ECOLOGY AND UTILIZATION OF MEDICINAL PLANTS WITH SPECIAL REFERENCE TO SELECT TRIBAL GROUPS IN THE NILGIRI BIOSPHERE RESERVE

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in
Botany

by
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CERTIFICATE

This is to certify that the thesis, entitled "**Ecology and utilization of medicinal plants with special reference to select tribal groups in the Nilgiri Biosphere Reserve**" is a record of original work done by **Mr. A. Rajasekaran** in the Division of Terrestrial Ecology, Sálim Ali Centre for Ornithology and Natural History, as a full time Research Scholar during the period of study 1994 - 2000 under my guidance and supervision for the award of the Degree of Doctor of Philosophy in BOTANY. I further certify that this research work has not previously formed the basis for the award of any other Degree or Diploma or Associateship or Fellowship or other similar title to any candidate of this or any other University.

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DECLARATION

I do hereby declare that the thesis entitled **"Ecology and utilization of medicinal plants with special reference to select tribal groups in the Nilgiri Biosphere Reserve"** submitted to the Bharathiar University, Coimbatore, for the award of the Degree of Doctor of Philosophy in BOTANY, is a record of original and independent research work done by me during 1994 -2000 under the supervision and guidance of Dr. S. N. Prasad, Principal Scientist, Sálim Ali Centre for Ornithology and Natural History, Coimbatore and it has not previously formed the basis for the award of any Degree, Diploma, Associateship, Fellowship or other similar title to any candidate of this or any other University.

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SUMMARY

Forest dwellers have been using the plants around their settlements to treat their health ailments since time immemorial, the knowledge of which was obtained from their ancestors orally. However, in recent years such traditional knowledge is getting depleted among tribal groups, due to cultural westernisation, industrialisation, urbanisation and rapid loss of their natural resource base. Traditionally, the tribals extracted medicinal plants for sustenance and local sales. But, increasing commercialisation has lead to over-exploitation of medicinal plants resulted in the reduction of the population of these species. Although, there is considerable evidence for over-harvesting of medicinal plants, quantitative data on the effect of extraction on natural populations are very few. Moreover, information on density, population structure and the resource base for future utilization is unknown for most extractive reserves.

Nilgiri Biosphere Reserve (NBR) in the Western Ghats was selected as study area as it harbours tremendous floristic wealth and ethnic people diversity. In addition, most of the tribals in the NBR are still dependent on forests for their day- to-day life and collecting medicinal plants in large scale for preparing drugs. The objectives of this study were;

i. to document ethnomedicinal uses of plants by surveying a few less studied tribal groups of NBR and to initiate preliminary phytochemical screening of selected medicinal plant species hitherto not investigated,

ii. to assess the status of species richness, density and regeneration of medicinal plants in different habitats of NBR and to

iii. assess the impact of commercial harvesting on the abundance and regeneration of medicinal plants.

The study was carried out between 1994 and 1998 in selected habitats of NBR. The field studies included i) documentation of ethnomedicinal plants; ii) quantitative studies on medicinal plants; iii) studies on commercially exploited medicinal plants and iv) impact of fire on medicinal plant populations. Irulas, Kurumbas, Kattunaickans and Mudugas were given focus for documentation of tribal knowledge. Utilization of medicinal plants by the tribals in the NBR was documented using questionnaire survey method. Quantitative data on medicinal plants were collected from twenty quadrats of 0.1 ha (50 x 20 m) each in dry deciduous, moist deciduous and riverine habitats, and old teak plantations. Impact of commercial extraction of medicinal plants on species composition, diversity and regeneration of plant populations were compared between the Bandipur National Park (least harvested site) and Wayanad Wildlife Sanctuary (harvested site). Impact of fire on the abundance and regeneration of medicinal plant species was studied in a less fire frequent and a higher-fire-frequent area of dry deciduous forest of Wayanad WLS.

Chapter 3 discusses utilization of medicinal plants by selected tribal groups and preliminary phytochemical screening of medicinal plants. In total, 188 ethnomedicinal plants belonging to 72 families were recorded from four tribal groups. Euphorbiaceae (14 sp.) followed by Verbenaceae were the dominant families. Herbs constituted the maximum (34.9%) of ethnomedicinal plants. Utilization of underground parts (roots, rhizome, tuber and bulb, 32%) and leaves

(31%) to treat various ailments were of common practice among the tribals of NBR. *Glycosmis arborea, Helicteres isora* and *Cyclea peltata* were the three species used frequently by Irulas. Among the diseases treated, maximum number of species (n = 29) were used to treat digestive disorders. Medicinal plants are administered either singly or in combination with other plants, presumably because the mixture has a synergistic effect. At times a single plant species is used for treating more than one ailment, while single ailment is treated by several species. In such instances, it is difficult to assess the effective role of a particular plant species. Only phytochemical studies and clinical trials can confirm the efficacy of a particular species in treating the disease. Steroids and alkaloids were found in all the ethnomedicinal plant species screened.

Chapter 4 assesses the species richness, density and regeneration of medicinal plants in different habitats of NBR. Species richness of ethnomedicinal plants was highest (69) in the moist deciduous forests followed by riverine habitat (62). Tree species diversity was significantly higher in the moist deciduous forest while shrub species diversity was significantly higher in the riverine forests. However, herb species diversity showed no significant difference among the habitats sampled. Density of medicinal trees was significantly higher in the dry deciduous forest of Bandipur National Park while density of medicinal shrubs was higher in the riverine forests of Attappady Reserve Forest. However, medicinal herb density showed no significant difference among the habitats. Old teak plantations were also rich in medicinal plant wealth, which may be attributed to the secondary succession taking place.

Regeneration of medicinal trees in various habitats of NBR was also assessed in the present study. The results showed that the regeneration of most of the medicinal plants in NBR is inadequate to replace the adults. Species such as *Mitragyna parvifolia, Semecarpus anacardium* and *Schrebera swietenioides* lacked regeneration in all the habitats sampled. Among the commercially exploited trees, species such as *Diospyros malabarica, Gmelina arborea, Strychnos nux-vomica* and *Terminalia chebula* showed poor regeneration while species such as *Pterocarpus marsupium, Phyllanthus emblica* and *Cassia fistula* showed good regeneration. The poor regeneration of *T.chebula* may be due to poor germination capacity of its seeds, fire and commercial exploitation of its fruits. Poor recruitment of tree species could also result from grazing and other disturbances.

Chapter 5 examines the commercial utilization of medicinal plants and assess the impact of commercial harvesting on the abundance and regeneration of medicinal plants in the NBR. In total, 85 medicinal plant species were identified, of which trees (34%) were found to be the dominant growth forms exploited for commercial purposes. Destructive extraction of medicinal plants is of common practice (42%). Cutting of tree branches to harvest the fruits of *Phyllanthus emblica* and *Mangifera indica* was observed. Autecological information of commercially exploited medicinal plant species is also discussed. About 34% of the commercially exploited species occur in dry deciduous and scrub forests.

Diversity and density of tree and herb species showed no significant difference between the harvested and least-harvested habitat while shrub species diversity and density were significantly higher in the least-harvested than in the

harvested habitat. Density of some commercially exploited medicinal herbs such as *Biophytum sensitivum, Cyclea peltata, Desmodium velutinum, Hemidesmus indicus, Rauwolfia serpentina* and *Sida rhombifolia* was also significantly higher in the least-harvested than in the harvested habitat. Regeneration of seedlings was also significantly higher in the least-harvested than in the harvested habitat. Regeneration of Non Timber Forest Product species such as *Phyllanthus emblica* and *Terminalia chebula* was higher in the least-harvested habitat. The above findings indicate the need for more sustainable utilization of medicinal plants. However, the differences in forest structure and regeneration between these habitats could be also due to differences in historical and current land use patterns. Differences in microclimate, soil, frequency of fires and grazing could also influence the outcome.

Chapter 6 examines the impact of fire on species richness, density and regeneration of plant populations in a dry deciduous forest. Tree species richness, diversity and density were higher in the less burnt area than in the severely burnt area. The size class distributions of trees (GBH $\geq$ 20 cm) were significantly different for both the areas. Medicinal shrub species density showed no significant difference between the less burnt and severely burnt habitats. However, regeneration of seedlings were significantly higher in the severely burnt area. Fire also promotes the growth of grass species and exotic weeds such as *Chromolaena odorata* and *Lantana camara*. The present study supports the earlier findings that the fire affects species composition, abundance and regeneration of plant populations.

The important steps to be taken to conserve the medicinal plants are; 1) Dry deciduous forests in the NBR, which harbour greater variety of medicinal plants should be protected. 2) Medicinal plants, which are under threat should be given conservation priority. 3) Formulation of suitable management plans for the sustainable utilization of medicinal plants. 4) Tribal people who are involved in the extraction of medicinal plants should be given training in scientific way of collection to avoid destructive collection. 5) Cultivation of medicinal plants should be encouraged with the participation of tribals. 6) Long-term monitoring of medicinal plant population is needed for effective utilization and management. 7) Research especially on genetic diversity, autecology and productivity of medicinal plants should be taken up on a priority basis.

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A. RAJASEKARAN

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CHAPTER I

INTRODUCTION AND OBJECTIVES

1.1. INTRODUCTION

Medicinal plants are important as an integral part of traditional therapy of local people and as a possible source of valuable phytochemicals. The World Health Organisation (WHO) has estimated that 80% of the people in developing countries rely on plant based drugs (Farnsworth 1988). Moreover, the resurgence in natural systems of cure all over the world has again brought medicinal plants into forefront. Thus, many people continue to rely on traditional medical practice, using plants, which by trial and error over a period have proved to be effective, safe, cheap and readily available.

To obtain a clear view of the relationship between people and their natural environment and to suggest sustainable management options, it is necessary to gather data on type and source of resources used, their importance within the cultural context and alternatives if the resource is scarce and needs to be conserved for the preservation of genetic diversity and future benefit. There are several other complementary reasons for documenting medicinal plants. The traditional use of a plant may be an indication of the presence of chemicals valuable to medical progress. In fact, 74% of the 121 biologically active plant derived compounds presently in use worldwide, have been discovered through ethnomedical approach (Farnsworth *et al* 1985). However, traditional knowledge is under threat. There is a steady decline in human expertise capable of recognising various medicinal plants. Much of this wealth of knowledge is

becoming lost as traditional culture gradually disappear. Destruction and degradation of high diversity ecosystems not only erode traditional contact which local people have with their native floras, but also reduces the chances of discovering new economically useful plants (Sequeira 1994). In view of the recently emerging controversies related to biopiracy and Intellectual Property Rights (IPR), it is absolutely necessary that proper documentation of ethnomedicinal knowledge is done.

Traditionally the tribals utilize medicinal plants for their use for treating various ailments. However, in the recent past, with increasing commercialisation of the medicinal plants, the practice has become more commercial. Extraction of medicinal plants, like any other form of exogenous disturbance (Clear felling, slash and burn agriculture) may have both short term and long term consequences on the structure and function of forest ecosystems. Over-harvesting may alter population size, growth rates, and reproductive capacity of harvested species, leading to a reduction in the quantities of Non-Timber Forest Products (Hall and Bawa 1993). The impact of extraction on individual medicinal plants may vary depending on the plant part extracted and the intensity of extraction. A general response of over-harvesting is depletion of populations of target plant species (Kahn 1988; Nepstad *et al* 1992; Homma 1992; Peters 1993; Murali *et al* 1996; Uma Shankar *et al* 1998). Unsustainable harvesting of plant products is not restricted to products that are being collected for commercial markets. Medicinal plants used primarily by indigenous communities are also being depleted by unsustainable extraction (Browder 1992). Although, there is considerable evidence for over-harvesting of medicinal plants, quantitative analyses of the

effect of extraction on natural populations are not many (Daniels *et al* 1993a, Murali *et al* 1996, Uma Shankar *et al* 1998). Besides, knowledge of natural distribution, abundance and population structure across a landscape is required for each species to assess the sustainability of utilization. These data are critical to evaluation of the management and conservation potentials of different types of forest cover for medicinal plant resources.

1.2. Studies in India

India, one of the 12 mega biodiversity countries of the world (Myers 1992) has one of the oldest, richest and most diverse cultural traditions associated with the use of medicinal plants. Dr. E.K. Janaki Ammal initiated studies on ethnobotany in 1954, in the country. Since then lot of ethnobotanical studies have been carried out in various parts of the country (Jain 1963 & 1965; Maheshwari and Singh 1984; Pande and Pangtey 1987; Rawat and Pangtey 1987; Viswanathan 1989; Dwarakan and Ansari 1992; Geetha 1995; Gaud and Pullaiah 1996; Vijayakumar and Pullaiah 1998; Balasubramanian and Rajasekaran 1998). Several authors have recorded medicinal plants used by the tribals in the Western Ghats (Nagendra Prasad and Abraham 1984; Pushpangadan and Atal 1986; Pushpangadan *et al* 1988; Hosagoudar and Henry 1996a & b; Radhakrishnan *et al* 1996). Binu *et al* (1992) compiled an outline of ethnobotanical work carried out in India. Lalramnghinglova and Jha (1999) reviewed the ethnobotanical research all over the world. The All India Coordinated Research Project on Ethnobiology (AICREP) conducted a nation-wide ethnobiological investigations and it recorded about 7,500 species of plants used by 465 ethnic communities for human and veterinary health care (Anon. 1994). Although, ethnobotanical information was

extensively collected, quantitative ecological information, particularly on density and distribution (Prasad and Pandey 1987; Pandey and Shrivastava 1989; Shanker and Joshi 1990; Daniels *et al* 1993a; Murali *et al* 1996;Uma Shankar *et al* 1998) is scanty.

1.3. Nilgiri Biosphere Reserve

The Nilgiri Biosphere Reserve (NBR) situated in the Western Ghats and one of the biodiversity `hot spots' (Khoshoo 1995), was chosen for the present study for several reasons. First, it harbours enormous floristic diversity: of the 4000 flowering plants found in the Western Ghats, 3187 species have been recorded from this reserve, of which 135 are endemic to this area (Balakrishnan and Ansari 1990). Secondly, these forests harbour tremendous wealth of wild relatives of cultivated, medicinal and other economically important plants. Thirdly, presence of rich ethnic diversity; NBR harbours about 26 tribal groups, most of them are still dependent on local plants for their day today life (Anon. 1992) and are involved in large scale commercial exploitation of medicinal plants. Finally, it is expected that management of Nilgiri Biosphere Reserve for the conservation of medicinal plants would also ensure the survival of other taxa of flora and fauna.

1.3.1. Studies in the NBR

In NBR, most of the botanical studies were concentrated on the flora of various areas (Subramanyam 1959; Subramanian 1966; Naithani 1966; Sharma *et al* 1978; Stephen 1994; Manilal 1988; Vajravelu 1992). Several authors documented the ethnobotanical knowledge of the tribals in NBR (Ragunathan 1976; Anon.1980; Bhatt *et al* 1980; Abraham 1981, 1990; Pushpangadan and Atal

1984; Sankaranarayanan 1988; Lakshmanan and Sankaranarayanan 1988, 1990; Ramachandran and Maniyan 1989; Rajan and Sethuraman 1991, 1993; Gopalakrishnan and Krishnaprasad 1992; Balasubramanian and Prasad 1996; Mandal and Basu 1996; Hosagoudar and Henry 1996c; Rajan *et al* 1997) and they reported only 373 medicinal plants used by the tribals (Prasad *et al* 1999) . In spite of the above studies, considering the diversity of plants and rich ethnic communities of NBR, informations about the ethnomedicinal uses of plants is meagre and still some of the tribal groups, namely Irulas and Kattunaickans are less studied. Moreover, ecological information on medicinal plants, which are important for conservation and sustainable utilization are lacking. Puyravaud *et al* (1995) studied the impact of fire on a dry deciduous forest in the Bandipur National Park. Although, phytosociological studies carried out in different forest plant communities (George and Varghese 1984; Sharma *et al* 1983, 1986; Manilal *et al* 1986, 1989; Singh *et al* 1988; Sukumar *et al* 1992) showed the status of some plant species in the NBR, the present status of medicinal plants in different habitats of NBR and the impact of commercial exploitation on the medicinal plant population are lacking. The present study is the first of the kind to compare quantitatively the species richness, density, and size class distribution of medicinal plants found in various habitats of the NBR. The present study also assessed the regeneration of medicinal woody species in the NBR.

1.4. OBJECTIVES

The specific objectives of this study were as follows;

i. to document ethnomedicinal uses of plants by surveying a few less studied tribal groups of NBR and to initiate preliminary

phytochemical screening of selected medicinal plant species hitherto not investigated.

ii. to assess the status of species richness, density and regeneration of medicinal plants in different habitats of NBR and to

iii. assess the impact of commercial harvesting on the abundance and regeneration of medicinal plants.

Fieldwork was conducted between May 1994 and November 1998 in selected forest localities in the NBR. After reconnaissance surveys, intensive study sites and local tribal groups were selected. For documentation of tribal knowledge, Irulas, Kurumbas, Kattunaickans and Mudugas were given major focus. The status and distribution of medicinal plants were examined in dry deciduous, moist deciduous and riverine habitats and old teak plantations.

The thesis is divided into seven chapters, Chapters I and II give introduction, objectives and study area, Chapter III discusses the medicinal uses of plants by selected tribal groups and preliminary phytochemical screening of medicinal plants, Chapter IV deals with the status, distribution and regeneration of medicinal plants in different habitats of the NBR, Chapter V examines the commercial exploitation of medicinal plants, Chapter VI assesses the impact of fire on the abundance, distribution and regeneration of medicinal plant populations, and Chapter VII presents the research and management programme for conservation of medicinal plants.

CHAPTER II

STUDY AREA

The Nilgiri Biosphere Reserve (NBR) is biogeographically a part of the Indo-Malayan realm and an appropriate representative of the topographic and climatic complexity of the Western Ghats, one of the two biodiversity `hot-spots' of India.

2.1. Topography

The Nilgiri Biosphere Reserve (NBR), the first biosphere reserve in India, is spread over three south Indian states of Tamil Nadu, Karnataka and Kerala, covering an area of 5520 km^2. It lies between 10° 50'- 12° 16' N and 76° -77° 15' E (Figure 2.1). It stretches from the Coorg-Wayanad plateau just east of the Brahmagiri, south to Attappady- Boluvampatti hills at the northern edge of the Palghat gap and eastwards into the Talamalai-Hasanur plateau of the Eastern Ghats. For management, the Reserve area has been classified into a core zone (1240 km^2), manipulation forestry zone (3239 km^2), tourism zone (335 km^2) and restoration zone (706 km^2). The NBR has a remarkable topographic diversity with altitudes ranging from as low as 80 m (Nilambur plains) to over 2600 m (Nilgiri plateau) above mean sea level (Anon. 1992).

2.2. Geology

The NBR belongs to the continental block of peninsular India, made up of metamorphic archean, i.e. Pre-cambrian rocks, mainly gneisses, charnockites and schists (Anon. 1992).


Moyar RF
Gudalur
Udagamandalam
Bhavani River
Attappady
Siruvani Hills

2.3. Climate

The biosphere reserve encompasses a wide range of rainfall zones. Precipitation occurs both during South-West (June-September) and North-East (December-March) monsoons and rainfall varies between 500 and 5000 mm annually. Some amount of rainfall occurs during the inter-monsoonal period (April-May) also. The most conspicuous feature regarding the temperature is its inverse relationship with elevation. Annual average temperature at elevations between 500 -1000 m is 23° C. The minimum temperature reaches O°C during winter (December and January) in the higher hills of Nilgiris.

2.4. Flora

Nilgiri Biosphere Reserve is known for its rich biodiversity. About 80% of the flowering plants reported from the Western Ghats occur in the NBR (Vivekananthan *et al* 1997). The floristic diversity of NBR is evident from the fact that of the 17,000 species of flowering plants estimated to occur in India, 3187 species have been recorded from the reserve (Balakrishnan and Ansari 1990). Apart from the angiosperms, 71 species of gymnosperms and 134 species of pteridophytes have been reported from here (Balakrishnan and Ansari 1990). Mohanan and Balakrishnan (1991), in their studies on the orchid flora of NBR, recorded 175 species in 60 genera, out of which 38 are endangered and eight are endemic to NBR. Sanjappa (1991) recorded 80 species of endemic legumes from the Western Ghats and a majority of these occur in the NBR and adjacent areas.

Besides the vegetation diversity, another characteristic feature of the flora is the presence of endemics. According to Nair and Daniel (1986) there are about

141 endemic genera in India, out of which 50 genera spread over 25 families are endemic to the Western Ghats and 11 genera to the Nilgiris. At species level, out of an estimated 2100 species of flowering plants endemic to peninsular India, about 818 are found in the Nilgiris and adjoining areas (Mohanan and Balakrishnan 1991). Another important aspect on the diversity and richness of flora of the reserve is the presence of a large number of wild relatives of cultivated plants (Eg. *Curcuma neilgherrensis, Oryza granulata, O.nivara* and *Piper betle*).

2.5. Fauna

Endangered mammals such as Asian Elephant (*Elephas maximus*), Nilgiri tahr (*Hemitragus hylocrius*), Blackbuck (*Antilope cervicapra*), Tiger (*Panthera tigris*), Lion-Tailed Macaque (*Macaca silenus*) and Nilgiri Langur (*Trachypithecus johnii*) occur in NBR. Smaller mammals including the Clawless Otter (*Aonyx cinerea*), Civets (*Vivericula* spp and *Paradoxurus* spp), Mongooses (*Herpestes* spp) and the Lesser Cats (*Felis* spp) also occur within the Reserve. The Gaur (*Bos gaurus*), Sambar (*Cervus unicolor*), Spotted Deer or Chital (*Axis axis*), Indian Wild Boar (*Sus scrofa*) and Sloth Bear (*Melursus ursinus*) are commonly seen in the NBR. Over 300 species of birds are known from the NBR. 39 species of fishes, 31 amphibians and 60 reptiles endemic to Western Ghats occur in this reserve (Daniels 1996).

2.6. Vegetation

The plant communities in the NBR are categorised based on edaphic, climatic and orographic conditions, which decide species distribution. The classification adopted by Puri *et al* (1983) and the vegetation map prepared by the

French Institute, Pondicherry are the two major sources of information about the vegetation. The natural vegetation in the NBR are classified into: Wet Evergreen forests; Climax moist deciduous forests; Dry deciduous forests and Scrub or thorn forests.

2.6.1. Wet evergreen forests

There are three types of wet evergreen forests in the Biosphere Reserve area. These are:

1. Low elevation wet evergreen forest: These forests are found in the Western Kerala at low elevations (0 -600 m) in the river valleys adjoining the plains. These forests are classified under *Dipterocarpus - Mesua - Palaquium* series. The annual rainfall is over 2000 mm with four to five dry months. Remnants of this forest occur in the New Amarambalam and Muthikulam (Palghat hills).

2. Medium elevation wet evergreen forest (600 -1400m): These forests are found in the Palghat hills, Muthikulam, Silent Valley and Attappady Reserve Forest, New Amarambalam, Nilambur special Division and Coimbatore Division. The vegetation is of *Cullenia - Mesua - Palaquium* series, and occurs under very wet conditions with a rainfall of more than 3000 mm and a very short dry season.

3. High elevation wet evergreen forest: The "Shola" forests interspersed with high elevation grasslands come under this forest type. These forests are restricted to valleys and depressions where the moisture content is higher. This forest type found in the Nilgiri South Division, Mukurthi and in the Upper reaches of Silent Valley, Attappady and New Amarambalam. Smaller pockets of this forest

also occur in Palghat and Coimbatore Division. This forest type is encountered above an elevation of 1400 - 1800 m with an average dry season of one month. Puri *et al* (1983) classify these forests under the Shola montane forest type.

2.6.2. Moist deciduous forests

These forests occur in most parts of Wayanad plateau, South Western parts of Rajiv Gandhi National Park (Nagarhole National Park) and the Western part of the Mudumalai Wildlife Sanctuary (Plate 1a). This forest type is characterised by rainfall of 2000 - 4000 mm, with a dry season of 3 - 4 months. The climax vegetation is called as moist deciduous forests and there are a number of degraded stages. Puri *et al* (1983) classify these forests under the *Tectona - Dillenia - Lagerstroemia microcarpa - Terminalia paniculata* series.

2.6.3. Dry deciduous forests

These forests are found within the Wayanad Wildlife Sanctuary, Bandipur Tiger Reserve and along the Southern and Western edges of the Mudumalai Wildlife Sanctuary (Plate 1b). Annual rainfall ranges from 800 mm to 1800 mm; the dry season may last from six to eight months. The dry deciduous forests in the NBR come under the main series of *Terminalia - Anogeissus latifolia- Tectona grandis* and *Anogeissus latifolia - Hardwickia binata*. The degraded stages of dry deciduous forest commonly found are generally referred to as "open forest" by Puri *et al* (1983). Depending on the mode of degradation, fire or grazing, this forest show two types of retrogression: a) Savannah type and b) Scrub and thicket type. The *Anogeissus latifolia -Hardwickia binata* series of dry deciduous forest is found in the Hasanur Plateau in Sathyamangalam Forest Division.

Swamps occur in Mudumalai Wildlife Sanctuary, Wayanad Wildlife Sanctuary and Bandipur National Park. Riverine forests also occur along the river banks (Plate 1c). In addition to the above natural vegetation types, plantations of teak (*Tectona grandis*), blue gum (*Eucalyptus spp*), wattle (*Acacia meamsi*), tea (*Camellia chinensis*) and coffee (*Coffea arabica*) also occur in the NBR.

2.7. Water resources

A group of reservoirs have been constructed within and outside the Nilgiri Biosphere Reserve. The major river valley projects in the NBR are Upper Bhavani, Kundha, Pykara, and Pillur. These reservoirs have not only affected the river and stream flow but also submerged vast stretches of forests. A few perennial and seasonal streams also occur. The major perennial rivers are Bhavani, Moyar, Kunthipuzha and Nulpuzha.

2.8. Tribals

Being blessed with thick forests with rich natural resources, NBR has been the home of several tribes since time immemorial. About 26 tribal groups are known from NBR, ranging from pre-agricultural Cholainaickans to the pastoral Todas. Therefore, NBR is a rich mosaic of ethnic diversity, along with its rich plant and animal diversity. Distribution and occupational details of tribals are given in Appendix.I. According to 1981 census, Paniyas (Plate 2a), with a population of approximately 62000 people are numerically dominant followed by Irulas (28000), Kurichians (22000), Kattunaickans (8800) and Adiyans (8100). Aranadans (95) of the Nilambur hills are the smallest among the scheduled tribes.

a)

b)

c)

Plate 1 Views of different vegetation types of NBR
a) Moist deciduous b) Dry deciduous c) Riverine

2.9. Study sites

The present study was conducted in the following sites within the NBR;

i) Wayanad Wildlife Sanctuary: It forms a part of the western portion of the NBR (11^0 33' to 11^0 51' N and 76^0 02' to 76^0 27'E). The area falls in Wayanad district of Kerala state as two discontinuous pockets and extends over an area of 344 km^2. The soil is loamy and average rainfall is 2000mm. The vegetation of the sanctuary is mostly of deciduous type. Apart from the natural forests, a sizeable part of the sanctuary is under teak and eucalyptus plantations. Paniyas, Kurumbas, Kattunaickans and Wayanadan chettis are the indigenous people living in these forests. Anthropogenic factors such as fire, tourism and cultivation are well pronounced in this sanctuary. Hence, disturbed dry deciduous forests were selected from here. Other details of the sanctuary can be seen elsewhere (Gopinathan 1989).

ii) Bandipur National Park: It is situated in the Mysore District of Karnataka state and lies between 76^0 12' to 76^0 51' E and 11^0 35' to 11^0 57' N. It is drained by Kabini, Nugu and Moyar rivers. The total area of the park is 866 km^2. The altitude ranges from 650 m to 1150m. Dry deciduous, moist deciduous and scrub forests are present in addition to swamps. There is no tribal settlements in this National Park. Least disturbed dry deciduous forests were selected from here. Other details of the sanctuary can be seen elsewhere (Ramaiah and Rajeev 1993).

iii) Attappady Reserve Forest: It lies adjacent to the Coimbatore Forest Division. Red loamy, sandy, black cotton, gravelly and loamy soils are found. River

Bhavani flows through this area and is the major water source. The vegetation ranges from deciduous to wet evergreen forests. Teak plantations are also seen. Irulas, Kurumbas and Mudugas are the major tribal communities in these forests.

iv) Mudumalai Wildlife Sanctuary: It lies between 11^0 30' and 11^0 39' N and 76^0 27' to 76^0 43' E. The soil types are black loamy and red clay loamy. The sanctuary, falls in the Nilgiri district of Tamil Nadu state and extends over an area of 321 km^2. River Moyar flows through the sanctuary and is the major water source. The rainfall ranges between 900 mm and 1800. The temperature varies from 17^0 to 33^0 C. The altitude ranges between 625m to 1258. Both dry deciduous and moist deciduous forest form nearly 50% of the total forested area in the sanctuary. Teak plantations are also seen. Kurumbas, Kattunaickans, Paniyas and Chettis inhabit the sanctuary.

v) Coimbatore Forest Division: It falls between 10^0 37' to 11^0 31' N and 76^0 39' - 77^0 5' E. Red loamy, sandy and black cotton soils are found in plains and gravelly and loamy soils in the hill areas. Elevation ranges from 500 to 1800 m. The main forest types in this area are thorn forests, dry mixed deciduous, semi-evergreen and wet evergreen. In addition to the natural forests, teak, eucalyptus and tamarind plantations are also seen. Irulas are the major tribes in this division. In addition to the Irulas, Mudugas are also present in Boluvampatty RF.

2.10. Tribal groups studied

Tribal groups such as Irulas, Kurumbas, Kattunaickans and Mudugas were selected for documenting ethnomedicinal knowledge. Distribution and occupational details of these tribals are given below.

Irulas: The Irulas are scattered all over the peninsular India with different customs and lifestyles in different areas. Those in the Nilgiris must have migrated from the east, having been ousted by the Malaiyalis from the Shervaroys, Javadi, Kolli and Pachamalais (Anon. 1992). In NBR, they live in Gobi and Coimbatore taluks, in the Attappady valley, and on the adjacent Nilgiri slopes. Irulas are excellent craftsmen and artisans. They are good in catching snakes. They make ploughshares, wheels, bamboo mats and baskets for themselves.

Kurumbas: The Kurumbas of Attappady were the earliest inhabitants of the area, who lived in complete harmony with the forest and depended to a large extent on forest products. They mostly live in the valleys of river Bhavani. They cultivate ragi, red gram, mustard, black gram and chilly on the hill slopes of Attappady reserve. Roots and tubers are collected especially when there is a scarcity of grain. They also collect honey and wax from the forests. They make bamboo baskets for their own use and for other local people.

Kattunaickans: The Kattunaickans (Plate 2b) are a Kannada speaking tribe, similar in customs and manner to the Jenu Kurumbas. Immigrants usually employ them as labourers. In NBR, they live in Mudumalai Wildlife Sanctuary, Wayanad Wildlife Sanctuary and Nilambur.

Mudugas: The Mudugas live in the dense forest clad hills of Attappady Reserve Forest in Pottikkal and Muthikulam areas. They practice agriculture, food gathering and fishing. Their customs are very similar to those of the Kurumbas.

(a)

(b)

Plate 2 a) Tribal settlement in the Wayanad Wildlife Sanctuary
b) Kattunaicken collecting *Curcuma aromatica* tuber

CHAPTER III

ETHNOMEDICINE

3.1. INTRODUCTION

Ethnomedicine, a branch of botanical research, deals with the study of relationships of indigenous people with their plant environment. These studies have in recent decades, received much attention owing to their wide local acceptability and clues for new or less known medicinal herbs (Farnsworth *et al* 1985). A long intimate association with the local flora has enabled the local people to develop a strong and effective traditional system of medicine. But the traditional knowledge accumulated through trial and error is getting depleted, with the advent of modern education and cultural changes such as westernization (Schultes 1986, 1989). Documentation of ethnobotanical knowledge is important for evaluating human-plant relationships and for understanding the human ecological relations to their environment (Alcorn 1981). Moreover, destruction and degradation of high diversity ecosystems erode the traditional contact, which local people have with their native floras and reduces the chances of discovering new economically useful plants (Sequeira 1994). The history of drug discovery indicates that the ethnobotanical approach is the most productive of the plant surveying methods (Cox and Balick 1994). Hence, documentation of ethnobotanical knowledge is highly essential.

Various authors documented the ethnobotanical knowledge of the tribals in NBR. In Tamil Nadu part of NBR, Ragunathan (1976), Abraham (1981, 1990), Rajan and Sethuraman (1991, 1993), Mandal and Basu (1996), Hosagoudar and

Henry (1996c) and Rajan *et al* (1997) have studied the ethnobotany of the Nilgiri tribes. Ramachandran and Maniyan (1989) gave an ethnobotanical note on the Irula tribe of Coimbatore District. Lakshmanan and Sankaranarayanan (1988, 1990) and Sankaranarayanan (1988) have studied the folklore medicines in Coimbatore District. Anon. (1980), Bhatt *et al* (1980) and Gopalakrishnan and Krishnaprasad (1992) have recorded the medicinal plants used by the tribals in Attappady Reserve Forest of Kerala. Pushpangadan and Atal (1984) have studied the ethnobotany of tribals in Kerala part of NBR. These authors reported a total of 373 medicinal plants used by the tribals in the NBR (Prasad *et al* 1999). In spite of the above studies, in relation to the floristic and ethnic people diversity of NBR, information about the medicinal uses of plants is meagre and some tribal groups such as Irulas, Kattunaickans and Mudugas are less studied. Information on the habitat, distribution and microhabitat preference of medicinal plants are insufficient. Moreover, only a few attempts have been made for the scientific verification of folklore claim of the tribals concerning the utility of plants and for identification of new drugs. Therefore, the present study was made with the following objectives:

i) to comprehensively review the existing ethnomedicinal information and based on the review results carry out documentation of under explored tribal groups in the Nilgiri Biosphere Reserve.

ii) to know the commonly used medicinal plants among the selected tribals in the NBR and to initiate preliminary phytochemical screening of selected ethnomedicinal plants.

3.2. METHODS

3.2.1. Review of ethnomedicinal information

Ethnomedicinal information (species name, family, part used, uses and tribal group) reported from the NBR were collected from published sources and entered in a database. (Anon. 1980; Bhatt *et al* 1980; Pushpangadan and Atal 1984; Lakshmanan and Sankaranarayanan 1988, 1990; Sankaranarayanan 1988; Ramachandran and Maniyan 1989; Abraham 1981, 1990; Rajan and Sethuraman 1991, 1993; Gopalakrishnan and Krishnaprasad 1992; Mandal and Basu 1996; Hosagoudar and Henry 1996c; Rajan *et al* 1997). The completeness of ethnomedicinal information reported by these authors was assessed by calculating breadth of the ethnomedicinal information (Martin 1995).

$$Breadth\ of\ plant\ families = \frac{Number\ of\ families\ recorded\ during\ the\ survey}{Total\ number\ of\ families\ recorded\ (NBR)} \times 100$$

Total number of plant families reported from the NBR was collected from various flora (Gamble 1957; Subramanyam 1959; Subramanian 1966; Naithani 1966; Sharma *et al* 1978; Nair and Henry 1983; Henry *et al* 1987,1989; Vajravelu 1992; Stephen 1994).

3.2.2. Utilization of medicinal plants

Information on the uses of plants for medicinal purposes was collected from Irula, Kurumba, Kattunaickan and Muduga of Nilgiri Biosphere Reserve. Since, Irulas are one of the largest tribal groups in the NBR (Anon. 1992), more emphasis was given to them while documenting ethnomedicinal information. In total, 45 field surveys were conducted in selected tribal villages in Coimbatore Forest Division, Attappady, Wayanad and Mudumalai Wildlife Sanctuary. A total of 40 tribals (30 men and 10 women) including local healers was interviewed. The age of the informants ranged from 22 to 70. Time devoted with each informant ranged from one

to five hours. The information documented was checked and confirmed at various villages and among different local healers whenever possible. Information on the name of the plant used, part used, uses, methods of preparation and mode of administration were gathered from the tribals. Ecological notes such as habitat, associated plants and microhabitat were also made. Ethnomedicinal information was also collected from the local market at Boluvampatty Reserve Forest. The collected medicinal plant specimens were identified and confirmed at the Botanical Survey of India, Southern Circle, Coimbatore.

An attempt was also made to find out the most commonly used medicinal plants among the tribals. For this purpose, household survey was conducted among the Irulas of Attappady and Coimbatore Forest Division. Thirty-one tribals from 21 settlements were interviewed. Medicinal plants, which are used by most number of tribals were considered as most commonly used medicinal plants.

3.2.3. Phytochemical screening

Four ethnomedicinal plant species (*Acalypha fruticosa, Callicarpa tomentosa, Caesalpinia mimosoides* and *Vanilla walkeriae*), which were not screened earlier were selected for preliminary phytochemical screening. Fresh plant materials were collected and identified with the help of local flora (Gamble 1957). The plant material was shade-dried and powdered. The dried plant (100 gram) was extracted with aqueous ethanol (3 x 3 hours) and concentrated in a rotary evaporator under reduced pressure. The crude extract was screened for different group of phytochemicals. However, due to the complex nature of the crude extract it does not answer clearly for individual group of secondary metabolites. Hence, by using solvents of different polarity the particular group of compounds were fractionated, thus making the extract less complex to conduct group tests.

Ten millilitre (ml) of the crude extract was taken and fractionated with solvents starting with hexane, toluene, ether and ethyl acetate. The resulting concentrates were screened for the presence of flavonoid, saponin, steroid, alkaloid and triterpenoid following standard methods (Harborne 1973; Kumar *et al* 1990; Sivakumar 1991; Alagesaboopathi and Balu 1996). Tannins were tested from the left over aqueous extract.

3.3. RESULTS

3.3.1. Existing information

Review of literature showed that a total of 373 plant species under 102 families were used as ethnomedicine. Among them, Euphorbiaceae were the most dominant (7.5%) family. Leaves were the most frequently (36%) used plant part. The completeness of previous ethnobotanical studies was assessed by calculating the breadth of the plant families as suggested by Martin (1995) and details of computations are given in 3.2.1. The breadth of the ethnomedicinal information was 53%. In relation to diversity of plants in the NBR, the breadth of the information was low. Thus there is a tremendous scope for further conducting the primary ethnobotanical investigations.

3.3.2. Ethnomedicinal plants

Plant species used by the tribals of NBR for treating various ailments are considered here as ethnomedicinal plants. The present study recorded 188 such species belongs to 72 families used by the tribals of NBR. Data were compared with the available literature on ethnomedicinal plants (Jain 1991) and found that many usages recorded during this study have not been recorded earlier. However,

for some plants the usage was found to be similar to the information already available. Fifteen new ethnomedicinal plants and fifty-six new uses were recorded during this study. A list of ethnomedicinal plant species, habitat, part used, uses and tribal groups studied are given in Appendix II and III.

Of the 188 ethnomedicinal plant species, some were used by more than one tribal group. Irulas used 157 species of plants as medicines while 32 species were recorded for Kattunaickans, six species each were recorded for Kurumbas and Mudugas. Of the 72 plant families recorded from the present study, twelve were the most dominant. Euphorbiaceae were the largest contributor followed by Verbenaceae, Fabaceae, Asclepiadaceae and Acanthaceae (Figure 3.1). The total contribution of these families alone was 25%. Herbs contributed about 35% of the species followed by shrubs and trees each contributing about 24%, climbers contributed about 16% while epiphytes contributed 1% (Figure 3.2). In total, 14 different parts of medicinal plants were used. Utilization of underground parts (roots, rhizome, tuber and bulb, 32%) and leaves (31%) to treat various ailments were of common practice among the tribals of NBR (Figure 3.3).

For the data analysis all the reported diseases were grouped into 54 use categories following Jain (1991). Some ailments were treated by more than one plant species. For example, 29 ethnomedicinal plants species were used for treating digestive disorders and 23 species to heal cuts and wounds (Figure 3.4). Peninsular endemic (Ahmedullah and Nayar 1987) species such as *Tamilnadia uliginosa* (Plate 3a) and *Capparis grandiflora* (Plate 3b) are used to treat digestive disorders. Most of the ethnomedicinal plants used by the tribals were to treat one

specific ailment. Species such as *Hemionitis arifolia* (Plate 4a) and *Vanilla walkeriae* (Plate 4b) are used as children's diseases and veterinary medicine respectively. However, some species were used to treat more than one ailment. For example, *Terminalia chebula* (Combretaceae) was used to treat cuts and wounds, cough, burn injuries and to reduce toothache while *Cassia occidentalis* was used to treat four ailments, namely digestive disorders, body pain, rheumatism and gynaecological complaints.

3.3.3. Most commonly used ethnomedicinal plants

In total, 31 tribals from 21 settlements were interviewed to find out most commonly used ethnomedicinal plants. In total 90 medicinal plant species were recorded of which, species such as *Glycosmis arborea*, *Helicteres isora*, *Cyclea peltata*, *Hemidesmus indicus*, *Sida acuta*, *Toddalia asiatica*, *Clerodendrum serratum*, *Dalbergia latifolia*, *Plumbago zeylanica* and *Thespesia lampas* were the ten most commonly used medicinal plants among the Irula tribes (Table 3.1). About 68% of medicinal plant species were used to treat one ailment and 32% of plants were used to treat two or more ailments. *Dalbergia latifolia*, *Glycosmis arborea*, *Helicteres isora* and *Sida acuta* were used for treating four ailments. *Clerodendrum serratum*, *Datura metel*, *Mimosa pudica* and *Phyllanthus emblica* were used for treating three ailments. Euphorbiaceae, Caesalpiniaceae, Asclepiadaceae, Solanaceae and Verbenacae were the most commonly used plant families by the Irulas.

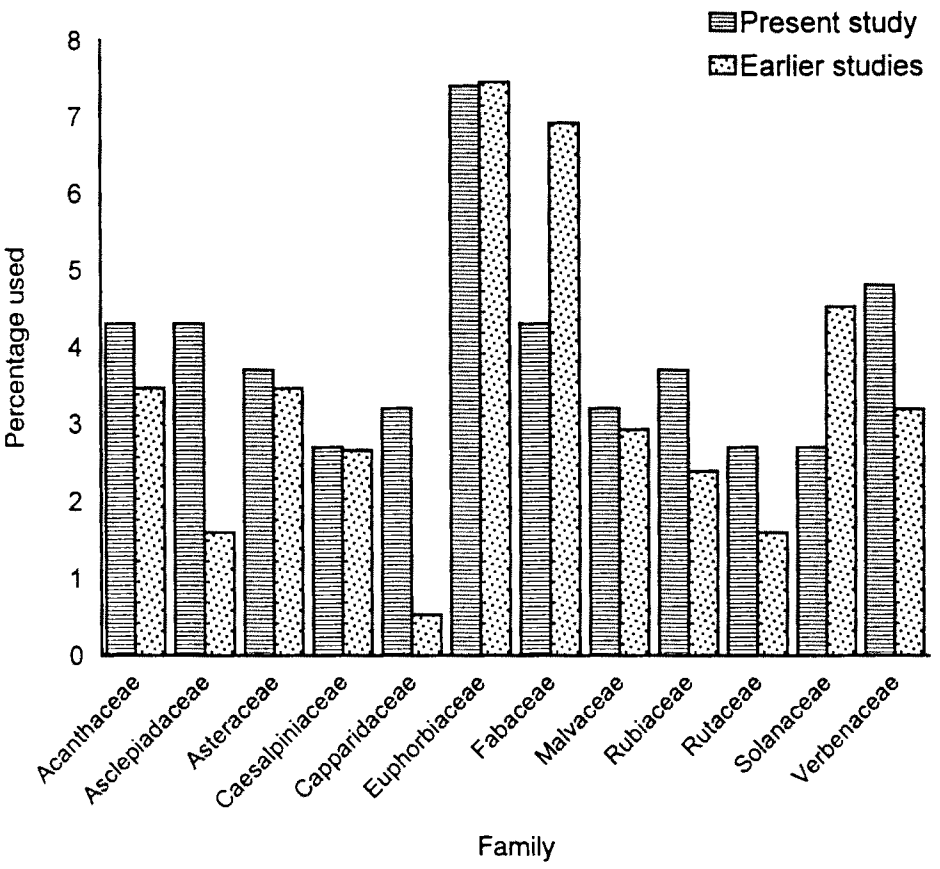


Figure 3.1. Dominant families of ethnomedicinal plants in the NBR

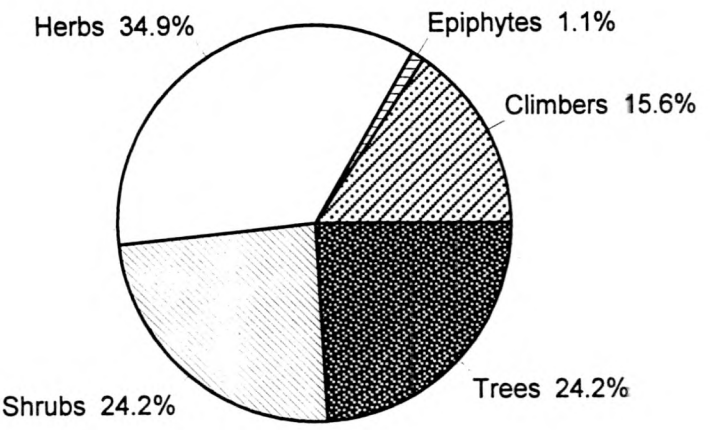


Figure 3.2. Use of ethnomedicinal plant species by growth forms (n =188)

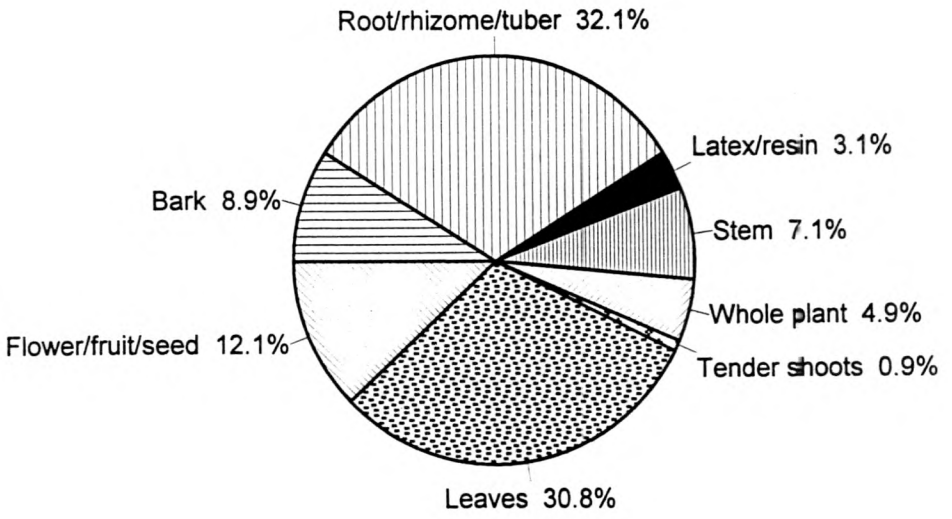


Figure 3.3. Use of ethnomedicinal plant species by parts (n =188)

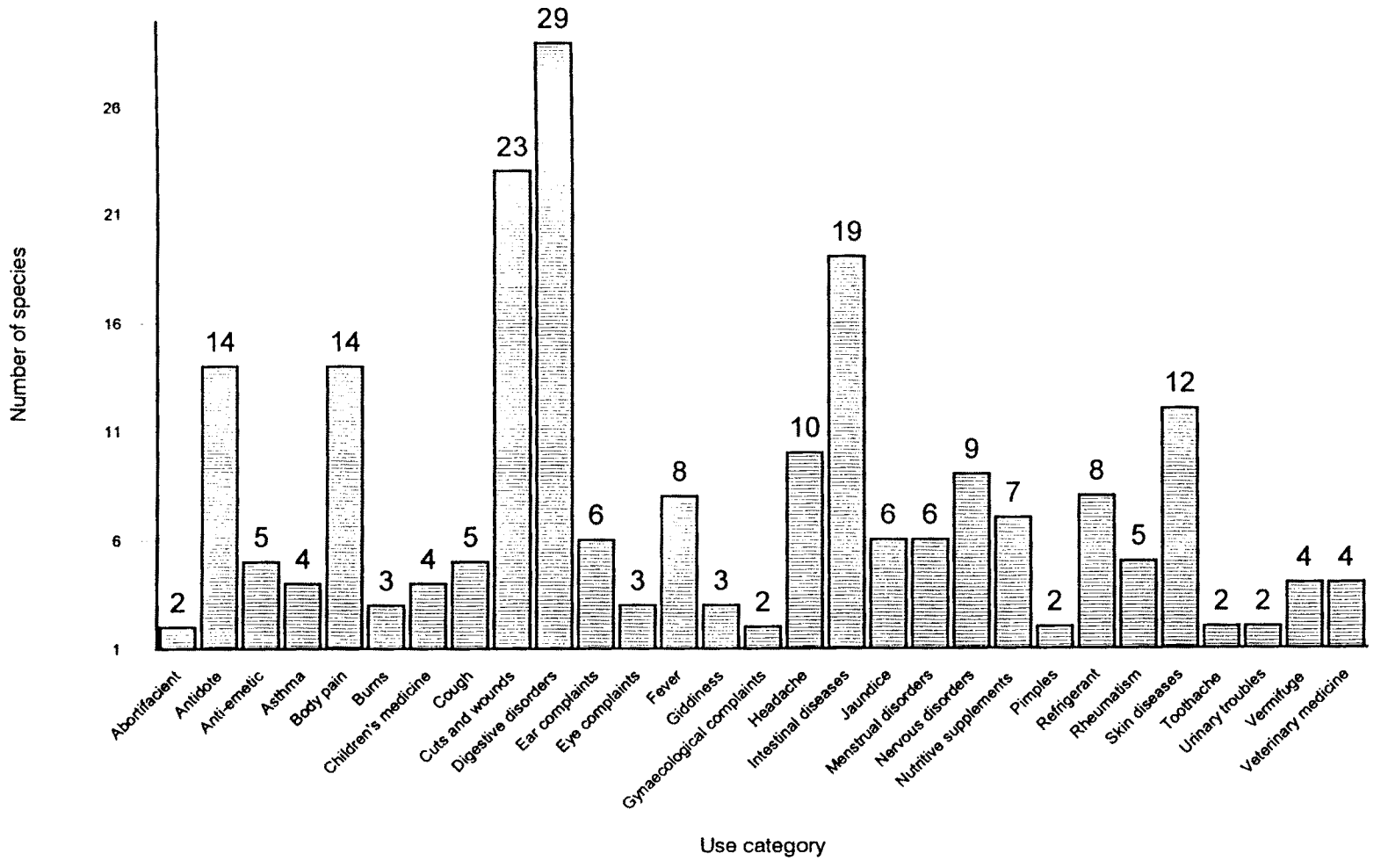


Figure 3.4. Number of ethnomedicinal plant species by important use category in the NBR

(a)

(b)

Plate 3 a) *Tamilnadia uliginosa* - an ethnomedicinal plant
b) *Capparis grandiflora* - a peninsular endemic medicinal plant.

(a)

(b)

Plate 4 a) *Hemionitis arifolia* - a medicinal plant used to treat children's diseases
b) *Vanilla walkeriae* - an ethnoveterinary plant

3.3.4. Phytochemical screening

Four medicinal plants were screened for the presence / absence of secondary metabolites. Steroids and alkaloids were present in all the plants screened (Table 3.2). Flavonoids and tannin gave positive results in all the plants except in *Acalypha fruticosa*. Presence of saponin was detected in all the plants screened except in *Vanilla walkeriae*. All the plant extracts gave negative results for the presence of triterpenoids. Secondary metabolites isolated from selected medicinal plants are given in Appendix IV.

Table 3.1. Ten most common ethnomedicinal plants used by the Irulas of NBR

S.No	Species	Use category	No. of tribals (n = 31)
1	*Glycosmis arborea*	Body pain, stomach ache, vermifuge	16
2	*Helicteres isora*	Fever, vermifuge, rheumatism, stomach ache	16
3	*Cyclea peltata*	Stomach ache	16
4	*Hemidesmus indicus*	Stomach ache	15
5	*Toddalia asiatica*	Stomach ache	15
6	*Sida acuta*	Cuts & wounds, dysentery, head ache, rheumatism	14
7	*Plumbago zeylanica*	Head ache	14
8	*Thespesia lampas*	Jaundice, stomach ache	14
9	*Dalbergia latifolia*	Dysentery, piles, rheumatism, stomach ache	14
10	*Clerodendrum serratum*	Body pain, rheumatism, stomach ache	14

Table 3.2. Presence/absence of phytoconstituents of medicinal plant species

Species/part/extract	ST	PC	FL	SA	TT	TA
Acalypha fruticosa (Leaves)						
Benzene	+++	-	+	-	-	-
Ether	-	-	-	+	-	-
Ethyl acetate	-	-	-	-	-	-
Methanol	-	+++	-	-	-	-
Callicarpa tomentosa (Leaves)						
Hexane	+++	-	-	-	-	-
Ether	-	+	+	-	-	-
Ethyl acetate	-	-	-	-	-	-
Aqueous	-	+++	-	+	-	+++
Caesalpinia mimosoides (Young shoot)						
Hexane	+++	-	-	-	-	-
Toluene	+++	+++	-	-	-	+++
Ether	-	+++	+++	+	-	+++
Ethyl acetate	-	+++	-	-	-	-
Aqueous	-	+++	-	-	-	+
Vanilla walkeriae (Stem)						
Hexane	+++	-	-	-	-	-
Toluene	-	-	-	-	-	+
Ether	-	+	+	-	-	-
Ethyl acetate	-	-	-	-	-	-
Aqueous	-	-	-	-	-	+++

ST- Steroids; PC - Phenolic compounds; FL - Flavonoids; SA - Saponins; TT - Triterpenoids and TA - Tannins; + Positive; - Negative. Note: +++ indicate higher concentration

Bty - 13

3.4. DISCUSSION

3.4.1. Ethnobotanical knowledge

The present investigation showed that the tribals in the NBR make use of a wide range of plants from their environment. Of the 188 ethnomedicinal plants recorded, some species were used by more than one tribal group. The knowledge regarding the utility of plants and plant products may either have been passed on to the present generation by their ancestors or to be based on experience. Evidently, medicinal plant uses in NBR were spread over many families and there is a great deal of diversity in the species and the way in which they are used. It is quite interesting that the family Euphorbiaceae had more medicinal plants. Mutchnick and Mc Carthy (1997) and Milliken and Albert (1997) also made similar observation in Guatemala and Brazil respectively. Other families that have more medicinal plants include Fabaceae, Asclepiadaceae, Caesalpiniaceae and Solanaceae. These families are known to be useful since ancient times (Banerji 1980; Shah 1990; Jain 1991). These important families that contain many medicinally useful species should be carefully studied, with the aim of managing and perhaps domesticating. Although this may be taken as a pointer to the most pharmacologically active families in the NBR, it is important to bear in mind the relative sizes and diversities of those families, which will clearly have an influence upon their representation. However, clear disparities between family size and 'family use value' have been demonstrated for medicinal plants in Peru by Phillips and Gentry (1993a & b).

Leaves and underground parts were the most frequently used plant parts among the tribals in the NBR. Anon. (1997) reported that leaves and

underground parts were the commonly used plant parts in south India. Diallo *et al* (1996) and Samvatsar and Diwanji (1999) also made similar observation in West Africa and Madhya Pradesh, India respectively. Basically leaves are used because they are readily available, easily collected, easy to process, and as the main centre of photosynthetic metabolism one finds high levels of secondary metabolites. As for roots, they act as storage organ for secondary metabolites. In NBR, conventionally the tribals use medicinal plants for their own use but in the recent past, the practice has become more commercial leading to over exploitation of medicinal plants. Browder (1992) cites many examples from South America that medicinal plants used primarily by local communities are being depleted by unsustainable use. Data on density, population structure and regeneration of medicinal plants is required for the effective utilization of these invaluable resources.

The present study showed that plants used to treat digestive disorders were the most consistently used. Similar observation was made by various authors (Pushpangadan and Atal 1984; Johns and Kimanani 1991; Diallo *et al* 1996). This may suggest a high occurrence of gastrointestinal disorders among the tribals of NBR.

3.4.2. Preparation of medicine

Plant parts were prepared as decoctions, pastes, juices and powders. The addition of pepper was recommended in many preparations in the belief that it will enhance the efficacy of the drugs. Mostly preference was given to drugs prepared from fresh plants collected from wild. Medicinal plants are administered

either singly or in combination with other plants, presumably because the mixture has a synergistic effect. At times a single plant species is used for treating more than one ailment, while single ailment is treated by several species. In such instances, it is difficult to assess the effective role of a particular plant species. Only phytochemical studies and clinical trials can confirm the efficacy of a particular species in treating the disease.

A single medicinal plant was often used for treating more than one ailment (Eg. *Terminalia chebula, Cassia occidentalis, Glycosmis arborea* and *Homonoia riparia*). This is common in many traditional systems. For example in Sáo Tomé *Trema guineensis* is used against venereal disease, diarrhoea and prenatal pain (Sequeira 1994). However, it is known that the activities of different chemical constituents are enhanced by different factors, such as preparation, dosage and part used (Iwu 1993).

3.4.3. Commonly used medicinal plants

The ten most commonly used medicinal plants among the Irulas were *Glycosmis arborea*, *Helicteres isora*, *Cyclea peltata*, *Hemidesmus indicus*, *Sida acuta*, *Toddalia asiatica*, *Clerodendrum serratum*, *Dalbergia latifolia*, *Plumbago zeylanica* and *Thespesia lampas*. Ethnomedicinal uses of these plants have been well documented (Jain 1991; Jain and De Filipps 1991) and it reflects the therapeutic value of these plants. This has important implications for any conservation or management measures to be undertaken. As most of these species are highly adaptive, they can be grown even in kitchen gardens.

3.4.4. Sources of medicinal plants

By examining the source of the resource used, an idea could be gained of the existing conflicts between their utilization and conservation needs. During the interviews, the informants were asked where the plant was found and wherever possible, were requested to show the individual plants from which they obtained their material. Using this information with the observation on their habitat, the plants were grouped into three broad categories of source type: those which are cultivated, those occurring in areas subjected to human disturbance and those growing in secondary forests of varying stages of development. It was found that approximately two-thirds of the documented plants came from forest source and a few were cultivated. Thus, most of the plants used for medicinal purposes came from secondary forest areas, which fall inside the reserve. Some medicinal plants were also purchased from the local markets. The present study supports the view that the secondary forests are reservoirs of useful species (Toledo *et al* 1992; Chazdon and Coe 1999).

Market place represent an important centre of ethnobotanical information. The importance of documenting the ethnobotanical information from market place was discussed by Bye and Linares (1983) and Martin (1995). Fruits of *Terminalia chebula* are sold in dried condition while *Myristica dactyloides* and *Fagraea ceylanica* fruits are sold as fresh. This indicate the efficacy of active principles in different condition of the plant. Of the plants introduced into the country, some have evolved secondary medicinal uses such as *Brassica nigrum, Cuminum cyminum, Allium cepa, Chromolaena odorata* and *Mimosa pudica.* Also of importance are spontaneous plants commonly growing near settlements and

disturbed areas, as they are accessible to the human population without requiring cultivation or care. These included plants such as *Sida acuta* (Cuts and Wounds), *Acalypha indica* (Skin diseases) and *Boerhavia diffusa* (Body pain).

3.4.5. Phytochemical screening

Presence of steroids and alkaloids was observed in all the plants screened in the present study. This agrees with the previous findings that they are more common to species of tropical areas (Lewin and York 1978). All the plant extracts gave negative results for the presence of triterpenoids, which may be due to plant/parts screened, which is lacking aromatic plant/parts. Presence of alkaloids, steroids, flavonoids, saponins and tannins were observed whose presence might be attributed to the medicinal properties of plants (Kapoor *et al* 1989; Chhabra *et al* 1984; Gill *et al* 1993). Tannins that are well documented for the astringent, cytotoxic and antineoplastic activities and used in diarrhoea, haemorrhage, wound healing and deep burns. Occurrence of steroids, flavonols and phenols in the genus *Acalypha* was reported by (Chopra *et al* 1992), which is in accordance with our present findings (Appendix. IV). *Acalypha fruticosa* leaves were being used for stomach disorders by the Irulas. It is interesting that Kiritikar and Basu (1987) reported the uses of this plant by the "Vaidyas" in Southern India for stomachache. This suggests the therapeutic activity of the plant. Occurrence of steroids and phenolic compounds was well established in *Callicarpa* spp (Ahmed and Zaman 1973; Chatterjee *et al* 1972; Anjaneyalu *et al* 1977; Singh and Agrawal 1994), which is in accordance with the present findings (Appendix. IV). The literature survey shows genus *Vanilla* to contain polyphenolic compounds (Anon. 1989), which is according to the present findings (Appendix-

III). Detailed study of the polyphenolics may give a chemotaxonomic marker in *Vanilla* species.

From the present study, it is inferred that the biological action may be due to the presence of one or combination of the above secondary metabolites. The active principle can be identified by a detailed phytochemical examination of each group by isolating and identifying the structure of the compounds. It was observed that our findings confirmed earlier screening in related species. The preliminary phytochemical screening of medicinal plants show promising results. Hence, detailed phytochemical examination of each group of secondary metabolites and structure related activity could be attempted in these species. Such studies are of special significance for India, where the medicinal plant wealth is rich and a sizeable rural population still relies on herbal medicine for primary health care.

The study revealed that there is enormous ethnomedicinal plant diversity in NBR. The formulation and standardization of some effective herbal medicine either with single plant or in combination with other plants with appropriate dosage for its sustainable use should be encouraged. The data on ethnobotanical plants will serve as a useful tool to prepare development and action plant to herbal drug industry for improving and uplifting the life and economy of the tribals of this region. It is therefore, imperative that the traditional knowledge regarding the uses of plants in medicine from ethnobotanically unexplored and under explored areas should be documented systematically

before it is lost along with the dwindling traditional culture and natural resources of such areas due to rapid urbanization and industrialization.

3.5. SUMMARY

The objectives of the study were to document the ethnomedicinal knowledge of under explored tribal groups in the NBR and to initiate preliminary phytochemical screening of selected ethnomedicinal plants.

1) Ethnomedicinal information was collected from Irula, Kurumba, Kattunaickan and Muduga of Nilgiri Biosphere Reserve. In total 188 ethnomedicinal plants belonging to 72 families were recorded. Species of Euphorbiaceae family were consistently used as ethnomedicine.

2) Utilization of underground parts (roots, rhizome, tuber and bulb, 32%) and leaves (31%) to treat various ailments were of common practice among the tribals of NBR. Plants used as gastrointestinal remedies were the most consistently used by the tribals.

3) Medicinal plants are administered either singly or in combination with other plants, presumably because the mixture has a synergistic effect. At times a single plant species is used for treating more than one ailment, while single ailment is treated by several species. In such instances, it is difficult to assess the effective role of a particular plant species. Only phytochemical studies and clinical trials can confirm the efficacy of a particular species in treating the disease.

4) *Glycosmis arborea*, *Helicteres isora*, *Cyclea peltata*, *Hemidesmus indicus*, *Sida acuta*, *Toddalia asiatica*, *Clerodendrum serratum*, *Dalbergia latifolia*, *Plumbago zeylanica* and *Thespesia lampas* were the ten most commonly used medicinal plants among the Irulas of Attappady and Coimbatore Forest Division. As most of these species are highly adaptive, they can be grown even in kitchen gardens.

5) Four medicinal plants were screened for the presence / absence of secondary metabolites. Steroids and alkaloids were present in all the plants screened. Flavonoids and tannin gave positive results in all the plants except in *Acalypha fruticosa*. Presence of saponin was detected in all the plants screened except in *Vanilla walkeriae*. The preliminary phytochemical screening of medicinal plants show promising results. Hence, detailed phytochemical examination of each group of secondary metabolites and structure related activity could be attempted in these species.

CHAPTER IV

STATUS AND DISTRIBUTION OF MEDICINAL PLANTS

4.1. INTRODUCTION

Habitat degradation and commercial harvesting seem to be the factors that concern the conservation of medicinal plants. In recent times, continuous and often indiscriminate collection and deforestation activities from diverse ecosystems, coupled with destruction of natural habitats have resulted in irreplaceable loss of valuable genetic diversity. Hence, it is imperative that before we stand to lose these invaluable economic resource, we need to assess the status, distribution and regeneration of medicinal plants. Although, ethnobotanical knowledge of the tribals in India was documented by several authors (Janaki Ammal 1956; Nagendra Prasad and Abraham 1984; Pushpangadan and Atal 1986; Pushpangadan *et al* 1988; Jain 1991; Anon. 1994; Gaud and Pullaiah 1996), quantitative data on density and regeneration of medicinal plants (Prasad and Pandey 1987; Pandey and Shrivastava 1989; Shanker and Joshi 1990; Jashi *et al* 1990) are scanty.

Although, phytosociological studies carried out in different forest plant communities (George and Varghese 1984; Sharma *et al* 1986; Manilal *et al* 1986, 1989; Singh *et al* 1988; Sukumar *et al* 1992) showed the status of some plant species in the NBR, the present status of medicinal plants in different habitats of NBR is lacking. Therefore, an attempt was made to assess the status of medicinal plants in

various habitats of NBR. An effort has also been made to compare the abundance of medicinal plants in disturbed and least disturbed habitats. The objectives of the study were;

i) to examine the status and distribution of medicinal plants in various habitats of NBR and

ii) to assess the regeneration status of medicinal plants in the NBR.

4.1.1. Study sites

Study sites were selected after reconnaissance surveys in the NBR. Moist deciduous and dry deciduous forests in Muthanga Range of Wayanad WLS, dry deciduous forests in Bandipur NP, riverine forests in Coimbatore Forest Division (CFD) and Attappady Reserve Forest (ARF) and teak plantations in Mudumalai WLS were selected for sampling (Figure 2.1). These areas form an ideal unit to examine the status of medicinal plants. The tribals in these areas have retained their traditional system of medicine; moreover, medicinal plants are being collected in large scale to meet the demands of local ayurvedic and commercial demands. Therefore, to know the resource base for the future extraction, the above sites were selected for sampling.

4.2. METHODS AND ANALYSES

4.2.1. Density and distribution of medicinal plants

The vegetation in each site was sampled in different strata viz., trees (GBH≥20 cm), shrubs (>1m height), herbs (<1m height), seedlings (<10 cm GBH)

and saplings (10 - 19 cm GBH). Density and distribution of medicinal plants were studied using 0.1 ha (50 x 20 m) quadrat. Twenty 0.1 ha. quadrats were laid in each habitat. In each 0.1 ha. quadrat, all woody vegetation ≥ 20 cm Girth at Breast Height (GBH) were enumerated. GBH of trees was measured using a measuring tape at 1.3 m above ground level. Four 5 x 5 m quadrats were laid within the 0.1 ha. quadrat and were sampled for number of individuals of shrub and climber species and their percentage cover. Within the 5 x 5 m quadrat, four 1 x 1 m quadrat were laid at random. Number of individuals of each herb species and their percentage cover were noted.

Impact of human interference on the status, distribution and regeneration of medicinal plant populations were assessed in dry deciduous and riverine forests. Two hectares were sampled in each habitat. Quantitative data from these habitats were collected as discussed above.

The vegetation data was analysed for density, abundance and frequency following Curtis and Mc Intosh (1950, Box 4.1). The Importance Value Index (IVI), an integrated measure of relative frequency, relative density and relative dominance, was derived following Curtis (1959). For herbs and shrubs, IVI was calculated by adding relative frequency and relative density. Species diversity index was determined by the formula of Shannon and Weiner (1963):

$$H' = - \sum p_i \log_{10} (p_i)$$

Where, pi = is the proportions of species in the samples.

Apart from 188 ethnomedicinal plants documented in the present study (Appendix II), density and distribution were calculated for other ethnomedicinal plant species reported from the NBR by earlier workers also (Ragunathan 1976; Anon.1980; Bhatt *et al* 1980; Abraham 1981, 1990; Pushpangadan and Atal 1984; Sankaranarayanan 1988; Lakshmanan and Sankaranarayanan 1988, 1990; Ramachandran and Maniyan 1989; Rajan and Sethuraman 1991, 1993; Gopalakrishnan and Krishnaprasad 1992; Balasubramanian and Prasad 1996; Mandal and Basu 1996; Hosagoudar and Henry 1996c; Rajan *et al* 1997).

BOX.1. Habitat parameters studied

Habitat parameters	Formulae
Frequency	= Number of quadrats in which species occurs
Relative frequency	= $\frac{\text{Frequency value for a species}}{\text{Total frequency values for all species}} \times 100$
Abundance	= $\frac{\text{Number of individuals}}{\text{Number of quadrats of occurrence}}$
Relative abundance	= $\frac{\text{Abundance}}{\text{total abundance values for all species}} \times 100$
Density	= $\frac{\text{Number of individuals}}{\text{Total number of quadrats}}$
Relative density	= $\frac{\text{Density value for a species}}{\text{Total density for all species}} \times 100$
Basal area	= $\Sigma(Gbh^2/4\Pi)$
Relative dominance	= $\frac{\text{Basal area}}{\text{Sum of all basal area}} \times 100$
Importance value index (IVI)	= Relative frequency + Relative Density + Relative dominance

4.2.2. Size class distribution of medicinal plants

Population structure was analysed at community level and for selected species of medicinal plants. Size class selected for community level ranged from 20 cm GBH to the maximum girth attained. Percentage of individuals in each size class was calculated.

4.2.3. Regeneration of medicinal plants

The natural regeneration of medicinal trees was studied using 5 x 5 m quadrat. Four 5 x 5 m quadrat were laid within the 0.1 ha. quadrat, thus eighty 5 x 5 m quadrat were laid in each of the above habitats and the plantations. Data on number of individuals of each species at two successive stages of development, i.e., seedlings (<10 cm GBH) and saplings (10 - 19 cm GBH) were recorded. Density of seedlings and saplings per hectare for each species was calculated. The ratio between the number of individuals of mature trees to number of individuals of seedlings and saplings was also calculated for each species. Plant species were identified using Gamble (1957) and other local floras. Plant nomenclature was followed using Nair and Henry (1983) and Henry *et al* (1987 and 1989).

4.2.4. Statistical analyses

Data on habitat parameters were analysed using mostly non-parametric statistics (Siegel and Castellan 1988). Differences between two independent samples were tested using Mann-Whitney U test (M-W); the differences among more than two samples were tested using Kruskal-Wallis test (K-W). The significance level decided

was 0.05 two tailed. Most of the analyses were done using SPSS package (Norusis 1990).

4.3. RESULTS

4.3.1. Phytosociology of medicinal plants in the NBR

4.3.1.1. Species diversity index (H')

Tree species diversity index showed significant difference (K-W test $x^2 = 7.54$, $P = 0.05$) among the habitats sampled, it was highest in the moist deciduous and lowest in the old teak plantations (Table 4.1). Shrub species diversity index also showed significant difference (K-W test $x^2 = 27.8$, $P < 0.001$) among the habitats. It was highest in the riverine forests (Coimbatore Forest Division) and lowest in the riverine forests (Attappady Reserve Forest). However, herb species diversity index showed no significant difference among the habitats. Shannon-Weiner diversity index ranged from 0.60 to 2.95 for trees, 1.64 to 2.66 for shrubs and 3.01 to 3.38 for herbs.

4.3.1.2. Species richness

Total species richness was highest in the moist deciduous forests and lowest in the teak plantations. Ethnomedicinal species richness varied between 39 and 69 and it was highest in the moist deciduous forests (Table 4.2). However, percentage of medicinal plants was highest in the riverine forests followed by dry deciduous forests (WWLS).

4.3.1.3. Density

Density of medicinal trees was significantly (K-W test x^2 = 9.1, P= 0.003) higher in the dry deciduous forests of Bandipur NP (Table 4.3.). Density of medicinal shrubs also showed significant difference (K-W test x^2 = 29.4, P<0.001) among the habitats and it was highest in the riverine forests of Attappady (ARF). However, density of medicinal herbs showed no significant difference among the habitats.

Table 4.1. Species diversity index in various habitats of the NBR.

Vegetation type	Species diversity index (H')		
	Trees	Shrubs	Herbs
Moist deciduous	2.95	2.31	3.38
Dry deciduous (WWLS)	2.12	1.74	3.13
Dry deciduous (BNP)	2.40	2.00	3.23
Riverine forests (CFD)	2.57	2.66	3.21
Riverine forests (ARF)	1.32	1.64	3.15
Teak plantations	0.60	2.31	3.01
Kruskal-Wallis test	Sig.	Sig.	n.s

WWLS - Wayanad Wildlife Sanctuary; BNP - Bandipur National Park; CFD - Coimbatore Forest Division; ARF - Attappady Reserve Forest.

Table 4.2. Species richness of plants in various habitats of the NBR.

Vegetation type	Species richness				
	Total	Medicinal plants		Other plants	
		No.	%	No.	%
Moist deciduous	143	69	48	74	52
Dry deciduous (WWLS)	113	62	55	51	45
Dry deciduous (BNP)	127	65	51	62	49
Riverine forests (CFD)	106	61	58	45	42
Riverine forests (ARF)	88	49	60	36	40
Teak plantations	80	39	49	40	51

Table 4.3. Density of plants recorded in various habitats of the NBR.

Habitats and Habit	Density of plants		
	Total	Medicinal plants	Others
Moist deciduous			
Trees	42.8 ± 2.82	26.5 ± 2.30	16.3 ± 1.70
Shrubs	16.9 ± 3.00	8.45 ± 2.40	8.5 ± 3.80
Herbs	17.7 ± 1.22	6.3 ± 0.60	11.4 ± 1.48
Dry deciduous - WWLS			
Trees	49.1 ± 3.60	35.5 ± 3.98	13.6 ± 1.09
Shrubs	18.2 ± 1.69	14.3 ± 1.67	3.97 ± 0.60
Herbs	14.8 ± 0.78	6.6 ± 0.49	8.24 ± 0.71
Dry deciduous - BNP			
Trees	53.6 ± 4.06	41.0 ± 4.3	12.6 ± 1.20
Shrubs	27.8 ± 1.73	14.7 ± 1.38	13.0 ± 1.37
Herbs	18.3 ± 1.24	6.8 ± 0.61	11.52 ± 1.49
Riverine forests - CFD			
Trees	12.4 ± 1.22	10.6 ± 1.18	1.75 ± 0.27
Shrubs	9.9 ± 1.51	7.5 ± 1.74	2.41 ± 0.36
Herbs	11.8 ± 1.32	7.7 ± 0.76	4.14 ± 1.03
Riverine forests - ARF			
Trees	16.0 ± 1.76	14.8 ± 1.76	1.25 ± 0.46
Shrubs	27.0 ± 2.75	22.8 ± 3.07	4.14 ± 1.14
Herbs	15.7 ± 1.21	7.4 ± 0.88	8.25 ± 1.35
Teak plantations			
Trees	29.3 ± 2.90	28.4 ± 2.89	0.85 ± 0.34
Shrubs	13.3 ± 1.56	9.9 ± 1.39	3.41 ± 0.80
Herbs	6.61 ± 0.76	3.16 ± 0.41	3.48 ± 0.35

Values in table are mean and Standard Error; Density of trees/0.1 ha; Density of shrubs/25m^2; Density of herbs/m^2.

4.3.2. Moist deciduous forests

Two hectares were sampled in the moist deciduous forests of Wayanad WLS, to assess the status of medicinal plants. A total of 143 plant species was recorded, which included 50 trees, 20 shrubs and 73 herb species. Of the 143 species, 69 (48.3%) were used by the tribals for treating various ailments, which included 26 trees, 13 shrubs and 30 herbs. Eight endemic species of peninsular India (Ahmedullah and Nayar 1987), namely *Andrographis neesiana*, *A. serpyllifolia*, *Argyreia cuneata*, *Curcuma pseudomontana*, *Gomphostemma heyneanum*, *Gynura nitida*, *Nervilia aragoana* and *Lagerstroemia microcarpa* used by the tribals of NBR for medicine were recorded from this habitat. Four medicinal plants (*Gloriosa superba*, *Nervilia aragoana*, *Rauwolfia serpentina* and *Schrebera swietenioides*) listed in the red list of medicinal plants of south India (Anon. 1997) and 22 species of commercially exploited medicinal plants were also observed from this habitat.

4.3.2.1. Trees

Of the 50 tree species recorded in this habitat (Appendix V), 52% (26) were used by the tribals for medicinal purposes (Table 4.4). Among the medicinal trees, six were commercially exploited. Number of tree species in individual quadrat ranged from nine to 19 (Mean = 12.6, Sd = 2.89). Tree species diversity index (H') in this habitat was 2.95.

Size class distribution of individuals of all trees (GBH ≥20 cm) showed L-shaped distribution and it showed higher number of individuals in the lower class

indicating good recruitment (Figure 4.1). However, size class distribution of individuals of three NTFP species (*Phyllanthus emblica, Terminalia bellirica* and *T. chebula*) showed reduction of individuals in the lower class that indicate poor recruitment of these species (Figure 4.2). GBH of all trees above 20 cm varied from 20 to 410 (average 85.8).

Tree (GBH ≥ 20 cm) density in this habitat was 428/ha. of which 62% was medicinal trees. Among the medicinal tree species, *Anogeissus latifolia* (56/ha.) exhibited the highest density followed by *Kydia calycina* (50) and *Tectona grandis* (30). When put together, these three species, comprised 32% of the total tree species. Density of *Lagerstroemia microcarpa* (Plate 5a), an endemic medicinal tree species was 7/ha (Table 4.4). Density of *Cassia fistula* (Plate 5b), a commercially exploited medicinal tree species was 9/ha. Three medicinal tree species namely *Buchanania axillaris, Shorea roxburghii* and *Terminalia chebula* were represented by single individual each. Three major NTFP species (*Phyllanthus emblica, Terminalia bellirica* and *T. chebula*) comprised about 6% of the total tree density.

Total basal area of tree species (GBH ≥ 20 cm) was 36.179 m^2/ha. Medicinal trees comprised about 62% (22.3m^2/ ha.) of the total basal area. The three most common medicinal tree species, namely *Anogeissus latifolia, Kydia calycina* and *Tectona grandis* make up 32% of the total basal area. Among the medicinal trees, *Tectona grandis* had the highest basal area (73460 cm^2/ha) followed by *Anogeissus latifolia* (27660) and *Schleichera oleosa* (21790). Three major NTFP species

comprised only 5% of the total basal area. Importance Value Index of medicinal tree species ranged from 1 to 34 (Table 4.4). There were six species with ≤1 IVI. *Tectona grandis* (34), *Anogeissus latifolia* (27) and *Kydia calycina* (22) were the dominant medicinal tree species in this habitat.

4.3.2.2. Shrubs

Of the 20 shrub species recorded (Appendix VI), 13 (65%) have medicinal uses (Table 4.5). Among the 13 medicinal shrubs, five were commercially exploited. Diversity index (H') of shrub species in this habitat was 2.31.

Total shrub density was 16.75/25m^2. Of which, density of medicinal shrubs was 49% (8.2/25m^2) while density of commercially exploited shrubs was 10% (1.75/25m^2). The highest density was exhibited by *Glycosmis arborea* (2.46/25 m^2) while *Clerodendrum serratum* had the lowest density (0.04). Density of *Argyreia cuneata* and *Gomphostemma heyneanum*, endemic medicinal plants was 0.09 and 0.35/25m^2 respectively. Among the medicinal shrubs, *Helicteres isora* (IVI 19) and *Glycosmis arborea* (IVI 19) were dominant.

4.3.2.3. Herbs

Of the 73 herb species recorded in this habitat (Appendix VII), 30 were used by the tribals for medicine (Table 4.6), which make up 41% of the total herb species recorded from this habitat. Among the 30 medicinal herbs, eleven were commercially exploited. Herb species diversity index was (H') 3.38 in this habitat.

Total herb density was 17.7/m^2 while density of medicinal herbs was 6.3. Among the medicinal herbs, *Curculigo orchioides* had the highest density (1.06/m^2) followed by *Elephantopus scaber* (1.03) while *Alternanthera sessilis* (0.003) and *Phyllanthus virgatus* (0.003) had the lowest density. Density of two endangered medicinal herbs (Anon. 1997), namely *Rauwolfia serpentina* and *Nervilia aragoana* was 0.05 and 0.25/m^2 respectively. These two species are being collected in a large scale by the tribals. The herb community was dominated by *Curculigo orchioides* and *Elephantopus scaber* (Table 4.6).

4.3.2.4. Regeneration

Of the 26 medicinal tree species recorded in this habitat, species such as *Buchanania axillaris, Lagerstroemia parviflora, Mitragyna parvifolia, Semecarpus anacardium, Terminalia chebula* and *T. paniculata* lacked regeneration in the moist deciduous forests. *Schrebera swietenioides*, a red listed medicinal plant of south India (Anon. 1997) also lacked regeneration in this habitat. Twelve species of medicinal trees did not have any saplings and ten species did not have any seedlings. *Naringi crenulata* and *Tamilnadia uliginosa*, which lacked mature individuals in this forest were recorded in the regeneration quadrat.

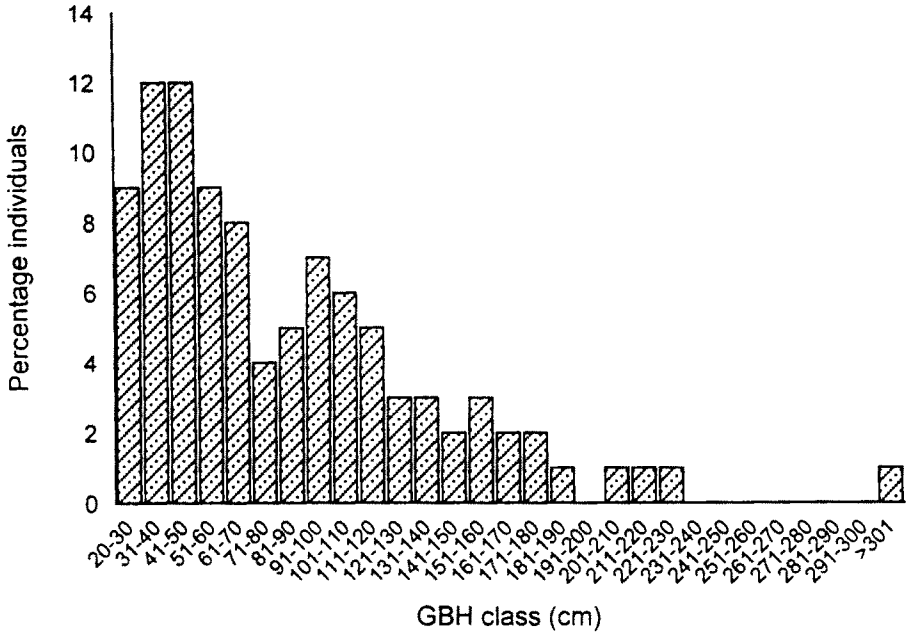


Figure 4.1. Size class distribution of trees (≥20cm GBH) in the moist deciduous forests of Wayanad Wildlife Sanctuary

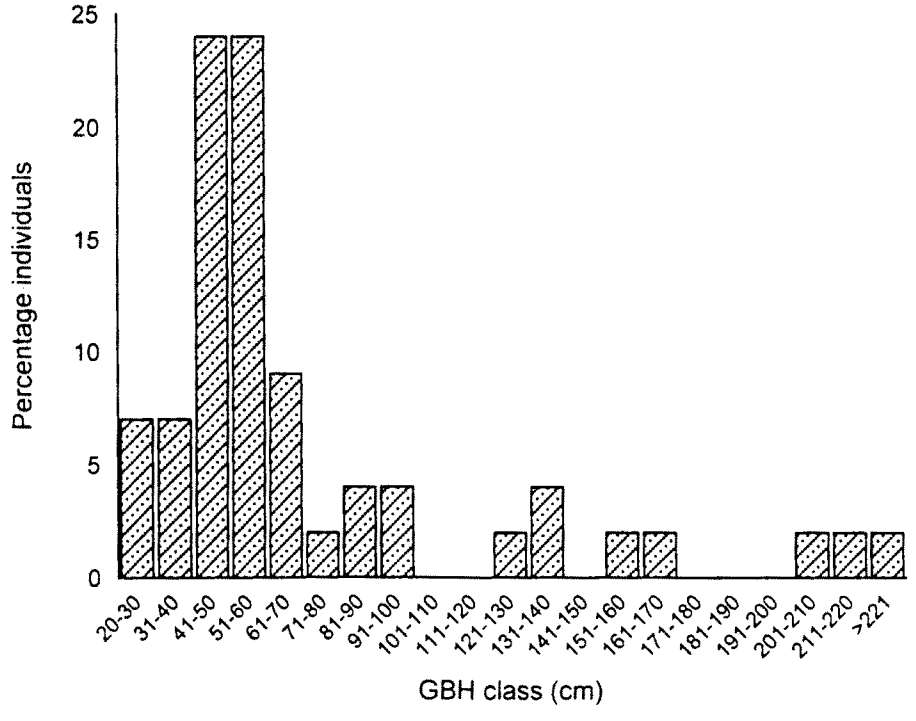


Figure 4.2. Size class distribution of major NTFP trees (*Phyllanthus emblica*, *Terminalia bellirica* and *T. chebula*) in the moist deciduous forests of Wayanad Wildlife Sanctuary

(a)

(b)

Plate 5 a) *Lagerstroemia microcarpa* - a peninsular endemic tree species in the moist deciduous forest.
b) *Cassia fistula* - a commercially exploited tree species in NBR

4.3.2.4.1. Seedlings

Among the medicinal plants, *Randia dumetorum* (510/ha.) had the highest density of seedlings followed by *Kydia calycina* (475) while *Tamilnadia uliginosa* (5/ha) and *Gmelina arborea* (5/ha) had the lowest density of seedlings. Total density of seedlings was 2785/ha. while density of medicinal seedlings was 1785/ha.

4.3.2.4.2. Saplings

Total density of saplings was 1865/ha. while density of medicinal plant saplings was 1275/ha. Among the medicinal plants, *Randia dumetorum* (360/ha) had the highest saplings density followed by *Cassia fistula* (170). Commercially exploited medicinal tree species such as *Phyllanthus emblica, Terminalia bellirica* and *Terminalia chebula* showed poor regeneration. The ratio between the mature trees and seedlings and saplings for these species was 1:7, 1:4 and 1:0 respectively. Among the medicinal trees, *Naringi crenulata*, *Randia dumetorum* and *Syzygium cumini* had good regeneration in the moist deciduous forests. The ratio between the mature trees and seedlings and saplings for these species was 0:165, 1:73 and 1:50 respectively.

Table 4.4. Abundance, density, basal area and IVI of trees in the moist deciduous forests.

Species	Abundance	Density[1]	Basal area[2]	IVI
MEDICINAL TREES				
Anogeissus latifolia	6.9	56	27660	27
Bauhinia racemosa	1.3	3	870	3
Bridelia retusa	2.6	9	6470	7
Buchanania axillaris	2.0	1	730	1
Careya arborea	1.0	2	100	2
Cassia fistula	1.8	9	1900	7
Dalbergia latifolia	1.5	11	6230	10
Gmelina arborea	1.4	4	3330	4
Kydia calycina	7.1	50	15220	22
Lagerstroemia microcarpa	1.6	7	10170	8
Lagerstroemia parviflora	2.0	2	280	1
Lannea coromandelica	2.3	5	2430	3
Mitragyna parvifolia	1.5	2	1120	1
Phyllanthus emblica	2.8	17	4270	10
Pterocarpus marsupium	1.3	8	12680	10
Radermachera xylocarpa	1.4	4	1680	3
Randia dumetorum	3.0	12	4020	7
Schleichera oleosa	1.8	5	21790	9
Schrebera swietenioides	2.2	6	3130	4
Semecarpus anacardium	2.5	8	4050	5
Shorea roxburghii	1.0	1	20	1
Syzygium cumini	3.0	2	2480	1
Tectona grandis	3.8	30	73460	34
Terminalia bellirica	1.3	7	13980	9
Terminalia chebula	1.0	1	910	1
Terminalia paniculata	6.0	3	4030	2
OTHER TREES *	24 Species	163	138780	108
TOTAL	50 Species	428	361790	300
Species diversity index (H')	2.95			

Density[1] denotes the number of individuals per ha; Basal area[2] in cm^2/ha.; IVI - Importance Value Index;
* Other trees are given in Appendix V.

Table 4.5. Frequency, abundance, density and IVI of shrubs in the moist deciduous forests.

Species	Frequency	Abundance	Density[1]	IVI
MEDICINAL SHRUBS				
Argyreia cuneata	3	2.33	0.09	2
Asparagus racemosus	5	2.80	0.18	3
Chromolaena odorata	22	3.00	0.83	15
Clerodendrum serratum	3	1.00	0.04	2
Flemingia strobilifera	19	6.16	1.46	18
Gloriosa superba	2	2.00	0.05	1
Glycosmis arborea	8	24.63	2.46	19
Gomphostemma heyneanum	5	5.60	0.35	4
Grewia hirsuta	3	1.33	0.05	2
Helicteres isora	24	4.13	1.24	19
Lantana camara	13	6.62	1.08	12
Naravelia zeylanica	12	1.58	0.24	7
Solanum anguivi	1	14.00	0.18	2
OTHER SHRUBS *	7 Species		8.50	94
TOTAL	20 Species		16.75	200
Species diversity index (H')	2.31			

Density[1] denotes the number of individuals per $25m^2$; IVI - Importance Value Index; * Other shrubs are given in Appendix VI.

Table 4.6. Frequency, abundance, density and IVI of herbs in the moist deciduous forests.

Species	Frequency	Abundance	Density[1]	IVI
MEDICINAL HERBS				
Adiantum lunulatum	3	2.67	0.030	0.3
Ageratum conyzoides	37	2.73	0.320	4.3
Alternanthera sessilis	1	1.00	0.003	0.1
Andrographis neesiana	2	2.00	0.010	0.2
Andrographis serpyllifolia	4	1.75	0.020	0.4
Biophytum sensitivum	49	4.49	0.690	7.2
Cassia occidentalis	3	2.67	0.030	0.3
Centella asiatica	2	1.00	0.010	0.2
Costus speciosus	7	1.86	0.040	0.7
Curculigo orchioides	84	4.05	1.060	11.7
Curcuma aromatica	7	3.43	0.080	0.9
Curcuma longa	46	4.17	0.600	6.5
Curcuma pseudomontana	73	3.48	0.790	9.4
Cyclea peltata	14	1.79	0.080	1.4
Desmodium triflorum	17	1.94	0.100	1.7
Desmodium velutinum	12	2.50	0.090	1.3
Dioscorea pentaphylla	1	3.00	0.010	0.1
Elephantopus scaber	56	5.91	1.030	9.6
Gynura nitida	13	2.38	0.100	1.4
Hemidesmus indicus	8	2.38	0.060	0.9
Mimosa pudica	17	3.94	0.210	2.3
Nervilia aragoana	34	2.38	0.250	3.7
Oxalis corniculata	1	2.00	0.010	0.1
Phyllanthus virgatus	1	1.00	0.003	0.1
Pimpinella monoica	15	1.67	0.080	1.5
Rauwolfia serpentina	11	1.45	0.050	1.0
Sida acuta	41	1.90	0.240	4.2
Sida rhombifolia	21	2.19	0.140	2.2
Thespesia lampas	17	2.12	0.110	1.8
Urena lobata	17	1.29	0.070	1.5
OTHER HERBS*	43 Species		11.380	123.0
TOTAL	73 Species		17.700	200.0
Species diversity index (H')	3.38			

Density[1] denotes the number of individuals per m^2; IVI-Importance Value Index;
* Other herbs are given in Appendix VII.

Table 4.7. Regeneration of trees in the moist deciduous forests.

Species	Density/ha.			
	Mature trees	Seedlings	Saplings	Ratio[1]
MEDICINAL PLANTS				
Anogeissus latifolia	56	15	45	1:1
Bauhinia racemosa	3	70	-	1:23
Bridelia retusa	9	20	15	1:4
Buchanania axillaris	1	-	-	1:0
Careya arborea	2	30	-	1:15
Cassia fistula	9	135	170	1:34
Dalbergia latifolia	11	220	60	1:26
Gmelina arborea	4	5	-	1:1
Kydia calycina	50	475	135	1:12
Lagerstroemia microcarpa	7	40	-	1:5
Lagerstroemia parviflora	2	-	-	1:0
Lannea coromandelica	5	-	15	1:3
Mitragyna parvifolia	2	-	-	1:0
Naringi crenulata	-	40	125	0:165
Phyllanthus emblica	17	80	30	1:6
Pterocarpus marsupium	8	60	85	1:18
Radermachera xylocarpa	4	-	20	1:5
Randia dumetorum	12	510	360	1:73
Schleichera oleosa	5	45	40	1:17
Schrebera swietenioides	6	-	-	1:0
Semecarpus anacardium	8	-	-	1:0
Shorea roxburghii	1	10	20	1:30
Syzygium cumini	2	-	75	1:32
Tamilnadia uliginosa	-	5	-	0:5
Tectona grandis	30	15	65	1:3
Terminalia bellirica	7	10	15	1:3
Terminalia chebula	1	-	-	1:0
Terminalia paniculata	3	-	-	1:0
OTHER PLANTS*	166	1000	590	1:10
TOTAL	420	2785	1865	1:11
Species diversity index (H')	2.95	2.80	2.72	

Ratio[1] between the number of mature trees to number of seedlings and saplings; Other trees are given in Appendix VIII.

4.3.3. Dry deciduous forests

Status of medicinal plants in dry deciduous forests was assessed in Mulehole range of Bandipur NP and adjacent Muthanga range of Wayanad WLS. Two hectares were sampled in each of the habitats. There is no human settlement in the Bandipur NP and collection of NTFP's is banned, moreover human disturbance was negligible in the Bandipur NP. In the Wayanad WLS, collection of NTFP's are allowed and human disturbance was higher because of the presence of large number of settlements inside the forests. In addition to that the forests in the Wayanad WLS were subjected to grazing. A total of 127 species (38 trees, 15 shrubs and 74 herbs) was recorded in the Bandipur NP (Least disturbed) while 113 species (35 trees, 17 shrubs and 61 herbs) were recorded in the Wayanad WLS (Disturbed).

4.3.3.1. Trees

Total number of tree species was higher in the Bandipur NP (38) than in the Wayanad WLS (35). Similarly, number of medicinal tree species was also higher in the Bandipur NP (25) than in the Wayanad WLS (23; Table 4.8). Nevertheless, the percentage of medicinal tree species was same between the Bandipur NP (65.78%) and Wayanad WLS (65.71%). The number of tree species in individual quadrat ranged from 9 to 17 (Mean =11.6, Sd = 2.7) in the Bandipur NP and from 6 to 16 (Mean = 9.6, Sd = 2.6) in Wayanad WLS. Shannon-Weiner's species diversity index showed no significant difference between the Bandipur NP (2.40) and Wayanad WLS (2.12). The evenness or homogeneity index, the measure of observed diversity as

a proportion of the maximum possible diversity (Zar 1984), was more for Bandipur NP (66%) than in the Wayanad WLS (60%).

Size class distribution of individuals of all species, showed normal L - shaped distribution in both the areas (Figure 4.3). The size class distributions were not significantly different between these areas. However, the percentage of individuals in the lower size classes was higher in the Bandipur NP than in the Wayanad WLS, which indicate new recruitments.

The size class distribution of individuals of only NTFP species such as *Phyllanthus emblica* (Plate 6a), *Terminalia bellirica* and *Terminalia chebula* put together showed greater proportion of individuals in the lower size classes in the Bandipur NP than that of Wayanad WLS (Figure 4.4). It reflects the poor recruitment of NTFP species in the Wayanad WLS. However, the difference was not statistically significant.

There was no significant difference in total tree density between the Bandipur NP (536/ha) and Wayanad WLS (490/ha). Similarly, medicinal tree density also showed no significant difference between these habitats. *Anogeissus latifolia* was the most common species both in the Bandipur NP (161/ha) and Wayanad WLS (185/ha) followed by *Kydia calycina* in the Bandipur NP (67/ha) and *Tectona grandis* in the Wayanad WLS (55/ha; Table 4.8). Five species in the Bandipur NP and six species in the Wayanad WLS had representation by only a single individual. *Lagerstroemia*

microcarpa, an endemic medicinal plant was recorded only in the Bandipur NP. *Phyllanthus emblica* and *Terminalia chebula*, fruits of both are collected in large quantities, had higher density in the Bandipur NP than the Wayanad WLS. However, the difference was not significant. *Terminalia bellirica* had greater density in the Wayanad WLS than in Bandipur NP however, the difference was not significant.

Total basal area showed no difference between the Bandipur NP (27.6 m^2/ha) and Wayanad WLS (27.2 m^2/ha). Although, the basal area of medicinal tree species (GBH $\geq$ 20 cm) was higher in the Bandipur NP (20.3m^2/ha) than the Wayanad WLS (17.6 m^2/ha; Figure 4.5.), it was not significant. Twelve medicinal tree species had higher basal area in the Bandipur NP than in the Wayanad WLS while ten species had higher basal area in the Wayanad WLS than the Bandipur NP.

Among medicinal tree species, *Anogeissus latifolia* (IVI 59 in the BNP, 67 in WWLS) and *Tectona grandis* (IVI 39 in BNP, 43 in WWLS) were the dominant trees both in the Bandipur NP and Wayanad WLS. NTFP species such as *Phyllanthus emblica, Terminalia bellirica* and *T.chebula* had higher importance value index in the Bandipur NP than in Wayanad WLS (Table 4.8). However, the difference was not statistically different. There were five species with 1$\leq$ IVI each in the Bandipur NP and Wayanad WLS.

Although, species such as *Anogeissus latifolia, Kydia calycina, Phyllanthus emblica* and *Tectona grandis* occured in dry deciduous (Bandipur NP and Wayanad

WLS) and moist deciduous forests, Importance Value Index of *P. emblica* and *T.grandis* showed no significant difference among these habitats. While Importance Value Index of *A. latifolia* and *K. calycina* showed significant difference (K-W X^2 = 22.7, P <0.001; K-W X^2 = 10, P=0.006) among these habitats (Table 4.8a).

4.3.3.2. Shrubs

Number of medicinal shrub species was higher in the Wayanad WLS (11) than in Bandipur NP (9). Shrub species diversity index (H') was significantly (M-W test U= 96, P= 0.005) greater in the Bandipur NP (H' = 2.00) than in the Wayanad WLS (H'=1.74). Total shrub density was also significantly (M-W test U=76.5, P= 0.001) higher in the Bandipur NP (27.88/25m^2) than in the Wayanad WLS (18.23/25m^2). However, medicinal shrubs density showed no significant difference between the Bandipur NP (14.7) and Wayanad WLS (14.3). *Leea indica* was the most common medicinal shrub species in both the habitats. Although, the density of *Gomphostemma heyneanum*, an endemic medicinal plant was higher in the Bandipur NP than in the Wayanad WLS, the difference was not significant. Commercially exploited shrubs such as *Asparagus racemosus*, *Clerodendrum serratum* and *Helicteres isora* also showed no significant difference between these habitats. *Leea indica* was the dominant shrub species both in the Wayanad WLS and in Bandipur NP (Table 4.9). IVI of *Chromolaena odorata*, an exotic weed showed significant difference (M-W test U = 41 P=0.006) between these habitats, it was higher in the Wayanad WLS than in Bandipur NP.

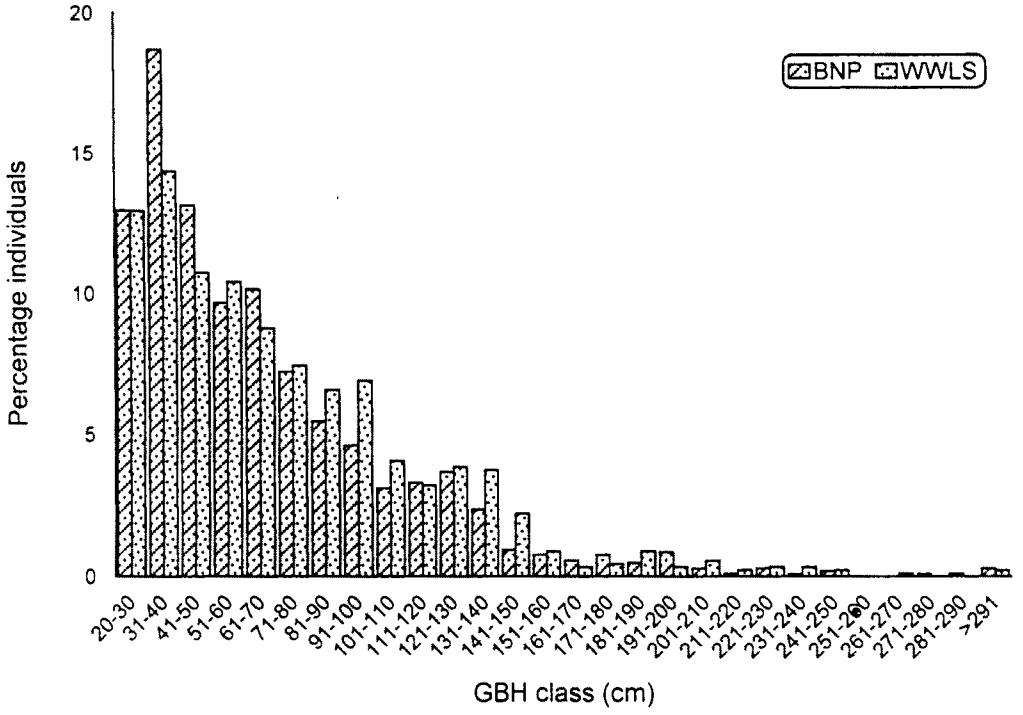


Figure 4.3. Size class distribution of trees in the dry deciduous forests of Bandipur National Park and Wayanad Wildlife Sanctuary

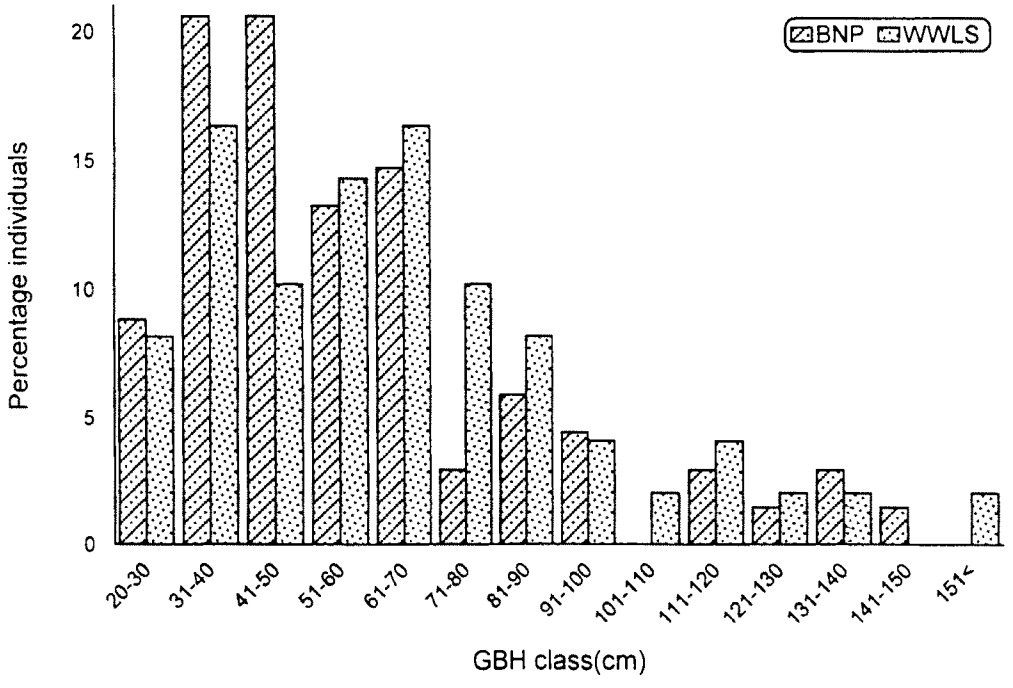


Figure 4.4. Size class distribution of major NTFP tree species (*Phyllanthus emblica, Terminalia bellirica* and *T.chebula*) in the dry deciduous forests of Bandipur National Park and Wayanad Wildlife Sanctuary

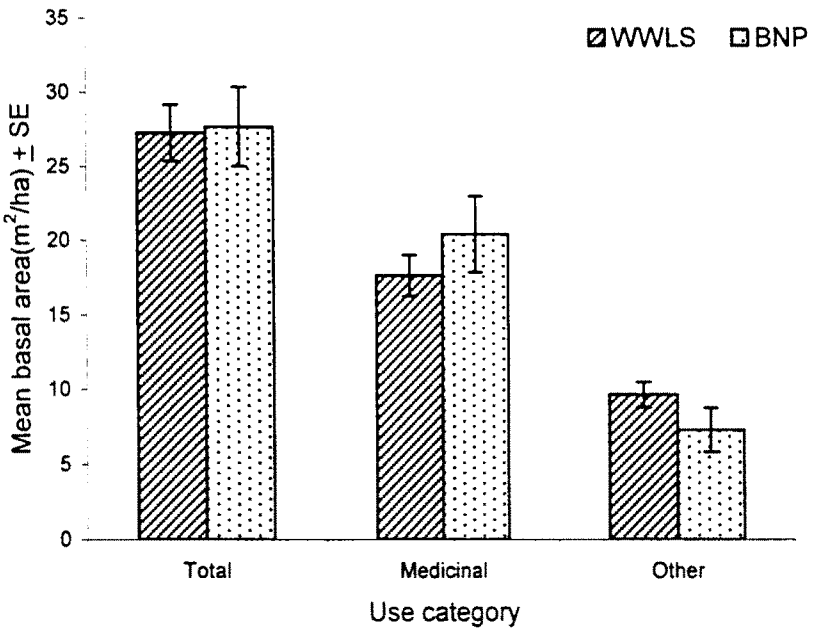


Figure 4.5. Mean basal area (m^2/ha) of trees ± SE in the dry deciduous forests of Wayanad Wildlife Sanctuary and Bandipur National Park

4.3.3.3. Herbs

Total number of herb species was higher in the Bandipur NP (74) than in Wayanad WLS (61). The same trend was observed for medicinal herb species also (31 in the Bandipur NP and 28 in the Wayanad WLS). Herb species diversity index showed no significant difference between these habitats.

Total herb and medicinal herbs density showed no significant difference between the Wayanad WLS and Bandipur NP. However, density of some of the commercially exploited medicinal herbs such as *Biophytum sensitivum, Cyclea peltata, Desmodium velutinum, Hemidesmus indicus* (Plate 6b), *Rauwolfia serpentina* and *Sida rhombifolia* showed significant difference (M-W test U = 2, P=0.036; M-W test U = 7, P=0.026; M-W test U = 4, P=0.024; M-W test U = 2, P= 0.015; M-W test U <0, P= 0.039; M-W test U = 36.5, P= 0.041 respectively) between these habitats. However, endemic medicinal herbs such as *Andrographis neesiana*, *A. serpyllifolia*, *Curcuma pseudomontana* and *Nervilia aragoana* showed no significant difference between these habitats. But, density of *Gynura nitida* was significantly (M-W test U = 9, P= 0.020) higher in the Bandipur NP than in the Wayanad WLS.

4.3.3.4. Regeneration

Of the 25 medicinal tree species recorded in the Bandipur NP, seven species such as *Bauhinia racemosa, Buchanania axillaris, Gmelina arborea, Lagerstroemia microcarpa, Lannea coromandelica, Schleichera oleosa* and *Terminalia bellirica*

lacked regeneration. Of the 23 medicinal tree species recorded in the Wayanad WLS, eight species such as *Bridelia retusa, Careya arborea, Gmelina arborea, Lagerstroemia parviflora, Schrebera swietenioides, Semecarpus anacardium, Tamilnadia uliginosa* and *Terminalia chebula* lacked regeneration. *Gmelina arborea*, a commercially exploited medicinal tree lacked regeneration in both the habitats.

Total seedling and medicinal seedlings density was significantly (M-W test U = 23, $P < 0.001$; M-W test U = 25.5, $P < 0.001$ respectively) higher in the Bandipur NP than in Wayanad WLS (Table 4.11.). However, total saplings and medicinal saplings density showed no significant difference between these areas. Seedlings density of *Phyllanthus emblica* showed significant difference (M-W test U = 104, P= 0.004) between these habitats while saplings density showed no significant difference between these habitats.

Among the medicinal plant seedlings, *Kydia calycina* exhibited the highest density both in the Bandipur NP (585/ha) and in the Wayanad WLS (295). *Shorea roxburghii* exhibited highest density among the medicinal plant saplings in the Bandipur NP (280) and *Dalbergia latifolia* (200) in the Wayanad WLS. *Shorea roxburghii* exhibited good regeneration in the Bandipur NP where the ratio between the number of mature trees and number of seedlings and saplings was the highest (1:560) while *Randia dumetorum* exhibited the highest ratio (1:153) in the Wayanad WLS. Regeneration was relatively poor for other medicinal tree species in both the places.

(a)

(b)

Plate 6 a) *Phyllanthus emblica* - a commercially exploited tree species in NBR
b) *Hemidesmus indicus* - a commercially exploited climbing herb in NBR

Regeneration of NTFP species such as *Phyllanthus emblica* and *Terminalia chebula* was higher in the Bandipur NP where the ratio between the mature tree and seedlings and saplings was higher (1:21 and 1: 5 respectively) than in Wayanad WLS (1:6 and 1:0 respectively). However, regeneration of *Terminalia bellirica* another NTFP species was higher in the Wayanad WLS (1:3) than in Bandipur NP (1:0).

Table 4.8. Abundance, density, basal area and IVI of medicinal trees in the dry deciduous forests.

Species	Bandipur National Park				Wayanad Wildlife Sanctuary			
	Abundance	Density	Basal area	IVI	Abundance	Density	Basal area	IVI
MEDICINAL TREES								
Anogeissus latifolia	16.1	161.0	56000	59	18.0	185.0	51720	67
Bauhinia racemosa	1.0	1.5	360	2	2.6	3.0	310	2
Bridelia retusa	1.3	2.0	310	2	1.0	2.0	650	3
Buchanania axillaris	1.0	3.0	1700	4	1.0	1.0	80	1
Careya arborea	1.6	4.0	450	3	1.0	1.0	100	1
Cassia fistula	2.0	2.0	250	1	1.6	7.0	1050	6
Dalbergia latifolia	2.1	9.5	9430	9	1.9	15.0	9960	14
Ficus religiosa	-	-	-	-	1.0	1.0	570	1
Gmelina arborea	1.0	1.0	40	1	2.0	1.0	70	1
Kydia calycina	8.9	66.5	11680	23	3.4	9.0	5720	6
Lagerstroemia microcarpa	3.7	5.5	6180	5	-	-	-	-
Lagerstroemia parviflora	3.1	25.0	3410	13	3.5	14.0	3630	8
Lannea coromandelica	4.0	4.0	2040	2	1.5	9.0	3050	9
Phyllanthus emblica	3.3	29.5	8390	16	3.4	24.0	7040	14
Pterocarpus marsupium	1.4	9.0	12250	12	1.7	10.0	15560	13
Radermachera xylocarpa	1.0	1.0	370	1	-	-	-	-
Randia dumetorum	1.5	1.5	160	1	1.0	2.0	250	2
Schleichera oleosa	1.0	1.0	1580	2	-	-	-	-
Schrebera swietenioides	3.5	26.5	11600	15	1.6	6.0	2430	6
Semecarpus anacardium	1.0	1.0	1020	1	1.0	1.0	460	1
Shorea roxburghii	1.0	1.5	450	2	2.3	5.0	5530	5
Tamilnadia uliginosa	2.0	3.0	400	2	1.5	3.0	200	3
Tectona grandis	4.2	39.5	64020	39	5.8	55.0	64620	43
Terminalia bellirica	1.0	1.0	7300	4	1.0	2.0	790	2
Terminalia chebula	1.6	4.0	2270	4	1.0	1.0	1010	2
Terminalia paniculata	2.1	7.5	2170	5	2.3	5.0	1920	4
OTHER TREES*	13 Species	126.0	72830	76	12 Species	136.0	95750	86
TOTAL	38 Species	536.0	276660	300	35 Species	490.0	272470	300

Density denotes the number of individuals per ha.; Basal area cm^2/ha.; IVI- Importance Value Index; *Other trees are given in Appendix IX.

Table 4.8a Importance Value Index of selected medicinal trees in dry deciduous and moist deciduous forests

Species	MD	DD(WWLS)	DD(BNP)
*Anogeissus latifolia**	28.15 ± 3.41	67 ± 5.4	59 ± 4.6
*Kydia calycina**	22 ± 4.6	6 ± 2.6	23 ± 5.6
Phyllanthus emblica	9.54 ± 2.59	14 ± 3.14	16 ± 2.0
Tectona grandis	34.2 ± 4.58	43 ± 3.8	39 ± 3.5

MD - Moist deciduous; DD(WWLS) - Dry deciduous in Wayanad Wildlife Sanctuary; DD(BNP) - Dry deciduous in Bandipur National Park. * Significant at $P < 0.05$ level

Table 4.9. Abundance, density and IVI of medicinal shrubs in the dry deciduous forests.

Species	Bandipur National Park			Wayanad Wildlife Sanctuary		
	Abundance	Density[1]	IVI	Abundance	Density[1]	IVI
MEDICINAL SHRUBS						
Acacia sinuata	-	-	-	3.00	0.04	0.6
Argyreia cuneata	1.90	0.75	11.8	-	-	-
Asparagus racemosus	8.70	0.65	4.1	1.30	0.11	3.1
Chromolaena odorata	7.00	2.19	15.2	2.00	0.93	18.3
Cipadessa baccifera	-	-	-	4.70	0.18	2.0
Clerodendrum serratum	1.00	0.01	0.3	1.70	0.21	4.8
Flemingia strobilifera	4.70	0.53	4.5	3.80	0.61	8.0
Gomphostemma heyneanum	2.00	0.10	1.5	1.50	0.03	0.9
Grewia hirsuta	2.80	0.56	6.7	3.60	1.30	17.5
Helicteres isora	5.00	0.13	1.0	4.30	0.32	3.9
Lantana camara	-	-	-	1.30	0.11	3.1
Leea indica	12.10	9.85	54.4	11.40	10.41	83.3
OTHER SHRUBS*	6 Species	13.47	100.5	6 Species	3.97	54.5
TOTAL	15 Species	27.88	200.0	17 Species	18.23	200.0
Species diversity index (H')	2.00			1.74		

Density denotes the number of individuals per $25m^2$; *Other shrubs are given in Appendix X.

Table 4.10. Abundance, density and IVI of medicinal herbs in the dry deciduous forests.

Species	Bandipur National Park			Wayanad Wildlife Sanctuary		
	Abundance	Density	IVI	Abundance	Density	IVI
Medicinal plants						
Adiantum lunulatum	3	0.025	0.6	2	0.006	0.2
Ageratum conyzoides	3	0.316	6.0	4	0.500	8.7
Alternanthera sessilis	1	0.003	0.1	-	-	-
Andrographis neesiana	4	0.078	1.1	2	0.009	0.3
Andrographis serpyllifolia	3	0.156	2.5	2	0.034	0.9
Biophytum sensitivum	4	0.666	9.9	2	0.034	0.8
Cassia occidentalis	3	0.025	0.6	2	0.034	1.0
Centella asiatica	1	0.006	0.2	-	-	-
Cissampelos pareira	-	-	-	1	0.003	0.1
Costus speciosus	2	0.041	1.0	-	-	-
Curculigo orchioides	4	1.063	18.2	4	2.563	49.6
Curcuma aromatica	3	0.075	1.5	-	-	-
Curcuma longa	4	0.600	10.3	-	-	-
Curcuma pseudomontana	3	0.794	15.7	3	0.041	0.9
Cyclea peltata	3	0.109	2.2	1	0.053	1.7
Desmodium triflorum	2	0.103	2.3	3	0.084	1.7
Desmodium velutinum	5	0.172	2.3	2	0.069	1.8
Dioscorea pentaphylla	3	0.009	0.2	-	-	-
Elephantopus scaber	6	1.034	14.6	3	0.391	9.4
Gynura nitida	2	0.097	1.9	1	0.050	1.6
Hemidesmus indicus	4	0.138	2.0	1	0.050	1.6
Mimosa pudica	4	0.209	3.8	4	0.500	8.9
Naravelia zeylanica	-	-	-	3	0.041	0.8
Nervilia aragoana	4	0.319	4.6	3	0.016	0.4
Oxalis corniculata	2	0.006	0.2	2	0.006	0.2
Phyllanthus virgatus	1	0.003	0.1	1	0.019	0.6
Pimpinella monoica	2	0.078	2.0	3	1.009	20.7
Piper longum	2	0.006	0.1	1	0.003	0.1
Pseudarthria viscida	-	-	-	3	0.378	7.5
Rauwolfia serpentina	2	0.072	1.6	1	0.006	0.2
Scoparia dulcis	-	-	-	1	0.022	0.9
Sida acuta	2	0.244	5.6	2	0.125	3.9
Sida rhombifolia	2	0.144	3.3	2	0.478	11.3
Thespesia lampas	2	0.113	2.6	-	-	-
Urena lobata	1	0.069	2.1	4	0.081	1.4
OTHER HERBS*	43 Species	11.52	180.8	43 Species	8.24	162.80
TOTAL	74 Species	18.30	300	61 Species	14.84	300
Species diversity index (H')	3.23			3.13		

Density denotes the number of individuals per m^2; * Other herbs are given in Appendix XI

Table 4.11. Regeneration status of medicinal trees in the dry deciduous forests.

Species	Bandipur National Park				Wayanad Wildlife Sanctuary			
	Density/ha				Density/ha			
	Mature trees	Seedlings	Saplings	Ratio*	Mature trees	Seedlings	Saplings	Ratio*
MEDICINAL PLANTS								
Anogeissus latifolia	161.0	160	45	1:1	185.0	120	95	1:1
Bauhinia racemosa	1.5	-	-	1:0	3.0	-	35	1:11
Bridelia retusa	2.0	135	15	1:75	2.0	-	-	2:0
Buchanania axillaris	3.0	-	-	3:0	1.0	-	5	1:5
Careya arborea	4.0	10	-	1:2	1.0	-	-	1:0
Cassia fistula	2.0	80	30	1:55	7.0	45	10	1:8
Dalbergia latifolia	9.5	205	50	1:27	15.0	270	200	1:31
Gmelina arborea	1.0	-	-	1:0	1.0	-	-	1:0
Kydia calycina	66.5	585	205	1:12	9.0	295	90	1:42
Lagerstroemia microcarpa	5.5	-	-	6:0	-	-	-	-
Lagerstroemia parviflora	25.0	30	10	1:2	14.0	-	-	14:0
Lannea coromandelica	4.0	-	-	4:0	9.0	-	5	1:2
Phyllanthus emblica	29.0	490	105	1:21	24.0	115	40	1:6
Pterocarpus marsupium	9.0	135	55	1:21	10.0	115	25	1:14
Radermachera xylocarpa	0.5	10	-	1:20	-	-	-	-
Randia dumetorum	1.5	65	-	1:43	2.0	145	85	1:115
Schleichera oleosa	1.0	-	-	1:0	-	-	-	-
Schrebera swietenioides	26.5	40	-	1:2	6.0	-	-	6:0
Semecarpus anacardium	1.0	10	5	1:15	1.0	-	-	1:0
Shorea roxburghii	1.5	560	280	1:560	5.0	195	150	1:69
Tamilnadia uliginosa	3.0	175	20	1:65	3.0	-	-	3:0
Tectona grandis	39.0	30	115	1:4	55.0	85	40	1:2
Terminalia bellirica	1.0	-	-	1:0	2.0	-	5	1:2
Terminalia chebula	4.0	20	-	1:5	1.0	-	-	1:0
Terminalia paniculata	7.5	75	50	1:17	5.0	15	40	1:11
TOTAL	410.0	2815	985	1:9	356.0	1400	825	1:6
Species diversity index(H')	2.4	2.69	2.53		2.12	2.54	2.67	

Ratio* between the number of mature tree and number of seedlings and saplings; Other plants are given in Appendix XII.

4.3.4. Riverine forests

Status and distribution of medicinal plants in riverine forests was examined in Coimbatore Forest Division and Attappady Reserve Forest. The riverine forest in Attappady RF is subjected to grazing and tree cutting. Moreover, canopy gaps are more in the Attappady RF while the riverine forests in the Coimbatore Forest Division is comparatively less disturbed. A total of 69 medicinal plant species was recorded in the riverine forests, which included 16 trees, 14 shrubs and 39 herb species (Pooled data). *Cycas circinalis*, a threatened (Anon. 1997) medicinal plant and *Gynura nitida*, an endemic medicinal plant (Ahmedullah and Nayar 1987) were also recorded in this habitat. Twelve species of medicinal plants were commercially exploited from this habitat.

4.3.4.1. Trees

Total number of tree species was greater in the Coimbatore FD (23) than that of the Attappady RF (12). The same trend was observed for medicinal tree species also (15 species in the Coimbatore FD and nine species in the Attappady RF). Number of species in individual quadrat ranged from 3 to 12 (mean = 6.5, SD = 2.4) in the Coimbatore FD and from 2 to 7 (mean = 3.05, SD = 1.6) in the Attappady RF. Tree species diversity index (H') was significantly (M-W test U = 24, P <0.001) higher in the Coimbatore FD (2.57) than in the Attappady RF (1.32).

Size class distribution of individuals of all trees (GBH ≥ 20 cm GBH) was L-shaped for both the areas (Figure 4.6). In the riverine forest of Attappady RF, percentage of individuals was higher in the smaller size classess while in the riverine forest of Coimbatore FD, it was higher in the larger size classess.

Although, total tree density was higher in the riverine forest of Attappady RF (160/ha) than in Coimbatore FD (123/ha), it was not significant. Similarly, medicinal tree density also showed no significant difference between the Attappady RF (148/ ha) and Coimbatore FD (106/ha). *Crataeva magna* and *Pongamia pinnata* contributed nearly 85% of the total trees in the Attappady RF (Table 4.12). Density of *Pongamia pinnata* was significantly (M-W test U = 80, P=0.01) greater in the riverine forest of Attappady RF than in the Coimbatore FD. *Cycas circinalis* (5/ha), a threatened medicinal tree was recorded only in the Coimbatore FD.

Total basal area was significantly (M-W test U =1, P<0.001) higher in the Coimbatore FD (24.7m^2/ha) than in the Attappady RF (17.7m^2/ha). Similarly, basal area of medicinal trees also showed significant difference (M-W test U <1, P< 0.001) between these habitats. It was greater in the Coimbatore FD (23.7 m^2/ha) than in the Attappady RF (9.8 m^2/ha; Figure 4.7.). Basal area of *Crataeva magna*, *Mangifera indica* and *Pongamia pinnata* also showed significant difference (M-W test U = 8, P=0.05; M-W test U = 3, P=0.026; M-W test U = 2, P<0 respectively) between these habitats (Table 4.12.).

Importance Value Index (IVI) of medicinal trees ranged from 2 to 89 in the Attappady RF while in the Coimbatore FD it ranged from 1 to 52 (Table 4.12). *Crataeva magna* exhibited the highest IVI (89) closely followed by *Pongamia pinnata* (84) in the Attappady RF while *P. pinnata* exhibited the highest IVI (52) in the Coimbatore FD followed by *Terminalia arjuna*. There was a significant difference (M-W test U=8, *P*=0.05; M-W test U=55, *P*=0.01) in IVI of *Crataeva magna* and *Pongamia pinnata* between these habitats (Table 4.12.).

4.3.4.2. Shrubs

Total shrub species was higher in the Coimbatore FD (25) than in Attappady RF (18). Similar trend was observed for medicinal shrubs also (13 in the Coimbatore FD and 11 in the Attappady RF). Although, shrub species diversity index (H') was greater in the Coimbatore FD (2.66) than the Attappady RF (1.64, Table 4.13), it was not statistically significant.

Total shrub density showed significant difference (M-W test U = 15, *P* > 0.001) between the Attappady RF (27/25m^2) and Coimbatore FD (9.9/25m^2). Similarly, medicinal shrub density also showed significant difference (M-W test U =15, *P*= 0.001) between the Attappady RF (22.8/25m^2) and Coimbatore FD (7.48/25 m^2). *Homonoia riparia* was the dominant medicinal shrub both in the Attappady RF (13.5/25m^2, Table 4.13) and in the Coimbatore FD (1.82/25 m^2).

4.3.4.3. Herbs

Total herb species and medicinal herb species showed no difference between the Coimbatore FD and Attappady RF (Table 4.14). Shannon-Weiner species diversity index showed no significant difference between these habitats.

Although, the density of medicinal herbs was higher in the Coimbatore FD (7.75/m^2) than in Attappady RF (7.5/m^2), it was not significant. Dominant medicinal herbs in the Coimbatore FD included, *Ageratum conyzoides* (2.39/m^2), *Scoparia dulcis* (1.56) and *Spermacoce ocymoides* (0.45) while *Ageratum conyzoides* (2.51/m^2), *Spermacoce ocymoides* (0.62) and *Scoparia dulcis* (0.53) were the dominant medicinal herbs in the Attappady RF (Table 4.14).

4.3.4.4. Regeneration

Of the 17 medicinal tree species recorded in the riverine forests only nine had regeneration. Seedlings of *Cycas circinalis, Diospyros malabarica, Ficus benghalensis, Madhuca longifolia, Mallotus phillippensis, Murraya paniculata, Pterocarpus marsupium* and *Strychnos nux-vomica* were recorded only in the Coimbatore FD (Table 4.15). Seedlings of eight medicinal trees were recorded in the Coimbatore FD while five medicinal trees had seedlings in the Attappady RF (Table 4.15).

Total seedling density was higher in the Attappady RF than in Coimbatore FD. Medicinal seedlings and saplings density were higher in the Coimbatore FD (498 and 258/ha respectively) than in Attappady RF (413 and 83/ha respectively), however, it was not significant. *Pongamia pinnata* exhibited the highest density both in the Attappady RF (345/ha) and Coimbatore FD (320/ha). In the Coimbatore FD, *Pongamia pinnata* and *Murraya paniculata* exhibited good regeneration where the ratio between the mature trees to seedlings and saplings was highest (1:16). While in the Attappady RF, *Ficus racemosa* and *Streblus asper* exhibited good regeneration where the ratio was 1:10 and 1:8 respectively.

Table 4.12. Abundance, density, basal area and IVI of medicinal trees in the riverine forests.

Species	Coimbatore Forest Division				Attappady Reserve Forest			
	Abundance	Density	Basal Area	IVI	Abundance	Density	Basal Area	IVI
MEDICINAL TREES								
Alstonia scholaris	-	-	-	-	1	1	6600	8
Bambusa arundinacea	-	-	-	-	3	2	1900	4
Crataeva magna	3	5	2650	7	8	67	27600	89
Cycas circinalis	2	5	1200	9	-	-	-	-
Diospyros malabarica	3	13	24140	28	-	-	-	-
Ficus benghalensis	1	1	4970	4	-	-	-	-
Ficus racemosa	1	4	7550	11	2	1	400	2
Madhuca longifolia	2	7	25270	22	-	-	-	-
Mallotus phillipensis	1	1	100	1	-	-	-	-
Mangifera indica	1	8	40650	33	1	2	10300	12
Murraya paniculata	1	1	3280	4	-	-	-	-
Pongamia pinnata	4	31	30390	52	8	69	18200	84
Pterocarpus marsupium	1	1	2720	4	-	-	-	-
Streblus asper	1	1	80	1	1	3	1700	9
Strychnos nux-vomica	2	9	2680	15	-	-	-	-
Syzygium cumini	2	11	24440	29	2	2	11000	12
Terminalia arjuna	1	9	67210	47	3	2	20300	3
OTHER TREES*	8 Species	17	9790	33	3 Species	13	79700	77
TOTAL	23 Species	124	247120	300	12 Species	160	177700	300
Diversity index (H')	2.57				1.32			

Density denotes the number of individuals per ha.; IVI-Importance Value Index; * Other trees are given in Appendix XIII.

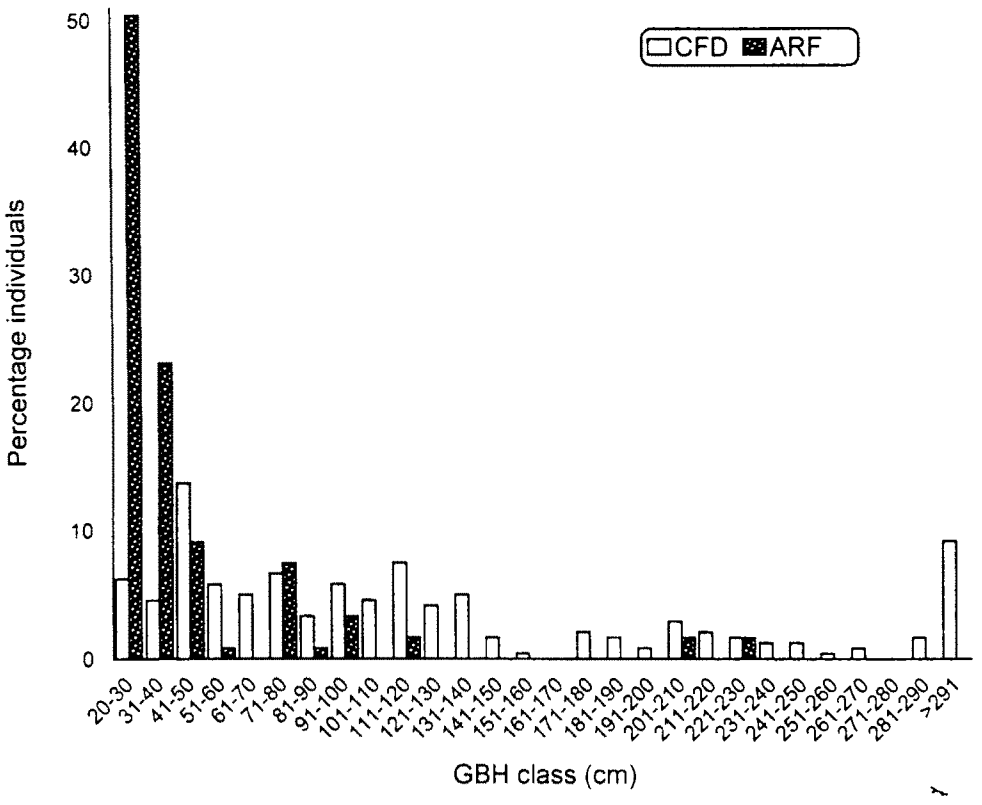


Figure 4.6. Size class distribution of trees (≥20cm GBH) in the riverine forest of Coimbatore Forest Division (CFD) and Attappady Reserve Forest (ARF)

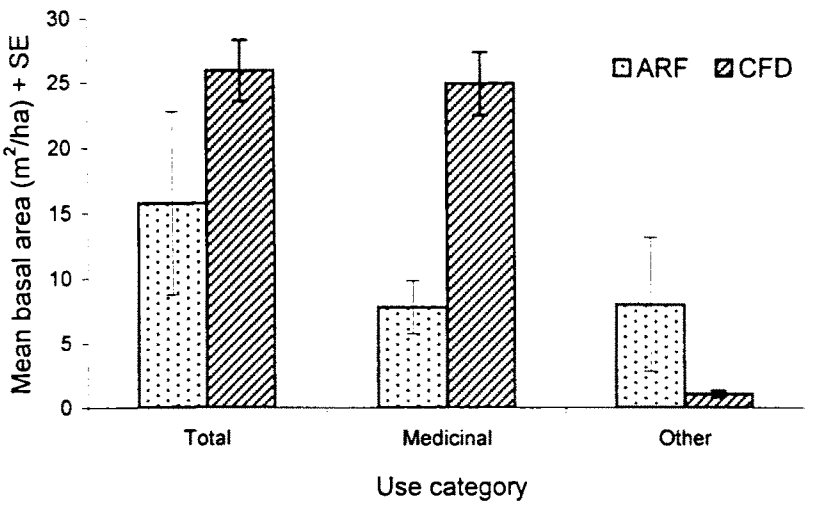


Figure. 4. 7. Mean basal area of trees (GBH $\geq$ 20cm) $\pm$ SE in the riverine forests

Table 4.13. Abundance, density and IVI of shrubs in the riverine forests.

Species	Coimbatore Forest Division			Attappady Reserve Forest		
	Abundance	Density	IVI	Abundance	Density	IVI
MEDICINAL SHRUBS						
Acalypha fruticosa	2	0.10	4	-	-	-
Chromolaena odorata	9	1.48	28	1	0.10	4
Colocasia esculenta	-	-	-	4	0.23	5
Crotalaria verrucosa	5	0.15	4	-	-	-
Glycosmis arborea	9	1.18	29	5	1.35	20
Homonoia riparia	5	1.82	51	20	13.50	108
Justicia betonica	-	-	-	1	0.02	1
Lantana camara	1	0.03	2	-	-	-
Ludwigia octovalvis	4	0.95	29	4	1.48	24
Polygonum barbatum	3	0.40	15	7	5.62	66
Ricinus communis	5	0.15	4	2	0.13	4
Solanum erianthum	2	0.35	16	2	0.10	3
Solanum indicum	1	0.07	4	1	0.02	1
Solanum torvum	4	0.78	23	3	0.33	6
Toddalia asiatica	1	0.02	1	-	-	-
OTHER SHRUBS*	12 Species	2.41	90	7 Species	4.13	58
TOTAL	25 Species	9.90	300	18 Species	27.00	300
Diversity index (H')	2.66			1.64		

Density denotes the number of individuals per $25m^2$; IVI - Importance Value Index;
* Other shrubs are given in Appendix XIV.

Table 4.14. Abundance, density and IVI of medicinal herbs in the riverine forests.

Species	Coimbatore Forest Division			Attappady Reserve Forest		
	Abundance	Density	IVI	Abundance	Density	IVI
MEDICINAL HERBS						
Achyranthes aspera	2	0.02	0.5	1	0.04	1.3
Ageratum conyzoides	4	2.39	48.7	5	2.51	41.2
Alternanthera sessilis	3	0.42	10.7	2	0.21	5.4
Amaranthus spinosus	2	0.12	4.2	2	0.24	6.8
Amaranthus viridis	1	0.01	0.4	4	0.04	0.9
Argemone mexicana	2	0.10	3.1	1	0.05	1.5
Asclepias curassavica	2	0.27	9.0	2	0.14	3.5
Bacopa monneri	1	0.02	0.9	1	0.02	0.7
Cardiospermum halicacabum	1	0.01	0.4	1	0.01	0.3
Cassia occidentalis	2	0.04	1.1	3	0.19	3.9
Catharanthus roseus	2	0.18	5.6	-	-	-
Centella asiatica	2	0.06	2.2	-	-	-
Chenopodium ambrosoides	1	0.12	4.2	-	-	-
Desmodium triflorum	3	0.03	0.7	2	0.02	0.5
Eclipta alba	2	0.16	4.2	2	0.02	0.4
Euphorbia hirta	2	0.21	6.1	3	0.27	5.7
Gynura nitida	2	0.33	9.4	2	0.52	11.7
Heliotropium indicum	2	0.03	1.1	2	0.25	6.2
Hemidesmus indicus	1	0.01	0.4	1	0.01	0.3
Hemionitis arifolia	-	-	-	2	0.04	1.1
Ipomoea staphylina	2	0.04	1.4	-	-	-
Leucas aspera	3	0.13	3.0	-	-	-
Mimosa pudica	2	0.07	2.0	2	0.28	7.6
Oxalis corniculata	1	0.23	8.0	2	0.17	4.6
Phyllanthus amarus	3	0.26	5.9	2	0.08	1.8
Polygonum chinense	-	-	-	1	0.02	0.8
Rotula aquatica	1	0.01	0.4	3	0.52	11.0
Scoparia dulcis	4	1.56	34.8	2	0.53	11.7
Sida acuta	1	0.04	1.4	2	0.20	4.9
Sida cordifolia	1	0.02	0.9	-	-	-
Sida rhombifolia	2	0.06	1.9	2	0.11	2.8
Smithia conferta	-	-	-	1	0.01	0.3
Solanum nigrum	2	0.12	3.7	2	0.06	1.7
Spermacoce hispida	3	0.09	2.1	3	0.13	2.7
Spermacoce ocymoides	3	0.45	11.0	3	0.62	11.9
Sphaeranthus indicus	1	0.01	0.4	3	0.09	1.9
Trichodesma zeylanicum	-	-	-	1	0.01	0.3
Tridax procumbens	3	0.09	2.4	1	0.01	0.3
Urena lobata	-	-	-	2	0.08	1.9
OTHER HERBS*	24 Species	4.25	108	25 Species	8.19	142
TOTAL	58 Species	11.96	300	58 Species	15.69	300
Species diversity Index (H')	3.21			3.15		

Density denotes the number of individuals per m^2; IVI - Importance Value Index; *Other herbs are given in Appendix XV.

Table 4.15. Regeneration of medicinal plants in the riverine forests (Density/ha).

Species	Attappady Reserve Forest				Coimbatore Forest Division			
	Density/ha				Density/ha			
	Mature trees	Seedlings	Saplings	Ratio	Mature trees	Seedlings	Saplings	Ratio
Alstonia scholaris	1.0	-	-	1:0	-	-	-	-
Bambusa arundinacea	2.0	-	-	1:0	-	-	-	-
Crataeva magna	68.0	30	8	1:0.5	5.0	42	8	1:10
Cycas circinalis	-	-	-	-	5.0	6	1	1:1
Diospyros malabarica	-	-	-	-	13.0	22	5	1:2
Ficus benghalensis	-	-	-	-	1.0	-	-	-
Ficus racemosa	1.0	10	-	1:10	4.0	10	2	1:3
Madhuca longifolia	-	-	-	-	7.0	16	8	1:3
Mallotus philippensis	-	-	-	-	1.0	-	-	1:0
Mangifera indica	2.0	-	-	1:0	8.0	-	-	1:0
Murraya paniculata	-	-	-	-	1.0	12	4	1:16
Pongamia pinnata	69.0	345	70	1:6	31.0	320	180	1:16
Pterocarpus marsupium	-	-	-	-	1.0	-	-	1:0
Streblus asper	3.0	16	4	1:6	1.0	-	-	1:0
Strychnos nux-vomica	-	-	-	-	9.0	-	2	1:0
Syzygium cumini	2.0	12	1	1:7	11.0	70	48	1:11

Ratio* between the number of mature tree and number of seedlings and saplings; Other plants are given in Appendix XVI.

4.3.5. Teak plantations

A total of 80 plant species was recorded in the old teak plantations of Mudumalai Wildlife Sanctuary. Of the 80 species, 39 (48.75%) were used by tribals for medicinal purpose (Table 4.1). It included eight species of trees, 12 shrubs and 19 herbs. Three endemic medicinal plants of peninsular India (Ahmedullah and Nair 1987; *Lagerstroemia microcarpa, Gomphostemma heyneanum* and *Gynura nitida*) and a endangered (Anon. 1997) medicinal plant (*Rauwolfia serpentina*) were also recorded. Twelve species of medicinal plants were commercially exploited from this plantation.

4.3.5.1. Trees

Of the 14 tree species recorded, eight (57%) were used by the tribals for medicinal purposes (Table 4.16). Number of tree species in individual quadrat ranged from 1 to 6 (mean = 2.95, SD = 1.50). Shannon -Weiner species diversity index was 0.60 in this plantation. *Tectona grandis* and *Lagerstroemia microcarpa* were the most frequently occurred medicinal trees in this plantation.

Size class distribution of individuals of all tree species showed a reduction in the number of individuals in the higher and lower classes and higher number of individuals in the middle classes (Figure 4.8). GBH of all trees in the teak plantations varied from 21 cm to 213 (average 91.5).

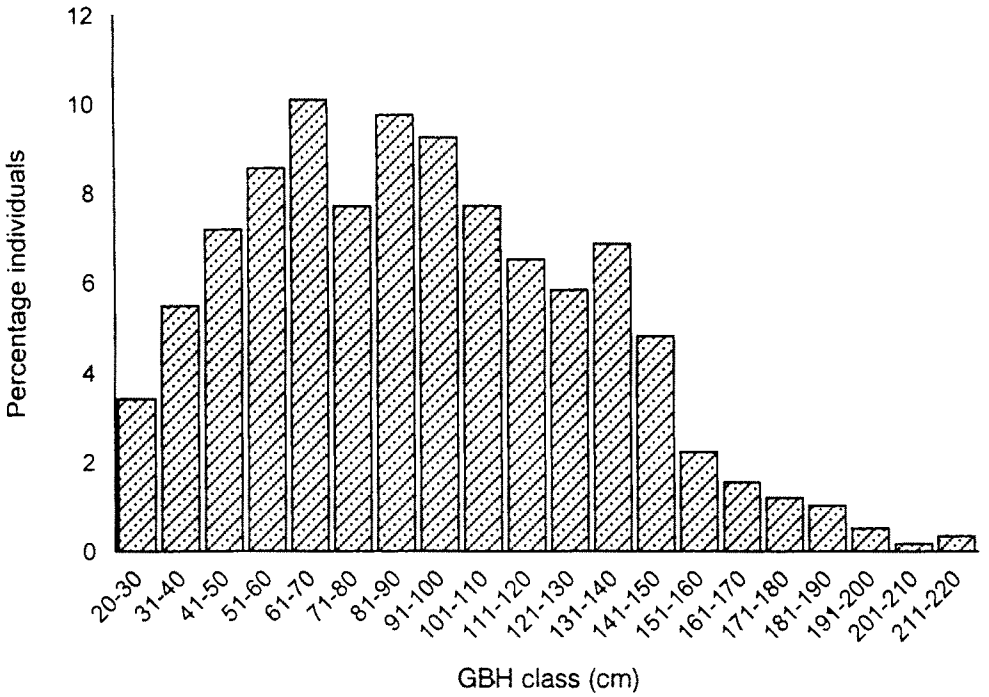


Figure 4.8. Size class distribution of trees (≥20 cm GBH) in the teak plantations of Mudumalai Wildlife Sanctuary

Total tree density (GBH ≥ 20 cm) was 292/ha while density of medicinal trees alone was 283/ha (Table 4.16.). Among the medicinal tree species, *Tectona grandis* (258/ha.) exhibited the highest density followed by *Lagerstroemia microcarpa* (13) an endemic medicinal tree. Both *Tectona grandis* and *Lagerstroemia microcarpa* constitute about 93% of the total density. Two species such as *Bauhinia racemosa* and *Syzygium cumini* were represented by single individual each.

Total basal area of individuals of all trees (GBH ≥20 cm) was 23.1 m^2/ha. while basal area of medicinal trees alone was 22.7 m^2/ha. Medicinal trees make up 98% of the total basal area while *Tectona grandis* alone formed 91.6% of the total basal area. *Tectona grandis* had the highest basal area (21219.45 cm^2/ha) followed by *Lagerstroemia microcarpa* (1178.15 cm^2/ha).

Importance value index of trees ranged from 2 to 211. *Tectona grandis* was the dominant species with an IVI of 211 followed by *Lagerstroemia microcarpa* (IVI 35). While *Bauhinia racemosa* (2) exhibited the lowest IVI followed by *Syzygium cumini* (4). Importance value of medicinal tree species alone was 280.

4.3.5.2. Shrubs

In total, 18 shrub species including 12 medicinal shrubs (66.6%) were recorded in the teak plantations. Among the medicinal shrubs, five were commercially exploited. Species diversity index (H') index in this plantation was 2.31. *Chromolaena*

odorata, Helicteres isora and *Lantana camara* are the most frequently observed shrubs in this plantation (Table 4.17.).

The highest density was exhibited by *Chromolaena odorata*, an exotic plant (2.86/25 m^2) followed by *Glycosmis arborea* (2.09/25 m^2). *Desmodium velutinum,* a commercially exploited plant had the lowest density (0.01) followed by *Gomphostemma heyneanum* (0.03), an endemic medicinal shrub. Among the medicinal shrubs, *Chromolaena odorata* had the highest IVI (36.6, Table 4.17.).

4.3.5.3. Herbs

In total, 48 herb species were recorded in the teak plantations, of which 19 including four species endemic to peninsular India were used for medicine (39.58%) by the tribals in the NBR. Shannon -Weiner species diversity index in this plantation was 3.01.

Total density of herbs was 6.6/m^2 while density of medicinal herbs was 3.13/m^2. Among the medicinal herbs, *Mimosa pudica* (0.83/m^2) exhibited the highest density followed by *Ageratum conyzoides* (0.67). Density of *Rauwolfia serpentina*, a endangered medicinal plant was low (0.009/m^2) in the teak plantations (Table 4.18). Density endemic species such as *Andrographis neesiana, Andrographis serpyllifolia, Gynura nitida* and *Nervilia aragoana* was 0.01, 0.02, 0.10 and 0.25/m^2 respectively.

4.3.5.4. Regeneration

Of the 14 tree species recorded in the teak plantations, *Bauhinia racemosa*, *Butea monosperma, Casearia esculenta, Cinnamomum macrocarpum, Cordia wallichi* and *Lagerstroemia microcarpa* lacked regeneration (Table 4.19). Number of seedlings and saplings of *Tectona grandis* was comparatively lower than mature trees and can be suggested that either in this stage the tree die by some natural cause or they were destroyed. Medicinal tree species such as *Diospyros montana, Kydia calycina, Phyllanthus emblica* and *Pterocarpus marsupium,* which were not recorded in the tree quadrat had good regeneration. The highest number of seedlings was recorded for *Dalbergia latifolia* (480/ha) followed by *Tectona grandis* (100/ha) while *Randia dumetorum* exhibited the highest density (7840/ha) of saplings followed by *Kydia calycina* (940/ha). *Randia dumetorum* exhibited highest regeneration with the highest ratio of 1:2640 followed by *Kydia calycina* with 0:940 (Table 4.19).

Table 4.16. Frequency, abundance, density, basal area and IVI of trees in the teak plantations.

Species	Frequency	Abundance	Density[1]	Basal area[2]	IVI[3]
MEDICINAL TREES					
Bauhinia racemosa	1	1	1	50	2
Cassia fistula	6	1	3	360	11
Dalbergia latifolia	3	1	2	1030	6
Lagerstroemia microcarpa	16	2	13	11780	35
Radermachera xylocarpa	4	1	2	340	7
Randia dumetorum	2	3	3	270	4
Syzygium cumini	2	1	1	1120	4
Tectona grandis	20	26	258	212190	211
OTHER TREES*	6 Species		9	4380	20
TOTAL	14 Species		292	231520	300
Species diversity index (H')	0.60				

Density[1] denotes the number of individuals per ha; Basal area[2] in cm^2/ha; IVI[3] - Importance Value Index; *Other tree species are given in Appendix XVII.

Table 4.17. Frequency, abundance, density and IVI of shrubs in the teak plantations.

Species	Frequency	Abundance	Density[1]	IVI
Medicinal shrubs				
Asparagus racemosus	8	2.13	0.21	7.93
Desmodium velutinum	1	1	0.01	0.87
Chromolaena odorata	19	12.05	2.86	36.57
Flemingia strobilifera	3	6.33	0.24	4.18
Glycosmis arborea	9	18.56	2.09	22.84
Gomphostemma heyneanum	1	2	0.03	1.02
Grewia hirsuta	6	2.33	0.18	6.11
Helicteres isora	17	7.47	1.59	25.44
Lantana camara	16	9.69	1.94	27.28
Solanum torvum	4	1.75	0.09	3.85
Solanum erianthum	2	1.5	0.04	1.89
Thespesia lampas	4	12.25	0.61	7.75
OTHER SHRUBS*	6 Species		3.4	54.0
TOTAL	18 Species		13.3	200.0
Species diversity index (H')	2.3			

Density[1] denotes the number of individuals per $25m^2$; IVI -Importance Value Index; * Other shrubs are given in Appendix XVIII.

Table 4.18. Frequency, abundance, density and IVI of medicinal herbs in the teak plantations.

Species	Frequency	Abundance	Density	IVI
Medicinal herbs				
Ageratum conyzoides	84	2.6	0.670	18.6
Anisomelas malabarica	1	1	0.003	0.1
Biophytum sensitivum	13	1.4	0.060	2.1
Cassia occidentalis	20	1.3	0.080	3.2
Clematis gouriana	1	1	0.003	0.1
Cryptolepsis buchanani	17	1.7	0.090	3.0
Curculigo orchioides	4	1.3	0.020	0.6
Cyclea peltata	49	1.2	0.190	7.8
Dioscorea tomentosa	1	1	0.003	0.1
Gynura nitida	38	1.3	0.160	6.2
Hemidesmus indicus	18	1.7	0.100	3.3
Mimosa pudica	115	2.3	0.830	24.1
Naravelia zeylanica	12	1.2	0.040	1.9
Pimpinella monoica	4	1.8	0.020	0.7
Rauwolfia serpentina	3	1	0.009	0.4
Sida acuta	48	1.7	0.250	8.7
Sida cordifolia	8	1.4	0.030	1.3
Sida rhomboidea	58	3	0.530	13.9
Urena lobata	9	1.9	0.050	1.7
OTHER HERBS	29 Species		3.460	102.1
TOTAL	48 Species		6.600	200.0
Diversity index (H')	3.01			

IVI-Importance Value Index; * Other herbs are given in Appendix XIX.

Table 4.19. Regeneration status of medicinal plants in the teak plantations.

Species	Density/ha			
	Mature trees	Seedlings	Saplings	Ratio*
Medicinal plants				
Bauhinia racemosa	1.0	-	-	1:0
Cassia fistula	3.0	60	-	1:17
Dalbergia latifolia	2.0	480	-	1:240
Diospyros montana	-	-	240	0:240
Kydia calycina	-	-	940	0:940
Lagerstroemia microcarpa	13.0	-	-	1:0
Phyllanthus emblica	-	-	100	0:100
Pterocarpus marsupium	-	-	40	0:40
Radermachera xylocarpa	2.0	40	-	1:20
Randia dumetorum	3.0	80	7840	1:2640
Syzygium cumini	1.0	20	-	1:20
Tectona grandis	258.0	100	-	1:0.3
Other plants*	10.0	1480	20	1:150
Total (19 species)	293.0	2260	9180	1:39
Species diversity index (H')	0.60	1.23	1.33	

Ratio between the number of mature trees to number of seedlings and saplings;
* Other plants are given in Appendix XX.

4.3.6. Endemic medicinal plants and their status in the NBR

Eight endemic plants of peninsular India (Ahmedullah and Nayar 1987), namely *Lagerstroemia microcarpa, Argyreia cuneata, Gomphostemma heyneanum, Andrographis neesiana, A. serpyllifolia, Curcuma pseudomontana, Gynura nitida* and *Nervilia aragoana* used by the tribals of NBR for medicinal purposes were recorded (Table 4.20). All the eight species occurred in the moist deciduous and dry deciduous (BNP) forests, six in dry deciduous (WWLS) forest, three in the teak plantations and one species in riverine forests.

Although, *Lagerstroemia microcarpa* had higher density in the teak plantations than other habitats (Table 4.20), the differences was not significant. However, the importance value index was significantly (K-W test $X^2 = 12.59$, $P= 0.002$) higher in the teak plantations (IVI = 34.71, Table 4.16) than in other habitats (MD- IVI = 7.51, Table 4.4; DD- at Bandipur NP IVI=5, Table 4.8). Density of *Argyreia cuneata* and *Gomphostemma heyneanum* showed no significant difference among the habitats sampled.

Density of endemic herbs such as *Andrographis neesiana*, A. *serpyllifolia*, *Curcuma pseudomontana* and *Nervilia aragoana* showed no significant difference among the habitats sampled. However, *Gynura nitida* showed significant difference (K-W test $X^2 = 18.6$, $P= 0.002$) among the habitats sampled.

Table 4.20. Density of endemic medicinal plants in the NBR.

Species	Habit	MD	DD (BNP)	DD (WWLS)	RI (C)	RI (A)	TP
Lagerstroemia microcarpa	Tree	7	5.5	-	-	-	13
Argyreia cuneata	Shrub	0.090	0.750	-	-	-	-
Gomphostemma heyneanum	Shrub	0.350	0.100	0.030	-	-	0.030
Andrographis neesiana	Herb	0.010	0.078	0.009	-	-	-
Andrographis serpyllifolia	Herb	0.020	0.156	0.034	-	-	-
Curcuma pseudomontana	Herb	0.790	0.794	0.041	-	-	-
Gynura nitida	Herb	0.100	0.097	0.050	0.330	0.520	0.160
Nervilia aragoana	Herb	0.250	0.319	0.016	-	-	-

MD - Moist deciduous; DD (BNP) - Dry deciduous (Bandipur National Park); DD (WWLS) - Dry deciduous (Wayanad Wildlife Sanctuary); RI (C) - Riverine (Coimbatore); RI (A) - Riverine (Attappady) TP - Teak plantations; Density for trees /ha; for shrubs $25m^2$; for herbs $1m^2$.

4.4. DISCUSSION

The present study showed that ethnomedicinal species richness was highest in the moist deciduous forests. However, percentage of medicinally useful species was higher in the riverine forests. Various authors have estimated the use value of forests to different tribal groups (Boom 1989, Pinedo-Vasquez *et al* 1990, Caniago and Siebert 1998). However, simply totalling the number of useful species in a given forest is not a measure of that forest's importance (Phillips *et al* 1994). Most species have minor uses and only a few are exceptionally useful. Moreover, number of useful species will vary from culture to culture and more the informants interviewed more likely to get higher number of useful species. Recently, Phillips *et al* (1994) compared the usefulness of six forest types to mestizo people in Peru using a new technique called "Informant indexed use value". However, such studies are beyond the scope of the present study.

4.4.1. Forest structure and composition

It was found that herb species constituted a higher percentage compared to other growth forms in all the vegetation types. Based on floras, Daniels *et al* (1995) have shown that for the Western Ghats in general, herbs (52%) form the dominant component followed by trees (20%) and shrubs (16%). Thus, the dominance of herbs in the NBR appears to represent the dominant pattern of growthform of Western Ghats.

According to Sukumar *et al* (1992), deciduous forests are the major vegetation types in the NBR and little is known about its structure and composition. The results from the present study on the composition of the deciduous forests are comparable to those obtained by Sukumar *et al* (1992) conducted in the Mudumalai WLS. Concerning vegetation composition, the forests of Mudumalai are different from those of present study in the Wayanad WLS. In Mudumalai WLS, the three dominant species, in the order of Importance, are *Kydia calycina, Lagerstroemia microcarpa* and *Tectona grandis.* In the sampled area in Wayanad WLS, the three dominant species are, *T. grandis, Anogeissus latifolia* and *K. calycina.* Though, *L. microcarpa* was present in the Wayanad WLS, importance was less which could be due to differences in the edaphic and other factors.

4.4.2. Conservation priority for habitats

Priority for conservation can be given to habitats, greater value can be assigned to larger habitat with high species richness, endangered communities in which medicinal plants are present and to communities which have species with highly restricted range of distribution (Daniels *et al* 1993b; Johnson 1995). Phillips *et al* (1994) used utility as a criterion for selecting habitats on conservation priority basis in the Amazon. The present study reveals that the moist deciduous forest is comparatively richer in medicinal plant wealth including endemics and thus needs higher priority among the habitats. However, as utility alone was used as a criteria in setting conservation priority other forest type need not be overlooked.

Dry tropical forests account for 46% of the total forest cover of India (Singh and Singh 1988) and it is almost lost in its original form due to encroachments, grazing and persistent subsistence demands of the local population. Apart from forest degradation, over-exploitation of natural resources is also one of the threat to these habitats. Over-exploitation has already affected the density and regeneration of some of the medicinal plants. During the present study, it was observed that dry forests are one of the most threatened habitats in the NBR. Gadgil and Meher Homji (1986) also point to this. Dry deciduous forests in the Bandipur NP harbours the highest density of medicinal trees. It also harbours six endemic medicinal plant species.

The present study showed that the moist deciduous forests of Wayanad WLS and dry deciduous forests of Bandipur NP harbour greater variety of medicinal plants. Since these forests are subjected to frequent fire and other human disturbances immediate attention is required to find out remedial measures for better protection and also to maintain the biodiversity and improve the natural regeneration of these forests.

4.4.3. Conservation priority for species

For prioritising species for conservation, several criteria have been used. They include special measures to protect and conserve species with restricted range of distribution, species with narrow habitat preference, species that serve as key stone resources or when one species is more valuable than its relatives (Daniels *et al* 1993b; Johnson 1995). Utility of species is also used as one of the criteria, for prioritising species for conservation (Phillips

1994, Johnson 1995). A threat assessment exercise (Conservation Assessment and Management Plan) according to the latest IUCN guidelines has already listed 112 species of medicinal plants that are rare, endangered and threatened for southern India (Anon. 1997). However, species namely *Curcuma pseudomontana, Cycas circinalis, Gloriosa superba, Madhuca longifolia, Nervilia aragoana, Pseudarthria viscida, Rauwolfia serpentina, Schrebera swietenioides* and *Terminalia arjuna* were only encountered in the present study as rest of them were evergreen species.

Curcuma pseudomontana (Zingiberaceae) an endemic species of peninsular India (Ahmedullah and Nayar 1987) was recorded in the deciduous forests of NBR (MD=0.79/m^2; DD-BNP=0.79; DD-WWLS = 0.04). It has been assigned the threat status of vulnerable/globally (Anon. 1997). The plant was commercially exploited from other parts of Western Ghats (Sadhale 1991).

Cycas circinalis, a gymnosperm and a critically endangered/regionally species (Anon. 1997) was recorded in NBR only from the riverine forests. The density of this species in the riverine forest of Coimbatore Forest Division was 5/ha. however, it was not recorded from the riverine forests of Attappady RF. Utilization for domestic purposes and habitat destruction could be the factors affecting the population of this plant.

Gloriosa superba, is a common climbing shrub found along the hedges was recorded in the moist deciduous forests with a density of 0.05/25m^2. Although, the plant was included in low risk-near threatened/regionally category (Anon. 1997), if the habitat destruction continues, the population will be severely affected.

Madhuca longifolia (Sapotaceae) an endangered/regionally species (Anon. 1997) was recorded in the less disturbed riverine forest of Coimbatore FD with a density of 7/ha. Habitat degradation is the main factor that affects this tree species.

Although, *Nervilia aragoana* (Orchidaceae), a terrestrial endemic orchid of peninsular India has been included in the endangered/ regionally category (Anon. 1997), it is one of the common herbs in the moist deciduous forests of NBR (0.25/m^2). The whole plant was collected on a large scale for the preparation of ayurvedic drugs.

Pseudarthria viscida (Fabaceae), a climber was recorded in the dry deciduous forests (0.37/m^2) of NBR. The range of distribution of this plant is narrow and the root of this plant is being collected on a large scale. Although, the plant is included in the low risk/near threatened category (Anon. 1997), if the collection practice continues the wild populations of this plant will be severely affected.

Rauwolfia serpentina (Apocynaceae) a well known undergrowth was given threat status as endangered/regionally (Anon. 1997). Sporadic occurrence of this species has also been reported from other parts of Western Ghats (Mathew Dan and Shanavakshan 1991). In the present study, it was observed in moist deciduous (0.05/m^2) and dry deciduous forests (0.07 in BNP; 0.006 WWLS), and in teak plantations (0.009/m^2). The natural populations of this plant are diminishing due to large scale collections of underground parts. The present study supports the inclusion of this species in the endangered category (Anon. 1997).

Schrebera swietenioides (Oleaceae) a vulnerable/regionally species (Anon. 1997) was recorded in the deciduous forests and it lacks regeneration in both the dry

deciduous and moist deciduous forests of NBR. The density of this tree species was less in the disturbed dry deciduous forest (6/ha) than in the least disturbed dry deciduous forest (26.5/ha).

Terminalia arjuna (Combretaceae), a low risk near threatened category species (Anon. 1997) characteristic to the river banks was recorded in the riverine forests of Coimbatore FD with a density of 9/ha. It is one of the abundant tree species in the river banks of Coimbatore Division.

Apart from the above species, priority for conservation should also be given to species such as *Terminalia chebula*, *Rotula aquatica* and *Decalepis hamiltonii*. *T. chebula*, one of the commercially exploited medicinal tree was recorded with less abundance and poor regeneration in both dry deciduous and moist deciduous forests. It could be due to the extraction of this fruit for commercial purposes. Fire also affects the regeneration of this species (Srivastava *et al* 1998). *R. aquatica*, is a peninsular Indian endemic shrub occur in the riverine forests of the NBR, a habitat which is under severe anthropogenic pressure. *D. hamiltonii*, is a woody climber endemic to peninsular India, with high volume of domestic trade of roots. It has been assigned the threat status as endangered. Reduced abundance of *D. hamiltonii* was observed in the Mudumalai Wildlife Sanctuary (Stephen, Pers. comm.). Hence, conservation priority should be given to these species also.

4.4.4. Status of endemic medicinal plants

Eight endemic medicinal plant species were encountered only in the moist deciduous forests. The present study showed the reduced abundance of some of the

endemic medicinal plants in the disturbed areas. Among them, *Nervilia aragoana* was commercially exploited. It was also included in the red list of medicinal plants of south India (Anon. 1997). *Lagerstroemia microcarpa*, an endemic tree of peninsular India reported to have high degree of seed sterility (Narayanan 1988), showed poor regeneration in the habitats sampled. Hence, suitable management programmes should be undertaken to conserve and utilize these endemic species.

4.4.5. Regeneration status of medicinal plants

Regeneration status of tree species in many of the India's forests, including the forests of Western Ghats is inadequate to replace the adults (Sukumar *et al* 1992). However, Manilal *et al* (1989), Ganesh *et al* (1996) and Sundrapandian and Swamy (1997) recorded good natural regeneration for dominant tree species in the less disturbed evergreen forests of Silent Valley, Kalakad-Mundanthurai Reserve and Kodayar respectively. Murali *et al* (1996) observed poor regeneration of NTFP species such as *Phyllanthus emblica, Terminalia bellirica* and *T. chebula* in the Biligiri Rangan Hills. The present study showed that species namely *Mitragyna parvifolia, Semecarpus anacardium* and *Terminalia chebula* showed poor regeneration in the habitats sampled. *Schrebera swietenioides* and *T.chebula*, red listed medicinal plants of south India (Anon. 1997) lacked regeneration in the disturbed dry deciduous forests, which indicates that the regeneration is affected by human disturbances. Among the medicinal trees, *Randia dumetorum* exhibited the highest regeneration in teak plantations. where the ratio of the number of mature trees to seedlings and saplings was high followed by *Dalbergia latifolia* in teak plantations. The higher rate

of regeneration of these species may be due to higher seed germination capacity and adaptability of the species to surrounding environment. Although, these species have higher regeneration lower number of mature trees as compared to seedlings and saplings suggests that either in this stage the trees die by some natural cause or affected by some artificial means.

Regeneration of tree species is greatly influenced by the interaction of biotic and abiotic factors of the environment (Boring *et al* 1981; Lange and Graham 1983: Aksamit and Irving 1984; Khan *et al* 1986) and intrinsic factors of the seed (Mohan Kumar 1997). These factors may affect the recruitment, survival and growth of seedlings and sprouts. The present study showed that commercial exploitation is one of the factor which affect the regeneration of tree species. For example, *Phyllanthus emblica* had significantly higher seedlings density in the Bandipur NP (unharvested site) than in the Wayanad WLS (harvested site). The present study also showed that total seedling density was significantly higher in the Bandipur NP (unharvested habitat) than in the Wayanad WLS (harvested site). However, poor regeneration could also be due to other factors such as grazing and fire. Among the commercially exploited tree species, species such as *Diospyros malabarica, Gmelina arborea, Strychnos nux-vomica* and *Terminalia chebula* showed poor regeneration. The lack of regeneration of *T. chebula* may be due to poor germination capacity of its seeds (Singh 1988), fire (Srivastava *et al* 1998) and commercial exploitation of its fruits. Poor recruitment of tree species could also result from grazing and disturbances. The study by Agarwal *et al* (1988) on the effect of biotic pressure on regeneration of tree

species in a mixed deciduous forest in the Garwal Himalayas showed that the biotic pressures have a serious effect on regeneration of trees. Prasad and Pandey (1992) also have observed very little regeneration closer to human habitations in the deciduous forests in Madhya Pradesh. Although, *Shorea roxburghii* exhibited good regeneration in the dry deciduous forests, the number of mature trees was less. Sukumar *et al* (1992) has observed a high degree of mortality of *S. roxburghii* due to the attack by a stem borer insect in the Mudumalai Wildlife Sanctuary, which may explain the present lower number of matured trees when compared to the number of seedlings and saplings.

Seeds of some medicinal tree species such as *Schleichera oleosa, Syzygium cumini, Terminalia chebula, Terminalia bellirica* and *Phyllanthus emblica* are dispersed by birds and mammals. It is possible that the combined `predation' by animals and humans could have a negative effect on recruitment of these species. Moreover, populations of animal dispersed species are more vulnerable to human disturbances such as harvesting, fire and grazing than those of wind dispersed or passively dispersed species (Ganeshaiah *et al* 1998). Hence, adequate measures has to be undertaken for the effective regeneration of the above species.

The present study showed that tree and shrub species diversity index showed significant difference between the disturbed and undisturbed riverine and dry deciduous forests respectively. However, the difference in species diversity could also be influenced by several factors such as fire, grazing and competition by weeds. The

preponderance of small sized individuals in the lower size classes in the riverine forest of Attappady indicate a past disturbance in the form of large scale extraction of forest products including timber. Boom (1996) also reported the abundance of smaller sized individuals as an evidence of early successional community. In the dry deciduous forests, the present study showed no significant difference in tree density and basal areas between the least disturbed (Bandipur NP) and disturbed (Wayanad WLS) habitats. However, in the riverine forests significant difference in basal area was observed between the least disturbed (Coimbatore FD) and disturbed (Attappady RF) habitats. Murali *et al* (1996) observed no significant difference in tree density between the sites proximal to human settlement and distant site in the Biligiri Rangan Hills, India. However, they have observed significant difference in basal areas between the above sites. Uma Shankar *et al* (1998) observed significant difference in stand density and basal area between the stand proximal to human settlement and distant stand in the scrub forests of Biligiri Rangan Hills, India. However, tree density may vary between area and year, hence long term monitoring of tree population is necessary. The difference in tree diversity, density and basal area could also be due to differences in history and current land use patterns. Diffrences in microclimate, soils, frequency of fires and grazing could also influence the outcome.

The status survey of various medicinal plants in the NBR showed that over exploitation of medicinal plants, habitat degradation and other human pressures have resulted in reduced abundance of many species in their natural habitats. It is also clear that the regeneration of most of the medicinal plants in the NBR is inadequate

to replace the adults. Thus, the extraction of medicinal plants without adequate controls and management can further reduce the already inadequate regeneration. The forest managers in India have neglected the management of non-timber forest products, which annually contribute heavily to the rural economy (Champers *et al* 1989). Tribals of NBR depend on forest products for their survival. Therefore, maintenance of regenerating forests is important to safeguard the tribal interest. Adequate management action and research should be undertaken to conserve the medicinal resources. Adequate management requires information about the actual availability or productivity of resources, the amounts collected per unit area, and the impact of extraction on forest structure and composition.

4.5. SUMMARY

The objectives of this study were to examine the status and distribution of medicinal plants in different habitats of NBR and to assess the regeneration status of medicinal plants in the NBR. The status, distribution and regeneration of medicinal plants in different forests types of Nilgiri Biosphere Reserve was studied using 0.1 ha quadrat (50 x 20 m).

i. Tree and shrub species diversity index showed significant difference among the habitats sampled. However, herb species diversity index showed no significant difference among the vegetation types sampled. Ethnomedicinal species richness was highest in the moist deciduous forests.

ii. Density of medicinal trees was significantly higher in the dry deciduous forests of Bandipur NP. Density of medicinal shrubs also showed significant difference among the forests type sampled, it was highest in the riverine forests in Attappady (ARF).

iii. Among the habitats sampled, moist deciduous forest is rich in ethnomedicinal plant resources as well as endemic medicinal plants. Therefore, the moist deciduous forests should get higher priority while formulating conservation and management.

iv. Species richness, basal area and regeneration are higher in the least disturbed area than the disturbed area and therefore least disturbed areas have higher conservation value.

V. Our results also indicate that the regeneration of most of the medicinal plants in the NBR is inadequate to replace the adults. Species such as *Mitragyna parvifolia, Semecarpus anacardium, Terminalia chebula* and *Schrebera swietenioide*s needs immediate action as they lack regeneration. While species such as *Randia dumetorum, Dalbergia latifolia* and *Shorea roxburghii* showed good regeneration. Thus, the extraction of medicinal plants without adequate controls and management can further limit the already inadequate regeneration.

CHAPTER V

COMMERCIAL EXPLOITATION OF MEDICINAL PLANTS

5.1. INTRODUCTION

Medicinal plants the major raw materials for many pharmaceuticals and ayurvedic industries are mostly collected from the wild and mainly by the tribals. With the increase in human population, the demands for raw materials also increase and as a consequence many medicinal plants are being over exploited. In majority of the cases, the entire plant is uprooted without compensating their natural regeneration. In India, there are about 3,000 medium to large scale drug manufacturing units that utilize several medicinal plants, both from cultivated and wild sources (Suri *et al* 1994). Over 95% of the medicinal plants used by the pharmaceutical industry are collected from the wild, less than twenty species of plants are under commercial cultivation while 400 species are used in production by industry and over 70% of the collections involve destructive harvesting (Anon. 1997). In Kerala state, of the 540 species of medicinal plants reported (Nambiar *et al* 1985), nearly 150 are used in the manufacture of ayurvedic medicines (Sasidharan 1991).

5.1.1. Impact of commercial harvesting on plant population

The overall ecological impact of forest utilization depends on the floristic composition of the forest, the nature and intensity of harvesting, and the particular species or type of resource under exploitation (Peters 1993). There are many examples of depletion of plant populations because of unsustainable utilization in the tropics (Homma 1992; Pinard 1993; Peters 1993; Cunningham 1991).

Commercial harvesting of *Jessenia bataua* and *Orbignya phalerata* fruits in the Amazon resulted in reduced abundance of these species (Kahn 1988). Collection of "gharu" plant exudate (*Aquilaria spp.*) in most part of southeast Asia virtually eliminated the trees from all but most remote and inaccessible areas (Peters 1993). Connelly (1985) reported that over exploitation killed many species of rattans in Philippines. Reining *et al* (1991) showed that two palm species collected and exported for floral arrangements are harvested in an unsustainable manner in Maya Biosphere Reserve of Guatemala. Depletion of plant populations in Amazonian forests frequented by rubber tappers was reported by Nepstad *et al* (1992). Unsustainable harvesting of plant products restricted not only to products that are being collected for commercial markets but medicinal plants used primarily by local communities are also being depleted by unsustainable extraction (Browder 1992). Hall and Bawa (1993) provided methods to monitor the effects of extraction on natural populations of target species and the composition of forests to determine, if the extraction rates are sustainable. Daniels *et al* (1993a), Murali *et al* (1996) and Uma Shankar *et al* (1998) showed the impact of Non Timber Forest Products extraction on the forest structure and regeneration in the Western Ghats, India. Apart from the above studies, a few studies showed the population dynamics and economic valuation of NTFPs (De Beer and McDermott 1989; Godoy *et al* 1993; Pinard 1993; LaFrankie 1994 and Lawrence *et al* 1994). However, the impact of extraction of NTFP on forest structure and composition is unknown for most extractive reserves (Murali *et al* 1996). These analyses are important to find out if medicinal plant species are exploited on a sustainable basis and to design appropriate conservation and management plans.

In India, various authors (Nayar 1964; Prasad and Pratibha 1993; Singh 1993; Moumita Roy and Santra 1995) studied the commercially important medicinal plants in different forest areas. However, the impacts of extraction of NTFP on the plant populations (Daniels *et al* 1993; Murali *et al* 1996; Uma Shankar *et al* 1998) are scanty. As far as the NBR is concerned, Anon. (1980), Sasidharan (1991) and Balachander (1993) recorded the commercially important medicinal plants. However, the list is incomplete and quantitative information on the abundance and regeneration of commercially exploited medicinal plant species is lacking. In this background, the present study was undertaken in the Nilgiri Biosphere Reserve with the following objectives;

i) to identify the commercially exploited medicinal plants in the Nilgiri Biosphere Reserve,

ii) to collect autecological information of commercially exploited medicinal plants and

iii) to assess the impact of commercial harvesting of medicinal plants on the abundance, species composition and regeneration of plant populations.

Impact of commercial extraction on species diversity, density and regeneration of plant populations were assessed in a least-harvested site (Bandipur NP) and a harvested site (Wayanad WLS). Forests in these areas are contiguous and the tribals in the Wayanad WLS collect NTFP species. Besides, the forests in the Wayanad WLS were subjected to grazing. Collection of NTFP

is not allowed in the Bandipur NP and there are no tribal settlements inside this Park.

5.2. METHODS

5.2.1. Commercial exploitation

Commercially exploited medicinal plants are those, which are collected in large quantities and sold for the preparation of drugs. Information on the commercially exploited plants was collected from both field studies and secondary sources (Anon. 1980; Sasidharan *et al* 1991; Balachander 1993). Field surveys were conducted in selected forest areas of NBR namely Coimbatore Forest Division, Sathyamangalam Forest Division, Attappady Reserve Forest and Wayanad Wildlife Sanctuary between May 1994 and October 1997. Data on local name, part collected, place of collection and month of collection were gathered from the tribal people. Plant specimens were collected and identified with the help of local floras (Gamble 1957; Vajravelu 1992) and confirmed at the Botanical Survey of India, Coimbatore.

A survey was conducted to collect information on medicinal plants sold in the local market at Poondi, Boluvampatty RF. Field surveys were conducted between 1997 and 1998. Information on local name of the plant, part sold, uses, locality of collection and market value were gathered from the shop owners.

5.2.2. Autecology

Autecological information of commercially exploited medicinal plant species were gathered from field studies, herbarium and secondary sources. Information

on time of flowering, fruiting, vegetation type and habitat requirements of commercially exploited medicinal plant species were gathered from these sources.

5.2.3. Impact of extraction

Two hectares were sampled each in the least-harvested and harvested habitat to assess the impact of extraction on the species composition, diversity and regeneration of medicinal plant populations. Data was collected from these two habitats and analysed as discussed in chapter IV. Status of commercially exploited medicinal plants in different habitats of NBR were also assessed as discussed in chapter IV.

5.3. RESULTS

5.3.1. Commercial utilization

Tribals in the NBR have been living in the area for hundreds of years, practising hunting-gathering and shifting agriculture. Although, the practice of shifting agriculture was stopped, they continued to extract non-timber forest products. The collected products are mostly sold through tribal cooperative societies known as Large Scale Adivasi [Tribal] Multipurpose Societies (LAMPS). Some harvested plants are marketed directly by the tribals, bypassing tribal cooperative societies.

Eighty-five species of commercially exploited medicinal plants belonging to 42 families were recorded from the Nilgiri Biosphere Reserve (Appendix XXI). Of the 85 species, information on 58 species was obtained from secondary sources while information on the remaining 27 was collected during the present study (Table 5.1). Only four families were represented by four or more species

(Table 5.2). Fabaceae was the largest contributor contributing 8% of the species. Asclepiadaceae, Solanaceae and Liliaceae contributed about 5% each. The contributions of these four families were 22%. Among the 85 species, trees contributed 36.5% of the species, followed by climbers, herbs and shrubs (Figure 5.1). Destructive extraction of many medicinal plants was observed in the present study. Of the 85 species of commercially exploited medicinal plants, 49% were collected for underground parts (root/rhizome/tuber), 12% for reproductive parts (flower/fruit/seed), 14% for whole plant, 12% for bark and 13% for other parts (Figure 5.2). It was observed that while harvesting the fruits of *Phyllanthus emblica* and *Mangifera indica*, branches were lopped. Three peninsular endemic species (Ahmedullah and Nayar 1987), namely *Cinnamomum malabatrum, Nilgirianthus barbatus* and *N. ciliatus* were also found commercially exploited in the NBR. Of the eighty-five species, 19 were listed in the "red list" of medicinal plants of south India (Anon. 1997). Among them, species such as *Nervilia aragoana, Nilgirianthus ciliatus, Oroxylum indicum, Rauwolfia serpentina, Salacia oblonga* and *Saraca asoca* are listed in endangered category.

About 58% of the commercially exploited medicinal plants occurred in more than one habitat. Scrub forests alone harbours 14% of the species (Table 5.3). Evergreen forest has about 10% of the species, riverine 8%, dry deciduous about 5% and moist deciduous forest about 4% of the species. Commercially exploited medicinal plants such as *Crataeva magna, Strychnos nux-vomica, Rotula aquatica* and *Terminalia arjuna* were found only in riverine forests. Similarly species such as *Aphanamixis polystachya, Myristica dactyloides, Neolamarkia cadamba*,

Nilgirianthus barbatus, N. ciliatus, Oroxylum indicum, Salacia oblonga, Saraca asoca and *Symplocos cochinchinensis* were distributed only in evergreen forests.

Table 5.1. Commercially exploited medicinal plants recorded in the NBR during this study.

Species	Family	Habit	Part(s) collected
Acacia leucophloea	Mimosaceae	Tree	Bark
Acacia sinuata	Mimosaceae	Climbing shrub	Fruit
Canarium strictum	Burseraceae	Tree	Resin
Carissa carandas	Apocynaceae	Shrub	Fruit
Clerodendrum serratum	Verbenaceae	Shrub	Root
Coleus zeylanicus	Lamiaceae	Shrub	Whole plant
Curcuma aromatica	Zingiberaceae	Shrub	Rhizome
Cymbidium aloifolium	Orchidaceae	Epiphyte	Whole plant
Decalepis hamiltonii	Asclepiadaceae	Climber	Root
Diospyros malabarica	Ebenaceae	Tree	Fruit
Evolvulus alsinoides	Convolvulaceae	Herb	Whole plant
Ficus benghalensis	Moraceae	Tree	Bark
Gymnema sylvestre	Asclepiadaceae	Climber	Leaves
Limonia acidissima	Rutaceae	Tree	Fruit
Naravelia zeylanica	Ranunculaceae	Climber	Root
Premna latifolia	Verbenaceae	Tree	Root bark
Ricinus communis	Euphorbiaceae	Shrub	Root
Shorea roxburghii	Dipterocarpaceae	Tree	Resin
Sida rhombifolia	Malvaceae	Herb	Root
Sida schimperiana	Malvaceae	Herb	Root
Solanum indicum	Solanaceae	Shrub	Root
Solanum melongena var. *insanum*	Solanaceae	Shrub	Root
Solanum torvum	Solanaceae	Shrub	Fruit and root
Strychnos nux-vomica	Loganiaceae	Tree	Seed
Terminalia chebula	Combretaceae	Tree	Fruit
Terminalia bellerica	Combretaceae	Tree	Fruit
Tribulus terrestris	Zygophyllaceae	Herb	Whole plant

Table 5.2. Dominant families of commercially exploited medicinal plant species.

Family	Species	
	No.	%
Fabaceae	7	8.2
Asclepiadaceae	4	4.7
Solanaceae	4	4.7
Liliaceae	4	4.7
Caesalpiniaceae	3	3.5
Malvaceae	3	3.5
Mimosaceae	3	3.5
Moraceae	3	3.5
Orchidacae	3	3.5
Verbenaceae	3	3.5

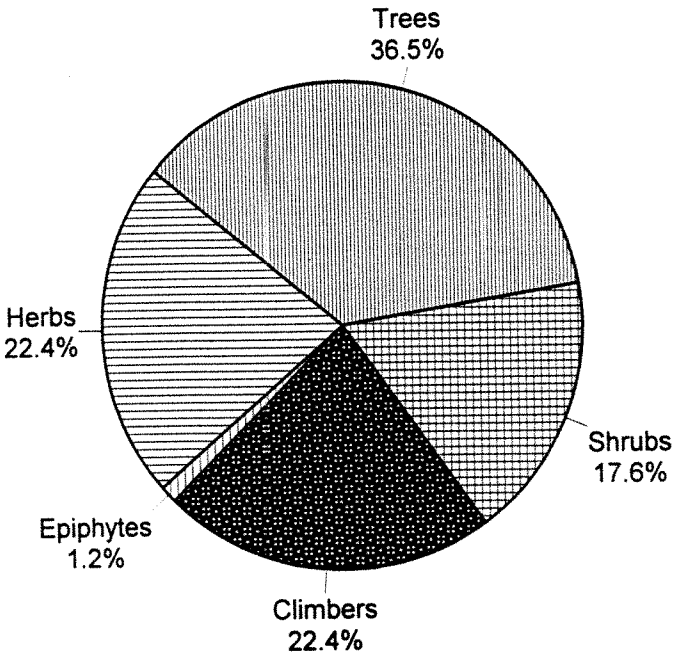


Figure 5.1. Growth forms of commercially exploited medicinal plants in the NBR (n=85 species)

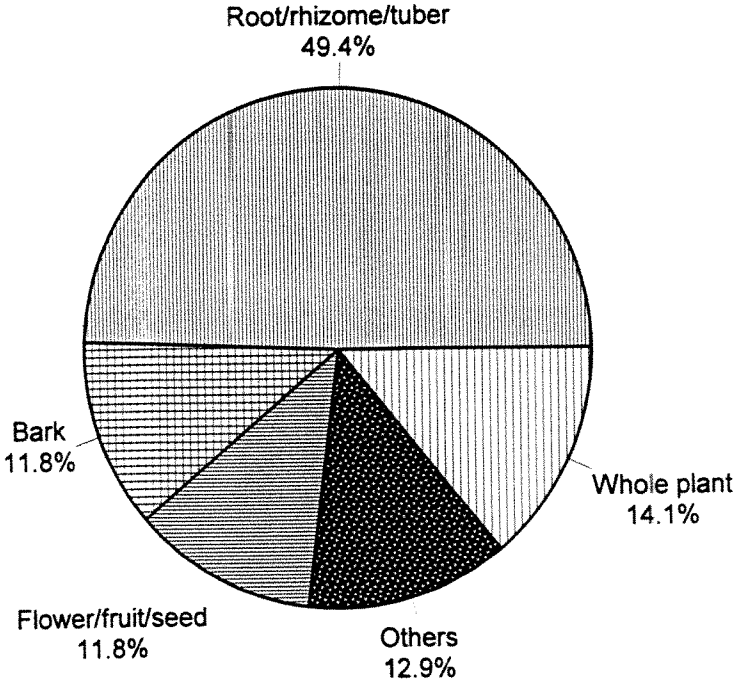


Figure 5.2. Commercially exploited medicinal plant parts in the NBR (n=85 species)

Table 5.3. Distribution of commercially exploited medicinal plant species in different habitats.

Habitats	Species Number	%
AF	3	3.5
DD	4	4.7
DD-MD	11	12.9
DD-SC	13	15.3
E	9	10.6
E-MD-RI	1	1.2
E-MD-SH	1	1.2
E-RI	1	1.2
MD	3	3.5
MD-E	9	10.6
MD-RI	2	2.4
MD-TP	2	2.4
RI	7	8.2
RI-AF	1	1.2
SC	12	14.1
SC-DD-MD	5	5.9
SC-DD-MD-E	1	1.2

Habitats: AF- Agricultural fields; DD - Dry deciduous; MD - Moist deciduous; SC - Scrub; E - Evergreen; RI - Riverine; TP - Teak plantations.

5.3.2. Plants sold in the local market

A significant amount of medicinal plants is collected and sold locally by the tribals without entering major marketplaces and tribal cooperative societies. Tribals in the Boluvampatti Reserve Forest of Coimbatore Forest Division are collecting and selling plants in the local market at Poondi (Plate 7a). In total, 25 species were recorded in the market place (Table 5.4.). Of the 25 species, 8 were trees, 9 shrubs, 2 herbs, 4 epiphytes and 2 were climbers. The medicinal plants sold in the local market include six endemic species of peninsular India (Ahmedullah and Nayar 1987) such as *Impatiens parasitica* (Plate 7b), *Medinilla beddomei*, *Amomum cannicarpum*, *Anisochilus argenteus*, *Hypericum mysurense* and *Bulbophyllum neilgherrense*. Most of the medicinal plants sold in the market were collected from the wild while species such as *Vetiveria zizanioides*,

Andrographis paniculata, *Gardenia resinifera*, *Curcuma aromatica* and *Acorus calamus* were procured from nearby major market places. Among the 25 species, 28% were sold for their underground parts (roots/rhizome), 24% for reproductive parts (flower/fruit/seed), leaves 16%, stem 8%, whole plant and resin 12% each.

Table 5.4. Medicinal plants sold in the market at Poondi.

Species	Family	Habit	Part	Status*
Acorus calamus	Araceae	S	Rhizome	Vulnerable
Amomum cannicarpum	Zingiberaceae	S	Rhizome	Endemic
Andrographis paniculata	Acanthaceae	S	Aerial part	-
Anisochilus argenteus	Lamiaceae	S	Leaves	Endemic
Bulbophyllum neilgherrense	Orchidaceae	E	Whole plant	Endemic
Canarium strictum	Burseraceae	T	Resin	Vulnerable
Curcuma aromatica	Zingiberaceae	S	Rhizome	-
Euphorbia rothiana	Euphorbiaceae	H	Leaves	-
Fagraea ceylanica	Loganiaceae	T	Fruit	-
Gardenia resinifera	Rubiaceae	T	Resin	-
Gymnema sylvestre	Asclepiadaceae	C	Leaves	-
Helicteres isora	Sterculiaceae	S	Seed	-
Hypericum mysurense	Hypericaceae	S	Leaves	Endemic
Impatiens parasitica	Balsaminaceae	E	Root	Endemic
Medinilla beddomei	Melastomataceae	E	Root	Endemic
Myristica dactyloides	Myristicaceae	T	Fruit	Vulnerable
Notonia grandiflora	Asteraceae	S	Stem	-
Oberonia sp	Orchidaceae	E	Whole plant	-
Peperomia tetraphylla	Piperaceae	H	Whole plant	-
Piper sp	Piperaceae	C	Root	-
Pterocarpus marsupium	Fabaceae	T	Resin	-
Schefflera racemosa	Araliaceae	T	Inflorescence	-
Strychnos nux-vomica	Loganiaceae	T	Seed	-
Terminalia chebula	Combretaceae	T	Fruit	-
Vetiveria zizanioides	Poaceae	S	Root	-

Habit: T - Tree, S - Shrub, H - Herb, C- Climber, E - Epiphyte; * Based on Anon. (1997) and Ahmedullah and Nayar (1987).

(b)

Plate 7 a) Market survey in Poondi, Boluvampatty Reserve forest
b) *Impatiens parasitica* - a peninsular endemic epiphyte available in the market

5.3.3. Autecology of medicinal plants

Autecological information of important commercially exploited medicinal plants are given below. The taxa are arranged alphabetically, notes on distribution and conservation status (Ahmedullah and Nayar 1987; Nayar and Sastry 1987), plant part collected and uses are also given for various taxa.

***Acacia leucophloea* (Roxb.) Willd. (Mimosaceae)**

Local name: Velvelam

A moderate sized deciduous tree species upto three meter in height. Distributed in the dry Siwalik hills of Himachal Pradesh, Punjab and Haryana, sub-himalayan tract, plains of Uttarpradesh, Madhyapradesh, Orissa, Rajasthan, Gujarat and south India (Bennet *et al* 1991). Observed in the deciduous forests of Attappady RF and Coimbatore FD. Pollination is by bees (Murali and Sukumar 1994). Propagation is by seeds. Flowering: August - October; Fruiting: December. Bark of this tree is collected throughout the year.

***Acacia sinuata* (Lour.) Merrill (Mimosaceae)**

Local name: Cheekakai

A climbing shrub with prickles on stems and leaves. It occurs in tropical jungles and hotter parts of India (Bennet *et al* 1991). Observed in the riverine forests of Coimbatore FD, Attappady RF, New Amarambalam, Mudumalai WLS, Wayanad WLS and Bandipur NP. Propagation is by seeds. Flowering: March - July; Fruiting: August - January. Fruits are collected during January to March and sold for the preparation of soap and shampoo.

***Aegle marmelos* Corr. (Rutaceae)**

Local name: Koovalam, Vilvam

A medium sized deciduous tree in scrub forest, distributed throughout India. Also reported from Burma, Indochina, Baluchistan (Brandis 1990). Observed in Attappady RF and Coimbatore FD. Natural reproduction is mainly through coppice and root suckers and seedling regeneration is not very reliable because the seeds are liable to insect attack. Artificial propagation is by sowing fresh seeds (Singh 1988). Because of population reduction and loss of habitat, the species has been assigned the threat status as vulnerable/regionally (Anon. 1997). Flowering: March - May; Fruiting: April - June. Roots are one of the ingredients of 'dasamula', the ten roots used in ayurveda system of medicine.

***Anisochilus carnosus* (L.F.) Wall. (Lamiaceae)**

Local name: Karpooravalli

An aromatic undershrub, distributed in India, Sri Lanka and south east Asia (Matthew 1991). Observed in the scrub forests of Coimbatore FD and Attappady RF. Propagation is by stem cuttings. Flowering and fruiting: November. Whole plant is used in ayurveda.

***Aphanamixis polystachya* (Wall.) Parker (Meliaceae)**

Local name: Chemmaram

An evergreen tree species distributed throughout India. In south India, it is common in the Western Ghats from north Kanara downwards to Tirunelveli (Anon. 1985). Typical of moist shady localities, occur commonly in ravines along the shady banks of streams. It was reported in Campshed, Ayyappankoil area, Silent

Valley of Palghat District (Vajravelu 1992). Natural regeneration is often plentiful around the parent trees. Flowering and fruiting: October - January. Bark was collected in large scale for the preparation of herbal medicine. However, now it is not being collected. Natural population of this species is reduced hence, it has been assigned the threat status as vulnerable/regionally (Anon. 1997).

***Aristolochia indica* Linn. (Aristolochiaceae)**

Local name: Isharamul, Karutakodi

A herbaceous twiner with a woody root-stock, found throughout the low hills and plains of India from Nepal and lower Bengal to Chittagong in the Deccan, Peninsula from Konkan southwards and in Sri Lanka up to 3000m (Brandis 1990). Observed in the Coimbatore FD and Attappady RF. Flowering and fruiting: November- December. Leaves and roots are used in ayurveda system of medicine.

***Asparagus racemosus* Willd. (Liliaceae)**

Local name: Sathavari

A scandent spinous undershrub with tuberous roots, distributed in tropical and sub-tropical parts of the country including the Andamans; ascending in the Himalayas upto an altitude of 1500 m (Bennet *et al* 1991). Observed in dry deciduous, moist deciduous and evergreen forests. Also observed in teak plantations. Propagation is generally by root cuttings, also by seeds (Bennet *et al* 1991). Flowering: June - September; Fruiting: October - December. Tuberous roots are collected almost throughout the year. Roots are edible and also used in many ayurvedic medicines.

***Biophytum sensitivum* (L.) DC. (Oxalidaceae)**

Local name: Mukkutti, Thottavadi

A slender erect annual herb with a rosette of leaves on top of the stem. Distributed throughout the hotter parts of India as weeds in moist shady places (Warrier *et al* 1993). Observed in moist deciduous forests of New Amarambalam, Wayanad WLS, Mudumalai WLS and Bandipur NP. Propagation is by seeds. Flowering and fruiting: May - November. Whole plant is collected during August - November and sold for the preparation of ayurvedic drugs.

***Boerhavia diffusa* L. (Nyctaginaceae)**

Local name: Mukkurattai

A perennial creeping plant, with pinkish flowers, distributed throughout India in wastelands and road sides (Warrier *et al* 1993). It is common in open and wastelands. Propagation is by seeds. Flowering and fruiting: October. The officinal part is root and it forms a chief ingredient of several ayurvedic formulations.

***Canarium strictum* Roxb. (Burseraceae)**

Local name: Kunthirikkam, Kungilium

A large tree species found in evergreen forests, distributed from Konkan southwards through Kanara, Malabar, Coorg, Mysore to Travancore and Cochin upto about 1500 m (Brandis 1990). Observed in Attappady RF, Boluvampatty RF and New Amarambalam forests. Flowering: March - April; Fruiting: March - May. Resin is collected almost throughout the year in New Amarambalam forests.

***Carissa carandas* L. (Apocynaceae)**

Local name: Kallakkay

An evergreen spinous shrub, distributed in many parts of the country; also cultivated in many places (Bennet *et al* 1991). Observed in the scrub forests of Coimbatore FD. Propagation is by seeds (Bennet *et al* 1991). Flowering: April - June; Fruiting: August - September. Fruits are collected mostly for the preparation of pickles.

***Cassia fistula* L. (Caesalpiniaceae)**

Local name: Konnai

A moderate sized deciduous tree, usually occurring in deciduous forests, ascending to 1200 m in the sub-himalayan tract. It is usually found scattered in south and north Indian moist deciduous, southern and northern tropical dry deciduous and southern tropical thorn forests (Anon. 1983). It is commonly seen in Mudumalai WLS, Wayanad WLS, Bandipur NP, Coimbatore FD and Mukkali Forests of NBR. Pollination is by bees and seed dispersal is by animals (Murali and Sukumar 1994). Natural reproduction is by seeds, coppice and root-suckers. Artificial propagation can be done by direct sowing, planting out entire seedlings or stump planting. Flowering: May - August; Fruiting: February - April. Stem bark was collected in the Wayanad Wildlife Sanctuary.

***Clerodendrum serratum* (L.) Spreng. (Verbenaceae)**

Local name: Siruthekku, Angaravalli

A shrub species distributed almost throughout India; upto an altitude of 1500 m in the Himalayas (Bennet *et al* 1991). Observed in dry deciduous and moist

deciduous forests and in teak plantations. Natural regeneration is by seeds (Bennet *et al* 1991). Flowering: May - July; Fruiting: November. Roots are used in many ayurvedic medicines.

***Coscinium fenestratum* (Gaertn.) Colebr. (Menispermaceae)**

Local name: Maramanjal, Manjavalli

A woody climber with hoary young shoots, distributed in the Western Ghats, in Nilgiris and Travancore. It has been collected in the foot hills of Kolathupuzha, Pulikal range of Prambikulam and Sampaj of Coorg (Amalraj *et al* 1991). It was found that this plant is usually localized within restricted geographical areas ranging from 1,00 - 500 m elevation and are thinly scattered over a extensive areas in the moist forests (Mathew Dan and Shanavakshan 1991). It was observed in the Nilgiris (Gamble 1957). The plant is included in the IUCN list of endangered plants. Population reduction and loss of habitat are the threats to this species. Natural population of this species has been reduced considerably, hence it has been assigned the threat status as critically endangered/globally (Anon. 1997).

***Costus speciosus* (Koen.) Smith (Zingiberaceae)**

Local name: Kostam

Erect herbaceous plant with fleshy perennial rootstock, distributed throughout India upto an altitude of 1350 m; common in Bengal and Konkan (Bennet *et al* 1991). Observed in moist deciduous and semi-evergreen forests. Also cultivated as an ornamental plant. Propagation is by stem cuttings. Flowering and fruiting: July - August. Tuberous roots are used in ayurveda medicine.

***Crataeva magna* (Lour.) DC. (Capparidaceae)**

Local name: Neermathalam, Maralingam

A deciduous tree widely distributed in India, often cultivated (Bennet *et al* 1991). Observed in the riverine forests of Coimbatore FD and Attappady RF. Propagation is by seeds (Bennet *et al* 1991). Flowering: April - May; Fruiting: May - June. Bark was collected in large scale for the preparation of ayurvedic drugs.

***Curcuma aromatica* Sal. (Zingiberaceae)**

Local name: Kasthurimanchal

It is a herb with perennial root-stock, wild throughout India, cultivated in Bengal and Kerala (Warrier *et al* 1993). Observed in Mudumalai WLS, Wayanad WLS and Bandipur NP. Propagation is by planting rhizome. Flowering and fruiting: November - December. Tuberous roots are used to treat skin infection.

***Cyclea peltata* Diels (Menispermaceae)**

Local name: Pada Kizhangu/Kurruppa

Climbing herbs with peltate leaves occurs in Sikkim, Assam, Khasi hills, Burma, western coast of the Peninsula, from Konkan southwards (Brandis 1990). Observed in dry deciduous and moist deciduous forests. Propagation is by seeds and tuber. Flowering: February - March; Fruiting: March - May. Roots are collected during December to January.

***Cymbidium aloifolium* (L.) Sw. (Orchidaceae)**

Local name: Seguttuola

An epiphyte distributed in India and Sri Lanka to east Asia, Malaysia (Matthew 1991), also cultivated. Observed in Coimbatore FD and Attappady RF. Flowering and fruiting: April - July (Joseph 1987). Whole plant is collected during July to September.

***Decalepis hamiltonii* Wight & Arn. (Asclepiadaceae)**

Local name: Mahalikizhangu

A twining shrub distributed in Deccan, Horsleykodan, at 1,500m, Madampalle in Chittoor at 3,000 ft, hills of north Coimbatore, Carnatic, hills of Nellore, Anamalais (Gamble 1957). Observed in Sathyamangalam FD and Nilgiris. Propagation is by rhizome. Habitat destruction and over-exploitation are the main threat to this species. It has been included in the endangered/globally category in the 'redlist' of medicinal plants of south India (Anon. 1997). Flowering and fruiting: May - November. Roots are collected during July to October and used as pickle, also as medicines.

***Desmodium gangeticum* (L.) DC. (Fabaceae)**

Local name: Orila

An erect herb distributed throughout India in dry forests upto 900m elevation and as forest undergrowth in low elevation (Warrier *et al* 1993). Observed in moist deciduous and evergreen forests of Mukkali (Vajravelu 1992). Propagation is by seeds. Flowering and fruiting: April - November. Roots are one of the ingredients of ayurvedic drug, 'dasamula'.

***Desmodium velutinum* (Willd.) DC. (Fabaceae)**

Local name: Orilla

A large shrub, often with a short stem, distributed in sal forests of subhimalayan tract, from Dehra Dun eastward (Brandis 1990). Observed in dry deciduous and moist deciduous forests, and in teak plantations. Propagation is by seeds. Flowering: August - January; Fruiting: September - January. Roots are collected during August to December and are dried before marketing. The dried roots are one of the ingredients of 'dasamula and can be stored up to 3 - 4 months.

***Diospyros malabarica* (Desr.) Kostel. (Ebenaceae)**

Local name: Thumbika

A moderate sized evergreen tree, distributed almost throughout India, chiefly along streams, river banks and backwaters extending into the Valleys of the Ghats, also planted (Bennet *et al* 1991). Observed in the riverine forests of Coimbatore FD and Attappady RF. Natural regeneration is by seeds. Flowering: March - May; Fruiting: December. Fruits are used for tanning and also for medicine.

***Drosera peltata* Sm. (Droseraceae)**

Local name: Azhukunni

It is a stemless insectivorous herb with peltate leaves, occur in moist ground especially on thin layer of soil on exposed rocks in hills of Western Ghats (Amalraj *et al* 1991). Observed in evergreen and moist deciduous forests of Aruvanpara and Karasuryamalai, Palghat District. Threats to this species include over-exploitation, loss of habitats and population reduction. It has been assigned the

threat status as vulnerable/regionally (Anon. 1997). Flowering and fruiting: July - September. Whole plant was collected for the preparation of ayurvedic drugs.

***Evolvulus alsinoides* L. (Convolvulaceae)**

Local name: Vishnugirandhi

A hairy perennial herb, common in open and grassy places throughout the country, ascending to 1900m in the Himalayas (Bennet *et al* 1992). Observed in scrub forests, open places and roadsides. Propagation is by seeds. Flowering: July - September; Fruiting: September - December. Whole plant is collected mostly during August to October.

***Gloriosa superba* Linn. (Liliaceae)**

Local name: Kanvallikizhangu

It is a beautiful herbaceous climber, distributed throughout tropical India from sea level to about 2000 m elevation. Also distributed in South Africa, Madagascar, Indonesia and Malaysia (Sivarajan and Indira 1994). The plant is also cultivated in south India. Observed in dry deciduous, semi-evergreen and scrub forests. Propagation is by divisions of rhizomes planted before the rains in light rich soil with good drainage (Anon. 1985). Flowering and fruiting: July - October. Whole plant is used in ayurveda medicines.

***Gmelina arborea* Roxb. (Verbenaceae)**

Local name: Kumulu

A moderate to large deciduous tree upto 30m found wild in India. Also distributed in Sri Lanka and Philippines (Sivarajan and Indira 1994). Observed in dry deciduous, moist deciduous and evergreen forests. Pollination is by bees and

seed dispersal is by animals (Murali and Sukumar 1994). It can be raised by direct sowing or planting out entire plants or stumps (Pokhriyal *et al* 1992). Flowering: January - June; Fruiting: February - June. Fruits and roots are used in ayurveda.

***Gymnema sylvestre* R. Br. (Asclepiadaceae)**

Local name: Sarkaraikolli

It is a climber common in the deciduous forests, distributed in India, Sri Lanka and tropical Africa (Sivarajan and Mathew 1997). Observed in the deciduous forests of Attappady RF and Coimbatore FD. Propagation is by stem cuttings (Muraleedharan *et al* 1997). Flowering and fruiting: September - January. Leaves are collected during August to October.

***Helicteres isora* L. (Sterculiaceae)**

Local name: Idampuri-Valampuri

A shrub species distributed almost throughout India, mostly in the hilly tracts usually upto an altitude of 1500 m (Bennet *et al* 1992). Observed in dry deciduous and moist deciduous forests, and in teak plantations. Propagation is by seeds. Flowering: July - December; Fruiting: October - January. Fruits are collected during October to January.

***Hemidesmus indicus* R.Br. (Asclepiadaceae)**

Local name: Nannari

A much twining undershrub with nearly woody aromatic rootstock and polymorphic leaves. Common in Peninsular India along the hedges (Brandis 1990). Observed in dry deciduous, moist deciduous, evergreen and riverine forests, and in teak plantations. Due to indiscriminate collection of roots, the population of this plant

is being depleted. Propagation of this species is by stem cuttings (10 cm length), root cuttings (Amalraj *et al* 1991) and seeds (Bennet *et al* 1991). Flowering: August - September; Fruiting: October - December. Roots are used as flavouring material and also as medicine.

***Holostemma ada-kodien* Schultes (Asclepiadaceae)**

Local name: Adapathiyan

This twining shrub is distributed almost throughout India upto an altitude of 2000m (Bennet *et al* 1991). Observed in the deciduous forests of NBR. It grows over hedges in open forests especially on the lower slopes of the Hills. Propagation is by seeds (Mathew Dan and Shanavakshan 1991). Flowering: July - September; Fruiting: January. Roots are used in ayurveda.

***Hydnocarpus pentandra* (Buch-Ham.) Oken (Bixaceae)**

Local name: Maraveri

This tree species is commonly seen in semi-evergreen and evergreen forests, distributed along the W. Ghats from Konkan southwards also below the Ghats in Malabar (Brandis 1990). Observed in Dhoni RF, Mukkali forest (Vajravelu 1992), Nilambur (Sivarajan and Mathew 1997) and Boluvampatty RF. Under natural conditions, seeds germinate during the rains shortly after falling to the ground. It can be propagated from seeds. This peninsular endemic species (Ahmeduallah and Nayar 1987) has been assigned the threat status as vulnerable/globally (Anon. 1997). Flowering and fruiting: January - March. Seeds are used as medicine.

***Iphigenia indica* Kunth. (Liliaceae)**

Local name: Nirpanai

It is an erect herb, found throughout India upto an altitude of 2,000 m (Anon. 1989). Also distributed in Sri Lanka, Burma, Malaysia and Australia (Matthew 1983). It is occasional along the foot hills and in deciduous forests. Flowering: July- August; Fruiting: August - December.

***Ipomoea pes-tigridis* Linn. (Convolvulaceae)**

Local name: Pulichuvadi

A spreading herbaceous annual found almost throughout India, ascending upto 4000 ft usually in hedges, grasslands, wastelands, bushes, fields and sea coast. Propagation is by stem cuttings (Anon. 1989). Observed in the forests of Nilambur. Flowering and fruiting: September - December.

Limonia acidissima L. (Syn. *Feronia elephantun* Correa), **(Rutaceae)**

Local name: Vilanga

A tree with axillary thorns, occurs wild and cultivated in many parts of India. It is distributed almost throughout the country usually upto an elevation of about 500m. Common in south India and Madhya Pradesh (Bennet *et al* 1992). Observed in Boluvampatty RF and Sathyamangalam FD. Propagation is by seed, stem cuttings and budding. Flowering: April - May; Fruiting: June - July.

***Malaxis rheedii* SW. (Orchidaceae)**

Local name: Jeevagam

Slender, erect, stoloniferous herbs, distributed in Western Ghats, Deccan and Shervarays (Fyson 1995). Observed in Nilgiris and Silent Valley (Vajravelu 1992).

Propagation is by tuber. Flowering: July; Fruiting: October - November.

***Melothria maderaspatana* (Linn.) Cogn. (Cucurbitaceae)**

Local name: Musumusukkai

A prostrate annual herb distributed in Africa, India, China, Malaysia, Australia and New Zealand. In India it is seen in Deccan, Carnatic and lower hills of Western Ghats (Sivarajan and Indira 1994). Common in deciduous and scrub forests. Propagation is by seeds. Flowering and fruiting: September - January. Whole plant is used in ayurveda medicines.

***Myristica dactyloides* Gaertn. (Myristicaceae)**

Local name: Malaijathikai; Pathiripoo

This medium sized tree is found in evergreen and semi-evergreen forests, distributed in Punnamala (Silentvalley), Pothundy forest, Mandhampatty forest, Valiyaparathode (Palghat District, Vajravelu 1992) and Boluvampatty RF. Population reduction and habitat loss are the main threats to this species. It has been assigned the threat status as vulnerable/regionally (Anon. 1997). Propagation is by seeds. Flowering and fruiting: February - April. Aril of this plant is collected from mature fruits during March to June, which is used for making herbal medicine and also for making natural dyes.

***Naravelia zeylanica* (Linn.) DC. (Ranunculaceae)**

Local name: Vattakkoti

A climbing shrub common on hedges and thickets in almost all districts, especially at higher elevations (Sivarajan and Indira 1994). Observed in the Attappady RF. Flowering: June - December. Whole plant is used in ayurveda.

***Nervilia aragoana* Gaud. (Orchidaceae)**

Local name: Orilaithamara

A herb in the deciduous forests, mostly on wet open places, distributed in Indo-Malaysia (Sasidharan and Sivarajan 1996). Observed in moist deciduous and dry deciduous forests of Wayanad WLS, Mudumalai WLS and Bandipur NP. Propagation is by tubers. Threats to this species include habitat destruction, population reduction and over-exploitation. Hence, the species has been assigned the threat status as endangered/regionally (Anon. 1997). Flowering: May - June (Joseph 1987). Ayurveda system of medicine uses the whole plant in some drugs.

***Nilgirianthus ciliatus* (Nees) Bremek. (Acanthaceae)**

Local name: Karimkuringi

It is a shrub species growing in the semi-evergreen and evergreen forests, distributed in W.Ghats, in Karnataka to Travancore hills (Ahmedullah and Nayar 1987). Observed in the forests of Kannoth (Palghat District). Over-exploitation is the main threat to this species. The species has been assigned the threat status as endangered/globally (Anon. 1997). Flowering and fruiting: December - February. Roots along with basal portion of stem are collected during August to December and are dried before marketing. It is an important ingredient in many ayurvedic medicines.

***Oroxylum indicum* Vent. (Bignoniaceae)**

Local name: Palakapayyani

It is a tree species distributed throughout India in moist places of the deciduous and evergreen forests upto 1000m(Sivarajan and Indira 1994). Observed in Dhoni

RF and Mukkali forest of Palghat District (Vajravelu 1992). Tree reproduces naturally by seeds, which germinate in the beginning of the rainy season. Artificial propagation is by sowing seeds in nursery during March - April. Threats to this species include loss of habitat and over harvesting of roots. Hence, the species is listed under vulnerable/regionally category in the "red" list of medicinal plants of south India (Anon. 1997). Flowering: June - July; Fruiting: January - March. It is one of the ingredients of 'dasamula'.

***Phyllanthus emblica* L. (Euphorbiaceae)**

Local name: Nellikai

A moderate sized (upto 10 m), mostly deciduous tree species, commonly found in most parts of the country except in the arid regions (Singh 1988). Observed in dry deciduous and moist deciduous forests. Pollination is by bees and seed dispersal is by animals such as spotted deer (Murali and Sukumar 1994). Propagation is usually by seeds, and also vegetatively by budding and cutting (Singh 1988). Flowering and fruiting: February - May. Fruits are edible, used as pickle and also for the preparation of medicines. It is one of the ingredients of ayurvedic drug, 'Triphala'.

***Pongamia pinnata* (Linn.) Pierre. (Fabaceae)**

Local name: Pungam

This tree species has wide range of distribution in the country, chiefly along streams and rivers and in beach and tidal forests. It is also widely planted along roadsides (Pokhriyal *et al* 1992). It is common in plains along streams and riverine forests of the NBR. Natural reproduction is through seed, coppice and root

suckers. Artificial propagation is by direct sowing, seedlings and by stem cuttings (Singh 1988). Flowering: April - July; Fruiting: May - September. Oil from seed is used in ayurveda.

***Premna latifolia* Roxb. (Verbenaceae)**

Local name: Munnai

A middle sized tree, distributed in Bihar, Orissa, eastern India and south India upto an altitude of 1500m; mostly in deciduous forests (Bennet *et al* 1991). Observed in dry deciduous forests of Coimbatore FD and Sathyamangalam FD. Propagation is by seeds (Bennet *et al* 1991). Flowering: April - June; Fruiting: July.

***Pseudarthria viscida* (Linn.) W. & A. (Fabaceae)**

Local name: Moovila

It is a perennial herb found in the moist deciduous forests, distributed in all the district of southern India (Sivarajan and Indira 1994). Observed in Attappady RF, Wayanad WLS, Bandipur NP and Mudumalai WLS. Propagation is by seeds. Flowering: August - January; Fruiting: September - January. Dried roots are one of the ingredients of 'Dasamula'. Roots are collected during August to December and dried before marketing. It is listed in the low risk - near threatened/regionally category of red list of medicinal plants of south India (Anon. 1997).

***Pterocarpus marsupium* Roxb. (Fabaceae)**

Local name: Vengai

This tree species is mainly found in the Indian Peninsular, central India and Chota Nagpur (Singh 1988). Observed in moist deciduous and semi-evergreen forests. Pollination is by bees and seeds are dispersed by wind (Murali and Sukumar

1994). Propagation is by direct sowing or by planting out seedlings or stumps (Singh 1988). Flowering: May - July; Fruiting: December - January. Heartwood and gums are used in ayurvedic medicines.

***Rauvolfia serpentina* Benth. (Apocynaceae)**

Local name: Amalpori

It is an undergrowth in moist deciduous forests upto 1,000m (Mathew Dan and Shanavakshan 1991). Distributed in tropical Himalaya, India, Sri Lanka and Malaysia (Matthew 1983). Observed in moist deciduous and dry deciduous forests, teak and eucalyptus plantations. Propagation is by seeds, stem and root cuttings (Atal and Kapur 1982). Flowering: October - May; Fruiting: October - May. Roots are collected during August to October. It has great demand in the market, ever since it was found to be efficacious in treating hypertension. It has been assigned the threat status as endangered/regionally (Anon. 1997).

***Ricinus communis* Linn. (Euphorbiaceae)**

Local name: Amannakku

It is a native of tropical Africa, now found wild throughout the hotter parts of India. Also extensively cultivated for the seeds in the drier parts. It grows on any type of soil by roadsides and on wasteland (Sivarajan and Indira 1994). Propagation is by seeds. Flowering and fruiting is almost throughout the year. Roots are used in the preparation of ayurvedic medicines.

***Rotula aquatica* Lour. (Boraginaceae)**

Local name: Kallurvanchi

A small, much branched shrub, commonly growing along rocky riverbanks. It is

widely distributed in India, Sri Lanka, tropical south east Asia and Latin America (Sivarajan and Indira 1994). Observed along the Bhavani river banks of Attappady RF and Coimbatore FD. Flowering and fruiting: February - May. Roots are used in ayurvedic medicines.

***Rubia cordifolia* L. (Rubiaceae)**

Local name: Manchatti

A climbing herb with perennial root-stock found in evergreen forests of Peninsular India. Also reported from China, Japan, Vietnam and Malaysia (Sivarajan and Indira 1994). Observed in Silent Valley National Park, Nilambur and Attappady RF (Vajravelu 1992). Flowering: December - January; Fruiting: January.

***Salacia oblonga* Wall ex Wight & Arn. (Hippocrateaceae)**

Local name: Ponkoranti

This climber species is found in W.Ghats from Konkan southwards to Kerala (Anon. 1989). Observed in the evergreen forests of Coimbatore and Nilgiris district (Nair and Henry 1983). Population reduction and habitat destruction are the threats to this species. The species has been included in endangered/regionally category of the 'redlist' of medicinal plants of south India (Anon. 1997). Propagation is by seeds. Flowering and fruiting: February - May.

***Saraca asoca* (Roxb.) De Wilde (Caesalpiniaceae)**

Local name: Ashokam

It is a tree species found in evergreen forests, distributed throughout India, particularly northern Circars, south Canara, Mysore and Travancore. It is scarce in the wild, but it is widely cultivated (Sivarajan and Indira 1994), also found in

Andaman Islands. Observed along streams and on the shade of the evergreen forests of Silent Valley NP (Vajravelu 1992). Propagation is by seeds. The occurrence of this species is limited and it has been assigned the threat status as endangered/regionally (Anon. 1997). Flowering: February - April; Fruiting: September - October. Bark is used in many ayurvedic medicines.

***Scilla hyacinthiana* (Roth) Macb. (Liliaceae)**

Local name: Kattu Vengayam

A small bulbous plant found almost in every part of the country from Uttarpradesh and Bihar southwards to Kerala. It is commonly found in grassy areas or near the sea coast, appearing with the first fall of rain after summer (Anon. 1989). Observed in the dry deciduous forest of NBR. Propagation is by tuber. Flowering and fruiting: April - July.

***Shorea roxburghii* G.Don (Dipterocarpaceae)**

Local name: Jalura

A large tree species, distributed in the hills of southern Deccan, also on the west side from north Canara southwards (Brandis 1990). Observed in dry deciduous forests of Wayanad WLS, Mudumalai WLS (Suresh *et al* 1996) and Bandipur NP. Flowering: December - February, Fruiting: February - April. High degree of mortality of *S. roxburghii* due to the attack by a stem borer insect in the Mudumalai Wildlife Sanctuary was reported by Sukumar *et al* (1992)

***Sida acuta* Burm. (Malvaceae)**

Local name: Kurunthotti

It is a common herb along the roads, forest paths and open lands. Distributed

throughout the hotter parts of India and Malaysia (Sivarajan and Indira 1994). Propagation is by seeds. Flowering and fruiting: August - October. Roots and leaves are used in ayurveda system of medicine.

***Sida rhombifolia* Linn. (Malvaceae)**

Local name: Kurunthotti

An erect, very variable perennial undershrub, distributed in tropical and subtropical regions, Malaysia and throughout India (Sivarajan and Indira 1994). It is commonly seen along the pathsides in dry deciduous and moist deciduous forests. Propagation is by seeds (Anon. 1989). Flowering: June - January; Fruiting: August -January. Roots are collected during August to December and used in ayurvedic medicines.

***Solanum indicum* L. (Solanaceae)**

Local name: Puthiri Sunda, Mullu Sunda

A much branched prickly undershrub upto 1.8 m high, distributed in India, Malaysia, Philippines and Taiwan (Matthew 1983). Propagated by seeds and stem cuttings (Pal and Bhandari 1994). Flowering and fruiting is almost throughout the year, but mostly during October - May. Roots are used in ayurvedic medicines.

***Solanum pubescens* Willd (Solanaceae)**

Local name: Sirusundai

A shrub species found in the southern part of Deccan, common in foot of the hills (Brandis 1990). Observed in scrub and dry deciduous forests of Sathyamangalam FD, Coimbatore FD and Attappady RF. Natural reproduction is by seeds. Flowering: December - February; Fruiting: January. Fruits are edible.

***Solanum torvum* Swartz (Solanaceae)**

Local name: Sundai

A shrub with herbaceous branches, common in lower Bengal, Manipur, Chittagong, Chota Nagpur, Burma and Sri Lanka. It is also cultivated throughout the country (Brandis 1990). Flowering and fruiting is almost throughout the year. Fruits are edible.

***Stereospermum colais* Mabberley (Bignoniaceae)**

Local name: Pathiri

A moderate sized deciduous tree found almost throughout India, also reported from Sri Lanka, Thailand and Malaysia (Sivarajan and Indira 1994). Observed in moist deciduous forests of Mudumalai WLS, Bandipur NP, Wayanad WLS and also in Palghat District. Pollination is by bees and seed dispersal is by wind (Murali and Sukumar 1994). The species can be raised either by direct sowing or planting out nursery raised seedlings (Pokhriyal *et al* 1992). Flowering: May - June; Fruiting: August - November.

***Strychnos nux-vomica* L. (Loganiaceae)**

Local name: Etti, Kanjiram

A tree species distributed in Peninsular India extending northwards to the Orissa, Raipur and Konkan (Singh 1988). Observed in the riverine forests of Coimbatore FD, Silent Valley NP, Bandipur NP and Attappady RF. Propagation is by seeds. Flowering: April - May; Fruiting: September - December. Seeds have export value.

***Symplocos cochinchinensis* (Lour.) Moore (Symplocaceae)**

Local name: Pachotti

An evergreen tree species, distributed in south and southeast Asia and Malaysia (Sivarajan and Indira 1994). In India, it is common on hills, more abundantly in shola forests. Observed in Karasuryamalai, Kunthipuzha, Kaikatty, Poochipara forest of Palghat District (Vajravelu 1992). Threats to this species include habitat destruction and over-exploitation. The plant has been included in the low risk-near threatened/regionally category (Anon. 1997). Flowering and fruiting: May - August.

***Terminalia arjuna* Bedd. (Combretaceae)**

Local name: Neermaruthu

It is a tree species found mostly along stream and river banks, common throughout the greater part of India except arid regions in western Rajasthan, Punjab and Haryana. In peninsular, it grows chiefly in moist valleys (Singh 1988). Observed along the banks of river Bhavani and Moyar. Propagation is mainly through seed and coppice. Artificially raised by direct sowing or by planting out nursery raised seedlings (Singh 1988). The species has been included in the low risk- near threatened/regionally category of red list of medicinal plants of south India (Anon. 1997). Flowering: April - July; Fruits ripening: December - February.

***Terminalia bellerica* (Gaertn.) Roxb. (Combretaceae)**

Local name: Thannikai

A large tree species (Plate 8a) upto 40 m height, distributed throughout the greater part of India except arid regions in western Rajasthan, Punjab and Haryana. In Indian peninsula it grows chiefly in moist valleys (Singh 1988).

Observed in moist deciduous, semi-evergreen and evergreen forests. Flowers are pollinated by bees while the seeds are dispersed by animals (Murali and Sukumar 1994). Natural regeneration is through seeds and coppice. Artificial propagation can be by direct sowing or by planting out nursery raised seedlings (Singh 1988). Flowering: March - May; Fruiting: November - February. It is one of the ingredients of ayurvedic drug, 'Triphala'.

***Terminalia chebula* Retz. (Combretaceae)**

Local name: Kadukka

A medium sized tree (Plate 8b) distributed throughout the greater parts of the country. In the sub- himalayan tracts it occurs from Ravi eastwards to west Bengal and Assam, ascending upto an altitude of 1500m (Singh 1988). Observed in the dry deciduous and scrub forests. Flowers are pollinated by bees and the seeds are dispersed by animals (Murali and Sukumar 1994). Propagation is by seeds. Flowering: April - May; Fruiting: November - January. Fruits are collected from November and dried before marketing. It is one of the ingredients of ayurvedic drug, 'Triphala'.

***Tribulus terrestris* L. (Zygophyllaceae)**

Local name: Nerungi

it is an annual herb, distributed throughout India, and also in the tropical and warm temperature regions of the world (Sivarajan and Indira 1994). Common on roadsides and open places in the plains. Propagation is by seeds. Flowering and fruiting is almost throughout the year. Dried roots are one of the ingredients of ayurvedic drug, 'Dasamula'.

(a)

(b)

Plate 8 a) Seeds of *Terminalia bellirica* - commercially exploited from NBR
b) *Terminalia chebula* - fruits exploited commercially

***Trichosanthes cucumerina* L. (Cucurbitaceae)**

Local name: Kattupadavalam

A climber distributed throughout India and Malaysia (Sivarajan and Mathew 1997). Common in semi-evergreen forests on bushes and thickets. Observed in the forests of Palghat and New Amarambalam (Vajravelu 1992). Propagation is by seeds. Flowering: June - February; Fruiting: February - April. Roots are used in ayurvedic medicines.

5.3.4. Impact of extraction on medicinal plant populations

Impact of commercial extraction on species diversity, density and regeneration of plant populations were assessed between the least-harvested site (Bandipur NP) and harvested site (Wayanad WLS). A total of 127 species (38 trees, 15 shrubs and 74 herbs) was recorded in the least-harvested site (Bandipur NP) while 113 species (35 trees, 17 shrubs and 61 herbs) were recorded in the harvested site (Wayanad WLS).

5.3.4.1. Trees

Total number of tree species was higher in the least-harvested (38) than in the harvested (35) habitat. Similarly, number of medicinal tree species was also higher in the least-harvested (25) than in the harvested habitat (23). Tree species diversity index (H') showed no significant difference between these habitats (Table 5.5). The size class distributions of trees also showed no significant difference between these areas (Figure 5.3). Although, the size class distribution of major NTFP species (*Phyllanthus emblica, Terminalia bellirica* and *Terminalia chebula*)

showed greater proportion of individuals in the lower size classes in the least-harvested habitat than in the harvested (Figure 5.4.), it was not significant. Density and basal area of medicinal trees showed no significant difference between the least-harvested and the harvested habitat (Figure 5.5 and 5.6). NTFP species such as *Phyllanthus emblica, Terminalia bellirica* and *T. chebula* had higher importance value index in the least-harvested than in the harvested habitat (Table 5.6). However, the inter habitat difference was not statistically significant.

Table 5.5. Tree species richness and diversity index in the least-harvested and harvested habitats.

Habitat	Species richness			H'
	Total	Medicinal trees	Other trees	
Least-harvested (Bandipur NP)	38	25 (65.7%)	13 (34.3%)	2.40
Harvested (Wayanad WLS)	35	23 (65.7%)	12 (34.3%)	2.12

Table 5.6. Density, basal area and IVI of important medicinal trees in the least-harvested and harvested habitats.

Species	Least-harvested			Harvested		
	Density	Basal area	IVI	Density	Basal area	IVI
Anogeissus latifolia	161	56000	59	185	51720	67
Cassia fistula	2	250	1	7	1050	6
Gmelina arborea	1	40	1	1	70	1
Phyllanthus emblica	29.5	8390	16	24	7040	14
Pterocarpus marsupium	9	12250	12	10	15560	13
Shorea roxburghii	1.5	450	2	5	5530	5
Tectona grandis	39.5	64020	39	55	64620	43
Terminalia bellirica	1	7300	4	2	790	2
Terminalia chebula	4	2270	4	1	1010	2
OTHER TREES*	287.5	125690	162	200	125080	147
TOTAL (38 in Least-harvested & 35 in harvested)	536	276660	300	490	272470	300

Density denotes the number of individuals per ha; Basal area in cm^2/ha; IVI - Importance Value Index; Other trees are given in Appendix IX.

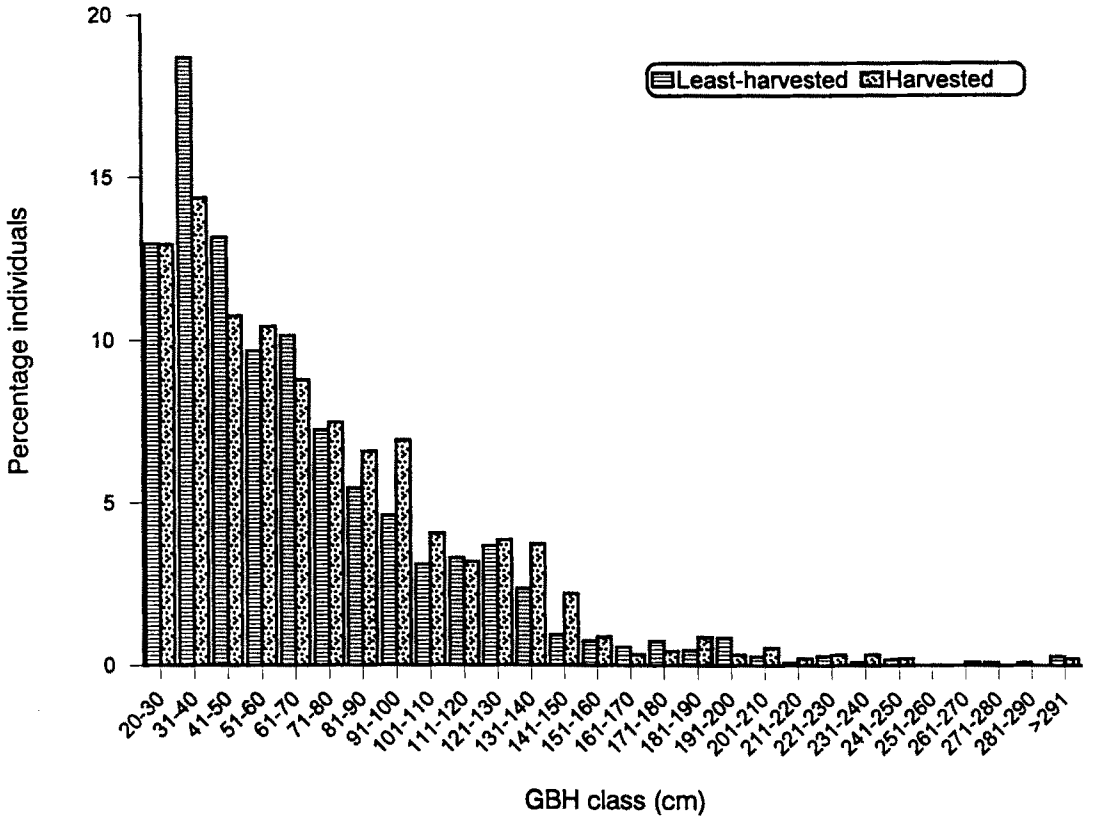


Figure 5.3. Size class distribution of trees (>20cm GBH) in the least-harvested and harvested habitats in the NBR

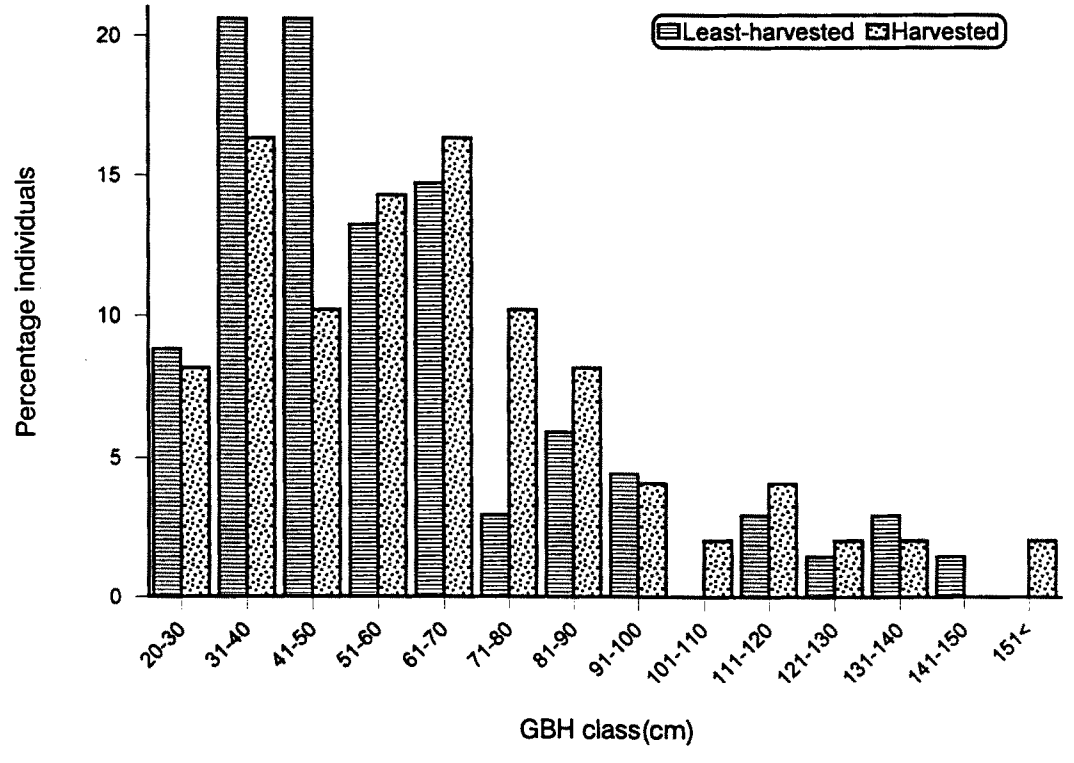


Figure 5.4. Size class distribution of NTFP species *(Phyllanthus emblica, Terminalia bellirica* and *T. chebula*) in the least-harvested and harvested habitats in the NBR

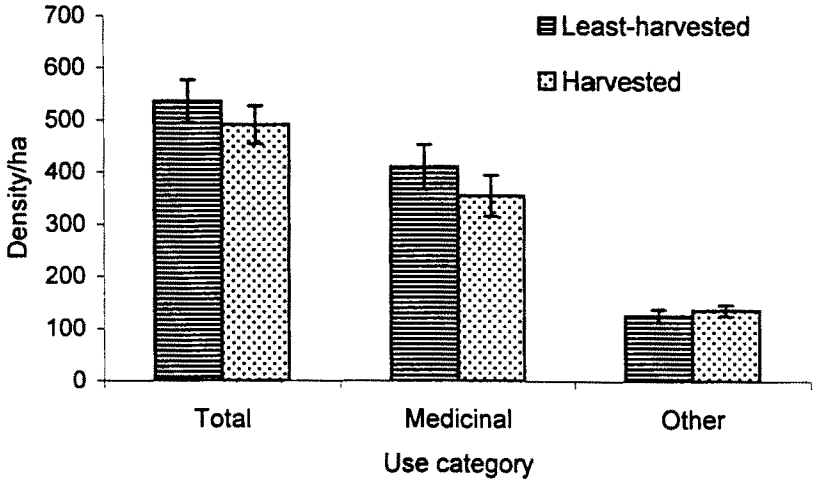


Figure 5.5. Mean density of trees ± SE in the least-harvested and harvested habitats

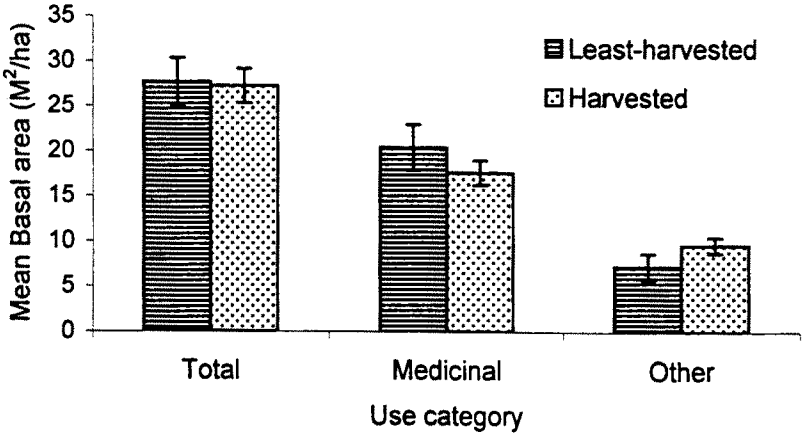


Figure 5.6. Basal area of trees (≥20cm GBH) ± SE in the least-harvested and harvested habitats

5.3.4.2. Shrubs

Species diversity index (H') was significantly (M-W test U=96, *P*=0.005) higher in the least-harvested habitat (H'=2.00) than in the harvested habitat (H'=1.74). Similarly, total shrub species density also showed significant difference (M-W test U=76.5, *P*=0.001) between these habitats (Figure 5.7). However, density of commercially exploited shrubs such as *Asparagus racemosus*, *Clerodendrum serratum* and *Helicteres isora* showed no significant difference between these habitats (Table 5.7).

Table 5.7. Abundance, density and IVI of important medicinal shrubs in the least-harvested and harvested habitats.

Species	Least-harvested			Harvested		
	Abundance	Density	IVI	Abundance	Density	IVI
Acacia sinuata	-	-	-	3	0.04	0.6
Asparagus racemosus	8.7	0.65	4.1	1.3	0.11	3.1
Clerodendrum serratum	1	0.01	0.3	1.7	0.21	4.8
Helicteres isora	5	0.13	1	4.3	0.32	3.9
Leea indica	12.1	9.85	54.4	11.4	10.41	83.3
OTHER SHRUBS*	11 Species	17.24	140.2	12 Species	7.18	104.9
TOTAL	15 Species	27.88	200	17 Species	18.23	200
Species diversity index (H')	2			1.74		

Density denotes the number of individuals per $25m^2$;*Other shrubs are given in Appendix X.

5.3.4.3. Herbs

Number of medicinal herb species was higher in the least-harvested (31) than in harvested habitat (28). Herb species diversity index (H') showed no significant difference between these habitats (Table 5.8). Total herb and medicinal herb species density also showed no significant difference between the least-harvested and harvested habitat (Figure 5.8). However, density of some commercially exploited herb species such as *Biophytum sensitivum, Cyclea peltata, Desmodium velutinum, Hemidesmus indicus* and *Rauwolfia serpentina* was significantly higher in the least-harvested habitat than in the harvested habitat

(M-W test U=2, P =0.036; M-W test U=7, P=0.026; M-W test U=4, P=0.024; M-W test U=2, P=0.015; M-W test U <0, P=0.039 respectively). But, density of *Sida rhombifolia* was significantly higher in the harvested habitat than in the least-harvested habitat (M-W test U=36.5, P=0.041). *Gynura nitida*, an endemic herb species also showed significant difference (M-W test U=9, P=0.020) between these habitats (Table 5.8).

Table 5.8. Abundance, density and IVI of important medicinal herbs in the least-harvested and harvested habitats.

Species	Least-harvested			Harvested		
	Abundance	Density	IVI	Abundance	Density	IVI
Biophytum sensitivum	4	0.666	9.9	2	0.034	0.8
Costus speciosus	2	0.041	1	-	-	-
Curculigo orchioides	4	1.063	18.2	4	2.563	49.6
Curcuma longa	4	0.6	10.3	-	-	-
Cyclea peltata	3	0.109	2.2	1	0.053	1.7
Desmodium velutinum	5	0.172	2.3	2	0.069	1.8
Elephantopus scaber	6	1.034	14.6	3	0.391	9.4
Gynura nitida	2	0.097	1.9	1	0.05	1.6
Hemidesmus indicus	4	0.138	2	1	0.05	1.6
Nervilia aragoana	4	0.319	4.6	3	0.016	0.4
Pseudarthria viscida	-	-	-	3	0.378	7.5
Rauwolfia serpentina	2	0.072	1.6	1	0.006	0.2
Sida acuta	2	0.244	5.6	2	0.125	3.9
Sida rhombifolia	2	0.144	3.3	2	0.478	11.3
OTHER HERBS	61 Species	13.601	222.5	49 Species	10.627	210.2
TOTAL	74 Species	18.3	300	61 Species	14.84	300
Species diversity (H')	3.23			3.13		

Density denotes the number of individuals per m^2; Other herbs are given in Appendix XI.

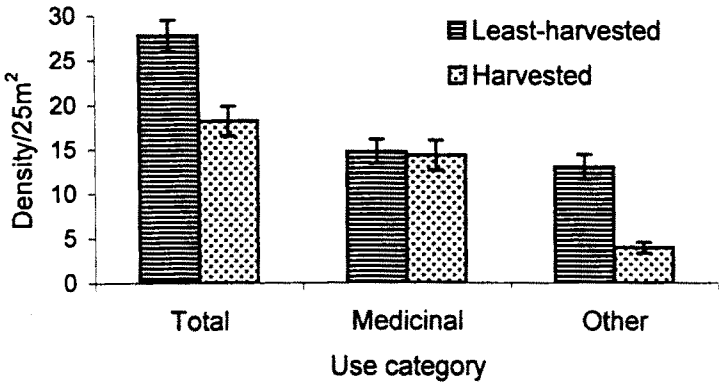


Figure 5.7. Density of shrubs ± SE in the least-harvested and harvested habitats

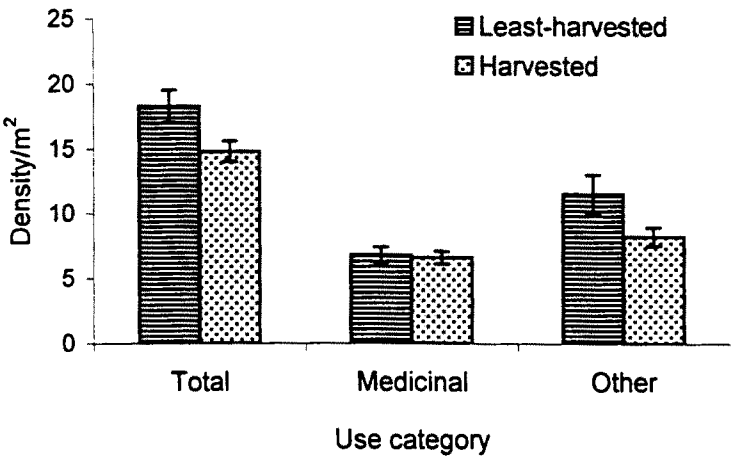


Figure 5.8. Density of herbs ± SE in the least-harvested and harvested habitats

5.3.4.4. Regeneration

Density of medicinal plant seedlings was significantly (M-W test U=25.5, P < 0.001) higher in the least-harvested habitat than in the harvested habitat (Figure 5.9). However, density of medicinal plant saplings showed no significant difference between these areas (Figure 5.9). Seedlings density of *Phyllanthus emblica* showed significant difference (M-W test U=104, *P*=0.004) between these habitats while saplings density showed no significant difference between these habitats.

5.3.5. Status of commercially exploited medicinal plants

Thirty-four commercially exploited medicinal plants were recorded in the quadrats, which included 14 trees, eight shrubs and 12 herb species. Some commercially exploited medicinal plant species occurred in more than one habitat. Twenty-one commercially exploited medicinal plant species were recorded in the moist deciduous forests, 20 in the dry deciduous (WWLS), 19 in the dry deciduous forests (BNP), 14 in the riverine forests (ARF), 10 in the riverine forests (CFD) and 9 in the teak plantations.

5.3.5.1. Trees

Among the commercially exploited medicinal tree species, *Pongamia pinnata* exhibited the highest density (69.5/ha) in the riverine forests followed by *Crataeva magna* (67.5, Table 5.9). Density of *Cassia fistula* and *Phyllanthus emblica* showed no significant difference (K-W x^2=7.6, *P*=0.06; K-W x^2=5.1, *P*=0.07 respectively) among the habitats. However, density of *Pterocarpus marsupium* showed significant difference (K-W x^2=14.7, *P*=0.002) among the

habitats of NBR (Table 5.9). Importance Value Index of *P. marsupium* also showed significant difference (K-W x^2=11, *P*=0.01) among the moist deciduous, dry deciduous (BNP), dry deciduous (WWLS) and riverine (CFD) forests (10; 12; 13; 4 respectively).

5.3.5.2. Shrubs

Among the commercially exploited shrubs, *Helicteres isora* exhibited the highest density (6.35/25m^2) in teak plantations (Table 5.9). Density of *Asparagus racemosus* showed significant difference (K-W test X^2=7.6, *P*=0.05) among the habitats. However, density of *Helicteres isora, Clerodendrum serratum* and *Solanum torvum* showed no significant difference among the habitats of the NBR (Table 5.9).

5.3.5.3. Herbs

Among the commercially exploited medicinal herbs, *Biophytum sensitivum* exhibited the highest density (0.69/m^2) in the moist deciduous forests (K-W test X^2=13.5, *P*=0.004; Table 5.9). Density of commercially exploited herbs such as *Cyclea peltata*, *Desmodium velutinum*, *Rauwolfia serpentina* and *Sida rhombifolia* showed significant difference (K-W test X^2=7.70, *P*=0.05; K-W test X^2=5.7, *P*=0.05; K-W test X^2=9.5,, *P*=0.02; K-W test X^2=9.95, *P*=0.04 respectively) among the habitats sampled. However, species such as *Hemidesmus indicus*, *Nervilia aragoana*, *Sida acuta* showed no significant difference among the habitats sampled. Species such as *Costus speciosus, Curcuma longa* occurred in moist deciduous and dry deciduous forests only. Density of these plants showed no significant difference between moist deciduous and dry deciduous (BNP) forests.

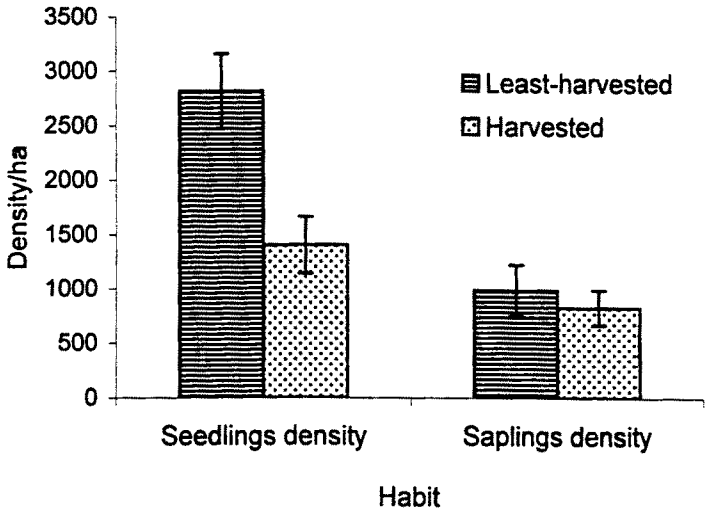
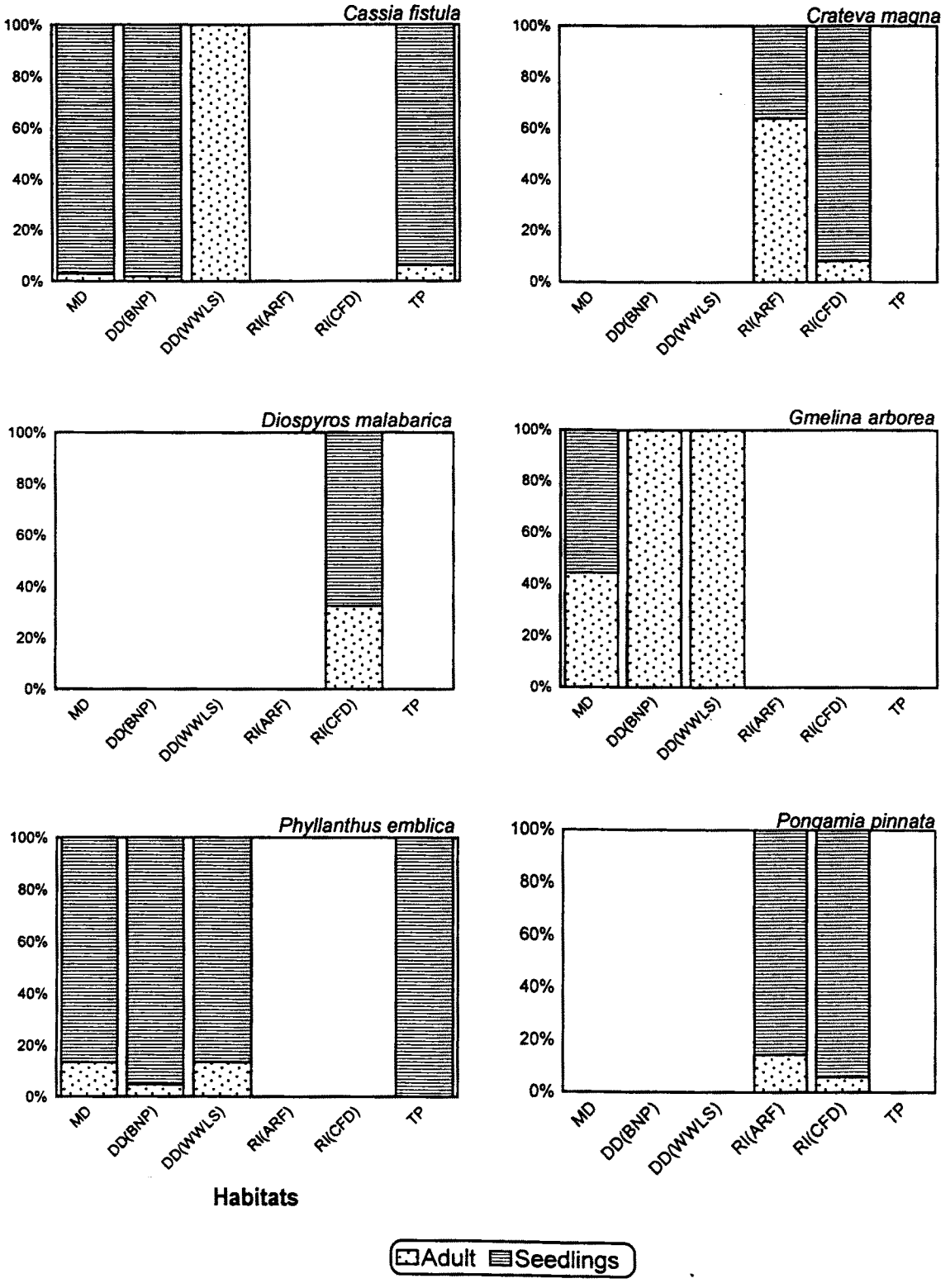


Figure 5.9. Density of medicinal plant seedlings and saplings ± SE in the least-harvested and harvested habitats

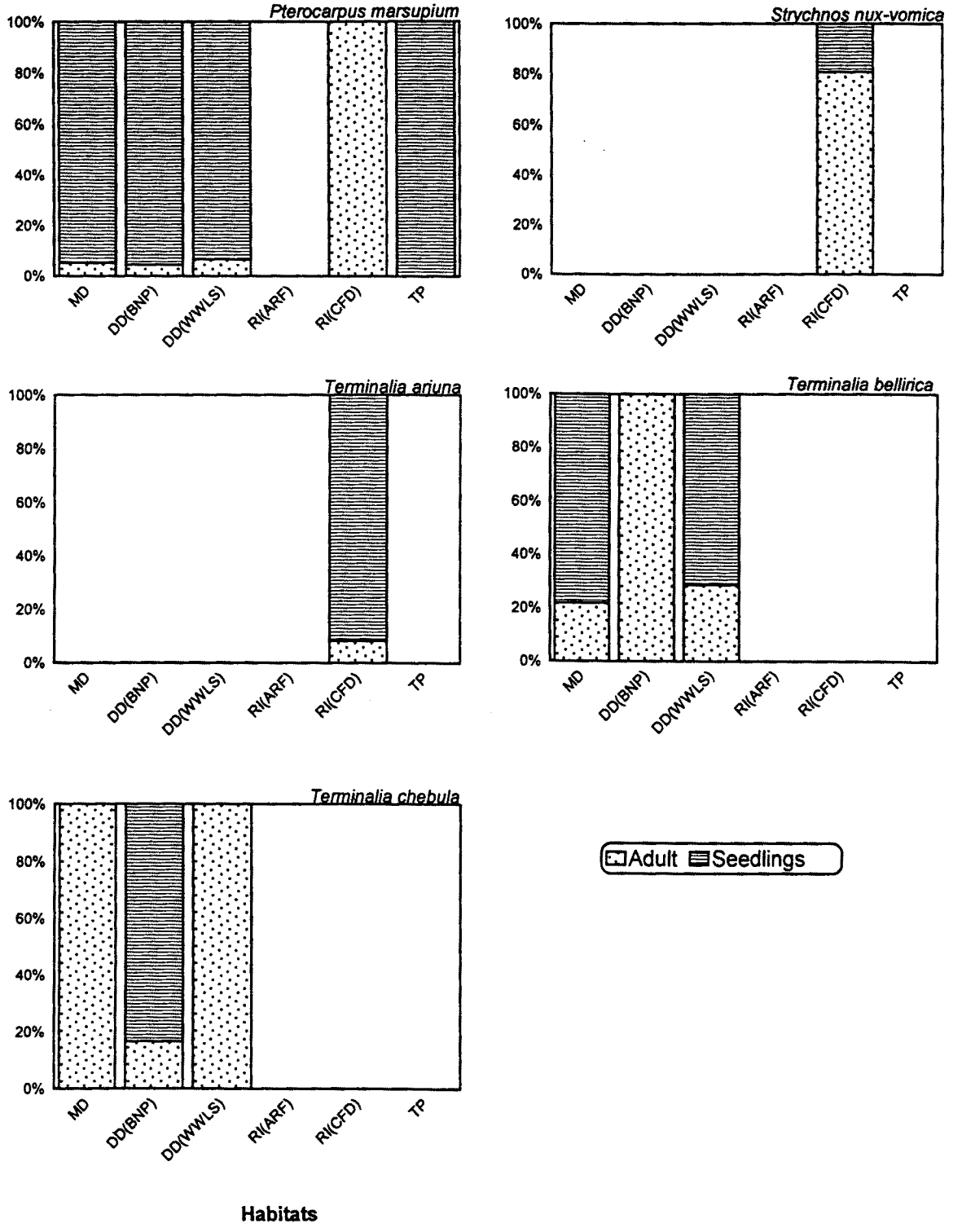
5.3.5.4. Regeneration

The results showed that the regeneration was poor for most of the species (Figure 5.10a & b). Among the commercially exploited trees, species such as *Diospyros malabarica, Gmelina arborea, Strychnos nux-vomica* and *Terminalia chebula* showed poor regeneration. Among them, *S. nux-vomica* and *D. malabarica* occurred in riverine habitat only. Although, *Terminalia arjuna* occurred only in riverine forests, it showed good regeneration. While *Crataeva magna* showed less regeneration in the disturbed riverine forest (Attappady RF) than in the least disturbed riverine forest (Coimbatore FD). Species such as *Pterocarpus marsupium*, *Phyllanthus emblica* and *Cassia fistula* showed good regeneration. Percentage of seedlings was more than 80% for these species in most of the habitats. Although, mature trees of *P. emblica* and *P. marsupium* was not observed in the old teak plantations of Mudumalai WLS, these species showed good regeneration (Figure 5.10a & b).



Md - Moist deciduous, DD(BNP) - Dry deciduous (Bandipur National Park), DD(WWLS) - Dry deciduous (Wayanad Wildlife Sanctuary, RI(ARF) - Riverine (Attappady Reserve Forest), RI - Riverine (Coimbatore Forest Division), TP - Teak plantations

Figure 5.10a. Percentage of adults and seedlings of commercially exploited trees in various habitats of NBR



Md - Moist deciduous, DD(BNP) - Dry deciduous (Bandipur National Park), DD(WWLS) - Dry deciduous (Wayanad Wildlife Sanctuary, RI(ARF) - Riverine (Attappady Reserve Forest), RI - Riverine (Coimbatore Forest Division), TP - Teak plantations

Figure 5.10b. Percentage of adults and seedlings of commercially exploited trees in various habitats of NBR

Table 5.9. Density of commercially exploited medicinal plants in the NBR.

Species	Part collected	Density					
		MD	DD (BNP)	DD (WWLS)	RI (ARF)	RI (CFD)	TP
Trees (Density / 0.1 ha)							
Cassia fistula	Bark, Fruit	9.00	2.00	7.00	-	-	3.50
Crataeva magna	Bark	-	-	-	67.50	4.50	-
Diospyros malabarica	Fruit	-	-	-	-	13.00	-
Ficus benghalensis	Bark	-	-	-	-	10.00	-
Ficus racemosa	Bark	-	-	-	1.00	4.00	-
Ficus religiosa	Bark	-	-	0.50	-	-	-
Gmelina arborea	Fruit	3.50	0.50	1.00	-	-	-
Phyllanthus emblica	Fruit	16.50	29.50	24.00	-	-	-
Pongamia pinnata	Fruit	-	-	-	69.50	31.00	-
Pterocarpus marsupium	Resin	7.50	9.00	10.00	-	1.00	-
Strychnos nux-vomica	Seed	-	-	-	-	8.50	-
Terminalia arjuna	Fruit	-	-	-	1.50	9.00	-
Terminalia bellirica	Fruit	6.50	1.00	1.50	-	-	-
Terminalia chebula	Fruit	1.00	4.00	1.00	-	-	-
Shrubs (Density / 25 m^2)							
Acacia sinuata	Fruit	-	-	0.04	-	-	-
Asparagus racemosus	Rhizome	0.18	0.65	0.11	-	-	0.85
Clerodendrum serratum	Root	0.04	0.01	0.21	-	-	-
Gloriosa superba	Rhizome	0.05	-	-	-	-	-
Helicteres isora	Seed	1.23	0.13	0.32	-	-	6.35
Naravelia zeylanica	Root	0.24	-	-	-	-	-
Solanum indicum	Root, Fruit	-	-	-	0.02	0.07	-
Solanum torvum	Root, Fruit	-	-	-	0.33	0.78	0.35
Herbs (Density / 1 m^2)							
Biophytum sensitivum	Whole plant	0.69	0.66	0.03	-	-	0.06
Costus speciosus	Rhizome	0.04	-	-	-	-	-
Curcuma longa	Rhizome	0.60	-	-	-	-	-
Cyclea peltata	Root	0.08	0.11	0.05		-	0.19
Desmodium velutinum	Root	0.09	0.17	0.07	-	-	-
Hemidesmus indicus	Root	0.06	0.14	0.05	0.01	0.01	0.10
Nervilia aragoana	Whole plant	0.25	0.32	0.02	-	-	-
Pseudarthria viscida	Root	-	-	0.38	-	-	-
Rotula aquatica	Root	-	-	-	0.52	0.01	-
Rauwolfia serpentina	Root	0.05	0.07	0.01	-	-	0.01
Sida acuta	Whole plant	0.24	0.24	0.13	0.20	0.04	0.25
Sida rhombifolia	Whole plant	0.14	0.14	0.48	0.11	0.06	-

MD - Moist deciduous; DD (BNP) - Dry deciduous in the Bandipur NP; DD(WWLS)- Dry deciduous in the Wayanad WLS; RI (CFD) - Riverine in the Coimbatore FD; RI (ARF) - Riverine in the Attappady RF; TP - Teak plantations.

5.4. DISCUSSION

5.4.1. Commercial extraction

Traditionally, the tribals in the NBR extracted medicinal plants for sustenance and local sales. They harvested a variety of products, but in small quantities partly because of low demand and partly due to the consideration of sustainable use. However, medicinal plants are a part of larger ecosystem and its sustainability, largely, depend upon sustainability of forest ecosystem. Because of large scale deforestation, encroachments and other developmental activities, the medicinal plant resources are also depleted from the forests. Moreover, the demand for medicinal plants on a commercial scale has been increased. In the context of increased demand for certain products such as *Phyllanthus emblica, Terminalia bellirica*, *T. chebula* and *Rauwolfia serpentina* and consequent changes in prices, the gatherers (tribals) are forced to collect products having higher demand. Attracted by high prices, the gatherers have undertaken intensive harvesting of valuable items which may affect the species composition in the wild. Over-harvesting or continued extraction may alter population size, growth rate and reproductive capacity of the harvested species, leading to a reduction in the quantities of medicinal plants (Hall and Bawa 1993). The distance travelled by the gatherers is increased recently, this indicates that the commercially important medicinal plants are sparsely distributed and products are not harvested sustainably.

Among the NTFP's, only few medicinal plants are exploited in large scale in the NBR, because they are the common species in the community and therapeutically valuable. Furthermore, often density and distribution of given

species are also limiting factors for their extraction. The opportunity cost for collection of common species should be less than those of uncommon species (Godoy and Bawa 1993). Thus, the most common species is expected to be harvested more intensively than the less abundant species. However, low density resources are difficult for collectors to locate, require long travel time, produces a low yield per unit area, and are extremely prone to over-harvesting (Peters 1993). Differences in the density and distribution of medicinal plants in a given area may also lead to diverse range of ways in which the local people exploit the vegetation. In the NBR, commercially important species are mostly traded and other NTFP's are partly marketed and partly used by the local people as food, medicine and for general uses.

The present study showed that Fabaceae were the largest family contributing to the diversity of the commercially important medicinal plant species, which reflects the trend in the flora of the NBR and the therapeutic value of this plant family. Toledo *et al* (1992) also reported the similar observation in Mexico. Trees were the most important growth form in commercial exploitation. This has significant implications in any conservation or management measures to be undertaken. Rani *et al* (1994) reported that trees (54%) are the most important growth forms of medicinal plants utilized in south India, followed by climbers (27%) and a negligible number of shrubs and herbs. Caniago and Sie bert (1998) also reported the same in Kalimantan, Indonesia. Trees can be sustainably harvested over a long time as compared to other life forms. However, trees have long periods of growth and loss of a reproducing adult tree of a rare species can drastically modify the recruitment and regeneration patterns (Lovejoy *et al* 1983).

The present study showed low abundance and poor regeneration of *Terminalia chebula* in various habitats of the NBR. Moreover germination capacity of its seeds is very poor (Singh 1988), which may alter the recruitment pattern. Srivastava *et al* (1998) have also reported poor regeneration of this species in the Eastern Ghats, India.

The uses of other life forms were largely destructive even when small or limited collections were made. Most of these life forms were patchily distributed in the forests and loss or fragmentation of reproductive populations of species could lead to modifications in the species composition of community, the implications of which are not fully recognised (Lovejoy *et al* 1983, 1984). In the present study, *Hemidesmus indicus* showed reduced abundance in the harvested habitat than in the least-harvested habitat. Moreover, regeneration in this species is mainly by rooting and accidental separation of creeping branches (Swarupanandan 1991). Hence, if the current extraction practice continues it may affect its wild population. The population of some commercially exploited species such as *Pseudarthria viscida*, *Clerodendrum serratum* and *Asparagus racemosus* may not be affected much by the present rate of extraction, largely due to the efficient and diverse regenerative methods of these species capable of overcoming the exploitation rate. It is observed that while collecting roots of *Pseudarthria viscida, Asparagus racemosus* and *Clerodendrum serratum* the smaller and weaker plants are left out and only vigorous plants are collected. The smaller and weaker plants could grow and become the seed source for the next growing season. The tuberous roots of *Asparagus racemosus* are difficult to remove completely. This species is also capable of regenerating from the left out

roots. However, the genetic diversity is affected by the removal of vigorous plants. The availability of these plant species can be further enhanced by replanting them immediately after collecting the tuberous roots/rhizomes.

5.4.2. Destructive extraction

Destructive extraction will affect the population and regeneration of the plant species being harvested. The impact of extraction on individual medicinal plants may vary depending on the plant part extracted and the intensity of extraction (Uma Shankar *et al* 1998). As compared to the collection of aerial parts, collection of underground parts of a plant will be more destructive and it will ultimately affect the wild population. This mode of collection can be described as Total Annihilation Technique. Destructive collection of medicinal plants seems to be in common practice in the NBR. Destructive practice of harvesting of forest products was also reported by various workers (Vasquez and Gentry 1989; Phillips 1993). Toledo *et al* (1992) showed that products whose extractions are nondestructive (whose extraction is in the form of leaves, fruits, barks or exudates) are more abundant than products whose extraction involves destructive action (roots, tubers or whole plant). *Asparagus racemosus, Clerodendrum serratum, Cyclea peltata, Decalepis hamiltonii, Desmodium velutinum, Hemidesmus indicus, Rauwolfia serpentina* and *Rotula aquatica* are some of the plants collected for underground parts. Among these, *C. peltata*, *D. velutinum, Hemidesmus indicus* and *Rauwolfia serpentina* showed less abundance in the harvested habitat than in the least-harvested habitat. Natural population of *Rauwolfia* has considerably shrunk in W.Ghats since the past few decades due to large scale root collection (and seeds too) by uprooting the plants from natural sites. Because of this threat,

the species has been included in the endangered/regionally category (Anon. 1997). *D. hamiltonii* is another species over-exploited in the forests of NBR. Moreover, the habitat in which the species occurs is being destructed. Low abundance of *D. hamiltonii* was observed in Mudumalai Wildlife Sanctuary (Stephen Per. comm.).

The collection of fruits of *Phyllanthus emblica* and *Mangifera indica* is done by lopping the branches. Cutting of tree branches to harvest the fruits of *Phyllanthus emblica* and *Mangifera indica* was also reported by Balachander (1993) and Muraleedharan *et al* (1997). A more destructive way of collecting fruit was observed in the case of *Acacia sinuata* in Kerala (Muraleedharan *et al* 1997). The base of the woody climber was cut off to avoid the effort of climbing, the fallen fruits are collected after few days. Cutting of tree branches to harvest its fruit may have a drastic impact on the distribution and abundance of fruit resources within the forest. Harvesting fruits and seeds also decreases the availability of food for frugivore populations. Scarce, slow growing species are vulnerable to over-exploitation (Cunningham 1991).

Acacia sinuata, Phyllanthus emblica, Solanum pubescence, Terminalia bellirica and *T. chebula* were exploited for their reproductive parts. Harvesting reproductive parts of plants will not only affect the wild population of the concerned species but also affect the genetic composition of the plant population being exploited. For example in *Phyllanthus emblica*, trees with bigger fruits and sweet taste were preferred than those with smaller fruits and bitter taste. Therefore, the genetic diversity of the medicinal plants should be studied.

Commercial harvesting of medicinal plants affects all the three vital attributes essential for replacement of plant species (Noble and Slatyer 1980) namely the means of dispersal or persistence at the site before and after disturbance; the ability of the species to establish and grow to maturity in a developing community and the time taken to reach critical life stages.

The responses of the forest vegetation to harvesting may depend upon the reproductive features and regeneration potential of its flora. In the present study, coppice regeneration was observed in *Pongamia pinnata*. Daniels *et al* (1993a) showed that species with good coppicing ability were less vulnerable to anthropogenic disturbance than those with poor potential for coppicing in the tropical humid forest of Western Ghats in south India. Dispersal mode of plant species could also influence the survival of plant species due to anthropogenic disturbances such as harvesting, fire and grazing. In Biligiri Rangan Hills, Ganeshaiah *et al* (1998) observed that populations of animal dispersed species are more vulnerable to human disturbance than those of wind dispersed or passively dispersed species. Among the commercially important medicinal plants, species such as *Terminalia bellirica*, *T. chebula*, *Phyllanthus emblica*, *Gmelina arborea* and *Cassia fistula* are dispersed by animals. Hence, adequate management measures have to be undertaken for the sustainable utilization and conservation of commercially exploited species. To lessen the negative impacts of over-exploitation, the tribals involved in the collection of medicinal plants should be given sufficient training in the scientific ways of collection. Collection programmes should be planned properly and restricted to only a particular season. Cutting of tree branches to harvest the fruits should not be allowed.

5.4.3. Distribution

The present study showed that scrub and dry deciduous forests harbour about 35% of the commercially exploited species in the NBR. Rani *et al* (1994) also reported larger number of medicinal plants in the dry deciduous forests of south India. Dry tropical forests account for 46% of the total forest cover of India (Singh and Singh 1988), which is largely threatened by lopping, burning, overgrazing and above all clearing for cultivation. Dry deciduous forest is almost lost in its original form due to encroachments, grazing and persistent subsistence demands of the local population (Gadgil and Meher-Homji 1986). Obviously these dry forests have to be given more importance while making conservation and management plans.

5.4.4. Status of commercially exploited medicinal plants

A perusal of the data indicates that the current intensity of exploitation is unsustainable as the density of some of the medicinal plants was very low in the sampled area. Although, commercially exploited medicinal tree species such as *Crataeva magna, Strychnos nux-vomica* and *Terminalia arjuna* were distributed only in riverine forests, they are the common species in the riverine forests. However, *S. nux-vomica* and *T. arjuna* were not recorded in the disturbed riverine forests (Attappady RF). The present study supports the inclusion of *T. arjuna* in the low risk-near threatened category in the red list of medicinal plants of southern India (Anon. 1997).

Species such as *Diospyros malabarica, Gmelina arborea, Strychnos nux-vomica* and *Terminalia chebula*, which are collected for their reproductive parts

(Fruits and Seeds) showed poor regeneration. Cunningham (1991) also observed the same in South Africa. However, poor regeneration of a species could also be due to other extrinsic factors. Medicinal plant species such as *Cyclea peltata, Hemidesmus indicus* and *Rauwolfia serpentina*, which are collected for their underground parts had significantly lower densities in the harvested habitat than in the least-harvested habitat. Thus, the present study clearly showed that the harvest of underground parts of plants would affect the wild populations of the plant being harvested.

The study showed no significant difference in tree and herb species diversity index (H') between the harvested and least-harvested site. However, shrub species diversity index showed significant difference between these areas. The difference in species diversity could also be influenced by several factors such as fire, grazing and competition by weeds. Size class distribution of trees above 20 cm GBH were not significantly different between the harvested (Wayanad WLS) and least-harvested area (Bandipur NP) of dry deciduous forests. However, percentage of individuals in smaller size classes was higher in the least-harvested than in the harvested habitat. This indicates the poor regeneration in the later habitat.

In the present study, tree density and basal areas showed no significant difference between the harvested and least-harvested habitats. Murali *et al* (1996) also observed no significant difference in tree density between the sites proximal to human settlement and distant site in the Biligiri Rangan Hills, India. However, they have observed significant difference in basal areas between the above sites.

Uma Shankar *et al* (1998) observed significant difference in stand density and basal area between the proximal and distant stands in the scrub forests of Biligiri Rangan Hills, India. In the Mudumalai WLS, Sukumar *et al* (1992) noted a decline in the population of woody species in a 50 ha. plot by as much as 14% in two years. Gaulier *et al* (1995) also reported the decline in tree density in the Ainurmarigudi Reserve Forest of Bandipur NP, because of damage caused by the elephants and periodic fire. Hence, it is essential to assess the impact of fire on medicinal plant population, such an attempt was also made in the present study (See Chapter VI).

Species such as *Biophytum sensitivum, Cyclea peltata, Desmodium velutinum, Hemidesmus indicus* and *Rauwolfia serpentina* had significantly greater density in the least-harvested habitat (Bandipur NP) than in the harvested habitat (Wayanad WLS). Thus, it is clear that some of the commercially exploited medicinal plants in the NBR are utilized in an unsustainable manner. Reduced abundance and regeneration of medicinal plants because of over-exploitation was reported by various authors (Kahn 1988; Nepstad *et al* 1992; Prasad and Pratibha 1993; Peters 1993).

5.4.5. Other human impacts

Apart from the commercial exploitation, the forests of NBR have been subjected to various human pressures such as fire, grazing and invasion of exotic plants for a long time. The differences in the forest structure and regeneration between the least-harvested (Bandipur NP) and harvested habitat (Wayanad WLS) could also be due to the differences in history and current land use

patterns. Differences in microclimate, soils, frequency of fires and grazing could also influence the outcome.

5.4.5. Need for people participation

To reduce the pressure of commercial exploitation on wild medicinal plants and to avoid adulteration of crude drugs, cultivation of medicinal plants can be encouraged with the participation of local tribes. Judicious harvesting of NTFPs can enhance the rural incomes. Moreover, local communities can be involved in conservation because of the economic interest they are likely to have in sustainable use of natural resources. Simultaneously, a substantial amount of biodiversity can be conserved. Thus, recently various authors (Peters *et al* 1989; Murali *et al* 1996; Manandhar 1996; Uma Shankar *et al* 1998) have shown considerable interest in management of tropical forests for forest products.

The present study gives considerable evidence for the unsustainable utilization of medicinal plants. Sustainable extraction should not have long-term deleterious effect on the reproduction and regeneration of populations being harvested. Moreover, sustainable harvest should have no discernible adverse effect on other species in the community, or an ecosystem structure and function (Hall and Bawa 1993). To assess sustainability of utilization of medicinal plants, knowledge of the natural distribution, abundance, regeneration and population structure across a landscape is required for all medicinal plants. Need for such a study has been emphasised by various authors (Balachander 1993; Campbell 1996; Olsen and Helles 1997; Rani *et al* 1997). Therefore, such an attempt was also made in the present study in selected forests of NBR (see Chapter IV).

5.5. SUMMARY

Studies on commercially exploited medicinal plants were carried out in selected forest areas of NBR. The goals of the study were to identify the commercially exploited medicinal plant species in the NBR, to collect autecological information and to assess the impact of commercial harvesting on the abundance, species composition and regeneration of medicinal plant populations.

i) In total, 85 medicinal plant species spread over 42 families were commercially exploited in the NBR. Fabaceae were the largest contributor contributing 8% of the species. Among the growth forms, trees were found to be the most exploited (37%) followed by climbers, herbs and shrubs.

ii) Of the 85 species, 49% of the plants were collected for root, rhizome or tuber, and 14% for whole plant. This kind of destructive collection could ultimately affect the wild population of the concerned species. Similarly, harvesting fruits by cutting down the tree branches may have a negative impact on the distribution and abundance of fruit resources within the forest.

iii) Among the habitats, scrub and dry deciduous harbour about 34% of the medicinal plant species. These forests have to be given more importance while making conservation and management plans.

iv) Species such as *Decalepis hamiltonii*, *Rauwolfia serpentina* and *Rotula aquatica* had low abundance in their natural habitats. These plants can be cultivated to reduce the pressure of commercial harvesting.

v) Species richness, total density and regeneration were higher in the least-harvested compared to the harvested area and therefore least-harvested areas have higher conservation value.

CHAPTER VI

IMPACT OF FIRE ON MEDICINAL PLANTS

6.1. INTRODUCTION

Fire is known to cause major impacts on plant communities. It kills the seedlings of fire-sensitive species (Naidu and Srivasuki 1994). Depending on its frequency, intensity and temperature it reduces the tree cover and promotes the growth of grasses (Kozlowski and Ahlgren 1974). Fire intensity affects vegetation structure and dynamics through differential effects on survival of plants and propagules on the site and differential effects on the physical and biological factors that define the regeneration niche of any given species. Frequent fire also reduce the number of species (Pinard and Huffman 1997) and the resulting changes in the species composition have tremendous impact on the carrying capacity of the ecosystem. Season in which fire occurs also affects structure of vegetation because it interacts with plant phenology and post fire weather to moderate plant survival and reproduction (Kruger 1984). Fire plays a typical role in maintaining the different plant communities of woodlands and closed forests (Kozlowski and Ahlgren 1974; Tyler 1995). Effect of fire on different plant communities was extensively studied in many parts of the world (Hill and Read 1984; McFarland 1988; Sirois and Payette 1989; Goto *et al* 1996; Pinard and Huffman 1997; Pausas *et al* 1999; DeSimone and Zedler 1999; Hoffmann 1999; Fule and Covington 1999). In India, several workers have studied the effect of fire on different forest communities (Toky and Ramakrishnan 1983; Prasad 1985; Khan and Tripathi 1989; Paulsamy 1992; Naidu and Srivasuki 1994; Paulsamy *et*

al 1995; Kikkim and Yadava 1998; Senthilkumar *et al* 1998).

Though several workers have studied the various vegetation structure in NBR (George and Varghese 1984; Sharma *et al* 1986; Manilal *et al* 1986, 1989; Singh *et al* 1988; Sukumar *et al* 1992), information about the Impact of fire on the abundance and regeneration on plant populations is scanty (Puyravaud *et al* 1995). Moreover, ecological impact of fire varies markedly from vegetation to vegetation and seasons (Kruger 1984). As far as NBR is concerned the major vegetation is of dry deciduous type (Pascal 1988) and are subjected to severe fire and fire is often set by the local people for getting new grazing material for their cattle. Therefore, during this study, an attempt was made to assess the impact of fire on medicinal plant abundance and regeneration in this habitat. The objectives of this study were;

i) to examine the Impact of fire on plant species composition and abundance and to

ii) assess the regeneration of medicinal plant populations.

A proper and desirable method would be to follow an experimental approach to evaluate the Impact of fire and other anthropogenic factors. However, due to time constraint such a study was beyond the scope of the present study. Fieldwork was conducted during 1996 to 1997 in the Muthanga range of Wayanad Wildlife Sanctuary (WLS), which forms a part of the western portion of the NBR (11^0 33' to 11^0 51' N and 76^0 02' to 76^0 27' E). The vegetation of the Sanctuary is mostly of deciduous type. The dry deciduous forests of the Sanctuary are subjected to severe fire and fire is often set by the local people for getting new

grazing material for their cattle. In the present study, I have compared the species richness, density and regeneration between a less-fire-frequent area and an adjoining higher-fire-frequent area. The above categorisation was based on the information collected from the local tribal people and forest officials.

6.2. METHODS AND ANALYSES

Impact of fire on the abundance of medicinal plant species was studied in a less- fire-frequent (Less burnt) and a higher-fire-frequent (Severely burnt) area in the dry deciduous forest. The vegetation in each site was sampled in five different strata viz., trees, shrubs, herbs, seedlings and saplings.

A total of twenty 0.1 ha. (50 x 20 m) quadrats were laid each in less and severely burnt area. In each 0.1 ha. quadrat, all the woody vegetation above 20cm Girth at Breast Height (GBH) was enumerated. For each individual, GBH was measured using a measuring tape at 1.3 m above ground level. Four 5 x 5 m quadrats were laid within the 0.1 ha. quadrat and number of individuals of shrub and climber species and their percentage cover were recorded. In each 5 x 5 m quadrat, four 1 x 1 m quadrats were laid at random. Number of individuals of each herb species and their percentage cover were noted. Analysis of vegetation data was done separately as discussed in the chapter IV for the two areas and the abundance of medicinal plants was compared between these habitats. For herbs and shrubs, Importance Value Index was calculated adding relative density and relative frequency only. Horn's similarity index was calculated between quadrats for tree species both in the less and severely burnt area.

Population structure was analysed at community level and for selected species of medicinal plants. Size class selected for community level ranged from 20 cm to 250 cm GBH, but for individual species the size class category varied based on the maximum girth attained. Percentage of individuals in each size class was calculated.

To study the Impact of fire on regeneration of medicinal plants, seedlings (<10 cm GBH) and saplings (10-19 cm GBH) were sampled by quadrat method. A total of eighty 5 x 5 m quadrats was laid each in the less and severely burnt areas. Density of seedling and sapling of each species per hectare was calculated and compared between these habitats.

Statistical analyses were done using Statistical Package for Social Sciences (Norusis 1990). Differences in plant species diversity, density and basal area between less and severely burnt areas were tested using Mann-Whitney U test (M-W U test). Kolomogorov - Smirnov two sample test (Siegel and Castellan 1988) was used to analyse the difference between the girth class distributions of trees in the less and severely burnt areas.

6.3. RESULTS

6.3.1. Forest structure and composition

A total of 99 plant species belonging to 86 genera of 43 families (excluding unidentified species) were recorded in the less and severely burnt areas of dry deciduous forests (29 trees, 22 shrubs and 48 herbs). Of the 43 families, 24 families were represented by one species and19 families were represented by

more than one species. Fabaceae were the dominant family represented by 11 species followed by Poaceae with 10 species. Only eight genera exhibited more than one species *Desmodium, Grewia* and *Terminalia* (each with 3 species), *Andrographis, Chlorophytum, Mariscus, Phyllanthus* and *Themeda* (each with two species).

Of the 99 plant species recorded, 45 were used by tribals as medicine. Three medicinal plant species such as *Rauwolfia serpentina*, *Pseudarthria viscida* and *Schrebera swietenioides*, which are listed in the "Red list" of medicinal plants of south India (Anon. 1997) were also recorded from the fire affected areas. All the above three species of medicinal plants were recorded from the less burnt area while only *Schrebera swietenioides* was recorded in the severely burnt area. The less burnt area had a higher species richness (80, which includes 29 trees, 18 shrubs and 33 herbs) than that of the severely burnt area (61, which includes 22 trees, 13 shrubs and 26 herbs). However, the percentage of medicinal plant species showed not much difference between the less (53.75%) and severely burnt area (52.45%).

6.3.2. Trees

6.3.2.1. Species diversity and richness

Shannon -Weiner diversity index showed no significant difference between the less and severely burnt area (Table 6.1). Number of tree species was higher in the less burnt (29) than in the severely burnt (22) area. Number of tree species in individual quadrat ranged from 6 to 14 (Mean=10.2, SD=2.69) in the less burnt habitat and from 5 to 12 (Mean=8.4, SD=2.27) in the severely burnt habitat.

Percentage of medicinal trees was higher in the severely burnt area (77%) than that of the less burnt area (72%). Similarity index between any two transects in the less burnt varied from 0.84 to 0.98 (Mean=0.926, SD=0.04458) and in the severely burnt area from 0.86 to 0.98 (Mean=0.937, SD=0.04099), indicating that there was appreciable homogeneity among the quadrats in both the areas.

Table 6.1. Tree species richness and diversity index in the less and severely burnt area.

Habitat	Species richness			H'
	Total	Medicinal trees	Other trees	
Less burnt	29	21 (72%)	8 (28%)	2.29
Severely burnt	22	17 (77%)	5 (23%)	2.10

6.3.2.2. Size class distribution

Girth class distribution of all individuals (GBH >20cm) was L-shaped for both the areas (Figure 6.1). Higher number of individuals in lower GBH classes in the less burnt area shows recruitment of individuals. However, the size class distributions of individuals of all the tree species were not significantly different between these areas (Kolomogorov-Smirnov test D=0.590, p<0.87). Medicinal tree species such as *Buchanania lanzan, Kydia calycina, Randia dumetorum, Stereospermum colais* and *Tamilnadia uliginosa* were recorded only from the less burnt area. Number of smaller trees of *Bauhinia racemosa, Cassia fistula, Dalbergia latifolia, Lagerstroemia parviflora* and *Phyllanthus emblica* (Figure 6.2) were more in the less burnt area than in the severely burnt area.

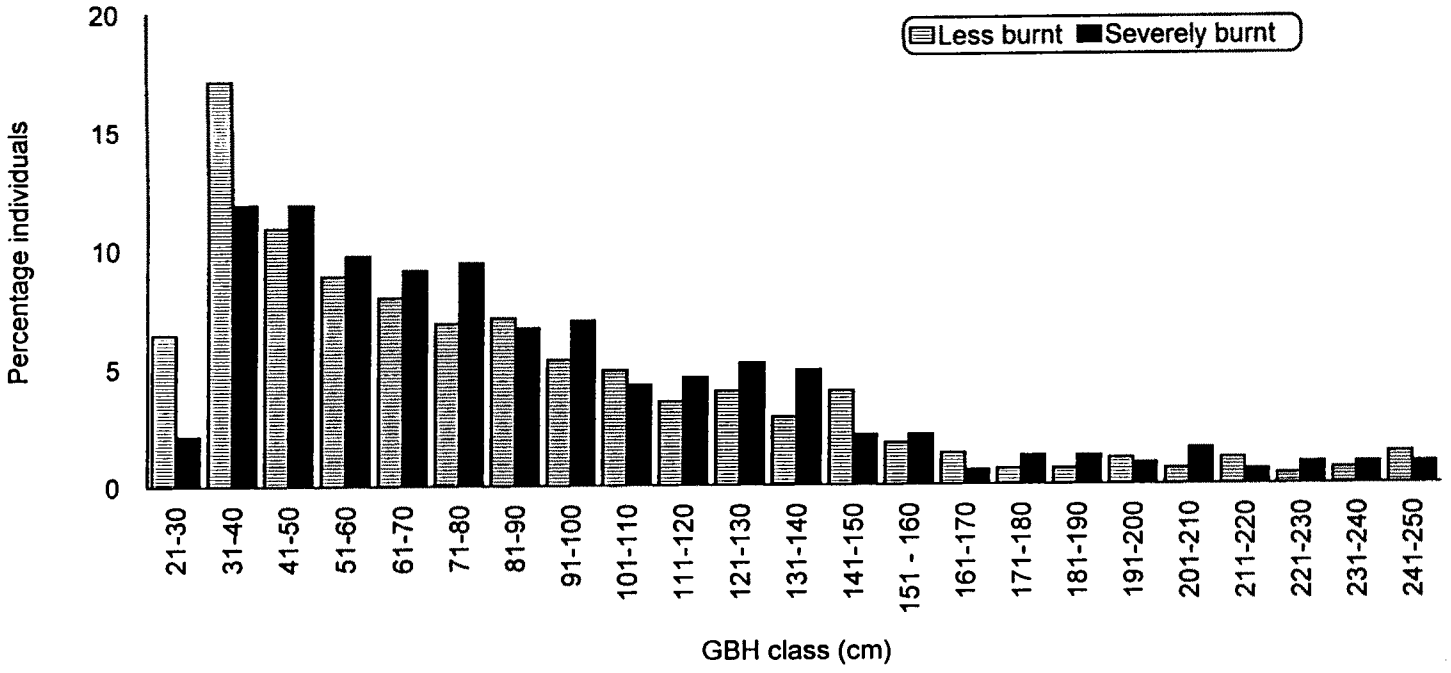


Figure 6.1. Size class distribution of trees (GBH ≥20 cm) in the less and severely burnt area

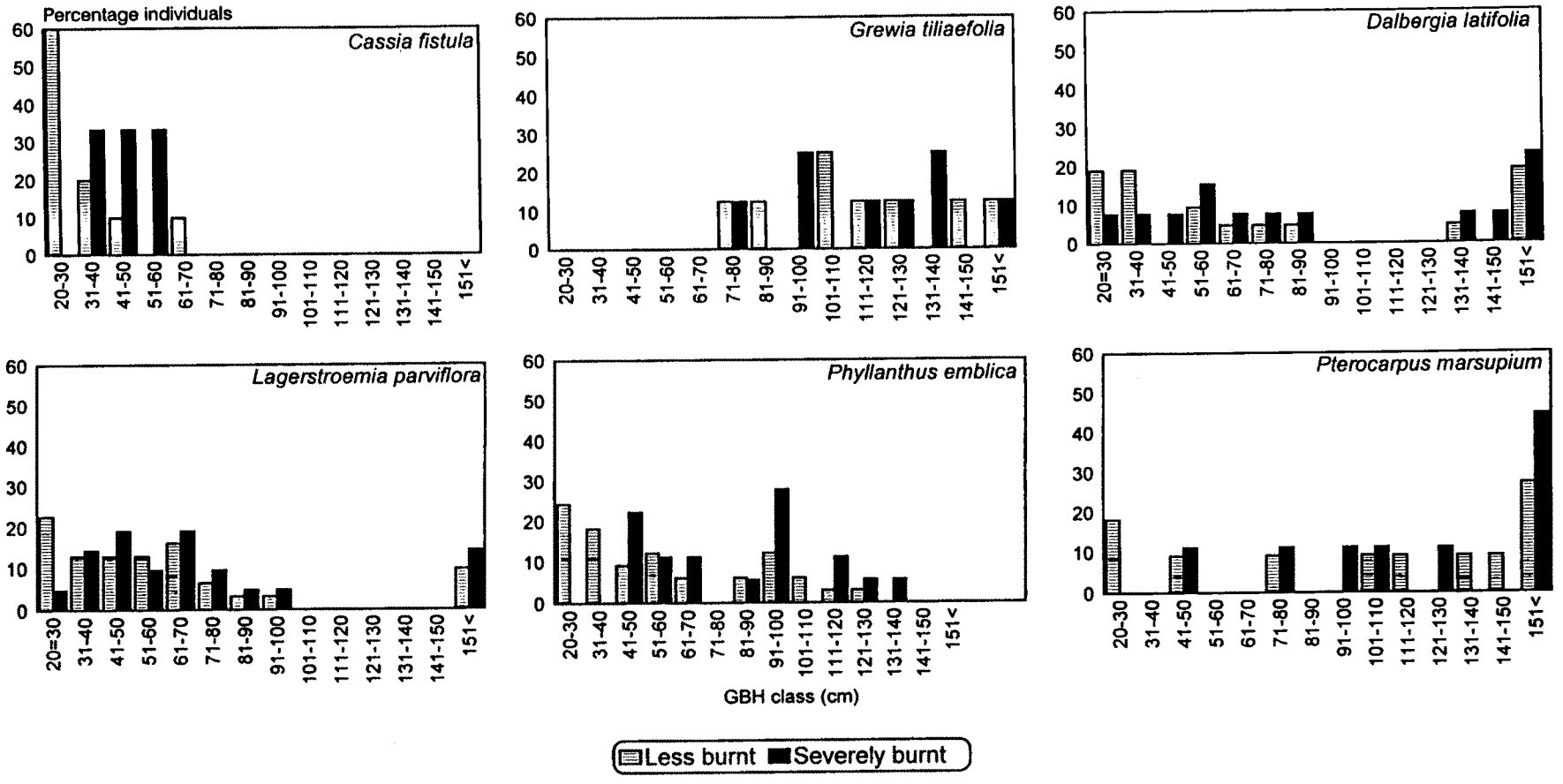


Figure. 6.2. GBH class distribution of some medicinal tree species in the less and severely burnt area

6.3.2.3. Density

Total tree density showed no significant difference (M-W test U=29.5, *P*=0.12) between the less and severely burnt area. Density of medicinal trees also showed no significant difference (M - W test U= 30, *P*= 0.13) between these habitats (Table 6.2). *Anogeissus latifolia* was the most common species (142 in less burnt, 117 in Severely burnt) in both the areas. Medicinal trees such as *Anogeissus latifolia, Bauhinia racemosa, Cassia fistula, Dalbergia latifolia, Lagerstroemia parviflora, Phyllanthus emblica, Pterocarpus marsupium, Semecarpus anacardium, Shorea roxburghii* and *Terminalia paniculata* had greater density in the less burnt area than in the severely burnt area. However, the difference was not statistically significant (Table 6.3).

Table 6.2. Tree density in the less and severely burnt area.

Habitat	Number of trees /ha		
	Total	Medicinal	Other trees
Less burnt	449 ± 45.4	329 ± 41.3	120 ± 16
Severely burnt	328 ± 40	240 ± 33.2	88 ± 12. 4
M-W test	*n.s*	*n.s*	*n.s*

M-W - Mann-Whitney U test; n.s - No significance.

6.3.2.4. Basal area

Total basal area of trees (GBH ≥ 20 cm) was higher in the less burnt area (28.3m^2/ ha) than in the severely burnt area (26.88m^2/ha). However, the difference was not significant (M-W test U=42, *P*=0.54). Basal area of medicinal trees also showed no significant difference between these areas (Figure 6.3).

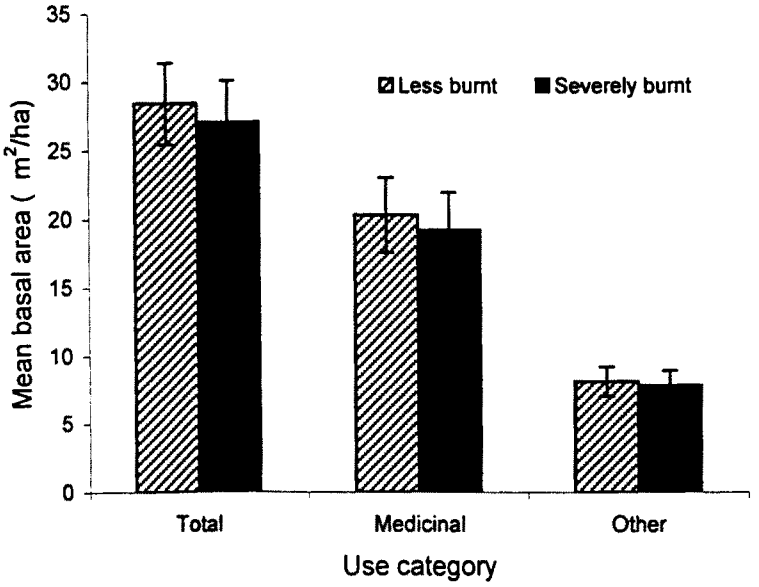


Figure 6.3. Mean basal area ± SE of trees in the less and severely burnt areas

Table 6.3. Abundance, density, basal area and IVI of tree species in the less burnt (LB) and severely burnt (SB) areas.

Species	Less burnt area				Severely burnt area			
	Abundance	Density[1]	Basal area[2]	IVI[3]	Abundance	Density[1]	Basal area[2]	IVI[3]
MEDICINAL TREES								
Anogeissus latifolia	14.2	142	53150	60	11.7	117	49510	66
Bauhinia racemosa	8	8	770	3	4	4	710	3
Bridelia retusa	1	1	560	1	1	1	480	2
Buchanania lanzan	1	1	260	1	-	-	-	-
Careya arborea	1	2	210	2	1	1	260	2
Cassia fistula	2	10	890	7	1.5	3	530	3
Dalbergia latifolia	2.63	21	16910	19	1.86	13	15450	17
Diospyros montana	1.25	5	1910	6	1	2	1770	4
Kydia calycina	1	1	70	1	-	-	-	-
Lagerstroemia parviflora	4	28	6220	15	2.57	18	5100	15
Lannea coramandelica	1	3	4330	5	1	3	4410	6
Phyllanthus emblica	3.67	33	8630	19	2.57	18	8690	16
Pterocarpus marsupium	3.67	11	17730	13	3	9	17210	12
Randia dumetorum	1	1	70	1	-	-	-	-
Schrebera swietenioides	1	2	2180	3	1	2	2180	4
Semecarpus anacardium	2	2	1560	2	1	1	800	2
Shorea roxburghii	2.25	9	11150	10	1.33	4	10950	9
Tamilnadia uliginosa	1	1	50	1	-	-	-	-
Tectona grandis	3.56	32	64830	41	3.44	31	63480	44
Terminalia chebula	1	2	2020	3	1	2	1990	4
Terminalia paniculata	2	14	9270	13	1.83	11	8490	14
OTHER TREE SPECIES								
Butea monosperma	7	7	1610	3	4	4	40	3
Casearia esculenta	1	1	250	1	-	-	-	-
Cordia domestica	2	2	190	2	1	1	110	2
Eriolaena quinquelocularis	1	1	130	1	-	-	-	-
Grewia tiliaefolia	2	8	9510	9	2	8	9730	11
Streospermum colais	1	1	40	1	-	-	-	-
Terminalia crenulata	9.9	99	69080	56	7.4	74	66830	59
Zizyphus xylopyrus	1	1	360	1	1	1	170	2
Total		**449**	**283940**	**300**		**328**	**268890**	**300**

Density[1] denotes number of individuals per ha.; Basal area[2] in cm^2 per ha.; IVI[3] - Importance Value Index.

6.3.2.5. Importance Value Index

Anogeissus latifolia was the dominant species with an importance value of 60.1 in the less burnt and 65.8 in the severely burnt area. Importance Value Index of medicinal trees such as *Cassia fistula, Diospyros montana, Phyllanthus emblica* and *Shorea roxburghii* were lower in the severely burnt area than in the less burnt area while for *Anogeissus latifolia, Bridelia retusa, Lagerstroemia parviflora, Lannea coramandelica, Pterocarpus marsupium, Schrebera swietenioides, Tectona grandis, Terminalia chebula* and *T. paniculata* the IVI was greater in the severely burnt area than in the less burnt area. There were nine species with ≤1 IVI in less burnt area, compared to five such species in severely burnt area.

6.3.3. Shrubs

Of the twenty-two species of shrubs recorded in both the areas, the tribals used twelve as medicine while five were commercially exploited in large scale.

6.3.3.1. Species diversity and richness

Although, shrub species diversity index was greater in the less burnt area (H'= 1.76) than in the severely burnt area (H'=1.66), the difference was not significant (M-W test U=26.5, *P*= 0.07). Total number of shrub species was higher in the less burnt area (18) than in the severely burnt area (13). Similarly, number of medicinal shrubs was also higher in the less burnt area (11) than in the severely burnt area (7).

6.3.3.2. Density

There was no significant difference between the two sites with respect to the total density of shrubs (M-W test U=37.5, *P*=5.4; Table 6.4). Similarly, the density of medicinal shrubs also showed no significant difference (M-W test U=42, *P*=0.80) between the less (15.82/25m^2) and severely burnt areas (15.6/25m^2). Most of the medicinal shrubs had greater density in the less burnt area than in the severely burnt area (Table 6.4). Commercially valuable medicinal plants such as *Asparagus racemosus, Clerodendrum serratum* and *Helicteres isora* were recorded only in the less burnt area while *Desmodium velutinum* was recorded in both the areas. *Leea indica* had the highest density both in the less (10) and severely burnt (8) areas. Density of *Chromolaena odorata,* an exotic weed was significantly (M-W test U= 0.0001, *P*= 0.003) higher in the severely burnt area than in the less burnt area.

6.3.4. Herbs

Of the 48 herb species recorded in the less and severely burnt areas, eighteen were used by the tribals as medicine.

6.3.4.1. Species richness and diversity

Total number of herb species was higher in the less burnt area (33) than in the severely burnt area (26). Similarly, number of medicinal herbs was also higher in the less burnt area (13) than in the severely burnt area (9, Table 6.5). Herb species diversity index was significantly higher (M-W test U=7.5, *P*=0.03) in the less burnt area (H'=2.69) than in the severely burnt area (H'=2.12).

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6.3.4.2. Density

Total density of herbs was higher in the severely burnt area (17.5/m^2) than in the less burnt area (14.98/m^2, Table 6.5). However, the difference was not significant (M-W test U= 15, *P*= 0.22). Similarly, density of medicinal herbs also showed no significant difference (M-W test U= 14, *P*=0.17) between the severely burnt (10.31/1m^2) and less burnt area (5.93). Among the medicinal herbs, *Curculigo orchioides* exhibited the highest density both in the less (2.25/ m^2) and severely burnt (6.11/m^2) areas. The difference was significant (M-W test U=3.5, *P*=0.007).

Table 6.4. Abundance, density and IVI of medicinal shrubs in the less burnt (LB) and severely burnt (SB) habitats.

Species	Less burnt area			Severely burnt area		
	Abundance	Density[1]	IVI	Abundance	Density[1]	IVI
MEDICINAL SHRUBS						
Argyreia cuneata	-	-	-	2	0.1	1.21
Asparagus racemosus	3.5	0.5	6.69	-	-	-
Chromolaena odorata	2.6	0.5	6.93	9.5	6.2	55.99
Clerodendrum serratum	2.3	0.4	5.74	-	-	-
Desmodium velutinum	3	0.5	7.33	3	0.4	6.69
Flemingia strobilifera	4.8	2.6	28.3	-	-	-
Gomphostemma heyneanum	1	0.01	0.78	2.5	0.3	5.1
Grewia hirsuta	1.8	0.9	16.9	5	0.3	3.17
Helicteres isora	1.3	0.1	2.46	-	-	-
Lantana camara	1.4	0.3	5.84	3	0.2	2.67
Leea indica	11.5	10	76.7	9	8.1	75.4
Solanum indicum	1	0.01	0.78	-	-	-
OTHER SHRUBS						
Cymbopogon flexosus	-	-	-	6.1	1.2	13.84
Decaschistia crotonifolia	2	0.3	4.56	11	0.6	4.68
Desmodium pulchellum	4.2	0.6	7.23	1.5	0.1	2.3
Grewia rotundifolia	2	0.3	4.56	-	-	-
Heteropogon contortus	2.8	0.9	13.2	-	-	-
Imperata cylindrica	4	0.1	1.18	18.5	0.9	6.56
Pavetta tomentosa	1.7	0.3	5.2	-	-	-
Sophora velutina	2.2	0.3	5.61	-	-	-
Themeda cymbaria	-	-	-	6.8	1.4	14.47
Themeda triandra	-	-	-	2.8	0.4	7.9
Total		**18.62**	**200**		**20.2**	**200**
Species diversity Index (H')		**1.76**			**1.66**	

Density denotes number of individuals per 25 m^2; IVI - Importance Value Index.

Table 6.5. Abundance, density and IVI of herbs in the less burnt and severely burnt areas.

Species	Less burnt area			Severely burnt area		
	Abundance	Density	IVI	Abundance	Density	IVI
MEDICINAL PLANTS						
Ageratum conyzoides	5	1.02	11.2	-	-	-
Andrographis neesiana	2	0.02	0.34	1.6	0.08	1.62
Andrographis serphyllifolia	-	-	-	1	0.03	0.87
Anisomeles malabarica	-	-	-	2.2	0.22	3.56
Arisaema tortuosum	-	-	-	1	0.01	0.29
Cissampelos pareira	1	0.01	0.28	1	0.01	0.29
Curculigo orchioides	3.5	2.25	28.7	6.92	6.11	55.86
Cyclea peltata	2.3	0.18	2.84	-	-	-
Hemidesmus indicus	1.6	0.14	2.79	1.43	0.1	2.19
Mimosa pudica	4.5	1.41	16.1	-	-	-
Naravelia zeylanica	1.3	0.04	0.88	-	-	-
Pimpinella monoica	2	0.04	0.67	1.25	0.05	1.21
Premna herbacea	-	-	-	6.79	2.53	23.31
Pseudarthria viscida	3.6	0.18	2.22	-	-	-
Rauwolfia serpentina	1	0.02	0.54	-	-	-
Sida rhomboidea	2.2	0.4	6.62	-	-	-
Urena lobata	2.8	0.22	3.1	-	-	-
OTHER HERBS						
Aneilemma sp.	-	-	-	2.83	1.17	16.45
Apluda mutica	2	0.02	0.34	-	-	-
Arisaema tortuosum	1.3	0.04	0.88	-	-	-
Blumea membranacea	4.2	0.7	8.18	1.5	0.06	1.27
Chlorophytum laxum	1	0.04	1.09	-	-	-
Cholrophytum tuberosum	1.7	0.05	0.95	-	-	-
Coleus malabarica	-	-	-	1	0.03	0.87
Commelina sp	1.8	0.81	15	-	-	-
Curcuma montana	1.9	0.42	7.58	2.8	1.1	15.59
Cynoglossum furcatum	1	0.03	0.82	-	-	-
Cyanotis tuberosa	-	-	-	2.14	0.15	2.47
Desmodium sp	4.6	2.63	29.6	-	-	-
Desmodium triquetrum	2	0.56	9.75	1.57	0.11	2.25
Dioscorea wallichi	1.2	0.07	1.7	-	-	-
Digitaria adscendens	-	-	-	2	0.04	0.69
Globba bulbifera	2.9	0.46	6.4	2.4	0.82	12.86
Indigofera linnaei	1.9	0.19	3.31	2.39	0.66	10.28
Leucas ciliatus	1	0.03	0.82	1.67	0.05	0.98
Mariscus paniceus	-	-	-	4.6	2.34	25.5
Mariscus pictus	-	-	-	1	0.01	0.29
Opilismenas compositus	2.5	0.26	4.05	-	-	-
Paspalidum flavidum	-	-	-	5.03	1.48	15.44
Phyllanthus sp	1.3	0.05	1.16	-	-	-
Polygala sp	-	-	-	1	0.03	0.87
Pteris pellucida	8	1.41	13.2	-	-	-
Scilla sp	-	-	-	1	0.01	0.29
Setaria pallidifusa	3	0.03	0.41	-	-	-
Thunbergia alata	1	0.01	0.28	-	-	-
Trichosanthes sp	-	-	-	1	0.03	0.87
Triumfetta rotundifolia	2.7	1.25	18.3	-	-	-
Vigna radiata	-	-	-	3.44	0.3	3.84
Total		14.98	200		17.5	200
Shannon-Wiener diversity index		2.69			2.12	

Density denotes the number of individuals per m^2; IVI - Importance Value Index..

6.3.5. Regeneration of medicinal trees

6.3.5.1. Seedlings

Density of medicinal plant seedlings showed significant difference (M-W test U= 3, P<0.001) between the less (1930/ha) and severely burnt area (7050/ha). In the less burnt area, *Dalbergia latifolia* exhibited the highest density of seedlings followed by *Anogeissus latifolia* (Table 6.6.). While in the severely burnt area *Phyllanthus emblica* exhibited the highest density of seedlings followed by *Shorea roxburghii* and *Anogeissus latifolia*. The seedlings of *Lagerstroemia microcarpa, Schrebera swietenioides, Semecarpus anacardium* and *Zizyphus xylopyrus* were recorded only in the severely burnt area. The opposite was true in the case of *Pongamia pinnata* and *Randia dumetorum*. Medicinal trees such as *Cassia fistula, Lagerstroemia parviflora, Phyllanthus emblica, Pterocarpus marsupium, Shorea roxburghii* and *Terminalia paniculata* showed higher density of seedlings in the severely burnt area than in the less burnt area (Figure 6.4). But, *Dalbergia latifolia* produced higher number of seedlings in the less burnt area (450/ha) than in the severely burnt area (210/ha) however, the difference was not significant.

6.3.5.2. Saplings

Species contributing a higher number of seedlings in the severely burnt area had fewer individuals in the saplings. However, *Lagerstroemia parviflora, Phyllanthus emblica* and *Shorea roxburghii* produced higher number of saplings in the severely burnt area (Figure 6.4). Although, density of medicinal plant saplings was higher in the severely burnt area (2800/ha) than in the less burnt area (1480/ha), the difference was not statistically significant (M-W test U= 31, *P*=0.13). In the less burnt area, *Shorea roxburghii* exhibited the highest density of

saplings followed by *Grewia tiliaefolia* (Table 6.6) while in the severely burnt area, *Shorea roxburghii* exhibited the highest density followed by *Phyllanthus emblica*. The saplings of *Lannea coromandelica* and *Sophora velutina* were recorded only in the less burnt area while *Bridelia retusa* and *Semecarpus anacardium* were recorded only in the severely burnt area. *Terminalia chebula* which had mature trees both in the less and severely burnt area lacked regeneration. The ratio between the number of individuals of adults and seedlings and saplings were greater in the severely burnt area for most of the medicinal plants than in the less burnt area (Table 6.6).

Table 6.6. Density/ha of seedlings and saplings in the less and severely burnt areas

Species	Less burnt area				Severely burnt area			
	A	SE	SA	Ratio*	A	SE	SA	Ratio*
Anogeissus latifolia	142	390	10	1:3	117	870	280	1:10
Bauhinia racemosa	8	50	-	1:6	4	80	-	1:20
Bridelia retusa	1	40	-	1:40	1	250	80	1:330
Cassia fistula	10	70	30	1:10	3	90	-	1:30
Dalbergia latifolia	21	450	230	1:32	13	210	-	1:16
Grewia tiliaefolia	8	100	300	1:60	8	300	-	1:3
Lagerstroemia microcarpa	-	-	-	1:0	-	340	-	0:340
Lagerstroemia parviflora	28	50	-	1:2	18	240	120	1:20
Lannea coramandelica	3	-	10	1:3	3	-	-	1:0
Phyllanthus emblica	33	260	90	1:11	18	1460	560	1:112
Pongamia pinnata	-	20	-	0:20	-	-	-	-
Pterocarpus marsupium	10	110	20	13	9	270	-	1:30
Randia dumetorum	1	90	140	1:230	-	-	-	-
Schrebera swietenioides	2	-	-	1:0	2	160	-	1:80
Semecarpus anacardium	2	-	-	1:0	1	560	80	1:640
Shorea roxburghii	9	100	410	1:57	4	1210	1480	1:673
Sophora velutina	-	-	80	0:80	-	-	-	-
Tectona grandis	32	110	130	1:8	31	350	200	1:18
Terminalia chebula	2	-	-	2:0	2	-	-	2:0
Terminalia paniculata	14	90	30	1:9	11	580	-	1:53
Zizyphus xylopyrus	1	-	-	1:0	1	80	-	1:80
Total		1930	1480			7050	2800	

A - Mature trees, SE - Seedlings, SA - Saplings; Ratio between the number of individuals of adults and seedlings and saplings.

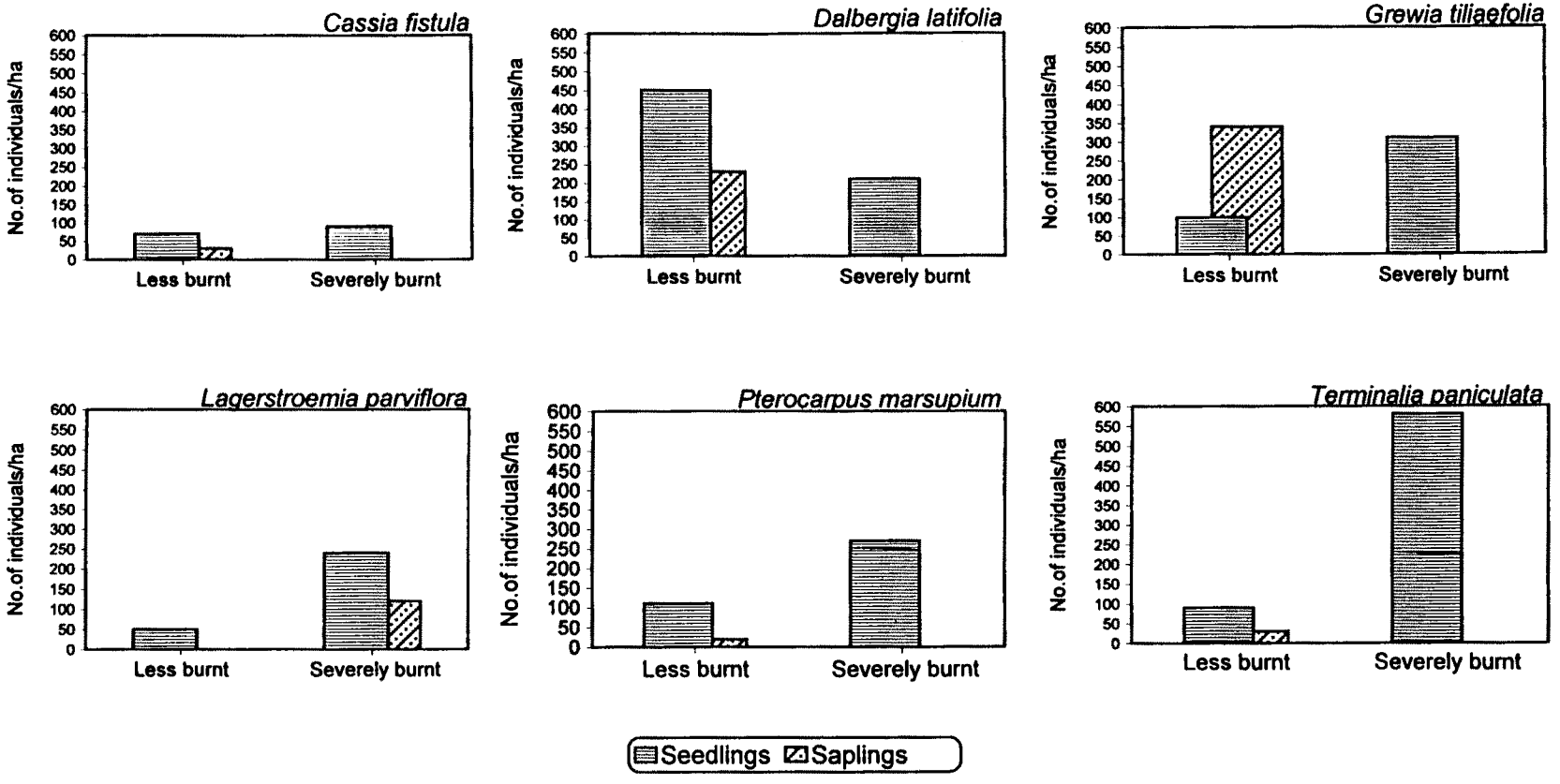

Figure. 6. 4. Density/ha of seedlings and saplings of some medicinal tree species in the less and severely burnt area

6.4. DISCUSSION

The main causes of the dry-season fire are undoubtedly due to man for getting grazing material for their cattle. It is especially difficult to protect dry tropical forests from the pyrogenic activities of humans in the densely populated lands in Asia (Goldammer 1990). In Wayanad WLS, fire is often set by local people to produce new grazing material. Grass species such as *Imperata cylindrica* and *Themeda* spp. were abundant in the burned areas. The dead shoot materials of these grass species form an acute fire hazard (Mueller-Dombois and Goldammer 1990).

Fire also promotes the growth of grass species than the other woody species (Goldammer 1990; Kinnaird and O'Brien 1998), in other words fire affects the species composition. Fire also increases biomass production in burned natural grasslands in southern India (Senthilkumar *et al* 1998). In the present study, grasses such as *Themeda cymbaria* and *T.triandra* were recorded only from the severely burnt area while *Imperata cylindrica* had higher density in the severely burnt area. Similarly, density of *Chromolaena odorata*, an exotic weed was significantly higher in the severely burnt area than in less burnt area. This exotic weed competes with other native species mainly for space, nutrients, light and water (Ramakrishnan 1991). *C. odorata* is capable of resprouting after burning and converts the forest in to thickets by its vigorous growth and sprawling habit (Ramakrishnan 1991) and it is also highly allelopathic to other plants (Sahid and Sugau 1993). Thus, the present study indicates that fire not only changes the species composition but also promote the growth of grass and exotic weed species.

6.4.1. Impact of fire on species richness, diversity and density

It has been observed that frequent fire reduce the species richness (Pinard and Huffman 1997). In the present study, shrub species richness was higher in the less burnt than the severely burnt area. In tropical forests species richness may vary from 19 to 39 species per hectare (Sukumar *et al* 1992). Therefore, the observed differences may not be ecologically significant.

Tree and shrub species diversity index showed no significant difference between the less burnt and severely burnt area. However, herb species diversity index was significantly higher in the less burnt area than in the severely burnt area. Lesser herb species diversity index in the severely burnt area could be due to lack of nutrients and lack of propagules.

There was no significant difference between the two sites with respect to the total and medicinal density of trees, shrubs and herb species. However, density of medicinal plant seedlings was significantly higher in the severely burnt area than in the less burnt area. The higher seedlings density in the severely burnt area could be due to the availability of more sun light because of tree mortality, immigration of seeds through wind and animals, reduced competition and germination of seeds.

Frequent fire clearly affect the size-class distribution of the trees by widening the gap between the mature overstorey and regeneration (Goldammer 1990). However, in Wayanad WLS, the size class distributions of trees (GBH $\geq$ 20cm) were not significantly different between the less and severely burnt area.

Lesser number of trees in lower GBH classes of the severely burnt area indicate the mortality of young trees due to burn injury. The high mortality rates in the lower size classes could also be due to self-thinning (Harper 1977), grazing and other human disturbances.

6.4.2. Impact of fire on regeneration

Species regeneration and recruitment in the fire affected areas occurred from resident sources such as resprouting stumps and rhizomes, seed bank germination, and from immigration of seeds, such as via wind and birds. Homer *et al* (1998) have also reported the same in Melajo Nature Reserve, Trinidad and Tobago. The present study showed that seedlings density was significantly higher in the severely burnt area than in the less burnt. Several authors (Puyravaud *et al* 1995; Kikkim and Yadava 1998; Calvo *et al* 1999) have also reported the enhanced germination after fire. The higher regeneration in the severely burnt area may be due to the creation of large number of microsites by forest burning, which might help in germination of large number of tree seeds (Reader *et al* 1995). Removal of overstorey trees might have also favoured germination and seedling establishment through increased solar radiation on the forest floor and consequent increase in surface temperature and reduced competition from the trees of upper canopy (Noble and Slatyer 1980). On the other hand, poor seedling population in the less burnt area may be due to the unavailability of the same favourable conditions. Besides, thick layer of litter also acts as a mechanical barrier for seedling emergence.

The seedlings of *Lagerstroemia microcarpa, Schrebera swietenioides, Semecarpus anacardium* and *Zizyphus xylopyrus* were recorded only in the severely burnt area. Burning may induce the recruitment of seedlings of these species by removing seed coat coupled with the availability of more nutrients from ash. The enhanced germination after fire has been reported as an adaptation to recurring fire (Tarrega and Luis 1987 and Goto *et al* 1996).

However, survival of the seedlings seems to have been affected by fire in the study area. Most of the species that had a higher number of seedlings in the severely burnt area had fewer individuals in the sapling classes. Puyravaud *et al* (1995), Cochrane and Schulze (1999) have also recorded the reduced abundance of saplings after fire in a dry deciduous forest in the Bandipur National Park and in the tropical forests of eastern Amazon respectively. It has been reported that frequent fire is the most important factor that affect the natural regeneration in the forest and cause its degradation (Rai and Saxena 1997; Kikkim and Yadava 1998).

Anogeissus latifolia exhibited higher density of mature trees and seedlings in the severely burnt area. It shows the fire tolerance of this species. Fire tolerance of *Anogeissus latifolia* was also recorded by Naidu and Srivasuki (1994) in Seshachalam Hills, south India. *Dalbergia latifolia* produced higher number of seedlings in the less burnt area, which is consistent with Puyravaud *et al* (1995). This could be due to the sensitiveness of this species to fire. The failure of regeneration of *Terminalia chebula* both in the less burnt and severely burnt areas may be due to the devastation of its seed during fire and commercial extraction

of fruits. Srivastava *et al* (1998) also observed the failure of regeneration of *T.chebula* after fire in the Eastern Ghats. However, it is essential to look into the possible impacts of other anthropogenic pressures such as grazing, harvesting of NTFP and Impact of exotic weeds to arrive in the role of fire on medicinal plant regeneration. In order to do so we require elaborate experimental studies for a long term period.

6.4.3. Impact of human activities

Human beings have impacted the forests in Wayanad WLS for a very long time. Paniyas, Kurumbas and Bettakurumbas are the tribal groups who have been living in these areas for several years, gathering forests products, practising shifting cultivation and hunting wild animals (Prabhakar 1994). The differences in the species composition, abundance and regeneration between the less burnt and severely burnt area could also be due to differences in history and current land use patterns. Differences in microclimate, soils and grazing could also influence the outcome.

The present study supports the observation that frequent fire reduce the species richness and change the species composition by promoting the growth of grass species (Pinard and Huffman 1997). Fire also promotes the growth of *Chromolaena odorata,* an exotic weed, which is a rapid coloniser and it is highly allelopathic to other indigenous species. Though, fire promotes the regeneration of seedlings, it affected the saplings. However, the effect of fire in ecosystems can vary considerably, depending on its succession stage, condition of the vegetation and fuels, season, and the nature of fire. Therefore, long-term monitoring of

impacts of fire on the status, distribution and regeneration of medicinal plants over a larger area will give more information. As the Impact of fire on plant population may vary between habitats, studies on Impact of fire on medicinal plants in other fire prone habitats are suggested.

6.5. SUMMARY

Impact of fire on the structure, species composition and regeneration of medicinal plant population in dry deciduous forests were studied in the less and severely burnt areas of Wayanad WLS. Categorisation of less and severely burnt area was based on the information collected from the local tribal people and forest officials.

i Total tree species richness, diversity index, tree density and basal area showed no significant difference between the less and severely burnt area. Similarly, size class distribution of trees (GBH $\geq$ 20cm) also showed no significant difference between the less and severely burnt area.

ii. Species richness, diversity index and density of medicinal shrub species also showed no significant difference between the less and severely burnt sites. However, herb species diversity index between these two sites showed significant difference. Although total density of herbs was higher in the severely burnt area than in less burnt area, the difference was not significant.

iii. Density of seedlings was significantly higher in the severely burnt area

than in the less burnt area. However, density of saplings showed no significant difference between these two habitats.

iv. The present study supports the earlier findings that the fire changes the species composition of habitat by promoting the growth of grass and exotic plant species. However, the Impact of fire on plant populations may vary between the area, year and season. Therefore, long term studies on the Impact of fire on other areas of NBR are suggested to get more supportive information on this matter.

CHAPTER VII

MEASURES FOR CONSERVATION OF MEDICINAL PLANTS

7.1. INTRODUCTION

The study showed that continued extraction of commercially important medicinal plants, without management interventions, may lead to substantial changes in various phytosociological attributes of a forest community. The species diversity, density and basal area, and consequently biomass may decline. The present study also showed that the regeneration of most of the medicinal plants in NBR is inadequate to replace the adults. Thus, the present study gives considerable evidence for unsustainable utilization of medicinal plants in the NBR. The study also showed that deciduous forests harbour greater variety of medicinal plants. The results assume greater significance since deciduous forests cover the major portion of forests in NBR and these forests are subjected to frequent fire and other human disturbances.

The forests in the NBR have been subjected to various human pressures for a long time. Collection of forest products, fire and grazing continues in some part of the NBR. Invasion of exotic plants namely *Ageratum conyzoides*, *Chromolaena odorata*, *Lantana camara*, *Mimosa pudica* and *Opuntia dillenii* affects the population of native species. Moreover, habitat destruction and other human pressures have already depleted the medicinal plant populations. Therefore, conservation of medicinal plants is important for the sustainable utilization of these resources. It is suggested that the following measures for the sustainable utilization and conservation of medicinal plants be taken up.

7.2. Measures for conservation of medicinal plants

7.2.1. Guidelines for management

Since, the current intensity of utilization of some medicinal plant is unsustainable, the following steps should be followed to ensure that conservation of medicinal plants is carried out in an efficient and effective manner.

1) There is clearly a need to prevent destruction of medicinal plants and their habitats during activities unconnected to collection as grazing, fire, firewood collection. Daniels (1993b) emphasized the need for giving conservation priority to habitats, which harbour rich medicinal plant wealth, species rich communities and to communities that have restricted range. Tropical deciduous forests in NBR harbours more medicinal plant wealth, moreover lopping, burning, and overgrazing threaten these habitats. So, management plans should be formulated to give more protection to these habitats.

2) Those medicinal plant species, which have narrow distribution or disjunct distribution, less tolerance to habitat change and are likely to be affected by various environmental and anthropogenic factors should be given conservation priority. Based on the present study, medicinal plants such as *Curcuma pseudomontana, Cycas circinalis, Gloriosa superba, Madhuca longifolia, Nervilia aragoana, Pseudarthria viscida, Rauwolfia serpentina, Schrebera swietenioides, Rotula aquatica, Decalepis hamiltonii, Costus speciosus* and *Terminalia arjuna* were selected as priority species. The criteria for the selection of these species include habitat loss, population reduction, extent of occurrence and commercial extraction. Among the above 12 species, nine species were also listed in the "red

list" of medicinal plants of south India (Anon. 1997). Ex-situ conservation measures such as micropropagation and germplasm maintenance can also be undertaken for the conservation of these species.

3) Destructive extraction (See Chapter V), less abundance and poor regeneration of many commercially exploited medicinal plants were observed in the present study. This clearly points to the unsustainable utilization of medicinal plants. Hence, suitable management plans should be implemented for the sustainable utilization of medicinal plants. Any management strategy for sustainable harvesting needs to incorporate ways of controlling over-exploitation, while allowing levels of exploitation that are sufficient to meet legitimate needs. Muraleedharan *et al* (1997) have initiated such a work in the Wayanad Wildlife Sanctuary. Most medicinal trees rely on animals to pollinate their flowers and disperse seeds (Peters 1993). Therefore, any serious program of commercial resource exploitation must include measures to conserve viable population of these animals. A team of botanists, medicinal plant specialists and park managers should prepare a plan for each area providing details on how the medicinal plants can be used on a sustainable basis.

4) Destructive collection of medicinal plants is common in the NBR. Nearly 45% of the collections of medicinal plants in NBR are destructive. I also observed that for collecting fruits branches of trees were cut this is mainly done by the tribals. Therefore, the tribals and other local people who are involved in the collection of medicinal plants should be given sufficient training in scientific way of collection. Collection programmes should be planned properly and restricted to

a particular season. Cutting of tree branches to harvest its fruit should be avoided. Annual medicinal herbs can be continued to be collected by leaving enough propagules for next season's growth. So also, flowers and fruits without destroying plants. Thus, by rationalising the collection of medicinal plants, they can provide a sustained yield from the forests.

5) To reduce the pressure of commercial exploitation on wild medicinal plants and to avoid adulteration of crude drugs, cultivation of medicinal plants can be encouraged with the participation of local tribes. Judicious harvesting of NTFP's can enhance the rural incomes. Moreover, local communities can be involved in conservation because of the economic interest they are likely to have in sustainable use of natural resources. Tribals (Irulas) in the NBR are willing to participate in cultivation of medicinal plants. Therefore, tribals can be involved in the cultivation.

7.2.2. Management oriented research

The following are the areas of research that could identify management requirements, and improve our understanding of the conservation of medicinal plants.

1) Commercial harvesting of reproductive parts of medicinal plants not only effect the wild population but also affect the genetic composition of the plant being exploited (Peters 1993). Genetic diversity of most of the medicinal plants are unknown. Therefore, the genetic diversity of medicinal plants should be studied for germplasm preservation and conservation of medicinal plants.

2) Autecological information (seed dispersal, germination, phenology, propagation methods, habitats in which they occur, their distribution and microhabitat requirements) of important medicinal plants are very helpful in designing appropriate conservation and management plans. Autecological information are valuable aid to germplasm collection and exchange. Hence, autecological information of medicinal plants should be studied for better management of the resources.

3) The present study shows that the current intensity of exploitation of medicinal plants is unsustainable as the density and regeneration of some medicinal plants were very low in the harvested area compared to least harvested area. Sustainable utilization is defined here as the level of utilization that does not impair the ability of the harvested population to replace itself. Moreover, sustainable harvest should have no discernible adverse effect on other species in the community, or an ecosystem structure and function (Hall and Bawa 1993). Although, the present study indicates the unsustainable utilization of NTFP's in the NBR, populations change over time and sampling must continue to determine patterns of natural change in population structure. Similarly decline in population and regeneration can occur due to a number biotic and abiotic causes and population dynamics of a given species is influenced by other species in the community.

Need for productivity studies

Unless levels of harvests are linked with total productivity, a sustainable level of extraction may be difficult to achieve. Phillips (1993) assessed the

productivity of forest products in Amazon. Uma Shankar *et al* (1996) assessed the productivity and extraction of *Phyllanthus emblica* in Biligiri Rangan Hills, India. However, productivity levels for most NTFP's per unit area are unknown. In the absence of such data, the notion that extraction of NTFP's is compatible with sustained use and conservation of forest resources remains untenable (Godoy and Bawa 1993). Productivity of resources such as fruit is affected by several factors (Phillips 1993), moreover, productivity may vary from one year to another and vary from one forest to another (Phillips 1993). Productivity of fruits can be affected by parasitic plants also. During my field visits, I found two common parasitic plants, *Taxillus tomentosus* and *Dendrophthoe falcata* affected the fruit production of *Phyllanthus emblica* (Amla). However, productivity studies of medicinal plants are beyond the scope of this study because of time constraints.

The exact percentage of resources that must be left to enable a maximum sustainable yield is difficult to estimate and varies from one species to another. Uma Shankar *et al* (1996) showed that harvesting 60 to 80% of *Phyllanthus emblica* had a negative effect on new recruitment in the Biligiri Rangan Hills, India. Hence, harvesting below 50% of the total productivity could be sustainable way to use this species. Muraleedharan *et al* (1997) showed that harvesting 95% population of *Asparagus racemosus*, *Curcuma aromatica* and *Hemidesmus indicus* not affected their regeneration. However, a precise calculation of the maximum level of sustainable harvesting would require monitoring the population over a number of years, a technique which require much time and work. Therefore, for the sustainable use of a given species, apart from density and

distribution patterns, its regeneration potential in different levels of harvest and level of productivity should be assessed.

4) Vegetation and land use maps, species distribution patterns, identification of zones of speciation and demarcation of hotspots of biological diversity (Gentry 1992) globally aid conservation efforts. Hence, formation of a database of medicinal plants of NBR will not only help in understanding the distribution pattern and ecology of medicinal plants but also helps in conservation of medicinal plants. Guidelines for the establishment of medicinal plant database are discussed in Synge and Heywood (1991). French Institute, Pondicherry, India has already formed an ecological database of some south Indian medicinal plants (Rani *et al* 1997). Adding species based information from various fields in basic and applied sciences can enlarge the scope of such database.

5) Medicinal plant populations may change over time and sampling must continue for long time to find out patterns of natural change in population structure. Similarly, decline in population and regeneration can occur due to many biotic and abiotic factors and population dynamics of a given species is influenced by other species in the community. Therefore, long term monitoring of medicinal plant population is recommended. Besides, the above areas research could be undertaken on minimum effective population size of medicinal plants, relationship of soil chemistry to active compounds in medicinal plants, effects of exotics and parasitic plants on the medicinal plant population.

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Appendix.I. Distribution and major occupational details of the tribes of NBR

Tribal group	Occupation	Locality	Vegetation type	Spoken Language
Adiyans	Field labourers Hill cultivation	Wayanad, Mysore	Moist deciduous	Kannada Malayalam
Aranadans	Labourers, Hunting	Nilambur hills	Evergreen	—
BettaKurumbas	Woodsmen	Nagarhole, Kakanalla	Deciduous	Tamil, Kannada
Cholanaickans	Hunting, food gathering	Nilambur valley	Evergreen	Kannada, Tamil
Edanadan Chettis	Agriculture	Wayanad plateau	Deciduous	—
Irulas	Agricultural labourers, Collecting tubers, Artisans	Coimbatore, Attappady Nilgiris	Deciduous Evergreen	Tamil
Jenu Kurumbas	Agriculture, Food gatherers	Begur, Kakkankote Ainurumarigudi	Deciduous	Kannada with Tamil
Kaders	Agricultural labourers	Wayanad	Deciduous	
Kattunaickans	Labourers Collecting tubers, Hunting	Wayanad, Mudumalai	Deciduous	Kannada
Karimpalans	Shifting cultivation, Collection of wild pepper	North Malabar, Foot hills of Camel's Hump	—	Malayalam
Kurichians	Agriculture, Hunting	Wayanad	Deciduous	Malayalam
Kurumbas of Attappady	Agriculture	Attappadi	Deciduous, Evergreen	—
Kotas	Artisans, Agriculture	Nilgiris	—	Tamil
Mandatan Chettis	Agriculture	Wayanad (Veliyembam Pulpalli)	—	—
Mudugas	Agriculture Labourers	Attappadi Muthikulam	Evergreen, Deciduous	—
Mullu Kurumbas	Agriculture	Wayanad, Gudalur	–	Malayalam Tamil
Paniyas	Labourers	Wayanad, Coorg, Mysore, Nilgiris	Deciduous	Malayalam, Tamil
Pani Yeravas	Hunting	Coorg Dt, Kakankote RF	Deciduous	—
Panjari Yeravas	Labourers	Coorg Dt, Kakankote RF	Deciduous	—
Pathiyans	Agriculture	Wayanad	Deciduous	—
Soligas	Labourers, Cultivation	Sathyamangalam plateau	Deciduous	–
Todas	Pastoral	Nilgiris	Shola forests	Tamil
Uralis	Agricultural labourers	Sathyamangalam	Deciduous	Tamil
Urali Kurumba	Artisans, labourers	Wayanad	Moist deciduous	Malayalam Kannada
Wayanadan Chettis	Agriculture	Wayanad	Moist deciduous	—

Appendix II Ethnomedicinal plant species recorded among select tribes in the NBR

Species	Family	Part used	Use group
Irulas			
******Acacia torta (Roxb.) Graib*	Mimosaceae	Leaves	Nutritive supplements
		Leaves	Digestive disorders, Fever
*****Acalypha fruticosa Forsk.*	Euphorbiaceae	Roots	Digestive disorders
******Acalypha indica L.*	Euphorbiaceae	Leaves, Roots	Skin diseases
Achyranthes aspera L.	Amaranthaceae	Roots	Antidote
******Adiantum incisum Forsk.*	Adiantaceae	Leaves	Antiemetic, Intestinal diseases
Ailanthus excelsa Roxb.	Simaroubaceae	Bark	Veterinary medicine
Alternanthera sessilis (L.) R.Br.	Amaranthaceae	Leaves, Stem	Nutritive supplements
******Amaranthus spinosus L.*	Amaranthaceae	Leaves	Nervous disorders
Andrographis paniculata (Burm.f.) Wall.	Acanthaceae	Leaves	Body pain
Andrographis neesiana	Acanthaceae	Stem	Antidote
Argemone mexicana L.	Papaveraceae	Stem	Cuts and Wounds
**Argyreia hirsuta Arn.*	Convolvulaceae	Latex	Cuts and Wounds
Argyreia pomacea (Roxb.) Choisy	Convolvulaceae	Roots	Jaundice
Arisaema totulosum (Wall.) Schott.	Araceae	Rhizome	Piles
Asclepias curassavica L.	Asclepiadaceae	Leaves	Epilepsy
Asparagus racemosus L.	Liliaceae	Rhizome	Menstrual disorders, Urinary troubles, Chloera
Bambusa arundinacea Ait.	Poaceae	Tender shoots	Nutritive supplements
Barleria mysorensis Heyne ex Roth.	Acanthaceae	Leaves	Antidote
******Basella rubra L.*	Basellaceae	Leaves, Stem	Increases memory
******Bauhinia racemosa Lam.*	Caesalpiniaceae	Seed	Abortifacient
Begonia sp	Begoniaceae	Whole plant	Cuts and Wounds
Biophytum sensitivum DC.	Oxalidaceae	Whole plant	Digestive disorders
******Blepharis maderaspatensis (L) Roth.*	Acanthaceae	Leaves	Nervous disorders
Boerhavia diffusa L.	Nyctaginaceae	Roots	Body pain
Borreria hispida (L.) K.Schum.	Rubiaceae	Roots	Antidote

Species	Family	Part used	Use group
Borreria ocymoides (Burm.f) DC.	Rubiaceae	Leaves	Lactation problems
Brassica nigrum (L.) Koch.	Brassicaceae	Seed	Headache
Caesalpinia mimosoides Lam.	Caesalpiniaceae	Leaves	Body pain, Eye complaints, Refrigerant
***Callicarpa tomentosa (L.) Murray*	Verbenaceae	Leaves	Intestinal diseases
Canarium strictum Roxb.	Burseraceae	Resin	Childrens medicine, Cough
Canscora diffusa R.Br	Gentianaceae	Whole plant	Nervous disorders
Capparis grandis L.f.	Capparaceae	Leaves	Skin diseases
**Capparis grandiflora*	Capparaceae	Root	Digestive disorders
***Capparis zeylanica L.*	Capparaceae	Roots	Dental complaints
Capsicum frutescens L.	Solanaceae	Fruit	Fever, Headache
Caralluma adscendens R.Br.	Asclepiadaceae	Stem, Tender shoots	Vermifuge, Digestive disorders
Cardiospermum halicacabum L.	Sapindaceae	Leaves	Antiemetic, jaundice, Rheumatism, To reduce bulkiness
Carmona retusa (Vahl) Mesumune	Boraginaceae	Leaves	Menstrual disorders
		Fruit	Venereal disease
Cascabela thevetia (L.) Lipp.	Apocynaceae	Seed	Poison
Cassia fistula L.	Caesalpiniaceae	Bark	Antiemetic
***Cassia occidentalis L.*	Caesalpiniaceae	Roots	Body pain, Gynaecological complaints, Rheumatism
***Cassia tora L.*	Caesalpiniaceae	Leaves	Body pain
***Catunaregam spinosa (Thunb.) Tiruvengadam*	Rubiaceae	Bark	Skin diseases
Cayratia pedata Juss.	Vitaceae	Leaves	Vermifuge
Centella asiatica Urb.	Apiaceae	Leaves	Refrigerant
Chenopodium ambrosoides L.	Chenopodiaceae	Leaves	Fever
Chloroxylon swietenia DC.	Flindersiaceae	Stem	Gynaecological complaints
Chromolaena odorata (L.) King & Robinson	Asteraceae	Leaves	Cuts and Wounds
***Cipadessa baccifera (Roth) Miq.*	Meliaceae	Bark	Allergy
Cissus quadrangularis L.	Vitaceae	Stem	Digestive disorders

Species	Family	Part used	Use group
Cissus vitiginea L.	Vitaceae	Whole plant	Body swellings
****Clausena heptaphylla (Roxb.) Wt. & Arn.*	Rutaceae	Roots	Cuts and Wounds
****Clematis gouriana Roxb.*	Ranunculaceae	Roots	Headache
****Cleome monophylla L.*	Cleomaceae	Leaves	Ear complaints
Clerodendrum serratum (L.) Moon	Verbenaceae	Roots	Digestive disorders
****Coccinia grandis (L.) Voigt.*	Cucurbitaceae	Leaves	Intestinal diseases
Cocculus hirsutus Diels.	Menispermaceae	Leaves	Refrigerant
		Leaves	Cuts and Wounds
		Roots	Cuts and Wounds
**Coleus amboinicus Rowr.*	Lamiaceae	Stem	Cuts and Wounds
****Crataeva magna (Lour.) DC.*	Capparaceae	Roots	Ear complaints
****Crateva adansonii DC.*	Capparaceae	Bark	Cuts and Wounds
****Crinum latifolium L.*	Liliaceae	Tuber	Tumour
Croton bonplandianum Baill.	Euphorbiaceae	Leaves	Headache
Cryptolepis buchanani R. & S.	Asclepiadaceae	Roots	Antidote
Cuminum cyminum (L.)	Apiaceae	Seed	Menstrual disorders
Curculigo orchioides Gaertn.	Amaryllidaceae	Tuber	Antidote
		Leaves	Fever
Cyclea peltata (Lam.) Hook.f. & Thoms.	Menispermaceae	Roots	Digestive disorders
**Cynanchum tunicatum (Retz.) Alston*	Asclepiadaceae	Tuber	Antiemetic
		Flower	Asthma
		Leaves	Asthma
		Roots	Body pain
****Datura metel L.*	Solanaceae	Seed	Asthma
Desmodium triflorum DC.	Fabaceae	Leaves	Skin diseases
Desmodium velutinum (Willd.) DC.	Fabaceae	Roots	Body pain
****Dioscorea tomentosa Koen.ex. Spreng*	Dioscoreaceae	Tuber	Allergy

Species	Family	Part used	Use group
		Leaves	Bone fracture
Dodonaea viscosa L.	Sapindaceae	Whole plant	Body swellings
***Dolichos trilobus L.*	Fabaceae	Tuber	Nervous disorders
Erythroxylum monogynum Roxb.	Erythroxylaceae	Stem	Skin diseases
		Stem	Intestinal diseases
***Euphorbia hirta L.*	Euphorbiaceae	Whole plant	Menstrual disorders
Euphorbia rothiana Spr.	Euphorbiaceae	Leaves	Jaundice
Evolvulus alsinoides L.	Convolvulaceae	Leaves	Antidote
Fagraea obovata Wall.	Loganiaceae	Fruit, Seed	Skin diseases
Feronia elephantum Corr.	Rutaceae	Leaves	Cough
Ficus racemosa L.f.	Moraceae	Bark	Intestinal diseases
		Resin	Children's medicine
			Cough
			Fever
***Gardenia resinifera Roth.*	Rubiaceae		Headache
Givotia rottleriformis Griff.	Euphorbiaceae	Seed	Nutritive supplements
Glinus lotoides(L.) Ktze.	Aizoaceae	Leaves	Body pain
Glycosmis arborea (Roxb.) DC.	Rutaceae	Roots	Digestive disorders, Rheumatism, Tumour, Rheumatism
Gymnema sylvestre R.Br.	Asclepiadaceae	Leaves	Diabetes
Gynandropsis pentaphylla	Capparaceae	Roots	Ear complaints
**Hardwickia binata Roxb.*	Caesalpiniaceae	Seed	Intestinal diseases
Helicteres isora L.	Sterculiaceae	Roots	Digestive disorders
Heliotropium indicum L.	Boraginaceae	Leaves	"Maru"
Hemidesmus indicus (L.) R.Br.	Asclepiadaceae	Roots	Digestive disorders
		Leaves	Children's diseases (Fever)
**Hemionitis arifolia (Burm.) Moore*	Hemionitidaceae	Roots	Children's diseases (Polio)
Hibiscus ovalifolius (Forsk.) Vahl.	Malvaceae	Leaves	Refrigerant
Holoptela integrifolia Pl.	Ulmaceae	Bark	Skin diseases
		Bark	Body pain, Giddiness
**Homonoia riparia Lour.*	Euphorbiaceae		

Species	Family	Part used	Use group
		Fruit	Nervous disorders
Hugonia mystax L.	Linaceae	Roots	Intestinal diseases
Hybanthus ennaespermus (L) F.V. Muell.	Violaceae	Leaves	Childrens medicine
***Hygrophila salicifolia Nees*	Acanthaceae	Leaves	Body pain
**Indigofera spicata Forsk.*	Fabaceae	Roots	Digestive disorders
		Latex	Cornfoot
Ipomoea staphylina Roem. & Schult.	Convolvulaceae	Roots	Antidote
Jatropha curcas L.	Euphorbiaceae	Bark	Cuts and Wounds
Justicia adhatoda L.	Acanthaceae	Leaves	Body pain, Cough
***Justicia tranquebariensis Lf.*	Acanthaceae	Leaves	Eye complaints
Kalanchoe pinnata (Lamk.) Pers.	Crassulaceae	Leaves	Cuts and Wounds
		Leaves	Respiratory disorders
***Lantana indica Roxb.*	Verbenaceae	Roots	Digestive disorders
Lantana wightiana	Verbenaceae	Leaves	Cuts and Wounds
Malvastrum coromandelianum (L.) Garcke	Malvaceae	Roots	Cuts and Wounds
Mangifera indica L.	Anacardiaceae	Bark	Intestinal diseases
***Melothria maderpatensis Cogn.*	Cucurbitaceae	Rhizome	Cornfoot
***Mimosa pudica L.*	Mimosaceae	Roots	Cuts and Wounds
***Mukia maderaspatana (L.) Cogn.*	Cucurbitaceae	Roots	Headache
Myrstica dactyloides	Myristicaceae	Fruit	Digestive disorders
***Naravelia zeylanica (L.) DC.*	Ranunculaceae	Roots	Headache
Naringi crenulata (Roxb.) Nicol.	Rutaceae	Roots	Body pain
Notonia grandiflora DC.	Asteraceae	Stem	Pimples
Ocimum gratissimum L.	Lamiaceae	Leaves	Refrigerant
Oldenlandia umbellata L.	Rubiaceae	Whole plant	Menstrual disorders
**Opilia amentacea Roxb.*	Opiliaceae	Leaves	Nutritive supplements
***Orthosiphon glabratus Benth.*	Lamiaceae	Leaves	Menstrual disorders
Oxalis corniculata L.	Oxalidaceae	Leaves	Digestive disorders

Species	Family	Part used	Use group
**Pancratium triflorum Roxb.	Amaryllidaceae	Tuber	Cornfoot
Passiflora foetida L.	Passifloraceae	Tuber	Nervous disorders
**Pentanema indicum (L.) Ling.	Asteraceae	Leaves	Cuts and Wounds
Peperomia tetraphylla (Forst.f.)Hk. & Arn.	Peperomiaceae	Whole plant	Digestive disorders
**Pergularia daemia (Forsk.) Chiov.	Asclepiadaceae	Leaves	Fever, veterinary medicine
Phyllanthus amarus Schum. & Thann.	Euphorbiaceae	Leaves, Roots	Jaundice
Phyllanthus virgatus Forst.	Euphorbiaceae	Leaves	Jaundice, Refrigerant
Piper longum L.	Piperaceae	Seed	Asthma, Digestive disorders
Piper longum L.	Piperaceae	Whole plant	Rheumatism
		Leaves, Roots	Headache
Plumbago zeylanica L.	Plumbaginaceae	Roots	Cuts and Wounds
Polygonum barbatum L.	Polygonaceae	Leaves	Nervous disorders
Pouzolzia auriculata W.	Urticaceae	Leaves	Digestive disorders
*Pouzolzia wightii Benn.	Urticaceae	Roots, Stem	Nervous disorders
Premna latifolia var. viburnoides Clarke.	Verbenaceae	Leaves	Nutritive supplements
**Premna tomentosa Willd.	Verbenaceae	Leaves	Nervous disorders, Skin diseases
Priva cordifolia	Verbenaceae	Leaves	Skin diseases, Eye complaints
Pterocarpus marsupium Roxb.	Fabaceae	Latex	Childrens medicine
Rauvolfia serpentina L.	Apocynaceae	Roots	Antidote, Digestive disorders
**Rhinacanthus nasuta (L.) Kurz.	Acanthaceae	Roots	Goitre
Rotula aquatica	Boraginaceae	Leaves	Dandruff
**Sarcostemma brunonianum Wt. & Arn.	Asclepiadaceae	Latex	Gluteal swelling
Scoparia dulcis L.	Scrophulariaceae	Roots	Digestive disorders
**Securinega virosa (Roxb. ex Willd.) Pax. & Hoffm	Euphorbiaceae	Roots	Burns
Sida acuta Burm.	Malvaceae	Leaves	Cuts and Wounds
**Sida spinosa L.	Malvaceae	Roots	Asthma
**Smithia conferta J.E. Smith	Fabaceae	Leaves	Body pain
**Solanum anguivi Lamk.	Solanaceae	Roots	Digestive disorders

Species	Family	Part used	Use group
		Fruit	Nutritive supplements
****Solanum incanum L.**	Solanaceae	Roots	Digestive disorders
Solanum nigrum L.	Solanaceae	Leaves	Cuts and Wounds, Digestive disorders
****Sphaeranthus indicus L.**	Asteraceae	Leaves	Cuts and Wounds
Streblus asper Lour.	Moraceae	Latex	"Maru"
		Fruit	Cornfoot
Strychnos nux-vomica L.	Loganiaceae	Stembark	Antidote
****Strychnos potatorum Linn. f.**	Loganiaceae	Fruit	Vermifuge
Terminalia chebula Retz.	Combretaceae	Fruit	Toothache, Cough
****Thespesia lampas (Cav.) Dalz. & Gibs.**	Malvaceae	Roots	Jaundice
		Leaves	Headache
****Toddalia asiatica (L.) Lam.**	Rutaceae	Roots	Digestive disorders, Giddiness
Tribulus terrestris L.	Zygophyllaceae	Roots	Intestinal diseases
		Roots	Skin diseases
Trichodesma zeylanicum (Burm.f.) R.Br.	Boraginaceae	Whole plant	Rheumatism
Vanda tessellata (Roxb.) HK. f. ex. Don.	Orchidaceae	Leaves	Ear complaints
***Vanilla walkeriae Wight**	Orchidaceae	Stem	Veterinary medicine
Kattunayakkas			
Acacia sinuata (Lour.) Merr.	Mimosaceae	Fruit	Cuts and Wounds, Headache
Allium cepa L.	Liliaceae	Bulb	Aphrodisiac
Anogeissus latifolia Wall.	Combretaceae	Bark	Digestive disorders, Intestinal diseases
Bridelia retusa Spr.	Euphorbiaceae	Bark	Antidote
Cassia fistula L.	Caesalpiniaceae	Bark	Digestive disorders
		Leaves	Antidote
Cocculus hirsutus Diels.	Menispermaceae	Roots	Intestinal diseases
Cryptolepis buchanani R. & S.	Asclepiadaceae	Roots	Intestinal diseases
Curcuma aromatica Sal.	Zingiberaceae	Rhizome	Pimples
Curcuma longa L.	Zingiberaceae	Rhizome	Antidote

Species	Family	Part used	Use group
Cyclea peltata (Lam.) Hook.f. & Thoms.	Menispermaceae	Tuber	Veterinary medicine
Cymbidium aloifolium Hk.f.	Orchidaceae	Fruit	Ear complaints
Cymbopogon citratus Stapf.	Poaceae	Whole plant	Body swellings
Dalbergia latifolia W.	Fabaceae	Bark	Intestinal diseases
Diospyros montana Roxb.	Ebenaceae	Bark	Fever, Skin diseases
Diospyros montana Roxb.	Ebenaceae	Leaves	Fever, Skin diseases
Elephantopus scaber L.	Asteraceae	Roots	Antiemetic
		Roots	Intestinal diseases, Antidote
Helicteres isora L.	Sterculiaceae	Seed	Ear complaints
Lagerstroemia microcarpa Wt.	Lythraceae	Bark	Burns, Intestinal diseases
Lannea coromandelica (Houtt.)Merr.	Anacardiaceae	Bark	Giddiness
Mitragyna parvifolia Korth.	Rubiaceae	Bark	Intestinal diseases
Phyllanthus emblica L.	Euphorbiaceae	Fruit	Fertility in men
**Pimpinella monoica Dalz.*	Apiaceae	Seed	Intestinal diseases
		Latex	Abortifacient, Antifertility for women
Pterocarpus marsupium Roxb.	Fabaceae	Roots	Urinary troubles
Rauvolfia serpentina L.	Apocynaceae	Roots	Digestive disorders
Schleichera oleosa (Lour.) Oken	Sapindaceae	Seed	Skin diseases
Schrebera swietenioides Roxb.	Poaceae	Bark	Body swellings
Sida rhomboidea Roxb.	Malvaceae	Roots	Cuts and Wounds
Tamilnadia uliginosa	Rubiaceae	Fruit	Digestive disorders
Tectona grandis L.f.	Verbenaceae	Bark	Intestinal diseases
		Bark	Burns, Cuts and Wounds
Terminalia chebula Retz.	Combretaceae	Fruit	Cuts and Wounds
Thespesia lampas (Cav.) Dalz. & Gibs.	Malvaceae	Roots	Intestinal diseases
***Thottea siliquasa*	Aristolochiaceae	Roots	Digestive disorders
Kurumbas			
Anisomeles ovata R.Br.	Lamiaceae	Stem	Refrigerant
Biophytum sensitivum DC.	Oxalidaceae	Whole plant	Asthma

Species	Family	Part used	Use group
Cassia occidentalis L.	Caesalpiniaceae	Roots	Digestive disorders
Clerodendrum infortunatum L.	Verbenaceae	Roots	Digestive disorders
Costus speciosus Sm.	Zingiberaceae	Stem	Refrigerant
Cryptolepis buchanani R. & S.	Asclepiadaceae	Roots	Cornfoot
Mudugas			
Baccaurea courtallensis	Euphorbiaceae	Fruit	Tonic
Dracena terniflora	Agavaceae	Roots	Cuts and Wounds
Jasminum rottlerianum Wall. ex. DC.	Oleaceae	Leaves	Cuts and Wounds
***Lobelia nicotianifolia*	Asteraceae	Roots	Cuts and Wounds
		Leaves	Dandruff, vermifuge
***Rotula aquatica*	Boraginaceae	Roots	Body pain
***Vernonia indica*	Asteraceae	Roots	Digestive disorders

** New uses reported ; * New Ethnomedicinal plant reported

Appendix III Ethnomedicinal plant species recorded among select tribes in the NBR

Species	Habitat	Distribution
Acacia torta (Roxb.) Graib	Dry deciduous	Coimbatore FD
Acalypha indica L.	Dry deciduous	Coimbatore FD
***Adiantum incisum Forsk.*	Dry deciduous	Coimbatore FD
***Amaranthus spinosus L.*	Dry deciduous	Coimbatore FD
***Basella rubra L.*	Dry deciduous	Coimbatore FD
***Bauhinia racemosa Lam.*	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
***Blepharis maderaspatensis (L) Roth.*	Dry deciduous	Coimbatore FD
***Callicarpa tomentosa (L.) Murray*	Moist deciduous	Attappady Rf
***Capparis zeylanica L.*	Dry deciduous	Coimbatore FD
***Cassia occidentalis L.*	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
***Cassia tora L.*	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
***Catunaregam spinosa (Thunb.) Tiruvengadam*	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
***Cipadessa baccifera (Roth) Miq.*	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
***Clausena heptaphylla (Roxb.) Wt. & Arn.*	Dry deciduous	Coimbatore FD
***Clematis gouriana Roxb.*	Dry deciduous	Coimbatore FD
***Cleome monophylla L.*	Dry deciduous	Coimbatore FD
***Coccinia grandis (L.) Voigt.*	Dry deciduous	Coimbatore FD
***Crataeva magna (Lour.) DC.*	Riverine	Coimbatore FD
***Crateva adansonii DC.*	Riverine	Coimbatore FD
***Crinum latifolium L.*	Dry deciduous	Coimbatore FD
***Datura metel L.*	Dry deciduous	Coimbatore FD
***Dioscorea tomentosa Koen.ex. Spreng*	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
***Dolichos trilobus L.*	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
***Euphorbia hirta L.*	Dry deciduous	Coimbatore FD
***Gardenia resinifera Roth.*	Dry deciduous	Coimbatore FD
***Hygrophila salicifolia Nees*	Dry deciduous	Coimbatore FD
***Justicia tranquebariensis Lf.*	Dry deciduous	Coimbatore FD
***Lantana indica Roxb.*	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs

Species	Habitat	Distribution
****Lobelia nicotianifolia**	Dry deciduous	Attappady Rf
****Melothria maderpatensis Cogn.**	Dry deciduous	Coimbatore FD
****Mimosa pudica L.**	Dry deciduous	Coimbatore FD
****Mukia maderaspatana (L.) Cogn.**	Dry deciduous	Coimbatore FD
****Naravelia zeylanica (L.) DC.**	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
****Orthosiphon glabratus Benth.**	Dry deciduous	Coimbatore FD
****Pancratium triflorum Roxb.**	Dry deciduous	Coimbatore FD
****Pentanema indicum (L.) Ling.**	Dry deciduous	Coimbatore FD
****Pergularia daemia (Forsk.) Chiov.**	Dry deciduous	Coimbatore FD
****Premna tomentosa Willd.**	Dry deciduous	Coimbatore FD
****Rhinacanthus nasuta (L.) Kurz.**	Dry deciduous	Coimbatore FD
****Rotula aquatica**	Riverine	Attappady Rf
****Sarcostemma brunonianum Wt. & Arn.**	Dry deciduous	Coimbatore FD
****Securinega virosa (Roxb. ex Willd.) Pax. & Hoffm**	Dry deciduous	Coimbatore FD
****Sida spinosa L.**	Dry deciduous	Coimbatore FD
****Smithia conferta J.E. Smith**	Riverine	Coimbatore FD
****Solanum anguivi Lamk.**	Dry deciduous	Coimbatore FD
****Solanum incanum L.**	Dry deciduous	Coimbatore FD
****Sphaeranthus indicus L.**	Riverine	Coimbatore FD
****Strychnos potatorum Linn. f.**	Dry deciduous	Coimbatore FD
****Thespesia lampas (Cav.) Dalz. & Gibs.**	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
****Thottea siliquasa**	Evergreen	Attappady Rf
****Toddalia asiatica (L.) Lam.**	Dry deciduous	Coimbatore FD
****Vernonia indica**	Dry deciduous	Attappady Rf
***Acalypha fruticosa Forsk.**	Dry deciduous	Coimbatore FD
***Argyreia hirsuta Arn.**	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
***Capparis grandiflora**	Dry deciduous	Coimbatore FD
***Coleus amboinicus Rowr.**	Dry deciduous	Coimbatore FD
***Cynanchum tunicatum (Retz.) Alston**	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
***Hardwickia binata Roxb.**	Dry deciduous	Coimbatore FD

Species	Habitat	Distribution
**Hemionitis arifolia (Burm.) Moore*	Riverine	Coimbatore FD
**Homonoia riparia Lour.*	Riverine	Wayand WLS, Bandipur NP and Mudumalai WLs
**Indigofera spicata Forsk.*	Dry deciduous	Coimbatore FD
**Opilia amentacea Roxb.*	Dry deciduous	Coimbatore FD
**Pimpinella monoica Dalz.*	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
**Pouzolzia wightii Benn.*	Dry deciduous	Coimbatore FD
**Vanilla walkeriae Wight*	Dry deciduous	Coimbatore FD
Acacia sinuata (Lour.) Merr.	Riverine	Wayand WLS, Bandipur NP and Mudumalai WLs
Achyranthes aspera L.	Dry deciduous	Coimbatore FD
Ailanthus excelsa Roxb.	Dry deciduous	Coimbatore FD
Allium cepa L.	Cultivated	Coimbatore FD
Alternanthera sessilis (L.) R.Br.	Dry deciduous	Coimbatore FD
Andrographis neesiana	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Andrographis paniculata (Burm.f.) Wall.	Dry deciduous	Coimbatore FD
Anisomeles ovata R.Br.	Dry deciduous	Coimbatore FD
Anogeissus latifolia Wall.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Argemone mexicana L.	Dry deciduous	Coimbatore FD
Argyreia pomacea (Roxb.) Choisy	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Arisaema totulosum (Wall.) Schott.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Asclepias curassavica L.	Dry deciduous	Coimbatore FD
Asparagus racemosus L.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Baccaurea courtallensis	Evergreen	Attappady Rf
Bambusa arundinacea Ait.	Moist deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Barleria mysorensis Heyne ex Roth.	Dry deciduous	Coimbatore FD
Begonia sp	Dry deciduous	Coimbatore FD
Biophytum sensitivum DC.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Biophytum sensitivum DC.	Moist deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Boerhavia diffusa L.	Dry deciduous	Coimbatore FD
Borreria hispida (L.) K.Schum.	Dry deciduous	Coimbatore FD
Borreria ocymoides (Burm.f) DC.	Dry deciduous	Coimbatore FD

Species	Habitat	Distribution
Brassica nigrum (L.) Koch.	Agricultural fields	Coimbatore FD
Bridelia retusa Spr.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Caesalpinia mimosoides Lam.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Canarium strictum Roxb.	Moist deciduous	Attappady Rf
Canscora diffusa R.Br	Dry deciduous	Coimbatore FD
Capparis grandis L.f.	Dry deciduous	Coimbatore FD
Capsicum frutescens L.	Dry deciduous	Coimbatore FD
Caralluma adscendens R.Br.	Dry deciduous	Coimbatore FD
Cardiospermum halicacabum L.	Dry deciduous	Coimbatore FD
Carmona retusa (Vahl) Mesumune	Dry deciduous	Coimbatore FD
Cascabela thevetia (L.) Lipp.	Cultivated	Coimbatore FD
Cassia fistula L.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Cassia fistula L.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Cassia occidentalis L.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Cayratia pedata Juss.	Dry deciduous	Attappady Rf
Centella asiatica Urb.	Moist deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Chenopodium ambrosoides L.	Dry deciduous	Coimbatore FD
Chloroxylon swietenia DC.	Dry deciduous	Coimbatore FD
Chromolaena odorata (L.) King & Robinson	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Cissus quadrangularis L.	Dry deciduous	Coimbatore FD
Cissus vitiginea L.	Dry deciduous	Coimbatore FD
Clerodendrum infortunatum L.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Clerodendrum serratum (L.) Moon	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Cocculus hirsutus Diels.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Cocculus hirsutus Diels.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Costus speciosus Sm.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Croton bonplandianum Baill.	Dry deciduous	Coimbatore FD
Cryptolepis buchanani R. & S.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Cryptolepis buchanani R. & S.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Cryptolepis buchanani R. & S.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs

Species	Habitat	Distribution
Cuminum cyminum (L.)	Cultivated	Coimbatore FD
Curculigo orchioides Gaertn.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Curcuma aromatica Sal.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Curcuma longa L.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Cyclea peltata (Lam.) Hook.f. & Thoms.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Cyclea peltata (Lam.) Hook.f. & Thoms.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Cymbidium aloifolium Hk.f.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Cymbopogon citratus Stapf.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Dalbergia latifolia W.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Desmodium triflorum DC.	Dry deciduous	Coimbatore FD
Desmodium velutinum (Willd.) DC.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Diospyros montana Roxb.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Diospyros montana Roxb.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Dodonaea viscosa L.	Dry deciduous	Coimbatore FD
Dracena terniflora	Dry deciduous	Attappady Rf
Elephantopus scaber L.	Moist deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Erythroxylum monogynum Roxb.	Dry deciduous	Coimbatore FD
Euphorbia rothiana Spr.	Evergreen	Coimbatore FD
Evolvulus alsinoides L.	Dry deciduous	Coimbatore FD
Fagraea obovata Wall.	Evergreen	Coimbatore FD
Feronia elephantum Corr.	Dry deciduous	Coimbatore FD
Ficus racemosa L.f.	Dry deciduous	Coimbatore FD
Givotia rottleriformis Griff.	Dry deciduous	Coimbatore FD
Glinus lotoides(L.) Ktze.	Riverine	Coimbatore FD
Glycosmis arborea (Roxb.) DC.	Riverine	Coimbatore FD,
Gymnema sylvestre R.Br.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Gynandropsis pentaphylla	Dry deciduous	Coimbatore FD
Helicteres isora L.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Helicteres isora L.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Heliotropium indicum L.	Dry deciduous	Coimbatore FD

Species	Habitat	Distribution
Hemidesmus indicus (L.) R.Br.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Hibiscus ovalifolius (Forsk.) Vahl.	Dry deciduous	Coimbatore FD
Holoptela integrifolia Pl.	Dry deciduous	Coimbatore FD
Hugonia mystax L.	Dry deciduous	Coimbatore FD
Hybanthus ennaespermus (L) F.V. Muell.	Dry deciduous	Coimbatore FD
Ipomoea staphylina Roem. & Schult.	Dry deciduous	Coimbatore FD
Jasminum rottlerianum Wall. ex. DC.	Dry deciduous	Attappady Rf
Jatropha curcas L.	Dry deciduous	Coimbatore FD
Justicia adhatoda L.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Kalanchoe pinnata (Lamk.) Pers.	Dry deciduous	Coimbatore FD
Lagerstroemia microcarpa Wt.	Moist deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Lannea coromandelica (Houtt.)Merr.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Lantana wightiana	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Malvastrum coromandelianum (L.) Garcke	Dry deciduous	Coimbatore FD
Mangifera indica L.	Cultivated	Coimbatore FD
Mitragyna parvifolia Korth.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Myrstica dactyloides	Evergreen	Coimbatore FD
Naringi crenulata (Roxb.) Nicol.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Notonia grandiflora DC.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Ocimum gratissimum L.	Dry deciduous	Coimbatore FD
Oldenlandia umbellata L.	Dry deciduous	Coimbatore FD
Oxalis corniculata L.	Dry deciduous	Coimbatore FD
Passiflora foetida L.	Dry deciduous	Coimbatore FD
Peperomia tetraphylla (Forst.f.)Hk. & Arn.	Evergreen	Coimbatore FD
Phyllanthus amarus Schum. & Thann.	Dry deciduous	Coimbatore FD
Phyllanthus emblica L.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Phyllanthus virgatus Forst.	Dry deciduous	Coimbatore FD
Piper longum L.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Plumbago zeylanica L.	Dry deciduous	Coimbatore FD
Polygonum barbatum L.	Riverine	Coimbatore FD

Species	Habitat	Distribution
Pouzolzia auriculata W.	Dry deciduous	Coimbatore FD
Premna latifolia var. viburnoides Clarke.	Dry deciduous	Coimbatore FD
Priva cordifolia	Dry deciduous	Coimbatore FD
Pterocarpus marsupium Roxb.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Pterocarpus marsupium Roxb.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Rauvolfia serpentina L.	Moist deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Rauvolfia serpentina L.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Rotula aquatica	Riverine	Coimbatore FD
Schleichera oleosa (Lour.) Oken	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Schrebera swietenioides Roxb.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Scoparia dulcis L.	Riverine	Coimbatore FD
Sida acuta Burm.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Sida rhomboidea Roxb.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Solanum nigrum L.	Riverine	Coimbatore FD
Streblus asper Lour.	Riverine	Coimbatore FD
Strychnos nux-vomica L.	Riverine	Coimbatore FD
Tamilnadia uliginosa	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Tectona grandis L.f.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Terminalia chebula Retz.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Terminalia chebula Retz.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Thespesia lampas (Cav.) Dalz. & Gibs.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Tribulus terrestris L.	Dry deciduous	Coimbatore FD
Trichodesma zeylanicum (Burm.f.) R.Br.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs
Vanda tessellata (Roxb.) HK. f. ex. Don.	Dry deciduous	Wayand WLS, Bandipur NP and Mudumalai WLs

Appendix.IV. Secondary metabolites isolated from the select medicinal plants								
Species name	Part screened	Phytoconstituents						
		Steroids	Alkaloids	Phenolic compounds	Flavonoids	Saponins	Triterpenoids	Tannins
Present study								
Acalypha fruticosa	Leaves	++	+	+	–	++	–	-
Callicarpa tomentosa	Leaves	++	+	+++	+	+	-	+
Caesalpinia mimosoides	Leaves	++	+	+++	+	+	-	-
Vanilla walkeriae	Stem	++	+	+	+	-	-	-
Previous works								
Acalypha indica	Leaves and Aerial parts	Acalyphamide, Tri-O-methylellagic acid 2 methylanthraquinone, Succinimide β-sitosterol,Aurantiamide, Acalyphin, Cyanoglucoside, β-sitosterol						
Acalphya australis	–	Gallic acid, Caffeic acid, Rutin, Isoquercitrin, Corilagin, Furaosin and Geranin (Phenolic compounds)						
Callicarpa arborea	Leaves and Heart wood	Maslinic, Oleanolic & Ursolic acids, lupeole acetate, β-amyrin & β-Sitosterol acetate β-sitosterol & Oleanolic acid						
Callicarpa longifolia	Leaves	Calliterpenone & Ursolic acid						
Callicarpa macrophylla	Leaves	Luteolin, Apigenin, Luteolin-7-O-glucuronide Apigenin-7-O-glucuronide Flavone						
Callicarpa bodinieri & *Callicarpa purpurea*	——	Cyanidin, Paeonidin & Petunidine anthocyanin aglycones						
Caesalpinia bonduc	Seeds	Caesalpin						
Caesalpinia pulcherrima	Bark Flowers Young plant	Caesalpin, β-sitosterol, Scbacic acid, quercimeritin & leucodelphinidin Cyanin, lupeol, gallic acid, quercetin, rutin Gallic acid, leucodelphinidin, Tannin , Tannin C.						
Caesalpinia sappan	Heart wood	β-amyrin glucoside						
Vanilla planifolia	Bean	Vanillin (4-hydroxy-3-methoxybenzaldehyde) & p-hydroxybenzaldehyde, vanillic acid						

Appendix V Abundance, density, basal area and IVI of trees in the moist deciduous forests

Species	Abundance	Density[1]	Basal area[2]	IVI[3]
Medicinal trees				
Anogeissus latifolia	6.94	56	2766	27.17
Bauhinia racemosa	1.25	3	86.9	2.41
Bridelia retusa	2.57	9	647.1	6.7
Buchanania axillaris	2	1	72.8	0.83
Careya arborea	1	2	10.2	1.57
Cassia fistula	1.8	9	189.5	6.61
Dalbergia latifolia	1.47	11	623.3	10.25
Gmelina arborea	1.4	4	333.5	3.72
Kydia calycina	7.07	50	1522.4	21.52
Lagerstroemia microcarpa	1.63	7	1016.8	7.51
Lagerstroemia parviflora	2	2	28.3	1.35
Lannea coromandelica	2.25	5	243.4	3.31
Mitragyna parvifolia	1.5	2	111.7	1.46
Phyllanthus emblica	2.75	17	426.9	9.83
Pterocarpus marsupium	1.25	8	1268.4	10.02
Radermachera xylocarpa	1.4	4	168.3	3.27
Randia dumetorum	3	12	402.4	7.12
Schleichera oleosa	1.8	5	2178.6	9.06
Schrebera swietenioides	2.2	6	313	4.15
Semecarpus anacardium	2.5	8	405	5.27
Shorea roxburghii	1	1	1.6	0.51
Syzygium cumini	3	2	248.4	1.44
Tectona grandis	3.75	30	7345.7	33.75
Terminalia bellirica	1.3	7	1398	9.35
Terminalia chebula	1	1	90.9	1.28
Terminalia paniculata	6	3	403	2.22
Other trees				
Albizia odoratissima	1	1	223.8	1.65
Casearia esculenta	1	1	6.1	1.05
Chionanthes mala-elengi	8	12	180.7	4.54
Chukrasia tabularis	1	1	41.3	1.14
Eriolaena quinquelocularis	1.2	3	197.6	3.24
Ficus sp.	1	1	124.6	0.85
Grewia tiliifolia	2.44	20	1910.7	16.23
Haldina cordifolia	2	1	13.4	0.67
Hydnocarpus pentandra	1	1	2.3	0.52
Mallotus tetracoccus	2	1	23.5	0.69
Olea dioica	6.25	25	1071.9	12.07
Pterygota alata	1.5	2	36.5	1.25
Sterculia villosa	1	1	30.1	0.59
Stereospermum colais	1	1	0.9	0.51
Terminalia crenulata	8.68	83	8918	51.8
Terminalia tomentosa	2.5	5	809.9	5
Trewia polycarpa	4	2	45.6	1
Unknown (Ana)	1	1	140.6	0.9
Unknown (Kavanai)	2	1	13.9	0.67
Unknown (Senbagam)	1	1	20.9	1.09

Unknown (Yenichi)	1	1	4.1	0.52
Unknown1	1	1	5.8	1.05
Vitex altissima	1	1	50.8	0.65
Total (50 species)		**432**	**36174.6**	**300**
Shannon-Weiner species diversity Index	2.95			

Density[1] denotes the number of individuals per ha; Basal area[2] in cm²/ha.; IVI[3]-Importance Value Index

Appendix VI. Frequency, abundance, density and IVI of shrubs in the moist deciduous forests

Species	Frequency	Abundance	Density[1]	IVI
Medicinal shrubs				
Argyreia cuneata	3	2.33	0.1	1.9
Asparagus racemosus	5	2.8	0.2	3.4
Chromolaena odorata	22	3	0.8	15.3
Clerodendrum serratum	3	1	0	1.6
Flemingia strobilifera	19	6.16	1.5	17.7
Gloriosa superba	2	2	0.1	1.2
Glycosmis arborea	8	24.63	2.5	18.5
Gomphostemma heyneanum	5	5.6	0.4	4.5
Grewia hirsuta	3	1.33	0.1	1.7
Helicteres isora	24	4.13	1.2	18.7
Lantana camara	13	6.62	1.1	12.6
Naravelia zeylanica	12	1.58	0.2	7.1
Solanum anguivi	1	14	0.2	1.5
Other shrubs				
Acacia sp.	2	2.5	0.1	1.3
Imperata cylindrica	3	18	0.7	5.5
Jasminum sp.	10	3.4	0.4	7.3
Leea indica	34	11.5	4.9	45.3
Solanum torvum	2	6.5	0.2	1.9
Sophora velutina	30	5.17	1.9	25.7
Zizyphus rugosa	11	2.45	0.3	7.2
Total (20 species)			**16.7**	**200**
Shannon-Weiner diversity	2.31			

Density[1] denotes the number of individuals per 25m²; IVI-Importance Value Index

Appendix VII. Frequency, abundance, density and IVI of herbs in the moist deciduous forests

Species	Frequency	Abundance	Density[1]	IVI
Medicinal herbs				
Adiantum lunulatum	3	2.67	0.03	0.3
Ageratum conyzoides	37	2.73	0.32	4.3
Alternanthera sessilis	1	1	0.003	0.1
Andrographis neesiana	2	2	0.01	0.2
Andrographis serpyllifolia	4	1.75	0.02	0.4
Biophytum sensitivum	49	4.49	0.69	7.2
Cassia occidentalis	3	2.67	0.03	0.3
Centella asiatica	2	1	0.01	0.2
Costus speciosus	7	1.86	0.04	0.7
Curculigo orchioides	84	4.05	1.06	11.7
Curcuma aromatica	7	3.43	0.08	0.9
Curcuma longa	46	4.17	0.60	6.5
Curcuma pseudomontana	73	3.48	0.79	9.4
Cyclea peltata	14	1.79	0.08	1.4
Desmodium triflorum	17	1.94	0.10	1.7
Desmodium velutinum	12	2.5	0.09	1.3
Dioscorea pentaphylla	1	3	0.01	0.1
Elephantopus scaber	56	5.91	1.03	9.6
Gynura nitida	13	2.38	0.10	1.4
Hemidesmus indicus	8	2.38	0.06	0.9
Mimosa pudica	17	3.94	0.21	2.3
Nervilia aragoana	34	2.38	0.25	3.7
Oxalis corniculata	1	2	0.01	0.1
Phyllanthus virgatus	1	1	0.003	0.1
Pimpinella monoica	15	1.67	0.08	1.5
Rauwolfia serpentina	11	1.45	0.05	1
Sida acuta	41	1.9	0.24	4.2
Sida rhombifolia	21	2.19	0.14	2.2
Thespesia lampas	17	2.12	0.11	1.8
Urena lobata	17	1.29	0.07	1.5
Other herbs				
Aeginetia indica	3	1.67	0.02	0.3
Chlorophytum laxum	4	2.25	0.03	0.4
Chlorophytum sp.	88	5.88	1.62	15.1
Chlorophytum tuberosum	12	2.5	0.09	1.3
Cissus sp.	3	1.33	0.01	0.3
Commelina sp.	18	1.5	0.08	1.7
Cyanotis cristata	35	2.17	0.24	3.7
Cymbopogon flexuosus	5	7.4	0.12	1
Cyperus rotundus	9	2.33	0.07	1
Decaschistia crotonifolia	34	4.38	0.47	4.9
Desmodium motorium	44	3.45	0.48	5.7
Desmodium triquetrum	10	3.3	0.10	1.3

Dioscorea tomentosa	4	2	0.03	0.4
Dioscorea wallichi	31	2.45	0.24	3.4
Eragrostilla sp.	9	2.22	0.06	1
Glinus oppositifolius	3	1	0.01	0.3
Globba bulbifera	95	6.41	1.90	17.2
Hedyotis sp.	6	2.33	0.04	0.7
Ipomoea sp.	16	1.31	0.07	1.5
Justicia japonica	1	1	0.003	0.1
Justicia sp.	1	1	0.003	0.1
Knoxia mollis	15	2	0.09	1.6
Kyllingia memoralis	2	4	0.03	0.3
Leucas ciliata	5	5.4	0.08	0.8
Mariscus pictus	1	1	0.003	0.1
Murdannia nudiflora	14	1.93	0.08	1.4
Opilismenus compositus	16	4.25	0.21	2.3
Orthosiphon thymiflorus	2	2	0.01	0.2
Panicum sp.	5	2.4	0.04	0.6
Piper longum	1	2	0.01	0.1
Pogostemon paniculatus	9	7.11	0.20	1.7
Pteris pellucida	65	7.68	1.56	13.2
Selaginella sp.	9	4.78	0.13	1.4
Sida alnifolia	11	1.45	0.05	1
Smilax perfoliata	13	3.69	0.15	1.7
Spermacoce mauritiana	11	1.55	0.05	1.1
Spilanthes acmella	3	3.67	0.03	0.4
Synedrella nodiflora	30	4.5	0.42	4.4
Themeda triandra	61	6.1	1.16	10.7
Thunbergia alata	52	3.38	0.55	6.6
Trichosanthes sp.	2	1.5	0.01	0.2
Triumfetta rotuntifolia	101	2.62	0.83	11.5
Unknown1	3	1.33	0.01	0.3
Total (73 species)			17.7	200
Shannon-Weiner species diversity Index	3.38			

Density[1] denotes the number of individuals per 1m^2; IVI-Importance Value Index

Appendix VIII. Regeneration of seedlings and saplings in the moist deciduous forests

Species	Density/ha.			
	Mature trees	Seedlings	Saplings	Ratio*
Medicinal plants				
Anogeissus latifolia	55	15	45	1:1
Bauhinia racemosa	2.5	70	-	1:28
Bridelia retusa	9	20	15	1:4
Buchanania axillaris	1	-	-	1:0
Careya arborea	1.5	30	-	1:20
Cassia fistula	9	135	170	1:34
Dalbergia latifolia	11	220	60	1:26
Gmelina arborea	3.5	5	-	1:1
Kydia calycina	49	475	135	1:12
Lagerstroemia microcarpa	6.5	40	-	1:6
Lagerstroemia parviflora	2	-	-	1:0
Lannea coromandelica	4.5	0	15	1:3
Mitragyna parvifolia	1.5	-	-	1:0
Naringi crenulata	-	40	125	0:165
Phyllanthus emblica	16	80	30	1:7
Pterocarpus marsupium	7.5	60	85	1:19
Radermachera xylocarpa	3.5	-	20	1:6
Randia dumetorum	12	510	360	1:73
Schleichera oleosa	4.5	45	40	1:19
Schrebera swietenioides	5.5	-	-	1:0
Semecarpus anacardium	7.5	-	-	1:0
Shorea roxburghii	1	10	20	1:30
Syzygium cumini	1.5	-	75	1:50
Tamilnadia uliginosa	-	5	-	0:5
Tectona grandis	30	15	65	1:3
Terminalia bellirica	6.5	10	15	1:4
Terminalia chebula	1	-	-	1:0
Terminalia paniculata	3	-	-	1:0
Other plants				
Albizzia odorarttissima	1	-	-	1:0
Acacia sp	-	5	-	0:5
Casearia esculenta	1	10	-	1:10
Chionanthes mala-elengi	12	5	60	1:5
Chukrasia tabularis	1	-	15	1:15
Eriolaena quinquelocularis	3	125	10	1:45
Ficus sp	1	-	-	1:0
Grewia tiliifolia	20	265	95	1:18
Haldinia cordifolia	1	-	-	1:0
Hydnocarpus pentandra	1	-	-	1:0
Mallotus tetracoccus	1	-	-	1:0
Olea dioica	25	70	195	1:10
Perygota alata	1	-	-	1:0

Sterculia villosa	1	260	-	1:260
Stereospermum colais	1	-	-	1:0
Terminalia crenulata	83	40	125	1:2
Terminalia tomentosa	5	-	-	1:0
Toona ciliata	-	10		0:10
Trewia polycarpa	2	-	-	2:0
Vitex altissima	1	-	-	1:0
Zizyphus xylopyrus	-	210	85	0:295
Unidentified (5species)	5	-	5	1:1
Total	420	2785	1865	1:11
Species diversity index (H')	2.95	2.80	2.72	

*Ratio between the number of mature trees to number of seedlings and saplings

Appendix IX Frequency, abundance, density, basal area and IVI of medicinal trees in dry deciduous forests at th Bandipur National Park and at the Wayanad Wildlife Sanctuary

Species	Bandipur National Park					Wayanad Wildlife Sanctuary				
	Frequency	Abundance	Density	Basal area	IVI	Frequency	Abundance	Density	Basal area	IVI
Medicinal trees										
Anogeissus latifolia	20	16.1	16.1	5600	59	20	18	18.5	5172	67
Bauhinia racemosa	3	1.0	0.15	36	2	2	2.6	0.3	31	2
Bridelia retusa	3	1.3	0.2	31	2	4	1	0.2	65	3
Buchanania axillaris	6	1.0	0.3	170	4	1	1	0.1	8	1
Careya arborea	5	1.6	0.4	45	3	2	1	0.1	10	1
Cassia fistula	2	2.0	0.2	25	1	8	1.6	0.7	105	6
Dalbergia latifolia	9	2.1	0.95	943	9	15	1.9	1.5	996	14
Ficus religiosa	-	-	-	-	-	1	1	0.1	57	1
Gmelina arborea	1	1.0	0.05	4	1	1	2	0.1	7	1
Kydia calycina	15	8.9	6.65	1168	23	5	3.4	0.9	572	6
Lagerstroemia microcarpa	3	3.7	0.55	618	5	-	-	-	-	-
Lagerstroemia parviflora	16	3.1	2.5	341	13	8	3.5	1.4	363	8
Lannea coromandelica	2	4.0	0.4	204	2	12	1.5	0.9	305	9
Phyllanthus emblica	18	3.3	2.95	839	16	14	3.4	2.4	704	14
Pterocarpus marsupium	13	1.4	0.9	1225	12	11	1.7	1.0	1556	13
Radermachera xylocarpa	1	1.0	0.05	37	1	-	-	-	-	-
Randia dumetorum	2	1.5	0.15	16	1	3	1	0.2	25	2
Schleichera oleosa	2	1.0	0.1	158	2	-	-	-	-	-
Schrebera swietenioides	15	3.5	2.65	1160	15	7	1.6	0.6	243	6
Semecarpus anacardium	2	1.0	0.1	102	1	1	1	0.1	46	1
Shorea roxburghii	3	1.0	0.15	45	2	4	2.3	0.5	553	5
Tamilnadia uliginosa	3	2.0	0.3	40	2	4	1.5	0.3	20	3
Tectona grandis	19	4.2	3.95	6402	39	19	5.8	5.5	6462	43
Terminalia bellirica	2	1.0	0.1	730	4	3	1	0.2	79	2
Terminalia chebula	5	1.6	0.4	227	4	2	1	0.1	101	2
Terminalia paniculata	7	2.1	0.75	217	5	4	2.3	0.5	192	4
Other trees										**86**
Antidesma sp	1	1.0	0.05	3	1	-	-	-	-	-
Bombax malabaricum	-	-	-	-	-	1	1.0	0.05	141	1
Butea monosperma	1	3.0	0.15	171	1	1	7.0	0.35	79	2
Casearia esculaenta	2	1.0	0.10	27	1	1	1.0	0.05	3	1
Chukrasia tabularis	-	-	-	-	-	1	1.0	0.05	177	1
Cordia domestica	2	1.5	0.15	14	1	2	1.5	0.15	81	2
Diospyros melanoxylon	2	1.5	0.15	23	1	4	1.3	0.25	94	3
Eriolaena quinquelocularis	5	1.4	0.35	92	3	1	1.0	0.05	7	1
Grewia tiliaefolia	14	1.9	1.35	1159	13	6	3.3	1.00	963	9
Haldinia cordifolia	2	2.0	0.20	40	1	2	1.5	0.15	87	2
Mitragyna parviflora	1	1.0	0.05	11	1	-	-	-	-	-
Stereospermum personatum	1	1.0	0.05	93	1	-	-	-	-	-
Terminalia crenulata	20	9.4	9.40	5453	46	20	11.3	11.30	7912	62
Unidentified	1	1.0	0.05	5	1	1	3.0	0.15	13	1

Zizyphus xylopyrus	1.5	0.55	192	5	1.0	0.05	18	1
Total	38 species	53.6	27662	300	35 species	49	27248	300
Shannon-Weiner species diversity index	2.40					2.12		

Density[1] denotes the number of individuals per 0.1ha.; Basal area cm^2/2ha.; IVI- Importance Value Index;

Appendix X Frequency, abundance, density and IVI of medicinal shrubs in a dry deciduous forests at the Bandipur National Park and at the Wayanad Wildlife Sanctuary

Shrub species	Bandipur National Park			Wayanad Wildlife Sanctuary		
	Frequency	Abundance	Density[1]	Frequency	Abundance	Density[1]
Medicinal shrubs						
Acacia sinuata	-	-	-	1	3	0.04
Argyreia cuneata	31	1.9	0.75	-	-	-
Asparagus racemosus	6	8.7	0.65	7	1.3	0.11
Chromolaena odorata	25	7.0	2.19	37	2	0.93
Cipadessa baccifera	-	-	-	3	4.7	0.18
Clerodendrum serratum	1	1.0	0.01	10	1.7	0.21
Flemingia strobilifera	9	4.7	0.53	13	3.8	0.61
Gomphostemma heyneanum	4	2.0	0.10	2	1.5	0.03
Grewia hirsuta	16	2.8	0.56	29	3.6	1.30
Helicteres isora	2	5.0	0.13	6	4.3	0.32
Lantana camara	-	-	-	7	1.3	0.11
Leea indica	65	12.1	9.85	73	11.4	10.41
Other Shrubs						
Cymbopogon sp	49	5.53	3.39	-	-	-
Decaschistia crotonifolia	34	2.38	1.01	-	-	-
Desmodium pulcellum	9	3.00	0.34	-	-	-
Heteropogon contortus	-	-	-	20	2.7	0.68
Imperata cylindrica	16	11.13	2.23	15	3.7	0.69
Pavetta tomentosa	-	-	-	10	2.7	0.34
Sophora velutina	20	2.15	0.54	12	6.1	0.91
Themeda cymbaria	53	8.49	5.63	8	3.8	0.38
Zizyphus rugosa	-	-	-	26	3.0	0.99
Total	15 species		27.88	17 species		18.23
Shannon-weiner diversity index			2.00			1.74

Density denotes the number of individuals per $25m^2$; IVI - Importance Value Index

Appendix XI Density and IVI of herbs in the dry deciduous forests

species	Bandipur National Park			Wayand WLs		
	abund	dens	ivi	abund	dens	ivi
Adiantum lunulatum	2.67	0.025	0.55	2	0.0063	0.18
Aeginetia indica	1.67	0.016	0.4	2	0.0125	0.29
Ageratum conyzoides	2.73	0.316	6.03	4.32	0.5000	8.66
Alternanthera sessilis	1	0.003	0.12	-	-	-
Andrographis neesiana	4.17	0.078	1.05	1.5	0.0094	0.28
Andrographis serpyllifolia	3.33	0.156	2.51	2.2	0.0344	0.87
Apluda mutica	-	-	-	2	0.0063	0.18
Arisaema tortuosum	-	-	-	1.33	.0125	0.42
Biophytum sensitivum	4.35	0.666	9.88	2.2	0.034	0.82
Blumea membranacea	-	-	-	1	.003	.13
Cassia occidentalis	2.67	0.025	0.55	1.83	.34	1
Centella asiatica	1	0.006	0.21	-	-	-
Chlorophytum laxum	2.25	0.028	0.65	3	.0469	.99
Chlorophytum sp.	5.5	1.616	21.4	-	-	-
Chlorophytum tuberosum	2.5	0.094	1.92	3	0.046	0.92
Cissus sp.	1.33	0.013	0.36	1	0.009	0.34
Commelina sp.	1.5	0.084	2.23	1.2-	.018-	0.67
Cissampelos pareira		-	-	1	.0031	0.13
Costus speciosus	1.86	0.041	0.99	-	-	-
Curculigo orchioides	4.05	1.063	18.2	1.2	0.0188	0.67
Curcuma aromatica	3	0.075	1.5	4.08	2.5625	49.59
Curcuma longa	4.17	0.6	10.3	3.25	0.8531	18.13
Curcuma pseudomontana	3.43	0.794	15.7	4.39	1.1938	22.69
Cyanotis cristata	2.17	0.238	5.22	3.25	0.0406	0.91
Cyclea peltata	2.5	0.109	2.17	1.97	0.775	20.28
Cymbopogon flexuosus	7.4	0.116	1.4	1.42	0.0531	1.71
Cyperus rotundus	2.33	0.066	1.28	1	0.0094	0.36
Decaschistia crotonifolia	4.38	0.466	7.33	1.67	0.0313	0.84
Desmodium motorium	3.38	0.475	8.08	5.06	0.2844	4.56
Desmodium triflorum	1.94	0.103	2.33	4.56	0.1281	2.12
Desmodium triquetrum	3.3	0.103	1.97	3	0.0844	1.74
Desmodium velutinum	4.58	0.172	2.27	1.74	0.1031	2.93
Dioscorea pentaphylla	3	0.009	0.15	2.44	0.0688	1.82
Dioscorea tomentosa	1.6	0.025	0.66	1.72	0.0969	2.75
Dioscorea wallichi	2.45	0.238	4.78	2.84	0.3906	9.44
Elephantopus scaber	5.61	1.034	14.6	2.69	0.5969	13.43
Eragrostilla sp.	2.22	0.063	1.4	1.23	0.05	1.63
Glinus oppositifolius	1	0.009	0.3	1.45	0.05	1.56
Globba bulbifera	5.49	1.903	27	3	0.0094	0.18
Gynura nitida	2.38	0.097	1.9	2.75	0.9125	20.97
Hedyotis sp.	2.33	0.044	0.98	1.5	0.0094	0.27
Hemidesmus indicus	4	0.138	1.98	7.13	0.1781	2.57
Ipomoea sp.	1.31	0.066	2.41	5.71	0.25	4.18

Justicia japonica	1	0.003	0.11	4.64	0.2031	3.46
Justicia sp.	1	0.003	0.12	3.9	0.5	8.92
Knoxia mollis	2	0.094	2.33	2.6	0.0406	0.83
Kyllingia memoralis	4	0.025	0.54	2.5	0.0156	0.42
Leucas ciliata	5.4	0.084	1.17	4.5	0.0281	0.45
Mariscus pictus	1	0.003	0.11	2.2	0.0344	1.52
Mimosa pudica	3.94	0.209	3.77	2	0.0063	0.18
Murdannia nudiflora	1.93	0.084	2	1.2	0.0188	0.59
Nervilia aragoana	4.25	0.319	4.56	3.11	1.0094	20.71
Nervilia plicata	1.7	0.053	1.33	1	0.0031	0.11
Opilismenus compositus	4.25	0.213	4.55	2.87	0.1344	2.65
Orthosiphon thymiflorus	2	0.013	0.32	3.18	0.3781	7.48
Oxalis corniculata	2	0.006	0.19	6.26	0.8406	12.61
Panicum sp.	2.4	0.038	0.75	1	0.0063	0.22
Phyllanthus virgatus	1	0.003	0.11	1	0.0219	0.88
Pimpinella monoica	1.67	0.078	2.01	3	0.0094	0.21
Piper longum	2	0.006	0.13	1.54	0.125	3.92
Pogostemon paniculatus	7.11	0.2	2.81	2.47	0.4781	11.32
Pteris pellucida	7.68	1.559	19	5.78	0.1625	2.4
Rauwolfia serpentina	2.09	0.072	1.63	1.47	0.0781	2.81
Selaginella sp.	4.78	0.134	2.4	2.17	0.6656	16.37
Sida acuta	1.9	0.244	5.64	3.71	0.0813	1.4
Sida alnifolia	1.45	0.05	1.53	1	0.0031	0.13
Sida rhombifolia	2.19	0.144	3.28	5.78	0.1625	2.4
Smilax perfoliata	3.69	0.15	2.59	1.47	0.0781	2.81
Spermacoce mauritiana	1.55	0.053	1.4	2.17	0.6656	16.37
Spilanthes acmella	3.67	0.034	0.62	3.71	0.0813	1.4
Synedrella nodiflora	4.35	0.422	6.65	1	0.0031	0.13
Themeda triandra	6	1.163	15.1	1	0.0219	0.88
Thespesia lampas	2.12	0.113	2.64	3	0.0094	0.21
Thunbergia alata	3.26	0.55	9.16	1.54	0.125	3.92
Trichosanthes sp.	1.5	0.009	0.24	2.47	0.4781	11.32
Triumfetta rotuntifolia	2.57	0.828	16	5.78	0.1625	2.4
Unidentified	1.33	0.013	0.34	1.47	0.0781	2.81
Urena lobata	1.29	0.069	2.06	2.17	0.6656	16.37
Total		18.3	300		14.8	300

Appendix XII. Regeneration status of medicinal tree at the Bandipur National Park and at the Wayanad Wildlife Sanctuary in dry deciduous forests

Species	Bandipur National Park				Wayanad Wildlife Sanctuary			
	Mature trees	Seedlings	Saplings	Ratio	Mature trees	Seedlings	Saplings	Ratio
Anogeissus latifolia	161	160	45	1:1	185	120	95	1:1
Bauhinia racemosa	1.5	-	-	1:0	2.5	-	35	1:14
Bridelia retusa	2	135	15	1:75	2	-	-	2:0
Buchanania axillaris	3	-	-	3:0	1	-	5	1:5
Careya arborea	4	10	-	1:2	1	-	-	1:0
Cassia fistula	2	80	30	1:55	6.5	45	10	1:8
Dalbergia latifolia	9.5	205	50	1:27	14.5	270	200	1:32
Gmelina arborea	1	-	-	1:0	1	-	-	1:0
Kydia calycina	66.5	585	205	1:12	8.5	295	90	1:45
Lagerstroemia microcarpa	5.5	-	-	6:0	-	-	-	-
Lagerstroemia parviflora	25	30	10	1:2	14	-	-	14:0
Lannea coromandelica	4	-	-	4:0	9	-	5	1:2
Phyllanthus emblica	29	490	105	1:21	24	115	40	1:6
Pterocarpus marsupium	9	135	55	1:21	9.5	115	25	1:15
Radermachera xylocarpa	0.5	10	-	1:20	-	-	-	-
Randia dumetorum	1.5	65	-	1:43	1.5	145	85	1:153
Schleichera oleosa	1	-	-	1:0	-	-	-	-
Schrebera swietenioides	26.5	40	-	1:2	5.5	-	-	6:0
Semecarpus anacardium	1	10	5	1:15	1	-	-	1:0
Shorea roxburghii	1.5	560	280	1:560	4.5	195	150	1:77
Tamilnadia uliginosa	3	175	20	1:65	3	-	-	3:0
Tectona grandis	39	30	115	1:4	55	85	40	1:2
Terminalia bellirica	1	-	-	1:0	1.5	-	5	1:3
Terminalia chebula	4	20	-	1:5	1	-	-	1:0
Terminalia paniculata	7.5	75	50	1:17	4.5	15	40	1:12
Total	410	2815	985	1:9	356	1400	825	1:6
Shannon-Weiner diversity		2.69	2.53			2.54	2.67	

Ratio between the number of mature tree and number of seedlings and saplings; Values are density per ha.

Appendix XIII. Frequency, abundance, density, basal area and IVI of trees in the riverine forests

Species	Coimbatore FD				Attappady RF			
	Abundance	Density	Basal Area	IVI	Abundance	Density	Basal Area	IVI
Medicinal Trees								
Alstonia scholaris	-	-	-	-	1	1	66	8
Bambusa arundinacea	-	-	-	-	3	1.5	19	4
Crataeva magna	3	4.5	265	7	8	67.5	276	89
Cycas circinalis	2	5	120	9	-	-	-	-
Diospyros peregrina	3	4.5	2414	28	-	-	-	-
Ficus benghalensis	1	1	497	4	-	-	-	-
Ficus racemosa	1	4	755	11	2	1	4	2
Madhuca longifolia	2	6.5	2527	22	-	-	-	-
Mallotus phillipensis	1	0.5	10	1	-	-	-	-
Mangifera indica	1	8	4065	33	1	1.5	103	12
Murraya paniculata	1	1	328	4	-	-	-	-
Pongamia pinnata	4	31	3039	52	8	69.5	182	84
Pterocarpus marsupium	1	1	272	4	-	-	-	-
Strebulus asper	1	0.5	8	1	1	2.5	17	9
Strychnos nux-vomica	2	8.5	268	15	-	-	-	-
Syzygium cumini	2	11	2444	29	2	2	110	12
Terminalia arjuna	1	9	6721	47	3	1.5	2.03	3
Other trees								
Ficus microcarpa	2	1.5	134	3	-	-	-	-
Ficus sp.	1	1.0	12	2	-	-	-	-
Ficus glomerata	-	-	-	-	2	2.5	729	53
Hydnocarpus laurifolia	2	2.5	149	5	-	-	-	-
Manilkara roxburghii	1	1.0	96	3	-	-	-	-
Olea dioca	1	0.5	16	1	-	-	-	-
Salix tetrasperma	2	5.5	177	9	4	7	56	14
Trewia polycarpa	1	0.5	13	1	2	3	12	9
Unidentified species	2	4.0	382	9	-	-	-	-
Total species	23 Species				12 Species			
Species diversity (H')	2.57				1.32			

Appendix XIV Phytosocological analysis of shrubs in the riverine forests

Species	Coimbatore FD				Attappady Rf			
	Frequency	Abundance	Density	IVI	Frequency	Abundance	Density	IVI
Medicinal shrubs								
Acalypha fruiticosa	3	2	0.10	4	-	-	-	-
Chromolaena odorata	10	9	1.48	28	5	1	8.90	4
Colocasia esculenta	-	-	-	-	4	4	0.23	5
Crotalaria verrucosa	2	5	0.15	4	-	2	4.50	5
Glycosmis arborea	8	9	1.18	29	15	5	8.88	20
Homonoia riparia	22	5	1.82	51	41	20	4.95	108
Justicia betonica	-	-	-	-	1	1	0.02	1
Lantana camara	2	1	0.03	2	-	-	-	-
Ludwigia octovalvis	15	4	0.95	29	20	4	3.80	24
Polygonum barbatum	8	3	0.40	15	45	7	3.00	66
Ricinus communis	2	5	0.15	4	5	2	4.50	4
Solanum erianthum	10	2	0.35	16	3	2	2.10	3
Solanum indicum	3	1	0.07	4	1	1	1.33	1
Solanum torvum	13	4	0.78	23	6	3	3.62	6
Toddalia asiatica	1	1	0.02	1	-	-	-	-
Other shrubs*		13 species				6 Species		
Artemisia nilagirica	2	4.50	0.1500	2.93	-	-	-	-
Breynia retusa	6	4	0.42	15	2	1.00	0.0333	1.55
Carmona microphylla	5	3	0.20	10	-	-	-	-
Carrisa carandus	1	3	0.10	2	-	-	-	-
Cassia hirsuta	5	2	0.20	7	-	-	-	-
Equisetum sp	1	6	0.1	3	-	-	-	-
Eupatorium repantum	5	5	0.40	11	-	-	-	-
Ficus heterophylla	4	3	0.2	7	17	3	0.8833	17.52
Ixora pavetta	3	2	0.1	5	-	-	-	-
Kirganellia reticulata	8	3	0.4	15	15	8	2.0667	25.11
Murrya koenigi	1	2	0.0	2	-	-	-	-
Urraria sp.	-	-	-	-	1	1	0.0167	0.96
Vitex leucocephala	4	3	0.2	8	-	-	-	-
Xanthium strumarium	4	2	0.10	6	3	3	0.1667	3.52
Unidentified species	-	-	-	-	3	16.33	0.8167	7.04
Total species		25 species				17 species		
Species diversity (H')		2.66				1.64		

Density[1] denotes the number of individuals per $25m^2$; IVI - Importance Value Index

Appendix XV Frequency, abundance, density and IVI of herbs in the Attappady reserve forest (A) and Coimbatore forest division (C)

Species	Coimbatore FD				Attappady RF			
	Frequency	Abundance	Density	IVI	Frequency	Abundance	Density	IVI
Medicinal herbs								
Achyranthes aspera	1	2	0.02	0.5	3	1	0.04	1.3
Ageratum conyzoides	55	4	2.39	48.7	55	5	2.51	41.2
Alternanthera sessilis	14	3	0.42	10.7	9	2	0.21	5.4
Amaranthus spinosus	8	2	0.12	4.2	14	2	0.24	6.8
Amaranthus viridis	1	1	0.01	0.4	1	4	0.04	0.9
Argemone mexicana	6	2	0.10	3.1	4	1	0.05	1.5
Asclepias curassavica	16	2	0.27	9.0	6	2	0.14	3.5
Bacopa monneri	2	1	0.02	0.9	2	1	0.02	0.7
Cardiospermum halicacabum	1	1	0.01	0.4	1	1	0.01	0.3
Cassia occidentalis	2	2	0.04	1.1	6	3	0.19	3.9
Catharanthus roseus	8	2	0.18	5.6	-	-	-	-
Centella asiatica	3	2	0.06	2.2	-	-	-	-
Chenopodium ambrosoides	9	1	0.12	4.2	-	-	-	-
Desmodium triflorum	1	3	0.03	0.7	1	2	0.02	0.5
Eclipta alba	7	2	0.16	4.2	1	2	0.02	0.4
Euphorbia hirta	11	2	0.21	6.1	10	3	0.27	5.7
Gynura nitida	16	2	0.33	9.4	21	2	0.52	11.7
Heliotropium indicum	2	2	0.03	1.1	13	2	0.25	6.2
Hemidesmus indicus	1	1	0.01	0.4	1	1	0.01	0.3
Hemionitis arifolia	-	-	-	-	2	2	0.04	1.1
Ipomoea staphylina	2	2	0.04	1.4	-	-	-	-
Leucas aspera	4	3	0.13	3.0	-	-	-	-
Mimosa pudica	4	2	0.07	2.0	17	2	0.28	7.6
Oxalis corniculata	16	1	0.23	8.0	10	2	0.17	4.6
Phyllanthus amarus	10	3	0.26	5.9	4	2	0.08	1.8
Polygonum chinense	-	-	-	-	2	1	0.02	0.8
Rotula aquatica	1	1	0.01	0.4	17	3	0.52	11.0
Scoparia dulcis	38	4	1.56	34.8	23	2	0.53	11.7
Sida acuta	3	1	0.04	1.4	9	2	0.20	4.9
Sida cordifolia	2	1	0.02	0.9	-	-	-	-
Sida rhombifolia	4	2	0.06	1.9	6	2	0.11	2.8
Smithia conferta	-	-	-	-	1	1	0.01	0.3
Solanum nigrum	6	2	0.12	3.7	4	2	0.06	1.7
Spermacoc hispida	3	3	0.09	2.1	5	3	0.13	2.7
Spermacoc ocymoides	16	3	0.45	11.0	18	3	0.62	11.9
Sphaeranthus indicus	1	1	0.01	0.4	3	3	0.09	1.9
Trichodesma zeylanicum	-	-	-	-	1	1	0.01	0.3
Tridax procumbense	3	3	0.09	2.4	1	1	0.01	0.3
Urena lobata	-	-	-	-	4	2	0.08	1.9
Other herbs								
Adiantum sp.	-	-	-	-	1	5	0.05	1.1
Ammania baccifera	13	2	0.20	6.9	-	-	-	-
Ammania octandra	1	2	0.02	0.6	1	2	0.02	0.5
Aster sp.	5	2	0.11	2.7	4	1	0.05	1.5
Blumea sp.	1	1	0.01	0.4	-	-	-	-

Species	Coimbatore FD				Attappady RF			
	Frequency	Abundance	Density	IVI	Frequency	Abundance	Density	IVI
Boerhavia chinensis	1	2	0.02	0.6	-	-	-	-
Cissus sp.	-	-	-	-	1	1	0.01	0.3
Commelina benghalensis	1	1	0.01	0.4	4	2	0.06	1.7
Crotalaria sp.	-	-	-	-	2	1	0.02	0.8
Cyperus pangori	-	-	-	-	10	8	0.77	10.6
Cyperus rotundus	19	3	0.62	14.3	36	5	1.93	29.6
Cyperus sp	5	3	0.17	4.3	13	11	1.48	18.2
Drymaria cordata	6	2	0.14	3.9	4	2	0.08	2.1
Eragrostris sp.	1	4	0.04	0.9	-	-	-	-
Euphorbia geniculata	5	1	0.06	2.3	-	-	-	-
Hyptis sp.	-	-	-	-	1	1	0.01	0.4
Lindernia pusilla	9	4	0.37	8.0	9	4	0.34	6.2
Ludwickia hyssofolia	22	2	0.36	11.6	17	2	0.36	8.6
Mariscus pictus	11	6	0.66	11.5	21	5	1.02	16.7
Memordica sp.	-	-	-	-	1	1	0.01	0.3
Mollugo oppositifolia	13	3	0.36	9.2	16	3	0.54	10.6
Mollugo pentaphylla	-	-	-	-	4	2	0.08	1.9
Passiflora edulis	-	-	-	-	1	1	0.01	0.5
Phyllanthus maderaspatensis	4	1	0.04	1.7	1	2	0.02	0.5
Polygonum glabra	7	3	0.24	5.9	2	3	0.06	1.2
Sida cordata	1	1	0.01	0.4	-	-	-	-
Spilanthus calva	15	3	0.43	10.8	27	3	0.79	16.6
Stachytarpheta indica	6	2	0.14	4.3	3	1	0.04	1.1
Stemodia viscosa	1	2	0.02	0.5	-	-	-	-
Synedrella nodiflora	7	2	0.12	3.7	14	2	0.29	7.0
Triumfetta rotundifolia	5	2	0.09	2.8	9	2	0.14	4.1
Vernonia sp.	1	1	0.01	0.4	-	-	-	-
Unidentified species	-	-	-	-	1	1	0.01	0.3
Total	58 Species				58 Species			
Species diversity	3.21				3.15			

Density denotes the number of individuals per $1m^2$; IvI- Importance Value Index;

Appendix . XVI. Regeneration of medicinal plants in the riverine forests (Density/ha).

Species	Attappady Reserve Forest				Coimbatore Forest Division			
	Density/ha				Density/ha			
	Mature trees	Seedlings	Saplings	Ratio	Mature trees	Seedlings	Saplings	Ratio
Alstonia scholaris	1.0	-	-	1:0	-	-	-	-
Bambusa arundinacea	2.0	-	-	1:0	-	-	-	-
Crataeva magna	68.0	30	8	1:0.5	5.0	42	8	1:10
Cycas circinalis	-	-	-	-	5.0	6	1	1:1
Diospyros malabarica	-	-	-	-	13.0	22	5	1:2
Ficus benghalensis	-	-	-	-	1.0	-	-	-
Ficus racemosa	1.0	10	-	1:10	4.0	10	2	1:3
Madhuca longifolia	-	-	-	-	7.0	16	8	1:3
Mallotus philippensis	-	-	-	-	1.0	-	-	1:0
Mangifera indica	2.0	-	-	1:0	8.0	-	-	1:0
Murraya paniculata	-	-	-	-	1.0	12	4	1:16
Pongamia pinnata	69.0	345	70	1:6	31.0	320	180	1:16
Pterocarpus marsupium	-	-	-	-	1.0	-	-	1:0
Streblus asper	3.0	16	4	1:6	1.0	-	-	1:0
Strychnos nux-vomica	-	-	-	-	9.0	-	2	1:0
Syzygium cumini	2.0	12	1	1:7	11.0	70	48	1:11

Ratio* between the number of mature tree and number of seedlings and saplings.

Appendix XVIIFrequency, abundance, density, basal area and IVI of trees in the teak plantation

Species	Frequency	Abundance	Density[1]	Basal area[2]	IVI[3]
Medicinal trees					
Bauhinia racemosa	1	1.0	0.1	5	1.75
Cassia fistula	6	1.2	0.4	36	10.74
Dalbergia latifolia	3	1.3	0.2	103	5.82
Lagerstroemia microcarpa	16	1.7	1.4	1178	34.71
Radermachera xylocarpa	4	1.0	0.2	34	7.08
Randia dumetorum	2	3.0	0.3	27	4.28
Syzygium cumini	2	1.0	0.1	112	3.95
Tectona grandis	20	25.9	25.9	21219	211.27
Other trees					
Butea monosperma	1	3.0	0.2	41	2.25
Casearia esculenta	2	1.0	0.1	11	3.52
Cinnamomum macrocarpum	1	1.0	0.1	111	2.21
Cordia wallichi	2	1.5	0.2	73	3.95
Grewia tiliaefolia	2	2.5	0.3	174	4.73
Olea dioica	2	1.5	0.2	28	3.76
Total (14 species)			29.7	23152	300
Shannon-Wiener diversity index			0.60		

Density[1] denotes the number of individuals per 0.1 ha; Basal area[2] in cm^2/2ha; IVI[3] - Importance Value Index

Appendix XVIII. Frequency, abundance, density and IVI of shrubs in the teak plantations

Species	Frequency	Abundance	Density[1]	IVI
Medicinal shrubs				
Asparagus racemosus	8	2.13	0.21	7.93
Desmodium velutinum	1	1	0.01	0.87
Chromolaena odorata	19	12.05	2.86	36.57
Flemingia strobilifera	3	6.33	0.24	4.18
Glycosmis arborea	9	18.56	2.09	22.84
Gomphostemma heyneanum	1	2	0.03	1.02
Grewia hirsuta	6	2.33	0.18	6.11
Helicteres isora	17	7.47	1.59	25.44
Lantana camara	16	9.69	1.94	27.28
Solanum torvum	4	1.75	0.09	3.85
Solanum erianthum	2	1.5	0.04	1.89
Thespesia lampas	4	12.25	0.61	7.75
Other shrubs				
Cippadessa baccifera	2	11.5	0.29	3.77
Desmodium pulcellum	9	4.78	0.54	11.2
Solanum indicum	8	6	0.6	10.86
Sophora glauca	13	9.08	1.48	21.44
Vernonia indica	3	9.33	0.35	5.01
Zizyphus oenoplia	1	13	0.16	1.99
Total (18 species)			13.3	200
Shannon-Weiner diversity index			2.31	

Density denotes the number of individuals per 25 m^2; IVI-Importance Value Index

Appendix XIX. Frequency, abundance, density and IVI of herbs in the teak plantations

Species	Frequency	Abundance	Density	IVI
Medicinal herbs				
Ageratum conyzoides	84	2.6	0.67	28.26
Anisomelas malabarica	1	1.0	0.00	0.20
Biophytum sensitivum	13	1.4	0.06	2.84
Cassia occidentalis	20	1.3	0.08	4.16
Clematis gouriana	1	1.0	0.00	0.20
Cryptolepsis buchanani	17	1.7	0.09	4.76
Curculigo orchioides	4	1.3	0.02	0.89
Cyclea peltata	49	1.2	0.19	11.19
Dioscorea tomentosa	1	1.0	0.00	0.25
Gynura nitida	38	1.3	0.16	8.71
Hemidesmus indicus	18	1.7	0.10	5.31
Mimosa pudica	115	2.3	0.83	35.56
Naravelia zeylanica	12	1.2	0.04	3.19
Pimpinella monoica	4	1.8	0.02	1.11
Rauwolfia serpentina	3	1.0	0.01	0.57
Sida acuta	48	1.7	0.25	12.14
Sida cordifolia	8	1.4	0.03	1.83
Sida rhomboidea	58	3.0	0.53	19.68
Urena lobata	9	1.9	0.05	2.36
Other herbs				
Adiantum lunulatum	1	2.0	0.01	0.25
Aeginetia indica	3	1.3	0.01	0.60
Commelina sp	2	1.5	0.01	0.44
Curcuma sp	5	1.0	0.02	0.95
Cyanotis cristata	3	1.3	0.01	0.62
Cynoglossom furgatum	1	1.0	0.00	0.20
Cyperus sp	12	2.0	0.08	3.40
Desmodium sp	6	1.2	0.02	1.33
Desmodium triquetrum	3	1.7	0.02	0.74
Dioscorea sp	21	1.7	0.11	5.91
Dioscorea wallichi	19	3.5	0.21	9.30
Fabaceae climber	7	1.4	0.03	1.56
Globba bulbifera	21	1.8	0.12	5.78
Hedyotis sp	15	1.5	0.07	3.34
Hibiscus solandra	37	2.4	0.27	11.67
Ipomoea sp	1	1.0	0.00	0.25
Justicia simplex	17	2.2	0.12	4.81
Justicia sp	3	1.3	0.01	0.74
Leucas ciliatus	22	1.2	0.08	5.12
Oplismenus compositus	86	2.8	0.76	35.86
Oryza granulare	8	2.0	0.05	2.17
Plectranthes sp	49	1.9	0.28	13.73
Rungia sp	2	1.5	0.01	0.47
Smilax perfoliata	2	1.0	0.01	0.50
Spilanthes calva	11	1.2	0.04	2.21
Synedrella nodiflora	53	3.9	0.64	22.31
Thunbergia alata	2	1.0	0.01	0.40

Triumfetta rotundifolia	75	1.9	0.45	21.39
Vernonia sp	4	1.0	0.01	0.75
Total (48 species)			6.6	300
Shannon-Weiner Species diversity Index			3.01	

Density denotes the number of individuals per $1m^2$; IVI-Importance Value Index

Appendix XX. Regeneration status of medicinal plants in the teak plantations

Species	Density/ha			Ratio*
	Mature trees	Seedlings	Saplings	
Medicinal plants				
Bauhinia racemosa	1	-	-	1:0
Cassia fistula	3.5	60	-	1:17
Dalbergia latifolia	2	480	-	1:240
Diospyros montana	-	-	240	0:240
Kydia calycina	-	-	940	0:940
Lagerstroemia microcarpa	13.5	-	-	1:0
Phyllanthus emblica	-	-	100	0:100
Pterocarpus marsupium	-	-	40	0:40
Radermachera xylocarpa	2	40	-	1:20
Randia dumetorum	3	80	7840	1:2640
Syzygium cumini	1	20	-	1:20
Tectona grandis	258	100	-	1:0.3
Other plants				
Acacia sp.	-	80	-	0:80
Butea monosperma	1	-	-	1:0
Casearia esculenta	2	-	-	1:0
Cinnamomum macrocarpum	1	-	-	1:0
Cordia domestica	-	300	-	0:300
Cordia wallichi	2	-	-	1:0
Dalbergia paniculata	-	200	-	0:200
Diospyros montana	-	240	-	0:240
Grewia tiliaefolia	2	600	-	1:300
Haldinia cordifolia	-	40	20	0:60
Olea dioica	2	20	-	0:20
Total (19 species)	293	2260	9180	1:39
Shannon-Weiner species diversity index	0.60	1.23	1.33	

Ratio between the number of mature trees to number of seedlings/saplings

Appendix.XXI. Commercially exploited medicinal plants in the NBR

Species	Family	Habit	Part collected	Status*
Acacia leucophloea	Mimosaceae	T	Bark	-
Acacia sinuata	Mimosaceae	C	Fruit	-
Aegle marmelos	Rutaceae	T	Root	VU/R
Anisochilus carnosus	Lamiaceae	H	Whole plant	-
Aphanamixis polystachya	Meliaceae	T	Bark	VU/R
Aristolochia indica	Aristolochiaceae	C	Whole plant	-
Asparagus racemosus	Liliaceae	C	Tuber	-
Biophytum sensitivum	Oxalidaceae	H	Whole plant	-
Boerhavia diffusa	Nyctaginaceae	H	Root	-
Canarium strictum	Burseraceae	T	Resin	-
Carissa carandas	Apocynaceae	S	Fruit	-
Cassia fistula	Caesalpiniaceae	T	Bark	-
Cinnamomum spp.	Lauraceae	T	Leaves	VU/G
Clerodendrum serratum	Verbenaceae	S	Root	-
Coleus zeylanicus	Lamiaceae	S	Whole plant	-
Coscinium fenestratum	Menispermaceae	C	Bark & stem	CR/G
Costus speciosus	Zingiberaceae	H	Rhizome	-
Crateva magna	Capparidaceae	T	Bark	-
Curcuma aromatica	Zingiberaceae	S	Rhizome	-
Cyclea peltata	Menispermaceae	C	Root	-
Cymbidium aloeifolium	Orchidaceae	E	Whole plant	-
Decalepis hamiltonii	Asclepiadaceae	C	Root	-
Desmodium gangeticum	Fabaceae	S	Root	-
Desmodium latifolium	Fabaceae	S	Root	-
Desmodium velutinum	Fabaceae	S	Root,whole plant	-
Diospyros malabarica	Ebenaceae	T	Fruit	-
Drosera peltata	Droseraceae	H	Whole plant	VU/R
Evolvulus alsinoides	Convolvulaceae	H	Whole plant	-
Feronia elephantum	Rutaceae	T	Fruit	-
Ficus benghalensis	Moraceae	T	Bark	-
Ficus racemosa	Moraceae	T	Bark	-
Ficus religiosa	Moraceae	T	Bark	-
Gloriosa superba	Liliaceae	C	Seed	LR-NT/R
Gmelina arborea	Verbenaceae	T	Fruit/root/stem	-
Gymnema sylvestre	Asclepiadaceae	C	Leaves	-
Helicteres isora	Sterculiaceae	S	Fruit	-
Hemidesmus indicus	Asclepiadaceae	C	Root	-
Holoptelia integrifolia	Ulmaceae	T	Bark	-
Holostemma adakodien	Asclepiadaceae	C	Root	-

Appendix.XXI. Commercially exploited medicinal plants in the NBR

Species	Family	Habit	Part collected	Status*
Hydnocarpus pentandra	Bixaceae	T	Fruit	VU/G
Iphigenia indica	Liliaceae	H	Bulbs	-
Ipomea pestiridis	Convolvulaceae	C	Root	-
Kingiodendron pinnatum	Caesalpiniaceae	T	Bark	EN/G
Malaxis rheedi	Orchidaceae	H	Whole plant	-
Melothria madraspatana	Cucurbitaceae	C	Stem	-
Myristica dactyloides	Myristicaceae	T	Aril/seed	VU/R
Naravelia zeylanica	Ranunculaceae	C	Root	-
Neolamarkia cadamba	Rubiaceae	T	Root bark	-
Nervilia aragoana	Orchidaceae	H	Rhizome	EN/R
Nilgirianthus barbatus	Acanthaceae	S	Root	-
Nilgirianthus ciliatus	Acanthaceae	S	Root/stem	EN/G
Oroxylum indicum	Bignoniaceae	T	Root	VU/R
Persea macrantha	Lauraceae	T	Bark	EN/R
Phaseolus trilobus	Fabaceae	H	Root	-
Phyllanthus emblica	Euphorbiaceae	T	Fruit	-
Piper trioicum	Piperaceae	C	Fruit/root	-
Pongamia pinnata	Fabaceae	T	Bark/seed	-
Premna latifolia	Verbenaceae	T	Root bark	-
Pseudarthria viscida	Fabaceae	H	Root/wholeplant	LR-NT/R
Pterocarpus marsupium	Fabaceae	T	Gum	-
Rauvolfia serpentina	Apocynaceae	H	Root	EN/R
Ricinus communis	Euphorbiaceae	S	Root	-
Rotula aquatica	Boraginaceae	S	Root	-
Rubia cordifolia	Rubiaceae	C	Root	-
Salacia fruticosa	Hippocrateaceae	C	Root	-
Salacia oblonga	Hippocrateaceae	C	Root	EN/R
Saraca asoca	Caesalpiniaceae	T	Bark/flower	EN/R
Scilla hyacinthina	Liliaceae	H	Bulbs	-
Shorea roxburghii	Dipterocarpaceae	T	Resin	-
Sida acuta	Malvaceae	H	Root/wholeplant	-
Sida rhombifolia	Malvaceae	H	Root	-
Sida schimperiana	Malvaceae	H	Root	-
Solanum indicum	Solanaceae	S	Root	-
Solanum melongena var. incanum	Solanaceae	S	Root	-
Solanum pubescens	Solanaceae	S	Fruit/root	-
Solanum torvum	Solanaceae	S	Fruit/root	-
Stereospermum colais	Bignoniaceae	T	Root	-
Strychnos nux-vomica	Loganiaceae	T	Seed	-

Appendix.XXI. Commercially exploited medicinal plants in the NBR

Species	Family	Habit	Part collected	Status*
Symplocos cochinchinensis	Symplocaceae	T	Bark	LR-NT/R
Terminalia arjuna	Combretaceae	T	Bark	LR-NT/R
Terminalia bellerica	Combretaceae	T	Fruit	-
Terminalia chebula	Combretaceae	T	Fruit/leafgalls	-
Tribulus terrestris	Zygophyllaceae	H	Whole plant	-
Trichosanthes cucumerina	Cucurbitaceae	C	Stem/wholeplant	-
Uraria rufescens	Fabaceae	H	Root	-

Habit: T - Tree; S - Shrub; H - Herb; C - Climber; E - Epiphyte
Status*: Based on Anon. (1997); VU - Vulnerable; R - Rare; CR - Critically Endangered; EN - Endangered; LR - Low Risk; G - Globally; R -Regionally; NT - Near threatened

Appendix.XXII. Monthwise calender of collection of commercially exploited medicinal plants in the NBR

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Acacia sinuata	*	*	*									
Asparagus racemosus	*	*	*	*	*	*	*	*	*	*	*	*
Canarium strictum	*	*	*	*	*	*	*	*	*	*	*	*
Carissa carandas						*	*	*	*			
Clerodendrum serratum							*	*	*	*	*	*
Coleus zeylanicus	*	*	*									*
Curcuma aromatica								*	*			
Cyclea peltata	*											*
Cymbidium aloeifolium							*	*	*			
Decalepis hamiltonii							*	*	*	*		
Desmodium velutinum							*	*	*	*	*	*
Diospyros malabarica							*	*	*			
Evolvulus alsinoides								*	*	*	*	
Ficus benghalensis	*	*	*	*	*	*	*	*	*	*	*	*
Ficus racemosa	*	*	*	*	*	*	*	*	*	*	*	*
Ficus religiosa	*	*	*	*	*	*	*	*	*	*	*	*
Gloriosa superba									*	*	*	
Gmelina arborea	*	*	*	*	*	*	*	*	*	*	*	*
Gymnema sylvestre								*	*	*		
Helicteres isora	*									*	*	*
Hemidesmus indicus							*	*	*	*	*	*
Holoptelia integrifolia												
Naravelia zeylanica							*	*	*			
Neolamarkia cadamba												
Nervilia aragoana							*	*	*			
Persea macrantha	*	*	*	*	*	*	*	*	*	*	*	*
Phyllanthus emblica	*										*	*
Premna latifolia							*	*	*	*	*	*
Pseudarthria viscida							*	*	*			
Rauvolfia serpentina								*	*	*		
Ricinus communis								*	*	*		
Shorea roxburghii	*	*	*	*	*	*	*	*	*	*	*	*
Sida acuta							*	*	*			
Sida rhombifolia							*	*	*			
Sida schimperiana							*	*	*			
Solanum indicum							*	*	*			
Solanum melongena var. incanum							*	*	*			
Solanum pubescens							*	*	*			
Solanum torvum						*	*	*				
Stereospermum colais	*	*	*	*	*	*	*	*	*	*	*	*
Strychnos nux-vomica								*	*	*		
Terminalia bellerica	*							*	*	*	*	*
Terminalia chebula								*	*	*	*	*
Tribulus terrestris							*	*	*			
Total	17	13	13	11	11	13	30	38	38	25	21	21

* Indicate collection

Species name changes

Randia dumetorum (Page no. 72, 87 and 103) should be read as *Catunaregam spinosa*