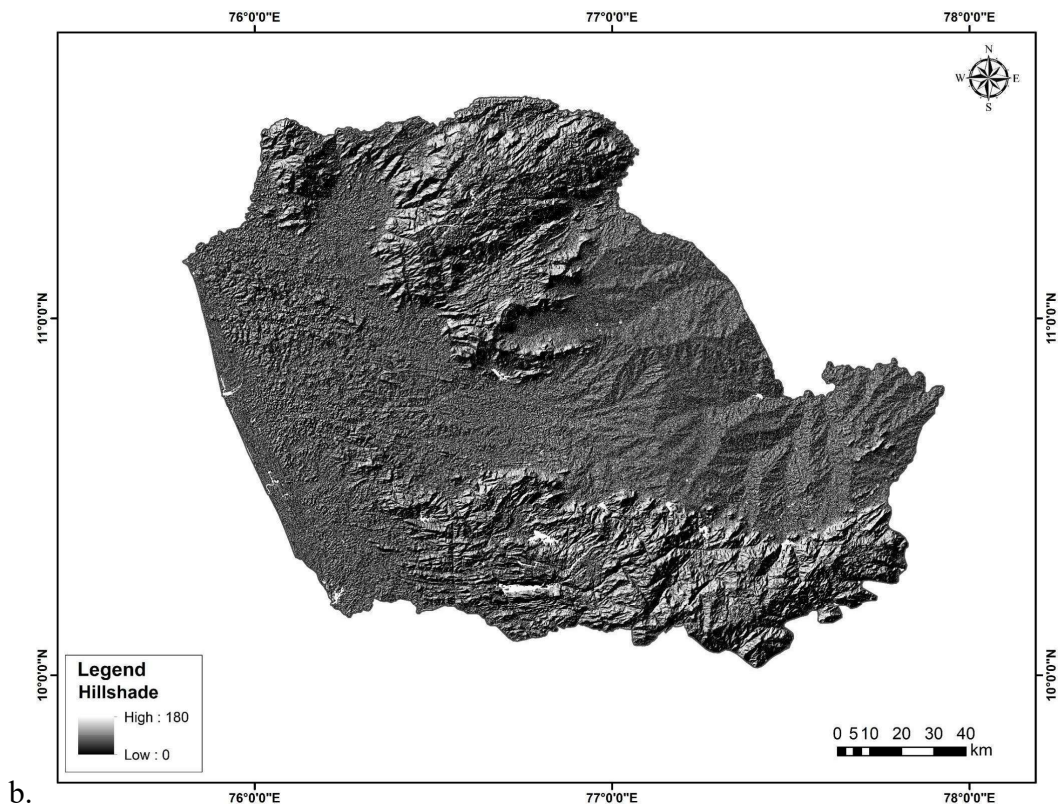
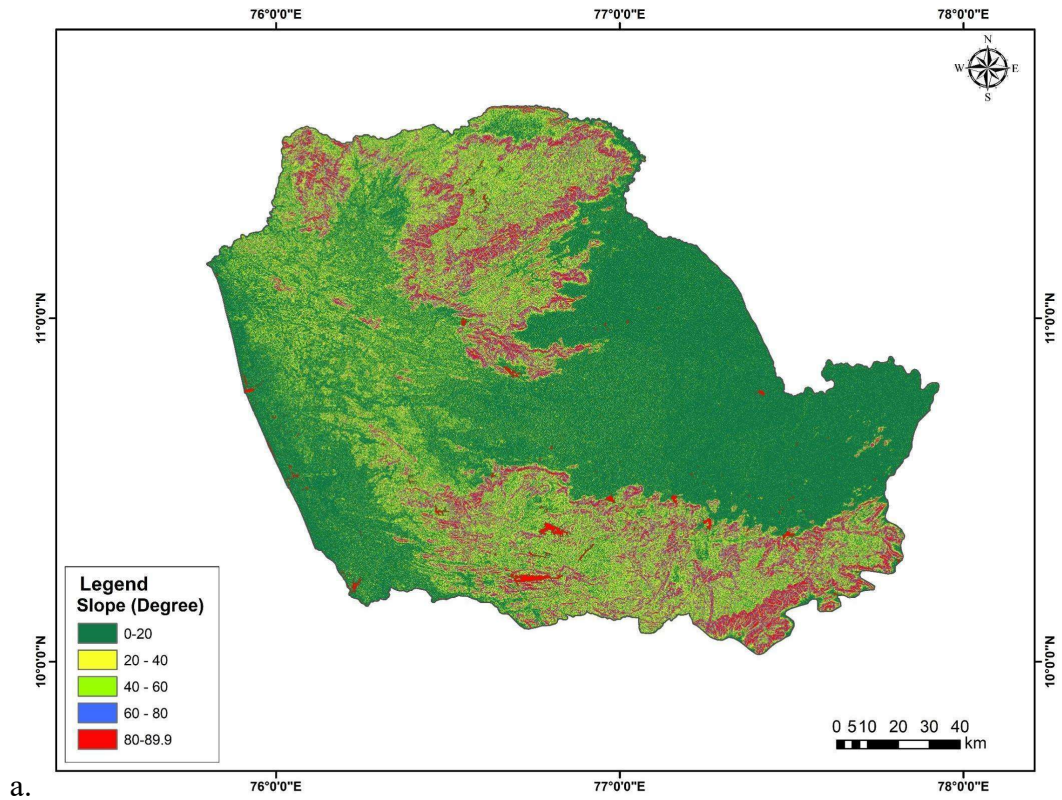


Fig. 4.12: a. Slope map of Palghat Gap and Gap influenced area b. Aspect map of Palghat Gap and Gap influenced area

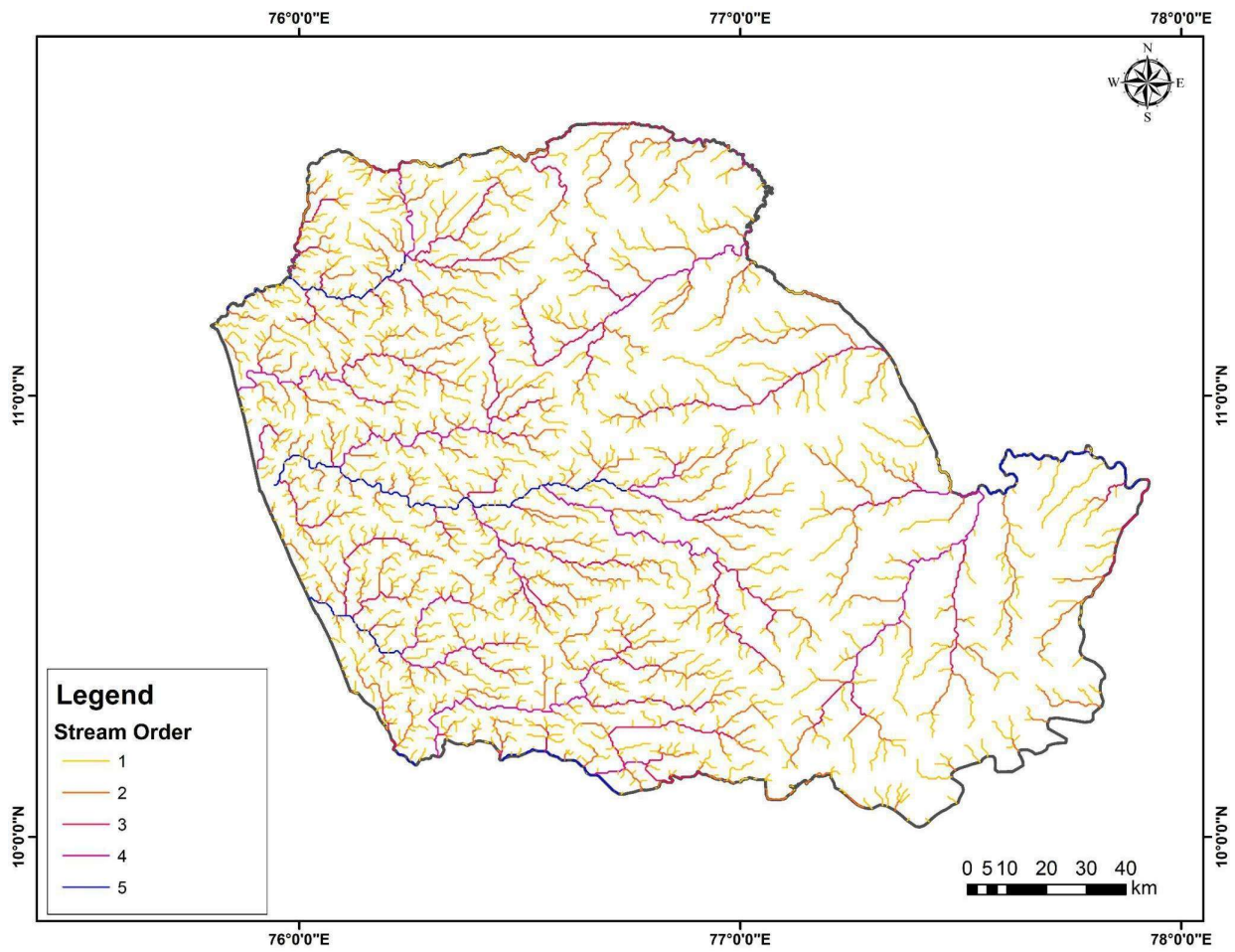
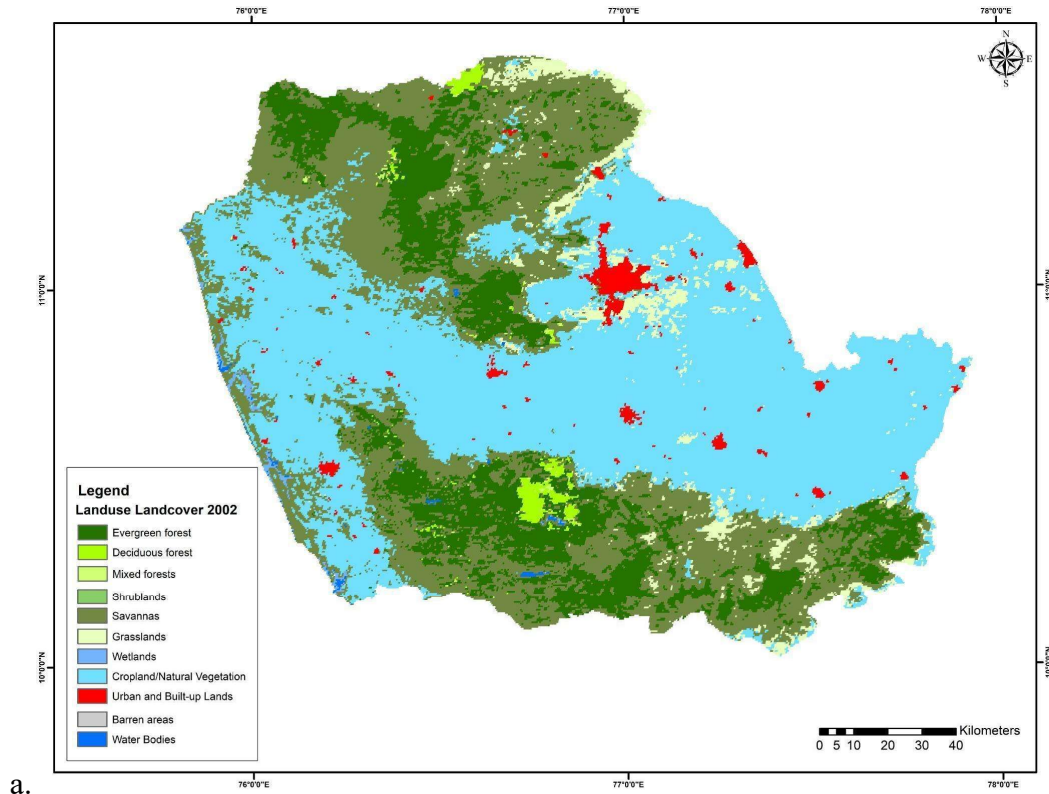
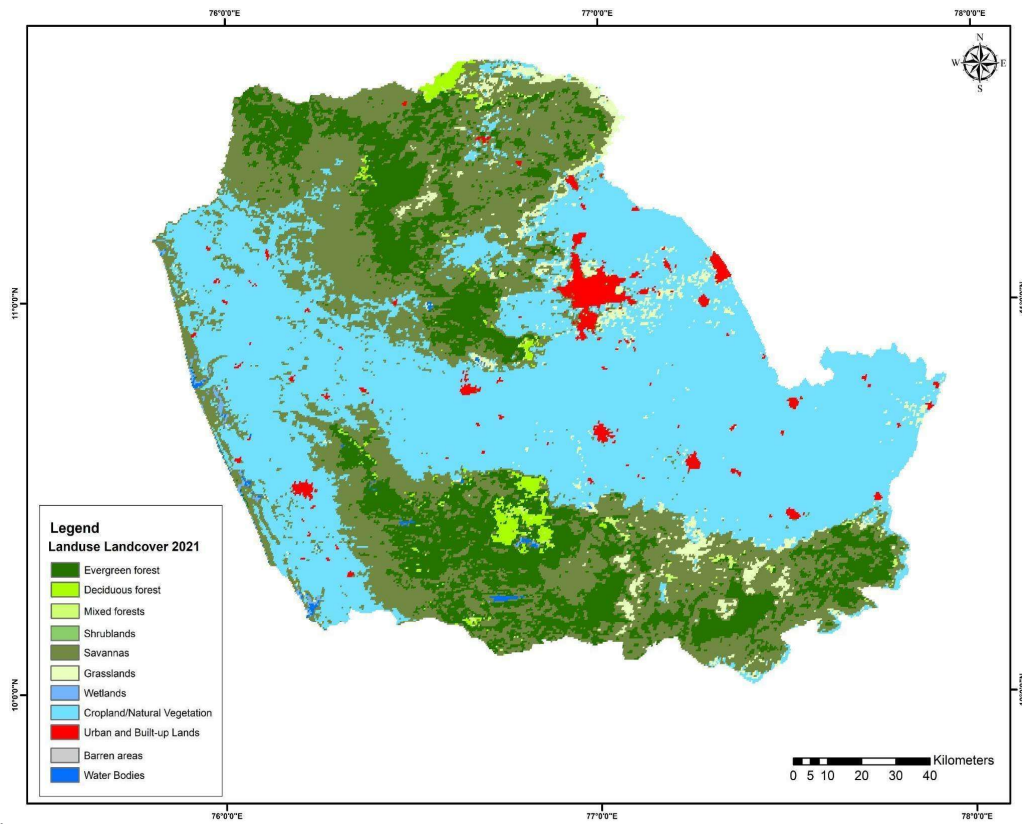


Fig. 4.13: Hydrology map of Palghat Gap and Gap influenced area

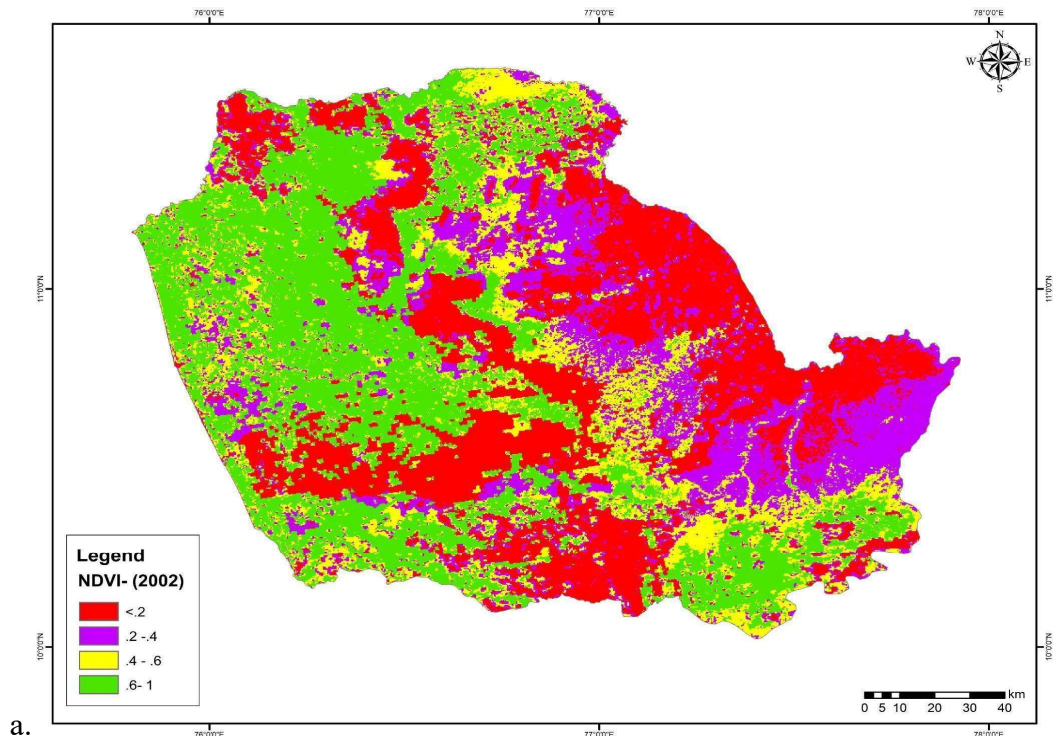


a.

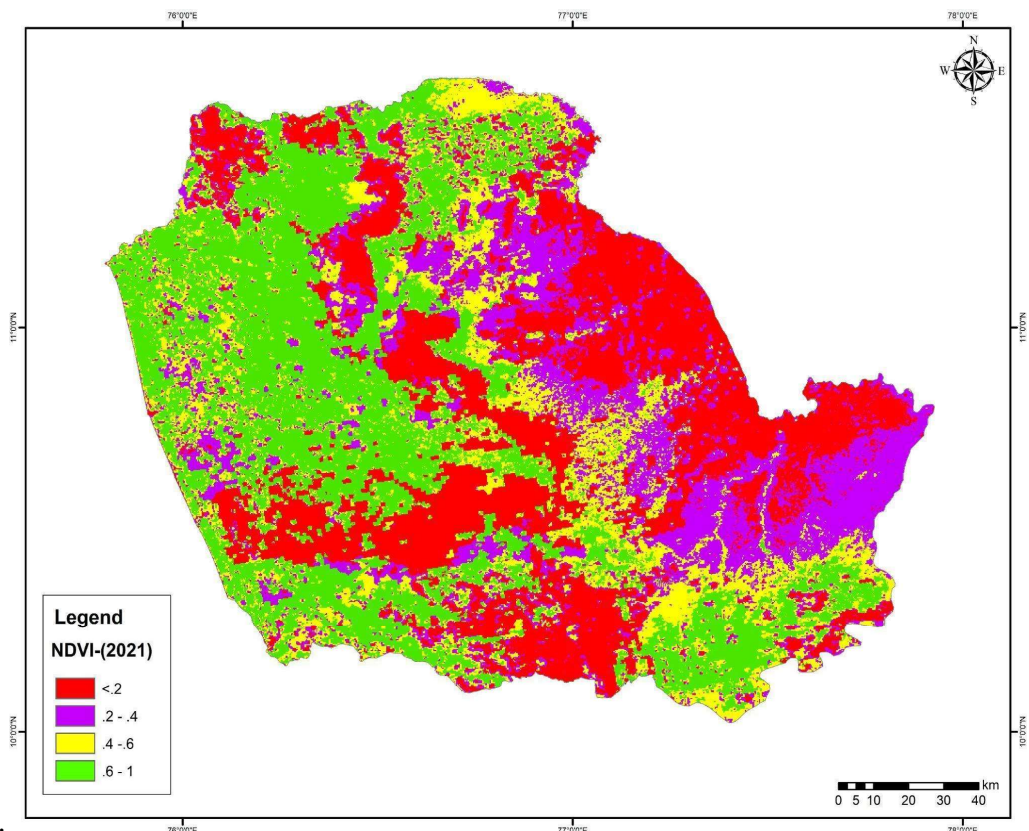


b.

Fig. 4.14. LULC map of Palghat Gap and Gap influenced area in the time period of a. 2002 b. 2021



a.



b.

Fig. 4.15. NDVI map of Palghat Gap and Gap influenced area in the time period of: a. 2002

b. 2021

IV.5.2. NDVI Analysis

Normalised Difference Vegetation Index calculated for the Gap influenced area showed four different range values in the previous two decades. In NDVI analysis, four ranges were considered; the low NDVI value (between -1 to 0 for water body), medium NDVI value (between 0.1 to 0.2 for barren rocks or sand), high NDVI values (between 0.3 to 0.5 indicates shrubs, grassland or senescing crops) and very high NDVI values (between 0.6 to 1.0 indicates dense forest and tropical rainforests). The NDVI analysis of two time periods, 2002 and 2021, of the study area is comparable with the maps obtained in LULC analysis of the study area. The area coming under the low NDVI value range is reduced in 2021 compared to 2002. The area coming under the other three ranges of NDVI value has increased to some extent as compared with 2002. So, it indicates that the area of the wetlands has decreased progressively, and that the dense vegetation and tropical rainforests have increased a little (Fig. 4.15; Table 4.9). Recent forest cover assessments report depreciation in forests, as is the case, the present increase recorded while using software might be due to recording of all green dense vegetation of even plantations as forests.

Table 4.8. Area coverage of LULC of Palghat Gap and Gap influenced areas in the time period of 2002 and 2021

Sl. No.	LULC_class	LULC_2002	LULC_2021
		Area (sq km)	Area (sq km)
1	Evergreen forest	4070.45 (15.585%)	4317 (16.529%)
2	Deciduous forest	227.25 (0.8701%)	270.28 (1.034%)
3	Mixed forest	44.08 (0.168%)	95.54 (0.365%)
4	Shrublands	0.78 (0.00298%)	0.27 (0.00103%)
5	Grasslands intermixed with shrubs and small trees	7901.47 (30.2541%)	7794.12 (29.843%)
6	Grasslands	1020.93 (3.909%)	727.36 (2.785%)
7	Wetlands	71.62 (0.274%)	58.01 (0.222%)
8	Croplands/Natural vegetation	12359.88 (47.325%)	12378.47 (47.396%)
9	Urban and Built-Up lands	373.51 (1.430%)	425.58 (1.629%)
10	Barren areas	1.63 (0.00624%)	0.27 (0.00103%)
11	Water bodies	45.4 (0.173%)	50.1 (0.191%)
Total	26117	26117	

Table 4.9. Area of NDVI analysis of Gap influenced area between 2002 and of 2021

Class	2002 (sq. km)	2021(sq. km)
Low NDVI	7862.11	5539.93
Medium NDVI	5280.46	5741.28
High NDVI	4466.59	5283.41
Very high NDVI	8507.84	9552.46
Total	26117	26117

The degradation in one ecosystem is not simply the disappearance of that particular ecosystem alone, but it causes vanishing of many species specific to that ecosystem, which ultimately leads to loss of biodiversity. Any change in habitats like grasslands will affect taxa like *Anemia schimperiana* subsp. *wightiana* and *Selaginella wightii*. Similarly, when wetlands are disturbed, it may cause the disappearance of taxa adapted to such habitats.

The altitudinal analysis of vegetation cover showed that the evergreen and grassland patches are more in the higher altitudes (1600-2590 m). The middle altitudinal classes, 400-1600 m., have mixed forest, deciduous forests, shrublands and grasslands intermixed with shrubs and small trees, whereas the low altitude ranges viz., 1-400 m., have very low vegetation cover, as transformed into urban areas, built up areas, crop lands, wetlands and water bodies.

IV.5.3. Altitudinal distribution of endemic and IUCN red listed taxa

The distribution of the endemic and IUCN red listed taxa of pteridophytes were mapped in the study area based on the altitudinal distribution. A total of 21 endemics and 17 IUCN red listed taxa (after Chandra *et al.*, 2008; Fraser-Jenkins, 2012; Ebihara *et al.*, 2012) were identified from the Gap influenced area of southern Western Ghats. The endemic taxa were found to be distributed in both South and North of the Gap. Higher concentrations of endemic taxa were recorded in the

evergreen forests of the Silent Valley National Park, Nelliampathy hills, Pampadum Shola National Park and Mathikettan Shola National Park (Fig. 4.16; Table 4.10).

Diplazium leptophyllum Christ, designated as critically endangered (CR) for India (Fraser-Jenkins, 2012), was found distributed in both South and North of the Gap at an altitude range of 1000-1500 m. (Fig. 4.17). From the study area, 7 endangered (EN) taxa were recorded, viz., *Blechnum melanocaulon* (Brack.) T.C. Chambers & P.A. Farrant subsp. *pallens* (T.C.Chambers & P.A.Farrant) Parris (1200-2400 m), *Cyathea crinita* (Hook.) Copel. (1000-1200 m), *Cyrtomium micropterum* (Kunze) Ching (2300-2400 m), *Elaphoglossum nilgircum* Krajina ex Sledge (900-1100 m), *Loxogramme parallela* Copel. (2300-2400 m), *Oreogrammitis attenuata* (Kunze) Parris (1300-2100 m) and *Polystichum subinerme* (Kunze) Fraser-Jenk. (1100-2400 m). (Fig. 4.18; Table 4.8). The vulnerable (VU) taxa include *Bolbitis semicordata* (Baker) Ching (50-1900 m), *Dryopsis scabrosa* (Kunze) Kuntze (900-1000) and *Pellaea boivinii* Hook. (1100-2100 m) (Fig. 4.19; Table 4.12). Similarly, near threatened (NT) taxa viz., *Asplenium emarginatodentatum* Zenker (1000-1100 m), *A. mysorensense* Roth (300-2000 m), *Davallia trichomanoides* Blume (500-2400 m), *Diplazium travancoricum* Bedd. (900-1700 m), *Elaphoglossum beddomei* Sledge (900-2000 m) and *Selaginella miniatospora* (Dalzell) Baker (1200-1400 m) were also found distributed in the study area (Fig. 4.20; Table 4.10). The distribution mapping of NT and VU taxa, showed that taxa belonging to these categories are more concentrated in the North of the Gap, than in the South (Fig. 4.19 & 4.20; Table 4.12 & 4.13).

The Gap influenced area comprises crop lands/natural vegetation as the major vegetation type, followed by evergreen forests (Table 4.8). The area of evergreen, deciduous and mixed forests showed an expansion over the last decades, due to increased afforestation activities by the Forest Department and other agencies involved in greening the planet.

The endemics or narrowly distributed and IUCN red listed taxa in the area are distributed in the altitude zones 'below 100' to 'above 2300 m', with more

aggregation in the 900 to 2400 m altitude zones. Any disturbances leading to the deterioration of quality of the habitats in this area may hence adversely affect the existence of these taxa and may lead to local extinction events.

Table 4.10. Altitudinal ranges and distribution of endemic taxa in the Palghat Gap influenced region

Sl.No.	Species	Altitude range (m)	Distribution
1	<i>Anemia schimperiana</i> C. Presl subsp. <i>wightiana</i> (Gardner) Fraser-Jenk.	900-1400	Southern India (Tamil Nadu, Kerala)
2	<i>Asplenium andreisii</i> Fraser-Jenk.	1400-2000	Southern India (Tamil Nadu, Kerala)
3	<i>Asplenium decrescens</i> Kunze	500-2300	Southern India (Karnataka, Kerala, Tamil Nadu); Sri Lanka
4	<i>Asplenium emarginatodentatum</i> Zenker	1000-1100	Southern India (Karnataka, Kerala, Tamil Nadu)
5	<i>Asplenium zenkerianum</i> Kunze	1300-1900	Southern India (Karnataka, Kerala, Tamil Nadu); Sri Lanka
6	<i>Bolbitis beddomei</i> Fraser-Jenk. & Gandhi	300-1600	Southern India (Goa, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Tamil Nadu)
7	<i>Bolbitis semicordata</i> (Baker) Ching	50-1900	Southern India (Kerala, Karnataka, Tamil Nadu); Sri Lanka
8	<i>Cyathea crinita</i> (Hook.) Copel.	1000-1200	Southern India (Kerala, Tamil Nadu); Sri Lanka
9	<i>Cyathea nilgirensis</i> Holttum	900-2300	Southern India (Andhra Pradesh, Karnataka, Kerala, Tamil Nadu)
10	<i>Diplazium travancoricum</i> Bedd.	900-1700	Southern India (Kerala, Tamil Nadu); Sri Lanka
11	<i>Dryopsis scabrosa</i> (Kunze) Kuntze	900-1000	Southern India (Kerala, Tamil Nadu)
12	<i>Dryopteris odontoloma</i> (T.Moore ex Bedd.) C.Chr.	900-1000	Southern India (Tamil Nadu)
13	<i>Elaphoglossum beddomei</i>	900-2000	Southern India (Kerala,

Sl.No.	Species	Altitude range (m)	Distribution
	Sledge		Tamil Nadu, Karnataka)
14	<i>Elaphoglossum nilgiricum</i> Krajina ex Sledge	900-1100	Southern India (Kerala, Tamil Nadu, Karnataka)
15	<i>Oreogrammitis attenuata</i> (Kunze) Parris	1300-2100	Southern India (Tamil Nadu, Kerala); Sri Lanka
16	<i>Polystichum harpophyllum</i> (Zenker ex Kunze) Sledge	1000-2300	Southern India (Kerala, Tamil Nadu); Sri Lanka
17	<i>Polystichum subinerme</i> (Kunze) Fraser-Jenk.	1100-2400	Southern India (Kerala, Tamil Nadu, Karnataka)
18	<i>Selaginella miniatospora</i> (Dalzell) Baker	1200-1400	Southern India (Maharashtra, Goa, Karnataka)
19	<i>Selaginella radicata</i> (Hook. & Grev.) Spring	900-1000	Southern India (Andhra Pradesh, Karnataka, Kerala, Tamil Nadu)
20	<i>Selaginella wightii</i> Hieron.	1100-1400	Southern India (Andhra Pradesh, Karnataka, Kerala, Tamil Nadu); Sri Lanka
21	<i>Tectaria wightii</i> (C.B.Clarke) Ching	100-2300	Southern India (Karnataka, Kerala, Tamil Nadu)

Table 4.11. Altitudinal ranges of endangered (EN) taxa from Palghat Gap region

Sl. No.	Code	Species	Altitude (m)
1	BlMeP	<i>Blechnum melanocaulon</i> (Brack.) T.C. Chambers & P.A. Farrant subsp. <i>pallens</i> (T.C.Chambers & P.A.Farrant) Parris	1200-2400
2	CyCr	<i>Cyathea crinita</i> (Hook.) Copel.	1000-1200
3	CyMi	<i>Cyrtomium micropterum</i> (Kunze) Ching	2300-2400
	ElNi	<i>Elaphoglossum nilgiricum</i> Krajina ex Sledge	900-1100
5	LoPa	<i>Loxogramme parallela</i> Copel.	2300-2400
6	OrAt	<i>Oreogrammitis attenuata</i> (Kunze) Parris	1300-2100
7	PoS	<i>Polystichum subinerme</i> (Kunze) Fraser-Jenk.	1100-2400

Table 4.12. Altitudinal ranges of vulnerable (VU) taxa from Palghat Gap region

Sl. No.	Code	Species	Altitude (m)
1	BoSe	<i>Bolbitis semicordata</i> (Baker) Ching	50-1900
2	DrSc	<i>Dryopsis scabrosa</i> (Kunze) Kuntze	900-1000
3	PeBo	<i>Pellaea boivinii</i> Hook.	1100-2100

Table 4.13. Altitudinal ranges of near threatened (NT) taxa collected from Palghat Gap region

Sl. No.	Code	Species	Altitude (m)
1	AsEm	<i>Asplenium emarginatodentatum</i> Zenker	1000-1100
2	AsMy	<i>Asplenium mysorensense</i> Roth.	300-2000
3	DaTr	<i>Davallia trichomanoides</i> Blume	500-2400
4	DiTr	<i>Diplazium travancoricum</i> Bedd.	900-1700
5	ElBe	<i>Elaphoglossum beddomei</i> Sledge	900-2000
6	SeMi	<i>Selaginella miniatospora</i> (Dalzell) Baker	1200-1400

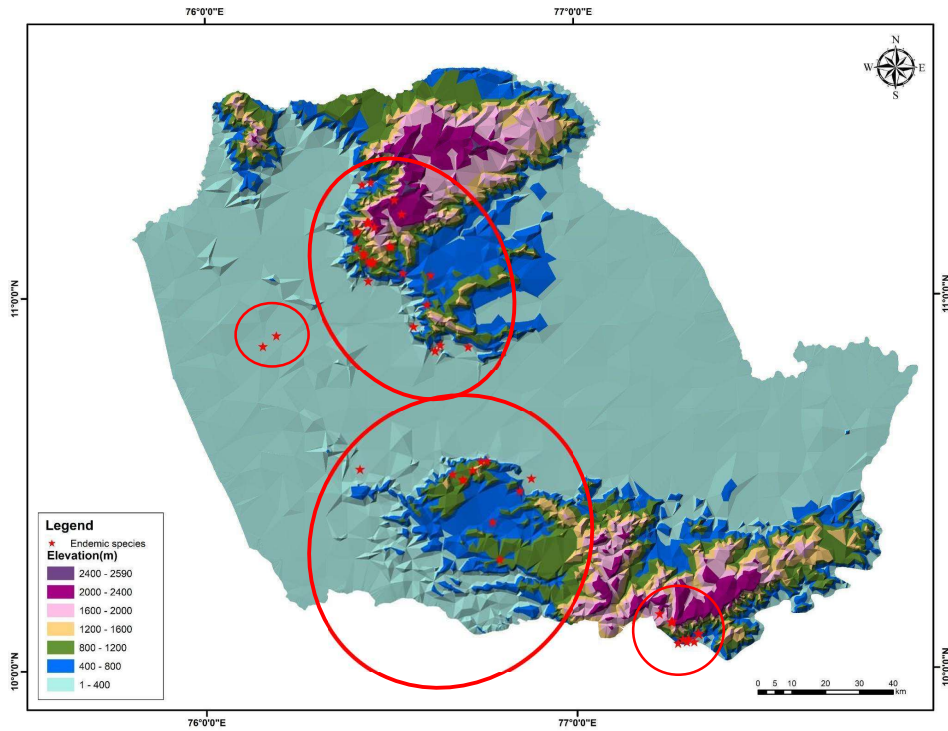


Fig. 4.16. Altitudinal distribution mapping of narrowly distributed taxa (Southern India and Sri Lanka)

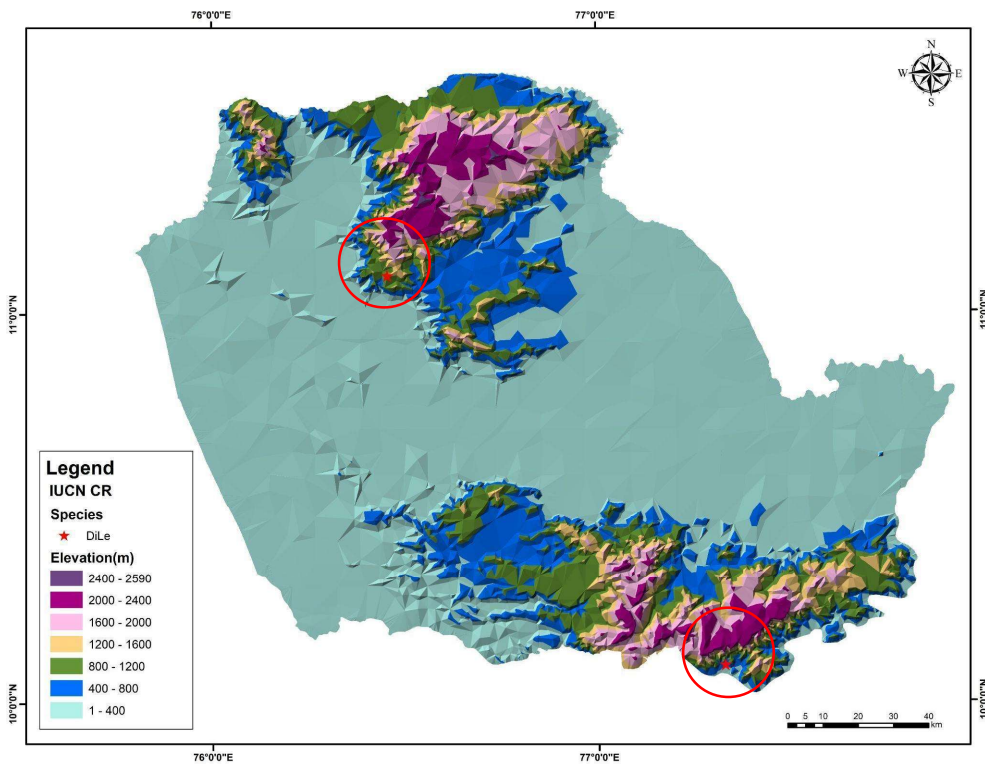


Fig. 4.17. Altitudinal distribution mapping of critically endangered (CR) taxon *Diplazium leptophyllum* Christ (DiLe) along the Palghat Gap region

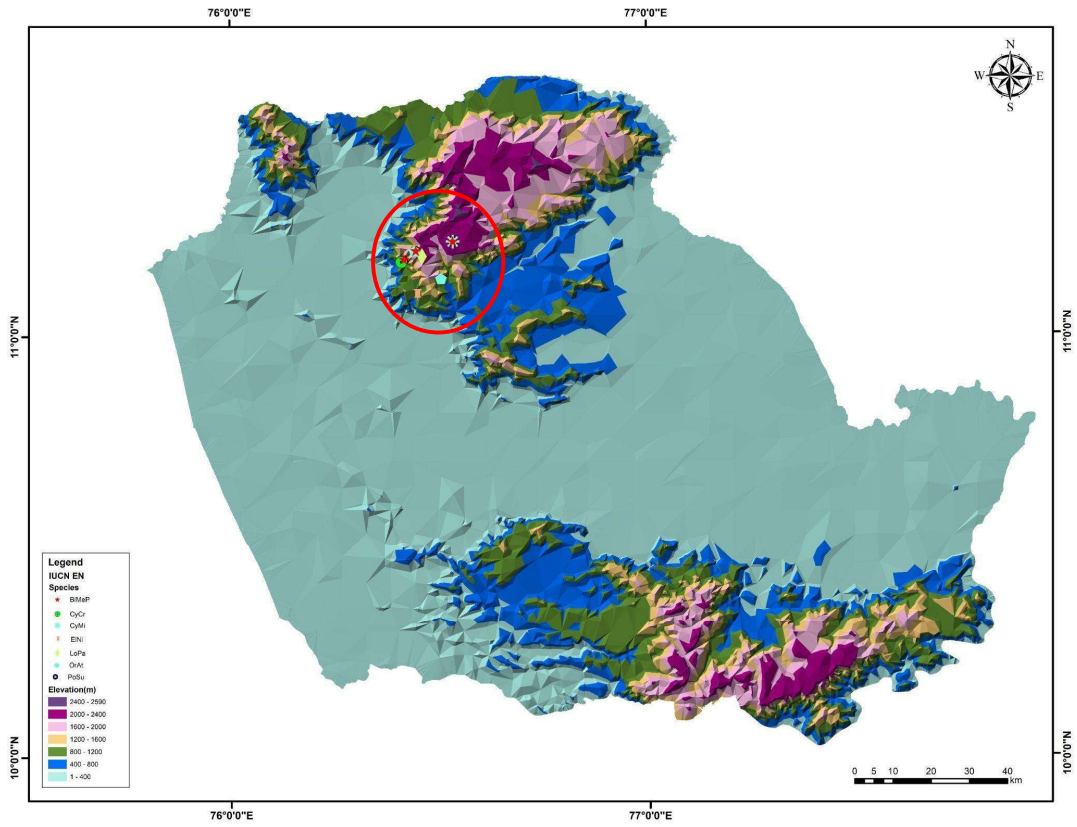


Fig. 4.18. Altitudinal distribution mapping of endangered (EN) taxa along Palghat Gap region

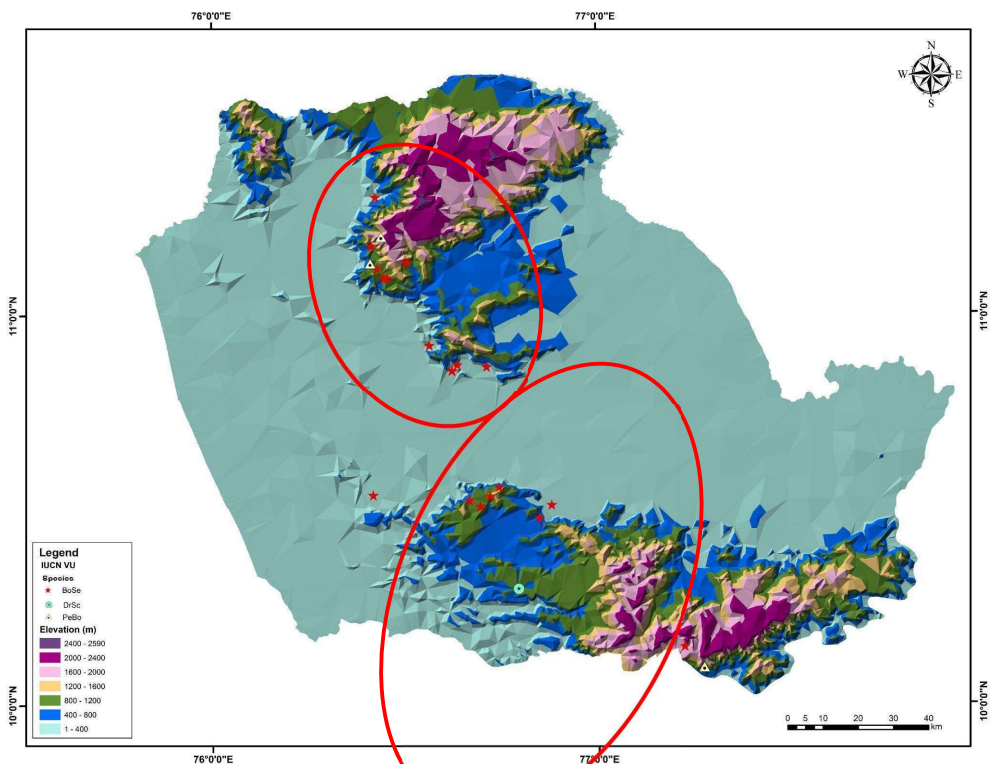


Fig. 4.19. Altitudinal distribution mapping of vulnerable (VU) taxa along Palghat Gap region

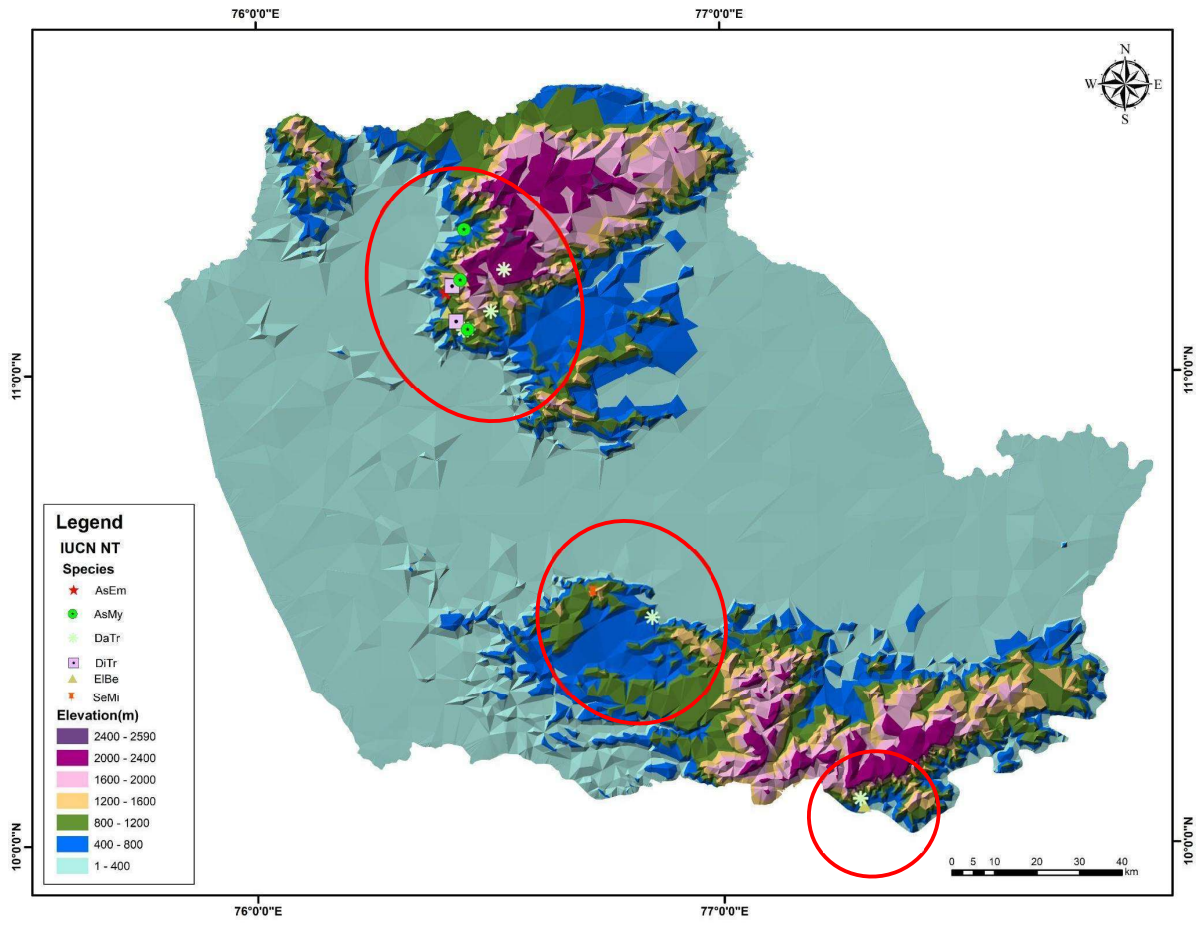


Fig. 4.20. Altitudinal distribution mapping of near threatened (NT) taxa along Palghat Gap region

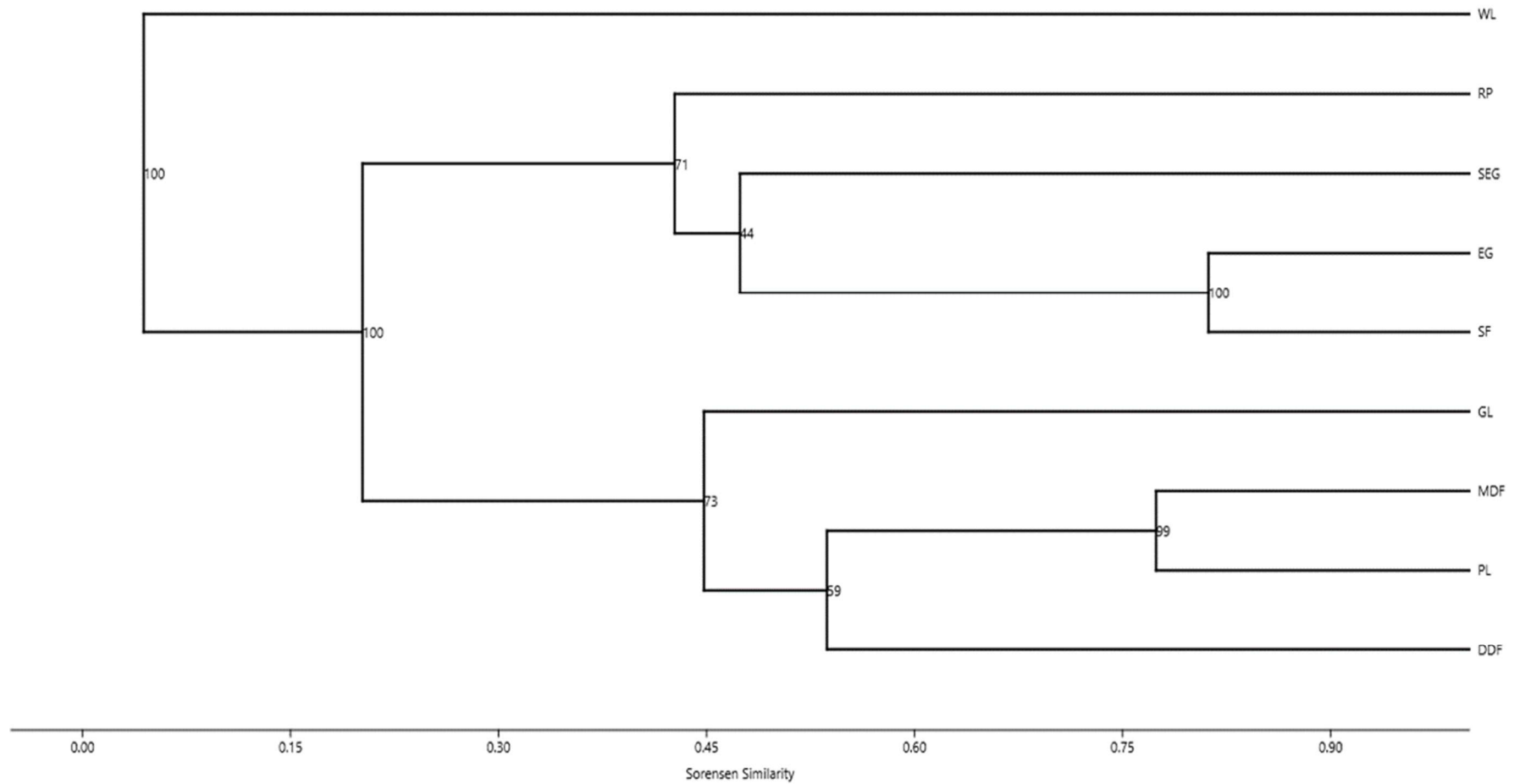


Fig. 4.21. Dendrogram based on the Sorensen similarity index on the pteridophytes along different habitats in the study area [WL - Wet land; DDF- Dry Deciduous Forest, GL - Grassland; PL - Plantation; MDF - Moist Deciduous Forest; RP - Riparian; SEG - Semi Evergreen Forest; SF - Shola Forest; EG- Evergreen Forest]

IV. 6. Ecological studies and Ecological Niche Modelling

Ecosystem traits were subjected to analysis based on different criteria to assess the adaptability and survival regimes of the different ferns and lycophytes across the Gap region. The distribution of taxa along different habitats, microhabitats and altitudinal classes were analysed using Sorensen's similarity index, taxonomic distinctness and species richness.

IV.6.1. Distributional range of ferns and lycophytes across habitats

Forest types and distribution of taxa

The eco-climatic settings of each vegetation type is different and hence, the assemblage of pteridophytes inhabiting the area also varies accordingly. The data on distribution of pteridophytes recorded during 2018 to 2023 were analysed to check for the patterns of distribution across the Gap influenced area.

Lycophytes and ferns inhabiting Dry deciduous forests

A total of 18 taxa, belonging to 14 genera under 8 families were recorded from the dry deciduous forests. Among which, members of Pteridaceae, with 9 taxa showed prominence in distribution (Table 4.14). Of the species recorded, *Actiniopteris radiata*, *Doryopteris concolor* and *Oeosporangium tenuifolium* serve as indicator species of this habitat.

Lycophytes and ferns inhabiting Moist deciduous forests

A total of 52 species were recorded from moist deciduous forests across the Gap influenced area, belonging to 24 genera and 13 families. Among these, Pteridaceae have the highest number of taxa (Annexure 1). This forest formation across the Gap zone constitutes one of the major habitats for this group of plants. Most of the species inhabiting this zone of vegetation, thrive well in the immediate post monsoon season. *Athyrium cumingianum*, *Dicranopteris linearis* and *Thelypteris terminans* serve as indicator taxa of this habitat.

Lycophytes and ferns inhabiting Semi evergreen forests

Semi-evergreen forests constitute an important habitat for many ferns and lycophytes. A total of 84 species, belonging to 30 genera and 14 families of pteridophytes were recorded from semi-evergreen forests of the Palghat Gap influenced areas. Most of the taxa belong to the family Pteridaceae (Annexure 2). *Asplenium formosum*, *Stenochlaena palustris*, *Lindsaea heterophylla*, *L. ensifolia* and *Microlepia speluncae* serve as indicators of semi-evergreen forests.

Table 4.14. Pteridophyte taxa recorded from the dry deciduous forests in the study area

S. No	Species	Genus	Family
1	<i>Actiniopteris radiata</i> (J.Koenig ex Sw.) Link	<i>Actiniopteris</i>	Pteridaceae
2	<i>Adiantum caudatum</i> L.	<i>Adiantum</i>	Pteridaceae
3	<i>Adiantum philippense</i> L.	<i>Adiantum</i>	Pteridaceae
4	<i>Adiantum zollingeri</i> Mett. ex Kuhn	<i>Adiantum</i>	Pteridaceae
5	<i>Aleuritopteris bicolor</i> (Roxb.) Fraser-Jenk.	<i>Aleuritopteris</i>	Pteridaceae
6	<i>Dicranopteris taiwanensis</i> Ching & P.S.Chiu in Chien & Chun	<i>Dicranopteris</i>	Gleicheniaceae
7	<i>Doryopteris concolor</i> (Langsd. & Fisch.) Kuhn	<i>Doryopteris</i>	Pteridaceae
8	<i>Drynaria quercifolia</i> (L.) J.Sm.	<i>Drynaria</i>	Polypodiaceae
9	<i>Dryopteris cochleata</i> (D.Don) C.Chr.	<i>Dryopteris</i>	Dryopteridaceae
10	<i>Lygodium flexuosum</i> (L.) Sw.	<i>Lygodium</i>	Lygodiaceae
11	<i>Mickelopteris cordata</i> (Roxb. ex Hook. & Grev.) Fraser-Jenk.	<i>Mickelopteris</i>	Pteridaceae
12	<i>Oeosporangium tenuifolium</i> (Burm.f.) Fraser-Jenk. & Pariyar	<i>Oeosporangium</i>	Pteridaceae
13	<i>Pteridium aquilinum</i> (L.) Kuhn subsp. <i>wightianum</i> (Wall. ex J.Agardh) W.C.Shieh	<i>Pteridium</i>	Dennstaedtiaceae
14	<i>Pteris argyraea</i> T.Moore	<i>Pteris</i>	Pteridaceae
15	<i>Selaginella delicatula</i> (Desv. ex Poir.) Alston	<i>Selaginella</i>	Selaginellaceae
16	<i>Selaginella wightii</i> Hieron	<i>Selaginella</i>	Selaginellaceae
17	<i>Thelypteris dentata</i> (Forssk.) E.P.St.John	<i>Thelypteris</i>	Thelypteridaceae
18	<i>Thelypteris parasitica</i> (L.) Tardieu	<i>Thelypteris</i>	Thelypteridaceae

Lycophytes and ferns inhabiting Evergreen Forests

The evergreen forests of the study area support about 136 species, belong to 47 genera and 20 families of pteridophytes. Unlike the other vegetation types, Aspleniaceae (Annexure 3) with 21 taxa showed prominence in this vegetation type. Characteristic taxa of evergreen forests include *Huperzia phlegmaria*, *H. phyllantha*, *H. squarrosa*, *Asplenium phyllitidis*, *Leptochilus axillaris*, *Microsorium membranaceum*, *M. punctatum*, *Blechnum melanocaulon* subsp. *pallens*, *Cyathea crinita*, *C. gigantea*, *C. nilgirensis*, *Davallia trichomanoides*, *Katoella pulchra*, *Polystichum harpophyllum*, *P. subinerme*, *Elaphoglossum beddomei*, *E. nilgircum*, *Trichomanes bilabiatum*, *T. bimarginatum*, *T. campanulatum*, *T. exiguum*, *T. minutum*, *T. obscurum*, *Marattia fraxinea* and *Antrophyum plantagineum*.

Lycophytes and ferns inhabiting Shola forests

Shola vegetation across the Gap zone is being distributed in the north of Palghat Gap and also at Shola National Parks in Idukki district. A total of 98 species, belonging to 38 genera and 17 families of pteridophytes were recorded from the shola forests of the study area. Here also Aspleniaceae with 20 taxa showed prominence (Annexure 4). Some common elements of Shola habitat include, *Huperzia phlegmaria*, *H. squarrosa*, *Asplenium phyllitidis*, *A. tenuifolium*, *Athyrium solenopteris*, *Bolbitis asplenifolia*, *Lindsaea heterophylla*, *Leptochilus axillaris*, *Deparia japonica* subsp. *sledgei*, *Blechnum melanocaulon* subsp. *pallens*, *Cyathea crinita*, *C. nilgirensis*, *Arachniodes palmipes*, *Elaphoglossum beddomei*, *E. nilgircum*, *Hymenophyllum exsertum*, *Botrychium daucifolium*, *Oreogrammitis attenuata*, *Antrophyum plantagineum*, *Cyrtomium caryotideum* and *Lindsaea odorata*.

Lycophytes and ferns inhabiting Grassland ecosystem

Montane grasslands at higher altitudes also harbour pteridophytes, but the frequency of occurrence is minimal compared to other habitats. A total of 35 species, belonging to 19 genera and 11 families were recorded from this habitat and most of them belong to Pteridaceae (Annexure 5). Some of the significant taxa in the grassland habitat include *Selaginella wightii*, *Lycopodiella cernua*, *Lycopodium wightianum*, *Pyrrosia porosa*, *Deparia japonica* subsp. *sledgei*, *Mickelopteris*

cordata, *Lindsaea ensifolia*, *Anemia schimperiana* subsp. *wightiana*, *Pteridium aquilinum* subsp. *wightianum*, *Dryopteris cochleata*, *Dicranopteris linearis*, and *D. thaiwanensis*.

Riparian Zones and Pteridophytes

The riparian zones also form suitable habitats for lycophytes and ferns. A total of 65 species, belonging to 29 genera and 19 families were recorded from this habitat (Annexure 6). The Gap zone and gap influenced areas have five fifth order riverine beds and the largest river Bharathappuzha drains through the Gap. This habitat harbour taxa such as *Equisetum ramosissimum*, *Lindsaea heterophylla*, *Asplenium formosum*, *Stenochlaena palustris*, *Bolbitis appendiculata*, *Cyathea crinita*, *C. gigantea*, *C. nilgirensis*, *Trichomanes bilabiatum*, *T. bimarginatum*, *Angiopteris crassipes*, *A. helferiana*, *Diplazium esculentum*, *D. polypodioides*, *D. travancoricum*, *Trichomanes campanulatum*, *T. exiguum*, *T. minutum*, *T. intramarginale*, *Marsilea minuta*, *Osmunda acuta*, *Ceratopteris thalictroides*, *Thelypteris calcarata* and *Thelypteris interrupta*.

Wetlands and Pteridophytes

The wetlands also form suitable habitat for pteridophytes. A total of 6 taxa, belonging to 6 genera and 5 families could be recorded from this habitat. (Table 4.15).

Table 4.15. Pteridophyte taxa recorded from the wetland habitat in the study area

Sl. No	Species	Genus	Family
1	<i>Azolla pinnata</i> R. Br.	<i>Azolla</i>	Salviniaceae
2	<i>Ceratopteris thalictroides</i> (L.) Brongn.	<i>Ceratopteris</i>	Pteridaceae
3	<i>Diplazium esculentum</i> (Retz.) Sw.	<i>Diplazium</i>	Athyriaceae
4	<i>Isoetes coromandelina</i> L.f.	<i>Isoetes</i>	Isoetaceae
5	<i>Marsilea minuta</i> L.	<i>Marsilea</i>	Marsileaceae
6	<i>Salvinia</i> × <i>molesta</i> Mitch.	<i>Salvinia</i>	Salviniaceae

Lycophytes and Ferns inhabiting Plantations

The study area has different plantations of tea, coffee, rubber and teak, and the pteridophytes growing in these plantations account for 41 species, belonging to 21 genera and 12 families. Majority of the taxa in this habitat belong to the family Pteridaceae (Annexure 7). Some common members in this habitat include, *Selaginella tenera*, *Pteris argyraea*, *Pityrogramma calomelanos*, *Mickelopteris cordata*, *Lepisorus nudus*, *Pyrrosia porosa*, *P. lanceolata*, *P. heterophylla*, *Lygodium flexuosum* and *Helminthostachys zeylanica*.

IV.6.2. Pteridophytes and microhabitat diversity

Within the major or macro habitats there exist a variety of microhabitats. The distribution of the taxa is influenced or related to eco-climatic regimes in these microhabitats and many of the pteridophytes are specific to certain microhabitats. Following is a summary of microhabitat preferences of pteridophytes across the Gap zone.

Epiphytes

Ferns and lycophytes occupy the micro environments provided by tree trunks, branches, rock surfaces and crevices. A total of 39 epiphytic species belonging to 19 genera and 9 families were recorded from the study area. Polypodiaceae are the dominant family represented in epiphytic pteridophytes (Annexure 8). Dominance of epiphytic taxa showed a gradation from shola vegetation through evergreen, semi-evergreen and moist deciduous forests.

Psammophytes

Psammophytes are the species which inhabit sandy soils and their rhizomes are well adapted for a life in sandy habitats with wet conditions. A total of 14 species belonging to 7 genera and 7 families were recorded under this category (Table 4.16). These are confined to the riverine margins and on banks of rivulets.

Table 4.16. Pteridophyte taxa recorded from the psammophytic habitats

Sl. No	Species	Genus	Family
1	<i>Bolbitis semicordata</i> (Baker) Ching in C. Chr.	<i>Bolbitis</i>	Dryopteridaceae
2	<i>Cyathea crinita</i> (Hook.) Copel.	<i>Cyathea</i>	Cyatheaceae
3	<i>Cyathea spinulosa</i> Wall. ex Hook.	<i>Cyathea</i>	Cyatheaceae
4	<i>Diplazium esculentum</i> (Retz.) Sw.	<i>Diplazium</i>	Athyriaceae
5	<i>Equisetum ramosissimum</i> Desf.	<i>Equisetum</i>	Equisetaceae
6	<i>Hypolepis polypodioides</i> (Blume) Hook.	<i>Hypolepis</i>	Dennstaedtiaceae
7	<i>Ophioglossum costatum</i> R. Br.	<i>Ophioglossum</i>	Ophioglossaceae
8	<i>Osmunda acuta</i> (Burm.f.) Fraser-Jenk.	<i>Osmunda</i>	Osmundaceae
9	<i>Pellaea longipilosa</i> Bonap.	<i>Pellaea</i>	Pteridaceae
10	<i>Thelypteris arbuscula</i> (Willd.) K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae
11	<i>Thelypteris ochthodes</i> (Kunze) Ching	<i>Thelypteris</i>	Thelypteridaceae
12	<i>Thelypteris subtruncatus</i> (Bory) Panigrahi	<i>Thelypteris</i>	Thelypteridaceae
13	<i>Thelypteris triphylla</i> (Sw.) K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae
14	<i>Thelypteris</i> × <i>thwaitesii</i> (Hook.) C.F.Reed	<i>Thelypteris</i>	Thelypteridaceae

Terrestrial Pteridophytes

In terrestrial microhabitat, a total of 124 species, belonging to 42 genera and 19 families were recorded (Annexure 9). Pteridaceae are the dominant family in this microhabitat.

Lithophytes

Lithophytic pteridophytes from the study area include 52 species, belonging to 21 genera and 12 families. Aspleniaceae are the most represented family with 13 species of *Asplenium* (Annexure 10).

Hydrophytes

Of the taxa recorded, 6 taxa belonging to 6 genera and 4 families are exclusive hydrophytes inhabiting the aquatic habitats (Table 4.17).

Table 4.17. Hydrophytic pteridophyte taxa recorded from study area

Sl. No.	Species	Genus	Family
1	<i>Azolla pinnata</i> R.Br.	<i>Azolla</i>	Salviniaceae
2	<i>Ceratopteris thalictroides</i> (L.) Brongn.	<i>Ceratopteris</i>	Pteridaceae
3	<i>Equisetum ramosissimum</i> Desf.	<i>Equisetum</i>	Equisetaceae
4	<i>Marsilea minuta</i> L.	<i>Marsilea</i>	Marsileaceae
5	<i>Osmunda acuta</i> (Burm.f.) Fraser-Jenk.	<i>Osmunda</i>	Osmundaceae
6	<i>Salvinia</i> × <i>molesta</i> Mitch.	<i>Salvinia</i>	Salviniaceae

Mud cliffs

A total of 87 species belonging to 34 genera and 17 families were collected from the mud cliffs of the study area. Pteridaceae are the dominant family in this microhabitat (Annexure 11).

Rock cliffs

Rock cliffs of the study area are inhabited by 22 species belonging to 13 genera and 9 families. Among these, Polypodiaceae are the dominant family (Table 4.18).

Table 4.18. Pteridophyte taxa recorded from the rock cliffs in the study area

S. No	Species	Genus	Family
1	<i>Adiantum caudatum</i> L.	<i>Adiantum</i>	Pteridaceae
2	<i>Adiantum incisum</i> Forssk.	<i>Adiantum</i>	Pteridaceae
3	<i>Adiantum philippense</i> L.	<i>Adiantum</i>	Pteridaceae
4	<i>Adiantum zollingeri</i> Mett. ex Kuhn	<i>Adiantum</i>	Pteridaceae
5	<i>Anemia schimperiana</i> C.Presl <i>subsp.</i> <i>Wightiana</i> (Gardner) Fraser-Jenk.	<i>Anemia</i>	Anemiaceae
6	<i>Asplenium crinicaule</i> Hance	<i>Asplenium</i>	Aspleniaceae
7	<i>Asplenium decrescens</i> Kunze	<i>Asplenium</i>	Aspleniaceae
8	<i>Asplenium laciniatum</i> D.Don <i>subsp.</i> <i>fraser-jenkinsii</i> Reichst. ex Pangtey & Khullar	<i>Asplenium</i>	Aspleniaceae
9	<i>Asplenium nitidum</i> Sw.	<i>Asplenium</i>	Aspleniaceae
10	<i>Drynaria quercifolia</i> (L.) J.Sm.	<i>Drynaria</i>	Polypodiaceae
11	<i>Dryopteris cochleata</i> (D.Don) C.Chr.	<i>Dryopteris</i>	Dryopteridaceae
12	<i>Dryopteris odontoloma</i> (T.Moore ex Bedd.) C.Chr.	<i>Dryopteris</i>	Dryopteridaceae
13	<i>Leptochilus pteropus</i> <i>subsp.</i> <i>minor</i> (Bedd.) Fraser-Jenk.	<i>Leptochilus</i>	Polypodiaceae
14	<i>Leptochilus thwaitesianus</i> Fee	<i>Leptochilus</i>	Polypodiaceae
15	<i>Microsorium membranaceum</i> (D.Don) Ching	<i>Microsorium</i>	Polypodiaceae
16	<i>Microsorium punctatum</i> (L.) Copel.	<i>Microsorium</i>	Polypodiaceae
17	<i>Oleandra musifolia</i> (Bl.) Presl	<i>Oleandra</i>	Oleandraceae
18	<i>Pityrogramma chrysophylla</i> (Sw.) Link	<i>Pityrogramma</i>	Pteridaceae
19	<i>Selaginella involvens</i> (Sw.) Spring	<i>Selaginella</i>	Selaginellaceae
20	<i>Selliguea montana</i> (Sledge) Hovenkamp	<i>Selliguea</i>	Polypodiaceae
21	<i>Thelypteris mollissima</i> (Fisch. ex Kunze) Thapa	<i>Thelypteris</i>	Thelypteridaceae
22	<i>Trichomanes schmidiana</i> Zenker ex Taschner	<i>Trichomanes</i>	Hymenophyllaceae

Rheophytes

Rheophytes are the plants grown in fast flowing streams or rivers. During the present exploration, 8 species belonging to 7 genera and 7 families were recorded from the fast-flowing streams of the study area (Table 4.19). These rheophytes have

a well-developed rhizome system for firm attachment on rocks or other hard objects and are adapted to grow in sandy soil in the river bottom. They also withstand the flooding during monsoon seasons. Due to the large number of streams, the rheophytic plant populations are more in evergreen forests like Silent Valley National Park and Shola forests.

Table 4.19. Rheophytic pteridophyte taxa recorded from the study area

Sl. No.	Species	Genus	Family
1	<i>Bolbitis appendiculata</i> (Willd.) K. Iwatz	<i>Bolbitis</i>	Dryopteridaceae
2	<i>Diplazium esculentum</i> (Retz.) Sw.	<i>Diplazium</i>	Athyriaceae
3	<i>Equisetum ramosissimum</i> Desf.	<i>Equisetum</i>	Equisetaceae
4	<i>Leptochilus pteropus</i> subsp. <i>minor</i> (Bedd.) Fraser-Jenk.	<i>Leptochilus</i>	Polypodiaceae
5	<i>Osmunda acuta</i> (Burm.f.) Fraser-Jenk.	<i>Osmunda</i>	Osmundaceae
6	<i>Thelypteris calcarata</i> (Blume) Ching	<i>Thelypteris</i>	Thelypteridaceae
7	<i>Trichomanes exiguum</i> (Bedd.) Baker	<i>Trichomanes</i>	Hymenophyllaceae
8	<i>Trichomanes intramarginale</i> Hook. & Grev.	<i>Trichomanes</i>	Hymenophyllaceae

Xerophytes

As Palghat Gap and Gap influenced locations are under severe drought and high temperature regimes in most of the period and hence many taxa show adaptations that make them tolerant to such adverse situations. A total of 10 species belonging to 7 genera and 3 families were recorded from the xerophytic habitats of the study area. Pteridaceae are the dominant family with more representatives (Table 4.20).

Pteridophytes of Disturbed habitats

From the disturbed habitats, about 29 species belonging to 18 genera under 9 families were recorded. Dominant family is Pteridaceae (Table 4.21).

Table 4.20. Xerophytic pteridophyte taxa recorded from the study area

Sl. No.	Species	Genus	Family
1	<i>Actiniopteris radiata</i> (Sw.) Link	<i>Actiniopteris</i>	Pteridaceae
2	<i>Aleuritopteris bicolor</i> (Roxb.) Fraser-Jenk.	<i>Aleuritopteris</i>	Pteridaceae
3	<i>Anemia schimperiana</i> C.Presl subsp. <i>wightiana</i> (Gardner) Fraser-Jenk.	<i>Anemia</i>	Anemiaceae
4	<i>Doryopteris concolor</i> (Langsd. & Fisch.) Kuhn	<i>Doryopteris</i>	Pteridaceae
5	<i>Oeosporangium elegans</i> (Poir.) Fraser- Jenk. & Pariyar	<i>Oeosporangium</i>	Pteridaceae
6	<i>Oeosporangium tenuifolium</i> (Burm.f.) Fraser-Jenk. & Pariyar	<i>Oeosporangium</i>	Pteridaceae
7	<i>Adiantum caudatum</i> L.	<i>Adiantum</i>	Pteridaceae
8	<i>Adiantum incisum</i> Forssk.	<i>Adiantum</i>	Pteridaceae
9	<i>Dicranopteris linearis</i> (Burm.f.) Underw.	<i>Dicranopteris</i>	Gleicheniaceae
10	<i>Dicranopteris taiwanensis</i> Ching & P.S.Chiu	<i>Dicranopteris</i>	Gleicheniaceae

While analysing the distribution of lycophytes and ferns in different habitats and microhabitats, it is observed that some taxa may occur in more than one micro-habitat. *Microsorium pteropus* is grown on submerged rocks in streams as well as in the river banks. Likewise, *Diplazium esculentum* is distributed near streamlets or swampy areas of disturbed and forest habitats. Similarly, the taxa like *Drynaria quercifolia*, *Hymenophyllum exsertum*, *Asplenium phyllitidis*, *Elaphoglossum beddomei*, *Microsorium membranaceum* and *M. membranifolium* were observed as epiphytic as well as lithophytic. These taxa were grown as either epiphytic or lithophytic in an area with favourable temperature, humidity and shades of the specific altitudinal ranges. This is due to the inherent adaptation of fern taxa to occur in diverse habitats.

Table 4.21. Pteridophyte taxa recorded from disturbed habitats of the study area

Sl. No	Species	Genus	Family
1	<i>Actiniopteris radiata</i> (J.Koenig ex Sw.) Link	<i>Actiniopteris</i>	Pteridaceae
2	<i>Adiantum caudatum</i> L.	<i>Adiantum</i>	Pteridaceae
3	<i>Adiantum hispidulum</i> Sw.	<i>Adiantum</i>	Pteridaceae
4	<i>Adiantum latifolium</i> Lam.	<i>Adiantum</i>	Pteridaceae
5	<i>Adiantum philippense</i> L.	<i>Adiantum</i>	Pteridaceae
6	<i>Aleuritopteris bicolor</i> (Roxb.) Fraser-Jenk.	<i>Aleuritopteris</i>	Pteridaceae
7	<i>Athyrium hohenackerianum</i> (Kunze) T.Moore	<i>Athyrium</i>	Athyriaceae
8	<i>Azolla pinnata</i> R.Br.	<i>Azolla</i>	Salviniaceae
9	<i>Blechnum orientale</i> L.	<i>Blechnum</i>	Blechnaceae
10	<i>Ceratopteris thalictroides</i> (L.) Brongn.	<i>Ceratopteris</i>	Pteridaceae
11	<i>Dicranopteris linearis</i> (Burm.f.) Underw.	<i>Dicranopteris</i>	Gleicheniaceae
12	<i>Dicranopteris taiwanensis</i> Ching & P.S.Chiu	<i>Dicranopteris</i>	Gleicheniaceae
13	<i>Diplazium esculentum</i> (Retz.) Sw.	<i>Diplazium</i>	Athyriaceae
14	<i>Doryopteris concolor</i> (Langsd. & Fisch.) Kuhn	<i>Doryopteris</i>	Pteridaceae
15	<i>Drynaria quercifolia</i> (L.) J.Sm.	<i>Drynaria</i>	Polypodiaceae
16	<i>Lygodium flexuosum</i> (L.) Sw.	<i>Lygodium</i>	Lygodiaceae
17	<i>Mickelopteris cordata</i> (Roxb. ex Hook. & Grev.) Fraser-Jenk.	<i>Mickelopteris</i>	Pteridaceae
18	<i>Nephrolepis brownii</i> (Desv.) Hovenkamp & Miyam.	<i>Nephrolepis</i>	Nephrolepidaceae
19	<i>Pityrogramma austroamericana</i> Domin	<i>Pityrogramma</i>	Pteridaceae
20	<i>Pityrogramma calomelanos</i> (L.) Link	<i>Pityrogramma</i>	Pteridaceae
21	<i>Pityrogramma chrysophylla</i> (Sw.) Link	<i>Pityrogramma</i>	Pteridaceae
22	<i>Pteridium aquilinum</i> (L.) Kuhn subsp. <i>wightianum</i> (Wall. ex J.Agardh) W.C.Shieh	<i>Pteridium</i>	Dennstaedtiaceae
23	<i>Pteris argyraea</i> T.Moore	<i>Pteris</i>	Pteridaceae

24	<i>Pteris cretica</i> L. subsp. <i>laeta</i> (Wall. ex Ettingsh.) Fraser-Jenk.	<i>Pteris</i>	Pteridaceae
25	<i>Pteris ensiformis</i> Burm.f.	<i>Pteris</i>	Pteridaceae
26	<i>Pteris vittata</i> L.	<i>Pteris</i>	Pteridaceae
27	<i>Salvinia</i> × <i>molesta</i> Mitch.	<i>Salvinia</i>	Salviniaceae
28	<i>Thelypteris dentata</i> (Forssk.) E.P.St.John	<i>Thelypteris</i>	Thelypteridaceae
29	<i>Thelypteris interruptus</i> (Willd.) K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae

IV.6.3. Distribution of taxa among different habitats

The dendrogram based on Sorensen's index of distribution along the habitat gradient showed clustering of riparian, semi-evergreen, evergreen and shola forests in a clade, whereas grassland, moist-deciduous, dry deciduous and plantations formed another clade. Results showed that wetland taxa grouped into a separate clade in this analysis (Fig.4.21). High Sorensen's similarity index value of 81.197% was observed between evergreen and shola forests indicating sharing up of these habitats by similar taxa, whereas least similarity index value, or no similarity, was observed between wetland ecosystems with dry and moist deciduous forests (Table 4.22). The taxonomic distinctness value is high for wetlands (2.964) indicating unique habitat traits and taxa adapted to such a habitat are not represented in other habitats, whereas less distinctness was observed for plantations (2.723), which holds only generalist species (Table 4.23). The highest number of species, genera and family were recorded in evergreen forests (Fig.4.22) and least number in wetlands (Fig.4.22).

The taxa present in wetlands are not adapted to grow in other habitats and almost all species known from the wetland habitats of Kerala are recorded from the present study area. The evergreen forests harbour more taxa, and thus act as a critical habitat for most of the ferns and lycophytes.

Table 4.22: Sorensen similarity index of lycophytes and ferns along habitat gradient in the Palghat Gap influenced areas [DDF – Dry Deciduous Forest; MDF – Moist Deciduous Forest; SEG – Semi-Evergreen Forest; EG – Evergreen Forest; SF – Shola Forest; GL – Grasslands; RP – Riparian Forest; WL – Wet lands; PL – Plantations]

	DDF	MDF	SEG	EG	SF	GL	RP	WL	PL
DDF									
MDF	0.50704								
SEG	0.21359	0.57353							
EG	0.05161	0.20213	0.56364						
SF	0.03419	0.09333	0.38462	0.81197					
GL	0.40741	0.43678	0.31933	0.15205	0.10526				
RP	0.09524	0.2735	0.44295	0.45771	0.38037	0.24			
WL	0	0	0.02174	0.01389	0.01887	0.09302	0.16438		
PL	0.56667	0.77419	0.432	0.14689	0.07194	0.5	0.22642	0.04082	

Table 4.23: Taxonomic distinctness of lycophytes and ferns along habitat gradient in the Palghat Gap and its influenced areas [DDF – Dry Deciduous Forest; MDF – Moist Deciduous Forest; SEG – Semi-Evergreen Forest; EG – Evergreen Forest; SF – Shola Forest; GL – Grasslands; RP – Riparian Forest; WL – Wet lands; PL – Plantations]

	DDF	MDF	SEG	EG	SF	GL	RP	WL	PL
Diversity	2.737	2.773	2.849	2.877	2.84	2.849	2.857	2.964	2.723
Lower limit	2.766	2.817	2.83	2.842	2.835	2.802	2.825	2.643	2.805
Upper limit	2.936	2.904	2.895	2.886	2.893	2.914	2.899	3	2.909
Distinctness	2.737	2.773	2.849	2.877	2.84	2.849	2.857	2.964	2.723
Lower limit	2.784	2.831	2.844	2.855	2.848	2.814	2.839	2.679	2.82
Upper limit	2.947	2.915	2.907	2.899	2.904	2.924	2.91	3	2.923

IV.6.4. Distribution of taxa among different microhabitats

The Sorensen's similarity analysis showed clustering of hydrophytes, psammophytes and rheophytic taxa into one clade; lithophytes, epiphytes and rock cliffs into second clade; and, taxa belonging to terrestrial, mud cliff, xerophytes and disturbed habitats into another clade (Fig.4.23). Highest similarity index value

(69.194%) was observed between terrestrial and mud cliffs, and least similarity or no similarity was observed between epiphytes with psamphytes, hydrophytes, rheophytes, xerophytes; between psamphytes with lithophytes, xerophytes and rock cliffs; hydrophytes with lithophytes, mud cliffs and rock cliffs; rheophytes with rock cliffs, xerophytes with hydrophytes and rheophytes (Table 4.24). Taxonomic distinctness is high in hydrophytic habitat (2.933). This is due to the occurrence of maximum diversity at the family and genus level; 6 species under 6 genera and 5 families. It is lesser in xerophytic habitat (2.361) (Table 4.25). Among the different microhabitats, the highest number of taxa were recorded in the terrestrial habitat followed by mud cliffs (Fig.4.24). Whereas the least number of taxa were recorded in psammophytic, hydrophytic and xerophytic habitats (Fig.4.24).

Table 4.24: Sorensen similarity index of lycophytes and ferns along micro-habitat gradient in the Palghat Gap influenced areas [EP – Epiphytes; PS – Psammophytes; TR – Terrestrial; LT – Lithophytes; MC – Mud cliffs; RC – Rock cliffs; HD – Hydrophytes; RH – Rheophytes; XR – Xerophytes; DH – Disturbed habitats]

	EP	PS	TR	LT	MC	RC	HD	RH	XR	DH
EP										
PS	0									
TR	0.0613	0.1594								
LT	0.4615	0	0.22727							
MC	0.0476	0.0594	0.69194	0.20144						
RC	0.2295	0	0.09589	0.48649	0.14679					
HD	0	0.1	0.04615	0	0	0				
RH	0	0.2857	0.01527	0.13559	0.02128	0	0.15385			
XR	0	0	0.07519	0.09836	0.16667	0.19355	0	0		
DH	0.0294	0.0465	0.26144	0.07407	0.37931	0.15686	0.17143	0.05556	0.26316	

Table 4.25: Taxonomic distinctness of lycophytes and ferns along micro-habitat gradient in the Palghat Gap influenced areas [EP – Epiphytes; PS – Psammophytes; TR – Terrestrial; LT – Lithophytes; MC – Mud cliffs; RC – Rock cliffs; HD – Hydrophytes; RH – Rheophytes; XR – Xerophytes; DH – Disturbed habitats]

	EP	PS	TR	LT	MC	RC	HD	RH	XR	DH
Diversity	2.718	2.758	2.85	2.765	2.843	2.797	2.933	2.905	2.361	2.653
Lower limit	2.783	2.703	2.83	2.799	2.817	2.727	2.533	2.524	2.639	2.759
Upper limit	2.914	2.956	2.886	2.906	2.893	2.931	3	3	2.972	2.924
Distinctness	2.718	2.758	2.85	2.765	2.843	2.797	2.933	2.905	2.361	2.653
Lower limit	2.796	2.711	2.841	2.812	2.829	2.742	2.6	2.571	2.639	2.771
Upper limit	2.923	2.967	2.896	2.914	2.903	2.939	3	3	3	2.933

IV.6.5. Distribution along the altitudinal gradients across Palghat Gap

The Sorensen's similarity index analysis along the altitudinal classes showed high similarity between the altitudinal classes 1600-1700 m and 1700-1800 m (97.5%) and least similarity index value (6.349%) between the altitudinal classes 'up to 100 m' and 'above 2300 m' (Annexure 12). In the dendrogram, the altitudinal class up to 100 to 500-600 m forms one clade (Fig.4.25). Similarly, taxonomic distinctness is high in the altitudinal class 'above 2300 m' (2.981), and less in the altitudinal class 300-400 m (2.948) (Annexure 12). The highest number of taxa were recorded in the altitudinal class 900-1000 m, followed by 1000-1100 m (Fig.4.26 & 4.27) where the evergreen and semi evergreen forests got distributed.

Palghat Gap and Gap influenced areas of Southern Western Ghats have major habitat types such as dry deciduous forest, moist deciduous forest, semi-evergreen, evergreen, tropical montane evergreen or shola forests and montane open grasslands. The habitat gradient in the study area is correlated to the altitude gradient and topography of the area. Palghat Gap influenced areas comprises the altitudinal gradient from 'below 100 m' to 'above 2300 m'. The highest number of species were recorded from evergreen forests, which offer the cool and shady environment, the most favourable condition for most of the pteridophytes. Similarly, with regard to the distribution across microhabitats, terrestrial members dominated over others.

While analysing the altitudinal distribution, highest numbers of species were recorded in the middle altitudinal classes, as the usual species distribution pattern in tropics (Rahbek, 2005). The middle altitudinal classes have moderate environmental conditions, and to both ends of altitudinal ranges, the environmental conditions are extreme which limits the species distribution. So, in the present study also results showed the usual bell-shaped curve, typical of tropical areas (Fig. 4.26 & 4.27).

The gradation from moist deciduous forests to montane grasslands are conspicuous in the Gap influenced areas of Palghat Gap. Within the Gap area, the maximum altitude reached around 100 m from the mean sea level. As the Palghat Gap forms a corridor between the West coast of Malabar and the Deccan Plateau, the environmental conditions in the Palghat Gap are similar to the Deccan Plateau, with high temperature and low humidity. Similarly, within the Gap area the anthropogenic activities are more as compared to Northern and Southern highlands of Gap influenced areas. Due to these reasons, the number of pteridophytes is very low within the Gap region, as compared to the Northern and Southern lips of Palghat Gap.

The clustering of habitats or microhabitats or altitudinal classes is based on how many similar species they share in common and also it reflects similarity in environmental and edaphic conditions between two locations (Scheiner *et al.*, 2011). The clustering of most similar habitats occurred in the Sorensen similarity index analysis of different habitats across the Palghat Gap and Gap influenced regions (Fig. 4.21). Here the evergreen forests and shola forests clustered together with a similarity value, as 81.356%. The wetland flora does not share any similarity with dry and moist deciduous forests. The analysis of different microhabitats across the Palghat Gap showed the highest similarity between terrestrial and mud cliffs (Table 4.24). In case of distribution along the altitudinal gradient, the highest Sorensen's index was observed between the altitudinal classes which are adjacent and overlapping (Annexure 12). This is due to the sharing of similar environmental and edaphic factors in the nearby zones, which also holds similar species composition. Such similarity could not be expected in altitudinal zones, which are far apart.

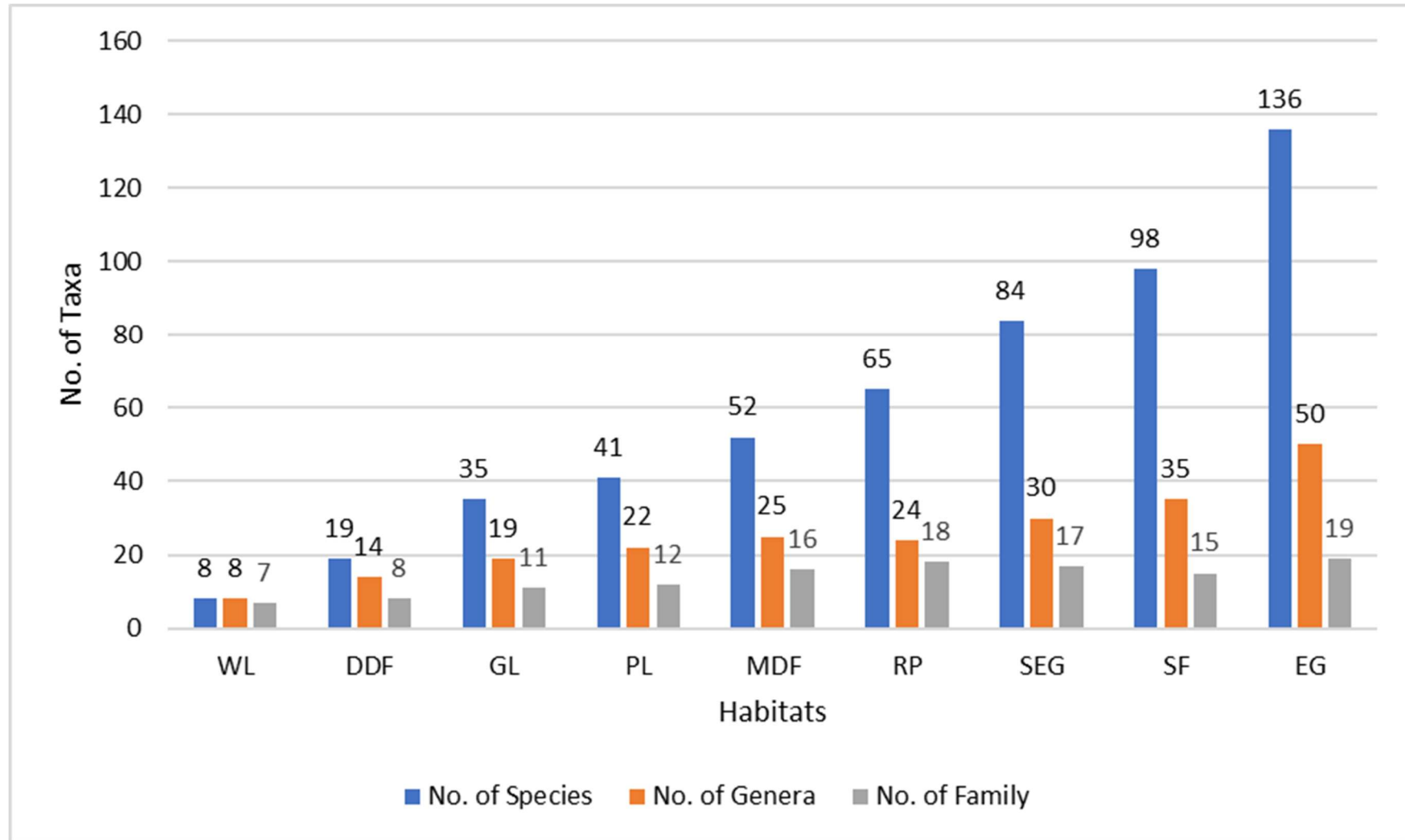


Fig. 4.22. Composition of pteridophytes species-genera-family in the different habitats of the study area. [WL - Wet land; DDF- Dry Deciduous Forest, GL - Grassland; PL - Plantation; MDF - Moist Deciduous Forest; RP - Riparian; SEG - Semi Evergreen Forest; SF - Shola Forest; EG- Evergreen Forest].

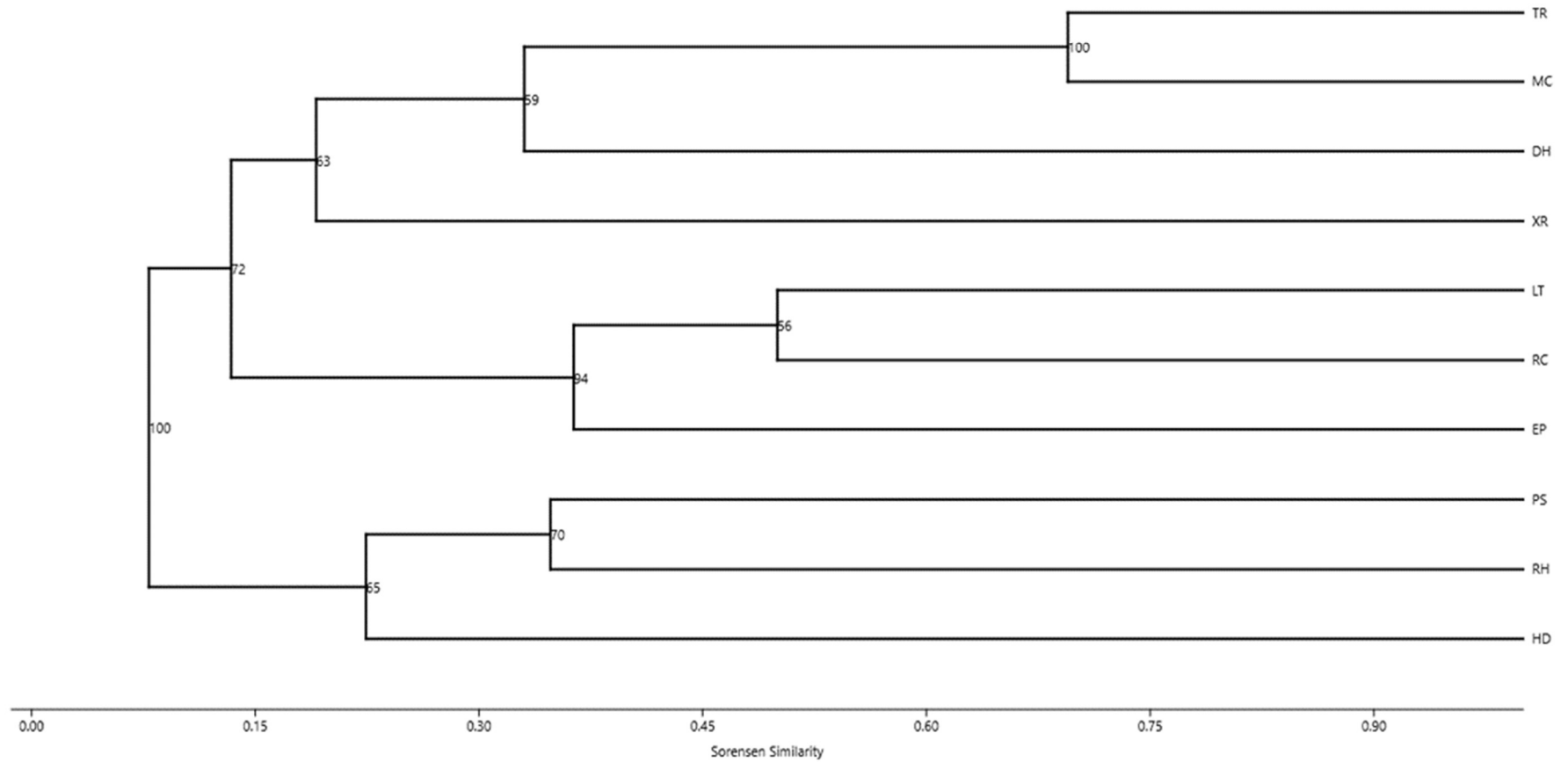


Fig. 4.23. Dendrogram based on the Sorensen similarity index on the pteridophytes along different micro-habitats in the study area [HD - Hydrophytes; RH - Rheophytes; XR - Xerophytes; PS - Psammophytes; RC - Rock cliffs; DH - Disturbed habitats; EP - Epiphytes; LT - Lithophytes; MC - Mud cliffs; TR - Terrestrial]

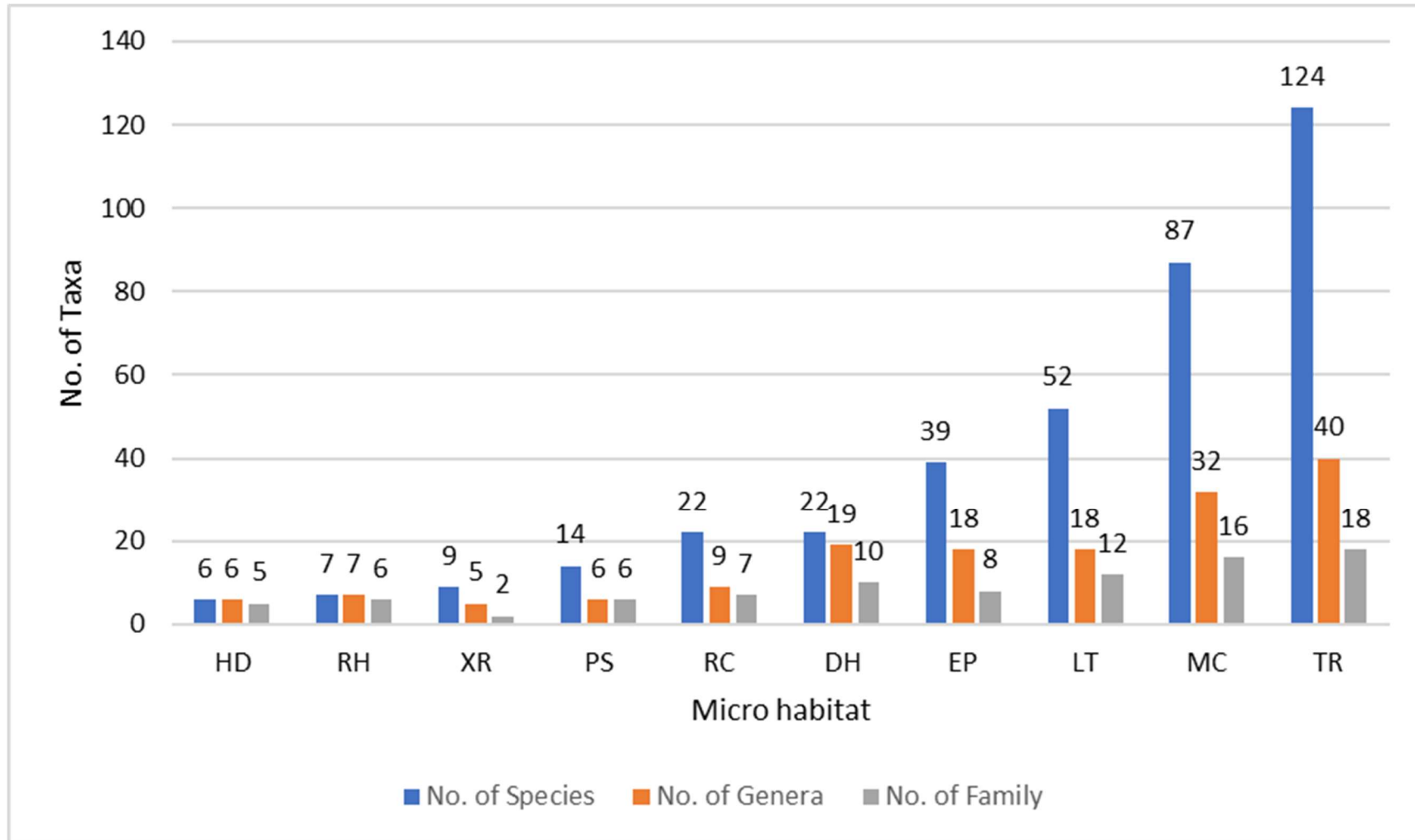


Fig. 4.24. Composition of pteridophytes species-genera-family in the different micro-habitats of the study area [HD - Hydrophytes; RH - Rheophytes; XR - Xerophytes; PS - Psammophytes; RC - Rock cliffs; DH - Disturbed habitats; EP - Epiphytes; LT - Lithophytes; MC - Mud cliffs; TR - Terrestrial]

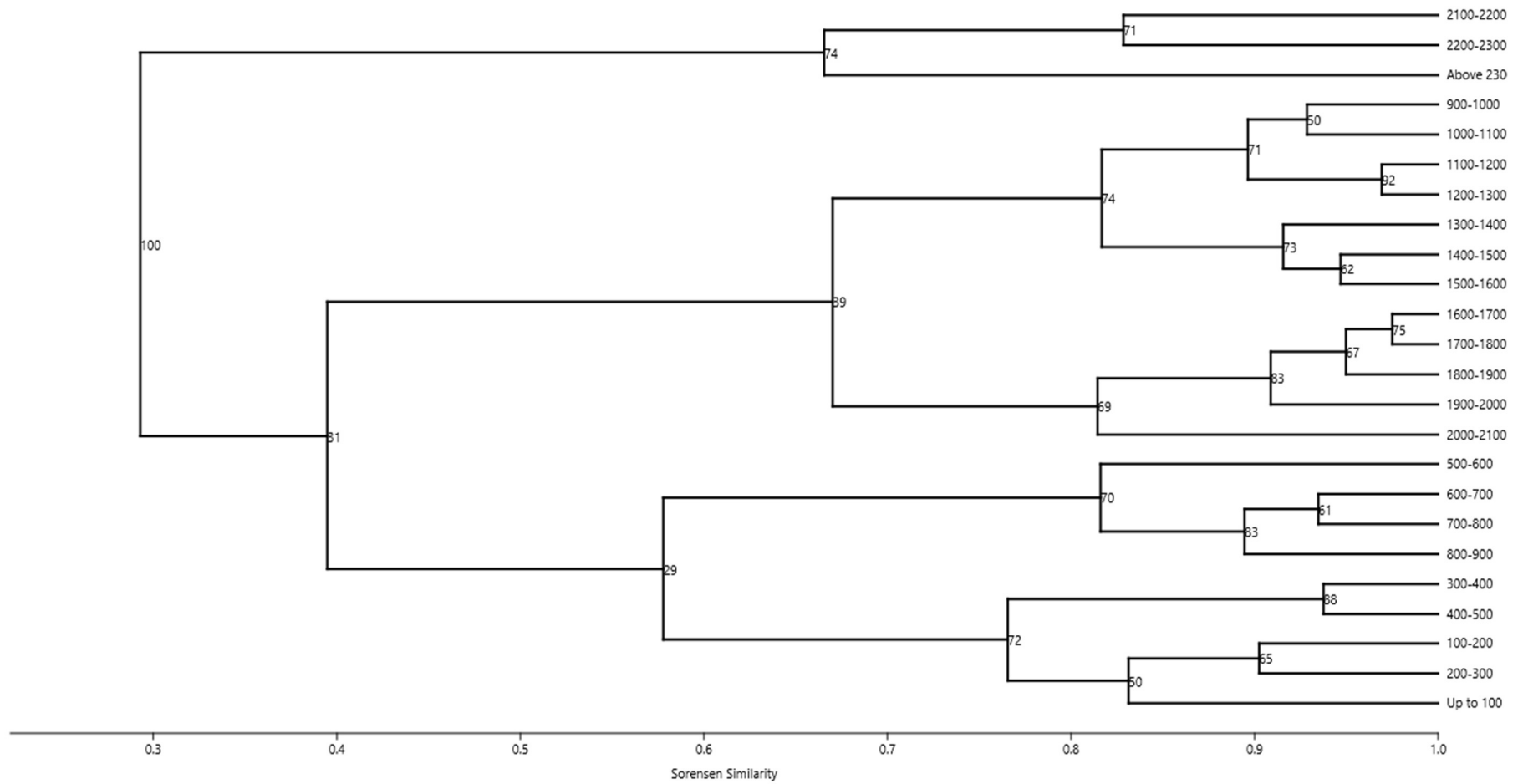


Fig. 4.25. Dendrogram based on the Sorensen similarity index on the pteridophytes along altitudinal gradation in the study area.

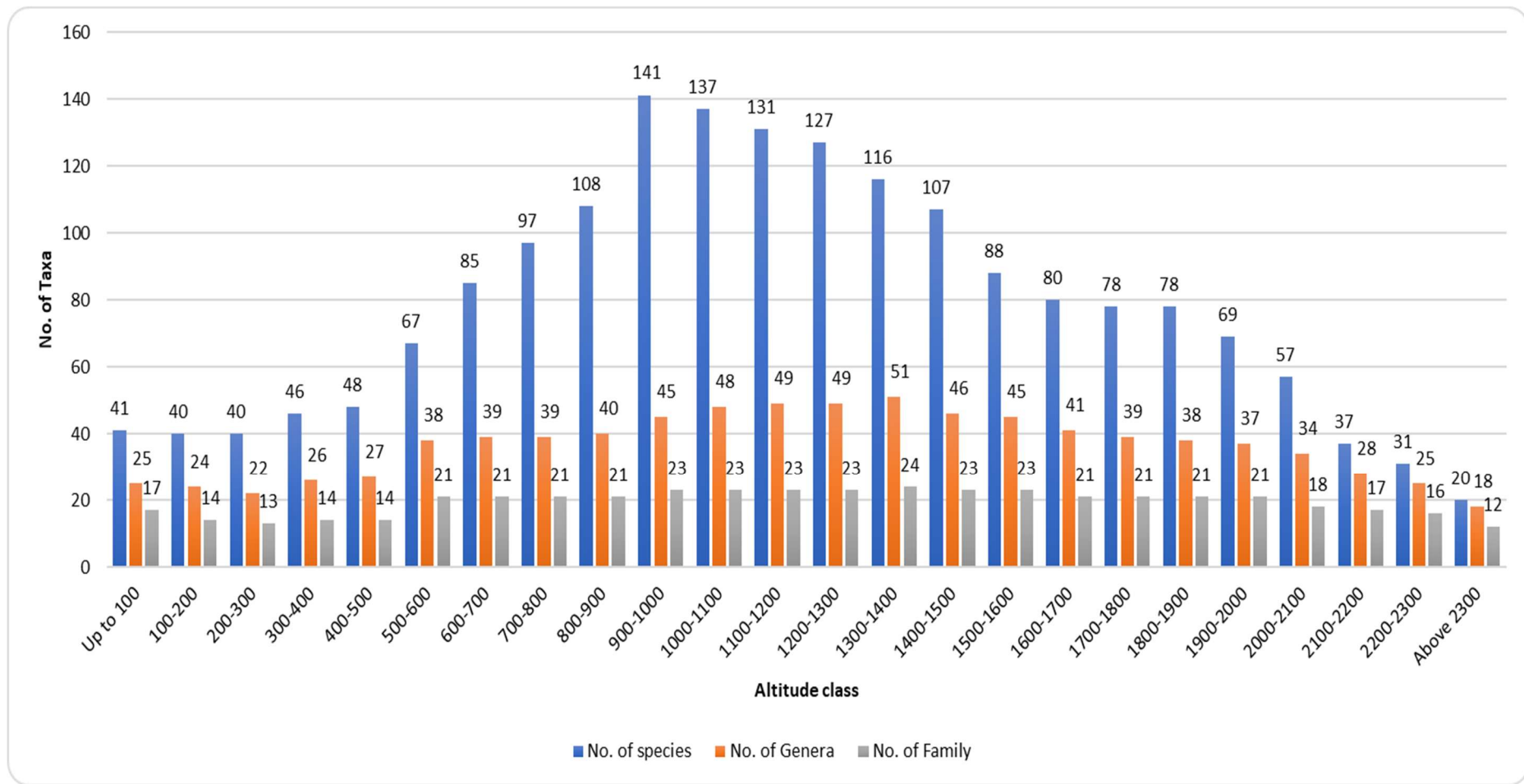


Fig. 4.26. Composition of pteridophytes species-genera-family in the different altitude classes of the study area.

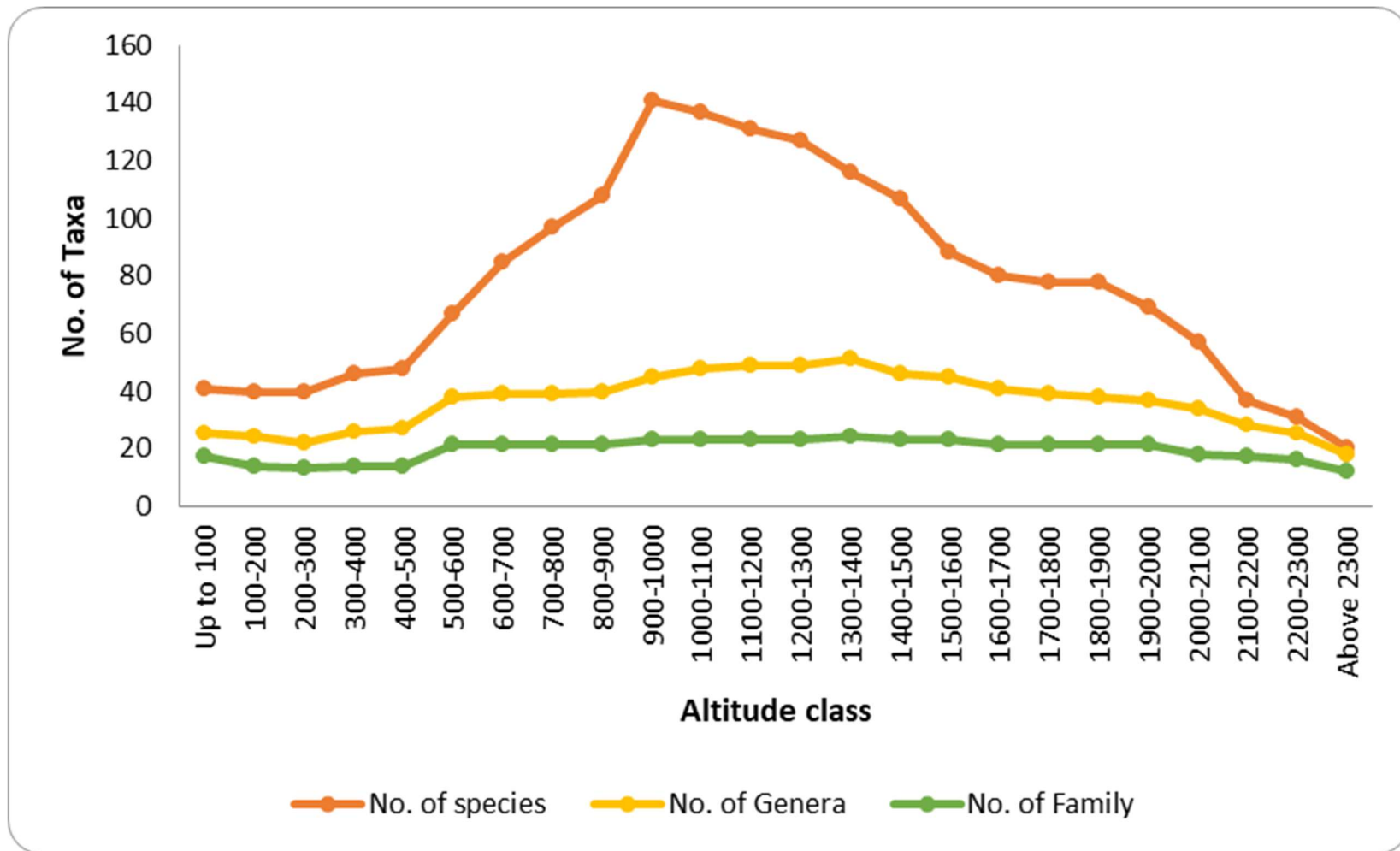


Fig. 4.27. Patterns of richness of pteridophytes along the altitudinal gradient in the study area.

Taxonomic distinctness is a measurement of uniqueness or distinctness of a habitat or location based on how many species belong to different genera and families in that particular area or habitat. It is a diversity index which uses the taxonomic or phylogenetic relationship of species, and is independent of species richness (Ricotta, 2004). In the present study area, the wetlands showed high taxonomic distinctness value, whereas plantations had the lowest (Table 4.23). Wetland has only 8 species of pteridophytes, and belong to 8 genera and 7 families, which makes the wetland a distinct habitat. Whereas, the plantations contain 143 species, belonging to 21 genera and 12 families. In altitude wise distribution analysis, the highest distinctness value, 2.942 was recorded in the altitude class 'above 2300 m', and the lowest value, 2.843 for the zone 300-400 m. The regions 'above 2300 m' are inhabited by less number of pteridophytes due to the extreme environmental conditions like wind, low temperature, etc. But these taxa belong to different genera and families. This makes the altitude region 'above 2300 m' more distinct from other altitudinal classes. The species in lower and mid altitude zones are generalists, compared to the specialists in higher altitudes. The climatic conditions in higher altitudes make the species more specialist than lower altitude classes.

Sorensen similarity index has been used widely for many purposes such as analysing the effect of urbanisation on biodiversity (Morelli, 2013), assessing the effect of afforestation on biodiversity (Jiao *et al.*, 2012), etc. It was also used to assess the distributional analysis of pteridophytes in Amazonia, Brazil for framing better conservation strategies (Zuquim *et al.*, 2012). In India, however, its use for analysing the Pteridophyte distribution is limited, as in Sikkim by Ganguly and Mukhopadhyay (2012). No ecological analysis based on similarity indices were attempted for the pteridophytes of the present study area and the present one thus is the first of its kind.

IV.6.6. Ecological Niche Modelling

Distribution of each species, especially the pteridophyte taxa, is very specific to the eco-climatic parameters of the locality. Any change in the climate of a specific area will affect the existence of taxa specific to the ecosystem. The climate change due to global warming alters the distribution of taxa which are highly specific to a specific habitat. Hence, climate change affects the existence of endemics which inhabit a small geographical location with specific climatic and habitat attributes.

So, in the present study, one southern Western Ghats endemic taxon *Elaphoglossum beddomei*, has been used to find out the bioclimatic variables that determine the distribution and to find out the suitable habitat for in current and future climatic scenarios using Ecological Niche Modelling.

MaxEnt modelling and influenced bioclimatic variables

E. beddomei is known to be endemic to Southern Western Ghats of India. As per earlier IUCN Red List assessment it was considered as least concern (LC) and demanded further studies to clarify its geographic distribution. In recent assessments, the status was redesignated as near threatened (NT) (Benniamin *et al.*, 2020; Fraser-Jenkins *et al.*, 2021).

After the preliminary correlation analysis, five bioclimatic variables – Mean Temperature of Wettest Quarter (bio8), Precipitation of Driest Quarter (bio17), Precipitation of Warmest Quarter (bio18), Precipitation of Wettest Quarter (bio16) and Temperature Annual Range (bio7) – were selected (Table 4.26) that showed less correlation.

Then different models were run using the selected 5 bioclimatic variables for getting the most accurate prediction model. As per the jackknife analysis in these predictions, Precipitation of Warmest Quarter (bio18) had the most influence in determining the distribution of *E. beddomei*, with a permutation importance of 83% (Table 4.27). Temperature Annual Range (bio7) and Precipitation of Driest Quarter (bio17) showed least influence in determining the distribution of *E. beddomei*, and

hence, the models created without these variables were considered for prediction (Table 4.27).

Table 4.26. The 19 Bioclimatic variables used (Bioclimatic variables selected after correlation analysis are in bold)

Code	Description
BIO1	Annual Mean Temperature
BIO2	Mean Diurnal Range (Mean of monthly (max temp-min temp))
BIO3	Isothermality (BIO2/BIO7) ($\times 100$)
BIO4	Temperature Seasonality (standard deviation $\times 100$)
BIO5	Max Temperature of Warmest Month
BIO6	Min Temperature of Coldest Month
BIO7	Temperature Annual Range (BIO5-BIO6)
BIO8	Mean Temperature of Wettest Quarter
BIO9	Mean Temperature of Driest Quarter
BIO10	Mean Temperature of Warmest Quarter
BIO11	Mean Temperature of Coldest Quarter
BIO12	Annual Precipitation
BIO13	Precipitation of Wettest Month
BIO14	Precipitation of Driest Month
BIO15	Precipitation Seasonality (Coefficient of Variation)
BIO16	Precipitation of Wettest Quarter
BIO17	Precipitation of Driest Quarter
BIO18	Precipitation of Warmest Quarter
BIO19	Precipitation of Coldest Quarter

Table 4.27 Contribution of selected bioclimatic variables to the distribution of *E. beddomei* in current climatic regime

Selected bioclimatic variables	Percent contribution	Permutation importance
Bio18	47	83
Bio8	27.5	14
Bio16	25.5	3.1
Bio7	0	0
Bio17	0	0

Species distribution modelling in current scenario

The available data from literature (Manickam and Irudayaraj, 1992; Benniamin and Sundari, 2020; Benniamin *et al.*, 2020), herbaria (CALI, KFRI, MH, ZGC) and field observations confirm that *E. beddomei* is known to occur in a narrow zone of the Western Ghats of Kerala, Tamil Nadu and Karnataka that possess specific cool, evergreen, climatic parameters. Hence, from the multiple model evaluations using the selected variables, the best model was selected based on True Skill Statistics (TSS) and overall accuracy, calculated using R package ENM Tools (Chaitanya and Meiri, 2021), and Area Under the receiver operating characteristic Curve (AUC) from the MaxEnt output. The predicted model with an AUC value 0.838, TSS value of 0.6852 and overall accuracy of 0.9346 was selected as the best model based on these values. Figure 4.28 summarises the predicted distribution of *E. beddomei* in current climatic regimes, representing its potential distribution along the Western Ghats in a range of 1 to 0 where 1 for the most suitable habitats and 0 for the unsuitable habitats. In figure 4.28, the areas with dark blue colouration - denoted as 1 - are the most favourable areas for the existence of *E. beddomei* and light blue regions - denoted as 0 - are the less favourable areas. The predicted suitable areas for *E. beddomei* at present was approximately about 11,181.6 square km in the Southern Western Ghats, in the states of Kerala, Tamil Nadu and Karnataka.

The predicted global trend in forest ecosystems showed that the concentration of the evergreen forests is confined more to higher altitudes and shows drastic decline at higher rates (Laurance *et al.*, 2012), causing severe loss of tropical cloud forest ecosystems (Murugan *et al.*, 2009; Karger *et al.*, 2021), which may adversely affect most of the high altitude evergreen endemic species (Munoz *et al.*, 2021). So, *E. beddomei*, a species inhabiting evergreen habitat may become more threatened in future climatic regimes due to lack of suitable habitats.

The predicted potential habitats in current climatic regimes showed a possibility to record *E. beddomei* from other potential habitats of the Western Ghats. There are similar reports of rediscoveries and extended distribution records found by the analysis of occurrence of species like *Micromeria serbaliana* and *Veronica kaiseri* (Omar and Elgamal, 2021) in Egypt, and ferns under RET categories (Williams *et al.*, 2009) in the United States through distribution models. Field checking based on the present modelling however, was not attempted as most of the areas lies beyond the present study area.

Predicted changes in future climatic scenarios

Based on the prediction of potential habitats, calculated the habitat loss and gain in the future time periods also by subtracting the predicted suitable area under two climatic change scenarios - ssp126 and ssp585 - of the 2041-2070 climatic regime from the prediction in the current time period. Predicted future species distribution model of potential habitat gain and loss of *E. beddomei* is being depicted in Figure 4.29. Here the potential habitat gain and loss are tabulated in a range of 1 to -1 and here 1 denotes gaining of potential habitats, -1 potential habitat loss and the value of 0 for an unchanged habitat. Similarly, Table 4.28 summarises the potential habitat gain and loss or niche shift in the future climatic period (2041-2070) compared with the current climatic regime. Here in all climatic scenarios, habitat loss was more than that of habitat gain in future time periods (2041-2070). The average of loss of suitable habitat in two scenarios is 19.406% and the average of gain of suitable habitats in two scenarios is 0.5205%. The loss of suitable habitat was greater in ssp126 (20.718%) climatic scenarios of 2041-2070 (Thulasi *et al.*,

2024). Niche shift of *E. beddomei* is very negligible in future climatic periods, as average habitat gain is 0.5205% (Table 4.28).

Table 4.28. Habitat loss and gain in 2041-2070 and 2070-2100 time periods

Time period >>	2041-2070			2071-2100		
	ssp126	ssp370	ssp585	ssp126	ssp370	ssp585
Habitat loss (sq. km)	6049.8	5455.8	5495.4	6140.7	6325.2	5681.7
Unchanged habitats (sq. km)	23077.8	23630.4	23472	22887	22802.4	23231.7
Habitat gain (sq. km)	72	113.4	232.2	171.9	72	286.2

The predicted potential distribution in the future climatic regime – 2041-2070 – showed a trend of decline for *E. beddomei* in Southern Western Ghats (Fig. 4.28), as the average loss of potential habitats in the 2041-2070 is 19.796%. Whereas, the average gain of potential habitats or niche shifts in the climatic period - 2041-2070 - is only 0.5205%. This is indeed a disturbing trend for an endemic species of wet evergreen forests of the Western Ghats (Thulasi *et al.*, 2024).

While analysing the influence of bioclimatic variables, the distribution of *E. beddomei* proved to be limited by precipitation. As *E. beddomei* is an evergreen high altitude fern species, the temperature and precipitation characteristics of high-altitude evergreen forests determine the growth and distribution. So, the predicted future distribution reflects a change in precipitation pattern in Southern Western Ghats which in turn should affect the existence of *E. beddomei* in Southern Western Ghats. It can be concluded that the suitable habitats for *E. beddomei* will progressively decline in future due to the variations in global temperature and precipitation. Although the forcing level differs between the 126 and 585 SSP scenarios, it does not mean that the predicted rainfall patterns should differ much between the two scenarios. For instance, under the CNRM-CM6-1 model, Munoz *et al.* (2021) found that the variation of bio12 (annual rainfall) and bio18 (rainfall of

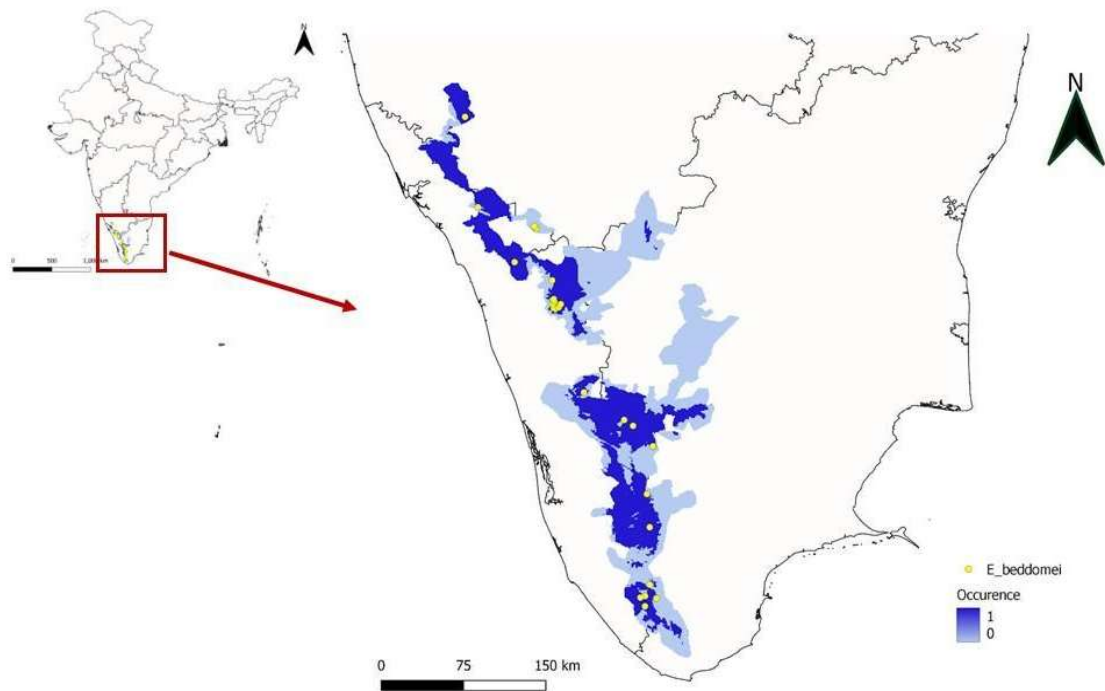


Fig. 4.28. The background map generated based on the evergreen forest patches in southern Western Ghats (Biodiversity Information System <https://bis.iirs.gov.in/>) showing the distribution locations of *Elaphoglossum beddomei* in southern Western Ghats (yellow dots) and predicted potential habitat of *E. beddomei* in current climatic regime indicated in dark blue colour.

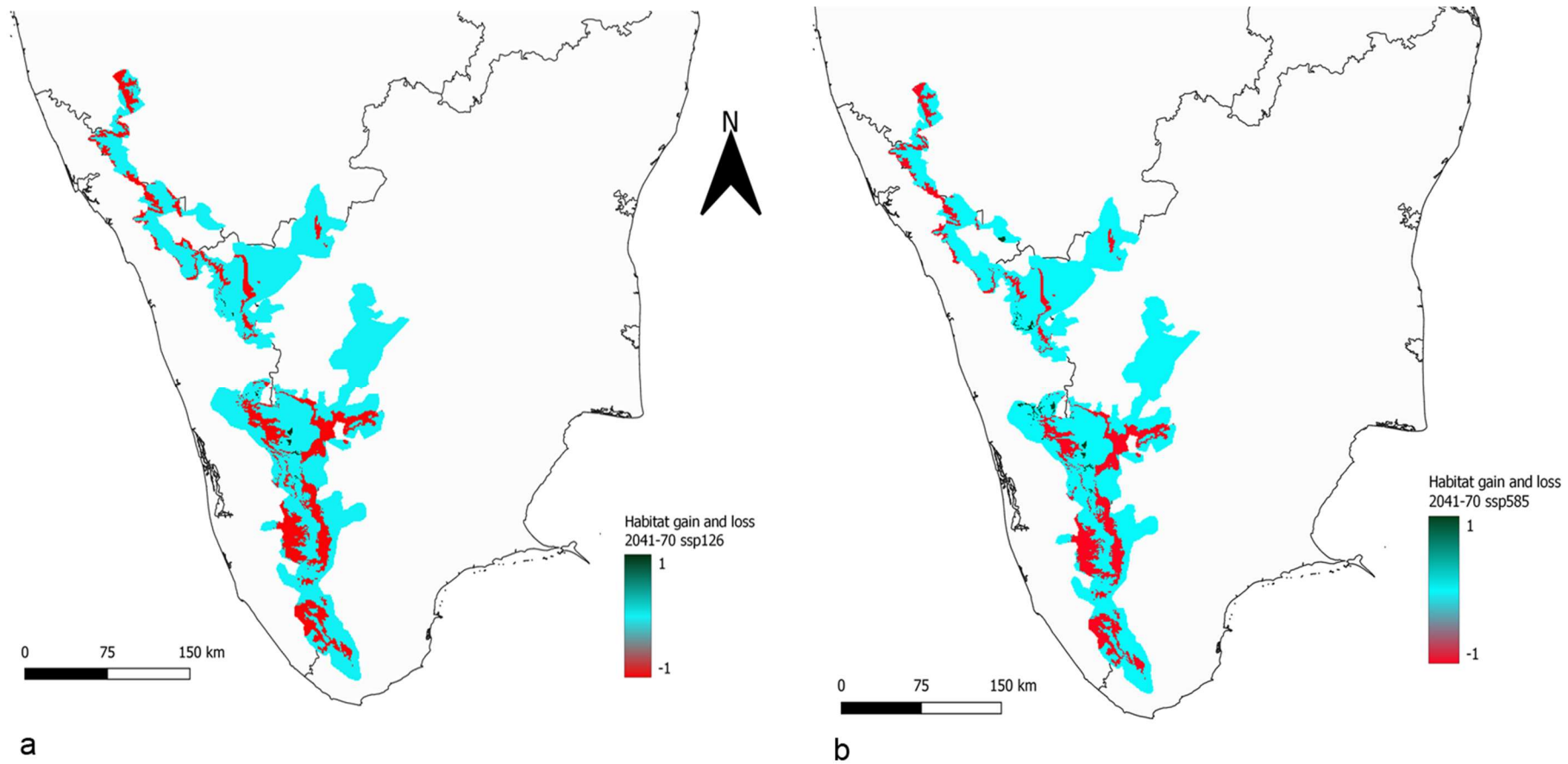


Fig. 4.29. Habitat gain-unchanged-loss map of *E. beddomei* in 2040-2071 a. ssp126 scenario - black (1) indicated habitat gain; blue (0) indicated unchanged habitat; red (-1) indicated habitat loss. b. ssp585 scenario - black (1) indicated habitat gain; blue (0) indicated unchanged habitat; red (-1) indicated habitat loss.

the warmest quarter) in 2060 between the two SSP scenarios will only be about 0.8% and 5.3% on average, respectively. This could be the reason why our predictions of occurrences of *E. beddomei* are quite similar between SSP scenarios (Munoz *et al.*, 2021). The study of endemics in the Western Ghats by Bose *et al.* (2015) mentioned that the variation in precipitation pattern from past climatic regimes to current climatic conditions might be the reason for higher endemism in the Western Ghats, especially in the Southern Western Ghats. So, the predicted future decline of *E. beddomei* from the Southern Western Ghats points to a drastic change in precipitation pattern in the Southern Western Ghats regions. Fluctuating rainfall patterns are due to increased global warming (Murugan *et al.*, 2009) and it may affect the existence of evergreen species like *E. beddomei* of the Western Ghats.

Increase in temperature and variable precipitation patterns may act as the limiting factors for such strict evergreen taxa. The changes in the distribution pattern of animals, birds or plants had been used to predict the trend in future environmental conditions in India and other countries (Jose and Nameer, 2020; Sony *et al.*, 2018; Li *et al.*, 2019). The expansion of the Peafowl (*Pavo cristatus*) population in the Peninsular Indian state of Kerala (Jose and Nameer, 2020) has been taken as an indication of desertification and increase in temperature regimes in the state of Kerala. Similarly, a reduction in suitable habitat due to climate change is anticipated for the endemic ungulate mammal, Nilgiri Tahr (*Nilgiritragus hylocrius*) population in the Western Ghats (Sony *et al.*, 2018). The studies on plants, especially the impact of climate change on endemics and threatened category taxa, warn for establishing proper conservation strategies, like *in situ* as well as *ex situ* - for the maintenance of threshold minimum population globally. The potential distribution and impact of climate change on the endangered fern genus *Isoetes* (Yang *et al.*, 2022) in China, rare and endangered fern species *Brainea insignis* (Wanga *et al.*, 2012) in Taiwan, and the micro-endemic plant species *Cistus ladanifer* subsp. *sulcatus* (Ferreira *et al.*, 2021) in Portugal showed the reduction of potential habitats in future climatic regimes due to drastic change in climatic conditions. Along with these predictions addressing the impact of climate change on species existence and distribution, there

are studies that predict suitable habitats for endangered lycophytes and fern species for designing suitable conservation strategies (Wang *et al.*, 2016; Li *et al.*, 2019). These strategies include *in situ* conservation by locating potential habitats and re-establishment of the species, as well as *ex situ* methods like procurement of such species from natural habitats and maintaining them in botanical gardens along with germplasm conservation through cryobanks and spore banks.

Likewise, *Elaphoglossum beddomei* is a near threatened, endemic species of the Western Ghats (Ebihara *et al.*, 2012; Chandra *et al.*, 2008; Benniamin *et al.*, 2020; Fraser-Jenkins *et al.*, 2021). If the climate changes to a hostile level, it may adversely affect the survival of *E. beddomei*. This species distribution modelling study of *E. beddomei* provides deep insights on the trend of distribution of Pteridophytes, and warrants formulating suitable conservation strategies for such taxa. Except for some preliminary attempts of *in vitro* spore germination and gametophyte development studies (Benniamin *et al.*, 2020), the protocols for mass propagation and field trials for re-introduction of this species are yet to be formulated. Suitable strategies, both short term and long-term are essential to ensure the conservation of this species. The case of *E. beddomei* is also an indication for the trend in distribution patterns of endemics of the Southern Western Ghats in the age of climate change (Thulasi *et al.*, 2024).

V. CONCLUSIONS

The Western Ghats mountains with three major gaps, Goa Gap, Palghat Gap and Shencottah Gap, constitute one of the major biodiversity rich areas in India and is a global biodiversity hotspot. Among the Gaps, the widest and most ancient Gap is the Palghat Gap. It splits the Ghats into southern and northern parts, as well as acts as a barrier of species movement from south to north and vice versa. The Gap region is with drier climate and less vegetation cover compared to southern and northern lips and thus limits the movement of organisms from one side to the other. There are reports that this separation gradually makes these populations on either side get reproductively isolated and start to evolve independently in different lineages. It was in this backdrop, the current research has been undertaken to analyse the influence of Palghat Gap, if any, on the distribution of lycophytes and ferns in the Southern Western Ghats, through different dimensions utilising ecological, taxonomical, micro morphological and molecular parameters.

The present documentation of ferns and lycophytes in the Palghat Gap influenced zone revealed the presence of 158 taxa belonging to 63 genera and 26 families. The comprehensive compilation with herbarium records revealed the presence of 33 more taxa making the numbers to 191 taxa belonging to 65 genera and 27 families. But these 33 taxa could not be located in the present explorative studies in this region.

The spore morphological analysis of *Angiopteris crassipes*, *A. helferiana*, *Actiniopteris radiata* and *Mickelopteris cordata* undertaken in the present research showed differences in spore morphology between the population from South, North and within the Gap areas. Similarly molecular analysis of different populations of *Actiniopteris radiata* resulted in the grouping of southern and northern populations in different clades and that of *Angiopteris* spp. and *Mickelopteris cordata* form clades irrespective of geographic distribution, which necessitated a further detailed molecular study in more populations using more molecular markers. The ecological analysis by similarity index and niche modelling were done to understand the

ecosystem preferences. Ecological niche modelling of *E. beddomei*, Southern Western Ghats endemic taxon, predicted the shrinking of evergreen patches in the Western Ghats in the near future. Following are the specific outcomes of the present study.

- Present exploration could document a total of 158 taxa belonging to 63 genera and 26 families from the Palghat Gap and Gap influenced areas.
- For comprehensive analysis, details of 33 taxa recorded in earlier studies (e.g. Nayar and Geevarghese, 1993) from the current study area were also included totalling the taxa to 191 belonging to 65 genera and 27 families.
- The dominant genus is *Asplenium* (20 taxa) and family Pteridaceae (34 taxa).
- Zone wise analysis revealed variations in diversity of lycophytes and ferns in the region, viz., North of the Gap (177 species, 62 genera and 26 families), South of the Gap (122 species, 56 genera and 25 families) and within the Gap (23 species, 18 genera and 10 families).
- Pteridaceae form the dominant family in the South (27 species, 12 genera), North (33 species, 11 genera) and within the Gap (8 species, 6 genera). *Asplenium* and *Thelypteris* are the dominant genera in the North (17 species). In the South of the Gap *Asplenium* forms the dominant genus (15 species). *Pteris* turned out to be the dominant genus within the Gap (8 species) areas.
- Among the recorded taxa, 21 were endemics (South India-Sri Lanka) or narrowly distributed ones.
- A total of 17 species listed under the IUCN red list categories were recorded with varying distribution patterns viz., from North (13 species), South (7 species) and in the Gap region (1 species).
- The spore morphological analysis of populations of *Angiopteris crassipes*, *A. helferiana*, *Actiniopteris radiata* and *Mickelopteris cordata* showed tendencies in population diversification along the Palghat Gap region.

- The molecular analysis of the populations of *Angiopteris* *Angiopteris crassipes* and *A. helferiana* based on plastid gene regions (*rbcL*, *trnL-F*, *atpB*) showed clustering of South Indian populations together in a clade irrespective of their morphological variations and distribution in North and South of the Gap.
- The molecular analysis of *Actiniopteris radiata* based on plastid gene regions (*rbcL*, *trnL-F*, *atpB*) showed clustering of Southern and Northern populations in two distinct clades, and signifies the influence of Palghat Gap in population diversification.
- In *Mickelopteris cordata*, different populations did not show any characteristic grouping, though the populations showed minor morpho-variants along the Gap zone.
- Critical evaluation of area coverage of different land use forms revealed that there is increase in evergreen, deciduous and mixed forests and this may be due to increased forest management practices by way of social forestry and agroforestry activities by Forest Department and other agencies involved in greening the planet action. Moreover, the software used may be accounting all green plants as forests. Also, many of the private plantations are now under the Forest Department, since the lease period is over and now these plantations are left undisturbed for the natural regeneration and restoration of the forest.
- Documentation revealed higher frequency of pteridophyte taxa from evergreen forests, which offers the most suitable ecological conditions for the majority of the fern species.
- Terrestrial micro-habitat offered a conducive environment for more taxa compared to other microhabitats found in the study area.
- The altitudinal distribution showed a maximum number of taxa in the middle zone ranging between 900 m and 1500 m.

- The Sorensen similarity index analysis of habitats showed maximum similarity between evergreen and shola vegetations, and least between dry and moist deciduous forests and wetlands. The maximum Sorensen similarity index was observed between terrestrial habitat and mud cliffs which share many common species.
- The taxonomic distinctness analysis of habitats showed maximum distinctness value for wetland and least in plantations. Highest taxonomic distinctness was observed for aquatic micro-habitat and least in xerophytic micro-habitat.
- Taxonomic distinctness is high in the altitudinal class 'above 2300' m and least in the class 300-400 m.
- Ecological Niche Modelling (ENM) based on MaxEnt of *Elaphoglossum beddomei* predicted a declining trend in the current as well as the future climatic regimes (2041-2071). ENM analysis showed that the distribution of *E. beddomei* is limited by precipitation in the Southern Western Ghats and consequent decline of evergreen habitats.
- The populations of pteridophytes in some parts of the study area were affected by the factors such as consecutive flood and landslides that happened during the years 2018 and 2019. The uncontrolled anthropogenic activities like expansion of mono-cultures, quarrying and ecotourism activities are also contributing to the decline of populations of pteridophytes in the area.

VI. RECOMMENDATIONS

Next to the flowering plants, pteridophytes are the major elements of vascular flora in the Southern Indian landscapes. They play significant roles in the ecosystem dynamics, such as prevention of soil erosion, reducing nutrient leaching, removing pollutants through hyper accumulation, etc. They also act as gap fillers, and provide suitable micro habitats, and micro climate for other groups of organisms, especially in the forest ecosystem. However, due to lack of awareness, this group of plants is usually overlooked and undervalued by the general public, policy makers, ecosystem managers, etc. Following recommendations are hence put forward under two sections; future line of studies and future line of actions.

Future line of studies

The potential of this group could be utilised more effectively by proper documentation and monitoring, that would give valuable insights into the health and status of the ecosystem of an area. Such studies and expertise may be promoted.

Based on the insights gained from the present study, it is strongly recommended that this plant group be given due consideration during biodiversity assessments and other activities involving alteration of the habitats.

As in the previous studies, the present one also confirmed the influence of the Palghat Gap on the diversification of the populations. Considering the unique climatic and geographical features of the area, more studies may be promoted in the area in getting a better understanding on evolution.

The case study of *Elaphoglossum beddomei*, proved the potential of niche modelling in predicting future distribution patterns in the present study. The results are alarming, as they forecast the degradation of evergreen and shola forests in the area, thereby risking the existence of many taxa. Further analyses are necessary to gain deeper insights and such studies should be promoted.

Due to limitations in resources and time, the molecular phylogeny

analysis of the present study was limited to three gene regions of four taxa. Future research could be expanded to explore the potential of larger-scale genomic data, such as whole chloroplast genomes or whole-genome analyses, to gain a deeper understanding of the phylogeny of pteridophyte taxa - a plant group of long evolutionary history found in the Palghat Gap, an area with significant geological antiquity.

Future line of actions

At present there are no specific policies for the effective management of this plant group. An effective policy may be prepared on handling this plant group. Due consideration should be given to this plant group in forest management plans.

Same is the case with conservation programmes for this plant group, which is lacking for the time being. Some of them are narrow endemics or of restricted distribution, known from a few populations. Efforts should also be made to translocate or transplant members of this group, especially the endemic or threatened members from areas at risk of degradation due to anthropogenic or natural factors. It is assumed that the populations of this group, within the protected areas, are relatively safe from anthropogenic pressures. However, those in non-protected forests and other areas face extreme danger of devastation. The plight of these populations needs to be addressed separately. Key stakeholders of biodiversity conservation and ecosystem management - such as the Forest and Wildlife Departments, State Biodiversity Boards, Local Governing Bodies, etc in Kerala and Tamil Nadu may develop appropriate protocols to prevent damage to this plant group in the wild, and facilitate translocation from threatened habitats.

The present study has identified some pteridophyte-rich critical habitats or zones, which harbour unique assemblages. When planning biodiversity management and conservation, due importance may be given to these critical habitats or zones.

Steps should also be taken to bridge the knowledge gap and raise awareness about this plant group among all stakeholders of biodiversity, including students and

the general public.

The stakeholders of biodiversity also may frame appropriate long-term conservation strategies to mitigate the impacts of habitat loss, as predicted in the niche modelling. Conservation plans such as multiplication, relocation, reintroduction, etc can be adopted as an alternate strategy.

Industrial pollution along with water and soil pollution creates problems in the population of pteridophytes and hence proper pollution checks and control measures should be implemented by the authorities to monitor and regulate the working of industries located in close vicinity to the forest areas and hillocks. Proper implementation of existing rules and regulations in the maintenance of water quality of the rivers in the area should be monitored periodically that in turn cause serious threats to the population of ferns and lycophytes. As ferns inhabit plantations and agricultural lands, unscientific practices should be regulated along with strict checks against excessive pesticide application in the farming fields, plantations and estates in order to maintain a healthy environment.

Infestation of forest tracts, road margins, riverine beds and wetlands by alien invasive taxa needs to be checked and effective methods are required to control such infestation as it adversely affects the fern population in the study area. Along with this, afforestation programmes in the landslide struck sites will slowly recover the fertility of topsoil and the recolonization of the sciophytic ground vegetation will happen in near future. This will slowly restore the health of the forest vegetation and will reduce the fragmentation of forest ecosystems to a great extent.

The population diversification studies here are considered as a preliminary step to the undeciphered evolutionary influence of Palghat Gap on pteridophyte distribution. Further studies in molecular studies using more gene regions or whole chloroplast genome as well as spore morphological analysis, along with cytological studies may clarify the influence of Palghat Gap in the fern flora of this region.

A critical review of the geography of the Gap influenced area along with floral and faunal wealth and associated ecosystems they are thriving must be made by the authority before permissions for any infrastructural development such as new settlements, industries or roads are given. Moreover, infrastructural development should be carried out with least effect on co - existence of organisms in any ecosystem.

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Annexure 1

Lycophytes and Ferns recorded from Moist Deciduous forests in the Palghat Gap influenced areas

Sl. No	Species	Genus	Family
1.	<i>Actiniopteris radiata</i> (J.Koenig ex Sw.) Link	<i>Actiniopteris</i>	Pteridaceae
2.	<i>Adiantum caudatum</i> L.	<i>Adiantum</i>	Pteridaceae
3.	<i>Adiantum incisum</i> Forssk.	<i>Adiantum</i>	Pteridaceae
4.	<i>Adiantum philippense</i> L.	<i>Adiantum</i>	Pteridaceae
5.	<i>Adiantum raddianum</i> C.Presl	<i>Adiantum</i>	Pteridaceae
6.	<i>Adiantum zollingeri</i> Mett. ex Kuhn	<i>Adiantum</i>	Pteridaceae
7.	<i>Aleuritopteris bicolor</i> (Roxb.) Fraser-Jenk.	<i>Aleuritopteris</i>	Pteridaceae
8.	<i>Asplenium formosum</i> Willd.	<i>Asplenium</i>	Pteridaceae
9.	<i>Athyrium cumingianum</i> (C.Presl) Ching	<i>Athyrium</i>	Athyriaceae
10.	<i>Athyrium hohenackerianum</i> (Kunze) T.Moore	<i>Athyrium</i>	Athyriaceae
11.	<i>Bolbitis semicordata</i> (Baker) Ching in C. Chr.	<i>Bolbitis</i>	Dryopteridaceae
12.	<i>Dicranopteris linearis</i> (Burm.f.) Underw.	<i>Dicranopteris</i>	Gleicheniaceae
13.	<i>Dicranopteris taiwanensis</i> Ching & P.S.Chiu in Chien & Chun	<i>Dicranopteris</i>	Gleicheniaceae
14.	<i>Doryopteris concolor</i> (Langsd. & Fisch.) Kuhn	<i>Doryopteris</i>	Pteridaceae
15.	<i>Drynaria quercifolia</i> (L.) J.Sm.	<i>Drynaria</i>	Polypodiaceae
16.	<i>Dryopteris cochleata</i> (D.Don) C.Chr.	<i>Dryopteris</i>	Dryopteridaceae
17.	<i>Helminthostachys zeylanica</i> (L.) Hook.	<i>Helminthostachys</i>	Ophioglossaceae
18.	<i>Hypolepis polypodioides</i> (Blume) Hook.	<i>Hypolepis</i>	Dennstaedtiaceae
19.	<i>Lygodium flexuosum</i> (L.) Sw.	<i>Lygodium</i>	Lygodium
20.	<i>Mickelopteris cordata</i> (Roxb. ex Hook. & Grev.) Fraser-Jenk. in Fraser-Jenkins et al.	<i>Mickelopteris</i>	Pteridaceae

21.	<i>Microlepia speluncae</i> (L.) T.Moore	<i>Microlepia</i>	Dennstaedtiaceae
22.	<i>Nephrolepis brownii</i> (Desv.) Hovenkamp & Miyam.	<i>Nephrolepis</i>	Nephrolepidaceae
23.	<i>Nephrolepis hirsutula</i> (Forst.) Presl	<i>Nephrolepis</i>	Nephrolepidaceae
24.	<i>Oeosporangium elegans</i> (Poir.) Fraser-Jenk. & Pariyar in Fraser- Jenkins et al.	<i>Oeosporangium</i>	Pteridaceae
25.	<i>Oeosporangium tenuifolium</i> (Burm.f.) Fraser-Jenk. & Pariyar	<i>Oeosporangium</i>	Pteridaceae
26.	<i>Pityrogramma calomelanos</i> (L.) Link	<i>Pityrogramma</i>	Pteridaceae
27.	<i>Pityrogramma chrysophylla</i> (Sw.) Link	<i>Pityrogramma</i>	Pteridaceae
28.	<i>Pteridium aquilinum</i> (L.) Kuhn subsp. <i>wightianum</i> (Wall. ex J.Agardh) W.C.Shieh	<i>Pteridium</i>	Dennstaedtiaceae
29.	<i>Pteris argyraea</i> T.Moore	<i>Pteris</i>	Pteridaceae
30.	<i>Pteris biaurita</i> L.	<i>Pteris</i>	Pteridaceae
31.	<i>Pteris blumeana</i> J.Agardh	<i>Pteris</i>	Pteridaceae
32.	<i>Pteris cretica</i> L. subsp. <i>laeta</i> (Wall. ex Ettingsh.) Fraser-Jenk.	<i>Pteris</i>	Pteridaceae
33.	<i>Pteris ensiformis</i> Burm.f.	<i>Pteris</i>	Pteridaceae
34.	<i>Pteris vittata</i> L.	<i>Pteris</i>	Pteridaceae
35.	<i>Pyrrosia heterophylla</i> (L.) M.G.Price	<i>Pyrrosia</i>	Polypodiaceae
36.	<i>Pyrrosia lanceolata</i> (L.) Farewell	<i>Pyrrosia</i>	Polypodiaceae
37.	<i>Pyrrosia porosa</i> (C.Presl) Hovenkamp	<i>Pyrrosia</i>	Polypodiaceae
38.	<i>Selaginella ciliaris</i> (Retz.) Spring	<i>Selaginella</i>	Selaginellaceae
39.	<i>Selaginella delicatula</i> (Desv. ex Poir.) Alston	<i>Selaginella</i>	Selaginellaceae
40.	<i>Selaginella tenera</i> (Hook. & Grev.) Spring	<i>Selaginella</i>	Selaginellaceae
41.	<i>Tectaria coadunata</i> (J.Sm.) C.Chr.	<i>Tectaria</i>	Tectariaceae
42.	<i>Tectaria paradoxa</i> (Fée) Sledge	<i>Tectaria</i>	Tectariaceae
43.	<i>Tectaria wightii</i> (C.B.Clarke) Ching	<i>Tectaria</i>	Tectariaceae
44.	<i>Thelypteris arbusculus</i> (Willd.) K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae
45.	<i>Thelypteris articulata</i> (Houlston & T.Moore) Tagawa & K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae

46.	<i>Thelypteris dentata</i> (Forssk.) E.P.St.John	<i>Thelypteris</i>	Thelypteridaceae
47.	<i>Thelypteris interruptus</i> (Willd.) K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae
48.	<i>Thelypteris ochthodes</i> (Kunze) Ching	<i>Thelypteris</i>	Thelypteridaceae
49.	<i>Thelypteris parasitica</i> (L.) Tardieu	<i>Thelypteris</i>	Thelypteridaceae
50.	<i>Thelypteris subtruncatus</i> (Bory) Panigrahi	<i>Thelypteris</i>	Thelypteridaceae
51.	<i>Thelypteris terminans</i> (J.Sm. ex Hook.) Tagawa & K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae
52.	<i>Thelypteris torresiana</i> (Gaudich.) Alston	<i>Thelypteris</i>	Thelypteridaceae

Annexure 2

Lycophytes and Ferns recorded from Semi Evergreen forests in the Palghat Gap influenced areas

Sl. No.	Species	Genus	Family
1.	<i>Adiantum philippense</i> L.	<i>Adiantum</i>	Pteridaceae
2.	<i>Adiantum raddianum</i> C. Presl	<i>Adiantum</i>	Pteridaceae
3.	<i>Aleuritopteris bicolor</i> (Roxb.) Fraser-Jenk.	<i>Aleuritopteris</i>	Pteridaceae
4.	<i>Asplenium andreisii</i> Fraser-Jenk.	<i>Asplenium</i>	Aspleniaceae
5.	<i>Asplenium excisum</i> C.Presl	<i>Asplenium</i>	Aspleniaceae
6.	<i>Asplenium falcatum</i> Lam.	<i>Asplenium</i>	Aspleniaceae
7.	<i>Asplenium formosum</i> Willd.	<i>Asplenium</i>	Aspleniaceae
8.	<i>Asplenium inaequilaterale</i> Bory ex Willd.	<i>Asplenium</i>	Aspleniaceae
9.	<i>Asplenium phyllitidis</i> D.Don	<i>Asplenium</i>	Aspleniaceae
10.	<i>Athyrium cumingianum</i> (C.Presl) Ching	<i>Athyrium</i>	Athyriaceae
11.	<i>Athyrium hohenackerianum</i> (Kunze) T.Moore	<i>Athyrium</i>	Athyriaceae
12.	<i>Athyrium solenopteris</i> (Kunze) T.Moore	<i>Athyrium</i>	Athyriaceae
13.	<i>Blechnum occidentale</i> L.	<i>Blechnum</i>	Blechnaceae
14.	<i>Blechnum orientale</i> L.	<i>Blechnum</i>	Blechnaceae
15.	<i>Bolbitis angustipinna</i> (Hayata) Ito	<i>Bolbitis</i>	Dryopteridaceae
16.	<i>Bolbitis appendiculata</i> (Willd.) K. Iwatz.	<i>Bolbitis</i>	Dryopteridaceae
17.	<i>Bolbitis asplenifolia</i> (Bory) K.Iwatz.	<i>Bolbitis</i>	Dryopteridaceae
18.	<i>Bolbitis beddomei</i> Fraser-Jenk. & Gandhi	<i>Bolbitis</i>	Dryopteridaceae
19.	<i>Bolbitis semicordata</i> (Baker) Ching in C. Chr.	<i>Bolbitis</i>	Dryopteridaceae
20.	<i>Dicranopteris taiwanensis</i> Ching & P.S.Chiu	<i>Dicranopteris</i>	Gleicheniaceae
21.	<i>Diplazium manickamii</i> Fraser- Jenk. & Kholia	<i>Diplazium</i>	Athyriaceae
22.	<i>Drynaria quercifolia</i> (L.) J.Sm.	<i>Drynaria</i>	Polypodiaceae
23.	<i>Dryopteris cochleata</i> (D.Don) C.Chr.	<i>Dryopteris</i>	Dryopteridaceae
24.	<i>Dryopteris juxtaposita</i> Christ	<i>Dryopteris</i>	Dryopteridaceae

25.	<i>Dryopteris odontoloma</i> (T.Moore ex Bedd.) C.Chr.	<i>Dryopteris</i>	Dryopteridaceae
26.	<i>Hypolepis polypodioides</i> (Blume) Hook.	<i>Hypolepis</i>	Dennstaedtiaceae
27.	<i>Lepisorus nudus</i> (Hook.) Ching	<i>Lepisorus</i>	Polypodiaceae
28.	<i>Leptochilus axillaris</i> (Cav.) Kaulf.	<i>Leptochilus</i>	Polypodiaceae
29.	<i>Leptochilus decurrens</i> Bl.	<i>Leptochilus</i>	Polypodiaceae
30.	<i>Leptochilus pteropus</i> subsp. <i>minor</i> (Bedd.) Fraser-Jenk.	<i>Leptochilus</i>	Polypodiaceae
31.	<i>Leptochilus thwaitesianus</i> Fee	<i>Leptochilus</i>	Polypodiaceae
32.	<i>Lindsaea ensifolia</i> Sw.	<i>Lindsaea</i>	Lindsaeaceae
33.	<i>Lindsaea heterophylla</i> Dryand.	<i>Lindsaea</i>	Lindsaeaceae
34.	<i>Mickelopteris cordata</i> (Roxb. ex Hook. & Grev.) Fraser-Jenk.	<i>Mickelopteris</i>	Pteridaceae
35.	<i>Microlepia nepalensis</i> (Spreng.) Fraser-Jenk.	<i>Microlepia</i>	Dennstaedtiaceae
36.	<i>Microlepia rhomboidea</i> (Hook.) C.Presl ex Prantl	<i>Microlepia</i>	Dennstaedtiaceae
37.	<i>Microlepia speluncae</i> (L.) T.Moore	<i>Microlepia</i>	Dennstaedtiaceae
38.	<i>Microsorium membranaceum</i> (D.Don) Ching	<i>Microsorium</i>	Polypodiaceae
39.	<i>Microsorium membranifolium</i> (R.Br.) Ching	<i>Microsorium</i>	Polypodiaceae
40.	<i>Microsorium punctatum</i> (L.) Copel.	<i>Microsorium</i>	Polypodiaceae
41.	<i>Nephrolepis brownii</i> (Desv.) Hovenkamp & Miyam.	<i>Nephrolepis</i>	Nephrolepidaceae
42.	<i>Nephrolepis cordifolia</i> (L.) C.Presl	<i>Nephrolepis</i>	Nephrolepidaceae
43.	<i>Nephrolepis hirsutula</i> (Forst.) Presl	<i>Nephrolepis</i>	Nephrolepidaceae
44.	<i>Nephrolepis undulata</i> (Afzel. ex Sw.) J.Sm.	<i>Nephrolepis</i>	Nephrolepidaceae
45.	<i>Oeosporangium elegans</i> (Poir.) Fraser-Jenk. & Pariyar	<i>Oeosporangium</i>	Pteridaceae
46.	<i>Pellaea boivinii</i> Hook.	<i>Pelleae</i>	Pteridaceae
47.	<i>Pellaea longipilosa</i> Bonap.	<i>Pellaea</i>	Pteridaceae
48.	<i>Pityrogramma calomelanos</i> (L.) Link	<i>Pityrogramma</i>	Pteridaceae
49.	<i>Pityrogramma chrysophylla</i> (Sw.)	<i>Pityrogramma</i>	Pteridaceae

	Link		
50.	<i>Pteridium aquilinum</i> (L.) Kuhn subsp. <i>wightianum</i> (Wall. ex J.Agardh) W.C.Shieh	<i>Pteridium</i>	Dennstaedtiaceae
51.	<i>Pteris argyraea</i> T. Moore	<i>Pteris</i>	Pteridaceae
52.	<i>Pteris biaurita</i> L.	<i>Pteris</i>	Pteridaceae
53.	<i>Pteris blumeana</i> J.Agardh	<i>Pteris</i>	Pteridaceae
54.	<i>Pteris cretica</i> L. Subsp. <i>laeta</i> (Wall. ex Ettingsh.) Fraser-Jenk.	<i>Pteris</i>	Pteridaceae
55.	<i>Pteris mertensioides</i> Willd.	<i>Pteris</i>	Pteridaceae
56.	<i>Pteris pellucens</i> J.Agardh	<i>Pteris</i>	Pteridaceae
57.	<i>Pteris scabripes</i> Wall. ex J.Agardh.	<i>Pteris</i>	Pteridaceae
58.	<i>Pyrrosia lanceolata</i> (L.) Farewell	<i>Pyrrosia</i>	Polypodiaceae
59.	<i>Pyrrosia porosa</i> (C.Presl) Hovenkamp	<i>Pyrrosia</i>	Polypodiaceae
60.	<i>Selaginella chrysorrhizos</i> Spring	<i>Selaginella</i>	Selaginellaceae
61.	<i>Selaginella crassipes</i> Wall. ex C.Presl	<i>Selaginella</i>	Selaginellaceae
62.	<i>Selaginella delicatula</i> (Desv. ex Poir.) Alston	<i>Selaginella</i>	Selaginellaceae
63.	<i>Selaginella involvens</i> (Sw.) Spring	<i>Selaginella</i>	Selaginellaceae
64.	<i>Selaginella tenera</i> (Hook. & Grev.) Spring	<i>Selaginella</i>	Selaginellaceae
65.	<i>Selliguea montana</i> (Sledge) Hovenkamp	<i>Selliguea</i>	Polypodiaceae
66.	<i>Stenochlaena palustris</i> (Burm.f.) Beddome	<i>Stenochlaena</i>	Blechnaceae
67.	<i>Tectaria coadunata</i> (J.Sm.) C.Chr.	<i>Tectaria</i>	Tectariaceae
68.	<i>Tectaria paradoxa</i> (Fée) Sledge	<i>Tectaria</i>	Tectariaceae
69.	<i>Tectaria wightii</i> (C.B.Clarke) Ching	<i>Tectaria</i>	Tectariaceae
70.	<i>Thelypteris arbusculus</i> (Willd.) K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae
71.	<i>Thelypteris articulata</i> (Houlston & T.Moore) Tagawa & K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae
72.	<i>Thelypteris dentata</i> (Forssk.) E.P.St.John	<i>Thelypteris</i>	Thelypteridaceae
73.	<i>Thelypteris flaccida</i> (Blume) Ching	<i>Thelypteris</i>	Thelypteridaceae

74.	<i>Thelypteris hispidula</i> (Decne.) C.F.Reed	<i>Thelypteris</i>	Thelypteridaceae
75.	<i>Thelypteris interruptus</i> (Willd.) K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae
76.	<i>Thelypteris ochthodes</i> (Kunze) Ching	<i>Thelypteris</i>	Thelypteridaceae
77.	<i>Thelypteris parasitica</i> (L.) Tardieu	<i>Thelypteris</i>	Thelypteridaceae
78.	<i>Thelypteris subtruncatus</i> (Bory) Panigrahi	<i>Thelypteris</i>	Thelypteridaceae
79.	<i>Thelypteris terminans</i> (J.Sm. ex Hook.) Tagawa & K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae
80.	<i>Thelypteris torresiana</i> (Gaudich.) Alston	<i>Thelypteris</i>	Thelypteridaceae
81.	<i>Thelypteris triphylla</i> (Sw.) K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae
82.	<i>Thelypteris</i> × <i>thwaitesii</i> (Hook.) C.F.Reed	<i>Thelypteris</i>	Thelypteridaceae
83.	<i>Trichomanes intramarginale</i> Hook. & Grev.	<i>Trichomanes</i>	Hymenophyllaceae
84.	<i>Vittaria elongata</i> Sw.	<i>Vittaria</i>	Pteridaceae

Annexure 3

Lycophytes and Ferns recorded from Evergreen forests in the Palghat Gap influenced areas

Sl. No.	Species	Genus	Family
1.	<i>Adiantum hispidulum</i> Sw.	<i>Adiantum</i>	Pteridaceae
2.	<i>Adiantum raddianum</i> C.Presl	<i>Adiantum</i>	Pteridaceae
3.	<i>Anemia schimperiana</i> C.Presl subsp. <i>wightiana</i> (Gardner) Fraser-Jenk.	<i>Anemia</i>	Anemiaceae
4.	<i>Angiopteris crassipes</i> Wall. ex C.Presl	<i>Angiopteris</i>	Marattiaceae
5.	<i>Angiopteris helferiana</i> C.Presl	<i>Angiopteris</i>	Marattiaceae
6.	<i>Antrophyum plantagineum</i> Kaulf.	<i>Antrophyum</i>	Pteridaceae
7.	<i>Antrophyum reticulatum</i> (G.Forst.) Kaulf.	<i>Antrophyum</i>	Pteridaceae
8.	<i>Arachniodes palmipes</i> (Kunze) Fraser-Jenk.	<i>Arachniodes</i>	Dryopteridaceae
9.	<i>Arachniodes sledgei</i> Fraser-Jenk.	<i>Arachniodes</i>	Dryopteridaceae
10.	<i>Asplenium aethiopicum</i> (Burm.f.) Bech.	<i>Asplenium</i>	Aspleniaceae
11.	<i>Asplenium andreisii</i> Fraser-Jenk. in Fraser-Jenkins et al.	<i>Asplenium</i>	Aspleniaceae
12.	<i>Asplenium cheilosorum</i> Kunze ex Mett.	<i>Asplenium</i>	Aspleniaceae
13.	<i>Asplenium crinicaule</i> Hance	<i>Asplenium</i>	Aspleniaceae
14.	<i>Asplenium decrescens</i> Kunze	<i>Asplenium</i>	Aspleniaceae
15.	<i>Asplenium emarginatodentatum</i> Zenker ex Kunze	<i>Asplenium</i>	Aspleniaceae
16.	<i>Asplenium excisum</i> C.Presl	<i>Asplenium</i>	Aspleniaceae
17.	<i>Asplenium falcatum</i> Lam.	<i>Asplenium</i>	Aspleniaceae
18.	<i>Asplenium formosum</i> Willd.	<i>Asplenium</i>	Aspleniaceae
19.	<i>Asplenium hondoense</i> N.Murak. & Hatan.	<i>Asplenium</i>	Aspleniaceae
20.	<i>Asplenium inaequilaterale</i> Bory ex Willd.	<i>Asplenium</i>	Aspleniaceae
21.	<i>Asplenium lanciniatum</i> D.Don subsp. <i>fraser-jenkinsii</i> Reichst. ex Pangtey & Khullar	<i>Asplenium</i>	Aspleniaceae
22.	<i>Asplenium mysorensense</i> Roth	<i>Asplenium</i>	Aspleniaceae

23.	<i>Asplenium nitidum</i> Sw.	<i>Asplenium</i>	Aspleniaceae
24.	<i>Asplenium normale</i> D.Don	<i>Asplenium</i>	Aspleniaceae
25.	<i>Asplenium obscurum</i> Blume	<i>Asplenium</i>	Aspleniaceae
26.	<i>Asplenium phyllitidis</i> D.Don	<i>Asplenium</i>	Aspleniaceae
27.	<i>Asplenium serricula</i> Fée	<i>Asplenium</i>	Aspleniaceae
28.	<i>Asplenium tenuifolium</i> D. Don.	<i>Asplenium</i>	Aspleniaceae
29.	<i>Asplenium zenkerianum</i> Kunze	<i>Asplenium</i>	Aspleniaceae
30.	<i>Athyrium solenopteris</i> (Kunze) T. Moore	<i>Athyrium</i>	Athyriaceae
31.	<i>Blechnum melanocaulon</i> (Brack.) T.C. Chambers & P.A. Farrant subsp. <i>pallens</i> T.C.Chambers & P.A.Farrant	<i>Blechnum</i>	Blechnaceae
32.	<i>Blechnum occidentale</i> L.	<i>Blechnum</i>	Blechnaceae
33.	<i>Blechnum orientale</i> L.	<i>Blechnum</i>	Blechnaceae
34.	<i>Bolbitis angustipinna</i> (Hayata) Ito	<i>Bolbitis</i>	Dryopteridaceae
35.	<i>Bolbitis appendiculata</i> (Willd.) K. Iwatz.	<i>Bolbitis</i>	Dryopteridaceae
36.	<i>Bolbitis asplenifolia</i> (Bory) K.Iwats.	<i>Bolbitis</i>	Dryopteridaceae
37.	<i>Bolbitis beddomei</i> Fraser-Jenk. & Gandhi	<i>Bolbitis</i>	Dryopteridaceae
38.	<i>Bolbitis semicordata</i> (Baker) Ching in C. Chr.	<i>Bolbitis</i>	Dryopteridaceae
39.	<i>Botrychium daucifolium</i> Wall. ex Hook. et Grev.	<i>Botrychium</i>	Ophioglossaceae
40.	<i>Botrychium lanuginosum</i> Wall. ex Hook. & Grev.	<i>Botrychium</i>	Ophioglossaceae
41.	<i>Cyathea crinita</i> (Hook.) Copel.	<i>Cyathea</i>	Cyatheaceae
42.	<i>Cyathea gigantea</i> (Wall. ex Hook.) Holttum	<i>Cyathea</i>	Cyatheaceae
43.	<i>Cyathea nilgirensis</i> Holttum	<i>Cyathea</i>	Cyatheaceae
44.	<i>Cyathea spinulosa</i> Wall. ex Hook.	<i>Cyathea</i>	Cyatheaceae
45.	<i>Cyrtomium micropterum</i> (Kunze) Ching	<i>Cyrtomium</i>	Dryopteridaceae
46.	<i>Davallia trichomanoides</i> Blume	<i>Davallia</i>	Davalliaceae
47.	<i>Deparia japonica</i> subsp. <i>petersenii</i> (Kunze) Fraser-Jenk.	<i>Deparia</i>	Athyriaceae
48.	<i>Diplazium latifolium</i> T.Moore	<i>Diplazium</i>	Athyriaceae
49.	<i>Diplazium leptophyllum</i> Christ	<i>Diplazium</i>	Athyriaceae
50.	<i>Diplazium manickamii</i> Fraser-Jenk. & Kholia	<i>Diplazium</i>	Athyriaceae

51.	<i>Diplazium polypodioides</i> Blume	<i>Diplazium</i>	Athyriaceae
52.	<i>Diplazium sylvaticum</i> (Bory) Sw.	<i>Diplazium</i>	Athyriaceae
53.	<i>Diplazium travancoricum</i> Bedd.	<i>Diplazium</i>	Athyriaceae
54.	<i>Drynaria quercifolia</i> (L.) J.Sm.	<i>Drynaria</i>	Polypodiaceae
55.	<i>Dryopsis scabrosa</i> (Kunze) Holttum & P.J.Edwards	<i>Dryopsis</i>	Dryopteridaceae
56.	<i>Dryopteris atrata</i> (Kunze) Ching	<i>Dryopteris</i>	Dryopteridaceae
57.	<i>Dryopteris hirtipes</i> (Blume) Kuntze	<i>Dryopteris</i>	Dryopteridaceae
58.	<i>Dryopteris odontoloma</i> (T.Moore ex Bedd.) C.Chr.	<i>Dryopteris</i>	Dryopteridaceae
59.	<i>Dryopteris sparsa</i> (D.Don) Kuntze subsp. <i>rectipinnula</i> Fraser-Jenk.	<i>Dryopteris</i>	Dryopteridaceae
60.	<i>Elaphoglossum beddomei</i> Sledge	<i>Elaphoglossum</i>	Dryopteridaceae
61.	<i>Elaphoglossum nilgiricum</i> Krajina ex Sledge	<i>Elaphoglossum</i>	Dryopteridaceae
62.	<i>Huperzia hamiltonii</i> (Spreng.) Trevis.	<i>Huperzia</i>	Lycopodiaceae
63.	<i>Huperzia phlegmaria</i> (L.) Rothm.	<i>Huperzia</i>	Lycopodiaceae
64.	<i>Huperzia phyllantha</i> (Hook. & Arn.) Holub	<i>Huperzia</i>	Lycopodiaceae
65.	<i>Huperzia squarrosa</i> (G.Forst.) Trevis.	<i>Huperzia</i>	Lycopodiaceae
66.	<i>Hymenophyllum exsertum</i> Wall. ex Hook.	<i>Hymenophyllum</i>	Hymenophyllaceae
67.	<i>Katoella pulchra</i> (D. Don) Fraser-Jenk.	<i>Katoella</i>	Davalliaceae
68.	<i>Lepisorus contortus</i> (Christ) Ching	<i>Lepisorus</i>	Polypodiaceae
69.	<i>Lepisorus nudus</i> (Hook.) Ching	<i>Lepisorus</i>	Polypodiaceae
70.	<i>Leptochilus axillaris</i> (Cav.) Kaulf.	<i>Leptochilus</i>	Polypodiaceae
71.	<i>Leptochilus decurrens</i> Bl.	<i>Leptochilus</i>	Polypodiaceae
72.	<i>Leptochilus pteropus</i> subsp. <i>minor</i> (Bedd.) Fraser-Jenk.	<i>Leptochilus</i>	Polypodiaceae
73.	<i>Leptochilus thwaitesianus</i> Fee	<i>Leptochilus</i>	Polypodiaceae
74.	<i>Lindsaea ensifolia</i> Sw.	<i>Lindsaea</i>	Lindsaeaceae
75.	<i>Lindsaea heterophylla</i> Dryand.	<i>Lindsaea</i>	Lindsaeaceae
76.	<i>Loxogramme involuta</i> (D.Don) C.Presl	<i>Loxogramme</i>	Polypodiaceae
77.	<i>Loxogramme parallela</i> Copel.	<i>Loxogramme</i>	Polypodiaceae
78.	<i>Lycopodium wightianum</i> Grev. & Hook.	<i>Lycopodium</i>	Lycopodiaceae
79.	<i>Marattia fraxinea</i> Sm.	<i>Marattia</i>	Marattiaceae

80.	<i>Mickelopteris cordata</i> (Roxb. ex Hook. & Grev.) Fraser-Jenk.	<i>Mickelopteris</i>	Pteridaceae
81.	<i>Microlepidia nepalensis</i> (Spreng.) Fraser-Jenk.	<i>Microlepidia</i>	Dennstaedtiaceae
82.	<i>Microlepidia rhomboidea</i> (Hook.) C.Presl ex Prantl	<i>Microlepidia</i>	Dennstaedtiaceae
83.	<i>Microlepidia spelunca</i> (L.) T.Moore	<i>Microlepidia</i>	Dennstaedtiaceae
84.	<i>Microsorium cuspidatum</i> (D.Don) Tagawa. subsp. <i>beddomei</i> (S.R.Ghosh) Fraser-Jenk.	<i>Microsorium</i>	Polypodiaceae
85.	<i>Microsorium membranaceum</i> (D.Don) Ching	<i>Microsorium</i>	Polypodiaceae
86.	<i>Microsorium membranifolium</i> (R.Br.) Ching	<i>Microsorium</i>	Polypodiaceae
87.	<i>Microsorium punctatum</i> (L.) Copel.	<i>Microsorium</i>	Polypodiaceae
88.	<i>Nephrolepis cordifolia</i> (L.) C.Presl	<i>Nephrolepis</i>	Nephrolepidaceae
89.	<i>Nephrolepis undulata</i> (Afzel. ex Sw.) J.Sm.	<i>Nephrolepis</i>	Nephrolepidaceae
90.	<i>Odontosoria chinensis</i> (L.) J.Sm.	<i>Odontosoria</i>	Lindsaeaceae
91.	<i>Oleandra musifolia</i> (Bl.) Presl	<i>Oleandra</i>	Oleandraceae
92.	<i>Oreogrammitis attenuata</i> (Kunze) Parris	<i>Oreogrammitis</i>	Pteridaceae
93.	<i>Pellaea boivinii</i> Hook.	<i>Pellaea</i>	Pteriaceae
94.	<i>Pellaea longipilosa</i> Bonap.	<i>Pellaea</i>	Pteridaceae
95.	<i>Pityrogramma calomelanos</i> (L.) Link	<i>Pityrogramma</i>	Pteridaceae
96.	<i>Polystichum anomalum</i> (Hook. & Arn.) J.Sm. subsp. <i>travancoricum</i> (Bedd.) Fraser-Jenk.	<i>Polystichum</i>	Dryopteridaceae
97.	<i>Polystichum harpophyllum</i> (Zenker ex Kunze) Sledge	<i>Polystichum</i>	Dryopteridaceae
98.	<i>Polystichum squarosum</i> (D.Don) Fée	<i>Polystichum</i>	Dryopteridaceae
99.	<i>Polystichum subinerme</i> (Kunze) Fraser-Jenk.	<i>Polystichum</i>	Dryopteridaceae
100.	<i>Pteris argyraea</i> T.Moore	<i>Pteris</i>	Pteridaceae
101.	<i>Pteris biaurita</i> L.	<i>Pteris</i>	Pteridaceae
102.	<i>Pteris cretica</i> L. subsp. <i>cretica</i> Fraser-Jenkins et al.	<i>Pteris</i>	Pteridaceae
103.	<i>Pteris mertensioides</i> Willd.	<i>Pteris</i>	Pteridaceae
104.	<i>Pteris multiaurita</i> J.Agardh.	<i>Pteris</i>	Pteridaceae
105.	<i>Pteris pellucens</i> J.Agardh	<i>Pteris</i>	Pteridaceae

106	<i>Pteris scabripes</i> Wall. ex J.Agardh.	<i>Pteris</i>	Pteridaceae
107	<i>Pyrrrosia lanceolata</i> (L.) Farewell	<i>Pyrrrosia</i>	Polypodiaceae
108	<i>Pyrrrosia porosa</i> (C.Presl) Hovenkamp	<i>Pyrrrosia</i>	Polypodiaceae
109	<i>Selaginella chrysorrhizos</i> Spring	<i>Selaginella</i>	Selaginellaceae
110	<i>Selaginella crassipes</i> Spring	<i>Selaginella</i>	Selaginellaceae
111	<i>Selaginella intermedia</i> (Blume) Spring	<i>Selaginella</i>	Selaginellaceae
112	<i>Selaginella involvens</i> (Sw.) Spring	<i>Selaginella</i>	Selaginellaceae
113	<i>Selaginella tenera</i> (Hook. & Grev.) Spring	<i>Selaginella</i>	Selaginellaceae
114	<i>Selliguea montana</i> (Sledge) Hovenkamp	<i>Selliguea</i>	Polypodiaceae
115	<i>Stenochlaena palustris</i> (Burm.f.) Beddome	<i>Stenochlaena</i>	Blechnaceae
116	<i>Tectaria coadunata</i> (J.Sm.) C.Chr.	<i>Tectaria</i>	Tectariaceae
117	<i>Tectaria paradoxa</i> (Fée) Sledge	<i>Tectaria</i>	Tectariaceae
118	<i>Tectaria wightii</i> (C.B.Clarke) Ching	<i>Tectaria</i>	Tectariaceae
119	<i>Thelypteris dentata</i> (Forssk.) E.P.St.John	<i>Thelypteris</i>	Thelypteridaceae
120	<i>Thelypteris flaccida</i> (Blume) Ching	<i>Thelypteris</i>	Thelypteridaceae
121	<i>Thelypteris hispidula</i> (Decne.) C.F.Reed	<i>Thelypteris</i>	Thelypteridaceae
122	<i>Thelypteris ochthodes</i> (Kunze) Ching	<i>Thelypteris</i>	Thelypteridaceae
123	<i>Thelypteris ornata</i> (J.Sm.) Ching	<i>Thelypteris</i>	Thelypteridaceae
124	<i>Thelypteris terminans</i> (J.Sm. ex Hook.) Tagawa & K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae
125	<i>Thelypteris torresiana</i> (Gaudich.) Alston	<i>Thelypteris</i>	Thelypteridaceae
126	<i>Thelypteris triphylla</i> (Sw.) K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae
127	<i>Thelypteris truncata</i> (Poir.) K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae
128	<i>Thelypteris</i> × <i>thwaitesii</i> (Hook.) C.F.Reed	<i>Thelypteris</i>	Thelypteridaceae
129	<i>Trichomanes bilabiatum</i> Nees & Blume	<i>Trichomanes</i>	Hymenophyllaceae
130	<i>Trichomanes bimarginatum</i> (Bosch.) Bosch	<i>Trichomanes</i>	Hymenophyllaceae
131	<i>Trichomanes campanulatum</i> Roxb.	<i>Trichomanes</i>	Hymenophyllaceae
132	<i>Trichomanes exiguum</i> (Bedd.) Baker	<i>Trichomanes</i>	Hymenophyllaceae

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133	<i>Trichomanes minutum</i> Blume	<i>Trichomanes</i>	Hymenophyllaceae
134	<i>Trichomanes obscurum</i> Blume	<i>Trichomanes</i>	Hymenophyllaceae
135	<i>Trichomanes schmidiana</i> Zenker ex Taschner	<i>Trichomanes</i>	Hymenophyllaceae
136	<i>Vittaria elongata</i> Sw.	<i>Vittaria</i>	Pteridaceae

Annexure 4

Lycophytes and Ferns recorded from Shola forests in the Palghat Gap influenced areas

Sl. No.	Species	Genus	Family
1.	<i>Adiantum hispidulum</i> Sw.	<i>Adiantum</i>	Pteridaceae
2.	<i>Angiopteris crassipes</i> Wall. ex C.Presl	<i>Angiopteris</i>	Marattiaceae
3.	<i>Angiopteris helferiana</i> C.Presl	<i>Angiopteris</i>	Marattiaceae
4.	<i>Antrophyum plantagineum</i> Kaulf.	<i>Antrophyum</i>	Pteridaceae
5.	<i>Antrophyum reticulatum</i> (G.Forst.) Kaulf.	<i>Antrophyum</i>	Pteridaceae
6.	<i>Arachniodes palmipes</i> (Kunze) Fraser-Jenk.	<i>Arachniodes</i>	Dryopteridaceae
7.	<i>Arachniodes sledgei</i> Fraser-Jenk.	<i>Arachniodes</i>	Dryopteridaceae
8.	<i>Asplenium aethiopicum</i> (Burm.f.) Bech.	<i>Asplenium</i>	Aspleniaceae
9.	<i>Asplenium andreisii</i> Fraser-Jenk. in Fraser-Jenkins et al.	<i>Asplenium</i>	Aspleniaceae
10.	<i>Asplenium cheilosorum</i> Kunze ex Mett.	<i>Asplenium</i>	Aspleniaceae
11.	<i>Asplenium crinicaule</i> Hance	<i>Asplenium</i>	Aspleniaceae
12.	<i>Asplenium decrescens</i> Kunze	<i>Asplenium</i>	Aspleniaceae
13.	<i>Asplenium emarginatodentatum</i> Zenker ex Kunze	<i>Asplenium</i>	Aspleniaceae
14.	<i>Asplenium excisum</i> C.Presl	<i>Asplenium</i>	Aspleniaceae
15.	<i>Asplenium falcatum</i> Lam.	<i>Asplenium</i>	Aspleniaceae
16.	<i>Asplenium formosum</i> Willd.	<i>Asplenium</i>	Aspleniaceae
17.	<i>Asplenium hondoense</i> N.Murak. & Hatan.	<i>Asplenium</i>	Aspleniaceae
18.	<i>Asplenium inaequilaterale</i> Bory ex Willd.	<i>Asplenium</i>	Aspleniaceae
19.	<i>Asplenium lancinatum</i> D. Don subsp. <i>fraser-jenkinsii</i> Reichst. ex Pangtey & Khullar	<i>Asplenium</i>	Aspleniaceae
20.	<i>Asplenium mysorensense</i> Roth	<i>Asplenium</i>	Aspleniaceae
21.	<i>Asplenium nitidum</i> Sw.	<i>Asplenium</i>	Aspleniaceae
22.	<i>Asplenium normale</i> D.Don	<i>Asplenium</i>	Aspleniaceae
23.	<i>Asplenium obscurum</i> Blume	<i>Asplenium</i>	Aspleniaceae
24.	<i>Asplenium phyllitidis</i> D.Don	<i>Asplenium</i>	Aspleniaceae

25.	<i>Asplenium serricula</i> Fée	<i>Asplenium</i>	Aspleniaceae
26.	<i>Asplenium tenuifolium</i> D. Don	<i>Asplenium</i>	Aspleniaceae
27.	<i>Asplenium zenkerianum</i> Kunze	<i>Asplenium</i>	Aspleniaceae
28.	<i>Athyrium solenopteris</i> (Kunze) T.Moore	<i>Athyrium</i>	Athyriaceae
29.	<i>Blechnum melanocaulon</i> (Brack.) T.C. Chambers & P.A. Farrant subsp. <i>pallens</i> T.C.Chambers & P.A.Farrant	<i>Blechnum</i>	Blechnaceae
30.	<i>Blechnum occidentale</i> L.	<i>Blechnum</i>	Blechnaceae
31.	<i>Blechnum orientale</i> L.	<i>Blechnum</i>	Blechnaceae
32.	<i>Bolbitis angustipinna</i> (Hayata) Ito	<i>Bolbitis</i>	Dryopteridaceae
33.	<i>Bolbitis appendiculata</i> (Willd.) K. Iwatz.	<i>Bolbitis</i>	Dryopteridaceae
34.	<i>Bolbitis asplenifolia</i> (Bory) K.Iwats.	<i>Bolbitis</i>	Dryopteridaceae
35.	<i>Bolbitis semicordata</i> (Baker) Ching in C. Chr.	<i>Bolbitis</i>	Dryopteridaceae
36.	<i>Botrychium daucifolium</i> Wall. ex Hook. & Grev.	<i>Botrychium</i>	Ophioglossaceae
37.	<i>Botrychium lanuginosum</i> Wall. ex Hook. & Grev.	<i>Botrychium</i>	Ophioglossaceae
38.	<i>Cyathea crinita</i> (Hook.) Copel.	<i>Cyathea</i>	Cyatheaceae
39.	<i>Cyathea gigantea</i> (Wall. ex Hook.) Holttum	<i>Cyathea</i>	Cyatheaceae
40.	<i>Cyathea nilgirensis</i> Holttum	<i>Cyathea</i>	Cyatheaceae
41.	<i>Cyathea spinulosa</i> Wall. ex Hook.	<i>Cyathea</i>	Cyatheaceae
42.	<i>Cyrtomium caryotideum</i> (Wall. ex Hook. & Grev.) C.Presl	<i>Cyrtomium</i>	Dryopteridaceae
43.	<i>Davallia trichomanoides</i> Blume	<i>Davallia</i>	Davalliaceae
44.	<i>Deparia japonica</i> subsp. <i>petersenii</i> (Kunze) Fraser-Jenk.	<i>Deparia</i>	Athyriaceae
45.	<i>Diplazium leptophyllum</i> Christ	<i>Diplazium</i>	Athyriaceae
46.	<i>Diplazium manickamii</i> Fraser- Jenk. & Kholia	<i>Diplazium</i>	Athyriaceae
47.	<i>Drynaria quercifolia</i> (L.) J.Sm.	<i>Drynaria</i>	Polypodiaceae
48.	<i>Dryopsis scabrosa</i> (Kunze) Holttum & P.J.Edwards	<i>Dryopsis</i>	Dryopteridaceae
49.	<i>Dryopteris atrata</i> (Kunze) Ching	<i>Dryopteris</i>	Dryopteridaceae
50.	<i>Dryopteris hirtipes</i> (Blume) Kuntze	<i>Dryopteris</i>	Dryopteridaceae
51.	<i>Dryopteris odontoloma</i> (T.Moore	<i>Dryopteris</i>	Dryopteridaceae

	ex Bedd.) C.Chr.		
52.	<i>Dryopteris sparsa</i> (D.Don) Kuntze subsp. <i>rectipinnula</i> Fraser-Jenk.	<i>Dryopteris</i>	Dryopteridaceae
53.	<i>Elaphoglossum beddomei</i> Sledge	<i>Elaphoglossum</i>	Dryopteridaceae
54.	<i>Huperzia hamiltonii</i> (Spreng.) Trevis.	<i>Huperzia</i>	Lycopodiaceae
55.	<i>Huperzia phlegmaria</i> (L.) Rothm.	<i>Huperzia</i>	Lycopodiaceae
56.	<i>Huperzia phyllantha</i> (Hook. & Arn.) Holubs	<i>Huperzia</i>	Lycopodiaceae
57.	<i>Huperzia squarrosa</i> (G.Forst.) Trevis.	<i>Huperzia</i>	Lycopodiaceae
58.	<i>Hymenophyllum exsertum</i> Wall. ex Hook.	<i>Hymenophyllum</i>	Hymenophyllaceae
59.	<i>Katoella pulchra</i> (D. Don) Fraser- Jenk.	<i>Katoella</i>	Davalliaceae
60.	<i>Lepisorus contortus</i> (Christ) Ching	<i>Lepisorus</i>	Polypodiaceae
61.	<i>Leptochilus axillaris</i> (Cav.) Kaulf.	<i>Leptochilus</i>	Polypodiaceae
62.	<i>Leptochilus decurrens</i> Bl.	<i>Leptochilus</i>	Polypodiaceae
63.	<i>Leptochilus pteropus</i> subsp. <i>minor</i> (Bedd.) Fraser-Jenk.	<i>Leptochilus</i>	Polypodiaceae
64.	<i>Leptochilus thwaitesianus</i> Fee	<i>Leptochilus</i>	Polypodiaceae
65.	<i>Lindsaea heterophylla</i> Dryand.	<i>Lindsaea</i>	Lindsaeaceae
66.	<i>Lindsaea odorata</i> Roxb.	<i>Lindsaea</i>	Lindsaeaceae
67.	<i>Loxogramme involuta</i> (D.Don) C.Presl	<i>Loxogramme</i>	Polypodiaceae
68.	<i>Loxogramme parallela</i> Copel.	<i>Loxogramme</i>	Polypodiaceae
69.	<i>Lycopodium wightianum</i> Grev. & Hook.	<i>Lycopodium</i>	Lycopodiaceae
70.	<i>Microsorium cuspidatum</i> (D.Don) Tagawa. subsp. <i>beddomei</i> (S.R.Ghosh) Fraser-Jenk.	<i>Microsorium</i>	Polypodiaceae
71.	<i>Microsorium membranaceum</i> (D.Don) Ching	<i>Microsorium</i>	Polypodiaceae
72.	<i>Microsorium membranifolium</i> (R.Br.) Ching	<i>Microsorium</i>	Polypodiaceae
73.	<i>Microsorium punctatum</i> (L.) Copel.	<i>Microsorium</i>	Polypodiaceae
74.	<i>Oleandra musifolia</i> (Bl.) Presl	<i>Oleandra</i>	Oleandraceae
75.	<i>Oreogrammitis attenuata</i> (Kunze) Parris	<i>Oeosporangium</i>	Pteridaceae
76.	<i>Polystichum anomalum</i> (Hook. & Arn.) J.Sm. subsp. <i>travancoricum</i> (Bedd.) Fraser-Jenk.	<i>Polystichum</i>	Dryopteridaceae

77.	<i>Polystichum harpophyllum</i> (Zenker ex Kunze) Sledge	<i>Polystichum</i>	Dryopteridaceae
78.	<i>Polystichum squarosum</i> (D.Don) Fée	<i>Polystichum</i>	Dryopteridaceae
79.	<i>Polystichum subinerme</i> (Kunze) Fraser-Jenk.	<i>Polystichum</i>	Dryopteridaceae
80.	<i>Pteris argyraea</i> T.Moore	<i>Pteris</i>	Pteridaceae
81.	<i>Pteris cretica</i> L. subsp. <i>cretica</i> Fraser-Jenkins et al.	<i>Pteris</i>	Pteridaceae
82.	<i>Pteris mertensioides</i> Willd.	<i>Pteris</i>	Pteridaceae
83.	<i>Pteris pellucens</i> J.Agardh	<i>Pteris</i>	Pteridaceae
84.	<i>Pyrrosia porosa</i> (C.Presl) Hovenkamp	<i>Pyrrosia</i>	Polypodiaceae
85.	<i>Selaginella chrysorrhizos</i> Spring	<i>Selaginella</i>	Selaginellaceae
86.	<i>Selaginella intermedia</i> (Blume) Spring	<i>Selaginella</i>	Selaginellaceae
87.	<i>Selaginella involvens</i> (Sw.) Spring	<i>Selaginella</i>	Selaginellaceae
88.	<i>Selliguea montana</i> (Sledge) Hovenkamp	<i>Selliguea</i>	Polypodiaceae
89.	<i>Stenochlaena palustris</i> (Burm.f.) Beddome	<i>Stenochlaena</i>	Blechnaceae
90.	<i>Tectaria coadunata</i> (J.Sm.) C.Chr.	<i>Tectaria</i>	Tectariaceae
91.	<i>Tectaria paradoxa</i> (Fée) Sledge	<i>Tectaria</i>	Tectariaceae
92.	<i>Thelypteris mollissima</i> (Fisch. ex Kunze) Thapa	<i>Thelypteris</i>	Thelypteridaceae
93.	<i>Thelypteris ornata</i> (J.Sm.) Ching	<i>Thelypteris</i>	Thelypteridaceae
94.	<i>Thelypteris truncata</i> (Poir.) K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae
95.	<i>Trichomanes bilabiatum</i> Nees & Blume	<i>Trichomanes</i>	Hymenophyllaceae
96.	<i>Trichomanes bimarginatum</i> (Bosch.) Bosch	<i>Trichomanes</i>	Hymenophyllaceae
97.	<i>Trichomanes schmidiana</i> Zenker ex Taschner	<i>Trichomanes</i>	Hymenophyllaceae
98.	<i>Vittaria elongata</i> Sw.	<i>Vittaria</i>	Pteridaceae

Annexure 5

Lycophytes and Ferns recorded from Grasslands in the Palghat Gap influenced areas

Sl. No.	Species	Genus	Family
1	<i>Aleuritopteris bicolor</i> (Roxb.) Fraser-Jenk.	<i>Aleuritopteris</i>	Pteridaceae
2	<i>Aleuritopteris bullosa</i> (Kunze) Ching	<i>Aleuritopteris</i>	Pteridaceae
3	<i>Anemia schimperiana</i> C.Presl subsp. <i>wightiana</i> (Gardner) Fraser-Jenk.	<i>Anemia</i>	Anemiaceae
4	<i>Deparia japonica</i> subsp. <i>petersenii</i> (Kunze) Fraser-Jenk.	<i>Deparia</i>	Athyriaceae
5	<i>Dicranopteris linearis</i> (Burm.f.) Underw.	<i>Dicranopteris</i>	Gleicheniaceae
6	<i>Dicranopteris taiwanensis</i> Ching & P.S.Chiu	<i>Dicranopteris</i>	Gleichiniaceae
7	<i>Doryopteris concolor</i> (Langsd. & Fisch.) Kuhn	<i>Doryopteris</i>	Pteridaceae
8	<i>Drynaria quercifolia</i> (L.) J.Sm.	<i>Drynaria</i>	Polypodiaceae
9	<i>Dryopteris cochleata</i> (D.Don) C.Chr.	<i>Dryopteris</i>	Dryopteridaceae
1	<i>Dryopteris juxtaposita</i> Christ	<i>Dryopteris</i>	Dryopteridaceae
1	<i>Lepisorus nudus</i> (Hook.) Ching	<i>Lepisorus</i>	Polypodiaceae
1	<i>Lindsaea ensifolia</i> Sw.	<i>Lindsaea</i>	Lindsaeaceae
1	<i>Lindsaea heterophylla</i> Dryand.	<i>Lindsaea</i>	Lindsaeaceae
1	<i>Lindsaea odorata</i> Roxb.	<i>Lindsaea</i>	Lindsaeaceae
1	<i>Lycopodiella cernua</i> (L.) Pic.Serm.	<i>Lycopodiella</i>	Lycopodiaceae
1	<i>Lycopodium wightianum</i> Grev. & Hook.	<i>Lycopodium</i>	Lycopodiaceae
1	<i>Mickelopteris cordata</i> (Roxb. ex Hook. & Grev.) Fraser-Jenk.	<i>Mickelopteris</i>	Pteridaceae
1	<i>Oeosporangium tenuifolium</i> (Burm.f.) Fraser-Jenk. & Pariyar	<i>Oeosporangium</i>	Pteridaceae
1	<i>Ophioglossum costatum</i> R. Br.	<i>Ophioglossum</i>	Ophioglossaceae
2	<i>Pityrogramma austroamericana</i> Domin	<i>Pityrogramma</i>	Pteridaceae
2	<i>Pityrogramma calomelanos</i> (L.) Link	<i>Pityrogramma</i>	Pteridaceae
2	<i>Pityrogramma chrysophylla</i> (Sw.) Link	<i>Pityrogramma</i>	Pteridaceae
2	<i>Pteridium aquilinum</i> (L.) Kuhn subsp. <i>wightianum</i> (Wall. ex J.Agardh) W.C.Shieh	<i>Pteridium</i>	Dennstaedtiaceae
2	<i>Pteris vittata</i> L.	<i>Pteris</i>	Pteridaceae
2	<i>Pyrrosia lanceolata</i> (L.) Fawcett	<i>Pyrrosia</i>	Polypodiaceae
2	<i>Pyrrosia porosa</i> (C.Presl) Hovenkamp	<i>Pyrrosia</i>	Polypodiaceae

2	<i>Selaginella delicatula</i> (Desv. ex Poir.) Alston	<i>Selaginella</i>	Selaginellaceae
2	<i>Selaginella miniatospora</i> (Daiz.) Baker	<i>Selaginella</i>	Selaginellaceae
2	<i>Selaginella radicata</i> (Hook. & Grev.) Spring	<i>Selaginella</i>	Selaginellaceae
3	<i>Selaginella tenera</i> (Hook. & Grev.) Spring	<i>Selaginella</i>	Selaginellaceae
3	<i>Selaginella wightii</i> Hieron	<i>Selaginella</i>	Selaginellaceae
3	<i>Thelypteris articulata</i> (Houlston & T.Moore) Tagawa & K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae
3	<i>Thelypteris interruptus</i> (Willd.) K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae
3	<i>Thelypteris mollissima</i> (Fisch. ex Kunze) Thapa	<i>Thelypteris</i>	Thelypteridaceae
3	<i>Thelypteris ochthodes</i> (Kunze) Ching	<i>Thelypteris</i>	Thelypteridaceae

Annexure 6

Lycophytes and Ferns recorded from Riparian zones in the Palghat Gap influenced areas

Sl. No.	Species	Genus	Family
1.	<i>Adiantum latifolium</i> Lam.	<i>Adiantum</i>	Pteridaceae
2.	<i>Adiantum philippense</i> L.	<i>Adiantum</i>	Pteridaceae
3.	<i>Angiopteris crassipes</i> Wall. ex C.Presl	<i>Angiopteris</i>	Marattiaceae
4.	<i>Angiopteris helferiana</i> C.Presl	<i>Angiopteris</i>	Marattiaceae
5.	<i>Antrophyum plantagineum</i> Kaulf.	<i>Antrophyum</i>	Pteridaceae
6.	<i>Antrophyum reticulatum</i> (G.Forst.) Kaulf.	<i>Antrophyum</i>	Pteridaceae
7.	<i>Asplenium cheilosorum</i> Kunze ex Mett.	<i>Asplenium</i>	Aspleniaceae
8.	<i>Asplenium formosum</i> Willd.	<i>Asplenium</i>	Aspleniaceae
9.	<i>Asplenium inaequilaterale</i> Bory ex Willd.	<i>Asplenium</i>	Aspleniaceae
10.	<i>Asplenium phyllitidis</i> D.Don	<i>Asplenium</i>	Aspleniaceae
11.	<i>Bolbitis appendiculata</i> (Willd.) K. Iwatz.	<i>Bolbitis</i>	Dryopteridaceae
12.	<i>Bolbitis asplenifolia</i> (Bory) K.Iwats.	<i>Bolbitis</i>	Dryopteridaceae
13.	<i>Ceratopteris thalictroides</i> (L.) Brongn.	<i>Ceratopteris</i>	Pteridaceae
14.	<i>Cyathea crinita</i> (Hook.) Copel.	<i>Cyathea</i>	Cyatheaceae
15.	<i>Cyathea gigantea</i> (Wall. ex Hook.) Holttum	<i>Cyathea</i>	Cyatheaceae
16.	<i>Cyathea nilgirensis</i> Holttum	<i>Cyathea</i>	Cyatheaceae
17.	<i>Cyathea spinulosa</i> Wall. ex Hook.	<i>Cyathea</i>	Cyatheaceae
18.	<i>Deparia japonica</i> subsp. <i>petersenii</i> (Kunze) Fraser-Jenk.	<i>Deparia</i>	Athyriaceae
19.	<i>Diplazium esculentum</i> (Retz.) Sw.	<i>Diplazium</i>	Athyriaceae
20.	<i>Diplazium leptophyllum</i> Christ	<i>Diplazium</i>	Athyriaceae
21.	<i>Diplazium polypodioides</i> Blume	<i>Diplazium</i>	Athyriaceae
22.	<i>Diplazium travancoricum</i> Bedd.	<i>Diplazium</i>	Athyriaceae
23.	<i>Drynaria quercifolia</i> (L.) J.Sm.	<i>Drynaria</i>	Polypodiaceae
24.	<i>Dryopteris atrata</i> (Kunze) Ching	<i>Dryopteris</i>	Dryopteridaceae
25.	<i>Equisetum ramosissimum</i> Desf.	<i>Equisetum</i>	Equisetaceae
26.	<i>Leptochilus pteropus</i> subsp. <i>minor</i> (Bedd.) Fraser-Jenk.	<i>Leptochilus</i>	Polypodiaceae
27.	<i>Leptochilus thwaitesianus</i> Fee	<i>Leptochilus</i>	Polypodiaceae
28.	<i>Lindsaea heterophylla</i> Dryand.	<i>Lindsaea</i>	Lindsaeaceae

29.	<i>Marsilea minuta</i> L.	<i>Marsilea</i>	Marsileaceae
30.	<i>Microlepia nepalensis</i> (Spreng.) Fraser-Jenk.	<i>Microlepia</i>	Dennstaedtiaceae
31.	<i>Microlepia rhomboidea</i> (Hook.) C.Presl ex Prantl	<i>Microlepia</i>	Dennstaedtiaceae
32.	<i>Microlepia speluncae</i> (L.) T.Moore	<i>Microlepia</i>	Dennstaedtiaceae
33.	<i>Microsorium cuspidatum</i> (D.Don) Tagawa. subsp. <i>beddomei</i> (S.R.Ghosh) Fraser-Jenk.	<i>Microsorium</i>	Polypodiaceae
34.	<i>Nephrolepis brownii</i> (Desv.) Hovenkamp & Miyam.	<i>Nephrolepis</i>	Nephrolepidaceae
35.	<i>Ophioglossum costatum</i> R. Br.	<i>Ophioglossum</i>	Ophioglossaceae
36.	<i>Osmunda acuta</i> (Burm.f.) Fraser-Jenk.	<i>Osmunda</i>	Osmundaceae
37.	<i>Pellaea longipilosa</i> Bonap.	<i>Pellaea</i>	Pteridaceae
38.	<i>Pityrogramma calomelanos</i> (L.) Link	<i>Pityrogramma</i>	Pteridaceae
39.	<i>Pyrrosia porosa</i> (C.Presl) Hovenkamp	<i>Pyrrosia</i>	Polypodiaceae
40.	<i>Salvinia</i> × <i>mollesta</i> Mitch.	<i>Salvinia</i>	Salviniaceae
41.	<i>Selaginella chrysoorrhizos</i> Spring	<i>Selaginella</i>	Selaginellaceae
42.	<i>Selaginella delicatula</i> (Desv. ex Poir.) Alston	<i>Selaginella</i>	Selaginellaceae
43.	<i>Selaginella tenera</i> (Hook. & Grev.) Spring	<i>Selaginella</i>	Selaginellaceae
44.	<i>Stenochlaena palustris</i> (Burm.f.) Beddome	<i>Stenochlaena</i>	Blechnaceae
45.	<i>Thelypteris arbusculus</i> (Willd.) K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae
46.	<i>Thelypteris articulata</i> (Houlston & T.Moore) Tagawa & K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae
47.	<i>Thelypteris calcarata</i> (Blume) Ching	<i>Thelypteris</i>	Thelypteridaceae
48.	<i>Thelypteris hispidula</i> (Decne.) C.F.Reed	<i>Thelypteris</i>	Thelypteridaceae
49.	<i>Thelypteris interruptus</i> (Willd.) K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae
50.	<i>Thelypteris mollissima</i> (Fisch. ex Kunze) Thapa	<i>Thelypteris</i>	Thelypteridaceae
51.	<i>Thelypteris ochthodes</i> (Kunze) Ching	<i>Thelypteris</i>	Thelypteridaceae
52.	<i>Thelypteris ornata</i> (J.Sm.) Ching	<i>Thelypteris</i>	Thelypteridaceae
53.	<i>Thelypteris parasitica</i> (L.) Tardieu	<i>Thelypteris</i>	Thelypteridaceae
54.	<i>Thelypteris subtruncatus</i> (Bory) Panigrahi	<i>Thelypteris</i>	Thelypteridaceae
55.	<i>Thelypteris terminans</i> (J.Sm. ex Hook.) Tagawa & K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae

56.	<i>Thelypteris triphylla</i> (Sw.) K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae
57.	<i>Thelypteris</i> × <i>thwaitesii</i> (Hook.) C.F.Reed	<i>Thelypteris</i>	Thelypteridaceae
58.	<i>Trichomanes bilabiatum</i> Nees & Blume	<i>Trichomanes</i>	Hymenophyllaceae
59.	<i>Trichomanes bimarginatum</i> (Bosch.) Bosch	<i>Trichomanes</i>	Hymenophyllaceae
60.	<i>Trichomanes campanulatum</i> Roxb.	<i>Trichomanes</i>	Hymenophyllaceae
61.	<i>Trichomanes exiguum</i> (Bedd.) Baker	<i>Trichomanes</i>	Hymenophyllaceae
62.	<i>Trichomanes intramarginale</i> Hook. & Grev.	<i>Trichomanes</i>	Hymenophyllaceae
63.	<i>Trichomanes minutum</i> Blume	<i>Trichomanes</i>	Hymenophyllaceae
64.	<i>Trichomanes schmidiana</i> Zenker ex Taschner	<i>Trichomanes</i>	Hymenophyllaceae
65.	<i>Vittaria elongata</i> Sw.	<i>Vittaria</i>	Pteridaceae

Annexure 7

Lycophytes and Ferns recorded from Plantations in the Palghat Gap influenced areas

Sl. No.	Species	Genus	Family
1.	<i>Adiantum caudatum</i> L.	<i>Adiantum</i>	Pteridaceae
2.	<i>Adiantum incisum</i> Forssk.	<i>Adiantum</i>	Pteridaceae
3.	<i>Adiantum latifolium</i> Lam.	<i>Adiantum</i>	Pteridaceae
4.	<i>Adiantum philippense</i> L.	<i>Adiantum</i>	Pteridaceae
5.	<i>Adiantum raddianum</i> C.Presl	<i>Adiantum</i>	Pteridaceae
6.	<i>Adiantum zollingeri</i> Mett. ex Kuhn	<i>Adiantum</i>	Pteridaceae
7.	<i>Aleuritopteris bicolor</i> (Roxb.) Fraser-Jenk.	<i>Aleuritopteris</i>	Pteridaceae
8.	<i>Athyrium cumingianum</i> (C.Presl) Ching	<i>Athyrium</i>	Athyriaceae
9.	<i>Athyrium hohenackerianum</i> (Kunze) T.Moore	<i>Athyrium</i>	Athyriaceae
10.	<i>Dicranopteris linearis</i> (Burm.f.) Underw.	<i>Dicranopteris</i>	Gleicheniaceae
11.	<i>Dicranopteris taiwanensis</i> Ching & P.S.Chiu	<i>Dicranopteris</i>	Gleicheniaceae
12.	<i>Doryopteris concolor</i> (Langsd. & Fisch.) Kuhn	<i>Doryopteris</i>	Pteridaceae
13.	<i>Drynaria quercifolia</i> (L.) J.Sm.	<i>Drynaria</i>	Polypodiaceae
14.	<i>Dryopteris cochleata</i> (D.Don) C.Chr.	<i>Dryopteris</i>	Dryopteridaceae
15.	<i>Helminthostachys zeylanica</i> (L.) Hook.	<i>Helminthostachys</i>	Ophioglossaceae
16.	<i>Lepisorus nudus</i> (Hook.) Ching	<i>Lepisorus</i>	Polypodiaceae
17.	<i>Lindsaea heterophylla</i> Dryand.	<i>Lindsaea</i>	Lindsaeaceae
18.	<i>Lygodium flexuosum</i> (L.) Sw.	<i>Lygodium</i>	Lygodiaceae
19.	<i>Mickelopteris cordata</i> (Roxb. ex Hook. & Grev.) Fraser-Jenk.	<i>Mickelopteris</i>	Pteridaceae
20.	<i>Microlepia speluncae</i> (L.) T.Moore	<i>Microlepia</i>	Dennstaedtiaceae
21.	<i>Nephrolepis brownii</i> (Desv.) Hovenkamp & Miyam.	<i>Nephrolepis</i>	Nephrolepidaceae
22.	<i>Nephrolepis hirsutula</i> (Forst.) Presl	<i>Nephrolepis</i>	Nephrolepidaceae
23.	<i>Oeosporangium tenuifolium</i> (Burm.f.) Fraser-Jenk. & Pariyar	<i>Oeosporangium</i>	Pteridaceae
24.	<i>Pityrogramma austroamericana</i> Domin	<i>Pityrogramma</i>	Pteridaceae
25.	<i>Pityrogramma calomelanos</i> (L.) Link	<i>Pityrogramma</i>	Pteridaceae

26.	<i>Pityrogramma chrysophylla</i> (Sw.) Link	<i>Pityrogramma</i>	Pteridaceae
27.	<i>Pteridium aquilinum</i> (L.) Kuhn subsp. <i>wightianum</i> (Wall. ex J.Agardh) W.C.Shieh	<i>Pteridium</i>	Dennstaedtiaceae
28.	<i>Pteris argyraea</i> T.Moore	<i>Pteris</i>	Pteridaceae
29.	<i>Pteris blumeana</i> J.Agardh	<i>Pteris</i>	Pteridaceae
30.	<i>Pteris cretica</i> L. subsp. <i>laeta</i> (Wall. ex Ettingsh.) Fraser-Jenk.	<i>Pteris</i>	Pteridaceae
31.	<i>Pteris ensiformis</i> Burm.f.	<i>Pteris</i>	Pteridaceae
32.	<i>Pteris vittata</i> L.	<i>Pteris</i>	Pteridaceae
33.	<i>Pyrrosia heterophylla</i> (L.) M.G.Price	<i>Pyrrosia</i>	Polypodiaceae
34.	<i>Pyrrosia lanceolata</i> (L.) Farewell	<i>Pyrrosia</i>	Polypodiaceae
35.	<i>Pyrrosia porosa</i> (C.Presl) Hovenkamp	<i>Pyrrosia</i>	Polypodiaceae
36.	<i>Selaginella ciliaris</i> (Retz.) Spring	<i>Selaginella</i>	Selaginellaceae
37.	<i>Selaginella delicatula</i> (Desv. ex Poir.) Alston	<i>Selaginella</i>	Selaginellaceae
38.	<i>Selaginella tenera</i> (Hook. & Grev.) Spring	<i>Selaginella</i>	Selaginellaceae
39.	<i>Thelypteris dentata</i> (Forssk.) E.P.St.John	<i>Thelypteris</i>	Thelypteridaceae
40.	<i>Thelypteris parasitica</i> (L.) Tardieu	<i>Thelypteris</i>	Thelypteridaceae
41.	<i>Vittaria elongata</i> Sw.	<i>Vittaria</i>	Pteridaceae

Annexure 8

Lycophytes and Ferns recorded from Epiphytic habitats in the Palghat Gap influenced areas

Sl. No.	Species	Genus	Family
1.	<i>Antrophyum plantagineum</i> Kaulf.	<i>Antrophyum</i>	Pteridaceae
2.	<i>Antrophyum reticulatum</i> (G.Forst.) Kaulf.	<i>Antrophyum</i>	Pteridaceae
3.	<i>Asplenium aethiopicum</i> (Burm.f.) Bech.	<i>Asplenium</i>	Aspleniaceae
4.	<i>Asplenium andreisii</i> Fraser-Jenk.	<i>Asplenium</i>	Aspleniaceae
5.	<i>Asplenium crinicaule</i> Hance	<i>Asplenium</i>	Aspleniaceae
6.	<i>Asplenium decrescens</i> Kunze	<i>Asplenium</i>	Aspleniaceae
7.	<i>Asplenium excisum</i> C.Presl	<i>Asplenium</i>	Aspleniaceae
8.	<i>Asplenium falcatum</i> Lam.	<i>Asplenium</i>	Aspleniaceae
9.	<i>Asplenium formosum</i> Willd.	<i>Asplenium</i>	Aspleniaceae
10.	<i>Asplenium phyllitidis</i> D.Don	<i>Asplenium</i>	Aspleniaceae
11.	<i>Asplenium serricula</i> Fée	<i>Asplenium</i>	Aspleniaceae
12.	<i>Davallia trichomanoides</i> Blume	<i>Davallia</i>	Davalliaceae
13.	<i>Drynaria quercifolia</i> (L.) J.Sm.	<i>Drynaria</i>	Polypodiaceae
14.	<i>Elaphoglossum beddomei</i> Sledge	<i>Elaphoglossum</i>	Dryopteridaceae
15.	<i>Elaphoglossum nilgiricum</i> Krajina ex Sledge	<i>Elaphoglossum</i>	Dryopteridaceae
16.	<i>Huperzia hamiltonii</i> (Spreng.) Trevis.	<i>Huperzia</i>	Lycopodiaceae
17.	<i>Huperzia phlegmaria</i> (L.) Rothm.	<i>Huperzia</i>	Lycopodiaceae
18.	<i>Huperzia phyllantha</i> (Hook. & Arn.) Holub	<i>Huperzia</i>	Lycopodiaceae
19.	<i>Huperzia squarrosa</i> (G.Forst.) Trevis.	<i>Huperzia</i>	Lycopodiaceae
20.	<i>Hymenophyllum exsertum</i> Wall. ex Hook.	<i>Hymenophyllum</i>	Hymenophyllaceae
21.	<i>Katoella pulchra</i> (D. Don) Fraser-Jenk.	<i>Katoella</i>	Davalliaceae
22.	<i>Lepisorus contortus</i> (Christ) Ching	<i>Lepisorus</i>	Polypodiaceae
23.	<i>Lepisorus nudus</i> (Hook.) Ching	<i>Lepisorus</i>	Polypodiaceae
24.	<i>Leptochilus axillaris</i> (Cav.) Kaulf.	<i>Leptochilus</i>	Polypodiaceae
25.	<i>Leptochilus decurrens</i> Bl.	<i>Leptochilus</i>	Polypodiaceae
26.	<i>Loxogramme involuta</i> (D.Don) C.Presl	<i>Loxogramme</i>	Polypodiaceae

27.	<i>Loxogramme parallela</i> Copel.	<i>Loxogramme</i>	Polypodiaceae
28.	<i>Microsorium cuspidatum</i> (D.Don) Tagawa. subsp. <i>beddomei</i> (S.R.Ghosh) Fraser-Jenk.	<i>Microsorium</i>	Polypodiaceae
29.	<i>Microsorium membranaceum</i> (D.Don) Ching	<i>Microsorium</i>	Polypodiaceae
30.	<i>Microsorium membranifolium</i> (R.Br.) Ching	<i>Microsorium</i>	Polypodiaceae
31.	<i>Microsorium punctatum</i> (L.) Copel.	<i>Microsorium</i>	Polypodiaceae
32.	<i>Nephrolepis cordifolia</i> (L.) C.Presl	<i>Nephrolepis</i>	Nephrolepidaceae
33.	<i>Oleandra musifolia</i> (Bl.) Presl	<i>Oleandra</i>	Oleandraceae
34.	<i>Pyrrosia heterophylla</i> (L.) M.G.Price	<i>Pyrrosia</i>	Polypodiaceae
35.	<i>Pyrrosia lanceolata</i> (L.) Farewell	<i>Pyrrosia</i>	Polypodiaceae
36.	<i>Pyrrosia porosa</i> (C.Presl) Hovenkamp	<i>Pyrrosia</i>	Polypodiaceae
37.	<i>Selliguea montana</i> (Sledge) Hovenkamp	<i>Selliguea</i>	Polypodiaceae
38.	<i>Trichomanes bilabiatum</i> Nees & Blume	<i>Trichomanes</i>	Hymenophyllaceae
39.	<i>Vittaria elongata</i> Sw.	<i>Vittaria</i>	Pteridaceae

Annexure 9

Lycophytes and Ferns recorded from Terrestrial habitat in the Palghat Gap influenced areas

Sl. No.	Species	Genus	Family
1.	<i>Actiniopteris radiata</i> (J. Koenig ex Sw.) Link	<i>Actiniopteris</i>	Pteridaceae
2.	<i>Adiantum hispidulum</i> Sw.	<i>Adiantum</i>	Pteridaceae
3.	<i>Adiantum incisum</i> Forssk.	<i>Adiantum</i>	Pteridaceae
4.	<i>Adiantum latifolium</i> Lam.	<i>Adiantum</i>	Pteridaceae
5.	<i>Adiantum philippense</i> L.	<i>Adiantum</i>	Pteridaceae
6.	<i>Adiantum raddianum</i> C.Presl	<i>Adiantum</i>	Pteridaceae
7.	<i>Adiantum zollingeri</i> Mett. ex Kuhn	<i>Adiantum</i>	Pteridaceae
8.	<i>Aleuritopteris bullosa</i> (Kunze) Ching	<i>Aleuritopteris</i>	Pteridaceae
9.	<i>Angiopteris crassipes</i> Wall. ex C.Presl	<i>Angiopteris</i>	Marattiaceae
10.	<i>Angiopteris helferiana</i> C.Presl	<i>Angiopteris</i>	Marattiaceae
11.	<i>Arachniodes palmipes</i> (Kunze) Fraser-Jenk.	<i>Arachniodes</i>	Dryopteridaceae
12.	<i>Arachniodes sledgei</i> Fraser-Jenk.	<i>Arachniodes</i>	Dryopteridaceae
13.	<i>Asplenium aethiopicum</i> (Burm.f.) Bech.	<i>Asplenium</i>	Aspleniaceae
14.	<i>Asplenium cheilosorum</i> Kunze ex Mett.	<i>Asplenium</i>	Aspleniaceae
15.	<i>Asplenium crinicaule</i> Hance	<i>Asplenium</i>	Aspleniaceae
16.	<i>Asplenium emarginatodentatum</i> Zenker ex Kunze	<i>Asplenium</i>	Aspleniaceae
17.	<i>Asplenium excisum</i> C.Presl	<i>Asplenium</i>	Aspleniaceae
18.	<i>Asplenium formosum</i> Willd.	<i>Asplenium</i>	Aspleniaceae
19.	<i>Asplenium hondoense</i> N.Murak. & Hatan.	<i>Asplenium</i>	Aspleniaceae
20.	<i>Asplenium inaequilaterale</i> Bory ex Willd.	<i>Asplenium</i>	Aspleniaceae
21.	<i>Asplenium lancinatum</i> D. Don subsp. <i>fraser-jenkinsii</i> Reichst. ex Pangtey & Khullar	<i>Asplenium</i>	Aspleniaceae
22.	<i>Asplenium mysorensense</i> Roth	<i>Asplenium</i>	Aspleniaceae
23.	<i>Asplenium nitidum</i> Sw.	<i>Asplenium</i>	Aspleniaceae
24.	<i>Asplenium normale</i> D.Don	<i>Asplenium</i>	Aspleniaceae
25.	<i>Asplenium obscurum</i> Blume	<i>Asplenium</i>	Aspleniaceae
26.	<i>Asplenium tenuifolium</i> D. Don.	<i>Asplenium</i>	Aspleniaceae

27.	<i>Asplenium zenkerianum</i> Kunze	<i>Asplenium</i>	Aspleniaceae
28.	<i>Athyrium cumingianum</i> (C.Presl) Ching	<i>Athyrium</i>	Athyriaceae
29.	<i>Athyrium hohenackerianum</i> (Kunze) T. Moore	<i>Athyrium</i>	Athyriaceae
30.	<i>Athyrium solenopteris</i> (Kunze) T.Moore	<i>Athyrium</i>	Athyriaceae
31.	<i>Blechnum melanocaulon</i> (Brack.) T.C. Chambers & P.A. Farrant subsp. <i>pallens</i> T.C.Chambers & P.A.Farrant	<i>Blechnum</i>	Blechnaceae
32.	<i>Blechnum occidentale</i> L.	<i>Blechnum</i>	Blechnaceae
33.	<i>Blechnum orientale</i> L.	<i>Blechnum</i>	Blechnaceae
34.	<i>Bolbitis angustipinna</i> (Hayata) Ito	<i>Bolbitis</i>	Dryopteridaceae
35.	<i>Bolbitis appendiculata</i> (Willd.) K. Iwatz.	<i>Bolbitis</i>	Dryopteridaceae
36.	<i>Bolbitis asplenifolia</i> (Bory) K.Iwats.	<i>Bolbitis</i>	Dryopteridaceae
37.	<i>Bolbitis beddomei</i> Fraser-Jenk. & Gandhi	<i>Bolbitis</i>	Dryopteridaceae
38.	<i>Bolbitis semicordata</i> (Baker) Ching	<i>Bolbitis</i>	Dryopteridaceae
39.	<i>Botrychium daucifolium</i> Wall. ex Hook. & Grev.	<i>Botrychium</i>	Ophioglossaceae
40.	<i>Botrychium lanuginosum</i> Wall. ex Hook. & Grev.	<i>Botrychium</i>	Ophioglossaceae
41.	<i>Ceratopteris thalictroides</i> (L.) Brongn.	<i>Ceratopteris</i>	Pteridaceae
42.	<i>Cyathea crinita</i> (Hook.) Copel.	<i>Cyathea</i>	Cyatheaceae
43.	<i>Cyathea gigantea</i> (Wall. ex Hook.) Holttum	<i>Cyathea</i>	Cyatheaceae
44.	<i>Cyathea nilgirensis</i> Holttum	<i>Cyathea</i>	Cyatheaceae
45.	<i>Cyathea spinulosa</i> Wall. ex Hook.	<i>Cyathea</i>	Cyatheaceae
46.	<i>Cyrtomium caryotideum</i> (Wall. ex Hook. & Grev.) C.Presl	<i>Cyrtomium</i>	Dryopteridaceae
47.	<i>Cyrtomium micropterum</i> (Kunze) Ching	<i>Cyrtomium</i>	Dryopteridaceae
48.	<i>Deparia japonica</i> subsp. <i>petersenii</i> (Kunze) Fraser-Jenk.	<i>Deparia</i>	Athyriaceae
49.	<i>Dicranopteris taiwanensis</i> Ching & P.S.Chiu	<i>Dicranopteris</i>	Gleicheniaceae
50.	<i>Diplazium manickamii</i> Fraser-Jenk. & Kholia	<i>Diplazium</i>	Athyriaceae
51.	<i>Dryopsis scabrosa</i> (Kunze) Holttum & P.J.Edwards	<i>Dryopsis</i>	Dryopteridaceae

52.	<i>Dryopteris atrata</i> (Kunze) Ching	<i>Dryopteris</i>	Dryopteridaceae
53.	<i>Dryopteris juxtaposita</i> Christ	<i>Dryopteris</i>	Dryopteridaceae
54.	<i>Dryopteris odontoloma</i> (T.Moore ex Bedd.) C.Chr.	<i>Dryopteris</i>	Dryopteridaceae
55.	<i>Helminthostachys zeylanica</i> (L.) Hook.	<i>Helminthostachys</i>	Ophioglossaceae
56.	<i>Hypolepis polypodioides</i> (Blume) Hook.	<i>Hypolepis</i>	Dennstaedtiaceae
57.	<i>Isoetes coromandalina</i> L.f.	<i>Isoetes</i>	Isoetaceae
58.	<i>Lindsaea ensifolia</i> Sw.	<i>Lindsaea</i>	Lindsaeaceae
59.	<i>Lindsaea heterophylla</i> Dryand.	<i>Lindsaea</i>	Lindsaeaceae
60.	<i>Lindsaea odorata</i> Roxb.	<i>Lindsaea</i>	Lindsaeaceae
61.	<i>Lycopodiella cernua</i> (L.) Pic.Serm.	<i>Lycopodiella</i>	Lycopodiaceae
62.	<i>Lycopodium wightianum</i> Grev. & Hook.	<i>Lycopodium</i>	Lycopodiaceae
63.	<i>Lygodium flexuosum</i> (L.) Sw.	<i>Lygodium</i>	Lygodiaceae
64.	<i>Marattia fraxinea</i> Sm.	<i>Marattia</i>	Marattiaceae
65.	<i>Marsilea minuta</i> L.	<i>Marsilea</i>	Marsileaceae
66.	<i>Mickelopteris cordata</i> (Roxb. ex Hook. & Grev.) Fraser-Jenk.	<i>Mickelopteris</i>	Pteridaceae
67.	<i>Microlepia nepalensis</i> (Spreng.) Fraser-Jenk.	<i>Microlepia</i>	Dennstaedtiaceae
68.	<i>Microlepia rhomboidea</i> (Hook.) C.Presl ex Prantl	<i>Microlepia</i>	Dennstaedtiaceae
69.	<i>Microlepia speluncae</i> (L.) T.Moore	<i>Microlepia</i>	Dennstaedtiaceae
70.	<i>Nephrolepis brownii</i> (Desv.) Hovenkamp & Miyam.	<i>Nephrolepis</i>	Nephrolepidaceae
71.	<i>Nephrolepis cordifolia</i> (L.) C.Presl	<i>Nephrolepis</i>	Nephrolepidaceae
72.	<i>Nephrolepis hirsutula</i> (Forst.) Presl	<i>Nephrolepis</i>	Nephrolepidaceae
73.	<i>Nephrolepis undulata</i> (Afzel. ex Sw.) J.Sm.	<i>Nephrolepis</i>	Nephrolepidaceae
74.	<i>Odontosoria chinensis</i> (L.) J.Sm.	<i>Odontosoria</i>	Lindsaeaceae
75.	<i>Oeosporangium elegans</i> (Poir.) Fraser-Jenk. & Pariyar	<i>Oeosporangium</i>	Pteridaceae
76.	<i>Oeosporangium tenuifolium</i> (Burm.f.) Fraser-Jenk. & Pariyar	<i>Oeosporangium</i>	Pteridaceae
77.	<i>Ophioglossum costatum</i> R. Br.	<i>Ophioglossum</i>	Ophioglossaceae
78.	<i>Pellaea boivinii</i> Hook.	<i>Pellaea</i>	Pteridaceae
79.	<i>Pellaea longipilosa</i> Bonap.	<i>Pellaea</i>	Pteridaceae
80.	<i>Pityrogramma austroamericana</i> Domin	<i>Pityrogramma</i>	Pteridaceae

81.	<i>Pityrogramma calomelanos</i> (L.) Link	<i>Pityrogramma</i>	Pteridaceae
82.	<i>Polystichum anomalum</i> (Hook. & Arn.) J.Sm. subsp. <i>travancoricum</i> (Bedd.) Fraser-Jenk.	<i>Polystichum</i>	Dryopteridaceae
83.	<i>Polystichum harpophyllum</i> (Zenker ex Kunze) Sledge	<i>Polystichum</i>	Dryopteridaceae
84.	<i>Polystichum squarosum</i> (D.Don) Fée	<i>Polystichum</i>	Dryopteridaceae
85.	<i>Polystichum subinerme</i> (Kunze) Fraser-Jenk.	<i>Polystichum</i>	Dryopteridaceae
86.	<i>Pteridium aquilinum</i> (L.) Kuhn subsp. <i>wightianum</i> (Wall. ex J.Agardh) W.C.Shieh	<i>Pteridium</i>	Dennstaedtiaceae
87.	<i>Pteris argyraea</i> T.Moore	<i>Pteris</i>	Pteridaceae
88.	<i>Pteris biaurita</i> L.	<i>Pteris</i>	Pteridaceae
89.	<i>Pteris blumeana</i> J.Agardh	<i>Pteris</i>	Pteridaceae
90.	<i>Pteris cretica</i> L. subsp. <i>cretica</i>	<i>Pteris</i>	Pteridaceae
91.	<i>Pteris cretica</i> L. Subsp. <i>laeta</i> (Wall. ex Ettingsh.) Fraser-Jenk.	<i>Pteris</i>	Pteridaceae
92.	<i>Pteris ensiformis</i> Burm.f.	<i>Pteris</i>	Pteridaceae
93.	<i>Pteris mertensioides</i> Willd.	<i>Pteris</i>	Pteridaceae
94.	<i>Pteris multiaurita</i> J.Agardh.	<i>Pteris</i>	Pteridaceae
95.	<i>Pteris pellucens</i> J.Agardh	<i>Pteris</i>	Pteridaceae
96.	<i>Pteris scabripes</i> Wall. ex J.Agardh.	<i>Pteris</i>	Pteridaceae
97.	<i>Pteris vittata</i> L.	<i>Pteris</i>	Pteridaceae
98.	<i>Selaginella chrysorrhizos</i> Spring	<i>Selaginella</i>	Selaginellaceae
99.	<i>Selaginella ciliaris</i> (Retz.) Spring	<i>Selaginella</i>	Selaginellaceae
100.	<i>Selaginella crassipes</i> Spring	<i>Selaginella</i>	Selaginellaceae
101.	<i>Selaginella delicatula</i> (Desv. ex Poir.) Alston	<i>Selaginella</i>	Selaginellaceae
102.	<i>Selaginella intermedia</i> (Blume) Spring	<i>Selaginella</i>	Selaginellaceae
103.	<i>Selaginella miniatospora</i> (Daiz.) Baker	<i>Selaginella</i>	Selaginellaceae
104.	<i>Selaginella radicata</i> (Hook. & Grev.) Spring	<i>Selaginella</i>	Selaginellaceae
105.	<i>Selaginella tenera</i> (Hook. & Grev.) Spring	<i>Selaginella</i>	Selaginellaceae
106.	<i>Stenochlaena palustris</i> (Burm.f.) Bedd.	<i>Stenochlaena</i>	Blechnaceae
107.	<i>Tectaria coadunata</i> (J.Sm.) C.Chr.	<i>Tectaria</i>	Tectariaceae
108.	<i>Tectaria paradoxa</i> (Fée) Sledge	<i>Tectaria</i>	Tectariaceae
109.	<i>Tectaria wightii</i> (C.B.Clarke) Ching	<i>Tectaria</i>	Tectariaceae

110.	<i>Thelypteris arbusculus</i> (Willd.) K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae
111.	<i>Thelypteris articulata</i> (Houlston & T.Moore) Tagawa & K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae
112.	<i>Thelypteris dentata</i> (Forssk.) E.P.St.John	<i>Thelypteris</i>	Thelypteridaceae
113.	<i>Thelypteris flaccida</i> (Blume) Ching	<i>Thelypteris</i>	Thelypteridaceae
114.	<i>Thelypteris hispidula</i> (Decne.) C.F.Reed	<i>Thelypteris</i>	Thelypteridaceae
115.	<i>Thelypteris interruptus</i> (Willd.) K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae
116.	<i>Thelypteris ochthodes</i> (Kunze) Ching	<i>Thelypteris</i>	Thelypteridaceae
117.	<i>Thelypteris ornata</i> (J.Sm.) Ching	<i>Thelypteris</i>	Thelypteridaceae
118.	<i>Thelypteris parasitica</i> (L.) Tardieu	<i>Thelypteris</i>	Thelypteridaceae
119.	<i>Thelypteris subtruncatus</i> (Bory) Panigrahi	<i>Thelypteris</i>	Thelypteridaceae
120.	<i>Thelypteris terminans</i> (J.Sm. ex Hook.) Tagawa & K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae
121.	<i>Thelypteris torresiana</i> (Gaudich.) Alston	<i>Thelypteris</i>	Thelypteridaceae
122.	<i>Thelypteris triphylla</i> (Sw.) K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae
123.	<i>Thelypteris truncata</i> (Poir.) K.Iwats.	<i>Thelypteris</i>	Thelypteridaceae
124.	<i>Thelypteris</i> × <i>thwaitesii</i> (Hook.) C.F.Reed	<i>Thelypteris</i>	Thelypteridaceae

Annexure 10

Lycophytes and Ferns recorded from Lithophytic habitat in the Palghat Gap influenced areas

Sl. No.	Species	Genus	Family
1.	<i>Adiantum caudatum</i> L.	<i>Adiantum</i>	Pteridaceae
2.	<i>Adiantum incisum</i> Forssk.	<i>Adiantum</i>	Pteridaceae
3.	<i>Adiantum zollingeri</i> Mett. ex Kuhn	<i>Adiantum</i>	Pteridaceae
4.	<i>Anemia schimperiana</i> C.Presl subsp. <i>wightiana</i> (Gardner) Fraser-Jenk.	<i>Anemia</i>	Anemiaceae
5.	<i>Asplenium aethiopicum</i> (Burm.f.) Bech.	<i>Asplenium</i>	Aspleniaceae
6.	<i>Asplenium cheilosorum</i> Kunze ex Mett.	<i>Asplenium</i>	Aspleniaceae
7.	<i>Asplenium crinicaule</i> Hance	<i>Asplenium</i>	Aspleniaceae
8.	<i>Asplenium decrescens</i> Kunze	<i>Asplenium</i>	Aspleniaceae
9.	<i>Asplenium excisum</i> C.Presl	<i>Asplenium</i>	Aspleniaceae
10.	<i>Asplenium formosum</i> Willd.	<i>Asplenium</i>	Aspleniaceae
11.	<i>Asplenium inaequilaterale</i> Bory ex Willd.	<i>Asplenium</i>	Aspleniaceae
12.	<i>Asplenium lanciniatum</i> D.Don subsp. <i>fraser-jenkinsii</i> Reichst. ex Pangtey & Khullar	<i>Asplenium</i>	Aspleniaceae
13.	<i>Asplenium mysorensense</i> Roth	<i>Asplenium</i>	Aspleniaceae
14.	<i>Asplenium nitidum</i> Sw.	<i>Asplenium</i>	Aspleniaceae
15.	<i>Asplenium normale</i> D.Don	<i>Asplenium</i>	Aspleniaceae
16.	<i>Asplenium obscurum</i> Blume	<i>Asplenium</i>	Aspleniaceae
17.	<i>Asplenium zenkerianum</i> Kunze	<i>Asplenium</i>	Aspleniaceae
18.	<i>Bolbitis appendiculata</i> (Willd.) K. Iwatz.	<i>Bolbitis</i>	Dryopteridaceae
19.	<i>Bolbitis asplenifolia</i> (Bory) K.Iwats.	<i>Bolbitis</i>	Dryopteridaceae
20.	<i>Elaphoglossum beddomei</i> Sledge	<i>Elaphoglossum</i>	Dryopteridaceae
21.	<i>Huperzia hamiltonii</i> (Spreng.) Trevis.	<i>Huperzia</i>	Lycopodiaceae
22.	<i>Hymenophyllum exsertum</i> Wall. ex Hook.	<i>Hymenophyllum</i>	Hymenophyllaceae
23.	<i>Katoella pulchra</i> (D. Don) Fraser-Jenk.	<i>Katoella</i>	Davalliaceae
24.	<i>Lepisorus contortus</i> (Christ) Ching	<i>Lepisorus</i>	Polypodiaceae
25.	<i>Lepisorus nudus</i> (Hook.) Ching	<i>Lepisorus</i>	Polypodiaceae

26.	<i>Leptochilus axillaris</i> (Cav.) Kaulf.	<i>Leptochilus</i>	Polypodiaceae
27.	<i>Leptochilus decurrens</i> Bl.	<i>Leptochilus</i>	Polypodiaceae
28.	<i>Leptochilus pteropus</i> subsp. <i>minor</i> (Bedd.) Fraser-Jenk.	<i>Leptochilus</i>	Polypodiaceae
29.	<i>Leptochilus thwaitesianus</i> Fee	<i>Leptochilus</i>	Polypodiaceae
30.	<i>Microsorium membranaceum</i> (D.Don) Ching	<i>Microsorium</i>	Polypodiaceae
31.	<i>Microsorium punctatum</i> (L.) Copel.	<i>Microsorium</i>	Polypodiaceae
32.	<i>Nephrolepis cordifolia</i> (L.) C.Presl	<i>Nephrolepis</i>	Nephrolepidaceae
33.	<i>Oleandra musifolia</i> (Bl.) Presl	<i>Oleandra</i>	Oleandraceae
34.	<i>Oreogrammitis attenuata</i> (Kunze) Parris	<i>Oreogrammitis</i>	Polypodiaceae
35.	<i>Pityrogramma chrysophylla</i> (Sw.) Link	<i>Pityrogramma</i>	Pteridaceae
36.	<i>Pteris vittata</i> L.	<i>Pteris</i>	Pteridaceae
37.	<i>Pyrrosia lanceolata</i> (L.) Farewell	<i>Pyrrosia</i>	Polypodiaceae
38.	<i>Pyrrosia porosa</i> (C.Presl) Hovenkamp	<i>Pyrrosia</i>	Polypodiaceae
39.	<i>Selaginella involvens</i> (Sw.) Spring	<i>Selaginella</i>	Selaginellaceae
40.	<i>Selaginella miniatospora</i> (Daiz.) Baker	<i>Selaginella</i>	Selaginellaceae
41.	<i>Selaginella radicata</i> (Hook. & Grev.) Spring	<i>Selaginella</i>	Selaginellaceae
42.	<i>Selaginella wightii</i> Hieron	<i>Selaginella</i>	Selaginellaceae
43.	<i>Selliguea montana</i> (Sledge) Hovenkamp	<i>Selliguea</i>	Polypodiaceae
44.	<i>Thelypteris calcarata</i> (Blume) Ching	<i>Thelypteris</i>	Thelypteridaceae
45.	<i>Thelypteris mollissima</i> (Fisch. ex Kunze) Thapa	<i>Thelypteris</i>	Thelypteridaceae
46.	<i>Trichomanes bilabiatum</i> Nees & Blume	<i>Trichomanes</i>	Hymenophyllaceae
47.	<i>Trichomanes bimarginatum</i> (Bosch.) Bosch	<i>Trichomanes</i>	Hymenophyllaceae
48.	<i>Trichomanes campanulatum</i> Roxb.	<i>Trichomanes</i>	Hymenophyllaceae
49.	<i>Trichomanes exiguum</i> (Bedd.) Baker	<i>Trichomanes</i>	Hymenophyllaceae
50.	<i>Trichomanes intramarginale</i> Hook. & Grev.	<i>Trichomanes</i>	Hymenophyllaceae
51.	<i>Trichomanes minutum</i> Blume	<i>Trichomanes</i>	Hymenophyllaceae
52.	<i>Trichomanes schmidiana</i> Zenker ex Taschner	<i>Trichomanes</i>	Hymenophyllaceae

Annexure 11
Lycophytes and Ferns recorded from Mud cliffs in the Palghat Gap influenced areas

Sl. No.	Species	Genus	Family
1.	<i>Actiniopteris radiata</i> (J.Koenig ex Sw.) Link	<i>Actiniopteris</i>	Pteridaceae
2.	<i>Adiantum caudatum</i> L.	<i>Adiantum</i>	Pteridaceae
3.	<i>Adiantum hispidulum</i> Sw.	<i>Adiantum</i>	Pteridaceae
4.	<i>Adiantum incisum</i> Forssk.	<i>Adiantum</i>	Pteridaceae
5.	<i>Adiantum latifolium</i> Lam.	<i>Adiantum</i>	Pteridaceae
6.	<i>Adiantum philippense</i> L.	<i>Adiantum</i>	Pteridaceae
7.	<i>Adiantum raddianum</i> C.Presl	<i>Adiantum</i>	Pteridaceae
8.	<i>Adiantum zollingeri</i> Mett. ex Kuhn	<i>Asplenium</i>	Aspleniaceae
9.	<i>Aleuritopteris bicolor</i> (Roxb.) Fraser-Jenk.	<i>Aleuritopteris</i>	Pteridaceae
10.	<i>Aleuritopteris bullosa</i> (Kunze) Ching	<i>Aleuritopteris</i>	Pteridaceae
11.	<i>Angiopteris crassipes</i> Wall. ex C.Presl	<i>Angiopteris</i>	Marattiaceae
12.	<i>Angiopteris helferiana</i> C.Presl	<i>Angiopteris</i>	Marattiaceae
13.	<i>Arachniodes palmipes</i> (Kunze) Fraser-Jenk.	<i>Arachniodes</i>	Dryopteridaceae
14.	<i>Arachniodes sledgei</i> Fraser-Jenk.	<i>Arachniodes</i>	Dryopteridaceae
15.	<i>Asplenium aethiopicum</i> (Burm.f.) Bech.	<i>Asplenium</i>	Aspleniaceae
16.	<i>Asplenium cheilosorum</i> Kunze ex Mett.	<i>Asplenium</i>	Aspleniaceae
17.	<i>Asplenium emarginatodentatum</i> Zenker ex Kunze	<i>Asplenium</i>	Aspleniaceae
18.	<i>Asplenium excisum</i> C.Presl	<i>Asplenium</i>	Aspleniaceae
19.	<i>Asplenium formosum</i> Willd.	<i>Asplenium</i>	Aspleniaceae
20.	<i>Asplenium hondoense</i> N.Murak. & Hatan.	<i>Asplenium</i>	Aspleniaceae
21.	<i>Asplenium inaequilaterale</i> Bory ex Willd.	<i>Asplenium</i>	Aspleniaceae
22.	<i>Asplenium lancinatum</i> D.Don. subsp. <i>fraser-jenkinsii</i> Reichst. ex Pangtey & Khullar	<i>Asplenium</i>	Aspleniaceae

23.	<i>Asplenium nitidum</i> Sw.	<i>Asplenium</i>	Aspleniaceae
24.	<i>Asplenium normale</i> D.Don	<i>Asplenium</i>	Aspleniaceae
25.	<i>Athyrium cumingianum</i> (C.Presl) Ching	<i>Athyrium</i>	Athyriaceae
26.	<i>Athyrium hohenackerianum</i> (Kunze) T.Moore	<i>Athyrium</i>	Athyriaceae
27.	<i>Athyrium solenopteris</i> (Kunze) T.Moore	<i>Athyrium</i>	Athyriaceae
28.	<i>Blechnum melanocaulon</i> (Brack.) T.C. Chambers & P.A. Farrant subsp. <i>pallens</i> T.C.Chambers & P.A.Farrant	<i>Blechnum</i>	Blechnaceae
29.	<i>Blechnum occidentale</i> L.	<i>Blechnum</i>	Blechnaceae
30.	<i>Blechnum orientale</i> L.	<i>Blechnum</i>	Blechnaceae
31.	<i>Bolbitis angustipinna</i> (Hayata) Ito	<i>Bolbitis</i>	Dryopteridaceae
32.	<i>Bolbitis semicordata</i> (Baker) Ching	<i>Bolbitis</i>	Dryopteridaceae
33.	<i>Cyathea crinita</i> (Hook.) Copel.	<i>Cyathea</i>	Cyatheaceae
34.	<i>Cyathea gigantea</i> (Wall. ex Hook.) Holttum	<i>Cyathea</i>	Cyatheaceae
35.	<i>Cyathea nilgirensis</i> Holttum	<i>Cyathea</i>	Cyatheaceae
36.	<i>Cyrtomium micropterum</i> (Kunze) Ching	<i>Cyrtomium</i>	Dryopteridaceae
37.	<i>Deparia japonica</i> subsp. <i>petersenii</i> (Kunze) Fraser-Jenk.	<i>Deparia</i>	Athyriaceae
38.	<i>Dicranopteris linearis</i> (Burm.f.) Underw.	<i>Dicranopteris</i>	Gleicheniaceae
39.	<i>Dicranopteris taiwanensis</i> Ching & P.S.Chiu	<i>Dicranopteris</i>	Gleicheniaceae
40.	<i>Diplazium esculentum</i> (Retz.) Sw.	<i>Diplazium</i>	Athyriaceae
41.	<i>Diplazium latifolium</i> T.Moore	<i>Diplazium</i>	Athyriaceae
42.	<i>Diplazium leptophyllum</i> Christ	<i>Diplazium</i>	Athyriaceae
43.	<i>Diplazium manickamii</i> Fraser-Jenk. & Kholia	<i>Diplazium</i>	Athyriaceae
44.	<i>Diplazium polypodioides</i> Blume	<i>Diplazium</i>	Athyriaceae
45.	<i>Diplazium sylvaticum</i> (Bory) Sw.	<i>Diplazium</i>	Athyriaceae
46.	<i>Diplazium travancoricum</i> Bedd.	<i>Diplazium</i>	Athyriaceae
47.	<i>Doryopteris concolor</i> (Langsd. & Fisch.) Kuhn	<i>Doryopteris</i>	Pteridaceae

48.	<i>Dryopsis scabrosa</i> (Kunze) Holtum & P.J.Edwards	<i>Dryopsis</i>	Dryopteridaceae
49.	<i>Dryopteris atrata</i> (Kunze) Ching	<i>Dryopteris</i>	Dryopteridaceae
50.	<i>Dryopteris cochleata</i> (D.Don) C.Chr.	<i>Dryopteris</i>	Dryopteridaceae
51.	<i>Dryopteris hirtipes</i> (Blume) Kuntze	<i>Dryopteris</i>	Dryopteridaceae
52.	<i>Dryopteris juxtaposita</i> Christ	<i>Dryopteris</i>	Dryopteridaceae
53.	<i>Lindsaea ensifolia</i> Sw.	<i>Lindsaea</i>	Lindsaeaceae
54.	<i>Lindsaea odorata</i> Roxb.	<i>Lindsaea</i>	Lindsaeaceae
55.	<i>Lycopodiella cernua</i> (L.) Pic.Serm.	<i>Lycopodiella</i>	Lycopodiaceae
56.	<i>Lycopodium wightianum</i> Grev. & Hook.	<i>Lycopodium</i>	Lycopodiaceae
57.	<i>Lygodium flexuosum</i> (L.) Sw.	<i>Lygodium</i>	Lygodiaceae
58.	<i>Marattia fraxinea</i> Sm.	<i>Marattia</i>	Marattiaceae
59.	<i>Mickelopteris cordata</i> (Roxb. ex Hook. & Grev.) Fraser-Jenk.	<i>Mickelopteris</i>	Pteridaceae
60.	<i>Microlepia speluncae</i> (L.) T.Moore	<i>Microlepia</i>	Dennstaedtiaceae
61.	<i>Nephrolepis brownii</i> (Desv.) Hovenkamp & Miyam.	<i>Nephrolepis</i>	Nephrolepidaceae
62.	<i>Nephrolepis hirsutula</i> (Forst.) Presl	<i>Nephrolepis</i>	Nephrolepidaceae
63.	<i>Odontosoria chinensis</i> (L.) J.Sm.	<i>Odontosoria</i>	Lindsaeaceae
64.	<i>Oeosporangium elegans</i> (Poir.) Fraser-Jenk. & Pariyar	<i>Oeosporangium</i>	Pteridaceae
65.	<i>Oeosporangium tenuifolium</i> (Burm.f.) Fraser-Jenk. & Pariyar	<i>Oeosporangium</i>	Pteridaceae
66.	<i>Pityrogramma austroamericana</i> Domin	<i>Pityrogramma</i>	Pteridaceae
67.	<i>Pityrogramma calomelanos</i> (L.) Link	<i>Pityrogramma</i>	Pteridaceae
68.	<i>Pityrogramma chrysophylla</i> (Sw.) Link	<i>Pityrogramma</i>	Pteridaceae
69.	<i>Polystichum anomalum</i> (Hook. & Arn.) J.Sm. subsp. <i>travancoricum</i> (Bedd.) Fraser-Jenk.	<i>Polystichum</i>	Dryopteridaceae
70.	<i>Polystichum harpophyllum</i> (Zenker ex Kunze) Sledge	<i>Polystichum</i>	Dryopteridaceae
71.	<i>Polystichum squarosum</i> (D.Don) Fée	<i>Polystichum</i>	Dryopteridaceae

72.	<i>Polystichum subinerme</i> (Kunze) Fraser-Jenk.	<i>Polystichum</i>	Dryopteridaceae
73.	<i>Pteris blumeana</i> J.Agardh	<i>Pteris</i>	Pteridaceae
74.	<i>Pteris cretica</i> L. subsp. <i>cretica</i>	<i>Pteris</i>	Pteridaceae
75.	<i>Pteris cretica</i> L. subsp. <i>laeta</i> (Wall. ex Ettingsh.) Fraser-Jenk.	<i>Pteris</i>	Pteridaceae
76.	<i>Pteris ensiformis</i> Burm.f.	<i>Pteris</i>	Pteridaceae
77.	<i>Pteris vittata</i> L.	<i>Pteris</i>	Pteridaceae
78.	<i>Selaginella chrysorrhizos</i> Spring	<i>Selaginella</i>	Selaginellaceae
79.	<i>Selaginella intermedia</i> (Blume) Spring	<i>Selaginella</i>	Selaginellaceae
80.	<i>Selaginella miniatospora</i> (Daiz.) Baker	<i>Selaginella</i>	Selaginellaceae
81.	<i>Selaginella tenera</i> (Hook. & Grev.) Spring	<i>Selaginella</i>	Selaginellaceae
82.	<i>Tectaria coadunata</i> (J.Sm.) C.Chr.	<i>Tectaria</i>	Tectariaceae
83.	<i>Tectaria paradoxa</i> (Fée) Sledge	<i>Tectaria</i>	Tectariaceae
84.	<i>Tectaria wightii</i> (C.B.Clarke) Ching	<i>Tectaria</i>	Tectariaceae
85.	<i>Thelypteris dentata</i> (Forssk.) E.P.St.John	<i>Thelypteris</i>	Thelypteridaceae
86.	<i>Thelypteris ornata</i> (J.Sm.) Ching	<i>Thelypteris</i>	Thelypteridaceae
87.	<i>Trichomanes obscurum</i> Blume	<i>Trichomanes</i>	Hymenophyllaceae

Annexure 12

Sorensen similarity index of lycophytes and ferns along altitudinal gradient in the Palghat Gap and its influenced areas

	Up to 100	100-200	200-300	300-400	400-500	500-600	600-700	700-800	800-900	900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800	1800-1900	1900-2000	2000-2100	2100-2200	2200-2300	Above 2300	
Up to 100																									
100-200	0.86747																								
200-300	0.79518	0.90244																							
300-400	0.69663	0.79545	0.88636																						
400-500	0.65934	0.73333	0.82222	0.9375																					
500-600	0.54545	0.6055	0.6789	0.78261	0.83761																				
600-700	0.46875	0.51969	0.58268	0.67669	0.72593	0.88312																			
700-800	0.42857	0.47482	0.53237	0.62069	0.66667	0.81928	0.93478																		
800-900	0.38411	0.41333	0.46667	0.55128	0.59494	0.74576	0.86154	0.92754																	
900-1000	0.30435	0.32787	0.36066	0.43386	0.4712	0.60952	0.7193	0.78333	0.85259																
1000-1100	0.28889	0.31285	0.34637	0.4	0.4385	0.58252	0.69643	0.76271	0.83401	0.92857															
1100-1200	0.27586	0.30058	0.31214	0.35754	0.38674	0.53	0.65138	0.71304	0.78008	0.87591	0.94074														
1200-1300	0.28235	0.30769	0.31953	0.36571	0.39548	0.54082	0.66355	0.72566	0.79325	0.85926	0.90977	0.96923													
1300-1400	0.25157	0.27848	0.29114	0.34146	0.36145	0.51892	0.61084	0.65116	0.72566	0.79537	0.84706	0.8996	0.93061												
1400-1500	0.24	0.25503	0.26846	0.30968	0.33121	0.5	0.5567	0.60194	0.67281	0.744	0.79675	0.84167	0.87288	0.94222											
1500-1600	0.19858	0.21429	0.22857	0.27397	0.2973	0.45509	0.51892	0.55838	0.63462	0.70539	0.75105	0.79654	0.81938	0.88889	0.94686										
1600-1700	0.1626	0.18033	0.19672	0.21875	0.24615	0.41611	0.45509	0.4581	0.52632	0.6009	0.63927	0.68545	0.70813	0.77778	0.83598	0.88889									
1700-1800	0.14876	0.16667	0.18333	0.20635	0.23438	0.40816	0.44848	0.45198	0.52128	0.57919	0.61751	0.66351	0.68599	0.7551	0.81283	0.86517	0.975								
1800-1900	0.14876	0.16667	0.18333	0.20635	0.23438	0.40816	0.44848	0.45198	0.51064	0.56109	0.59908	0.64455	0.66667	0.73469	0.79144	0.83146	0.9375	0.96203							
1900-2000	0.125	0.12613	0.14414	0.17094	0.20168	0.3913	0.4359	0.44048	0.49162	0.5283	0.56731	0.60396	0.62626	0.68449	0.74157	0.78107	0.88742	0.89933	0.9396						
2000-2100	0.12	0.12121	0.14141	0.15238	0.18692	0.38095	0.40278	0.41026	0.43114	0.46	0.5	0.53684	0.55914	0.60571	0.63855	0.67516	0.77698	0.78832	0.81752	0.875					
2100-2200	0.1	0.10127	0.10127	0.11765	0.13793	0.24528	0.25806	0.27941	0.29932	0.32222	0.35227	0.37647	0.39759	0.42581	0.45205	0.48175	0.57143	0.5812	0.61538	0.66667	0.79167				
2200-2300	0.10811	0.10959	0.10959	0.12658	0.12346	0.24	0.23729	0.24615	0.2695	0.25287	0.28235	0.30488	0.325	0.34899	0.37143	0.39695	0.46018	0.46847	0.5045	0.54902	0.64444	0.82857			
Above 2300	0.06349	0.06452	0.06452	0.08824	0.08571	0.17978	0.16822	0.16807	0.18462	0.15951	0.1761	0.19608	0.21477	0.23188	0.24806	0.26667	0.31373	0.32	0.32	0.35165	0.43038	0.57627	0.75472		

Annexure 13

Taxonomic distinctness of lycophytes and ferns along altitudinal gradient in the Palghat Gap and its influenced areas

	Up to 100	100-200	200-300	300-400	400-500	500-600	600-700	700-800	800-900	900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800	1800-1900	1900-2000	2000-2100	2100-2200	2200-2300	Above 2300
Diversity	2.231	2.224	2.223	2.219	2.221	2.228	2.224	2.224	2.223	2.223	2.223	2.225	2.225	2.225	2.226	2.226	2.226	2.226	2.224	2.228	2.229	2.234	2.239	2.255
Lower limit	1.878	1.863	1.868	1.879	1.924	1.968	1.999	1.997	2.019	2.052	2.038	2.047	2.029	2.03	2.007	2.013	1.992	1.982	1.965	1.968	1.918	1.837	1.811	1.735
Upper limit	2.482	2.514	2.486	2.48	2.462	2.436	2.413	2.406	2.392	2.369	2.379	2.383	2.365	2.378	2.389	2.409	2.422	2.423	2.428	2.436	2.452	2.504	2.545	2.605
Distinctness	2.962	2.953	2.952	2.948	2.95	2.963	2.96	2.96	2.959	2.96	2.961	2.963	2.962	2.963	2.963	2.963	2.962	2.962	2.959	2.964	2.963	2.965	2.969	2.981
Lower limit	2.942	2.939	2.94	2.943	2.942	2.946	2.947	2.95	2.95	2.952	2.952	2.952	2.951	2.951	2.95	2.949	2.949	2.946	2.947	2.946	2.945	2.939	2.936	2.927
Upper limit	2.98	2.979	2.98	2.979	2.978	2.975	2.974	2.974	2.973	2.972	2.972	2.972	2.972	2.973	2.973	2.974	2.974	2.975	2.975	2.975	2.977	2.98	2.983	2.986

List of Publications

- **Thulasi R.**, Nair, M.C. and Rajesh, K.P. 2022. Distribution of Lycophytes and Ferns along Altitudinal Gradients in Palghat Gap Region of the Western Ghats – A preliminary analysis. *Indian Fern Journal*, 39(2), pp. 34-57.
- **Thulasi, R.**, Munoz, F. Sreekumar, E.R., Nair, M.C. and Rajesh, K.P. 2024. Predicted distribution of the endemic fern *Elaphoglossum beddomei* reveals threats to rainforests of Western Ghats of India. *Journal of Tropical Ecology*. **(In press)**.

List of Presentations

1. **Thulasi, R.**, Nair, M.C. and Rajesh, K.P. 2024. **Analysis of distribution of Lycophytes and Ferns in different habitats of Palghat Gap influenced areas.** *In:* International Seminar on ‘Plant Systematics: Present Status and Future Prospects, at University of Calicut from 15th to 17th February 2024. **(Best Paper Award)**
2. **Thulasi, R.**, Nair, M.C. and Rajesh, K.P. 2024. **Floristic and distribution studies of pteridophytes along the Palghat Gap influenced areas of Southern Western Ghats, India.** *In:* XVIII Annual Conference of the Indian Fern Society and National Symposium, at Kalyani University, Kolkata, West Bengal from 22nd to 24th November 2023.
3. **Thulasi, R.**, Nair, M.C. and Rajesh, K.P. 2022. **Geospatial mapping of some IUCN red listed and narrowly distributed pteridophytes in Palghat Gap influenced areas of Southern Western Ghats of India.** *In:* XVII Annual Conference of the Indian Fern Society and National Symposium on Advances in Pteridology Research: Present status and Future strategies, at Mansarovar Global University, Bhopal Madhya Pradesh, from 25th to 27th November 2022.
4. **Thulasi, R.**, Nair, M.C. and Rajesh, K.P. 2022. **GIS mapping of Lycophytes and Ferns in Nelliampathy Hills of Southern Western Ghats, Kerala.** *In:* XVI Conference of the Indian Fern Society and

International Symposium on Research in Pteridology: Priorities and Challenges, at University of Calicut, Kerala, from 17th to 19th March 2022.

5. **Thulasi, R.**, Nair, M.C. and Rajesh, K.P. 2020. **Ecological Niche Modelling of *Actiniopteris radiata* (Sw.) Link and *Elaphoglossum beddomei* Sledge using MaxEnt.** *In:* National Conference on Pteridology Today and Tomorrow: Relevance to Impact on Diversity and Climate change, at Maharaja Sayajirao University of Baroda, Vadodara, Gujarat, from 24th to 25th February 2020.
6. **Thulasi, R.**, Maya, C. Nair and Rajesh, K.P. 2019. **Preliminary analysis of distribution of Lycophytes and Ferns in different microhabitats along the Palghat Gap region.** *In:* 42nd Indian Botanical Society Conference, at University of Calicut, from 6th to 8th November 2019.
7. **Thulasi, R.**, Maya, C. Nair and Rajesh, K.P. 2019. **Distribution of Lycophytes and Ferns along Habitat Gradient in the Palghat Gap Region – A Preliminary Analysis.** *In:* *International Conference on Next Generation Pteridology: Indian Perspectives*, at Dr. Bhupendra Nath Dutta Smriti Mahavidhyalaya, Barddhaman, West Bengal, from 8th to 10th March 2019.