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# *Summary*

New Amarambalam reserved forest, a part of the Nilgiri Biosphere Reserve, covers an area of 265.72 km$^2$. The reserve is the abode of all the seven hill forest types of southern India, namely tropical moist deciduous, tropical semievergreen, tropical evergreen, subtropical hill forests, subtropical savannahs, montane wet temperate forests and montane wet temperate grasslands, apart from teak plantations raised within the reserve, containing indigenous arborescent flora. Analyses of different forest types in the study area for floristic, insect, bird and mammalian diversity were accomplished by laying sample plots in different vegetation types during 1997 to 2000.

Floristic analysis of the arborescent species represented in sample plots in different forest types and teak plantations resulted in the recording of 305 taxa, under 212 genera belonging to 73 families. All these taxa are enumerated family-wise with up-to-date nomenclature, diagnostic description and distribution pattern for each species, highlighting endemics among them. The most dominant family represented in the area is Euphorbiaceae (33 species), followed by Lauraceae (18 species) and Rubiaceae (17 species). The dominant genera in the area are *Litsea* (7 species), *Elaeocarpus* (5 species) and *Symplocos*, *Diospyros*, *Cinnamomum* and *Dalbergia*, each containing four species. Almost 32 per cent of the arborescent flora of the area is composed of endemic species of Peninsular India, and many of them are either restricted in their distribution to southern Western Ghats or the Western Ghats of Kerala. The study could also locate few taxa either reported in literature as endangered or extinct.

Structural data generated on the arborescent flora of the area were analyzed vegetation-wise and the number of species represented in various plots in each forest type, number of individuals per hectare, basal area, diversity index, dominance index, richness index and evenness index were calculated. The diversity analysis showed that arborescent species of tropical semievergreen forests have highest diversity index (H') value of 3.89, which is followed by subtropical hill forests (3.58), tropical evergreen forests (3.45), montane wet temperate forests (3.15) and tropical moist deciduous forests (3.07). The diversity value of the arborescent flora is the lowest (2.57) for subtropical savannahs. These values were also compared with identical forest types represented in other areas of Kerala, analyzed earlier. Such a comparison had shown that the flora of New Amarambalam is more diverse than all other areas so far studied in the State, except for Silent Valley, where the vegetation is more diverse than that of New Amarambalam. It is concluded that this floristically rich and comparatively less disturbed area should be more effectively protected as a unique part of the Nilgiri Biosphere Reserve.

Altogether 860 species of insects were recorded during this study from New Amarambalam. Of these, 535 species belonging to 14 orders and 83 families were collected from representative sample plots laid out in different forest types at various altitudes in order to study the insect community parameters. Maximum number of insects and species were

recorded from the semi-evergreen and evergreen forests. With regard to species diversity, the evergreen forest recorded the highest value (4.51) followed by semi evergreen (4.35), moist deciduous (4.21) and sub tropical hill forest (4.30). The montane sholas recorded the lowest value (3.48). The dominant insect groups, with regard to the number of individuals, were Lepidoptera (29.82%) and Coleoptera (20.47%) followed by Trichoptera, Diptera and Hymenoptera. Species richness and diversity of Lepidoptera was greatest in the evergreen forests, followed by semi evergreen, sub tropical, moist deciduous and shola forests. With regard to Coleoptera also, the trend was more or less the same except that the number of species recorded from the subtropical forest was less compared to that of the moist deciduous forest.

The insect fauna also contained a high proportion of rare and endemic species. Among butterflies, of the 133 species recorded, 28 species were found to be of high conservation status being either endemic/protected species. The evergreen forest had the maximum number of endemic/protected species (20) followed by semi evergreen forest (15 spp.), moist deciduous forest (7 spp.), sub tropical hill forest (7 spp.) and montane shola forest (5 spp.). There were also a number of rare species having great aesthetic value like the cicadas *Cryptotympana varicolor* and *Platypleura insignis*; the stag beetle *Odontolabis cuvera* and the colourful saturnids *Actias selene* and *Loepa sikkima*. On the whole, the fauna of New Amarambalam reserve forest is rich, varied and containing a high proportion of rare and endemic forms having close similarity with the Malaysian elements.

A total of 2293 birds were seen and altogether 100 taxa of birds were recorded from the whole region. Nilgiri House Swallow (*Hirundo tahitica domicola*), Bluewinged Parakeet (*Psittacula columboides*), and Yellowbrowed Bulbul (*Hypsipetes indicus*) were the most common and dominant species in the evergreen forest where as Roseringed Parakeet (*Psittacula krameri*), Jungle Myna (*Acridotheres fuscus*), and Common Babbler (*Turdoides caudatus*) were the most common and the dominant species in the moist deciduous forest. Species richness was highest in winter months and lowest in May and June. Highest number of birds was recorded in January, February and March. Shannon-Weiner diversity Index showed high value (3.73) which is comparable with other tropical forests of the Western Ghats. Slightly higher bird diversity was recorded in the moist deciduous forests (3.70) than the evergreen forests (3.15). Species richness indices were also higher in moist deciduous forests (R1=11.23) than the evergreen forest (R1=9.88). Highest density of birds was recorded in the moist deciduous forests (775 birds/km$^2$), followed by Shola (402 birds/km$^2$) and the evergreen forests (400 birds/km$^2$). Only 10 migratory species were confirmed from the area, namely Rufoustailed Flycatcher, Paradise Flycatcher, Great Reed Warbler, Tickell's Leaf Warbler, Plain Leaf Warbler, Greenish Leaf Warbler, Blue Rock Thrush, Forest Wagtail, Yellow Wagtail and Grey Wagtail. Maximum number of species (44) were from insectivorous feeding guild. Presence of eight endemic and threatened species of birds of the Western Ghats shows the conservation value of the forest area.

Twenty-six large sized mammals were recorded from transect survey in different forest types of the area. The mammalian fauna in the study area belonged to seven orders, namely Artiodactyla, Carnivora, Primates, Rodentia, Proboscidea, Pholidota, and Lagomorpha. These represent 16 mammalian families. Order Carnivora had eight species, followed by Artiodactyla with seven species and Rodentia with four species. Proboscidea, Pholidota and Lagomorpha had single species each. The primates observed are the endangered lion-tailed macaque (*Macaca silenus*), Nilgiri langur (*Trachypithecus johnii*), Bonnet macaque (*Macaca radiata*) and Hanuman langur (*Semnopithecus entellus*). Nine troops of Lion-tailed macaques with 172 individuals were estimated in this study. The locations of sightings were mostly in the middle elevation evergreen forests. The troop number varied from 12 to 27 individuals. Bonnet macaque was sighted in moist deciduous forests, teak plantations, semi-evergreen and low elevation evergreen forests. Nilgiri langur was observed in moist deciduous forests, semievergreen and evergreen forests of low, middle and high altitude areas of the reserve. The total number of individuals sighted in 26 Nilgiri langur troops were 208. The troop number varied from three to 15 individuals. Hanuman langur was observed in the moist deciduous forests and teak plantations in the low elevation areas. Malabar giant squirrel (*Ratufa indica*) was common to all wooded areas except teak plantations and Palm squirrels were found throughout the reserve.

Herbivorous mammals were seen more frequently in the lower portions of the reserve in the moist deciduous and plantation areas. Spotted deer was found in the lower portion of the reserve, around 300 m latitude. However, sambar deer was distributed throughout the reserve, even though their number was low in the evergreen forests. Elephants were sighted nine times with a total of 53 individuals and indirect evidences of elephants were seen in almost all the vegetation types. Gaur was sighted only once even though indirect evidences indicated that these frequent the moist deciduous and evergreen areas. Wild boar was rather confined to the lower altitudes of the reserve.

The upper reaches of New Amarambalam, bordering the Mukurthi National Park which slopes to Kerala side along the crestline, is the habitat where the endemic Nilgiri Tahr is present in the reserve. Two direct sightings of the Nilgiri Tahr with a total of 20 individuals and five indirect evidences were also recorded within the New Amarambalam reserve. Among the carnivores, tiger was not sighted in the reserve but indirect evidences were recorded on eight occasions. Leopard was sighted twice, once with two individuals together. Direct sighting of Sloth bear was only once but indirect evidences were observed on 10 occasions. A pack of wild dog was sighted with three individuals and two indirect evidences were also observed. New Amarambalam could be more rich in mammalian species than reported here, as the present survey was based on limited sample transects and the least known groups like bats and rodents were not surveyed.

Spatial depiction of sampling patterns of different components of the study is provided along with integrated information on the total biodiversity of the area. This will help to chalk

out programmes to conserve the total biodiversity of New Amarambalam by a systems approach, rather than plant or animal component, taken separately.

It is noted that anthropogenic disturbance in the area is at the risk of the plant and animal diversity. This area holds rich populations of the three endemic large mammalian species of the Western Ghats, namely Lion-tailed macaque (*Macaca silenus*), Nilgiri langur (*Trachypithecus johnii*) and Nilgiri tahr (*Hemitragus hylocrius*), apart from several endemic species of arborescent plants, insects and birds. The area is also of high conservation value as it is part of a viable habitat of Asian elephant, tiger, panther, sloth bear and gaur, which are Schedule I species of the Indian Wildlife (Protection) Act, 1972. Also, the continuity of New Amarambalam forests with Nilambur North Forest Division and Mukurthi National Park makes it a potential conservation area. Considering all these, the New Amarambalam reserve, forest may be declared as a Wildlife Sanctuary as a prelude to making it a National Park in future for better conservation of the biodiversity of the area.

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## Chapter 1

# General introduction

Biodiversity and its conservation is the central theme in modern management of natural forests. Forest ecosystems comprising of plants, animals and micro-organisms of varied species in a unique physical environment have developed over a period of time, influenced by climatic, topographic, edaphic and biotic factors. The tropical forests exhibit great deal of diversity in architecture and species composition of plants and animals. The high degree of diversity is possibly one of the major conditions for the sustained functioning of the ecosystem. The humid tropical environment permits the ecosystem to persist in spite of its fragility, because the perturbations are relatively small and restricted to small areas. There is sufficient reason to assume that any living community is related to the energy, water and nutrient regimes of the site. Therefore, floristic diversity in a community is formed or developed by the combined effects of all such factors in addition to the micro and macro environment. Likewise, animal diversity in an ecosystem is also dependent largely on the type of vegetation and flora.

Holistic studies aimed at understanding the structure and functioning of various components of the tropical forest ecosystem are rather rare. Although, much work has been done on qualitative biodiversity of Silent Valley, the core area of Nilgiri Biosphere Reserve, there is practically no detailed analysis on the plant and animal diversity of the study area, namely New Amarambalam Reserved Forests, where all the major forest types of Peninsular India are represented. In this multi-disciplinary study on the biodiversity of New Amarambalam, forming part of the core area of the Nilgiri Biosphere Reserve (NBR), an attempt has been made to analyze the diversity of the vegetation and flora along with faunistic analysis on the variety and populations of dominant animal groups like insects, birds and mammals. Similarly, there is no documentation available on the insect diversity of the Reserve except for an enumeration of the butterflies of the Nilgiri Biosphere region by Larsen (1987, 1988), which also does not exhaustively cover New Amarambalam. The study on insects of the adjacent Silent Valley region had shown that the forests of the region are rich in insect fauna with their close relatives only in the Malesian and African regions (Mathew, 1990). With regard to other animals also Western Ghats is well known for its diversity and endemism and according to Swengel (1992), the fauna

represent almost one percent of the total animal species of the world. To understand the uniqueness of the floral and faunal diversity, details on the historical background of the Reserve, its edaphic and climatic conditions and tribal populations inhibiting the area are also highlighted.

### 1.1. The study area - location and physiography

New Amarambalam Reserved Forest is situated in the Western Ghats biogeographic region of Peninsular India, in Malappuram District of Kerala State (Fig. 1.1). It covers an area of 265.57 $km^2$ and is located between 11° 14' and 11° 24' N latitude and between 76° 11'and 76° 33' E longitude. The reserved forest is situated North-West of Silent Valley National Park forming a contiguous forest belt in the Kerala part of the Nilgiri Biosphere Reserve. The altitude of the area ranges from 40 to 2554 m above msl (Fig.1.2). The Mukurthi National Park of Tamil Nadu State borders New Amarambalam Reserved Forest in the East. Vazhikadavu Range of

**Fig. 1.3. A view of Mukurthi peak from New Amarambalam side**

Nilambur North Forest Division borders its northern and western sides and the Kalikavu Forest Range of Nilambur South Forest Division borders the South (Fig.1.1). Mukurthi is the highest peak (2554 m), which lies at the interstate border between Tamil Nadu and Kerala [Fig. 1.3]. By virtue of its geographic location, New Amarambalam reserved forest occupy the western slope of Nilgiri plateau. The upper reaches of this reserve form part of the core area of the Nilgiri Biosphere Reserve along with Silent Valley National Park.

### 1.2. Historical background

The New Amarambalam forests were purchased from the private ownership of Edavana Kovilagam in a public auction and was taken into possession of the Government in 1888. The deciduous forests in the lower portion probably suffered from fire. During the private ownership period, extraction of trees such as teak and rosewood were carried out from the fringes of the forest area, even though extensive felling was not possible at that time due to the remoteness of the locality. Exploitation of timber started during 1930-31 when an abandoned cart track from Kanhirakadavu at the foothill was reopened and a serambi was built at Meenmutti during 1931-32. The objective of Browne's Working Plan prescription for the reserved forest from 1937-38 to 1947-48 was conservation of New Amarambalam Reserve for protecting the catchment of the watercourses to prevent soil erosion and land slides. The Working Plan prescribed three working circles, consisting of 18,425 acres (7370 ha) of the less accessible portions of New Amarambalam. The species regeneration was mainly natural, even though artificial regeneration with valuable species were also tried in the gaps. In the forest area, the right of collection of minor forest produces had been leased out at intervals - including that of cane. Bamboo had been extracted from more accessible areas. The leasing of the right to collect dammar from *Canarium strictum* trees and the felling of *Hopea* and *Mesua* trees for railway sleepers paved way for disturbances to the forest tract. Attempt was made to introduce *Hopea parviflora, Artocarpus hirsuta,* etc. with negligible success rate. The area had limited access except for a forest road that traversed from Nedumgayam to Meenmutti, which is covering a stretch of about 16 km (Fig. 1.1). There were no bridges along the river Karimpuzha, and later, to facilitate timber transport, a bridge was built at Nedumgayam by Dawson, the then forest engineer. The lower portion of New Amarambalam was also partly converted into teak plantations.

In 1986, when the Nilgiri Biosphere Reserve was established, the qualifying criterion was to declare it as a benchmark area in the Western Ghat Biogeographic Region for preservation (Nair, 1988). The first area to be declared as a Biosphere Reserve in India was Nilgiri, which also included the New Amarambalam Reserved Forests. This RF is about 5 per cent of the total area of the Nilgiri Biosphere Reserve and 18 per cent of the Kerala State's share of the area designated under the Biosphere Reserve. The natural vegetation of New Amarambalam is mainly constituted by moist deciduous, semievergreen, evergreen, subtropical hill forests, subtropical savannahs, montane wet temperate forests and montane grasslands depending on altitudinal zonation, i.e., from the lower portion to the crestline of the

Ghats. There are also plantations of teak in the outer fringes of moist deciduous forests established in patches, along the sides of forest roads and paths. Out of the total 265.57 $km^2$ area of the New Amarambalam RF, about 9.8 per cent is occupied by teak plantations and the remaining area is covered by natural forests.

### 1.3. Environment and biodiversity

*1.3.1. Geology and soil*

The study area forms part of the Precambrian Shield of peninsular India consisting dominantly of Archaean granulites and its retrograded equivalents, *viz.* hornblende gneiss and the biotite gneiss (Thampi *et al.*, 1983]. The area forms the hinge portion of the regional closure of trend lines within the southern Peninsula. Other rock types observed during the course of surveys by Geological Survey of India are amphibolite, metapyroxonite, magnetite-quartzite, carbonatite and a number of dolerite and gabbroic dykes. The pyroxene granulite represents granulite facies metamorphic rocks, which remigmatised to give rise to charnokite. Hypersthene present in charnokite is inherited from pyroxene granulites. This association is at different stages of retrogression and migmatisation giving rise to hornblende and biotite gneisses. Amphibolite/ metapyroxenite occur as palacosomes in biotite gneiss and charnokite (Thampi *et al.*, 1983).

The North-western part of New Amarmbalam RF comprises dominantly hornblende gneisses which grade into pyroxene granulite/charnokite assemblages further South-East. Geological Survey of India, based on the interpretation of the aerial photographs of New Amarambalam area, has reported that major lineaments in the region may be fracture controlled. In the New Amarambalam area, the main fracture trends are NNW-SSE, NE-SW and NW-SE. In the southern portions of New Amarmbalam are the heavice collected from Karimpuzha, which along with its tributaries show dominance of garnet over opaque (ilmenite and magnetite). Among the garnets, the pale pink variety dominates over the bright red. Monazite becomes appreciably more in northern part of the Reserve.

*1.3.2. Climate*

The southern Western Ghats, where New Amarambalam is located, is within the humid tropical climatic zone. However, there is considerable variation among the different areas within the zone, depending on location, topography, altitude, and so on. From the plains in the foothills of the Ghat, this change is quite noticeable. In Nilambur plains, located in the foothills of New Amarambalam, the temperature often raises to about 45 $^0$C during the summer season, whereas, in the Ghat

portion between 500 and 1000 m elevation the annual average temperature remains around 23 $^0$C and the monthly temperature values in the whole area vary hardly by 3 to 6 $^0$C. This inverse relationship of temperature with the altitude is a striking feature of the area. However, due to the in accessibility of the area, there are no installations there to monitor the exact climatic parameters and available details on rainfall is provided here.

*1.3.3. Rainfall*

The annual rainfall distribution pattern of Nilgiri Biosphere Reserve has been documented by the French Institute, Pondicherry. According to the published record, the western escarpment of the Western Ghats that includes the New Amarambalam area receives more than 4000 mm annual rainfall. It is one of the localities in the whole of Western Ghats, receiving the maximum precipitation, distributed in two monsoon periods of the year, similar to Wayanad, Sholayar, Idukki and Kulathupuzha areas of the State.

*1.3.4. Drainage*

New Amarambalam reserved forest is situated in the upper reaches of Karimpuzha catchment draining to the Chaliyar river basin. The river basin is about 2923 km$^2$, of which about 2535 km$^2$ is in Kerala State and the remaining 388 km$^2$ is in Tamil Nadu State. This river basin, one among the 44 river basins in Kerala, covers 6.7 per cent of the total area of Kerala river basins (CWRDM, 1995). It is also one among the 41 West-flowing rivers in Kerala. The Chaliyar river originates at Ilambalari in Tamil Nadu, at an elevation of 2066 meters. The length of the main stream is almost 169 kilometers. The main tributaries are Karimpuzha, Cherupuzha, Kanjirapuzha, Kurumbanpuzha, Vadapurampuzha and Iruthillypuzha (CWRDM, 1995). The major stream systems draining the New Amarambalam area is that of Cherupuzha and its tributaries, the Karimpuzha and its tributaries and the Punnapuzha and its tributaries (Figs. 1.4,1.5). The major tributaries of this system have a NW-SE or NE-SW course with straight stream courses indicating fractures in these directions. All the streams show active erosion and are confined to the steep narrow 'V'-shaped valleys. Huge boulders are seen throughout the course of the stream within the area. Magnificent water falls like the one having a fall of about 175 m in the tributary of the Olikkathode are common along the downward course of the streams, mostly originating from the edge of the Nilgiri plateau. The West-flowing Karimpuzha river [Fig. 1.6] and its tributaries such as Talipuzha, Panapuzha, Manjakallanthodu and Arikayamthodu are some of the major tributaries draining

into the river Chaliar. Numerous cascades are common along the course of the Karimpuzha, Arikkayam puzha, Majakallan puzha and Chinnathalipuzha.

The northern boundary of Silent Valley, formed of Sispara-Koyilpara-Thekkekota Mala ridge, is also the southern boundary of Kottapuzha Valley. The valley is a 3 km wide and 10 km long watershed opening into the Malappuram District, near Chokkad, and extending deep into the Niligiri South-western edge, coming in between New Amarambalam reserve in the north and Silent Valley Reserve in the South. The head of the Kottapuzha valley with an elevation of hardly 1000 m asl, abruptly rises upto 2400 m, with in less than 2 km distance. A spur hill from the Nilgiri edge starting from Nadukani Mala (2429 m) falls steeply to the West, separating the Kottapuzha watershed from the northern Cherupuzha watershed. Kottapuzha joins the Kuthirapuzha, a tributary of Chaliyar river. North of Kottapuzha is an extensive valley formed of the western Nilgiri edges and the South-eastern face of the Wyanad plateau by Chaliyar and its tributaries. The forest tract

**Fig. 1.6. A view of Karimpuzha river at Kanjirakkadavu**

from Pandiar-Punnapuzha in the North to Cherupuzha in the South is treated as the Karimpuzha valley, which constitutes the eastern portion of Chaliyar basin. It is essentially a series of sharp ridges running down from the Nilgiri edges, starting from an elevation of about 2300 m and descending to the Nilambur plains, less than 100 m above msl. These ridges radiate out in the South, either West or in the North-West directions and vary in length from about 5 km to less than 12 kilometers.

The Karimpuzha valley extends about 20 km deep into the Nilgiri flank and the right bank valleys opening into it are from the North-East to South-West, while the left bank valleys are oriented South-East to North-East. The upper reaches of the hills above 1500 m are clothed by evergreen forests, which at the crest line or above 1800 m become the Southern montane wet temperate forests, otherwise called the shola forests with extensive grasslands in between patches of tree formations, restricted to the sheltered hill folds and valleys. The shola forests of New Amarambalam are extensions of the forest type characteristic to the Nilgiris of South India and are exceptionally rich in biological diversity and endemic species (Nair *et al.*, 2001).

Between New Amarambalam and Silent Valley, lies the catchment of Palkachipuzha, which also drains into the down stream of Chaliar River flowing through Nilambur. The entire eastern portion of the reserve forms a crestline portion which slopes down to the Karimpuzha basin. Chinna Talipuzha is the major tributary of Chaliar, which flows from the North draining the northern areas, before it joins with Talipuzha and later with the Karimpuzha. Other major tributaries such as Manjakallanthodu, which drains the South-eastern portion of New Amarambalam forests, join the Karimpuzha and Panapuzha, which drains the southern portion of New Amarambalam reserve. All the tributaries of Karimpuzha are perennial in character and with copious water flow even in the non-rainy season.

*1.3.5. Tribal population*

The evergreen and semievergreen forests, virtually undisturbed, are the well known habitats of Cholanaikans and their near relative group called Pathinaikans [Fig. 1.7]. They are least modified, hunter-gatherer, nomadic community of tribals in the Indian subcontinent, numbering to less than 150. They stay in caves and engage in non-timber forest products collection, including canes and bamboos. They sell the forest produces to the tribal society at Mancheri and purchase rice and other commodities from there. Some of them also engage as lobourers or watchers of the Forest Department. An effort to rehabilitate the tribal population of the reserve at Mancheri was not successful and they are now living within the reserve, especially along the riverbanks.

*1.3.6. Vegetation, flora and fauna*

New Amarambalam forms part of the core area of Nilgiri Biosphere Reserve and so far no detailed study has been conducted on the vegetation diversity and floristic

richness and diversity of this most important undisturbed region of the Biosphere Reserve. This area, difficult to access, is still in a pristine condition, where biological

**Fig. 1.7. Tribals in the forests of New Amarambalam**

processes take place unabated. In fact, district floras like that of Malappuram (Babu, 1990) and Nilambur Forest Division (Sivarajan and Mathew, 1997) almost

**Fig. 1.8. A view of the forests of New Amarambalam**

excluded this area in their floristic surveys. Therefore, first hand information on vegetation types, their floristic composition and structural diversity aspects, much relevant to the management and conservation of the plant diversity of any area, is

generated by the study. Floristic information also assumes much importance in the case of protected areas like New Amarambalam, where not only plants but also the dependant animal diversity has also to be preserved.

The natural vegetation of New Amarambalam Reserve is mainly composed of tropical moist deciduous, tropical semievergreen, tropical evergreen, subtropical hill forests, subtropical savannahs, montane wet temperate forests and montane wet temperate grasslands, distributed along the altitudinal gradient, rising from40 m to 2554 metres above msl [Fig. 1.8]. There are also plantations of teak along the outer fringes of moist deciduous forests, mostly planted in patches, depending on the availability and suitability of the area. The study area is ecologically much diverse and floristically very rich with several rare and endangered plant species growing there.

Due to the diverse vegetation structure represented in the area, animal populations are also quite varied there. In the past, certain details have been generated on the insect species of Nilgiri Biosphere Reserve and the faunal content of selected groups in Silent Valley National Park. However, no such documentation in detail is available for New Amarambalam area of the Biosphere, especially from the faunal diversity point of view, in relation to the vegetation diversity of the area. As no logging operation had taken place in the past in the upper part of the reserve and there is least disturbance caused to the natural forests there, the animal population of the reserve is in a more or less pristine condition, worth analyzing and documenting in the context of evolving better strategies for its conservation oriented management.

### 1.4. Objectives

*1.4.1. Floristic diversity*

Floristic inventory with emphasis on tree species

Species and community diversity

*1.4.2. Insect diversity*

Inventory and diversity of selected insect groups i.e., Lepidoptera and Coleoptera

*1.4.3. Bird and mammalian diversity*

Inventory and diversity of birds and mammals in the reserve.

*1.4.4. Integration of floristic, insect, bird and mammalian diversity data using GIS.*

### 1.5. Presentation of results

Methodology and results pertaining to each objective are given separately in various chapters. There is also a chapter on integration using GIS data obtained from various sources like toposheets, forest working plans and other records, several study reports, etc. apart from the details generated and presented under various components of the study. Thematic maps were generated using Mapinfo GIS Software for different components of the study and also for the synthesis and conclusion parts.

#### 1.5.1. Vegetation and floristic diversity

The structural diversity of arborescent angiosperms represented in 287 sample plots laid in different vegetation types, represented in the study area, are given. This is followed by the enumeration of all the woody elements of the flora, for which structural data have been gathered and interpreted. Endemic, rare and endangered taxa of arborescent angiosperms located in the study area are also highlighted, apart from comparison of the floristic richness of different forest types with that of identical forest areas represented in other parts of Kerala State.

#### 1.5.2. Insect diversity

Details on 535 species of insects recorded from representative sample plots laid in different forest types in the area are given. Different diversity indices were also worked out for the faunal component with details on endemism of butterflies, moths and other insects, along with the characteristics of major insect groups in the area and their habitat preferences. Results on forest type-wise analysis of insect diversity, richness and evenness of lepidoptera and coleoptra species, habitat associations, population trends and insect-plant relationships are also provided.

#### 1.5.3. Avian diversity

Results pertaining to enumeration of avian fauna, their endemism and abundance and density analysis are given. Dominance index of bird species characteristic to moist deciduous, evergreen and shola forests of the study area have also been worked out. Results generated on species diversity indices of birds, month-wise and vegetation-type-wise, and density of selected bird species are provided. Occurrence of avifauna, their abundance and density, diversity and richness and comparison with other forest areas are discussed in detail.

### 1.5.4. Mammalian diversity

The diversity of medium and large sized mammals was studied, recording a total of 27 species in the study area, occurring in different forest types. Number of sightings, total number of individuals sighted and number of indirect evidences observed are given for all the 27 species. Detailed distribution data of primates, herbivores, other mammals like the flying squirrel and carnivores in the study area, are also provided. Even though no diversity index is worked out due to lack of sufficient data, the abundance and distribution details of various species are discussed locality-wise. The anthropogenic disturbances in the natural habitats of the mammalian fauna at New Amarambalam are also highlighted.

### 1.5.5. Integration using GIS techniques

In this part, spatial depiction of sampling patterns of different components of the study are given along with integrated information related to individual components. Baseline maps were also prepared for the study area which are given in each of the component chapter. Also, available data on total biodiversity are integrated and provided in this chapter.

### 1.5.6. Synthesis and conclusions

The major findings of the study on the biodiversity of New Amarambalam, covering vegetation, flora, insect fauna, avian population and mammalian species are integrated and synthesized. An attempt is made to bring together the spatial data pertaining to the total biodiversity of the area, including those data generated earlier on different groups, like the reptile and amphibian components of the fauna, using GIS. This integrated information on various components of biodiversity will serve as a model, much useful in the management and conservation of the ecosystem of New Amarambalam reserve forming one of the most important part of Nilgiri Bosphere Reserve.

## Chapter 2

# Vegetation and floristic diversity

### 2.1. Introduction

New Amarambalam forms part of the core area of Nilgiri Biosphere Reserve and so far no detailed study has been conducted to throw light on the floristic richness and diversity of this most important component of the Biosphere Reserve. The area, difficult to access, is still in a more or less pristine condition, where biological processes are taking place unabated. In fact, district floras like that of Malappuram (Babu, 1990) and the Flora of Nilambur Forest Division (Sivarajan and Mathew, 1997) almost excluded this area in their floristic surveys. As such, first hand information on vegetation types and their floristic composition and structural diversity are aspects much relevant to the management and conservation of the plant diversity of any area. Floristic data also assumes much importance in the case of protected areas like New Amarambalam, where not only plants but also the related animal diversity has also to be preserved.

In this chapter, family-wise floristic enumeration and details of structural data gathered and analyzed are presented. The structural data generated is also compared with that of the different forest types represented in other parts of the State. Also, endemic, rare and threatened species in the study area are also highlighted.

### 2.2. Review of literature

Floristic and phytosociological studies pertaining to the vegetation and flora of the Western slopes of Nilgiri Biosphere Reserve are much related to the study on the plant diversity of New Amarambalam. In fact, already exhaustive bibliographies are available on the angiosperm flora of Kerala (Nair, 1997) and the Biosphere Reserves of India and Nilgiri is one among them which includes the New Amarambalam reserve also. During 1980, the Ministry of Environment and Forests, Government of India (Anonymous, 1980) had also published a document on the various aspects of the organization and establishment of NBR, where in New Amarambalam Reserve was classified partly as the core zone and partly the manipulation zone of the Biosphere Reserve.

Forests of Silent Valley, which is a continuation of New Amarambalam forests is floristically well explored. Publications like Manilal (1988), Vajravelu (1990), Subramanian *et al.* (1987), Subramanian and Basha (1988), Singh *et al.* (1984), Manilal *et al.* (1988) and Basha (1987) deal with the flora and vegetation of Silent Valley. Also, many new taxa, new records and endemic species were recorded from Silent Valley forests by Vajravelu *et al.* (1983), Ravindran *et al.* (1987), Nair (1986), Manilal and Kumar (1983-86) and Bhargavan and Mohanan (1982). There are also several popular and review articles on Silent Valley flora published in the context of the hydroelectric project proposed in the area, like Ramakrishnan (1984), Nair *et al.* (1980) and Manilal (1981).

Manilal (1988) and Basha (1987, 1992) also conducted phytosociological studies on the vegetation of Silent Valley. Basha (1987, 1992) and Basha *et al.* (1992) had dealt with various forest types, physiognomy, vegetation diversity and altitudinal distribution of various plant species occurring in Silent Valley and also prepared the biological spectrum of the area. Manilal (1988) attempted to arrive at the importance value index (IVI) of plant species in two forest areas - one inside Silent Valley National Park and the other outside the National Park and concluded that the maximum diverse plant group in the Silent Valley area is the tree component of the vegetation, as compared to shrubs, herbs, saplings and seedlings.

Natural regeneration aspect of 12 important tree species of Silent Valley was studied by Manilal *et al.* (1989) - an aspect not dealt with in the present study. Also, the floristic diversity and human impact on the evergreen forests of Western Ghats of Peninsular India was studied by Parthasarathy *et al.* (1992). Chandrashekara and Ramakrishnan (1994) analyzed the vegetation and gap dynamics of Nelliampathy forests of Palghat District in Kerala. Ganesh *et al.* (1996) conducted a detailed analysis of the species richness and diversity of the evergreen forests at Mundanthurai Tiger Reserve. Utkarsh, *et al.* (1998) described the patterns of tree diversity in the Western Ghats of India and species richness, tree density and basal area, and species recruitment details in the evergreen and moist deciduous forests areas of Uttara Kannada District of the Western Ghats in South India were studied by Bhat *et al.* (2000).

Certain details of floristic composition of Nilambur Forest Division is available in the Forest Working Plan of the Division (Ranganathan, 1981). Also, few plants available in New Amarambalam Reserve are included in the Flora of Malappuram prepared by Babu (1990). Recently, Sivarajan and Mathew (1997) had brought out a more exhaustive flora of Nilambur forests covering the Nilambur and Karulai Forest

Ranges and also vested forest ranges of Chungathara, Kali kavu, Punchakolli and Nilambur belonging to Nilambur Special Division. Even though, New Amarambalam forests belongs to Karulai Forest Range of Nialmbur Division, as noted from the floristic account of Sivarajan and Mathew (1997), only very few plant taxa are recorded from this difficult, but rich terrain. However, flora of Nilambur, which enumerates 1132 species of flowering plants belonging to 130 families, is the only available scientific document on the arborescent flora of the vicinity and lower areas of New Amarambalam Reserve.

## 2.3. Materials and methods

The methodologies used for vegetation studies and floristic analysis of New Amarambalam Reserved Forest are as follows.

### 2.3.1. Floristic studies

Floristic surveys were conducted concentrating on arborescent species available in the 287 sample plots of 30 m x 30 m size, laid in the different vegetation types represented in the area (Table 2.1). The locations of sample plots are given in Figure 2.1.

**Table 2.1. Details of sample plots laid in different vegetation types**

| Sl. No. | Vegetation types | Sampled area (ha) | No. of plots |
|---|---|---|---|
| 1 | Teak plantations | 2.6 | 29 |
| 2 | Southern tropical moist deciduous forests | 4 | 45 |
| 3 | West coast tropical semievergreen forests | 3.8 | 43 |
| 4 | West coast tropical evergreen forests | 8.2 | 92 |
| 5 | Southern subtropical hill forests | 6.1 | 68 |
| 6 | Southern subtropical savannahs | 0.45 | 5 |
| 7 | Southern montane wet temperate forests | 0.45 | 5 |
| 8 | Southern montane wet temperate grasslands | Not sampled | - |
| | **Total** | **25.6** | **287** |

Flowering or fruiting specimens were collected during different seasons of the year and relevant field notes were also recorded. The collected specimens were processed and herbarium specimens prepared as per the methodology given in Jain and Rao (1977). The specimens were first classified into families and subsequently identified into different genera with the help of taxonomic literature. They were further scrutinized for species identity with the help of dissected flower parts and other diagnostic features.

Subsequently, the identities were confirmed with the help of authentically identified specimens in the herbaria of the Kerala Forest Research Institute (KFRI) and Botanical Survey of India, Southern Circle, (MH). Wherever required, revisions or monographs of genera or families were also consulted before arriving at the exact identity of various species. The species names were also made up-to-date in accordance with the *International Code of Botanical Nomenclature* (1998) and are enumerated alphabetically under various families arranged according to Bentham and Hooker's (1862-1883) classification. It is for these species that diversity data were gathered and presented, classified under different forest types. All the specimens cited in this work area deposited in the herbarium of Kerala Forest Research Institute (KFRI).

**2.3.2. Plant diversity studies**

For vegetation analysis, initially available data on the vegetation types were gathered and a vegetation map of the area was prepared. Based on this, exhaustive surveys were conducted in each of the forest type represented in the area and data were generated on their locational characteristics, area-wise distribution, floristic composition, etc pertaining to the study area. Structural data were collected from 287 sample plots of 30 m x 30 m size laid in different forest types, the number of the plots laid in each type approximately representing 0.1 per cent of the total area (Table 2.1). While laying the plots, representation of the forest types and also variation in their altitudinal distribution were also considered (Fig. 2.1). As per the objectives of the study, structural data collection was restricted to arborescent species (above 10 cm gbh) which included shrubs, lianas and trees. Herbaceous plants were not accounted in the diversity evaluation.

Each of the sample plot was demarcated in the field using 4 ropes of 30 m length. Initially, all the standing trees, shrubs and lianas above 10 cm gbh were enumerated and their gbh measured at a standard height of 1.37 m from the base. Buttressed tree species were measured above the buttressed portion. Altitude and location of each plot were also recorded on the map of the area using pocket altimeter with a sensitivity of 20 m. The data gathered from various plots under each vegetation type were analyzed forest type-wise. Following are the phytosociological parameters worked out for each plot using the formulae (Phillips, 1959; Misra, 1968) given against each. Importance Value Index (IVI) of various species were also worked out as the sum of Relative density, Relative frequency and Relative dominance of each of them.

| | | |
|---|---|---|
| Density | = | Total no. of individuals / Total no. of quadrats sampled |
| % Frequency | = | No. of occurrence of each species x 100 / Total no. of quadrats |
| Basal area | = | $\frac{(gbh)^2}{4\pi}$ [ $\pi$ = 3.14 ] |
| Relative density | = | Density of each species x 100 / Total density of all species |
| Relative frequency | = | Frequency of each species x 100 / Total frequency of all species |
| Relative dominance | = | BA of each species x 100 / Total BA of all species |

Based on the phytosociological data analyzed for the above aspects, species diversity, species dominance, species richness and species evenness were calculated using the following indices.

i. Shannon index of species diversity (Margalef, 1968)

$H' = - \sum\{(n_i/N) \log (n_i/N)\}$

ii. Simpson's index of dominance (Simpson, 1949)

$\lambda = \sum(ni\ (ni-1)\ /N\ (N-1)$

iii. Menhinick's index of species richness (1964)

$R = S/\sqrt{n}$

iv. Pielou's index of species evenness (1975)

$E = H'/\log S$

**where,**

H' = Shannon index of species diversity

$n_i$ = Number of individuals of species, i

N = Total number of species in the community

**$\lambda$ =** Index of dominance

S = Total number of species in the community

R = Richness index

E = Evenness index

## 2.4. Results

The data generated and analyzed for floristic diversity and vegetation diversity are given as three different sections. The floristic diversity part includes structural data generated for different vegetation types represented in the study area and analysis of the data for various diversity indices.

### 2.4.1. Vegetation diversity

Vegetation of the Reserved Forest, extending to a total area of 265.72 km$^2$, at an altitudinal range varying from 40 to 2554 m above msl, is represented by moist deciduous, semievergreen, evergreen, subtropical hill forests, savannahs, southern montane wet temperate forests (otherwise known as sholas) and temperate grasslands, varying in extent depending mainly on the altitudinal factor. Therefore, all the forest-types of peninsular India in the classification of Champion and Seth (1968) are represented in the study area. Substantial area belonging to the moist deciduous forests is presently under teak plantations of different age classes, often rich in natural vegetation and plant diversity, mainly depending on the age class. In Figure 2.2, the area covered by different vegetation types is graphically represented. Details on the vegetation diversity of the area are elucidated forest type-wise with notes on locational peculiarities, specific formations and overall species composition of each of the type.

#### 2.4.1.1. Southern tropical moist deciduous forests

Moist deciduous forests cover about 4000 ha in the study area, which is almost 15 per cent of the total area of New Amarambalam forests. In the reserve, the forest type is distributed mainly in the plains and along the gentle slopes of the mountainous track at Nedunkayam, Kanjirakadavu, Paduka and Mancheri (Fig. 2.3). The forest type is now in a much degraded condition. Altitudinal range within which the forest type is distributed varies from 40-400 m above msl. The height of certain tree species growing along the hilltops is often lesser than their height when they are distributed in the plains. Trees constituting a major share of the forest type are often with fluted trunk and rough bark. Most of them shed their leaves during summer season. The defoliation of trees starts by December and extends up to February. Also, most of the trees flower during December to April and their fruits ripen by during July- August. Trees attain a maximum average height of 35 m. Liana species are rather rare in the moist deciduous forests, as compared to the adjoining semievergreen forests. Many of the dominant deciduous species are also found in the open rocky areas of the ghat up to an elevation of 1100 m.

The common top canopy species in the moist deciduous forests of New Amarambalam are *Xylia xylocarpa, Terminalia paniculata, T. bellirica, T. alata, Radermachera xylocarpa, Artocarpus gomezianus, A. hirsutus, Stereospermum colais, Dalbergia latifolia, D. sissoides, Tetrameles nudiflora, Bombax ceiba, Pterocarpus marsupium, Careya arborea, Wrightia tinctoria, Tectona grandis* and *Dillenia pentagyna.* The evergreen species, which are mostly confined to the middle canopy,

include *Persea macrantha, Calophyllum polyanthum, Hydnocarpus pentandra* and *Ixora brachiata*. Among the deciduous trees, *Wrightia tinctoria, Terminalia paniculata, Gmelina arborea, Miliusa tomentosa, Pterocarpus marsupium* and *Phyllanthus emblica* are common in the rocky slopes at high elevations. As the trees are rather sparsely distributed, breakes and gaps in the canopy are quite common. Hence, indigenous herbs, shrubs and exotic weeds are quite common in this forest type.

Even though *Xylia xylocarpa, Terminalia paniculata* and *Wrightia tinctoria* are the most dominant species, *Terminalia paniculata* has wider distribution in distribution as compared to other species. Species like *Careya arborea, Terminalia alata, Hydnocarpus pentandra, Tamilnadia uliginosa* and *Lagerstroemia hirsuta* are mostly confined to areas, marshy or very wet during the rainy season. In certain locations, *Lagerstroemia microcarpa* are seen colonizing (Kanjirakadavu) or forming association with *Terminalia alata* (at Uchakulam) and *Cleistanthus collinus* (at Kanjirakadavu). The common liana species are *Calycopteris floribunda, Acacia torta, Entada rheedii, Gnetum ula, Ziziphus oenoplia* and *Z. rugosa,* which are common along the river or stream and other moist places.

**Fig. 2.3. Moist deciduous forests of Nedumkayam**

Ground floor of moist deciduous forests is rather dense, occupied by shrubs and herbs, which are more diverse and abundant in open and disturbed areas. The common shrubby species in the forest type include *Helicteres isora, Antidesma acidum, Clerodendrum viscosum, Mimosa diplotricha* and *Chromolena odorata.*

Grasses like *Panicum typhyson, Apluda mutica* and *Themeda triandra* and also other herbs such as *Sida acuta, S. alnifolia, Cleome viscosa, Cassia tora, Justicia diffusa, Parthenium hysterophorus* and *Ageratum conyzoides* are common.

In Uchakulam, Paduka and Nedunkayam, there are seasonal marshy areas and ponds, which dry up during summer, leaving cracks on the surface, due to the high clay content of the topsoil. Dominant species in such habitats are mainly grasses, sedges, marshy plants like *Drocera indica, Uricularia* sp., *Ludwigia* spp., and aquatic plants such as *Hydrilla verticillata* and *Nymphoides indicus*. In such areas the common tree species are *Thamilnadia uliginosa, Careya arborea* and *Terminalia alata.*

In the moist deciduous forests of Mancheri and Panapuzha, there is luxuriant growth of bamboos. The area is frequented by forest fire, promoted by the dry and rocky nature of the terrain. In those bamboo breakes, light loving plants like *Helicteres isora, Clerodendrum viscosum, Terminalia paniculata, Wrightia tinctoria* and *Pterocarpus marsupium* are also common along with under shrubs like *Chromolena odorata* and *Ziziphus oenoplia* and herbs like *Mimosa pudica* and *Ageratum conizoids*. The tree species *Terminalia paniculata, Wrightia tinctoria* and *Pterocarpus marsupium* found in such areas are much stunted in growth, due to poor soil depth and rocky terrain.

**2.4.1.2. Teak plantations**

Moist deciduous forests are intermingled with teak plantations of different age groups, raised by the Forest Department (Fig. 2.4). Both old and young plantations are seen at Nedunkayam, Paduka and Kanjirakadavu areas. These plantations remain leafless during February to June. Due to leaf shedding, the temperature increases in these areas making them fire prone. Forest fire affect the survival and growth of young seedlings. Natural flora in the young teak plantations (up to 25 years) is more than that of older plantations (above 25 years). The common tree species seen in teak plantations of New Amarambalam are *Terminalia paniculata, Xylia xylocarpa, Wrightia tinctoria, Cleistanthus collinus* and *Dalbergia latifolia* and shrubs like *Helicteres isora, Clerodendrum viscosum, Chromalena odorata,* and *Zizyphus oenoplia* are quite prevalent. Lianas common in the older plantations are *Calycopteris floribunda* and *Acacia torta*. The ground flora is almost similar to that of moist deciduous forests, but for the density of herbs, which is higher in teak plantations.

### 2.4.1.3. West coast tropical semievergreen forests

Semievergreen is a transitional forest type, which contains a mixture of evergreen and moist deciduous species. It is found at Panapuzha, Thalichola, Kalkulam and Irumbanchola, at elevations ranging from 400 to 650 m, or sometimes ascending up to 750 m in certain areas. The extent of the area under this forest type is approximately 3800 hectare, which is about 14 per cent of the total area. Slope of the terrain here is comparatively gentle. Trees are taller (up to 45 m) than that of the moist deciduous forests, but not as high as that of the evergreen forests. Buttressed trees are common in the semievergreen forests; lianas are quite abundant. Undergrowth is denser than that of evergreen forests but less rich as compared to that of moist deciduous areas.

**Fig. 2.4. Teak plantations of New Amarambalam**

The canopy structure of the forest is mainly of three storied. The height of top canopy trees ranges from 30 to 45 m, and is composed of *Bischofia javanica, Calophyllum polyanthum, Tetrameles nudiflora, Chrysophyllum roxburghii, Antiaris toxicaria, Artocarpus gomezianus, Dalbergia sissoides, Elaeocarpus tuberculatus, Syzygium gardneri, Pterygota alata, Terminalia paniculata, T. bellirica, Polyalthia fragrans* and *Knema attenuata.* Middle layer trees species ranging from 20 to 30 m in height consists of *Vepris bilocularis, Myristica malabarica, Miliusa tomentosa, Dimocarpus longan, Harpullia arborea, Palaquium ellipticum, Chionanthus mala-elengi, Pterospermum diversifolium, Otonephelium stipulaceum, Turpinia malabarica, Holigarna beddomei, Sterculia guttata, Croton malabaricus, Polyalthia fragrans* and *Drypetes oblongifolia.*

In the lower canopy, less tall trees like *Xanthophyllum arnottianum, Gomphandra tetrandra, Ixora brachiata, Lasianthus jackianus, Memecylon lawsonii* and *Syzygium mundagam* are common. The riverine vegetation of semievergreen zone is quite characteristic and consists of tree species such as *Madhuca neriifolia, Pongamia pinnata, Ficus tsjahela, Syzygium heyneanum, Holigarna arnottiana, Persea macrantha, Hydnocarpus pentandra* and *Vitex altissima*. Shrubaceous species like *Homonoia riparia* and *Rotula aquatica* are also quite common in the riverine forests.

Semievergreen forests are traversed by streams and streamlets of Karimpuzha river, which retains high moisture level in the soil, almost throughout the year. Along with canopy gaps, the habitat becomes very suitable for the growth of liana species. Because of this, semievergreen forests of New Amarambalam are rich in liana species. Among them *Entada rheedii, Salacia oblonga, Anamirta cocculus, Derris brevipes, Calycopteris floribunda* and *Gnetum ula* are very common. Bamboo breakes are usually seen along the fringes of semievergreen forests, composed of *Bambusa bambos, Ochlandra travancorica, O. setigera* and *Schizostachym beddomei,* often forming gregarious patches in the moist depressions and also along stream banks. Rattan species are rarely seen in the semievergreen and adjoining the evergreen forests. However, due to destructive collection of canes by tribals and labourers employed by the tribal societies, their population is very poor and mature clumps are seldom seen in the forest, especially at lower elevations where accessibility is better.

Herbs and shrubs forming the ground flora of the semievergreen forests is comparatively less dense when compared to the moist deciduous forests. The common shrubby species of the semievergreen forests of New Amarambalam are *Thottea siliquosa, Chassalia curviflora, Helicteres isora* and *Allophyllus cobbe.* Tuberous plants like *Arisaema leschnaultii, Habenaria plantagenea* and *Amorphaphallus paeoniifolius* are quite common in the ground flora. Epiphytic orchids *Pholidota pallida, Luisia zeylanica, Dendrobium ovatum, D. herbaceum* and *Cottonia peduncularis* are observed on tree trunks and rocks in this forest type at New Amarambalam.

#### 2.4.1.4. West coast tropical evergreen forests

Evergreen forests dominate the vegetation of New Amarambalam Reserved Forest covering about 31 per cent of the total area. It is found at Meenmutti, Manakadavu, Thalichola, Pullukuthimala and Irumbanchola (Fig. 2.5). The altitude of the evergreen forests ranges from 650 to 1200 m with a total extent of 8200 ha. The

slope of evergreen forests ranges from 15 to 60 per cent and the tree height is up to 50 m. Large, buttressed and long and clean boled trees are very common, especially at lower elevations; at higher elevations these trees get stunted. Lianas are common in at low elevations, whereas, at higher altitude, their population becomes poor.

**Fig. 2.5. Evergreen forests of New Amarambalam**

The canopy configuration of evergreen forests is divisible into three strata. The top canopy trees attain a height of 40-50 m and are generally with spreading canopy, assuming an umbrella shape. They are also usually long boled and unbranched at least up to two-third of their height. The common evergreen trees of the top canopy are *Calophyllum polyanthum, Palaquium ellipticum, Chrysophyllum roxburghii, Mesua ferrea, Cullenia exarillata, Elaeocarpus tuberculatus, Bischofia javanica, Artocarpus heterophyllus, A. gomezianus, Mangifera indica, Pterygota alata, Syzygium gardneri, Persea macrantha, Antiaris toxicaria* and *Ficus beddomei.*

Middle storey of evergreen forests is composed of trees ranging in height between 20-35 metres. The canopy layer is composed of *Vepris bilocularis, Actinodaphne bourdillonii, Persea macrantha, Litsea coriacea, L. stocksii, Elaeocarpus glandulosus, E. serratus, Myristica dactyloides, Garcinia morella, Turpinia malabarica, Garcinia gummi-gutta, Knema attenuata, Cinnamomum malabatrum, Dimocarpus longan, Harpullia arborea, Holigarna beddomei, H. nigra, Ficus nervosa, Syzygium cumini, Vernonia arborea, Diospyros sylvatica, D. paniculata, Drypetes elata* and *D. oblongifolia.*

The lowest tree layer of this forest type attains a height of less than 15 m height. Common species are *Xanthophyllum arnottianum, Gomphandra tetrandra, Aglaia*

*indica, Syzygium laetum, Lasianthus jackianus* and *Reinwardtiodendron anamallayanum*. Lianas are fairly common in evergreen forests especially at low elevations (i.e. up to 800 m). Woody climbers commonly found in this forest are *Derris brevipes, Sarcostigma kleinii, Quisqualis malabarica, Luvunga sarmentosa, Thumbergia mysorensis, Calamus thwaitesii* and *C. pseudotenuis*. The layer merges with the ground flora composed of shrubs and herbs. Shrubaceous flora of evergreen forest at New Amarambalam is formed of *Thottea siliquosa, Elatostemma acuminata, Begonia malabarica, Elatteria cardamomum, Schumanianthus virgatus* and *Amomum muricatum* and herbs like *Arisaema leschenaultii, Begonia fallax, Curculigo trichocarpa, Neanotis monosperma, Ophiorrhiza hirsutula* and several ferns are seen growing amidst them. Most of the species in the ground flora of evergreen forests have either fleshy or with tuberous underground stems. Epiphytes are also fairly well represented in the forest type. *Bulbophyllum neilgherrens, B. fischeri, Cymbidium aloifolium, Dendrobium ovatum, D. herbaceum, Hoya wightii* and *Fagraea zeylanica* are the common examples of the plants in the region. Also, common root parasites like *Agenetia pedunculata, A. indica* and *Balanophora fungosa* and stem parasites like *Dendrophthoe falcata,* and *Viscum angulatum* are well distributed in the forest type at New Amarambalam.

Characteristic associations of various tree species is a notable character of west coast tropical evergreen forests. Association of *Cullenia exarillata, Palaquium ellipticum* and *Mesua ferrea* is the quite common at New Amarambalam as in the case of evergreens in other areas in South India. These associations are seen at the elevation ranging from 800 to 1200 m, especially at Pullukuthi mala and Ganiyamala where, the altitude ranges from 1000 to 1100 m. Among the associated species, *Cullenia exarillata* is restricted only to west coast tropical evergreen forests whereas the other components of the association are more common in other adjoining forest types, distributed at elevations between 500 and 1600 m. There is also an overwhelming growth of *Agrostistachys borneensis* at Pullukuthimala, where the elevation of the Ghats is 900 to 1100 m, and this may be due to the suitability of the habitat, promoting the very high regeneration of the species.

#### 2.4.1.5. Southern subtropical broad leaved hill forests

This is the second dominant vegetation type in the study area distributed at Kedakamala, Ganiyamala and Irumbanchola areas. The coverage of this forest type in New Amarambalam is approximately 6100 hectare, which represents about 23 per cent of the whole Reserved Forest. Slope of the area ranges from 30 to 80 per cent, and altitude varies between 1200 to 1800 metres. The rocky terrain and

shallow soil, limits the growth of trees to a maximum of 25 m. These open areas are the abode of luxuriant growth of *Strobilanthes* species. Owing to the steep slope, occurrence of *Strobilanthes* here is ecologically very important, preventing soil erosion in the sloping terrain during rainy season. Species density and diversity of subtropical forests is quite high as compared to west coast tropical evergreen forests. Canopy stratification is not very distinct in this forest type (Fig. 2.6). The

**Fig. 2.6. Subtropical hill forests of New Amarambalam**

common tree species in the forest type are *Myristica dactyloides, Litsea stocksii, Palaquium ellipticum, Litsea wightiana, L. floribunda, Syzygium densiflorum, S. benthamianum, Syzygium lanceolatum, Neolitsea cassia, Mesua ferrea, Actinodaphne bourdillonii, Meliosma pinnata, Gordonia obtusa* and *Turpinia nepalensis.* Liana species are comparatively rare and the more common ones are *Calamus hookerianus, C. pseudotenuis* and *Derris brevipes.* Small patches of *Sinarundinaria wightiana* are also seen along the slopes in open areas. Branches of trees are covered by abundant growth of mosses and also epiphytic orchids *Bulbophyllum kaitens, Dendrobium heyneanum, Podochilus malabarica, Liparis virudiflora* and *Malaxis latifolia. Srobilanthes* spp. and herbs like *Arisaema leschenaultii, Epipogium roseum* and *Calanthe triplicata* mainly cover the ground.

In this forest type at New Amarambalam, *Mesua ferrea, Palaquium ellipticum* and *Myristica dactyloides* association is common at the elevations of 1300 to 1600 m. *Palaquium ellipticum* is also seen associated with *Myristica dactyloides* or *Mesua ferrea* separately at Ganiyamala. Another association seen in the forest type is *Litsea stocksii* and *Myristica dactyloides*, which is very common at Kedakamala and Ganiyamala at an elevation between 1400 and 1700 m.

### 2.4.1.6. Southern subtropical hill savannahs (Woodlands)

The grasslands at low elevations with scattered stunted trees (10 to 20 m high) are characteristic of southern subtropical hill savannah (Fig. 2.7). At New Amarambalam, this forest type is seen at elevations between 1000 and 1500 m and the extent of the forest is 450 ha, which is about 1.7 per cent of the total area. In fact, the vegetation is degraded due to clearing or burning or both. The forest type is distributed mainly at Erumala, Vilakumala and Pullukuthimala, in dry and rocky areas with poor soil depth. Most of the areas are burnt at frequent intervals or at least annually. Therefore, fire resistant trees are characteristic of the formation.

**Fig. 2.7. Subtropical savannahs of New Amarambalam**

The common tree species associated with these forests are *Wendlandia thyrsoidea, Glochidion neilgherrense, Elaeocarpus munronii, Pterocarpus marsupium, Phyllanthus emblica, Symplocos cochinchinensis* and *Holigarna nigra.* Shrubby species like *Gnidia glauca, Hypericum mysorense, Lobelia nicotianifolia, Phoenix humilis, Chromolena odorata* and *Arundina graminifolia* are common. Grasses dominate growing to a height of 2-3 m. The common grass species met with in this zone are *Themeda cymbaria, Chrysopogon zeylanicum, Tripogon bromoides, Arundinella ciliata.* Herbs L*eucas hirta, Plectanthus wightii, Pogostemon mottis* and *Blumea barbata* are also common in the area.

### 2.4.1.7. Southern montane wet temperate forests (Sholas)

This forest type commonly called 'sholas', is the extension of sholas in Nilgiri hills. It is mostly found below Mukuruthi peak, Neelimala and Arikkayam mala areas of the

New Amarambalam, towards the crest of the Ghats (Fig. 2.8). Usually this forests are an extension of subtropical hill forests seen as extended patches in the depressions of hillocks. This dense, stunted evergreen forest of high elevation (above 1800 m) is surrounded by rolling grasslands. Tree heights of shola patches range between 10 and 15 m and are stunted due to high wind speed, low temperature and less soil depth. Boles of the shola trees are short and thick, branches are very dense, crooked, twisted and covered with mosses, lichens and epiphytic orchids and leaves are coriaceous in nature.

**Fig. 2.8. Shola forests around Mukurthi**

Common tree species encountered in the forest type are *Turpinia nepalensis, Rhododendron arboreum* ssp. *nilagiricum, Vaccinium leschenaultii, Rhodomyrtus tomentosus, Litsea wightiana, L. floribunda, Neolitsea cassia* and *Syzygium calophyllifolium*. Liana species in the forest are *Calamus huegelianus* and *Toddalia asiatica*. Shrubby plants *Gaultheria fragrantissima, Schefflera rostrata, Stobilanthes pulniyensis, S. luridus* and *Psychotria congesta,* and herbs *Impatiens cordata, I. pusilla, Senecio lavundilaefolius, Viola pectonissifolia* and *Fragaria rosacea* constitute the ground flora. Epiphytic species *Coelogyne odoratissima, Aeridis maculosa, A. crispa* and *Seidenfadeniella rosea* are also quite common in these forests, apart from several species of mosses and lichens, almost covering the branches and branchlets of shola trees.

### 2.4.1.8.Southern montane wet temperate grasslands

Since this vegetation type is devoid of tree species and is composed of grasses intermingled with herbs and small shrubs, this forest type is excluded from tree

diversity analysis. Elevation of the area under the formation ranges between 1800 and 2554 m and the vegetation type occupies an area of 900 ha, consisting of about 3.34 per cent the total study area. During summer season, grasslands dry up. The common species in the formation are *Hedyotis bourdillonii, H. herbacea, Panicum* sp*., Anaphalis neelgherryana, Ipsea malabarica* and *Themeda cymbaria.* In marshy areas of the forests *Eriocaulon ensiformis, E. odoratum, Burmania* spp. and *Habenaria* spp. are seen.

### 2.4.2. Floristic inventory

Floristic details of 305 arborescent species recorded from 287 sample plots belonging to 212 genera under 73 families are given here. Of the 305 species, 298 taxa belong to dicotyledons, five species are monocotyledons and gymnosperms are represented by only two species. All the arborescent species recorded from New Amarambalm forests are enumerated with up to date nomenclature, phenology, ecological notes and world distribution. Details of species representation of different plant groups in each forest type are given in the Table 2.2.

**Table 2.2. Number of dicots, monocots and gymnosperms recorded from different forest types**

| Forest types | Dicots | Monocots | Gymnosperms | Total |
|---|---|---|---|---|
| Moist deciduous forests | 79 | 1 | 2 | 82 |
| Teak plantations | 27 | 1 | - | 28 |
| Semievergreen forests | 136 | 2 | 1 | 139 |
| Evergreen forests | 153 | 2 | 1 | 155 |
| Subtropical hill forests | 103 | 1 | 1 | 105 |
| Savannahs | 27 | - | - | 27 |
| Montane forests | 39 | - | - | 39 |
| **Total** | **298** | **5** | **2** | **305** |

Among the families, *Euphorbiaceae* is the largest one with 33 species, followed by *Lauraceae* (18 species), *Rubiaceae* (17 species) and *Fabaceae* (12 species). With regard to dominance of families in each forest type, *Fabaceae* and *Euphorbiaceae* represent maximum in deciduous and semievergreen forests, *Euphorbiaceae* and *Lauraceae* dominate evergreen forests and subtropical hill forests, and shola forests are dominated by the families *Lauraceae* and *Myrtaceae*. With regard to dominant genera, *Syzygium* is the most dominant genus in New Amarambalam with 11 species, followed by *Litsea* (7 species), *Elaeocarpus* (5 species) and *Symplocos,*

**Table 2.3. Dominant families and genera represented in different forest types**

| Forest types | Dominant genus * | Dominant family * | Total species |
|---|---|---|---|
| Moist deciduous forests | *Dalbergia* (4)<br>*Terminalia* (3)<br>*Lagerstroemia* (2) | Euphorbiaceae (8)<br>Rubiaceae (5)<br>Fabaceae (5) | 82 |
| Teak plantations | *Dalbergia* (2) | Euphorbiaceae (6)<br>Fabaceae (2)<br>Sterculiaceae (2) | 28 |
| Semievergreen forests | *Diospyros* (4)<br>*Elaeocarpus* (3)<br>*Syzygium* (3) | Euphorbiaceae (16)<br>Lauraceae (8)<br>Fabaceae (5) | 139 |
| Evergreen forests | *Syzygium* (7)<br>*Litsea* (5)<br>*Diospyros* (4) | Euphorbiaceae (17)<br>Lauraceae (17)<br>Myrtaceae (9) | 155 |
| Subtropical hill forests | *Litsea* (8)<br>*Syzygium* (8)<br>*Psychotria* (3) | Lauraceae (16)<br>Myrtaceae (10)<br>Rubiaceae (7) | 105 |
| Subtropical savannahs | _ | Euphorbiaceae (6)<br>Lauraceae (4)<br>Fabaceae (2) | 26 |
| Montane forests | *Litsea* (3)<br>*Syzugium* (3)<br>*Symplocos* (3) | Lauraceae (5)<br>Myrtaceae (4)<br>Syzygium (3) | 39 |

** Number of species given in parenthesis*

*Diospyros, Cinnamomum* and *Dalbergia* with four species each. Dominant families and genera represented in different forest types are given in the Table 2.3.

### 2.4.2.1. Endemism and rarity of the flora

Arborescent flora of New Amarambalam shows high degree of endemism. Of the total 305 arborescent species recorded from the 287 plots, 98 species are endemic to Western Ghats, which is about 32 per cent of the total arborescent species represented the sample plots (Table 2.4). They include those confined to Peninsular

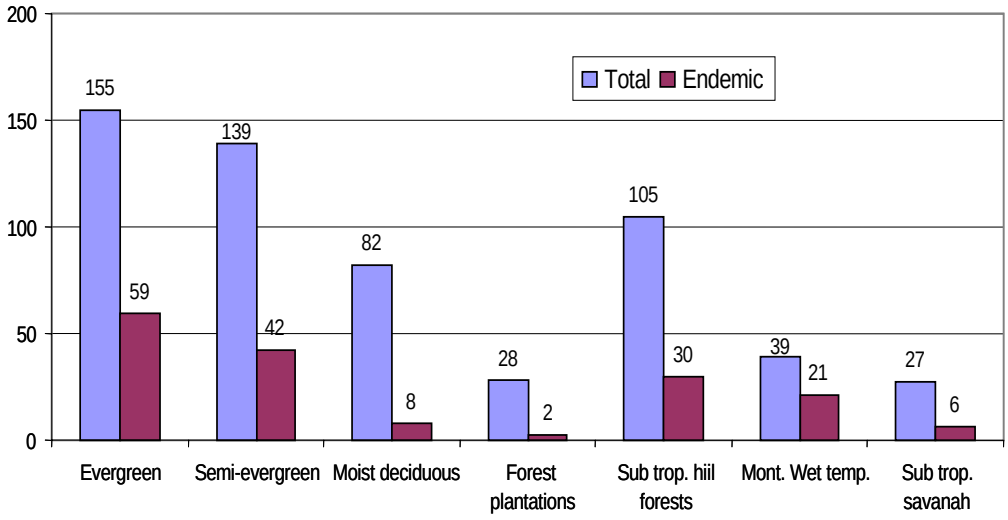


**Fig. 2.9. Total and endemic tree species in different forest types of New Amarambalam**

India (76 species), Kerala (2 species) and other parts of Western Ghats and species and other details are given in Table 2.4. Among the 98 endemic species of New Amarambalam, majority are belonging to the family Lauraceae (17 species), followed by Euphorbiaceae (10 species), Rubiaceae (6 species), Myrtaceae (5 species) and Meliaceae (4 species). The forest type-wise representation of endemic arborescent species confined to Western Ghats of India is depicted in Figure 2.9.

**Table 2.4. Endemic arborescent species of the Western Ghats represented in the study area and their distribution pattern**

| Species | Family | Western Ghats | | |
|---|---|---|---|---|
| | | Kerala | South India | Other parts |
| *Holigarna arnottiana* | Anacardaceae | | | * |
| *Holigarna beddomei* | Anacardaceae | | * | |
| *Holigarna nigra* | Anacardaceae | | * | |
| *Nothopegia recemosa* | Anacardaceae | | | * |
| *Ancistrocladus heyneanus* | Ancistrocladaceae | | * | |
| *Meiogyne pannosa* | Annonaceae | | | * |
| *Orophea erythrocarpa* | Annonaceae | | * | |
| *Orophea uniflora* | Annonaceae | | * | |
| *Polyalthia fragrans* | Annonaceae | | * | |
| *Ilex wightiana* | Aquifoliaceae | | * | |
| *Saprosma fragrans* | Araliaceae | | * | |
| *Schefflera rostrata* | Araliaceae | | * | |
| *Arenga wightii* | Arecaceae | | * | |
| *Calamus thwaitesii* | Arecaceae | | * | |
| *Pinaga dicksonii* | Arecaceae | | | * |
| *Berberis tinctoria* | Berberidaceae | | * | |
| *Radermachera xylocarpa* | Bignoniaceae | | * | |
| *Euonymous angulatus* | Celastraceae | | | * |
| *Microtropis latifolia* | Celastraceae | | * | |
| *Microtropis ramiflora* | Celastraceae | | * | |
| *Garcinia gummi-gutta* | Clusiaceae | | * | |
| *Gordonia obtusa* | Clusiaceae | | | * |
| *Quisqualis malabarica* | Combretaceae | | * | |
| *Terminalia paniculata* | Combretaceae | | * | |
| *Diospyros paniculata* | Ebenaceae | | | * |
| *Elaeocarpus munronii* | Elaeocarpaceae | | * | |
| *Elaeocarpus recurvatus* | Elaeocarpaceae | | * | |
| *Rhododendron arboreum* | Ericaceae | | * | |
| *Agrostistachys indica* | Euphorbiaceae | | * | |
| *Antidesma menasu* | Euphorbiaceae | | * | |
| *Bridelia scandens* | Euphorbiaceae | | * | |
| *Croton malabaricus* | Euphorbiaceae | | | * |
| *Drypetes elata* | Euphorbiaceae | | * | |
| *Drypetes wightii* | Euphorbiaceae | | * | |
| *Epiprinus mallotiformis* | Euphorbiaceae | | * | |

*Cont'd....*

Table 2.4. *Cont'd...*

| | | | | |
|---|---|---|---|---|
| *Exocaria robusta* | Euphorbiaceae | | * | |
| *Glochidion malabaricum* | Euphorbiaceae | | * | |
| *Glochidion neilgherrens* | Euphorbiaceae | | * | |
| *Glochidion ellipticum* | Euphorbiaceae | | | * |
| *Cynometra travancorica* | Fabaceae | | * | |
| *Dalbergia sissoides* | Fabaceae | | * | |
| *Derris brevipes* | Fabaceae | | | * |
| *Kunstleria keralensis* | Fabaceae | * | | |
| *Flacourtia montana* | Flacourtiaceae | | * | |
| *Gnetum ula* | Gnetaceae | | * | |
| *Gomphandra coriacea* | Icacinaceae | | * | |
| *Actinodaphne bourdillonii* | Lauraceae | | * | |
| *Actinodaphne lanata* | Lauraceae | | * | |
| *Actinodaphne malabarica* | Lauraceae | | * | |
| *Beilschmedia wightii* | Lauraceae | | * | |
| *Cinnamomum malabatrum* | Lauraceae | | * | |
| *Cinnamomum perotttetii* | Lauraceae | | * | |
| *Cinnamomum sulphuratum* | Lauraceae | | * | |
| *Cinnamomum wightii* | Lauraceae | | * | |
| *Litsea bourdillonii* | Lauraceae | | * | |
| *Litsea coriacea* | Lauraceae | | * | |
| *Litsea floribunda* | Lauraceae | | * | |
| *Litsea ligustrina* | Lauraceae | | | * |
| *Litsea oleoids* | Lauraceae | | * | |
| *Litsea stocksii* | Lauraceae | | * | |
| *Litsea wightiana* | Lauraceae | | * | |
| *Neolitsea scrobiculata* | Lauraceae | | * | |
| *Lagerstroemia microcarpa* | Lythraceae | | | * |
| *Michelia nilagirica* | Magnoniaceae | | * | |
| *Memecylon flavescens* | Melastomaceae | | * | |
| *Memecylon lawsonii* | Melastomaceae | | * | |
| *Aglaia indica* | Meliaceae | | * | |
| *Aglaia lawii* | Meliaceae | | | * |
| *Dysoxylum malabaricum* | Meliaceae | | * | |
| *Reinwardtiodendron anamalayanum* | Meliaceae | | | |
| *Artocarpus hirsutus* | Moraceae | | * | |
| *Ficus beddomei* | Moraceae | ` | * | |
| *Myristica malabarica* | Myristicaceae | | | * |
| *Eugenia bracteata* | Myrtaceae | | * | |
| *Syzygium benthamianum* | Myrtaceae | | * | |
| *Syzygium bourdillonii* | Myrtaceae | * | | |
| *Syzygium densiflorum* | Myrtaceae | | * | |
| *Syzygium laetum* | Myrtaceae | | | * |
| *Erythropalum scandens* | Olacaceae | | * | |
| *Schizostachym beddomei* | Poaceae | | * | |
| *Ventilago bombaiensis* | Rhamnaceae | | | * |
| *Coffea crassifolia* | Rubiceae | | | * |
| *Ixora brachiata* | Rubiceae | | * | |

*Cont'd ...*

Table 2.4. *Cont'd...*

| | | | | |
|---|---|---|---|---|
| *Lasianthus acuminatus* | Rubiceae | | * | |
| *Lasianthus jackianus* | Rubiceae | | * | |
| *Psychotria nilgiriensis* | Rubiceae | | * | |
| *Psychotria truncata* | Rubiceae | | | * |
| *Salacia oblonga* | Rubiceae | | | * |
| *Atlantia wightii* | Rutaceae | | * | |
| *Vepris bilocularis* | Rutaceae | | | * |
| *Lepisanthes tetraphylla* | Sapindaceae | | * | |
| *Otonephelium stipulaceum* | Sapindaceae | | * | |
| *Pterospermum rubiginosum* | Sterculiaceae | | * | |
| *Symplocos gardneriana* | Symplocaceae | | * | |
| *Symplocos macrophylla* | Symplocaceae | | * | |
| *Symplocos obtusa* | Symplocaceae | | * | |
| *Ternstroemia japonica* | Ternstroemiaceae | | * | |
| *Debregeasia ceylanica* | Urticaceae | | * | |
| *Vaccinium leschenaultii* | Vacciniaceae | | * | |

**Table 2.5. Rare, threatened and endangered arborescent species of New Amarambalam**

| Species | Recorded status | Authority |
|---|---|---|
| *Actinodaphne lanata* | Possibly extinct | Nayar, 1997 |
| *Actinodaphne malabarica* | Rare | Nayar, 1997 |
| *Coffea crassifolia* | Possibly extinct | Nayar, 1997 |
| *Dalbergia horrida* | Vulnerable | Nayar, 1997 |
| *Debregeasia ceylanica* | Threatened | Vivekananthan, 1978 |
| *Derris brevipes* | Possibly extinct | Nayar, 1997 |
| *Elaeocarpus munronii* | Rare | Nayar & Sastry, 1990 |
| *Euonymous angulatus* | Vulnerable | Nayar, 1997 |
| *Holigarna beddomei* | Vulnerable | Nayar, 1997 |
| *Holigarna nigra* | Rare | Nayar, 1997 |
| *Kunstleria keralensis* | Rare | Nayar, 1997 |
| *Lasianthus jackianus* | Rare | Nayar, 1997 |
| *Memecylon flavescens* | Endangered | Nayar & Sastry, 1990 |
| *Myristica malabarica* | Rare | Ahmedullah & Nayar, 1987 |
| *Nothopegia beddomei* | Rare | Nayar, 1997 |
| *Orophea uniflora* | Rare | Nayar & Sastry, 1988 |
| *Rhododendron arboreum* | Rare | Nayar, 1997 |
| *Saprosma fragrans* | Vulnerable | Nayar, 1997 |
| *Symplocos macrophylla* | Rare | Henry et al., 1987 |
| *Syzygium benthamianum* | Rare | Nayar, 1997 |
| *Syzygium bourdillonii* | Critically endangered | Nayar, 1997 |

A number of rare species such as *Syzygium benthamianum, Debregeasia ceylanica, Actinodaphne malabarica* and *Nothopegia beddomei,* and few endangered species like *Memecylon flavescens* and *Syzygium bourdillonii* were also recorded from New Amarambalam. Also, three possibly extinct species (Nayar, 1997), viz. *Actinodapne lanata, Coffea crassifolia* and *Derris brevipes*, were rediscovered during the study and more details on such species are given in Table 2.5.

In Appendix 2.1, all arborescent taxa recorded from the sample plots laid in the study area are enumerated family-wise according to the system of Bentham and Hooker (1862-83) with slight modifications appeared in subsequent literature.

### 2.4.3. Floristic diversity

New Amarambalam forests is heterogenous in nature, consisting of 7 forest types. The vegetation types varies from moist deciduous forests to montane forests from the bottom to top of the ghat and they were sampled proportional to the extent of each forest type. Total area of the forests here is 26572 ha (i.e., 265 $km^2$) and sampled area is 25.6 ha, which is 0.1 per cent of the total area. The most dominant vegetation type of New Amarambalam is the evergreen forests, which is about 31 per

**Table 2.6. Number of species represented in different forest types**

| Vegetation types | No. of species | | | |
|---|---|---|---|---|
| | **Trees** | **Lianas** | **Shrubs** | **Total** |
| Teak plantations | 25 | 1 | 2 | 28 |
| Tropical moist deciduous forests | 66 | 9 | 7 | 82 |
| Tropical semi evergreen forests | 111 | 21 | 7 | 139 |
| Tropical evergreen forests | 128 | 19 | 8 | 155 |
| Subtropical hill forests | 87 | 8 | 10 | 105 |
| Subtropical hill savannahs | 20 | 1 | 5 | 27 |
| Montane wet temperate forests | 32 | 1 | 6 | 39 |
| **Total** | **236** | **41** | **28** | **305** |

cent of the total reserve area. It is followed by subtropical forests (23%), moist deciduous forests (15%), semievergreen forests (14.4%), teak plantations (9.8%) and montane grasslands (3.4%). Vegetation types like savannahs and sholas are poorly represented by about 1.7 per cent each of the total area. The number of arborescent species in different forest types is given in the Table 2.6, as recorded from the sample plots laid in each type.

### 2.4.3.1. Southern tropical moist deciduous forests

Analysis of the structural data gathered from 45 quadrats of 30 m x 30 m size showed that there are a total of 82 arborescent species, which include 69 tree, seven liana and five shrubs. Average number of species per plot is eight and 16 is the highest number of species recorded from a single plot. *Xylia xylocarpa* is the most dominant species with highest density (66.17), followed by *Terminalia paniculata* (43.21), *Lagerstroemia microcarpa* (27.16), *Wrightia tinctoria* (26.67), *Hydnocarpus*

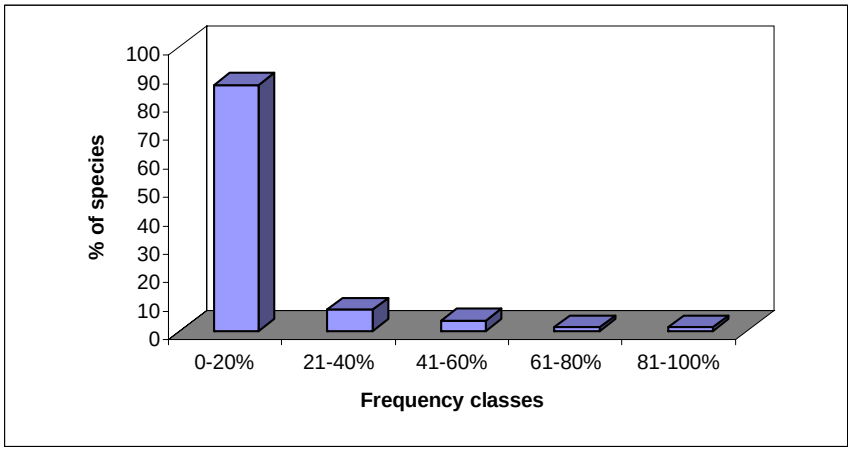


**Fig. 2.10. Percentage of frequency of species in moist deciduous forests**

*pentandra* (23.7) and *Calycopteris floribunda* (16.3). The species which were rarely represented in the forest type are *Phyllanthus emblica, Spatholobus parviflorus, Spondias pinnata, Sterculia urens* and *Ziziphus xylopyrus* (all in the density class of one). The mean stem density of the arborescent species in the forest is 315 individuals per hectare. The percentage of species in different frequency classes is shown in Figure 2.10. Species with high basal area ($m^2$/ha) are *Terminalia paniculata* (10.42), *Lagerstroemia microcarpa* (5.84), *Hydnocarpus pentandra* (4.29)

**Table 2.7. Floristic composition and phytosociological parameters of moist deciduous forests**

| Species | Density | Frequency (%) | Basal area ($cm^2$/ha) | IVI |
|---|---|---|---|---|
| *Terminalia paniculata* | 43.21 | 91.11 | 104118.52 | 49.77 |
| *Xylia xylocarpa* | 66.17 | 68.89 | 46892.06 | 40.15 |
| *Lagerstroemia microcarpa* | 27.16 | 55.56 | 58482.52 | 29.33 |
| *Hydnocarpus pentandra* | 23.70 | 35.56 | 42937.36 | 22.18 |
| *Wrightia tinctoria* | 26.67 | 33.33 | 5654.40 | 13.42 |
| *Terminalia alata* | 8.89 | 28.89 | 20829.78 | 11.17 |
| *Sterospermum colais* | 7.65 | 37.78 | 18607.50 | 11.15 |
| *Dalbergia latifolia* | 11.85 | 48.89 | 6225.07 | 10.51 |
| *Calycopteris floribunda* | 16.30 | 42.22 | 2595.02 | 10.29 |

*Cont'd ..*

Table 2.7. *Cont'd...*

| | | | | |
|---|---|---|---|---|
| *Tectona grandis* | 7.16 | 35.56 | 8968.30 | 8.32 |
| *Bambusa bambos* | 2.96 | 13.33 | 17630.90 | 6.83 |
| *Dillenia pentagyna* | 4.69 | 24.44 | 4921.66 | 5.33 |
| *Pterocarpus marsupium* | 2.22 | 15.56 | 8298.89 | 4.46 |
| *Radermachera xylocarpa* | 3.21 | 17.78 | 2573.20 | 3.55 |
| *Tetrameles nudiflora* | 1.98 | 11.11 | 5749.95 | 3.27 |
| *Dalbergia sissoides* | 1.98 | 13.33 | 3095.64 | 2.83 |
| *Miliusa tomentosa* | 2.22 | 11.11 | 3284.18 | 2.71 |
| *Schleichera oleosa* | 2.22 | 15.56 | 1347.18 | 2.69 |
| *Holarrhena pubescens* | 2.47 | 17.78 | 48.15 | 2.67 |
| *Mallotus philippensis* | 2.22 | 15.56 | 1162.82 | 2.65 |
| *Cassia fistula* | 1.73 | 15.56 | 1648.37 | 2.62 |
| *Strychnos nux-vomica* | 2.72 | 11.11 | 1943.88 | 2.53 |
| *Terminalia bellirica* | 0.99 | 6.67 | 5730.05 | 2.48 |
| *Helicteres isora* | 2.47 | 15.56 | 52.81 | 2.44 |
| *Sterculia guttata* | 2.47 | 13.33 | 954.44 | 2.43 |
| *Alangim salvifolium* | 3.46 | 11.11 | 193.34 | 2.33 |
| *Cordia wallichii* | 1.73 | 13.33 | 986.67 | 2.21 |
| *Careya arborea* | 2.47 | 8.89 | 1275.31 | 2.04 |
| *Anogeisus latifolia* | 1.23 | 4.44 | 4075.23 | 1.90 |
| *Polyalthia fragrans* | 1.73 | 8.89 | 1474.39 | 1.86 |
| *Ziziphus rugosa* | 1.48 | 8.89 | 16.10 | 1.41 |
| *Streblus asper* | 0.99 | 8.89 | 215.07 | 1.30 |
| *Macaranga peltata* | 1.23 | 6.67 | 746.11 | 1.29 |
| *Grewia umbellifera* | 0.99 | 4.44 | 1608.89 | 1.19 |
| *Ficus nervosa* | 0.49 | 4.44 | 2193.56 | 1.19 |
| *Naringi crenulata* | 1.23 | 6.67 | 44.74 | 1.11 |
| *Butea monosperma* | 0.99 | 6.67 | 192.36 | 1.07 |
| *Cleistanthus collinus* | 1.48 | 4.44 | 356.39 | 1.03 |
| *Ixora sp.* | 0.99 | 6.67 | 22.72 | 1.03 |
| *Persea macrantha* | 0.99 | 6.67 | 16.65 | 1.02 |
| *Sapindus trifoliata* | 0.74 | 6.67 | 142.72 | 0.98 |
| *Acacia torta* | 0.74 | 6.67 | 41.52 | 0.95 |
| *Melia azedarach* | 0.74 | 4.44 | 955.30 | 0.94 |
| *Lagerstroemia hirsuta* | 1.23 | 4.44 | 244.09 | 0.92 |
| *Bridelia airy-shawii* | 0.74 | 4.44 | 467.53 | 0.82 |
| *Ixora brachiata* | 0.74 | 4.44 | 308.42 | 0.78 |
| *Gnetum ula* | 0.74 | 4.44 | 121.96 | 0.73 |
| *Grewia tiliaefolia* | 0.49 | 4.44 | 300.35 | 0.71 |
| *Bombax ceiba* | 0.49 | 4.44 | 272.79 | 0.70 |
| *Mitragyna parvifolia* | 0.49 | 4.44 | 250.17 | 0.69 |
| *Bauhinia malabarica* | 0.49 | 4.44 | 99.75 | 0.66 |
| *Vitex altissima* | 0.49 | 4.44 | 73.09 | 0.65 |
| *Cissus repens* | 0.49 | 4.44 | 41.11 | 0.64 |
| *Dalbergia horrida* | 0.49 | 4.44 | 47.03 | 0.64 |
| *Ziziphus oenoplia* | 0.49 | 4.44 | 6.72 | 0.63 |
| *Tiliacora acuminata* | 0.99 | 2.22 | 237.69 | 0.61 |
| *Cipadessa baccifera* | 0.74 | 2.22 | 58.41 | 0.48 |
| *Spondias pinnata* | 0.25 | 2.22 | 505.68 | 0.45 |

*Cont'd...*

Table 2.7. *Cont'd...*

| | | | | |
|---|---|---|---|---|
| *Dalbergia volubilis* | 0.25 | 2.22 | 480.71 | 0.44 |
| *Albizia odoratissima* | 0.25 | 2.22 | 421.06 | 0.43 |
| *Artocarpus hirsutus* | 0.49 | 2.22 | 75.56 | 0.42 |
| *Aganosma sp.* | 0.49 | 2.22 | 8.40 | 0.40 |
| *Alstonia scolaris* | 0.25 | 2.22 | 333.83 | 0.40 |
| *Haldina cordifolia* | 0.25 | 2.22 | 256.71 | 0.39 |
| *Holoptelea inegrifolia* | 0.25 | 2.22 | 163.58 | 0.36 |
| *Phyllanthus emblica* | 0.25 | 2.22 | 139.38 | 0.36 |
| *Artocarpus gomezianus* | 0.25 | 2.22 | 123.28 | 0.35 |
| *Cycas circinalis* | 0.25 | 2.22 | 86.04 | 0.34 |
| *Bauhinia racemosa* | 0.25 | 2.22 | 22.83 | 0.33 |
| *Clausena heptaphylla* | 0.25 | 2.22 | 28.52 | 0.33 |
| *Ziziphus jujuba* | 0.25 | 2.22 | 28.52 | 0.33 |
| *Albizia lebbeck* | 0.25 | 2.22 | 18.98 | 0.32 |
| *Neolamarkia cadamba* | 0.25 | 2.22 | 1.98 | 0.32 |
| *Antidesma acidum* | 0.25 | 2.22 | 2.39 | 0.32 |
| *Breynia vitis-idaea* | 0.25 | 2.22 | 2.39 | 0.32 |
| *Callicarpa tomentosa* | 0.25 | 2.22 | 3.34 | 0.32 |
| *Clerodendrum viscosum* | 0.25 | 2.22 | 1.98 | 0.32 |
| *Elaeagnus indica* | 0.25 | 2.22 | 9.56 | 0.32 |
| *Hopea parviflora* | 0.25 | 2.22 | 12.35 | 0.32 |
| *Spatholobus parviflorus* | 0.25 | 2.22 | 16.61 | 0.32 |
| *Sterculia urens* | 0.25 | 2.22 | 14.40 | 0.32 |
| *Tabernaemontana alternifolia* | 0.25 | 2.22 | 9.56 | 0.32 |
| **Total** | **315.80** | **---** | **393740.05** | **300.00** |

and *Bambusa bambos* (1.76). Mean basal area cover of the vegetation is 39.37 $m^2$/ha for species >10 cm gbh. The species of highest frequency, i.e. maximum distributed in the area, is *Terminalia paniculata* (Table 2.7). Dominant species with

**Table 2.8. Diversity indices of moist deciduous forests**

| Parameters | Values |
|---|---|
| No. of species represented | 82 |
| No. of individuals/ha | 315 |
| Basal area ($m^2$ $hectare^{-1}$) | 39.37 |
| Diversity index (Margalef, 1968) | 3.07 |
| Dominance index (Simpson, 1949) | 0.089 |
| Richness index (Menhinick, 1964) | 7.22 |
| Evenness index (Pielou, 1975) | 0.69 |

maximum mean IVI are *Terminalia paniculata*, *Xylia xylocarpa, Lagerstroemia microcarpa* and *Hydnocarpus pentandra* and this is because of their high basal area of those species.

Shannon's index (Margalef, 1968) of arborescent species in this forest type at New Amarambalam is 3.07. When compared to species diversity index values of the

same forest type in other areas like Nilambur (2.52). Idukki (2.14), Aralam (1.96), Achankovil (2.2), Parappa (2.7), Parambikulam (1.9), Chimmony Wildlife Sanctuary (1.89-2.37) and Agastyamala (1.98), the diversity index is higher at New Amarambalam. Concentration of dominance (Simpson, 1949) value is 0.089 and as compared with the data of Peppara (0.18) and Andamans (0.032), the value is low. Species richness index value (Menhinick, 1964) of the forest at New Amarambalam is 7.22 and species evenness index (Pielou, 1975) value 0.69 (Table 2.8).

### 2.4.3.2. Teak plantations

Since teak plantations are intermingled with moist deciduous forests, a number of moist deciduous species are seen in the plantations. It is quite natural that the most dominant species in the plantation forest is *Tectona grandis* (219 individual/hectare), followed by *Terminalia paniculata, Cleistanthus collinus* and *Xylia xylocarpa*. For sampling in teak forests, trees were measured in different age categories of plantations. The mean stem density of teak plantation is 382 individuals/hectare and mean basal area is 21.15 $m^2$/ha (>10 cm gbh) (Table 2.9). The percentages of species in various frequency classes are shown in Figure 2.11.

**Table 2.9. Floristic composition and phytosociological parameters of teak plantations**

| Species | Density | Frequency (%) | Basal area ($cm^2$/ha) | IVI |
|---|---|---|---|---|
| *Tectona grandis* | 219.54 | 100.00 | 168025.11 | 157.82 |
| *Terminalia paniculata* | 34.87 | 51.72 | 2862.49 | 19.36 |
| *Cleistanthus collinus* | 31.03 | 44.83 | 2788.45 | 17.15 |
| *Xylia xylocarpa* | 26.05 | 41.38 | 2563.68 | 15.14 |
| *Holarrhena pubescens* | 22.22 | 75.86 | 583.33 | 19.04 |
| *Mallotus philippensis* | 10.73 | 41.38 | 9751.30 | 14.71 |
| *Helicteres isora* | 7.28 | 24.14 | 182.07 | 6.11 |
| *Dalbergia latifolia* | 6.90 | 34.48 | 1545.52 | 8.45 |
| *Hydnocarpus pentandra* | 3.83 | 24.14 | 10938.77 | 10.55 |
| *Calycopteris floribunda* | 3.45 | 20.69 | 136.28 | 4.50 |
| *Bridelia airy-shawii* | 3.07 | 20.69 | 391.05 | 4.52 |
| *Careya arborea* | 2.30 | 17.24 | 106.09 | 3.59 |
| *Alangium salvifolium* | 0.77 | 6.90 | 165.09 | 1.46 |
| *Bauhinia recemosa* | 0.77 | 6.90 | 29.92 | 1.39 |
| *Catunaregam spinosa* | 0.77 | 3.45 | 8.12 | 0.79 |
| *Dalbergia sissoides* | 0.77 | 6.90 | 507.71 | 1.63 |
| *Grewia tiliaefolia* | 0.77 | 6.90 | 22.19 | 1.39 |
| *Miliusa tomentosa* | 0.77 | 6.90 | 28.02 | 1.39 |
| *Phyllanthus emblica* | 0.77 | 3.45 | 25.78 | 0.80 |
| *Strychnos nux-vomica* | 0.77 | 3.45 | 15.94 | 0.80 |
| *Swietenia macrophylla* | 0.77 | 6.90 | 16.83 | 1.39 |

*Cont'd...*

Table 2.9. *Cont'd...*

| | | | | |
|---|---|---|---|---|
| *Antidesma acidum* | 0.38 | 3.45 | 3.07 | 0.69 |
| *Bambusa bambos* | 0.38 | 3.45 | 237.36 | 0.81 |
| *Ceiba pentandra* | 0.38 | 3.45 | 4.41 | 0.69 |
| *Dillenia pentagyna* | 0.38 | 3.45 | 22.34 | 0.70 |
| *Lagerstroemia hirsuta* | 0.38 | 3.45 | 12.26 | 0.70 |
| *Macaranga peltata* | 0.38 | 3.45 | 3.71 | 0.69 |
| *Sterculia guttata* | 0.38 | 3.45 | 412.44 | 0.89 |
| **Total** | **382.38** | **---** | **201598.46** | **300.00** |

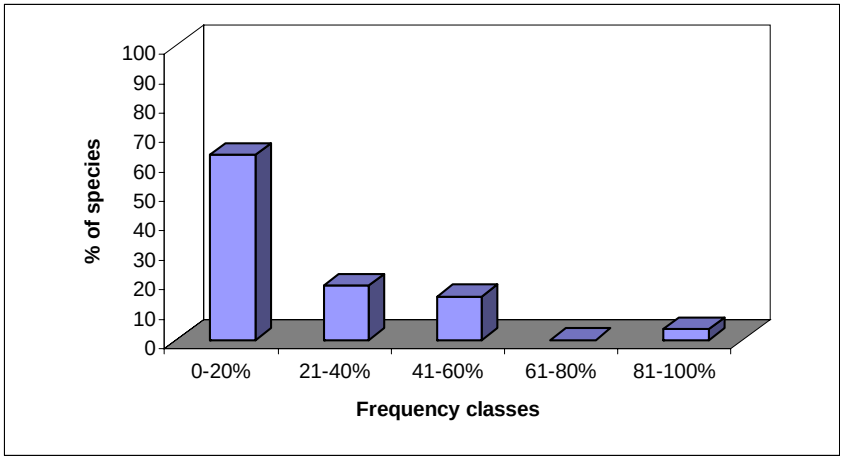


**Fig. 2.11. Percentage of frequency of species in teak plantations**

Shannon index value (Margalef, 1968) of the vegetation type is 1.6, which indicates very low species diversity as compared to natural forests. Concentration of dominance (Simpson, 1949) of the vegetation is 0.035, species richness (Menhinick, 1964) value is 2.5 and evenness index (Pielou, 1975) value 0.49 (Table 2.10).

### 2.4.3.3. West coast tropical semievergreen forests

Structural analysis of semievergreen forests at New Amarambalam shows the presence of a total of 147 arborescent species. These include 110 tree, 29 liana and eight shrubaceous taxa. Dominant species in the forest type is *Reinwardtiodendron anamallayanum* followed by *Xylia xylocarpa, Pterygota alata, Palaquium ellipticum* and *Xanthophyllum arnottianum* and species that are rarely represented in the forest type are *Tetrastigma salcata, Ziziphus rugosa, Wrightia tinctoria* and *Symplocos macrophylla*. Species that are most widely distributed include *Reinwardtiodendron anamallayanum, Pterigota alata, Palaquium ellipticum* and *Ixora brachiata.* The percentage of species in various frequency classes is shown in Figure 2.12. The mean stem density of the forest type is 669 individuals/ha and mean basal area (Table 2.11) of the natural vegetation is 48 $m^2$/ha (>10 cm gbh).

**Table 2.10. Diversity indices values of the teak plantations in New Amarambalam**

| Parameters | Values |
|---|---|
| No. of species represented | 28 |
| No. of individuals/ha | 382 |
| Basal area ($m^2$ $hectare^{-1}$) | 21.15 |
| Diversity index (Margalef, 1968) | 1.60 |
| Dominance index (Simpson, 1949) | 0.035 |
| Richness index (Menhinick, 1964) | 2.50 |
| Evenness index (Pielou, 1975) | 0.49 |

**Table 2.11. Floristic composition and phytosociological parameters of semi-evergreen forests.**

| Species | Density | Frequency (%) | Basal area ($cm^2$/ha) | IVI |
|---|---|---|---|---|
| *Reiwardtiodendron anamallayanum* | 132.04 | 60.47 | 15763.10 | 25.75 |
| *Xylia xylocarpa* | 41.09 | 34.88 | 76000.36 | 23.56 |
| *Pterygota alata* | 26.36 | 62.79 | 32689.02 | 13.61 |
| *Terminalia bellirica* | 11.37 | 46.51 | 46407.83 | 13.49 |
| *Terminalia paniculata* | 7.24 | 39.53 | 32559.51 | 9.66 |
| *Drypetes elata* | 17.31 | 46.51 | 20109.00 | 8.90 |
| *Palaquium ellipticum* | 23.26 | 58.14 | 11292.09 | 8.47 |
| *Apodytis dimidiata* | 20.41 | 39.53 | 12041.27 | 7.36 |
| *Ixora brachiata* | 18.09 | 65.12 | 3721.40 | 6.45 |
| *Polyalthia fragrans* | 9.82 | 44.19 | 13831.51 | 6.36 |
| *Cinnamomum malabatrum* | 14.21 | 58.14 | 7305.48 | 6.29 |
| *Diospyros sylvatica* | 19.90 | 41.86 | 6641.50 | 6.26 |
| *Xanthophyllum arnottianum* | 21.19 | 32.56 | 5542.10 | 5.80 |
| *Olea dioica* | 16.80 | 41.86 | 3568.11 | 5.16 |
| *Myristica dactyloides* | 10.08 | 34.88 | 6370.60 | 4.43 |
| *Croton malabaricus* | 11.37 | 46.51 | 2056.63 | 4.25 |
| *Bischofia javanica* | 2.58 | 18.60 | 14034.16 | 4.16 |
| *Calophyllum polyanthum* | 5.43 | 30.23 | 9154.86 | 4.10 |
| *Naringi crenulata* | 14.47 | 25.58 | 3285.04 | 4.01 |
| *Syzygium gardneri* | 2.07 | 16.28 | 13801.92 | 3.93 |
| *Baccaurea courtallensis* | 11.89 | 37.21 | 1154.52 | 3.71 |
| *Dimocarpus longan* | 6.72 | 37.21 | 4084.62 | 3.54 |
| *Drypetes oblongifolia* | 13.70 | 16.28 | 3477.46 | 3.51 |
| *Stereospermum colais* | 5.68 | 27.91 | 4535.18 | 3.06 |
| *Artocarpus hirsutus* | 2.33 | 18.60 | 7654.42 | 2.79 |
| *Vepris bilocularis* | 3.62 | 16.28 | 6485.98 | 2.63 |
| *Celtis timorensis* | 5.68 | 30.23 | 1618.56 | 2.57 |
| *Garcinia sp.* | 6.46 | 18.60 | 3555.81 | 2.55 |
| *Mallotus philippensis* | 5.94 | 30.23 | 854.33 | 2.45 |
| *Dalbergia sissoides* | 1.55 | 13.95 | 7297.69 | 2.39 |
| *Actinodaphne bourdillonii* | 4.39 | 27.91 | 1631.65 | 2.27 |
| *Sterculia guttata* | 4.39 | 27.91 | 1595.50 | 2.26 |
| *Oreocnide integrifolia* | 7.49 | 20.93 | 560.67 | 2.19 |

*Cont'd …*

Table 2.11. *Cont'd...*

| | | | | |
|---|---|---|---|---|
| *Mitragyna parvifolia* | 4.65 | 25.58 | 1029.26 | 2.07 |
| *Ficus nervosa* | 0.52 | 4.65 | 7777.26 | 1.91 |
| *Macaranga peltata* | 3.36 | 23.26 | 1652.75 | 1.90 |
| *Acacia torta* | 5.68 | 20.93 | 420.50 | 1.89 |
| *Sapindus trifoliata* | 3.88 | 23.26 | 1010.74 | 1.85 |
| *Strychnos cinnamomea* | 6.20 | 16.28 | 736.50 | 1.82 |
| *Gnetum ula* | 3.36 | 25.58 | 506.80 | 1.78 |
| *Syzygium laetum* | 4.13 | 23.26 | 438.12 | 1.77 |
| *Vitex altissima* | 2.07 | 16.28 | 3446.33 | 1.77 |
| *Prunus zeylanicus* | 2.33 | 18.60 | 2619.72 | 1.75 |
| *Elaeocarpus glandulosus* | 2.33 | 11.63 | 4036.70 | 1.72 |
| *Chionanthus mala-elangi* | 4.65 | 18.60 | 775.67 | 1.70 |
| *Dysoxylum malabaricum* | 3.62 | 20.93 | 675.22 | 1.63 |
| *Harpullia arborea* | 2.58 | 18.60 | 1887.39 | 1.63 |
| *Hydnocarpus pentandra* | 3.36 | 20.93 | 547.01 | 1.56 |
| *Ventilago bombaiensis* | 3.10 | 23.26 | 203.75 | 1.56 |
| *Calycopteris floribunda* | 2.33 | 18.60 | 1543.21 | 1.52 |
| *Polyalthia coffeoides* | 1.03 | 9.30 | 4444.71 | 1.50 |
| *Bambusa bambos* | 0.78 | 6.98 | 4881.96 | 1.46 |
| *Pterospermum diverfolium* | 1.55 | 6.98 | 4056.08 | 1.39 |
| *Cissus repens* | 3.62 | 16.28 | 165.47 | 1.31 |
| *Diospyros buxifolia* | 2.58 | 16.28 | 459.02 | 1.23 |
| *Orophea erythrocarpa* | 1.81 | 13.95 | 1540.36 | 1.23 |
| *Holigarna beddomei* | 1.29 | 11.63 | 2146.25 | 1.17 |
| *Syzygium hemisphericum* | 1.03 | 6.98 | 3162.79 | 1.13 |
| *Bombax ceiba* | 1.03 | 9.30 | 2566.99 | 1.10 |
| *Pterocarpus marsupium* | 0.78 | 6.98 | 3032.66 | 1.07 |
| *Turpinia malabarica* | 1.81 | 13.95 | 785.32 | 1.07 |
| *Hopea parviflora* | 1.03 | 9.30 | 2319.07 | 1.05 |
| *Cinnamomum sp.1* | 1.81 | 11.63 | 1171.10 | 1.04 |
| *Antiaris toxicaria* | 1.55 | 11.63 | 1278.87 | 1.03 |
| *Garcinia morella* | 2.33 | 13.95 | 184.47 | 1.03 |
| *Spondias indica* | 0.52 | 4.65 | 3564.01 | 1.03 |
| *Litsea coriacea* | 2.07 | 11.63 | 796.86 | 1.01 |
| *Flacourtia montana* | 1.55 | 13.95 | 545.67 | 0.98 |
| *Cinnamomum sp.2* | 1.03 | 4.65 | 2869.17 | 0.96 |
| *Schleichera oleosa* | 1.29 | 11.63 | 1037.03 | 0.94 |
| *Garcinia gummi-gutta* | 1.29 | 9.30 | 1284.75 | 0.88 |
| *Ancistrocladus heyneanus* | 2.07 | 11.63 | 73.10 | 0.86 |
| *Chrysophyllum roxburghii* | 1.55 | 11.63 | 462.20 | 0.86 |
| *Gomphandra tetrandra* | 2.07 | 11.63 | 47.03 | 0.85 |
| *Lagerstroemia microcarpa* | 1.29 | 11.63 | 608.91 | 0.85 |
| *Mangifera indica* | 0.78 | 6.98 | 1953.18 | 0.85 |
| *Grewia umbellifera* | 2.58 | 9.30 | 91.94 | 0.83 |
| *Persea macrantha* | 1.29 | 11.63 | 487.67 | 0.82 |
| *Canarium strictum* | 1.29 | 11.63 | 384.52 | 0.80 |
| *Dillenia pentagyna* | 1.03 | 6.98 | 1544.12 | 0.79 |
| *Ficus beddomei* | 0.52 | 4.65 | 2265.63 | 0.76 |
| *Combretum latifolium* | 1.81 | 9.30 | 268.89 | 0.75 |

*Cont'd ...*

Table 2.11. *Cont'd...*

| | | | | |
|---|---|---|---|---|
| *Derris brevipes* | 1.03 | 9.30 | 382.16 | 0.65 |
| *Acronychia pedunculata* | 1.29 | 4.65 | 1098.11 | 0.63 |
| *Litsea oleoids* | 1.29 | 9.30 | 75.25 | 0.63 |
| *Glochidion ellipticum* | 1.03 | 9.30 | 216.93 | 0.62 |
| *Nothopegia beddomei* | 1.29 | 9.30 | 44.59 | 0.62 |
| *Celastrus paniculatus* | 1.03 | 9.30 | 82.29 | 0.59 |
| *Elaeocarpus serratus* | 0.78 | 6.98 | 614.12 | 0.57 |
| *Clausena heptaphylla* | 1.03 | 6.98 | 247.28 | 0.52 |
| *Helicteres isora* | 1.29 | 6.98 | 32.38 | 0.52 |
| *Leea indica* | 1.29 | 6.98 | 43.27 | 0.52 |
| *Grewia tiliaefolia* | 0.52 | 4.65 | 1064.21 | 0.51 |
| *Alangium salvifolium* | 0.78 | 6.98 | 195.88 | 0.48 |
| *Spondias pinnata* | 0.78 | 6.98 | 171.60 | 0.48 |
| *Tetrameles nudiflora* | 0.78 | 6.98 | 165.74 | 0.47 |
| *Cissus latifolia* | 0.78 | 6.98 | 67.88 | 0.45 |
| *Dalbergia latifolia* | 0.78 | 6.98 | 29.48 | 0.45 |
| *Litsea sp.* | 0.78 | 6.98 | 62.12 | 0.45 |
| *Embelia ribes* | 0.78 | 6.98 | 23.17 | 0.44 |
| *Moullava spicata* | 0.78 | 6.98 | 15.91 | 0.44 |
| *Drypetes oblongifolia* | 1.03 | 4.65 | 328.27 | 0.43 |
| *Quisqualis malabarica* | 1.03 | 4.65 | 330.63 | 0.43 |
| *Scolopia crenata* | 0.78 | 4.65 | 503.28 | 0.43 |
| *Croton laccifer* | 1.03 | 4.65 | 28.49 | 0.37 |
| *Lepisanthus tetraphylla* | 0.78 | 4.65 | 212.19 | 0.37 |
| *Anamirta cocculus* | 0.78 | 4.65 | 131.22 | 0.36 |
| *Caesalpinia cucullata* | 0.78 | 4.65 | 48.91 | 0.34 |
| *Diospyros candolleana* | 1.29 | 2.33 | 135.19 | 0.33 |
| *Pavetta zeylanica* | 0.78 | 4.65 | 11.20 | 0.33 |
| *Holigarna arnottiana* | 1.03 | 2.33 | 231.73 | 0.31 |
| *Artocarpus gomezianus* | 0.52 | 4.65 | 27.95 | 0.30 |
| *Debregeasia ceylanica* | 0.52 | 4.65 | 40.39 | 0.30 |
| *Erycibe paniculata* | 0.52 | 4.65 | 45.99 | 0.30 |
| *Glochidion malabaricum* | 0.52 | 4.65 | 33.34 | 0.30 |
| *Holoptelia integrifolia* | 0.52 | 4.65 | 36.73 | 0.30 |
| *Margaritaria indica* | 0.52 | 4.65 | 60.55 | 0.30 |
| *Tiliacora acuminata* | 0.52 | 4.65 | 66.58 | 0.30 |
| *Toona ciliata* | 0.52 | 4.65 | 37.25 | 0.30 |
| *Clerodendrum viscosum* | 0.52 | 4.65 | 19.72 | 0.29 |
| *Mallotus tetracoccus* | 0.52 | 2.33 | 474.32 | 0.29 |
| *Diospyros paniculata* | 1.03 | 2.33 | 37.48 | 0.27 |
| *Leportia crenulata* | 0.78 | 2.33 | 83.95 | 0.25 |
| *Callicarpa tomentosa* | 0.26 | 2.33 | 387.99 | 0.23 |
| *Neolitsea cassia* | 0.52 | 2.33 | 84.09 | 0.21 |
| *Cassia fistula* | 0.26 | 2.33 | 263.96 | 0.20 |
| *Otonephelium stipulaceum* | 0.52 | 2.33 | 36.07 | 0.20 |
| *Cryptolepis buchananii* | 0.52 | 2.33 | 21.93 | 0.19 |
| *Entada rheedii* | 0.26 | 2.33 | 171.18 | 0.19 |
| *Madhuca neriifolia* | 0.26 | 2.33 | 82.05 | 0.17 |
| *Catunaregam spinosa* | 0.26 | 2.33 | 53.77 | 0.16 |

*Cont'd ...*

Table 2.11. *Cont'd...*

| | | | | |
|---|---|---|---|---|
| *Neolamarckia cadamba* | 0.26 | 2.33 | 25.32 | 0.16 |
| *Agrostistachys borneensis* | 0.26 | 2.33 | 11.91 | 0.15 |
| *Artabotrys zeylanicus* | 0.26 | 2.33 | 17.39 | 0.15 |
| *Calamus thwaitesii.* | 0.26 | 2.33 | 2.07 | 0.15 |
| *Diploclisia glaucascens* | 0.26 | 2.33 | 5.29 | 0.15 |
| *Elaeocarpus tuberculatus* | 0.26 | 2.33 | 8.27 | 0.15 |
| *Erythrina stricta* | 0.26 | 2.33 | 5.97 | 0.15 |
| *Lannea coromandelica* | 0.26 | 2.33 | 9.12 | 0.15 |
| *Psychotria nigra* | 0.26 | 2.33 | 4.65 | 0.15 |
| *Pterospermum rubiginosum* | 0.26 | 2.33 | 19.87 | 0.15 |
| *Symplocos macrophylla* | 0.26 | 2.33 | 5.97 | 0.15 |
| *Tetrastigma salcata* | 0.26 | 2.33 | 4.05 | 0.15 |
| *Wrightia tinctoria* | 0.26 | 2.33 | 10.01 | 0.15 |
| *Zizyphus rugosa* | 0.26 | 2.33 | 15.07 | 0.15 |
| **Total** | **669.51** | **---** | **480028.82** | **300.00** |

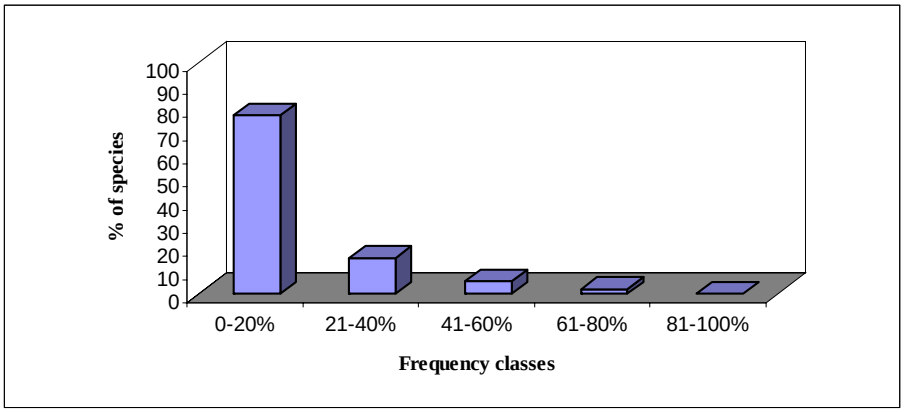


**Fig. 2.12. Percentage of frequency of species in tropical semievergreen forests**

**Table 2.12. Diversity indices values of semievergreen forests**

| Parameters | Values |
|---|---|
| No of species represented | 139 |
| No. of individuals/ ha | 669 |
| Basal area ($m^2$ $ha^{-1}$) | 48 |
| Diversity index (Margalef, 1968) | 3.87 |
| Dominance index (Simpson, 1949) | 0.054 |
| Richness index (Menhinick, 1964) | 13.66 |
| Evenness index (Pielou, 1975) | 0.76 |

Shannon index (Margalef, 1968) of the forest is 3.87. As compared to indices values of the same forest type in central Kerala at Chimmoni (3.2), northern Kerala at Aaralam (3.22) and Agasthiamalai and Peppara in southern Kerala (2.94 and 2.82 respectively), the tropical semievergreen forests of New Amarambalam is very rich with regard to arborescent flora. Concentration of dominance (Simpson,

1949) value of the study area is 0.54. Species richness (Menhinick, 1964) value of the arborescent flora of the forest type is 13.66 and 0.76 is the species evenness (Pielou, 1975) value (Table 2.12).

### 2.4.3.4. West coast tropical evergreen forests

A total of 155 arborescent species comprising 132 tree, 18 liana and four shruaceous elements are recorded from 92 plots extending to 8200 ha laid in the evergreen forests. The most dominant species found in this forest type is *Agrostistachys borneensis* followed by *Palaquium ellipticum, Reinwardtiodendron anamallayanum, Myristica dactyloides* and *Xanthophyllum arnottianum.* The most highly distributed species is *Myristica dactyloides,* followed by *Garcinia morella, Xanthophyllum arnottianum* and *Drypetes elata*. The percentage of species

**Table 2.13. Floristic composition and phytosociological parameters of evergreen forests**

| Species | Density | Frequency (%) | Basal area ($cm^2$/ha) | IVI |
|---|---|---|---|---|
| *Palaquium ellipticum* | 142.15 | 100.00 | 127168.60 | 42.51 |
| *Agrostistachys borneensis* | 150.60 | 41.30 | 23893.30 | 21.67 |
| *Myristica dactyloides* | 68.96 | 93.48 | 34970.99 | 17.76 |
| *Cullenia exarillata* | 29.11 | 48.91 | 63631.28 | 16.93 |
| *Reinwardtiodendron anamallayanum* | 86.23 | 52.17 | 12317.36 | 13.46 |
| *Xanthophyllum arnottianum* | 51.81 | 73.91 | 7776.92 | 10.10 |
| *Drypetes elata* | 30.80 | 66.30 | 16061.61 | 9.14 |
| *Garcinia morella* | 41.43 | 79.35 | 4763.06 | 8.74 |
| *Dimocarpus longan* | 19.93 | 57.61 | 18143.42 | 8.02 |
| *Syzygium laetum* | 26.57 | 60.87 | 3670.39 | 6.18 |
| *Calophyllum polyanthum* | 5.43 | 30.43 | 21071.74 | 5.82 |
| *Drypetes oblongifolia* | 22.22 | 31.52 | 7010.44 | 5.00 |
| *Gomphandra tetrandra* | 17.03 | 59.78 | 1278.71 | 4.72 |
| *Terminalia bellirica* | 1.57 | 14.13 | 21209.88 | 4.72 |
| *Mesua ferrea* | 6.64 | 29.35 | 12101.46 | 4.25 |
| *Apodytis dimidiata* | 12.44 | 30.43 | 5820.12 | 3.73 |
| *Holigarna nigra* | 7.37 | 35.87 | 6162.47 | 3.52 |
| *Syzygium gardneri* | 3.14 | 22.83 | 7530.49 | 2.76 |
| *Oreocnide integrifolia* | 10.51 | 31.52 | 1309.20 | 2.75 |
| *Diospyros candolleana* | 7.61 | 32.61 | 1938.16 | 2.63 |
| *Litsea oleoides* | 8.94 | 27.17 | 2605.55 | 2.63 |
| *Stereospermum colais* | 2.17 | 10.87 | 9939.46 | 2.55 |
| *Dysoxylum malabaricum* | 4.11 | 26.09 | 4743.99 | 2.48 |
| *Baccaurea courtallensis* | 8.21 | 30.43 | 918.16 | 2.40 |
| *Diospyros sp.* | 5.68 | 27.17 | 2600.78 | 2.30 |
| *Croton malabricus* | 6.52 | 26.09 | 2226.85 | 2.27 |
| *Polyalthia fragrans* | 5.19 | 29.35 | 2107.42 | 2.26 |
| *Neolitsea cassia* | 5.19 | 30.43 | 1419.52 | 2.18 |

*Cont'd …*

Table 2.13. *Cont'd...*

| | | | | |
|---|---|---|---|---|
| *Ventilago bombaiensis* | 5.31 | 33.70 | 427.62 | 2.16 |
| *Canarium strictum* | 3.50 | 26.09 | 2934.85 | 2.09 |
| *Litsea stocksi* | 9.30 | 16.30 | 1276.45 | 1.94 |
| *Cinnamomum malabatrum* | 5.19 | 25.00 | 1384.00 | 1.92 |
| *Aglaia lawii* | 3.26 | 22.83 | 2678.58 | 1.87 |
| *Bischofia javanica* | 0.97 | 7.61 | 6919.92 | 1.72 |
| *Psychotria nigra* | 4.11 | 27.17 | 93.91 | 1.68 |
| *Litsea bourdillonii* | 2.17 | 16.30 | 3622.04 | 1.64 |
| *Mangifera indica* | 1.69 | 14.13 | 4436.17 | 1.64 |
| *Litsea coriacea* | 4.71 | 21.74 | 831.34 | 1.63 |
| *Syzygium hemisphericum* | 1.09 | 9.78 | 5232.90 | 1.52 |
| *Ficus beddomei* | 0.36 | 3.26 | 7166.42 | 1.51 |
| *Actinodaphne bourdillonii* | 3.26 | 20.65 | 1108.11 | 1.48 |
| *Aglaia indica* | 4.83 | 20.65 | 144.83 | 1.47 |
| *Bridelia scandens* | 0.12 | 1.09 | 7482.13 | 1.44 |
| *Turpinia malabarica* | 3.14 | 19.57 | 1210.48 | 1.44 |
| *Knema attenuata* | 2.78 | 16.30 | 1742.03 | 1.35 |
| *Prunus zeylanicus* | 2.05 | 16.30 | 1869.84 | 1.30 |
| *Elaeocarpus tuberculatus* | 1.57 | 11.96 | 2894.23 | 1.24 |
| *Salacia oblonga* | 3.14 | 17.39 | 648.18 | 1.24 |
| *Drypetes wightii* | 5.19 | 13.04 | 461.37 | 1.21 |
| *Cinnamomum perrottetii* | 2.29 | 13.04 | 1619.15 | 1.13 |
| *Pterygota alata* | 3.74 | 9.78 | 1559.40 | 1.12 |
| *Antidesma menasu* | 2.54 | 15.22 | 818.75 | 1.11 |
| *Gnetum ula* | 2.29 | 15.22 | 192.64 | 0.97 |
| *Mallotus philippensis* | 1.81 | 14.13 | 312.99 | 0.89 |
| *Toona ciliata* | 0.36 | 3.26 | 3654.11 | 0.86 |
| *Vepris bilocularis* | 1.33 | 10.87 | 1165.69 | 0.85 |
| *Macaranga peltata* | 1.81 | 10.87 | 693.57 | 0.81 |
| *Harpullia arborea* | 1.57 | 10.87 | 684.57 | 0.79 |
| *Litsea sp.* | 1.57 | 11.96 | 440.59 | 0.79 |
| *Elaeocarpus glandulosus* | 1.69 | 10.87 | 512.25 | 0.76 |
| *Eugenia sp.1* | 1.69 | 9.78 | 730.74 | 0.75 |
| *Persea macrantha* | 1.09 | 8.70 | 1301.98 | 0.75 |
| *Holigarna beddomei* | 0.85 | 7.61 | 1534.47 | 0.72 |
| *Clerodendrum viscosum* | 1.45 | 11.96 | 72.33 | 0.71 |
| *Hydnocarpus pentandra* | 2.17 | 6.52 | 990.46 | 0.70 |
| *Pinanga dicksonii* | 5.68 | 2.17 | 87.19 | 0.70 |
| *Syzygium benthamianum* | 0.72 | 5.43 | 2048.06 | 0.70 |
| *Garcinia gummi-gutta* | 1.45 | 9.78 | 498.10 | 0.69 |
| *Celtis timorensis* | 1.21 | 10.87 | 231.36 | 0.66 |
| *Nothopegia beddomei* | 1.21 | 10.87 | 186.45 | 0.65 |
| *Ancistrocladus heyneanus* | 1.57 | 9.78 | 42.53 | 0.62 |
| *Terminalia paniculata* | 0.36 | 2.17 | 2599.46 | 0.62 |
| *Glochidion neilgherrense* | 2.29 | 5.43 | 578.83 | 0.59 |
| *Ixora brachiata* | 1.45 | 7.61 | 200.62 | 0.54 |
| *Combretum latifolium* | 1.09 | 7.61 | 365.58 | 0.53 |
| *Diospyros sylvatica* | 1.57 | 5.43 | 644.13 | 0.53 |
| *Ficus nervosa* | 0.85 | 7.61 | 476.08 | 0.53 |

*Cont'd ...*

Table 2.13. *Cont'd...*

| | | | | |
|---|---|---|---|---|
| *Glochidion ellipticum* | 0.97 | 8.70 | 105.51 | 0.52 |
| *Beilschmedia wighti* | 0.97 | 7.61 | 306.89 | 0.51 |
| *Artocarpus gomezianus* | 0.72 | 4.35 | 1081.59 | 0.47 |
| *Dysoxylum sp.* | 0.60 | 3.26 | 1329.58 | 0.45 |
| *Sapindus trifoliata* | 0.97 | 7.61 | 19.60 | 0.45 |
| *Artocarpus heterophyllus* | 0.72 | 4.35 | 895.25 | 0.43 |
| *Lasianthus acuminatus* | 0.85 | 6.52 | 226.71 | 0.43 |
| *Hopea parviflora* | 0.24 | 2.17 | 1506.94 | 0.40 |
| *Elaeocarpus munronii* | 0.72 | 5.43 | 362.35 | 0.39 |
| *Eugenia bracteata* | 0.72 | 5.43 | 381.99 | 0.39 |
| *Asclepias sp.* | 1.21 | 4.35 | 304.01 | 0.38 |
| *Chrysophyllum roxburghii* | 0.60 | 4.35 | 640.48 | 0.38 |
| *Symplocos cochinchinensis* | 1.21 | 5.43 | 32.81 | 0.38 |
| *Antiaris toxicaria* | 0.24 | 2.17 | 1348.76 | 0.37 |
| *Laportia crenulata* | 1.09 | 5.43 | 62.12 | 0.37 |
| *Otonephelium stipulaceum* | 1.33 | 4.35 | 128.27 | 0.36 |
| *Derris brevipes* | 0.97 | 5.43 | 26.97 | 0.35 |
| *Sarcostigma kleinii* | 0.72 | 5.43 | 182.32 | 0.35 |
| *Flacourtia montana* | 0.60 | 3.26 | 550.21 | 0.31 |
| *Nothopegia racemosa* | 0.36 | 3.26 | 507.90 | 0.28 |
| *Sterculia guttata* | 0.48 | 4.35 | 162.35 | 0.28 |
| *Antidesma menasu* | 0.60 | 3.26 | 322.09 | 0.27 |
| *Dalbergia sissoides* | 0.12 | 1.09 | 1116.91 | 0.27 |
| *Lagerstroemia microcarpa* | 0.24 | 2.17 | 795.91 | 0.27 |
| *Drypetes sp.* | 0.48 | 4.35 | 13.18 | 0.25 |
| *Pterospermum diversifolium* | 0.36 | 3.26 | 306.63 | 0.25 |
| *Leea indica* | 0.85 | 3.26 | 14.74 | 0.24 |
| *Moullava spicata* | 0.72 | 3.26 | 35.86 | 0.23 |
| *Diospyros paniculata* | 0.48 | 2.17 | 404.43 | 0.22 |
| *Polyalthia coffeoides* | 0.36 | 3.26 | 162.33 | 0.22 |
| *Elaeocarpus serratus* | 0.24 | 2.17 | 443.49 | 0.20 |
| *Scolopia crenata* | 0.36 | 3.26 | 31.74 | 0.20 |
| *Syzygium sp.1* | 0.36 | 3.26 | 40.42 | 0.20 |
| *Meiogyne pannosa* | 0.36 | 3.26 | 37.4 | 0.19 |
| *Celastrus paniculata* | 0.36 | 3.26 | 21.78 | 0.19 |
| *Schizostachyum beddomei* | 0.12 | 1.09 | 653.14 | 0.18 |
| *Margaritaria indica* | 0.36 | 2.17 | 123.19 | 0.16 |
| *Calophyllum austroindicum* | 0.36 | 2.17 | 33.94 | 0.15 |
| *Garcinia sp.* | 0.48 | 2.17 | 19.22 | 0.15 |
| *Artocarpus hirsutus* | 0.24 | 2.17 | 97.47 | 0.14 |
| *Diospyros buxifolia* | 0.24 | 2.17 | 89.60 | 0.14 |
| *Diploclisia glaucascens* | 0.36 | 2.17 | 11.57 | 0.14 |
| *Lasianthus jackianus* | 0.36 | 2.17 | 3.75 | 0.14 |
| *Vitex altissima* | 0.36 | 2.17 | 7.53 | 0.14 |
| *Acronychia pedunculata* | 0.24 | 2.17 | 71.30 | 0.13 |
| *Neolitsea scrobiculata* | 0.24 | 2.17 | 52.45 | 0.13 |
| *Syzygium cumini* | 0.24 | 2.17 | 28.65 | 0.13 |
| *Actinodaphne malabarica* | 0.24 | 2.17 | 9.66 | 0.12 |
| *Agrostistachys indica* | 0.24 | 2.17 | 3.53 | 0.12 |

*Cont'd ...*

Table 2.13. *Cont'd...*

| | | | | |
|---|---|---|---|---|
| *Cinnamomum riparium* | 0.24 | 2.17 | 6.96 | 0.12 |
| *Luvanga eleuntherandra* | 0.24 | 2.17 | 10.09 | 0.12 |
| *Spondias indica* | 0.12 | 1.09 | 306.13 | 0.12 |
| *Strychnos cinnamomea* | 0.24 | 2.17 | 4.07 | 0.12 |
| *Cinnamomum sp.* | 0.24 | 2.17 | 6.98 | 0.12 |
| *Cissus sp.* | 0.24 | 2.17 | 3.14 | 0.12 |
| *Quisqualis malabarica* | 0.48 | 1.09 | 7.73 | 0.10 |
| *Vernonia arborea* | 0.12 | 1.09 | 158.30 | 0.09 |
| *Meliosma pinnata* | 0.12 | 1.09 | 85.37 | 0.08 |
| *Syzygium lanceolatum* | 0.24 | 1.09 | 53.34 | 0.08 |
| *Aphanamixis polystachya* | 0.24 | 1.09 | 16.13 | 0.07 |
| *Debregeasia ceylanica* | 0.24 | 1.09 | 5.02 | 0.07 |
| *Tabernaemontana alternifolia* | 0.12 | 1.09 | 29.23 | 0.07 |
| *Alstonia scholaris* | 0.12 | 1.09 | 4.68 | 0.06 |
| *Apodytes dimidiata* | 0.12 | 1.09 | 0.97 | 0.06 |
| *Derris enlata* | 0.12 | 1.09 | 6.04 | 0.06 |
| *Embelia ribes* | 0.12 | 1.09 | 5.57 | 0.06 |
| *Erythropalum scandens* | 0.12 | 1.09 | 8.70 | 0.06 |
| *Maesa indica* | 0.12 | 1.09 | 2.47 | 0.06 |
| *Nothapodytes nimmoniana* | 0.12 | 1.09 | 2.47 | 0.06 |
| *Orophea uniflora* | 0.12 | 1.09 | 2.17 | 0.06 |
| *Oroxylum indicum* | 0.12 | 1.09 | 16.24 | 0.06 |
| *Pheobe lanceolata* | 0.12 | 1.09 | 0.97 | 0.06 |
| *Symplocos sp.* | 0.12 | 1.09 | 9.89 | 0.06 |
| *Syzygium sp.2* | 0.12 | 1.09 | 4.68 | 0.06 |
| *Tetrastigma salcata* | 0.12 | 1.09 | 3.13 | 0.06 |
| *Toddalia asiatica* | 0.12 | 1.09 | 6.04 | 0.06 |
| **Total** | **979.35** | **---** | **542972.06** | **300.00** |

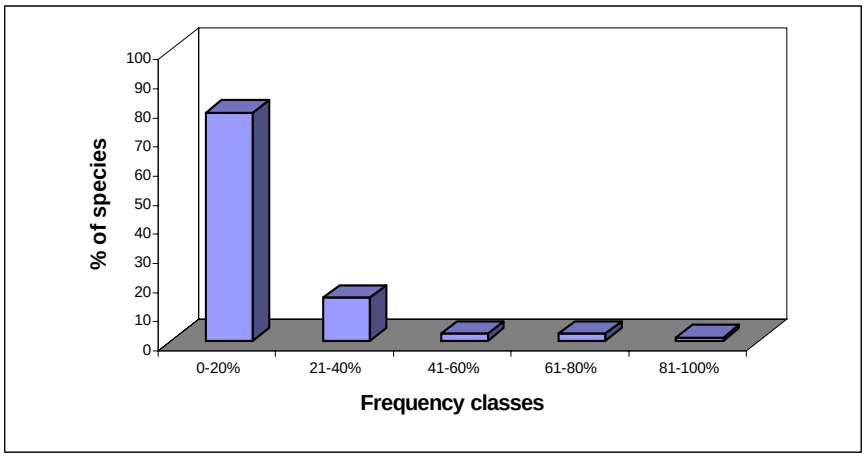


**Fig. 2.13. Percentage of frequency of species in tropical evergreen forests**

in various frequency classes are shown in Figure 2.13. The mean stem density of the forest is 979 individuals/ha and mean basal area is 54.29 $m^2$/ha (> 10 cm gbh).

Dominant species with maximum IVI are *Palaquium ellipticum, Agrostistachys borneensis, Myristica dactyloids* and *Cullenia exarillata* (Table 2.13).

Shannon index (Margalef, 1968) of the forest type is 3.45, which is higher than evergreen forest of Agasthiamala (2.58) and lower than that of Silent Valley National Park (4.01). Concentration of dominance (Simpson, 1949) of the forest type is 0.54, which is lower as compared to Peppara Wildlife Sancuary (0.06) and Andamans (0.041). Species richness value (Menhinick, 1964) of the evergreen vegetation at New Amarambalam is 17.84 and species evenness value (Pielou, 1975) is 0.67 (Table 2.14).

**Table 2.14. Diversity indices of evergreen forests**

| | |
|---|---|
| No of species represented | 155 |
| No of individuals/ha | 979 |
| Basal area ($m^2$ $ha^{-1}$) | 54.29 |
| Diversity indices (Margalef, 1968) | 3.45 |
| Dominance index (Simpson, 1949) | 0.067 |
| Richness index (Menhinick, 1964) | 14.76 |
| Evenness index (Pielou, 1975) | 0.67 |

### 2.4.3.5. Southern subtropical broad leaved hill forests

Analysis of data gathered from 68 plots showed that there are a total of 105 arborecent species in the vegetation type at New Amarambalam. They include 91 tree, six liana and eight shruby species. Dominant species in the forest type are *Myristica dactyloides, Palaquium ellipticum, Litsea stocksii, Mesua ferrea* and *Drypetes wightii.* Rarely represented species in the vegetation are *Eugenia bracteata, Symplocos cochinchinensis* and *Psychotria congesta*. Species like *Myristica dactyloids, Palaquium ellipticum, Litsea stocksii* and *Psychotria congesta* are widely distributed in the forest. The percentage of species in various frequency classes are shown in Figure 2.14. Mean density of arborescent species is 837 individuals/hectare and mean basal area of the forest type 42.74 $m^2$/ha (>10 cm gbh) (Table 2.15).

Divesity index (Margalef, 1968) value of the forest is 3.58 and as compared to subtropical hill forests of Peppara Wildlife Sanctuary (2.79) and Kolli Hills in Tamil Nadu (2.74-3.45), the index value of New Amarambalam is higher. Concentration of dominance (Simpson, 1949) is 0.057 and as compared to Peppara (0.092) and Kolli Hills (0.036-0.83). Species richness (Menhinick, 1964) of the forest in the study area is 10.44 and species evenness (Pielou, 1975) 0.74 (Table 2.16).

**Table 2.15. Floristic composition and phytosociological parameters of subtropical hill forests**

| Species | Density | Frequency (%) | Basal area ($cm^2$/ha) | IVI |
|---|---|---|---|---|
| *Myristica dactyloides* | 140.86 | 100.00 | 64395.66 | 37.21 |
| *Palaquium ellipticum* | 77.06 | 59.68 | 85092.99 | 32.21 |
| *Mesua ferrea* | 33.51 | 62.90 | 60048.45 | 21.13 |
| *Litsea stocksii* | 74.37 | 96.77 | 16747.26 | 17.64 |
| *Calophyllum austroindicum* | 12.90 | 50.00 | 25073.42 | 9.81 |
| *Holigarna nigra* | 20.43 | 67.74 | 10379.72 | 8.13 |
| *Psychotria congesta* | 28.49 | 70.97 | 874.50 | 7.04 |
| *Drypetes wightii* | 24.37 | 56.45 | 4383.68 | 6.69 |
| *Artocarpus heterophyllus* | 12.54 | 53.23 | 10833.32 | 6.58 |
| *Garcinia gummi-gutta* | 17.74 | 50.00 | 8136.45 | 6.44 |
| *Dimocarpus longan* | 15.77 | 50.00 | 8330.19 | 6.25 |
| *Macaranga peltata* | 16.49 | 45.16 | 8489.72 | 6.14 |
| *Syzygium laetum* | 9.86 | 56.45 | 6857.46 | 5.47 |
| *Agrostistachys sp.* | 14.16 | 50.00 | 5783.28 | 5.45 |
| *Syzygium sp.* | 18.10 | 41.94 | 2538.39 | 4.79 |
| *Elaeocarpus munronii* | 9.32 | 37.10 | 8067.08 | 4.78 |
| *Litsea oleoids* | 10.22 | 45.16 | 5531.25 | 4.67 |
| *Diospyros candolleana* | 12.54 | 41.94 | 4633.30 | 4.60 |
| *Aglaia indica* | 12.90 | 54.84 | 832.65 | 4.36 |
| *Clerodendrum viscosum* | 15.05 | 43.55 | 1142.13 | 4.18 |
| *Neolitsea scrobiculata* | 8.96 | 43.55 | 3704.21 | 4.03 |
| *Litsea floribunda* | 10.04 | 33.87 | 2854.90 | 3.50 |
| *Litsea coriacea* | 8.06 | 33.87 | 2611.05 | 3.19 |
| *Prunus zeylanicus* | 6.09 | 19.35 | 6484.13 | 3.18 |
| *Apollonias arnottii* | 13.44 | 25.81 | 1278.76 | 3.17 |
| *Oreocnide integrifolia* | 10.93 | 29.03 | 1197.15 | 2.99 |
| *Microtropis latifolia* | 8.06 | 24.19 | 3017.98 | 2.84 |
| *Syzygium benthamianum* | 6.63 | 25.81 | 3383.84 | 2.82 |
| *Isonandra lanceolata* | 7.71 | 22.58 | 2583.62 | 2.61 |
| *Tetrastigma salcata* | 6.45 | 35.48 | 501.48 | 2.59 |
| *Glochidion neilgherrense* | 5.73 | 27.42 | 1563.70 | 2.37 |
| *Lasianthus acuminatus* | 5.91 | 32.26 | 259.80 | 2.31 |
| *Agrostistachys borneensis* | 10.93 | 14.52 | 1119.65 | 2.29 |
| *Agrostistachys indica* | 6.99 | 14.52 | 2193.51 | 2.05 |
| *Actinodaphne lawsonii* | 3.94 | 29.03 | 697.53 | 2.01 |
| *Hydnocarpus macrocarpa* | 4.66 | 16.13 | 2759.49 | 1.98 |
| *Saprosma fragrans* | 3.94 | 19.35 | 1746.48 | 1.81 |
| *Diospyros sp.* | 3.23 | 17.74 | 1900.45 | 1.67 |
| *Gordonia obtusa* | 1.97 | 11.29 | 3309.66 | 1.54 |
| *Litsea sp. 1* | 1.61 | 11.29 | 3168.77 | 1.47 |
| *Unidentified 1* | 6.63 | 11.29 | 335.65 | 1.43 |
| *Litsea sp.2* | 2.87 | 17.74 | 1013.56 | 1.42 |
| *Ficus nervosa* | 0.90 | 8.06 | 3611.16 | 1.33 |
| *Gnetum ula* | 3.76 | 16.13 | 341.31 | 1.30 |

*Cont'd …*

Table 2.15 *Cont'd...*

| | | | | |
|---|---|---|---|---|
| *Meliosma pinnata* | 1.97 | 11.29 | 1432.82 | 1.11 |
| *Diospyros sylvatica* | 2.15 | 14.52 | 294.84 | 1.02 |
| *Nothapodytes nimmoniana* | 2.51 | 12.90 | 444.86 | 1.02 |
| *Dysoxylum malabaricum* | 2.51 | 11.29 | 365.96 | 0.93 |
| *Aglaia lawii* | 1.08 | 9.68 | 1397.63 | 0.91 |
| *Syzygium caryophyllatum* | 1.08 | 4.84 | 2371.53 | 0.91 |
| *Sterculia guttata* | 1.79 | 9.68 | 937.58 | 0.89 |
| *Syzygium hemisphericum* | 1.25 | 8.06 | 1555.99 | 0.89 |
| *Coffea crassiflora* | 2.33 | 11.29 | 209.21 | 0.87 |
| *Ficus sp.* | 0.18 | 1.61 | 3167.03 | 0.84 |
| *Syzygium lanceolatum* | 1.61 | 11.29 | 486.39 | 0.84 |
| *Canarium strictum* | 1.43 | 9.68 | 858.77 | 0.83 |
| *Elaeocarpus tuberculatus* | 1.25 | 8.06 | 1167.98 | 0.80 |
| *Actinodaphne bourdillonii* | 2.15 | 9.68 | 160.28 | 0.76 |
| *Symplocos cochinchinensis* | 0.90 | 6.45 | 1468.48 | 0.75 |
| *Unidentified 2* | 1.25 | 8.06 | 882.18 | 0.74 |
| *Chionanthus sp.* | 0.54 | 3.23 | 2102.26 | 0.71 |
| *Beilschmedia wightii* | 1.97 | 3.23 | 1168.94 | 0.66 |
| *Ventilago bombaiensis* | 1.43 | 9.68 | 103.73 | 0.65 |
| *Acronychia pedunculata* | 1.61 | 6.45 | 601.15 | 0.64 |
| *Ficus beddomei* | 0.36 | 3.23 | 1929.75 | 0.64 |
| *Garcinia morella* | 1.08 | 6.45 | 785.81 | 0.61 |
| *Hajnia trijuaga* | 1.43 | 8.06 | 212.34 | 0.61 |
| *Eugenia sp.* | 0.90 | 6.45 | 826.69 | 0.60 |
| *Scolopia crenata* | 0.90 | 6.45 | 605.50 | 0.55 |
| *Debregeasia longifolia* | 1.25 | 8.06 | 56.94 | 0.54 |
| *Salacia oblonga* | 1.08 | 8.06 | 115.26 | 0.54 |
| *Syzygium bourdillonii* | 0.54 | 4.84 | 771.74 | 0.48 |
| *Ardisia pauciflora* | 1.08 | 6.45 | 11.96 | 0.43 |
| *Syzygium cumini* | 0.54 | 4.84 | 466.13 | 0.41 |
| *Meliosma simplicifolia* | 0.72 | 3.23 | 723.67 | 0.41 |
| *Sapium insigne* | 0.54 | 4.84 | 415.72 | 0.40 |
| *Eugenia bracteata* | 1.08 | 4.84 | 123.70 | 0.39 |
| *Symplocos sp.* | 0.54 | 4.84 | 383.04 | 0.39 |
| *Aphanomixis polystachya* | 0.72 | 4.84 | 130.44 | 0.35 |
| *Debregeasia ceilanica* | 0.72 | 4.84 | 33.72 | 0.33 |
| *Nothopegia recemosa* | 0.54 | 4.84 | 41.18 | 0.31 |
| *Shefflera venulosa* | 0.54 | 4.84 | 12.45 | 0.30 |
| *Cullenia exarillata* | 0.18 | 1.61 | 825.81 | 0.29 |
| *Maesa indica* | 1.08 | 3.23 | 60.52 | 0.29 |
| *Derris sp.* | 0.90 | 3.23 | 60.13 | 0.27 |
| *Persea macrantha* | 0.54 | 3.23 | 120.33 | 0.25 |
| *Shefflera sp.* | 0.54 | 3.23 | 45.08 | 0.23 |
| *Toddalia asiatica* | 0.54 | 3.23 | 15.03 | 0.22 |
| *Toona ciliata* | 0.36 | 3.23 | 31.77 | 0.20 |
| *Atlantia wightii* | 0.36 | 3.23 | 3.17 | 0.19 |
| *Orophea uniflora* | 0.36 | 3.23 | 15.21 | 0.19 |
| *Litsea sp.3* | 0.36 | 1.61 | 134.19 | 0.15 |
| *Cinnamomum perrottetii* | 0.36 | 1.61 | 29.66 | 0.13 |

*Cont'd ...*

Table 2.15 *Cont'd...*

| | | | | |
|---|---|---|---|---|
| *Caryota urens* | 0.18 | 1.61 | 27.76 | 0.11 |
| *Derris brevipes* | 0.18 | 1.61 | 30.34 | 0.11 |
| *Turpinia nepalensis* | 0.18 | 1.61 | 58.72 | 0.11 |
| *Lasianthus sp.* | 0.18 | 1.61 | 11.24 | 0.10 |
| *Elaeocarpus serratus* | 0.18 | 1.61 | 2.06 | 0.10 |
| *Tetrastigma leucostaphylum* | 0.18 | 1.61 | 3.67 | 0.10 |
| *Litsea sp.* | 0.18 | 1.61 | 1.43 | 0.10 |
| *Neolitsea cassia* | 0.18 | 1.61 | 14.68 | 0.10 |
| *Psychotria sp.* | 0.18 | 1.61 | 1.43 | 0.10 |
| *Litsea wightiana* | 0.18 | 1.61 | 2.06 | 0.10 |
| *Psychotria truncata* | 0.18 | 1.61 | 9.69 | 0.10 |
| **Total** | **810.75** | **---** | **427436.34** | **300.00** |

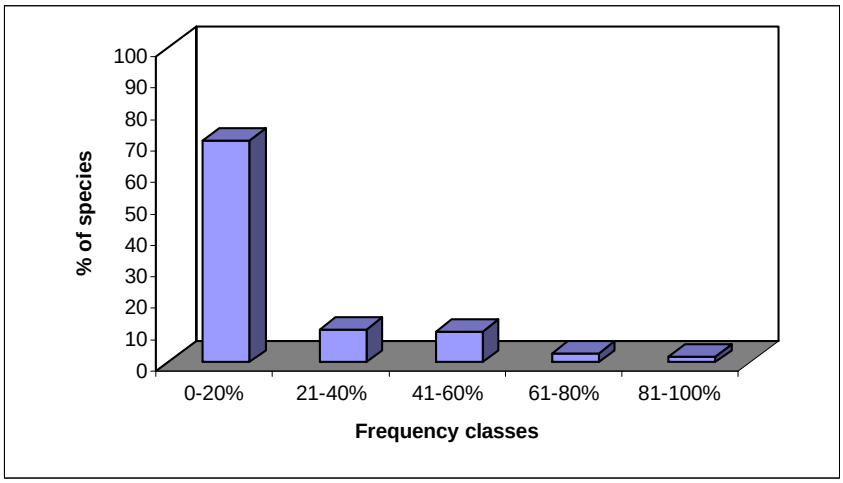


**Fig. 2.14. Percentage of frequency of species in subtropical hill forests**

**Table 2.16. Diversity indices values of subtropical hill forests**

| | |
|---|---|
| No. of species represented | 105 |
| No. of individuals/ha | 810 |
| Basal area ($m^2$ $ha^{-1}$) | 42.74 |
| Diversity index (Margalef, 1968) | 3.58 |
| Dominance index (Simpson, 1949) | 0.057 |
| Richness index (Menhinick, 1964) | 10.44 |
| Evenness index (Pielou, 1975) | 0.74 |

Since, this forest type is a transitional zone between the evergreen and shola forests, both evergreen and shola elements occur in the vegetation. This may indicate that this zone is suitable both for the evergreen and shola species and also for common species exclusively found in subtropical forests. Therefore, species diversity of subtropical forests is higher than evergreen and shola forests.

### 2.4.3.6. Southern subtropical hill savannahs

A total of 27 arborescent species consisting of 22 trees and 5 shrubs were recorded from this forest type, covering an area of 450 hectare. Most dominant and highly distributed species are *Wendlandia thyrsoidea* followed by *Gnidia glauca, Pterocarpus marsupium* and *Macaranga peltata.* Mean stem density of the forest type is 336 individuals per hectare. The percentage of species in various frequency classes are shown in Figure 2.15. Species with highest basal area is *Wendlandia thyrsoidea* and mean basal area of the forest type is 3.14 $m^2$/ha (>10 cm gbh) (Table 2.17).

**Table 2.17. Floristic composition and phytosociological parameters of savannahs**

| Species | Density | Frequency (%) | Basal area ($cm^2$/ha) | IVI |
|---|---|---|---|---|
| *Wendlandia thyrsoidea* | 91.11 | 100.00 | 8017.78 | 71.57 |
| *Gnidia glauca* | 46.67 | 100.00 | 1665.53 | 31.15 |
| *Pterocarpus marsupium* | 13.33 | 60.00 | 2887.47 | 21.19 |
| *Macaranga peltata* | 15.56 | 100.00 | 1007.53 | 17.93 |
| *Zizyphus rugosa* | 15.56 | 60.00 | 1123.27 | 14.94 |
| *Glochidion neilgherrence* | 13.33 | 60.00 | 958.53 | 13.52 |
| *Holigarna nigra* | 4.44 | 40.00 | 1589.51 | 11.28 |
| *Acronychia pedunculata* | 6.67 | 40.00 | 1211.20 | 10.54 |
| *Phyllanthus emblica* | 8.89 | 20.00 | 1392.36 | 10.29 |
| *Sapium insigne* | 6.67 | 60.00 | 572.07 | 9.72 |
| *Elaeocarpus munroni* | 6.67 | 40.00 | 669.53 | 8.38 |
| *Allophyllus cobbe* | 6.67 | 60.00 | 146.67 | 8.02 |
| *Maesa indica* | 6.67 | 40.00 | 470.40 | 7.59 |
| *Erythrina stricta* | 6.67 | 40.00 | 367.67 | 7.18 |
| *Hypericum mysurensis* | 8.89 | 40.00 | 150.93 | 7.08 |
| *Mallotus sp.* | 6.67 | 40.00 | 340.27 | 7.07 |
| *Clerodendrum viscosum* | 4.44 | 40.00 | 79.11 | 5.27 |
| *Syzygium benthamianum* | 2.22 | 20.00 | 598.04 | 4.86 |
| *Actinodaphne philippensis* | 2.22 | 20.00 | 518.40 | 4.54 |
| *Symplocos cochinchinensis* | 2.22 | 20.00 | 256.71 | 3.50 |
| *Neolitsea cassia* | 2.22 | 20.00 | 205.51 | 3.30 |
| *Diospyros sp.* | 2.22 | 20.00 | 170.84 | 3.16 |
| *Litsea floribunda* | 2.22 | 20.00 | 149.51 | 3.07 |
| *Bridelia scandens* | 2.22 | 20.00 | 139.38 | 3.03 |
| *Vernonia arborea* | 2.22 | 20.00 | 139.38 | 3.03 |
| *Cinnomomum sulphuratum* | 2.22 | 20.00 | 102.40 | 2.89 |
| *Gmelina arborea* | 2.22 | 20.00 | 64.18 | 2.74 |
| **Total** | **293.33** | **---** | **25143.69** | **300.00** |

Diversity index (Margalef, 1968) of 2.59 is a low value when compared to diversity index value of similar vegetation in Peppara Wildlife Sanctury (2.77).

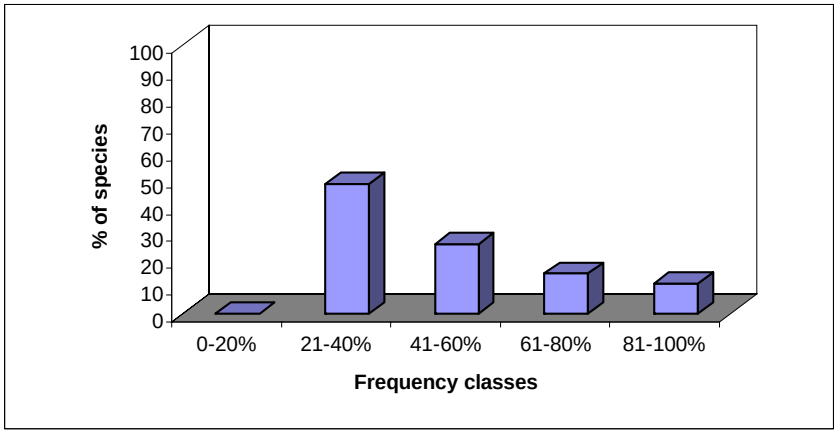


**Fig. 2.15. Percentage of frequency of species in subtropical savannahs**

**Table 2.18. Diversity indices values of savannahs**

| | |
|---|---|
| No. of species represented | 27 |
| No. of individuals/ha | 293 |
| Basal area ($m^2$ $ha^{-1}$) | 2.51 |
| Diversity index (Margalef, 1968) | 2.59 |
| Dominance index (Simpson, 1949) | 0.13 |
| Richness index (Menhinick, 1964) | 2.43 |
| Evenness index (Pielou, 1975) | 0.77 |

Concentration of dominance (Simpson, 1949) at New Amarambalam is 0.13, species richness (Menhinick, 1964) 2.43 and species evenness index (Pielou, 1975) 0.77 (Table 2.18).

### 2.4.3.7. Southern montane wet temperate forests (Sholas)

From the forest type at New Amarambalam, the total number of species recorded from five sample plots covering 450 ha area is 39, consisting of 32 tree, six shrub and one liana species. Dominant species in the forest type are *Turpinia nepalensis, Rhododendron arboreum, Symplocos obtusa* and *Syzygium calophyllifolium* and species which are rarely represented in the vegetation are *Ternstroemia japonica, Berberis tinctoria, Euodia lunu-ankenda* and *Gnidia glauca.* The mean stem density of the forest type is 1286 individuals/hectares. *Litsea wightiana, Turpinia nepalensis* and *Rhododendron arboreum* are the tree species with more wider distribution. The percentage of species in various frequency classes is shown in Figure 2.16. Species with high basal area are *Rhododendron arboreum, Turpinia nepalensis* and *Michelia nilagirica* and mean basal area (Table 2.19) cover of the forest type is 35.32 $m^2$/ha (>10 cm gbh).

**Table 2. 19. Floristic composition and phytosociological parameters of shola forests**

| Species | Density | Frequency (%) | Basal area ($cm^2$/ha) | IVI |
|---|---|---|---|---|
| *Turpinia nepalensis* | 157.78 | 100.00 | 43698.13 | 30.03 |
| *Rhododendron arboreum* | 151.11 | 100.00 | 43574.40 | 29.48 |
| *Syzygium calophyllifolium* | 88.89 | 80.00 | 21871.11 | 17.41 |
| *Litsea wightiana* | 68.89 | 100.00 | 21140.62 | 16.73 |
| *Symplocos obtuse* | 93.33 | 80.00 | 14185.73 | 15.57 |
| *Michelia nilagirica* | 42.22 | 80.00 | 27593.49 | 15.41 |
| *Syzygium densiflorum* | 33.33 | 100.00 | 23959.33 | 14.77 |
| *Rhodomyrtus tomentosa* | 71.11 | 100.00 | 5691.02 | 12.52 |
| *Microtropis ramiflora* | 57.78 | 80.00 | 12811.64 | 12.42 |
| *Litsea floribunda* | 37.78 | 60.00 | 13260.00 | 9.93 |
| *Vaccinium leschenaultii* | 26.67 | 40.00 | 17834.40 | 9.28 |
| *Memecylon flavescens* | 53.33 | 40.00 | 9792.00 | 9.07 |
| *Glochidion neilgherrense* | 42.22 | 60.00 | 7279.53 | 8.57 |
| *Ilex wightiana* | 37.78 | 20.00 | 15917.29 | 8.53 |
| *Ilex thwaitesii* | 28.89 | 40.00 | 5902.29 | 6.07 |
| *Symplocos gardneriana* | 17.78 | 20.00 | 8445.16 | 4.86 |
| *Ligustrum decaisnei* | 15.56 | 40.00 | 2394.00 | 4.04 |
| *Symplocos cochinchinensis* | 17.78 | 40.00 | 1195.20 | 3.87 |
| *Gaultheria fragrantissima* | 20.00 | 40.00 | 327.40 | 3.79 |
| *Pittosporum nilghirense* | 13.33 | 40.00 | 1529.60 | 3.62 |
| *Gomphandra coriacea* | 11.11 | 20.00 | 4746.11 | 3.29 |
| *Schefflera rostrata* | 8.89 | 40.00 | 86.76 | 2.86 |
| *Syzygium caryophyllaeum* | 4.44 | 20.00 | 3544.89 | 2.44 |
| *Acronychia pedunculata* | 4.44 | 20.00 | 2629.69 | 2.18 |
| *Pittosporum tetraspermum* | 6.67 | 20.00 | 570.87 | 1.76 |
| *Lasianthus acuminatus* | 6.67 | 20.00 | 187.40 | 1.65 |
| *Psychotria congesta* | 6.67 | 20.00 | 86.07 | 1.62 |
| *Viburnum erubescens* | 4.44 | 20.00 | 496.36 | 1.57 |
| *Litsea ligustrina* | 4.44 | 20.00 | 177.78 | 1.48 |
| *Actinodaphne bourdillonii* | 4.44 | 20.00 | 160.00 | 1.48 |
| *Cinnamomum wightii* | 4.44 | 20.00 | 65.60 | 1.45 |
| *Un identified1* | 2.22 | 20.00 | 557.51 | 1.41 |
| *Cinnamomum sp.* | 2.22 | 20.00 | 139.38 | 1.29 |
| *Gnidia glauca* | 2.22 | 20.00 | 120.18 | 1.28 |
| *Isonandra lanceolata* | 2.22 | 20.00 | 120.18 | 1.28 |
| *Actinodaphne malabarica* | 2.22 | 20.00 | 45.51 | 1.26 |
| *Euodia lunu-ankenda* | 2.22 | 20.00 | 21.51 | 1.26 |
| *Ternstroemia japonica* | 2.22 | 20.00 | 25.60 | 1.26 |
| *Berberis tinctoria* | 2.22 | 20.00 | 25.60 | 1.26 |
| **Total** | **1286.67** | **---** | **352549.51** | **300.00** |

Diversity index (Margalef, 1968) of the shola forest at New Amarambalam is 3.16, which is higher when compared to Mannavan shola (2.5) in Idukki District

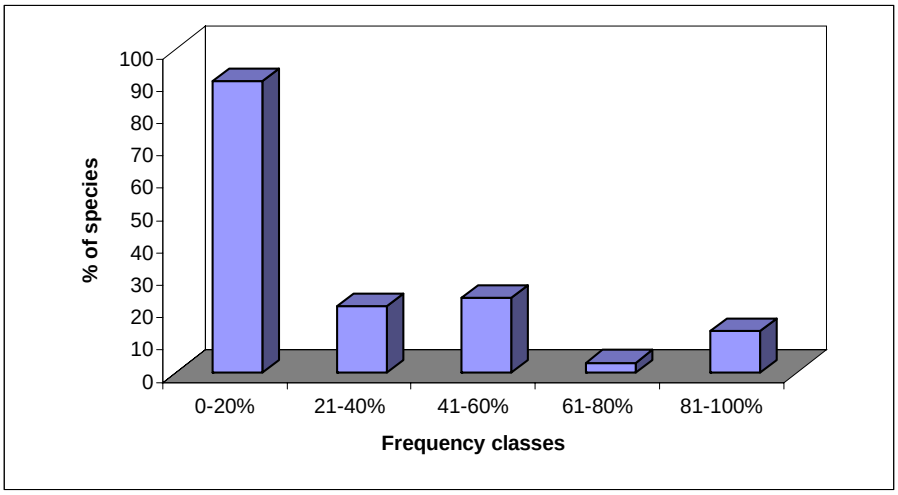


**Fig. 2.16. Percentage frequency of species in shola forests**

**Table 2. 20. Diversity indices values of shola forests**

| | |
|---|---|
| No. of species represented | 39 |
| No. of individuals/ha | 1286 |
| Basal area ($m^2$ $ha^{-1}$) | 35.25 |
| Diversity indices (Margalef, 1968) | 3.15 |
| Dominance index (Simpson, 1949) | 0.058 |
| Richness index (Menhinick, 1964) | 4.35 |
| Evenness index (Pielou, 1975) | 0.80 |

of Kerala. Dominance index (Simpson, 1949) value is 0.058 and the species richness (Menhinick, 1969) value of the forest type 4.35 with a species evenness (Pielou, 1975) value of 0.080 (Table 2.20).

### 2.4.4. Discussion

Comparison of phytosociological parameters and diversity indices of different vegetation types of New Amarambalam revealed the differences in their floristic structure. Regarding density, among the different vegetation types (Fig. 2.17), montane wet temperate forests shows the highest value of 1286 individuals/ha, followed by tropical evergreen (979), subtropical hill forests (810), tropical semievergreen (669), moist deciduous forests (315) and subtropical hill savannahs (293). With regard to basal area (Fig. 2.18), tropical evergreen forests have the largest coverage of 54.3 $m^2$/ha, followed by tropical semievergreen (48), subtropical hill forests (42.7), moist deciduous forests (39.7) and montane forests (35.3). The vegetation type at New Amarambalam having the least basal area is the subtropical savannahs (2.51). This low basal area of the vegetation type is due to poor gbh and

low density of arborescent species in the area. The values are compared in Table 2.21.

With regard to species diversity (Margalef, 1968), among different forest types, semievergreen forests have the highest value of 3.87 (Figs. 2.19, 2.20), followed by

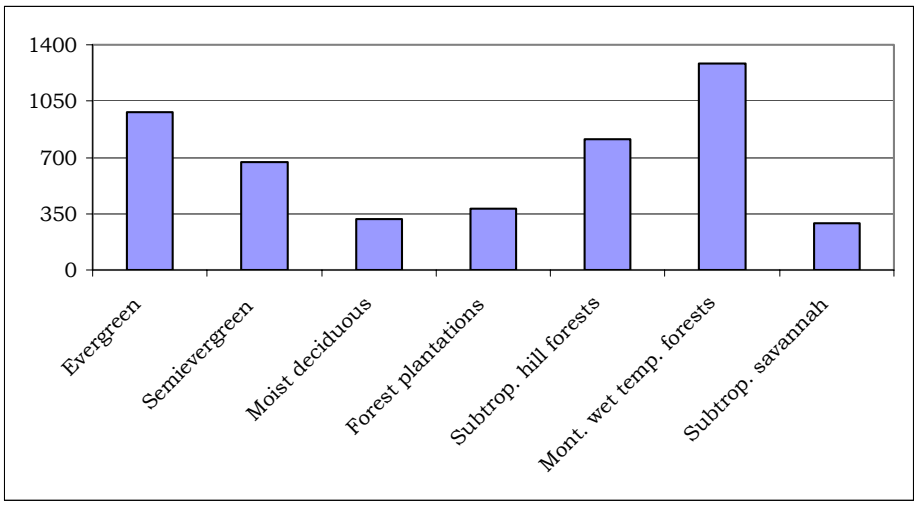


**Fig. 2.17. Comparison of tree density (individuals/ha) in different forest types at New Amarambalam**

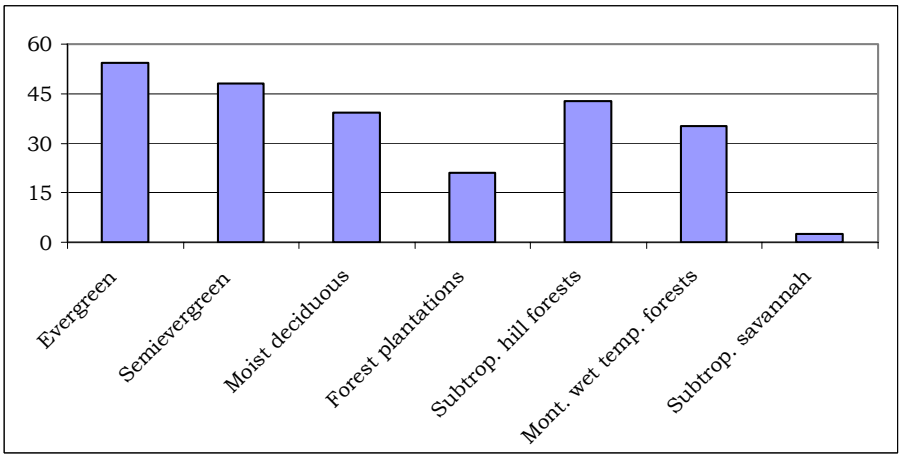


**Fig. 2.18. Comparison of basal area ($m^2$/ha) of trees different forest types of at New Amarambalam**

subtropical hill forests (3.58), evergreen forests (3.45), montane forests (3.15) and moist deciduous forests (3.05). The diversity value is least for subtropical hill savannahs (Table 2.21). This indicates that the semievergreen forests of New Amarambalam has individuals of various arborescent species distributed evenly, whereas, the population of tree species is less evenly distributed in the moist

deciduous forests and least even in the case of savannahs. Of course, species richness is also a factor contributing to the diversity values.

**Table 2. 21. Comparison of phytosociological parameters and diversity indices of different vegetation types of New Amarambalam**

| Vegetation types | Density | Basal area ($m^2$/ha) | Shannon's index | Simpson's index |
|---|---|---|---|---|
| Moist deciduous forests | 315 | 39.37 | 3.07 | 0.089 |
| Teak plantations | 382 | 21.15 | 1.60 | 0.49 |
| Tropical semievergreen forests | 669 | 48 | 3.87 | 0.054 |
| Tropical evergreen forests | 979 | 54.29 | 3.45 | 0.067 |
| Subtropical hill forests | 810 | 42.74 | 3.58 | 0.057 |
| Subtropical savannahs | 293 | 2.51 | 2.59 | 0.13 |
| Montane forests | 1286 | 35.25 | 3.15 | 0.058 |

### 2.4.4.1. Comparison of floristic diversity with other areas of Kerala

Comparison of diversity values of different vegetation types of New Amarambalam with those of other forest areas of Kerala revealed that New Amarambalam forests is richer than most of the other forest areas of the State except evergreen forests of

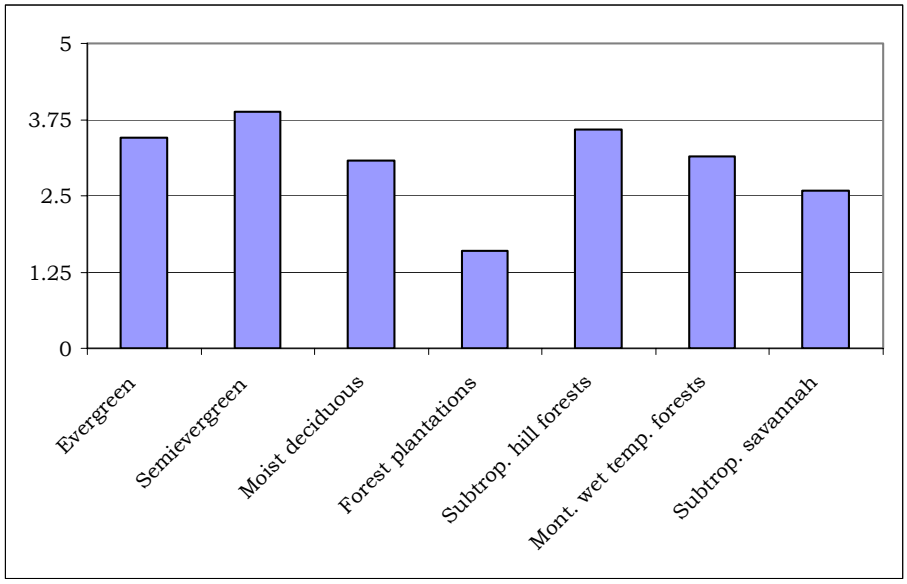


**Fig. 2.19. Comparison of tree diversity (Shannon's index) of different forest types of New Amarambalam**

Silent Valley and Attappady region. With regard to moist deciduous forests, Shannon's index value of New Amarambalam is 3.07, which is higher than the index value of Aralam (1.90), Peppara (2.7, 2.28) and Chimmony (1.85-2.37). For semievergreen forests, the diversity value of the study area is 3.89, which is higher than the index value of Idukki (2.11), Aralam (2.71), Agasthyavanam

Biological Park area (2.82), and Peppara (2.94) and Chimmony Wildlife Sanctuaries (2.70-3.20). For the evergreen forests of New Amarambalam, Shannon's index value is 3.45, which is slightly lower than Silent Valley (3-3.9), Attappady (4) and Nelliampathy (3-3.7) and higher than Achenkovil (1.5-2.2) and Agastyamalai (2.35-3.07). Diversity value of subtropical hill forests of New Amarambalam is 3.58, which is higher than the value for Peppara (2.77), Eravikulam (3.38) and Kolli hills (2.24-3.45). For the montane forests of New Amarambalam, Shannon's index value is 3.15, which is also higher than Eravikulam (2.75-2.92) and Kanthallur (3.05), (Table 2.22).

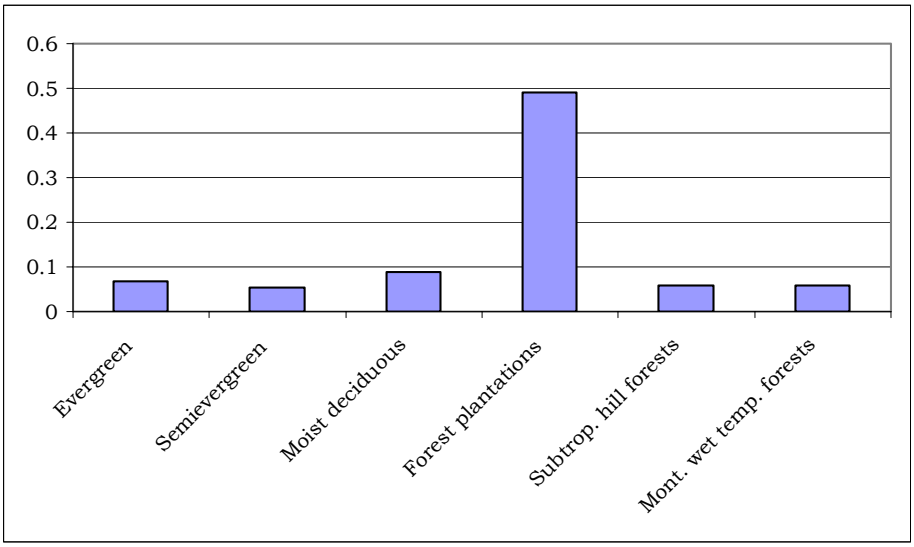


**Fig. 2.20. Comparison of tree diversity (Simpson's index) of different forest types of New Amarambalam**

**Table 2.22. Comparison of diversity indices with other areas**

| Forest types | Forest areas | Authority | Shannon's Index |
|---|---|---|---|
| Tropical moist deciduous forests | New Amarambalam | Present study | **3.07** |
| | Aralam | Menon, 1997 | 1.96 |
| | Peppara | Vargheese, 1997 | 2.28 |
| | Agastyamalai | Sanal kumar, 1997 | 2.09-3.12 |
| | Chimmony, 1997 | Suraj, 1997 | 1.85-2.37 |
| Tropical semimevergreen forests | New Amarambalam | Present study | **3.89** |
| | Idukki | Sanal, 1997 | 2.11 |
| | Aralam | Menon, 1997 | 2.71 |
| | Agasthyavanam BP | Vargheese, 1997 | 2.82 |
| | Peppara | Vargheese, 1997 | 2.94 |
| | Kolli hills | Lakshmi, 1997 | 3.22 |
| | Agastyamalai | Sanal, 1997 | 2.4-3.5 |
| | Chimmony | Suraj, 1997 | 2.70-3.20 |
| Tropical evergreen forests | New Amarambalam | Present study | **3.45** |
| | Silent Valley | Basha, 1992 | 3-3.9 |
| | Nelliampathi | Chandrashekara, 1998 | 3-3.7 |

*Cont'd...*

Table 2.22. *Cont'd...*

| | | | |
|---|---|---|---|
| | Nilambur<br>Attappadi<br>Agastyamalai<br>Peppara<br>Agastyamalai | Sanal, 1997<br>Pascal, 1988<br>Sanal, 1997<br>Vargheese & Menon, 1998<br>Vargheese & Balasubramaniyan, 1999 | 3.5<br>4<br>2.35-3.00<br>3.25<br>3.14 |
| Subtropical hill forests | New Amarambalam<br>Peppara<br>Eravikulam<br>Kolli hills | Present study<br>Vargheese, 1997<br>Suresh Babu, 1998<br>Lakshmi, 1995 | **3.58**<br>2.77<br>3.38<br>2.74-3.45 |
| Subtropical savannahs | New Amarambalam | Present study | **2.57** |
| Montane temperate forests | New Amarambalam<br>Eravikulam<br>Kanthalur | Present study<br>Suresh Babu, 1998<br>Swarupanandan *et al.*, 1998 | **3.15**<br>2.75-2.95<br>3.05 |

### 2.4.4.2. Threats to the floristic diversity of New Amarambalam

Moist deciduous forests at Nedumkayam, Kanjirakadavu, Paduka, Uchakulam, Kalkulam, Saivila and others very near to human habitation, are highly disturbed due to destructive collection of firewood by the local people and also tribals (Fig. 2.21). During summer season, forest dwellers and locals burn the undergrowth of

**Fig. 2.21. Collection of firewood from New Amarambalam forests**

the forests for easy collection of firewood and to scare away elephants from the area. Cattle grazing is yet another destructive factor of plant diversity here. As a result of such disturbances, sapling and pole stages of trees are much less and seedlings are very rare in these areas. This is a sign of recovering disturbances. During the study, it has been observed that large quantities *Calamus* stems (Fig.

2.22) are collected from the shola region by the local tribals and laborers, including those from Tamil Nadu,. Tribals of New Amarambalam collect NWFP like Black dammer (*Canarium strictum*), Cheevaka, (*Acacia sinuata*), Nutmeg (*Myristica dactyloides*), honey, etc. and sell to tribal society for the purchase of provisions and

**Fig. 2.22. Collection of canes from New Amarambalam forests**

other food materials (Fig. 2.23). They extract Black dammer from the bark of *Canarium strictum* by wounding the bark and also burning the wounded portion for the easy exudation of the resin. Bamboo extraction is also quite frequent in

**Fig. 2.23. Collection and processing of NWFP for sale**

bamboo rich areas like Mancheri, Paduka, Panapuzha and Kanjirakadavu. Seasonal fire in the montane grasslands of Mukurthi areas by Tamil Nadu people and tourists, causes the destruction of grassland flora as well as trees and

seedlings along the fringes of shola forests, thereby reducing the extent of shola forests in the region.

Poaching of animals and fishing is common in New Amarambalam by local people. Fishing is done with the help of Copper sulphate ($CuSO_4$) and explosives (Thotta), which results in mass killing of fish fauna and other aquatic oraganisms. Tribals (Chola Naikans and Pathi Naikans) of New Amarambalam, who lead a nomadic and hunter-gatherer lifestyle, hunt animals like Deer, Nilghiri langur, Lion-tailed macaque, Malabar giant squirrel, etc. with the help of different types of traps.

Such man made activities cause much loss to the biodiversity of New Amarambalam. So, there is an urgent need to protect this rich and diverse forest wealth, which form part of Nilgiri Biosphere Reserve. Since, floristic richness and diversity of New Amarambalam is higher than other forest areas of Kerala (Table 2.22), the area acquires more importance from a conservation point of view, and what is essential is to protect the rich floristic and faunistic wealth of the area through more location-specific management strategies rather than the overall protection offered for the area as part of the Nilgiri Biosphere Reserve.

## Appendix 2.1. Floristic enumeration

**MAGNOLIACEAE**

***Michelia nilagirica*** Zenk., Pl. Ind. 21. t. 20. 1835.

Common in the shola forests; flowers and fruits during February to May (Mukuruthi, JR 8590).

*Distribution*: Endemic to south Western Ghats of Peninsular India.

**DILLENIACEAE**

***Dillenia pentagyna*** Roxb., Pl. Corom. 1: 21, t. 20. 1795

Common in the deciduous and semievergreen forests; flowers and fruits during January to May (Panapuzha, Mancheri, Nedunkayam, JR 8500).

*Distribution*: India, China, Java.

**ANNONACEAE**

***Artabotrys zeylanicus*** Hook.f. *et* Thoms., Fl. Ind. 128. 1855.

Common in the evergreen and semievergreen forests at low elevations; flowers and fruits during September to May (Karimpuzha, Poochapara, Panapuzha, JR 20479).

*Distribution*: Peninsular India, Sri Lanka.

***Meiogyne pannosa*** (Dalz.) Sinclair, Sarawak Mus. J. 5: 604. 1951.

Fairly common in the evergreen forests at low elevation; flowers and fruits during March to May (Thalichola, Manakadavu, Poochapara, *RJ* 8501).

*Distribution*: India.

***Miliusa tomentosa*** (Roxb.) Sinclair, Gard. Bull. Singapore 14: 378. 1955.

Occasional in the deciduous forests; flowers and fruits during December to February (Nedunkayam, Moochala, *RJ* 22353).

*Distribution*: India, Sri Lanka, Nepal.

***Orophea erythrocarpa*** Bedd., Madras J. Lit. Sci. 22: 71. 1861.

Occasional in the semievergreen and evergreen forests of low elevations; flowers and fruits during December to February (Panapuzha, Meenmutti, *RJ* 22351).

*Distribution*: Western Ghats of Peninsular India.

***Orophea uniflora*** Hook.f., *et* Thoms., Fl. Ind. 111. 1855.

Fairly common in the evergreen forests; flowers and fruits during February to June (Manakadavu, Pullukuthimala, *RJ* 22352).

*Distribution*: Endemic to South India.

***Polyalthia coffeoides*** (Thw. *ex* Hook.f. *et* Thoms.) Thw., Enum. Pl. Zeyl. 399. 1864.

Occasional, in the evergreen forests; flowers and fruits during June to October (Irumbanchola, Karimpuzha, *RJ* 22301).

*Distribution*: Peninsular India, Sri Lanka.

***Polyalthia fragrans*** (Dalz.) Bedd., Fl. Sylvat. 74. 1871.

Very common in the semievergreen forests; flowers and fruits during April to September (Panapuzha, Thalichola, Meenmutti, *RJ* 8502).

*Distribution*: Western Ghats of Peninsular India.

**MENISPERMACEAE**

***Anamirta cocculus*** (L.) Wt. *et* Arn., Prodr. 446. 1834.

Fairly common in the deciduous and semievergreen forests, especially along river sides; flowers and fruits during August to March (Vilakumala, Panapuzha, Mancheri, *RJ* 8503).

*Distribution*: India, Sri Lanka, South-East Asia, New Guinea.

***Diploclisia glaucescens*** (Bl.) Diels in Engl., Pflanzenr. 4. 94: 225. 1910.

Fairly common along river sides in the semievergreen and evergreen forests; flowers and fruits during February to April (Mancheri, Panapuzha, *RJ* 9227).

*Distribution*: Tropical Asia.

***Tiliacora acuminata*** (Lamk.) Miers., Ann. Mag. nat. Hist. 7: 39. 1851.

Fairly common in the deciduous and semievergreen forests; flowers and fruits during October to May (Nedunkayam, Mancheri, *RJ* 22302).

*Distribution*: India, Nepal, Sri Lanka.

**BERBERIDACEAE**

***Berberis tinctoria*** Lesch., Mus. Nat. Hist. Soc. 9: 306. 1822.

Very rare in the edges of shola forests; flowers and fruits during February to June (Mukuruthi, *RJ* 22364).

*Distribution*: Endemic to Nilgiri Biosphere Reserve.

**FLACOURTIACEAE**

***Flacourtia montana*** Grah., Cat. Pl. Bombay 10. 1839.

Fairly common in the semievergreen and evergreen forests; flowers and fruits during January to April (Irumbanchola, Panapuzha, *RJ* 8504).

*Distribution*: Western Peninsular India.

***Hydnocarpus macrocarpa*** (Bedd.) Warb. in Engl. *et* Prantl, Pflanzenfam. 3, 6a: 21. 1893.

Occasional in the evergreen forests; flowers and fruits during February to June (Ganiyamala, *RJ* 8505).

*Distribution*: Western Ghats.

***Hydnocarpus pentandra*** (Buch.-Ham.) Oken, Allg. Natur. 3(2): 1381. 1841.

Common in the deciduous and semievergreen forests, especially in river sides and water logged areas; flowers and fruits during January to July (Nedunkayam, Panapuzha *RJ* 8505).

*Distribution*: South-West India.

***Scolopia crenata*** (Wt *et* Arn.) Clos., Ann. Sci. Nat. Bot. 4,8: 250. 1857.

Fairly common in the evergreen forests of low elevations; flowers and fruits during January to April (Meenmutti, Erumala, *RJ* 22303).

*Distribution*: India to Malesia.

**PITTOSPORACEAE**

***Pittosporum neilgherrense*** Wt. *et* Arn., Prodr. 154. 1834.

Rare in the shola forests; flowers and fruits during July to Decembar (Mukuruthi, *RJ* 22361).

*Distribution*: South-West India.

***Pittosporum tetraspermum*** Wt. *et* Arn., Prodr. 154. 1834.

Fairly common in the shola forests and subtropical hill forests; flowers and fruits during February to May (Mukuruthi, Pullukuthimala, *RJ* 21343, 21409).

*Distribution*: South-West India, China, Vietnam, Sri Lanka.

**POLYGALACEAE**

***Xanthophyllum arnottianum*** Wt., Ill. 1: 50 t. 23. 1840.

Common in the semievergreen and evergreen forests; flowers and fruits during January to March (Thalichola, Panapuzha, Meenmutti, etc. *RJ* 9346).

*Distribution*: India, Malesia, Sri Lanka.

**HYPERICACEAE**

***Hypericum mysurense*** Heyne *ex* Wt. *et* Arn., Prodr. 99. 1834.

Common in the savannahs and open rocky areas of higher ghats; flowers and fruits during December to March (Erumala, Vilakumala, *RJ* 21331).

*Distribution*: Western Ghats of Peninsular India, Sri Lanka.

**CLUSIACEAE**

***Calophyllum polyanthum*** Wall. *ex* Choisy, Deser. Guttif. Ind. 43. 1849.

Common in the semievergreen and evergreen forests; flowers and fruits during December to April (Vilakumala, Panapuzha, Karimpuzha, etc. *RJ* 21442).

*Distribution*: South-West India, Malesia, China.

***Calophyllum austroindicum*** Kosterm. *ex* Sterens J. Arnold Arbor. 61. 250. 1980.

Fairly common in the evergreen forests of higher elevation and subtropical hill forests; flowers and fruits during March to June (Pullukuthimala, Kedakamala, *RJ* 8506).

*Distribution*: Southern Western Ghats.

***Garcinia gummi-gutta*** (L.) Robson, Brittonia 20: 103. 1968.

Fairly common in the evergreen and subtropical forests; flowers and fruits during January to September (Meenmutti, Pullukuthimala, Ganiyamala, Karimpuzha, *RJ* 21641).

*Distribution*: Peninsular India in the Western Ghats.

***Garcinia morella*** (Gaertn.) Deser. in Lamk., Encycl. 8: 701. t. 405. J. 2. 1792.

Common in the semievergreen and evergreen forests; flowers and fruits during January to August (Vilakumala, Karimpuzha, Pullukuthimala, Goddamaripotti, *RJ* 20439, 21265).

*Distribution*: India, Sri Lanka, Malesia.

***Mesua ferrea*** L., Sp. Pl. 515. 1753.

Very common in the evergreen and subtropical hill forests; flowers and fruits during January to June (Ganiyamala, Pullukuthimala, *RJ* 22304).

*Distribution*: South India, Sri Lanka.

**THEACEAE**

***Eurya nitida*** Korth. in Termminck., Verh. Nat. Gesch. Bot. 3: 115. t. 1840.

Fairly common in the shola forests; flowers and fruits during January to June (Mukuruthi, *RJ* 21567, 21469).

*Distribution*: India to Malesia.

***Gordonia obtusa*** Wall. *ex* Wt. *et* Arn. Prodr. 87. 1834.

Common in the subtropical hill forests of and shola forests especially along river sides; flowers and fruits during January to May (Pullukuthimala, Mukuruthi, *RJ* 9176, 21405).

*Distribution*: Western Ghats of India.

**DIPTEROCARPACEAE**

***Hopea parviflora*** Bedd., Fl. Sylvat. t. 7. 1869.

Fairly common in the deciduous and semievergreen forests; flowers and fruits during March to June (Panapuzha, Nedunkayam, *RJ* 22304).

*Distribution*: South-West India.

***Hopea ponga*** (Dennst.) Mabb., Taxon 28: 587. 1979.

Fairly common in the deciduous and semievergreen forests especially along the river banks; flowers and fruits during March to May (Panapuzha, Nedunkayam, *RJ* 22305 ).

*Distribution*: South-West India.

***Ternstroemia japonica*** (Thumb.) Thumb., Trans. Linn. Soc. London 2: 335. 1794.

Fairly common in the shola forests; flowers and fruits during November to March (Mukuruthi, *RJ* 21763, 21394).

*Distribution*: Endemic to Peninsular India.

**ANCISTROCLADACEAE**

***Ancistrocladus heyneanus*** Wall. *ex* Graham, Cat. Pl. Bombay 28: 1839.

Fairly common in the semievergreen and evergreen forests; flowers and fruits during March to May (Pullukuthimala, *RJ* 9197).

*Distribution*: Western Peninsular India.

**BOMBACACEAE**

***Bombax ceiba*** L., Sp. Pl. 511: 1753.

Fairly common in the deciduous and semievergreen forests; flowers and fruits during February to June (Vilakumala, Panapuzha, Mancheri, *RJ* 8507).

*Distribution*: Tropical Asia, New Guinea.

***Ceiba pentandra*** (L.) Gaertn., Fruct. Sem. Pl. 2. 144. t. 133. 1791.

An exotic tree, fairly common in the disturbed deciduous forests and teak plantations; flowers and fruits during January to May (Nedunkayam, Mancheri, *RJ* 22305).

*Distribution*: Throughout the tropics.

***Cullenia exarillata*** Robyns, Bull. Jard. Bot. Nat. Belg. 40: 249. t. 213. 1970.

Common in the evergreen forests; flowers and fruits during December to June (Ganiyamala, Pullukuthimala, *RJ* 21500).

*Distribution*: Endemic to South-West India.

**STERCULIACEAE**

***Helicteres isora*** L., Sp. Pl. 963: 1753.

Common in the deciduous forests and teak plantations; flowers and fruits during September to May (Nedunkayam, Paduka, Vilakumala, Mancheri, *RJ* 22306).

*Distribution*: India to Australia.

***Pterospermum diversifolium*** Bl., Bijdr. 88. 1825.

Occasional in the semievergreen and evergreen forests; flowers and Fruits during November to May (Panapuzha, Meenmutti, *RJ* 22307).

*Distribution*: Peninsular India to Malesia.

***Pterospermum rubiginosum*** Heyne *ex* Wt. *et* Arn., Prodr. 68. 1834.

Rarely seen in the semievergreen and evergreen forests; flowers and fruits during January to July (Meenmutti, Manakadavu, *RJ* 22308).

*Distribution*: South and North East India.

***Pterygota alata*** (Roxb.) R. Br. in Bennett *et* Br., Pl. Jar. Rar. 234. 1844.

Very common in the semievergreen forests; flowers and fruits during March to December (Karimpuzha, Meenmutti, Irumbanchola, *RJ* 22309).

*Distribution*: South-West and East India.

***Sterculia guttata*** Roxb.*ex* DC., Prodr. 1: 482. 1824.

Very common in the semievergreen forests; flowers and fruits during November to May (Panapuzha, Erumala, Mancheri, Nedunkayam, *RJ* 21623, 21310).

*Distribution*: Peninsular India, Sri Lanka, Malesia.

***Sterculia urens*** Roxb., Pl. Cor. t. 24. 1795.

Occasional in the deciduous forests and also in open rocky areas of higher ghats; flowers and fruits during November to March (Vilakumala, Panapuzha, *RJ* 20445).

*Distribution*: India, Sri Lanka, Malesia.

**TILIACEAE**

***Grewia tiliaefolia*** Vahl, Symb. Bot. 1: 35. 1790.

Fairly common in the deciduous and semievergreen forests; flowers and fruits during March to July (Nedunkayam, Mancheri, Panapuzha, *RJ* 22310).

*Distribution*: Tropical Africa, India, Burma.

***Grewia umbellifera*** Bedd., For. Man. Bot. 37. 1871.

Rare in the semievergreen forests and rocky open areas of higher ghats; flowers and fruits during September to February (Erumala, Karimpuzha, *RJ* 21401).

*Distribution*: SouthWest India.

**ELAEOCARPACEAE**

***Elaeocarpus glandulosus*** Wall. *ex* Merr., J. Arnold Arbr. 32. 194. 1951.

Common in the semievergreen and evergreen forests; flowers and fruits during August to March (Punchakolli, Karimpuzha, Meenmutti, Manakadavu, *RJ* 21329).

*Distribution*: South Asia.

***Elaeocarpus munronii*** (Wt.) Mast. in Hook.f., Fl. Brit. India 1: 407. 1874.

Common in the subtropical hill forests and also sholas; flowers and fruits during October to April (Erumala, Mukuruthi, Ganiyamala, *RJ* 21329).

*Distribution*: Western Ghats of Peninsular India.

***Elaeocarpus recurvatus*** Corner in Gard. Bull. Straits Settl. 10: 324. 1939.

Rare in the shola forests; flowers and fruits during May to October (Mukuruthi, *RJ* 21571).

*Distribution*: Endemic to South India.

***Elaeocarpus serratus*** L., Sp. Pl. 515. 1753.

Fairly common in the semievergreen and evergreen forests; flowers and fruits during March to June (Thalichola, Karimpuzha, *RJ* 8508).

*Distribution*: India, Sri Lanka, Nepal, Bhutan, Myanmar, China, Malaysia and Indonesia.

***Elaeocarpus tuberculatus*** Roxb., Fl. Ind. 2: 594. 1832.

Common in the semievergreen and evergreen forests; flowers and fruits during January to August (Panapuzha, Meenmutti, Manakadavu, *RJ* 9543, 21204).

*Distribution*: India, Malesia.

**MALPIGHIACEAE**

***Hiptage benghalensis*** (L.) Kurz, J. Asiat. Soc. Bengal 43(2): 136. 1874.

Fairly common in the semievergreen and evergreen forests of low elevation; flowers and fruits during March to October (Karimpuzha, Meenmutti, *RJ* 22311).

*Distribution*: India, Sri Lanka, Myanmar, South China, Taiwan, Indonesia, Malesia, Philippines.

**RUTACEAE**

***Acronychia pedunculata*** (L.) Miq., Fl. Ind. Bot. Suppl. 532. 186.

Occasional along the edges of the savannahs and also inside the shola forests; flowers and fruits during August to December (Vilakumala, Erumala, *RJ* 20414).

*Distribution*: India to Malesia.

***Atlantia wightii*** Tanaka, Bull. Soc. Bot. France 75: 714. 1928.

Common in the semievergreen and evergreen forests; flowers and fruits during January to March (Panapuzha, Karimpuzha, Irumbanchola, *RJ* 8509).

*Distribution*: Peninsular India in the Western Ghats.

***Clausena heptaphylla*** (Roxb.) Wt. *et* Arn., Prodr. 95. 1834.

Fairly common in the semievergreen and evergreen forests; flowers and fruits during May to September (Karimpuzha, Thalichola, *RJ* 8510).

*Distribution*: India, Myanmar.

***Euodia lunu-ankenda*** (Gaertn.) Merr., Phillip. J. Sci. Bot. 7: 378. 1913.

Fairly common in the subtropical hill forests and also rarely seen in shola forests; flowers and fruits during September to January (Erumala, Kedakamala, *RJ* 21628).

*Distribution*: India, Malesia.

***Luvunga sarmentosa*** (Bl.) Kurz, J. Asiat. Soc. Bengal 39: 69. 1879.

Fairly common in the evergreen forests; flowers and fruits during September to May (Meenmutti, *RJ* 22312).

*Distribution*: India to Malesia.

***Naringi crenulata*** (Roxb.) Nicols. in Sald. *et* Niclos., Fl. Hassan Dt. 387. 1976.

Fairly common in the deciduous and semievergreen forests; flowers and fruits during April to September (Panapuzha, Mancheri, *RJ* 8512).

*Distribution*: India.

***Toddalia asiatica*** (L.) Lamk., Tabl. Encycl. 2. 116. 1797.

Rare in semievergreen, evergreen and shola forests; flowers and fruits during December to April (Manakadavu, Kedakamala, Mukuruthi, *RJ* 21408).

*Distribution*: India, Sri Lanka, Malesia.

***Vepris bilocularis*** (Wt. *et* Arn.) Engl. in Engl. *et* Prantl, Pflanzenfam. 3(4): 178. 1896.

Fairly common in the semievergreen and evergreen forests at low elevations; flowers and fruits during April to July (Manakadavu, Karimpuzha, Panapuzha, Irumbanchola, *RJ* 21515).

*Distribution*: South-West India.

***Zanthoxylum rhetsa*** (Roxb.) DC., Prodr. 1: 728. 1824.

Fairly common in the deciduous and semievergreen forests; flowers and fruits during December to March (Irumbanchola, Nedunkayam, *RJ* 22313).

*Distribution*: India to Malesia.

**BURSERACEAE**

***Canarium strictum*** Roxb., Fl. Ind. 3. 1832.

Fairly common in the evergreen forests; flowers and fruits during June to November (Irumbanchola, Pullukuthimala, Vilakumala, *RJ* 22314).

*Distribution*: India to Myanmar.

**MELIACEAE**

***Aglaia indica*** (Hook.f.) Harms in Engl. *et* Prantl., Pflanzenfam. (ed. 2) 1: 146. 1940.

Common undergrowth in the evergreen forests; flowers and fruits during December to March (Pullukuthimala, Manakadavu, Irumbanchola, *RJ* 8513).

*Distribution*: Peninsular India in the Western Ghats.

***Aglaia lawii*** (Wt.) Sald. in Sald. *et* Nicol., Fl. Hassan Dist. 392. 1776.

Occasional in the evergreen forests; flowers and fruits during March to July (Meenmutti, Manakadavu, Karimpuzha, *RJ* 22360).

*Distribution*: Endemic to Western Ghats of Peninsular India.

***Aphanamixis polystachya*** (Wall. *ex* Roxb.) Parker, Indian For. 57: 486. 1931.

Common in the evergreen forests; flowers and fruits during November to January (Manakadavu, Meenmutti, Pullukuthimala, *RJ* 8514).

*Distribution*: India to Malesia.

***Cipadessa baccifera*** (Roth) Miq., Mus. Bot. Lugd. Bat. 4: 6. 1868.

Fairly common in the evergreen and semievergreen forests; flowers and fruits during May to October (Pullukuthimala, Thalichola, Karimpuzha, *RJ* 20422).

*Distribution*: Peninsular India, Sri Lanka, Java.

***Dysoxylum malabaricum*** Bedd. *ex* Hiern in Hook.f., Fl. Brit. India 1: 548. 1875.

Fairly common in the evergreen forests; flowers and fruits during March to July (Irumbanchola, Thalichola, Manakadavu, *RJ* 20452).

*Distribution*: Western Peninsular India.

***Melia azedarach*** L., Sp. Pl. 384. 1753. Hook.f., Fl. Brit. India 1: 544. 1875.

Fairly common in the deciduous forests and rare in semievergreen forests; flowers and fruits during February to August (Panapuzha, *RJ* 8515).

*Distribution*: Tropical Asia, Australia, Africa.

***Reinwardtiodendron anamallayanum*** (Bedd.) Sald. in Sald. *et* Nicols., Fl. Hassan Dt. 392. 1976.

Very common in the evergreen and semievergreen forests; flowers and fruits during March to June (Panapuzha, Irumbanchola, Karimpuzha, Meenmutti, *RJ* 8531).

*Distribution*: South-West India.

***Swietenia macrophylla*** King in Hook.f., Ic. Pl. t. 1550. 1886.

Planted (Nedumkayam area, *RJ* 9345).

*Distribution*: Tropical America, West Indies; introduced in India.

***Toona ciliata*** Roem., Syn. Hesper. 139. 1846.

Occasional in the semievergreen and evergreen forests at low elevations; flowers and fruits during December to April (Panapuzha, Meenmutti, *RJ* 21705).

*Distribution*: India, Pakistan, Myanmar to Malesia, Australia.

***Trichilia cannaroides*** (Wt. *et* Arn.) Bentvelzen in Acta Bot. Neerl. 11: 13. 1962.

Fairly common in the evergreen forests; flowers and fruits during February to October (Pullukuthimala, Manakadavu, Meenmutti, *RJ* 22364).

*Distribution*: India, Malesia.

***Walsura trifolia*** (A. Juss.) Harms in Engl. *et* Prantl, Pflanzenf. ed. 2. 19 b: 119, 177. 1940.

Rare, in the evergreen forests; flowers and fruits during October to February (Karimpuzha, *RJ* 22315).

*Distribution*: Peninsular India, Sri Lanka.

**OLACACEAE**

***Erythropalam scandens*** Bl., Bijdr. 922. 1826.

Common in the evergreen and semievergreen forests, mostly seen along river sides; flowers and fruits during January to April (Panapuzha, Manakadavu, *RJ* 20511).

*Distribution*: Peninsular India in the Western Ghats.

**ICACINACEAE**

***Apodytes dimidiata*** E. Mayer *ex* Arn. in Hook., J. Bot. 3: 155. 1840.

Fairly common in the evergreen and semievergreen forests; flowers and fruits during March to October (Manajkallan, *RJ* 22316).

*Distribution*: Peninsular India, Sri Lanka, Myanmar, Indo-China, Malesia, North-East to South Africa, Angola, Conorus, Medagaskar, Mauritius, Thailand.

***Gomphandra coriacea*** Wt., Ill. 1: 103. 1840.

Fairly common in the evergreen and shola forests; flowers and fruits during December to April (Erumala, Mukuruthi, *RJ* 21462, 21761).

*Distribution*: Western Ghats of Peninsular India.

***Gomphandra tetrandra*** (Wall.) Sleumer., Notizbl. Bot. Gard. Berlin-Dahlem 15: 238. 1940.

Fairly common in the evergreen and semievergreen forests; flowers and fruits during March to September (Meenmutti, Irumbanchola, Karimpuzha, *RJ* 21611, 21232).

*Distribution*: South-West India, Sri Lanka.

***Nothapodytes nimmoniana*** (Grah.) Mabb. in Mani., Bot. Hist. Hort. Malab. 88. 1980.

Fairly common in the evergreen forests; flowers and fruits during December to March (Meenmutti, Ganiyamala, *RJ* 21291).

*Distribution*: India, China, Malesia.

***Sarcostigma kleinii*** Wt. *et* Arn., Edinberg New Philos. J. 14: 209. 1833.

Fairly common in the evergreen and semievergreen forests; flowers and fruits during December to April (Karimpuzha, Meenmutti, *RJ* 20521).

*Distribution*: South India, Malesia.

**AQUIFOLIACEAE**

***Ilex wightiana*** Wall. *ex* Wt., Ic. t. 1216. 1848.

Fairly common in the shola forests; flowers and fruits during January to April (Mukuruthi, *RJ* 8517).

*Distribution*: Endemic to Western Ghats of Peninsular India.

**CELASTRACEAE**

***Celastrus paniculatus*** Willd., Sp. Pl. 1: 1125. 1797.

Fairly common in the deciduous and semievergreen forests especially in river banks; flowers and fruits during February to April (Meenmutti, Karimpuzha, Mancheri, *RJ* 22306).

*Distribution*: South Asia, Australia.

***Euonymous angulatus*** Wt., Ic. t. 1053. 1846.

Occasional in the shola forests; flowers and fruits during January to April (Mukuruthi, *RJ* 8591).

*Distribution*: Western Ghats.

***Microtropis latifolia*** Wt. *ex* Laws. in Hook.f., Fl. Brit. India 1: 613. 1875.

Fairly common in the evergreen and subtropical hill forests; flowers and fruits during March to June (Irumbanchola, Ganiyamala, Pullukuthimala, *RJ* 21223, 21238).

*Distribution*: Peninsular India in the Western Ghats.

***Microtropis ramiflora*** Wt., Ic. t. 977. 1845.

Common in the shola forests; flowers and fruits during January to May (Mukuruthi, *RJ* 21764, 21566).

*Distribution*: Western Ghats of Peninsular India.

**HIPPOCRATEACEAE**

***Salacia fruiticosa*** Heyne *ex* Laws. in Hook.f., Fl. Brit. India 1: 628. 1875.

Fairly common in the semievergreen and evergreen forests of low elevations; flowers and fruits during February to April (Karimpuzha, Meenmutti, *RJ* 22317).

*Distribution*: India, Sri Lanka.

***Salacia oblonga*** Wall. *ex* Wt. *et* Arn., Prodr. 106. 1834.

Fairly common in the evergreen forests; flowers and fruits during March to May (Meenmutti, Karimpuzha, *RJ* 22318).

*Distribution*: Western Gahts.

**RHAMNACEAE**

***Ventilago bombaiensis*** Dalz. in Hook., Kew J. Bot. 3: 36. 1851.

Very common in the semievergreen, evergreen and subtropical hill forests; flowers and fruits during January to April (Panapuzha, Irumbanchola, Manakadavu, Pullukuthimala, Ganiyamala, *RJ* 8518).

*Distribution*: Western Ghats.

***Zizyphus oenoplia*** (L.) Miller, Gard. Dict. ed. 8, 3. 1768.

Very common in teak plantations and deciduous and semievergreen forests, especially in disturbed areas; flowers and fruits during November to March (Nedunkayam, kanjirakadavu, Panapuzha, Mancheri, Kalkulam, *RJ* 20544).

*Distribution*: Tropical Asia, Australia.

***Zizyphus rugosa*** Lamk., Encyl. 3: 319. 1789.

Fairly common in the deciduous forests and open rocky areas of upper ghats; flowers and fruits during January to May (Erumala, Meenmutti, Panapuzha, *RJ* 8519).

*Distribution*: India, Sri Lanka, Myanmar.

***Zizyphus xylopyrus*** **(**Retz.) Willd., Sp. Pl. 1: 1164. 1798.

Fairly common in the moist deciduous forests; flowers and fruits during August to March (Nedunkayam, Uchakulam, *RJ* 9415, 9390).

*Distribution*: India, Sri Lanka.

**VITACEAE**

***Cissus latifolia*** Lamk., Encycl. 1: 31. 1783.

Fairly common in the semievergreen and evergreen forests; flowers and fruits during June to September (Karimpuzha, Meenmutti, *RJ* 22319).

*Distribution*: Peninsular India, Sri Lanka.

***Cissus repens*** Lamk., Encycl. 1: 30. 1783.

Occasional, in the deciduous and semievergreen forests; flowers and fruits during September to December (Nedunkayam, *RJ* 8532).

*Distribution*: Western ghats of India

***Tetrastigma leucostaphylum*** (Dennst.) Alston *ex* Mabb., Taxon 26. 539. 1977.

Fairly common in the semievergreen and evergreen forests; flowers and fruits during December to March (Mancheri, Meenmutti, Pullukuthimala, *RJ* 9292).

*Distribution*: Peninsular and N.E. India, Malayan Peninsula, Sri Lanka.

**LEEACEAE**

***Leea indica*** (Burm.f.) Merr., Philip. J. Sci. 14: 245. 1919.

Common in the deciduous, semievergreen and evergreen forests; flowers and fruits during June to December (Mundakadavu, Panapuzha, Pullukuthimala, Mancheri, *RJ* 20343).

*Distribution*: South-East Asia, Sri Lanka.

**STAPHYLEACEAE**

***Turpinia malabarica*** Gamble in Kew Bull. 135. 1916.

Occasional in the semievergreen and evergreen forests of low elevations; flowers and fruits during December to March (Meenmutti, *RJ* 21791).

*Distribution*: South-West India.

***Turpinia nepalensis*** Wall. *ex* Wt. *et* Arn., Prodr. 1834.

Very common in the shola forests and also frequent in the subtropical hill forests; flowers and fruits during January to April (Mukuruthi, Ganiyamala, *RJ* 8520).

*Distribution*: India to Malesia.

**SAPINDACEAE**

***Allophylus cobbe*** (L.) Raeusch., Nomencl. Bot. ed. 3. 108. 1797.

Fairly common in the deciduous forests and also in the gaps of semievergreen forests; flowers and fruits during June to December (Panapuzha, Meenmutti, Mancheri, *RJ* 8521).

*Distribution*: Sri Lanka, South-East Asia.

***Dimocarpus longan*** Lour., Fl. Cochinch. 233. 1790.

Common in the evergreen forests and occasional in semievergreen forests; flowers and fruits during March to June (Pullukuthimala, Karimpuzha, Meenmutti, Manakadavu, *RJ* 21495).
*Distribution*: Pantropical.

***Harpullia arborea*** (Blanco) Radlk., Sitzungsber, Moth. Phy. Cl. Konigl. Bayer. Akad. Wiss. Munchen 16: 404. 1890.

Common in the evergreen and semievergreen forests; flowers and fruits during January to June (Karimpuzha, Vilakumala, Panapuzha, Kulayalakadavu, *RJ* 20481, 9170).

*Distribution*: India to Malesia.

***Lepisanthes tetraphylla*** (Vahl) Radlk., Sitzungsber Math.-Phy. Cl. Loenigl. Bayer Akad. Wiss. Muenchen 8: 276. 1878.

Fairly common in the evergreen and semievergreen forests; flowers and fruits during March to December (Irumbanchola, Karimpuzha, Meenmutti, *RJ* 8522).

*Distribution*: Western Peninsular India.

***Otonephelium stipulaceum*** (Bedd.) Radlk., Sapindac. Holl.-Ind. 71. 1879.

Occasional in the evergreen forests; flowers and fruits during March to July (Thalichola, *RJ* 8523).

*Distribution*: Western Peninsular India.

***Sapindus trifoliata*** L., Sp. Pl. 367. 1753.

Fairly common in the semievergreen and deciduous forests; flowers and fruits during November to March (Karimpuzha, Mancheri, Panapuzha, *RJ* 20480).

*Distribution*: India, Sri Lanka.

***Schleichera oleosa*** **(**Lour.) Oken, Allg. Naturgesh. 3(2): 1341. 1841.

Trees common in the deciduous and semievergreen forests; flowers and fruits during February to May (Panapuzha, Nedunkayam, Mancheri, *RJ* 21278).

*Distribution*: India, Sri Lanka, Malesia.

**SABIACEAE**

***Meliosma pinnata*** (Roxb.) Maxim. ssp. ***barbulata*** (Cufod.) Beus. in Dassanayake *et* Fosberg, Rev. Handb. Fl. Cylon 3: 384. 1981.

Occasional in rocky areas in the evergreen forests; flowers and fruits during November to March (Erumala, Pullukuthimala, *RJ* 8524).

*Distribution*: India, Sri Lanka, Burma, China, Japan, Taiwan, South Korea, Philippines, Malaya Peninsula, Malesia, Laos.

***Meliosma simplicifolia*** (Roxb.) Walp., Hook.f., Fl. Brit. India 2: 5. 1876.

Common riverine species in the evergreen forests; flowers and fruits during March to September (Meenmutti, Manakadavu, *RJ* 21609, 9143).

*Distribution*: India, China, Malesia.

**ANACARDIACEAE**

***Holigarna arnottiana*** Hook.f., Fl. Brit. India 2: 36. 1876.
Common in the deciduous and semievergreen forests mostly in stream banks; flowers and fruits during January to April (Mancheri, Panapuzha, Nedunkayam, *RJ* 9293).

*Distribution*: Southern Western Ghats.

***Holigarna beddomei*** Hook.f., Fl. Brit. India 2: 38. 1876.

Fairly common in the evergreen and semievergreen forests; flowers and fruits during January to March (Karimpuzha, Meenmutti, Manakadavu, *RJ* 8526).

*Distribution*: Peninsular India.

***Holigarna nigra*** Bourd., Indian For. 30. 95. 1904.

Common in the evergreen forests of high elevations and subtropical hill forests; flowers and fruits during April to August (Pullukuthimala, Ganiyamala, Erumala, *RJ* 21446).

*Distribution*: Peninsular India.

***Lannea coromandelica*** (Houtt.) Merr., J. Arnold Arbor. 19: 353. 1939.

Occasional in the deciduous and evergreen forests; flowers and fruits during January to April (Meenmutti, Panapuzha, *RJ* 22321).

*Distribution*: South and South-East Asia, China.

***Mangifera indica*** L., Sp. Pl. 200. 1753.

Fairly common in the deciduous evergreen forests mostly seen on stream banks; flowers and fruits during December to March (Nedunkayam, Panapuzha, Mancheri, Pullukuthimala, *RJ* 21406).

*Distribution*: Indo-Malesia.

***Nothopegia beddomei*** Hook.f., Fl. Brit. India 2: 40. 1876.

Fairly common in the semievergreen and evergreen forests at low elevations; flowers and fruits during March to August (Manjakallan, Karimpuzha, Manakadavu, *RJ* 8527).

*Distribution*: Peninsular India, Sri Lanka.

***Nothopegia racemosa*** (Dalz.) Raman. in Sald. *et* Nicol., Fl. Hassan Dist. 377. 1976

Rare in the evergreen forests; flowers and fruits during October to February (Irumbanchola, *RJ* 22322).

*Distribution*: Western Ghats.

***Spondias pinnata*** (L.f.) Kurz, Prelim. Rep. Forest Peg. App. A. 44 & B 42. 1875.

Occasional in the deciduous and semievergreen forests, especially near habitations; flowers and fruits during March to August (Panapuzha, Kalkulam *RJ* 22325).

*Distribution*: India extending to Malesia.

**FABACEAE**

***Butea monosperma*** (Lamk.) Taub. in Engl. *et* Prantl, Pflazenfam. 3(3): 366. 1894.

Occasional in the deciduous forests; flowers and fruits during December to March (Nedunkayam, *RJ* 22325).

*Distribution*: Tropical Asia.

***Dalbergia horrida*** (Dennst.) Mabb., Taxon 26. 538. 1997.

Common in the deciduous and semievergreen forests mostly along river or stream sides; flowers and fruits during December to March (Nedunkayam, Panapuzha, Poochapara, *RJ* 22324).

*Distribution*: South-West India.

***Dalbergia latifolia*** Roxb., Pl. Corom. t. 113. 1799.

Fairly common in the deciduous and semievergreen forests; flowers and fruits during April to February (Nedunkayam, Panapuzha, Mancheri, Karimpuzha, *RJ* 8528).

*Distribution*: India, Nepal, Malesia.

***Dalbergia sissoides*** Grah. *ex* Wt. *et* Arn., Prodr. 265. 1834.

Fairly common in the deciduous forests and rare in the semievergreen forests; flowers and fruits during March to August (Nedunkayam, Panapuzha, Kanjirakadavu, *RJ* 20552).

*Distribution*: Peninsular India.

***Dalbergia volubilis*** Roxb., Pl. Corom. t. 191. 1805.

Fairly common in the deciduous forests and teak plantations; flowers and fruits during March to June (Nedunkayam, Kanjirakadavu, Moochala, Mancheri, *RJ* 8529).

*Distribution*: India, Sri Lanka, Myanmar, Bangladesh.

***Derris brevipes*** (Benth.) Baker var. ***coriacea*** Baker in Hook.f., Fl. Brit. India 2: 244. 1876.

Occasional in the semievergreen and evergreen forests; flowers and fruits during October to February (Meenmutti, Panapuzha, Manakadavu, *RJ* 8530).

*Distribution*: Western Ghats.

***Derris scandens*** (Roxb.) Benth., J. Linn. Soc. Bot. 4 (Suppl.): 103. 1860.

Fairly common in the semievergreen and evergreen forests, mostly along river sides; flowers and fruits during October to February (Meenmutti, Manakadavu, *RJ* 8530).

*Distribution*: India, Sri Lanka, Bangladesh, China, South-East Asia, North Australia.

***Erythrina stricta*** Roxb., (Hort. Beng. 53. 1914 *nom. nud.*) Fl. Ind. 3: 251. 1832.

Fairly common in the disturbed areas of deciduous forests and the open rocky areas above; flowers and fruits during February to April (Mancheri, Paduka, Thalichola, Erumala, *RJ* 22326).

*Distribution*: India, China, Nepal, Thailand, Vietnam.

***Kunstleria keralensis*** Mohanan *et* Nair, Proc. Indian Acad. Sci. (B) 90: 207. 1981.

Fairly common in the semievergreen and evergreen forests, especially along river banks; flowers and fruits during June to December (Panapuzha, Meenmutti, Manakadavu, *RJ* 22357).

*Distribution*: Kerala.

***Pongamia pinnata*** (L.) Pierre, Fl. For. Cochinch. t. 385. 1899.

Fairly common along river banks of deciduous and semievergreen forests; flowers and fruits during March to July (Mancheri, Kanjirakadavu, Nedunkayam, *RJ* 9215).

*Distribution*: South and South-East Asia, Polynesia, Australia.

***Pterocarpus marsupium*** Roxb., Pl. Corom. t. 116. 1799.

Fairly common in the deciduous forests and rare in the semievergreen forests; flowers and fruits during October to December (Kakulam, Panapuzha, Kanjirakadavu, *RJ* 22327).

*Distribution*: India, Sri Lanka.

***Spatholobus parviflorus*** (Roxb. *ex* DC.) O. Ktze., Gen. Pl. 1: 205. 1891.

Fairly common in the deciduous forests; flowers and fruits during September to March (Nedunkayam, Kanjirakadavu, *RJ* 22359).

*Distribution*: India, Sri Lanka, Malesia.

**CAESALPINIACEAE**

***Bauhinia malabarica*** Roxb., Fl. Ind. 2: 321. 1832.

Occasional in the deciduous forests; flowers and fruits during September to December (Nedumkayam, Mundakadavu, *RJ* 20237).

*Distribution*: India, Myanmar, Malesia.

***Bauhinia recemosa*** Lamk., Encycl. 1: 390. 1785.

Fairly common in the deciduous forests; flowers and fruits during March to June (Nedumkayam, Kalkulam, Moochala, *RJ* 20334).

*Distribution*: India, Sri Lanka.

***Caesalpinia cucullata*** Roxb., Fl. Ind. 2: 358. 1832.

Fairly common in the semievergreen and evergreen forests; flowers and fruits during May to October (Kalkulam, Karimpuzha, Panapuzha, *RJ* 20582).

*Distribution*: Peninsular and North-East India to Malesia.

***Cassia fistula*** L., Sp. Pl. 377. 1753.

Fairly common in deciduous forests and rare in the semievergreen forests; flowers and fruits during April to August (Nedumkayam, Mancheri, *RJ* 9242).

*Distribution*: India, Myanmar, Sri Lanka.

***Cynometra travancorica*** Bedd., Fl. Sylvat. t. 316.1978.

Rare, in the evergreen forests; flowers and fruits during January to May (Vilakumala, *RJ* 22328).

*Distribution*: Western Ghats of Peninsular India.

**MIMOSACEAE**

***Acacia sinuata*** (Lour.) Merr., Trans. Amer. Philos. Soc. 24(2): 186. 1935.

Common in the semievergreen forests; flowers and fruits during February to June (Panapuzha, Mancheri, *RJ* 8592).

*Distribution*: India, Nepal, Sri Lanka, South China, Malesia, New Guinea.

***Acacia torta*** Craib, Kew Bull. 410. 1915.

Common in the deciduous and semievergreen forests especially in disturbed areas and along river sides; flowers and fruits during December to April (Panapuzha, Nedunkayam, Kanjirakadavu, Mancheri, *RJ* 8593).

*Distribution*: India, Pakistan.

***Albizia lebbeck*** Willd., Sp. Pl. 4: 1066. 1806.

Fairly common in the deciduous and semievergreen forests; flowers and fruits during March to September (Panapuzha, Nedunkayam, *RJ* 21503).

*Distribution*: India, Sri Lanka, South-East Asia, South China; extensively cultivated in tropics and subtropics.

***Albizia odoratissima*** (L.f.) Benth., London J. Bot. 3: 88. 1844.

Occasional in the deciduous forests, especially along river banks; flowers and fruits during April to August (Vilakumala, Nedunkayam, *RJ* 9269).

*Distribution*: India, Sri Lanka, South-East Asia, China.

***Entada rheedii*** Spreng., Syst. Veg. 2: 325. 1825.

Rare, in the moist deciduous and semievergreen forests, mostly along river sides; flowers and fruits during April to October (Mancheri, Panapuzha, Meenmutti, *RJ* 8594).

*Distribution*: India to Malesia, Australia, Africa.

***Mimosa diplotricha*** C. Wt. *ex* Sauvalle, Ann. Real Acad. C: Habana 5: 405. 1865.

A common weed in the disturbed and open areas of deciduous forests and also in teak plantations; flowers and fruits during October to March (Nedunkayam, Paduka, Kalkulam, *RJ* 20576, 20338).

*Distribution*: Tropical America, introduced in India.

***Xylia xylocarpa*** (Roxb.) Taub., Bot. Central bl. 47. 395. 1891.

Very common in the deciduous and semievergreen forests; flowers and fruits during February to May (Nedunkayam, Paduka, Kalkulam, Kanjirakadavu, Mancheri, Panapuzha, *RJ* 8533).

*Distribution*: India to Malesia.

**ROSACEAE**

***Prunus ceylanica*** (Wt.) Miq., Fl. Ind. Bat. ser. 1. 1: 366. 1855.

Fairly common in the semievergreen and evergreen forests; flowers and fruits during October to July (Karimpuzha, Manakadavu, Pullukuthimala, *RJ* 8534).

*Distribution*: India, Sri Lanka, Bangladesh, Burma, Thailand, Laos, South Vietnam.

***Rubus ellipticus*** Sm. in Rees, Cyclop. 30 n. 16. 1819.

Fairly common in open areas of the evergreen and shola forests; flowers and fruits during December to April (Mukuruthi, Erumala, *RJ* 8535).

*Distribution*: India, Sri Lanka, Myanmar.

**COMBRETACEAE**

***Anogeissus latifolia*** (Roxb. *ex* DC.) Wall. *ex* Guill. *et* Perr., Fl. Seneg. Tent. 7: 280. 1832.

Occasional, in the deciduous forests; flowers and fruits during April to August (Pulimunda, Uchakulam, *RJ* 20223, 21636).

*Distribution*: India, Sri Lanka, Pakistan.

***Calycopteris floribunda*** (Roxb.) Poir. in Lamk., Encycl. 2: 41. 1811.

Very common in the deciduous and semievergreen forests; flowers and fruits during December to April (Nedunkayam, Paduka, Mancheri, Panapuzha, *RJ* 9228).

*Distribution*: India to Malesia.

***Combretum latifolium*** Bl., Bidr. 641. 1825.

Fairly common in the semievergreen and evergreen forests of low elevations, especially near water course; flowers and fruits during December to April (Thalichola, Panapuzha, karimpuzha, Meenmutti, *RJ* 21518).

*Distribution*: India to Malesia.

***Quisqualis malabarica*** Bedd., Ic. Pl. Ind. Orient. t. 155. 1874.

Fairly common in semievergreen and evergreen forests, mostly along river sides; flowers and fruits during January to June (Panapuzha, Meenmutti, *RJ* 21415, 21798).

*Distribution*: Peninsular India.

***Terminalia alata*** Heyne *ex* Roth, Nov. Pl. Sp. 379. 1821.

Common in deciduous forests, mostly in the flat, of water logged areas; flowers and fruits during October to March (Uchakulam, Mundakadavu, *RJ* 8536).

*Distribution*: India to Malesia.

***Terminalia bellirica*** (Gaertn.) Roxb., Pl. Corom. t. 198. 1805 (*bellerica*) .

Fairly common in the deciduous and semievergreen forests; flowers and fruits during March to June (Nedunkayam, Panapuzha, Karimpuzha, Meenmutti, *RJ* 22329).

*Distribution*: India to Malesia.

***Terminalia paniculata*** Roth, Nov. Pl. Sp. 383. 1821.

Very common in the deciduous and semievergreen forests; flowers and fruits during November to May (Nedunkayam, Paduka, etc. *RJ* 20499).

*Distribution*: Peninsular India.

**MYRTACEAE**

***Eugenia bracteata*** (Willd.) Roxb. *ex* DC., Prodr. 3: 264. 1828.

Rare, in the subtropical hill forests; flowers and fruits during March to July (Kedakamala, Ganiyamala, *RJ* 8537).

*Distribution*: Southern Peninsular India.

***Rhodomyrtus tomentosus*** (Ait.) Hassk., Flora 25: 35. 1842.

Fairly common in the shola forests; flowers and fruits during January to May (Mukuruthi, *RJ* 21463).

*Distribution*: India, China, Malesia, Sri Lanka.

***Syzygium benthamianum*** (Wt. *ex* Duthie) Gamble, Fl. Presid. Madras 1: 478. 1919.

Fairly common in evergreen forests of high elevations and also subtropical hill forests; flowers and fruits during January to April (Pullukuthimala, Ganiyamala, Erumala, *RJ* 21417).

*Distribution*: Peninsular India.

***Syzygium bourdillonii*** (Gamble) Rathkr. *ex* Nair, J. Econ. Tax. Bot. 4: 287. 1983.

Rare, in the evergreen forests at elevations above 1000 m, especially along river sides; flowers and fruits during March to June (Pullukuthimala, Ganiyamala, *RJ* 8541).

*Distribution*: Kerala.

***Syzygium calophyllifolium*** Walp., Rep. 2: 180. 1843.

Common in the shola forests; flowers and fruits during March to August (Mukuruthi, *RJ* 8538).

*Distribution*: Western Ghats of Peninsular India, Sri Lanka.

***Syzygium caryophyllatum*** (L.) Alston in Trimen, Handb. Fl. Ceylon 6: 116. 1931.

Fairly common in shola forests and subtropical hill forests; flowers and fruits during March to January (Mukuruthi, Kedakamala, *RJ* 21395).

*Distribution*: Peninsular India, Sri Lanka.

***Syzygium cumini*** (L.) Skeels, USDA Bur. Pl. Industr. Bull. 248: 2. 1912.

Fairly common in deciduous, semievergreen and evergreen forests, especially along river sides; flowers and fruits during March to July (Panapuzha, Nedunkayam, Pullukuthimala, *RJ* 21494).

*Distribution*: India, South-East. Asia.

***Syzygium densiflorum*** Wall. *ex* Wt. *et* Arn., Prodr. 329. 1834.

Common in the shola forests; flowers and fruits during February to April (Mukuruthi, *RJ* 21370).

*Distribution*: Western Ghats.

***Syzygium gardneri*** Thw., Enum. Pl. Zeyl. 117. 1859.

Common in evergreen and semievergreen forests; flowers and fruits during December to March (Karimpuzha, Irumbanchola, Meenmutti, Onakapuzha, Pullukuthimala, *RJ* 22330).

*Distribution*: Peninsular India, Sri Lanka.

***Syzygium hemisphericum*** (Wt.) Alston in Trimen, Handb. Fl. Ceylon 6: 115. 1931.

Fairly common in evergreen forests; flowers and fruits during January to May (Pullukuthimala, Ganiyamala, *RJ* 21432).

*Distribution*: Peninsular India, Sri Lanka.

***Syzygium laetum*** (Buch.-Ham.) Gandhi in Sald. *et* Nicol., Fl. Hassan Dist. 282. 1976.

Common in semievergreen and evergreen forests; flowers and fruits during February to July (Panapuzha, Meenmutti, Irumbanchola, Manakadavu, *RJ* 21289).

*Distribution*: Southern Western Ghats.

***Syzygium lanceolatum*** (Lamk.) Wt. *et* Arn., Prodr. 330. 1834.

Occasional in the evergreen forests at low elevations; flowers and fruits during March to August (Pullukuthimala, Erumala, *RJ* 21334).

*Distribution*: Peninsular India, Sri Lanka.

**LECYTHIDACEAE**

***Careya arborea*** Roxb., Corom., Pl. t. 218. 1811.

Occasional, in the moist deciduous forests, especially in marshy areas; flowers and fruits during March to June (Nedunkayam, Uchakulam, *RJ* 9411).

*Distribution*: Tropical Asia.

**MELASTOMACEAE**

***Memecylon flavescens*** Gamble, Kew Bull. 1919: 226. 1919 .

Very rare in the shola forests; flowers and fruits during September to March (Mukuruthi, *RJ* 22331).

*Distribution*: Endemic to Western Ghats of Peninsular India.

***Memecylon lawsonii*** Gamble, Kew Bull. 1919: 226. 1919.

Fairly common in evergreen and semievergreen forests; flowers and fruits during December to March (Kozhimala, Manakadavu, *RJ* 9148).

*Distribution*: Western Ghats of Peninsular India.

**LYTHRACEAE**

***Lagerstroemia microcarpa*** Wt., Ic. t. 109. 1839.

Fairly common in deciduous and semievergreen forests; flowers and fruits during March to July (Nedunkayam, Mundakadavu, Panapuzha, Meenmutti, *RJ* 9389).

*Distribution*: South-West India.

***Lagerstroemia hirsuta*** (Lamk.) Willd., Sp. Pl. 2. 1178.

Fairly common in the deciduous forests in wet places and along streams and river banks; flowers and fruits during April to July (Nedunkayam, Paduka, *RJ* 9398).

*Distribution*: India, Myanmar, New Guinea.

**DATISCACEAE**

***Tetrameles nudiflora*** R. Br. in Bennett, Pl. Jav. Rar 79. t. 17. 1838.

Fairly common in deciduous and semievergreen forests; flowers and fruits during March to May (Nedunkayam, Panapuzha, Kalkulam, *RJ* 9284).

*Distribution*: Paleotropic.

**ARALIACEAE**

***Schefflera rostrata*** (Wt.) Harms in Engl. et Prantl, Pflanzenfam. 3(8): 38. 1894.

Rare, along shola edges; flowers and fruits during December to March (Mukuruthi, *RJ* 21754, 21479).

*Distribution*: Peninsular India in the Western Ghats.

***Schefflera venulosa*** (Wt. *et* Arn.) Harms in Engl. *et* Prantl., Pflanzenfam. 3(8): 39. 1894.

Fairly common in the evergreen forests; flowers and fruits during March to June (Thalichola, Pullukuthimala, Panapuzha, *RJ* 21552).

*Distribution*: India, Myanmar, Indo-China.

**ALANGIACEAE**

***Alangium salvifolium*** (L.f.) Wang. ssp. ***sundanum*** (Miq.) Bloem., Bull. Jard. Bot. Buitenz. III, 16: 156. 1939.

Fairly common in deciduous and semievergreen forests; flowers and fruits during April to July (Nedunkayam, Paduka, Panapuzha, Karimpuzha, *RJ* 21516).

*Distribution*: India, Sri Lanka, China, Vietnam, Thailand, Africa.

**CAPRIFOLIACEAE**

***Viburnum erubescens*** Wall. *ex* DC., Prodr. 4: 329. 1830.

Rare in the shola forests; flowers and fruits during February to May (Mukuruthi, *RJ* 8596).

*Distribution*: India, North Myanmar, South-East Tibet, China.

**RUBIACEAE**

***Catunaregam spinosa*** (Thunb.) Tirvengadum, Bull. Mus. Hist. Nat. (Paris) 35: 13. 1978 .

Occasional, in deciduous forests and teak plantations; flowers and fruits during April to July (Nedunkayam, Paduka, Panapuzha, Kanjirakadavu, *RJ* 9557).

*Distribution*: Tropical Asia, Africa.

***Chassalia ophioxyloides*** (Wall. *ex* Kurz) Craib, Gard. Bull. Straits Settlem. 6: 474. 1930.

Fairly common undershrubs in deciduous and semievergreen forests; flowers and fruits during July to January (Karimpuzha, Mancheri, Panapuzha, Meenmutti, Kalkulam, *RJ* 20597, 9306, 9152).

*Distribution*: South India, Sri Lanka.

***Coffea crassifolia*** Gamble in Kew Bull. 248. 1920.

Rare in sholas and subtropical hill forests; flowers and fruits during November to February (Mukuruthi, Kedakamala, *RJ* 21490).

*Distribution*: Western Ghats.

***Haldina cordifolia*** (Roxb.) Ridsd., Blumea 24: 361. 1978.

Occasional, in the deciduous forests; flowers and fruits during June to September (Mundakadavu, Moochala, *RJ* 9409).

*Distribution*: India, Myanmar, Sri Lanka, Indo-china.

***Ixora brachiata*** Roxb., (Hort. Beng. 10. 1814 *nom. nud.*) Fl. Ind. 1: 381. 1832.

Common, in deciduous and semievergreen forests; flowers and fruits during November to March (Nedunkayam, Kalkulam, Thalichola, Mancheri, *RJ* 8542).

*Distribution*: Western Peninsular India.

***Lasianthus acuminatus*** Wt., Calcutta J. nat. Hist. 6: 511. 1846.

Fairly common in subtropical hill forests and shola forests; flowers and fruits during July to November (Irubanchola, Kedakamala, Mukuruthi, Ganiyamala, *RJ* 21239, 21684).

*Distribution*: Peninsular India.

***Lasianthus jackianus*** Wt., Calcutta J. nat. Hist. 6: 502. 1845.

Fairly common in the evergreen forests; flowers and fruits during June to December (Irubanchola, Manakadavu, Pullukuthimala, Ganiyamala, *RJ* 9554).

*Distribution*: Peninsular India in the Western Ghats.

***Mitragyna parvifolia*** (Roxb.) Korth., Obs. Naucl. Ind. 19. 1839.

Fairly common in the deciduous forests; flowers and fruits during May to September (Mundakadavu, Moochala, Kanjirakadavu, Mancheri, *RJ* 8543).

*Distribution*: India, Sri Lanka, Malesia.

***Neolamarckia cadamba*** (Roxb.) Boisser, Adansonia ser. 4. 6: 247. 1984.

Fairly common in deciduous and semievergreen forests, mostly along river banks; flowers and fruits during June to September (Panapuzha, Nedunkayam, *RJ* 8544).

*Distribution*: Asia, Pacific, Australia.

***Pavetta tomentosa*** Roxb. *ex* Sm. in Rees, Cyclop. 26. 1819.

Fairly common in the semievergreen forests; flowers and fruits during July to December (Panapuzha, Thalichola, *RJ* 9263).

*Distribution*: India, Indo-China.

***Pavetta zeylanica*** (Hook.f.) Gamble, Fl. Presid. Madras 2: 633. 1921.

Fairly common in deciduous and semievergreen forests; flowers and fruits during January to August (Panapuzha, Mancheri, *RJ* 8597).

*Distribution*: Peninsular India, Sri Lanka.

***Psychotria nilgiriensis*** Deb. *et* Gang. in Taxon 31: 546. 1982.

Occasional in the shola forests; flowers and fruits during March to July (Mukuruthi, *RJ* 8545).

Distribution: Peninsular India.

***Psychotria nigra*** (Gaertn.) Alston in Trimen, Handb. Fl. Ceylon 6 (Suppl.): 152. 1932.

Fairly common in the evergreen forests; flowers and fruits during April to June (Ganiyamala, Irumbanchola, *RJ* 8546).

*Distribution*: Peninsular India, Sri Lanka.

***Psychotria truncata*** Wall. in Roxb., Fl. Ind. 2: 162. 1824.

Rare, in subtropical hill forests and shola forests; flowers and fruits during April to August (Mukuruthi, Kedakamala, *RJ* 8547).

*Distribution*: Western Ghats.

***Saprosma fragrans*** Bedd., Fl. Sylvat. t. 134. 1871.

Occasional in the evergreen forests; flowers and fruits during December to March (Ganiyamala, Pullukuthimala, Irumbanchola, *RJ* 8548).

*Distribution*: Peninsular India in the Western Ghats.

***Tamilnadia uliginosa*** (Retz.) Tirveg. *et* Sastri, Maruit. Inst. Bull. 8(4): 85. 1979.

Rare, in swampy or marshy areas of deciduous forests; flowers and fruits during June to September (Nedunkayam, Uchakulam, *RJ* 22332).

*Distribution*: India, Myanmar.

***Wendlandia thyrsoidea*** (Roem. *et* Schult.) Steud., Nomencl. *ed*. 2. 2: 786. 1841.

Common in the subtropical hill savannahs; flowers and fruits during February to April (Vilakumala, Erumala, Pullukuthimala, *RJ* 8549).

*Distribution*: Peninsular India, Sri Lanka.

**ASTERACEAE**

***Vernonia arborea*** Buch.-Ham., Trans. Linn. Soc. London 14: 218. 1824.

Fairly common in evergreen forests at low elevations and also in the savannahs above; flowers and fruits during January to March (Meenmutti, Manakadavu, Erumala, *RJ* 21284).

*Distribution*: Tropical Asia, Africa, Australia, New Zealand.

**VACCINIACEAE**

***Vaccinium leschenaultii*** Wt., Ic. Pl. Ind. Orient. t. 1188. 1848.

Fairly common in the shola forests; flowers and fruits during January to May (Mukuruthi, *RJ* 8550).

*Distribution*: Peninsular India in the Western Ghats.

**ERICACEAE**

***Gaultheria fragrantissima*** Wall., Asiat. Res. 13: 397. 1820.

Common along edges of the shola forests; flowers and fruits throughout the year (Mukuruthi, *RJ* 21378).

*Distribution*: India, Nepal, Myanmar.

***Rhododendron arboreum*** J.E. Sm. ssp. ***nilagiricum*** Tagg. in Steveson, Sp. Rhod. 15. 1930.

Common, along the edges of shola forests; flowers and fruits during December to March (Mukuruthi, Kedakamala, *RJ* 21371).

*Distribution*: Southern Western Gahts.

**MYRSINACEAE**

***Ardisia pauciflora*** Heyne *ex* Roxb., Fl. Ind. 2: 279. 1824.

Rare, in the evergreen forests at high elevations; flowers and fruits during December to March (Pullukuthimala, *RJ* 21498, 21422).

*Distribution*: Peninsular India, Sri Lanka.

***Embelia ribes*** Burm.f., Fl. Ind. 62. t. 23. 1768.

Fairly common in semievergreen forests and evergreen forests at low elevations; flowers and fruits during March to May (Thalichola, Meenmutti, *RJ* 22332).

*Distribution*: India, Sri Lanka, Malaya, South China.

***Maesa indica*** (Roxb.) A. DC., Trans. Linn. Soc. London 17: 134. 1834.

Occasional, in evergreen and subtropical hill forests; flowers and fruits during October to March (Pullukuthimala, Erumala, Kedakamala, *RJ* 9198).

*Distribution*: India, Pakistan, Sri Lanka, Malesia.

***Rapanea wightiana*** (Wall. *ex* DC.) Mez, Monogr. Myrsin. 360. 1902

Occasional, in the shola forests; flowers and fruits during December to March (Mukuruthi, *RJ* 21391).

*Distribution*: South India, Sri Lanka.

**SAPOTACEAE**

***Chrysophyllum roxburghii*** G. Don, Gen. Syst. 4: 33. 1988.

Common in the evergreen forests; flowers and fruits during September to March (Panapuzha, Karimpuzha, Irumbanchola, Manakadavu, *RJ* 22333).

*Distribution*: Tropical Asia.

***Isonandra lanceolata*** Wt., Ic. t. 359. 1840.

Fairly common in the subtropical hill forests; flowers and fruits during December to June (Kedakamala, Ganiyamala, *RJ* 21690).

*Distribution*: Peninsular India, Sri Lanka.

***Palaquium ellipticum*** (Dalz.) Baillon, Traite Bot. Med. Pham. 1500. 1884.

Very common in evergreen and subtropical hill forests; flowers and fruits during December to May (Karimpuzha, Meenmutti, Manakadavu, Thalichola, Pullukuthimala, Ganiyamala, *RJ* 8538)

*Distribution*: South-West India.

**EBENACEAE**

***Diospyros buxifolia*** (Bl.) Hiern, Trans. Cambridge Philos. Soc. 12: 218. 1873.

Rare, in the semievergreen forests; flowers and fruits during January to April (Karimpuzha, Panapuzha, *RJ* 22334).

*Distribution*: Indo-Malesia.

***Diospyros paniculata*** Dalz. Hook., J. Bot. Kew Gard. Misc. 4. 107. 1852.

Fairly common in the evergreen forests; flowers and fruits during December to May (Karimpuzha, Meenmutti, Manakadavu, *RJ* 8551).

*Distribution*: Peninsular India.

***Diospyros sylvatica*** Roxb., Pl. Corom. t. 47. 1795; Hook.f., Fl. Brit. India 3: 559. 1882.

Fairly common in the evergreen forests; flowers and fruits during May to November (Karimpuzha, Meenmutti, Irumbanchola, *RJ* 8552).

*Distribution*: India to Malesia.

**SYMPLOCACEAE**

***Symplocos cochinchinensis*** (Lour.) Moore ssp. ***laurinia*** (Retz.) Nooteb., Revis. Symploc. Old World 156. 1975.

Fairly common in evergreen forests at higher elevations and in subtropical hill savannahs; flowers and fruits during December to March (Pullukuthimala, Erumala, Kedakamala, *RJ* 21328).

*Distribution*: India, Sri Lanka, Myanmar, Indo-China, China, Formosa, Japan to Malesia.

***Symplocos gardneriana*** Wt., Ic. t. 1231. 1848.

Rare, in sholas and subtropical hill forests; flowers and fruits during November to February (Mukuruthi, Kedakamala, *RJ* 8589).

*Distribution*: Southern Western Ghats.

***Symplocos macrophylla*** Wt. *ex* A. DC. in DC., Prodr. 8: 257. 1844.

Rare in sholas and subtropical hill forests; flowers and fruits during December to March (Mukuruthi, Kedakamala, *RJ* 8553).

*Distribution*: Peninsular India.

***Symplocos obtusa*** Wall. in G. Don, Gen. Hist. 4: 3. 1887.

Fairly common in the shola forests; flowers and fruits during January to April (Mukuruthi, *RJ* 21396).

*Distribution*: Endemic to Peninsular India.

**OLEACEAE**

***Chionanthus mala-elengi*** (Dennst.) Green in Bull. bot. Surv. India 26. 124. 1984.

Common in semievergreen and also deciduous forests, especially along river sides; flowers and fruits during February to June (Panapuzha, Karimpuzha, Thalichola, *RJ* 8554).

*Distribution*: Peninsular India.

***Jasminum flexile*** Vahl., Symb. Bot. 3: 1. 1794 & Enum. Pl. 1: 31. 1804.

Common, in evergreen and semievergreen forests especially along hedges and river sides; flowers and fruits during December to March (Panapuzha, Meenmutti, Manakadavu, *RJ* 20520).

*Distribution*: Peninsular India, Java.

***Ligustrum decaisenei*** Clark in Hook.f., Fl. Brit. India 3: 616. 1882.

Rare, in the shola forests; flowers and fruits during May to October (Mukuruthi, *RJ* 22356).

*Distribution*: Peninsular India in the Western Ghats.

***Olea dioica*** Roxb., Fl. Ind. 1: 105. 1820.

Fairly common in deciduous and semievergreen forests; flowers and fruits during February to October (Panapuzha, Nedunkayam, Mancheri, *RJ* 9258).

*Distribution*: India.

**APOCYNACEAE**

***Alstonia scholaris*** (L.) R. Br., Mem. Wern. nat. Hist. Soc. 1: 76. 1811.

Fairly common in deciduous forests but occasionally seen in the semievergreen forests also; flowers and fruits during June to August (Nedunkayam, Meenmutti, Kanjirakadavu, *RJ* 20431).

*Distribution*: South and South-East Asia, Australia.

***Aganosma cymosa*** (Roxb.) G. Don, Gen. Syst. 4: 77. 1837-1838.

Fairly common in deciduous and semievergreen forests; flowers and fruits during January to May (Nedunkayam, Panapuzha, *RJ* 8555).

*Distribution*: Peninsular India, Sri Lanka, Bangladesh.

***Holarrhena pubescens*** (Buch.-Ham.) Wall. *ex* G. Don, Gen. Syst. 78. 1837.

Common undergrowth in teak plantation and deciduous forests; flowers and fruits during April to September (Nedunkayam, Moochala, Munadakadavu, Paduka, *RJ* 20239).

*Distribution*: India, South-East Asia.

***Tabernaemontana alternifolia*** L., Sp. Pl. 211. 1753.

Fairly common in semievergreen and deciduous forests; flowers and fruits during March to September (Nedumkayam,Erumala, *RJ* 21402).

*Distribution*: South-West India.

***Wrightia tinctoria*** (Roxb.) R. Br., Mem. nat. Hist. Soc. 1: 74. 1811.

Common in the deciduous forests and also in open, rocky slopes above; flowers and fruits during April to June (Nedunkayam, Paduka, Kanjirakadavu, Vilakumala, *RJ* 20545).

*Distribution*: India, Myanmar, Timor.

**ASCLEPIADACEAE**

***Cryptolepis buchananii*** Roem. *et* Schult., Syst. Veg. 4: 409. 1818.

Fairly common in deciduous and evergreen forests; flowers and fruits during March to August (Nedunkayam, Kanjirakadavu, Panapuzha, *RJ* 8556).

*Distribution*: India, Sri Lanka, Myanmar, China.

**LOGANIACEAE**

***Strychnos nux-vomica*** L., Sp. Pl. 189. 1753.

Occasional in the deciduous forests; flowers and fruits during February to May (Nedunkayam, Mancheri, *RJ* 8557).

*Distribution*: India, Indo-china, Sri Lanka, Malesia.

***Strychnos wallichiana*** Steud. *ex* DC., Prodr. 9: 13. 1845.

Occasional in the semievergreen and evergreen forests; flowers and fruits during February to November (Panapuzha, Meenmutti, Manakadavu, *RJ* 8557).

*Distribution*: India, Sri Lanka, Malesia.

**BORAGINACEAE**

***Cordia wallichi*** G. Don, Gen. Hist. 4: 379. 1837.

Fairly common in the deciduous forests; flowers and fruits during January to May (Nedumkayam, Paduka, *RJ* 22335).

*Distribution*: South-West India.

**BIGNONIACEAE**

***Oroxylum indicum*** (L.) Benth. *ex* Kurz, For. Fl. Brit. Burma 2: 237. 1877.

Occasional, in deciduous and semievergreen forests; flowers and fruits during January to May (Panapuzha, Mancheri, Meenmutti, *RJ* 21300).

*Distribution*: Peninsular India, Sri Lanka.

***Pajanelia longifolia*** (Willd.) K. Schum. in Engl. *et* Prantl., Pflanzenfam. 4(3b): 244. 1895.

Fairly common in the semievergreen forests; flowers and fruits during December to March (Thalichola, Karimpuzha, Irumbanchola, *RJ* 22355).

*Distribution*: India, Myanmar.

***Radermachera xylocarpa*** (Roxb.) K. Schum. in Eng. *et* Prantl, Pflanzenfam. 4(3b): 243. 1895.

Occasional, in the deciduous forests; flowers and fruits during March to June (Nedunkayam, Paduka, *RJ* 22336).

*Distribution*: Peninsular India.

***Stereospermum colais*** (Dillw.) Mabb., Taxon 27: 553. 1978.

Fairly common in deciduous and semievergreen forests especially along river sides; flowers and fruits during May to August (Mancheri, Nedumkayam, Panapuzha, *RJ* 9206).

*Distribution*: Indian subcontinent, Sri Lanka, Indo-china, Malesia.

**ACANTHACEAE**

***Thumbergia mysorensis*** (Wt.) T. Anders., J. Linn. Soc. Bot. Lond. 9: 448. 1867.

Fairly common in semievergreen and evergreen forests, especially along the river sides; flowers and fruits during December to March (Karimpuzha, Thalichola, Meenmutti, *RJ* 9102).

*Distribution*: Peninsular India.

**VERBENACEAE**

***Callicarpa tomentosa*** (L.) Murr., Syst. Veg. ed. 13. 130. 1774.

Fairly common in semievergreen and deciduous forests; flowers and fruits during December to March (Kanjirakadavu, Mancheri, Panapuzha, *RJ* 9111).

*Distribution*: Peninsular India, Sri Lanka.

***Clerodendrum viscosum*** Vent., Jard. Malm. 1: t. 25. 1803.

Common in disturbed and open areas of almost all the forests types expect the sholas; flowers and fruits during February to July (Nedunkayam, Kanjirakadavu, Mancheri, Panapuzha, Meenmutti, Pullukuthimala, Ganiyamala, Kedakamala, *RJ* 20490).

*Distribution*: Indo-Malesia.

***Gmelina arborea*** Roxb., Pl. Corom. t. 246. 1815.

Fairly common in deciduous and semievergreen forests and also in open, rocky areas in the savannahs; flowers and fruits during March to June (Thalichola, Vilakumala, Erumala, Kalkulam, *RJ* 21314).

*Distribution*: India, Sri Lanka, Philippines.

***Tectona grandis*** L.f., Suppl. Pl. 151. 1781.

Extensively planted and also in wild deciduous forests; flowers and fruits during September to December (Nedunkayam, Paduka, Kanjirakadavu, Kalkulam, Mancheri, Panapuzha, *RJ* 8558).

*Distribution*: Tropical Asia.

***Vitex altissima*** L.f., Suppl. Pl. 294. 1781.

Fairly common in deciduous and semievergreen forests, mostly along riverbanks; flowers and fruits during April to July (Nedunkayam, Paduka, Karimpuzha, Mancheri, Panapuzha, *RJ* 9525, 9374).

*Distribution*: India, Indo-china, Malesia, Sri Lanka; cultivated in Europe and USA.

**MYRISTICACEAE**

***Knema attenuata*** (Hook.f. *et* Thoms.) Warb., Monogr. Myrist. 590. 1897.

Common in evergreen and semievergreen forests; flowers and fruits during March to June (Meenmutti, Vilakumala, Karimpuzha, Irumbanchola, Panapuzha, *RJ* 9264, 20509, 20554).

*Distribution*: South-West India.

***Myristica dactyloides*** Gaertn., Fruct. 1: 195. t. 41. fig. 20-d. 1788.

Very common in semievergreen, evergreen and subtropical hill forests; flowers and fruits during March to June (Meenmutti, Manakadavu, Karimpuzha, Pullukuthimala, Ganiyamala, Kedakamala, *RJ* 8559).

*Distribution*: Peninsular India, Sri Lanka.

***Myristica malabarica*** Lamk., Hist. Acad. Roy. Sci. Mem. Math. Phys. (Paris) 162. 1791.

Rare in the evergreen forests at low elevations; flowers and fruits during January to June (Meenmutti, Manakadavu, *RJ* 8560).

*Distribution*: South-West India.

**LAURACEAE**

***Actinodaphne bourdillonii*** Gamble, Kew Bull. 129. 1925.

Common in evergreen and subtropical hill forests; flowers and fruits during December to May (Pullukuthimala, Manakadavu, Kedakamala, Ganiyamala, *RJ* 8561).

*Distribution*: Western Ghats of Peninsular India.

***Actinodaphne lanata*** Meisiner in DC., Prodr. 15(1): 210. 1864.

The species is reported (Nayar,1997) as possibly extict. However, in the shola forest of the study area, it rarely seen. Flowers and fruits during May to September (Mukuruthi, *RJ* 21563).

*Distribution*: Endemic to Nilgiri Biosphere Reserve.

***Actinodaphne malabarica*** Balak., J. Bombay Nat. Hist. Soc. 63: 329. 1967.

Fairly common in evergreen and subtropical hill forests; flowers and fruits during August to April (Pullukuthimala, Ganiyamala, Erumala, Onakapuzha, *RJ* 8562).

*Distribution*: Western Ghats of Peninsular India.

***Apollonias arnottii*** Nees., Syst. Laurin. 670. 1836.

Fairly common in evergreen forests of high elevations and very common in the subtropical hill forests; flowers and fruits during December to March (Ganiyamala, Irumbanchola, Kedakamala, Pullukuthimala, *RJ* 21692, 21228).

*Distribution*: Peninsular India.

***Beilschemedia wightii*** (Nees.) Benth. *ex* Hook.f., Fl. Brit. India 5: 124. 1886.

Occasional, in evergreen and shola forests; flowers and fruits during December to March (Mukuruthi, Kedakamala, *RJ* 22363).

*Distribution*: Endemic to Peninsular India.

***Cinnamomum malabatrum*** (Burm.f.) Bl., Rumphia 1: 38. t. 13. f. 3-4. 1836.

Common in semievergreen and evergreen forests; flowers and fruits during February to May (Panapuzha, Meenmutti, Manakadavu, Pullukuthimala, *RJ* 8563).

*Distribution*: Western Ghats of Peninsular India.

***Cinnamomum perrottetii*** Meisn. in DC., Prodr. 15: 22. 504. 1864.

Occasional in evergreen and shola forests; flowers and fruits during March to June (Ganiyamala, Manakadavu, Pullukuthimala, *RJ* 22337).

*Distribution*: Western Ghats of Peninsular India.

***Cinnamomum sulphuratum*** Nees in Wall., Pl. Asiat. Rar. 2: 74. 1831.

Occasional, in subtropical hill forests and savannahs; flowers and fruits during March to June (Kedakamala, Erumala, *RJ* 8564).

*Distribution*: Western Ghats of Peninsular India.

***Cinnamomum wightii*** Meisn. in DC., Prodr. 15: 11. 1864.

Fairly common in the shola forests; flowers and fruits during April to June (Mukuruthi, *RJ* 8565).

*Distribution*: Western Ghats of Peninsular India.

***Litsea bourdillonii*** Gamble in Kew Bull. 131. 1925 .

Occasional, in the evergreen forests; flowers and fruits during January to April (Mankadavu, *RJ* 8566).

*Distribution*: Western Gahts of Peninsular India.

***Litsea coriacea*** (Heyne *ex* Meisn.) Hook.f., Fl. Brit. India 5: 166. 1886.

Fairly common in semievergreen and evergreen forests; flowers and fruits during April to August (Mankadavu, Panapuzha, Karimpuzha, Meenmutti, *RJ* 21520).

*Distribution*: Peninsular India.

***Litsea floribunda*** (Bl.) Gamble, Fl. Presid. Madras 2: 1238. 1925.

Fairly common in subtropical hill forests and shola forests; flowers and fruits during December to March (Erumala, Mukuruthi, Kedakamala, Ganiyamala, *RJ* 21330, 21732, 21710).

*Distribution*: Peninsular India in the Western Ghats.

***Litsea oleoides*** (Meisn.) Hook.f., Fl. Brit. India 5: 175. 1886.

Fairly common in the evergreen forests; flowers and fruits during December to March (Thalichola, Manakadavu, Meenmutti, Pullukuthimala, *RJ* 8567).

*Distribution*: Peninsular India.

***Litsea stocksii*** (Meisn.) Hook.f., Fl. Brit. India 5: 176. 1886.

Very common in the subtropical hill forests; flowers and fruits during November to April (Kedakamala, Ganiyamala, Pullukuthimala, *RJ* 21491).

*Distribution*: Western Ghats of Peninsular India.

***Litsea wightiana*** (Nees) Hook.f. in Benth. *et* Hook.f., Gen. Pl. 3: 162. 1880.

Fairly common in the shola forests; flowers and fruits during May to August (Mukuruthi, Kedakamala, *RJ* 21552).

*Distribution*: Western Ghats of Peninsular India.

***Neolitsea cassia*** (L.) Kosterm., J. Sci. Res. (Jakarta) 1: 85. 1953.

Occasional in the evergreen forests at high elevations; flowers and fruits during March to August (Kedakamala, Ganiyamala, *RJ* 22338).

*Distribution*: Indo-Malaya.

***Neolitsea scrobiculata*** (Meisn.) Gamble, Fl. Presid. Madras 2: 1240. 1925.

Fairly common in the subtropical hill forests; flowers and fruits during December to March (Ganiyamala, Kedakamala, Pullukuthimala, *RJ* 21312).

*Distribution*: Peninsular India.

***Persea macrantha*** (Nees) Kosterm., Reinwardtia 6: 193. 1962.

Fairly common in semievergreen and evergreen forests and also along river banks and moist areas of deciduous forests; flowers and fruits during January to April (Kanjirakadavu, Kalkulam, Meenmuti, Pullukuthimala, *RJ* 20554).

*Distribution*: Peninsular India, Sri Lanka.

**ELAEAGNACEAE**

***Elaeagnus indica*** Serv., Herb. Boiss. (ser. 2) 8: 393. 1908.

Fairly common in evergreen and deciduous forests; flowers and fruits during November to March (Panapuzha, Nedunkayam, Manakadavu, *RJ* 22350).

*Distribution*: India to Malesia.

**THYMELIACEAE**

***Gnidia glauca*** (Fresen.) Gilg, Bot. Jahrb. Syst. 19: 265. 1894.

Common in the subtropical hill savannahs and also rarely along the edges of shola forests; flowers and fruits during January to May (Erumala, Vilakumala, Mukuruthi, *RJ* 20460).

*Distribution*: South-West India, Sri Lanka, Africa.

**EUPHORBIACEAE**

***Agrostistachys borneensis*** Becc., Nelle For. Born. 331. 1902.

Very common in evergreen forests of high elevations and rare in subtropical hill forests; flowers and fruits during October to January (Irumbanchola, Pullukuthimala, Ganiyamala, Kedakamala, *RJ* 21217).

*Distribution*: Indo-Malesia.

***Agrostistachys indica*** Dalz. in Hook., Kew J. Bot. 2: 41. 1850.

Fairly common in the evergreen forests; flowers and fruits during September to December (Karimpuzha, Meenmutti, Manakadavu, *RJ* 22339).

*Distribution*: Peninsular India.

***Antidesma acidum*** Retz., Obs. Bot. 5: 30. 1788.

Fairly common in the deciduous forests; flowers and fruits during August to December (Nedunkayam, Kanjirakadavu, Paduka, *RJ* 9334).

*Distribution*: India, Myanmar, South China, Indo-china, Java.

***Antidesma menasu*** Miq. *ex* Tul., Ann. Sci. Nat. Bot. 15: 218. 1851.

Fairly common in the evergreen forests, especially along river sides; flowers and fruits during March to June (Pullukuthimala, Manakadavu, Ganiyamala, *RJ* 21538).

*Distribution*: Peninsular India.

***Aporusa lindleyana*** (Wt.) Baill., Etud. Gen. Euphorb. 645. 1858.

Fairly common in semievergreen and evergreen forests especially along river sides; flowers and fruits during January to April (Panapuzha, Manakadavu, Meenmutti, Irumbanchola, *RJ* 22340).

*Distribution*: Peninsular India, Sri Lanka.

***Baccaurea courtallensis*** (Wt.) Muell.-Arg. in DC., Prodr. 15(2): 459. 1866.

Common in semievergreen and evergreen forests at low elevations; flowers and fruits during March to June (Panapuzha, Karimpuzha, Meenmutti, Irumbanchola, *RJ* 8568).

*Distribution*: India, Malesia, Pacific Islands.

***Baliospermum solanifolium*** (J. Burm.) Suresh in Nicols. *et al.*, Interpret. Hort. Malab. 106. 1988.

Fairly common in the deciduous forests; flowers and fruits during December to March (Nedunkayam, Paduka, *RJ* 22341).

*Distribution*: India, Indo-china, Indonesia.

***Bischofia javanica*** Bl., Bijdr. 1168. 1827.

Common in semievergreen forests; flowers and fruits during March to June (Panapuzha, Karimpuzha, Meenmutti, Thalichola, *RJ* 8569).

*Distribution*: India, Malesia, Pacific Islands.

***Bridelia scandens*** (Roxb.) Willd., Sp. Pl. 4: 979. 1806.

Fairly common in the semievergreen forests; flowers and fruits during December to March (Panapuzha, Nedunkayam, Meenmutti, *RJ* 8571).

*Distribution*: Western Peninsular India.

***Cleidion javanicum*** Bl., Bijdr. 613. 1825.

Occasional, in deciduous and semievergreen forests along river banks; flowers and fruits during September to December (Nedunkayam, Panapuzha, *RJ* 8572).

*Distribution*: India, Sri Lanka, South-China, Malesia,.

***Cleistanthus collinus*** (Roxb.) Benth. *ex* Hook.f., Fl. Brit. India 5: 274. 1887.

Fairly common in the deciduous forests; flowers and fruits during September to December (Nedunkayam, Mundakadavu, Paduka, Uchakulam, *RJ* 8573).

*Distribution*: India, Sri Lanka.

***Croton caudatus*** Geisel., Croton. Monogr. 73. 1807.

Common in semievergreen and evergreen forests at low elevations especially along the river sides; flowers and fruits during March to June (Poochapara, Meenmutti, Manakadavu, Panapuzha, *RJ* 21532).

*Distribution*: India, Sri Lanka, South-East Asia, western Malesia.

***Croton malabaricus*** Bedd., Ic. t. 181. 1874.

Fairly common in the evergreen forests at low elevations and also in semievergreen forests; flowers and fruits during March to June (Thalichola, Meenmutti, Manakadavu, Bellakettumala, Irumbanchola, *RJ* 21517).

*Distribution*: South-West India.

***Daphniphyllum neilgherrense*** (Wt.) K. Rosenth. in Engl., Pflanzenr. 4(147a): 7. 1919.

Fairly common in evergreen and shola forests; flowers and fruits during November to March (Mukuruthi, Pullukuthimala, *RJ* 21393).

*Distribution*: Peninsular India, Sri Lanka, Korea, Java.

***Drypetes elata*** (Bedd.) Pax *et* Hoffm. in Engl., Pflanzenr. 81: 268. 1922.

Common in semievergreen and evergreen forests at low elevations; flowers and fruits during December to March (Thalichola, Meenmutti, Manakadavu, Irumbanchola, Vilakumala, Karimpuzha, *RJ* 8574).

*Distribution*: Peninsular India.

***Drypetes oblongifolia*** (Bedd.) Airy Shaw, Kew Bull. 23: 57. 1969.

Common in semievergreen and evergreen forests; flowers and fruits during March to June (Poochapara, Kuppamala, Manakadavu, Irumbanchola, Vilakumala, Karimpuzha, *RJ* 8575).

*Distribution*: India, Sri Lanka, Malesia.

***Drypetes wightii*** (Hook.f.) Pax *et* Hoffm. in Engl., Pflanzenr. 81: 273. 1922.

Common in evergreen forests at high elevations and also subtropical hill forests; flowers and fruits during February to May (Pullukuthimala, Kedakamala, Irumbanchola, Ganiyamala, *RJ* 21428).

*Distribution*: Western Gahts of Peninsular India.

***Epiprinus mallotiformis*** (Muell.-Arg.) Croizat, J. Arnold Arbor. 23: 52. 1942.

Fairly common in the evergreen forests; flowers and fruits during September to March (Meenmutti, Manakadavu, Irumbanchola, *RJ* 8577).

*Distribution*: Peninsular India.

***Excoecaria crenulata*** Wt., Ic. Pl. Ind. Orient. t. 1865. 1852.

Rare, in the evergreen forests; flowers and fruits during December to March (Vilakumala, *RJ* 8576).

*Distribution*: Western Peninsular India.

***Excoecaria robusta*** Hook.f., Fl. Brit. India 5: 474. 1888.

Occasional, in the evergreen forests; flowers and fruits during March to July (Karimpuzha, Meenmutti, Manakadavu, Irumbanchola, *RJ* 22343).

*Distribution*: Peninsular India.

***Glochidion ellipticum*** Wt., Ic. t. 1906. 1852.

Fairly common in the evergreen forests at high elevations; flowers and fruits during January to March (Manakadavu, Meenmutti, Erumala, Pullukuthimala, *RJ* 9177).

*Distribution*: India to Malesia.

***Glochidion malabaricum*** Bedd., For. Man. Bot. 194. 1873.

Fairly common in semievergreen and evergreen forests; flowers and fruits during January to April (Panapuzha, Irumbanchola, *RJ* 21227, 21592).

*Distribution*: Peninsular India in the Western Ghats.

***Glochidion neilgherrense*** Wt., Ic. Pl. Ind. Orient. 5: 29. 1852.

Common in shola forests and subtropical hill savannahs; flowers and fruits during December to March (Mukuruthi, Kedakamala, Erumala, *RJ* 22344).

*Distribution:* Peninsular India.

***Macaranga peltata*** (Roxb.) Muell.-Arg. in DC., Prodr. 15: 1010. 1866.

Fairly common in the disturbed, open areas all over; flowers and fruits during December to January (Panapuzha, Nedunkayam, Erumala, Pullukuthimala, Mancheri, Kedakamala, Mukuruthi *RJ* 9211).

*Distribution*: India, Sri Lanka.

***Mallotus philippensis*** (Lamk.) Muell.-Arg., Linnaea 34: 196. 1865.

Fairly common in the deciduous and semievergreen forests; flowers and fruits during January to April (Panapuzha, Nedunkayam, Meenmutti, *RJ* 9525).

*Distribution*: India, Sri Lanka, Malesia, Australia.

***Mallotus tetracoccus*** (Roxb.) Kurz, J. Asiat. Soc. Bengal 16: 245. 1873 .

Fairly common in deciduous and semievergreen forests, mostly along river banks; flowers and fruits during December to April (Panapuzha, Nedunkayam, Vilakumala, *RJ* 20476, 9275).

*Distribution*: India, Sri Lanka, China.

***Margaritaria indica*** (Dalz.) Airy Shaw, Kew Bull. 20: 387. 1966.

Occasional in the semievergreen and evergreen forests; flowers and fruits during January to April (Panapuzha, Irumbanchola, *RJ* 22345).

*Distribution*: India to Formosa, Sri Lanka, Malesia, South-East Asia, New Guinea, Queensland.

***Phyllanthus emblica*** L., Sp. Pl. 982. 1753.

Fairly common in deciduous and also open rocky areas of savannah forests; flowers and fruits during July to December (Nedunkayam, Erumala, *RJ* 8578).

*Distribution*: Throughout tropics.

***Sapium insigne*** (Royle) Benth. *et* Hook.f., Gen. Pl. 3: 335. 1880.

Rare in rocky areas of evergreen forests and savannahs; flowers and fruits during December to February (Odalappara, Erumala, *RJ* 21246).

*Distribution*: India, Sri Lanka, Myanmar, Indo-China, Malaya peninsula.

***Trewia nudiflora*** L., Sp. Pl. 1193. 1753.

Fairly common in the deciduous forests mostly along river banks; flowers and fruits during February to May (Nedumkayam, Moochala *RJ* 8595).

*Distribution*: India, China, Sri Lanka, Myanmar, Malesia.

**URTICACEAE**

***Debregeasia ceylanica*** Hook.f., Fl. Brit. India 5: 592. 1888.

Rare, in the semievergreen forests, especially along river sides; flowers and fruits during June to September (Vilakumala, Meenmutti, *RJ* 20436).

*Distribution*: Peninsular India, Sri Lanka.

***Debregeasia longifolia*** (Burm.f.) Wedd. in DC., Prodr. 16: 235. 1869.

Fairly common in moist, shady places of evergreen forests; flowers and fruits during December to March (Vilakumala, Thalichola, *RJ* 20436).

*Distribution*: Indo-Malesia.

***Oreocnide integrifolia*** (Gaud.) Miq., Ann. Mus. Bot. Lugd.-Bat. 4: 306. 1869.

Fairly common in semievergreen and evergreen forests; flowers and fruits during December to March (Manakadavu, Ganiyamala, Pullukuthimala, Panapuzha, *RJ* 20528).

*Distribution*: India, Sri Lanka, Myanmar.

***Laportea crenulata*** Gaud. in Freyc., Voy. Bot. 498. 1830.

Fairly common in the evergreen forests; flowers and fruits during October to February (Meenmutti, Pullukuthimala, Irumbanchola, Thalichola, *RJ* 21437).

*Distribution*: Peninsular India, Sri Lanka.

**ULMACEAE**

***Celtis timorensis*** Spanoghe, Linnaea 15: 343. 1841.

Occasional, in semievergreen and evergreen forests; flowers and fruits during January to March (Meenmutti, Manjakallanpuzha, Panapuzha, *RJ* 8579).

*Distribution*: Tropical Africa, Asia, Australia.

***Holoptelea integrifolia*** (Roxb.) Planch., Ann. Sci. nat. Bot. Ser. 3. 10: 259. 1848.

Occasional, in deciduous and semievergreen forests; flowers and fruits during February to April (Nedunkayam, Karimpuzha, Panapuzha, *RJ* 22346).

*Distribution*: India, Sri Lanka, Myanmar, Himalaya, Indo-China.

**MORACEAE**

***Antiaris toxicaria*** Lesch., Ann. Mus. natl. Hist. Nat. 16: 478. t. 22. 1820.

Occasional in the semievergreen and evergreen forests; flowers and fruits during February to May (Meenmutti, Karimpuzha, Panapuzha, Thalichola, Manakadavu, *RJ* 22347).

*Distribution*: Asia, Africa, Australia.

***Artocarpus gomezianus*** Wall. *ex* Trecul, Ann. Sci. nat. Bot. Ser. 3, 8: 118. 1847 .

Rare, in deciduous and semievergreen forests; flowers and fruits during March to May (Kalkulam, Panapuzha, *RJ* 22348).

*Distribution*: South-West India, Sri Lanka.

***Artocarpus heterophyllus*** Lamk., Encyl. 3: 209. 1789.

Fairly common in semievergreen and evergreen forests; flowers and fruits during March to June (Kedakamala, Erumala, Meenmutti, *RJ* 22349).

*Distribution*: Probably from South India, cultivated in the tropics.

***Artocarpus hirsutus*** Lamk., Encyl. 3: 210. 1789.

Occasional, in deciduous and semievergreen forests and also rarely occuring in the higher ghats; flowers and fruits during March to June (Thalichola, Nedunkayam, Panapuzha, Vilakumala, *RJ* 21445).

*Distribution*: Peninsular India.

***Ficus beddomei*** King, Ann. roy. Bot. Gard. Calcutta 1: t. 24. 1887.

Fairly common in semievergreen and evergreen forests; flowers and fruits during December to March (Meenmutti, Pullukuthimala, Panapuzha, Karimpuzha, *RJ* 8580).

*Distribution*: Peninsular India.

***Ficus exasperata*** Vahl, Enum. Pl. 2: 197, 402. 1806.

Occasional, in the semievergreen forests; flowers and fruits during February to May (Mancheri, Panapuzha, Karimpuzha, *RJ* 9342).

*Distribution*: India, Sri Lanka, East Africa, Arabia.

***Ficus hispida*** L.f., Suppl. Pl. 442. 1781.

Fairly common in deciduous and semievergreen forests; flowers and fruits during March to July (Mancheri, Panapuzha, Meenmutti, *RJ* 8581).

*Distribution*: India, Sri Lanka, South-China to Guinea, Queensland.

***Ficus nervosa*** Heyne *ex* Roth in Roem. *et* Schult., Syst. Veg. 1: 513. 1817.

Fairly common in deciduous and semievergreen forests; flowers and fruits during January to May (Nedunkayam, Panapuzha, Meenmutti, Manakadavu, Thalichola, *RJ* 21413).

*Distribution*: India, China, Sri Lanka, New Guinea.

***Ficus virens*** Ait., Hort. Kew. 3: 451. 1759.

Occasional in the evergreen forests; flowers and fruits during January to March (Karimpuzha, Meenmutti, Thalichola, *RJ* 22350).

*Distribution*: India, Sri Lanka, Solomon Islands.

***Streblus asper*** Lour., Fl. Cochinch. 615. 1790.

Occasional, along the river banks of deciduous forests; flowers and fruits during January to March (Kalkulam, Kanjirakadavu, *RJ* 21506).

*Distribution*: India, China, Malesia.

**GNETACEAE**

***Gnetum ula*** Brongn. in Duperr., Voy. Bot. 12. 1829.

Fairly common in evergreen and moist areas of deciduous forests; flowers and fruits during February to July (Nedunkayam, Manakadavu, Panapuzha, Vilakumala, *RJ* 22359).

*Distribution*: Peninsular India.

**CYCADACEAE**

***Cycas circinalis*** L., Sp. Pl. 1188. 1753.

Fairly common in the deciduous forests; flowers and fruits during February to August (Nedunkayam, Paduka, *RJ* 22359).

*Distribution*: India, Sri Lanka, Malesia, Madagascar, Tropical Africa.

**ARECACEAE**

***Arenga wightii*** Griff., Calcutta J. nat. Hist. 5: 475. 1845.

Occasional, in the semievergreen forests, along river banks; flowers and fruits throughout the year (Panapuzha, Karimpuzha, *RJ* 8582).

*Distribution*: Endemic to Western Ghats in Peninsular India.

***Calamus thwaitesii*** Becc. *ex* Becc. *et* Hook.f., Fl. Brit. India 6: 441. 1893 .

Occasional in the evergreen forests of low elevations; flowers and fruits during July to May (Manakadavu, Irumbanchola, *RJ* 8585).

*Distribution*: Peninsular India in the Western Ghats and Sri Lanka.

***Caryota urens*** L., Sp. Pl. 1189. 1753.

Fairly common in semievergreen, evergreen and subtropical hill forests; flowers and throughout the year (Mancheri, Pullukuthimala, Kedakamala, Ganiyamala, Meenmutti, *RJ* 8586).

*Distribution*: India, Sri Lanka, Malaya, Myanmar.

***Pinanga dicksonii*** (Roxb.) Bl., Rumph. 2: 85. 1838.

Occasional in the evergreen forests; flowers and throughout the year (Irumbanchola, Pullukuthimala, *RJ* 8587).

*Distribution*: Endemic to Western Ghats of Peninsular India.

**POACEAE**

***Bambusa bambos*** (L.) Voss in Vilmorin's Blumeng. ed 3, Sieb. *et* Voss 1: 1189. 1985.

Gregarious, in the deciduous forests and also in open areas of semievergreens; flowers only once in life and the culms perishes after that (Nedunkayam, Kalkulam, Panapuzha, Karimpuzha, Uchakulam, *RJ* 8588).

*Distribution*: India, Sri Lanka.

***Schizostachyum beddomei*** (Fischer) Majumdar in Karthikeyan *et al.* (eds.) Fl. India Enum. Monocot 281. 1989.

Gregarious in the semievergreen and evergreen forests, especially in moist places; flowers and fruits at long intervals and die after flowering (Meenmutti, Manjakallan).

*Distribution*: Endemic to Western Ghats of Peninsular India.

## Chapter 3

# Insect diversity

### 3.1. Introduction

Invertebrates constitute about 99 per cent of the world's biodiversity (Wilson, 1987, 1988), and over half of these in terms of number of species, are represented by insects with nearly one million species being recorded from different habitats (Stork, 1991). Because of their highly diverse habits, insects have been very successful in diversifying and establishing in as many ecological niches as possible. They also play diverse roles and thus contribute to the sustainability of various ecosystems. Estimates on the number of insect species in the world range from 3 to 10 million.

The tropical forests, which cover less than 7 per cent of the earth's land surface, are one of the richest centers of biological diversity. It has been estimated that nearly 50 per cent of all known species belong to this ecosystem (Myers, 1988). There is considerable pressure on tropical forests mainly due to human interference. Incidence of fire, indiscriminate lopping of trees for fodder and firewood, forest logging for introduction of plantation crops like tea, coffee, rubber, teak, eucalypts etc., submersion of forest due to establishment of hydro-electric and irrigation projects, encroachment as well as cattle grazing are the major disturbances to tropical forests. Such activities affect forest regeneration leading to disappearance of several organisms. Insects being highly fragile in nature, the impact of disturbances is significant with the survival of many species being adversely affected leading to depletion of biological resources. Inventorying of biodiversity is the first step in any conservation programme.

#### 3.1.1. Study area

Due to its formidable terrain, the tropical forests of New Amarambalam are the least surveyed forest tract in the Western Ghats. Except for a study of odonates by Rao and Lahiri (1982), there is no information on the organisms occurring in these forests. An attempt has been made to generate baseline data on the insect diversity patterns in different forest habitats of New Amarambalam Reserve forest and to prepare an inventory of insects belonging to major insect groups.

## 3.2. Review of literature

### 3.2.1. Insect diversity of India

Different workers have proposed various estimates of the total number of insect species found in India. As per an estimate by Menon (1965), there could be about 50000 insect species in India. Varshney (1997) estimates 59353 species of insects belonging to 619 families as having reported from India. Whatever be the case, data that have so far been generated, constitutes merely 6.83 per cent of the world insect fauna. Considering the diverse natural ecosystems existing in India, this number would have been high but for the poor coverage of various ecosystems and especially the forests, which are known to be store houses of great diversity.

Amateurs have carried out most of the initial surveys as early as the 18th century. The materials collected by these workers was passed on to experts in Europe who made descriptions of the organisms and prepared faunal treatises. The results of these surveys are contained in the 'Fauna of British India' series published in the later part of 19th century. Most of the earlier surveys were carried out in easily accessible areas or in locations close to human settlements. As a result, the inaccessible areas including the forests were only poorly covered. During the 20th century, considerable information has been generated by various workers (Fletcher, Stebbing, Gardner, Beeson, Chatterjee, Misra, Ramdas Menon, Mani, Roonwal, Usha Ramakrisnan, Gupta, Swaraj Ghai, Farooqui, Anand, Ipe, Mathur, Arora, Dhillon etc.), which lie scattered in the literature.

### 3.2.2. Insect diversity of Kerala

Although Kerala was included in most of the faunal surveys mentioned earlier, only a few locations have been covered in any great detail. Despite this, considerable information pertaining to the insect diversity of Kerala has been generated primarily through the works of various taxonomists who have surveyed the different ecosystems and prepared treatises on various insect groups. The major ecosystems covered includes agricultural as well as forest areas. Lepidoptera, Hymenoptera, Coleoptera and Collembola were the groups that have been covered in any great detail. An account of the major studies on the insect fauna of Kerala is given here.

During 1967 to 1976, Joseph, Abdurahiman and Narendran studied the hymenopteran fauna of Kerala reporting several new species belonging to Torymidae, Agaonidae and Chalcididae (Abdurahiman and Joseph, 1967, 1975; Joseph *et al.,* 1973,1976). Narendran and other workers continued the studies on Hymenoptera discovering several new taxa of the families Scelionidae, Chalcididae,

Torymidae and Eurytomidae (Narendran, 1986, 1992; Narendran and Sureshan, 1989; Narendran and Sheela, 1995). Prabhoo (1971) studied the soil insects and conducted several investigations on the soil arthropods particularly the Collembola of Kerala, describing several new species. Mathew and Menon (1984) worked on the Lepidoptera. They worked on the systematics of the pyralids of Kerala, recording nearly 100 species as additional records from the State. Rahmathulla (1991) worked on the geometrid moths of Kerala recording about 150 species, mostly collected from the forests. Mathew and Nair (1986) in a survey on the bagworms of Kerala recorded 17 species associated with various forest trees. During 1987 to 1988, Larsen made a detailed study of butterflies of the Nilgiri Mountains. In his seven months' observations, Larsen recorded 299 species of butterflies most of which were also noted as occurring in the Kerala part of Western Ghats.

Rao and Lahiri (1982), conducted a preliminary study on the Odonates of Silent Valley and New Amarambalam and reported 23 species. During 1979-'80, four faunistic explorations were conducted in the Silent Valley National Park reporting 242 species of insects (ZSI, 1986). This included 128 species of Coleoptera (10 new), 15 species of Diptera (1 new), 39 species of Hemiptera (6 new), 2 species of Homoptera (both new), 27 species of Lepidoptera and 33 species of Orthoptera (1 new). Thus, out of a total of 242 species of insects reported, 8.2 per cent were new to science. Obviously, the above study on insects of Silent Valley is very incomplete as indicated by a subsequent study by Mathew (1990) on the Lepidoptera of this region in which he reported 500 species, including 100 species of butterflies and 400 species of moths. A total of 340 species out of the 500 species collected were identified which included 95 species of butterflies and 245 species of moths. Among the butterflies, five were protected species and 13 very rare ones (The Indian Wildlife (Protection) Act, 1982). In another study on the insect fauna of Malayattoor forests, Mathew (1992) reported 262 species belonging to 75 families and 11 orders, of which 210 were identified. This included 104 species of Lepidoptera (47 species of butterflies and 57 species of moths), compared to 500 species of Lepidoptera collected from Silent Valley.

The insect diversity in the Idukki Hydel Project catchment was studied by Cherian (1985) who recorded a total of 266 species - nine species of Coleoptera, two of Dictyoptera, 208 of Diptera, six of Hemiptera, 35 of Lepidoptera and six of Orthoptera. The impact of forest disturbances like fire, plantation programmes and fuel and fodder extraction, on the insect species diversity was studied by Mathew *et al.* (1998) at Nelliampathy, Silent Valley, Sholayar and Parambikulam in the Kerala

part of Western Ghats. Of the four locations, Nelliampathy registered the highest diversity of insects followed by Silent Valley, Sholayar and Parambikulam. It was found that forest disturbance has an adverse effect on the insect diversity based on a comparison of diversity values in disturbed *versus* undisturbed areas. Altogether 1250 species of insects belonging to 15 orders were collected from all localities, of which 586 species could be identified. Maximum number of species collected belonged to Lepidoptera and Coleoptera.

During 1994 to 1997, Sudheendrakumar and Mathew (1999) carried out a study in the Parambikulam Wildlife Sanctuary in which a total of 1049 species belonging to 13 orders and 106 families were collected. With regard to their distribution pattern, evergreen forests had the highest diversity followed by moist deciduous forests and teak plantations.

Sreekumar and Balakrishnan (1998) studied the animal diversity in the Athirappally area (Vazhachal Forest Division) reporting 215 species of animals of which 117 species were insects belonging to 9 insect orders. Of these, the identity of 44 species of butterflies has been established.

### 3.2.3. Insect diversity of New Amarambalam

As has been stated earlier, Rao and Lahiri (1982), conducted a preliminary study on the Odonates of Silent Valley and New Amarambalam areas and reported 23 species. During 1979-'80, four faunistic explorations were conducted in the Silent Valley National Park, located adjacent to the New Amarambalam forests, reporting 242 species of insects (ZSI, 1986). Mathew *et al.* (1998) carried out a faunal survey in the SilentValley National Park. These studies have indicated survival of a diverse and specialized fauna in this region having affinities with Malaysian elements. Excepting these, no survey has been made on the insect fauna of New Amarambalam area.

## 3.3. Materials and methods

### 3.3.1. Sampling of insects

The study was carried out in representative plots selected at different altitudes ranging from 50 to 2500 m and vegetation types covering moist deciduous (Nedumgayam), semievergreen (Panapuzha, Meenmutti), evergreen (Manacadavu, Pullukuthimala, Poochappara), subtropical hill (Ganiyanmala) and shola forests (Mukkuruthi) (Table 3.1, Fig. 3.1). The sampling sites were selected in relation to the plots laid out for vegetation sampling. Data thus obtained were analysed for

computing insect community parameters such as diversity index, dominence index, evenness, species richness index, etc. In addition to sampling carried out in the study plots, collections were also made from various locations as well with a view to take stock of the faunal wealth of the reserve. Due to inaccessibility caused by flooding of rivers and streams during the rainy season, collections were made mostly in the non monsoon months of the year.

**Table 3.1. Details of sampling sites in New Amarambalam**

| Sl. No. | Location | Habitat | Altitude (m) | Plot number for reference (with sites selected for vegetation sampling) | No. of days of sampling |
|---|---|---|---|---|---|
| 1 | Nedumgayam | Moist deciduous | 60 | 30,31 | 19 |
| 2 | Panapuzha | Semievergreen | 350 | 75,78 | 22 |
| 3 | Meenmutti | Semievergreen | 650 | 117,128 | 11 |
| 4 | Manacadavu | Evergreen | 800 | 149,150 | 5 |
| 5 | Pullukuthimala | Evergreen | 1000 | 187,194 | 8 |
| 6 | Poochappara | Evergreen | 1100 | 300 | 4 |
| 7 | Ganiyanmala | Subtropical hill | 1400 | 239, 243 | 8 |
| 8 | Mukkuruthi | Montane shola | 2400 | 284 | 7 |

Sampling of insects was carried out using a battery operated Mathew's -model light trap (Fig. 3.2), specially fitted with a switching device to facilitate automatic operation at specified hours (Mathew, 1996). In addition to trap catches, collections were also made during day time (8 am to 1 pm) using hand nets. The insects collected were sorted out to species and the number of individuals for each species was recorded on data sheets. As it was not possible to identify all the species readily, code numbers were assigned to various species. The insects were later identified by comparison with material available in KFRI collection and by referring to experts in different institutions.

### 3.3.2. Analysis of data

*3.3.2.1.Diversity index*

The quantification of diversity must address two statistical properties common to any mixture of different objects. The first property is the number of different classes or types of object i.e., species, genera, families, different habitats and so on. The second property is the distribution of objects among classes, such as the relative abundance of individuals of different taxa or the relative area of the habitat that falls into different habitat types. In this study only species diversity was studied. For this, the Shannon-Weiner diversity index (H) was used (Magurran, 1988)

$$H = -\sum P_i \log_e P_i$$

Where 'H' is the Shannon's index of species diversity and $P_i$ is the proportion of individuals in the $i^{th}$ species. In order to find out whether any significant differences existed in the insect diversity betweenthe vegetation types, a 't' test was done (Magurran, 1988) using the following formula:

$$t = \frac{H_1 - H_2}{\left[\text{var}(H_1) + \text{var}(H_2)\right]^{1/2}}$$

**Fig. 3.2. Light trap used for insect sampling**

Where '$H_1$' and '$H_1$' are diversity indices of first and second locality, and var ($H_1$) and var ($H_2$) are their variances. Variance of diversity index (Magurran, 1988) is defined as follows:

$$\text{Var}(H) = \frac{\sum P_i(\log_e P_i)^2 - [\sum P_i \log_e P_i]^2}{N} + \frac{S-1}{2N^2}$$

Where $n_i$ = number of insects in the '$i$'$^{th}$ Order; 'S' is the number of species recorded and N is the total number of insects in all the orders collected during the study period.

*3.3.2.2. Dominance index*

Patterns of relative abundance of species that determine the dominance of each insect Order in a locality was determined by calculating the dominance index using the following formula:

$$\text{Relative dominance} = n_i \times \frac{100}{N}$$

*3.3.2.3.Evenness or equitability index*

This index, which measures the evenness of species abundance, is complimentary to the diversity index concept and it indicates how the individuals of various species are distributed in the community.

For estimating evenness, Shannon's evenness index was calculated (Pielou, 1975). Mathematically, the evenness of frequency distribution of species abundance in a community with 'S' component species, is the degree to which it approximates the uniform distribution for 'S' species i.e., equal abundance of all species in the sample or community.

In a collection or in a community with 'S' component species, diversity will be greater if all 'S' species are well represented. In this condition, there is high evenness and low dominance. On the contrary, if a few of the species, say 't' are very common and the rest (S-t) are very rare, then it is a case of low evenness and high dominance.

The Shannon's evenness index of the community (E) was calculated following Pielou (1975).

$$E = H/\log_e(S)$$

Where, 'H' is the Shannon-Weiner index of diversity.

*3.3.2.4.Species richness index*

The index of species richness (d) was calculated using the formula given by Menhinick 1964):

$$D = S/\sqrt{N}$$

Where 'N' is the total number of individuals summed over all species.

## 3.4. Results

### 3.4.1. Insect fauna

Of about 30 insect orders, insects belonging to 14 orders were collected, of which only a few orders like Lepidoptera, Hymenoptera and Coleoptera were studied in great detail. Moths and butterflies for which sufficient taxonomic expertise is available could also be studied in some detail. Of the 860 species collected from New Amarambalam, 503 species have been identified which included 133 species of butterflies, 202 of moths, 65 of Coleoptera, 51 of Hymenoptera, 35 of Hemiptera, eight of Orthoptera, six of Odonata, two of Dictyoptera, and one of Neuroptera. Details pertaining to different group of insects are as follows:

*3.4.1.1. Butterflies*

The butterflies belonged to 10 families with Nymphalidae and Lycaenidae containing maximum number of species followed by Danaidae and Satyridae. The families Riodinidae, Libytheidae and Acraeidae contained only one species each (Appendix 3.1). The evergreen forests contained maximum number of butterflies (96 spp.), followed by semievergreen (84 spp.), moist deciduous (64 spp.), sub tropical hill forest (30 spp.) and montane shola forest (22 spp.).

The distribution of various species showed specialization in relation to the habitat. For instance, *Papilio paris tamilana, Pathysa antiphates* (Papilionidae), *Cyrestris thyodamas ganescha* (Nymphalidae), *Mycalesis anaxias* (Satyridae), *Potanthus pava pava* (Hesperiidae), *Acytolepis puspa, Petrelaea dana, Prosotas nora, P. dubiosa indica, Nacaduba ?kurava, N. beroe* and *Anthene lycaenina* (Lycaenidae) were present only in the semievergreen and evergreen habitats. *Papilio buddha* (Papilionidae) was found only in the evergreen and sub tropical forests. *Pantoporia ranga* (Nymphalidae) was found only in the subtropical hill forest, while *Pieris canidia* (Pieridae), *Argynnis hyperbius* (Nymphalidae), *Zizula hylax and Zizeeria karsandra* (Lycaenidae) were recorded only from the shola forests. Similarly, *Eurema lacteola* (Pieridae) and *Spialia galba* (Hesperiidae) were recorded from the semievergreen forests. *Eurema laeta, Cepora nadina, Leptosia nina* (Pieridae), *Orsotrioena medus, Mycalesis perseus, Elymnias caudata* (Satyridae), *Telicota acigias* (Hesperiidae) and *Neopithecops almora* (Lycaenidae) were present only in moist deciduous forests.

Twenty-eight species of butterflies recorded in this study were found to be of high conservation status being either endemic or protected species (Table 3.2; Fig. 3.3). The evergreen forest contained the maximum number (20 spp.) followed by semievergreen (15 spp.), moist deciduous (7 spp.), subtropical hill forest (7 spp.) and montane shola forest (5 spp.).

**Table 3.2. List of endemic/protected butterflies recorded from New Amarambalam**

| Family/species | Forest types | | | | |
|---|---|---|---|---|---|
| | Moist deciduous | Semiever green | Evergreen | Subtropical hill | Montane shola |
| Papilionidae | | | | | |
| *Chilasa clytia* Lin. # | P | P | | | |
| *Troides minos* Cram. + | P | P | P | | |
| *Papilio buddha* Westwood +# | | | P | P | |
| *P. liomedon* Moore+# | | | P | P | |
| *P. hector* Lin. # | P | P | P | | |
| *P. pandiyana* Moore + | | | P | | |
| Nymphalidae | | | | | |
| *Parthenos sylvia virens* Moore # | P | P | P | | |
| *Tanaecia lepidea* (Butler) # | | P | P | | |
| *Euthalia aconthea* Fruhstorfer # | P | P | | | |
| *H. misippus* Lin. # | | P | P | P | P |
| *N. jumbah* Moore # | | P | P | | |
| *Pantoporia ranga* (Moore) # | | | | P | |
| Danaidae | | | | | |

*Cont'd...*

Table 3.2. *Cont'd...*

| | | | | | |
|---|---|---|---|---|---|
| *P. nilgiriensis* Moore + | | | | P | P |
| *Idea malabarica malabarica* Moore + | | | | | |
| Pieridae | | | | | |
| *Appias libythea* Fb. # | | | P | | P |
| *A. albina* Boisduval # | P | P | P | P | |
| *A. indra* Moore # | | P | P | P | |
| *Cepora nadina* Moore # | | P | P | | |
| *Colias nilgiriensis* Feld. & Feld. + | | | | | P |
| *Appias wardi* (Moore) + # | | P | P | | |
| *Appias lyncida* (Cramer) # | | | P | | |
| *Prioneris sita* C&R Felder # | | | P | | |
| Satyridae | | | | | |
| *Mycalesis anaxias* Hewitson # | | P | P | | |
| *M. igilia* Fb. + | | | P | | |
| *Zipoetis saitis* Hewitson + # | | | P | | |
| Lycaenidae | | | | | |
| *Spindasis lohita lazularia* Moore # | | P | | | |
| *Euchrysops cnejus* (Fb.) # | P | P | | | |
| *Lampides boeticus (*Lin.*)* # | | | P | | P |

+ Endemic to Western Ghats; # Protected under Indian Wildlife Act:; P = Species present.

*3.4.1.2. Moths*

The 202 species of moths identified belonged to 11 families (Appendix 3.1). The families Pyraloidea and Noctuidae contained maximum number of species. While some moths were quite large and colourful like the saturnids *Actias selene* and *Loepa sikkima,* majority were moderate sized with intricate wing patterns. The economic importance of a few has been established while that of the majority is still unknown.

The moths of economic importance included primarily those that have been reported to be pests of various plants. This included *Psalis pennatula* (Arctiidae), *Cnaphalocrocis medinalis, Nymphula depunctalis, Schoenobius minutellus, Scirpophaga* sp. (Pyraloidea) and *Spodoptera mauritia* (Noctuidae) attacking rice, maize, sugar cane, etc., *Utethesia pulchellale* (Arctiidae), *Psara licarsicalis, P. basalis* (Pyraloidea), *Helicoverpa armigera* (Noctuidae) and *Euproctis* spp. (Lymantridae) attacking pulse and vegetable crops, *Pericallia ricini* (Arctiidae) attacking castor, *Thalassodes* sp. (Geometridae) attacking mango, *Eligma narcissus* (Arctiidae) attacking *Ailanthus triphysa, Hypsa* spp. (Hypsidae)attacking *Ficus, Semiothisa* sp. (Geometridae) attacking *Xylia xylocarpa, Parasa lepida* (Limacodidae) attacking palms, *Othreis fullonica* (Noctuidae) attacking fruits, *Creatonotus gangis* (Arctiidae) attacking lilly and *Asura* spp. (Arctiidae) attacking mosses.

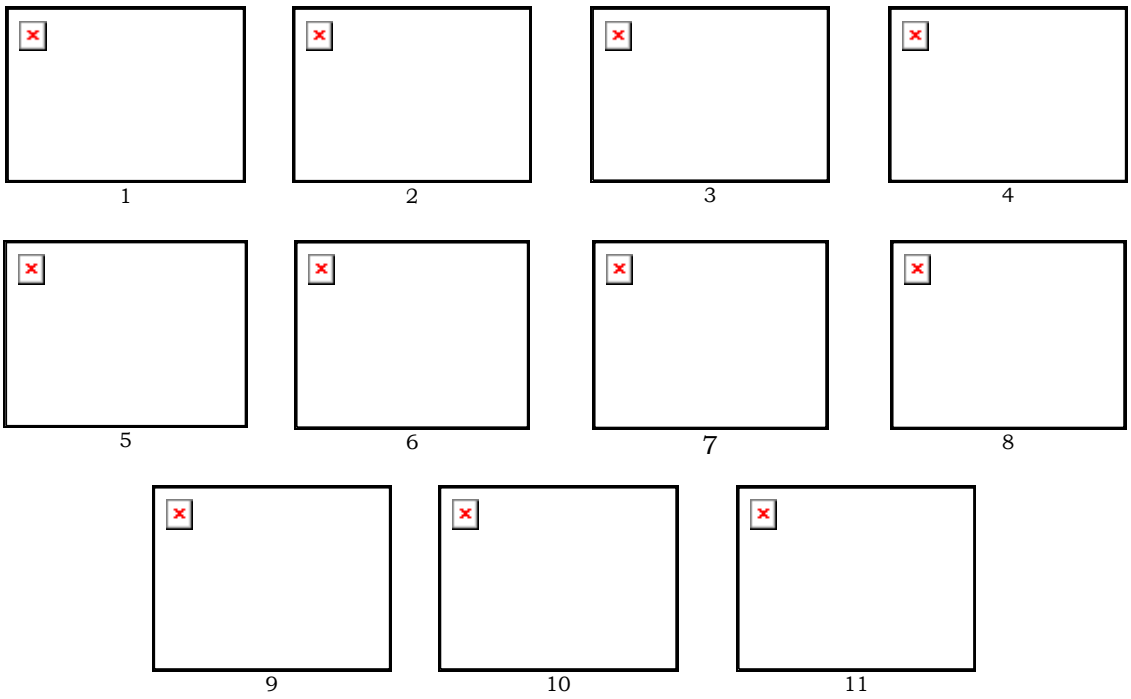


**Fig. 3.3*:** ***Troides minos 1; Pachliopta hector 2; Pachliopta pandiyana 3; Papilio buddha 4; Papilio liomedon 5; Chilasa clytia 6; Appias lyncida 7; Appias libythea 8; Mycalesis anaxias 9; Hypolimnas misippus 10; Euthalia aconthea 11 [* - Not to scale]***

*3.4.1.3. Other insects*

The beetles contained phytophagous, xylephagous, predatory and scavenger forms. The phytophagous beetles mostly belonged to the family Chrysomelidae. This included the pumpkin beetle *Aulacophora cincta*, the gmelina defoliator *Calopepla leayana* and several polyphagous beetles like *Chlamys* sp., *Hoplasoma unicolor* and *Monolepta longitarsis.* The families Cerambycidae, Buprestidae, Bostrychidae, Anthribidae, Curculionidae, Lucanidae, Platypodidae, Scolytidae and Passalidae contained the xylephagous forms. This included *Cerosterna scabrator* (Eucalyptus girdler), the cashew borer *Plocaederus ferrugineus* (Cerambycidae); the bamboo ghoon borer *Dinoderus minutus* (Bostrychidae), the bamboo culm borer *Mecistocerus fluctiger* (Curculionidae), the stag beetle *Odontolabis cuvera* (Lucanidae) as well as the shot-hole borer *Xyleborus maximus* (Scolytidae). The predatory beetles belonged to the families Carabidae and Cicindelidae. The scavenger beetles included the dung rollers *Anomala* spp., *Copris* spp. and *Maladera* sp. (Scarabaeidae). *Oryctes rhynocerus* (attacking palm), *Popillia* sp. (attacking petals of rose), *Maladera* sp. (attacking foliage of mangium) and the white grub *Holotrichia serrata* attacking the roots of seedlings in the nursery have economic significance. The bugs contained several species of economic significance such as the ear-head bug *Chilochoris*

*angustatus* (Miridae) and the plantain spittlebug *Cosmocarta* sp. (Cercopidae). Two species of cicadas *viz.*, *Cryptotympana varicolor* and *Platypleura insignis* have also been recorded. With regard to Hymenoptera, several species of wasps (belonging to the families Eumenidae, Sphecidae, Chrysididae and Pompilidae); parasitic wasps (of the families Braconidae, Ichneumonidae and Bethylidae); bees (belonging to the families Apidae, Xylocopidae, Megachilidae and Anthophoridae) as well as ants (Formicidae) have been recorded. In addition neuropterans, grasshoppers, gryllids, mantids, roaches as well as dragonflies were also recorded.

### 3.4.2. Insect community

Altogether 535 species belonging to 14 orders and 83 families were collected through samplings from the plots laid out to study insect community parameters. Of these, 179 species were from moist deciduous forests (Nedumgayam), 271 species from semievergreen (Panapuzha and Meenmutti), 263 species from evergreen (Manakadavu, Pullukuthimala and Poochapara), 165 species from sub tropical hill forest (Ganiyanmala) and 47 species from the shola forests (Mukuruthi) (Table 3.2). Maximum number of insects and their species were recorded from the semievergreen and evergreen forests and the least from the shola forest. A numeric representation of insects found in different forest types is provided in Figure 3.4.

**Table 3.3. Characteristics of insect community in New Amarambalam**

| Habitat/altitude | Total no. of species collected | Total no. of individuals collected | Richness | Diversity* | Evenness |
|---|---|---|---|---|---|
| Moist deciduous 50-300 m | 179 | 1333 | 4.90 | 4.21$^{c}$ | 0.81 |
| Semi-evergreen 300-700 m | 271 | 3287 | 4.73 | 4.35$^{b}$ | 0.78 |
| Evergreen 700-1300 m | 263 | 2673 | 5.09 | 4.51$^{a}$ | 0.81 |
| Sub tropical hill forest 1300-1700 m | 165 | 886 | 5.54 | 4.30$^{bc}$ | 0.84 |
| Montane shola 1700-2500 m | 47 | 131 | 4.11 | 3.48$^{d}$ | 0.90 |
| **Total** | **535** | **8310** | **5.87** | **4.92** | **0.78** |

*Figures represented by the same letter do not differ significantly at P=0.01

#### *3.4.2.1. Species abundance*

The total number of insects collected from various habitats in the study area ranged from 131 in montane shola to 3287 in semievergreen forests (Table 3.3). From the

evergreen and moist deciduous forests respectively, 2673 and 1333 insects were collected.

*3.4.2.2. Species richness*

The subtropical hill forest was the richest in terms of species (5.54) followed by evergreen (5.09) and moist deciduous (4.90) forest types. Montane shola had the lowest value (4.11) (Table 3.3).

*3.4.2.3. Dominance index*

The dominance indices for insect groups collected from various habitats in New Amarambalam are given in Table 3.4. The dominant insect orders with respect to number of individuals in the various habitats at New Amarambalam were Lepidoptera and Coleoptera followed by Trichoptera, Diptera and Hymenoptera.

**Table 3.4. Dominance indices for insect groups in different forest types at New Amarambalam**

| Insect order | Forest types | | | | | Total |
|---|---|---|---|---|---|---|
| | Moist deciduous | Semi evergreen | Evergreen | Sub tropical hill forest | Montane shola | |
| Lepidoptera | 15.0 | 23.39 | 42.05 | 58.46 | 64.12 | 29.82 |
| Coleoptera | 29.71 | 19.83 | 13.99 | 9.03 | 9.16 | 20.47 |
| Diptera | 16.43 | 15.33 | 11.52 | 7.90 | 15.27 | 13.85 |
| Hymenoptera | 9.23 | 9.19 | 8.01 | 7.79 | 1.53 | 8.54 |
| Homoptera | 11.18 | 8.88 | 4.08 | 1.13 | - | 7.11 |
| Heteroptera | 2.03 | 2.07 | 0.71 | 0.68 | 0.76 | 1.08 |
| Trichoptera | 11.03 | 17.98 | 15.56 | 12.42 | 8.40 | 15.34 |
| Ephemeroptera | 0.30 | 1.37 | 0.19 | - | - | 0.65 |
| Dictyoptera | 1.58 | 0.27 | 0.56 | 0.79 | | 0.65 |
| Neuroptera | 0.08 | 0.06 | 0.45 | 0.34 | 0.76 | 0.20 |
| Orthoptera | 3.38 | 0.79 | 0.11 | 0.79 | - | 0.98 |
| Dermaptera | 0.08 | 0.12 | - | - | - | 0.06 |
| Plecoptera | - | 0.43 | 0.22 | 0.68 | - | 0.31 |
| Isoptera | - | 0.27 | 2.54 | - | - | 0.93 |

- *Not collected*

Maximum number of insects collected belonged to Lepidoptera (29.82%). Of the various forest types, the montane shola contained more Lepidoptera followed by sub tropical hill forests, evergreen forests, semievergreen and moist deciduous forests (Table 4). With regard to Coleoptera, which formed 20.47 per cent of the insects collected, the pattern of abundance was just the reverse with moist deciduous forest containing maximum number of insects. With regard to the number of species collected (Table 3.3), Lepidoptera contained the maximum number (Fig. 3.5) of

species (42.80%), followed by Coleoptera (34.46%), Homoptera (4.30%) and Hymenoptera (3.93%).

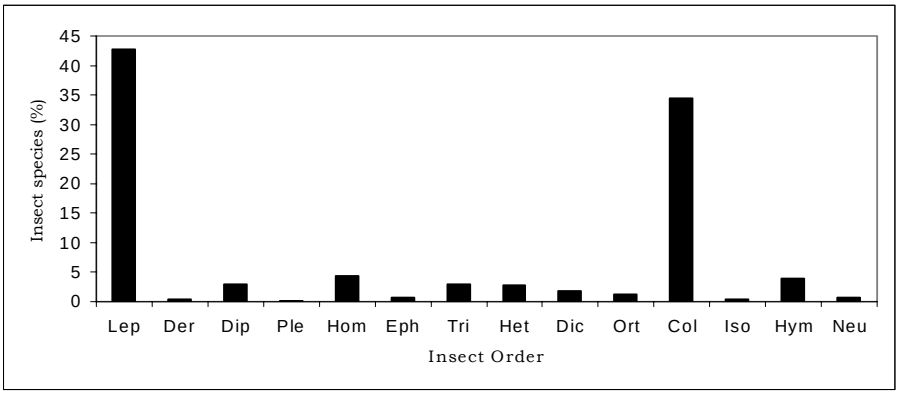


**Fig.3.5. Insect species recorded in various orders from the study area**

*3.4.2.4. Species diversity*

Shannon's index of insect diversity is presented in Table 3. Evergreen forest recorded the highest species diversity (4.51) followed by semievergreen (4.35), subtropical hill (4.30) and moist deciduous forests (4.21). The montane sholas recorded the lowest value of 3.48.

The faunal diversity of evergreen and shola forests was found to be significantly different from that of all other forest types, but not between them. Between evergreen forest and shola, there was significant difference in diversity. With regard to the semi- evergreen forest, the faunal diversity did not differ significantly from that of the subtropical forest although there was significant difference with moist deciduous and shola forests. The subtropical hill forests differed significantly from the shola although it did not differ much from the moist deciduous forests.

*3.4.2.5. Evenness or equitability indices*

The evenness index, which measures the evenness of species abundance, is complimentary to the diversity index concept and it indicates how the individuals of various species are distributed in the community.

The evenness indices obtained for the montane shola (0.90) was the highest followed by sub tropical hill forest (0.84) (Table 3.3). This indicates that the species present in these habitats are more uniformly distributed than those in other habitats. This might be due to less diverse ecological conditions present in shola forests compared to very complex ecosystems present in evergreen forests. The distribution pattern in moist deciduous and evergreen forests was more or less similar (0.81), although they had only low level of evenness. It may be noted here

that these forest types have a variety of habitats each supporting a characteristic flora which in turn support a more diverse fauna.

### 3.4.3. Major insect groups

*3.4.3.1. Habitat associations*

Lepidoptera and Coleoptera are the major insect groups containing the highest number of taxa. The members of these groups being mostly phytophagous in habits show distinct association with vegetation. The characteristics of these insect groups in different vegetation types are given in Table 3.4. The semi-evergreen forests contained maximum number of individuals and species followed by evergreen, moist deciduous, sub tropical hill and shola forests.

**Table 3.4. Characteristics of major insect groups in different vegetation types**

| Forest type/insect group | Total no. of species | Total no. of individuals | Diversity | Richness | Evenness |
|---|---|---|---|---|---|
| Moist deciduous (50-300 m) | | | | | |
| Lepidoptera | 66 | 200 | 3.74 | 4.67 | 0.89 |
| Coleoptera | 46 | 396 | 2.59 | 2.31 | 0.68 |
| Semi evergreen (300-700 m) | | | | | |
| Lepidoptera | 135 | 772 | 4.03 | 4.86 | 0.82 |
| Coleoptera | 51 | 646 | 2.85 | 2.01 | 0.72 |
| Evergreen (700-1300 m) | | | | | |
| Lepidoptera | 169 | 1262 | 4.15 | 4.76 | 0.81 |
| Coleoptera | 53 | 266 | 3.39 | 3.25 | 0.85 |
| Subtropical hill forest (1300-1700 m) | | | | | |
| Lepidoptera | 118 | 522 | 4.01 | 5.16 | 0.84 |
| Coleoptera | 20 | 76 | 2.59 | 2.29 | 0.87 |
| Montane shola (1700-2500 m) | | | | | |
| Lepidoptera | 30 | 84 | 2.99 | 3.27 | 0.88 |
| Coleoptera | 5 | 12 | 1.23 | 1.44 | 0.77 |

In the case of Lepidoptera, the evergreen forest contained the maximum number of species followed by semievergreen, subtropical, moist deciduous and shola forests. The diversity and richness also showed the same trend. With regard to Coleoptera also, the trend was more or less the same except that the number of individuals recorded was high. The abundance of these groups in the evergreen and semi evergreen forest habitats indirectly indicates the diverse plant species composition in these habitats.

The moist deciduous and montane shola forests had less number of insects, which reflects the comparatively less heterogeneous flora present in these areas. In the former, the herbaceous flora is more or less changing with seasons with the result the insect assemblage; composition and abundance vary at different seasons. For instance, during summer, much of the herbaceous perennial flora disappears which considerably affects the species diversity in these forests. Similarly, because of the altitude and temperate conditions, the flora of the shola forests shows specialization being dominated by ferns, grasses as well as plants belonging to the families Lauraceae and Myrtaceae. As a result, the fauna also shows great specializations.

*3.4.3.2. Insect population trends*

Because of its stable ecosystem, forests are known to have stable populations of insects. However, due to changes in the vegetation structure, or due to climatic or edaphic factors, the animal populations tend to fluctuate. Although the estimates on insect populations were based mainly on the data generated through samplings carried out in study plots, observations on easily observable organisms such as butterflies have provided fairly good information on the dynamics of insect populations. Observations on the population outbreaks of butterflies are given below.

Population outbreaks and migration of butterflies

Small-scale population build up of butterflies was first observed on 6thNovember, 2000 at Ganiyan mala area situated at 1400 m asl. The butterflies were flying at about 1-2 m above the ground and the course of the flight was along the banks of the river Karimpuzha from northeast to southwest direction. The populations attained highest density at mid elevations and further observations were carried out at Meenmutti located at 650 m asl.

Species composition

Altogether, 17,795 butterflies were counted in 27 research hours spent in studying the migratory patterns of butterflies at Meenmutti. Five species of butterflies were observed in the migration viz., the common albatross (*Appias albina darada),* the plain puffin (*Appias indra shiva),* the lesser albatross (*Appias wardii*), the lesser gull (*Cepora nadina remba),* and the common blue bottle (*Graphium sarpedon teredon*). Apart from these, the polyphenetic forms of the females of *A. albina darada,* viz., form *semiflava* and form *flava* were also recorded.

Of the various butterflies observed, *A. albina darada* (including the polyphenetic forms, *semiflava* and *flava*) constituted about 53.55 per cent of the total followed by *A. indra shiva* (37.16%), *G. sarpedon teredon* (4.92%) and *A. wardii* (2.73%) of the total population (Fig. 3.6). Least abundance was recorded for *C. nadina remba,*

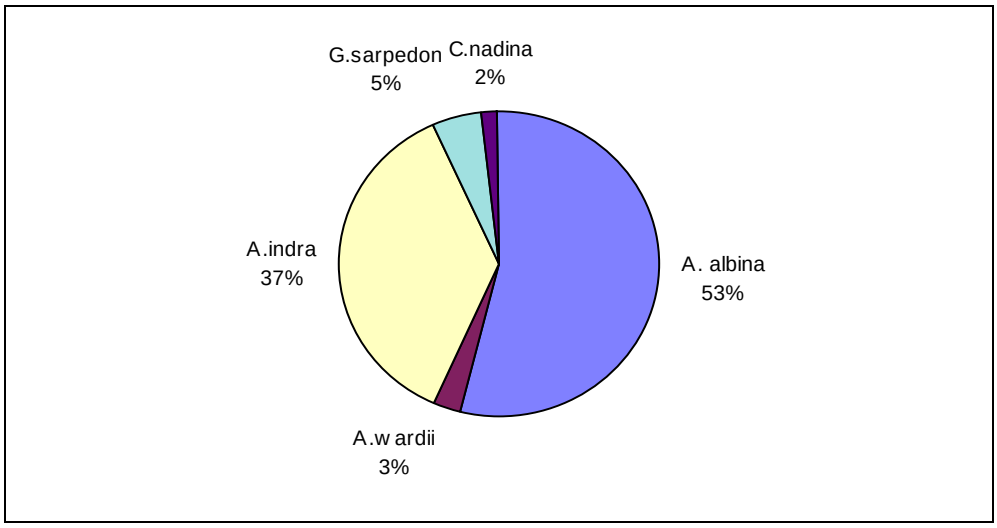


**Fig.3.6. Percentage of butterfly species in migration**

(1.64%). All the species recorded above are pierids except *G. sarpedon teredon,* which is a papilionid. The proportion of males among migrating populations was about 77 per cent and the male to female ratio was 3.4:1.

Periodicity of migrant butterflies

The flight of butterflies started at around 800 h and was over by 1700 h. The density of the migrating butterflies was the maximum during 1200-1300 h on all days of observation. During this period, up to 160 butterflies were counted per minute. The abundance slowly started to decline from 1430 h when about 56 butterflies were recorded per minute (Fig. 3.7). Thereafter, the density and flight pattern became irregular. By 1630 h the density of butterflies was minimum with just two butterflies recorded per minute. It should be noted here that the highest abundance for butterflies was recorded during the hottest period (1200-1300 h) of the day. There was no significant difference in abundance or in flight activity during the three days of observation.

Mud-puddling behaviour

Even as the migration was taking place, a small population of butterflies was found to rest on damp patches along the migratory path. These butterflies appeared to be

attracted to natural (mud puddles on rocky depressions) as well as man-made salt licks (burnt wood, charcoal, etc.). This included the migrant butterflies mentioned earlier as well as some other butterflies that were not found in swarms such as the

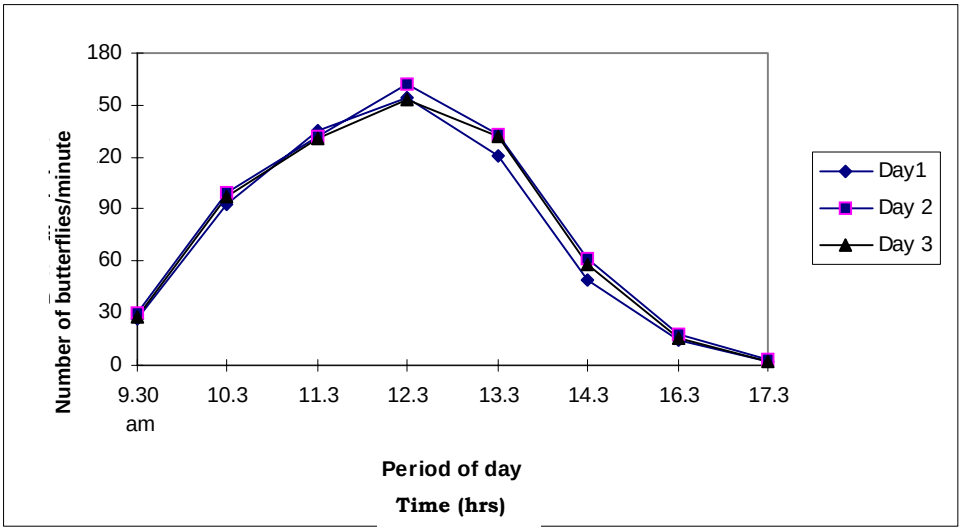


**Fig.3.7. Periodicity of migrant butterflies at New Amarambalam**

blue Mormon (*Papilio polymnestor*), the red helen (*P. helenus*), the common blue bottle (*G. sarpedon teredon*) (Papilionidae), the common club beak (*Libythea myrrha*), the map butterfly (*Cyrestris thyodamas*), the blue tiger (*Tirumala limniace*) (Nymphalidae), the common pierrot (*Castalius rosimon*), the banded blue pierrot

**Table 3.5. Butterflies involved in mud-puddling during migration**

| Common name | Scientific name | Family | Remarks |
|---|---|---|---|
| Blue mormon | *Papilio polymnestor* | Papilionidae | Endemic to S.India & Sri Lanka |
| Red helen | *P. helenus* | Papilionidae | |
| Five bar swordtail | *Graphium antiphates* | Papilionidae | |
| Common blue bottle | *G. sarpedon teredon* | Papilionidae | |
| Club beak | *Libythea myrrha* | Nymphalidae | |
| Map butterfly | *Cyrestris thyodamas* | Nymphalidae | |
| Tawny rajah | *Charaxes bernardus* | Nymphalidae | |
| Blue tiger | *Tirumala limniace* | Nymphalidae | |
| Common pierrot | *Castalius rosimon* | Lycaenidae | |
| Banded blue pierrot | *Discolampa ethion* | Lycaenidae | |
| Malayan | *Megisba malaya* | Lycaenidae | |
| Common hedge blue | *Acytolepis puspa* | Lycaenidae | |
| Line blues | *Nacaduba* spp. | Lycaenidae | |
| Common albatross | *A.albina darada* | Pieridae | Prot., Sch. II.* |
| Lesser albatross | *A. wardii* | Pieridae | Endemic to Western Ghats, Prot., Sch. II.* |
| Plain puffin | *A.indra shiva* | Pieridae | Prot., Sch. II. * |
| Lesser gull | *C. nadina remba* | Pieridae | Prot., Sch. II. * |

* - As per the Indian Wildlife Act (Protection), 1982 (1972).

(*Discolampa ethion*), the malayan (*Megisba malaya*), the common hedge blue (*Acytolepis puspa*) and line blues (*Nacaduba* spp.) (Lycaenidae) (Table 3.5). Of these, the females of *A. albina darada* were also found to be very much active in mud-puddling. At 1030 h only about 50 individuals were found in the mud-puddling swarms. Around 1300 h, which was the hottest period of the day, as many as 500 individuals per salt lick were observed. Butterflies are known to visit 'mud puddles' mainly for sodium salts (Arms *et al.,* 1974). So far, only the males are reported to visit the puddles. The requirement for more water and salts during migration might be the reason for this.

During the time of peak aggregation, individual butterflies vying for the limited space available in the salt licks, were found to alight on one another leading to mortality. The cause may be either due to drowning or by wing damage as a result of fixation in mud and water. It was found that for a group of around 300 individuals, approximately six instances of mortality were observed after 1 hour. Mortality was assessed by periodically scaring away the butterflies from the salt licks. Twenty such salt licks/damp patches were observed for this purpose.

### 3.4.4. Insect-plant interrelationships

*3.4.4.1. Insect herbivory*

Observations made on insects feeding on various plants have indicated that quite a number of insects show specificity to selected plant species. Mass build up of such insects have often resulted in observable damage to the plants. Beetles and lepidopteran caterpillars dominated the plant-feeding group of insects (Table 3.6).

*Drypetes oblongifolia, Cassia fistula,* and *Grewia tiliifolia* were the important tree species found to be affected by insects especially by caterpillars. In most cases, the damage caused was only of a minor nature although in some cases severe defoliation has been recorded. Leaf feeding by various caterpillars was also noticed on various other species like *Symplocos cochinchinensis, Ficus hispida, Careya arborea, Sterculia urens* and *Bischofia javanica.* Damage by insects is likely to affect the regeneration of seedlings and saplings thereby affecting the structure of the forest vegetation. It may be noted here that in natural forest stands insect attack seldom becomes serious on account of the equilibrium existing among the various components of the forest ecosystem (Nair *et al.,* 1986). Information on the impact of insect pests is of importance in the selection plant species for plantation programmes.

**Table 3.6. Insects recorded on various host plants at New Amarambalam**

| Name of the plant | Insect pests | Nature of damage | Remarks |
|---|---|---|---|
| *Drypetes oblongifolia* | *Appias indra shiva* Swinhoe (Lepidoptera: Pieridae) | Leaf feeding | Minor pest |
| *Ficus hispida* | *Glyphodes* sp. | Leaf feeding | Minor pest |
| *Cassia fistula* | *Eurema* sp. (Lepidoptera: Pieridae) | Severe defoliation | Potential pest of saplings |
| *Cassia fistula* | Unidentified caterpillar | Leaf feeding | Minor pest |
| *Bischofia javanica* | Unidentified caterpillar | Leaf feeding | Minor pest |
| *Symplocos cochinchinensis* | Unidentified lymantrid caterpillar | Leaf feeding | Minor pest |
| *Grewia tiliifolia* | Unidentified caterpillar | Leaf feeding | Minor pest |
| *Homonoia riparia* | *Euproctis* sp. (Lepidoptera: Lymantridae) | Leaf feeding | Minor pest |
| *Homonoia riparia* | Unidentified caterpillar | Leaf rolling | Minor pest |
| *Impatiens* sp. | Pyralid caterpillar | Leaf webbing | Minor pest |
| Mosses | *Asura confirta* Wlk. (Lepidoptera: Arctiidae) | Feeding | Abundant during July-August at the banks of rivers. |
| *Sterculia urens* | Unidentified caterpillar | Leaf feeding | Minor pest |
| *Careya arborea* | *Aeolanthes dicraea* Meyr. (Lepidoptera: Arctiidae) | Leaf feeding | Minor pest |
| *Pteris? vittatta* | Unidentified caterpillar | Leaf feeding | Minor pest |

Mass build up of the pierid butterfly, *Appias indra* on the foliage of the tree *D. oblongifolia* resulted in the formation of large swarms. Local aggregations of this butterfly have been recorded in the low altitude evergreen forests. This butterfly, which is mostly confined to forest habitats, has great aesthetic value. Similarly, the tree *D. oblongifolia* was also of interest since it supported both immature and adult stages of this butterfly - the larvae fed on the foliage and the adults fed at the flowers (Binoy and Mathew, 2000). Information generated on the host and habitat preferences of this butterfly has conservation significance.

## 3.4.5. Discussion

### 3.4.5.1. Insect fauna

The distribution of various species showed specialization in relation to the habitat. The papilionids *Papilio paris tamilana, Pathysa antiphates*; the nymphalid, *Cyrestis thyodamas ganescha*; the satyrid *Mycalesis anaxias*; the hesperiid *Potanthus pava pava* and the lycaenids *Acytolepis puspa, Petrelaea dana, Prosotas nora, P. dubiosa indica, Nacaduba ?kurava, N. beroe* and *Anthene lycaenina* were present only in the semi evergreen and evergreen habitats. Similar specializations have been observed for other forest types as well.

An interesting feature of the fauna is the occurrence of a high degree of endemism. There were also a number of rare and protected species besides several species having great aesthetic value. Among butterflies 28 belonged to the category of endemic or protected species (Table 3.2). Maximum number (20 spp.) was found in the evergreen forest followed by semi evergreen forest, moist deciduous forest, sub tropical hill forest and montane shola forests. Although the ecological and economic significance of some insects are already known, that of several species still remains to be established.

### 3.4.5.2. Insect diversity

Due to the difficult terrain and poor accessibility, a very detailed exploration could not be undertaken and hence the sampling was having only a limited coverage being confined to only a few typical habitats selected at various altitudes and vegetation classes as indicated in Table 3.1. Intensive surveys carried out at these locations have given a more or less reasonable account of the faunal diversity present in this area.

The insect species diversity at New Amarambalam was found to be considerably rich and varied in comparison with other biodiversity 'hotspots' in the Kerala part of the Western Ghats. It also contained the highest number of protected species (Table 3.7). With regard to diversity, the area was comparable to other biodiversity 'hotspots' such as Silent Valley, Parambikulam and Sholayar. An interesting feature of this area was the availability of highly diverse and specialised ecological conditions offered by the undulating terrain interspersed with extensive forests ranging from 60 to 2400m elevation. Such conditions offer appropriate habitats for the survival of a myriad of organisms showing high habitat specificity.

**Table 3.7. A comparison of insect diversity at New Amarambalam and other areas of Kerala**

| Locality | No. of individuals | No. of species | Diversity | Species endemic to Western Ghats | Protected species |
|---|---|---|---|---|---|
| Silent Valley | 10451 | 578 | 4.83 | 9 | 16 |
| Nelliampathy | 2804 | 372 | 5.13 | 7 | 16 |
| Parambikulam | 8192 | 418 | 4.50 | 6 | 11 |
| Sholayar | 1306 | 199 | 4.74 | 3 | 5 |
| Mannavan Shola | 1051 | 344 | 5.36 | 5 | 5 |
| Chembra Hills | 150 | 81 | 4.22 | 1 | 3 |
| New Amarambalam | 8310 | 535 | 4.92 | 6 | 22 |

The distribution pattern of insects in the Reserved Forest was interesting. The semi-evergreen forests contained maximum number of individuals and species followed by evergreen, moist deciduous, sub tropical hill and shola forests. The abundance of faunal elements in these forest types might be due to the physiognomic, altitudinal and vegetation characteristics of these forests.

The moist deciduous and montane shola forests had less number of insects. In the former, the insect assemblage, composition and abundance varied at different seasons due to changes in the herbaceous flora. Similarly, the high altitude and prevailing temperate conditions of the shoal forests have contributed a highly specialized flora and fauna. Faunal diversity of evergreen and shola forests was significantly different from that of all other forest types. Although subtropical hill forest and shola forest have more or less similar environmental conditions, insect diversity of the former differed significantly from that of the latter.

**Appendix 3.1. Insects recorded from various habitats in New Amarambalam**

| **Forest types** | **MDF** | **SEV** | **EVG** | **STH** | **MSF** |
|---|---|---|---|---|---|
| **Order/ Family** | | | | | |
| **LEPIDOPTERA** | | | | | |
| **RHOPALOCERA** | | | | | |
| | | | | | |
| **PAPILIONIDAE** | | | | | |
| | | | | | |
| *Chilasa clytia* Lin. # | P | P | | | |
| *Troides minos* Cram. + | P | P | P | | |
| *Papilio helenus* Lin. | P | P | P | P | |
| *P. polymnestor parinda* Moore | P | P | P | P | |
| *P. polytes thesus* Cramer | P | P | P | | P |
| *P. demoleus demoleus* Lin. | P | P | | | P |
| *P. paris tamilana* Moore | | P | P | | |
| *P. buddha* Westwood +# | | | P | P | |
| *P. liomedon* Moore+# | | | P | P | |
| *Graphium sarpedon teredon* Felder | P | P | P | P | P |
| *G. agamemnon agamemnon* Lin. | P | P | P | | |
| *G. doson doson* Felder | | P | P | | |
| *Pachliopta aristolochiae* Lin. | P | P | P | | |
| *P. hector* Lin. # | P | P | P | | |
| *P. pandiyana* Moore + | | | P | | |
| *Pathysa antiphates* (Fb.) | | P | P | | |
| | | | | | |
| **NYMPHALIDAE** | | | | | |
| | | | | | |
| *Pantoporia hordonia* Stoll | P | P | P | | |
| *Vindula erota soloma de* Niceville | P | P | | | |
| *Parthenos sylvia virens* Moore # | P | P | P | | |
| *Tanaecia lepidea* (Butler) # | | P | P | | |
| *Cupha erymanthis maja* Fruhstorfer | P | P | P | P | |
| *Charaxes bernardus imna* Butl. | | P | | | |
| *Cyrestis thyodamas ganescha* Kollar | | P | P | | |
| *Junonia heirta* Fb. | | P | P | | P |

P - Species present, + - Endemic to Western Ghat, # - Protected under Indian Wildlife Act, MDF - Moist deciduous forest, SEV - Semievergreen forest, EVG - Evergreen forest, STH - Subtropical hill forest, MSF - Montane shola forest



*Cont'd...*

Appendix 3.1. *Cont'd...*

| | | | | | |
|---|---|---|---|---|---|
| *J. atlites* Lin. | P | P | P | | |
| *J. lemonias vaisya* Fruhstorfer | P | P | P | | P |
| *J. orithya* Butl. | P | P | | | |
| *Cirrochroa thais thais* Fb. | | P | P | P | P |
| *Euthalia aconthea* Fruhstorfer # | P | P | | | |
| *Precis iphita pluvialis* Fruhstorfer | P | P | P | | |
| *Phalanta phalanta* Drury | | | P | P | |
| *Euploea core core* Cramer | P | P | P | | |
| *Vanessa cardui* Lin. | | | P | | |
| *Ergolis merione* Cramer | P | P | P | | |
| *Hypolimnas bolina* Lin. | P | P | P | P | |
| *H. misippus* Lin. # | | P | P | P | P |
| *Neptis hylas varmona* Moore | | P | P | P | |
| *N. jumbah* Moore# | | P | P | | |
| *Rohana parisatis* Fruh. | | | | *P* | |
| *Kaniska canace haronica* Moore | | P | P | | |
| *Eriboea athamas* Drury | | P | | | |
| *Ergolis ariadne* (Johanssen) | P | P | P | | |
| *Pantoporia ranga* (Moore) # | | | | P | |
| *Argynnis hyperbius* (Johannsen) | | | | | P |
| *Moduza procris* Cramer | P | P | P | | |
| | | | | | |
| **DANAIDAE** | | | | | |
| | | | | | |
| *Tirumala limniace leopardus* Butler | P | P | P | P | |
| *T.septentrionis dravidarum* Fruhstorfer | P | P | P | P | |
| *Parantica aglea* Stoll | P | P | P | | |
| *P. nilgiriensis* Moore + | | | | P | P |
| *Danaus genuita genuita* Cramer | P | P | P | | |
| *D. chrysippus* (Lin.) | P | P | P | | |
| *Idea malabarica malabarica* + Moore | P | P | P | P | |
| | | | | | |
| **PIERIDAE** | | | | | |
| | | | | | |
| *Delias eucharis* Drury | P | P | P | P | |
| *Appias libythea* Fb. # | | | P | | P |
| *A. albina* Boisduval # | P | P | P | P | |
| *A. indra* Moore # | | P | P | P | |
| *C. pomona* Fb. | P | P | P | P | P |
| *C. pyranthe* (Lin.) | P | P | P | P | |
| *Cepora nadina* Moore # | | P | P | | |
| *Colias nilgiriensis* Feld. & Feld.+ | | | | | *P* |
| *Pieris canidia* (Sparrman) | | | | | *P* |
| *E. blanda* Boisd. | | | P | | |
| *E. lacteola* Dist. | | P | | | |
| *E. laeta* Boisduval | P | | | | |
| *E hecabe* Lin. | P | P | P | P | P |
| *Hebomoia glaucippe* (Lin.) | P | P | P | | |
| *Appias wardi* (Moore) +# | | P | P | | |
| *Appias lyncida* (Cramer) # | | | P | | |
| *Cepora nerissa* Fb. | P | | | | |
| *Leptosia nina* Fb. | P | | | | |
| *Prioneris sita* (C. & R. Felder)# | | | P | | |
| | | | | | |
| **SATYRIDAE** | | | | | |
| | | | | | |
| *Orsotrioena medus* (Fb.) | P | | | | |
| *Mycalesis anaxias* Hewitson # | | P | P | | |

*Cont'd...*

Appendix 3.1. *Cont'd...*

| | | | | | |
|---|---|---|---|---|---|
| *M. perseus* Fb. | P | | | | |
| *M. igilia* Fb. + | | | P | | |
| *M. patnia* Moore | P | P | P | | |
| *Mycalesis* sp. | | | | | *P* |
| *Lethe rohria* Frushstorfer | | P | P | | |
| *L. europa* Fb. | P | | P | | |
| *Lethe* sp. | | | | | *P* |
| *Ypthima ceylonica* Hewitson | P | P | P | | |
| *Y. baldus* Fb. | P | P | P | | |
| *Ypthima* sp. | P | | P | | |
| *Elyminas caudata* Butler | P | | | | |
| *Zipoetis saitis* Hewitson +# | | | P | | |
| *Melanitis leda* Lin. | P | P | P | | |
| *M. phedima varaha* Moore | P | P | P | | |
| | | | | | |
| **HESPERIDAE** | | | | | |
| | | | | | |
| *Celaenorrhinus leucocera* (Kollar) | | P | P | P | |
| *C. ambareesa* (Moore) | P | P | | | |
| *Tagiades litigiosa* Moschler | P | P | P | | |
| *Spialia galba* Fb | | P | | | |
| *Badamia exclamationis* Fb | | | P | | |
| *Taractrocera ceramas* (Hewitson) | P | | P | | |
| *Telicota acigias* Lin. | P | | | | |
| *Potanthus pava pava* Fruhstorfer | | P | P | | |
| *P. palnia* Evans | | | | *P* | *P* |
| *Udaspes folus* Cram. | P | | P | | |
| *Coladenia dan* (Fb.) | | | P | | |
| *Hasora* sp. | | P | | | |
| *Bibasis jaina* (Moore) | | P | P | | |
| | | | | | |
| **LYCAENIDAE** | | | | | |
| | | | | | |
| *Acytolepis puspa* Toxop. | | P | P | | |
| *Petrelaea dana* de Niceville | | P | P | | |
| *Prosotas nora* Felder | | P | P | | |
| *P. dubiosa indica* Evans | | *P* | *P* | | |
| *Nacaduba ?kurava* Moore | | P | P | | |
| *N. beroe* Felder | | P | P | | |
| *Anthene lycaenina* Felder | | P | P | | |
| *Discolampa ethion* (Doubleday & Hewitson) | P | | P | | |
| *Castalius rosimon* (Fb.) | P | | P | P | |
| *Caleta caleta* Hewitson | P | | P | P | |
| *Thalicada nyseus* (Guerin.) | P | P | | | |
| *Curetis thetis* Drury | | P | P | | |
| *Loxura atymnus* Cramer | | P | P | | |
| *Cheritra freja* (Fb.) | P | P | | P | |
| *Jamides alecto* (Felder) | P | | P | | P |
| *J. celeno* (Cramer) | P | P | P | | |
| *Jamides* sp. | | P | P | | P |
| *Celastrina lavendularis* Moore | P | | P | | |
| *Chilades pandava* (Horsfield) | | | P | | |
| *Udara akasa* Horsfield | | | P | P | |
| *Spindasis lohita lazularia* Moore# | | P | | | |
| *Megisba malaya* (Moore) | | P | P | | |
| *Euchrysops cnejus* (Fb.) # | P | P | | | |
| *Catochrysops ?strabo* (Fb.) | | P | | | |

*Cont'd...*

Appendix 3.1. *Cont'd…*

| | | | | | |
|---|---|---|---|---|---|
| *Arhopala ?centaurus* Moore | | P | | | |
| *Lampides boeticus* (Lin.)# | | | P | | P |
| *Zeltus amasa* Hewitson | | P | | | |
| *Zizula hylax* Fabr. | | | | | *P* |
| *Zizeeria karsandra* Moore | | | | | P |
| *Neopithecops zalmora* Butl. | P | | | | |
| | | | | | |
| **RIODINIDAE** | | | | | |
| | | | | | |
| *Abisara echerius* Stoll | | P | P | P | |
| | | | | | |
| **LIBYTHEIDAE** | | | | | |
| | | | | | |
| *Libythea myrrha* Godart. | | P | P | | |
| | | | | | |
| **ACRAEIDAE** | | | | | |
| | | | | | |
| *Acraea violae* (Fb.) | P | P | P | | |
| | | | | | |
| **HETEROCERA** | | | | | |
| **ARCTIIDAE** | | | | | |
| | | | | | |
| *Asura confirta* Wlk. | P | P | P | | |
| *A. rubricosa* Moore. | | P | P | | |
| *A. metamelus* Hamp. | | P | P | | |
| *A. obsoleta* | | P | P | | |
| *Asura* sp.1 | | | | P | P |
| *Asura* sp.2 | | P | P | | |
| *Asura* sp.3 | | | P | P | |
| *Asura* sp.4 | | | P | | |
| *Asura* sp.5 | | P | | | |
| *Cyme gratiosa* Guerin. | P | P | P | | |
| *Cyme* sp.1 | | | | P | P |
| *Cyme* sp.2 | | | P | P | |
| *Estigmene perotetti* | P | P | P | | |
| *Creatonotus gangis* Lin. | P | P | | | |
| *Eilema tumida* Wlk. | | | P | P | |
| *E. tetragona* Wlk. | | P | P | | |
| *Eilema* sp.1 | | | P | P | |
| *Eilema* sp.2 | | | | P | P |
| *Eilema* sp.3 | P | | | P | P |
| *Eilema* sp.4 | | P | P | | |
| *Eilema* sp.5 | P | P | | | |
| *Psalis pennatula* Hubn. | | P | | | |
| *Nyctemera baulus* Boisd. | | | P | P | |
| *Aeolanthes dicraea* Meyr. | P | P | | | |
| *Neochera dominio* Cram. | | | P | P | |
| *Eligma narcissus* Cram. | | P | P | | |
| *Paraplastis hampsoni* Swinh. | | P | P | | |
| *Utethesia pulchellale* Wlk. | | | P | P | P |
| *Chioenema peregrina* Wlk. | | P | P | | |
| *Chioenema* sp. | P | P | | | |
| *Lemyra* sp. | | | P | | |
| *Spilosoma* sp.1 | | P | P | | |
| *Spilosoma* sp.2 | | | P | P | |
| *Macotasa nubecula* Holloway | P | P | P | P | |
| *Pericallia ricini* Fb. | P | P | | | |

*Cont'd…*

Appendix 3.1. *Cont'd…*

| | | | | | |
|---|---|---|---|---|---|
| *Rhodogastrea astreas* Drury | | | P | | |
| *Siccia taprobanis* Wlk. | | | P | P | |
| *Siccia* sp. | | | P | P | P |
| *Tinolius quadrimaculatus* Wlk. | | | P | | |
| *Dysphania percota* | P | P | | | |
| | | | | | |
| **HYPSIDAE** | | | | | |
| | | | | | |
| *Hypsa alceiphron* Cram. | | P | P | P | |
| *Hypsa* sp.1 | | | P | | |
| *Hypsa* sp.2 | | | P | P | |
| | | | | | |
| **PYRALIDAE** | | | | | |
| | | | | | |
| *Agrotera basinotata* Hamp. | P | P | | | |
| *Cnaphalocrocis medinalis* Guen. | P | P | | | |
| *Marasmia venilalis* Wlk. | | P | P | | |
| *M. trebunusalis* Wlk. | P | P | | | |
| *Phlyctaenodes nudalis* Hubn. | | P | P | | P |
| *Nymphula depunctalis* Snel. | P | P | | | |
| *Myelopsis* sp. | P | P | | | |
| *Filodes fulvidorsalis* (Hubn.) | | P | P | P | |
| *Filodes* sp. | | | P | P | |
| *Hyalobathra* sp. | | P | P | | |
| *Eurrhyparodes bracteolalis* Zell. | P | P | P | | |
| *Psara bicarsicalis* Wlk. | P | | | | |
| *P. basalis* Wlk. | | | P | P | |
| *P. cyanaralis* Wlk. | P | | P | | |
| *Schoenobius minutellus* Z. | P | | | | |
| *S. immeritalis* Wlk. | P | | P | P | |
| *Acrobasis olivalis* Hamps. | P | | P | | |
| *Phycita obliquifasciella* Hamps. | P | P | | | |
| *Parthenodes inextricata* Meyr. | P | P | | | |
| *Hypsipygia mauritialis* Boisd. | P | | | | |
| *Vitessa suradeva* Moore | | | P | P | |
| *Tyspanodes linealis* Moore | | | P | P | |
| *Goniorhynchus plumbeizonalis* Hamps. | | | P | P | |
| *Scirpophaga* sp. | | P | P | | |
| *Glyphodes laticostalis* Guen. | | | P | P | P |
| *G. vertumnalis* Wlk. | | P | P | | |
| *G. celsalis* Wlk. | P | P | | | |
| *G. bicolor* Swains. | P | | | | |
| *G. itysalis* Wlk. | P | P | P | | |
| *G. caesalis* Wlk. | | | P | P | |
| *G. stolalis* Guen. | P | | P | P | |
| *Glyphodes* sp. | | | | P | P |
| *Diaphania negatalis* (Wlk.) | | P | P | | |
| *Pyrausta signatalis* Wlk. | | P | P | | |
| *P. tetraplagialis* Hamps. | P | P | P | P | |
| *Omphisa repititalis* Wlk. | | | P | P | |
| *Bocchoris ?onychinalis* Guen. | | P | P | | |
| *Aulacodes* sp. | | | | P | P |
| *A. peribocalis* Wlk. | P | P | P | P | |
| *Talanga sexpunctalis* Moore | | P | P | P | |
| *Cataclysta blandalis* Wlk. | P | | P | | |
| *Piletocera aegimusalis* Wlk. | P | P | | | |
| *Phlyctaenia flavofimbriata* | P | | | | |

*Cont'd…*

Appendix 3.1. *Cont'd…*

| | | | | | |
|---|---|---|---|---|---|
| *Dichocrocis surusalis* Wlk. | P | P | | | |
| *Rhodoneura ?myrtacea* Drury | | | P | P | |
| | | | | | |
| **GEOMETRIDAE** | | | | | |
| | | | | | |
| *Ourapteryx marginata* Hamps. | | | P | P | |
| *Pingasa ruginaria* Guen. | | P | P | P | |
| *P. chlora* Stoll | | | P | P | |
| *Gasterocome pannosaria* Moore | | | P | | |
| *Fascellina chromataria* Wlk. | | | P | | |
| *Fascellina* sp. | | | P | P | |
| *Omiza pachiaria* Wlk. | | | P | P | |
| *Hypomecis* sp.1 | P | P | P | P | |
| *Hypomecis* sp.2 | | | P | P | |
| *H. pallida* Hamps. | | | P | | |
| *Anisozyga* sp. | | P | P | | |
| *Gnamptoloma aventiaria* (Guen.) | | P | P | | |
| *Antitrygodes divisaria* Wlk. | | P | P | | |
| *Semiothisa eleonora* Stoll | | | P | P | |
| *S. epicharis* Wehrli | | | P | P | |
| *Semiothisa* sp. | | P | P | P | P |
| *Ptochophyle* sp. | P | P | | | |
| *Hypochrosis festivaria* Fabr. | | | P | P | |
| *H. abstractaria* Wlk. | | | P | P | |
| *Hypochrosis* sp. | | | | P | P |
| *Luxiaria subrasata* Wlk. | | P | P | | |
| *Luxiaria* sp. | P | P | | | |
| *Sabaria costimaculata* Moore | | | P | P | |
| *S. incitata* Wlk. | P | P | P | | |
| *S. rondelaria* Fb. | | P | P | P | |
| *Sabaria* sp. | | | | P | P |
| *Comibaena integranota* Hamps. | | | P | P | |
| *C. inductaria* Guen. | P | P | P | | |
| *Episothalmia* sp. | | | P | P | |
| *Polynesia sunandava* Wlk. | | | P | P | P |
| *Buzura suppressaria* Guen. | | P | P | | |
| *Buzura* sp. | P | | P | P | |
| *Scopula opicata* Fb. | | | P | P | |
| *Scopula* sp.1 | | | | P | P |
| *Scopula* sp.2 | | | P | | P |
| *Timandra nelsoni* Prout | | P | P | | |
| *Thalassode* sp. | P | P | P | | |
| | | | | | |
| **NOCTUIDAE** | | | | | |
| | | | | | |
| *Mocis frugalis* Fb. | | | P | P | |
| *M. undata* Fb. | | | P | P | |
| *Mocis* sp. | | | | P | P |
| *Maliatha erecta* Moore | | | P | P | P |
| *Blenina donanus* Wlk. | | | P | P | |
| *Othreis fullonica* Clerck | | | P | P | |
| *Hypocala deflorata* Fb. | | | P | P | |
| *Bocana manifestalis* Wlk. | P | P | P | | |
| *Bocana* sp. | P | P | | | |
| *Westermannia superba* Hubn. | | | P | P | |
| *Ecliptopera subocellata* | | | P | P | |
| *Plutodes discigera* Butler | | | P | P | |

*Cont'd…*

Appendix 3.1. *Cont'd...*

| | | | | | |
|---|---|---|---|---|---|
| *Dierna* sp. | | P | P | P | |
| *Melipotis cyllaria* Cram. | | P | P | | |
| *Stictopera cuculleoides* Guen. | | | P | P | |
| *Carea endophaea* Hamp. | P | P | P | | |
| *C. subtilis* Wlk. | | | P | P | |
| *Carea* sp. | | | P | P | |
| *Condica illecta* Wlk. | | | P | P | |
| *Condica* sp. | P | P | | P | |
| *Sphetta apicalis* Wlk. | | P | P | P | |
| *Chasmina rejecta* Fb. | P | P | P | | |
| *Mythimna curvilinea* Hamp. | | P | P | | P |
| *M. vittatta* Hamp. | | P | P | | |
| *M. reversa* Moore | | | | | P |
| *Xenotrachea* sp. | | | P | P | |
| *Pseudogyrtona* sp. | | P | P | | |
| *Ptisciana* sp. | | P | P | | |
| *Paracrama latimargo* | | | P | P | |
| *Oxyodes scrobiculata* Fb. | | | P | P | |
| *Rhesala moestalis* Wlk. | P | P | | | |
| *Rhesala* sp. | | P | P | | P |
| *Helicoverpa armigera* Hubn. | P | P | | | |
| *Hyblaea puera* Cram. | P | P | | | |
| *Spodoptera mauritia* Boisd. | P | P | | P | |
| *S. litura* (Fb.) | P | P | | | |
| *Achaea janata* Fb. | P | P | P | | |
| *Arcte modesta* Van der Hoev. | | P | P | | |
| *Ischijya manlia* Cram. | | | P | P | |
| | | | | | |
| **LYMANTRIDAE** | | | | | |
| | | | | | |
| *Euproctis scintillans* Wlk. | P | P | P | | |
| *E. bipunctapex* Hamp. | | P | P | | |
| *E. percnogaster* Coll. | P | P | P | P | |
| *Euproctis* sp.1 | | P | | P | |
| *Euproctis* sp.2 | | | P | P | |
| *Aroa* sp. *plana* Wlk. | P | P | | | |
| *Aroa* sp. | P | P | P | | |
| *Redoa* sp. | | P | P | P | |
| *Lymantria* sp.1 | | | P | | |
| *Lymantria* sp.2 | | | P | P | |
| *Dasychira bhana* Moore | | | P | P | |
| *D. cerigoides* Wlk. | | | P | P | |
| *Dasychira* sp. | P | P | P | | |
| *Eugoa* sp. | | P | P | | |
| *Eupterote hibisci* Fb. | | | | | P |
| *Eupterote* sp.1 | | | | P | P |
| *Eupterote* sp.2 | | | P | P | |
| | | | | | |
| **LIMACODIDAE** | | | | | |
| | | | | | |
| *Miresa argentifera* | | P | P | | |
| *M. albipuncta* Herr.-Sch. | P | P | | | |
| *Miresa* sp. | P | P | | | |
| *Scopelodes velutina* Koll. | | P | P | | |
| *Scopelodes* sp. | P | P | | | |
| *Parasa lepida* Cram. | P | P | P | | |
| | | | | | |

*Cont'd...*

Appendix 3.1. *Cont'd…*

| | | | | | |
|---|---|---|---|---|---|
| **SYNTOMIDAE** | | | | | |
| | | | | | |
| *Syntomis thoracica* | | | P | P | |
| *Syntomis* sp. | | P | P | | |
| *Amata extensa* | | | P | P | |
| *Amata* sp. | | P | P | | |
| *Eressa confinis* Wlk. | | | P | P | |
| *Euchromia polymene* | | P | P | | |
| | | | | | |
| **SPHINGIDAE** | | | | | |
| | | | | | |
| *Acherontia lachesis* Fb. | | P | P | | |
| *A. styx* Westwood | P | P | | | |
| *Herse convolvuli* Lin. | | P | P | | |
| *Macroglossum aquila* Boisduval | | P | P | | |
| *Hippotion boerhaviae* Fb. | | P | P | | |
| *Hippotion* sp. | P | | | | |
| *Oxyambulyx* sp. | | | P | P | |
| *Theretra nessus* Drury | | P | | P | |
| | | | | | |
| **SATRUNIIDAE** | | | | | |
| | | | | | |
| *Actias selene* Hb. | | P | P | | |
| *Loepa sikkima* Moore | | | P | P | |
| | | | | | |
| **TORTRICIDAE** | | | | | |
| | | | | | |
| *Adoxophyes* sp. | | | P | P | |
| | | | | | |
| **COLEOPTERA** | | | | | |
| | | | | | |
| **Bostrychidae** | | | | | |
| *Dinoderus minutus* Fb. | P | P | P | | |
| *Sinoxylon atratum* Lesne | | P | P | | |
| **Buprestidae** | | | | | |
| *Chrysochroa* sp. | | | P | P | |
| *Ptiloctaenus rubroaureus* De Geer | | P | P | | |
| *Sphenoptera cyaniceps* Kerr. | P | P | | | |
| Carabidae | | | | | |
| *Chlaenius* sp. | P | P | P | | |
| *Chlaenius tenuilimbatus* Ball. | | P | P | | |
| *Omphra* sp. | | | P | P | |
| **Cerambycidae** | | | | | |
| *Acanthophorus serraticornis* Oliv. | P | P | | | |
| *Cerosterna scabrator* (Fb.) | P | P | P | | |
| *Nupserha madurensis* Pic. | | P | P | | |
| *Plocaederus ferrugineus* Linn. | P | | | | |
| *Prionomma atratum* Gmelin. | P | P | | | |
| *Sebasmia* sp. | | P | P | | |
| **Chrysomelidae** | | | | | |
| *Aulacophora cincta* (Fb.) | P | P | P | P | |
| *Aulacophora* sp. | | P | P | | |
| *Calopepla leayana* Latr. | P | P | | | |
| *Chlamys* sp. | | P | P | | |
| *Diapromorpha turcica* Fb. | P | | P | | |
| *Hoplasoma unicolor* Illig. | P | P | | | |
| *Hyphasis* sp. | | | P | P | |

*Cont'd…*

Appendix 3.1. *Cont'd…*

| | | | | | |
|---|---|---|---|---|---|
| *Monolepta longitarsis* Jac. | | P | P | | |
| **Cicindelidae** | | | | | |
| *Cicindela sexpunctata* Fb. | | | P | P | |
| *Neocollyris* sp. | | | P | | |
| **Anthribidae** | | | | | |
| *Baryrrhynchus planicollis* Wlk. | P | | P | | |
| **Attelabidae** | | | | | |
| *Attelabus* sp. | P | P | | | |
| **Ciidae** | | | | | |
| *Hypothenemus* sp. | | P | P | | |
| **Coccinellidae** | | | | | |
| *Epilachna vigintioctopunctata* Fb. | P | P | P | | |
| *Epilachna* sp. | | P | P | | |
| **Curculionidae** | | | | | |
| *Indomias cretaceus* (Fst.) | P | P | P | P | |
| *Mecistocerus fluctiger* Fst. | | | P | P | |
| *Mecistocerus* sp. | P | | P | P | |
| *Myllocerus viridanus* Fb. | P | P | | | |
| *Sternochaetus mangiferae* Fb. | P | P | | | |
| **Dermestidae** | | | | | |
| *Silesis* sp. | | P | P | | |
| **Elateridae** | | | | | |
| *Agrypnus ?holosericeus* | P | | P | | |
| *Agrypnus* sp. | | P | P | | |
| **Endomychidae** | | | | | |
| *Indalmus* sp. | | | | | |
| Gyrinidae | P | P | | | |
| *Orectochilus* sp. | | P | P | P | |
| **Lagriidae** | | | | | |
| *Lyprops curticollis* Fairm. | P | P | P | | |
| **Lampyridae** | | | | | |
| *Lampyris* sp. | P | P | P | | |
| **Lucanidae** | | | | | |
| *Odontolabis cuvera* Hope | | | P | P | |
| **Lyctidae** | | | | | |
| *Lyctus brunneus* (Steph.) | P | P | P | | |
| **Meloidae** | | | | | |
| *Epicauta* sp. | | P | P | P | |
| **Passalidae** | | | | | |
| *Pleurarina brachyphyllus* Stal. | | | P | P | |
| *Pleurarina* sp. | | | P | P | |
| **Platypodidae** | | | | | |
| *Platypus latifinis* Wlk. | P | P | P | P | |
| **Scarabaeidae** | | | | | |
| *Anomala ?ruficapilla* Burm. | P | | P | | |
| *Anomala* sp. | | P | P | | |
| *Copris* sp. | P | P | | | |
| *Gymnopleurus sinuatus* (Olivier) | | | P | P | |
| *Holotrichia serrata* (Fb.) | | P | P | | |
| *H. rufoflava* Brenske | | | P | | |
| *Maladera* sp. | | P | P | | |
| *Microserica* sp. | | | P | P | P |
| *Mimela* sp. | | | | P | P |
| *Oryctes rhinoceros* Lin. | P | P | | | |
| *Popillia complanata* Newm | | | P | P | P |
| *Popillia* sp. | | | | P | P |

*Cont'd…*

Appendix 3.1. *Cont'd…*

| | | | | | |
|---|---|---|---|---|---|
| **Scolytidae** | | | | | |
| *Xyleborus maximus* Samps. | P | P | P | | |
| **Tenebrionidae** | | | | | |
| *Amargymus purpureofossus* Fairm. | P | P | P | | |
| *Cryphaeus* sp. | | | P | P | |
| *Diaclinia* sp. | | P | P | | |
| *Strongylium* sp. | P | P | P | | |
| **Throscidae** | | | | | |
| *Lissomus* sp. | | P | P | | |
| | | | | | |
| **DIPTERA** | | | | | |
| | | | | | |
| *Bactrocera (Bactrocera) caryeae* (Kapoor) | | P | P | | |
| *Bactrocera (Bactrocera) dorsalis* (Hendel) | | P | P | | |
| *Bactrocera (Bactrocera) correcta* (Bezzi) | | P | P | | |
| *Bactrocera (Bactrocera) versicolor* (Bezzi) | | P | P | | |
| *Bactrocera (Bactrocera) zonata* Saunders | | P | P | | |
| *Bactrocera (Bactrocera) merapiensis* Drew & Hancock | | P | P | | |
| *Bactrocera (Bactrocera) vishnu* Drew and Hancock | | P | P | | |
| *Bactrocera (Zeugodacus) tau* Walker | | P | P | | |
| *Bactrocera (Zeugodacus) cucurbitae* (Coquillett) | | P | P | | |
| | | | | | |
| **HEMIPTERA** | | | | | |
| | | | | | |
| **Dictyopharidae** | | | | | |
| *Dictyopharina viridissima* Melicher | P | P | P | | |
| **Eurybrachidae** | | | | | |
| *Eurybrachis* sp. | P | | P | P | |
| *Messena pulverosa* (Hope) | | P | P | | |
| **Lygaeidae** | | | | | |
| *Odontopes nigricornis* Stal. | P | P | | | |
| *Macropes* sp. | | P | P | | |
| **Miridae** | | | | | |
| *Chilochoris angustatus* | P | P | P | | |
| **Notonectidae** | | | | | |
| *Enithares* sp. | | P | P | P | |
| **Reduvidae** | | | | | |
| *Androclus granulatus* Stal. | | P | P | | |
| **Pentatomidae** | | | | | |
| *Cantao ocellatus* Thunb. | P | P | | | |
| *Dunnius bellus* (Dist.) | | P | P | | |
| *Nezara antennata* Scott | P | P | | | |
| *Placosternum* sp. | | | P | P | |
| *Tipulparra trivandera producta* Ghauri | | P | P | | |
| *Sabaeus* sp. | P | P | | | |
| **Gerridae** | | | | | |
| *Jenagogonus (=Limnometria) longispinulus* Thirumalai | | P | P | | |
| *Metrocoris variegans* Thirumalai | | P | P | | |
| *Ptilomera argroides* Schmidt | P | P | P | | |
| **Cercopidae** | | | | | |
| *Cosmocarta* sp. | P | | P | P | |
| *Krishna strigicollis* Spinola | P | P | P | | |

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Appendix 3.1. *Cont'd…*

| | | | | | |
|---|---|---|---|---|---|
| **Cicadidae** | | | | | |
| *Cryptotympana varicolor* Dist. | | P | P | | |
| *Platypleura insignis* Dist. | | P | P | | |
| **Coreidae** | | | | | |
| *Dysdercus cingulatus* Fb. | P | P | | | |
| *Serinetha augur* Fb. | P | P | P | | |
| **Delphacidae** | | | | | |
| *Pundaluoya ernesti* (Kirby) | P | P | P | | |
| *Purohita* sp. | P | | P | P | |
| **Flattidae** | | | | | |
| *Phormnia* sp. | | | P | P | |
| Flata *sp.* | P | P | | | |
| **Fulgoridae** | | | | | |
| *Melicharia* sp. | P | | P | | |
| **Jassidae** | | | | | |
| *Bothrogonia ferruginea* Fb. | P | P | | | |
| *Hecalus* sp.1 | | | P | P | |
| *Hecalus* sp.2 | | | | | P |
| *Kolla* sp. | P | | | P | P |
| *Neodartus* sp. | P | P | | | |
| *Osbornellus* sp. | P | | P | | |
| *Scaphoideus* sp, | P | P | | | |
| **Membracidae** | | | | | |
| *Centrotypus* sp. | P | P | | | |
| | | | | | |
| **NEUROPTERA** | | | | | |
| | | | | | |
| **Chrysopidae** | | | | | |
| *Chrysopa* sp. | | P | P | | |
| | | | | | |
| **ORTHOPTERA** | | | | | |
| | | | | | |
| **Acrididae** | | | | | |
| *Catantops henryi* Bol. | P | P | P | | |
| *Catantops* sp. | P | P | | | |
| *Acrida turrita* Lin. | | P | P | | |
| *Acrida* sp. | P | | P | P | |
| **Gryllidae** | | | | | |
| *Gryllus* sp.1 | P | P | | | |
| *Gryllus* sp.2 | P | P | P | | |
| | | | | | |
| **DICTYOPTERA** | | | | | |
| | | | | | |
| **Blattidae** | | | | | |
| *Rhabdoblatta* sp. | | P | P | | |
| **Mantidae** | | | | | |
| *Humbertiella indica* Sauss. | | P | P | | |
| | | | | | |
| **ODONATA** | | | | | |
| | | | | | |
| *Macromia* sp. | P | P | P | | |
| *Nemothemis fulvia* Drury | P | P | P | P | |
| *N. intermedia* (Ramb.) | P | P | P | | |
| *Trithemis aurora* (Burm.) | P | P | P | P | |
| *T. festiva* (Ramb.*)* | P | P | P | | |
| *Neurobasis chinensis chinensis* Lin. | | P | P | P | |
| | | | | | |

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Appendix 3.1. *Cont'd...*

| **HYMENOPTERA** | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| **Apidae** | | | | | |
| *Apis dorsata* Fb. | P | P | P | P | P |
| *A. indica* Fb. | P | P | P | P | P |
| *A. florea* Fb. | P | P | P | P | P |
| *Thyreus ramosa* Lep.+ | | P | P | | |
| *Thyreus* sp.1 | | | P | P | |
| *Nomia thoracica* Smith+ | | P | P | | |
| **Xylocopidae** | | | | | |
| *Xylocopa dissimilis* Lep. | P | P | P | P | |
| *X. verticalis* Lep. | P | P | P | | |
| **Anthophoridae** | | | | | |
| *Anthophora niveocincta* Smith | | P | P | P | |
| *A. zonata* (Lin.) | P | | P | | |
| **Megachilidae** | | | | | |
| *Megachile lanata* Fb. | | P | P | P | |
| **Eumenidae** | | | | | |
| *Eumenes conica* Fb. | P | P | P | P | |
| *Eumenes* sp. | P | P | | P | |
| *Odynerus fragilis* Smith+ | P | P | P | | |
| *Rhynchium brunneum* (Fb.) | P | | P | P | |
| **Scoliidae** | | | | | |
| *Compsomeris* sp. | | | P | P | |
| *Scolia carbonaria* Sauss. | | | P | P | |
| **Sphecidae** | | | | | |
| *Ammatomes* sp. | P | P | P | | |
| *Chalybion bengalense* Dahl. | P | P | P | | |
| *Sceliphron javanum nalandicum* Lep. | P | P | P | P | |
| *S. coromandelicum* (Lep.) | P | P | | | |
| *S. madraspatanam madraspatanam* Fb. | P | P | | | |
| *Sphex praedator leutipennis* Mocsary | | | P | P | |
| *Trypoxylon errans* Sauss. | P | P | | | |
| **Chrysididae** | | | | | |
| *Stilbum cyanurum* Forster | P | | P | | |
| *Trichrysis lusca* Fb. | P | | | | |
| **Vespidae** | | | | | |
| *Vespa cincta* Fb. | P | | P | | |
| *Polistes* sp. | | | P | P | |
| **Pompilidae** | | | | | |
| *Pompilus* sp. | P | P | | | |
| *Pseudagenia blanda* Guer. | P | | P | P | |
| *Salius flavus* Fb. | | P | P | | |
| *Salius* sp.1 | | | | P | P |
| *Salius* sp.2 | | | P | P | |
| **Braconidae** | | | | | |
| *Cardiochile* sp. | | P | P | | |
| *Dolichogenedia* sp. | | P | P | | |
| *Neoclarkinella nilamburensis* (Sumodan & Narendran) | | P | | | |
| **Ichneumonidae** | | | | | |
| *Charops* sp. | | P | P | | |
| *Enicospilus vastator* (Smith) | P | P | P | P | |
| *Enicospilus* sp. | | | | P | P |
| *Xanthopimpla* sp. | | P | P | | |
| **Formicidae** | | | | | |
| *Camponotus* sp.1 | P | P | | | |

*Cont'd...*

Appendix 3.1. *Cont'd...*

| | | | | | |
|---|---|---|---|---|---|
| *Camponotus* sp.2 | P | P | P | | |
| *Crematogaster* sp. | | P | P | | |
| *Harpegnathos saltator* Jer. | P | P | P | | |
| *Oecophylla smaragdina* Fb. | P | P | P | P | |
| *Pheidologiton diversus* Jer. | | | P | P | |
| *Plagiolepis longipes* Jer. | P | P | P | | |
| *Polyrhachis mayri* Roger | | | P | P | |
| *Tetraponera* sp. | | P | P | | |
| **Mutillidae** | | | | | |
| *Mutilla semiaurata* Smith | | | P | P | |
| *Mutilla* sp. | | P | P | | |
| **Bethylidae** | | | | | |
| *Goniozus* sp. | | P | P | | |

## Chapter 4

# Avian Diversity

### 4.1. Introduction

Avian community studies are effective tools for monitoring forest ecosystems. Kerala is rich in avifauna and about 475 species of birds have been recorded from the State (Neelakantan *et al.*, 1993), representing about 25 percent of the Indian avifauna. Among this, 149 species have been located in the coastal areas and the remaining in the mid and high lands of the State. As early as 1876, Hume carried out the pioneering survey on the birds in the hills of Travancore. The most exhaustive investigation on forest birds of Travancore was conducted by Ali and Whistler (1935-1937). After this, many studies have been carried out in various parts of Kerala (Vijayan and Balakrishnan, 1977; Zacharias and Gaston, 1993; Srivasthava *et al.*, 1993).

In this study, an attempt is made to find the species composition and diversity of birds in the New Amarambalam Reserved Forests. Only a few avifaunal studies have been carried out in the New Amarambalam forests in the past. Birds of the adjacent Silent Valley National Park have been reported by various workers (Ramakrishnan, 1983; Pramod *et al.*, 1997; Jayson and Mathew, 2000 and Jayson and Mathew, 2000a). Similarly, birds of the nearby Nedumgayam forests also have been listed by the researchers from the Calicut University (Mathew, Pers. Comm.).

### 4.2. Review of literature

Community studies of birds in the forests of Kerala are rare. Ramakrishnan had reported on the birds of the Malabar forests (Ramakrishnan, 1983). Similarly Jayson (1994) had studied the birds of Silent Valley forests. Pramod *et al.* (1997) had evaluated the bird communities of the Western Ghats to plan for biodiversity friendly development. At national level, diversity and community structure of birds have been investigated by Johnsingh *et al.* (1987), Johnsingh and Joshua (1994), Katti (1989), Daniels (1996, 1997), Gokula and Vijayan (1996), Sundaramoorthy (1991) and Jayson and Easa (1999). The present study attempts to find out various diversity parameters of the bird community at New Amarambalam. Due to logistical reasons, the interior forest areas were not accessible during the months of monsoon.

## 4.3. Methods

### 4.3.1. Avifauna

Diversity of birds was assessed in representative plots (Fig. 4.1) selected in various forest types using point count method, ie. variable circular plots (Buckland *et al.*, 1993). Eighty-three points were sampled in the evergreen forests, 80 points in the moist deciduous forests and 8 points were covered in the shola forests. Each point was observed only once. The observations were taken during the months of January, February, March, April, May, June, September, November and December, from January 1997 to April 2000. Twenty minutes were spent at each point to record the presence of birds and radial distances to the sighted birds were recorded. Species richness and species composition of birds in the area were computed from the data obtained from the point count method and from field observations. Apart from the systematic sampling from the point counts, whenever a bird was sighted in the forest, it was identified and details recorded. The number of species recorded is considered as species richness. The relative dominance of each bird species in various vegetation types was determined by calculating Dominance Index using the following formula.

Relative Dominance = ni X 100/N

Where, ni = Number of individuals in the species

N = The total number of individuals of the all species seen during the study period.

*4.3.1.1. Abundance*

Total number of birds recorded each month was calculated using the point count data.

*4.3.1.2. Density*

Density of birds in each month and individual abundance of selected species were also calculated. The density was estimated using Point Count Method as described in Buckland *et al.* (1993). The density was computed using the software "DISTANCE". The Fourier series method, which is used for analysis, is not dependent on specific distribution assumptions about the detection probability of birds at various radial distances from the central point. In this method, density is computed from ungrouped radial distances from the central point. Flocks of birds were considered as single individuals and only one radial distance to the middle of the flock was measured. A bird call was considered equivalent to a single individual

and was used along with sighting record for the density estimation. The density estimation was done at two levels, as follows.

i. Total bird density was calculated for each month pooling the data for all species.
ii. Total bird density for each vegetation type was calculated pooling the data of all species.

The following formula is used for density estimation.

$D = n/k \Pi w^2$

Where, D= Density

n= Number of birds in the circular plots

k= number of plots

w= radial distance to the bird

*4.3.1.3. Species richness indices*

Another way of representing species richness is through the species richness indices. These indices provide easily understandable measures of diversity. Species richness as a yardstick of diversity was used in many earlier studies also. Species richness indices like Margalef Index (R1) and Menhinick Index (R2) were calculated for each vegetation type using the formula given by Magurran (1988).

Margalef Index , $D_{mg} = (S-1) / 1n (N)$

[ln = $\log_e$]

Menhinick Index , $D_{mn} = S/(N)^{**} ½$

Where, S=Number of species and N = Total number of individuals summed over all species.

*4.3.1.4. Diversity indices*

For the assessment of species diversity in the area, Shannon-Weiner Index, Simpson Index and Hill's diversity numbers N1 and N2 were calculated (Ludwig and Reynolds, 1988). Computations were done using the programme SPECDIVERS.BAS developed by Ludwig and Reynolds (1988). Even though species-abundance model provides full description of diversity, they cannot be compared by means of diversity indices. Indices based on the proportional abundance of species provide another approach to measure diversity. They are called heterogeneity indices because they take both evenness and species richness into account (Peet, 1974). Most widely used measures of diversity indices are based on the rational that diversity or information in a natural system can be measured the same way as that of

information contained in a code or message. Hills diversity numbers N1 and N2 which are in units of number of species, measure the effective number of species present in a sample. This index is calculated because N1 and N2 are suitable for addressing any question that a heterogeneity index can answer (Peet, 1974). Other diversity indices are merely variants of N1 and N2.

Shannon-Weiner Index

Shannon-Weiner Index of general diversity (H') is given as

$$H` = \frac{ni}{N} \log \frac{ni}{N}$$

$$H` = - \sum_{i=1} P_i \log P_i$$

Where, ni = importance value for each species

N = total of importance values

Pi = importance probability for each species = ni

Simpson's Index

The following equation is used to calculate the Simpson's Index.

Lamda = (ni (ni-1)/(N (N-1))

Where, ni = the number of individuals in the i $^{th}$ species,

N = total number of individuals.

Hill's diversity

Hill's diversity N1 is calculated from Shannon-Weiner Index, as follows.

$N1 = eH^1$

In addition, Hill's diversity N2 is calculated from Simpson's Index

N2=1/lamda

*4.3.1.5. Evenness indices*

A variety of evenness measures are available. Two of them are based on Shannon-Weiner Index and Simpson's Index. This index measures the evenness of species-abundance which is complimentary to the diversity index concept, and is a measure of how the individuals are appropriated among the species. The ratio of observed diversity to maximum diversity is taken as the measure of Evenness (E). Two evenness measures namely, Shannon Evenness and Sheldon Evenness were calculated using the computer programme SPDIVERS.BAS developed by Ludwig and

Reynolds (1988). The following formulae were used for calculating the two evenness measures based on Shannon-Weiner Index and Simpson's Index.

$$\text{i. Shannon Evenness (E1)} = \frac{H`}{\log (S)}$$

where H` = Shannon-Weiner Index

S = Number of species

$$\text{ii. Sheldon Evenness (E2)} = \frac{eH`}{S}$$

## 4.4. Results

### 4.4.1. Species composition of avifauna

Species composition and diversity of birds in a forest is related to the vegetation type, altitude, availability of microhabitats and various other factors. One hundred species of birds belonging to 13 Orders and 31 Families were recorded from the study area (Table 4.1). Common bird species found in New Amarambalam were

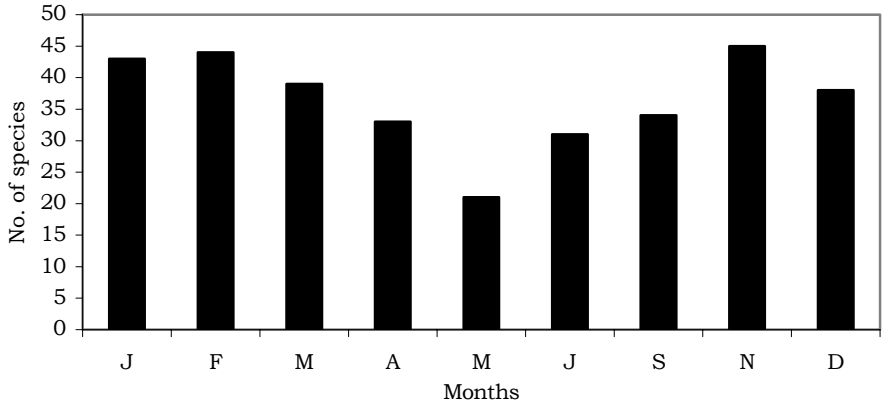


**Fig. 4.2. Species richness of birds in different months at New Amarambalam**

Black Bulbul, Black Drongo, Goldenbacked Woodpecker, Jungle Myna and Yellow-browed Bulbul. The population of Passeriformes was highest followed by Coraciiformes and Cuculiformes (Table 4.2). Only 10 migratory species were sighted from the area namely Rufoustailed Flycatcher, Paradise Flycatcher, Great Reed Warbler, Tickell's Leaf Warbler, Plain Leaf Warbler, Greenish Leaf Warbler, Blue Rock Thrush, Forest Wagtail, Yellow Wagtail and Grey Wagtail. Highest species richness was seen in February during summer and then in November (Fig.4.2).

Lowest was seen during May and June. Highest number of birds was insectivores (60), followed by frugivores and others (Table 4.2)

Of the 16 endemic and restricted range species of birds found in the Western Ghats and Kerala, the following eight species were recorded in New Amarambalam.

1. Nilgiri Wood Pigeon (*Columba elphinstonii*)
2. Bluewinged Parakeet (*Psittacula columboides*)
3. Malabar Grey Hornbill (*Tockus griseus)*
4. Southern Tree Pie (*Dendrocitta leucogastra*)
5. Small Sunbird (*Nectarinia minima*)
6. Greyheaded Bulbul (*Pycnonotus priocephalus*)
7. Nilgiri Flycatcher (*Eumyias albicaudata*)
8. Waynad Laughing Thrush (*Garrulax delesserti*)

Among these, the Nilgiri Wood Pigeon is a globally threatened species found only in India. A thematic representation of birds endemic to the Western Ghats recorded from the different forest types is given in Figure 4.3.

**Table 4.1. Birds recorded from New Amarambalam reserve forests**

| Sl. No. | Common name | Scientific name | Status * |
|---|---|---|---|
| 1. | Little Cormorant | *Phalacrocorax niger* | R |
| | **Ardeidae** | | |
| 2. | Indian Pond Heron | *Ardeola grayii* | R |
| 3. | Little Egret | *Egretta garzetta* | R |
| | **Ciconiidae** | | |
| 4. | Openbill Stork | *Anastomus oscitans Boddaert* | R |
| | **Accipitridae** | | |
| 5. | Feathertoed Hawk-Eagle | *Spizaetus nipalensis* | R |
| 6. | Crested Hawk-Eagle | *Spizaetus cirrhatus* | R |
| 7. | Black Eagle | *Ictinaetus malayensis* | R |
| 8. | Ceylon Shikra | *Accipiter badius* | R |
| | **Phasianidae** | | |
| 9. | Travancore Red Spurfowl | *Galloperdix spadicea* | R |
| 10. | Grey Jungle fowl | *Gallus sonneratii* | R |
| 11. | Red Jungle fowl | *Gallus gallus* | R |
| 12. | Indian Peafowl | *Pavo cristatus* | R |
| | **Columbidae** | | |
| 13. | Common Green Pigeon | *Treron phoenicoptera* | R |
| 14. | Imperial Pigeon | *Ducula aenea* | R |
| 15. | Nilgiri Wood Pigeon | *Columba elphinstonii Sykes* | R |
| 16. | Indian Spotted Dove | *Streptopelia chinensis* | R |
| 17. | Indian Emerald Dove | *Chalcophaps indica* | R |
| | **Psittacidae** | | |
| 18. | Roseringed Parakeet | *Psittacula krameri* | R |
| 19. | Blossomheaded Parakeet | *Psittacula cyanocephala* | R |
| 20. | Bluewinged Parakeet | *Psittacula columboides* | R |
| 21. | Malabar Lorikeet | *Loriculus vernalis* Stuart | R |

* R = Rare, LM = Local movement

*Cont'd...*

Table 4.1. *Cont'd...*

| | | | |
|---|---|---|---|
| | **Cuculidae** | | |
| 22. | Large Hawk-Cuckoo | *Cuculus sparverioides* | LM |
| 23. | Indian Cuckoo | *Cuculus micropterus* | R |
| 24. | Banded Bay Cuckoo | *Cacomantis sonneratii* | R |
| 25. | Indian Plaintive Cuckoo | *Cacomantis passerinus* | R |
| 26. | Pied Crested Cuckoo | *Clamator jacobinus* | R |
| 27. | Southern Crow-Pheasant | *Centropus sinensis* | R |
| | **Sub Family: Striginae** | | |
| 28. | Southern Spotted Owlet | *Athene brama brama* | R |
| | **Apodidae** | | |
| | **Sub Family: Apodinae** | | |
| 29. | Alpine Swift | *Tachymarptis malba* | R |
| 30. | Palm Swift | *Cypsiurus parvus* | R |
| 31. | Crested Tree Swift | *Hemiprocne coranata* | R |
| | **Sub Family: Hemiprocninae** | | |
| | **Trogonidae** | | |
| 32. | Malabar Trogon | *Harpactes fasciatus* | R |
| | **Alcedinidae** | | |
| 33. | Pied Kingfisher | *Ceryle rudis* | R |
| 34. | Common Kingfisher | *Alcedo atthis* | R |
| 35. | Whitethroated Kingfisher | *Halcyon smyrnensis* | R |
| 36. | Storkbilled Kingfisher | *Pelargopsis capensis* | R |
| | **Meropidae** | | |
| 37. | Little Green Bee-eater | *Merops orientalis* | R |
| | **Coraciidae** | | |
| 38. | Indian Roller | *Coracias benghalensis* | R |
| | **Bucerotidae** | | |
| 39. | Malabar Grey Hornbill | *Tockus griseus* | R |
| 40. | Grey Hornbill | *Tockus birostris* | R |
| 41. | Malabar Pied Hornbill | *Anthracoceros coronatus* | R |
| | **Capitonidae** | | |
| 42. | Small Green Barbet | *Megalaima viridis Boddaert* | R |
| | **Picidae** | | |
| 43. | Goldenbacked Woodpecker | *Dinopium benghalense* | R |
| | **Alaudidae** | | |
| 44. | Rufoustailed Finch Lark | *Ammomanes phoenicurus* | R |
| | **Hirundinidae** | | |
| 45. | Nilgiri House Swallow | *Hirundo tahitica domicola* | R |
| | **Oriolidae** | | |
| 46. | Golden Oriole | *Oriolus oriolus* | R |
| 47. | Blackheaded Oriole | *Oriolus xanthornus* | R |
| | **Dicruridae** | | |
| 48. | Black Drongo | *Dicrurus adsimilis* | R |
| 49. | Ashy Drongo | *Dicrurus leucophaeus* | R |
| 50. | Haircrested Drongo | *Dicrurus hottentottus* | R |
| 51. | Racket-tailed Drongo | *Dicrurus paradiseus* | R |
| | **Artamidae** | | |
| 52. | Ashy Swallow Shrike | *Artamus fuscus* | R |
| | **Sturnidae** | | |
| 53. | Common Myna | *Acridotheres tristis* | R |
| 54. | Jungle Myna | *Acridotheres fuscus* | R |
| 55. | Hill Myna | *Gracula religiosa* Cuvier | R |
| | **Corvidae** | | |
| 56. | Indian Tree Pie | *Dendrocitta vagabunda* | R |
| 57. | Whitebellied Tree Pie | *Dendrocitta leucogastra* | R |
| 58. | Jungle Crow | *Corvus macrorhynchos* | R |

*Cont'd...*

Table 4.1. *Cont'd…*

| | | | |
|---|---|---|---|
| | **Camphagidae** | | |
| 59. | Scarlet Minivet | *Pericrocotus flammeus* | R |
| | **Irenidae** | | |
| 60. | Goldfronted Leafbird | *Chloropsis aurifrons* | R |
| 61. | Asian Fairy Bluebird | *Irena puella* | R |
| 62. | Common Iora | *Aegithina tiphia* | R |
| | **Pycnonotidae** | | |
| 63. | Greyheaded Bulbul | *Pycnonotus priocephalus* | R |
| 64. | Redvented Bulbul | *Pycnonotus cafer* | R |
| 65. | Yellowbrowed Bulbul | *Hypsipetes indicus* | R |
| 66. | South Indian Black Bulbul | *Hypsipetes madagascariensis* | R |
| 67. | Whitebrowed Bulbul | *Pycnonotus xantholaemus*) | R |
| | **Muscicapidae** | | |
| | **Sub Family: Timaliinae** | | |
| 68. | Common Babbler | *Turdoides caudatus* | R |
| 69. | Jungle Babbler | *Turdoides striatus* | R |
| | **Sub Family: Muscicapinae** | | |
| 70. | Black-and-Orange Flycatcher | *Muscicapa nigrorufa* | R |
| 71. | Tickell's Blue Flycatcher | *Muscicapa tickelliae* | R |
| 72. | Nilgiri Verditer Flycatcher | *Muscicapa albicaudata* | R |
| 73. | Rufoustailed Flycatcher | *Muscicapa ruficauda* | M |
| | **Sub Family: Monarchinae** | | |
| 74. | Paradise Flycatcher | *Terpsiphone paradisi* | M |
| | **Sub Family: Sylviinae** | | |
| 75. | Ashy Wren Warbler | *Prinia socialis* | R |
| 76. | Great Reed Warbler | *Acrocephalus stentoreus* | M |
| 77. | Tickell's Leaf Warbler | *Phylloscopus affinis* | M |
| 78. | Plain Leaf Warbler | *Phylloscopus inornatus* | M |
| 79. | Greenish Leaf Warbler | *Phylloscopus trochiloides* | M |
| | **Sub Family: Turdinae** | | |
| 80. | Whiterumped Shama | *Copsychus malabaricus* | R |
| 81. | Oriental Magpie Robin | *Copsychus saularis* | R |
| 82. | Pied Bush Chat | *Saxicola caprata* | R |
| 83. | Malabar Whistling Thrush | *Myiophoneus horsfieldii* | R |
| 84. | Nilgiri Thrush | *Zoothera dauma* | R |
| 85. | Blue Rock Thrush | *Monticola solitarius* | M |
| 86. | Orangeheaded Ground Thrush | *Zoothera citrina* | R |
| 87. | Yellowbreasted Laughing Thrush | *Garrulax delesserti* | R |
| 88. | Blackcapped Blackbird | *Turdus merula*) | LM |
| | **Motacillidae** | | |
| 89. | Forest Wagtail | *Motacilla indica* | M |
| 90. | Large Pied Wagtail | *Motacilla maderaspatensis* | R |
| 91. | Yellow Wagtail | *Motacilla flava* | M |
| 92. | Grey Wagtail | *Motacilla caspica* | M |
| | **Dicaeidae** | | |
| 93. | Tickell's Flowerpecker | *Dicaeum erythrorhynchos* | R |
| 94. | Nilgiri Flowerpecker | *Dicaeum concolor* | R |
| 95. | Thickbilled Flowerpecker | *Dicaeum agile* | R |
| | **Nectariniidae** | | |
| 96. | Purplerumped Sunbird | *Nectarinia zeylonica* | R |
| 97. | Small Sunbird | *Nectarinia minima* | R |
| 98. | Indian Purple Sunbird | *Nectarinia asiatica* | R |
| | **Ploceidae** | | |
| | **Sub Family: Passerinae** | | |

*Cont'd…*

Table 4.1. *Cont'd...*

| | | | |
|---|---|---|---|
| 99. | Yellowthroated Sparrow | *Petronia xanthocollis* | R |
| | **Ploceidae** | | |
| | **Sub Family: Estrildinae** | | |
| 100. | Blackheaded Munia | *Lonchura malacca* | R |

### 4.4.2. Abundance and density

The mean number of birds recorded in different months during the study period is given in Fig. 4.4. The number of birds ranged from 85 to 596 at New Amarambalam. A slight reduction in the total number of birds was seen during May and June. Chi square test showed significant difference in total number of birds in various months ($X^2$= 318.02, P= 0.05, df=8). Nilgiri House Swallow was the dominant bird species in the evergreen forests where as Little Cormorant and Roseringed Parakeet were

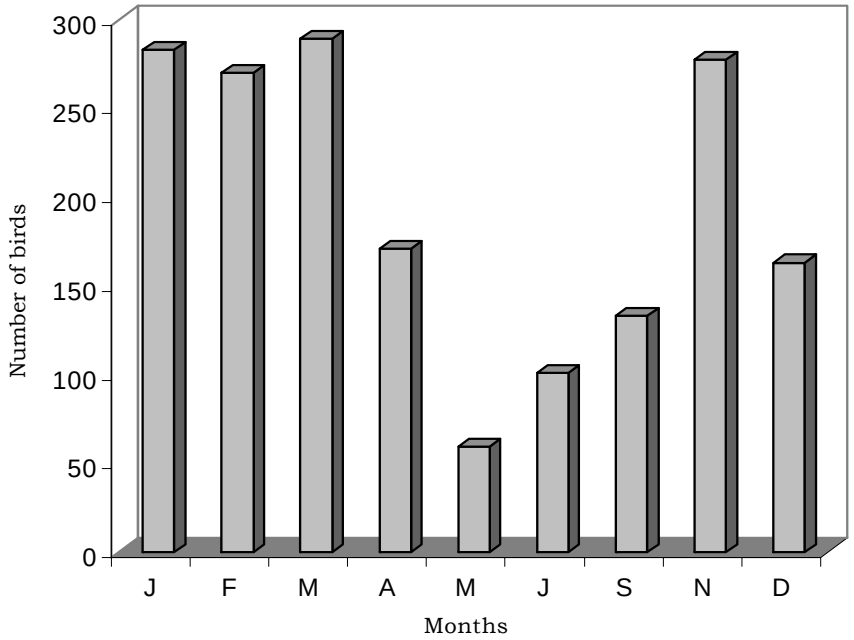


**Fig. 4.4. Total number of birds recorded from New Amarambalam in different months**

dominant in the moist deciduous forests and Nilgiri Flycatcher in the Shola forests. The recording of Little Cormorant as the dominant species can be considered as an exception, because as some point transects covered riversides also the number of Little Cormorants increased in the sampling. Dominance index of selected species of birds from the three vegetation types is given in Tables 4.3, 4.4, and 4.5.

**Table 4.2. Number and status of birds recorded at New Amarambalam**

| Sl. No. | Order | Status | | | Feeding guild | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | R | M | Total | A | I | G | N/ F | C | F | O |
| 1 | Pelecaniformes | 1 | - | 1 | 1 | - | - | - | - | - | - |

*Cont'd...*

Table 4.2. *Cont'd...*

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | Ciconiiformes | 3 | - | 3 | 3 | - | - | - | - | - | - |
| 3 | Falconiformes | 4 | - | 4 | - | - | - | - | 4 | - | - |
| 4 | Galliformes | 4 | - | 4 | - | 4 | - | - | - | - | - |
| 5 | Columbiformes | 5 | - | 5 | - | - | 5 | - | - | - | - |
| 6 | Psittaciformes | 4 | - | 4 | - | - | - | - | - | 4 | - |
| 7 | Cuculiformes | 6 | - | 6 | - | 5 | - | - | - | - | 1 |
| 8 | Strigiformes | 1 | - | 1 | - | - | - | - | 1 | - | - |
| 9 | Apodiformes | 4 | - | 4 | - | 4 | - | - | - | - | - |
| 10 | Trogoniformes | 1 | - | 1 | - | 1 | - | - | - | - | - |
| 11 | Coraciiformes | 9 | - | 9 | 4 | 2 | - | - | - | - | 3 |
| 12 | Piciformes | 2 | - | 2 | - | 2 | - | - | - | - | - |
| 13 | Passeriformes | 46 | 10 | 58 | - | 44 | 2 | 7 | - | 5 | - |
| | **Total** | **90** | **10** | **100** | **8** | **60** | **7** | **7** | **5** | **9** | **4** |

A = Aquatic feeders; I = Insectivores; G = Granivorous; N/F = Nectar and Frugivorous; C = Carnivorous; F = Frugivorous; O = Omnivorous; R = Resident; M = migrant.

**Table 4.3. Dominance Index of selected species of birds in the evergreen forests**

| Sl. No. | Species | Dominance Index |
|---|---|---|
| 1 | Nilgiri House Swallow | 24.73 |
| 2 | Bluewinged Parakeet | 9.83 |
| 3 | Yellowbrowed Bulbul | 7.48 |
| 4 | Malabar Whistling Thrush | 7.03 |
| 5 | Alpine Swift | 3.93 |
| 6 | Small Leaf Warbler | 3.78 |
| 7 | Jungle Myna | 3.70 |
| 8 | Ashy Drongo | 2.42 |
| 9 | Goldenbacked Woodpecker | 2.42 |
| 10 | Magpie Robin | 2.57 |

**Table 4.4. Dominance Index of selected species of birds in the moist deciduous forests**

| Sl. No. | Species | Dominance Index |
|---|---|---|
| 1 | Little Cormorant | 9.73 |
| 2 | Roseringed Parakeet | 7.86 |
| 3 | Jungle Myna | 7.55 |
| 4 | Common Babbler | 7.14 |
| 5 | Racket-tailed Drongo | 4.14 |
| 6 | Black Drongo | 3.00 |
| 7 | Small Leaf Warbler | 2.89 |
| 8 | Bluewinged Parakeet | 2.79 |
| 9 | Grey Hornbill | 2.79 |
| 10 | Jungle Crow | 2.58 |

**Table 4.5. Dominance Index of selected species of birds in the shola forests**

| Sl. No. | Species | Dominance Index |
|---|---|---|
| 1 | Nilgiri Flycatcher | 12.42 |
| 2 | Nilgiri Laughing Thrush | 8.28 |
| 3 | Whitethroated Ground Thrush | 5.91 |
| 4 | Nilgiri House Swallow | 5.32 |
| 5 | Yellowthroated Sparrow | 4.73 |

*Cont'd...*

Table 4.5. *Cont'd...*

| | | |
|---|---|---|
| 6 | Tickell's Leaf Warbler | 4.14 |
| 7 | Black Eagle | 2.36 |
| 8 | Black Bird | 1.77 |
| 9 | House Swallow | 1.18 |
| 10 | Jungle Myna | 1.18 |

**4.4.3. Diversity indices**

*4.3.3.1. Species diversity*

Values of four diversity indices obtained for New Amarambalam are given in Table 4.6.

**Table 4.6. Bird diversity in the New Amarambalam Reserve Forest**

| No. of species | No. of individuals | Simpson's Index | Shannon-Weiner Index | Hill's Number N1 | Hill's Number N2 |
|---|---|---|---|---|---|
| 100 | 2265 | 0.04 | 3.73 | 22.65 | 21.31 |

Shannon-Weiner Index showed a value of 3.73 and Simpson's index was 0.04. All the four diversity indices showed high values.

4.3.3.2. *Evenness or equitability indices*

Shannon Evenness E1 was 0.91 and Shannon Evenness E2 was 0.73.

*4.3.4.3. Diversity of birds in different vegetation types*

Diversity indices of birds (Fig. 4.5) in the three vegetation types were calculated as described earlier. Highest diversity index (H'= 3.70) was obtained for the moist

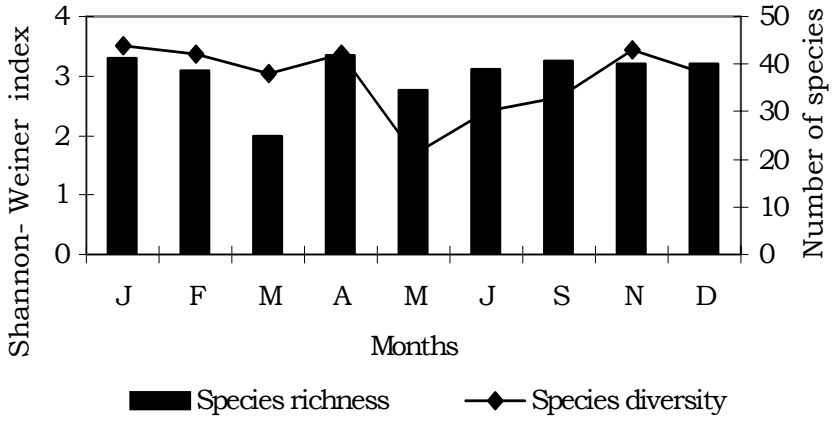


**Fig.4.5. Species richness and diversity of birds at New Amarambalam in different months**

deciduous forests (Table 4. 7) followed by evergreen forests and the sholas. Highest number of species was recorded from moist deciduous forests followed by evergreen and shola.

**Table 4.7. Diversity indices of birds in three vegetation types**

| Vegetation types | Shannon-Weiner Index | Simpson's Index | Hill's number N1 |
|---|---|---|---|
| Moist deciduous forests | 3.70 | -0.038 | 40.50 |
| Evergreen forests | 3.15 | 0.09 | 23.40 |
| Shola forests | 2.24 | 0.01 | 9.37 |

*Species richness indices*

Margalef Index and Menhinick Index showed higher value for the moist deciduous vegetation (Table 4.8). This indicates that the bird community in the moist deciduous forests is more diverse.

**Table 4.8. Species richness of birds in three vegetation types at New Amarambalam**

| Parameters | Moist deciduous forests | Evergreen forests | Shola forests |
|---|---|---|---|
| No. of species | 78 | 72 | 14 |
| Margalef Index R1 | 11.23 | 9.88 | 2.92 |
| Menhinick Index R2 | 2.53 | 1.98 | 1.50 |

*4.3.4.4. Species-abundance relationships*

Another way of expressing diversity in a community is through species-abundance or distribution models. This was introduced by Fischer *et al.* (1943). A species-abundance model utilises all the information gathered in a community and is the most complete mathematical description of the data (Magurran, 1988). Analyses were also carried out to see whether the truncated lognormal model suited the bird community of the study area. Species-abundance distribution of birds in the evergreen forest areas in semi-log scale is presented in Figure 4. 6 and that of moist deciduous forests in Figure 4.7. This distribution pattern indicates the absence of any single dominant species or a group of bird species and the presence of a large number of very rare species of birds at New Amarambalam. A truncated lognormal distribution is fitted to the data from the evergreen and moist deciduous forests (Tables 4.9 and 4. 10) (Pielou, 1975).

**Table 4.9. Number of birds recorded from evergreen forests At New Amarambalam**

| Sl. No. | Species | Number |
|---|---|---|
| 1. | Nilgiri House swallow | 327 |
| 2. | Bluewinged parakeet | 130 |
| 3. | Yellowbrowed bulbul | 99 |
| 4. | Malabar whistling thrush | 93 |
| 5. | Alpine swift | 52 |
| 6. | Small leaf warbler | 50 |
| 7. | Jungle myna | 49 |
| 8. | Ashy drongo | 35 |
| 9. | Goldenbacked woodpecker | 35 |
| 10. | Magpie robin | 34 |
| 11. | Blossomheaded parakeet | 28 |
| 12. | Purplerumped sunbird | 23 |
| 13. | Small sunbird | 23 |
| 14. | Small green barbet | 21 |
| 15. | Racket tailed drongo | 20 |

*Cont'd...*

Table 4.9. *Cont'd...*

| | | |
|---|---|---|
| 16. | Swifts | 20 |
| 17. | Black bulbul | 19 |
| 18. | Nilgiri flowerpecker | 17 |
| 19. | Grey junglefowl | 14 |
| 20. | Emerald dove | 13 |
| 21. | Scarlet minivet | 12 |
| 22. | Blackheaded oriole | 11 |
| 23. | Forest wagtail | 10 |
| 24. | Greyheaded bulbul | 10 |
| 25. | Hill myna | 10 |
| 26. | Jungle babbler | 10 |
| 27. | Tickell's flowerpecker | 8 |
| 28. | Yellowthroated sparrow | 8 |
| 29. | Indian cuckoo | 7 |
| 30. | Roseringed parakeet | 7 |
| 31. | Common babbler | 6 |
| 32. | Green pigeon | 6 |
| 33. | Hawk eagle | 6 |
| 34. | Koel | 6 |
| 35. | Lorikeet | 6 |
| 36. | Pied hornbill | 6 |
| 37. | Golden oriole | 5 |
| 38. | Grey wagtail | 5 |
| 39. | Whitethroated ground thrush | 5 |
| 40. | Black drongo | 4 |
| 41. | Crested tree swift | 4 |
| 42. | Goldenfronted leafbird | 4 |
| 43. | Nilgiri wood pigeon | 4 |
| 44. | Paradise flycatcher | 4 |
| 45. | Black bird | 3 |
| 46. | Blueheaded rock thrush | 3 |
| 47. | Common-hawk cuckoo | 3 |
| 48. | Grey hornbill | 3 |
| 49. | Imperial pigeon | 3 |
| 50. | Pond heron | 3 |
| 51. | Redwhiskered bulbul | 3 |
| 52. | Thickbilled flowerpecker | 3 |
| 53. | Whitebellied tree pie | 3 |
| 54. | Black eagle | 2 |
| 55. | Blackheaded munia | 2 |
| 56. | Crested serpent eagle | 2 |
| 57. | Fairy blue bird | 2 |
| 58. | Large Pied wagtail | 2 |
| 59. | Malabar trogon | 2 |
| 60. | Pied bush chat | 2 |
| 61. | Red spurfowl | 2 |
| 62. | Waynaad laughing thrush | 2 |
| 63. | Yellow wagtail | 2 |
| 64. | Crimsonbacked sunbird | 1 |
| 65. | Lesser pied kingfisher | 1 |
| 66. | Pied crested cuckoo | 1 |
| 67. | Redvented bulbul | 1 |
| 68. | Rufoustailed finch lark | 1 |
| 69. | Rufoustailed flycatcher | 1 |
| 70. | Small blue kingfisher | 1 |
| 71. | Spotted owlet | 1 |
| 72. | Storkbilled kingfisher | 1 |
| | **Total** | **1322** |

**Table 4.10. No. of birds recorded from moist deciduous forests at New Amarambalam**

| Sl. No | Species | Number |
|---|---|---|
| 1. | Little cormorant | 94 |
| 2. | Roseringed parakeet | 76 |
| 3. | Jungle myna | 73 |
| 4. | Common babbler | 69 |
| 5. | Racket tailed drongo | 40 |
| 6. | Black drongo | 29 |
| 7. | Small leaf warbler | 28 |
| 8. | Bluewinged parakeet | 27 |
| 9. | Grey hornbill | 27 |
| 10. | Jungle crow | 25 |
| 11. | Goldenbacked woodpecker | 24 |
| 12. | Yellowbrowed bulbul | 23 |
| 13. | Ashy drongo | 20 |
| 14. | Lorikeet | 20 |
| 15. | Tree pie | 20 |
| 16. | Koel | 16 |
| 17. | Small green barbet | 16 |
| 18. | Spotted dove | 16 |
| 19. | Grey junglefowl | 15 |
| 20. | Pond heron | 14 |
| 21. | Blackheaded oriole | 13 |
| 22. | Blossomheaded parakeet | 13 |

*Cont'd...*

Table 4.10. *Cont'd...*

| | | |
|---|---|---|
| 23. | Magpie robin | 13 |
| 24. | Tickell's flowerpecker | 12 |
| 25. | Greyheaded bulbul | 11 |
| 26. | Little egret | 11 |
| 27. | Whitebrowed bulbul | 11 |
| 28. | Black bulbul | 10 |
| 29. | Haircrested drongo | 10 |
| 30. | Jungle babbler | 10 |
| 31. | Scarlet minivet | 10 |
| 32. | Small sunbird | 10 |
| 33. | Hawk eagle | 9 |
| 34. | Black bird | 8 |
| 35. | Purplerumped sunbird | 8 |
| 36. | Crested tree swift | 7 |
| 37. | Malabar whistling thrush | 7 |
| 38. | Alpine swift | 6 |
| 39. | Black and orange flycatcher | 6 |
| 40. | Forest wagtail | 6 |
| 41. | Golden oriole | 6 |
| 42. | Blackheaded munia | 5 |
| 43. | Green pigeon | 5 |
| 44. | Indian cuckoo | 5 |
| 45. | Whitebreasted kingfisher | 5 |
| 46. | Common myna | 4 |
| 47. | Emerald dove | 4 |
| 48. | Fairy blue bird | 4 |
| 49. | Goldenfronted leafbird | 4 |
| 50. | Indian peafowl | 4 |
| 51. | Redwhiskered bulbul | 4 |
| 52. | Shikra | 4 |
| 53. | Ashy swallow shrike | 3 |
| 54. | Indian great reed warbler | 3 |
| 55. | Malabar trogon | 3 |
| 56. | Redvented bulbul | 3 |
| 57. | Spotted owlet | 3 |
| 58. | Whitebellied tree pie | 3 |
| 59. | Bay banded cuckoo | 2 |
| 60. | Common grey hornbill | 2 |
| 61. | Common iora | 2 |
| 62. | Crimsonbacked sunbird | 2 |
| 63. | Nilgiri wood pigeon | 2 |
| 64. | Palm swift | 2 |
| 65. | Red junglefowl | 2 |
| 66. | Shama | 2 |
| 67. | Swallow | 2 |
| 68. | Waynaad laughing thrush | 2 |
| 69. | Ashy wren warbler | 1 |
| 70. | Blueheaded rock thrush | 1 |
| 71. | Common-hawk cuckoo | 1 |
| 72. | Crested serpent eagle | 1 |
| 73. | Crow pheasant | 1 |
| 74. | Hill myna | 1 |
| 75. | Indian roller | 1 |
| 76. | Open billed stork | 1 |
| 77. | Paradise flycatcher | 1 |
| 78. | Small blue kingfisher | 1 |
| 79. | Small green bee-eater | 1 |
| **Total** | | **966** |

**Table 4.11. Truncated lognormal distribution of birds in the evergreen forests ($X^2$ test)**

| Class | Upper boundary | Observed | Expected |
|---|---|---|---|
| Behind veil line | 0.5 | - | 4.36 |
| 1 | 2.5 | 19 | 19.2 |
| 2 | 4.5 | 14 | 11.28 |
| 3 | 8.5 | 13 | 12.63 |
| 4 | 16.5 | 8 | 11.82 |
| 5 | 32.5 | 8 | 8.43 |
| 6 | 64.5 | 6 | 5.01 |
| 7 | 128.5 | 2 | 2.36 |
| 8 | | 2 | 1.27 |

The observed and expected numbers of species were computed using $X^2$ goodness of fit test. The test showed no significant difference between the observed

and expected distribution. This indicated that the distribution pattern of bird community was following truncated log-normal ($X^2$ = 2.6; df = 5; p= >0.7) model in the evergreen forests (Table 4. 11). In moist deciduous forests (4. 12) also, the distribution pattern of bird community was following truncated lognormal model ($X^2$ = 6.54; df=4; p= 0.1)

**Table 4.12. Truncated lognormal distribution of birds in the moist deciduous Forests ($x^2$ test)**

| Class | Upper boundary | Observed | Expected |
|---|---|---|---|
| Behind veil line | 0.5 | - | 2.45 |
| 1 | 2.5 | 21 | 19.35 |
| 2 | 4.5 | 12 | 13.45 |
| 3 | 8.5 | 13 | 16.03 |
| 4 | 16.5 | 18 | 14.09 |
| 5 | 32.5 | 10 | 9.27 |
| 6 | 64.5 | 1 | 4.6 |
| 7 | | 4 | 2.34 |

### 4.4.4. Seasonal fluctuations

Species richness and total number of birds varied in different months. Species richness recorded in various months is given in Figure 4.2. An increase in species richness is visible during the months of November, December and January. However, as the rain stopped, additional species started to arrive and a maximum of fifty-five species were recorded in the month of January (Table 4.13). Reduction in species richness during the monsoon season was observed throughout the study period. This was primarily due to the absence of migratory species such as wagtails and due to the local movement of species like Black bulbul. Similarly, a surge in species richness was recorded during summer, in all the years.

**Table 4. 13. Distribution of avifauna in different months at New Amarambalam**

| Syn. no.* | Species | Jan | Feb | Mar | Apr | May | Jun | Sep | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|
| 28 | Little cormorant | - | P | - | - | - | P | - | - | - |
| 42 | Pond heron | - | P | - | P | - | P | - | P | P |
| 46 | Little egret | - | P | - | - | - | - | - | - | - |
| 61 | Open billed stork | - | - | - | P | - | - | - | - | - |
| 139 | Shikra | - | - | - | - | - | P | - | P | - |
| 161 | Feathertoed hawk eagle | - | - | P | P | P | P | P | - | - |
| 172 | Black eagle | P | P | P | - | - | - | - | - | - |
| 197 | Crested serpent eagle | P | - | - | P | - | - | - | P | - |
| 275 | Red spur fowl | - | - | - | - | - | - | - | - | P |
| 299 | Red jungle fowl | - | - | - | - | - | - | - | P | - |
| 301 | Grey jungle fowl | P | P | - | P | P | - | P | P | - |
| 311 | Indian peafowl | - | P | - | P | P | - | - | P | - |
| 506 | Green imperial pigeon | P | P | - | P | P | P | - | - | - |
| 513 | Imperial pigeon | P | - | - | - | - | - | - | - | - |
| 521 | Nilgiri wood pigeon | P | P | P | P | - | P | - | - | - |
| 537 | Spotted dove | - | P | - | - | - | P | P | P | - |

P = Present, - = Not recorded * Ali and Ripley (1983) *Cont'd...*

Table 4.13. *Cont'd...*

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 542 | Emerald dove | P | - | P | P | P | - | P | P | P |
| 550 | Roseringed parakeet | - | P | - | P | P | P | - | P | - |
| 558 | Blossomheaded parakeet | P | P | - | P | - | - | - | P | P |
| 564 | Bluewinged parakeet | P | - | P | P | P | - | P | P | P |
| 566 | Indian lorikeet | - | P | - | - | P | - | - | P | P |
| 571 | Pied crested cuckoo | - | - | P | - | - | - | - | - | - |
| 573 | Common hawk cuckoo | - | - | - | - | - | - | P | - | P |
| 576 | Indian cuckoo | P | - | - | - | - | P | P | - | - |
| 582 | Indian banded bay cuckoo | P | P | P | P | - | - | - | - | P |
| 590 | Indian koel | P | P | - | P | P | P | P | P | - |
| 600 | Crow pheasant | - | - | - | P | - | - | - | P | - |
| 652 | Spotted owlet | - | - | - | - | - | P | - | - | - |
| 694 | Alpine swift | P | P | - | - | - | - | P | - | P |
| 707 | Palm swift | - | - | - | - | - | - | P | P | P |
| 709 | Crested tree swift | - | - | - | P | - | - | - | - | - |
| 710 | Malabar trogon | P | - | - | - | - | - | P | - | P |
| 720 | Lesser pied kingfisher | - | - | - | - | - | - | - | - | - |
| 722 | Small blue kingfisher | - | - | - | - | - | - | - | - | P |
| 730 | Storkbilled kingfisher | - | - | - | P | - | - | - | - | - |
| 735 | Whitebreasted kingfisher | - | P | P | P | - | P | - | P | - |
| 756 | Indian roller | - | - | - | - | - | P | - | - | - |
| 767 | Common gray hornbill | - | - | - | - | - | P | - | - | - |
| 768 | Malabar grey hornbill | P | P | P | P | P | P | - | P | - |
| 775 | Malabar Pied hornbill | P | - | - | - | - | - | - | - | - |
| 785 | Small green barbet | P | P | P | P | - | - | P | P | P |
| 785 | Small green bee-eater | - | - | - | - | - | - | P | - | - |
| 825 | Goldenbacked woodpecker | P | P | - | P | P | P | P | P | P |
| 883 | Rufoustailed finch lark | - | - | - | - | - | - | - | - | P |
| 916 | Swallow | P | - | P | P | - | - | - | P | - |
| 919 | House swallow | - | - | P | P | - | - | - | - | - |
| 952 | Golden oriole | P | P | P | - | - | - | P | P | P |
| 958 | Blackheaded oriole | P | P | P | - | - | P | P | - | P |
| 963 | Black drongo | P | P | - | P | P | P | - | P | P |
| 965 | Ashy drongo | P | - | P | - | - | - | P | - | P |
| 973 | Haircrested drongo | - | - | - | P | - | P | - | P | - |
| 977 | Racket-tailed drongo | P | P | - | P | P | P | P | P | P |
| 982 | Ashy swallow shrike | - | - | - | P | - | P | - | - | - |
| 1006 | Common myna | - | - | - | P | - | P | - | - | - |
| 1010 | Jungle myna | P | P | P | P | P | P | P | P | P |
| 1015 | Hill myna | - | P | - | - | - | - | - | - | - |
| 1033 | Indian tree pie | - | P | - | P | - | P | P | P | - |
| 1036 | Whitebellied tree pie | - | P | - | P | - | - | - | P | - |
| 1054 | Jungle crow | - | - | - | - | P | P | P | P | - |
| 1081 | Scarlet minivet | P | - | P | P | - | P | P | - | P |
| 1098 | Common iora | - | - | - | - | - | - | - | - | P |
| 1103 | Goldenfronted chloropsis | P | - | - | - | - | - | - | P | P |
| 1109 | Fairy bluebird | - | - | P | - | P | - | - | P | P |
| 1114 | Greyheaded bulbul | - | P | P | P | - | - | - | P | P |
| 1120 | Redwhiskered bulbul | - | - | - | - | - | - | P | P | P |
| 1127 | Redvented bulbul | P | - | - | - | - | - | P | - | - |
| 1138 | Whitebrowed bulbul | - | P | - | P | P | - | - | - | - |
| 1144 | Yellowbrowed bulbul | P | P | P | P | P | P | P | P | P |
| 1148 | Black bulbul | P | P | P | - | P | P | P | P | P |
| 1259 | Rufous babbler | - | P | - | - | - | P | P | P | - |
| 1265 | Jungle babbler | P | P | - | P | - | - | - | - | - |
| 1307 | Nilgiri laughing thrush | P | P | P | - | - | - | - | - | - |
| 1409 | Rufoustailed flycatcher | - | - | P | - | - | - | - | - | - |
| 1427 | Black-and-orange flycatcher | - | - | - | - | - | - | P | - | - |
| 1446 | Nilgiri flycatcher | - | - | P | - | - | - | - | - | - |

*Cont'd...*

Table 4.1.3. *Cont'd...*

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1461 | Paradise flycatcher | P | - | P | - | - | - | - | - | P |
| 1517 | Ashy wren warbler | - | - | P | - | - | - | - | - | - |
| 1550 | Indian great reed warbler | - | - | - | - | - | - | P | - | - |
| 1579 | Tickell's leaf warbler | P | P | P | - | - | - | P | P | P |
| 1605 | Green leaf warbler | - | - | - | - | - | - | - | P | - |
| 1662 | Magpie robin | P | P | P | - | - | P | P | P | P |
| 1665 | Shama | - | P | - | - | - | P | - | - | - |
| 1700 | Pied bush chat | - | - | - | - | - | - | - | - | P |
| 1726 | Blueheaded rock thrush | - | - | P | - | - | - | - | - | - |
| 1728 | Malabar whistling thrush | P | P | P | P | P | - | - | P | - |
| 1734 | Whitethroated ground thrush | - | - | P | - | - | - | - | - | - |
| 1752 | Eurasian black bird | P | - | P | P | - | - | P | - | P |
| 1874 | Forest wagtail | P | P | P | - | - | - | - | P | P |
| 1876 | Yellow wagtail | P | - | P | - | - | - | - | - | - |
| 1884 | Grey wagtail | - | - | - | P | - | - | - | - | P |
| 1891 | Large pied wagtail | P | P | - | - | - | - | - | - | P |
| 1892 | Thickbilled flowerpecker | - | - | - | - | - | - | - | P | - |
| 1899 | Tickell's flowerpecker | - | - | - | P | - | - | - | P | - |
| 1902 | Nilgiri flower pecker | - | P | - | - | P | - | - | P | - |
| 1907 | Purplerumped sunbird | P | P | P | - | - | - | P | - | P |
| 1909 | Small sunbird | P | P | P | P | - | - | - | P | - |
| 1917 | Purple sunbird | - | - | - | - | - | - | - | P | - |
| 1949 | Yellowthroated sparrow | - | - | P | P | - | - | - | - | - |
| 1978 | Blackheaded munia | P | P | - | - | - | - | P | - | - |

### 4.4.5. Density

Highest density of bird community was found in the month of November. Overall density of bird community at New Amarambalam was 510 birds/km$^2$. Density of birds in different moths were also calculated which is presented in Figure 4. 8.

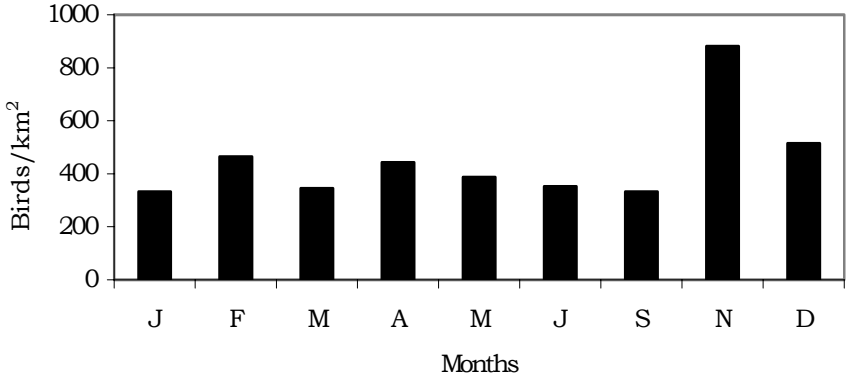


**Fig. 4.8. Density of birds recorded at New Amarambalam in different months**

Highest density was observed in moist deciduous forest (775 birds/km$^2$) followed by shola forests (402 birds/km$^2$). Lowest density was recorded in the evergreen forest (400 birds/km$^2$).

*4.4.5.1. Individual species density*

Densities of 26 common species of birds were calculated as described in the methods and the results are given in Table 4. 14. Highest density was obtained for the species Common babbler, followed by Black bulbul and Small leaf warbler. No comparison is possible as similar data is not available from other areas.

**Table 4.14. Density of selected bird species at New Amarambalam**

| Sl. No. | Species | Density (birds/km$^2$) |
|---|---|---|
| 1. | Common babbler | 691.70 |
| 2. | Black bulbul | 473.16 |
| 3. | Small leaf warbler | 469.49 |
| 4. | Purple sunbird | 402.66 |
| 5. | Spotted dove | 395.39 |
| 6. | Yellowbrowed bulbul | 333.27 |
| 7. | Black drongo | 308.16 |
| 8. | Racket-tailed drongo | 265.63 |
| 9. | Indian koel | 263.88 |
| 10. | Nilgiri flycatcher | 259.84 |
| 11. | Tree pie | 220.07 |
| 12. | Roseringed parakeet | 217.73 |
| 13. | Emerald dove | 210.40 |
| 14. | Grey hornbill | 203.75 |
| 15. | Goldenbacked woodpecker | 197.91 |
| 16. | Greyheaded bulbul | 164.60 |
| 17. | Jungle myna | 163.80 |
| 18. | Ashy drongo | 157.42 |
| 19. | Grey jungle fowl | 131.94 |
| 20. | Bluewinged parakeet | 131.8 |
| 21. | Blossomheaded parakeet | 127.32 |
| 22. | Magpie robin | 126.08 |
| 23. | Blackheaded oriole | 117.92 |
| 24. | Alpine swift | 64.96 |
| 25. | Malabar whistling thrush | 56.61 |
| 26. | Small sunbird | 53.68 |

## 4.4.6. Discussion

### 4.4.6.1. Occurrence of species

During this study, the birds were observed 1011 times and a total of 2293 individuals were counted. Out of the 100 species located from the whole study area, ten species were migrants and others were residents. New Amarambalam is not a major wintering area of palaeartic migrants and most of the birds were showing only local movements. The migrants that were recorded from here were Rufoustailed Flycatcher, Paradise Flycatcher, Great Reed Warbler, Tickell's Leaf Warbler, Plain Leaf Warbler, Greenish Leaf Warbler, Blue Rock Thrush, Forest Wagtail, Yellow Wagtail and Grey Wagtail. No wintering waterfowls were recorded from the area. This is due to the lack of wetlands in the study area. Presence of eight endemic

species of birds to the Western Ghats in New Amarambalam shows the importance of the area. Occurrence of Nilgiri Wood Pigeon, which is a globally threatened species, adds to conservation value of the area.

#### 4.4.6.2. Abundance and density

In the present study, 510 individuals/km$^2$ were recorded at New Amarambalam. This value is comparable to a number of similar studies on the composition and abundance of tropical forest birds, which are presently available. Karr (1971) estimated a population density of 1820 pairs of birds/km$^2$ in Panama's tropical forests. Thiollay (1986) reported a density of 760 pairs/km$^2$ for a total of 263 species in French Guiana. A long-term study conducted by Brosset (1990) in Gabon on 364 species of birds gave a density of 3,690 individuals/km$^2$. A study by Bell (1983) on birds of lowland rainforest in New Guinea produced a density of 3450 pairs/km$^2$. A study by Terborgh *et al.* (1990) on 245 species of Amazonian forest bird community had shown a density of 1910 individuals/km$^2$.

A drop in bird abundance during monsoon season with adverse climate (heavy rainfall), as observed in this study, was also reported by Ramakrishnan (1983) and Jayson (2000). Similarly, Morison *et al.* (1980) reported reduction of birds during non-winter period and their increase during winter. One factor, which may influence the abundance, is detectability. Seasonal differences in detectability are common for most of the bird species (Emlen, 1971). These differences result from changes in weather and habitat structure. Increasing foliage density decreased the visibility of birds. However, in the study area, foliage structure was similar in all seasons and only rainfall had some influence on detectability. During monsoon (June to September) a reduction in total number of birds and their density was recorded, which is also reported from other areas in the Western Ghats.

Density obtained for the moist deciduous forests of New Amarambalam is comparable with other tropical forests. Individual species density of birds showed that highest density was recorded for Common Babbler, followed by Black Bulbul. Similar results were reported from Silent Valley also in an earlier study (Jayson, 1994).

#### 4.4.6.3. Diversity indices

Shannon-Weiner diversity Index of 3.73 obtained is comparable to the adjacent Silent Valley forest, from where a value of 3.30 was obtained in an earlier study (Jayson, 1994). Highest diversity index was obtained for the bird community from

the moist deciduous forests. At New Amarambalam, bird diversity was possibly related to the history of the area and local migration of the species.

#### 4.4.6.4. Species richness indices

Species richness in an area is dependent on the availability of food resource, climate, evolutionary history and predation pressure. Species richness indices and diversity indices showed high diversity for New Amarambalam. Species richness of New Amarambalam is comparable to the adjacent Silent Valley forest (Jayson and Mathew, 2000a) (Table 4. 15). As reported from other areas of the State, high species richness was recorded for the moist deciduous forests. Lowest species richness was observed in the month of March, which is not the usual pattern for the Western Ghats.

*Species-abundance relationships*: In New Amarambalam, bird communities in both the evergreen and moist deciduous forests followed the truncated lognormal distribution, which is typical for the undisturbed tropical forests.

**Table 4. 15. Number of species of birds reported from different protected areas in Kerala**

| Forest area | Number of species | Source |
|---|---|---|
| Silent Valley forests (Tropical evergreen and moist deciduous) | 212 | Jayson (1994) |
| Periyar Tiger Reserve (Tropical evergreen, grasslands and sholas) | 249 | Srivasthava *et al.* (1993) |
| Parambikulam Wildlife Sanctuary (Tropical evergreen, moist deciduous and teak plantations) | 133 | Vijayan (1978) |
| Chinnar Wildlife Sanctuary (Dry deciduous and dry deciduous scrub) | 143 | Nair *et al.* (1993) |
| Peechi-Vazahni Wildlife Sanctuary (Moist deciduous and tropical evergreen) | 177 | NEST (1991) |
| Waynad Wildlife Sanctuary (Moist deciduous evergreen and plantations) | 275 | Zacharias (1993) |
| Chimmony Wildlife Sanctuary (Moist deciduous and tropical evergreen) | 161 | Jayson (Unpublished) |

Most of the Doves, Pigeons, Parakeets and Black Bulbuls (*Hypsipetes madagascariensis*) were not recorded during rainy season, but were seen returning to the area with the retreat of the rain. From the dominance index, it is clear that, barring a few species, all others are very rare. In addition to this, local movement of

species like Black Bulbul to the study area was observed during summer. Presence of several endemic and threatened species shows the conservation value of New Amarambalam forests. Therefore, it is recommended that the study area may be declared as a protected area.

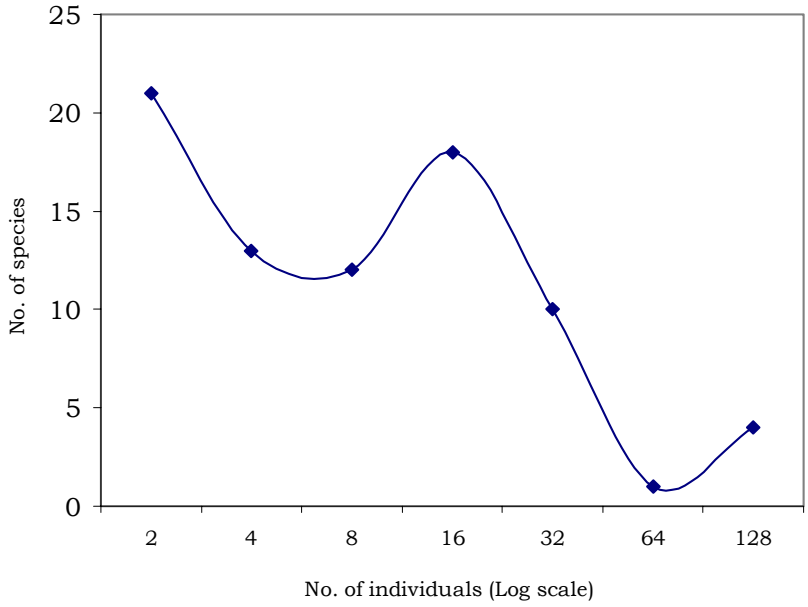


**Fig. 4.6. Species-abundance distribution of birds in the moist deciduous forests of New Amarambalam**

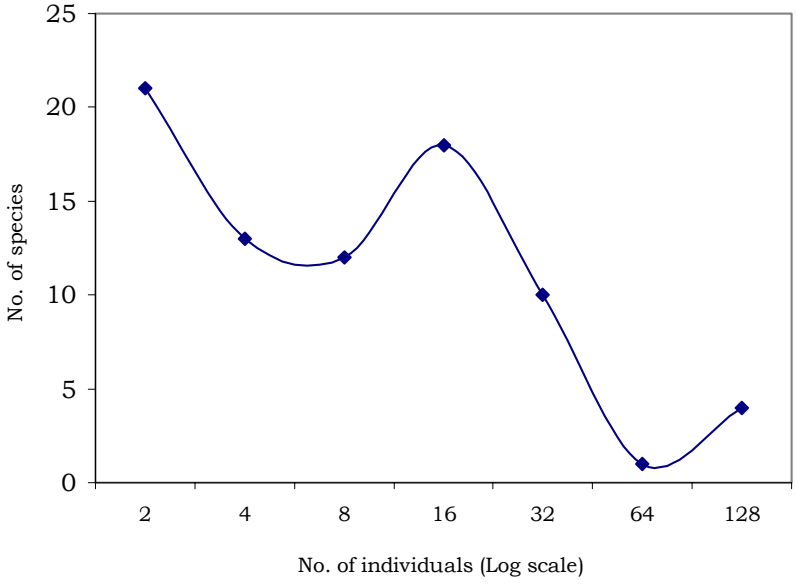


**Fig. 4.7. Species-abundance distribution of birds in the moist deciduous forests of New Amarambalam**

## Chapter 5

# Mammalian diversity

### 5.1. Introduction

Although several studies have been conducted on mammals in Wildlife sanctuaries and National Parks in Kerala, there has been very little effort to generate information on their status outside the protected areas. As there is no information available on the large mammals of New Amarambalam reserved forests of Nilgiri Biosphere Reserve, status of mammals in terms of abundance and distribution were investigated. This reserve forest area also form part of the Elephant Reserve No. 8 of the Project Elephant, which was launched during 1991-92, along with the other forest areas such as Nilambur and Silent Valley National Park, Attappadi, Nilgiri South and Coimbatore forests (GOI, 1993).

### 5.2. Methodology

To assess the diversity of mammalian fauna of New Amarambalam, the area was broadly stratified according to the seven different vegetation types, namely moist deciduous forests, moist deciduous with plantations, semi-evergreen forests, low elevation evergreen forests, medium elevation evergreens, high elevation evergreens and the savannah. Line transect method was followed for investigating the mammalian diversity in the area. Figure 5.1 shows the locations of the two-kilometre long transects laid for studying the mammalian diversity. The transect study was done in all the vegetation types. The line transects were taken in the same areas where floristic diversity plot were established. The animals were observed in the two kilometre transects, mostly during the morning hours. The observer moved along the transect at slow speed to reccord the mammals present in the area. Indirect evidences of mammals such as their calls, dung, hoof, pug mark, scat, etc. were also recorded during the transect study and random perambulations made. No survey of the chiropteran and small rodent populations was attempted, as it was beyond the scope of the present study.

### 5.3. Results

The mammals recorded from New Amarambalam reserved forests are listed in Table 5.1. Data on the total number of direct sightings of mammals, total number of

individuals sighted and number of indirect evidences observed species-wise are given in the Table 5.2.

**Table 5.1. Mammals recorded from New Amarambalam reserved forests**

| Sl. No. | Order/Family/Species |
|---|---|
| | **Order: Primates** |
| | **Family: Cercopithecidae** |
| 1 | Lion-tailed macaque (*Macaca silenus*) |
| 2 | Bonnet macaque (*Macaca radiata*) |
| 3 | Nilgiri langur (*Trachypithecus johni*) |
| 4 | Hanuman langur (*Semnopithecus entellus*) |
| | **Order: Artiodactyla** |
| | **Family: Cervidae** |
| 5 | Sambar (*Cervus unicolor*) |
| 6 | Spotted deer (*Axis axis*) |
| 7 | Barking deer (*Muntiacus muntjack*) |
| | **Family: Tragulidae** |
| 8 | Mouse deer (*Tragulus meminna*) |
| | **Family: Bovidae** |
| 9 | Gaur (*Bos gaurus*) |
| 10 | Nilgiri tahr (*Hemitragus hylocrius*) |
| | **Family: Suidae** |
| 11 | Wild boar (*Sus scrofa*) |
| | **Order: Proboscidea** |
| | **Family: Elephantidae** |
| 12 | Elephant (*Elephas maximus*) |
| | **Order: Rodentia** |
| | **Family: Sciuridae** |
| 13 | Malabar giant squirrel (*Ratufa indica*) |
| 14 | Palm squirrel (*Funambulus palmarum*) |
| 15 | Flying squirrel (*Petaurista petaurista*) |
| | **Family: Hystricidae** |
| 16 | Porcupine (*Hystrix indica*) |
| | **Order: Carnivora** |
| | **Family: Mustelidae** |
| 17 | Otter (*Lutra* sp.) |
| | Family: Herpestidae |
| 18 | Common mongoose (*Herpestes edwardsii*) |
| | **Family: Canidae** |
| 19 | Wild dog (*Cuon alpinus*) |
| | **Family: Ursidae** |
| 20 | Sloth bear (*Melurus ursinus*) |
| | **Family: Viverridae** |
| 21 | Small Indian civet (*Viverricula indica*) |
| 22 | Toddy cat (*Paradoxurus hermaphroditus*) |
| | **Family: Felidae** |
| 23 | Panther (*Panthera pardus*) |
| 24 | Tiger (*Panthera tigris*) |
| | **Order: Pholidota** |
| | **Family: Manidae** |
| 25 | Pangolin (*Manis crassicaudata*) |
| | **Order: Lagomorpha** |
| | **Family: Leporidae** |
| 26 | Blacknaped hare (*Lepus nigricollis*) |

Figure 5.2. gives the number of species observed in each mammalian order recorded from New Amarambalam RF. The mammalian fauna in the study area belonged to seven orders, namely Artiodactyla, Carnivora, Primates, Rodentia, Proboscidea, Pholidota, and Lagomorpha. They represent sixteen mammalian families. Order Carnivora had eight species, followed by Artiodactyla with seven species and Rodentia with four pecies. Proboscidea, Pholidota and Lagomorpha had single species each. Detailed mammal sighting data gathered included the date, time and

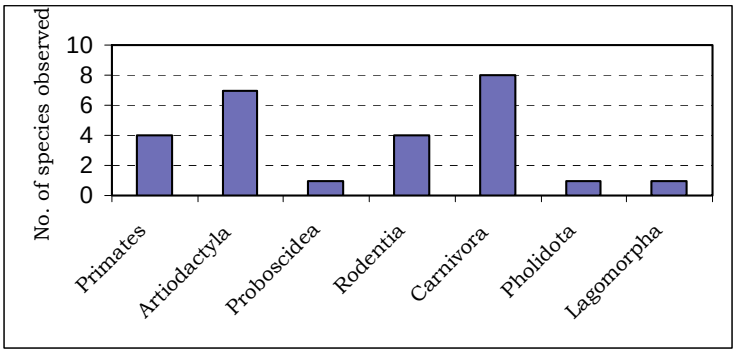


**Fig. 5.2. Number of species of mammals observed in different orders**

location of sighting, categorized species-wise, as given in Appendix 5.1. Table 5.3 gives the direct sightings of mammal species in the different vegetation types of the study area. Table 5.4 gives the indirect evidences of mammals inferred from calls of animals, dung, hoof/pug mark, scat, etc. Figure 5.2 shows the numerical representation of mammals recorded from different forest types of New Amarambalam. The populations of Nilgiri langur and Lion-tailed macaque were estimated based on repeated sightings of the animals in the same area and identifying the troop composition.

### 5.3.1. Arboreal mammals

The arboreal mammals observed in New Amarambalm include four species of primates and three species of squirrels. The primates sighted in the reserve are Lion-tailed macaque (*Macaca silenus*), Bonnet macaque (*Macaca radiata*), Nilgiri langur (*Trachypithecus johnii*) and Hanuman langur (*Semnopithecus entellus*). Bonnet macaque was sighted on 16 occasions with a total of 159 individuals (Appendix 5.1.3.). Hanuman langur was sighted on eight occasions with a total of 57 individuals. All the sightings were in the moist deciduous forests and teak plantation areas (Appendix 5.1.4.). Diurnal Malabar giant squirrel (*Ratufa indica*) was sighted 31 times during the transect survey with a tally of 36 individuals and Palm squirrel (*Funambulus palmarum)* was sighted on 16 times. Nocturnal flying squirrel (*Petaurista petaurista*) was sighted after dusk on seven occasions, with a total of eight individuals.

5.3.1.1. *Lion-tailed macaque (Macaca silenus)*

Distribution

Altogether 272 sightings of Lion-tailed macaques (Fig. 5.3.) were recorded during the transect survey with 39 sighting records. Nine troops of Lion-tailed macaque with 172 individuals were estimated at locations such as Manakadavu, Onakkathodu, Pullukuthimala, Gonianmala, Nanjanmala, Poochapara North, Poochapara South, and Poochapara and Gonianmala South.

**Fig. 5.3. A male Lion-tailed macaque in the evergreen forest canopy**

The population composition of the nine troops is given in Table 5.4. The troop number varied from 12 to 27 individuals (mean troop size = 19 and n = 9). All the direct sightings were at medium elevation evergreen forests. But calls of the Lion-tailed macaque troops were also recorded from high elevation evergreen forests (Fig. 5.3).

5.3.1.2. *Nilgiri langur* (*Trachypithecus johnii*)

Distribution

Nilgiri langur (Fig. 5.4) troops were observed for troop structures, 26 times. The locations of sightings and details of troop composition is given in Table 5.5. They were sighted in areas such as Chinnathalipuzha, Gonian North, Gonian South, Gonian top (HEG), Manakkadavu top, Manakkadavu West, Eramala, Meenmutty North, Meenmutty West, Onakkathod, Pullukuthy mala, Mukkurthi (HEG), Mukkurthi South, Kadukkamala, Panapuzha, Puchappara South, Pullukuthy South, Pullukuthy mala, Manakkadavu, Pullukuthy top, Nanjan mala, Gonian West, Talipuzha, Talipuzha top and Puchappara top. The total number of

individuals sighted in 26 troops were 208. The troop number varied from 3 to 15 individuals (mean = 8 and n = 26).

**Fig. 5.4. Nilgiri langur, the folivore primate seen in the reserve**

**Table 5.2. Details of mammals recorded from New Amarambalam reserved forests**

| Sl. No. | Species | Number of sightings | Total number of individuals sighted | Number of indirect evidences* recorded |
|---|---|---|---|---|
| | **Family: Cercopithecidae** | | | |
| 1 | Lion-tailed macaque (*Macaca silenus*) | 33 | 273 | 10 |
| 2 | Bonnet macaque (*Macaca radiata*) | 16 | 159 | 0 |
| 3 | Nilgiri langur (*Trachypithecus johni*) | 31 | 205 | 93 |
| 4 | Hanuman langur (*Semnopithecus entellus*) | 8 | 57 | 6 |
| | **Family: Cervidae** | | | |
| 5 | Sambar (*Cervus unicolor*) | 9 | 22 | 11 |
| 6 | Spotted deer (*Axis axis*) | 1 | 12 | 4 |
| 7 | Barking deer (*Muntiacus muntjack*) | 3 | 3 | 1 |
| | **Family: Tragulidae** | | | |
| 8 | Mouse deer (*Tragulus meminna*) | 2 | 2 | 1 |
| | **Family: Bovidae** | | | |
| 9 | Gaur (*Bos gaurus*) | 1 | 2 | 9 |
| 10 | Nilgiri tahr (*Hemitragus hylocrius*) | 2 | 20 | 5 |
| | **Family: Suidae** | 0 | 0 | |
| 11 | Wild boar (*Sus scrofa*) | 4 | 20 | 9 |
| | **Family: Elephantidae** | 0 | 0 | |
| 12 | Elephant (*Elephas maximus*) | 9 | 53 | 35 |
| | **Family: Sciuridae** | 0 | 0 | |
| 13 | Malabar giant squirrel (*Ratufa indica*) | 31 | 36 | 45 |
| 14 | Palm squirrel (*Funambulus palmarum*) | 15 | 15 | 4 |
| 15 | Flying squirrel (*Petaurista petaurista*) | 7 | 8 | 1 |
| | **Family: Mustelidae** | | | |
| 16 | Otter (*Lutra* sp.) | 1 | 3 | 3 |
| | **Family: Hystricidae** | 0 | 0 | |
| 17 | Porcupine (*Hystrix indica*) | 1 | 1 | 8 |
| | **Family: Viverridae** | 0 | 0 | |
| 18 | Small Indian civet (*Viverricula indica*) | 3 | 4 | 4 |
| 19 | Toddy cat (*Paradoxurus hermaphroditus*) | 3 | 3 | 13 |
| | **Family: Hystricidae** | 0 | 0 | |
| 20 | Common mongoose (*Herpestes edwardsii*) | 2 | 2 | 0 |

*Cont'd...*

Table 5.2. *Cont'd...*

| | | | | |
|---|---|---|---|---|
| | **Family: Canidae** | 0 | 0 | |
| 21 | Wild dog (*Cuon alpinus*) | 1 | 3 | 2 |
| | **Family: Ursidae** | 0 | 0 | |
| 22 | Sloth bear (*Melurus ursinus*) | 1 | 1 | 10 |
| | **Family: Felidae** | 0 | 0 | |
| 23 | Panther (*Panthera pardus*) | 1 | 2 | 12 |
| 24 | Tiger (*Panthera tigris*) | 0 | 0 | 8 |
| | **Family: Manidae** | | | |
| 25 | Pangolin (*Manis crassicaudata*) | 0 | 0 | 1 |
| | **Family: Leporidae** | | | |
| 26 | Blacknaped hare (*Lepus nigricollis*) | 3 | 3 | 0 |
| | **Total** | **188** | **909** | **295** |

** Includes calls, dung, hoof/pug mark, scat, burrows, etc.*

**Table 5.3. Direct sightings of mammals in the different vegetation types at New Amarambalm**

| Sl. No | Species | MDF | MDF (P) | SEG | LEG | MEG | HEG | SAV |
|---|---|---|---|---|---|---|---|---|
| 1 | Lion-tailed macaque (*Macaca silenus*) | - | - | - | - | P | - | - |
| 2 | Bonnet macaque (*Macaca radiata*) | P | P | P | P | - | - | - |
| 3 | Hanuman langur (*Semnopithecus entellus*) | P | P | - | - | - | - | - |
| 4 | Nilgiri langur (*Trachypithecus johni*) | - | - | P | P | P | P | - |
| 5 | Malabar giant squirrel (*Ratufa indica*) | P | - | P | P | P | P | - |
| 6 | Large brown flying squirrel (*Petaurista petaurista*) | - | - | P | P | P | - | - |
| 7 | Three striped Palm squirrel (*Funambulus palmarum*) | P | P | P | P | - | - | - |
| 8 | Porcupine (*Hystrix indica*) | P | P | - | - | - | - | - |
| 9 | Panther (*Panthera pardus*) | - | P | - | - | - | - | - |
| 10 | Small Indian Civet (*Viverricula indica*) | P | P | - | - | - | - | - |
| 11 | Toddy cat (*Paradoxurus hermaphroditus*) | P | P | - | - | - | - | - |
| 12 | Wild dog (*Cuon alpinus*) | P | - | - | - | - | - | - |
| | Sloth bear (*Melurus ursinus*) | - | - | P | - | - | - | - |
| 14 | Asian elephant (*Elephas maximus*) | P | P | P | P | P | - | - |
| 15 | Gaur(*Bos gaurus*) | P | - | P | - | - | - | - |
| 16 | Nilgiri tahr (*Hemitragus hylocrius*) | - | - | - | - | - | - | P |
| 17 | Sambar (*Cervus unicolor*) | - | - | P | - | - | - | - |
| 18 | Spotted deer (*Axis axis*) | P | P | - | - | - | - | - |
| 19 | Mouse deer (*Tragulus meminna*) | P | - | - | - | - | - | - |
| 20 | Wild boar (*Sus scrofa*) | P | P | - | - | - | - | - |
| 21 | Blacknaped hare (*Lepus nigricollis*) | P | - | - | - | - | - | - |
| **Total** | | **14** | **10** | **9** | **6** | **5** | **2** | **1** |

*P = Present*
*MDF = Moist deciduous forest*
*MDFP = Moist deciduous forest (plantation)*
*SEG = Semi-evergreen forest*
*LEG = Low evergreen forest*
*MEG = Medium elevation evergreen forest*
*HEG = High elevation evergreen forest*
*SAV = Savannah*

**Table 5.4. Indirect evidences of mammals in different vegetation types of New Aarambalam**

| Sl. No | Species | MDF | MDF (P) | SEG | LEG | MEG | HEG | SAV |
|---|---|---|---|---|---|---|---|---|
| 1 | Lion-tailed macaque (*Macaca silenus*) | - | - | - | - | P | P | - |
| 2 | Nilgiri langur (*Trachypithecus johni*) | - | - | - | - | - | P | P |
| 3 | Tiger (*Panthera tigris*) | P | P | P | - | P | | P |
| 4 | Panther (*Panthera pardus*) | - | P | P | P | P | P | - |
| 5 | Sloth bear (*Melurus ursinus*) | P | - | P | P | P | - | P |
| 6 | Asian Elephant (*Elephas maximus*) | P | P | P | P | P | P | - |
| 7 | Gaur (*Bos gaurus*) | P | - | P | P | P | - | - |
| 8 | Nilgiri tahr (*Hemitragus hylocrius*) | - | - | - | - | - | - | P |
| 9 | Sambar (*Cervus unicolor*) | - | P | P | P | P | P | P |
| 10 | Mouse deer (*Tragulus meminna*) | P | - | P | P | P | - | - |
| 11 | Wild boar (*Sus scrofa*) | P | P | - | - | - | - | - |
| 12 | Porcupine (*Hystrix indica*) | P | - | P | P | - | - | - |
| 13 | Small Indian civet (*Viverricula indica)* | P | P | P | P | P | - | - |
| 14 | Toddy cat (*Paradoxurus hermaphroditus*) | P | P | P | P | P | P | - |
| **Total** | | **9** | **7** | **10** | **9** | **10** | **6** | **5** |

*P = Present*
*- = Not recorded*
*MDF = Moist deciduous forest*
*MDFP = Moist deciduous forest (plantation)*
*SEG = Semi-evergreen forest*
*LEG = Low evergreen forest*
*MEG = Medium elevation evergreen forest*
*HEG = High elevation evergreen forest*
*SAV = Savannah*

**Table 5.5. Location of sightings and troop composition of Lion-tailed macaque in New Amarambalam**

| Sl. No. | Location | AM | AF | SAM | SAF | J | I | CF | CI | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Manakadavu | 1 | 4 | - | - | 3 | 2 | 1 | 1 | **12** |
| 2 | Onakkathodu | 2 | 6 | - | 2 | 2 | - | 1 | 1 | **14** |
| 3 | Pullukuthimala | 2 | 7 | 1 | 1 | 4 | 2 | - | - | **17** |
| 4 | Gonianmala | 2 | 9 | 1 | 2 | 3 | 3 | 1 | 1 | **22** |
| 5 | Nanjanmala | 2 | 8 | 2 | 3 | 2 | 3 | 2 | 2 | **24** |
| 6 | Poochapara North | 1 | 5 | 1 | 3 | 4 | 3 | 1 | 1 | **19** |
| 7 | Poochapara South | 1 | 4 | 2 | 2 | 3 | 1 | 2 | 2 | **17** |
| 8 | Poochapara | 2 | 9 | 1 | 3 | 2 | 3 | - | - | **20** |
| 9 | Gonianmala South | 2 | 10 | 3 | 2 | 4 | 4 | 1 | 1 | **27** |
| **Total** | | **15** | **62** | **11** | **18** | **27** | **21** | **9** | **9** | **172** |

*AM = Adult male*
*AF = Adult female*
*SAM = Subadult male*
*SAF = Subadult female*
*J = Juvenile*
*I = Infant*
*CF = Cradling female*
*CI = Cradled infants*

### 5.3.2. Herbivores

Sambar, Spotted deer, Mouse deer, Barking deer, Nilgiri tahr, Elephant and Gaur were the major herbivorous mammals recorded from New Amarambalam Reserved

Forests. The sambar sighting was low but were found in almost all types of forests. The sighting data of sambar is given in Appendix 5.9.6. The Spotted deer, which is an animal of the plains, was seen in Kanhirakadavu teak plantation, upto at an altitude of about 300 m. A herd of 12 individuals were sighted in that area. Indirect

**Table 5.6. Location of sightings and troop composition of Nilgiri langur in New Amarambalam**

| Sl. No. | Locations | AM | AF | SAM | SAF | J | I | CF | CI | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Chinnathalipuzha | 2 | 6 | - | - | 2 | - | - | - | **10** |
| 2 | Gonian North | 2 | 3 | - | - | 2 | - | 2 | 2 | **11** |
| 3 | Gonian South | 2 | 6 | - | - | 3 | 2 | - | - | **13** |
| 4 | Gonian top (HEG) | 2 | 3 | - | - | - | 2 | - | - | **7** |
| 5 | Gonian top North | 1 | 2 | - | 1 | 1 | - | - | - | **5** |
| 6 | Manakkadavu top | 1 | 2 | - | - | 2 | - | - | - | **5** |
| 7 | Manakkadavu west | 3 | 6 | - | 1 | 3 | - | 1 | 1 | **15** |
| 8 | Eramala | 1 | 2 | - | - | 1 | - | - | - | **4** |
| 9 | Meenmutty North | 1 | 3 | - | - | 1 | 1 | - | - | **6** |
| 10 | Meenmutty west | 1 | 1 | 1 | - | - | - | - | - | **3** |
| 11 | Onakkathod | 1 | 3 | - | - | 1 | - | - | - | **5** |
| 12 | Pullukuthy mala | 2 | 4 | - | - | 1 | - | 1 | 1 | **9** |
| 13 | Mukkurthi (HEG) | 2 | 3 | - | - | 2 | - | 1 | 1 | **9** |
| 14 | Mukkurthi south | 1 | 3 | - | - | 1 | - | - | - | **5** |
| 15 | Kadukkamala | 1 | 3 | - | - | 2 | 1 | - | - | **7** |
| 16 | Panapuzha | 2 | 6 | - | - | 2 | 2 | - | - | **12** |
| 17 | Puchappara south | 1 | 3 | - | - | 2 | - | - | - | **6** |
| 18 | Pullukuthy south | 2 | 4 | - | - | 1 | - | 1 | 1 | **9** |
| 19 | Pullukuthy mala | 1 | 3 | - | - | - | - | 1 | 1 | **6** |
| 20 | Manakkadavu | 1 | 2 | - | - | - | - | - | - | **3** |
| 21 | Pullukuthy top | 1 | 4 | - | - | 2 | 1 | - | - | **8** |
| 22 | Nanjan mala | 3 | 4 | - | - | 3 | 2 | - | - | **12** |
| 23 | Gonian west | 3 | 5 | - | 2 | - | 1 | - | - | **11** |
| 24 | Talipuzha | 1 | 5 | - | - | 2 | 1 | - | - | **9** |
| 25 | Talipuzha top | 1 | 3 | - | - | - | 2 | - | - | **6** |
| 26 | Puchappara top | 2 | 5 | - | - | 1 | - | 2 | 2 | **12** |
| **Total** | | **41** | **94** | **1** | **4** | **35** | **15** | **9** | **9** | **208** |

*AM = Adult male* *J = Juvenile* *AF = Adult female*
*I = Infant* *SAM = Subadult male* *CF = Cradling female*
*SAF = Subadult female* *CI = Cradled infants*

evidence of spotted deer was recorded from the lower plain areas of the reserve. Wild boar was seen in the moist deciduous areas of Karulai, Padukka, Nedumkayam, etc. Barking deer was observed during the transects study, on three occasions, and Mouse deer was observed on two occasions. Though the sighting of Gaur was only in moist deciduous area, indirect evidences indicated their presence in the moist deciduous, semi-evergreen, low evergreen and medium elevation

evergreen forests of the reserve. Nilgiri tahr, the endemic caprinae, was sighted twice in the grassland transect, West of Mukurthi, with a total of twenty individuals observed in the Kerala portion adjacent to the Mukuthi National Park of Tamil Nadu. Indirect evidences of Nilgiri tahr were observed on five occasions within New Amarambalam RF. Indirect evidences of elephants were seen in almost all the habitats expect the savannah. Elephants were sighted nine times with a total of 53 individuals. The details of the elephant sightings are given in Appendix 5.1.5.

### 5.3.3. Other mammals

Limited night observations revealed the presence of Common flying squirrel (*Petaurista petaurista*) in Panappuzha, Meenmutty, Puchappara, Talipuzha, Gonian and Pullukuthy, indicating that the animal is quite common in those areas. Blacknaped hare and Small Indian civet were sighted during night at Nedumkayam to Kanhirakadavu. Otter was directly observed in the Karimpuzha river on two occasions and scats were also seen along the bank.

### 5.3.4. Carnivores

Tiger was not directly sighted during the present study, eventhough the pugmarks were seen on eight occasions in the moist deciduous forests, teak plantations, semivergeen and evergreen forests and the savannah. This indicates that tiger has a wide range in most of the habitats of the reserve. Among the other carnivores, the Indian wild dog or Dhole was seen once in a pack consisting of three individuals. Leopard was observed once with two individuals at Nedumkayam, along the roadside. Sloth bear was sighted once, and indirect evidences were observed on ten occasions.

## 5.3.5. Discussion

### 5.3.5.1. Diversity of mammals

The mammal sighting data and indirect evidences were collected and compiled are presented. Twenty-six mammal species recorded from New Amarambalam Reserved Forest, represent seven mammalian orders and sixteen families. Order Carnivora had eight species, followed by Artiodactyla with seven species and Rodentia with four species. Proboscidea, Pholidota and Lagomorpha had single species each. A detailed diversity index is not attempted as the mammalian sighting data is insufficient for rigorous statistical analysis. The herbivore abundance is very low in the study area except in the low elevation moist deciduous areas, such as Nedugayam, Padukka, etc where most of the sightings of herbivores were seen. Overall distribution of large mammals is more in the low-lying areas of New

Amarambalam. If the number of Insectivores, Chiroptera and Rodentia and lesser-known lesser carnivores are considered, the diversity of mammals in New Amarambalam could give a totally different picture. Using scat density to study the presence of lesser carnivores, Yoganand and Kumar (1999) had reported that New Amarambalm Reserved Forests comes second to Silent Valley, which was ranked first in terms of abundance of lesser carnivores. The very few sightings of lesser carnivores in the area could be due to the less time spent on nocturnal observations.

Of the four diurnal primates found in the New Amarambalam Reserve, Hanuman langur is seen in moist deciduous forests and teak plantations, in the lower altitudes of the reserve, whereas, Bonnet macaques were found in moist deciduous, plantation, semi-evergreen and lower elevation evergreen forests (Fig. 5.5). During the Wildlife Census conducted through out the forests of Kerala State in 1993, six lion-tailed macaque troops were reported from New Amarambalam area. It was also reported that Silent Valley with the contiguous evergreen forests of New Amaramblam and Attappady Reserve can harbour one of the viable populations of Lion-tailed macaque with atleast about 300 individuals (KFRI, 1993; Easa *et al.*, 1997). Ramachandran and Joseph (2000), after detailed studies conducted in Silent Valley National Park, had found that not all the evergreen forest areas are ideal lion-tailed habitats, as certain tree species association and the respective resource distribution may restrict them, even though there is forest continuity. The evergreen forests of Manakadavu, Onakkathodu, Pullukuthimala, Gonianmala, Nanjanmala, Poochapara North, Poochapara South, Poochapara, and Gonianmala South are all middle elevation evergreen forests where Lion-tailed macaques were sighted and all these forests form one contiguous stretch of New Amarambalam Reserve. However, the present study gives more accurate information on the Lion-tailed macaque population, the forest areas where they exist and their population characteristics. The distribution of endangered primates in New Amarambalm Reserve Forests also corroborates the diurnal primate distribution in Silent Valley National Park and adjacent areas (Ramachandran and Joseph, 2001a). A number of studies are available on the status and distribution of Nilgiri langur (Pocock, 1928; Poirier, 1969; Daniel and Kannan, 1967; Kurup, 1978; Vijayan and Balakrishnan, 1977; Balakrishnan, 1984; Hohmann and Sunderraj, 1990; KFRI, 1993, and their ecology and behaviour (Poirier, 1968; 1969; 1970b; Horwich, 1972; Oates, *et al.*, 1980; Ramachandran, 1998; Srivasthava *et al.*, 1996) in different habitats. Although Poirier (1968) stated Nilgiri langur as a typical shola species, the middle elevation evergreen forests

between 700 and 1800 m, was identified as the ideal habitat for this folivorous primate in Silent Valley National Park and adjacent areas (Ramachandran and Joseph, 2001b). The present study also throws light on the distribution and status of Nilgiri langur in the semievergreen, low level evergreen, medium elevation and high elevation evergreen forests and savannah areas of New Amarambalam.

Nilgiri langur is a vulnerable primate species, which is endemic to the forests of Western Ghats. Although, this primate is adapted to different types of habitats such as montane sholas, evergreen, semi-evergreen and moist deciduous forests, its population has been dwindling mainly due to anthropogenic pressures. Extensive destruction of its natural habitat for plantations and other agricultural needs ultimately resulted in its present endangered status. Moreover, these black monkeys are poached for their flesh of alleged medicinal properties. However, the inclusion of considerable forest habitats in the protected area network like sanctuaries, National Parks and Biosphere Reserves and the implementation of the Wildlife Protection Act (1972) helped very much to recoup their populations to some extent.

Rodgers and Panwar (1988), in their report entitled 'Planning a Wildlife Protected Area Network in India' had pointed out the inadequacy of the two small National Parks (Silent Valley National Park and Mukurthi National Park) designated to conserve the great range of biological values of this part of the Western Ghats. They had proposed to gazette the forest block of Karimpuzha, which is adjacent to Mukurthi National Park and near Silent Valley National Park. In the larger context of conservation of the entire range of biological values of Western Ghats, there is urgency to know the biodiversity of the watershed between New Amarambalam and Silent Valley, which is the catchment of Palkachipuzha, draining into the Chaliyar River. This area might prove a possible corridor facilitating genetic transfer of the large mammals.

New Amarambalam has one of the largest continuous evergreen patches North of Palghat Gap in the Nilgiri Biosphere Reserve and may also form continuity for the elephant population in the North and South of the western slope of Nilgiris. This reserve is rich in mammalian diversity and much remains to be explored.

#### 5.3.5.2. Anthropic disturbances

The New Amarambalam forests contain the most primitive tribal group of the Western Ghats, the Cholanaickans (Figure 5.5). Their lack of exposure to modern developments compels them to follow their traditional hunter-gatherer existence. Due to their small declining population they deserve to be counted as a target

human population for conservation. Their knowledge of the evergreen forests and the ecology of animals make them the natural guardians of the forests. However, their hunting habit is a threat to some of the rare and endangered species in the

**Fig. 5.5. A Cholanaicken family living in rocky caves along river banks**

forest habitat. They are reported to use dogs for flushing out small animals like monitor lizard, mouse deer and black-naped hare. A good number of primate populations are under pressure of being hunted. Varghese (1992) had also reported the hunting of small mammals including black monkeys by the Cholanaickan tribe. They also trap the Nilgiri langur and Lion-tailed macaque. Five trapping locations, which were set by cutting trees, and setting net traps for capturing monkeys were observed during the study period.

The Cholanaickens are opportunistic omnivorous in that their diet consist of a good number of rare animals, including nestlings of Great Indian Hornbill, Pangolin, Mouse deer, Nilgiri langur, Lion-tailed macaque, Monitor lizard, Tortoise etc. A well conceived educational programme is needed in which they are gradually weaned away exterminating the rare and endangered species from this valuable conservation area of Nilgiri Biosphere Reserve.

## 5.4. Conclusions

The study shows that the New Amarambalam is rich in mammals. Twenty-seven large and medium sized mammals were recorded from different vegetation types in the study area. This area holds rich population of the endemic primates Lion-tailed macaque (*Macaca silenus*) and Nilgiri langur (*Trachypithecus johnii*) and the endemic

goat Nilgiri tahr (*Hemitragus hylocrius).* New Amarambalam RF has high conservation value as it is part of a viable habitat of Asian elephant, tiger, panther, sloth bear and gaur, which are Schedule I species of the Indian Wildlife (Protection) Act, 1972. The continuity of New Amarambalam forests with Nilambur North Forest Division and Mukurthi National Park makes it a potential conservation area for large mammals. Considering all these, the New Amarambalam Reserve, may be declared as a Wildlife Sanctuary as a prelude to declaring it as a National Park in future for better conservation of the biodiversity of the area.

# Appendix 5.1

**5.1.1. Direct sightings of Lion-tailed macaques**

| Sl. No. | Date | Place name | Time of sighting | Species | Total no. sighted |
|---|---|---|---|---|---|
| 1 | 2/15/99 | Meenmutty to Onakkathod | 10.40 | Lion-tailed macaque (LTM) | 2 |
| 2 | 2/15/99 | Onakkathod | 11.05 | LTM | 12 |
| 3 | 2/16/99 | Manakkadavu Top | 10.25 | LTM | 14 |
| 4 | 2/17/99 | Manakkadavu West (Tran.) | 9.25 | LTM | 15 |
| 5 | 3/15/99 | Pullukuthy Top | 10.10 | LTM | 2 |
| 6 | 3/15/99 | Pullukuthy Top | 10.45 | LTM | 17 |
| 7 | 4/15/99 | Puchappara North | 10.23 | LTM | 20 |
| 8 | 4/15/99 | Puchappara North | 10.23 | LTM | 20 |
| 9 | 4/15/99 | Puchappara North (Tran.) | 9.38 | LTM | 2 |
| 10 | 4/18/99 | Puchappara South | 10.47 | LTM | 2 |
| 11 | 4/18/99 | Puchappara South | 10.51 | LTM | 5 |
| 12 | 4/18/99 | Puchappara South | 11.25 | LTM | 17 |
| 13 | 4/19/99 | Puchappara West | 10.05 | LTM | 3 |
| 14 | 4/19/99 | Puchappara West | 10.40 | LTM | 1 |
| 15 | 4/19/99 | Puchappara West | 11.05 | LTM | 2 |
| 16 | 4/19/99 | Puchappara West | 11.20 | LTM | 20 |
| 17 | 12/11/99 | Meenmutty to Gonian | 12.23 | LTM | 5 |
| 18 | 12/12/99 | Gonian North | 9.53 | LTM | 3 |
| 19 | 12/12/99 | Gonian North | 10.05 | LTM | 1 |
| 20 | 12/12/99 | Gonian North | 10.23 | LTM | 7 |
| 21 | 12/12/99 | Gonian North | 10.40 | LTM | 22 |
| 22 | 12/12/99 | Gonian North (Tran.) | 9.35 | LTM | 2 |
| 23 | 12/13/99 | Gonian South | 10.13 | LTM | 1 |
| 24 | 12/13/99 | Gonian South | 10.25 | LTM | 5 |
| 25 | 12/13/99 | Gonian South | 10.53 | LTM | 3 |
| 26 | 12/13/99 | Gonian South | 11.05 | LTM | 26 |
| 27 | 12/19/99 | Pullukuthy to Nanchan | 11.40 | LTM | 3 |
| 28 | 12/19/99 | Pullukuthy to Nanchan | 11.50 | LTM | 1 |
| 29 | 12/19/99 | Pullukuthy to Nanchan | 11.53 | LTM | 8 |

*Cont'd...*

Appendix 5.1.1. *Cont'd...*

| | | | | | |
|---|---|---|---|---|---|
| 30 | 12/19/99 | Pullukuthy to Nanchan | 12.05 | LTM | 2 |
| 31 | 12/19/99 | Pullukuthy to Nanchan | 12.34 | LTM | 4 |
| 32 | 12/19/99 | Pullukuthy to Nanchan | 12.50 | LTM | 1 |
| 33 | 12/19/99 | Pullukuthy to Nanchan | 13.08 | LTM | 24 |

**5.1.2. Direct sightings of Bonnet macaques**

| Sl.No. | Date | Place name | Time of sighting | Species | Total no. sighted |
|---|---|---|---|---|---|
| 1 | 10/17/98 | Nedunkayam | 10.08 | Bonnet macaque (BM) | 14 |
| 2 | 10/18/98 | Nedunkayam | 8.53 | BM | 8 |
| 3 | 10/19/98 | Nedunkayam | 8.56 | BM | 9 |
| 4 | 11/13/98 | Meenmutty Rd. | 9.20 | BM | 3 |
| 5 | 12/5/98 | Panappuzha (Arikkayan) (Tran.) | 9.33 | BM | 7 |
| 6 | 12/29/98 | Manjakkallan | 9.23 | BM | 8 |
| 7 | 12/30/98 | Panappuzha | 9.25 | BM | 9 |
| 8 | 12/30/98 | Panappuzha | 9.25 | BM | 9 |
| 9 | 1/22/99 | Meenmutty West | 9.25 | BM | 10 |
| 10 | 1/26/99 | Meenmutty (Manjakkalan(Tran.) | 8.45 | BM | 6 |
| 11 | 1/27/99 | Meenmutty | 9.40 | BM | 11 |
| 12 | 3/14/99 | Panappu'a to Meenmtty | 7.43 | BM | 15 |
| 13 | 4/12/99 | Nedungayam Planta'n (Tran.) | 8.40 | BM | 11 |
| 14 | 4/21/99 | Maanjeri East Mdf (Tran.) | 9.01 | BM | 14 |
| 15 | 12/9/99 | To Maanjeri By Jeep | 8.30 | BM | 8 |
| 16 | 12/10/99 | Panapuzha  Meenmutty Seg (Tran.) | 8.40 | BM | 17 |

**5.1.3. Direct sightings of Nilgiri langur**

| Sl.No. | Date | Place name | Time of sighting | Species | Total no. sighted |
|---|---|---|---|---|---|
| 1 | 2/4/00 | Panappuzha to Meenmutty | 13.25 | Nilgiri langur (NL) | 2 |
| 2 | 2/4/00 | Panappuzha to Meenmutty | 13.40 | NL | 1 |
| 3 | 2/7/00 | Pullukuthy to Meenmutty | 12.40 | NL | 6 |
| 4 | 2/7/00 | Pullukuthy to Meenmutty | 13.40 | NL | 3 |
| 5 | 2/8/00 | Meenmutty | 9.25 | NL | 1 |
| 6 | 12/5/98 | Panappuzha (Arikkayan (Tran.) | 8.25 | NL | 2 |
| 7 | 1/22/99 | Meenmutty West | 9.00 | NL | 3 |
| 8 | 1/23/99 | Meenmutty (North (Tran.) | 9.30 | NL | 6 |
| 9 | 1/24/99 | Meenmutty (Kadukka (Tran.) | 9.20 | NL | 4 |
| 10 | 1/25/99 | Meenmutty (Onakkth0d (Tran.) | 8.33 | NL | 5 |
| 11 | 2/16/99 | Manakkadavu Top (Tran.) | 8.40 | NL | 5 |
| 12 | 3/14/99 | Meenmtty to Pullukuthy | 14.35 | NL | 9 |
| 13 | 3/15/99 | Pullukuthy Top (Tran.) | 9.20 | NL | 8 |
| 14 | 3/16/99 | Pullukuthy South (Tran.) | 8.40 | NL | 9 |
| 15 | 3/17/99 | To Gonian (Tran.) | 9.10 | NL | 11 |
| 16 | 4/14/99 | To Puchappara | 14.05 | NL | 12 |
| 17 | 4/16/99 | Talippuzha (Tran.) | 8.43 | NL | 9 |

*Cont'd...*

Appendix 5.1.3. *Cont'd...*

| | | | | | |
|---|---|---|---|---|---|
| 18 | 4/16/99 | Talippuzha (Tran.) | 9.23 | NL | 6 |
| 19 | 4/17/99 | Chinna Talippuzha (Tran.) | 9.25 | NL | 10 |
| 20 | 4/18/99 | Puchappara South (Tran.) | 9.20 | NL | 6 |
| 21 | 5/11/99 | Mukkuruthy South (Tran.) | 9.43 | NL | 5 |
| 22 | 5/13/99 | Mukkuruthy Down (Tran.) | 10.20 | NL | 9 |
| 23 | 5/14/99 | Mukkuruthy to Kadukka (Tran.) | 9.35 | NL | 7 |
| 24 | 12/11/99 | Meenmutty to Gonian | 9.40 | NL | 3 |
| 25 | 12/11/99 | Meenmutty to Gonian | 10.25 | NL | 12 |
| 26 | 12/12/99 | Gonian N (Tran.) | 9.21 | NL | 11 |
| 27 | 12/13/99 | Gonian South (Tran.) Meg | 8.10 | NL | 13 |
| 28 | 12/15/99 | Gonian Top (Tran.) Heg | 9.13 | NL | 7 |
| 29 | 12/17/99 | Gonian Top North (Tran.) Heg | 7.13 | NL | 6 |
| 30 | 12/19/99 | Pullukuthy to Nanchan (Tran.) Meg | 9.11 | NL | 12 |
| 31 | 12/20/99 | Pullukuthy to Meenmutty | 12.15 | NL | 2 |

**5.1.4. Direct sightings of Hanuman langur**

| Sl.No. | Date | Place name | Time of sighting | Species | Total no. sighted |
|---|---|---|---|---|---|
| 1 | 2/4/00 | Nedun'm to Panappu'a | 7.40 | Hanuman langur (HL) | 7 |
| 2 | 10/18/98 | Nedunkayam | 8.13 | HL | 12 |
| 3 | 10/18/98 | Nedunkayam | 8.45 | HL | 3 |
| 4 | 10/20/98 | Nedunkayam (Manjeri Rd.) | 8.03 | HL | 10 |
| 5 | 10/21/98 | Padukka Rd. | 8.13 | HL | 3 |
| 6 | 2/12/99 | Nedungayam to Manjeri | 9.23 | HL | 1 |
| 7 | 3/11/99 | Padukka plantation(Tran.) | 8.40 | HL | 8 |
| 8 | 3/13/99 | Nedungayam Tran | 8.55 | HL | 13 |

**5.1.5. Direct sightings of Elephant**

| Sl.No. | Date | Place name | Time of sighting | Species | Total no. sighted |
|---|---|---|---|---|---|
| 1 | 10/20/98 | Nedunkayam (Manjeri Rd.) | 8.52 | Elephant (EL) | 1 Tusker |
| 2 | 10/21/98 | Padukka Rd. | 8.42 | EL | 7 |
| 3 | 1/25/99 | Meenmutty- Onakkthod (Tran.) | 12.05 | EL | 6 |
| 4 | 3/12/99 | Padukka | 16.53 | EL | 9 |
| 5 | 4/14/99 | To Puchappara | 13.25 | EL | 15 |
| 6 | 4/15/99 | Puchappara North (Tran.) | 8.15 | EL | 3 |
| 7 | 4/19/99 | Puchappara to Manjeri | 14.40 | EL | 3 |
| 8 | 4/19/99 | Puchappara to Manjeri | 15.20 | EL | 1 Tusker |
| 9 | 4/23/99 | Panapuzha to Nedung'm By Jeep | 14.20 | EL | 8 |

**5.1.6. Direct sightings of Sambar**

| Sl.No. | Date | Place name | Time of sighting | Species | Total no. sighted |
|---|---|---|---|---|---|
| 1 | 11/11/98 | Meenmutty Rd. | 8.40 | Sambar deer (SD) | 1 |
| 2 | 1/22/99 | Meenmutty West | 8.43 | SD | 1 |

*Cont'd...*

Appendix 5.1.6. *Cont'd...*

| | | | | | |
|---|---|---|---|---|---|
| 3 | 3/13/99 | Manjeri Road | 20.20 | SD | 2 |
| 4 | 3/13/99 | Manjeri Road | 20.55 | SD | 1 |
| 5 | 4/17/99 | Chinna Talippuzha (Tran.) | 8.40 | SD | 1 |
| 6 | 5/9/99 | Mukkuruthy | 14.10 | SD | 1 |
| 7 | 5/11/99 | Mukkuruthy South (Tran.) | 10.25 | SD | 1 |
| 8 | 5/11/99 | Mukkuruthy South (Tran.) | 10.25 | SD | 1 |
| 9 | 12/17/99 | Gonian Top North (Tran.) Heg | 8.00 | SD | 1 |

**5.1.7. Direct sightings of Spotted deer**

| Sl.No. | Date | Place name | Time of sighting | Species | Total no. sighted |
|---|---|---|---|---|---|
| 1 | 3/12/99 | Kanjirakkadav Plant'n (Tran.) | 9.10 | Spotted deer (SPD) | 12 |

**5.1.8. Direct sightings of Barking deer**

| Sl.No. | Date | Place name | Time of sighting | Species | Total no. sighted |
|---|---|---|---|---|---|
| 1 | 1/28/99 | Meenmutty to Panappuzha | 9.40 | Barking deer (BD) | 1 |
| 2 | 2/12/99 | Nedungayam to Manjeri | 9.40 | BD | 1 |
| 3 | 4/14/99 | To Puchappara | 11.23 | BD | 1 |

**5.1.9. Direct sightings of Mouse deer**

| Sl.No. | Date | Place name | Time of sighting | Species | Total no. sighted |
|---|---|---|---|---|---|
| 1 | 1/23/99 | Meenmutty North (Tran.) | 8.15 | Mouse deer | 1 |
| 2 | 4/11/99 | Nedungayam | 19.55 | Mouse deer | 1 |

**5.1.10. Direct sightings of Nilgiri tahr**

| Sl.No. | Date | Place name | Time of sighting | Species | Total no. sighted |
|---|---|---|---|---|---|
| 1 | 2/13/99 | Mukkuruthy to Meenmutty | 12.00 | Nilgiri Tahr | 1 |
| 2 | 5/10/99 | Mukkuruthy East (Tran.) | 9.43 | Nilgiri Tahr | 19 |

**5.1.11. Direct sightings of Wild boar**

| Sl.No. | Date | Place name | Time of sighting | Species | Total no. sighted |
|---|---|---|---|---|---|
| 1 | 11/11/98 | Karulai Rd. | 19.10 | Wild boar (WB) | 1 |
| 2 | 11/11/98 | Padukka Rd. | 18.00 | WB | 8 |
| 3 | 3/12/99 | Padukka | 16.20 | WB | 10 |
| 4 | 4/13/99 | Pulimunda Plantation (Tran.) | 8.57 | WB | 1 |

**5.1.12. Direct sightings of Malabar giant squirrel**

| Sl.No. | Date | Place name | Time of sighting | Species | Total no. sighted |
|---|---|---|---|---|---|
| 1 | 2/4/00 | Panapuzha to Meenmutty | 12.35 | Malabar gaint squirral [MGS] | 1 |
| 2 | 2/5/00 | Meenmutty to Pullukuthy | 12.00 | MGS | 1 |

*Cont'd...*

Appendix 5.1.12. *Cont'd...*

| | | | | | |
|---|---|---|---|---|---|
| 3 | 2/7/00 | Pullukuthy to Meenmutty | 13.42 | MGS | 2 |
| 4 | 2/8/00 | Meenmutty | 10.05 | MGS | 1 |
| 5 | 2/8/00 | Meenmutty to Panapuzha | 11.03 | MGS | 1 |
| 6 | 11/11/98 | Meenmutty Rd. | 12.50 | MGS | 1 |
| 7 | 11/14/98 | Panappuzha (Irumban Tran.) | 8.51 | MGS | 1 |
| 8 | 12/29/98 | Manjakkallan | 9.15 | MGS | 1 |
| 9 | 1/22/99 | Meenmutty West | 8.07 | MGS | 1 |
| 10 | 1/23/99 | Meenmutty North (Tran.) | 8.40 | MGS | 1 |
| 11 | 1/23/99 | Meenmutty North (Tran.) | 9.13 | MGS | 1 |
| 12 | 1/24/99 | Meenmutty (Kadukka (Tran.) | 8.25 | MGS | 1 |
| 13 | 1/25/99 | Meenmutty (Onakkthod Tran.) | 8.07 | MGS | 1 |
| 14 | 1/26/99 | Meenmutty (Manjakkalan Tran.) | 8.25 | MGS | 1 |
| 15 | 1/28/99 | Meenmutty to Panappuzha | 10.40 | MGS | 1 |
| 16 | 1/28/99 | Meenmutty to Panappuzha | 10.40 | MGS | 1 |
| 17 | 3/13/99 | Nedungayam Tran. | 8.13 | MGS | 1 |
| 18 | 3/14/99 | Meenmtty to Pullukuthy | 15.25 | MGS | 1 |
| 19 | 3/14/99 | Panappu'a to Meenmtty | 8.19 | MGS | 1 |
| 20 | 3/15/99 | Pullukuthy Top Tran. | 8.25 | MGS | 1 |
| 21 | 3/15/99 | Pullukuthy Top Tran. | 8.43 | MGS | 1 |
| 22 | 3/17/99 | To Gonian Tran. | 8.30 | MGS | 1 |
| 23 | 4/14/99 | To Puchappara | 11.01 | MGS | 1 |
| 24 | 4/15/99 | Puchappara North Tran. | 8.53 | MGS | 1 |
| 25 | 4/18/99 | Puchappara South Tran. | 9.05 | MGS | 1 |
| 26 | 5/14/99 | Mukkuruthy to Kadukka Tran. | 10.15 | MGS | 1 |
| 27 | 12/10/99 | Panap'a Meenmutty Seg Tran. | 9.25 | MGS | 1 |
| 28 | 12/11/99 | Meenmutty to Gonian | 10.06 | MGS | 1 |
| 29 | 12/11/99 | Meenmutty to Gonian | 13.53 | MGS | 1 |
| 30 | 12/12/99 | Gonian N (Tran. | 8.40 | MGS | 1 |
| 31 | 12/13/99 | Gonian South | 9.40 | MGS | 1 |
| 32 | 12/15/99 | Gonian Top Heg (Tran.) | 8.43 | MGS | 1 |
| 33 | 12/16/99 | Gonian Top South Heg Tran. | 8.45 | MGS | 1 |
| 34 | 12/17/99 | Gonian Top North | 9.43 | MGS | 1 |
| 35 | 12/18/99 | Gonian To Pullukuthy | 10.53 | MGS | 1 |
| 36 | 12/20/99 | Pullukuthy To Meenmutty | 13.40 | MGS | 1 |

**5.1.13. Direct sightings of Flying squirrel**

| Sl.No. | Date | Place name | Time of sighting | Species | Total no. sighted |
|---|---|---|---|---|---|
| 1 | 11/14/98 | Panappuzha | 18.45 | Flying squirrel (FS) | 1 |
| 2 | 1/22/99 | Meenmutty | 18.43 | FS | 2 |
| 3 | 1/27/99 | Meenmutty | 18.45 | FS | 1 |
| 4 | 4/14/99 | Puchappara | 18.47 | FS | 1 |
| 5 | 4/16/99 | Talipuzha | 18.50 | FS | 1 |
| 6 | 12/12/99 | Gonian | 18.50 | FS | 1 |
| 7 | 12/18/99 | Pullukuthy | 18.45 | FS | 1 |

**5.1.14. Direct sightings of Palm squirrel**

| Sl.No. | Date | Place name | Time of sighting | Species | Total no. sighted |
|---|---|---|---|---|---|
| 1 | 2/4/00 | Nedun'm to Panapuzha | 9.05 | Palm squirrel (PS) | 1 |
| 2 | 10/17/98 | Nedunkayam | 9.38 | PS | 1 |
| 3 | 10/19/98 | Nedunkayam | 8.23 | PS | 1 |
| 4 | 10/20/98 | Nedunkayam (Manjeri Rd..) | 8.43 | PS | 1 |
| 5 | 11/11/98 | Manjeri Rd. | 8.50 | PS | 1 |
| 6 | 12/4/98 | Panappuzha (Irumban (Tran.) | 8.11 | PS | 1 |
| 7 | 12/30/98 | Panappuzha | 8.40 | PS | 1 |
| 8 | 1/25/99 | Meenmutty (Onakkthod (Tran.) | 9.25 | PS | 1 |
| 9 | 1/28/99 | Meenmutty to Panappuzha | 10.20 | PS | 1 |
| 10 | 2/15/99 | Mukkuruthy to Meenmutty | 8.50 | PS | 1 |
| 11 | 3/11/99 | Padukka Plantation (Tran.) | 9.10 | PS | 1 |
| 12 | 4/12/99 | Nedungayam Plantation (Tran.) | 8.23 | PS | 1 |
| 13 | 4/19/99 | Puchappara West (Tran.) | 8.25 | PS | 1 |
| 14 | 4/20/99 | Pana'a to Manjeri Mdf (Tran.) | 8.25 | PS | 1 |
| 15 | 4/22/99 | Manjeri West Mdf (Tran.) | 9.20 | PS | 1 |

**5.1.15. Direct sightings of Porcupine**

| Sl.No. | Date | Place name | Time of sighting | Species | Total no. sighted |
|---|---|---|---|---|---|
| 1 | 3/10/99 | Ndungayam to Mnjeri(jeep) | 20.25 | Porcupine POR | 1 |

**5.1.16. Direct sightings of Small Indian civet**

| Sl.No. | Date | Place name | Time of sighting | Species | Total no. sighted |
|---|---|---|---|---|---|
| 1 | 11/9/98 | Manjeri Rd. | 21.30 | Small Indian Civet (SIC) | 2 |
| 2 | 4/11/99 | Nedungayam | 19.40 | SIC | 1 |
| 3 | 12/13/99 | Gonian South Meg (Tran.) | 7.13 | SIC | 1 |

**5.1.17. Direct sightings of Toddy cat**

| Sl.No. | Date | Place name | Time of sighting | Species | Total no. sighted |
|---|---|---|---|---|---|
| 1 | 11/10/98 | Meenmutty Rd. | 19.53 | Toddy cat (TC) | 1 |
| 2 | 3/10/99 | Nedungayam to manjeri(jeep) | 20.13 | TC | 1 |
| 3 | 3/13/99 | manjeri road | 19.40 | TC | 1 |

**5.1.18. Direct sightings of Common mangoose**

| Sl.No. | Date | Place name | Time of sighting | Species | Total no. sighted |
|---|---|---|---|---|---|
| 1 | 4/20/99 | Panapuzha to Manjeri (Tran.) | 9.13 | Common mongoose (CM) | 1 |
| 2 | 12/9/99 | To Manjeri by jeep | 9.23 | CM | 1 |

**5.1.19. Direct sightings of Otter**

| Sl.No. | Date | Place name | Time of sighting | Species | Total no. sighted |
|---|---|---|---|---|---|
| 1 | 4/19/99 | Puchappara to Manjeri | 15.05 | Otter | 3 |

**5.1.20. Direct sightings of Sloth bear**

| Sl.No. | Date | Place name | Time of sighting | Species | Total no. sighted |
|---|---|---|---|---|---|
| 1 | 1/26/99 | Meenmutty- Manjakkalan (Tran.) | 9.23 | Sloth Bear | 1 |

**5.1.21. Direct sightings of Black naped hare**

| Sl.No. | Date | Place name | Time of sighting | Species | Total no. sighted |
|---|---|---|---|---|---|
| 1 | 11/11/98 | Karulai Rd. | 19.05 | Black naped hare (BNH) | 1 |
| 2 | 3/10/99 | Nedungayam to manjeri( by jeep) | 20.19 | BNH | 1 |
| 3 | 5/8/99 | To Manjeri by jeep | 7.03 | BNH | 1 |
| | | | | | |

**5.1.22. Direct sightings of Leopard**

| Sl.No. | Date | Place name | Time of sighting | Species | Total no. sighted |
|---|---|---|---|---|---|
| 1 | 5/8/99 | To Manjeri by jeep | 7.08 | Leopard LPD | 2 |

## Chapter 6

# Integration using GIS techniques

### 6.1. Introduction

In this section, an attempt is made to integrate all available information on biodiversity of New Amarambalam Reserve forests, which were generated during this study and those data generated earlier, with the help of Geographic Information System (GIS) to provide a holistic picture of the biodiversity status of the area.

The issue of spatial integration was addressed in this study under the following categories.

i. Preparation of baseline map layers on spatial attributes such as location, roads, drainage, altitudinal variation and forest types;
ii. Spatial integration of sampling patterns followed for studying different components of biodiversity such as vegetation, insects, birds and mammals in the form of map layers;
iii. Thematic layers prepared by bringing together the various data with respect to different parameters such as total number of species and endemic species for various components of biodiversity;
iv. Thematic layers showing the cumulative total of species belonging to arborescent plants, insects, birds, mammals, reptiles and amphibians, as well as those for endemic species recorded under each forest type;
v. Examples of representations of diversity indices and depiction of habitats of different species of ecological significance as thematic map layers.

They are in the form of different baseline and thematic layers and outputs prepared as maps of suitable scales.

### 6.2. Materials and methods

The details pertaining to materials used and methods applied in each of the above mentioned categories are as follows.

#### 6.2.1. Preparation of baseline maps

Since maps pertaining to location, drainage, road, places, relief and forest types of reasonable spatial accuracy and required scale were not available, for integration of

biodiversity parameters, various maps were generated. Considerable amount of data required for generating this information were available as published and unpublished information in the form of maps and data on various aspects, and also remote sensing data. Since the information available were made with varying objectives using different methods and different scales and accuracy, the task involved was to assemble, organize, computerize, integrate and generate thematic layers and prepare maps of reasonable accuracy in the desired scale. For preparation of baseline layers, the following data were identified and utilized.

i. Survey of India toposheets of 1:2,50,000, 1:50,000 and 1:25,000 scales.
ii. Forest Survey of India vegetation maps of the area in 1:50,000 and 1:2,50,000 scales.
iii. Various publications and research reports on biodiversity and maps available on Nilgiri Biosphere Reserve.
iv. The spatial and non-spatial data generated under different components, viz. plants, mammals, birds and insects, during the present study.
v. Field data on natural forests and forest plantations pertaining to New Amarambalam generated under other research projects of KFRI.
vi. Records of Kerala Forest Department such as Forest Working Plans, Forest Administration Reports and Forest Statistics.
vii. Forest map of the study area prepared by KFRI (1:2,50,000 scale) under the World Bank - Kerala Forest Department sponsored study on Mapping of degraded forests of Kerala (Nair, *et al.* 1997).
viii. Remote sensing satellite data of IRS-1C of 1998.
ix. Data gathered under the KFRI Research project 'Survey of Reptiles and Amphibians in Kerala part of the Nilgiri Biosphere Reserve' sponsored by the Ministry of Environment and Forests, Government of India, and brought out as KFRI research report No 148 (Easa, 1998).

These data were integrated in GIS environment with the help of software such as Map Info, IDRISI and ILWIS, using standard GIS procedures for computer scanning, onscreen digitization, geo-referencing, raster to vector conversion and *vice versa* and interpretation of remote sensing data (Map Info, 1997; ITC, 1998; Eastman, 1995; Jensen, 1996; Hohl, 1998; Lillesand and Kiefer, 2000). For interpreting and classifying the remote sensing data, training sites and test sites were carefully chosen independently from the spatial data available. Standard digital image processing methods such as supervised classification, unsupervised classification,

hybrid approach and knowledge base classification were employed. The layers obtained by interpretation of remote sensing in this fashion were compared with other maps in GIS environment by using methods such as contextual analysis and convergence of evidence to avoid probable errors involved in satellite data and its interpretation. Spatial information on altitude, rainfall, temperature and details on plantations and natural forests of the study area already available were utilised as the knowledge base for processing these data layers under GIS environment. Using this approach required baseline layers were prepared. Suitable scales were chosen to get the map output in $A_4$ size sheets.

### 6.2.2. Spatial depiction of sampling pattern

With the help of standard GIS techniques, composite thematic layers depicting the sampling pattern adopted for arborescent plants, insects, birds and mammals were prepared by merging sampling patterns with boundary and other associated layers and outputs generated as maps.

### 6.2.3. Spatial integration of information related to individual components of biodiversity

Available information pertaining to attributes namely, number of species and endemic species of different components of biodiversity, viz. arborescent plants, insects, birds, mammals and insects and amphibians under major forest types were integrated spatially using GIS by merging these attributes with forest type layer. Thematic layers on each parameter was prepared for different components. For this, apart from forest type layer and data generated in this project, data generated as part of a project on reptiles and amphibians (Easa, 1998) were also utilized.

### 6.2.4. Spatial integration of available information on total biodiversity

To provide an over view of the total biodiversity of the area based on available information, combined attributes, such as, total number of species and total number of endemic species of different components, namely, arborescent plants, insects, birds, mammals, reptiles and amphibians, were prepared for each forest type in the study area. Thematic layers were prepared by spatially integrating data on these attributes with forest type layers.

### 6.2.5. Spatial depiction of various other biodiversity parameters

Attempt was also made to integrate other parameters such as density, basal area, Shannon index and Simpson index corresponding to plant diversity, and sighting locations of Lion-tailed macaque and Nilgiri Langur forest type-wise and to prepare

thematic layers. These attributes were integrated with forest types using GIS software Map INFO and maps were prepared.

## 6.3. Results and discussion

### 6.3.1. Baseline maps

The maps showing detailed description of the study area and geographical extent of Nilgiri Biosphere Reserve (NBR) in three southern States, viz. Kerala, Karnataka and Tamil Nadu and the location and extent of New Amarambalam Reserve Forests as a part of NBR are provided in Chapter 1 (Figs. 1.1 to 1.4).

### 6.3.2. Spatial depiction of sampling pattern

Maps highlighting the sampling pattern used for diversity studies of vegetation, insects, birds and mammals are provided in Figures 2.1, 3.1, 4.1 and 5.1. The maps show a spatial pattern of sampling followed in plant diversity, insect, mammals and avifauna studies. The combined sampling structure is given in Figure 6.1.

### 6.3.3. Spatial integration of information on individual components

The number of arborescent plant, insect, bird, mammal, reptiles and amphibian species recorded from different forest types of New Amarambalam Reserve Forests are represented in Figure 6.2. Proportions of mammal species recorded from different forest types in the study area is given in Figure 6.3.

### 6.3.4. Spatial integration of available data on total biodiversity

Percentage representation of total number of species including arborescent plants, insects, birds, mammals, reptiles and amphibians recorded in different forest types

**Table 6.2. Number of species recorded in different components from all the forest types of New Amarambalam**

| Sl. No. | Forest type | Plants (gbh>10 cm) | Insects | Birds | Mammals | Reptiles & Amphibians |
|---|---|---|---|---|---|---|
| 1 | Forest plantations | 28 | - | - | 10 | 51 |
| 2 | Moist deciduous forests | 82 | 179 | 78 | 14 | 75 |
| 3 | Semi-evergreen forests | 139 | 271 | - | 9 | 83 |
| 4 | Evergreen forests | 155 | 263 | 72 | 6 | 51 |
| 5 | Sub-tropical hill forests | 105 | 165 | - | 5 | 1 |
| 6 | Sub-tropical Savannahs | 27 | - | - | 1 | 6 |
| 7 | Montane temperate forests | 39 | 47 | 14 | 2 | 1 |

is given in Figure 6.2. The same information is also provided in Table 6.2. Total number of endemic species recorded from different forest types is also summarized in Table 6.3.

**Table 6.3. Number of species endemic to Western Ghats recorded from different forest types of New Amarambalam**

| Sl. No. | Forest type | Plants (gbh > 10 cm) | Insects | Birds | Mammals | Reptiles & Amphibians |
|---|---|---|---|---|---|---|
| 1 | Forest plantations | 2 | - | - | 0 | 7 |
| 2 | Moist deciduous forests | 8 | 2 | 3 | 1 | 16 |
| 3 | Semi-evergreen forests | 42 | 3 | - | 1 | 21 |
| 4 | Evergreen forests | 59 | 8 | 7 | 2 | 21 |
| 5 | Sub-tropical hill forests | 30 | 4 | - | 1 | 0 |
| 6 | Sub-tropical savannahs | 6 | - | - | 1 | 1 |
| 7 | Montane temperate forests | 21 | 2 | - | 0 | 0 |

### 6.3.5. Spatial depiction of various other biodiversity parameters

Representations of various other parameters on plant diversity is shown in Figures 2.18, 2.19 and 2.20. Information on plant basal area is available in Figure 2.18 and Shannon and Simpson plant diversity indices in Figures 2.19 and 2.20. This will provide location specific and forest type-wise status of plant diversity of New Amarambalam. Spatial representation of the habitats of two important endemic species Lion- tailed macaque and Nilgiri langur are given in Figure 5.5. Table 6.4 provides the number of unidentified species highlighting the need for further studies on different aspects to understand the richness of the area in terms of biodiversity values. Figure 6.1 provides the integrated sampled locations and transects for vegetation, insects and mammal studies, giving the status of the data generated.

Maps were generated from the available digital data for New Amarambalam. Use of base map layers of larger scale will help spatial depiction of sampling pattern more location specific and precise and thus enhance their utility considerably. It is also possible to create composite maps by integrating the sampling patterns with other baseline layers such as vegetation types, elevation, drainage, slope, aspect, etc. Such composite maps, particularly when made in three-dimensional domain using digital elevation models, can help in analyzing the sampling patterns followed for different biodiversity components and their relationship with these land features. They can also help in improving the sampling pattern. Opportunities available for

effective stratification of the area into more or less homogenous terrain classes for sampling is one advantage. Facilities for adopting multi-resource inventory techniques for biodiversity monitoring through integrated surveys, taking into consideration the monitoring requirements of individual components in a total perspective, is another advantage (Avers, 1993; John, 1993] and reduce the cost of surveys substantially. They will also improve the quality of information.

**Table 6.4. Number of unidentified species recorded from different forest types of New Amarambalam**

| Sl. No. | Forest Type | Plants (gbh>10 cm) | Insects | Birds | Mammals | Reptiles & Amphibians |
|---|---|---|---|---|---|---|
| 1 | Forest plantations | 0 | - | 0 | 0 | 1 |
| 2 | Moist deciduous forests | 0 | 129 | 0 | 0 | 2 |
| 3 | Semi-evergreen forests | 0 | 156 | 0 | 0 | 2 |
| 4 | Evergreen forests | 0 | 142 | 0 | 0 | 1 |
| 5 | Sub-tropical hill forests | 7 | 144 | 0 | 0 | 0 |
| 6 | Sub-tropical savannahs | 0 | - | 0 | 0 | 1 |
| 7 | Montane temperate forests | 0 | 89 | 0 | 0 | 0 |

Spatial integration of biodiversity parameters carried out highlighted its potential in getting an idea about the biodiversity characteristics of different locations of New Amarambalam. Map compositions of different types that can be generated using the different GIS layers are helpful in providing a better insight into the relationship between various biodiversity components and the physical environment in which they exist. These layers, while providing an overview of the current scenario, will also be useful for planning and implementation of biodiversity monitoring programs for the area in a more organized manner.

Use of Internet GIS technology can also help in improving the exchange of data and information in a significant manner. There is also need for generating information on other aspects of biodiversity so as to provide an integrated information system required for biodiversity conservation and management. Further studies are required in this direction.

Since this study has been carried out with limited resources, many aspects of spatial integration, such as generation of digital elevation models, preparation of slope and aspect layers, their integration with other biodiversity parameters, digital

image processing of satellite data under integrated GIS environment comprising all these layers and determination of biodiversity hotspots which could have been possible, have not been tried. Analysis of relationship between different biodiversity features and the physical environment such as altitude, slope, aspect, drainage, soil types and vegetation also need further attention.

## Chapter 7

# Synthesis and conclusions

In the Chapters 2, 3, 4 and 5, details of data generated on different biodiversity components, namely vegetation, insects, birds and mammals were dealt with. In Chapter 6, the data were also spatially integrated with topographic data, along with avialable baseline data on reptiles and amphibians. In this chapter, all the information generated is analyzed from the biodiversity management perspective so as to facilitate better management of the New Amarambalam Reserved Forests, forming part of the core area of the Nilgiri Biosphere Reserve.

### 7.1. The physical environment

The characteristics and richness of biodiversity of any area is much influenced by the diversity of the locality factors present. In this context, New Amarambalam Reserve forests was found to be quite unique. Within an area of 265.57 $km^2$, the diversity seen in terms of topography, climate, geology and soil, and the biotic factors is remarkable, which provide different habitat conditions for a variety of plant and animal species including micro-organisms. The altitudinal variation from 40 m to 2555 m msl represents the lowest and highest ranges in the whole of India below the Himalayas and the Western Ghats in particular, contributing to the presence of variety of forest types ranging from moist deciduous, semievergreen, evergreen, subtropical and montane wet temperate forests, as the elevation increases. The slope varies from almost zero in the plains, moderate to steep in the lower hills and very steep to precipitous at higher elevations. Again, the presence a number of hills and valleys in the area results in the occurrence of different aspects, leading to varied degree of incidence of solar radiation and thus having profound influence on the diversity of the flora and fauna. The drainage network of the area controls the geology and soil diversity of the hills and plains influence the occurrence and distribution of diverse forest types and subtypes. The variation in rainfall (< 2600 mm to > 4000 mm average annual rainfall) and temperature (mean minimum and maximum temperature < 17 ºC to > 37 ºC) seen in the area also influences the vegetation, floristic and faunistic diversity. The biotic pressure from the people living in adjoining areas, influenzed by the topography, road and drainage network, occurrence of fire and also wind, influence the vegetation types and degree and extent of degradation to the vegetation flora and fauna. Activities

such as unauthorized cutting of trees, poaching of wild animals, unregulated collection of reeds, bamboo and canes, and other non-wood forest products, fire and cattle grazing are prevalent in the area, more concentrated along the fringes of human habitations and other easily accessible areas, adversely affect the biodiversity present in these regions. Forests in the inaccessible areas are fairly undisturbed and hence continues to be rich in flora and fauna. Again, the influence of wind and fire is very high in the ecotone areas of subtropical hill forests and savannahs, montane wet temperate forests and adjoining grasslands, and these two have their control over the structure and composition of plants and animals present there.

**7.2. Biodiversity zones of New Amarambalam**

Broadly, from the biodiversity point of view, there are three distinct zones identifiable in New Amarambalam reserve forests. Zone 1, the crescent shaped Upper Ghat Zone with an elevation ranging from 2600 m to 1250 m msl downwards, covering an approximate extent of 7500 ha. This zone comprises of subtropical hill forests, subtropical savannahs, montane wet temperate forests, high elevation montane wet temperate grasslands and extensive rocky patches. Zone 2, from the intermediate lower Ghat between 1250 m msl and 500 m msl elevation, occupying an extent of about 10,000 ha is covered by evergreen and semievergreen forests. Zone 3 is the plantation zone in the plains, occurring below 500 m msl with an extent of approximately 9000 ha of plantations and moist deciduous forests. After purchasing the reserve from private landlords in 1889 and bringing it under the Government control, most of the suitable areas in the third zone, i.e., moist deicduous forests were converted into plantations, mainly with teak. Today there are about 5000 ha under forest plantations. The forests of the intermediate zone, namely evergreen and the semievergreen, were managed under selection system and timber was extracted from all the accessible areas of this zone. Substantial quantity of bamboo and reeds as well as other non-wood forest products such as rattans were also extracted from the first and second zones. The forests in the Upper Ghat zone, lying in steep and inaccessible areas, were mostly preserved for the protection of the watershed and no extraction was done, except for collection of non-wood forest products, such as bamboo and rattans (Vasudevan, 1971; Renganathan, 1981). Considering the impact of past forest management and the significance of biodiversity conservation in these areas, available information on biodiversity in these three major zones is summarised here, in the

context of past forest management operations, bio-resource potential and future conservation needs (Figs. 7.1, 7.2, 7.3).

### 7.2.1. Upper ghat zone (Zone 1)

The Upper Ghat zone starts from 2600 m msl at the Kundha hills and is one of highest altitudinal zones of India below the Himalayas. This zone is distributed in localities like, Pachanam mala, Aduppukallu, Gulkal, Nadukani, Elamannu mala, Arabetta, Irumban mala, Govanan mala, Billibettu, Kolari betta, Manakkere, Pullukuthi, Pichal betta, Mukurthi peak, Nilgiri peak, Manarkombai, Mukurti Peak and Wapshare peak.

The eastern summit of the Kundah hills forms a sharp crescent facing the west. This crescent descends steeply with its arm of innumerable spurs and ledges converging to Karimpuzha and Punnapuzha valley providing a marvelous view from the ridges of Mancheri hills. Though situated within the tropical zone, due to the high altitude, both subtropical and temperate climate are prevalent here and hence, is one of the unique ecosystems of the world supporting forest types such as montane wet temperate forests, montane wet temperate grassland (shola grass land/high elevation grassland), subtropical hill forests and subtropical savannah.

Being the background vegetation of Karimpuzha, Punnapuzha, the tributaries of Chaliar river, which is one of the major rivers of Kerala, this zone plays a crucial role in ensuring the perennial water supply to the entire catchment area of Malappuram and Kozhikkode districts, down to the Lakshadweep sea. Being inaccessible due to the extreme difficult terrain, the forests here are fairly undisturbed from the biotic pressure. However, the effect of fire, particularly caused by people entering the area for collection of canes and other non-wood forest produces, sometimes from Tamil Nadu side also, has got a bearing on management of the forests here. Except for the collection of non-wood forest produces, this area was preserved exclusively for protection of watershed and was considered as Protection Working Circle in all the Working Plans. This zone is also a part of the core area of NBR.

Figures 7.1, 7.2, 7.3 provide an overview of the status of species diversity present in the different forest types of this zone. So far, 560 species of arborescent plants, insects, birds, mammals, reptiles and amphibians were recorded from this zone. Out of these, 56 species are endemic to the Western Ghats, 78 species are rarely seen in Kerala and 206 species are unidentified, indicating the biotic richness of the area. Species component-wise, the total number includes 116 species of

arborescent plants, 411 species of insects, 14 species of birds, 11 species of mammals and eight species of amphibians and reptiles. The main characteristics of different components of biodiversity in the zone namely vegetation, insects, birds, mammals, reptiles and amphibians are discussed briefly here.

*7.2.1.1. Vegetation*

The structure of the vegetation in different forest types of this zone in terms of number of species of different height classes is given in Table 7.1. Out of the total 116 species, 96 per cent are those having height less than 20 m and 57 per cent of species have height below 10 m indicating that the forest in this zone of stunted in nature. This is mainly due to the wind prevailing in this high altitude zone. In the case of montane temperate forests all the trees are with less than 15 m height and 79 per cent with potential height of less than 10 m.

**Table 7.1. Structure of vegetation in terms of height of species recorded from different forest types of Zone 1**

| **Vegetation types** | **Number of species in different height class** (percentage in brackets) | | | | |
|---|---|---|---|---|---|
| | **< 10 m** | **10-20 m** | **20-30 m** | **> 30 m** | **Total** |
| Subtropical hill forests | 59 (56) | 41 (39) | 5 (5) | - | 105 (100) |
| Savannahs | 16 (59) | 11 (41) | - | - | 27 (100) |
| Montane temperate forests | 31 (79) | 8 (21) | - | - | 39 (100) |
| Overall (zone 1) | 66 (57) | 45 (39) | 5 (4) | - | 116 (100) |

Table 7.2 summarizes the values on different diversity parameters, to provide more insight into the structural characteristics of vegetation.

**Table 7.2. Diversity indices values of differnet forest types of Zone 1**

| **Diversity parameters** | **STF** | **SS** | **MTF** |
|---|---|---|---|
| No. of species represented | 105 | 27 | 39 |
| No. of individuals/ha | 810 | 293 | 1286 |
| Basal area ($m^2$ $ha^{-1}$) | 42.74 | 2.51 | 35.25 |
| Diversity index (Margalef, 1968) | 3.58 | 2.59 | 3.15 |
| Dominance index (Simpson, 1949) | 0.057 | 0.13 | 0.058 |
| Richness index (Menhinick, 1964) | 10.44 | 2.43 | 4.35 |
| Evenness index (Pielou, 1975) | 0.74 | 0.77 | 0.80 |

The dominant genera of vegetation found in this zone are *Litsea, Syzygium, Psychotria* and *Simplocos*, and the dominant families include Lauraceae, Myrtaceae, Rubiaceae, Euphorbiaceae and Fabaceae.

### 7.2.1.2. Insects

Out of the 860 species of insects, 324 species were recorded from subtropical hill forests and 146 species from montane wet temperate forests of New Amarambalam.

With regard to species richness index, the subtropical hill forest showed the highest value 5.54 from among all the forests types in New Amarambalam. Montane wet temperate forests showed an index of 4.11. Species diversity based on Shannon Diversity index for subtropical hill forest was 4.30 and for shola forest it was 3.48. The evenness of species abundance 0.9 was highest for the shola forest followed by subtropical hill forest [0.84], indicating that the individuals of various species are more uniformly distributed in these habitats, compared to the rest. The dominant insect orders present in the zone with their dominance index values are listed in Table 7.3.

The montane shola forests had less number of insects. The high altitude and prevailing temperate conditions of shola forests have contributed to the development of highly specialized flora and fauna in the zone. Although, subtropical hill forests and shola forests have more or less similar environmental conditions, insect diversity of the former differed significantly from that of the latter.

**Table 7.3. Dominance indices for insect groups in different forest zones**

| Insect order | Upper Ghat Zone (Zone 1) | | |
|---|---|---|---|
| | STF | MTF | Total |
| Lepidoptera | 58.46 | 64.12 | 29.82 |
| Coleoptera | 9.03 | 9.16 | 20.47 |
| Diptera | 7.90 | 15.27 | 13.85 |
| Hymenoptera | 7.79 | 1.53 | 8.54 |
| Homoptera | 1.13 | - | 7.11 |
| Heteroptera | 0.68 | 0.76 | 1.08 |
| Trichoptera | 12.42 | 8.40 | 15.34 |
| Ephemeroptera | - | - | 0.65 |
| Dictyoptera | 0.79 | | 0.65 |
| Neuroptera | 0.34 | 0.76 | 0.20 |
| Orthoptera | 0.79 | - | 0.98 |
| Dermaptera | - | - | 0.06 |
| Plecoptera | 0.68 | - | 0.31 |
| Isoptera | - | - | 0.93 |

Out of the 133 species of butterflies observed in New Amarambalam, this zone had 52 species, of which 10 species were of high conservation status, either endemic or protected species. These are *Papilio buddha* Westwood, *P. liomedon* Moore (Fam: Papilionidae) *H. misippus* Lin, *Pantoporia ranga* (Moore) (Fam: Nymphalidae) *P. nilgiriensis* Moore (Fam: Danaidae) *Appias libythea* Fb, *A. albina*

Boisduval, *A. indra* Moore, *Colias nilgiriensis* Feld. & Feld (Fam: Pieridae) and *Lampides boeticus* Lin. (Fam: Lycaenidae).

*7.2.1.3. Birds*

Out of the 100 bird species recorded from New Amarambalam, 13 species belonging to five families are found in this zone. Of these, Nilgiri flycatcher (*Eumyias albicaudata*) is endemic to the Western Ghats and Black and Orange flycatcher (*Muscicapa nigrorufa* Jerdon) is a species rarely seen in Kerala. Five species, namely Ashy wren warbler (*Prinia socialis* Sykes*),* House swallow (*Hirundo tahitica domicola),* Nilgiri flycatcher (*Eumyias albicaudata*), Nilgiri laughing thrush (*Zoothera dauma* Blyth), Tickell's leafwarbler (*Phylloscopus affinis Tickell)* are not observed in other forest types of of New Amarambalam. The other common species observed from this zone include Black bird, Black eagle, Jungle myna, House swallow, Small leafwarbler, Whitethroated ground thrush, Yellowthroated sparrow, Grey Junglefowl and Swallow. Out of the 10 migratory birds observed from New Amarambalam, two species were recorded from this zone, namely, Small leafwarbler and Tickell's leafwarbler. Compared to the overall of density of 510 birds/km$^2$ for New Amarambalam, density for the upper Ghat zone was low, with only 402 species/km$^2$. The diversity index and species richness index were also low when compared to that of the whole of New Amarambalam. The values were Shannon - Weiner diversity index 2.24 and 3.73, Simpson's Index 0.01 and 0.04, Hill's Number

**Table 7.4. Dominance Index of selected species of birds in Zone1**

| Sl. No. | Species | Dominance Index |
|---|---|---|
| 1. | Nilgiri Flycatcher | 12.42 |
| 2. | Nilgiri Laughing Thrush | 8.28 |
| 3. | Whitethroated Ground Thrush | 5.91 |
| 4. | Nilgiri House Swallow | 5.32 |
| 5. | Yellowthroated Sparrow | 4.73 |
| 6. | Tickell's Leaf Warbler | 4.14 |
| 7. | Black Eagle | 2.36 |
| 8 | Black Bird | 1.77 |
| 9. | House Swallow | 1.18 |
| 10. | Jungle Myna | 1.18 |

9.37 and 22.65 respectively. Species richness indices, namely Margalef Index and Menhinick Index with values 2.92 and 1.5 were also low when compared to that of other zones indicating that the bird diversity is comparatively low in this zone might be due to the habitat conditions prevailing in this zone, different from the other two lower zones.

The birds based on the order of dominance in Zone 1 are given in table 7.4. Nilgiri Flycatcher was the most dominant species found in the zone.

*7.2.1.4. Mammals*

Out of the 27 mamamals observed in New Amarambalam, 10 were reported from zone 1. These include three endemic species, namely Lion-tailed macaque, Nilgiri langur and Nilgiri Tahr. Other species recorded were Malabar giant squirrel, Large brown flying squirrel, tiger, panther, sloth bear, sambar and porcupine. Some of these species are of conservation importance and have habitat preferences also.

*7.2.1.5. Reptiles and amphibians*

Out of the 62 reptiles and 30 Amphibians, only four species of reptiles and three amphibians reported the zone. One reptile, namely, *Amphiesma beddomii* (Family: Colubridae) is endemic to the Western Ghats. *Salea horsfieldii* Gray (Family: Agamidae) and *A.perroteti* (Dum&Biber)(Family: Colubridae), noted from the area are those rarely seen in Kerala.

The data generated on different aspects of the high altitude zone reveals the need for providing high conservation status to this ecosystem. However, a close assessment of available information on various biodiversity components pertaining the area also points to the information gaps. The presence of large number of unidentified species of insects points to lack of adequate understanding of the group in New Amarambalam. Available information with regard to the distribution, habitat preferences, ecosystem interactions, etc of species is also very scanty. Further, the complexity of the ecosystem and inacessibility of the area posed major challenges in generating data, even though the two aspects are related to the richness and sustenance of the plant and animal diversity of the zone. Therefore, more intensive studies of multidisciplinary nature to generate conservation oriented data for this ecosystem are necessary for the effective management of the zone.

**7.2.2. Intermediate zone (Zone 2)**

The area beween altitudinal range 1250 m and 500 m msl, with an approximate extent of about 10,000 ha, constitute the Intermediate zone [zone 2]. It comprises areas such as Talikolli, Chekuthan kundu, Ezhuthakallu, Kuppan mala, Kurumban mala, Aduppukallu, Pachanam mala, Elamannu mala, Irumban mala, Govanan mala, Panapuzha, Edakkutty mala, Bellakettu mala, Valakka mala, Meenmutti, Pullukuthi, Kudirikkal, Kedakkamala, Vallakkattam, Chembukallu, Manakkere,

Kozhimudi, Punjakolli mala, Pallara mala, Chinikkadavu, Padamala, Padukka and Tali mala.

Campared to the Upper Ghat Zone, the terrain here is of less steep and accessible and support luxuriant growth of evergreen and semievergreen forests. This zone was worked under selection system under two felling series, Thalippuzha and Karimpuzha, and selected trees of prescribed girth classes were harvested from all acessible areas since 1920. Species of bamboos, reeds, rattans, and non-wood forest produce species were extracted under Bamboo Working Circle, Rattan Working Circle and MFP Working Circle in the past (Brown, 1928; Vasudevan, 1971; Ranganathan, 1981). Selection felling was stopped as part of a policy decision taken at the State level in 1986.

The forests in this zone are typical examples of West coast tropical wet evergreen forests (1A/04) and West coast tropical wet semievergreen forests (2A/C2) of Champion and Seth [1968). However, due to failures in adhering to the prescriptions of working plans and other silvicultural guidelines in the extraction of timber trees, bamboos, rattans and other non-wood forest produce plants, considerable damage was done to the forests of the zone, depleting its biodiversity. Activities such as illicit extraction of various forest produces, cattle grazing and poaching also had then adverse impacts on vegetation and fauna of the area. Incidence of fire and soil erosion also affected badly on the biodiversity in the forests and almost 50 to 60 per cent of the forests here are in a degraded condition.

Approximate total number of species including arborescent plants, insects, birds, mammals, reptiles and amphibians reported from this zone is 938 and among them 218 species were plants, 554 insects, 72 birds, 11 mammals and 83 reptiles and amphibians. Also, there were 115 species endemic to Western Ghats, 188 species unidentified, 161 species which are rarely seen in Kerala, indicating the species richness and conservation value of this zone.

The main characteristics of different components, namely, vegetation, insects, birds, mammals, reptiles and amphibians of this zone are discussed briefly to provide an overview of the biodiversity of the intermediate altitudinal zone of New Amarambalam.

*7.2.2.1. Vegetation*

The structure of the vegetation in different forest types of this zone in terms of number of species in different height classes is given in Table 7.5. The forests here also show canopy stratification characteristic to different forest types. Out of the

total 218 tree species, 24 per cent of the species have potential height of above 30 m, 76 per cent below 30 m, 58 per cent below 20 m and 42 per cent below 10 m.

**Table 7.5. Structure of vegetation in terms of different height classes of species recorded from different forest types of Zone 2**

| Vegetation types | Number of species in different height classes (percentage in brackets) | | | | |
|---|---|---|---|---|---|
| | **< 10 m** | **10-20 m** | **20-30 m** | **> 30 m** | **Total** |
| Semi evergreen forests | 66 (47) | 24 (17) | 28 (20) | 25 (18) | 139 (100) |
| Evergreen forests | 70 (45) | 28 (18) | 30 (19) | 27 (17) | 155 (100) |
| Overall (zone 2) | 92 (42) | 36 (16) | 38 (17) | 52 (24) | 218 (100) |

While Table 7.6 provides the diversity parameters, Table 7.7 highlights the dominant genera and families represented in the zone, pointing to the overall structure of vegetation in this region.

**Table 7.6. Diversity parameters of vegetation in Zone 2**

| Parameters | Values | |
|---|---|---|
| | **Evergreen** | **Semievergreen** |
| No of species represented | 155 | 139 |
| No. of individuals/ ha | 979 | 669 |
| Basal area ($m^2$ $ha^{-1}$) | 54.29 | 48 |
| Diversity index (Margalef, 1968) | 3.45 | 3.87 |
| Dominance index (Simpson, 1949) | 0.067 | 0.054 |
| Richness index (Menhinick, 1964) | 14.76 | 13.66 |
| Evenness index (Pielou, 1975) | 0.67 | 0.76 |

Tables 7.8 and 7.9 highlights the floristic composition and phytosociological parameters of most dominant species of semi-evergreen and evergreen forests.

**Table 7.7. Dominant families and genera represented in different forest types in Zone 2**

| Forest types | Dominant genera * | Dominant families * | Total no. of species |
|---|---|---|---|
| Semievergreen forests | *Diospyros* (4)<br>*Elaeocarpus* (3)<br>*Syzygium* (3) | Euphorbiaceae (16)<br>Lauraceae (8)<br>Fabaceae (5) | 139 |
| Evergreen forests | *Syzygium* (7)<br>*Litsea* (5)<br>*Diospyros* (4) | Euphorbiaceae (17)<br>Lauraceae (17)<br>Myrtaceae (9) | 155 |

**Table 7.8. Floristic composition and phytosociological parameters of semievergreen forests in Zone 2**

| Species | Density (indi./ha) | Frequency (%) | Basal area ($cm^2$/ha) | IVI |
|---|---|---|---|---|
| *Reiwardtiodendron anamallayanum* | 132.04 | 60.47 | 15763.10 | 25.75 |
| *Xylia xylocarpa* | 41.09 | 34.88 | 76000.36 | 23.56 |
| *Pterygota alata* | 26.36 | 62.79 | 32689.02 | 13.61 |
| *Terminalia bellirica* | 11.37 | 46.51 | 46407.83 | 13.49 |
| *Terminalia paniculata* | 7.24 | 39.53 | 32559.51 | 9.66 |
| *Drypetes elata* | 17.31 | 46.51 | 20109.00 | 8.90 |
| *Palaquium ellipticum* | 23.26 | 58.14 | 11292.09 | 8.47 |
| *Apodytis dimidiata* | 20.41 | 39.53 | 12041.27 | 7.36 |
| *Ixora brachiata* | 18.09 | 65.12 | 3721.40 | 6.45 |
| *Polyalthia fragrans* | 9.82 | 44.19 | 13831.51 | 6.36 |
| *Cinnamomum malabatrum* | 14.21 | 58.14 | 7305.48 | 6.29 |
| **Total** | **669.51** | **---** | **480028.82** | **300.00** |

**Table 7.9. Floristic composition and phytosociological parameters of evergreen forests in Zone 2**

| Species | Density (indi./ha) | Frequency (%) | Basal area ($cm^2$/ha) | IVI |
|---|---|---|---|---|
| *Palaquium ellipticum* | 142.15 | 100.00 | 127168.60 | 42.51 |
| *Agrostistachys borneensis* | 150.60 | 41.30 | 23893.30 | 21.67 |
| *Myristica dactyloides* | 68.96 | 93.48 | 34970.99 | 17.76 |
| *Cullenia exarillata* | 29.11 | 48.91 | 63631.28 | 16.93 |
| *Reinwardtiodendron anamallayanum* | 86.23 | 52.17 | 12317.36 | 13.46 |
| *Xanthophyllum arnottianum* | 51.81 | 73.91 | 7776.92 | 10.10 |
| *Drypetes elata* | 30.80 | 66.30 | 16061.61 | 9.14 |
| *Garcinia morella* | 41.43 | 79.35 | 4763.06 | 8.74 |
| *Dimocarpus longan* | 19.93 | 57.61 | 18143.42 | 8.02 |
| *Syzygium laetum* | 26.57 | 60.87 | 3670.39 | 6.18 |
| *Calophyllum polyanthum* | 5.43 | 30.43 | 21071.74 | 5.82 |
| *Drypetes oblongifolia* | 22.22 | 31.52 | 7010.44 | 5.00 |
| *Gomphandra tetrandra* | 17.03 | 59.78 | 1278.71 | 4.72 |
| *Terminalia bellirica* | 1.57 | 14.13 | 21209.88 | 4.72 |
| *Mesua ferrea* | 6.64 | 29.35 | 12101.46 | 4.25 |
| **Total** | **979.35** | **---** | **542972.06** | **300.00** |

*7.2.2.2. Insects*

Maximum number of insect species were recorded from the semievergreen and evergreen forests of the zone. Out of the 8310 of insects collected from various habitats in the study area, 72 per cent was from this zone, with 3287 (40%) from semievergreen forests and 2673 (32%) from evergreen forests. The species richness

index, for semievergreen and evergreen forests was 5.09 and 4.73, respectively while the same for the whole of New Amarambalam was 5.87. Shannon's index of insect diversity was also high for evergreen forests (4.51) followed by semievergreen forests (4.35), while for New Amarambalam as a whole, was 4.92. With regard to evenness index, semievergreen forests have value 0.78 which is same as that of the overall index, whereas the index for evergreen forests was 0.81.

The dominant insect orders with respect to number of individuals in evergreen forests were Lepidoptera, Trichoptera and Coleoptera with dominance indices 42.05, 15.56 and 13.99 and in semievergreen forests. Lepidoptera, Coleoptera and Trichoptera were represented with dominance indices 23.39, 19.83 and 17.98.

Out of 133 species of butterflies recorded from New Amarambalam, evergreen forests contained maximum number of species of butterflies (96), followed by semievergreen forests (84). Out of the 28 endemic/protected butterflies reported from New Amarambalam, evergreen forests contained the maximum number of species (20) followed by the semievergreen forests (15).

The distribution of various species showed specialization in relation to the habitat. For instance, *Papilio paris tamilana, Pathysa antiphates (*Papilionidae), *Cyrestris thyodamas ganescha (*Nymphalidae), *Mycalesis anaxias (*Satyridae*), Potanthus pava pava* (Hesperiidae), *Acytolepis puspa, Petrelaea dana, Prosotas nora, P. dubiosa indica, Nacaduba kurava, N. beroe* and *Anthene lycaenina* (Lycaenidae) were present only in the semievergreen and evergreen habitats. *Papilio buddha* (Papilionidae) was found only in the evergreen and subtropical hill forests. Similarly, *Eurema lacteola* (Pieridae) and *Spialia galba* (Hesperiidae) were recorded from semievergreen forests. Also, major portion of insects collected from the zone could not be identified, many of which may turn out to be new/rare species.

Due to the difficult terrain and poor accessibility, very intensive exploration could not be undertaken and hence the sampling was having only a limited coverage, confined to only few typical habitats selected at various altitudes and vegetation classes. Therefore, more detailed survey is essential to get a complete picture of the insect wealth of this area.

*7.2.2.3. Birds*

Out of the 100 species of birds reported from New Amarambalam, 72 were reported from this zone. This includes seven species of high conservation status, as these are endemic to the Western Ghats of India.

i. Nilgiri Wood pigeon (*Columba elphinstonii*)
ii. Bluewinged parakeet (*Psittacula columboides*)
*iii.* Malabar Grey hornbill (*Tockus griseus)*
iv. Southern Tree pie (*Dendrocitta leucogastra*)
v. Small sunbird (*Nectarinia minima*)
vi. Greyheaded bulbul (*Pycnonotus priocephalus*)
vii. Wayanad Laughing thrush (*Garrulax delesserti*)

Out of these, Nilgiri Wood pigeon, Malabar Grey hornbill and Southern Tree pie were reported only from this zone. The Nilgiri Wood pigeon is a globally threatened species found only in India. Out of the 10 migratory species sighted from the study area, eight were reported from this zone, namely Rufoustailed Flycatcher, Paradise Flycatcher, Plain Leaf Warbler, Greenish Leaf Warbler, Forest Wagtail, Yellow Wagtail, Black capped blackbird, and Grey Wagtail and among these Grey Wagtail and Rufoustailed Flycatcher were restricted to this zone.

The average density of birds reported from the intermediate zone was low (400 birds/km$^{2}$) as compared to the overall density of birds at New Amarambalam (510 birds/km$^{2)}$. Out of the 72 species and 1322 total sightings reported from this zone, the first 26 species were sighted more than 10 times and 36 species (50%) were sighted less than five times. Among the endemic species, Bluewinged parakeets were sighted 130 times, Small sunbird 23 times and Grey headed bulbul 10 times. The rest of the species were sighted less than five times each. Nilgiri Wood Pigeon (*Columba elphinstonii*), an endangered bird species was sighted only four times, pointing to its raity in the area.

Out of the 26 most common bird species (maximum density) found in New Amaramblam, 21 species were reported from zone 2. The density of first 10 species ranged between 700 and 200 birds/km$^{2}$ and for the remaining 11 species it was between 200 and 50 birds/km$^{2}$. The most common birds reported from this category were Common babbler (691.7 birds/km$^{2}$), Black bulbul (473.16 birds/km$^{2}$), and Small leaf warbler (469.49 birds/km$^{2}$).

Species richness in an area is dependent on the availability of food, climate conditions, predation pressure, etc. Species richness indices and diversity indices of birds showed high values for New Amarambalam. The bird communities in the evergreen forests of New Amarambalam follow the truncated lognormal distribution, which is typical for the undisturbed tropical forests.

Lowest species richness was recorded in the month of March, which is not the usual pattern for the Western Ghats. The reason for this requires further investigation. Habitat heterogeneity, in addition to location of the area, is an important determinant of bird species richness. The habitat factors such as tree density, basal area, number of tree species, percent ground cover, percent canopy cover and canopy height, are also important in determining the density and diversity of avifauna. At New Amarambalam, bird diversity was possibly related to the history of the area and local migration of the species.

It is reported that the occurrence of a large number of rare species is typical of tropical forests (Lovejoy, 1975). The factors which control the species richness in an area are broadly divided into historical and ecological (Giller, 1984). Among the historical factors, speciation and the crossing of geological barriers and supply of colonists are important ones. Among the ecological factors, mortality due to predation is an important one. Many cases of mortality due to predation were recorded from the area.

Currently, four models are available for describing species-abundance distribution. These are the geometric series, the lognormal, the log series and Mac Arthur's Broken-stick Model. Preston (1948) introduced the lognormal distribution to explain the species-abundance data. Usually in ecological work, distribution of species is always truncated at the left side (Preston, 1962). Geometric series patterns are usually found in species-poor or harsh environments. Lognormal distribution is found in most of the biological populations.

Tropical wet evergreen forests are known to support more rare species than other habitats. Similar observations have also been reported in other studies (Pearson, 1977). As the evenness index shows high values, it can be concluded that individuals present in the area uniformly represent the species. Similarly, measures based on Simpson diversity also show the same trend. These measures are the ratio of numbers of very abundant species to abundant species. Diversity indices are extensively used to monitor and evaluate habitats as it provides a measure to assess the diversity of the habitats. Diversity indices are directly correlated with the stability of the ecosystem and will be high in biologically controlled systems.

For avifauna, the evergreen forest has Shannon-Weiner diversity index of 3.15, as compared to overall 3.73 for New Amarambalam. Simpson's diversity Index for this zone was 0.09 when compared to the overall value of 0.04. Hill's number N1 for the zone was 23.4 whereas the overall total was 22.65 and the number of species in

this zone was 72. The species richness index (Margalef Index) R1 and R2 were 9.88 and 1.98 respectively. Nilgiri House Swallow was the dominant bird species in the evergreen forests with a dominance index of 24.73. The index values for next three species are between 7 and 9 and the rest have values less than 4 further concluding that this zone has many species of rare nature.

*7.2.2.4. Mammals*

Being an intermediate altitudinal zone, out of the 27 mammals observed in New Amarambalam, all except Nilgiri Tahr was reported from this zone. The mammals sighted include two species, namely Lion-tailed macaque and Nilgiri langur, which are endemic to South India. Other species recorded are Malabar giant squirrel, Large brown flying squirrel, tiger, panther, elephant, sloth bear, sambar, barking deer, mouse deer, wild boar and porcupine. All these species are of high conservation status and hence protected species under Wildlife Protection Act (Annonymous, 1972). Most of these species have their own habitat preferences and hence are highly dependent on the habitat conditions prevailing in this zone.

*7.2.2.5. Amphibians and reptiles*

Out of the total 92 species of reptiles and amphibians recorded from New Amarambalam, 81 species were reported to be available from this zone. Out of them, 21 species are those endemic to the Western Ghats, seven rare and two unidentified, indicating that this zone is quite rich. Also, 32.72 per cent of the reptiles and 40.48 per cent of the amphibians in the whole of New Amarambalam were reported to be sighted from this zone and therefore this zone is fairly good in terms of species richness and diversity.

While amphibians preferred leaf litter and grass substrata as the most preferred habitat, the same for reptiles is mostly tree trunk. The environmental parameters negatively correlated with abundance of amphibians include, altitude, canopy, distance to water source, humus nature, number of shrubs, trees, temperature and slope. The parameters that had positive correlation include number of logs, humidity, number of grass clumps and number of herbs. In the case of reptiles, altitude, humidity, humus nature, number of shrubs and number of trees are negatively correlated. The factors which positively correlated include temperature, slope, number of logs, number of herbs and distance to water (Easa, 1998).

A close examination of available information reveals that evergreen and semievergreen forests are quite rich in biodiversity. These are multi-layered and play a key role in sustaining the flow of rivers and streams of the area. The zone is also a

rich source of medicinal plants and other wood and non-wood forest produces, which if scientifically managed can provide substantial economic, ecological and social benefits.

### 7.2.3. Plantation zone (Zone 3) comprising of moist deciduous forests and teak plantations

Out of the total area of approximately 9000 ha (30% of the area of the total reserve), about 5000 ha (19% of the area of the reserve) were converted into mostly monoculture plantations. Teak was the main species covering an extent of about 4500 ha (17% of the total area of the reserve; KFD, 1996). This zone is distributed mainly in localities of the plains, namely Athikappu forest colony, Karulai, Sankaran thodu, Nedungayam, Chathanmbratha, Karappuram, Muthedam, Kalkulam, Poolakkal para, Punjakolli, Viralimunda, Mayilampara, Bhumikkuthu, Kundalam padam, Cherangaan todu, Talikolli, Moochala, Chekuthan kundu, Mundakkadavu, Kanjirakkadavu, Padukka Chinikkadavu (<100 m msl), Ezhuthakallu (200 m msl), and along the gentle slopes of the mountainous track at Kuppan mala, Pulimunda and Talimala (400 - 500 m msl).

Most of these areas here are plain and accessible except few isolated hills. The moist deciduous forests of the zone are in a highly degraded condition due to excessive pressure from the people living in the adjoining areas. Because of conversions of moist deciduous forests into plantations, which took place during the last 100 years, the biodiversity of the area is reduced considerably. Operations such as clearfelling, slash burning, weeding, etc., carried out in different sites as part of raising plantations had its negative impact on this aspect. As teak was raised in all accessible areas without much consideration for site suitability, productivity of these plantations is quite poor. Most of the teak plantations in this zone, are below site quality 2 or 3. The excessive biotic pressure due to fire, grazing, over-exploitation of non-wood forest products such as bamboo, rattans and medicinal plants, illicit cutting of trees and poaching have also caused depletion of biodiversity of the area. The natural regeneration of various plant species in the moist deciduous forests and teak plantations areas is also very poor.

As observed, teak plantations of higher age group have more natural growth and therefore, more diverse in native flora, even though, structurally teak dominates the overall vegetation in these plantations. *Cleistanthus collinus, Lagerstroemia microcarpa, Calycopteris floribunda, Dalbergia sissoides* and *Terminalia alata* are more or less common in older teak plantations. The undergrowth of teak plantations, viz., the natural regeneration of various indegenous species including

medicinal herbs were affected by cattle grazing, unscientific and illegal harvesting and collection of firewood. Erosion of topsoil is another serious problem. The total number of species including arborescent plants, insects, birds, mammals, reptiles and amphibians reported from this zone is about 597, with 79 arborescent plants, 349 insects, 75 birds, 19 mammals and 75 reptiles and amphibians. Also, there are 30 species which are endemic to the Western Ghats, 131 species unidentified and 73 species which are rarely seen in Kerala indicating the species richness of this zone.

The major characteristics of different components, namely, vegetation, insects, birds, mammals, reptiles and amphibians of this zone are discussed briefly here.

*7.2.3.1.Vegetation*

The structure of the vegetation in this zone in terms of number of species of different height class is given in Table 7.10. The number of arborescent plants in this zone was only 82 species and forest plantations had only 28 species as understory vegetation. In forest plantations, six species (21%) had height growth of above 30 m, five species (18%) had height between 20 m and 30 m and 10 species (36%) were in the height class of less than 10 m. Moist deciduous forests were also poor in number of arborescent plant species (82) and the number of species falling

**Table 7.10. Structure of vegetation in terms of different heights of plant species recorded from Zone 3**

| **Vegetation types** | **Number of species in different height classes** (percentage in brackets) | | | | |
|---|---|---|---|---|---|
| | **< 10m** | **10-20 m** | **20-30 m** | **> 30 m** | **Total** |
| Teak plantations | 10 (36) | 7 (25) | 5 (18) | 6 (21) | 28 (100) |
| Tropical moist deciduous forests | 23 (28) | 26 (32) | 19 (23) | 14 (17) | 82 (100) |
| Overall (Zone 3) | 23 (28) | 26 (32) | 19 (23) | 14 (17) | 82 (100) |

**Table 7.11. Dominant families and genera represented in different forest types in Zone 3**

| **Forest types** | **Dominant genus *** | **Dominant family *** | **Total species** |
|---|---|---|---|
| Moist deciduous forests | *Dalbergia* (4)<br>*Terminalia* (3)<br>*Lagerstroemia* (2) | Euphorbiaceae (8)<br>Rubiaceae (5)<br>Fabaceae (5) | 82 |
| Teak plantations | *Dalbergia* (2) | Euphorbiaceae (6)<br>Fabaceae (2)<br>Sterculiaceae (2) | 28 |

under different height categories were also poor. This was mainly due to two factors viz: most of the rich moist deciduous forests in these areas have already been clearfelled and converted into plantations and the high biotic pressure has made these forest areas highly degraded.

The most dominant families and genera represented the zone is given in Table 7.11.

**Table 7.12. Plant diversity indices of Zone 3**

| Parameters | Values | |
|---|---|---|
| | Moist deciduous forest | Forest Plantation |
| No. of species represented | 82 | 28 |
| No. of individuals/ha | 315 | 382 |
| Basal area ($m^2$ $ha^{-1}$) | 39.37 | 21.15 |
| Diversity index (Margalef, 1968) | 3.07 | 1.60 |
| Dominance index (Simpson, 1949) | 0.089 | 0.035 |
| Richness index (Menhinick, 1964) | 7.22 | 2.50 |
| Evenness index (Pielou, 1975) | 0.69 | 0.49 |

The diversity parameters for moist deciduous forests and plantation of this zone are given in Table 7.12.

Shannon's index (Margalef, 1968) of arborescent species in the plantation zone at New Amarambalam is 3.07,which is high when compared to species diversity index values of the same forest type in other areas like Nilambur (2.52), Idukki (2.14), Aralam (1.96), Achankovil (2.2), Parappa (2.7), Parambikulam (1.9), Chimmony Wildlife Sanctuary (1.89-2.37) and Agastyamala (1.98).

Concentration of dominance (Simpson, 1949) value for the moist deciduous forests is 0.089, and as compared with the data of Peppara (0.18) and Andamans (0.032), the value is low. Species richness index value (Menhinick, 1964) of the forest type at New Amarambalam is 7.22 and species evenness index (Pielou, 1975) value 0.69.

Since teak plantations are intermingled with moist deciduous forests, a number of moist deciduous species are seen in the plantations. It is quite natural that the most dominant species in the plantation forest is *Tectona grandis* (219 individuals/ha) followed by *Terminalia paniculata, Cleistanthus collinus* and *Xylia xylocarpa*. The mean stem density of teak plantation at NA is 382 individuals/ha and mean basal area is 21.15 $m^2$/ha (>10 cm gbh).

Shannon index value (Margalef, 1968) of the moist deciduous forests is 1.6, which indicates very low species diversity as compared to natural forests.

Concentration of dominance (Simpson, 1949) of the vegetation is 0.035, species richness (Menhinick, 1964) value is 2.5 and evenness index (Pielou, 1975) value 0.49.

The floristic composition and phytosociological parameters of selected plant species of moist deciduous forests and plantations of this zone is given in Table 7.13.

**Table 7.13. Floristic composition and phytosociological parameters of selected plant species in moist deciduous forests (MD) and forest plantations (FP) of Zone 3**

| Species | Density (indi./ha) | | Frequency (%) | | Basal area ($cm^2$/ha) | | IVI | |
|---|---|---|---|---|---|---|---|---|
| | MD | FP | MD | FP | MD | FP | MD | FP |
| *Tectona grandis* | 7 | 220 | 36 | 100 | 8968 | 168025 | 8 | 158 |
| *Terminalia paniculata* | 43 | 35 | 91 | 52 | 104119 | 2862 | 50 | 19 |
| *Xylia xylocarpa* | 66 | 26 | 69 | 41 | 46892 | 2564 | 40 | 15 |
| *Hydnocarpus pentandra* | 24 | 7 | 36 | 34 | 42937 | 1546 | 22 | 8 |
| *Dalbergia latifolia* | 12 | 4 | 49 | 24. | 6225 | 10939 | 11 | 10 |
| *Calycopteris floribunda* | 16 | 3 | 42 | 21 | 2595 | 136 | 10 | 5 |
| *Bambusa bambos* | 3 | 0.4 | 13 | 3 | 17631 | 237 | 7 | 1 |
| *Dillenia pentagyna* | 5 | 0.4 | 24 | 3 | 4922 | 22 | 5 | 1 |
| **Total** | **315** | **386** | **-** | **-** | **393740** | **211598** | **300** | **300** |

*7.2.3.2. Insects*

From moist deciduous forests only less number of insects were recorded. Also, the insect assemblage, composition and abundance varied at different seasons due to changes in the herbaceous flora. From the forest type, a total of 179 species of insects are reported out of which 64 species are butterflies. Among the 28 species of butterflies with endemic/protected status found in New Amarambalam, seven species are from the moist deciduous forests. Out of these six species, namely *Chilasa clytia* Lin, *P. hector* Lin. (Papilionidae) *Parthenos sylvia virens* Moore, *Euthalia aconthea* Fruhstorfer (Nymphalidae), A. *albina* Boisduval, *Euchrysops cnejus* (Fb.) (Pieridae) are protected as per Indian Wild Life Act, 1972 and *Troides minos* Cram. (Papilionidae) is endemic to the Western Ghats.

With regard to distribution of various insects, preferences in relation to the habitat was observed. *Eurema laeta, Cepora nadina, Leptosia nina* (Pieridae), *Orsotrioena medus, Mycalesis perseus, Elymnias caudata* (Satyridae), *Telicota acigias*

(Hesperiidae) and *Neopithecops almora* (Lycaenidae) were species present only in moist deciduous forests.

Out of the 8310 insects collected through sampling, 1333 were from the plantation zone. The secies richness index is 4.9, which is lower than the overall index of 5.87 for New amarambalam. Diversity index value was 4.21 and eveness index 0.81 for the area, whereas, similar values for the total area were 4.92 and 0.78.

Lepidoptera and Coleoptera were the major insect groups containing the highest number of taxa. The members of these two groups, being mostly phytophagous in habit, show distinct association with vegetation. The dominant insect orders with respect to number of individuals in moist deciduous forest are Coleoptera (29.71) followed by Diptera (16.43); for whole of New Amarambalam are 20.47 and 13.85, respectively. With regard to the number of species collected, Lepidoptera contained the maximum number of species (42.80%), followed by Coleoptera (34.46%), Homoptera (4.30%) and Hymenoptera (3.93%).

*7.2.3.3. Birds*

In the case of birds, data were gathered only from moist deciduous forests. Out of the 100 species recorded 78 were from this forest type. The density (775 birds/km$^2$) was also quite high and is comparable with moist deciduous forests in other areas in the State. The overall value for New Amarambalam was 510 birds/km$^2$. This zone has also the highest diversity, noted from the diversity indices. Shannon-Weiner Index for the zone was 3.70. The Margalef Index and Menhinick Index of 11.23 and 2.53, are also higher than those for the entire reserve, suggesting that the bird community in the moist deciduous forest is much diverse. Little Cormorant and Roseringed Parakeet were the dominant species in the moist deciduous forest with dominance indices of 9.73 and 7.86. These also were maximum in number with 94 and 76 individuals respectively.

*7.2.3.4. Mammals*

Sambar, Spotted deer, Mouse deer, Barking deer, Elephant and Gaur were the major herbivorous mammals present in the plantations of New Amarambalam. Carnivorous animals include Tiger, Indian wild dog, Leopard, Sloth bear and Panther. Primates reported from this zone include Hanuman langur, Bonnet macaque and Nilgiri langur. Blacknaped hare, Small Indian Otter, Malabar giant squirrel, Three striped Palm squirrel, Porcupine, Toddy cat and Common mangoose are the other mammals reported from this zone.

*7.2.3.5. Amphibians and reptiles*

This zone was reported to possess maximum amphibians and reptile diversity. The zone comprising decidous forests and plantations had 52.38 per cent frequency of occurrence for amphibians, and 58.92 per cent for reptiles. Plantations showed highest abundance value (3.3) for amphibians, whereas for reptiles deciduous forests had higher value (1.0). The deciduous forests were also rich and diverse in the case of both amphibians and reptiles. Out of the 92 species of reptiles and amphibians reported from New Amarambalam, 75 species were found to occur in this zone. Among these, 16 were endemic to the Western Ghats. The habitat preference was often species specific. Presence of leaf litter, undergrowth, proximity to water, canopy cover and shade, tree trunk, micro temperature, with suitable microhabitat conditions were some of the micro habitat parameters which had a bearing on the occurrence of this important component of biodiversity

### 7.2.4. Biodiversity in different zones: A comparative analysis

A close examination of the information available on locality factors and biodiversity of the three zones, reveals that, the Upper Ghat Zone with its unique temperate and subtropical climate supports an ecosystem which is less represented, and of high conservation value in the whole of NBR. Its protection is very important for maintaining the flora and fauna present there as well as for protection of the watershed.

The total number of species including arborescent plants, insects, birds, mammals, reptiles and amphibians reported from different zones of New Amarambalam Reserve forests is about 1374 taxa. Among these, 305 species were arborescent plants, 860 insects, 100 birds, 27 mammals and 92 reptiles and amphibians. Also there were 144 species endemic to the Western Ghats, 362 species unidentified, 234 species which are rarely seen in Kerala indicating the species richness and biodiversity value of this area. Intermediate zone was the richest in terms of number of species belonging to various categories. This zone was richer in terms of arborescent plant species falling under various potential height classes (Table 7.14). Based on the available information, plantation zone was the most ideal habitat for reptiles and amphibians. Disturbances to habitat are more in the plantation zone, followed by intermediate zone. As these zones are contiguous, distrurbance to one zone affects the other two, in terms of species richness and population structurer of both plant and animal species there. Thus for effective management of biodiversity of New Amarambalam, it is essential to formulate strategies for each zone separetley and also jointly.

### 7.3. Management implications

The study which generated first hand information on different components of the biodiversity of New Amarambalam is useful for evolving effective management programmes for the area on scientific basis. It has brought out the following management issues which can be taken into consideration while evolving conservation oriented management strategies.

**Table 7.14. Structure of vegetation in terms of height of species recorded from different forest types of Intermediate zone (Zone 2)**

| Biodiversity zones | Number of species in Potential height class (percentage in brackets) | | | | |
|---|---|---|---|---|---|
| | < 10 m | 10-20 m | 20-30 m | > 30 m | Total |
| Upper Ghat zone (2600-1200 m msl) | 66 (57) | 45 (39) | 5 (5) | - | 116 (100) |
| Intermediate zone (1200- 500 m msl) | 92 (42) | 36 (16) | 38 (17) | 52 (24) | 218 (100) |
| Plantation zone (below 500 m msl) | 23 (28) | 26 (32) | 19 (23) | 14 (17) | 82 (100) |
| Overall (New Amarambalam) | 118 (39) | 60 (20) | 45 (15) | 66 (22) | 305 (100) |

i. New Amarambalam is one of the richest parts of NBR in terms of biodiversity. For effective conservation and sustainable utilisation of the bio-resources, all the three zones have to be managed in a more efficient manner.

ii. The upper Ghat zone needs to be preserved exclusively for protecting the watershed and also for maintaining the biological richness of the area. Careful management strategies and habitat improvement programmes need to be implemented to arrest forest degradation and biodiversity depletion in this area. As this zone is the habitat for many endangered and ecologically important species, it is very essential to look into site requirements and habitat preferences of various species in an integrated manner while preparing management plans.

iii. The Intermediate zone including semievergreen and evergreen forests is very rich in biodiversity. In this area, currently there is collection of bamboos, canes and other non-wood forest produces of economic importance. Unscientific extraction of such as forest produces adversely affected the ecosystem and also species richness. It is very essential to ensure that this is restricted and made sustainable. Measures to ensure scientifc extraction of products have to be made mandatory and for this suitable training has to be given to all concerned. Efforts are also essential to evolve scientific methods,

so as to generate adequate information on sustainable harvesting of various produces.

iv. As part of ecosystem rehabilitation, activities such as soil and water consevation, weed control and assisted natural regeneration are often carried out in natural forests and plantations. It is essential to ensure that such activities are not adversely affecting the habitat conditions of various biodiversity components such as insects, amphibians and reptiles and other smaller mammals.

v. Though selection felling was stopped in natural forests, the practice of harnessing dead and diseased trees is prevalent. While doing this, it has to be ensured that the habitats of various associated species and especially reptiles and amphibians are not affected.

vi. The productivity of teak plantations in lower zone of New Amarambalam is quite poor. This is mainly due to extension of plantation activities to unsuitable sites. To ensure conservation of biodiversity of the area, as well as to improve plantation productivity, efforts are required to identify nutrient deficiencies and silvicultural inputs essential for improvement. Also, plantations of poor quality can also be reverted to natural forests, therby adding to the biodiversity content of the area.

vii. To reduce biotic pressure from local people, serious measures are to be taken. The local people may be encouraged to raise various fodder, fuelwood and small timber species in their own land. They may also be made aware of the ill effects of unscientific extraction and over-exploitation of natural resources, over a period of time. For all these, support of local bodies and non-governmental organisations can also be sought.

viii. To make New Amarambalam as a model of vegetation and biodiversity, efforts can be initiated to implement more exhaustive conservation oriented programmes. Eco-freindly development programmes can also be considered in this context.

### 7.4. Further research needs

Though the study has generated lot of baseline information on the biodiversity of the area, still there are information gaps in many areas pertaining to its conservation and mangement. Due to difficult terrain conitions and resource constraints, the sampling carried out under various compomnents was limited. Also, information is lacking on aspects such as microbial diversity, soil microflora and fauna, herbacious plants, strategies for ecosystem rehabilitation, biodiversity conservation,

sustainable resource utilisation and impact assessment of management inputs. Multi-disciplinary studies on such aspects are required in order to fill the data gaps. Computer aided technologies such as remote sensing and geographic information system can be better tools to facilitate location specific multi-disciplinary studies of an integrated nature where considerable amount of capturing and processing of spatial data can be done.

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