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STUDIES ON THE SHOLA FORESTS OF KERALA

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SUMMARY

'Shola forests' *(s. l.)* are tropical forest vegetations comprising subtropical hill forests and the montane temperate forests, generally inhabiting over 1,500 m asl. The present study on the shola forests of Kerala has generated bench mark information on the floristics, community ecology and forest dynamics of the two major chunks of the shola forests, the Mannavan shola and the Eravikulam National Park, both situated in the Idukki District of the Kerala State.

A total of 543 plant species belonging to Pteridophytes and Angiosperms were collected from the study area. Nearly one fifth of the taxa (109 spp.) are 'endemic' and one fourth (128 spp.) 'rare'. Twenty six species belonged to the threatened category. One taxa *(Sinarundinaria microphylla)* proved to be a new record for Peninsular India and some are new records to Kerala. Some specimens belonging to the genera *Syzygium, Balanophora, Litsea* and a few other genera which could not be identified at the moment may probably turnout to be new taxa. The value of the shola forests in the context of biodiversity conservation therefore demands serious attention.

Community ecological studies were conducted by establishing six 0.25 ha semi-permanent plots across an elevational gradient from 1,600 to 2,100 m asl. Six 0.1 ha releves, each comprising ten non-contiguous 100 m^2 quadrats distributed in the entire elevational range were also studied for phytosociology. Enumeration of all individuals ≥ 1 cm dbh were done in the semi-permanent plots. In the releves, only those individuals which are ≥ 10 cm dbh were measured. The data were analysed for details of structure and composition, dominance, species richness, biodiversity content, and population structure of selected tree species.

When only the ≥ 10 dbh class was considered, the tree community was a *Cinnamomum wightii* type showing cent per cent constancy in all the releves studied. A constancy value of ≥ 70% was shown by 5 species and the rest of about 81 species showed a value less than that. Dominant species were constituted by 6-17 species, their aggregate Relative Importance Value Index (RIVI) ranged between 70-81 per cent.

The most dominant tree species in the community were: *Cinnamomum wightii, Litsea* sp., *Mastixia arborea, Hydnocarpus alpina, lsonandra candolleana, Persea macrantha, Syzygium* sp. and *Gomphandra coriacea*. The less frequent tree species accounted for 8-19 species with their importance value ranging between 18.30%.

Up to 1,950 m asl, the basal area of the stand was fairly high with a mean of 114.5 $m^2 ha^{-1}$; further up. it decreased drastically to an average of 56.2 $m^2 ha^{-1}$. Even within the elevational belt 1,600-1,950 m asl, the basal area showed variability, ranging between 56.7 m^2 ha^{-1} and 161.7 m^2 ha^{-1}. This indicates either difference in stand history of the sites or difference in species composition or both.

Of the total of 1,186 trees measured in the shola forests, the highest diameter measured was 160.7 cm for a species of *Syzygium* at about 1,800 m asl. From 1,850 m as1 onwards there was a gradual reduction in the highest dbh and as the elevation reaches 2,100 m asl, it goes down to 72.5 cm.

The total number of species of herbs and/or shrubs always outnumbered the number of tree species at all the undisturbed shola forest sites. Diversity of herbs was very high in grassland ecotones and in disturbed (eg. burned) region in comparison to the undisturbed regions. along the elevational gradient, no such appreciable increase was observed.

Species richness of trees, as well as all species taken together of the semi-permanent plots showed a decreasing trend with increasing elevation *(ie,* 94 spp. at 1,850 m and 84 spp. at 2,100 m). However, in the forest-grassland ecotone there were 112 species in comparison to the maximum number of 94 species observed at the undisturbed plot.

Gregarious occurrence of the reed bamboo, *Sinarudinaria densifolia* and the substorey shrub, *Strobilanthes homotropa,* accounted for the high values of density ≥ 1 cm dbh in some of the plots (eg. 11,700 ha^{-1} to 27,360 ha^{-1}).

The density of trees ≥ 10 cm dbh in the shola forests is comparable to that of the evergreen forests. A maximum of 1180 trees ≥ 10 cm dbh was encountered in a hectare of the shola forests at 1,700 m asl; the minimum being 510 trees ha^{-1}. There is no general trend in the number of trees ≥ 10 cm dbh across the elevational gradient, except that at very high elevations there is marked reduction of number of stems.

Species diversity of plants ≥ 1 cm dbh was highest at about 1,950 m asl, from there upwards it decreased. Such a trend however is not observed for species ≥ 10 cm dbh. Shannon's index of diversity for the shola forests is only comparable to that of moist deciduous or semi-evergreen forests and never reached closer to that of evergreen forests. Within the shola forests it was highest at 1,950 m as1 and thereafter it decreased. The dominance spectrum indicated by Simpson's index is highest at lower elevations and least at 2,100 m as1 in the shola forests. Evenness of species populations decreased from 1,850 m as1 upwards indicating an increase in rarity (sparseness) of species populations with increasing elevation. Although the indices of diversity of the shola tree life form spectrum is less in comparison to that of the wet evergreen forests, the particular segment of biodiversity containing many temperate tree species, not represented elsewhere in the South, is very unique.

Results of population analysis did not provide evidence of any serious constraints in the natural regeneration of trees within the shola groves. The tree population with mean values of 9688 nnestablished seedlings, 2223 established seedlings and 3910 saplings in a hectare of shola forest shows uninterrupted sylvigenesis. However, the process of invasion of the shola species to adjacent grasslands is very slow and might be an area for further research. Taken the tree species individually, some had all life stages represented while in others some stages were missing. These patterns of regeneration were met with in all constancy categories of species.

Gregarious growth of reed-bamboos within the shola groves are considered a result of past invasion of tire into the groves from the vast expanse of the surrounding grasslands. Enhancement of diversity of these stands through regeneration augmentation would be a meaningful venture. Regeneration augmentation would be desirable in other degraded shola forests too. Ecotonal tree species are to be given priority in such planting operations.

Mannavan Shola and the Eravikulam National Park are two living musea of shola forests. Of these, only Eravikulam has the status of a National Park. Mannavan Shola, the largest shola forest patch in the State, which contains many botanical rarities and novelties, should also be considered for a better protective status. Mannavan Shola, together with other larger adjacent shola patches (such as the Pullaradi Shola, Idivara Shola, Pambadam Shola, etc) are suitable candidate groves for consideration of constituting a shola forest sanctuary.

Chapter 1

INTRODUCTION

The cretaceous mountain building activities of the past has moulded a mega-relief on the west coast of Peninsular India, the Western Ghats. This relief, with its ascents and descents as it traverses from Cape Camorin to the Karwar in Gujarat (Meher-Homji, 1978) has provided very many kaleidoscopic biological, anthropological and cultural niches. The distribution patterns of the rare, endemic and endangered species along the Western Ghats really tune to this. The proliferation of the relief-dependent niches along the Western Ghats is also reflected in the kinds of vegetation types and the shola forests is one among them (Gadgil and Meher-Homji, 1990; Meher-Homji, 1984, 1990).

1.1 Shola forests: Origin of the name

The term *'shola'* is a corrupt form of the Tamil word *'chdlai'* borrowed and incorporated into forest typology by Schimper (1903). In Tamil, the term *'chdlai'* (Malayalam: *chdla)* refers to a cold place, a thicket, etc. Both *'shola'* and *'sholai vanam'* glorified ancient tamil literature, songs and films literally and all these connotations refer to streamlets and the associated forests.

An examination of words related to *'cholai'* (T)* in the Indo-European languages tell us that the word probably had an origin from Sanskrit, *jal,* which means water. The word *jal* stands more than for water to refer to 'the *liquid property'*. Liquids flow (move) automatically across level differences and the meaning of *'motion'* ***is*** inherent in the word *'jal",* as is also evidenced in its transformations: *jalu* (Te; to flow gently) and *chalu, chal* (M) which mean *'a streamlet'* or *'a furrow',* indicating the connotation of water.

The word chdlai (T) presumably originated from *jal* (S) through a series of intermediaries such as *jalika* (S, a spider), *jolha (H; a weaver) and chol (H), choli (S), jauli* (M), etc, all meaning dress. While *chol* (H), *choli* (S), *jauli* (M), all referred to clothes as covering on the body, the vegetal clothing on streams *(chal,* M; streamlet) and valleys were named chdlai and chdla in Tamil and Malayalam respectively.

Gradually *chdlai* transformed to *shola* (E) through the intermediary form *sholai.* Perhaps, at the time when the terms were only differentiating, the word *chdlai* (T) was used interchangeably to refer to both *'streamlet'* and *'forest associated with streamlets'*. At any rate the streamlet connotation is undisputable, as the patchy shola forests are found distributed too.

1.2 Shola forests: History of the vegetation type

Forestry in the modem sense of focussed activity on wooded and manageable geographic vegetal units perhaps started in India since the British period. Forest Working Plans and manuals written for regulation of forestry activities included different forest types and the term

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* E: English; M: Malayalam; S: Sanskrit; T Tamil; Te:

'shola(s)' enriched the nomenclature of forest types. These registers virtually carried the Schimperian (1903) sense of the term (Chandrasekharan, 1962 d). Following the British colonial supremacy during the 18th and 19th centuries in India, the British Forestry Academician, Champion (1936) advocated an elaborate forest type classification of the country. Later, he enlarged his classification jointly with his colleague (Champion and Seth, 1968). These documents equated the term *'shola forests'* with *'stunted forests of the high elevational belts'*.

Meher-Homji (1984) made a reclassification of the Indian vegetation types and he clubbed the subtropical hill forests together with the shola forests (montane wet temperate forests) for a slightly wider application of the latter term. Elevation is one among the main factors dictating the local climate, which influences the patterns of species distributions (flora) and the vegetation types. Along the Western Ghats, the evergreen forests inhabit lower elevations up to 1,500 m msl (Fig. I.l), which gradually transforms to subtropical hill forests between the elevational range 1,500 to 1,800 m msl (Figs. 1.2 & 1.4). The subtropical hill forests in tum, as the elevation ascends, merge with the patchy shola forests *(s. str.;* Figs. 1.5 & 1.6). Thus, the shola forests, in the wider sense of the term (as it is currently understood), inhabit altitudes above 1,500 m msl.

The shola forests actually represent a continuation of the evergreen forests in response to the elevational gradient, the sequence being: Wet Evergreen Forests → Subtropical Hill Forests → Montane Wet Temperate Forests (Figs. 1.1-1.4). With ascent in elevation, the stands show a retarded height growth and in the montane forests, the height is hardly 12-15 m (Figs.l.5 & 1.8).

1.3 Shola forests: The Relevance of study

The shola forests are unique montane vegetations occupying temperate habitats in tropical latitudes and are regarded as relictual communities. These forests are high altitude gallery forests restricted to valleys, depressions and especially along folds of hills and water courses. The shola forests are of high ecological significance in protecting the headwaters of rivers. They also help in retaining soil moisture and very slow release of rain water. These forests are found extensively along the High Ranges of Kerala and the Nilgiri Plateaus in Tamil Nadu.

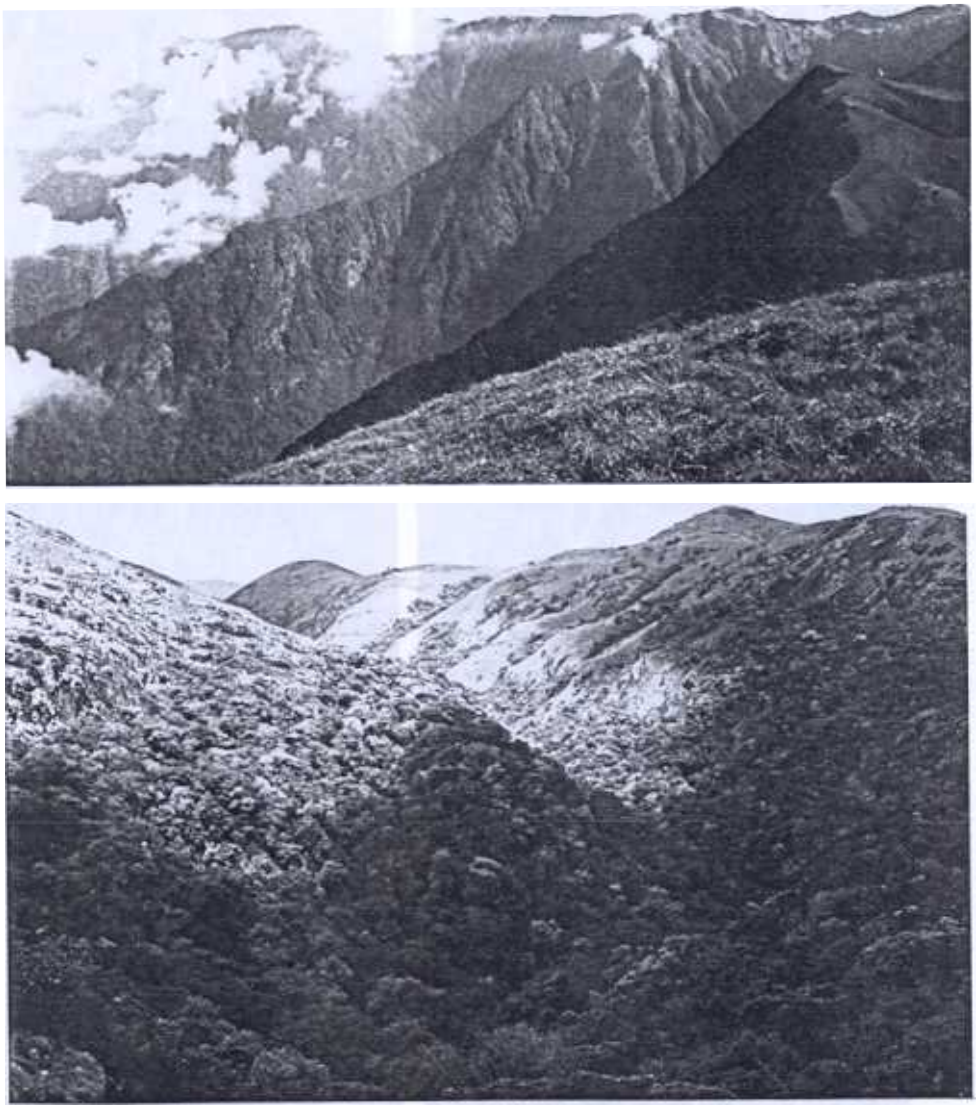
Only scanty information is available on the flora, diversity, vegetation structure and dynamics of the shola forests. The present study is intended to fill this information gap. Thus, the specific objectives of the project were:

I. To make a floristic account of the shola forests, by concentrating the studies in the Idukki District, especially Mannavan shola and Eravikulam.

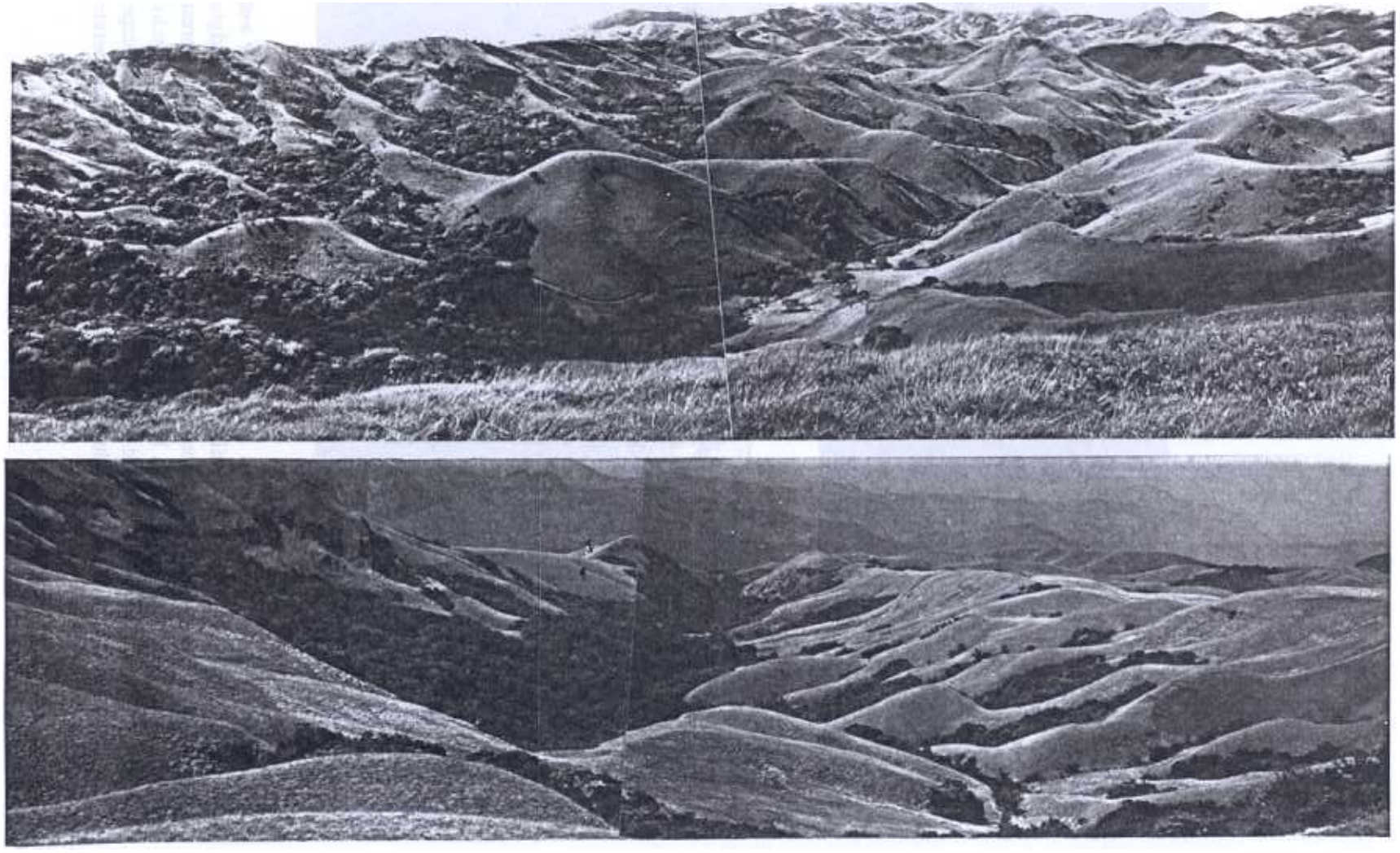
2. To generate structural and phytosociologic information on these forests including stocking, floristic diversity, altitudinal specificities in species distribution, diameter distribution, etc.

3. To make observations on the regeneration patterns of the tree species in the shola forests.

Three major aspects studied were: (1). floristic, (2). community ecological, and (3). regeneration ecology.



Figures 1.1 & 1.2 Landscapes showing the gradual transformation of wet evergreen forests to subtropical hill forests and montane forests. **Fig. 1.1** Ridges of the New Amarambalam forests, clothed with luxurious evergreen forest vegetation and the hill tops with high altitude grasslands (in which the patchy wet montane forests are sprinkled; not seen in the picture). **Fig. 1.2** Landscape of the subtropical hill forests gradually merging with the montane wet temperate forests.



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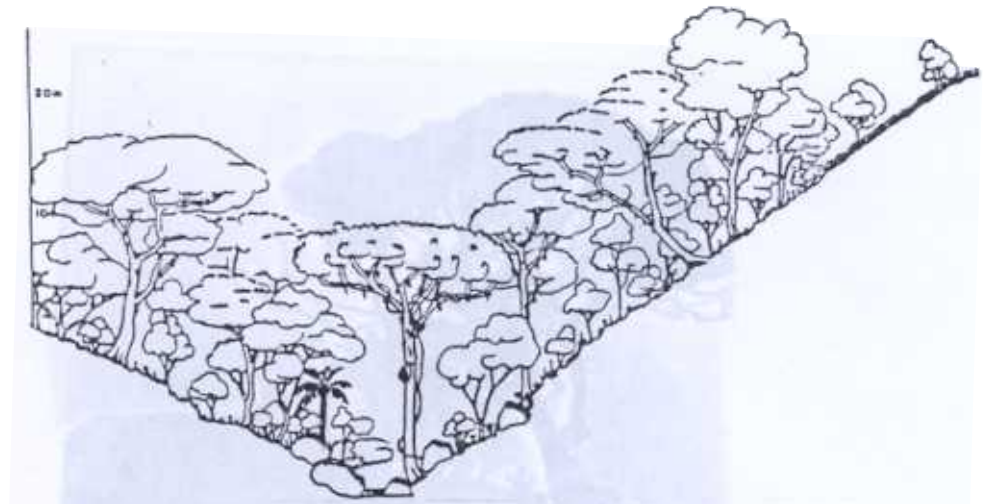


Figures 1.5 & 1.6 Two profiles of montane wet temperate shola forests. The stands are generally less than 15 m tall, and occupy depressions between the hillocks. **Fig. 1.6** A macroscopic view of the profile as in nature.

Figures 1.7 & 1.8 Pictures showing stunted trees of the sholas. The stands in the montane hill forests hardly grow over 15 m height and many tree species, the stems are characteristically crooked, as in Figure **1.8**.

Chapter 2

STUDY AREA

2.1 Introduction

The shola forests as redefined by Meher-Homji (1986) includes forest vegetations of the Peninsular India, growing above 1,500 m asl approximately. In terms of this broader definition, shola forests are found all along the upper reaches of the Western Ghats, where the elevation goes beyond 1,500m asl. The relief of the Western Ghats however is not uniform throughout its entire length and hence the distribution of the shola forests.

The Western Ghats reaches the highest points at Anamudi (2,695 m asl; Kerala) the highest point south of the Himalayas, and Dodabetta in Nilgiris (2,638 m asl; Tamilnadu). It is a natural law that the height of the mountain peak could only be proportionate to the basal area supporting it. Tuning to this law, the High Ranges in Kerala, together with the Pulney Hills and the Kodaikanal on the Tamilnadu side (Anamalais), form an elevated plateau supporting the Anamudi, south of the Palakkad gap and the Nilgiris plateau supporting the Dodabetta peak, north of the Palakkad gap. These are the two plateau regions of the Western Ghats supporting shola forests profoundly (Chandrasekharan, 1962a; Champion and Seth, 1968). In addition, as already mentioned, smaller extents of shola forests are met along the crests and on either side of the crests all along the Western Ghats, depending on the relief features.

The present studies, as already mentioned elsewhere, comprise of three components: 1. floristic studies 2. community ecological studies and 3. regeneration ecological studies. The studies were mainly focused at two locations (Fig. 2.1): 1. The Mannavan shola, where a preponderance of *'subtropical hill forests'* is met with, and 2. The Eravikulam National Park, where the counter component of the shola forests, the *'montane wet temperate forests'* are the characteristic wooded vegetation. Both the locations fall within the Munnar Division of Idukki District. Kerala State.

2.2 The Mannavan Shola

2.2.1 Physiography: The Mannavan Shola (Fig. 2.2) forms the largest shola forest patch in the Kerala State, with an approximate size of 5.18 km2. This forest patch is situated in the Idukki District, falling within the Marayur Forest Range of Munnar Division. The shola is located within 10° 10' 00" to 10° 12' 18" N latitudes and 77° 09' 50" to 77° 12' 18" E longitudes. The altitude ranges between 1,600-2,400 m asl. The forest is seen as a continuous patch from 1,600 upto 2,100 m asl, above which it is seen as small patches (in Idlimottai region) dispersed among the grasslands.

Three other major sholas, *Pambadam Shola* (Half a square mile), *Pullaradi Shola* (400 acres) (both in Vattavada Beat) and *Idivara Shola* (150 acres) lie adjacent to the Mannavan Shola.

2.2.2 Climate: The area receives both South West and North East monsoon, the South West being the prominent one. The average annual rainfall ranges between 2,000-3.000 The

coldest months are December and January when the minimum temperature goes down upto 5°-6°C even at lower elevations. There are 4-5 dry months, spanning between December and April.

The average minimum temperature of the coldest month (January) is 9°C (mean for 10 days in the permanent plot). The minimum temperature in the patchy shola forests (ca. 2,100 m asl) may go down to a 3-5°C down than this, but never reaches O°C inside the forests.

2.2.3 Vegetation: The vegetation comprises mostly of *Southern Subtropical Hill Forests* which gradually transform to the *Southern Montane Wet Temperare Forests* (Champion and Seth, 1968) towards the top (Idlimottai regions). Both these forest types are now considered under a single category, *Tropical Montane Forests* (Meher Homji, 1986, 1989).

2.2.4 Habitations: There is a Muthuva tribal colony at Gudalar situated along the north western borders of Mannavan Shola and another at Kulachivayal situated to the north of the Shola. Three other colonies namely, Perumala, Puthur and Kanthallur, inhabited mainly by Tamilian people are also situated on the outskirts of the Shola.

Some areas in the Mannavan Shola were given on lease for establishing housing colonies during 1960s. This is evidenced by remnances of a number of foundations of houses, presence of the planted economic species like orange, apple, *etc,* in the Perumala, Kalipettumala and Thalachor Kadavu regions of the shola. The habitations were later translocated to other areas by a court order.

About seven kilometers of the Kanthalloor-Sethu Parvathipurarn (SP Puram) road traverses the shola and hence the accessibility is good.

The right of way to Devikulam (via. Kanthalloor-Sethu Parvathipuram road), the right of water and the right of cutting small timber for agricultural purposes are the claims admitted to the local people. The people of Perumala, Kanthalloor, Puthur are wholly dependent on Mannavan shola for firewood, timber, and wood for various agricultural purposes.

2.3 Eravikulam National Park

2.3.1 Physiography: The Eravikulam National Park (Fig. 2.3) situated in the Idukki District at an average elevation of 2,100 m asl, between the latitudes 10°05' to 10°20 N and 77° 00' to 77° 10 E longitudes (Rice, 1984). Peaked by Anamudi (2,695 m), the highest peak in South India, the Eravikulam National Park can be considered the literal roof of the Western Ghats. On the north, it is bordered by the Anamalai Sanctuary (Tamilnadu) and south by the the Tata Tea Estates and the west by the Malayattur Forest Division and in east by the Chinnar Wildlife Sanctuary and the Munnar Forest Division (Fig. 2.3).

2.3.2 Geology and soil: The rock formations in the region have been dated to the Archean igneous series consisting of gneiss with minerals like silica, feldspars, muscovite, biotite etc. *(cf.* Karunakaran *et al.,* 1997). The soils are basically loam, acidic and with high contents of organic carbon (often in the form of peat in grasslands) and nitrogen.

2.3.3 Climate: The heavy rainfall received by the region averages to a quantum of over 5,200 mm per annum. This pluvial quantum is contributed by SW and NE monsoons but remains unimodal in a graphic representation (Fig. 2.4). The high rainfall swathed with fog and chilly

winds make the rainy season very hostile. The elevated position of the Park (average 2,000 m) has a remarkable influence on the atmospheric temperature, the thermometer readings being pushed down to a cooler climate compared to the valleys and downs.

The absolute diurnal temperature oscillates between -3 to 27° C. The mean maximum temperature is found to be 15.3° C, and the mean minimum -3°C (Rice, 1984). January is the coldest month and May, the warmest.

2.3.4 Vegetation: The Park landscape is a refugium of various plant and animal lifescapes of higher elevations in the peninsula and the patchy montane forests and the vast panoramic expanses of high elevational grasslands. In addition, the park also subtends smaller extents of subtropical hill forests in some portions of the foot hills where the elevation is low. A vegetal map of the park is also available (Menon, 1997).

2.3.5 Animals: The Nilgiri tahr *(Hemitragus hylocrius),* a highly endangered animal, inhabits the grasslands in the Park (Figs. 2.5 & 2.6) and the major objective of the park is the conservation of tahr populations.

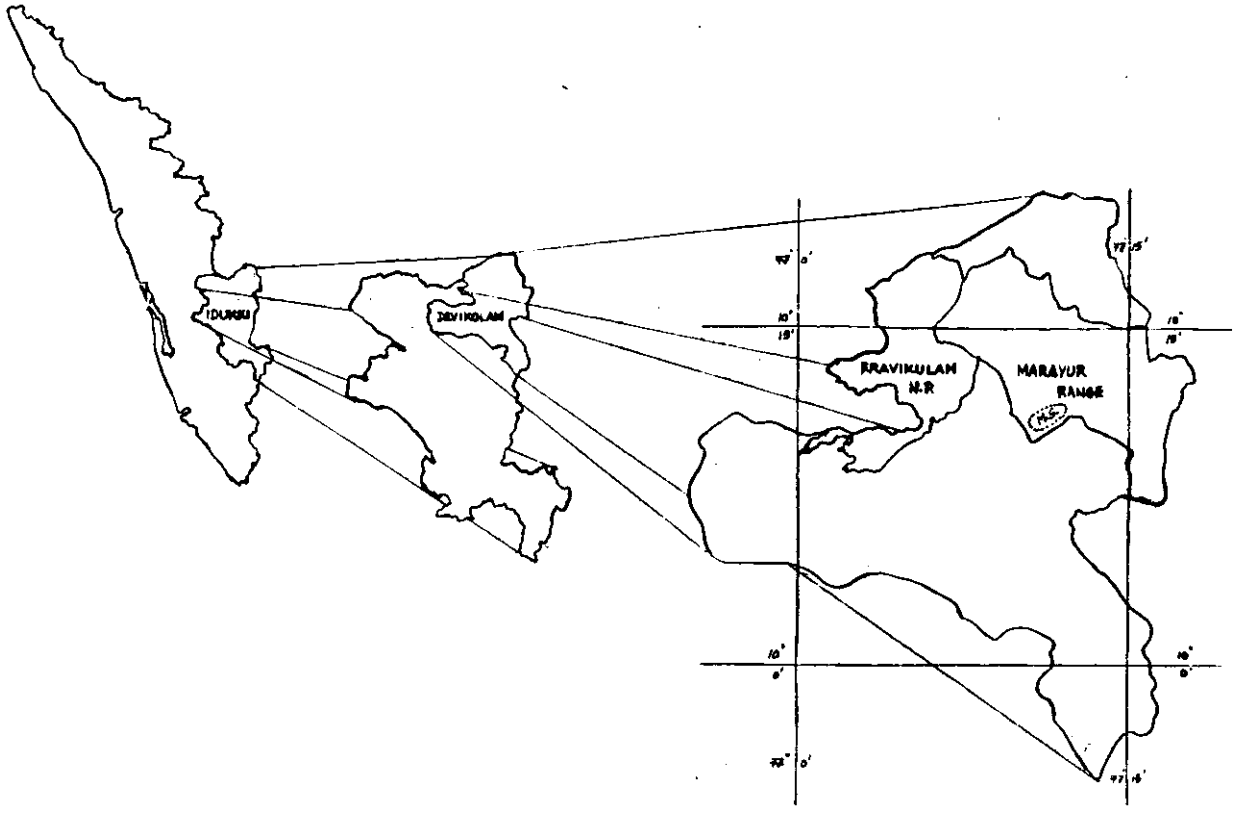
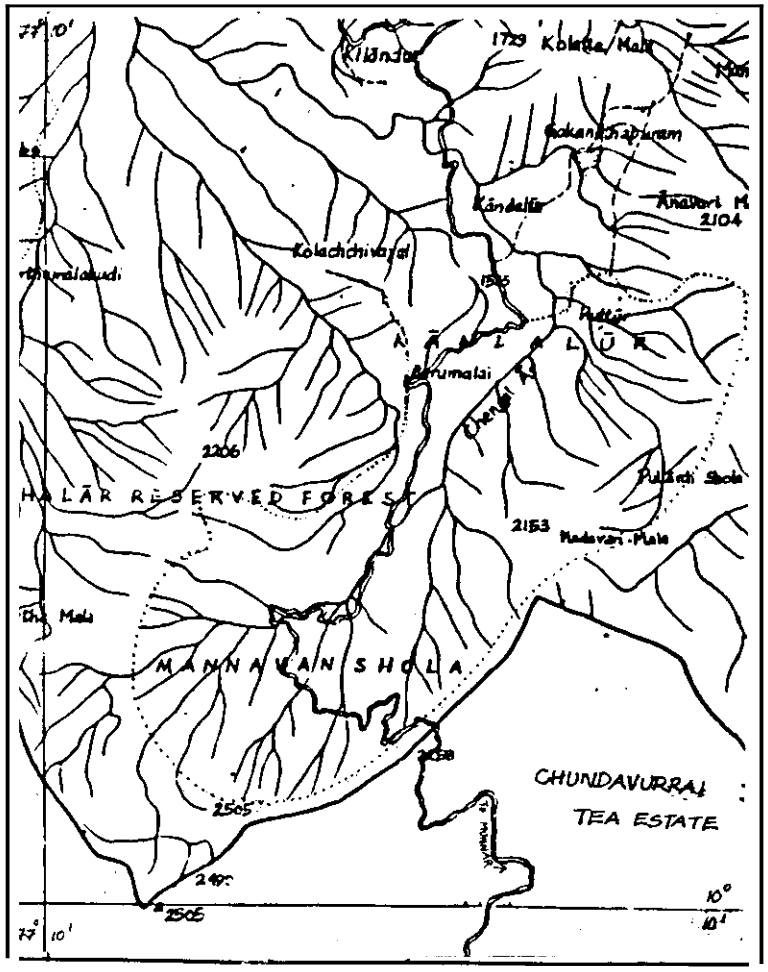


Figure 2.1 Map of Kerala showing the study areas. Mannavan Shola and Eravikulam National Park are the two areas, associated with the present study. Both the areas fall within the Devicolam Taluk of Idukki District. Mannavan Shola occupies the downward triangular projection of the Marayur Range.



Figures 2.2 Slightly enlarged map of Mannavan Shola.

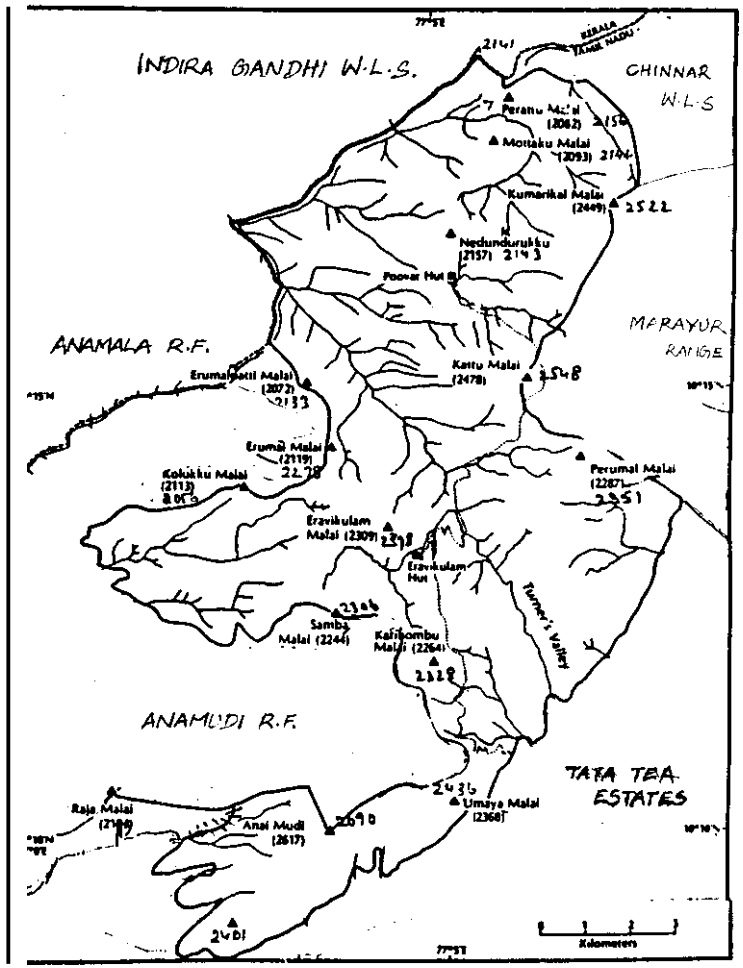


Figure 2.3 Map of Eravikulam National Park and the surrounding regions.

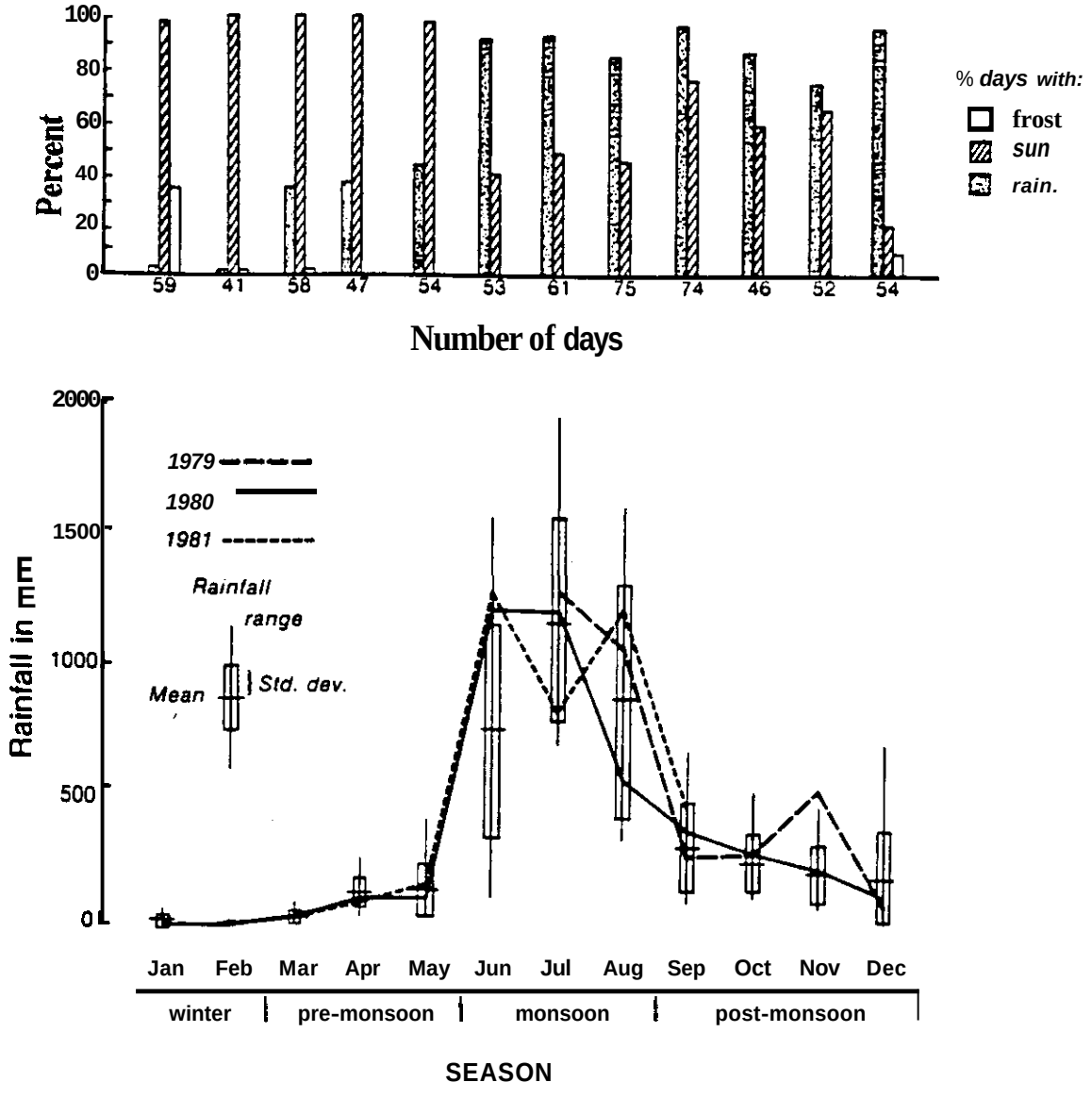
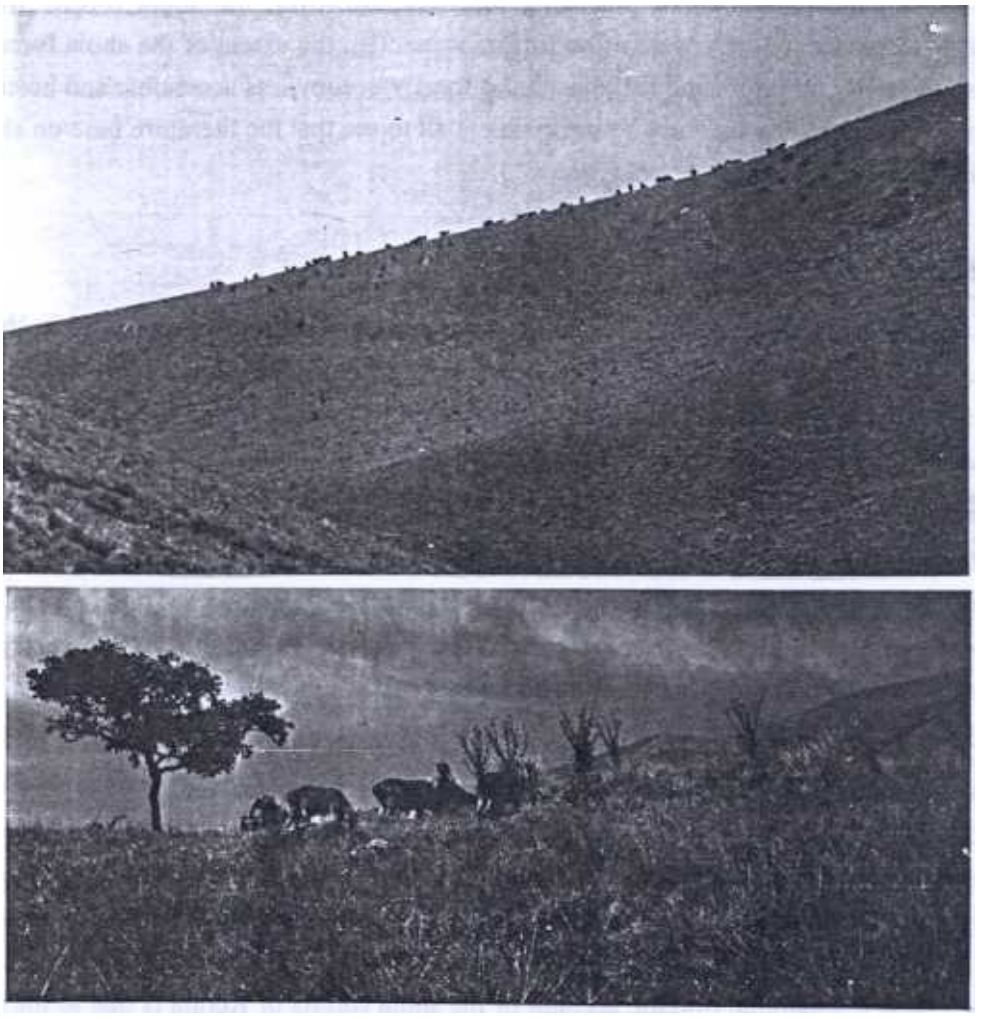


Figure 2.4 Climatic parameters for Vaguvarai near Eravikulam National Park (Reproduced from Rice, 1984).



Figures 2.5 & 2.6 Two views of the tahr herds from the Eravikulam National Park. Tahr is an endangered animal and forms the main attraction of the Eravikulam NP, besides the rolling grasslands, the patchy shola forests, and the chill climate.

Chapter 3

FLORISTIC STUDIES

3.1 Introduction

For most vegetation types in India, the pioneering botanical studies emerged out of the amature botanical interests of practising foresters. However, the shola forests were largely neglected because: (i) they were of no timber value, (ii). the extent of the shola forests is small and so the study on it too, and (iii). the sholas mostly occupy less accessible and hostile climatic regions. Therefore, it would not be surprising at all to see that the literature base on shola forests is thin, compared to other vegetal types.

3.2 Review of Literature

Limited information on the floristic elements of the shola forests are found in the *Working Plans*, the working documents for Forest Divisions. Much floristic information on the vegetation type is found in a fragmented state in earlier floristic works like Wight's (1835-1853) *Icones Plantarum Indiae Orientalis,* Hooker's (1872-1897) *Flora of British India,* Gamble and Fischer's (1915-1936) ***Flora of the Presidency of Madras,*** and other regional and local Floras.

However, a flora particularly devoted to shola forests is lacking. The conventional taxonomic practice is to study the plants (and animals) of selected geographic areas and are in no way, on the basis of vegetation types. The result is that floras exclusively devoted to individual vegetation types are wanting altogether and a literature search only proves the fact in the context of the shola forests too.

Perhaps the first monographic floristic account on the shola forests was that of Fyson's (1915-1921) *Flora of the Nilgiri and Pulney Hill-tops* and floristic particulars of other kinds of vegetations also occupy much coverage here. The flora and vegetation of the shola forests of the Nilgiris and Pulneys and Kodaikanal in Tamil Nadu were relatively well studied in comparison with that of Kerala (Gupta, 1960a. 1960b, 1962a; Mathew, 1959, 1969; Fyson, 1932; Sharma *et al.,* 1977). A comparable floristic account of the shola forests of Kerala is due to the pioneering studies of Shetty and Vivekananthan (1968, 1970. 1971, 1972, 1973a, 1973b, 1973c 1991), Sebastine and Vivekananthan (1967) and others. In no way, were these treatments intended as floristic monographs of shola forests; but it so happened that shola forests dominated hill stations, which formed the geographic frame of the study areas.

Taxonomic studies are required for assessing the biotic resources and their management in an ecologically and scientifically sound and sustainable way. In this sense, taxonomic studies should precede ecological studies. The scope of floristic accounts of the shola forests of Kerala, focusing exclusively on the vegetation type therefore cannot be over-emphasized.

3.3 Materials and Methods

3.3.1 Area of study: The study was focused exclusively on the two major natural shola forest chunks of the Idukki District: (i) The Mannavan Shola, where a preponderance of the

subtropical hill forests is met with, and (ii) the Eravikulam National Park, where the wooded vegetation is largely composed of montane wet temperate forests. The physiographic and climatic details of the areas are detailed in *Chapter* 2.

3.3.2 Methods: From 1994 onwards regular field trips were organized to Mannavan Shola and Eravikulam National Park and plant collections were made, herbaria prepared and conventional taxonomic studies made by consulting floras, monographs and the regional Herbaria: (i). the Kerala Forest Research Institute Herbarium, Peechi, Thrissur (KFRI), (ii). the Madras Herbarium, Botanical Survey of India, Coimbatore (MH) and (iii) Calicut University Herbarium, Calicut (CALI). All the herbarium specimens are deposited at KFRI.

The results of floristic studies are treated under three sections: (i) floristic analysis, (ii) taxonomic enumeration of species, and (iii) list of endemic and rare species.

Owing to space considerations, the descriptions of taxa in the enumeration part have been kept to a bare minimum. Author citations and selected few synonyms alone have been given. Standard taxonomic works dealing with correct citations, extended lists of synonyms, detailed descriptions, illustrations and identification keys otherwise exist among the regional floras (Gamble and Fischer, 1915-1935; Fyson, 1915-1921; Nair and Henry, 1983; Henry *et al.*, 1987, 1991), and we hope the excessive compression of the taxonomic part does not become an impediment in itself.

3.4 Floristic Analysis

From the shola forests and ecotones of Mannavan Shola and Eravikulam National Park, 543 species belonging to 346 genera and 126 families were collected. These include 463 Angiosperms (377 Dicots and 86 Monocots) and 80 Pteridophyte species (Fig. 3.1).

The Dicots consist of 243 genera under 88 families, while the Monocots count to 59 genera under 24 families. Among the Angiosperms, 110 species are endemic to Western Ghats (89 Dicots and 21 Monocots), while among Pteridophytes, only 4 are endemics. Of the 110 Angiosperm endemics, 7 are infra-specific taxa, while among the Pteridophytes, all the 4 taxa are of infra-specific ones. Rare angiosperms constitute 64 species (49 Dicots and 15 Monocots) while among Pteridophytes, there are 35 species under these category.

Floristic richness in terms of families, genera and species encountered is given in Table 3.1

Among the Pteridophytes, Aspleniaceae is the largest family with 1 genus and 12 species, followed by Polypodiaceae (6/8). Lycopodiaceae (3/7), Dryopteridaceae (3/6), Thelipteridaceae (3/5) and Pteridaceae (1/5).

Among the Dicots, Asteraceae is the largest family, represented by 28 genera and 44 species followed by Fabaceae (17/33), Rubiaceae (15/26), Lamiaceae (6/13) and Balsaminaceae (1/13) and Acanthaceae (7/12). But when the tree species alone is considered Lauraceae showed maximum representation (6/7), followed by Euphorbiaceae (6/6), Rubiaceae (5/5), Myrsinaceae (3/5), Oleaceae (3/5), Myrtaceae *(2/5).* Rosaceae (24) and Elaeocarpaceae (1/4).

Among the Monocots, Poaceae is the largest family with the representation of 20 genera and 25 species followed by Orchidaceae (16/24), Cyperaceae (7/11), and Commelinaceae

Twenty nine families among Angiosperms (25 Dicots and 4 Monocots) and eight among the Pteridophytes are represented by single species in each.

Table 3.1. Floristic richness across in various taxonomic hierarchies

Families	Genera	Species	Families	Genera	Species
Pteridophytes			**Dicots**		
Aspleniaceae	1	12	Asteraceae	28	44
Polypodiaceae	6	8	Fabaceae	17	33
Lycopodiaceae	3	7	Rubiaceae	15	26
Dryopteridaceae	3	6	Lamiaceae	6	13
Thelipteridaceae	3	5	Balsaminaceae	1	13
Pteridaceae	1	5	Acanthaceae	7	12
Families of tree species			**Monocots**		
Lauraceae	6	7	Poaceae	20	25
Euphorbiaceae	6	6	Orchidaceae	16	24
Rubiaceae	5	5	Cyperaceae	7	11
Myrsinaceae	3	5		2	6
Oleaceae	3	5			
Myrtaceae	2	5			
Rosaceae	2	4			
Elaeocarpaceae	1	4			

3.5 Endemic, Rare and Threatened species

Lists of endemic, rare and threatened species of Pteridophytes and Angiosperms are given in tables 3.3 and 3.4 respectively. A numerical summary of the tables 3.3 and 3.4 is given in table 3.2 (also see Fig. 3.2).

Taxonomic	Total species	Endemic species	Rare species	Threatened species
Pteridophytes	80	4	33	8
Angiosperms	463	109	128	26
Total	543	113	161	34

During this taxonomic study, some very rare species could also be collected. *Pimpinella pulneyensis* Gamble (Apiaceae), which was considered as possibly extinct and *Helichrysum perlanigerum* Gamble (Asteraceae) formerly collected from the high altitude grasslands in 1857

Table 3.3 List of Endemic(E), Rare (R) and Threatened(T) Pteridophytes

Family	Species	Status		
Angiopteridaceae	*Angiopteris evecta* (Forst.) Roff.		R	
Aspleniaceae	*Asplenium aethiopicum* (Burm. f.) Becherer		R	
Aspleniaceae	*Asplenium auritum* Swartz		R	
Aspleniaceae	*Asplenium erectum* Bory *ex* Willd.		R	
Aspleniaceae	*Asplenium polyodon* G. Forster		R	
Aspleniaceae	*Asplenium tenuifolium* D. Don		R	
Athyriaceae	*Dryoathyrium boryanum* (Willd.) Ching		R	
Cyatheaceae	*Cyathea crinita* (Hook.) Copel.		R	
Cyatheaceae	*Cyathea nilgirensis* Holttum var. *lobatus* Manickam & Irudayaraj	E	R	
Dryopteridaceae	*Arachnoides aristata* (Forster f.) Tindale		R	T
Dryopteridaceae	*Dryopteris juxtaposita* Christ.		R	
Gleicheniaceae	*Dicranopteris linearis* (Burm.f.) Underwood var. *sebastiana* Panigr. & Dixit	E	R	T
Grammitidaceae	*Ctenopteris subfalcata* (Blume) Kunze		R	
Grammitidaceae	*Grammitis attenuata* Kunze		R	
Hymenophyllaceae	*Trichomanes schmidianum* Zenker *ex* Taschn.		R	
Lomariopsidaceae	*Elaphoglossum stelligerum* Sledge		R	
Lycopodiaceae	*Huperzia ceylanica* (Spring) Trev.		R	
Lycopodiaceae	*Huperzia hamiltonii* (Spring) Trev.		R	
Lycopodiaceae	*Lycopodium japonicum* Thunb.		R	
Ophioglossaceae	*Botrychium daucifolium* Wall.		R	T
Ophioglossaceae	*Botrychium lanuginosum* Wall. *ex* Hook. f. & Grev.		R	T
Polypodiaceae	*Loxogramme chinensis* Ching		R	
Polypodiaceae	*Loxogramme cuspidata* (D. Don) C. Presl.		R	
Polypodiaceae	*Lepisorus amaurolepidus* (Sledge) Bir & Trikha		R	
Psilotaceae	*Psilotum nudum* (L.) P. Beauv.		R	
Pteridaceae	*Pteris argyraea* T. Moore		R	
Pteridaceae	*Pteris confusa* T. *G.* Walker		R	
Pteridaceae	*Pteris cretica* L.		R	
Pteridaceae	*Preris linearis* Poir.		R	
Selaginellaceae	*Selaginella involvens* (Sw.) Spring		R	T
Sinopteridaceae	*Cheilanthes farinosa* (Forsk.) Kaulf.		R	T
Thelypteridaceae	*Pseudocyclosorus ochthodes* (Kurz) Holttum var. *anamalayansis* Manikam *et* Irudayaraj	E	R	T
Thelypteridaceae	*Pseudocyclosorus ochthodes* (Kunze) Holttum var. *palniensis* Manickam et Irudayraj	E	R	T
	Total	4	33	8

and relocated in 1980 (Henry *et al.*, 1978; Nayar and Sastry, 1987; Kunhikrishnan, 1991) was collected from Mannavan Shola.

3.5.1 New records: Two rare Pteridophytes namely, *EIaphoglossum stelligerum* Sledge and *Pleopeltis macrocarpa* (Bory ex Willd.) Kaulf, collected from Mannavan Shola are new records to Kerala (Kumar, 1997). *Sinarundinaria microphylla* (Munro) Chao. & Renv., a dwarf bamboo confined to Bhutan and Khasia hills and considered to be of doubtful occurrence in India 1997) was collected from the grasslands of Eravikulam National Park, and is a new record to Peninsular India (Kumar and Kumar, 1997).

Families	Species	Status		
Acanthaceae	*Andrographis neesiana* Wight var. *neesiana* Clarke	E	R	
Acanthaceae	*Asystasia crispata* Benth.	E	R	
Acanthaceae	*Barleria involucrata* Nees var. *elata* (Dalz.) Clarke	E	R	
Acanthaceae	*Rungia laeta* Clarke	E	R	
Acanthaceae	*Strobilanthes kunthianus* (Nees) T. And. *ex* Benth.	E	R	
Acanthaceae	*Strobilanthes neilgherrensis* Bedd.	E	R	
Apiaceae	*Heracleum sprengelianum* Wight & Arn.	E	R	
Apiaceae	*Pimpinella candolleana* Wight & Arn.	E	R	
Apiaceae	*Pimpinella pulneyensis* Gamble	E	R	T
Apiaceae	*Vanasushava pedata* (Wight) Mukh. & Constance	E	R	T
Asclepiadaceae	*Tylophora mollissima* Wight & Arn.		R	
Asteraceae	*Anaphalis aristata* DC.	E	R	
Asteraceae	*Anaphalis lawii* (Hook. f.) Gamble	E	R	
Asteraceae	*Anaphalis meeboldii* W. W. Smith	E	R	
Asteraceae	*Anaphalis travancorica* W.W. Smith	E	R	
Asteraceae	*Emilia javanica* (Burm. f.) C.Robinson		R	
Asteraceae	*Gynura travancorica* W. W. Smith	E	R	
Asteraceae	*Helichrysum perlanigerum* Gamble	E	R	T
Asteraceae	*Lactuca hastata* DC		R	
Asteraceae	*Notonia walkeri* (Wight) Clarke		R	
Asteraceae	*Phyllocephalum courtallense* (Wight) Narayana		R	
Asteraceae	*Senecio corymbosus* Wall. *ex* DC.		R	
Asteraceae	*Vernonia bourneana* W. W. Smith	E	R	T
Asteraceae	*Vernonia conyzoides* DC.	E	R	
Asteraceae	*Vernonia heynei* Bedd. *ex* Gamble	E	R	T
Asteraceae	*Vernonia peninsularis* (Clarke) Clarke *ex* Hook. f.	E	R	T
Asteraceae	*Vernonia saligna* DC. var. *nilghirensis* Hook. f.	E	R	

Families	Species	Status		
Balanophoraceae	*Balanophora dioica* R. Br.		R	
Balanophoraceae	*Balanophora* sp .		R	
Balsaminaceae	*Impatiens cordata* Wight	E	R	
Balsaminaceae	*Impatiens elegans* Bedd.	E	R	T
Balsaminaceae	*Impatiens goughii* Wight	E	R	T
Balsaminaceae	*Impatiens herbicola* Hook. f.	E	R	
Balsaminaceae	*Impatiens jerdoniae* Wight	E	R	
Balsaminaceae	*Impatiens phoenicea* Bedd.	E	R	T
Balsaminaceae	*Impatiens tangachee* Bedd.	E	R	
Balsaminaceae	*Impatiens uncinata* Wight	E	R	
Balsaminaceae	*Impatiens wightiana* Bedd.	E	R	T
Berberidaceae	*Berberis tinctoria* Lesch.		R	
Berberidaceae	*Mahonia leschenaultii* (Wall. *ex* Wight & Arn.) Takeda	E	R	
Caprifoliaceae	*Viburnum coriaceum* Blume	E	R	
Celastraceae	*Euonymus crenulatus* Wall.	E	R	T
Cucurbitaceae	*Zehneria maysorensis* (Wight & Arn.) Arn.	E	R	
Elaeocarpaceae	*Elaeocarpus munronii* (Wight) Mast.	E	R	T
Elaeocarpaceae	*Elaeocarpus recurvatus* Corner	E	R	T
Euphorbiaceae	*Glochidion neilgherrense* Wight	E	R	
Euphorbiaceae	*Phyllanthus macraei* Muell.-Arg.	E	R	
Fabaceae	*Crotalaria fysonii* Dunn	E	R	
Fabaceae	*Crotalaria leschenaultii* DC.	E	R	
Fabaceae	*Crotalaria ovalifolia* Wall. *ex* Fyson	E	R	
Fabaceae	*Flemingia grahamiana* Wight & Arn.	E	R	
Gentianaceae	*Exacum courtallense* Arn. var. *laxiflorum*	E	R	
Gentianaceae	*Exacum wightianum* Arn.	E	R	
Gentianaceae	*Swertia corymbosa* (Griseb.) Wight *ex* Clarke	E	R	
Gesneriaceae	*Aeschynanthus perrottetii* A. DC.	E	R	
Icacinaceae	*Apodytes dimidiata* E. Meyer *ex* Arn.	E	R	
Lamiaceae	*Leucas hirta* (Heyne *ex* Roth) Spreng.	E	R	
Lamiaceae	*Leucas lamifolia* Desf.	E	R	
Lamiaceae	*Leucas lanceaefolia* Desf.	E	R	
Lamiaceae	***Pogostemon wightii* Benth.**	E	R	
Lauraceae	***Actinodaphne bourdillonii* Gamble**	E	R	
Lauraceae	***Actinodaphne salicina* Meissner**	E	R	
Lauraceae	***Beilschmiedia wightii* (Nees) Benth.**	E	R	
Lauraceae	***Cinnamomum wightii* Meissner**	E	R	
Lauraceae	***Litsea wightiana* (Nees) Hook. f.**	E	R	

Families	Species	Status		
Lauraceae	*Neolitsea fischeri* Gamble	E	R	
Lauraceae	*Neolitsea scrobiculata* (Meissner) Gamble	E	R	
Loranthaceae	*Dendrophthoe memecylifolia* (Wight & Arn.) Danser	E	R	
Loranthaceae	*Helixanthera intermedia* (Wight) Danser	E	R	
Loranthaceae	*Helixanthera obtusata* (Schultes) Danser	E	R	
Melastomataceae	*Medinilla malabarica* Bedd.	E	R	
Melastomataceae	*Osbeckia leschenaultiana* DC.	E	R	
Melastomataceae	*Sonerila speciosa* Zenk.	E	R	
Myrsinaceae	*Ardisia rhomboidea* Wight	E	R	
Myrsinaceae	*Rapanea thwaitesii* Mez.	E	R	T
Myrtaceae	*Syzygium densiflorum* Wall.	E	R	T
Oleaceae	*Ligustrum perrottetii* DC.	E	R	T
Onagraceae	*Circaea alpina* L. ssp. *imaicola* (Asch. & Magn.) Kitamura		R	T
Onagraceae	*Oenothera tetrapetala* Cav.		R	T
Orobanchaceae	*Campbellia cytinoides* Wight	E	R	
Orobanchaceae	*Christisonia bicolor* Grand		R	
Piperaceae	*Piper wightii* Miq.	E	R	
Podostemaceae	*Zeylanidium olivaceum* (Gard.) Engl.		R	
Rosaceae	*Photinia serratifolia* (Desf.) Kalkman		R	
Rubiaceae	*Hedyotis buxifolia* Bedd.	E	R	
Rubiaceae	*Hedyotis stylosa* R. Br. *ex* Wight & Arn.	E	R	
Rubiaceae	*Hedyotis swertioides* Hook. f.	E	R	T
Rubiaceae	*Ixora notoniana* Wall. *ex* G. Don	E	R	
Rubiaceae	*Lasianthus acuminatus* Wight	E	R	
Rubiaceae	*Neanotis monosperma* (Wall. *ex* Wight. & Arn.) W. H. Lewis	E	R	T
Rubiaceae	*Ophiorrhiza grandiflora* Wight	E	R	
Rubiaceae	*Pavetta breviflora* DC.	E	R	
Sapotaceae	*Isonandra candolleana* Wight	E	R	
Scrophulariaceae	*Pedicularis perrottetii* Benth.	E	R	
Symplocaceae	*Symplocos anamalayana* Bedd.	E	R	T
Symplocaceae	*Symplocos macrophylla* Wall. *ex* A. DC. subsp. *rosea* (Bedd.) Nooteb.	E	R	T
Symplocaceae	*Symplocos pendula* Wight		R	
Ternstroemiaceae	*Gordonia obtusa* Wall.	E	R	
Urticaceae	*Pouzolzia wightii* Benn.	E	R	
Valerianaceae	*Valeriana beddomei* Clarke	E	R	T
Valerianaceae	*Valeriana hookeriana* Wight & Arn.	E	R	
Vitaceae	*Tetrastigma leucostaphylum* (Dennst.) Alston	E	R	

Families	Species	Status		
Monocotyledons				
Arecaceae	*Calamus gamblei* Beccari *ex* Beccari & Hook. f.	E	R	
Araceae	*Arisaema attenuatum* Barnes & Fischer	E	R	T
Cyperaceae	*Fimbristylis kingii* Clarke	E	R	
Eriocaulaceae	*Eriocaulon pectinatum* Ruhl.	E	R	
Liliaceae	*Lilium wallichianum* Schultes & Schult. f. var. *neilgherrense* (Wight) Hara	E	R	
Orchidaceae	*Anoectochilus elatus* Lindl.	E	R	
Orchidaceae	*Brachycorythis splendida* Summerh.	E	R	
Orchidaceae	*Bulbophyllum fischeri* Seidenfaden		R	
Orchidaceae	*Cheirostylis flabellata* Wight		R	
Orchidaceae	*Coelogyne mossiae* Rolfe	E	R	
Orchidaceae	*Dendrobium anamalayanum* Chandrabose	E	R	
Orchidaceae	*Eria nana* A. Rich.	E	R	
Orchidaceae	*Eria pseudoclavicaulis* Blatter	E	R	
Orchidaceae	*Habenaria elliptica* Wight	E	R	
Orchidaceae	*Habenaria heyneana* Lindl.	E	R	
Orchidaceae	*Habenaria longicorniculata* Graham	E	R	
Orchidaceae	*Habenaria perrottetiana* A. Rich.		R	
Orchidaceae	*Oberonia chandrasekharanii* Nair *et al*	E	R	
Orchidaceae	*Oberonia sebastiana* Shetty & Vivek.	E	R	
Orchidaceae	*Seidenfadeniella chrysantha* (Alston) Sathish		R	
Poaceae	*Agrostis peninsularis* Hook. f.	E	R	
Poaceae	*Arundinella vaginata* Bor	E	R	
Poaceae	*Sinarundinaria densifolia* (Munro) Chao & Renv.	E	R	T
Poaceae	*Sinarundinaria microphylla* (Munro) Chao & Renv.		R	
Poaceae	*Tripogon ananthaswamianus* Sreekumar *et al*	E	R	
Poaceae	*Zenkeria elegans* Trin.	E	R	
Smilacaceae	*Smilax wightii* A. DC.	E	R	T
	Total	109	128	26

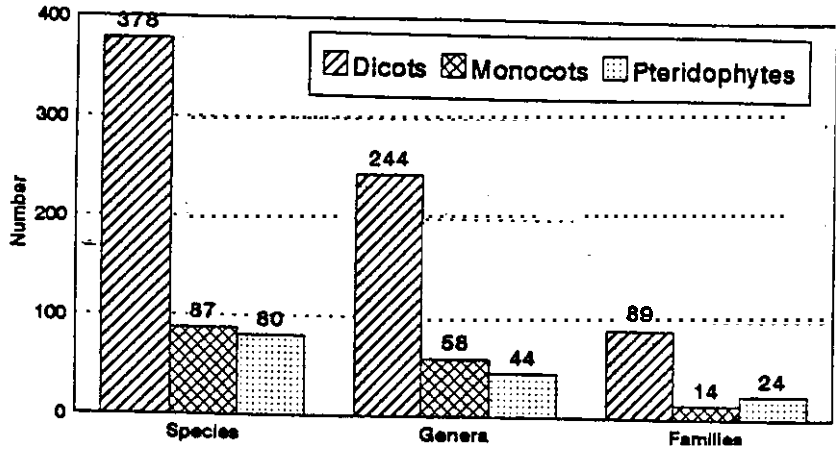


Figure 3.1 Bar diagram showing comparison of number of Species, Genera and Families represented across different taxonomic groups.

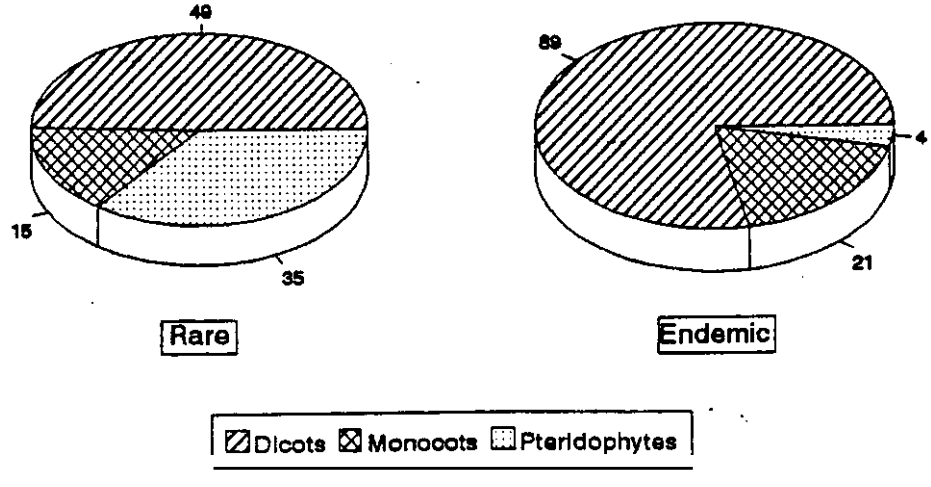


Figure 3.2 Pie diagram showing representation of Rare and Endemic species across different taxonomic groups.

3.6 Enumeration of species

3.6.1 PTERIDOPHYTES

ADIANTACEAE

Adiantum raddianum Presl

A. cuneatum Langsd. & Fischer

Terrestrial herbs with black stipes and tripinnate fronds.

Common, mostly along roadsides at lower altitudes in Mannavan Shola and Eravikulam

ANGIOPTERIDACEAE

Angiopteris evecta (Forst.) Hoff.

Polypodium evectum Forst.

Terrestrial herbs with massive stem and bipinnate fronds.

Occasional, along shaded stream banks in Mannavan Shola and Eravikulam

ASPLENIACEAE

Asplenium aethiopicum (Bum. f.) Becherer

Trichomanes aethiopicum Burm. f.; ***Asplenium furcatum*** Thumb.;

A. laserpitiifolium sensu Bedd.

Epiphytic herbs with hairy stipe and bipinnate fronds.

Rare, along shola margins and road sides in Mannavan Shola and Eravikulam.

Asplenium auritum Sw.

Epiphytic or lithophytic herbs with bipinnate or bipinnatifid fronds

Rare, along stream sides in Mannavan Shola.

Asplenium decrescens Kunze

A. contiguum sensu T. Moore; ***A. caudatum*** sensu Hook.

Epiphytic or lithophytic herbs. Stipes grooved above and rounded below, fronds simple pinnate.

Occasional, along stream banks in Mannavan Shola.

Asplenium erectum Bory ex Willd.

A. brasiliensis sensu Bedd.; ***A. lunulatum*** var. ***camptorachis*** (Kunze) Bedd.;

A. lunulatum var. ***erectum*** (Bory ex Willd.) Sm.

Small epiphytic herbs with tufted stipes and simple pinnate decrescent fronds

Rare, in shaded interior forests in Mannavan Shola.

Asplenium formosum Willd.

Terrestrial or lithophytic herbs with tufted stipes, fronds simple pinnate, decrescent.

Rare. in shaded interior forests in Mannavan Shola.

Asplenium inaequilaterale Willd.

A. trapeziforme sensu Bedd., non Roxb.; *A. lunulatum* var. *trapeziforme* Bedd.

Terrestrial herbs with erect or suberect rhizome, stipes grooved above and rounded below, fronds simple pinnate.

Very common, in shaded interior forests in Mannavan Shola.

Asplenium normale D. Don

A. minus Blume; *A. multijrigum* Wall.; *A. opacrrm* Kunze

Terrestrial herbs. Rhizome erect, fronds simply pinnate.

Very common, in moist places in Mannavan Shola.

Asplenium pnlyndnn G. Forst.

A. falcatum Lam; *Trichomanes adiantoides* L.; *Tarachia falcata* (Lam.) *C*. Presl

Epiphytic or lithophytic herbs. Rhizome erect, stipe grooved, rounded below, fronds simple pinnate.

Rare, along road sides in Mannavan Shola.

Asplenium pnlyndnn G. Forst. var. **bipinnatum** (Sledge) Sledge

A. falcatum var. *bipinnatum* Sledge; *A. mysorense* Roth;

Tarachia furcata var. *platyphylla C*. Presl

Epiphytic herbs with suberect rhizomes, stipes grooved above, fronds bipinnate

Rare, along road sides in Mannavan Shola.

Asplenium tenuifolium D. Don

Small terrestrial or lithophytic herbs with light green stipes and tripinnate fronds

Rare, in moist localities or as lithophytes in shady regions in Mannavan Shola.

Asplenium unilaterale Lam.

A. resectum Sm.; *A. trapeziforme* Wall. ex Roxb.; *A. erythrocaulon* Blume

Terrestrial herbs with creeping rhizome, stipes scattered, grooved above, fronds simple pinnate.

Common, along stream banks in Mannavan Shola.

Asplenium zenkeranum Kunze

A. persicifolium var. *latifolium* Hook.

Terrestrial or lithophytic herbs. Rhizome thick, stipes grooved above, fronds simple pinnate.

Rare, along shaded stream banks and interior forests in Mannavan Shola.

ATHYRIACEAE

Athyrium snlennpteris (Kunze) T. Moore

Allantodia solenopteris Kunze; *Asplenium ceylanense* Klotsch:

A. solenopteris (Kunze) Mett.

Terrestrial herbs. Rhizome erect, stipes grooved above, fronds bipinnate or subtripinnate.

Occasional, along road sides in Mannavan Shola.

Deparia petersenii (Kunze) M. Kato

Lunathyrium japonicum (Thunb.) Kurata; ***Asplenium japonicum*** Thunb.;
Diplazium japonicum (Thunb.) Bedd.

Terrestrial herbs found along stream banks and roadsides. Rhizome long creeping, stipes grooved above, fronds simple pinnate.

Fairly common, along road sides in Mannavan Shola.

Diplazium esculentum (Retz.) Sw.

Hemionitis esculenta Retz.; ***Asplenium esculentum*** (Retz.) Presl;
Anisogonium esculentum (Retz.) ***C.*** Presl

Terrestrial herbs. Rhizome erect, stipes tufted, fronds bipinnate.

Very common, along road sides and stream sides in Mannavan Shola and Eravikulam.

Dryoathyrium boryanum (Willd.) Ching

Aspidium boryanum Willd.; ***A. divisum*** Wall.; ***Lastrea boryana*** (Willd.) T. Moore

Terrestrial herbs. Rhizome suberect, stipes grooved above, fronds tripinnatifid.

Rare, along road sides in Mannavan Shola.

BLECHNACEAE

Blechnum orientale L.

Terrestrial herbs. Rhizome massive, fronds simple pinnate

Rare, in grassland ecotones in Eravikulam.

CYATHEACEAE

Cyathea crinita (Hook.) Copel

Alsophila crinita Hook.

Tree ferns. Trunk 5-8 m high, bearing leaf bases, young and mature fronds yellow, stipes spiny and swollen at base, lamina bipinnate.

Rare, along road sides and stream sides in Mannavan Shola.

Cyathea nilginensis Holttum var. **nilginensis**

Alsophila latebrosa Hook. var. ***schmidiana*** Kunze; ***A. latebrosa*** Hook.

Tree ferns. Trunk about ***2*** m high. Stipes brown hairy, swollen at base; lamina bipinnate.

Common, along stream sides and road sides in Mannavan Shola and Eravikulam.

Cyathea nilginensis Holttum var. **lobatus** Manickam & Irudayaraj

Tree ferns. A variety of the former with bipinnatifid lamina.

Rare, along stream sides in Mannavan Shola.

DENNSTAEDTIACEAE

Microlepia speluncae (L.) Moore

Polypodium speluncae L.; ***Microlepia speluncae*** var. ***hirta*** Bedd.

Terrestrial herbs. Rhizome long creeping. Stipes scattered, grooved above, fronds tripinnatifid or quadripinnate.

Common, along roadsides in Mannavan Shola.

Odontosoria chinensis (L.) J. Sm.

Sphenomeris chinensis (L.) Maxon; ***Trichomanes chinense*** L.;

Adiantum chinense (L.) Burm.

Terrestrial herbs. Rhizome short creeping, stipes scattered, fronds tripinnatifid or quadripinnate.

Very common, along road cuttings in Mannavan Shola and Eravikulam.

Pteridium aquilinum (L.) Kuhn

Preris aquilina L.

Terrestrial herbs. Rhizome long creeping, stipes scattered, fronds tripinnatifid at base, becoming bipinnatifid towards apex.

Very common, gregarious along grassy slopes, ecotones and road sides in Mannavan Shola and Eravikulam.

DRYOPTERIDACEAE

Arachniodes aristata (Forst. f.) Tindale

Polypodium aristatum Forst. f.; ***Polystichum aristatum*** Presl;

Lastrea aristata (Forst. f.) T. Moore

Terrestrial herbs. Rhizome long creeping, stipes scattered, fronds tripinnate at base, bipinnatifid or bipinnate above.

Rare, along stream banks or roadsides in Mannavan Shola and Eravikulam.

Arachniodes tripinnata (Goldm.) Sledge

Polystichum tripinnatum Goldm.; ***Lastrea coniifolia*** Bedd.; ***Polystichum corvifolium*** C. Chr,

Terrestrial herbs. Rhizome erect, stipes tufted, fronds tripinnatifid.

Common, in interior forests and along road sides in Mannavan Shola and Eravikulam.

Dryopteris hirtipes (Blume) Kuntze

Aspidium hirtipes Blume; ***A. atratum*** Wall.; ***Lastrea hirtipes*** (Blume) T. Moore

Terrestrial herbs with erect rhizome. Stipes tufted; lamina simple pinnate.

Common, along ecotones and road sides in Mannavan Shola.

Dryopteris juxtaposita Christ

Lastrea odontoloma T. Moore; ***Nephridiumfilix-mas*** var. ***normalis*** C. B. Clarke;

Aspidiumfilix-mas var. ***normalis (C.*** B. Clarke) Christ

Terrestrial herbs with suberect rhizome. Stipes tufted, fronds bipinnate.

Rare, along road sides and ecotones in Mannavan Shola.

Dryopteris sparsa (Buch.-Ham. ex D. Don) Kuntze

Nephrodium sparsum Buch.-Ham. ex D. Don;

Aspidium sparsum (Buch.-Ham. ex D. Don) Sprengel;

Lastrea sparsa (Buch.-Ham. ex D. Don) T. Moore

Terrestrial herbs, with erect rhizome. Fronds bipinnatifid.

Fairly common, along stream banks in Mannavan Shola.

Polystichum harpophyllum (Zenker ***ex*** Kunze) Sledge

Polypodium harpophyllum Zenker ***ex*** Kunze

Terrestrial herbs with erect or suberect rhizome. Stipes tufted, grooved above, fronds simple pinnate.

Common, along road sides in Mannavan Shola and Eravikulam.

GLEICHENIACEAE

Dicranopteris linearis (Burm. f.) Underwood var. **sebastiana** Panigrahi & Dixit

Terrestrial herbs with scattered stipe. Primary branches of the frond forked 3 or 4 times.

Rare, along road sides in Mannavan Shola.

GRAMMITIDACEAE

Ctenopteris subfalcata (Blume) Kunze

Polypodium subfalcatum Blume; ***P. subminutum*** Alderw. van Rosenb.;

Ctenopteris subminuta (Alderw. van Rosenb.) Holttum

Epiphytic herbs with erect rhizome. Stipes tufted, fronds pinnatifid.

Rare, in interior forests mostly at lower altitudes in Mannavan Shola.

Grammitis attenuata Kunze

Polypodium parasiticum Mett.; ***Grammitis beddomeana*** Copel.

Epiphytic herbs with short creeping rhizome. Stipes crowded, fronds simple.

Rare, along shola margins and ecotones in Mannavan Shola and Eravikulam.

HEMIONITIDACEAE

Hemionitis arifolia (Burm.) Moore

Asplenium arifolium Burm.; ***Hemionitis cordifolia*** Roxb. ***ex*** Bedd.

Terrestrial or lithophytic herbs. Rhizome creeping when mature, stipes compact, fronds simple cordate; dimorphic; fertile ones deltoid, trilobed.

Occasional, along stream banks and ecotones in Mannavan Shola.

HYMENOPHYLLACEAE

Trichomanes proliferum Blume

Gonocormous prolifer (Blume) Prantl.; ***Trichomanes subpinnatifidum*** v. d. B.; ***Gonocormous diffusus*** (Blume) v. d. B.

Epiphytic herbs with long creeping rhizome. Stipes scattered, fronds proliferate, pinnately or flabellately divided.

Fairly common, in interior forests in Mannavan Shola.

Trichomanes plicatum (v.d.B.) Bedd.

Didymoglossum plicatum v. d. B.

Crepidomanes plicatum (v. d. B.) Ching; ***Didymoglossum latealatum*** v. d. B.;

Epiphytic herbs with long creeping rhizome. Stipes flattened, winged, fronds tripinnatifid with numerous false veins.

Very common, in interior forests in Mannavan Shola and Eravikulam.

Trichomanes schmidiannm Zenker ***ex*** Taschn.

Vandenboschia schmidiana (Zenker) Copel.;

Crepidomanes schmidianum (Zenker ***ex*** Taschn.) Iwatsuki; *Trichomanes latifrons* v.d. B.

Epiphytic herbs with long creeping rhizome. Stipes flattened, narrowly winged, fronds bipinnatifid, false veins absent.

Rare, in interior forests in Mannavan Shola.

LINDSAEACEAE

Lindsaea odorata Roxb. *ex* Griffith

Adianrum cultratum Willd.; *Lindsaea cultrata* (Willd.) Sw.; *L. lobbiana* Hook.

Terrestrial or lithophytic herbs. Stipes scattered, grooved above, fronds simple pinnate.

Common, along fully shaded stream banks in Mannavan Shola and Eravikulam.

LOMARIOPSIDACEAE

Elaphoglossum stelligerum (Wall. *ex* Baker) T. Moore ***ex*** Alston & Bonner

Acrostichum stelligerum Wall. ex Baker; *A. neriifolium* Wall.

Epiphytic or lithophytic herbs with short creeping rhizome. Stipes crowded. fronds simple.

Very rare, along shola margins and ecotones in Mannavan Shola.

LYCOPODIACEAE

Huperzia ceylanica (Spring) Trev.

Lycopodium ceylanicum Spring

Small epiphytic herbs with erect stem. Sporangia not borne on distinct cones but on unreduced leaves indistinct from vegetative leaves.

Very rare, along shola margins in Eravikulam.

Huperzia hamiltonii (Spring) Trev.

Lycopodium hamilronii Spring; *Phlegmariurus hamiltonii* (Spring) Sen & Sen;

Lycopodium obrnsijolium Buch.-Ham.

Small epiphytic herbs with pendulous isodichotomously branched tufted stem, leaves numerous spirally arranged and spreading, sporangia not borne on cones.

Rare, in shola margins in Mannavan Shola and Eravikulam.

Huperzia hilliana (Nessel) Holub

Urostachys hillianus Nessel

Small, epiphytic and pendent herbs with tufted stem. Leaves numerous, spirally arranged, but adnate, ascending. Sporangia not borne on cones.

Occasional, in shola margins and ecotones in Mannavan Shola and Eravikulam.

Huperzia phyllantha (Hook. &Arn.) Holub.

Lycopodium phyllanthum Hook. & Arn.; *Phlegmariurus phyllanthum* (Hook. & Arn.) Dixit

Epiphytic herbs with pendulous stem. Leaves spreading, in six vertical rows, sporangia borne on distinct terminal branched cones.

Rare, along shola margins at lower altitudes in Mannavan Shola.

Lycopodiella cernua (L.) Pic. Ser.

Lycopodium cernum L.; ***L. capillaceum*** Willd.; ***Palhinhaea cemua*** (L.) Franco & Vasc.

Terrestrial branching herbs. Leaves sparse on main stem, dense on rest, cones terminal on the ultimate branches.

Occasional, along road sides in Mannavan Shola and Eravikulam.

Lycopodium japonicum Thunb.

L. clavatum sensu Clarke

Terrestrial herbs with prostrate stem branching aniso-dichotomously, Leaves spirally arranged, ascending, overlapping, cones borne on ultimate branches.

Very rare, found as felts along roadsides in Mannavan Shola.

Lycopodium wightianum Wall. ***ex*** Hook. & Grev.

Diphasiastrum wightianum (Wall. ***ex*** Hook. & Grev.) Holub

Terrestrial herbs with prostrate stem. Leaves dense on ultimate branchlets, sparse on other parts, cones borne on ultimate branches, pedunculate.

Common, along roadsides as felts in higher altitudes in Mannavan Shola and Eravikulam.

OLEANDRACEAE

Nephrolepis auriculata (L.) Trimen

Polypodium auriculatum L.; ***Nephrolepis cordifolia*** (L.) Presl; ***Polypodium cordifolium*** L.

Epiphytic or lithophytic herbs with tuberous roots. Rhizome erect, stipes tufted, fronds simple pinnate, pinna sessile.

Very common, in interior forests and along stream banks in Mannavan Shola and Eravikulam.

OPHIOGLOSSACEAE

Botrychium daucifolium Wall.

Botrychium subscarnosum (Wall. ex Hook. & Grev.) Lyon; ***B. subscarnosum*** Wall. ex Bedd.

Terrestrial herbs with erect rhizome and fleshy roots. Sterile stalk 3 branched, bearing bipinnatifid fronds, spike arising below the sterile blade.

Rare, in shaded moist forest floors in Mannavan Shola and Eravikulam.

Botrychium lanuginosum Wall. ex Hook. & Grev.

Botrypus lanuginosum (Wall. ex Hook. & Grev.) Ching;

Botrychium virginianum (L.) Sw. var. ***lanuginosum*** Bedd.; ***B. yunnanense*** Ching

Terrestrial herbs with erect rhizome, 3 primary sterile branches with bipinnatifid or tripinnatifid branching, spike arising from the rachis of sterile blade.

Very rare, in interior forests or grassland ecotones in Mannavan Shola and Eravikulam.

POLYPODIACEAE

Crypsinus montanus Sledge

Pleopeltis *oxyloba* Bedd.; ***P. hastata*** Bedd.; ***Phymatodes oxyloba*** (Wall. ***ex*** Kunze) Presl

Epiphytic or lithophytic herbs with long creeping rhizome, scattered stipe, grooved above, fronds pinnatifid.

Occasional, mostly found along shola margins in Mannavan Shola and Eravikulam.

Lepisorus amaurolepidus (Sledge) Bir & Trikha

Pleopeltis amaurolepida Sledge; *Polypodium gladiatum* Wall.

Lithophytic or epiphytic herbs. Rhizome short, creeping, stipes crowded, fronds simple, sori superficial.

Very rare, along shola margins and road sides in Mannavan Shola and Eravikulam.

Lepisorus nudus (Hook.) Ching

Pleopeltis nuda Hook; *P. linearis* Bedd.; *P. wightiana* Bedd.

Epiphytic or lithophytic herbs. Rhizome long creeping, stipes scattered, grooved above, fronds simple, son superficial.

Very common, along road sides and ecotones in Mannavan Shola and Eravikulam

Leptochilns decurrens Blume forma **lanceolatus**

L. lanceolatus Fee

Terrestrial, epiphytic or lithophytic herbs. Stipes scattered, grooved above. Sterile lamina simple, elliptic-lanceolate.

Common, along shaded stream banks in Mannavan Shola and Eravikulam.

Loxogramme chinensis Ching

L. parallela Copel.; ***L.*** *lanceolata* Presl

Small epiphytic herbs. Rhizome elongated, creeping, stipes scattered, fronds simple, linear-lanceolate.

Very rare, along shola margins and road sides in Mannavan Shola and Eravikulam.

Loxogramme cuspidata (Zenker) Price

Crammitis cuspidata Zenker; ***Loxogramme*** *involuta* (D. Don) *C*. Presl;

Grammitis involuta D. Don

Epiphtytic or lithophytic herbs. Rhizome long creeping, fronds scattered.

Rare, along road sides and shola margins in Mannavan Shola and Eravikulam.

Pleopeltis macrocarpa (Bory ex Willd.) Kaulf

Polypodium macrocarpum Bory ex Willd.; *P. lanceolatum* L.; *P. marginata* Bory ex Willd.

Epiphytic or lithophytic herbs. Rhizome long, creeping, densely covered by scales, stipes scattered, fronds simple, monomorphic.

Very rare, along road sides and ecotones at lower altitudes in Mannavan Shola.

Pyrrosia porosa Hovenkamp

Polypodium porosum Wall.; *Niphobolus porosus* Presl; *Cyclophorus porosus* Presl

Lithophytic or epiphytic herbs, Rhizome short, creeping, fronds scattered, simple, monomorphic.

Fairly common, along ecotones road sides in Mannavan Shola and Eravikulam.

PSILOTACEAE

Psilotum nudum (L.) P. Beauv.

Lycopodium nudum L.; *Psilotum triquetrum* Sw.

Terrestrial herbs. Rhizome short creeping, without roots, stems branch dichotomously; leaves absent.

Very rare. in forest ecotones in Mannavan Shola.

PTERIDACEAE

Pteris argyraea T. Moore

P. quadriaurita Retz. var. *argentea* Bedd.

Terrestrial herbs. Rhizome erect, stipes tufted, fronds bipinnate with prominent silvery white band along the costa above.

Rare, along road sides and interior forests in Mannavan Shola and Eravikulam.

Pteris confusa T.G. Walker

Terrestrial herbs with erect rhizome. Fronds bipinnate, pinna lobed almost to the costa

Rare, along roadsides in Mannavan Shola.

Pteris cretica L.

P. stenophylla Hook. & Grev.; *Pycnodoria cretica* (L.) Small

Terrestrial herbs. Rhizome erect, stipes tufted, fronds bipinnate.

Rare, in interior forests along stream banks at higher altitudes in Mannavan Shola.

Pteris linearis Poir.

P. normalis D. Don

Terrestrial herbs. Rhizome erect, fronds bipinnate.

Very rare, along road sides in Mannavan Shola.

Pteris quadriaurita Retz.

Terrestrial herbs. Rhizome suberect or erect, fronds bipinnatifid.

Very common, in interior forests in Mannavan Shola and Eravikulam.

SELAGINELLACEAE

Selaginella brachystachya (Hook. & Grev.) Spring

Lycopodium brachystachyum Hook. & Grev.;

Selaginella brachystachya var. *denticulata* Spring; *S. stolonifera* non Spring, sensu Ferguson

Terrestrial, prostrate herbs. Leaves dimorphic, arranged in 4 rows, sporophylls of spike dimorphic.

Very common, as dense undergrowth in shaded forest floors in Mannavan Shola.

Selaginella delicatula (Desv. ex Poir.) Alston

Lycopodium delicatulum Desv. ex Poir.; *L. flaccidum* Bory; *L. crassicaule* Hook. Grev.

Small terrestrial or lithophytic herbs. Stem erect or suberect, rooting at base, leaves scattered in 4 rows, sporophylls of spike monomorphic.

Common, along roadsides in Mannavan Shola and Eravikulam

Selaginella involvens (Sw.) Spring

Lycopodium involvens Sw.; *Selaginella caulescens* (Wall.) Spring; *Lycopodium caulescens* Wall.

Terrestrial or lithophytic herbs. Stem erect, rooting at base, leaves uniform at the base, sporophylls of cones uniform.

Common, along stream banks in Mannavan Shola.

SINOPTERIDACEAE

Cheilanthes farinosa (Forsk.) Kaulf.

Pteris farinosa Forsk.; *Aleuritopteris farinosa* (Forsk.) Fee; *Cheilanthes pulveracea* Pr.

Terrestrial or lithophytic herbs. Rhizome erect, fronds with silvery crest, indusia with incised margins.

Rare, along shola ecotones and road sides in Eravikulam.

Doryopteris concolor (Langsd. & Fischer) Kuhn

Pteris concolor Langsd. & Fischer; *Pellaea geranifolia* (Reddi) Fee

Terrestrial or lithophytic herbs. Rhizome erect or suberect, stipes tufted, fronds palmately lobed, bipinnatifid.

Rare, along shola margins or roadsides in Mannavan Shola.

Pellaea falcata Bedd.

P. seticaulis (Hook.) Ghosh; *Pteris seticaulis* Hook.; *Platyloma fulcatum* var. ***setosum*** Bedd.

Terrestrial herbs. Rhizome long, creeping, stipes scattered, lamina simple pinnate, pinnules hairy.

Occasional, in interior forests in Mannavan Shola.

THELYPTERIDACEAE

Pseudocyclosorus ochthodes (Kunze) Holttum var. **annamalayensis** Manickam & Irudayaraj

Terrestrial herbs. Rhizome erect, fronds simple pinnate, pubescent all over.

Rare, along roadsides in Mannavan Shola.

Pseudocyclosorus ochthodes (Kunze) Holttum var. **palniensis** Manickam & Irudayaraj

Terrestrial herbs. Rhizome erect or suberect, fronds simple pinnate, glabrous.

Rare, along road sides in Mannavan Shola.

Pseudocyclosorus tylodes (Kunze) Ching

Aspidium tylodes Kunze; *Lastrea tylodes* (Kunze) Moore; *L. ochthodes* var. *tylodes* Bedd.

Terrestrial herbs. Rhizome erect, stipes tufted purple in colour and grooved above, fronds pinnate, glabrous.

Occasional, along roadsides in Mannavan Shola.

Pseudophegopteris pyrrhorhachis (Kunze) Ching

Polypodium pyrrhorhachis Kunze; *P. distans* D.Don; *Lastrea microstegia* Bedd.

Terrestrial herbs. Rhizome short, creeping or suberect, rachis and stipe reddish-brown, fronds bipinnate, with a few pairs of basal pinna slightly reduced.

Rare, along roadsides in Mannavan Shola.

Stenogramma pozoi (Lagasca) K. Iwats

Hemionitis pozoi Lagasca; ***Polypodium tottum*** Willd.; ***Leptogramma totta*** J. Sm.

Terrestrial herbs. Rhizome short creeping, stipes grooved above, fronds simple pinnate.

Occasional, in Mannavan Shola along stream banks.

VITTARIACEAE

Antrophyum plantagineum (Cav.) Kaulf.

Hemionitis plantaginea Cav.; ***Antrophyum reticulatum*** sensu Bedd.

Epiphytic or lithophytic herbs. Rhizome short, creeping, fronds closely arranged, simple with anastamosing veins.

Rare, found in interior forests in Mannavan Shola.

Vittaria elongata Sw.

Pteris graminifolia Roxb. ex Griff.

Epiphytic herbs. Rhizome short, creeping. Fronds simple linear-oblong lanceolate with marginal sori.

Very common, in interior forests at lower altitudes in Mannavan Shola.

3.62 ANGIOSPERMS

3.6.2.1 DICOTYLEDONS

ACANTHACEAE

Andrographis neesiana Wight var. **neesiana** Clarke

Erect herbs.

Fairly common, along stream banks, ecotones and also along road sides in Mannavan Shola.

Asystasia crispata Benth.

Branching herbaceous undershrubs.

Common, along road sides in Mannavan Shola and Eravikulam

Barleria involucrata Nees var. **elata** (Dalz.) Clarke

B. elata Dalz.

Shrubs, upto 2.5 m tall.

Fairly common, along stream banks at lower altitudes in Mannavan Shola and Eravikulam.

japonica (Thunb.) Ellis

Justicia japonica Thunb.

Pubescent branching herbs.

Common, in grasslands in Mannavan Shola,

Rostellularia latispica (Clarke) Bremek.

Justicia procumbens L. var. *latispica* Clarke; *Rostellularia procumbens* sensu Wight; *Justicia latispica* (Clarke) Gamble

Diffuse branching subshrubs with zig-zag branches.

Common, along road sides and shola margins in Mannavan Shola and Eravikulam.

Rostellularia simplex (D. Don) Wight

Justicia simplex D. Don; *Justicia notha* Clarke

Pubescent branching herbs.

Common, along road sides and grassland ecotones in Mannavan Shola and Eravikulam

Rungia laeta Clarke

Shrubs with stout, terete, zig-zag branchlets.

Rare, in open disturbed areas and along road sides in Mannavan Shola and Eravikulam.

Strobilanthes homotropa Nees

Mackenziea homotropa (Nees) Bremek.; S. *sexeenis* Bedd.

Large shrubs with white flowers

Abundant. in the shola interiors in Mannavan Shola and Eravikulam.

Strobilanthes kunthianus (Nees) T. And. ex Benth.

Phlebophyllum kunthianum Nees

Gregarious bushy shrubs.

Very common, on grassy downs and along road sides in Mannavan Shola and Eravikulam.

Strobilanthes luridus Wight

Didyplosandra lurida (Wight) Bremek.

Large straggling shrubs.

Very common, in the interior sholas in Mannavan Shola and Eravikulam

Strobilanthes neilgherrensis Bedd.

Nilgirianthus neilgherrensis (Bedd.) Bremek.

Large shrubs with subtetragonal branches.

Common, along the road sides, ecotones and in the grasslands in Mannavan Shola and Eravikulam.

Thunbergia tomentosa Wall.

Slender climber.

Fairly common, along shola margins and along road sides in Mannavan Shola

AMARANTHACEAE

Allmania nodiflora (L.) R. Br. *ex* Wight

Celosia nodiflora L.; *Allmania albida* (Willd.) R. Br. ex Hook. f.; *Celosia albida* Willd.

Scandent, many branched herbs with stout root stock.

Occasional, in open areas at lower altitudes in Mannavan Shola and Eravikulam.

Achyranthes bidentata Blume

Ascending herbs with woody base.

Occasional, in open areas at lower altitudes in Mannavan Shola and Eravikulam.

APIACEAE

Bupleurum virgatum Wight & Arn.

B. *mucronatum* var. *virgatum* (Wight & Am.) Clarke

Tall erect herbs.

Common, in the ecotones and grasslands in Mannavan Shola and Eravikulam.

Bupleurum wightii Mukh.

A. *mucronatum* Wight & Arn.

Bushy herbs with knotted stems and many leaves.

Common, in ecotones and grasslands in Mannavan Shola and Eravikulam

Heracleum sprengelianum Wight & Arn.

Pastinaca sprengeliana (Wight & Arn.) Wight

Large erect herbs.

Rare, in grasslands and ecotones at higher altitudes in Eravikulam

Hydrocotyle javanica Thunb.

H. polycephala Wight & Am.

Creeping herbs with succulent stem.

Common, in moist places, along road sides and as undergrowth in degraded forest interiors in Mannavan Shola.

Pimpinella candolleana Wight & Am.

Erect pubescent, perennial herbs with white flowers.

Fairly common, in grasslands ecotones in Mannavan Shola and Eravikulam

Pimpinella pulneyensis Gamble

Tall herbs with white flowers.

Rare, in the grassland ecotones in Mannavan Shola and Eravikulam.

Sanicula elata Buch.-Ham.

S. europaea auct. non L.

Erect perennial herbs.

Very common, along road sides and in open areas in Mannavan Shola.

Vanasushava pedata (Wight) Mukh. Constance

Heracleum pedatum Wight

Trailing herbs with white flowers.

Rare, in the grassland ecotones and also along road sides in Mannavan Shola and Eravikulam.

APOCYNACEAE

Alstonia venenata R. Br.

Large shrubs to small trees with whorled leaves and white flowers.

Fairly common, in disturbed areas and along road sides in Mannavan Shola.

Rauvolfia densiflora (Wall) Benth. ***ex*** Hook. f.

Tabernaemontana densiflora Wall.

Much branched large shrubs.

Fairly common, at lower altitudes in Mannavan Shola.

AQUIFOLIACEAE

Ilex denticulata Wall. ex Wight

Small trees.

Fairly common, in shola margins at higher altitudes in Mannavan Shola and Eravikulam.

Ilex walkeri Wight & Gard. ex Thw.

I. thwaitesii Loes. ex Gamble

Small densely branched trees.

Fairly common, at lower altitudes in Mannavan Shola and Eravikulam.

Ilex wightiana Wall. ex Wight

Large handsome trees.

Fairly common, in Mannavan Shola.

ARALIACEAE

Polyscias acuminata (Wight) Seem.

Hedera acuminata Wight

Glabrous trees with long pinnate leaves.

Occasional, along the shola margins in Mannavan Shola and Eravikulam.

Schefflera racemosa (Wight) Harms

Hedera racemosa Wight; *Heptapleurum racemosum* (Wight) Bedd.

Small to medium sized trees.

Fairly common, along the road sides and in the shola-grassland ecotones in Mannavan Shola and Eravikulam.

ASCLEPIADACEAE

Tylophora mollissima Wight & Arn.

Slender pubescent climbers.

Very rare, in the interior shola forests in Mannavan Shola.

Wattakaka volubilis (L. f.) Stapf.

Asclepias volubilis L. f.; *Marsdenia volubilis* (L. Cooke;

Dregea volubilis (L. f.) Benth. ex Hook. f.

Large climbing shrubs.

Fairly common, at lower altitudes and along road sides in Mannavan Shola.

ASTERACEAE

Acanthospermum hispidum DC.

Annual pubescent herbs.

Occasional, along road sides at lower altitudes in Mannavan Shola.

Adenostemma lavenia (L.) Kuntze var. **lavenia**

Verbesina lavenia L.; *Adenostemma viscosum* Forst.

Erect herbs with sticky achenes.

Common, along damp stream sides and in shaded forest interiors in Mannavan Shola

Ageratina adenophora (Spreng.) .King & Robinson

Eupatorium adenophorum Spreng.; *E. glandulosum* Kunth

Perennial, branched undershrubs.

Abundant, along the road sides and other open areas in Mannavan Shola and Eravikulam.

Anaphalis aristata DC.

Wooly herbs with stout stem.

Common, in the ecotones and grasslands in Mannavan Shola and Eravikulam,

Anaphalis bournei Fyson

Much branched low herbs.

Fairly common, in grasslands and ecotones in Mannavan Shola and Eravikulam.

Anaphalis lawii (Hook. f.) Gamble

A. *oblonga* DC. var. *lawii* Hook. f.

Tall white herbs with white cottony leaves.

Fairly common, along higher altitude in shola margins and road sides in Mannavan Shola and Eravikulam.

Anaphalis marcescens (Wight) Clarke

Gnaphulium marcescens Wight

Graceful small herbs.

Occasional, in ecotones and grasslands in Mannavan Shola and Eravikulam

Anaphalis meeboldii W. W. Sm.

Much tufted woody herbs.

Rare, along ecotones at higher altitudes in Mannavan Shola and Eravikulam

Anaphalis subdecurrens (DC.) Gamble

Gnaphalium subdecurrens DC.; *Anaphalis oblonga* DC.

Stout herbs, stem covered with soft cottony wool.

Fairly common, in the ecotones and grasslands in Mannavan Shola and Eravikulam.

Anaphalis travancorica W. W. Sm.

Large herbs with woody base.

Common, in grasslands and ecotones in Mannavan Shola and Eravikulam

Artemisia nilagirica (Clarke) Pamp.

A. vulgaris L. var. *nilgirica* Clarke: *A. indica* sensu Wight; *A. vulgaris* auct. non L.

Tall profusely branched aromatic shrubs reaching 1-2 m tall.

Common, found chiefly along shola margins and adjoining inhabited areas in Mannavan Shola and Eravikulam.

Bidens pilosa L. var. **minor** (Blume) Sherff

B. sundaica var. *minor* Blume

Erect herbs.

Common along road sides and other open areas in Mannavan Shola and Eravikulam

Blumea sp.

Erect herbs

Rare, along grasslands ecotones in higher altitudes in Mannavan Shola

Cirsium wallichii DC. var. **wightii** (Hook. f.) Vivek.

Cnicus wallichii DC. var. *wightii* Hook. f.; *C. wallichii* sensu Fyson

Prickly shrubs with hollow pubescent stem.

Common, in open places and grasslands in Mannavan Shola and Eravikulam

Conyza stricta Willd.

Small herbs.

Fairly common, in grasslands and ecotones in Mannavan Shola and Eravikulam

Crassocephalum crepidioides (Benth.) S. Moore

Gynura crepidioides Benth.; *Erechtites valerianifolia* sensu Fischer

Erect annual herbs.

Occasional, along road sides and in other exposed regions in Mannavan Shola.

Dichrocephala chrysanthemifolia (Blume) DC.

Cotula chrysanthemifolia Blume

Annual herbs.

Common. in disturbed areas and ecotones in Mannavan Shola and Eravikulam

Dichrocephala integrifolia (L. **f.)** Kuntze

Hippia integrifolia L. f.; *Grangea latifolia* Lam.; *Dichrocephala latifolia* (Lam.) DC.

Herbs, rooting at nodes.

Common, along road sides and disturbed areas in Mannavan Shola and Eravikulam

Emilia scabra DC.

E. sonchifolia (L.) DC. var. *scabra* (DC.) Hook. f.

Small crispately pubescent herbs.

Common, along road sides in Mannavan Shola and Eravikulam.

Emilia javanica (Burm. f.)C. Robinson

Hieracium javanicum Burm. f.; *Emilia flammea* Gass.

Stout herbs.

Rare, found along ecotones and disturbed areas at higher altitudes in Mannavan Shola

Erigeron karvinskianus DC.

E. *mucronatus* DC.

Perennial herbs, stems woody at base.

Very common, along road sides and other open areas in Mannavan Shola.

Galinsoga parviflora Cav.

Annual herbs with viscous glandular fruits.

Fairly common, in disturbed areas in Mannavan Shola and Eravikulam.

Gnaphalium sp.

Erect herbs.

Fairly common, in the grasslands and ecotones at higher altitudes in Mannavan Shola.

Gynura travancorica W. W. Sm.

Stout herbs.

Occasional, along road sides and ecotones in Mannavan Shola and Eravikulam.

Helichrysum buddleioides DC.

H. Hookianum Wight & Arn.;

H. buddleioides DC. var. *Hookianum* (Wight & Arn.) Hook. f.

Undershrubs.

Occasional, in grasslands and shola margins and grasslands in Mannavan Shola and Eravikulam.

Helichrysum perlanigerum Gamble

Undershrubs.

Very rare and endangered species, found in ecotones in higher altitudes at Eravikulam

Lactuca hastata DC.

Mulgedium neilgheryense Wight

Erect herbs.

Rare, along road sides and in ecotones in Mannavan Shola.

Moonia heterophylla Am.

Chrysogonum heterophyllum (Am.) Benth. *ex* Clarke; *Moonia arnottiana* Wight: *Chrysogonum arnottianum* (Wight) Benth. *ex* Clarke

Perennial undershrubs.

Occasional, along the shola margins at higher altitudes in Eravikulam.

Myriactis wightii DC.

Stiff annual herbs.

Fairly common, along road sides and in other open areas in Mannavan Shola

Notonia grandiflora DC.

Fleshy shrubs with pale yellow flowers.

Very rare, found in disturbed regions at lower altitudes in Mannavan Shola

Notonia walkeri (Wight) Clarke

Gynura walkeri Wight

Undershrubs, stem and leaves soft and slightly fleshy.

Rare, in moist shady areas in Mannavan Shola.

Parthenium hysterophorus L.

Poisonous herbaceous weed

Common, along road sides at lowers altitudes in Mannavan Shola.

Phyllocephalum courtallense (Wight) Narayana

Decaneurum courtallense Wight: ***Centratherum courtallense*** (Wight) Benth. ***ex*** Hook. f.

Annual herbs.

Rare, along road sides and ecotones in Mannavan Shola and Eravikulam.

Senecio corymbosus Wall. ***ex*** DC. var. **corymbosus**

Cissampelopsis corymbosa (Wall. ***ex.*** DC) Jeffery & Chen.

Climbing shrubs, leaves white wooly beneath.

Fairly common, along road sides and shola margins in Mannavan Shola

Senecio corymbosus Wall. ***ex*** DC. var. **walkeri** (Am.) Grierson

Senecio walkeri Am.; **S.*araneosus*** DC.

Scandent shrubs.

Occasional, along road sides and other open places in Mannavan Shola and Eravikulam

Senecio scandens Bunch.-Ham. ***ex*** D. Don

Climbing shrubs with striate stem.

Occasional, along ecotones in Mannavan Shola and Eravikulam

Sonchus oleraceus L.

S. ciliatus Lam.

Milky annual herbs.

Rare, found in open areas at lower altitudes in Mannavan Shola

Spilanthes calva DC.

S. acmella auct. non (L.) Murr.

Erect pubescent annual herbs.

Common, along road sides and in other open areas at lower elevations in Mannavan Shola.

Vernonia bourneana W. W. Sm.

Shrub or undershrubs.

Fairly common, in grasslands at higher altitudes in Mannavan Shola.

Vernonia conyzoides DC.

V. cinerea sensu Hook. f.

Stout erect herbs.

Very common, in the ecotones, cleared regions and along road sides at lower altitudes in Mannavan Shola and Eravikulam.

Vernonia heynei Bedd. *ex* Gamble

Large erect undershrubs.

Rare, in the higher altitude grasslands in Mannavan Shola and Eravikulam.

Vernonia monosis Clarke

V. arborea var. *wightiana* Hook. f.; *Monosis wightiana* Wight

Small trees with purple flowers.

Occasional, along shola margins in Mannavan Shola and Eravikulam.

Vernonia peninsularis (Clarke) Clarke *ex* Hook. f.

V. bracteata Wall. var. *peninsularis* Clarke; *Decaneurum silhetense* Wight

Erect undershrubs with flexuous branches.

Rare, in open regions at higher altitudes in Mannavan Shola.

Vernonia saligna DC. var. **nilghirensis** Hook.f.

V. saligna sensu Fyson

Erect undershrubs.

Rare, along grassland ecotones at higher altitudes in Mannavan Shola and Eravikulam.

Youngia japonica (L.) DC.

Prenanthes japonica L.; *Youngia napifolia* (DC.) DC.; *Crepis japonica* (L.)

Very slender annual herbs.

Fairly common along road sides and in other open areas in Mannavan Shola.

BALANOPHORACEAE

Balanophora dioica R. Br.

Parasitic herbs with tuberous root stock, smaller than the other species.

Rare, found in interior forests in Mannavan Shola.

Balanophora fungosa J. R. & G. Forst. subsp. **indica** (Arn.) Hansen var. **indica**

Longdoffia indica Arn.; *Bulunophora indica* (Arn.) Wall. ex Griff.

Thick parasitic herbs with a tuberous root stock.

Occasional, in interior sholas in Mannavan Shola.

Balanophora fungosa J. R. & G. Forst subsp. **indica** (Arn.) Hansen var. **minor** (Eichl.) Hansen

B. indica (Am.) Wall. ex Griff. var. *minor* Eichl.; *Balanophora indica* (Arn.) Wall. ex Griff.

Parasitic herbs with tuberous root stock.

Occasional, in interior sholas in Mannavan Shola.

Balanophora sp.

Very large yellow coloured parasitic herbs having massive tuberous root stocks with 10-20 peduncles.

Very rare, along road sides and in other exposed regions in Mannavan Shola.

BALSAMINACEAE

Impatiens balsamina L.

Annual herbs.

Common, along road sides at lower altitudes in Mannavan Shola.

Impatiens cordata Wight

Herbs, about 30 cm tall.

Common, mostly found along road sides or along stream banks in Mannavan Shola

Impatiens cuspidata Wight

Glaucous shrubs.

Fairly common, in moist shady regions or along road sides in Mannavan Shola.

Impatiens elegans Bedd.

Annual herbs upto 30 cm tall.

Rare, in open areas in Mannavan Shola.

Impatiens goughii Wight

I. anamalayensis Bedd.

Small slender annual herbs.

Fairly common, in open but wet places or along stream sides in Mannavan Shola and Eravikulam.

Impatiens hensloviana Am.

Undershrubs with prominent scars of leaves on the stem.

Common, in open areas and ecotones at higher altitudes, in Mannavan Shola

Impatiens herbicola Hook. f.

Annual herbs.

Rare, in moist regions in Mannavan Shola

Impatiens jerdoniae Wight

I. parusitica Bedd.

Succulent epiphytes with swollen internodes.

Rare, on trees and moist rocks in Eravikulam

Impatiens phoenicea Bedd.

Erect suffruticose herbs.

Rare, along the road sides and in interior forests in Mannavan Shola

Impatiens tangachee Bedd.

Herbs with sub-procumbent stem.

Common, on rocks along the streams and other water courses in Mannavan Shola.

Impatiens uncinata Wight

Small annual herbs.

Rare, in moist dense shady areas in Mannavan Shola.

Impatiens wightiana Bedd.

Erect unbranched suffruticose herbs.

Rare. in shaded interior forests in Mannavan Shola

Impatiens sp.

Erect annual herbs with reddish brown flowers.

Rare, in grasslands at higher altitudes in Eravikulam.

BEGONIACEAE

Begonia malabarica Lam.

B. fallax A. DC.; *Diploclinium lindleyanum* Wight

Small shrubs.

Occasional, in disturbed forest areas at lower altitudes in Mannavan Shola

BERBERIDACEAE

Berberis tinctoria Lesch.

Erect thorny shrubs with pale brown shining twigs.

Very rare, in cleared forest areas and shola margins at lower altitudes in Mannavan Shola

Mahonia leschenaultii (Wall. ex Wight & Am.) Takeda

Berberis leschenaultii Wall. ex Wight & Am.;

B. nepalensis Spreng. var. *leschenaultii* (Wall. ***ex*** Wight & Am.) Hook. f.

Shrubs to small trees with corky bark.

Fairly common, along shola margins in Mannavan Shola and Eravikulam

BORAGINACEAE

Cynoglossum zeylanicum (Vahl ***ex*** Homem.) Thunb. ***ex*** Lehm.

Arichusa zeylanica Vahl ***ex*** Hornem; *Cynoglossum furcatum* Wall. ***ex*** Roxb.;

C. *denticulatum* A. DC. var. *zeylanicum* (Vahl ***ex*** Hornem.) Clarke

Erect herbs.

Common, along road sides and ecotones in Mannavan Shola and Eravikulam.

BRASSICACEAE

Cardamine africana L.

C. *borbonica* Pers.

Small perennial herbs.

Common, along road sides and disturbed areas in Mannavan Shola.

Cardamine trichocarpa Hochst. ex A. Rich.

C. *subumbellata* Hook. ex Hook. f.

Slender perennial herbs.

Common, along road sides in Mannavan Shola.

Coronopus didymus (L.) Sm.

Lepidium didymum L.; *Senebiera didyma* (L.) Pers.

Parasitic branching herbs.

Occasional, along road sides in Mannavan Shola.

BUXACEAE

Sarcococca coriacea (Hook.) Sweet

Pachysandra coriacea Hook.; *Sarcococca trinervia* Wight

Scandent shrubs.

Fairly common, in interior forests at lower altitudes in Mannavan Shola

CAMPANULACEAE

Wahlenbergia erecta (Roth ex Schultes) Tuyn

Dentella *erecta* Roth ***ex*** Schultes; *Cephalostigma schimperi* Hochst. ex A. Rich.

Annual erect herbs.

Occasional, along road sides and grasslands in Mannavan Shola.

Wahlenbergia marginata (Thunb.) A. DC.

Campanula marginata Thunb.; *Wahlenbergia agrostis* A. DC.; *W. gracilis* DC.

Erect perennial herbs.

Occasional, in grasslands in Mannavan Shola and Eravikulam.

CAPRIFOLIACEAE

Viburnum coriaceum Blume

V. hebanthum Wight & Arn.

Small trees.

Common, along road sides and ecotones in Mannavan Shola.

Viburnum erubescens Wall. ***ex*** DC.

V. wightianum Wight & Arn.

Small trees.

Occasional, along stream banks and road sides in Mannavan shola

Viburnum punctatum Buch. Ham. ***ex*** D. Don

V. acuminatum Wall ***ex.*** DC.

Small trees.

Common, in open areas and along road sides mostly at lower altitudes in Mannavan Shola.

CARYOPHYLLACEAE

Cerastium indicum Wight & Arn.

Scandent pubescent herbs.

Common, at lower altitudes in Mannavan Shola.

Spergula arvensis L.

Diffusely branched annual herbs with leaves clustered in whorls.

Common, mostly in open areas and along road sides at lower altitudes in Mannavan Shola.

CELASTRACEAE

Euonymus crenulatus Wall. ***ex*** Wight & Arn.

Small evergreen trees.

Rare, along the shola margins in Eravikulam

Microtropis ramiflora Wight

Medium sized trees.

Occasional, along the shola margins in Mannavan Shola and Eravikulam

CLUSIACEAE

Garcinia cowa Roxb. ***ex*** DC.

Small to medium sized trees with beaked fruit.

Common, along the shola margins and stream hanks at higher altitudes in Mannavan Shola and Eravikulam.

CONVOLVULACEAE

Argyreia hirsuta Wight var. **coacta** Clarke

Large shaggy climbers, branchlets sparsely hairy.

Common, along road sides and ecotones in Mannavan Shola and Eravikulam.

Cuscuta reflexa Roxb.

Wiry stemmed, yellow coloured parasite.

Common, in the ecotones at lower altitudes in Mannavan Shola

CORNACEAE

Mastixia arborea (Wight) Bedd. subsp. **arborea**

Bursinupetalum arboreum Wight

Large trees.

Common, at lower altitudes in Mannavan Shola and Eravikulam.

CUCURBITACEAE

Diplocyclos palmatus (L.) Jeffrey

Bryonia palmata L.; ***B. laciniosa*** L.; ***Bryonopsis laciniosa*** sensu Naud

Slender climbing annuals, perennating from thick root stocks.

Common, along road sides in Mannavan Shola.

Solena amplexicaulis (Lam.) Gandhi

Bryonia amplexicaulis Lam.; ***Solena heterophylla*** Lour.; ***Zehneria umbellata*** Thw.; ***Melothria heterophylla*** (Lour.) Cogn.

Climbing herbs with small yellowish white flowers.

Occasional, found along road sides at lower altitudes in Mannavan Shola.

Trichosanthes lobata Roxb.

T. ***perrottetiana*** Cogn.; ***T. villosula*** Cogn.; *T.* ***villosula*** Cogn. var. ***nilgirensis*** Kundu

Climbing herbs.

Occasional, found along road sides among hedges in lower altitudes in Mannavan Shola.

Zehneria maysorensis (Wight &Arn.) Am.

Bryonia maysorensis Wight & Am.; ***Melothria mucronata*** sensu Chakravarthy; *M.* ***perpusilla*** var. ***subtruncata*** Cogn.; ***M. perpusilla*** sensu Gamble

Slender climbers.

Common, in open areas at lower altitudes in Mannavan Shola.

DAPHNIPHYLLACEAE

Daphniphyllum neilgherrense (Wight) K. Rosenth.

Daphniphyllum glaucescens Muell. - Arg.

Medium sized trees.

Common, in the ecotones and open areas, rarely in interior forests in Mannavan Shola and Eravikulam.

DROSERACEAE

Drosera peltata Sm.

Herbs with tuberous root stock.

Common, in ecotones and grasslands in Mannavan Shola and Eravikulam.

ELAEAGNACEAE

Elaeagnus kologa Schlecht.

E. latifolia L.

Large scandent or climbing shrubs, some times thorny, leaves with silvery or stellate scales on under surface.

Common, along shola margins in Mannavan Shola and Eravikulam.

ELAEOCARPACEAE

Elaeocarpus munronii (Wight) Mast.

Monocera munronii Wight

Large trees, branchlets with prominent leaf scars.

Common, along ecotones in Mannavan Shola.

Elaeocarpus recurvatus Corner

E. ferrugineus (Wight) Bedd.; *Monocera ferruginea* Wight

Trees, young branches rusty tomentose; leaves recurved

Common along shola margins in Mannavan Shola and Eravikulam.

Elaeocarpus serratus L.

E. cuneatus Wight

Small trees with white flowers

Common, in interior forests in Mannavan Shola.

Elaeocarpus tuberculatus Roxb.

Large trees.

Common, at lower altitudes in Mannavan Shola.

ERICACEAE

Gaultheria fragrantissima Wall.

G. *leschenaultii* DC.

Shrubs with aromatic smell.

Abundant, in the ecotones and grasslands in Mannavan Shola and Eravikulam.

Rhododendron arboreum E. Sm. ssp. **nilagiricum** (Zenk.) Tagg.

R. nilagiricum Zenk.

Trees with brown fissured corky bark.

Common, in the ecotones and shola margins in Mannavan Shola and Eravikulam.

EUPHORBIACEAE

Antidesma menasu (Tul.) Miq.

A. pubescens Roxb. var. *menasu* Tul.

Small branching trees.

Common, along shola margins in Mannavan Shola and Eravikulam,

Aporusa fusiformis Thw.

Small trees with very coriaceous leaves.

Occasional. in interior forests in Mannavan Shola,

Bischofia javanica Blume

Large trees.

Common, in the interior as well as exposed regions in Mannavan Shola.

Euphorbia rothiana Spreng.

E. laeta Heyne ex Roth

Erect glaucous herbs

Common, along road sides in lower altitudes in Mannavan Shola.

Excoecaria crenulata Wight

Small trees.

Rare, in interior forests at medium altitudes in Mannavan shola.

Glochidion neilgherrense Wight

Moderate sized trees with zig-zag branches.

Common, along shola margins and road sides in Mannavan Shola and Eravikulam.

Mallotus tetracoccus (Roxb.) Kurz

Rottlera tetracocca Roxb.; *Mallotus albus* var. *occidentalis Hook.* f.

Small trees.

Common, in open areas and along road sides at low altitudes in Mannavan Shola.

Phyllanthus gardnerianus (Wight) Baill.

Macraea gardneriana Wight;

Phyllanthus simplex Retz. var. *gardneriana* (Wight) Muell.- Arg.

Erect herbs with elongated branches.

Common in ecotones and other exposed regions in Mannavan shola.

Phyllanthus macraei Muell: Arg.

Macraea rheedii Wt.

Shrubs.

Common, along road sides in Mannavan Shola.

Ricinus communis L.

Large shrubs.

Occasional, along road sides in lower altitudes in Mannavan Shola

FABACEAE

Abarema subcoriacea (Thw.) Kosterm.

Pithecellobiurn subcoriaceum Thw. ; *P. anamalayanum* Bedd.

Small trees.

Common, in lower and medium altitude forests in Mannavan Shola and Eravikulam.

Acacia dealbata Link

Evergreen trees with silvery foliage and densely tomentose branchlets

Earlier raised in plantations, now getting established in grasslands

Acacia melanoxylon R. Br.

Large trees.

Earlier raised in plantations, now getting established in grasslands

Atylosia rugosa Wight & Am.

Trailing herbs.

Common, along road sides and ecotones in Mannavan Shola.

Cassia leschenaultii DC.

C. *mimosoides* Lam. var. *wallichianum* (DC.) Baker; C. *wallichiana* DC.

Bushy herbs.

Fairly common, along road sides and in open areas in Mannavan Shola.

Canavalia virosa (Roxb.) Wight & Am.

Dolichos virosus Roxb.; *Canavalia ensiformis* DC. var. *virosa* (Roxb.) Baker

Larger climbers with pink flowers.

Occasional, in disturbed forest ecotones at lower altitudes in Mannavan Shola

Crotalaria calycina Schrank.

Herbs, with erect branches from the base.

Rare, in ecotones and grasslands in Mannavan Shola and Eravikulam

Crotalaria fysonii Dunn

Trailing perennial subshruhs.

Common, in grasslands in Mannavan Shola and Eravikulam

Crotalaria leschenaultii DC.

Erect herbaceous

Common, along shola margins, road sides and other exposed areas in Mannavan Shola

Crotalaria ovalifolia Wall. ***ex*** Fyson

C. rubiginosa sensu Baker

Spreading shrubs, densely clothed with grey pubescens; flowers yellow.

Common, in ecotones and grasslands in Mannavan Shola and Eravikulam

Crotalaria pallida Dryand.

C. striata DC.; *C. striata* DC. var. *acutifolia* Trimen

Glabrescent undershrubs.

Occasional, along road sides in Mannavan Shola and Eravikulam.

Crotalaria scabrella Wight & Arn.

C. *rubiginosa* Willd. var. *scabrella* (Wight & Arn.) Baker

Erect undershrubs.

Common, along road sides and ecotones in Mannavan Shola

Crotalaria semperflorens Vent.

C. *wallichiana* Wight & Arn.

Shrubs with rusty villous, terete branches ;Common, along shola margins and along road sides in Mannavan Shola and Eravikulam.

Crotalaria wightiana Graham ex Wight & Arn.

C. rubiginosa Willd. var. *wightiana* (Graham ***ex*** Wight & Arn.) Baker

Handsome shrubs.

Common, along ecotones in Mannavan Shola and Eravikulam.

Derris canarensis (Dalz.) Baker

Pongamia canarensis Dalz.

Climbing shrubs with white flowers

Common, along shola margins at higher altitudes in Mannavan shola and Eravikulam

Desmodium heterophyllum (Willd.) DC.

Hedysarum heterophyllum Willd.; *Desmodium trifrorum* (L.) DC. var. *majus* Wight & Arn.

Diffusely branched herbs.

Common in exposed places and in ecotones in Mannavan Shola.

Desmodium microphyllum (Thunb.) DC.

Hedysarum microphyllum Thunb.; *Desmodium parvifolium* DC.

Much branched prostrate herbs.

Fairly common, in the ecotones in Mannavan Shola and Eravikulam

Desmodium repandum (Vahl) DC.

Hedysarum repandum Vahl; *Desmodium scalpe* DC.; *D. strangulatum* Wight & Am

Herbaceous undershrubs.

Common, in shady and semi-shady places in Mannavan Shola.

Desmodium uncinatum (Jacq.) DC.

Hedysarum uncinatum Jacq.

Branched herbs with hooked hairs.

Fairly common, along road sides in lower altitudes in Mannavan shola.

Dumasia villosa DC.

Slender twining herbs.

Common, in grasslands and ecotones in Mannavan Shola and Eravikulam.

Flemingia bracteata (Roxb.) Wight

Hedysarum bracteatum Roxb.;

Flemingia strobilifera R. Br. ***ex*** Ait. var. *bracteata* (Roxb.) Baker

Erect branching shrubs.

Occasional, along road sides and ecotones in Mannavan Shola.

Flemingia grahamiana Wight & Arn.

Erect shrubs with red sticky glands.

Common, along disturbed areas and ecotones in Mannavan Shola.

Indigofera cassioides Rottl. ***ex*** DC.

I. *pulchella* auct. non Roxb.

Large shrubs.

Occasional, along road sides at lower altitudes in Mannavan shola.

Indigofera galegoides DC.

Tall shrubs with pale red flowers.

Occasional, in the ecotones in Mannavan Shola

Indigofera spicata Forssk.

Indigofera endecaphylla Jacq.

Trailing annual or biennial herbs.

Common, along road sides and disturbed areas in Mannavan Shola.

Neonotonia wightii (Graham ***ex*** Wight & Arn.) Lackey

Notonia wightii Graham ***ex*** Wight & Arn.; *Glycine javanica* auct. non L.

Glycine wightii (Graham **ex** Wight & Arn.) Verdc.

Twining herbs.

Common, along road sides and ecotones in Mannavan Shola and Eravikulam.

Parochetus communis

Trailing slender herbs rooting at nodes.

Common, in grasslands, mostly in moist areas at lower altitudes in Mannavan Shola.

Shuteria vestita Wight & Am.

Twinning herbs.

Common, along ecotones in Mannavan Shola and Eravikulam,

Tephrosia tinctoria Pres.

Procumbent undershrubs or herbs, with golden brown pubescence on stems and peduncles.

Common, along ecotones and open areas in Mannavan Shola.

Uraria rufescens (DC.) Schind.

Desmodium rufescens DC.; *Uraria hamosa* Wall. **ex** Wight & Arn.

Undershrubs, stem terete, woody.

Common, along road sides and ecotones in Mannavan Shola and Eravikulam,

Vigna radiata (L.) Wilezek var. **radiata**

Phaseolus radiatus L.; *P. mungo* L. var. *radiatus* (L.) Baker

Suberect pubescent herbs.

Fairly common, in the ecotones in Mannavan Shola.

Vigna radiata (L.) Wilezek var. **sublobata** (Roxb.) Verdc.

Phaseolus sublobatus Roxh.; *P. trinervius* Heyne ***ex*** Wight & Arn.

Slender hairy climbers.

Occasional, found in open areas at lower altitudes in Mannavan Shola

Vigna trilobata (L.) Verdc.

Dolichos trilobatus L.; *Phaseolus trilobatus* (L) Schreb.

Diffuse herbs.

Common, along shola margins and ecotones in Mannavan Shola.

FLACOURTIACEAE

Casearia coriacea Thw.

Small trees

Fairly common, in interior forests in Mannavan Shola.

Hydnocarpus alpina Wight

Large trees, young shoots glabrous.

Very common, in lower altitudes in Mannavan Shola and Eravikulam

Exacum courtallense Arn.

Perennial herbs with fleshy leaves.

Rare, in grassland ecotones in Mannavan Shola and Eravikulam.

Exacum wightianum Am.

E. atropurpureum Bedd. var. *palghatense* Gamble

Erect herbs upto 1 m high.

Common, in ecotones and grasslands in Mannavan Shola and Eravikulam

Gentiana quadrifaria Blume var. **zeylanica** (Griseb.) Kusnezov

C. zeylanica Griseb.; *G. quadrifaria* auct. non Blume

Erect herbs.

Fairly common, along road sides in higher altitudes in Mannavan shola and Eravikulam.

Swertia corymbosa (Griseb.) Wight ***ex*** Clarke

Ophelia corymbosa Griseb.

Erect herbs.

Fairly common, in grasslands and ecotones in Mannavan Shola and Eravikulam.

GERANIACEAE

Geranium nepalense Sweet

G. affine Wight & Am.

Slender diffuse perennial herbs.

Common, in grasslands in Mannavan Shola and Eravikulam.

GESNERIACEAE

Aeschynanthus perrottetii A. DC.

A. ceylanica sensu Wight *non* Gard.; *A. perrottetii* A. DC. var. *planiculmis* Clarke;

A. planiculmis (Clarke) Gamble

Scandent epiphytic undershrubs.

Common, in interior sholas in Mannavan Shola and Eravikulam.

Didymocarpus tomentosus Wight

Scapigerous lithophytic herbs.

Common, along road sides and other exposed regions in Mannavan shola.

HALORAGACEAE

Laurembergia coccinea (Blume) Ken.

Epilithes coccinea Blume; *Serpicula brevitis* Wight & Am.; *S. hirsuta* Wight & Arn

Small perennial herbs.

Occasional, in moist areas in the grasslands in Eravikulam.

HYPERICACEAE

Hypericum japonicum Thunb. ***ex***

Erect herbs.

Rare, in open marshy areas in the grasslands in Eravikulam.

Hypericum mysurense Heyne ***ex*** Wight & Am.

Norysca mysurensis (Heyne *ex* Wight & Am.) Wight

Large shrubs with yellow flowers.

Common, in grasslands in Mannavan Shola and Eravikulam.

ICACINACEAE

Apodytes dimidiata E. Meyer ***ex*** Am.

A. benthamiana Wight; ***A. beddumei*** Mast.

Medium sized trees.

Fairly common, in interior sholas in Mannavan Shola.

Gomphandra coriacea Wight

G. polymurpha Wight

Small trees.

Very common in interior forests and also along road sides at lower altitudes in Mannavan Shola.

Nothapodytes nimmoniana (Graham) Mabber.

Premna nimmoniana Graham; *Nothapodytes foetida* (Wight) Sleumer;

Mappia foetida (Wight) Miers

Large shrubs to small trees.

Occasional, in shola margins in Eravikulam.

LAMIACEAE

Coleus harhatus (Andr.) Benth.

Plectranthus barbatus Andr.

Pubescent herbs.

Fairly common, in the ecotones and road sides at lower altitudes in Mannavan Shola.

Coleus malabaricus Benth.

Herbs, stem obtusely 4-angled, purple.

Common, in interior regions in Mannavan Shola

Leucas chinensis (Retz.) R. Br.

Phlomis chinensis Retz.

Shrubby scandent hairy herbs.

Common, often found in the ecotones and grasslands in Mannavan Shola.

Leucas hirta (Heyne **ex** Roth) Spreng.

Phlomis Heyne *ex* Roth

Small shrubs with stout rootstock

Fairly common, in open areas in Mannavan Shola.

Leucas indica (L.) R. Br.

Leonurus indicus L.; *Leucas linifolia* (Roth) Spreng; *Phlomis linifolia* Roth; *Leucas lavenduliifolia* J. E. Sm.

Erect annual herbs.

Fairly common, in the open areas in Mannavan Shola.

Leucas lamifolia Desf.

Large straggling herbs with tawny villous stem and leaves.

Common, along ecotones in Mannavan Shola and Eravikulam.

Leucas lanceaefolia Desf.

Undershrubs with tetrangular tomentose stem.

Common, along the ecotones in Mannavan Shola.

Leucas suffruticosa Benth.

Low shrubs with many slender stems from thick woody rootstock.

Fairly common, in grasslands of Mannavan Shola and Eravikulam.

Micromeria biflora Benth.

Aromatic wiry herbs.

Common, in the grasslands in Mannavan Shola.

Plectranthus barbatus Andr.

Coleusforskohlii (Willd.) Briq.; *Plectranthus forskohlii* Willd.;

Coleus barbatus (Andr.) Benth.

Herbs with tetrangular pubescent stem.

Common, along road sides and ecotones in Mannavan Shola

Pogostemon pubescens Benth.

P. parviflorus Benth.

Herbs.

Common, along ecotones and open areas in Mannavan Shola

Pogostemon wightii Benth.

Erect herbs, 30 cm high with pink or reddish pubescent branches.

Common, in wet places in Mannavan Shola.

Scutellaria violacea Heyne

Erect herbs.

Common, in moist areas along road sides in Mannavan Shola.

LAURACEAE

Actinodaphne bourdillonii Gamble

Large trees.

Rare, in the interior sholas in Mannavan Shola and Eravikulam.

Actinodaphne salicina Meissner

Medium sized trees.

Rare, in the interior sholas of Mannavan Shola and Eravikulam

Beilschmiedia wightii (Nees) Benth. ex Hook. f.

Haasia wightii Nees

Large trees.

Occasional, in the interior forests of Mannavan Shola and Eravikulam

Cinnamomum wightii Meissner

Stout medium sized trees.

Common, throughout in Mannavan Shola and Eravikulam.

Litsea florihunda (Blume) Gamble

Cylicodaphne floribunda Blume; *Tetranthera wightiana* sensu Bedd. non Nees

Litsea wightiana Hook. f.

Large trees.

Common, in the sholas in Mannavan Shola and Eravikulam.

Litsea wightiana (Nees) Hook. f.

Cylicodaphne wightiana Nees

Large evergreen trees with tawny branchlets and foliage.

Common, in interior forests in Mannavan Shola and Eravikulam

Neolitsea cassia (L.) Kosterm.

Laurus cassia L.; *Neolitsea zeylanica* (Nees) Merr.; *Litsea zeylanica* Nees

Small or moderate-sized trees.

Occasional, in the interior regions in Mannavan Shola.

Neolitsea fischeri Gamble

Large trees.

Fairly common, in Mannavan Shola and Eravikulam

Neolitsea scrohiculata (Meissner) Gamble

Litsea scrobiculata Meissner; *L. zeylanica* sensu Hook. f

Moderate sized trees

Common, in Mannavan Shola and Eravikulam.

Persea macrantha (Nees) Kosterm.

Macranthus macrantha Nees

Large evergreen trees with flowers in subterminal panicle.

Common, in the interior forests in Mannavan Shola and Eravikulam

LENTIBULARIACEAE

Utricularia caerulea L.

U. nivea Vahl: *U. racemosa* Wall. ***ex*** Walp.

Erect herbs with pale blue flowers.

Common, in wet places in grasslands at higher altitudes in Eravikulam.

Utricularia nayarii Janath. & Henry

Erect slender herbs.

Common, in marshy places in the grasslands in Eravikulam.

LOBELIACEAE

Lobelia heyneana Schultes

L. trialuta Buch.-Ham. ***ex*** Don: *L. zeylanica* auct. non L.

An erect annual herbs

Occasional, in grasslands in Mannavan Shola.

Lobelia leschenaultiana (Presl) Skottsh:

Rapuntium leschenaultianum Presl; *Lobelia excelsa* Lesch.

Large herbs.

Common, along road sides and ecotones in Mannavan Shola and Eravikulam.

LOGANIACEAE

Fagraea ceilanica Thunb.

F. obovata Wall; ***F. malabarica*** Wight

Small trees, generally epiphytic when young.

Occasional, along stream banks and ecotones in Mannavan Shola

Gardneria ovata Wall.

G. *wallichii* Wight

Climbing shrubs.

Common, along the shola margins in Mannavan Shola.

LORANTHACEAE

Dendrophthoe memecylifolia (Wight & Am.) Danser

Loranthus memecylifolius Wight & Am.

Stout glabrous parasitic shrubs.

Fairly common, in Mannavan Shola.

Helixanthera intermedia (Wight) Danser

Loranthus intermedius Wight

Stout parasite shrubs.

Fairly common, in interior areas in Mannavan Shola.

Helixanthera obtusata (Schultes) Danser

Loranthus obtusarus Schultes

Large parasite shrubs.

Fairly common, in interior areas in Mannavan Shola.

Korthalsella japonica (Thunh.) Engl.

Viscumjaponicum Thunb.

Leafless parasitic herbs.

Rare, in Mannavan Shola and Eravikulam.

Macrosolen parasiticus (L.) Danser

Lonicera parasitica L.; *Loranthus loniceroides* L.; *Elytranthe loniceroides* (L.) *G*. Don

Large parasitic shrubs.

Fairly common, in interior areas in Mannavan Shola and Eravikulam.

Macrosolen capitellatus (Wight & Am.) Danser

Loranthus capitellatus Wight & Am.; *Elytranthe capitellata* (Wight & Am.) Engl.

Parasitic shrubs.

Fairly common, in interior areas in Mannavan Shola and Eravikulam.

Taxillus tomentosus (Heyne ***ex*** Roth) Tieghem

Loranthus tomentosus Heyne ***ex*** Roth

Small parasitic shrubs

Very common, in Mannavan Shola.

Viscum sp.

Yellow coloured parasitic herbs

Rare, found in lower altitudes in Mannavan Shola

LYTHRACEAE

Rotala indica (Willd.) Koehne

Peplis indica Willd.; *Ammannia peploides* Spreng.; *Ameletia indica* (Willd.) DC.

Much branched herbs.

Common, in marshy, disturbed forest ecotone regions in Mannavan Shola.

MAGNOLIACEAE

Michelia nilagirica Zenk.

Medium sized trees.

Common, in higher altitudes in Mannavan Shola and Eravikulam

MALVACEAE

Abelmoschus angulosus Wall. ***ex*** Wight & Am.

Hibiscus angulosus (Wall, **ex** Wight & Arn.) Steud.; *H. setinervis* Dunn

Erect herbs or undershruhs with thick bristly hairs.

Common, along road sides and stream sides in Mannavan Shola and Eravikulam.

Sida rhombifolia L.

S. rhomboidea Roxb.

Pubescent herbs.

Common, along road sides in Mannavan Shola.

Urena lobata L.

Erect undershrubs.

Common, in disturbed forests at lower altitudes in Mannavan Shola.

MELASTOMATACEAE

Medinilla malabarica Bedd.

Epiphytic shrubs.

Rare, along stream banks at high altitudes in Eravikulam.

Memecylon edule Roxb.

Small trees.

Rare, in the interior forests in Mannavan Shola.

Osbeckia aspera (L.) Blume var. wightiana (Benth. *ex* Wight &Arn.) Trimen

O. wightiana Benth.

Much branched shrubs.

Common, in grasslands and ecotones in Mannavan Shola.

Osbeckia leschenaultiana DC.

Bushy shrubs.

Common, along grassland ecotones in Mannavan Shola.

Sonerila speciosa Zenk.

Erect fleshy herbs

Common, in disturbed areas in Mannavan Shola and Eravikulam

MELIACEAE

Aglaia apiocarpa (Thw.)

Milnea apiocarpa Thw.

Small trees.

Occasional, in interior areas in Mannavan Shola.

Cipadessa baccifera (Roth) Miq.

Melia baccifera Roth.; *Cipadessa fruticosa* Blume

Small trees or shrubs.

Common, along road sides and ecotones in Mannavan Shola and Eravikulam

Trichilia connaroides (Wight & Am.) Bent.

Zanthoxylum connaroides Wight & Am.; *Heynea trijuga* Roxb. *ex* Sims; *Heynea affinis* A. Juss.

Medium sized trees.

Occasional, along the ecotones in Mannavan Shola and Eravikulam.

MENISPERMACEAE

Cocculus laurifolius DC.

Small trees.

Fairly common, in lower altitudes in Mannavan Shola

Stephania japonica (Thunb.) Miers

Menispermum japonicum Thunb.; *Stephania hernandifolia* sensu Hook. f.; *Cyclea hernandifolia* Wight & Arn.

Climbing shrubs, stems glabrous.

Common, along road sides and ecotones in Mannavan Shola.

MORACEAE

Ficus amplocarpa Govindarajalu & Masilamoney

F. macrocarpa (Miq.) Wight ex King; *Pogonorrophe macrocarpa* Miq.; *Ficus laevis* Blume var. *macrocarpa* (Miq.) Comer

Tall scandent shrubs.

Occasional, along water courses and in interior areas in Mannavan Shola.

MYRSINACEAE

Ardisia rhomboidea Wight

Small trees.

Very common, in Mannavan Shola and Eravikulam.

Maesa indica (Roxb.) DC.

Baeobotrys indica Roxb.; *Maesa indica* (Roxb.) DC. var. *perrottetiana* (A. DC.) Clarke; *Maesa perrottetiana* A. DC.

Shrubs to small trees.

Common, along road sides and ecotones in Mannavan Shola and Eravikulam.

Rapanea capitellata Mez var. sessilis Gamble

Small trees.

Occasional, along shola margins at higher altitudes in Mannavan shola and Eravikulam.

Rapanea thwaitesii Mez

Small trees.

Rare, along shola margins at higher altitudes in Mannavan Shola and Eravikulam.

Rapanea wightiana (Wall. ex DC.) Mez

Myrsine wightiana Wall.; *M. capitellata* Wall. var. *lanceolata* Clarke

M. capitellata sensu Wight

Small trees.

Common, along shola margins and ecotones in Mannavan Shola.

MYRTACEAE

Eucalyptus globulus Labill.

Large trees.

Very common, in ecotones and in grasslands at higher altitudes in Mannavan Shola and Eravikulam; probably escaped from cultivation.

Eucalyptus grandis Hill ex Maid.

Large trees.

In ecotones and in grasslands at lowers altitudes in Mannavan Shola and Eravikulam, established from earlier plantations.

Rhodomyrtus tomentosa (Ait.) Hassk.

Myrtus tomentosa Ait.

Thickly tomentose shrubs with grey tomentose foliage.

Fairly common, in exposed regions and in shola margins in Mannavan shola and Eravikulam.

Syzygium caryophyllatnm (L.) Alston

Myrtus caryophyllata L.; *Syzygium caryophyllaeum* auct. non Gaertn.;

Eugenia caryophyllaea Wight

Small trees.

Common. both in interior areas and ecotones in Mannavan Shola and Eravikulam.

Syzygium cumini (L) Skeels

Myrtus cummini L.; *Eugenia jambolana* Lam.; *Syzygium jambolanum* (Lam.) DC.

Large trees.

Common in ecotones as well as interior areas at lower altitudes in Mannavan Shola.

Syzygium densiflorum Wall. **ex** Wight & Am.

S. arnottianum Walp.; *Eugenia arnottiana* (Walp.) Wight

Large trees, bark grey, rough.

Fairly common, along shola margins in Mannavan Shola and Eravikulam.

OLEACEAE

Chionanthus linocieroides (Wight) Bennet & Razaida

Olea linocieroides Wight; *Linociera wighrii* Clarke

Medium sized trees.

Common, in interior forests in Mannavan Shola and Eravikulam

Chionanthus ramiflorus Roxb. var. **peninsularis** Ravikumar & Lakshmanan

Medium sized trees.

Occasional, in the shola margins of Mannavan Shola and Eravikulam.

Jasminum bignoniaceum Wall. ***ex*** G. Don

J. humile sensu Clarke

Shrubs with angular branchlets, flowers yellow

Rare, in interior forests in Eravikulam.

Jasminum roxburghianum Wall.

Pubescent climbing shrubs.

Occasional, along road sides at lower altitudes in Mannavan shola

Ligustrum rohustum (Roxb.) Blume. subsp. **walkeri** (Decne.) P. S. Green

L. walkeri Decne.

Small trees.

Occasional, along shola margins in Mannavan Shola and Eravikulam.

Ligustrum perrottetii DC.

L. neilgherrense Wight

Large shrubs.

Common, along shola margins in Mannavan Shola and Eravikulam

Olea glandulifera Wall. ***ex*** *G*. Don

O. bournei Fyson

Medium sized trees with white flowers.

Occasional, along road sides and interior forests in Mannavan shola

ONAGRACEAE

Circaea alpina L. subsp. **imaicola** (Asch. & Magn.) Kitamura

C. alpina L. var. *imaicola* Asch. & Magn.; *C. alpina* sensu Wight

Small herbs with white flowers.

Very rare, in shady places in interior areas in Mannavan Shola and Eravikulam

Oenothera tetraptera Cav.

Perennial herbs.

Rare, found in disturbed forest ecotones in Mannavan Shola

OROBANCHACEAE

Christisonia bicolor Grand.

C. auranriaca Wight

Fleshy root parasites.

Rare, mainly parasitic on *Strobilanthes* sp. in Mannavan Shola

Campbellia cytinoides Wight

Christisonia nilagirica Gard.

Fleshy parasitic herbs, yellow with pink shades

Very rare, in shady interior areas in Mannavan Shola.

OXALIDACEAE

Biophytum intermedium Wight

Small branched herbs.

Rare, found along road sides and in other exposed regions in Mannavan Shola.

Biophytum sensitivum (L.) DC. var. **candolleanum** (Wight) Edgew. & Hook. f.

B. ***candolleanum*** Wight

Annual herbs, up to 20 cm tall, stem unbranched.

Common, along road sides in Mannavan Shola.

Oxalis corniculata L.

Trailing herbs, rooting at nodes.

Common, along road sides and ecotones in Mannavan Shola and Eravikulam.

PASSIFLORACEAE

Passiflora edulis Sims

Tendril climbing shrubs.

Occasional, found along road sides and hedges at lower altitudes in Mannavan Shola.

Passiflora leschenaultii DC.

Tendril climbing shrubs

Common, along road sides and shola margins in Mannavan Shola.

PIPERACEAE

Peperomia portulacoides A. Dietr.

P. courtallensis Miq.

Small, erect and succulent epiphytic herbs.

Occasional, in interior forests in Mannavan Shola.

Peperomia tetraphylla (Forst. f.) Hook. & Arn.

Piper tetraphyllum Forst. f.; ***Peperomia reflexa*** (L. f.) Dietr.; ***Piper reflexum*** L. f.

Small, epiphytic herbs, erect and succulent.

Common, in interior forests and in exposed regions in Mannavan Shola and Eravikulam.

Piper mullesua

P. brachystachyum Wall.

Much branched woody climbers.

Occasional, in interior forests in Mannavan Shola

Piper wightii Miq.

Short climber with smooth stems.

Common, in interior forests in Mannavan Shola and Eravikulam.

PITTOSPORACEAE

Pittosporum tetraspermum Wight & Arn.

Small trees.

Common, along shola margins and ecotones at higher altitudes in Mannavan Shola and Eravikulam.

PLANTAGINACEAE

Plantago erosa Wall.

P. major sensu Hook. f.; *P. asiatica* auct. non L.

Scapigerous herbs.

Common, along road sides in Mannavan Shola

PODOSTEMACEAE

Zeylanidium olivaceum (Gard.) Engl.

Small aquatic herbs

Occasional, in the streams and lakes in Eravikulam.

POLYGALACEAE

Polygala arillata Buch.-Ham.

Large erect shrubs.

Common, along ecotones in Mannavan Shola.

Polygala rosmarinifolia Wight & Arn.

Sufftutescent annual herbs.

Occasional, in grasslands at higher altitudes in Mannavan Shola and Eravikulam.

Polygala sibirica L.

P. sibirica L. var. *heyneana* (Wall. ex Wight & Arn.) Bennet; *P. heyneana* Wall.

Perennial herbs.

Rare, found along road sides in Mannavan Shola.

POLYGONACEAE

Polygonum chinense L.

Scandent under shrubs.

Common, along moist areas, road sides and stream sides in Mannavan Shola and Eravikulam.

Polygonum nepalense Meissner

Polygonurn alarum Buch.-Ham. ex Spreng.; *Polygonum punctatum* Buch.-Ham. ex D. Don

Procumbent herbaceous weed.

Common, along road sides and stream banks at lower altitudes in Mannavan Shola.

Rumex nepalensis Spreng.

Tall stout annual or perennial herbs

Common, along road sides at lower altitudes in Mannavan Shola.

PORTULACACEAE

Portulaca oleracea L.

Small branching succulent herbs.

Rare, in wet places at lower altitudes in Mannavan Shola.

PRIMULACEAE

Lysimachia procumbens Baudo

L. deltoidea Wight

Slender trailing herbs.

Occasional, in ecotones and grasslands in Eravikulam.

PROTEACEAE

Grevillea robusta A. Cunn.

Large trees.

Common, along road sides at lower altitudes in Mannavan Shola and Eravikulam, probably planted earlier.

RANUNCULACEAE

Anemone rivularis Hamilton

Perennial herbs with white flowers.

Occasional, in ecotones and grasslands in Eravikulam.

Ranunculus reniformis Wall.

Perennial herbs with yellow flowers.

Common, found along road sides and in ecotones in Mannavan Shola and Eravikulam.

Ranunculus wallichianus Wight & Arn.

Perennial herbs.

Common, found along road sides and interior forests in Mannavan Shola

RHAMNACEAE

Ziziphus rugosa Lam.

Woody climbers with prickles.

Occasional, along shola ecotones at lower altitudes in Mannavan Shola.

ROSACEAE

Photinia integrifolia Lindl. var. **sublanceolata** Miq.

Photinia notoniana Wight & Arn.

Small trees.

Common in Mannavan Shola.

Photinia serratifolia (Desf.) Kalkman

Crataegus serratifolia Desf.; *Photinia lindleyana* Wight & Arn.

Small trees.

Rare, found in shola margins and ecotones in Eravikulam.

Prunus ceylanica (Wight) Miq.

Polydontia ceylanica Wight; *Pygeum acuminatum* Coleb; *P. gardneri* Hook, f.

Large trees.

Common, found along stream banks in Mannavan Shola.

Prunus persica (L.) Batsch.

Amygdalus persica L.

Small trees with drooping branches.

Occasional, in disturbed forests at lower altitudes in Mannavan Shola, probably planted earlier.

Rubus ellipticus Sm.

R. gowreephul Roxb.

Large straggling shrubs with stiff hairs and prickles.

Common, along the road sides and shola margins in Mannavan Shola and Eravikulam.

Rubus leucocarpus Arn.

R. lasiocarpus Sm. var. *subglaber* Thw.; *R. niveus* Thunb..var. *subglaber* (Thw.) Gamble

Straggling shrubs with prickles.

Common, along road sides and ecotones in Mannavan Shola and Eravikulam.

Rubus micropetalus Gard.

R. moluccanus sensu Hook. f.

Prickle climbers with recurved prickles.

Common, along road sides and ecotones in Mannavan Shola and Eravikulam.

RUBIACEAE

Chassalia curviflora (Wall. *ex* Kurz) Thw. var. **ophioxyloides** (Wall.) Deb. & Krishna

Psychotria ophioxyloides Wall.; *Chssalia curviflora* Wall;

Psychorria ambigua Wight & Arn.

Small shrubs with membranous leaves.

Common, in shady interior forests, shola margins and along road sides in Mannavan Shola.

Galium asperifolium Wall.

Galium mollugo sensu Hook.

Scandent, rambling, scabrous herbs.

Common, along road sides and ecotones in Mannavan Shola.

Hedyotis anamalayana (Gamble) Rao & Hem.

Oldenlandia anamalayana Gamble; *Hedyotis lessertiana* sensu Bedd.

Slender erect undershrubs.

Rare, found along shola margins in Mannavan Shola.

Hedyotis articularis R. Br. subsp. **santapaui** (Shetty & Vivek.) Deb. & Dutta

H. santapaui Shetty & Vivek.

Stiff shrubs.

Common, in the ecotones and along road sides in Mannavan Shola.

Hedyotis buxifolia Bedd.

Oldenlandia buxifolia (Bedd.) Kuntze

Stiff shrubs.

Rare, found in wet grasslands in Eravikulam.

Hedyotis corymbosa (L.) Lam.

Oldenlandia corymbosa L.

Small herbs.

Occasional, found along road sides and in ecotones in Mannavan Shola.

Hedyotis stylosa R. Br. ex Wight & Arn.

Oldenlandia stylosa (R. Br. ex Wight & Arn.) Kuntze

Large shrubs.

Common, along road sides and ecotones in Mannavan Shola and Eravikulam.

Hedyotis swertioides Hook. f.

Oldenlandia swertioides (Hook. f.) Kuntze

Low shrubs.

Common, along road sides and ecotones in Mannavan Shola and Eravikulam.

Ixora notoniana Wall. ex G. Don

Small trees

Occasional, along shola borders in Eravikulam.

Knoxia sumatrensis (Retz.) DC. var. **hookeriana** Bhattacharjee & Deb.

K. mollis auct. non R. Br.

Straggling herbs, sometimes woody at base.

Common, in disturbed areas in Mannavan Shola.

Lasianthus acuminatus Wight

Shrubs.

Abundant, in interior forests in Mannavan Shola and Eravikulam.

Mussaenda hirsutissima (Hook. f.) Hutchinson

M. frondosa L. var. *hirsutissima* Hook. f.

Large climbing shrubs, branchlets roughly hirsute-pilose.

Common, along shola margins at lower elevations in Mannavan Shola.

Neanotis indica (DC.) W. H. Lewis var. **affinis** (Wall. ex Wight & Arn.) W. H. Lewis

Hedyotis affinis Wall. ***ex*** Wight & Am.; *Anotis leschenaultiana* (Wall. ex Wight & Arn.) Hook. f. var. *affinis* (Wall. ***ex*** Wight & Am.) Hook. f.

Small herbs.

Occasional, along road sides and ecotones at higher altitudes in Mannavan Shola.

Neanotis indica (DC.) W. H. Lewis var. **indica**

Putoria indica DC.: *Anotis leschenaultiana* (Wall. ***ex*** Wight & Arn.) Hook. f.; *Hedyotis leschenaultiana* Wall. **ex** Wight & Am.

Tufted perennial herbs, stem rooting at nodes.

Common, along road sides in Mannavan Shola and Eravikulam.

Neanotis longiflora (Hutchinson) W. H. Lewis

Anotis longiflora Hutchinson

Erect perennial herbs.

Common. in disturbed areas in Mannavan Shola.

Neanotis monosperma (Wall. **ex** Wight & Am.) W. H. Lewis var. **monosperma**

Hedyotis monosperma Wall. **ex** Wight & *Am.;*

Anotis monosperma (Wall. ***ex*** Wight & Am.) Hook. f.

Slender herbs.

Rare, along road sides and ecotones in Mannavan Shola.

Ophiorrhiza grandiflora Wight

Erect under shrubs.

Common, in interior forests in Mannavan Shola.

Ophiorrhiza pectinata Am.

Erect undershrubs.

Occasional, in interior forests in Eravikulam.

Pavetta breviflora DC.

Shrubs with white flowers.

Occasional, along shola margins in Eravikulam

Psychotria elongata (Wight) Hook.

Grumilea elongata Wight

Large shrubs.

Common, along shola margins in Mannavan Shola.

Psychotria nilgiriensis Deb. & Gang. var. **nilgiriensis**

P. congesta (Wight & Arn.) Hook. f.; *Grumilea congesta* Wight & Am.

Large shrubs with white flowers

Common, both in shola borders and interior areas in Mannavan Shola.

Psychotria sp.

Small shrubs.

Occasional, in interior forests in Mannavan Shola

Rubia cordifolia L.

R. munjista Roxb.

Climbing herbs, very scabrous.

Occasional, along shola margins and ecotones in Mannavan Shola and Eravikulam.

Saprosma foetens (Wight) K. Scbum.

Lasianthusfoetens Wight; *Saprosma ceylanicum* (Gard.) Bedd.;

Dysodidendron ceylanica Gard.; *Serissa wightii* Bedd.

Tall shrubs, bad smelling when bruised.

Common undergrowth in the shola interiors in Mannavan Shola.

Spermacoce hispida L.

Borreria hispida (L.) K. Schum.; *B. articularis* (L. f.) F. Williams;

Spermacoce articularis L. f.

Hispid herbs.

Occasional, along road sides and ecotones in Mannavan Shola.

Wendlandia thyrsoidea (Schultes) Steud.

Canthium thyrsoideum Schultes; *Wendlandia notoniana* Wall.

Small trees.

Occasional, in the ecotones in Mannavan Shola and Eravikulam

RUTACEAE

Acronychia pedunculata (L.) Miq.

Jambolifera pedunculata L.; *Acronychia laurifolia* Blume; *A. barberi* Gamble

Small trees.

Common, in interior forests at lower altitudes in Mannavan Shola.

Atalantia ceylanica Oliv.

Thorny shrubs.

Occasional, in disturbed forest ecotones at lower altitudes in Mannavan Shola

Toddalia asiatica (L.) Lam.

Paullinia asiatica L.; *Toddalia aculeata* Pers.

Scandent shrubs with prickles on the stem.

Common, in interior forests in Mannavan Shola.

Zanthoxylum tetraspermum Wight & Am.

Climbing shrubs with prickly stems.

Common, along shola margins and road sides in Mannavan Shola

SABIACEAE

Meliosma pinnata (Roxb.) Maxim. ssp. **barbatula** (Cufod) Bues.

M. rhoifolia Maxim. subsp. *barbatula* Cufod.; *M. arnottiana* (Wight) Walp.; *Millingtonia arnottiana* Wight

Small to medium sized trees.

Occasional, along road sides and shola margins at Mannavan Shola and Eravikulam.

Meliosma simplicifolia (Roxb.) Walp. subsp. **simplicifolia**

Millingtonia simplicifolia Roxb.

Small trees.

Common, along road sides and other exposed regions at lower elevations in Mannavan Shola.

Meliosma simplicifolia (Roxb.) Walp. subsp. **pungens** (Wall. ***ex*** Wight & Arn.) Beus.

Millingtonia pungens Wall. **ex** Wight & Arn.: *Meliosma wightii* Planch. ***ex*** Brandis

Medium sized trees.

Common, along road sides and ecotones in Mannavan Shola and Eravikulam.

SAPOTACEAE

Isonandra candolleana Wight

Medium sized trees.

Common, in the interior forests of Mannavan Shola

SAPINDACEAE

Dodonaea viscosa (L.) Jacq.

Ptelea viscosa L.

Stiff shrubs or small trees

Common, along road sides and ecotones in Mannavan Shola

SAXIFRAGACEAE

Parnassia mysorensis Heyne

Small herbs.

Fairly common, in grasslands and along road sides at higher altitudes in Mannavan Shola and Eravikulam.

SCROPHULARIACEAE

Dopatrium nudicaule (Willd.) Benth.

Gratiola nudicaulis Willd.

Slender erect herbs

Occasional, along the sides of water courses in Mannavan Shola.

Pedicularis perrottetii Benth.

Semiparasitic herbs with long white flowers.

Occasional, in grasslands and ecotones at higher altitudes in Eravikulam.

Pedicularis zeylanica Benth.

Semiparasitic herbs with rose-pink flowers.

Fairly common, in ecotones and grasslands in Mannavan Shola and Eravikulam.

Sopubia delphiniifolia (L.) G. Don

Gerardia delphiniifolia L.

Erect herbs.

Occasional, in exposed forests and grassy slopes in Mannavan Shola and Eravikulam.

Sopubia trifida Buch.-Ham. ex D. Don

Small herbs.

Fairly common, in grasslands at lower altitudes in Mannavan Shola and Eravikulam.

Striga asiatica (L.) Kuntze var. **asiatica**

Small erect parasitic herbs.

Common, in ecotones and grasslands in Eravikulam.

SOLANACEAE

Lycianthes laevis (Dunal) Bitter

Solanum laeve Dunal

Subscandent undershrubs.

Occasional, in interior sholas in Mannavan Shola.

Nicandra physalodes (L.) Gaertn.

Atropa physaloides L.

Erect herbs

Common, along road sides in Mannavan Shola.

Physalis peruviana L.

Erect or rambling perennial herbs.

Common, along road sides, at lower altitudes in Mannavan Shola.

Solanum anguivi Lam. var. **multiflora** (Roth ***ex*** Roem. & Schultes) Chithra

S. multiflorum Roth; ***S.*** *indicum* var. ***multiflora*** (Roth ***ex*** Roem. & Schultes) Clarke;

S. ferox L. var. ***minus*** Wight

Large undershrubs, armed with stout and curved prickles on leaves and stem.

Common, along road sides in Mannavan Shola.

Solanum giganteum Jacq.

Large shrubs.

Fairly common, in disturbed forests at lower altitudes in Mannavan Shola.

Solanum nigrum L.

S. rubrum Mill.

Unarmed herbs.

Common, along road sides in Mannavan Shola

STAPHYLEACEAE

Turpinia cochinchinensis (Lour.) Merr.

Triceros cochinchinensis Lour.; *Turpinia nepalensis* Wall.; *T. pomifera* sensu Hiern

Moderate sized trees.

Common, along road sides and in interior forests in Mannavan Shola.

SYMPLOCACEAE

Symplocos anamalayana Bedd.

Small trees.

Rare, along road sides and in ecotones in Mannavan Shola.

Syrnplocos cochinchinensis (Lour.) Moore subsp. **laurina** (Retz.) Nooteb.

Myrtus *laurinus* Retz.; *Symplocos spicata* Roxb. var. *laurina* (Retz.) Clarke

Small trees.

Common, along road sides and ecotones in Mannavan Shola and Eravikulam

Symplocos pendula Wight

S. sessilis Clarke

Small or moderate-sized trees.

Rare, along ecotones in Mannavan Shola and Eravikulam.

Symplocos rnacrophylla Wall. ex A. DC. subsp. **rosea** (Bedd.) Nooteb.

S. rosea Bedd.; *S. barberi* Gamble

Small trees.

Rare, found in the ecotones in Mannavan Shola.

Symplocos sp.

Small trees.

Very rare, along road sides at higher altitudes in Mannavan Shola.

TERNSTROEMIACEAE

Eurya nitida Korth.

Eurya japonica Thunb. var. *thunbergii* Thw.; *Eurya japonica* auct. non Thunb.

Small trees with glabrous young parts.

Common, along road sides and in shola margins in Mannavan Shola

Gordonia obtusa Wall.

Tall trees with large white flowers.

Occasional, along stream banks at lower altitudes in Mannavan Shola

Ternstroemiajaponica (Thunb.) Thunb.

Cleyera japonica Thunh.; *C. gymnanthera* Wight & Arn.

Moderate sized trees.

Common, along road sides and ecotones in Mannavan Shola and Eravikulam.

THYMELEACEAE

Gnidia glauca (Fresen.) Gilg

Lasiosiphon glaucus Fresen.; *Gnidia eriocephala* Meissner;

Lasiosiphon eriocephalus (Meissner) Decne.

Large shrubs or small trees.

Occasional, found in open forests and ecotones in Mannavan Shola and Eravikulam.

TILIACEAE

Grewia umbellifera Bedd.

Scandent shrubs.

Occasional, in ecotones at lower altitudes in Mannavan Shola.

Triumfetta pilosa Roth

T. cana Blume

Large perennial herbs.

Common, along road sides and shola margins in Mannavan Shola

ULMACEAE

Trema orientalis (L.) Blume

Celtis orientalis L.

Medium sized trees

Occasional, in disturbed forests at lower altitudes in Mannavan Shola

URTICACEAE

Debregeasia longifolia (Burm. f.) Wedd.

Urtica longifolia Burm. f.; *Debregeasia velutina* Gaudich.

Large shrubs or small trees.

Common, along stream sides, shola margins and road sides in Mannavan Shola.

Droguetia diffusa Wedd.

Forskohlia urticoides Wight

Small diffuse herbs.

Common, in shady places and also along road sides in Mannavan Shola

Elatostema acuminatum Brongn.

Procris acuminata Poir.

Woody herbs.

Found in moist, marshy areas along water courses in Mannavan Shola.

Elatostema lineolatum Wight var. **falcigera** Thw.

Slender herbs with tomentose branches

Common, in cool and moist habitats like stream sides in Mannavan Shola.

Girardinia diversifolia (Link) Friis

Urtica diversifolia Link; ***Girardinia heterophylla*** Decne.; ***G. zeylanica*** Decne.; ***G. heterophylla*** Decne. var. ***zeylanica*** (Decne.) Hook. f.

Large strongly stinging herbs

Very common, along road sides at lower altitudes in Mannavan Shola.

Laportea bulhifera (Sieb & Zucc.) Wedd.

Urtica bulbifera Sieb & Zucc.; ***Laportea terminalis*** Wight

Erect herbs.

Common, along road sides at lower altitudes in Mannavan Shola.

Lecanthus peduncularis (Wall. ***ex*** Royle) Wedd.

Procis peduncularis Wall. ***ex*** Royle; ***Lecanthus wightii*** Wedd.

Succulent epiphytic herbs.

Fairly common, in interior sholas in Mannavan Shola.

Pilea melastornoides (Poir.) Blume

Urtica melastomoides Poir.; ***Pilea trinervia*** (Roxb.) Wight; ***Urtica trinervia*** Roxb

Succulent herbs with swollen internodes.

Common, in moist regions in Mannavan Shola.

Pilea wightii Wedd.

P. radicans Wight

Small succulent herbs.

Common, preferring shady moist environments such as stream sides in Mannavan Shola.

Pouzolzia bennettiana Wight var. **acuta** (Wight) Fischer

P. acuta Wight

Erect herbs.

Fairly common, along water courses or in other wet places in Mannavan Shola

Pouzolzia wightii Benn.

Tall herbs

Common, in wet places and along stream banks in Mannavan Shola.

VACCINIACEAE

Vaccinium leschenaultii Wight var. **leschenaultii**

Small trees with ovate-lanceolate leaves.

Common, along shola margins in Mannavan Shola and Eravikulam.

Vaccinium leschenaultii Wight var. **rotundifolia** (Wight) Clarke

V. rotundifolia Wight

Small trees with orbicular leaves.

Common, along shola margins in Mannavan Shola and Eravikulam.

VALERIANACEAE

Valeriana beddomei Clarke

Herbs with oblong radical leaflets.

Rare, in the grassland ecotones and road sides in Eravikulam

Valeriana hookeriana Wight & Arn.

Pubescent herbs.

Occasional, in shola ecotones and along road sides in Mannavan Shola and Eravikulam

VERBENACEAE

Clerodendrum serratum (L.) Moon

Volkameria serrata L.

Shrubs usually herbaceous but occasionally woody, with 4 angled stems

Common, along shola margins at lower altitudes in Mannavan Shola.

Clerodendrum viscosum Vent.

C. infortunarum auct. non L.

Shrubs or small trees with tetragonal stem.

Common, in lower altitudes in Mannavan Shola.

Lantana camara L. var. **aculeata** (L.) Mold.

L. aculeata L.

Rambling shrubs.

Very common, along road sides and in disturbed forests in Mannavan Shola and Eravikulam.

Lantana indica Roxb.

Erect shrubs.

Fairly common, along road sides in Mannavan Shola.

VIOLACEAE

Viola betonicifolia J. E. Sm. ssp. **nepalensis** (Ging.) Becker

V. patrinii var. *nepalensis* Ging.; *V. walkeri* Wight

Small stemless herbs.

Common, along the road sides in Mannavan Shola

Viola pilosa Blume

V. serpens Wall. ex Ging.; *V. wightiana* Wall. ex Wight

Small herbs.

Fairly common, along road sides and in ecotones in Mannavan Shola.

VITACEAE

Cayratia pedata (Lam.) Juss.

Cissus pedata Lam.; *Vitis pedata* (Lam.) Wall.

Large tomentose climbers.

Common, along road sides in Mannavan Shola.

Parthenocissus neilgherriensis (Wight) Planch.

Vitis neilgherriensis Wight; *V. himalayana* Brandis; *V. anamallayana* Bedd

Large climbers.

Common, along road sides in Mannavan Shola.

Tetrastigma leucostaphylum (Dennst.) Alston

Cissus leucostaphyla Dennst.; *Tetrastigma muricatum* (Wall. *ex* Wight & Arn.) Gamble

Vitis muricata Wall.

Large climbers, branchlets prominently warted.

Common, along shola margins and disturbed forest regions in Mannavan Shola.

3.63 MONOCOTYLEDONS

ARECACEAE

Calamus gamhlei Beccari *ex* Beccari & Hook. f.

Moderate sized scandent canes.

Rare, in the interior forests of Mannavan Shola and Eravikulam

ARACEAE

Arisaema attenuatum Barnes & Fischer

Tuberous herbs.

Rare, at lower altitudes in Eravikulam

Arisaema leschenaultii Blume

Tuberous herbs, spathe with purple vertical streaks.

Fairly common, in interior sholas or along shaded road sides in Mannavan Shola and Eravikulam.

Arisaema sp.

Tuberous herbs.

Rare, in shady shola interiors in Mannavan Shola

COMMELINACEAE

Commelina attenuata Koen. *ex* Vahl

Slender spreading herbs.

Common, in exposed regions in Mannavan Shola

Commelina sp.

Slender branching herbs.

Fairly common, in exposed regions in Mannavan Shola.

Cyanotis arachnoidea Clarke

Prostrate hairy herbs.

Occasional, in grasslands and along road sides at higher elevations in Mannavan Shola,

Cyanotis cristata (L.) D. Don

Commelina cristata L.

Succulent herbs

Fairly common, in exposed regions in Mannavan Shola.

Cyanotis pilosa Schultes & Schultes f.

Decumbent herbs.

Common, along road sides or in other exposed regions in Mannavan Shola.

Cyanotis villosa (Spreng.) Schultes & Schultes f.

Tradescantia villosa Spreng.; *Cyanotis lanceolata* Wight

Fleshy herbs with deep purple stem and leaves.

Common, in the ecotones in Mannavan Shola.

CYPERACEAE

Bulbostylis densa (Wall.) Hand.-Mazz.

Scirpus densus Wall.; *Bulbostylis capillaris* var. *trifida* (Nees) Clarke; *Isolepis trifida* Nees

Small herbs.

Common, in wet shady places and along stream banks in Mannavan Shola.

Carex baccans Nees

Coarse perennial herbs, stems robust, upto 2 m.

Very common, mostly along sides of water courses in Mannavan Shola.

Carex filicina Nees

Perennial herbs, stems sparsely tufted.

Common, along road sides and ecotones in Mannavan Shola.

Carex lindleyana Nees

Herbs with perennial rhizomes, leaves mainly at the of stem.

Common, along road sides and ecotones in Mannavan Shola and Eravikulam.

Carex myosurus Nees

Erect herbs with stout rhizome.

Common, along road sides in Mannavan Shola.

Carex phacota Spreng.

Herbs, stems leafy mainly at the base.

Common, along road sides and ecotones in Mannavan Shola and Eravikulam,

Cyperus cyperinus (Retz.) Valcken

Kyllinga cyperina Retz.; *Mariscus cyperinus* (Retz.) Vahl

Perennial herbs.

Common, in moist shady places, along river banks in Mannavan Shola

Fimbristylis kingii Clarke

Annual herbs.

Fairly common, in moist places, along road sides and in grasslands in Mannavan Shola

Kyllinga brevifolia Rottb.

Small perennial herbs.

Fairly common, along road sides in Mannavan Shola,

Pycreus globosus (All.) Reichb.

Cyperus globosus All.; *Pycreus capillaris* Nees var. *nilagiricus* C.B. Clarke

Small herbs.

Fairly common, in ecotones and grasslands in Mannavan Shola and Eravikulam.

Scirpus articulatus L.

Schoenoplectus articulatus (L.) Palla

Herbs.

Common, in moist, boggy lands at lower altitudes in Mannavan Shola.

ERIOCAULACEAE

Eriocaulon brownianum Mart. var. **nilagirense** Fyson

Large herbs.

Common, in water logged areas of the grasslands in Mannavan Shola and Eravikulam.

Eriocaulon pectinatum Ruhl.

Small herbs.

Common, in water logged areas in the grasslands in Mannavan Shola and Eravikulam.

HAEMODORACEAE

Ophiopogon intermedius D. Don

Ophiopogon indicus Wight

Erect rhizomatous herbs

Common, in shady interior forests in Mannavan Shola.

HYPOXIDACEAE

Curculigo orchioides Gaertn.

C. malabarica Wight

Herbs with elongated rhizomatous root stock.

Common, in lower altitudes in Mannavan Shola.

Hypoxis aurea Lour.

Erect herbs.

Very rare, found in interior sholas in Mannavan Shola.

IRIDACEAE

Aristea ecklonii Baker

Bilaterally flattened herbs.

Fairly common, along road sides and in grassland ecotones at higher altitudes in Mannavan Shola and Eravikulam.

JUNCACEAE

Juncus bufonius L.

Erect herbs, stems densely clustered.

Occasional, found in moist shady regions along water courses and road sides in Mannavan Shola.

Juncus inflexus L.

J. glaucus Ehrh.

Glabrous herbs.

Common, along road sides and wet areas in Mannavan Shola.

Juncus prismatocarpus R. Br

Glabrous, erect herbs.

Common, along road sides in Mannavan Shola.

LILIACEAE

Asparagus racemosus Willd.

Climbing shrubs with stipular spines.

Very common, along shola margins at lower altitudes in Mannavan Shola

Lilium wallichianum Schultes Schultes f. var. **neilgherrense** (Wight) Hara

L. neilgherrense Wight

Woody, unbranched leafy herbs with bulbous base.

Rare, found along road sides, grassland ecotones and in other open areas in Mannavan Shola.

Peliosanthes teta Andr.

Peliosanthes neilgherrensis Wight; *P. courtallensis* Wight

Scapigerous herbs with creeping root stock.

Rare, found in interior forests and in slightly exposed regions in Mannavan Shola

ORCHIDACEAE

Aerides ringens (Lindl.) Fischer

Saccolabium ringens Lindl.; *Saccolabium rubrum* Wight

Stout epiphytic herbs.

Common, along shola margins in Mannavan Shola and Eravikulam.

Anoectochilus elatus Lindl.

Terrestrial leafy herbs, stems creeping below.

Rare, in shady and moist habitats in Mannavan Shola

Brachycorythis splendida Summerh.

Habenaria iantha Hook. f.; *Phyllomphax obcordata* Schult. var. *iantha* Fischer

Terrestrial herbs.

Rare, found in ecotones and open grasslands in Mannavan Shola and Eravikulam.

Bulbophyllum fischeri Seidenfaden

Cirrhopetalum macraei sensu Wight; *C. wightii* Thw.; *C. gamblei* Hook.;

Bulbophyllum ***gamblei*** (Hook. f.) J. J. Sm.

Small epiphytic or lithophytic herbs.

Very rare, found along shola margins in Eravikulam.

Calanthe masuca (D. Don) Lindl.

Bletia masuca D. Don.; *Calanthe emarginata* Wight

Terrestrial herbs.

Common, in moist shady places in Mannavan Shola,

Cheirostylis flabellata Wight

Herbs with creeping rhizome.

Rare, along road sides in moist, shady places in Mannavan Shola,

Chrysoglossum maculatum Hook. f.

Ania maculata Thw.

Pseudobulbous herbs, pseudobulbs 1-leaved; racemes lateral.

Common, in interior forests of Mannavan Shola and Eravikulam

Coelogyne mossiae Rolfe

Epiphytic herbs with white flowers.

Rare, found along shola margins in Eravikulam.

Dendrobium anamalayanum Chandrabose *et al*

Epiphytic herbs.

Rare, along shola margins in Mannavan Shola and Eravikulam.

Diplocentrum recurvum Lindl.

Epiphytic herbs with narrow leaves.

Rare, at lower altitudes mostly on *Syzygium cumini* in Mannavan Shola.

Eria nana A. Rich.

Dendrobium filiforme Wight

Very small epiphytic herbs.

Rare, in interior forests in Eravikulam.

Eria pseudoclavicaulis Blatter

Epiphytic herbs with pinkish white flowers

Rare, along shola margins in Eravikulam.

Habenaria elliptica Wight

Herbs with greenish flowers

Rare, in the ecotones and grasslands in Eravikulam.

Habenaria heyneana Lindl.

Herb with white flowers.

Rare, in ecotones and grasslands in Eravikulam.

Habenaria longicorniculata Graham

H. longicalcarata A. Rich.

Tall herbs with white flowers.

Occasional, in ecotones and grasslands in Eravikulam.

Habenaria perrottetiana A. Rich.

Platanthera lutea Wight

Herbs with tuberous roots.

Rare, in grasslands in Eravikulam.

Liparis wightiana Thw.

Small fleshy herbs.

Rare, in disturbed forest floors in Mannavan Shola.

Oberonia arnottiana Wight

O. *wightiana* Lindl. var. *arnottiana* (Wight) Ansari *et al;*

O. *wightiana* Lindl. var. *nilgirensis* Ansari *et al*

Pendulous epiphytic herbs.

Occasional. in interior forests in Mannavan Shola.

Oberonia chandrasekharanii Nair *et al*

Epiphytic herbs with fleshy distichous leaves.

Occasional, in the interior forests in Mannavan Shola

Oberonia wightiana Lindl.

Malaxis wightiana (Lindl.) Kuntze

Epiphytic herbs.

Common, in interior forests in Mannavan Shola.

Oberonia sebastiana Shetty & Vivek.

Pendulous epiphytic herbs.

Common, in interior forests in Mannavan Shola.

Oberonia thwaitesii Hook. f.

Pendulous epiphytic herbs.

Common in interior forests in Mannavan Shola.

Satyrium nepalense D. Don

Terrestrial unbranched herbs with tuberous roots

Rare, along road sides and ecotones in Mannavan Shola and Eravikulam

Seidenfadeniella chrysantha (Alston) Sathish

Saccolabium chrysanthum Alston; *Sarcanthus filiformis* Wight; *Saccolabium filiforme* Lindl.

Epiphyte with needle like leaves.

Rare, in interior forests in Mannavan Shola and Eravikulam.

POACEAE

Agrostis peninsularis Hook. f.

Annual herbs

Rare, in ecotones and grasslands in Mannavan Shola and Eravikulam.

Apluda mutica L.

A. varia Hack. subsp. *mutica* (L.) Hack.

Ascending or decumbent leafy perennials

Common, in open disturbed sites and road sides in Mannavan Shola and Eravikulam.

Arundinella vaginata Bor

A. villosa var. *heynei* Hook. f.; *A. villosa* auct. non Arn. ex Steud.

Perennial herbs.

Common, in grasslands in Mannavan Shola and Eravikulam.

Chrysopogon zeylanicus (Nees ex Steud.) Thw.

Andropogon zeylanicus Nees

Erect herbs.

Occasional, in grasslands in Mannavan Shola.

Cymbopogon flexuosus (Nees ex Steud.) Wats.

Andropogon flexuosus Nees ex Steud.; *A. nardus* L. var. flexuosus (Nees ex Steud.) Hack.

Tall aromatic perennial herbs.

Common, in grasslands and ecotones in Mannavan Shola.

Cymbopogon travancorensis Bor

Perennial herbs.

Common, in grasslands in Mannavan Shola

Digitaria wallichiana (Wight &Arn. ex Steud.) Stapf

Panicum wallichianum Wight & Arn. ex Steud.; *Paspalum perrottetii* Hook, f.

Tufted herbs.

Common, in grasslands in Mannavan Shola.

Eragrostis nigra Nees

Small herbs.

Common, in grasslands and ecotones in Mannavan Shola and Eravikulam.

Eragrostis unioloides (Retz.) Nees ex Steud.

Poa unioloides Retz.; *Eragrostis amabilis* sensu Hook. f.

Erect herbs.

Common, along road sides and in grasslands in Mannavan Shola.

Eulalia phaeothrix (Hack.) Kuntze

Pollinia phaeothrix Hack.

Erect herbs with basal sheaths having a chocolate coloured indumentum.

Common, in grasslands and ecotones in Mannavan Shola and Eravikulam.

Isachne walkeri (Arn. ex Steud.) Wight & Arn. ex Thw.

Panicum walkeri Arn. ex Steud.

Perennial herbs.

Occasional, along road sides and ecotones in Mannavan Shola.

Ischaemum indicum (Houtt.) Merr.

Phleum indicum Houtt.; *lschaemum ciliare* Retz.; *I. aristatum* sensu Fischer

Slender herbs.

Common, in ecotones and grasslands in Mannavan Shola and Eravikulam.

Microstegium ciliatum (Trin.) A. Carnus

Pollinia ciliata Trin.

Tall herbs.

Fairly common, in grasslands of Mannavan Shola.

Oplismenus burmannii (Retz.) P. Beauv.

Panicum burmannii Retz.

Slender herbs.

Common, dong road sides in Mannavan Shola

Oplismenus compositus (L.) P. Beauv.

Panicum compositum L.

Procumbent or suberect perennial herbs.

Common, dong road sides and grasslands in Mannavan Shola

Poa aunua L.

Annual herbs.

Common, along road sides and in grasslands of Mannavan Shola and Eravikulam.

Setaria palmifolia (Koen.) Stapf

Panicum palmaefolium Koen.; *P. plicatum* sensu Hook. f., non Lam. 1797

Perennial herbs.

Fairly common, along road sides in the grasslands and ecotones in Mannavan Shola and Eravikulam.

Setaria pumila (Poir.) Roem. & Schultes

Panicum panilum Poir.; *Setaria pallidefusca* (Schum.) Stapf & Hubbard;

Panicum pailidefuscum Schum.

Tufted annual herbs.

Common. in the grasslands of Mannavan Shola and Eravikulam.

Sinarundinaria densifolia (Munro) Chao & Renv.

Arundinaria densifolia Munro; *Chimonobambusa densifolia* (Munro) Nakai

Erect woody shrubs.

Rare, along road sides, ecotones and interior forests in Mannavan Shola and Eravikulam.

Sinarundinaria microphylla (Munro) Chao & Renv.

Arundinaria microphylla Munro; *Yushania microphylla* (Munro) R. Majumdar

Small woody shrubs.

Very rare, found as patches along stream banks in the grasslands.

Sorghum nitidum (Vahl) Pers.

Holcus nitidus Vahl; *Andropogon serratus* Thunb.; *Sorghum serratum* (Thunb.) Kuntze

Perennial herbs.

Fairly common, in grasslands in Mannavan Shola.

Themeda triandra Forssk.

Anthistiria imberbis Retz.

Dense perennial herbs.

Common, in ecotones and grasslands in Mannavan Shola and Eravikulam.

Tripogon bromoides Roem. & Schultes

Slender herbs.

Common, in the grasslands of Mannavan Shola and Eravikulam.

Zenkeria elegans Trin

Tall perennial herbs.

Common, in grasslands and ecotones in Mannavan Shola.

SMILACACEAE

Smilax aspera L.

S. maculata Roxb.

Climbing shrubs with prickles.

Occasional, in interior forests in Mannavan Shola.

Smilax wightii A. DC.

Climbing shrubs.

Occasional, at higher elevation in Mannavan Shola and Eravikulam.

ZINGIBERACEAE

Hedychium flavescens Carey ex Rosc.

H. coronarium Koen. var. flavescens (Carey ex Rose.) Baker

Erect herbs with tuberous root stock

Common, along water courses in lower altitudes in Mannavan Shola.

Chapter 4

COMMUNITY ECOLOGICAL STUDIES

4.1 Introduction

Ecology deals with interaction of organisms with their external environment (Odum, 1971). Taken each individual organism separately, or in terms of individual sections of the biota, the remaining sects or organisms form part of their external environment. Community ecology therefore examines the result of differentiation of individual parametric properties of the different sectors of the community, often relating the facts to the integrated results. In the ecology of the higher plants therefore, phytosociology forms a major domain of ecological research (Mueller-Dombois and Ellenberg, 1974; Kimmins, 1987), providing indications on the interactions between the segments of the community.

The paucity of community ecological studies on shola forests, as in floristic studies, owe to the poor economic bearing of the shola forest resources, their restricted extent, remote access and the hostile climate. In addition, the high diversity of flora and the fewer rigorous floristic studies of the vegetal type is yet another impediment (For details refer: *Chaprer 2. Floristic studies).*

4.2 Review of Literature

Descriptions of the subtropical hill forests and the montane wet temperate forests (Champion, 1936; Champion and Seth, 1968) were largely based on visual assessment of preponderance or dominance of species, and were not really based on quantitative enumerations.

Early synecological attempts concerning the stand parameters of the shola forests were available in the studies by Champion (1936) and Ranganathan (1938). There has been a gap of several years after these pioneering studies, on the subject.

The magnificent grassy expanses and the mosaic of hundreds of small and larger glens scattered within it and which gulp and eject the cloudy mist, canvassed the landscape of the Nilgiri plateaux before the invasion of people and massive agriculture there (Ranganathan, 1938). These glens, the shola forests, received some research attention, although as an offside of the grassland studies. The studies of Aganval *et al*. (1961), Gupta (1960, 1962 a. 1962 b, 1971), Vishnu-Mittre and Gupta (1968), Vishnu-Mittre (1971) and Meher-Homji (1986) have generated valuable information on the shola forests.

Blasco (1971) made a phytogeographic analysis of the grassland-forest continuum along the hill tops of the Western Ghats. The next significant post-independent contribution on shola forests appeared as fragmented treatments. Chandrasekharan (I962 d) while attempting a classification of the forest types of Kerala provided some description of shola forests. Puri *et al* (1989) have provided a recent review of the ecological studies on the shola forests. Apart from these studies, the only recent phytosociological study on the shola forests of Kerala is by Jose *et al* (l994).

4.3 Materials and Methods

4.3.1 Area of Study: Most of the community ecological studies were conducted at two specific locations: (i). The Mannavan shola, and (ii). The Eravikulam National Park, the former abounding in the subtropical hill forest component of the shola forests and the latter with innumerable montane forest patches. The above areas were selected for location specific studies for two specific reasons. The Mannavan shola provides, a continuous elevational gradient starting from 1,500 m onwards to 2,100 m above asl. The poor representation of montane wet temperate forests in the upper reaches of the Mannavan Shola is compensated by including the Eravikulam National Park, which is a refugium for patchy montane forest vegetation. The physiographic, climatic, habitational and other details of the study areas are given in *Chapter* 2.

4.3.2 Plant life forms studied: While in floristic studies, the plants studied included all tracheophytes *(ie,* Pteridophytes and Angiosperms, as Gymnosperms were not encountered in the study area), the community ecological studies were largely confined to trees, except in specific instances of study. For consideration of a plant as a tree, the minimum height of ≥ 3 m was taken as the criterion, thus ascribing to a more 'arborescent' concept of tree definition. For many purposes, individuals ≥ 1 cm dbh (at 137 cm height) of all species which generally grow to a height ≥ 3 m, were enumerated and measured for population estimations. A further narrowing down of the scope of study was made by restricting enumeration and measurements to individuals ≥ 10 cm dbh, either to reduce the work load or to draw up a picture at in differing spatial magnitudes. Herbaceous and shrubby plants were included only in selected components.

4.3.3 Sample size: In the community ecological studies, two different kinds of samples were used: (i) some semi-permanent samples of 0.25 ha in size, and (ii) several releves, each measuring 0.1 ha and comprising of ten discontinuous 0.01 (10 m x 10 m) ha samples.

4.3.4 Semi-permanent plots of 0.25 ha size: Phytosociological studies are generally done in releves, the minimum sample size required for community ecological studies, determined through estimation of species-area relations. Releves generally provide only gross pictures of the vegetation and therefore for finer information especially relating to ecosystems, study of large-scale permanent plots and their longterm monitoring are being increasingly used (Sukumar and Sukumar, 1992). Six 0.25 ha (50 m x 50 m) sample plots were established, in the Eravikulam National Park and Mannavan Shola. The location of each semi-permanent plot were selected such that, each of them falls in a different elevational belt, and some of them represent disturbed sholas. Locational details of the semi-permanent plots are given in table 4.1.

The 50 m x 50 m plots were divided into twenty five 100 m^2 (10 m x 10 m) quadrats. Studies were restricted to tree species alone. Trees ≥ 10 cm dbh, ≥ 1 cm dbh and < 10 cm dbh, and all regeneration less than 1 cm dbh were enumerated in all the ***25*** quadrats in the sample plots.

4.3.5 Releves of 0.1 ha comprising 10 discontinuous quadrats: In addition to the studies on permanent plots, conventional phytosociological studies were also conducted in releves, in order to understand the distribution of measures of dominance, association, etc. Trees ≥ 10 cm dbh were measured and enumerated in quadrats of 10 m by 10 m (100 m^2) size in four elevational belts falling between the elevational belts of the semi-permanent plots (Table 4.2).

Table 4.1. Locations of semi-permanent plots and releves studied

No	Locations	Altitude (m)	Comments	Area	Enumeration
1.	Kalippettumala Mannavan Shola	1,700	Burnt stand	0.25 ha	Stems ≥ 1 cm dbh
2.	Kanthallur-4 Mannavan Shola	1,750	Forest ecotone	0.25 ha	Stems ≥ 1 cm dbh
3.	Kanthallur-5 Mannavan Shola	1,850	Undisturbed	0.25 ha	Stems ≥ 1 cm dbh
4.	Kanthallur-6.5 Mannavan Shola	1,950	Undisturbed	0.25 ha	Stems ≥ 1 cm dbh
5.	Nilagiri Teri Eravikulam (Fig. 4.1)	1,950	Undisturbed	0.25 ha	Stems ≥ 1 cm dbh
6.	V-point Eravikulam (Fig. 4.2)	2,100	Undisturbed	0.25 ha	Stems ≥ 1 cm dbh

Data from these releves were supplemented with data from ten 100 m^2 quadrats randomly selected from the permanent plots so that, altogether there were 10 elevational data available for phytosociological interpretations.

Table 4.2 Locations of 0.1 ha releves studied in the shola forests

No	Locations	Altitude (m)	Comments	Area	Enumeration
1.	Thalachorkadavu Mannavan Shola	1,600	Undisturbed	0.1 ha	Stems ≥ 10 cm dbh
2.	Kanthallur-3 Mannavan Shola	1,700	Undisturbed	0.1 ha	Stems ≥ 10 cm dbh
3.	Kanthallur-4 Mannavan Shola	1,800	Undisturbed	0.1 ha	Stems ≥ 10 cm dbh
4.	Kanthallur-6 Mannavan Shola	1,900	Undisturbed	0.1 ha	Stems ≥ 10 cm dbh
5.	Kanthallur-6.5 Mannavan Shola	1,950	Undisturbed	0.1 ha	Stems ≥ 10 cm dbh
6.	Kanthallur-9.5 Mannavan Shola	2,000	Undisturbed	0.1 ha	Stems ≥ 10 cm dbh
7.	Mathappu Mannavan Shola	2,100	Undisturbed	0.1 ha	Stems ≥ 10 cm dbh

4.3.6 Ecological parameters studied: The data obtained from bemi-permanent plots and releve samples were analyzed for understanding species-area relations in the vegetation type, the pattern of life spectrum distribution, distribution of tree life-forms, diversity, species associations, different measures of dominance such as density, basal area, importance, values and regeneration dynamics.

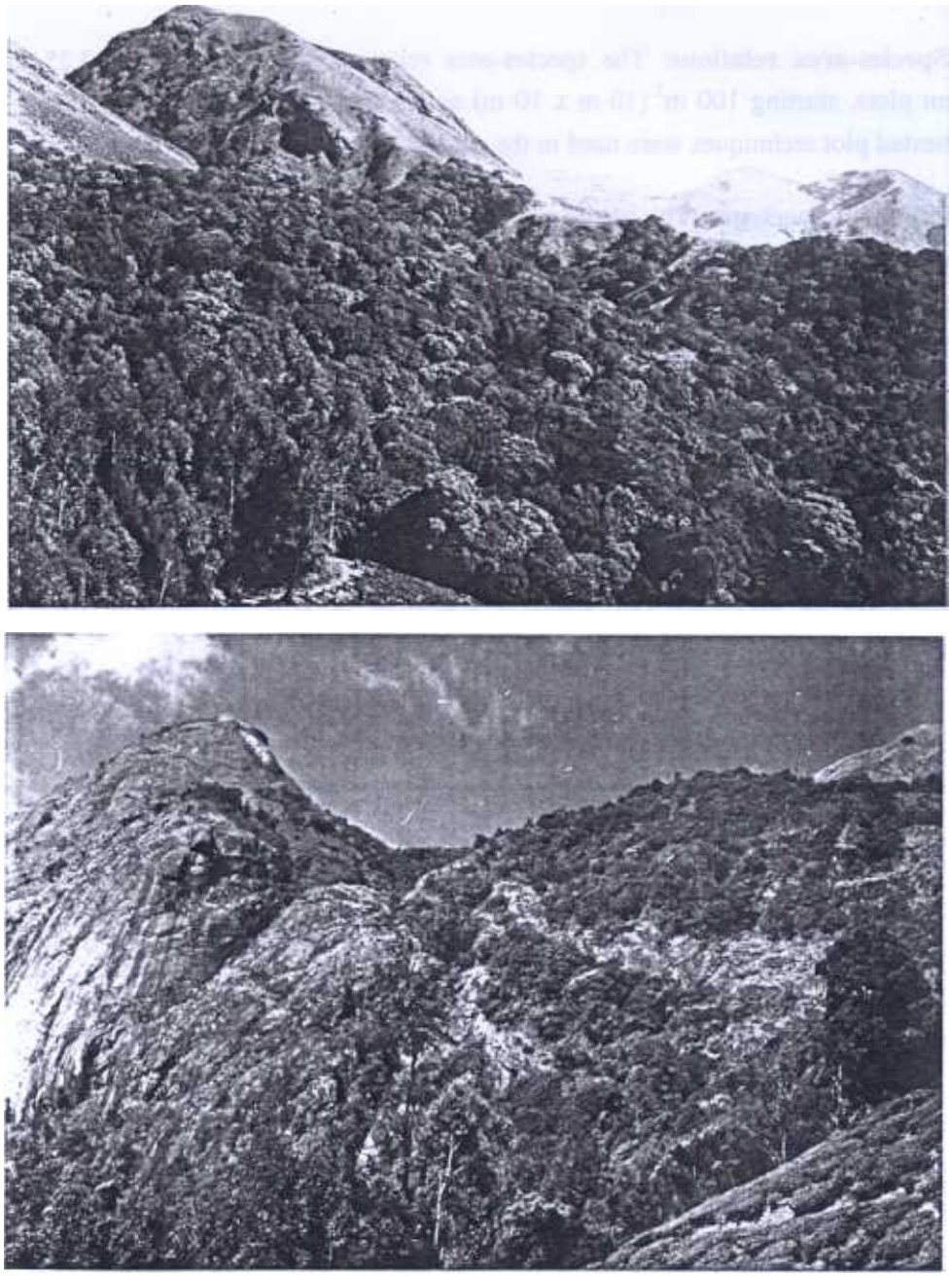


Figure 4.1 & **4.2** Photographs of two semi-permanent plots established for the present study. **Fig. 4.1** An outside view of the shola forest in which the semi-permanent plot 'Nilagiri Teri' is established. **Fig. 4.2** A view of the eastern aspect of the Umayamalai in Eravikulam NP. The semi-permanent plot 'V-Point' lies on the western aspect of this ridge.

4.3.6.1 Typology: The enumeration data on trees ≥ 10 cm dbh from the semi-permanent plots were randomly selected and pooled together with the releve data gathered from elevational belts in between that of the semi-permanent plots. The data were assembled into a synthesis table.

4.3.6.2 Species-area relations: The species-area relation was studied from 0.25 ha semi-permanent plots, starting 100 m^2 (10 m x 10 m) as the initial quadrat size. Expanding quadrat method\nested plot techniques were used in the study.

4.3.6.3 Life form spectrum: The plants encountered in the samples were classified into three life forms, viz, herbs, shrubs, and trees. No classification of the herbs into cryptophytes, geophytes, etc were done. Analysis of data for the life-form spectra was conducted only of the data obtained from the semi-permanent plots of 0.25 ha size.

4.3.6.4 Relationship between tree size and elevation: The enumeration data from the semi-permanent plots and releves were pooled so as to describe population properties of tree diameter. The trends in diameter distribution were examined at the ecosystem level as well as at individual tree species level.

4.3.6.5 Measures of diversity: The different. measures of diversity studied are given in Table 4.3.

Table 4.3 The different measures of diversity studied

Parameters		Formula/ method
Species richness	[S]	number of spp. encountered in the sample
Number of stems of species *i* in the sample	[n_i]	counts
Total number of stems of all species encountered in the sample area	[N]	$\sum_{i=I}^{S} n_i$
Mean number of stems per species in the sample area	[N/S]	N/S
Shannon's index of diversity (Shannon and Weiner, 1949)	[H]	$3.3219' \left[\log_{10} N-(1/N) \sum_{i=1} n, \log_{10} n_i\right]$
Pielou's index of evenness (Pielou, 1975)	[E]	H'/H_{max} (where $H_{max} = \log_2 S$)
Simpson's index of dominance (Simpson, 1975)	[D]	$1- \sum_{i=1}^{S} (n_i/N)^2$

*- factor for conversion from $\log_2$ to $\log_{10}$

Many of the aspects mentioned in the above table are discussed in separate headings in the section: *Results and Discussion*

4.3.6.6 Measures of Dominance: Various measures of dominance such as density, frequency and basal area were computed for each species in the releves and importance value calculated following the conventional phytosociological computations as defined in Table 4.4 so as to arrive at meaningful sociological interpretations.

Table **4.4 The various dominance parameters studied**#

Parameters	Formula	Terms
Density of species *i* [n(i)]	$\sum_{i=1}^{n} i$	i = each replicate individual of the species i
Relative Density [RD]	n(i) x 100/N	$N = \sum_{i=1}^{S} n(i)$; S = number of species
Frequency [f(*i*)]	q(i) x 100/q	q(i) = number of squares in which species (i) was present; q = the total number of squares studied
Relative frequency [RF]	f(i) x 100/F	$F = \sum_{i=1}^{S} f(i)$
Basal area [BA(*i*)]	$\sum_{n(i)=1}^{n(i)} BA_{n(i)}$	BAn(i) = $c^2/4$ pi; pi = 3.14; c = circumference at 1.37 m above the ground
Relative Basal Area [RBA]	$\frac{BA(i) \times 100}{\sum_{i=1}^{S} BA(i)}$	Percentile Basal Area
Importance Value Index [IVI]	RD + RF + RBA	Out of 300
Relative Importance Value Index [RIVI]	IVI/3	out of 100

#Adapted from: (1). Mueller Domhois and Ellenherg (1974), and Pascal (1988)

4.4 Results and discussion

4.4.1 Typology

The result of analysis of species compositions are given in Appendix-I and summarized in Table 4.23. Classification of species according to constancy percentages is given in Table 4.5.

Table 4.5 Classification of species according to constancy percentage

No.	Constancy percent	S#
1	100%	1
2	≥ 70% and < 100%	5
3	≥ 10% and < 70%	42
4	<10%	38

S# - Number of species

Table 4.6 Classification of species according to constancy

[data of 12 releves, each of 0.1 ha]

Constancy class	Species list #	
Species with 100 % constancy	1. *Cinnamomum wightii*	
Species with constancy ≥ 70% and < 100%	1. *Litsea* sp. 2. *Elaeocarpus munronii* 3. *Gomphandra coriacea*	4. *Persea macrantha* 5. *Saprosma foetens*
Species with constancy ≥ 10% and < 70% (Selected most constant species in the class)	1. *Hydnocarpus alpina* 2. *Isonandra candolleana* 3. *Mastixia arborea* 4. *Lasianthus acuminatus* 5. *Schefflera racemosa* 6. *Syzygium* sp. [pilla njaval] 7. *Chionanthus macrocarpa* 8. *Ternstroemia japonica* 9. *Turpinia nepalensis* 10. *Actinodaphne bourdillonii* 11. *Bhesa indica*	12. *Canthium dicoccum* 13. *Syzygium arnottiana* 14. *Acronychia laurifolia* 15. *Celtis wightii* 16. *Syzygium* sp. 17. *Glochidion neilgherrense* 18. *Isonandra* sp. [vella pala] 19. *Daphniphyllum neilgherrense* 20. *Ficus* sp. 21. *Ilex denticulata* 22. *Meliosma simplicifolia*

Taken only trees ≥ 10 cm dbh into consideration, in all the 12 releves studied (including sample from the semi-permanent plots) a single species, *Cinnamomum wightii*, showed hundred percent constancy, as derived from the synthesis table. The community therefore qualifies to be called *Cinnamomum wightii* community (Tables 4.5 & 4.6).

Another 5 species showed constancy between 70 and while there were as many as 42 species sharing a constancy rank between 10 and 70%. The category of less frequent species represented by less than 10% in the releves included 38 species thus substantiating high diversity (Table 4.6).

4.4.2 Life form spectrum

The observed relations between the different life forms in the semi-permanent plots (0.25 ha) are given in table 4.7 and part of it represented in Figures 4.3 and 4.4.

Table 4.7 Life form composition with elevation

Elevation (m asl)	Life form relations
≥ 1,500	$S_{(shrubs)} < S_{(trees)}$
1,950	$S_{(trees)} < S_{(herbs)}$
2,100	$S_{(trees)} > S_{(herbs)}$
≥ 1,500	$S_{(shrubs)} + S_{(herbs)} > S_{(trees)}$

4.4.2.1 Tree species: There is appreciable reduction in the number of tree species with ascending elevation from 1,850 m as1 onwards. This is probably because of the temperate-like climate above 1,800 m as1 (Table 4.7; Figs. 4.3 & 4.4).

4.4.2.2 Shrubs plus herbs: The aggregate figure for number of species of herbs and/or shrubs always outnumbered the number of tree species at all undisturbed shola forest sites. However, this aggregate figure was higher in the forest-grassland ecotone (82 spp.) and fire burnt plots (60 spp), compared to that in undisturbed plots (56 spp.) (Table 4.7; Figs. 4.3 & 4.4).

4.4.2.3 Shrub species: From 1850 to 2,100 m asl, there was no appreciable increase in the number of shrubby species. The number of shrub species was always found to be less than the aggregate figure for tree and/or herb species. However the attribute showed variations; at 1950 m as1 shrub species were fewer than tree species whereas at 2,100 m asl, the shrub species outnumbered the tree species. The number of shrub species was very low in the forest-grassland ecotone plot (9 spp.) and burnt shola plot (6 spp.), compared to the undisturbed plots ±18 spp.) (Table 4.7; Figs. 4.3 & 4.4).

4.4.2.4 Herbs: Throughout the elevational range, no appreciable increase in the number of species of herbs was observed. The number of herbaceous species was high in a grassland ecotone (73 spp) and the burnt plot (54 spp.), compared to that of the undisturbed plots (±39 spp.). As in evergreen and moist deciduous forests, the herbaceous forms have a definitive pioneer role here too (Figs. 4.3 & 4.4).

4.4.3 Relationship between tree diameter and elevation

4.4.3.1 At the all species level: Tree diameter distribution with respect to elevation is presented in Table 4.8.

Of 1,186 trees measured in the shola forests, the highest diameter measured was 160.7 cm at about 1,800 m asl. At 1,600 m as1 the maximum tree diameter was 155.3 cm dbh. From 1,850 m as1 onwards there was a gradual reduction in the maximum dbh of trees (cf. Table 4.8, Fig. 4.5) and at 2,100 m asl, the maximum diameter recorded was only 72.5 cm.

Although the maximum tree diameter decreased with ascending elevation (Fig. 4.5), the mean tree diameter however displayed a more or less normal distribution pattern (Fig. 4.6).

From 1,600 m as1 onwards, the mean tree diameter (31.4 cm dbh) began increasing to reach a maximum mean measure of 41.7 cm dbh at 1,900 m asl. Then onwards the trend was one of decreasing, to attain a mean minimum of 24.7 and 19.9 cm at 2,100 m asl (Fig. 4.6, Table 4.8). The variability of mean diameter as reflected in standard deviation was least for the 2.100 m as1 (14.8 and 11.4; cf. Table 4.8).

Table 4.8 Diameter distribution of trees at different altitudinal zones of the shola forests

Sample plots	Altitude (m)	dbh (centimeter)			n*
		Max #	Mean	SD	
Thalachor kadavu	1600	155.3	31.4	23.8	93
Kanthallur-3	1700	117.7	24.3	17.5	118
Kanthallur-4	1800	160.7	35.2	25.4	92
Kanthallur-5	1850	126.3	31.5	18.3	140
Kanthallur-6	1900	124.7	41.7	25.8	86
Kanthallur-6.5	1950	128.9	31.3	21.3	138
Nilagiri Teri	1950	104.7	24.3	16.1	166
Kanthallur 9.5	2000	111.7	33.8	23	95
Mathappu	2100	72.5	24.7	14.8	47
V-point	2100	83.4	19.9	11.4	211

#Minimum tree diameter is assumed as 10 cm dbh

* Number of trees studied in each location

The plot Kalippettumala (1,700 m asl) was successionally young having been subject to burning a few years back and therefore the measurements could not be used for any comparison in the context of elevation. Likewise, the plot Kanthallur-4 (1,750 m asl) was a forest-grassland ecotone and also at a successionally younger age.

4.4.3.2 At individual tree species level: In computing the diameter statistics of individual species, several patterns were observed:

Pattern I. Mean diameter with increasing elevation.

Eg. *Cinnamomum wightii, Hydnocarpris alpina* and *Meliosma simplicifolia* (Table 4.9)

Pattern *2.* Mean diameter increased with increasing elevation.

Eg. *Isonandra candolleana, Rhododendron nilagiricum, Litsea sp.,* etc (Table 4.10)

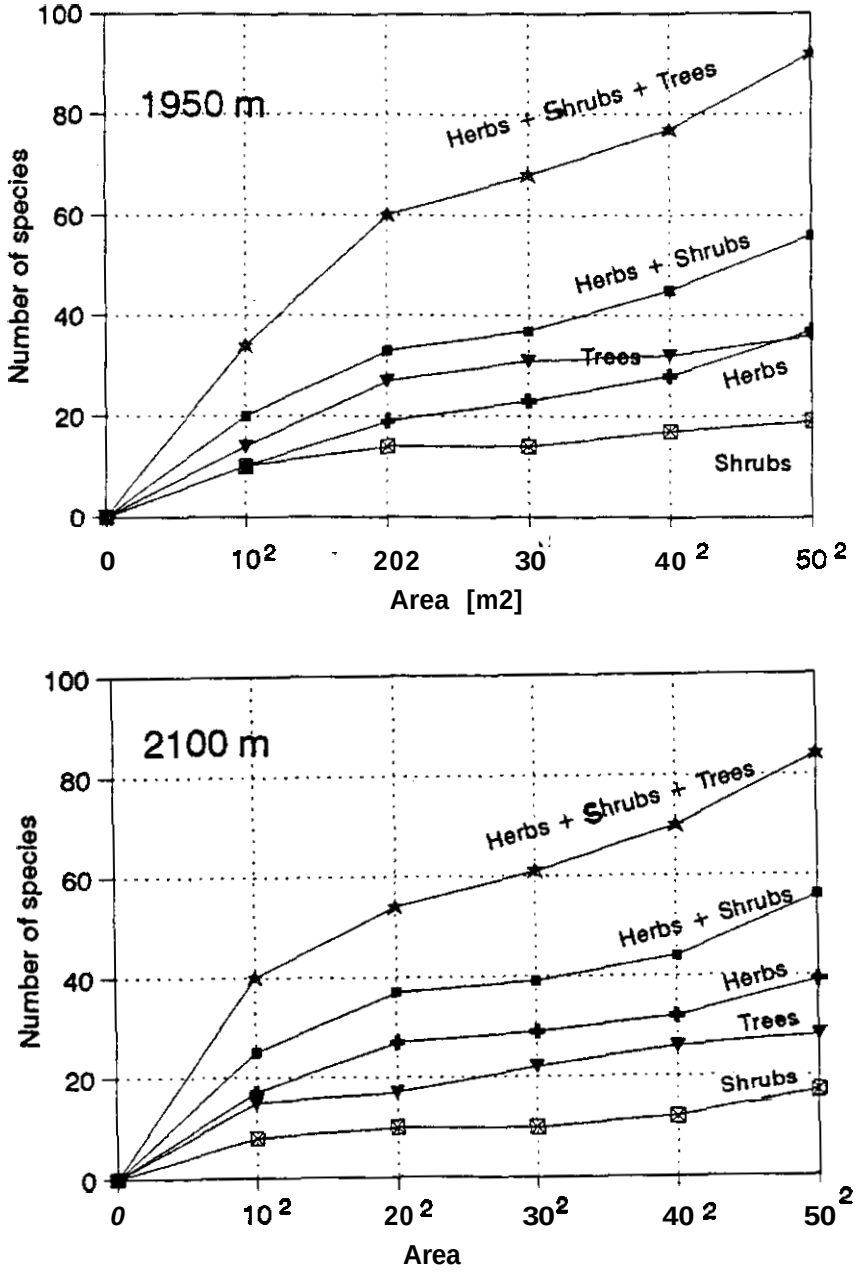
Pattern 3. Mean diameter decreasing with both increasing and decreasing elevation

Eg. *Chionanthus macrocarpa, Mastixia arborea,* etc (Table 4.I I).

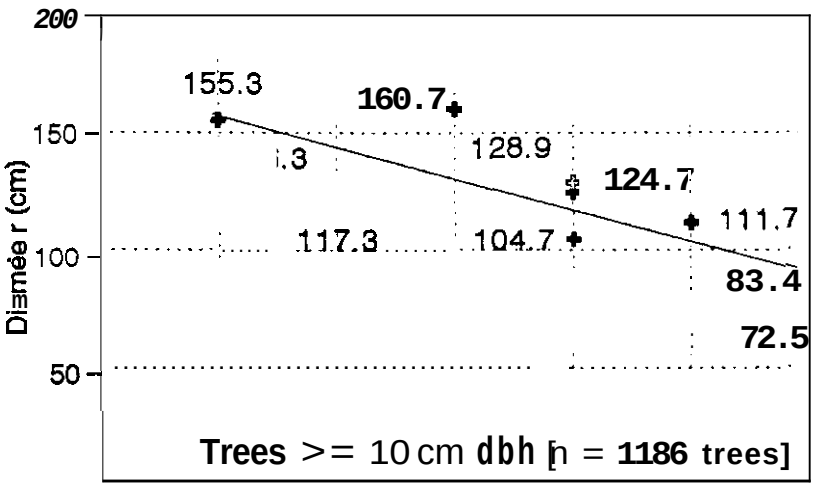
Pattern 4. No significant difference in mean diameter across elevational gradient.

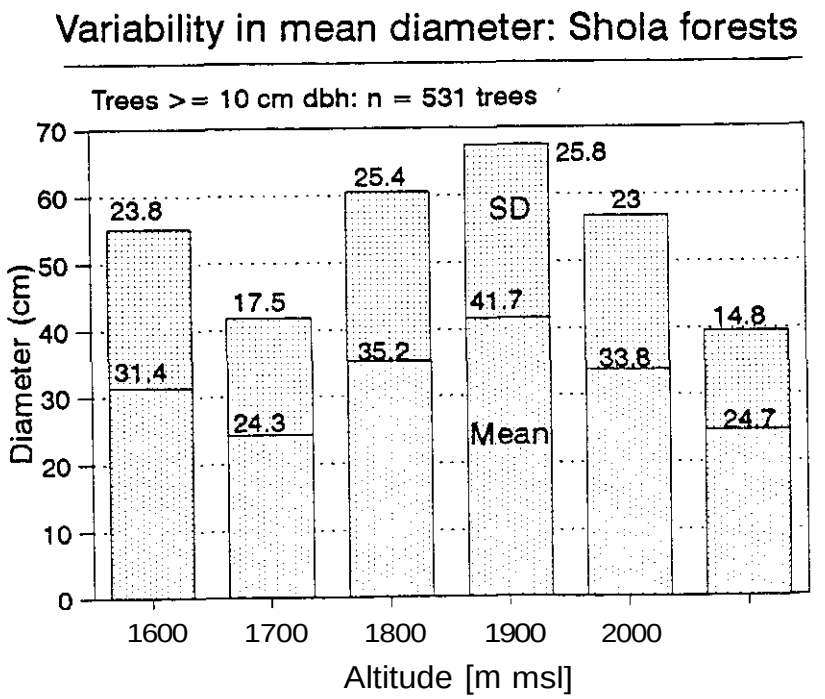
Eg. *Gomphandra coriacea, Persea macranrha* and *Turpinia nepalensis* (Table 4.12)

Species area curve: shola forests



Figures 4.3 & **4.4** Compartmented species area curves for different life forms in two semi-permanent plots, representing two elevational belts. The essential difference between the graphs is that in figure **4.3** the number of tree species are almost always greater than the number of herb species at 1,950m, whereas it is reversed at 2.100 m asl.





Figures **4.5** & **4.6** Tree diameter variability across elevational gradient in the shola forests. Only trees ≥ 10 cm dbh done were considered for these graphs. The general relationship is one of decreasing tree diameter with ascent in elevation **(Fig. 4.5).** Invariably in disturbed sites **(Fig. 4.6:** 1.600 m and 1,700 m), the mean tree diameter is low. But from 1,900 in asl onwards, there is a definite decline in mean tree diameter **(Fig. 4.6).**

Table 4.9 Diameter statistics of different shola tree species with an apparent reduction in diameter with increasing elevation

Alt. (m)	Diameter			n#
	Max	Mean	SD	
Cinnamomum wightii				
1850	76.4	58.4	25.5	2
1900	112	54	30.4	12
1950	79.5	27.9	13.5	14
2000	47	30	15	3
Hydnocarpus alpinia				
1800	67.8	28.9	16.4	15
1850	66.8	31	12.3	36
1950	23.5	20.2	4.7	2
Lasianthus acuminatus				
1900	30.9	17.4	11.7	3
1950	16.5	13	2	5
2000	14.6	14	0.9	2
Lauraceae : Cryptocarya ?				
1900	69.7	64.6	7.2	2
1950	59.2	27.2	14	18
2100	17.2	14	4.5	2

Alt. (m)	Diameter			n#
	Max	Mean	SD	
Litsea ligustrina				
2000	51.2	25.7	15.9	6
2100	24.5	13.8	5.2	10
Meliosma simplicifolia				
1600	47.7	26.6	10	21
1700	63	22	12.5	20
1800	20.4	20.4		2
Schefflera racemosa				
1600	80.8	62.4	26	2
1700	85	72.9	17	2
1800	22.9	17.4	7.9	2
1950	29.9	23	6.2	3

n# : Population size

Table 4.10 Diameter statistics of different shola tree species where increase in diameter with elevation apparent

Alt (m)	Diameter			n#
	Max	Mean	SD	
Isonandra candolleana				
1800	45.2	33.4	11.6	5
1850	59.8	32.3	11.8	22
1900	71	41.9	18.6	6
1950	62.7	39.9	12	20
Rhododendron nilagiricum				
1600	32.8	23.2	6.6	10
1700	29	21.6	7.6	6
2100	77.3	29	18.6	19

Alt (m)	Diameter			n#
	Max	Mean	SD	
Litsea sp.				
1700	45.2	30.2	12.9	5
1800	54.4	31	18.3	5
1850	41.7	23	11.5	8
1900	69	30.3	26.5	4
1950	53.5	34.3	17.8	7
2000	60.5	27.7	18.7	5
2100	54	49.2	7	2

n# : Population size

Table 4.11. Diameter statistics of different shola tree species where a unimodal curve of mean diameter plots apparent

Alt (m)	Diameter			n#
	Mean	SD		
Chionanthus macrocarpa				
1800	39.5	25.3	20	2
1850	27.8	24.9	4	2
1900	64.6	37.6	17.3	6
1950	72.2	29	14.2	40
2000	37.5	22.7	9.7	9
Mastixia arborea				
1800	75.7	40.7	23.2	15
1850	69	26.9	24.3	5
1900	93.5	49.3	21	13
1950	113.3	42	21.6	26
2000	91.9	51.4	21	10

Alt (m)				n#
1800	72.2	5 1	29.9	2
1900	124.7	80.3	33.7	6
1950	104.7	79.3	32	3
2100	51.5	18	8.7	21

n# : Population size

The above patterns of mean diameter variations partially reflect the habitat range of the species, the history of local succession or micro-level phytogeography and the local stand structure.

The highest maximum tree diameter encountered for any given individual was 160.7 cm dbh, at an elevation of 1,800 m as1 for *Syzygium arnottianum* (Tables 4.13). Out of the 10 releves considered for this parameter, in 5 instances the largest trees (in diameter) were of *Syzygium* species. Of the rest, in three instances the largest trees were of *Cinnamomum wightii, Elaeocarpus munronii,* and *Mastixia arborea* (Table 4.13).

The elevational range of the genus *Syzygium,* represented by five species, extends between 1.600 to 2,000 m asl. It is probable that each species of the genus has an elevational preference and that the elevational delineation might provide a reasonably sound subcategorization of the shola forests.

4.4.4 Species-area relations

Table 4.14 and Figures 4.3, 4.4, 4.7 and 4.8 summarize the results. For herbs. shrubs. herbs plus shrubs, and forest-grassland ecotone areas. a releve size of 400 m^2 was found satisfactory In burnt shola forests where secondary succession was in vogue, the releve size reduced to 200 m^2. For studying trees ≥ 1 cm dbh, in undisturbed shola forests a releve size of 600 m^2 was found necessary, while it was around 1,000 m^2 (0.1 ha) for studying trees ≥ 10cm dbh.

Table 4.12 Diameter statistics of different shola tree species where no difference in mean diameter apparent

Alt (m)	Diameter			n#
	Max	Mean	SD	
Gomphandra coriacea				
1800	35.3	22.6	8.5	6
1850	32	19.2	6.4	15
1900	27	23.4	3.4	12
1950	53.5	30.9	9.4	13
2000	34.7	19.7	9.3	8
Persea macrantha				
1600	49	35.8	9.3	8
1700	72.2	38.5	19.4	6
1850	50	39.2	9.3	6
1950	50.6	29	9	9
2000	89.4	55.2	48.4	2
Saprosma foetens				
1800	10.5	10.7	0.2	2
1850	23.9	18.8	3.8	7
1900	20.4	16.3	4	3
1950	27	16.5	3.8	11
2000	34.4	22.6	16.7	2

Alt (m)	Diameter			n#
	Max	Mean	SD	
Symplocos cochinchinensis				
1700	17.5	13.5	3.4	6
1950	23.2	15.3	5.2	5
2100	20.4	15.2	3.7	5
Turpinia nepalensis				
1600	28	20.9	6	6
1700	34.4	20.5	7.5	8
1800	32.5	26	5.9	3
1950	21.6	21.6	*	2
2000	32.8	21.8	10.2	5

n# : Population size

Table 4.13 Instances of maximum tree dbh records in stands

Species	Max dbh	Altitude (m)
Syzygium arnottianum	160.7	1,800
Syzygium arnottianum	155.3	1,600
Syzygium sp.	128.9	1,950
Syzygium sp. [pilla njaval]	126.3	1,850
Syzygium densiflorum	124.7	1,900
Mastixia arborea	113.3	1,950
Cinnamomum wightii	112	1,900
Elaeocarpus munronii	112	1,600
Syzygium sp. [pilla njaval]	111.7	2,000
Syzygium sp. [potti njaval]	100.2	2,000

Table 4.14 Releve sizes for various life forms in the shola forests

No.	Life forms	Quadrat size	Releve size
1.	Herbs	20 m x 20 m	400 m^2
2.	Shrubs	20 m x 20 m	400 m^2
3.	Trees ≥ 1 cm dbh @		
	(a). Forest ecotone area	20 m x 20 m	400 m^2
	(b). Burnt secondary succession area	20 m x 10 m	200 m^2
	(c). Undisturbed area	30 m x 20 m	600 m^2
4.	Trees ≥ 10 cm dbh #	30 m x 30 m	900 m^2 (=0.1 ha)
5.	Herbs + shrubs	20 m x20 m	400 m^2
6.	Herbs + shrubs + trees ≥ 10 cm dbh	30 m x 30 m	900 m^2 (=0.1 ha)

@ Fig. 4.7; #Fig. 4.8

4.4.5 Species richness

4.4.5.1 At all species level: The total number of species, (ie, irrespective of life form categories such as herbs, shrubs or trees, etc) in the 0.25 ha semi-permanent plots decreased from 1,850 m asl onwards (94 spp.), as the elevation ascended further up (2,100 m: 84 spp.). In the forest-grassland ecotone however, the species number (1750 m asl: 112 spp.), was much higher compared to the maximum number of species observed in undisturbed plots (1850 m asl: 94 spp.). The above statistic is given merely to give a general picture of the species abundance patterns against which the differentiated figures of different life forms are to be considered (Figs. 4.7 & 4.8).

4.4.5.2 At ≥ 1 cm dbh level: Details of this statistic are given in table 4.15.

Table 4.15 Species richness of trees ≥ 1 cm dbh in 0.25 ha samples

Location	Alt. (m)	S
Kanthallur-5	1850	31
Kanthallur-6.5	1950	55
Nilagiri Teri	1950	51

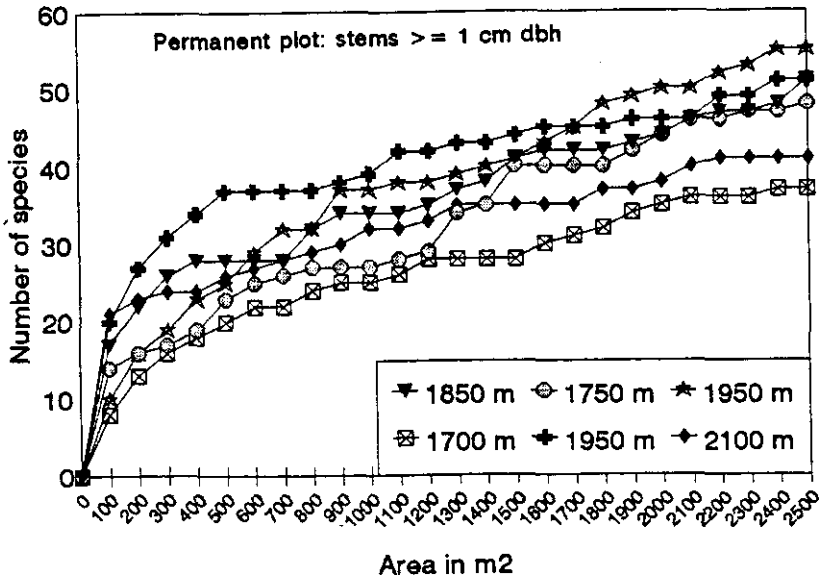
Location	Alt. (m)	S
V-point	2100	41
Kalippettumala#	1700	48
Kanthalllur-4$	1750	51

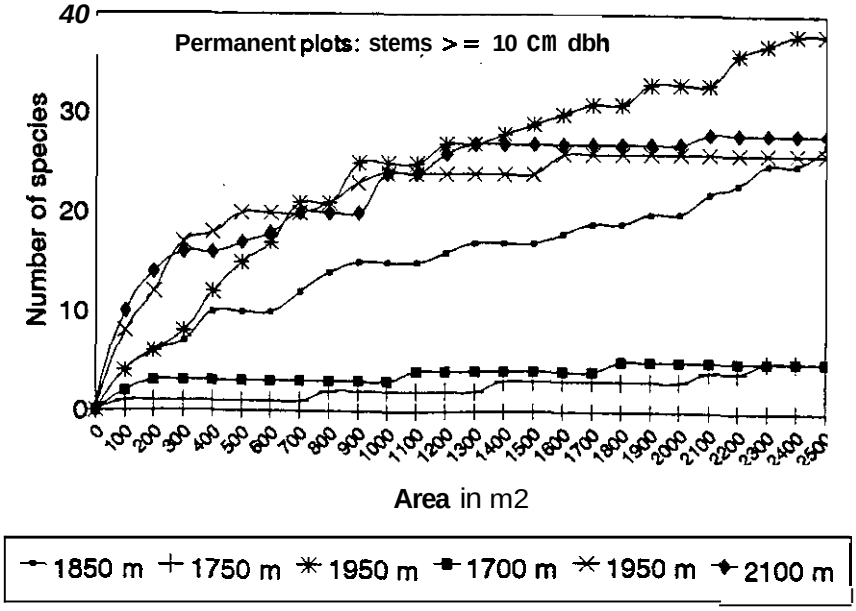
Burnt site; $ Forest-grassland ecotone

At ≥ 1 cm dbh level, the highest number of species observed was 55 species $ha^{-0.25}$ at an elevation of 1950 m asl. As the elevation goes up from 1950 to 2,100 m asl. a reduction in species number is observed (1950 m asl: 55 spp; 2,100 m: 41 spp.; cf. Table 4.15). The grassland ecotone stand also has shown high species number (51 spp.), indicating high successional activities.

Number of species ≥ 1 cm dbh showed a maximum at about 1,950 m asl but then reduced sharply at about 2,100 m asl (Table 4.15; Figure 4.9). This observation suggests that tree is not

Species area curve: Shola forest





Figures 4.7 & **4.8** Species area curves for plants >= 1 cm dbh and >= I0 cm dbh in semi-permanent plots distributed across different elevations. For both the size classes the curves stabilize at about 1000 m^2 or so. In **Fig. 4.8** for the elevations 1,700 m and 1,750 m. the curve has stabilized at about 200 m^2 itself. One of these plots (1,700 m) is a burnt forest stand, whereas the other (1,750 m) is a forest-grassland ecotone. The reduction of tree species in both of these plots is reflected in the graph.

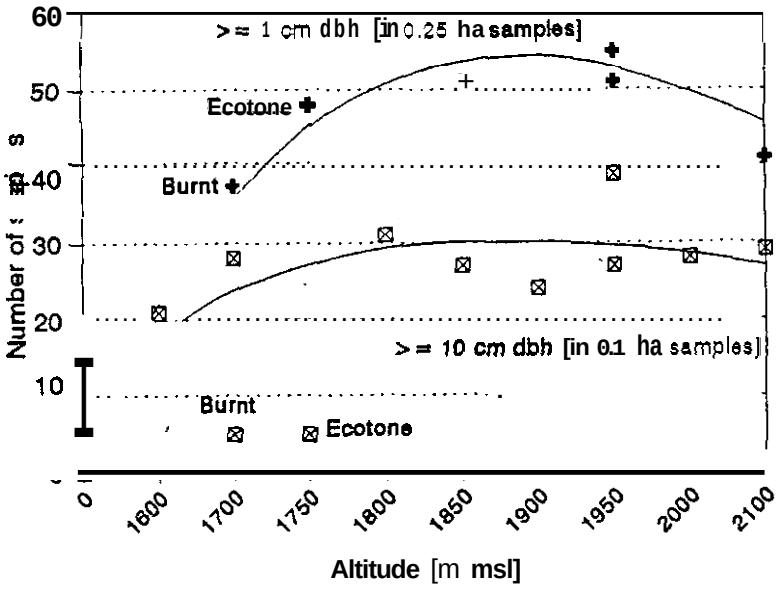


Figure 4.9 Patterns of species richness in shola forests across the altitudinal gradient. At ≥ 1 cm dbh level, the curve is unimodal with the number of species increasing up to about 1,950 m asl. At ≥ 10 cm dbh level, there is a slight increase in species richness from 1,600 to 1,800 m asl, but then onwards, the trend remains indeterminate.

the characteristic of life form at elevations beyond 1,950 m asl. It would also subscribe to Ranganathan's (1938) view that the grasslands of South Indian hill stations represent the climax. Yet Ranganathan's view may not be tenable as the stunted tree life forms do colonize the elevational belt as patchy shola forests (Swarupanandan *et al.,* 1998). although they represent a minority, and the size range of trees is less, compared to that of lower elevations.

In the grassland ecotone plot, where active secondary succession was taking place, the number of species with stems ≥ 1 cm dbh has been found to be fairly high (51 spp.), indicating the pioneer status. So was the case with the fire bumt plot, with 48 species ≥ 1 cm dbh. Disturbances like fire, landslides, etc, definitely affects species diversity. When such disturbances take place, the arborescent species, which retain higher quantity of living biomass, are best affected and the reduction in their number is experienced in the beginning; but sooner, with the onset of secondary succession, the number of species tend to increase and later stabilize, as the stand attains optimum development.

4.4.5.3 At ≥ 10 cm dbh level: Table 4.16 gives the values for different elevational belts.

Table 4.16 Species richness of trees≥ 10 cm dbh in 0.1 ha samples

Location	Alt (m)	S
Thalachorkadavu	1600	21
Kanthallur-3	1700	28
Kanthallur-4	1800	31
Kanthallur-5	1850	27
Kanthallur-6	1900	24
Kanthallur-6.5	1950	38
Nilagiri Teri	1950	27
Kanthallur-9.5	2000	28
V-point	2100	29
Kalippettumala#	1700	5
Kanthallur-4$	1750	5

#Burnt stand; $: Ecotone.

The maximum number of species encountered in 0.1 ha samples with a diam. ≥ 10 cm at breast height was 31 and the lowest value was 16. In the burnt plot and the grassland ecotone plot, the species number were extremely low (Burnt plot: 4 spp; Ecotone plot: 2 spp.).

4.4.6 Density

4.4.6.1 At all tree species level: The data from releves and semi-permanent plots were segmented for density distribution at various size levels (Table 4.17; Figs. 4.10 to 4.12).

4.4.6.2 Density of stems ≥ 1 cm dbh in 0.25 ha semi-permanent plots: Across the elevational gradient, there is not much of an observable trend in the number of stems ≥ 1 cm dbh in 0.25 ha, except that in some plots, because of the gregarious occurrence of one or two species like the reed-bamboo, *Sinarundinaria densifolia* or the substorey shrub, *Strobilanthes* species, such as *S. homotropa, S. luridus,* etc. The extreme values observed per hectare ranged between 11,700 and 27360 (=12,000 to 27,000 ha-1) In the burnt plot the number of stems was extremely low (=6,360 ha-1) while in the forest-grassland ecotone plot, the density (=12,930 ha-1) was more or less comparable to that of the other plots (Table 4.17; Fig. 4.10).

Table 4.17 Density in semi-permanent plots (0.25 ha)

No.	Locations	Altitude	Density@		
			≥ 1 cm	1-10 cm	≥ 10 cm
1.	Kanthallur-5	1,850	11640	11080	570
2.	Kanthallur-6.5	1,950	21700	21180	520
3.	Nilagiri Teri	1,950	11700	11010	700
4.	V-point	2,100	27360	26440	920
5.	Kanthallur-3#	1,700	6360	5310	1060
6.	Kanthallur-4$	1,750	12930	12400	530

@All figures rounded off to tens
#: Burnt stand; $: Ecotone.

4.4.6.3 Density of stems ≥ 10cm dbh in 0.1 ha releves: A maximum of 118 trees ≥ 10 cm dbh was measured in 0.1 ha at about 1,700 m asl. From this maximum, the values oscillated between the minimum of 51 trees ha-1. There is no general trend in the number of trees ≥ 10 cm dbh across the elevational gradient, except that at very high elevations there is marked reduction of number of stems (Fig. 4.11).

4.4.6.4 Density of trees ≥ 10cm dbh in 100 m2 quadrats (Micro-level density variabilities): Statistical details of tree (≥ 10 cm dbh) number variability in 100 m^2 ($ha^{-0.01}$) quadrats across elevational belts is detailed in Table 4.18 and Figure 4.12.

Table 4.18. Statistic of micro-level (in 100 m^2 quadrats) tree (≥ 10 cm dbh) density variability across elevational belts

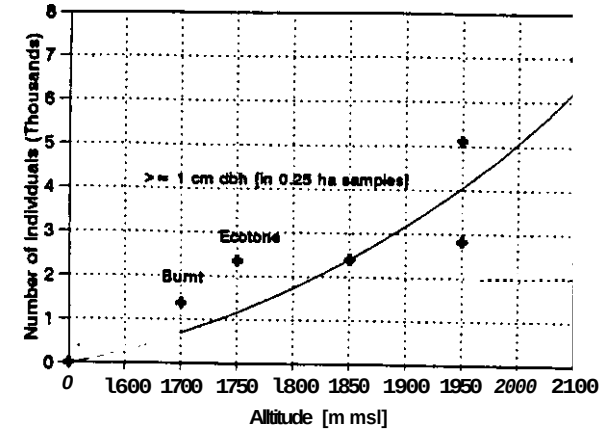
Altitudinal belt	Tree frequency class quadrat (Trees $ha^{-0.01}$)			n*
	Frequency class range	Modal quadrat	Median quadrat	
1600-2100 m	2-22	5, 6	5	154
1600-1800 m	5-22	9	8	20
1800-2000 m	2-12	6	9	94
2000-2100 m	2-22	6, 11	6	40
Burnt plot (1700 m)	4-20	11	8	25

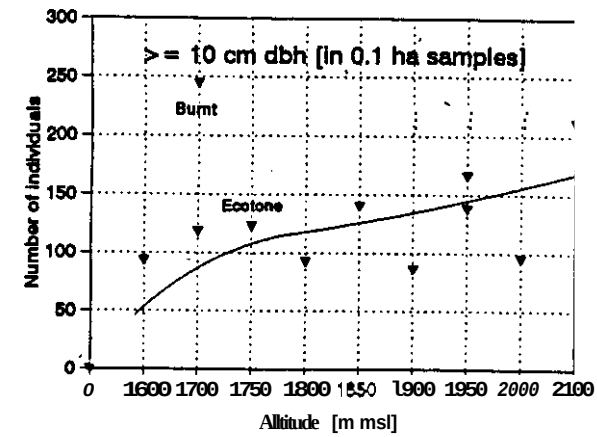
n* number of 100 m^2 quadrats studied

The total range of tree density in 0.01 ha (100 m^2) quadrats was between 2 and 22. Over 70% of the 100 m^2 quadrats fell in the 4-10 tree frequency class.

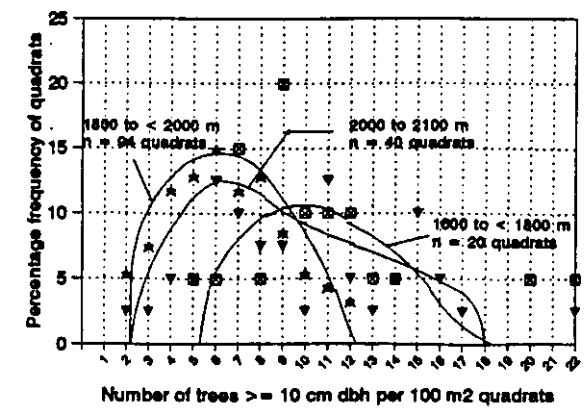
At elevation between 1,600-1800 m asl, ca. 70% of the 100 m^2 quadrats sampled belonged to the frequency classes 7-12 trees, the modal quadrat being with 9 trees $ha^{-0.01}$ and the median class with 8 trees $ha^{-0.01}$. In the elevational range 1,800-2,000 m asl, > 70% (800) quadrats of the 0.01 quadrats sampled belonged to the frequency class 3-9 trees, the modal class quadrat being those with 6 trees $ha^{-0.01}$ the median quadrat class being those with 9 trees $ha^{-0.01}$. At the elevation regime 2,000-2.100 m asl, 72% of the quadrats belonged to the frequency class 4- 16

Density variability: shola forest





Density variability in 100 m2 samples



Figures 4.10 - 4.12 Density variability in shola forests. At ≥ 1 cm dbh level, the number of individuals in samples increases with every ascent in altitude **(Fig. 4.10).** Figure **4.11** also displays a similar trend for trees ≥ 10 cm dbh, but here the slope of the curve is slightly gentle than for the size class ≥ 1 cm dbh. Figure **4.12** - graphs of tree density variability in microsamples (100 m2). The figure suggests that stocking of trees is best in the elevational belt 1,800-2,000 m

trees; the modal class was with 11 trees $ha^{-0.01}$ and the median one with 8 trees $ha^{-0.01}$. The reduction in the number of trees in the elevational belt 1,800-2,000 m as1 is striking.

The median tree frequency class quadrat for the whole ecosystem was 5 trees $ha^{-0.01}$, and the modal class quadrats were also quite close, 5 trees $ha^{-0.01}$ and 6 trees $ha^{-0.01}$. The elevational belt 1,600-1,800 m also displayed such a relation between the modal tree frequency class quadrat (8 trees $ha^{-0.01}$)and the median tree frequency quadrat (9 trees $ha^{-0.01}$). However, this was not so in the case of the elevational belts 1,800-2,000 m and 2,000-2,100 m as1 and in the burnt plot (cf. Table 4.18). This shows that the modal tree frequency class quadrat is a better measure of tree density than the median tree frequency class quadrat.

4.4.7 Mean number of stems per species (N/S)

The mean number of individuals ≥ 1 cm dbh in 0.25 ha samples ranged between 47 and 171 (Table 4.18), the higher values being that of plots where some gregarious species such as reed bamboo and *Strobilanthes* species existed. When trees ≥10 cm dbh in 0.1 ha sample plots were compared, the values ranged between 2 and 4.4. Again no trend could be observed across the elevational gradient. Compared to the undisturbed plots, the mean number of stems per species ≥ 10 cm dbh in 0.1 ha in the disturbed plots, the values were very high, owing to the fewer number of species (bum plot: 28 trees $ha^{-0.1}$; ecotone grassland plot: 27 trees $ha^{-0.1}$). However, this difference was not so prominent at 1 cm dbh level in 0.25 ha samples; owing to the fact that succession is very active there.

Table 4.19 Mean number of stems per species in different dbh levels

DBH: ≥ 1 cm dbh; Sample: 0.25 ha				
Location	Alt. (m)	S	N	N/s*
IKanthallur-5	1850	51	2397	47
Kanthallur-6.5	1950	55	5120	93
Nilagiri Teri	1950	51	2825	55
V-point	2100	41	6996	171
Kalimettumala#	1700	37	1372	37
Kanthallur-4$	1750	48	2352	49

DBH: ≥ 1 cm dbh; Sample: 0.25 ha				
Location	Alt. (m)	S	N	N/s*
Thalachorkadavu	1600	21	93	4
Kanthallur-3	1700	28	118	4
Kanthallur-4	1800	31	92	3
Kanthallur-5	1850	27	140	5
Kanthallur-6	1900	24	86	4
Kanthallur-6.5	1950	38	138	4
Nilagiri Teri	1950	27	166	6
Kanthallur-9.5	2000	28	95	3
V-point	2100	29	211	7
Kalippettumala #	1700	5	244	49
Kanthallur-4$	1750	5	123	25

* - Figures rounded off to whole number

- Burnt stand; $ - Ecotone.

4.4.8 Diversity indices

Out of a whole variety of diversity indices, four have been computed and interpreted: (1). Shannon's index (H'), (2) Simpson's index (D, Lambda), (3). $H_{max,}$ and (4). Pielou's index of evenness (E).

4.4.8.1 Shannon-Weinner's index of diversity (H'): The Shannon's index is a general index of diversity which takes into account the species richness component and the variability of density within each species, and is the most popular among the variety of indices of diversity. Shannon's index is only moderate in the undisturbed stands at ≥ 1 cm dbh level (in 0.25 ha stands) and again shows a definite elevational trend decreasing with increasing altitudes (Table 4.19). Compared to the higher values recorded for evergreen and semi-evergreen forests (> 3.5: cf. Pascal, 1988) the shola forests showed only lower values (±1.5 or around 2) and in this respect was found closer to the moist deciduous forests (±2.8). However, at ≥ 10 cm dbh level, in 0.1 ha sample stands, the Shannon's index was fairly high ranging between 2.5 and 3.4.

Table 4.20 Shannon' index at different dbh levels

Location	Alt. (m)	H
Kanthallurd	1850	1.72
Kanthallur-6.5	1950	1.47
Nilagiri Teri	1950	1.88
V-point	2100	1.03
Kalippettumala#	1700	2.32
Kanthallur-4$	1750	2.21

- Burnt stand: $- Ecotone

DBH: ≥ 10 cm; Sample: 0.1 ha		
Location	Alt. (m)	H'
Thalachorkadavu	1600	2.59
Kanthallur-3	1700	2.83
Kanthallur-4	1800	3.03
Kanthallur-5	1850	2.62
Kanthallur-6	1900	2.81
Kanthallur-6.5	1950	3.38
Nilagiri Teri	1950	2.76
Kanthallur-9.5	2000	3.05
V-point	2100	2.50
Kalippettumala#	1700	0.72
Kanthallur-4$	1750	0.42

Table 4.21 Simpson's index at different dbh levels

Location	Alt.(m)	D
Kanthallur-5	1850	0.70
Kanthallur-6.5	1950	0.61
Nilagiri Teri	1950	0.67
V-point	2100	0.42
Kalippettumala#	1700	0.84
Kanthallur-4$	1750	0.82

DBH: ≥ 10 cm; Sample: 0.1 ha		
Location	Alt. (m)	D
Thalachorkadavu	1600	0.90
Kanthallur-3	1700	0.92
Kanthallur-4	1800	0.93
Kanthallur-5	1850	0.88
Kanthallur-6	1900	0.92
Kanthallur-6.5	1950	0.96
Nilagiri Teri	1950	0.91
Kanthallur-9.5	2000	0.94
V-point	2100	0.83
Kalippettumala#	1700	0.38
Kanthallur-4$	1750	0.18

4.4.8.2 Simpson's index of dominance (Lambda): Simpson's index of dominance is a percentile (probability) measure ranging between 0 and 1; where dominance by fewer species exists, the index showed higher values and where there is not much dominance, vice versa. At ≥ 1 cm dbh level in 0.25 ha plots, Simpson's index registered high variability of values ranging between 0.42 and 0.70 (Table 4.20). A definite and gradually decreasing trend is observed in the values across elevational gradient at the ≥ 1 cm dbh level, with ascending altitudes. In disturbed plots, the index shows high values (burnt plot: 0.84: grassland ecotone plot: 0.82), showing high dominance by fewer number of species.

At ≥ 10 cm dbh level, however, the Simpson's index shows higher values ranging between 0.81 and 0.95 in the undisturbed plots showing low dominance and low values in disturbed plots (burnt plot: 0.38: grassland ecotone stand: 0.18), and exhibiting co-dominance of plant species. At this size level, no elevational trend could be detected.

4.4.8.3 H_{max}: Measures of this parameter are given in table below (Table 4.21)

Table 4.22 H_{max} at different dhh levels

DBH: ≥ 1 cm; Sample: 0.25 ha		
Location	Alt (m)	H_{max}
Kanthallur-5	1850	3.93
Kanthallur-6.5	1950	4.01
Nilagiri Teri	1950	3.93
V-point	2100	3.71
Kalippettumala[#]	1700	3.61
Kanthallur-4[$]	1750	3.87

[#] - Burnt stand: [$] - Ecotone

DBH: ≥ 10 cm; Sample: 0.1 ha		
Location	Atl (m)	H_{max}
Thalachorkadavu	1600	3.04
Kanthallur-3	1700	3.33
Kanthallur-4	1800	3.43
Kanthallur-5	1850	3.30
Kanthallur-6	1900	3.18
Kanthallur-6.5	1950	3.64
Nilagiri Teri	1950	3.30
Kanthallur-9.5	2000	3.33
V-point	2100	3.37
Kalippettumala[#]	1700	1.61
Kanthallur-4[$]	1750	1.61

4.4.8.4 Pielou's index of evenness (E): At ≥ 1 cm dbh level in 0.25 ha samples, the index of evenness showed very low values (all values were below 50%), the actual values ranging between 0.28 and 0.44 in the undisturbed stands (Table 4.22).

The low values of evenness infer the existence of a large number of rare species, ie, species represented by fewer individuals. In the burnt plot and the grassland ecotone stand (disturbed stands), the indices were high. At ≥ 10 cm dbh level in 0.1 ha releves, the index showed high degree of evenness (0.85 to 0.96) indicating that there are not many species in this size class.

4.4.9 Basal area

The variability of basal area per hectare across the elevational gradient is given in Table. 4.10. Here again, up to I950 m asl, the basal area is fairly high with a mean 11.5

further up, it reduces drastically to an average of 5.6 m^2. Even within the elevational belt 1,600-1,950 m asl, the basal area showed variability, ranging between ≈ 7 m^2 ha^{-1} and 16.2 m^2 ha^{-1} (Table 4.23). This indicates difference in stand history of the sites and or difference in species composition. Details of basal area of individual species in the plots are given in tables in Appendix-1.

Table 4.23 Pielou's index of evenness at different dbh levels

DBH: ≥ 1 cm; Sample: 0.25 ha		
Location	Alt. (m)	E
Kanthallur-5	1850	0.44
Kanthallur-6.5	1950	0.37
Nilagiri Teri	1950	0.48
V-point	2100	0.28
Kalippettumala#	1700	0.64
Kanthallur-4$	1750	0.57

- Burnt stand; $ - Ecotone

DBH: ≥ 10 cm; Sample: 0.1 ha		
Location	Alt. (m)	E
Thalachorkadavu	1600	0.85
Kanthallur-3	1700	0.85
Kanthallur-4	1800	0.88
Kanthallur-5	1850	0.79
Kanthallur-6	1900	0.88
Kanthallur-6.5	1950	0.93
Nilagiri Teri	1950	0.84
Kanthallur-9.5	2000	0.92
V-point	2100	0.74
Kalippettumala#	1700	0.45
Kanthallur-4$	1750	0.26

Table 4.24 Number of species, density and basal area across elevational belts in 12 releves (0.1 ha)

Location	Alt. (m)	S	D	BA (m^2)
Thalachorkadavu	1600	21	93	11.2852
Kanthallur-3	1700	28	118	8.2765
Kanthallur-4	1800	31	92	13.5453
Kanthallur-5	1850	21	60	6.9676
Kanthallur-6	1900	23	86	16.1665
Kanthallur-6.5	1950	28	95	12.4334
Kanthallur-6.5	1950	19	69	7.8273
Nilagiri Teri	1950	18	51	5.6657
Kanthallur-9.5	2000	16	47	3.0487
V-point	2100	16	56	5.9372
Kalippettumala#	1700	18	62	6.8183
Kanthallur-4$	1750	18	62	6.2569

BA: Basal area; D: Density; **S:** Number of species.
- Burnt stand; $ - Forest-Grassland ecotone

4.4.10 Importance Value and Overall Dominance

The number of dominant species (with RIVI ≥ 5%) across the 12 releves varied from 6 to 17. In parallel with the reduction with the basal area, a decrease in the density of trees ≥ 10 cm dbh is observed with higher elevations, ie, from 1950 m as1 onwards. Parameters such as relative density, relative frequency, and relative basal area and relative importance value of the dominant species did not show much variability across altitude (Table 4.24), except in one releve.

Table 4.25 Descriptive statistics of phytosocioiogical parameters of dominant species (RIVI > 5 %) in releves (0.1 ha)

Location	Altitude (m)	S	D	BA	RD	RF	RBA	RIVI
Thalachorkadavu	1600	9	76	8.8664	81.7	66.7	78.6	75.7
Kanthallur-3	1700	17	37	1.4046	31.4	40.3	17	29.6
Kanthallur-4	1800	12	62	11.7354	67.4	58.1	86.7	70.7
Kanthallur-5	1850	8	42	5.7555	70.0	60.5	82.6	71.0
Kanthallur-6	1900	7	59	12.8367	68.6	61.9	79.4	70.0
Kanthallur-6.5	1950	12	67	9.0206	70.5	67.1	72.6	70.1
Kanthallur-6.5	1950	6	51	5.5040	73.9	65.2	70.3	69.8
Nilagiri teri	1950	6	36	4.6595	70.6	62.5	82.3	71.8
Kanthallur-9.5	2000	7	37	2.3676	78.7	65.4	77.7	73.9
V-point	2100	8	44	5.2490	78.6	76.2	89.2	81.3
Kalippettumala[#]	1700 B	8	44	5.1317	71.9	70.8	75.3	72.4
Kanthallur-4[$]	1750 G	6	47	4.7826	75.8	66.7	76.4	73.0

BA: Basal area; D: Density; RBA: Relative basal area; RD: Relative density;
R F Relative frequency; RIVI: Relative importance value (= IVI/3); *S:* Number of species
[#] - Burnt stand: [$] - Forest-grassland Ecotone

Statistic of variability of sociological parameters of the less frequent species in the releves is given in Table 4.25.

The list of dominant tree species ≥ 10 cm dbh in the 12 releves is given in Table 4.25. A scan through the table shows that *Meliosma simplicifolia,* a dominant species in the releves at 1,600 and 1,700 m as1 releves, does not appear in the releves of higher latitudes. Likewise, *Persea macrantha,* which also appears to be a dominant species at the lower elevations disappear from the list from 1,900 m as1 onwards. From 1,700 onwards to 1,950 m asl, a species of *Litsea* shows dominance status, but however, this species does not have the same status from 1,950 m upwards.

From 1,600 m as1 onwards, several species of *Syzygium* are present in the dominance list, in most of the releves. The elevational limits of each of the species are yet to be ascertained, which of course might be very useful in further classification of the vegetation.

Other species of more common occurrence across the releves are *Turpinia nepalensis, Gomphandru coriucea, Mastixia arborea, Isonandra candolleana, Chionanthus macrocarpa,* etc.

Table 4.26. Descriptive statistics of dominance parameters of less frequent species (RIVI c 5%)in releves (0.1 ha)

Location	Altitude (m)	S	D	BA	RD	RF	RBA	RIVI
Thalachorkadavu	1600	12	17	2.4189	18.3	33.3	21.4	24.4
Kanthallur-3	1700	11	81	6.8718	68.6	59.7	83.0	70.4
Kanthallur-4	1800	19	30	1.8100	32.6	41.9	13.4	29.3
Kanthallur-5	1850	13	18	2.3233	26.1	34.8	29.7	30.2
Kanthallur-6	1900	16	27	3.3297	31.4	38.1	20.6	30.0
Kanthallur-6.5	1950	16	28	3.4130	29.5	32.9	27.5	29.9
Kanthallur-6.5	1950	13	18	2.3233	26.1	34.8	29.7	30.2
Nilagiri Teri	1950	12	15	1.0055	29.4	37.5	17.8	28.2
Kanthallur-9.5	2000	9	10	0.6810	21.3	34.7	22.3	26.1
V-point	2100	8	12	0.6882	21.5	23.8	10.8	18.7
Kalippettumala[#]	1700	10	18	1.6866	29.0	29.2	24.7	27.6
Kanthallur-4[$]	1750	12	15	1.4743	24.2	33.3	23.6	27.0

BA: Basal area; D: Density; RBA: Relative basal area; RD: Relative density;
RF: Relative frequency; RIVI: Relative importance value (= IVI/3); *S:* Number of species
[#] - Burnt stand; [$] - Forest-grassland Ecotone

Isonandra candolleana and *Hydnocarpus alpina* were the most dominant species. These species are otherwise highly dominant at 1,950 to 2,100 m asl across the stands. In two disturbed stands (one burnt stand and the other, a grassland-shola ecotone) these species have again become very highly dominant. This observation suggests that perhaps higher elevations above 1,950 m asl are also disturbed habitats, in the sense that the climate is very hostile for plant life.

Table 4.27. List of dominant tree (≥ 10 cm dbh) species (with RIVI ≥ 5%) in releves (0.1 ha) across the elevational gradient (1,600 to 1,800 m asl)

1. Thalachorkadavu (1,600 m)	**2.** Kanthallur-3 (1700 m)	**3.** Kanthallur-4 (1800 m)
Meliosma simplicifolia	*Meliosma simplicifolia*	*Mastixia arborea*
Syzygium arnottianum	*Viburnum acuminatum*	*Hydnocarpus alpina*
Persea macrantha	*Persea macrantha*	*Syzygium arnottianum*
Bischofia javanica	*Daphniphyllum neilgherrense*	*Gomphandra coriacea*
Turpinia nepalensis	*Turpinia nepalensis*	*Scolopia crenata*
Rhododendron nilagiricum	Unidentified sp. (Pe to)	*Syzygium calophyllifolium*
Elaeocarpus munronii	*Litsea* sp.	*Isonandra candolleana*
Viburnum acuminatum	*Glochidion neilgherrense*	*Litsea* sp.
Symplocos sp.	*Ternstroemia japonica*	Unidentified sp. [peenari]
	Bischofia javanica	*Pygeum gardneri*
	Schefflera racemosa	*Turpinia nepalensis*
		Syzygium densiflorum

Table 4.27 continued

4. Kanthallur-5 (1850 m)	**5.** Kanthallur-6 (1900 m)	**6.** Kanthallur-6.5 (1950 m)
Hydnocarpus alpina	*Cinnamomum wightii*	*Mastixia arborea*
Isonandra candolleana	*Mastixia arborea*	*Turpinia nepalensis*
Svzygium sp. [pilla njaval]	*Svzvgium densiflorum*	*Chionanthus macrocarpa*
Gomphandra coriacea	*Gomphandra coriacea*	*Gomphandra coriacea*
Litsea sp.	*lsonandra candolleana*	*Syzvgium* sp. [pilla njaval]
Persea macrantha	*Chionanthus macrocarpa*	*Litsea ligustrina*
Unidentified sp. (Hacoc)	*Celtis wightii*	*Phoebe* sp.
Mastixia arborea		*Syzygium arnottianum*
		Litsea sp.
		Photinia notoniana
		Syzygium sp. [potti njaval]
		Olea dioica

Table 4.27 continued

7. Kanthallur-6.5 (l 950 m)	**8.** Nilagiri teri (1950 m)	**9.** Kanthallur-9.5 (2000 m)
Hydnocarpus alpina	*Hydnocarpus alpina*	*Rhododendron nilagiricum*
Isonandra candolleana	*Isonandra candolleana*	*Elaeocarpus recurvatus*
Gomphandra coriacea	*Syzygium* sp. (pilla njaval)	*Turpinia nepalensis*
Syzygium sp. [pilla njaval]	*Gomphandra coriacea*	*Syzygium* sp.
Isonandra sp. [vella pala]	*Persea macranrha*	*Cinnamomum wightii*
	Ternstroemia japonica	*Litsea* sp.
		Vaccinium leschenaultii

Table 4.27 continued

10. V-point (2100 m)	**11.** Kalippettumala (1700 m) [Burnt stand]	**12.** Kanthallur-4 (1750 m) [Ecotone]
Isonandra candolleana	*Isonandra candolleana*	*Isonandra candolleana*
Hvdnocarpus alpina	*Hydnocarpris alpina*	*Hydnocarpus alpina*
Syzygium sp. [pilla njaval]	*Syzygium* sp. [pilla njaval]	*Gomphandra coriacea*
Elaeocarpus mrmronii	*Persea macrantha*	*Svzygium* sp. [pilla njaval]
Gomphandra coriacea	*Elaeocarpus munronii*	*lsonandra* sp. [vella
Saprosma foetens	*Gomphandra coriacea*	*Litsea* sp.
Cinnamomum wightii	*Saprosma foetens*	
Persea macrantha	*Cinnamomum wightii*	

For purpose of comparison, phytosociological parametres of the 12 releves (0.1 ha) studied are given in Appendix-1.

4.5 Conclusions

1. The compositional type of the shola forest vegetation is of the *Cinnamomum wightii* type, as this species is 100 percent constant in all the stands between 1,600-2,100 m asl.

2. The generalization that the number of tree species is less than the aggregate figure for the rest of plant forms, holds true for the shola forests too.

3. Mean and maximum diameter of tree species decrease with increasing elevation in the shola forests. This is more or less linked with the climate and the related physiological limitations of the plants.

4. Certain tree species showed a decreasing trend of diameter with ascending elevation; others showed an increase in diameter, while yet others no increasing or decreasing trend. These patterns reflect the distributional specificity of the species.

5. Species diversity of plants ≥ lcm dbh is highest at 1,950 m as1 or so, from when onwards it decreases. Such a trend however is not observed for species growing ≥ 10 cm dhh.

6. The per hectare density of trees ≥ 10 cm dbh in the shola forests is comparable to that of the evergreen forests. Although the density increases with elevation, the basal area decreases, indicating a reduction in tree size with elevation.

7. Shannon's index of diversity for the shola forests is only comparable to that of moist deciduous or semi-evergreen forests and never reaches closer to that of evergreen forests. Within the shola forests it is highest at 1,950 m as1 and thereafter it decreases. The dominance spectrum indicated by Simpson's index is highest at lower elevations and least at 2,100 m as1 in the shola forests. Evenness of species populations decreases from 1,850 m asl onwards to further up indicating an increase in rarity (sparseness) of populations with increasing elevation.

8. Six to 17 species constituted the dominant species in various stands of the shola forests studied. Their aggregate relative importance value ranged between 70% and 81%. The less frequent tree species in the stands comprised of 8-19 species, their importance value ranging between 18-30% in the stands.

9. Some of the common dominant tree species in the shola forests are: *Hydnocarpus alpina. Mastixia arborea, Gomphandra coriacea. Persea macrantha, Syzygium* spp., *Isonandra candolleana,* species of *Litsea,* etc.

10. The different species of *Syzygium* inhabiting at different elevational belts might perhaps he useful for further classification of the vegetation. Elevational ranges of important tree species are to be marked based on field investigations. which again might be useful for further classification as well as from the point of management.

Chapter 5

REGENERATION ECOLOGY

5.1 Introduction

In synecological terms, regeneration, the perpetuation of a forest stand, is a particular case of succession by the same species or species groups. Thus, the main interest with respect to the regeneration in the shola forests was to identify the regeneration patterns and stocking levels based on sample studies. An understanding of the regeneration pattern will help scientific management of the shola forests.

5.2 Materials and methods

There exists a certain relationship between size and age of trees and therefore, size structure of populations reflects the age structure. Analysis of population structure provides a very useful tool in understanding the process of sylvigenesis. This method has been used in the evaluation of regeneration status and the regeneration process.

The method of study involved analysis of enumeration data obtained from the six 0.25 ha semi-permanent plots established for community ecological studies. The locations of the semi-permanent plots are repeated here, for the sake of clarity (Table 5.1).

The analysis of the data involved partitioning frequency distribution into a series of size classes. In classifying the enumeration data, 9 size classes or life stages were recognized. They are as described in Table 5.2.

Table 5.1 Locations of semi-permanent plots

No	Locations	Altitude (m)	Comments	Area (ha)	Enumeration
1.	Kalippettumala Mannavan Shola	1,700	Burnt stand	0.25	Stems ≥ 1 cmdhh
2.	Kanthallur-4 Mannavan Shola	1,750	Grassland ecotone	0.25	Stems ≥ 1 cm dbh
3.	Kanthallur-5 Mannavan Shola	1,850	Undisturbed	0.25	Stems ≥ 1 cm dbh
4.	Kanthallur-6.5 Mannavan Shola	1,950	Undisturbed	0.25	Stems ≥ 1 cm dbh
5.	Nilagiri Teri Eravikulam	1,950	Undisturbed	0.25	Stems ≥ 1 cm dbh
6.	V-point Eravikulam	2,100	Undisturbed	0.25	Stems ≥ 1 cm dbh

The data were processed and interpreted at two levels: (1) for the whole shola forest ecosystem, and (2). for individual species. Population structure of individual species were analyzed only for the four undisturbed plots, while in the plot that has been subject to burning some years back, and the forest-grassland ecotone plot gross population structure alone has been analyzed.

Table 5.2 Size classes recognized

No.	Acronym	Height classes	Diameter (dbh#) classes	Conventional forestry terms
1.	h50	≤ 50 cm	...	Unestablished seedlings
2.	hg50	> 50 cm	...	Established seedlings
3.	d10	...	≥ 1-10 cm	Saplings
4.	d20	...	≥ 10-20 cm	Poles
5.	d30	...	≥ 20-30 cm	Trees
6.	d40	...	≥ 30-40 cm	Trees
7.	d50	...	≥ 40-50 cm	Trees
8.	d60	...	≥ 50-60 cm	Tees
9.	dg60	...	≥ 60 cm	Trees

- diameter at breast height

5.3 Results

5.3.1 Regeneration at the ecosystem level

Demographic details of population structure of the tree life form in the different semi-permanent plots is given in Table 5.3 and Figures 5.1-5.2.

Table 5.3 Population structure of trees (all species) in the semi-permanent plots[a,b]

Locality	Alt. (m)	Height classes		Diameter classes						
		h50	hg50	d10	d20	d30	d40	d50	d60	dg6
Kanthallur-5	1850	11780	3770	4500	130	190	96	52	40	36
Kanthallur-6.5	1950	16960	1300	5200	200	110	72	44	40	52
Nilagiri Teri	1950	3810	2490	4280	350	140	52	28	16	...
V-point	2100	6200	1330	1660	520	190	44	16	12	12
Max		16960	3770	5200	520	190	96	76	40	52
Min		3810	930	1660	130	110	44	16	12	12
Mean		9690	2220	3910	300	160	66	47	30	29
SD		5100	1080	1340	150	36	20	21	12	16
Kalippettumala[a]	1700	22850	3350	3670	840	120	12	4	...	...
Kanthallur-4[b]	1750	17550	2670	5470	430	60	...	...	...	...

[a] All figures > 100 rounded off to lens

[b] Size of semi-permanent plots = 0.25 ha

From figures given in the table, the average number of trees ≥ 10 cm dbh is 630± 110 ha^{-1}, which is fairly satisfactory. There is ample representation in each of the size classes. A population of 9,690 ± 5,100 unestablished seedlings (height < 50 cm), 1,710 ± 840 established seedlings (height ≥ 50 cm and diameter < 1 cm at breast height), 3,910 ± 1,340 saplings (1-10 cm dbh), 300 ± 150 poles (10-20 cm dbh), seem to be ample for a total of 630 110 trees ≥ 10 cm dbh.

The semilogarithmic graphs of population structure (Figs. 5.1 & 5.2) conform to a bimodal one, the highest representation being in the unestablished seedlings (height < 50 cm) and another peak in the sapling stage (1-10 cm dbh). In this sense, the graph practically differs from the generally observed exponential or reverse J-shaped population curve as described by Krebs (1972) and Harper and White (1974).

From the table and the figures (Figs. 5.1 & 5.2), an accumulation of large number of individuals in the sapling life stage (1-10 cm dbh class) is observed, compared to the poles and the established seedlings. The excessive representation of individuals in the lowermost size class is a natural phenomenon characteristic of exponential curves. But, higher frequency representation in the sapling stage than that in the neighbouring classes, ie, the established seedlings and poles is an unusual phenomenon.

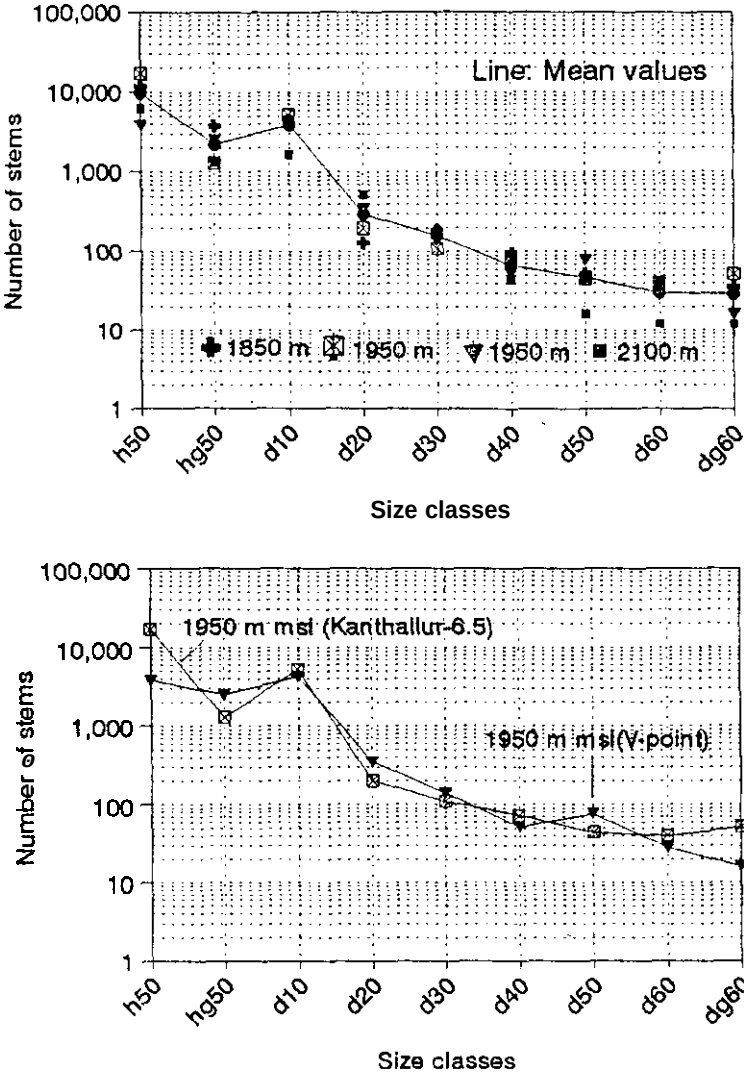
On partitioning the enumeration data for certain species it was found that out of the mean value of 3,910 individuals in the sapling population, 2,655 individuals were contributed by *Lasianthus acuminatus* and *Ardisia rhomboidea,* two dominant underwood trees. The balance of only 1,255 individuals were actually contributed by other tree species. Even this number is almost double the number of plants observed in the life stages, established seedlings (510) and poles (300).

Further partitioning of data for other underwood species is yet to be done. Nevertheless, it appears that the peak in the sapling stage of the curve appears to be due to the presence of some species which are adapted to the underwood stratum in the canopy and which characteristically remain in a lower dbh class. Species of *Strobilanthes* such as *S. homotropa, S. luridus, Ardisia rhomboidea* and *Lasianthus acuminatus* are examples of such underwood species. If the population of such species are exempted from the data, the population curve for the rest of the tree life forms would certainly follow an reverse-J shaped curve, although not exactly so.

Drastic difference in the number of unestablished seedlings is observed in two semi-permanent plots sharing an elevational status of 1,950 m asl. One of these plots belongs to Mannavan Shola (Kanthallur-6.5) and has been estimated to have 16,960 unestablished seedlings. The other plot, Nilagiri Teri belongs to the Eravikulam National Park and has recorded but only 3,810 unestablished seedlings. Differences in the population of established seedlings (height > 50 and < 1 cm dbh) is evident; but here, the larger population of established seedlings is observed where the population of unestablished seedlings is low. The differences in sire classes further up is not very much striking.

The exact reason for the differences in regeneration population, as explained in the previous paragraph, is not known, but could result from several reasons. (1) Perhaps compositional differences exist in the shola forests depending upon the site, and that this in turn reflect upon

Population structure of tree stratum



Figures 5.1 & 5.2. Population structure of tree stratum in the shola forests, depicted as semilogarithmic graphs. Fig. 5.1. The average population structure. Fig. 5.2. Population curves for two stands at 1950 m asl, one at Mannavan Shola (Kanthallur-6.5) and the other at Eravikulam (V-Point). All the graphs show an excessive accumulation of individuals in the sapling stage (d10). owing to the characteristic growth forms and limitation of the optimum size of certain underwood species (For details see the text).

the population structure in the stands. (2). It is equally probable that the sites differ in micro-level disturbances such as tree fall gaps. If that is the case, perhaps the differences could be due to the differing stages of stand development, as in a regeneration complex (Kimmins, 1987).

5.3.2 Regeneration in burnt and ecotone plots

Table 5.4 summarizes observed frequencies in younger regeneration classes in the six semi-permanent plots.

Table 5.4 Frequency distribution of plants in young regeneration classes of the semi-permanent plots[1,2.]

No.	Locations	Altitude (m)	Status	h50	hg50	d10
I.	Kanthallur-5	1,850	Undisturbed	11780	3770	4500
2.	Kanthallur-6.5	1,950	Undisturbed	16960	1300	5200
3.	Nilagiri Teri	1,950	Undisturbed	3810	2490	4280
4.	V-point	2,100	Undisturbed	6200	I330	1660
			Mean	9688	2223	3910
			SD	5887	1171	1550
5.	Kalippettumala	1,700	Burnt stand	22850	3350	3670
6.	Kanthallur-4	1,750	Ecotone	17550	2670	5470

From the Table 5.4, it can be seen that the number of unestablished seedlings (height < 50 cm) is very high in the burnt (22,850) and ecotone (17,550) plots, compared to the undisturbed plots. Although one of the undisturbed plots, Kanthallur-6.5, has a frequency almost equaling that of the ecotone plot (11,780), all other plots have low frequencies in this size class. The plot that has been subject to burning years back is in a disturbed state, and hence secondary succession is in vogue there: the forest-grassland ecotone plot is also in a successionally young and hence comparable to that of the burnt plot. The high percentage of unestablished seedlings of arborescent species in both of the plots therefore infers active succession taking place. However, such a pattern is not observed with respect to the established seedlings or saplings.

5.3.3 Regeneration at individual species level

As a result of phytosociological studies conducted, in 12 elevational belts, the tree species were categorized into three: (i). Species with high constancy (>75%), (ii). Species with medium constancy, (iii). Species with low constancy (cf. Chapter 4. Community ecology). In all these categories. two patterns of population structure were observed: (i). species for which all life stages are fairly well represented, and (ii). in which established regeneration is not fairly represented. The variety of species according to population structure are as given in Table 5.5.

In addition, individual species also differed in yet other features. Some species were not present in all the sites, while in others, although they were present in all or majority of the plots, different life stages were represented in different plots. This may be due to the elevational specificity of distribution of the species, and the consequent patterns of regeneration. Other

species had fair representation in all life stages in one of the plots, while in other plots only one or two life stages were represented. Such patterns of random distribution of life stages across samples could be due to the favourable of specific environmental niche, to which the species is adapted.

Table 5.5 Different kinds of tree species according to regeneration patterns

Species with a high constancy (≥ 75%) 1.1 All life stages fairly well represented Eg.: *Cinnamomum wightii, Litsea* sp., *Gomphandra coriacea* 1.2 Established regeneration not fairly represented Eg.: *Persea macrantha, Saprosma foetans*
Species of medium constancy 2.1 All life stages fairly well represented Eg.: *Symplocos cochinchinensis, Hydnocarpus alpina, Mastixia arborea, Chionanthus macrocarpa, Ternstroemia japonica, Actinodaphne bourdillonii, Canthium dicoccum* 2.2 Established regeneration not fairly represented Eg.: *Isonandra candolleana, Lasianthus acuminatus, Schefflera racemosa, Turpinia nepalensis, Syzygium densiflorum, Celtis wightii*
3. Other species 3.1 Species of high constancy in permanent plots 3.11 All life stages fairly well represented Eg.: *Syzygium* sp. (potti njaval) 3.12 Established regeneration not fairly represented Eg.: *Ardisia rhomboidea, Ligustrum perrorttetii, Syzygium* sp., *Daphniphyllum neilgherrense* 3.2 Species of low constancy in permanent plots 3.21 All life stages fairly well represented Eg.: *Phoebe* sp. 3.22 Established regeneration not fairly represented Eg.: *Scolopia crenata, Mahonia leschenaultii, Syzygium*

Regeneration patterns of some selected tree species are provided in *Appendix-2*

5.4 Discussion

5.4.1 Situations requiring regeneration augmentation: When we examine the life tables of tree populations in the shola forests they were found not deficient in regeneration. Deficiency of regeneration perhaps arises only where shola forest patches have been subject to burning or such other disturbances. In situations otherwise, eucalypt plantations along the High Ranges and elsewhere, have been found to be actively colonized by native shola forest species. Compared to the eucalypt plantations, the shola groves are much more efficient in holding the rain water for a

longer time, and for this reason, in both these situations regeneration augmentation by planting seedlings of shola species may be useful. The use of stumps (root shoot cuttings) for planting may be experimented with a few dominant shola tree species. Species which are resistant to fire. such as *Rhododendron nilagiricum,* and those species which are found generally along the margins of shola patches, or pioneer species that establish the nuclei of shola glen formation (see Figures 5.3-5.5) along the upstreams such as species of *Syzygium* need to be given preference for this experimental study.

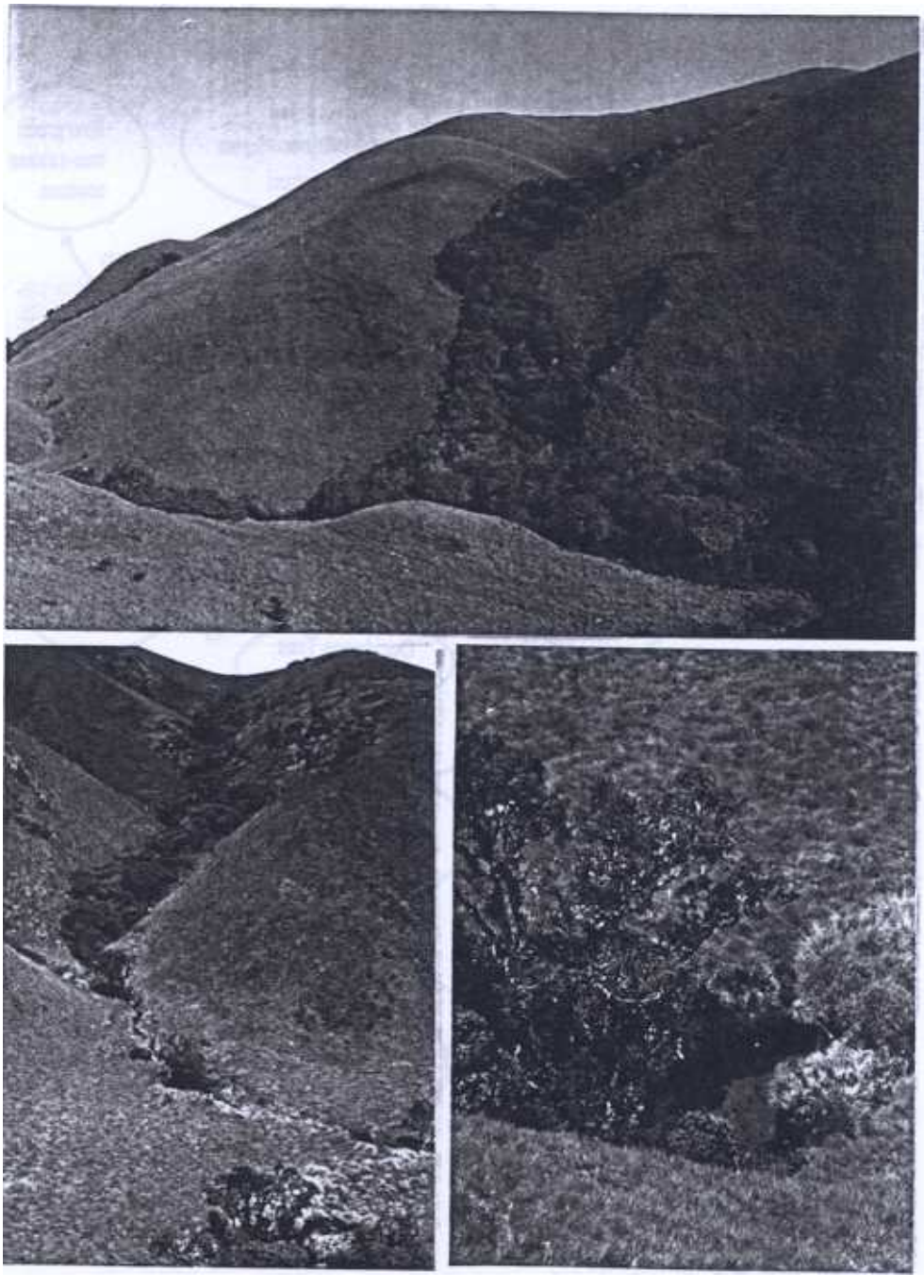
In wildlife preservatories such as the Eravikulam National Park, innumerable tiny montane shola forest patches are sprinkled in the vast landscape of hill top grasslands. having refuged to the little sinusia hidden between the rolling hillocks. A great majority of these glenlets are found to have reed-bamboos within them. The gregarious reed-bamboos with their perennial underground stems are capable of withstanding less intense fire, and therefore they are considered to be indicators of past fire in the groves. Shola patches with a few years fire history with standing burnt tree poles and stumps evidenced by the presence of charcoal on them, are also found to be invaded by reed-bamboos. Thus the shola patches with reed-bamboos in them are probably disclimaxes, produced as a result of tire (refer Figure 5.6).

Quantitative assessment of the shola groves invaded by reed-bamboos, the role of fire in advancing the reed growth, the probability of improving the species composition of these groves by augment planting are aspects that deserve further studies. Population ecology and autecology of shola tree species regeneration deserve special attention.

Preservation of the wild populations of the Nilgiri tahr, the endangered animal, is the top conservation priority of the Eravikulam National Park. As a matter of fact, the grasslands in the Park are burnt periodically such that any given area receives buming approximately once in every two years or so (Rice, 1984). Perhaps, fire escapes into the shola forests when the grasslands are burnt. Therefore, Fire protection measures should be ensured to the sholas before the grasslands are burnt.

5.5 Conclusions

1. At the ecosystem level, the tree stratum of the shola forest at Mannavan Shola and Eravikulam do not display deficiency of regeneration.
2. Regeneration of most of the tree species is fairly well represented, however several species have deficiency in some life stages.
3. Regeneration augmentation may be necessary only in disturbed shola forests or in eucalypt and other plantations where gradual conversion of the plantations to natural shola forests is desired.



Figures 5.3-5.5 The pictures show the formation stage of shola forests. Along hill top upstreams such developmental stages are observed. This suggests that the high correspondence of shola forest patches to valleys and depressions is largely a matter of soil moisture regimes than wind, temperature or other factors.

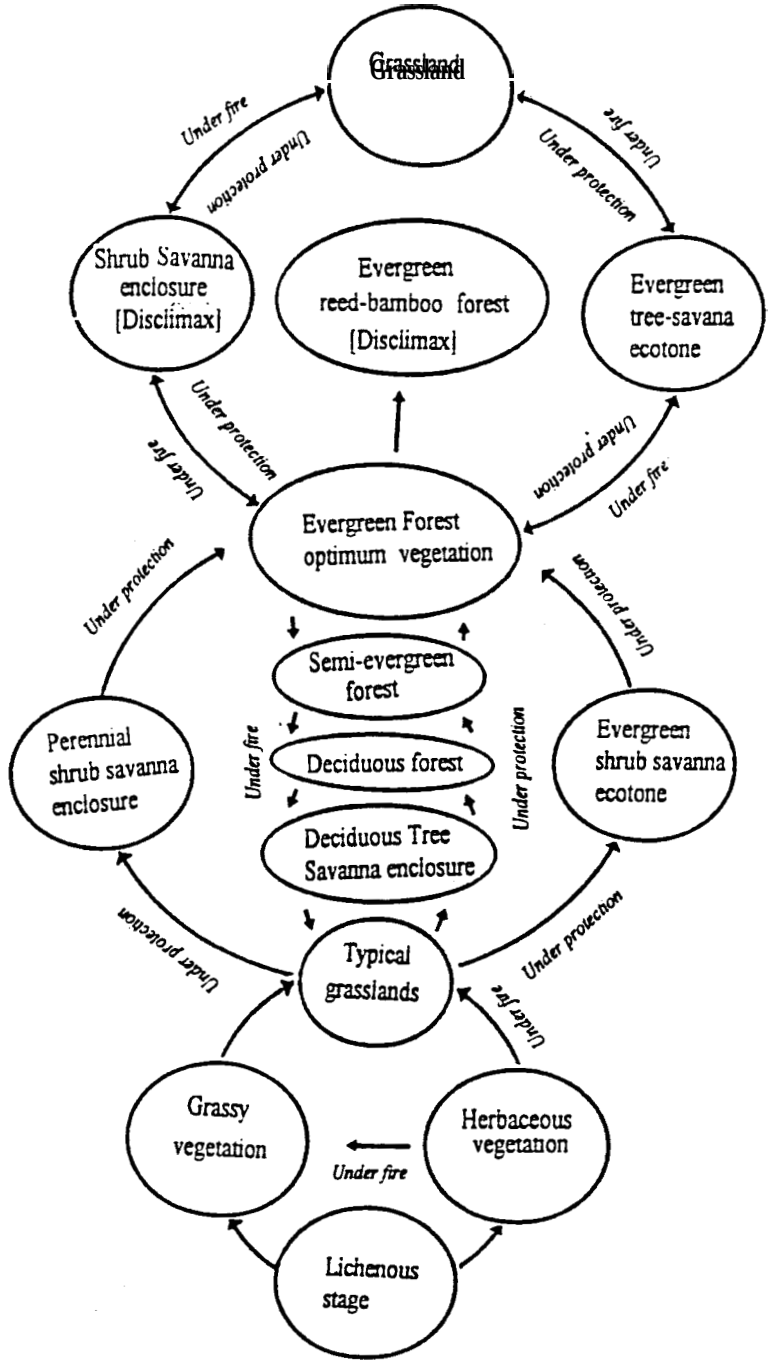


Figure 5.6 Successional sequences in grasslands of Kerala (reproduced from Swarupanandan *et al.,* 1998). The diagram shows that many of our shola forest patches are secondary in terms of succession. A greater percentage of the patchy high elevational shola forests have high percentage of reed-bamboos in them. Reed bamboos are generally indicators of fire and suggest the occurrence of repeated fires in the shola forests patches during the past. The patchy shola forests with high percentage of reed-bamboos therefore represent a disclimax, which is depicted in the uppermost circle of the succession chart.

Chapter 6

SYNTHESIS

6.1 Introduction

In the present study on the shola forests of Mannavan Shola and Eravikulam, four aspects are dealt with: (i) floristics, (ii) community ecology and (iii) regeneration ecology. Highlights from each of the study subjects are detailed below.

6.2 Floristic studies

The floristic studies identified 543 species of plants (Pteridophytes and Angiosperms together). Nearly one fifth of the taxa (109 spp.) collected are endemic and one fourth of the taxa (128 spp.) are classified as rare, and 26 species belong to the threatened category. *Sinarundinaria microphylla,* a dwarf bamboo collected Eravikulam National Park is a new record for Peninsular India (Kumar and Kumar, 1997). Fern species such as *Elaphoglossum stelligerum* and *Pleopeltis macrocarpa* collected from Mannavan Shola are new record for Kerala (Kumar, 1998). In addition, some specimens of the genera *Syzygium, Balanophora, Litsea, Taeniophyllum* and a few other genera remains to be identified. These materials in all probability represent new taxa.

The geographic extent of the floristic study was restricted to Mannavan Shola (ca. 5 km^2) and Eravikulam National Park (90 km^2), both falling within the Idukki District of Kerala. The area of the study is only a fraction of the total area occupied by shola forests in Kerala. From this point of view if an exhaustive study of the flora covering all the shola forest areas in the State is conducted, the number of endemics, rarities, and new taxa could be still high. The value of these forests in the context of biodiversity conservation therefore demand serious attention.

Selected plant species such as *Drosera peltata, Gaultheria fragrantissima, Anaphalis* spp., etc. which inhabit successional habitats adjoining shola forests are extracted in large quantities, of which there is no quantified information. Resource economics in terms of such produces, affecting the life of the local people in the area, deserves due attention.

6.3 Ecological studies

Bench mark information on the structure, composition, dominance, biodiversity content, population structure of selected tree species in the shola forests *etc,* have been generated by the present study. Tree regeneration is not much constrained.

In order to extract applied value of the generated ecological information, further extension of community ecology so as to identify the existing vegetal mosaics and their soil and stand composition, altitudinal subunits based on the distributional difference of key species such as species of *Syzygium,* specifics of regeneration dynamics or succession in each of the vegetal mosaics, need to be pursued further. This would also need to involve autecological studies of selected dominant tree species.

6.4 Artificial regeneration of the shola forests

The effect of fire on shola forests is reflected best in the patchy montane shola forests. The copiously growing reed-bamboos within the groves are considered the result of past fire invasion. It would be desirable that such patches be enriched with native shola forest species.

Smaller shola forest patches could be linked through sbola forest corridors. Such attempts would be desirable, both in evolving protected area management strategies, as well as in protecting the head waters and catchments.

In all the above situations, augmentation planting and artificial regeneration of shola forests is required. Silviculture of shola forest species, therefore should be a priority in both planning ecosystem development and research along South Indian Hill Stations.

6.5 Possibilities for a Shola Forest Sanctuary

The Eravikulam National Park is a living refugium of montane wet temperate sholas, while Mannavan Shola is another living museum of subtropical hill forests and its biota. The numerous patchy montane shola forest glens otherwise preserved by being situated in the Eravikulam National Park, is more or less well protected, except for the risk of occasional fire. The Mannavan Shola is the largest shola forest patch in the State, forming part of the Munnar Forest Division. Long term protection for this majestic vegetal stretch, which contains many botanical rarities and novelties to science, is not ensured. Because both clear felling and selection felling of natural forests in the State remains a closed chapter for the time being, there is no immediate danger of felling the Mannavan Shola and the adjacent larger shola groves in the near future. Yet, a legal protective measure ensuring long term protection of the groves is desirable.

In speculating measures to improve the efficacy of protected area networks in the State, Rodgers and Panwar (1988) have suggested establishing a shola forest sanctuary in the High Ranges, adjoining and strengthening the conservation potential of the Eravikulam National Park. The Mannavan Shola together with other larger adjacent shola patches such as Pullaradi Shola, Pambadam Shola and Idivara Shola would be suitable for consideration here. These four shola forest glens are discontinuous being interspersed with tea estates, grasslands and some eucalypt and wattle plantations. With the objective of plantation development, most of the grasslands lying in between have already been planted with eucalypts. Rodgers and Panwar's (1988) suggestion to constitute a shola forest reserve is very valuable when we realize the fact that in many places plantations have been actively colonized by natural shola forest species (Srivastava, 1994). The possibility of linking the three shola forest junks by developing corridors through artificial planting of shola forest species in the grasslands also exists.

The seven kilometer long Kanthallur-SP Puram road traverses the Mannavan Shola from bottom to top and connects Marayur-Kanthallur settlements to Kundala. In the interest of protection of the Mannavan Shola and other adjacent larger shola forest patches, it is desirable that authority of the road be vested with the Forest Department and the existing people's right to transport and motorize it may be given up.

6.6 Proposal for a High Altitude Ecology Chapter in South India

The shola forests and the poorly explored flora and fauna, the grasslands, the plantations of tea, eucalypt and wattle, all provide scope for a High Altitude Ecology Chapter in the South. The narrow equilibrium of the mountain ecosystems, the dwindling shola forest cover, increasing rates of disappearance of the grassy landscapes, the vagaries in the high altitude climate, the peculiar cultural development along the High Ranges associated with the tea plantations, all make the suggestion meaningful.

Appendix-1

RELATIVE IMPORTANCE OF SPECIES IN RELEVES

Releve # 1: Thalachorkadavu, Mannavan Shola
Altitude: 1,600 m asl; ***Releve size:*** 0.1 ha

Species	D	BA	RD	RF	RBA	RIVI	CRIVI
12 species with RIVI < 5%	17	2.4189	18.32	33.32	21.44	24.36	24.35
9 species with RIVI > 5%	76	8.8664	81.72	66.66	78.57	75.66	100.01
Dominant species							
Meliosma simplicifolia	21	1.3298	22.58	16.67	11.78	17.01	17.01
Syzygium densiflorum	7	3.5133	7.53	8.33	31.13	15.66	32.67
Persea macrantha	8	0.8545	8.60	8.33	7.57	8.17	40.84
Bischofia javanica	6	0.7038	6.45	8.33	6.24	7.01	47.85
Turpinia nepalensis	6	0.2210	6.45	10.42	1.96	6.28	54.13
Rhododendron nilagiricum	10	0.4545	10.75	2.08	4.03	5.62	59.75
Elaeocarpus munronii	2	1.3919	2.15	2.08	12.33	5.52	65.27
Viburnum acuminatum	7	0.2117	7.53	6.25	1.88	5.22	70.49
Syzygium sp.	9	0.1859	9.68	4.17	1.65	5.17	75.66
Total	93	11.2852	100.04	99.98	100.01	100.01	100.01

BA - Basal area; D - Density; RBA - Relative basal area; RD – Relative density; RF - Relative frequency; RIVI - Relative importance value (= IVI/3); S - Number of species.

Releve #2: Kanthallur-3, Mannavan Shola
Altitude: 1,700 m ***Releve size:*** 0.1 ha

Species	D	BA	RD	RF	RBA	RIVI	CRIVI
17 species with RIVI < 5%	37	1.4046	31.37	40.29	16.99	29.56	29.56
11 species with RIVI > 5%	81	6.8718	68.63	59.65	83.02	70.42	99.98
Dominant species							
Meliosma simplicifolia	20	1.0017	16.95	10.53	12.10	13.19	13.19
Viburnum acuminatum	18	0.4344	15.25	7.02	5.25	9.17	22.36
Persea macrantha	6	0.8486	5.08	7.02	10.25	7.45	29.81
Daphniphyllum neilgherrense	9	0.2858	7.63	7.02	3.45	6.03	35.84
Turpinia nepalensis	8	0.2942	6.78	7.02	3.55	5.78	41.62
Unidentified sp. (Pe to)	1	1.0890	0.85	1.75	13.16	5.25	46.87
Litsea sp.	5	0.4117	4.24	5.26	4.97	4.82	51.69

Contd…

Species	D	BA	RD	RF	RBA	RIVI	CRIVI
Glochidion neilgherrense	6	0.3404	5.08	5.26	4.11	4.82	56.51
Ternstroemia japonica	2	0.7288	1.69	3.51	8.81	4.67	61.18
Bischofia javanica	4	0.5799	3.39	3.51	7.01	4.64	65.82
Schefflera racemosa	2	0.8573	1.69	1.75	10.36	4.60	70.42
Total	118	8.2765	100.00	99.94	100.01	99.98	99.98

Releve # 3: Kanthallur-4, Mannavan Shola
Altitude: 1,800 m asl; ***Releve size***: 0.1 ha

Species	D	BA	RD	RF	RBA	RIVI	CRIVI
19 species with RIVI < 5%	30	1.8100	32.59	41.93	13.36	29.30	29.30
12 species with RIVI > 5%	62	11.7354	67.36	58.08	86.65	70.7	100.00
Dominant species							
Mastixia arborea	15	2.5396	16.30	9.68	18.75	14.91	14.91
Hydnocarpus alpina	15	1.2808	16.30	6.45	9.46	10.74	25.65
Syzygium densiflorum	2	2.3373	2.17	3.23	17.26	7.55	33.20
Gomphandra coriacea	6	0.2692	6.52	9.68	1.99	6.06	39.26
Scolopia crenata	3	1.2507	3.26	3.23	9.23	5.24	44.50
Syzygium caryophyllatum	3	1.0303	3.26	4.84	7.61	5.24	49.74
Isonandra candolleana	5	0.4806	5.43	6.45	3.55	5.14	54.88
Litsea sp.	5	0.4846	5.43	4.84	3.58	4.62	59.50
Unident sp. [peenari]	2	0.7146	2.17	3.23	5.28	3.56	63.06
Pygeum gardneri	1	0.7017	1.09	1.61	5.18	2.63	65.69
Turpinia nepalensis	3	0.1658	3.26	3.23	1.22	2.57	68.26
Syzygium sp. (pilla njaval)	2	0.4802	2.17	1.61	3.54	2.44	70.70
Total	92	13.5453	99.95	100.01	100.01	100.00	100.00

Releve # 4: Kanthallur-5, Mannavan Shola
Altitude: 1,850 m asl; ***Releve size***: 0.1 ha

Species	D	BA	RD	RF	RBA	RIVI	CRIVI
13 species with RIVI < 5%	18	1.2121	30.00	39.54	17.37	28.98	28.98
8 species with RIVI > 5%	42	5.7555	70.00	60.47	82.60	71.02	100.02
Dominant species							
Hydnocarpus alpina	14	1.1291	23.33	16.28	16.21	18.61	18.61
Isonandra candolleana	12	1.3846	20.00	13.95	19.87	17.94	36.55
Syzygium sp. [pilla njaval]	1	1.2537	1.67	2.33	17.99	7.33	43.88

Contd...

Species	D	BA	RD	RF	RBA	RIVI	CRIVI
Gomphandra coriacea	5	0.1101	8.33	9.30	1.58	6.40	50.28
Litsea sp.	4	0.2880	6.67	6.98	4.13	5.93	56.21
Persea macrantha	3	0.4256	5.00	4.65	6.11	5.25	61.46
Unidentified sp. (Hacoc)	1	0.7644	1.67	2.33	10.97	4.99	66.45
Mastixia arborea	2	0.4000	3.33	4.65	5.74	4.57	71.02
Total	60	6.9676	100.03	100.06	99.97	100.02	100.02

Releve # 5: Kanthallur-6, Mannavan Shola.
Altitude: 1,900 m asl; **Releve size**: 0.1 ha

Species	D	BA	RD	RF	RBA	RIVI	CRIVI
16 species with RIVI < 5%	27	3.3298	31.39	38.10	20.61	30.04	30.04
7 species with RIVI > 5%	59	12.8367	68.61	61.90	79.40	69.96	100.00
Dominant species							
Cinnamomum wightii	12	3.5489	13.95	12.70	21.95	16.20	16.20
Mastixia arborea	13	2.9005	15.12	12.70	17.94	15.25	31.45
Syzygium densiflorum	6	3.4853	6.98	4.76	21.56	11.10	42.55
Gomphandra coriacea	12	0.5267	13.95	11.11	3.26	9.44	51.99
Isonandra candolleana	6	0.9625	6.98	9.52	5.95	7.48	59.47
Chionanthus macrocarpa	6	0.7841	6.98	7.94	4.85	6.59	66.06
Celtis wightii	4	0.6287	4.65	3.17	3.89	3.90	69.96
Total	86	16.1665	100.00	100.00	100.01	100.00	100.00

Releve # 6: Kanthallur-6.5, Mannavan Shola
Altitude: 1,950 m asl; ***Releve size***: 0.1 ha

Species	D	BA	RD	RF	RBA	RIVI	CRIVI
16 species with RIVI < 70%	28	3.4128	29.47	32.89	27.46	29.94	29.94
12 species with RIVI > 70%	67	9.0206	70.54	67.15	72.55	70.08	100.02
Dominant species							
Mastixia arborea	10	2.3821	10.53	7.14	19.16	12.28	12.28
Turpinia nepalensis	9	0.5702	9.47	8.57	4.59	7.54	19.82
Chionanthes macrocarpa	9	0.4221	9.47	8.57	3.39	7.14	26.96
Gomphandra coriacea	8	0.2912	8.42	7.14	2.34	5.97	32.93
Syzygium sp. [pilla njaval]	3	1.2840	3.16	4.29	10.33	5.93	38.86
Litsea ligustrina	6	0.4093	6.32	7.14	3.29	5.58	44.44
Phoebe sp.	6	0.5435	6.32	5.71	4.37	5.47	49.91

Contd...

Species	D	BA	RD	RF	RBA	RIVI	CRIVI
Syzygium densiflorum	2	1.0218	2.11	2.86	8.22	4.40	54.31
Litsea sp.	5	0.4109	5.26	4.29	3.30	4.28	58.59
Photinia notoniana	4	0.5365	4.21	4.29	4.32	4.27	62.86
Syzygium sp. [potti]	2	0.8365	2.11	2.86	6.73	3.90	66.76
Olea dioica	3	0.3125	3.16	4.29	2.51	3.32	70.08
Total	95	12.4334	100.01	100.04	100.01	100.02	100.02

Releve # 7: Kanthallur-6.5, Mannavan Shola

Altitude: 1,950 m asl; ***Releve size***: 0.1 ha

Species	D	BA	RD	RF	RBA	RIVI	CRIVI
13 species with RIVI < 5%	18	2.3233	26.10	34.75	29.68	30.18	30.18
6 species with RIVI > 5%	51	5.5040	73.92	65.22	70.32	69.82	100.00
Dominant species							
Hydnocarpus alpina	16	1.5277	23.19	17.39	19.52	20.03	20.03
Isonandra candolleana	12	1.0434	17.39	15.22	13.33	15.31	35.34
Gomphandra coriacea	10	0.3026	14.49	13.04	3.87	10.47	45.81
Syzygium sp. [pilla njaval]	2	1.7549	2.90	4.35	22.42	9.89	55.70
Isonandra sp. [vella pala]	6	0.7447	8.70	8.70	9.51	8.97	64.67
Litsea sp.	5	0.1307	7.25	6.52	1.67	5.15	69.82
Total	69	7.8273	100.02	99.97	100.00	100.00	100.00

Releve # 8: Nilagiri Teri, Eravikulam NP

Altitude: 1,950 m asl; ***Releve size***: 0.1 ha

Species	D	BA	RD	RF	RBA	RIVI	CRIVI
12 species with RIVI < 5%	15	1.0062	29.40	37.50	17.77	28.22	28.22
6 species with RIVI > 5%	36	4.6595	70.58	62.50	82.25	71.78	100.00
Dominant species							
Hydnocarpus alpina	12	1.1002	23.53	17.50	19.42	20.15	20.15
Isonandra candolleana	12	0.8457	23.53	17.50	14.93	18.65	38.80
Syzygium sp. [pilla njaval]	2	1.7549	3.92	5.00	30.97	13.30	52.10
Gomphandra coriacea	5	0.1692	9.80	10.00	2.99	7.60	59.70
Persea macrantha	3	0.3257	5.88	7.50	5.75	6.38	66.08
Ternstroemia japonica	2	0.4638	3.92	5.00	8.19	5.70	71.78
Total	51	5.6657	99.98	100.00	100.02	100.00	100.00

Releve # 9: Kanthallur-9.5, Mannavan Shola.

Altitude: 1,950 m asl; ***Releve size***: 0.1 ha

Species	D	BA	RD	RF	RBA	RIVI	CRIVI
9 species with RIVI < 5%	10	0.6810	21.30	34.65	22.34	26.09	26.09
7 species with RIVI > 5%	37	2.3676	78.74	65.39	77.65	73.93	100.02
Dominant species							
Rhododendron nilagiricum	14	0.7842	29.79	15.38	25.72	23.63	23.63
Elaeocarpus recurvatus	6	0.2196	12.77	11.54	7.20	10.50	34.13
Turpinia nepalensis	5	0.2200	10.64	11.54	7.22	9.80	43.93
Syzygium sp.	4	0.2024	8.51	11.54	6.64	8.90	52.83
Cinnamomum wightii	2	0.4751	4.26	3.85	15.58	7.90	60.73
Litsea sp.	2	0.3836	4.26	3.85	12.58	6.90	67.63
Vaccinium leschenaultii	4	0.0827	8.51	7.69	2.71	6.30	73.93
Total	47	3.0487	100.04	100.04	99.99	100.02	100.02

Releve # 10: V-Point, Eravikulam.

Altitude: 2,100 m asl; ***Releve size***: 0.1 ha

Species	D	BA	RD	RF	RBA	RIVI	CRIVI
8 species with RIVI < 5%	12	0.6882	21.45	23.80	10.82	18.69	18.70
8 species with RIVI > 5%	44	5.2490	78.56	76.18	89.17	81.30	99.99
Dominant species							
Isonandra candolleana	13	0.8680	23.21	14.29	14.62	17.37	17.37
Hydnocarpus alpina	9	0.6881	16.07	14.29	11.59	13.98	31.35
Syzygium sp. [pilla njaval]	2	1.7549	3.57	4.76	29.56	12.63	43.98
Elaeocarpus munronii	4	0.7936	7.14	9.52	13.37	10.01	53.99
Gomphandra coriacea	7	0.2023	12.50	11.90	3.41	9.27	63.26
Saprosma foetens	4	0.1415	7.14	9.52	2.38	6.35	69.61
Cinnamomum wightii	2	0.5865	3.57	4.76	9.88	6.07	75.68
Persea macrantha	3	0.2591	5.36	7.14	4.36	5.62	81.30
Total	56	5.9372	100.01	99.98	99.99	99.99	99.99

Releve # 11: Kalippettumala, Mannavan Shola (Burnt stand).
Altitude: 1,700 m asl; ***Releve size***: 0.1 ha

Species	D	BA	RD	RF	RBA	RIVI	CRIVI
8 species with RIVI > 5%	44	5.1317	70.96	70.83	75.28	72.36	72.64
10 species with RIVI < 5%	18	1.6866	29.02	29.15	24.72	27.64	99.99
Dominant species							
Isonandra candolleana	15	1.2000	24.19	18.75	17.60	20.18	20.18
Hydnocarpus alpina	10	0.6799	16.13	16.67	9.97	14.26	34.44
Syzygium sp. [pilla njaval]	1	1.2537	1.61	2.08	18.39	7.36	41.80
Persea macrantha	4	0.5608	6.45	6.25	8.23	6.98	48.78
Elaeocarpus munronii	3	0.5637	4.84	6.25	8.27	6.45	55.23
Gomphandra coriacea	5	0.1749	8.06	8.33	2.57	6.32	61.55
Saprosma foetens	4	0.1122	6.45	8.33	1.65	5.48	67.03
Cinnamomum wightii	2	0.5865	3.23	4.17	8.60	5.33	72.36
Total	62	6.8183	99.98	99.98	100.00	99.99	100.00

Releve # 12: Kanthallur-4, Mannavan Shola (Forest-Grassland ecotone).
Altitude: 1,750 m asl; ***Releve size***: 0.1 ha.

Species	D	BA	RD	RF	RBA	RIVI	CRIVI
12 species with RIVI < 5%	15	1.4743	24.18	33.32	23.57	27.03	27.03
6 species with RIVI > 5%	47	4.7826	75.80	66.67	76.44	72.96	99.99
Dominant species							
Isonandra candolleana	14	1.2645	22.58	19.05	20.21	20.61	20.61
Hydnocarpus alpina	14	1.1438	22.58	16.67	18.28	19.18	39.79
Gomphandra coriacea	9	0.2890	14.52	14.29	4.62	11.14	50.93
Syzygium sp. [pilla njaval]	1	1.2537	1.61	2.38	20.04	8.01	58.94
Isonandra sp. [vella pala]	5	0.5436	8.06	7.14	8.69	7.96	66.90
Litsea sp.	4	0.2880	6.45	7.14	4.60	6.06	72.96
Total	62	6.2569	99.98	99.99	100.01	99.99	99.99

Appendix-2

REGENERATION PATTERNS OF SOME SELECTED TREE SPECIES

Note : For easiness of reference the descriptions are arranged in the alphabetic sequence of the species names. Stationary life tables of some of the species are also given.

5.33.1 ***Acronychia laurifolia:*** **A** low tree often found along forest edges; only in one plot (1950 m > asl) was the species well represented, where plants were found represented in all life stages (Table 5.6).

Table 5.6 Life table of *Acronychia* laurifolia

Alt	loc	h50	hg50	d10	d20	d30	d40	d50	n*
1850		31	..	..	..	4	..	..	35
1950		465	31	12	4	4	..	4	524
Total		496	31	12	4	4	..	4	559

n -total population

5.33.2 Actinodaphne bourdillonii: The species had a stable population structure with representation in all life stages, but in two out of the three plots in which the species was encountered, some life stages were missing (Table 5.7).

Table 5.7 Life table of *Actinodaphne bourdillonii*

Alt	loc	h50	hg50	d10	d20	d30	d40	d50	d60	n*
1850		..	109	16	..	..	..	..	4	129
1950	NT	217	582	240	32	4	4	8	4	1091
2100		31	..	20	12	..	..	..	..	63
Total		248	691	276	44	4	4	8	8	1283

n* - total population

5.33.3 ***Ardisia rhomboidea:*** This underwood species was encountered in all the four plots; it seldom attains a dbh over 20 cm; most of the population was found concentrated in the sapling stage; as in the case of Lasianthus acuminatus, the accumulation of the population in the sapling stage is partially responsible for a second peak in the sapling stage of the population curve of the tree spectrum for the shola forests; however in one of the plots, lower size classes were found amply represented (Table 5.8).

Table 5.8 Life table of *Ardisia rhomboidea*

Alt	loc	h50	hg50	d10	d20	n*
1850		..	..	604	4	608
1950		..	..	2376	8	2384
1950	NT	..	..	504	..	504
2100		868	202	212	8	1290
Total		868	202	3696	20	4786

n* - total population; NT: Nilagiri Ten

5.33.4 ***Canthium dicoccum;*** The species scarcely grows over 40 cm dbh: in three of the plots the species was encountered; the life table displays a stable population structure. Slight accumulation of individuals in the sapling stage compared to the established seedlings and pole stages is observed (Table 5.9).

Table 5.9 Life table of *Canthium dicoccum*

Alt	loc	h50	hg50	d10	d20	d30	n*
1850		..	..	8	..	4	12
1950		186	67	72	20	8	353
1950	NT	186	62	60	..	..	308
Total		372	129	140	20	12	673

n* - total population: NT: Nilagiri Ten

5.33.5 ***Celtis wightii:*** Observed population structure was all the same as for Acronychia laurifolia: most of the life stages were found restricted to one of the two plots where the species was found represented (Table 5.10).

Table 5.10 Life table of *Celtis wightii*

Alt	loc	h50	hg50	d10	d20	d30	d40	d50	d60	n*
1850		..	4	..	8	..	..	..	..	12
1950		31	..	8	12	4	4	4	4	67
Total		31	4	8	20	4	4	4	4	79

n*- total population

5.33.6 ***Chionanthus macrocarpa:*** The species was represented in three of the plots; only in one of the plots all the life stages were represented, where slight excess of representation of saplings (1-10cm dbh) (Table5.11).

Table 5.11 Life table of *Chionanthus macrocarpa*

Alt	loc	h50	hg50	d10	d20	d30	d40	d50	d60	n*
1850		..	..	4	..	8	..	..	..	12
1950		..	4	..	4	..	12	4	4	28
1950	NT	341	163	244	92	12	4	20	4	884
Total		341	167	248	96	20	16	24	8	924

n* - total population

5.33.7 ***Cinnamomum*** Having found represented in all the four sample plots, plants were found represented in all the size classes and no deficiency in any given life stage was evident, except that in some of the plots, the species was absent from sapling stage onward (Table 5.12).

Table 5.12 Life table of *Cinnamomum wightii* (Species with a high constancy (>= 75%) and all life stages fairly represented

Alt	loc	h50	hg50	d10	d20	d30	d40	d50	d60	n*
1850		589	283	24	..	..	..	4	..	904
1950		465	194	96	4	12	..	..	12	787
1950	NT	930	535	200	28	4	..	..	..	1697
2100		403	62	88	200	96	16	16	..	881
Total		2387	1074	408	232	112	16	20	12	4269

5.33.8 *Gomphandra coriacea:* Species found in all the five sample plots; In the plot at 2,100 m greater than asl, the species was poorly represented; in two plots only unestablished and established seedlings alone could be encountered (Table 5.13).

Table 5.13 Life table of *Gomphandra coriaeea*

Alt	loc	h50	hg50	d10	d20	d30	d40	n*
1850		496	93	36	32	24	4	685
1950		6572	31	..	..	..	..	6603
1950	NT	124	31	32	28	16	..	231
2100		..	..	4	..	..	..	4
Total		7192	155	72	60	40	4	7523

5.33.9 *Hydnoearpus alpina:* The species was present in only two of the semi-permanent plots; only in one plot all the life stages were represented. A slightly excess accumulation of individuals in the sapling stage, compared to the neighbouring classes is observed (Table 5.14).

Table 5.14 Life table of *Hydnocarpus alpina*

Alt	loc	h50	hg50	d10	d20	d30	d40	d50	d60	n*
1850		558	516	148	16	56	52	4	12	1366
1950		..	4	8	4	4				20
Total		558	520	156	20	60	52	4	12	1386

n* total population

5.33.10 *Ilex denticulata:* The joint population structure of the species by pooling of the data for the three plots in which the species was found represented had a stable structure (Table 5.15).

Table 5.15 Life table of *Ilex denticulafa*

Alt	loc	h50	hg50	d10	d20	d30	d40	d50	d60	n*
1850		124	101	8	..	..	..	..	..	233
1950		31	..	4	4	..	4	..	..	43
2100		465	31	20	36	12	16	..	4	588
Total		620	132	32	40	12	20	..	4	864

5.33.11 ***Isonandra candolleana:*** A species with a stable population structure with representation in all the life stages, encountered in all the four sample plots (Table 5.16).

Table 5.16 Life table of *Isonandra candolleana* (Species of medium constancy hut, established regeneration not fairly represented).

Alt	loc	h50	hg50	d10	d20	d30	d40	d50	d60	n*
1850		31	..	..	8	40	24	8	12	123
1950		62	31	..	4	12	8	12	4	137
1950	NT	403	62	16	4	12	4	16	..	517
2100		..	..	8	..	..	..	..	..	8
Total		496	93	24	16	64	36	36	16	785

5.33.12 ***Lasianthus acuminatus:*** The species as encountered in all the four plots was most represented in the sapling stage with a few individuals in the pole stage. The species is an underwood, and therefore do not grow beyond 30 cm dbh; only in one plot the species was found represented in unestablished and established seedling stages; however, this indicates that the species is capable of regenerating (Table 5.17).

Table 5.17 Life table of *Lasianthus acuminatus*

Alt	loc	h50	hg50	d10	d20	n*
1850		..	..	2804	4	2808
1950		..	..	2040	12	2052
1950	NT	..	..	1900	8	1908
2100		2015	283	180	..	2478
Total		2015	283	6924	24	9246

5.33.13 Ligustrum perrottetii: Out of the three plots in which the species was encountered only in one, the species was represented in most of the life stages; absence of representation in many life stages in the other plots may be because of the sparse distribution pattern of the species (Table 5.18).

Table 5.18 Life table of *Ligustrum perrottetii*

Alt	loc	h50	hg50	d10	d20	d30	d40	d50	d60	n*
1950		..	4	..	4	..	..	..	..	8
1950	NT		..	4	..	..	..	..	..	4
2100		1023	..	144	32	12	4	..	4	1219
Total		1023	4	148	36	12	4	..	4	1231

n* - total population

5.33.14 ***Litsea ligustrina:*** This species recorded in two out of the four semi-permanent plots had fair representation in most of the life stages; the tree hardly attains a dbh over 40 cm, and hence larger trees were not represented (Table 5.19).

Table 5.20 Life table of *Litsea ligustrina*

Alt	loc	h50	hg50	d10	d20	d30	n*
1950	NT			12			12
2100		217	186	44	36	8	491
Total		217	186	56	36	8	503

n* - total population

5.33.15 *Litsea* sp.: Only in one sample plot the specie was found represented in most of the life stages (Table 5.20).

Table 5.20 Life table of *Litsea* sp.

Alt	loc	h50	hg50	d10	d20	d30	d40	d50	d60	n*
1850		279	272	160	16	4	8	4	..	743
1950		217	334	68	8	4	4	4	8	647
1950	NT	124	31	..	..	..	..	..	..	155
2100		403	155	20	..	..	..	..	..	578
Total		1023	792	248	24	8	12	8	8	2123

n* - total population

5.33.16 *Mastixia arborea:* Encountered in three sample plots; all life stages are amply represented except that, in one of the plots, the samplings (1-10 cm dbh) were in excessive number (Table 5.21).

Table 5.21 Life table of *Mastixia arborea* (Species of medium constancy and all life stages fairly well represented)

Alt	loc	h50	hg50	d10	d20	d30	d40	d50	d60	n*
1850		1860	662	540	12	4	..	..	..	3082
1950		868	171	80	4	..	..	4	4	1143
1950	NT	..	70	116	40	24	4	12	..	266
Total		2728	903	736	56	28	4	16	4	4491

5.33.17 *Persea macrantha:* Species encountered in only three sample plots in the elevational belt 1850-1,950 m > asl; plants are represented in all life stages; in one of the plots there was an excessive exaggregation of unestablished seedlings (4,433 seedlings ha-1"perhaps this is due to dispersal of seeds by birds, which accumulate near the roosting trees (Table 5.22)

Table 5.22 Life table of *Persea macrantha* (Species with a high constancy 75%) but, established regeneration not fairly represented)

Alt	loc	h50	hg50	d10	d20	d30	d40	d50	d60	n*
1850		4433	128	8	..	8	..	12	4	4591
1950		155	12	8	8	4	8	..	..	195
1950	NT	..	31	4	..	..	4	4	8	51
Total		4588	171	20	8	12	12	16	12	4837

5.33.18 ***Pygeum gardneri:*** The species was found represented in most life stages only in one of the two plots, where a higher frequency was recorded in the sapling stage (Table 5.23).

Table 5.23 Life table of *Pygeum gardneri*

Alt	loc	h50	hg50	d10	d20	d30	d40	d50	n*
1950		..	..	..	..	..	4	..	4
1950	NT	..	39	100	8	4	..	8	159
Total		..	39	100	8	4	4	8	163

n* -total population

5.33.19 ***Rapanea wightiana:*** A species mostly occupying forest edges; different life stages were encountered in different plots; the frequency in established seedlings was less than that of unestablished seedlings and saplings (Table 5.24).

Table 5.24 Life table of *Rapanea wightiana* (Species of high constancy in permanent plots, but not in releves; established regeneration not amply represented)

Alt	loc	h50	hg50	d10	d20	d30	n*
1850		279	31	8	..	..	318
1950		..	31	4	4	..	39
1950	NT	186	..	24	..	..	210
2100		62	4	104	16	8	194
Total		527	66	140	20	8	761

5.33.20 ***Saprosma foetens:*** Species inhabiting all the four studied plots; the species was found poorly represented in the life stages, unestablished seedlings and established seedlings (Table 5.25).

Table 5.25 Life table of *Saprosma foetens*

Alt	loc	h50	hg50	d10	d20	d30	n*
1850		..	4	12	16	12	44
1950		248	4	36	24	8	320
1950	NT	..	4	32	12	..	48
2100		..	..	8	4	..	12
Total		248	12	88	56	20	424

5.33.21 ***Symplocos cochinchinensis:*** Met in all the four sample plots; the species is well represented in all life stages; the species seldom attains a diameter over 40 cm dbh (Table 5.26).

Table 5.26 Life table of *Symplocos cochinchinensis*

Alt	loc	h50	hg50	d10	d20	d30	n*
1850		465	442	8	..	..	915
1950		155	82	16	..	..	253
1950	NT	372	221	188	16	4	801
2100		93	31	304	16	4	448
Total		1085	776	516	32	8	2417

n* population

5.33.22 Species of *Syzygium:* Several species of Syzygium inhabits the shola forests. These species perhaps differ in elevational range and the upper diameter limit (dbh). Life tables of some species are given below, of which the correct identity could not be determined.

5.33.23 *Syzygium densiflorum:* The species was recorded only in tow plots >= 1950 m > asl; In the plot at 2,100 m > asl, the species was found represented in most of the life stages (Table 5.27).

Table 5.27 Life table of *Syzygium densiflorum*

Alt	loc	h50	hg50	d10	d20	d30	d40	d50	d60	n*
1950	NT	..	..	..	..	..	..	4	..	12
2100		93	..	104	36	4	..	..	4	241
Total		93	..	104	36	4	..	4	4	253

5.33.24 *Syzygium* sp. **(pilla njaval):** Only in two elevational samples the species was found represented; the species was not found growing beyond 20 cm dbh; regeneration cannot be considered insufficient for the 12 individuals represented in the sapling class (Table 5.28).

Table 5.28 Life table of *Syzygium* SP. [pilla niaval]

Alt	loc	h50	hg50	d10	n*
1850		155	31	12	206
1950	NT				
Total		155	31	12	210

5.33.25 *Syzygium* sp. **(potti njaval):** Species found inhabiting samples greater than 850 m > as1 was also fairly represented in regeneration. The species seldom grows beyond the sapling size (Table 5.29).

Table 5.29 Life table of *Syzygium* sp. **[potti njaval]**

Alt	loc	h50	hg50	d10	n*
1850		279	210	28	517
1950	NT	93	..	..	93
2100		93	62	..	155
Total		465	302	28	765

n* - total population

5.33.26 *Syzygium* sp.: A sparsely distributed species; young regeneration of the species was found satisfactory (Table 5.30).

Table 5.30 Life table of *Syzygium* sp

Alt	loc	h50	hg50	d10	d20	d30	d40	n*
1850		310	..	8	..	..	..	322
1950	NT	124	4	20	..	4	4	184
2100		248	..	..	..	..	..	248
Total		682	4	28	..	4	4	754

-total population

5.33.27 Ternstroemia japonica: All life stages of the species are encountered, hut some stages missing in each; the samples perhaps represents different stages of the regeneration cycle (Table 5.31; cf. Kimmins, 1987).

Table 5.32 Life table of *Ternstroemia japonica*

Alt	loc	h50	hg50	d10	d20	d30	d40	d50	n*
1850		..	..	..	..	..	..	4	8
1950	NT	..	62	12	..	8	..	..	82
2100		31	31	..	..	..	..	..	62
Total		31	93	12	..	8	..	4	152

n* - total population

5.33.28 *Viburnum coriaceum:* Only in two plots the species was encountered; in one plot the population structure was a sable one matching the reverse J-curve; in the other, the species was represented by unestablished seedling alone (Table 5.32).

Table 5.32 Life table of *Viburnum coriaceum*

Alt	loc	h50	hg50	d10	
1850		403	376	4	783
1950	NT	31			31
Total		433	376	4	814

n* - total population

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