

PRESENT STUDY

3.1 Choice of the Present study

The only account of the flora of the state of Assam is that of Kanjilal *et al* (1934 - 1940), which deals only with dicotyledonous species (except Poaceae by N.L. Bor, 1940). Pteridophytic plants are totally excluded in this work. Further, subsequent to the publication of flora of Assam (Kanjilal *et al* (1934-1940) there has been a large scale alteration in the native flora of the state, owing to several socio-cultural practices (Rao 1978). It is therefore, not only essential but worth recording the plant biodiversity of the state before many of the species occurring in the state wiped out for ever. Besides, basic information about plant species is essential for fuller exploitation of our plant resources, and this is particularly true for a state like Assam, which alongwith other states in northeastern India is on the threshold of numerous intensive developmental programmes.

After the reorganisation of Botanical Survey of India and with the establishment of a separate regional circle at Shillong in 1956, some studies have been made on plants of Assam but with a bias towards flowering plants. Except for occasional reference by Kachroo (1953, 1975), Panigrahi (1960, 1968), Panigrahi & Chowdhury (1961, 1962), Panigrahi & Patnaik (1961a, 1961b), Bir *et al* (1989), Kachroo *et al* (1989) and Vasudeva *et al* (1990) and the works of Handique & Konger (1986) and Barua *et al* (1989) no systematic account has so far been appeared on fern and fern-allies occurring within the present political boundary of Assam. Further, while emphasizing the need of a modern Pteridophytic flora of our country Bir (1987b) stated that the compilation of an up-to-date and exhaustive Pteridophytic Flora of India is a task which can not be ignored for long and for achieving this objective, it is essential to compile first the regional floras with exhaustive surveys of less explored and underexplored region.

It is with an aim to botanise the state and to fill the gap in our knowledge on fern flora of Assam that the present work was taken up. The choice of the present work was based on the fact that it will not only contribute towards our knowledge on the fern flora of Assam, which still remain underexplored, but it will also contribute for the compilation of a modern Pteridophytic flora of India.

3.2 Field and Herbarium Methods

The present account on Ferns of Assam is based on extensive collection made regularly from several areas in different parts of Assam (Pl. 5). These areas were visited periodically in different seasons during 1992 - 1996.

In the field, while collections, elaborate notes particularly on the habit, habitat, size of fronds, colour of scales if present, nature of rhizome and indusium where present (from young sori) were made in the field notebook. Commonly associated species and in case of epiphytes the host trees (where known) were also noted. Where possible, the whole plants including the rhizome were collected, but in case of larger ferns the approximate size of the trunk, fronds and the nature of rhizome were noted, alongwith collection of portions of these.

In general, collection, pressing and preparation of herbarium specimens follow the recommended procedures (Jain & Rao 1976). The field data has been incorporated on the herbarium sheets and the specimens, on which this study is based, have been deposited in the Herbarium of Botany Department, Gauhati University with one duplicate set in Kanjilal Herbarium, Shillong (ASSAM) and another in the Herbarium of Botany Department, Mangaldai College, Mangaldai, Assam.

Provisional identification of the specimens were made with the help of available literature and were latter determined in various Herbaria viz. Kanjilal Herbarium, Shillong, (ASSAM), Central National Herbarium, Howrah (CAL), Herbarium of National Botanical Research Institute (NBG) Lucknow, Herbarium of North-East Hill University, Shillong and Herbarium of State Forest research Institute, Arunachal Pradesh, Itanagar.

3.3 Accounts on Vegetation of Assam

3.3.1 General Vegetation

The vegetation of Assam region has been studied by a number of workers (Griffith 1847 ; Hooker 1872 - 1897, 1904 ; Kanjilal *et al* 1934 - 40 ; Sengupta 1937 ; Das 1942 ; Rowntree 1953 ; Kingdon Ward 1960 ; Rao & Panigrahi 1961 ; Rajkhowa 1961 ; Bhatnagar 1963 ; Das & Rajkhowa 1968 and Rao 1974) and based on these accounts the vegetation of the state can broadly be classified into : (i) Tropical Evergreen and Semi-evergreen forest, (ii) Tropical Moist and Dry Deciduous forest, (iii) Tropical Grassland, (iv) Swamp forest, (v) Subtropical mixed forest, and (vi) Mixed Bamboo forest.

i. Tropical Evergreen and Semi-evergreen Forest

Tropical evergreen and Semi-evergreen forests occur all along the boundary of the state with Bhutan, Arunachal Pradesh, Nagaland, Manipur, Mizoram and Meghalaya, northwestern part of Karbi-Anglong district and southeastern part of North Cachar Hills district of the State.

This type of forest is characterised by dense and impenetrable vegetation comprising of tall trees showing storied nature. The top storey consists of some of the important timber species such as *Dipterocarpus macrocarpus* Vesque, *Shorea assamica* Dyer, *Terminalia myriocarpa* Heurch *et* Muehl, *Artocarpus chama* Buch.-Ham., *A. chaplasha* Roxb., *Euphorbia longan* (Lour.) Steud., *Canarium bengalense* Roxb., *Tetrameles nudiflora* R.Br., *Ailanthes grandis* Prain, *Altingia excelsa* Noronha, *Kayea assamica* King *et* Prain, *Terminalia chebula* Retz., *Stereospermum chelonoides* (L. f.) DC., and a host of others with local variation in species composition form area to area. However, in Barak Valley, *Dipterocarpus turbinatus* Gaertn., *Kayea floribunda* Wall., *Mangifera sylvatica* Roxb., *Tetrameles nudiflora* R. Br., *Mesua ferrea* L., *Schima wallichii* (DC.) Korth., etc. from the top storey. Some of the upper canopy species show deciduous nature whose leafless nature is very short.

The middle storey is represented by small trees and shrubs like *Mesua ferrea* L., *Garuga pinnata* Roxb., *Toona ciliata* Roemer, *Ardisia solanacea* Roxb., *Unona discolor* Vahl., *Gynocardia odorata* R.Br., *Eurya acuminata* DC., *Amoora wallichii* King, *Vatica lanceaefolia* Bl., *Dysoxylum binectariferum* (Roxb.) Hook. f. *et* Bedd., *Carallia brachiata* (Lour.) Merr., *Castanopsis indica* (Roxb.) DC., etc. In moist areas these forests are often interspersed by bamboo species such as *Dendrocalamus hamiltonii* Nees *et* Arn., *Bambusa pallida* Munro, *Pseudostachyum polymorphum* Munro and *Melocanna bambusoides* Trin. In certain semi-evergreen patches this layer is however dominated over by *Bischofia javanica* Bl., *Dysoxylum procerum* Hiern., *Vatica lanceaefolia* Bl. and *Cyclostemon ellipticus* Hook. f.

The lower storey is characterised by *Talauma hodgsonii* Hook. f. *et* Th., *Ficus glomerata* Roxb., species of *Garcinia*, *Sterculia*, *Phoebe*, *Magnolia*, *Litsaea*, etc. together with a number of smaller trees of the higher storeys.

The trees in this type of forest are bestowed with innumerable climbers and lianas, chief among them are *Bauhinia vahlii* Wt. *et* Arn., *Derris scandens* (Roxb.) Benth., *Entada pursaetha* DC., *Calamus*

floribundus Griff., *Gnetum montanum* Mark., *Caesalpinia bonduc* (L.) Roxb., *Hodgsonia macrocarpa* (Bl.) Cogn., etc. In semi-evergreen forests at foothills a variety of canes (*Calamus* spp.) usually occur.

There is a profusion of epiphytic species heavily clothing the tree trunks and branches. The chief epiphytes are orchids, ferns, fern-allies and members of the family Zingiberaceae, Gesneriaceae and Asclepiadaceae. The common angiospermic epiphytes are species of *Bulbophyllum*, *Cymbidium*, *Dendrobium*, *Eria*, *Microstylis*, *Hoya*, *Dischidia*, etc. and some of the important epiphytic ferns in these forests are *Asplenium nidus* L., *Drynaria quercifolia* (L.) J.Sm., *Pseudodrynaria coronans* (Wall.) Ching, *Polypodiastrium argutum* (Wall. ex Hook.) Ching, *Polypodioides lachnopus* (Wall. ex Hook.) Ching, *Microsorium punctatum* (L.) Copel., *Pyrrhosia nummularifolia* (Sw.) Ching, etc. together with species of *Lycopodium*.

The ground flora comprises of *Achyranthes bidentata* Bl., *Alternanthera sessilis* (L.) R. Br. ex DC., *A. philoxeroides* (Mar.) Griseb., *Murdania nudiflora* (L.) Brenan, *Impatiens paludosa* Hook. f., *I. radiata* Hook. f., *Curcuma angustifolia* Roxb., *Costus speciosa* Sm., etc. and many ferns and fern-allies like *Lygodium flexuosum* (L.) Sw., *L. japonicum* (Thunb.) Sw., *Angiopteris evecta* (Forst.) Hoffm., *Leptochilus axillaris* (Cav.) Kaulf., *Blechnum orientale* L., species of *Athyrium*, *Cyclosorus*, *Diplazium*, *Dryopteris*, *Lycopodium*, *Selaginella*, etc. Tree ferns are also not uncommon in these forests.

ii. Tropical Moist and Dry Deciduous Forests

The major forest type in Assam belongs to this category and comprises the Sal areas of Goalpara, Dhuburi, Kokrajhar, Kamrup, Nagaon districts, and moist and dry deciduous forests without Sal in other areas of the state including North Cachar Hills and also the Western part of Darrang district and drier plains of Barak Valley.

Shorea robusta Gaertn. (Sal), is the dominant species in Sal tracts with prominent associates like *Careya arborea* Roxb., *Kydia calycina* Roxb., *Sterculia villosa* Roxb., *Lagerstroemia parviflora* Roxb., *Grewia elastica* Royle, *G. nervosa* (Lour.) Panig., *Schima wallichii* (DC.) Korth., *Terminalia bellerica* (Gaertn.) Roxb., *Albizia lucida* Benth., *A. odoratissima* (L.f.) Benth., *Catuaregam nutans* (DC.) Triuv., *Cassia fistula* L., etc. occur with local variation.

The deciduous forests in N.C. Hills, drier parts of Nagaon, Karbi-Anglong, Barak Valley and in other areas, where Sal do not occur, consist of *Bombax ceiba* Burm. f., *Mitragyna diversifolia* (Wall. ex G. Don) Havil, *Hibiscus macrophyllus* Roxb., *Semicarpus anacardium* L. f., *Sapium baccatum* Roxb., *Aquilaria malaccensis* Lam., *Macaranga denticulata* Muell.-Arg., *Oroxylum indicum* (L.) Vent., *Emblia officinalis* Gaertn., *Holarrhena antidysenterica* Wall., *Ficus racemosa* L., *F. rumphii* Bl., etc. besides most of the associates of Sal, mentioned above.

Compared to evergreen and semi-evergreen forests, the stratification is not clear everywhere in deciduous forests. However, in some areas the middle storey is formed by *Casearia glomerata* Roxb., *Croton joufra* Roxb., *C. roxburghii* Balak., *Wrightia arborea* (Dennst.) Mabb., *Mimosa himalayana* Gamble, *Morinda angustifolia* Roxb., *Aporosa octandra* (D. Don) Vickery, *Antidesma acidum* Retz., etc.

As regards the ground cover, the floor in Sal tract areas are usually covered with tall grass like *Narenga porphyrocoma* (Hance) Bor, *Imperata cylindrica* Beauv. and *Themeda arundinacea* (Roxb.) Ridley. These grasses are usually associated with terrestrial ferns like *Lygodium flexuosum* (L.) Sw. and species mostly belonging to genera such as *Diplazium*, *Athyrium* and *Cyclosorus*.

In areas of deciduous forests without Sal, the ground cover is usually formed by species like *Desmodium pulchellum* Baker, *Lepidagathes incurva* Don, *Ageratum conyzoides* L., *Sporobolus indicus* (L.) Br., *Synedrella nudiflora* (L.) Gaertn., species of *Clerodendrum*, *Solanum*, etc. together with a number of terrestrial ferns and fern-allies like *Microsorium pteropus* (Bl.) Copel., *Tectaria polymorpha* (Wall. ex Hook.) Copel., *Sphenomeris chinensis* (L.) Maxon, *Cheilanthes tenuifolia* (Burm.) Sw. and species of *Diplazium*, *Cyclosorus*, *Adiantum*, *Pronephrium*, *Dryopteris*, *Pteris*, *Athyrium*, *Lycopodium*, *Selaginella*, etc.

Compared to evergreen and semi-evergreen forests, the epiphytic growth here is very less and likewise the species of climbing habit are also few. Some of the epiphytic ferns in this type of forest are *Arthomeris wallichiana* (Spr.) Ching, *Drynaria quercifolia* (L.) Sm., *Pyrrosia* spp., *Goniophlebium amoenum* (Wall. ex Mett.) J. Sm., *Polypodiastrium argutum* (Wall. ex Hook.) Ching, *Leucostegia immersa* (Wall.) Presl, etc. Of the climbers, the important ones are *Mucuna pruriens* (L.) DC., *Ampelocissus latifolia* (Vahl.) Planch., *Milletia extensa* (Benth.) Baker, *Dalhousiea bracteata* Benth. and species of *Dioscorea*, *Smilax*, *Vitis*, etc.

iii. Tropical Grassland

The grassland in Assam can be classified into two types. The one in riparian flats, which are inundated every year during the rains and remain under water for considerable period and meet with in both Brahmaputra and Barak Valleys. The other in comparatively drier areas, which often in certain areas represents seral community. The main component species of grasses in riparian flats are *Saccharum spontaneum* L., *Sclerostachya fusca* (Roxb.) A. Camus, *Arundo donax* L., *Phragmites karka* (Retz.) Steud., *Erianthus munja* Tesw., *E. longisetosus* Anderss. ex Benth., *Themeda villosa* (Poir.) A. Camus, etc. There are a few trees and shrubs like *Dillenia indica* L., *Bischofia javanica* Bl., *Terminalia myriocarpa* Muell.-Arg., *Barringtonia acutangula* (L.) Gaertn., *Lagerstroemia speciosa* Pers., *L. parviflora* Roxb., *Duabanga sonneratioides* Buch.-Ham., *Pterospermum acerifolium* Willd., *Cudrania javanensis* Trec., *Flemingia linleata* Roxb., etc. with local variation forming tree savanas.

In drier areas, the grasslands are with comparatively hardy and smaller species of grass. The representative species are *Imperata cylindrica* (L.) Beauv., *Apluda mutica* L., *Microstegium ciliatum* A. Camus, *Themeda arundinacea* (Roxb.) Ridley, *Narenga prophyrocoma* (Hance) Bor, *Paspalum orbiculare* Forst., *Ischaemum aristatum* L., etc. The trees or shrubs in this type of grassland are species of *Leea*, *Clerodendrum*, *Ageratum*, *Macaranga*, *Grewia sapida* Roxb., *Streblus asper* Lour., *Trema orientalis* Bl., *Bombax ceiba* L., *Terminalia bellerica* (Gaertn.) Roxb., *Ziziphus mauritiana* Lamk., etc.

Apart from the angiospermic plants one can also observe certain species of ferns and fern-allies in these grasslands. *Pteridium aquilinum* (L.) Kuhn, *Dicranopteris linearis* (Burm.) Andrew., *Gleichenia volubilis* Jungh, *Blechnum orientale* L., *Lindsaea himalaica* Kram, *Sphenomeris chinensis* (L.) Maxon and species of *Lygodium*, *Pteris*, *Cyclosorus* and *Diplazium* are the common representative members of ferns and *Lycopodium cernuum* L., *Selaginella involvens* (Swartz) Spring, *S. monospora* Spring, and *Equisetum diffusum* D. Don are the fern-allies in these grasslands.

iv. Swamp Vegetation

This type of vegetation extends over the whole state in perennial stagnant water bodies, lakes and depressions containing water and *beels*, sometimes constituted of abandoned river channels. Such water bodies are found in almost all the districts of the state, but they occupy a sizable portion of the total area in the districts of Lakhimpur, Dhemaji, Goalpara, Kamrup and Barpeta. Aquatic

angiospermic herbs like *Euryle ferox* Salisb., *Nymphaea nouchali* Burm. f., *Nymphoides hydrophyllum* (Lour.) Ktze., *Nelumbo nucifera* Gaertn., *Trapa natans* L., *Typha angustifolia* Watt, *Eichhornia crassipes* Solm., and members of Araceae, Cyperaceae, Eriocaulaceae and Pontederiaceae together with several shrubby species like *Rotula aquatica* Lour., *Ludwigia octovalvis* (Jacq.) Raven, *Polygonum* spp., *Homonoia riparia* Lour., *Arundo donax* L., *Phragmites karka* (Retz.) Steud, *Catibium malaccensis* (Burm. f.) Holttum and *Ficus* spp. usually dominate in these areas.

Ceratopteris thalictroides (L.) Brougn., *Azolla pinnata* R. Br., *Salvinia cucullata* Roxb. ex Bory and *S. natans* (L.) All. are the common fern species in stagnant water bodies. One or the other of the above species sometimes even form pure colonies. In places, where soil is sandy and saturated with water *Equisetum* spp., *Marsilea minuta* L. form extensive cover. There are certain ferns which prefer to grow along the rim of water bodies. These include *Diplazium polypodioides* Bl., *D. esculentum* (Retz.) Sw., *Christella dentata* (Forssk.) Brownsey et Jermy, *Cyclosorus interruptus* (Willd.) H. Ito, etc.

v. Subtropical Mixed Forest

This type of vegetation occurs in certain areas of northern part of Karbi-Anglong and North Cachar Hills districts where altitude reach beyond 900 m above sea level. Due to prolonged rains and high humidity the vegetation is quite luxuriant. The top canopy is constituted by species such as *Castanopsis indica* A. DC., *Phobe cooperiana* Kanjilal ex Das, *Juglans regia* L., *Alnus nepalensis* D. Don, *Callicarpa arborea* Clarke, etc. The branches of these trees are heavily moss-laden and offer a suitable habitat for a luxuriant growth of epiphytes, specially orchids and ferns. Some of the important ferns belong to *Goniophlebium amoenum* (Wall. ex Mett.) J. Sm., *Asplenium nidus* L., *A. normale* Don, *Drynaria propinqua* (Wall. ex Mett.) J. Sm., *Lepisorus excavatus* (Bory) Ching, *Araiostegia pulchra* (D. Don) Copel., *Lepisorus* spp., *Microsorium membranaceum* (Bak.) Ching, *Pyrrosia* spp. and among the fern-allies *Lycopodium serratum* Buch.-Ham., *Huperzia hamiltonii* (Spreng) Trev., *H. squarrosa* (Forst.) Trev., *H. phlegmaria* Rothmaler form the striking feature of vegetation. The lower storey is composed of several evergreen species. In general *Engelhardtia spicata* Bl., *Magnolia campbellii* Hook. f. et Th., *Bischofia javanica* Bl., *Quercus* spp., *Symplocos* spp., etc. are common elements.

The ground cover is composed of *Plantago rosea* Wall., *Urena lobata* L., *Sigesbeckia orientalis* L., *Cardamine hirsuta* L. and species belonging to *Impatiens*, *Polygonum* and *Strobilanthes*. Association of several terrestrial fern species here makes the ground vegetation markedly significant. Species like *Pteridium aquilinum* (L.) Kuhn., *Pteris quadriaurita* Retz., *P. wallichiana* J.G. Agardh, *Microlepia speluncae* (L.) Moore, *Arachniodes aristata* (Forst. f.) Tindale and species of *Athyrium*, *Microlepia*, *Asplenium*, *Dryopteris*, *Pteris* and *Lycopodium*. Climbers are rather rare in these forests. However, *Clematis acuminata* DC. and *Holboelia latifolia* Wall. are commonly encountered climbers. The most striking aspect is that some of the species of this type of vegetation descend down to the evergreen and semi-evergreen forests at the lower hills.

vi. Mixed Bamboo Forest

One of the characteristic feature of vegetation in Assam is the occurrence of bamboo either in pure patches or in association with other trees. *Dendrocalamus hamiltonii* Nees et Arn. and *Neohouzeana dallooa* (Gamble) A. Camus usually occur in almost pure patches in evergreen, semi-evergreen and deciduous forests with a few standing trees here and there. In deciduous forests the above two species also form the middle storey in some areas. In addition to the above species, *Bambusa pallida* Munro, *Melocanna bambusoides* Trin., *Pseudostachyum polymorphum* Munro usually

occur in sizable patches in evergreen and semi-evergreen forests of the foothills area. Abandoned jhum areas in Karbi-Anglong and N.C. Hills are usually colonised by *Dendrocalamus hamiltonii* Nees et Arn. with occasional clumps of *Bambusa tulda* Roxb. Whenever bamboo occur in an area either in pure patch or as middle story, the undergrowths are rare. Likewise, the ferns are also rare in these forests except for species of *Pteris* and *Lygodium*, which often come up gregariously.

3.3.2. Pteridophytic Vegetation

The pteridophytic vegetation in Assam is predominantly evergreen and has distinctiveness on account of their species diversity and peculiar formations. Assam region occupies an important place on the route of dispersal of fern flora to the northwest and to the south in the country and also the fern flora of Assam is distinctive in its distributional pattern (Kachroo 1975). The pteridophytic vegetation in Assam can be discussed with reference to the following broad ecological categories :

Epiphytic Vegetation

The tall and well stratified trees in the forests provide a suitable habitat for the growth of epiphytic ferns. However, a few other ferns prefer open tree trunks and branches. The composition and density of the epiphytic flora markedly varies with altitude, climatic conditions and the nature of forests. Of the epiphytes, the more common and widely distributed species are *Asplenium nidus* L., *Drynaria quercifolia* (L.) J. Sm., *Microsorium punctatum* (L.) Copel., *Lepisorus thunbergianus* (Kaulf.) Ching, *Pyrrosia adnascens* (Sw.) Ching, *P. nummularifolia* (Sw.) Ching, *P. lanceolata* (L.) Farwell., *Nephrolepis cordifolia* (L.) Presl, *Drymoglossum heterophyllum* (L.) Trimen, *Vittaria* spp. etc. and these are often associated with fern-allies like *Huperzia squarrosa* (Forst.) Trev., *H. hamiltonii* (Spreng) Trev., *H. phlegmaria* Rothmaler, etc.

Asplenium nidus L., *Microsorium punctatum* (L.) Copel. (Ph. 1), *Drynaria quercifolia* (L.) J.Sm. (Ph. 2), *Pseudodrynaria coronans* (Wall.) Ching and others form huge clumps on tree trunks with creeping fleshy rhizomes and *Drynaria quercifolia* (L.) J. Sm. often with thick humous collecting leaves at their bases looking like nests. These species are usually occur in evergreen and semi-evergreen forests in the foothills region of the state and often even reach the subtropical mixed forests in higher up and down to the mixed deciduous forests. However, *Microsorium punctatum* (L.) Copel., *Drynaria quercifolia* (L.) J.Sm. even descended down to the adjacent plains of Brahmaputra Valley and growing profusely on a wide range of host plants including the smooth trunks and/or branches of *Areca catechu* L., *Citrus grandis* Osbek., *Ficus religiosa* L. etc. *Pyrrosia adnascens* (Sw.) Ching reach very high trees, whereas *Asplenium nitidum* Sw. (Ph. 3) is restricted to lower levels. *Tricholepidium normale* (D.Don) Ching, *Microsorium membranaceum* (Bak.) Ching, etc. are found near bases of trunks and often tend to grow as terrestrials on moss covered soil just at the base of tree trunk. Of the epiphytic ferns of the plains *Nephrolepis cordifolia* (L.) Presl, *Drynaria quercifolia* (L.) J.Sm., *Drymoglossum heterophyllum* (L.) Trimen and species of *Pyrrosia* are common, which grow on humous accumulated tree trunks and branches. *Pyrrosia lanceolata* (L.) Farwell., *P. adnascens* (Sw.) Ching, *P. heteracta* (Mett. ex Kuhn) Ching and *Drymoglossum heterophyllum* (L.) Trimen, commonly grow epiphytically on *Mangifera indica* L., *Ficus religiosa* L., *Ziziphus mauritiana* Lam. and other common trees throughout the plains in Assam. These species often tend to grow in pure colonies on exposed rather dry tree trunks, and at times even covering entire tree trunks with their slender long and wide creeping rhizome with extensive root systems. *Drynaria quercifolia* (L.) J.Sm. growing abundantly in plains, often clothed heavily the trunks and branches of trees. It is interesting to note that in Assam this species is growing more profusely on *Samanea saman* Merril., which is grown as avenue tree here, than on other trees. Sometimes

Drynaria quercifolia (L.) J.Sm. colonies are associated with *Phymatopteris crenato-pinnata* (Clarke) Pic. Ser. The evergreen and semi-evergreen forests in upper Assam Davallias and Asplenias form an important element in the epiphytic complex. *Stenochlaena palustris* (Burm.) Bedd., although a terrestrial, climbs over the whole length of the tall trees and its dropping pinnae in close order completely cover the tree trunks. Among the other prominent epiphytes of this region of Assam mention can be made of *Lemmaphyllum carnosum* (Wall.) Presl, *Pyrrhosia nummularifolia* (Sw.) Ching, *Nephrolepis exaltata* (L.) Schott, *Antrophyum reticulatum* (Forst.) Kaulf. and *Vittaria elongata* Sw. These ferns are commonly associated with fern-allies like *Huperzia phlegmaria* Rothmaler, *H. squarrosa* (Forst.) Trev., *H. hamiltonii* (Spreng) Trev., *Psilotum nudum* (L.) P. Beauv. and orchids, *Hoya* spp. and *Dischidia benghalensis* Colebr.

In higher elevations *Mecodium javanicum* (Spreng) Copel., *M. exsertum* (Wall. ex Hook.) Copel., *Colysis hemionitidea* (Wall. ex Mett.) Presl., *Pyrrhosia mollis* (Kunze) Ching, *P. flocculosa* (D. Don) Ching, *Drynaria propinqua* (Wall. ex Mett.) J. Sm., *Pseudodrynaria coronans* (Wall. ex Mett.) Ching, together with fern-allies like *Huperzia hamiltonii* (Spreng) Trev., *H. squarrosa* (Forst.) Trev., etc. are commonly noticed densely plastering the tree trunks. Certain other species like *Humata griffithiana* (Hook.) C. Chr., *Araiostegia pulchra* (D. Don) Copel., *Lepisorus excavatus* (Bory) Ching, *L. nudus* (Hook.) Ching, *Loxogramme grammitoides* (Bak.) C. Chr., *Pyrrhosia* spp. etc. prefer to grow on humous deposits on tree trunks. Epiphytes like *Arthomeris wallichiana* (Spreng) Ching, *Phymatopteris rhyncophylla* (Hook.) Pic. Ser. *Leucostegia immersa* (Wall. ex Hook.) Presl., *Microsorium superficiale* (Bl.) Ching, etc. with their wide creeping fleshy rhizomes have adapted to grow as terrestrials forming dense patches at the base of tree on shady, humous covered soils. *Vittaria elongata* Sw., *Lepisorus ussuriensis* (Regel et Mack.) Ching, *Loxogramme grammitoides* (Bak.) C. Chr., *Asplenium nidus* L. commonly found on branches of trees which are thickly clad with dripping festoons of liverworts and mosses. *Microsorium membranacium* (Bak.) Ching, *Tricholepidium normale* (D. Don) Ching, *Loxogramme grammitoides* (Bak.) C. Chr. *Asplenium nitidum* Sw. and *A. nidus* L. commonly found near the bases of tree trunks. On the other hand *Lepisorus excavatus* (Bory) Ching, *L. subconfluens* Ching, *L. sordidus* (C. Chr.) Ching, *Polypodiastrium argutum* (Wall. ex Hook.) Ching and *Arthomeris wallichiana* (Spreng) Ching, reach even the top of the tree trunks.

On the trunks at comparatively open places ferns like *Oleandra wallichii* (Hook.) Presl, with their long branched, stragling rhizophore like rhizomes that penetrate into humous deposits are common. *Pyrrhosia mollis* (Kunze) Ching and *Vittaria elongata* Sw. are also frequently met with in open areas.

Terrestrial Vegetation

Approximately 77 percent of the total fern flora in Assam belongs to this category. In evergreen and semi-evergreen forests where the forest flora is rich in humous and organic nutrients, ferns like *Asplenium finlaysonianum* Wall. ex Hook., *Diplazium bentamense* Bl., *Tectaria vasta* (Bl.) Copel., *T. polymorpha* (Wall. ex Hook.) Copel., *Christella dentata* (Forsk.) Brownsey et Jermy, *Egenolfia appendiculata* (Willd.) J.Sm., *Bolbitis heteroclita* (Presl) Ching, *Onychium siliculosum* (Desv.) C. Chr., *Cheilanthes tenuifolia* (Burm.) Sw., *Adiantum capillus-veneris* L., *Pteris cretica* L., *P. biaurita* L. (Ph. 4), *Microsorium pteropus* (Bl.) Copel. (Ph. 5), etc. together with species of *Lycopodium* and *Selaginella* are very common. While these species occupy the moist, shady places in dense forests, ferns like *Diplazium esculentum* (Retz.) Sw. (in old clearings), *Pronephrium nudatum* (Roxb.) Holtt. (Ph. 6) (edges), *Dicranopteris linearis* (Burm. f.) Underw. (edges ; also on hill slopes, etc.) (Ph. 7), *Pteris semipinnata* L., *P. quadriaurita* Retz., *P. biaurita* L., *Onychium siliculosum* (Desv.) C. Chr., *Christella parasitica* (L.) Lev., *Amphineuron extensum*

(Bl.) Moore, etc. along with *Selaginella involvens* (Sw.) Spreng, *Lycopodium clavatum* L., *Lycopodiella cernua* (L.) Pic. Ser., etc. are frequently met with in forest cleared areas, which represent largely edges of forests and also in secondary forests.

Along exposed hill slopes, moist road cuttings and similar situations one can commonly come across gregarious growth of *Dicranopteris linearis* (Burm.) Underw. associated with grasses and occasional individuals of *Blechnum orientale* L. (Ph. 8) and *Lycopodium clavatum* L. However, *Asplenium finlaysonianum* Wall. ex Hook., *Adiantum caudatum* L. (Ph. 9), *A. philippense* L., *Dryopteris cochleata* (D. Don) C. Chr., *D. sparsa* (D. Don) O. Ktze., *Diplazium esculentum* (Retz.) Sw., *Pteris quadriaurita* Retz., *Amphineuron extensum* (Bl.) Moore, etc. together with *Selaginella monospora* Spr., and *Lycopodium* spp. are also grown commonly on hill slopes, moist road cuttings and similar such situations. *Sphenomeris chinensis* (L.) Maxon and *Pteris semipinnata* L. are very common on cleared lands on outskirts of dense forests. On the shady slopes are found *Pteris biaurita* L., *Cheilanthes farinosa* (Forsk.) Kaulf., species of *Cyclosorus* and occasionally *Athyrium* spp.

In the immediate vicinity of a gorge, one finds shade loving species like *Cyathea gigantea* (Wall. ex Hook.), *C. spinulosa* Wall. ex Hook., *Cibotium barometz* (L.) J. Sm., *Angiopteris evecta* (Forst.) Hoffm., species of *Lycopodium* and *Selaginella* literally cloth the banks along with liverworts and *Marchantia*. Other common species in such localities are *Microlepia hookeriana* (Wall. ex Hook.), *Sphenomeris chinensis* (L.) Maxon, *Pteris quadriaurita* Retz., *P. biaurita* L., *P. semipinnata* L., *P. cretica* L., *Pteridium aquilinum* (L.) Kuhn., *Diplazium esculentum* (Retz.) Sw., *D. bentamense* Bl., *Tectaria vasta* (Bl.) Copel., *Colysis pedunculata* (Hook. et Grev.) Ching, *Paraleptochilus decurrens* (Bl.) Copel., *Leptochilus axillaris* (Cav.) Kaulf., *Blechnum orientale* L. etc. Along rivulets, streams and on banks of rivers, where temperature is low and humidity is high, shade loving species like *Athyrium puncticaule* (Bl.) Moore, *Humata griffithiana* (Hook.) C. Chr., *Onychium siliculosum* (Desv.) C. Chr., *Ophioglossum petiolatum* Hook., *Pteris vittata* L. etc. are prominent.

Several species of tree ferns can be noticed in rather exposed areas and in forest margins, specially along the foothills of Bhutan, Arunachal Pradesh, Nagaland, Meghalaya and in Karbi-Anglong and N.C. Hills districts, which form a conspicuous feature of vegetation. These tree ferns belong to *Cyathea gigantea* (Wall. ex Hook.) Holtt., *C. andersonii* (J. Scott. ex Bedd.) Copel., *C. khasyana* (Moore ex Kuhn) Domin., *C. spinulosa* Wall. ex Hook. (Ph. 10) and *C. henryi* (Bak.) Copel. Of the species of *Cyathea*, *C. gigantea* (Wall. ex Hook.) Holtt. and *C. spinulosa* Wall. ex Hook. are more commonly found species.

At higher elevations above 900 m, the pteridophytic vegetation shows variation and often extremely prolific with diverse species such as *Microlepia haflongensis* Nayar & Kaur, *Diplazium polypodioides* Bl., *Dennstaedtia scabra* (Wall.) Moore, *Arachniodes assamica* (Kuhn) Ching, *Polystichum biaristatum* (Bl.) Moore, *Asplenium unilaterale* Lamk., *Coniogramme fraxinea* (D. Don) Diels, *C. procera* Wall. ex Feé, *Colysis hemionitidea* (Wall. ex Mett.) Presl, and a number of *Dryopteris* and *Asplenium* species. Tree ferns belonging to *Cyathea gigantea* (Wall. ex Hook.) Holtt. and *C. khasyana* (Moore ex Kuhn) Domin. are not uncommon in these forests. Large ferns like *Cibotium barometz* (L.) J. Sm., *Diplazium bentamense* Bl., etc. make the slopy ground vegetation conspicuous in the high forests. On the other hand, the open places and sides of these hills are luxuriantly covered by *Dicranopteris linearis* (Burm.) Underw., *Gleichenia volubilis* Jungh., *Sphenomeris chinensis* Maxon, *Dryopteris cochleata* (D. Don) C. Chr., *Hypolepis punctata* (Thunb.) Mett. ex Kuhn, *Pteris* spp., *Diplazium* spp., *Selaginella monospora* Spreng, *S. involvens* (Sw.) Spreng, *Lycopodium serratum* Thunb., *L. clavatum* L., etc. Some of these species also form

a characteristic feature of vegetation along streams, waterfalls and river banks on hills. Occasionally *Angiopteris evecta* (Forst.) Haffm. (Ph. 11) is also noticed in these situations, specially in shaded areas.

The common associates of ferns in terrestrial vegetation are *Christella parasitica* (L.) Lev. and *Hypolepis punctata* (Thunb.) Mett. ex Kuhn and *Sphaerostephanos unitus* (L.) Holtt., association of *Dicranopteris linearis* (Burm.) Underw and *Blechnum orientale* L. and *Diplazium esculentum* (Retz.) Sw., *Cyclosorus gongylodes* (Schk.) Link (Ph. 12) and *Pteris vittata* L. In higher elevations *Dicranopteris linearis* (Burm.) Underw. and *Gleichenia volubilis* Jungh associations are common. Sometimes these associations form impenetrable thickets in open areas and along forest edges (Ph. 13).

Climbers

There are only seven species of climbing ferns in the pteridophytic vegetations of Assam. viz. *Stenochlaena palustris* (Burm.) Bedd., *Lygodium flexuosum* (L.) Sw. (Ph. 14), *L. japonicum* (Thunb.) Sw., *L. microphyllum* (Cav.) R. Br., *Leptochilus axillaris* (Cav.) Kaulf., *Tricholepidium normale* (D. Don) Ching and *Paraleptochilus decurrens* (Bl.) Copel. These species prefer to grow on rich humous soil and reach very great height on other trees. Of these *Stenochlaena palustris* (Burm.) Bedd. grows in graceful manner with its dropping dimorphic fronds in close order along the whole length of tall trees in partially shaded roadsides or inside forests in fully shaded places. This species even grows in seasonally inundated areas also. *Lygodium microphyllum* (Cav.) R. Br. is less common species, whereas, *L. flexuosum* (L.) Sw. and *L. japonicum* (Thunb.) Sw. are exceedingly common along fully or partially exposed roadsides or waysides, forest edges and in forest clearings. *Leptochilus axillaris* (Cav.) Kaulf., *Tricholepidium normale* (D. Don) Ching, and *Paraleptochilus decurrens* (Bl.) Copel. are shade loving species common in evergreen and semi-evergreen forests ; the rhizome of these species are firmly adressed to host plants by clasping roots.

Lithophytic Vegetation

Several pteridophytic plants are found growing on rocks and boulders with their creeping rhizomes. Two main categories of lithophytic pteridophytes can be recognized viz., species growing on exposed rocks, rock-crevices and old brick walls and species that grow on moss-covered rocks in dense forests, specially near water sources. Under the former category, *Adiantum capillus-veneris* L., *Cheilanthes farinosa* (Forsk.) Kaulf, *C. tenuifolia* (Burm.) Sw., *Onychium siliculosum* (Desv.) C. Chr., *Phymatopteris rhyncophylla* (Hook.) Pic. Ser., *Sphenomeris chinensis* (L.) Maxon, *Pteris vittata* L. (Ph. 15), *Humata griffithiana* (Hook.) C. Chr., *Asplenium* spp., *Selaginella* spp. etc. These species show xerophytic character and can overcome unfavourable conditions like severe cold, high temperature, etc.

The rocks and boulders with prolific growth of mosses and liverworts laying inside forests and near streams support altogether a different group of lithophytic pteridophytes such as *Asplenium falcatum* Lamk., *A. normale* D. Don, *A. unilaterale* Lamk., *Egenolfia appendiculata* (Willd.) J. Sw., *Bolbitis heteroclita* (Presl) Ching, *Oleandra wallichii* (Hook.) Presl, *Adiantum* spp., *Mecodium javanicum* (Spr.) Copel., *Selaginella involvens* (Sw.) Spr., *S. repanda* (Desv.) Spr., *Lycopodium complanatum* Lindl., etc.

Hydrophilous Vegetation

The hydrophilous vegetation along the banks of streams, ravines, waterfalls, etc. is quite rich and include, apart from numerous angiospermic plants a wide variety pteridophytic species. There are some ferns

which prefer to grow along water courses on hill slopes and stagnant water bodies formed by abandoned river channels, specially on calcareous soils. These include *Ampelopteris prolifera* (Retz.) Copel. (Ph. 16), *Diplazium polyodioides* Bl., *D. bentamense* Bl., *D. esculentum* (Retz.) Sw., *Pronephrium nudatum* (Roxb.) Holtt., *P. parishii* (Bedd.) Holtt., *P. lakhimpurensis* (Rosenst.) Holtt., *Tectaria vasta* (Bl.) Copel., *T. polymorpha* (Wall. ex Hook.) Copel., *Christella dentata* (Forsk.) Brownsey & Jermy, *Selaginella* spp., *Lycopodium* spp., etc. In certain localities one or the other of these species sometimes grow in almost pure formations.

Among the true rooted aquatics mention can be made of *Ceratopteris thalictroides* (L.) Brongn., *Marsilea minuta* L. (Ph. 17), which are common in paddy fields, swamps, beels, and in stagnant water bodies. *Equisetum ramosissimum* Desf. often form extensive mats on moist sand beds of alluvial rivers and *Isoetes coromandelina* L.f. colonised on fully exposed wet or marshy border of lakes or ponds.

There are three free-floating aquatic ferns in Assam viz., *Azolla pinnata* R. Br. (Ph. 18), *Salvinia natans* (L.) All. and *S. cucullata* Roxb. ex Bory. These ferns are common in almost all the stagnant water bodies, ponds, lakes, etc. throughout the state. Sometimes they form pure colonies also. *Azolla pinnata* R. Br. has also invaded the paddy fields.

Seasonal Variation

The varying nature of climatic conditions has a influence on growth and prevalence of pteridophytic vegetation and show a distinct seasonal variation. Most of the species flourish during the rainy season (May - September). With the receiving of premonsoon showers with increasing temperature of early summer (March - April) most of these ferns put forth new fronds and become fertile during August - October, just before the advent of winter. During this period one can commonly observe the green, tender fronds of *Diplazium* spp., *Adiantum* spp., *Pteris* spp., *Blechnum orientale* L., *Lygodium flexuosum* (L.) Sw., *Sphenomeris chinensis* (L.) Maxon, *Ophioglossum reticulatum* L., *Helminthostachys zeylanica* (L.) Hook., etc. Among the epiphytes, which carpet over tree trunks with young shoots and fronds, the common ones are *Drynaria quercifolia* (L.) J. Sm., *Lepisorus* spp., *Arthomeris wallichiana* (Spreng) Ching, *Leucostegia immersa* (Wall.) Presl, *Vittaria* spp., *Pyrrosia* spp., *Drymoglossum* spp., etc.

With the advent of winter (November - February) most of these species (both epiphytic and terrestrial) undergo dormancy. During this period of the year one can observe the shrivelled up and inrolled, yellowish lamina of certain epiphytic species like *Loxogramme grammitoides* (Bak.) C. Chr., *Phymatopteris crenato-pinnata* (Clarke) Pic. Ser., *Pyrrosia* spp., *Drymoglossum* spp., *Drynaria quercifolia* (Wall. ex Mett.) J. Sm., *Vittaria elongata* Sw., etc. In case of terrestrial species like *Leucostegia immersa* (Wall.) Presl, *Pteris vittata* L., *Dryopteris* spp. and many Athyroid and Thelypteroid ferns the aerial shoots die off either partially or completely. The underground or creeping rhizomes of these species overcome the severe cold of winter by the envelop formed with dead leaf bases, scales and hairs and become active with the advent of spring. However, there are certain species, which are not affected with change in climatic conditions and normally retain the green, fertile fronds throughout the year. In this category includes the hardier species like *Dicranopteris linearis* (Brum.) Underw., *Diplazium esculentum* (Retz.) Sw., *Pteridium aquilinum* (L.) Kunh., *Gleichenia volubilis* Jungh., etc. which grow in open places and *Angiopteris evecta* (Forst.) Hoffm., *Diplazium bentamense* Bl., *Bolbitis* spp., *Onychium japonicum* (Thunb.) Kunze, *Plagiogyria* spp., etc. which grow along

water sources.

3.3.3 The Present Account

In presenting the account here, the families are arranged according to Pichi-Sermolli's (1977) classification with minor changes following Ching (1978).

The taxonomic treatment includes an explicit keys to families, genera and species under family alongwith detailed description for each species. In general, the descriptions of species were made from either herbarium or from live specimens or from both. The genera are arranged alphabetically under each family and similarly species under genera are also arranged alphabetically.

In determining names of taxa, an effort has been made to present, as far as possible, the nomenclature accepted as valid in current literature. In this connection all the literature available to the author are consulted. Only important synonyms which have a relevance to Indian works, including some monographs and revisions, are included. Original citations of both accepted name and synonym(s) are provided.

Distribution of the species in the world and in India are worked out from the literature and are provided after the description of each species. This is followed by a brief remark about the habitat and occurrence of each taxon in the area of work alongwith exiccata.

Vernacular name(s) and uses of a species whenever recorded are also mentioned. Except for a few, most of these informations are recorded from literature.

Illustrations based on voucher specimens for all the species recorded from the area of present work are provided at the end of the present account. Habital photographs of some of the species are also included.

In the present account the following abbreviations are used : Ass - Assamese ; Eng - English ; Hin - Hindi ; Sans - Sanskrit ; Distrib - Distribution and Occur - Occurance.