PHYTO-ECOLOGY OF THE LION-TAILED MACAQUE (*Macaca silenus*) HABITATS IN SOUTHERN INDIA

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by
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CERTIFICATE

This is to certify that the thesis, entitled "Phyto-ecology of the lion-tailed macaque (*Macaca silenus*) habitats in southern India" is a record of original research work done by Mr. R. Krishnamani in the Division of Conservation Biology, Sálim Ali Centre for Ornithology and Natural History, as a full time Research Scholar during the period of study 1995-2002 under my guidance and supervision for the award of the Degree of Doctor of Philosophy in Zoology. 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 "Phyto-ecology of the lion-tailed macaque (*Macaca silenus*) habitats in southern India" submitted to the Bharathiar University, Coimbatore, for the award of the Degree of Doctor of Philosophy in Zoology is a record of original and independent research work done by me during 1995-2002 under the supervision and guidance of Dr. Ajith Kumar 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 any University.

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SUMMARY

The causal factors for the very high species diversity in tropical rainforests have been the focus of ecological research for several decades. It has become obvious that the high tropical species diversity has three major components, local (often called α-diversity), regional (β-diversity), and landscape (γ-diversity). Contribution of each of these components to overall diversity might vary from place to place, and from taxon to taxon. The pattern of variation in plant diversity is of particular interest since this would have a profound impact of the distribution and abundance of secondary consumers.

In this study, I examine the nature and extent of spatial variation in the species diversity of woody plants in the rainforest of the Western Ghats mountain ranges in south India, one among the eight most threatened biodiversity hotspots of the world. I also examine whether the diversity of food trees of the lion-tailed macaque (*Macaca silenus*), an endemic to the tropical rainforest of the Western Ghats and phylogenetically the ancestor of all extant Asian macaques, also show variation at different spatial scales that is similar to that of all wood plants. Since the phenology of plants also affects the secondary consumers, this issue is examined at one site. Although the Western Ghats mountain ranges extend over 1600 km, from 8°-21° N, this study was restricted to the tropical rainforest between 8°30' and 14°17' N within an altitudinal range of 100-1500 m, which formed the habitat of the lion-tailed macaque. The rainforest north of this is also heavily disturbed and highly fragmented. The variation in the woody plant community was examined primarily with reference to their species richness, density, and basal area.

The above study area was divided into four zones, and plants were enumerated from 12 belt transects (250x10 m, 0.25 ha) in each zone, and 48 belt transects in total (12 ha). Species richness was examined at the plot level, as well as pooled at the zone level.

Sorensen and Morisita-Horn's indices of overlap were used as an indicator of species turnover at different spatial scales. The study was done from 1994 to 2000.

There were totally 391 species, representing 210 genera and 64 plant families, with 5443 individual stems contributing to a basal area of 552.41 m^2 in an area of 12 ha. The species richness varied from 14 to 51 with a mean of 35.02 species per plot. Although there was no latitudinal gradient in species per plot, zonal species richness showed decline from Zone 4 to 1. Species richness was correlated although weakly with altitude, as did density and basal area. The pristine rainforests in the southern Western Ghats are confined to the higher reaches and hence species richness is higher at higher altitude. This could explain the higher densities and basal areas also in higher altitudes. However, at altitudes higher than that sampled, this may not hold true. Many of the dominant plant families in the study area were dominant in other parts of the world. The girth-class frequencies decreased monotonically with an increasing girth classes that were in concordance with other studies in India and elsewhere. However, the percentage of woody plant species in the higher girth classes decreased from south to north.

The distribution of most of the woody plant species (65.99%) was spatially clumped or aggregated while 22.25% were randomly and 11.76% were uniformly dispersed. Although, α-diversity (species/plot) did not vary among zones, β-diversity (between plots within a zone) was high in all the zones, especially in the southern part of the lion-tailed macaque habitat. The patterns exhibited by Sorenson and Morisita-Horn similarity indices were similar. The γ-diversity (between plots in different zones) was the highest between Zones 1 and 4, which was expected because they occupy the extreme limits of the lion-tailed macaque habitat.

As is the case with any ecological study on plant communities, an estimate to determine the overall species richness including 'missing species' was attempted. Various recent models, which take into account turnover of species, were used to estimate this, and Harte's Self-similarity model was selected as the best one. The estimated overall species richness of trees was 853 compared to 823 species that are currently known from the Western Ghats. However, this estimate is limited to the study area (8°30' and 14°17' N).

In this study special attention was given to the plant species that are used by the lion-tailed macaque as a food resource. A total of 114 woody food species were recorded during the survey, compared to 218 species reported as food sources. The food species recorded formed 29.16% of all species recorded from all the zones. However, the lion-tailed macaque food-species formed 39.5% to 41.5% of the total species richness in each Zone. The food species richness was not correlated with altitude or latitude. The density and basal area of the lion-tailed macaque food-species for the entire habitat was 54.60% and 62.18% respectively. Unlike the species richness and density, the food species basal area was correlated with altitude and latitude, although the variance in basal area accounted for by these gradients was quite low.

The *Ficus* (fig) densities were also calculated and it was found that their density decreased from north to south. *Cullenia exarillata*, an important food species, was dominant in the southern part of this macaque's habitat, above 700 m. The flowers of this trees species, much favored by these macaques, is available during periods of general fruit scarcity. This tree species could serve a pivotal role on these macaques and could be a limiting factor along with several *Ficus* species.

Phenology of 584 trees from 129 woody plant species was monitored in a lowland rainforest of Someshwara Wildlife Sanctuary, Karnataka for a period of 2 years, from 1997 to 1998. The presence/absence of vegetative and reproductive parts were recorded from 2 to 12 trees per species in two trails of 4 km and 12 km respectively. Phenological pattern was examined with reference to percentage of individual trees as well as species. The general fruiting patterns were more or less similar between years but that of the food species of the lion-tailed macaques were not. The fruiting of the food-species was more or less predictable although there was an inter-annual difference in fruiting. The eight *Ficus* species that were also monitored fruited in all the months of the years.

The phenological pattern was similar between years for all species together. However, there was significant difference between years in the percentage of food species that fruited, showing that overall fruiting need not reflect food availability for a specialized frugivore like the lion-tailed macaque.

The finding that, basal area of food trees show spatial variation is significant for the continued existence of the lion-tailed macaque. The areas best suited for these macaques, based on this parameter, are: Indira Gandhi Wildlife Sanctuary and Kalakkad-Mundanthurai Tiger Reserve in Tamil Nadu, Silent Valley National Park and Periyar Tiger Reserve in Kerala and Sharavathy Valley Wildlife Sanctuary and Kudremukha National Park and its adjacent areas in Karnataka. It is interesting to note that the rainforests of Madikeri (Coorg), although quite big (*ca*. 700 km^2), have the lowest lion-tailed macaque densities and poaching could be the reason attributed to this.

The rainforests in Western Ghats harbor very high species diversity. This is basically due to a very high β- and γ-diversity. Although α-diversity is also very high it is not correlated with latitude. Species richness decreased from the northern limit of the lion-tailed macaque to its southern limit. The food species richness of the lion-tailed macaque mirrored the general pattern. Higher girth classes were observed from the southern limit of this macaque's habitat.

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Chapter 1

General Introduction

1.1. Vegetation dynamics in rainforests

The tropical rainforests cover no more than six percent of the land area and yet as a storehouse of genetic and species diversity exceeds all other ecosystems of the world (Richards, 1975; Whitmore, 1990; McNeely *et al*., 1990). Ecologists are at wits end to explain the amazing variation in species richness or diversity that these rainforest communities show. Several causal factors that are often not mutually exclusive have been proposed to explain this diversity (see Rosenzweig, 1995 for a review).

Species diversity shows variations at three spatial scales - local, regional and landscape, also called α-, β- and γ-diversity, respectively. Although these names were coined by Whittaker (1977), these variations were noticed earlier by MacArthur (1965) who called it *within-habitat* and *between-habitat* diversity. Ecologists have by now recognized this and efforts are being made to measure this. This is particularly so for vegetation communities because they relate to primary productivity and hence form the basis of food webs on which other animals rely.

Besides spatial variation, the vegetation of rainforests also shows considerable temporal variation. Based on temperature records seasonal events were believed to be absent from tropical rainforests. However, seasonality in the tropical rainforests is now being increasingly appreciated (Leigh *et al*., 1982) Rainfall is critical in many tropical areas and wet and dry seasons have strong effects on the temporal variation. Profound variations in a plant's phenological cycle can have significant effects on the animal community that depend on them. The evolution of a wide range of morphological, behavioral and physiological adaptations has ensured that animals adapt well to the vagaries of nature. Both within-year and between-year variation in resource production can be pronounced. The abundance of these seasonal food resources may set the carrying capacity of the consumer community (Rathcke and Lacey, 1985; van Schaik *et al*., 1993).

This thesis examines the spatial variation in the community structure of woody plants in the tropical rainforest of the Western Ghats, and its relevance to the ecology and conservation of an indicator species, the lion-tailed macaque (*Macaca silenus*). The implications of seasonal phenological cycles are also examined.

The Western Ghats is an ideal area to examine spatial and temporal variation in plant communities. It is a mountain range that is nearly 1600 km long, with considerable variation in geology, topography and rainfall. The tropical rainforest in this mountain range has a high plant species richness and endemism (see Chapter 2 for details). The lion-tailed macaque (*Macaca silenus*) is an endangered primate and is an obligate rainforest species feeding predominantly on fruits and insects (Green and Minkowski, 1977). This macaque had always been rare when compared to the other primates of India (Kumar, 1985) and is considered the ancestor of all extant Asian macaques, therefore the longest resident in tropical rainforest. It is also one of the best-studied animal species in the Western Ghats. Thus, this species is an ideal subject to examine the implications of variation in vegetation community.

Several studies on rainforest vegetation of the Western Ghats have been conducted recently (Singh *et al*., 1981; Pascal, 1988; Swamy and Proctor, 1994; Ganesh *et. al*., 1996; Padaki and Parthasarathy, 2000; Pascal and Pelissier, 1996; Parthasarathy and Karthikeyan, 1997; Ayyapan and Parthasarathy, 1999; Parthsarathy 1999;

Pascal *et al.* 1999; Bhat *et al.* 2000; Srinivas and Parthasarathy, 2000). Even though there have been phytological studies in various localities of the Western Ghats in the last 5-6 decades, a systematic assessment of the variation in the community structure at different spatial scales has not been done. The implications of such variations on an animal species have also not been done.

1.2. Conservation problems in the rainforests

Tropical rainforest management policies have weak scientific foundations because of inadequate biological knowledge, particularly with regards to flora and fauna and their ecological relationships (Struhsaker, 1997). Traditional phyto-ecological and biodiversity assessments have concentrated on plant and animal species diversity and distributions to enhance the prospects of harvesting desirable species (Dallmeier and Comiskey, 1998). More recently, such assessments have also included habitats and population surveys of rare and endangered species to determine areas that are important for conservation (Dallmeier and Comiskey, 1998).

In the past, land for the conservation of biological diversity had been arbitrarily set-aside on an *ad hoc* basis. Protected areas declared in the early part of the 20^{th} century often do not match the ideals of current conservation theory (Maddock and du Plessis, 1999). In spite of this, the creation of a protected area network is a key strategy to combat deforestation and to curtail the loss of biodiversity. Both inside and outside protected areas emphasis has been on the loss or gain of forests but not on the landscape changes such as forest fragmentation and isolation (Sánchez-Azofeifa *et al.*, 1998). Hence the conservation of plant or animal species, in the face of habitat loss and fragmentation, necessitates the study of broad ecological landscapes in which they live (Kerkhoff *et al.* 2000).

The tropical rainforest vegetation cover is a reasonable indicator for identifying the lion-tailed macaque's habitat, as it provides food, potential access to mates and shelter, and thus has an impact on its fitness. In order to ensure the continued survival of these macaques, their habitat must contain a reasonable amount of forest cover, but deforestation and rainforest fragmentation still continue and poses to be the single major threat to the very existence of these macaques. Interpreting the managed landscape of the rainforests of Western Ghats with specific reference to lion-tailed macaques is thus critical to their conservation.

1.3. Natural history of the lion-tailed macaque

Primates have evolved from an arboreal ancestral stock and in general retain this character although some have returned to a terrestrial habitat. India is home to around 21 species of non-human primates (according to Groves, 2001; otherwise only 15) of which 7 are found in southern India (Table 1.1). The suborder Prosimii includes the Slender loris of southern India and the suborder Simiae includes the four langurs (see Table 1.1 legend) and two macaques.

The lion-tailed macaque (Figure 1.1) is one of the most endangered primates of India and is listed in the Indian Wildlife (Protection) Act, 1972. It is endemic to the Western Ghats, and to the States of Kerala, Karnataka and Tamil Nadu. It inhabits the dense tropical rainforests between 100-1500 m (msl). Its present distributional range is between 14º30´ N and 8º N. Recent population surveys suggest that there are about 4,000 individuals in the wild (Kumar, 1995b). Several ecological studies have been done on these macaques in the wild (Sugiyama, 1968; Green and Minkowski, 1977; Kumar, 1987; Ramachandran, 1993; Menon, 1993; Singh *et al*., 1997; Umapathy, 1998; Joseph, 1998).

Family	Common Name	Species and subspecies present in southern India
Lorisidae	Slender loris [1] subspecies (2)	*Loris tardigradus* (Linnaeus, 1758) *L. tardigradus lydekkerianus* (Caberera 1908) *L. tardigradus malabaricus* (Wroughton 1917) ¶
Cercopithecinae	Bonnet macaque [2] subspecies (2)	*Macaca radiata* (E. Geoffroy, 1812) *M. radiata radiata* (E. Geoffroy, 1812) ¶ *M. radiata diluta* (Pocock, 1931) ¶
	Lion-tailed macaque monotypic	*M. silenus* (Linnaeus, 1758)
Colobinae	Nilgiri langur monotypic	*Trachypithecus johnii* (Fischer, 1829) ¶ (= *Presbytis johnii* Ellerman and Morrison-Scott, 1951)
	Southern plains gray langur	*Semnopithecus dussumieri* (I. Geoffroy, 1843) ** ¶
	Black-footed gray langur	*S. hypoleucos* (Blyth, 1844) ** ¶
	Tufted gray langur	*S. priam* (Blyth, 1844) ** ¶ (possibly)

Table 1.1. Seven species of primates occur in southern or peninsular India. 1) Slender loris has 6 subspecies of which 2 are found in India; 2) Bonnet macaque has 2 subspecies and both are endemic to peninsular India. Author citation follows Roonwal and Mohnot (1977) and Oates *et al.* (1994). ¶ Primates those are sympatric with the lion-tailed macaque. ** Due to a recent taxonomical revision these subspecies of *Semnopithecus* have been promoted to a full species status and are monotypic (Groves, 2001 and pers. comm.). The subspecies, previously of *Semnopithecus* like *priamellus*, *elissa*, *achates* and *iulus* are now merged with *Semnopithecus dussumieri*. The other subspecies (*S. e. aeneas*) is now synonymous with *S. hypoleucos*. The distribution of the langurs mentioned in Groves (2001) is only a rough estimate and the exact distribution and status are presently not clear.

It is an obligate frugivore and has adapted to a highly arboreal life. Nearly 60% of its diet consists of fruits and the balance is made up of seeds, flowers, invertebrates and vertebrates. The lion-tailed macaque is known to depend on 212 woody plant species (Krishnamani and Kumar, 2000). Kumar (1987) observed that of the 84 species used as food-plants in the Anamalai Hills, 23 (27.38%) accounted for a whopping 70.9% of the lion-tailed macaque's annual diet. This means that a small fraction of the rainforest plant species contributes to a major portion of the macaque's diet. Females stay with the natal group throughout their lives while males migrate between groups. The home range varies from 1 sq. km to around 7 sq. km. depending upon the 'quality' of the habitat. It is diurnal and is among the most arboreal of all the macaques. Because of its shy nature, black color and its habit of living in dense rainforests, it is seldom seen.

Lion-tailed macaques live in groups of 8 to 40 animals, with an average of about 18 animals. Typically, groups have one adult male, one sub-adult male, 5-7 adult females, the remaining being juveniles and infants. The average adult sex ratio is about five females to one male. Births occur throughout the year with a peak between December and February. Females become primiparous at an average age of 6.6 years and the inter-birth interval is around 2.5 years, which is considerably higher compared to other macaques. The mean mortality rate irrespective of age/sex classes is around 0.045 per year, which is considerably lower than other macaques. The low population growth of these macaques is due to a delayed primiparity and very low birth rates but it is compensated by its high survival rate (Kumar 1995a). Sexual harassment in the wild among adult females has been observed probably due to competition among the females for mating. This competition could be the result of a high synchrony in estrus cycles among females, a high female to male ratio (5:1), and multiple mount ejaculation (Kumar, 2000).

The vocal communication in the lion-tailed macaque has a repertoire of 18 basic patterns (Hohmann & Herzog, 1985; Lindburg, 1990). The vocal repertoire is characterized by discrete, interaction- and situation-specific sound patterns. The essential elements of vocal communication, is adapted to the ecology and social organization of these macaques. One vocalization that is unique to the lion-tailed macaque is the proceptive calling (also called the ‘staccato’ call) by the females, during the follicular phase of the menstrual cycle either soliciting or during copulation (Lindburg, 1990).

Given the highly frugivorous diet of the lion-tailed macaque a phyto-ecological examination of its food plant species at various spatial scales would lead to a more robust understanding of it's long-term survival. Moreover, the lion-tailed macaque can be used as an “indicator species”, of the rainforests of the Western Ghats, the conservation of which would benefit a wide variety of other taxa.

1.4. Objectives

The goal of this study was to identify patterns of variation in woody plant communities in the rainforests of the Western Ghats at different spatial scales, especially with reference to an animal species that is a typical indicator of this habitat, namely the lion-tailed macaque. The specific objectives were to:

- Identify patterns of spatial distribution woody plant species in the rainforest of the Western Ghats and their relationship with gradients such latitude and altitude. Spatial distribution patterns refer to spatial variation in species richness, density, basal area, as well as overlap or turnover between sites in species composition.
- Estimate the overall species richness of woody plant species in the habitat of the lion-tailed macaque, in the context of turn over of species, using various models that are currently available
- Identify regional (zonal) differences in the abundance of food plants of the lion-tailed macaque (in terms of species richness, density and basal area) and thereby ascertain potentially important areas for conservation of this species. Particular attention has been paid to examine *Ficus*, a genus known to play a crucial role in tropical ecosystems.

- Understand the phenological patterns in a tropical lowland monsoon rainforest and thereby increase our knowledge on how these macaques survive periods of fruit scarcity.

1.5. Organization of this thesis

This thesis is organized into 6 chapters. Chapter 1 sets the background scenario for the phyto-ecological studies conducted in the rainforest habitats of the lion-tailed macaques. Chapter 2 describes the study areas, which is the Western Ghats and describes the methods used for the phyto-ecological studies. Four chapters describing the main results of this study follow Chapter 2.

Chapter 3 deals with the species, generic and family richness in four zones of the Western Ghats. The forth chapter examines the spatial distribution of the woody plant species, estimation of 'missing species' and the β- and γ-diversity or turnover of woody plant species in the rainforests of the Western Ghats.

The fifth chapter discusses the densities and dominance of the food-plant species of the lion-tailed macaque and tries to identify potential areas for their long-term survival. A mention on the *Ficus* species densities is a complementary addition to this chapter thereby trying to ascertain the effect of this vital fruit yielding species on these macaques. Chapter 6 monitors the selected woody plant species' phenological variations in a lowland rainforest of Karnataka and emphasis is given to the flowering and fruiting phenologies of this area.

There are eleven appendices given at the end of the Thesis. These appendices will be useful for anybody studying the flora and fauna of the Western Ghats.

Figure 1.1. An adult female and a juvenile, lion-tailed macaque (*Macaca silenus*), are sitting on a Jack-fruit tree (*Artocarpus heterophyllus*). © AJITH KUMAR

Chapter 2

Study area and methods

2. 1. The Western Ghats

The rainforests of the Western Ghats are often called “evergreen forest” (Pascal, 1988). Meher-Homji (1974) suggested that the northern drift of the Indian landmass during the Miocene-Pliocene resulted in southern India being at or near the equator, experiencing a hot humid climate with a shorter dry season, an ideal period for the wet evergreen forests to flourish. Further northward drift of the Indian subcontinent would have meant a longer dry season. This drift was also responsible for four uplifts that led to the elevation of the Himalayan range during the late Pliocene or early Pleistocene. It was with the last uplift that the present day monsoon regime got established (Meher-Homji, 1974).

The Western Ghats that may have got elevated to the maximum in Pliocene or late Tertiary (Pascal 1988). This finally shaped the present climate of peninsular India, with the eastern side of the Western Ghats in the rain shadow region. The rainforests of the Western Ghats are developed mostly between 100-2000 m along the western side where the mean rainfall is around 2000-5000 mm. While at higher elevations stunted montane rainforests are interspersed with grasslands, on the eastern side we find relatively less of the rainforests.

The Western Ghats is one of the ten biogeographic zones of India (Rodgers and Panwar, 1988). With about 45 Protected Areas, Western Ghats has the highest protected area coverage (10%) among the ten zones (Rodgers and Panwar, 1988). It extends over a distance of nearly 1,600 km south-north between 8º and 21º N and covers an area of

160,000 km^2. Its uninterrupted run is broken at around 11º N by the Palakkad Gap. It is almost parallel to the western coast with the distance from the sea ranging from 2 km (near Karwar) to 50 km (in most of the places) and traverses through the states of Gujarat, Maharastra, Goa, Karnataka, Kerala and Tamil Nadu. The average altitude ranges between 600-1400 with numerous peaks jutting out of which Anaimudi in Kerala, is the highest (2,695 m).

The main types of soils present in the Western Ghats are red soils, laterites and black soils (Subramanyam and Nayar, 1974; Bourgeon, 1989). The red soils are developed on the Archean crytallines and are brown, gray or black, are deficient in organic matter, phosphoric acid and nitrogen. Vegetation associations of *Calophyllum, Dipterocarpus, Hopea* and *Myristica* are characteristic of the red soil areas. The laterites consist of 90-95% iron, aluminium, titanium and manganese oxides and are deficient in lime and organic material and extend up to 1600 m. *Shorea* and *Xylia* are the dominant species in laterite soils of the Western Ghats. Black soils, formed out of the basaltic Deccan lava, are deficient in organic matter, nitrogen and phosphoric acid, but generally have enough lime and potash. The red and black soils occur in various combinations all along the Western Ghats (Subramanyam and Nayar, 1974).

2.2. Study sites

The vegetation studies were done in the habitats of the lion-tailed macaque, between 14°30′ N and 8° N (a detailed list of the study areas is given in Table 2.2). The entire lion-tailed macaque habitat was divided into four zones based on currently known vegetation composition (Pascal, 1988) and (Figure 2.1). The lion-tailed macaques are confined to a narrow and long stretch of tropical rainforests in the Western Ghats in three states of Karnataka, Kerala and Tamil Nadu. Various people have classified the Western Ghats into 3 or 4 zones (Subramanyam and Nayar, 1974; Pascal, 1988). For our purpose the entire habitat of the lion-tailed macaque was chosen as the study area, which was divided into 4 zones as follows:

2.2.1. Zone 1 (North of Madikeri up to the northern most limits of the lion-tailed macaque)

This area is relatively low in elevation compared to the other areas in the Western Ghats. Here the Western Ghats is the steep slope of the Karnataka Plateau, which joins the coastal Karnataka plain. The highest altitude is around 750 m and only in Kudremukha National Park and Kodachadri Reserved Forest the elevation exceeds 1000 meters, as peaks. To the south of this zone the Western Ghats rise abruptly with numerous peaks and at Pushpagiri Wildlife Sanctuary the highest elevation is a peak that is around 1713 m.

The vegetation association in this zone, for these rainforests are: *Dipterocarpus indicus – Diospyros candolleana – Diospyros oocarpa*; *Dipterocarpus indicus – Humboldtia brunonis – Poeciloneuron indicum*; *Poeciloneuron indicum – Palaquium ellipticum – Hopea ponga* and *Mesua ferrea – Palaquium ellipticum* (Ramesh and Pascal, 1997). This zone is dominated by the members of Dipterocarpaceae: *Dipterocarpus indicus, Hopea ponga, Hopea parviflora*, and *Vateria indica*. Two rare Dipterocarps, *Hopea canarensis* and *Hopea jacobi* are found only in this zone. The average annual rainfall in this zone is the highest when compared to other zones (> 7500 mm.) but the number of dry months is also the highest, around 6-7 months (Table 2.1).

2.2.2. Zone 2 (Madikeri to Palakkad Gap)

The Western Ghats is fairly high here with the highest point at Doddabetta (2635 m) in the Nilgiris. At about 11º30'N, the Western Ghats rise abruptly in the Nilgiri horst where they join the Eastern Ghats. The vegetation associations in the rainforests of this zone are: *Mesua ferrea – Palaquium ellipticum*; *Dipterocarpus indicus – Kingiodendron pinnatum – Humboldtia brunonis* and *Cullenia exarillata – Mesua ferrea – Palaquium ellipticum*. At higher reaches in the Nilgiris we find *Litsea* spp. - *Syzygium* spp. - *Microtropis* spp (Ramesh *et al*., 1997). This zone is the northern limit of *Cullenia exarillata*, an important food-plant of the lion-tailed macaque. The average annual rainfall in this zone is around 6000 mm. and the number of dry months is around 4.5 - 6 months (Table 2.1).

	Zone 1	Zone 2	Zone 3	Zone 4
Average annual rainfall	*ca.* 7500 mm.	*ca.* 6000 mm.	*ca.* 5000 mm.	*ca.* 3000 mm.
Average no. of dry months	7 - 6	6 - 4.5	5 - 3	3 - 2
Altitudinal range	600-1800	1200-2650	1400-2700	1000-1900
Latitudinal range	15° - 13° N	13° - 11° N	11° - 9° N	9° - 8° N
Woody plant species endemic to these zones*	*Hopea canarensis, Hopea jacobi, Maytenus rothiana.*	*Euonymus serrati-folius, Actinodaphne lanata.*	*Pseudoglochidion anamalayanum, Ardisia blatteri.*	*Gluta travancorica, Garcinia rubro-echinata.*

Table 2.1. Salient features of the 4 zones where vegetation sampling was done. * This list is not exhaustive and includes only a sample representation of 2 species each (Ramesh *et al*., 1997).

2.2.3. Zone 3 (South of Palakkad Gap to Shenkottah Pass)

The Western Ghats is here interrupted by the Palakkad Gap, which is about 30 km. wide and appears abruptly as the Anamalai-Nelliampathi Hills the south of which occurs Cardamom or High Wavy mountains. The highest peak south of Himalayas, Anaimudi (2695 m.) is found in this zone. The Western Ghats here have two east running ridges namely the Palni and Varshanadu Hills. The vegetation associations found in this zone are: *Dipterocarpus indicus – Kingiodendron pinnatum - Strombosia ceylanica*; *Cullenia exarillata – Mesua ferrea – Pallaquium ellipticum*; *Bhesa indica – Gomphandra tetrandra – Litsea* spp. and *Diospyros foliolosa – Mitrephora heyneana – Miliusa* spp. At higher reaches in the Palni Hills we find *Litsea* spp. - *Syzygium* spp. - *Microtropis* spp (Ramesh and Pascal, 1997). The average annual rainfall in this zone is around 5000 mm. and the number of dry months is around 3-5 months (Table 2.1).

2.2.4. Zone 4 (South of Shenkottah Pass)

In this zone the Western Ghats is a narrow ridge with steep slopes to the west and east, until about 20 km. before Kanyakumari. This last bit is very rugged and its highest peak is Agastyamalai (1869 m.). The vegetation associations found here are: *Cullenia exarillata – Mesua ferrea – Palaquium ellipticum* and *Diospyros foliolosa – Mitrephora heyneana – Miliusa* spp. – *Kingiodendron pinnatum* (Ramesh and Pascal, 1997). The average annual rainfall in this zone is around 3000 mm. and the number of dry months is around 3-2 months (Table 2.1).

LOCATION & ALTITUDE OF THE PLOTS		Coordinates	Altitude (metres)	Topo Sheet No. (1 : 50,000)
ZONE 1: North of Coorg (Mercara), until the northern limit of the lion-tailed macaques				
	AREA 1			
1	Gersoppa Reserved Forest	(14°17.3′ N, 74°42.3′ E)	450-500	48 J / 12
2	Sharavathy Valley Wildlife Sanctuary	(14°3′ N, 74°42′ E)	190-200	48 J / 12
3	Sharavathy Valley Wildlife Sanctuary	(14°1.3′ N, 74°44′ E)	260-320	48 J / 12
	AREA 2			
4	Mookambika Wildlife Sanctuary	(13°53.5′ N, 74°50′ E)	440-560	48 K / 13
5	Kodachadri Reserved Forest	(13°53.3′ N, 74°51′ E)	580-630	48 K / 13
6	Mookambika Wildlife Sanctuary	(13°53′ N, 74°46.30′ E)	340-420	48 K / 13
	AREA 3			
7	Someshwara Wildlife Sanctuary	(13°29.4′ N, 75°4.20′ E)	160-170	48 O / 3
8	Balehalli State Forest	(13°30′ N, 75°5′ E)	600-610	48 O / 3
9	Agumbe State Forest	(13°30′ N, 75°4.55′ E)	620-640	48 O / 3
	AREA 4			
10	Kudremukha National Park	(13°19.6′ N, 75°9.20′ E)	660-710	48 O / 3
11	Kudremukha national Park	(13°8.6′ N, 75°18.40′ E)	720-740	48 O / 3
12	Kudremukha National Park	(13°14′ N, 75°11′ E)	960-1020	48 O / 4
ZONE 2: North of Palakkad (Palghat) Gap to Coorg				
	AREA 5			
13	Kerti reserved Forest	(12°7′ N, 75°46′ E)	580-600	48 P / 16
14	Kerti Reserved Forest	(12°7.30′ N, 75°48′ E)	660-690	48 P / 16
15	Brahmagiri Ghats Wildlife Sanctuary	(12°7.1′ N, 75°48′ E)	500-560	48 P /16
	AREA 6			
16	Aralam Wildlife Sanctuary	11°58' N, 75° 48.30' E	340-380	49 M / 13
17	Aralam Wildlife Sanctuary	11°59' N, 78°49' E	400-410	49 M / 13
18	Aralam Wildlife Sanctuary	11°57' N, 75° 52' E	140-160	49 M / 13
	AREA 7			
19	Silent Valley National Park	11°6' N, 76°28' E	1030-1060	58 A / 8
20	Silent Valley National Park	11°6.15' N, 76°27.30' E	1000-1020	58 A / 8
21	Silent Valley National Park	11°5' N, 76° 27' E	1040-1060	58 A / 8
	AREA 8			
22	Bolampatti Reserved Forest	10°58' N, 76°41' E	760-860	58 B / 9
23	Bolampatti Reserved Forest	10°58.30' N, 76°42' E	860-870	58 B / 9
24	Bolampatti Reserved Forest	10°58.45' N, 76°41.3' E	980-1000	58 B / 9

ZONE 3: North of Shenkottah Pass to Palakkad Gap

	AREA 9			
25	Parambikulam Wildlife Sanctuary	10°28' N, 76°41' E	700-760	58 B / 11
26	Parambikulam Wildlife Sanctuary	10°27' N, 76°40' E	540-560	58 B / 11
27	Parambikulam Wildlife Sanctuary	10°27.3' N, 76° 40.4' E	640-680	58 B / 11
	AREA 10			
28	Indira Gandhi Wildlife Sanctuary	10°22' N, 76°59' E	1390-1400	58 B/15
29	Indira Gandhi Wildlife Sanctuary	10°23' N, 76°59' E	1250	58 B/15
30	Indira Gandhi Wildlife Sanctuary	10°21' N, 76°54' E	800	58 B/15
31	Indira Gandhi Wildlife Sanctuary	10°18' N, 76°54.30' E	1100	58 B/15
	AREA 11			
32	Megamalai Reserved Land	9°36' N, 77°26' E	780-820	58 G / 6
33	Megamalai Reserved Land	9°34' N, 77°24' E	700-720	58 G / 6
	AREA 12			
34	Periyar Tiger Reserve	9°26' N, 76° 57.15' E	195-210	58 C / 15
35	Periyar Tiger Reserve	9°27.5' N, 77°5' E	940-975	58 G / 3
36	Periyar Tiger Reserve	9°27' N, 77°9' E	1110-1140	58 G / 3
ZONE 4: South of Shenkottah Pass to the southern limit of the lion-tailed macaques				
	AREA 13			
37	Shendurney Wildlife Sanctuary	8°54.5' N, 77°7.5' E	460-520	58 H / 1
38	Shendurney Wildlife Sanctuary	8°52.75'N, 77°10.25' E	660-710	58 H / 1
39	Shendurney Wildlife Sanctuary	8°54' N, 77° 5' E	170-220	58 H / 1
	AREA 14			
40	Peppara Wildlife Sanctuary	8°41' N, 77°11.5' E	630-690	58 H / 2
	AREA 15			58 H / 6
41	Kalakkad-Mundanthurai Tiger Reserve	8º37’ N, 77º16’ E	820-840	58 H / 6
42	Kalakkad-Mundanthurai Tiger Reserve	8º38’ N, 77º15’ E	760	58 H / 6
43	Kalakkad-Mundanthurai Tiger Reserve	8º40’ N, 77°30' E	1240-1280	58 H / 6
44	Kalakkad-Mundanthurai Tiger Reserve	8°39' N, 77°30.3' E	1300	58 H / 6
45	Kalakkad-Mundanthurai Tiger Reserve	8°39 N, 77°20' E	1060-1100	58 H / 6
46	Kalakkad-Mundanthurai Tiger Reserve	8°39 N, 77°29' E	750-760	58 H / 6
47	Kalakkad-Mundanthurai Tiger Reserve	8º31’ N, 77º26’ E	1040-1100	58 H / 6
48	Kalakkad-Mundanthurai Tiger Reserve	8º30’ N, 77º27’ E	960-990	58 H / 6

Table 2.2. Location of the plots in the 4 zones.

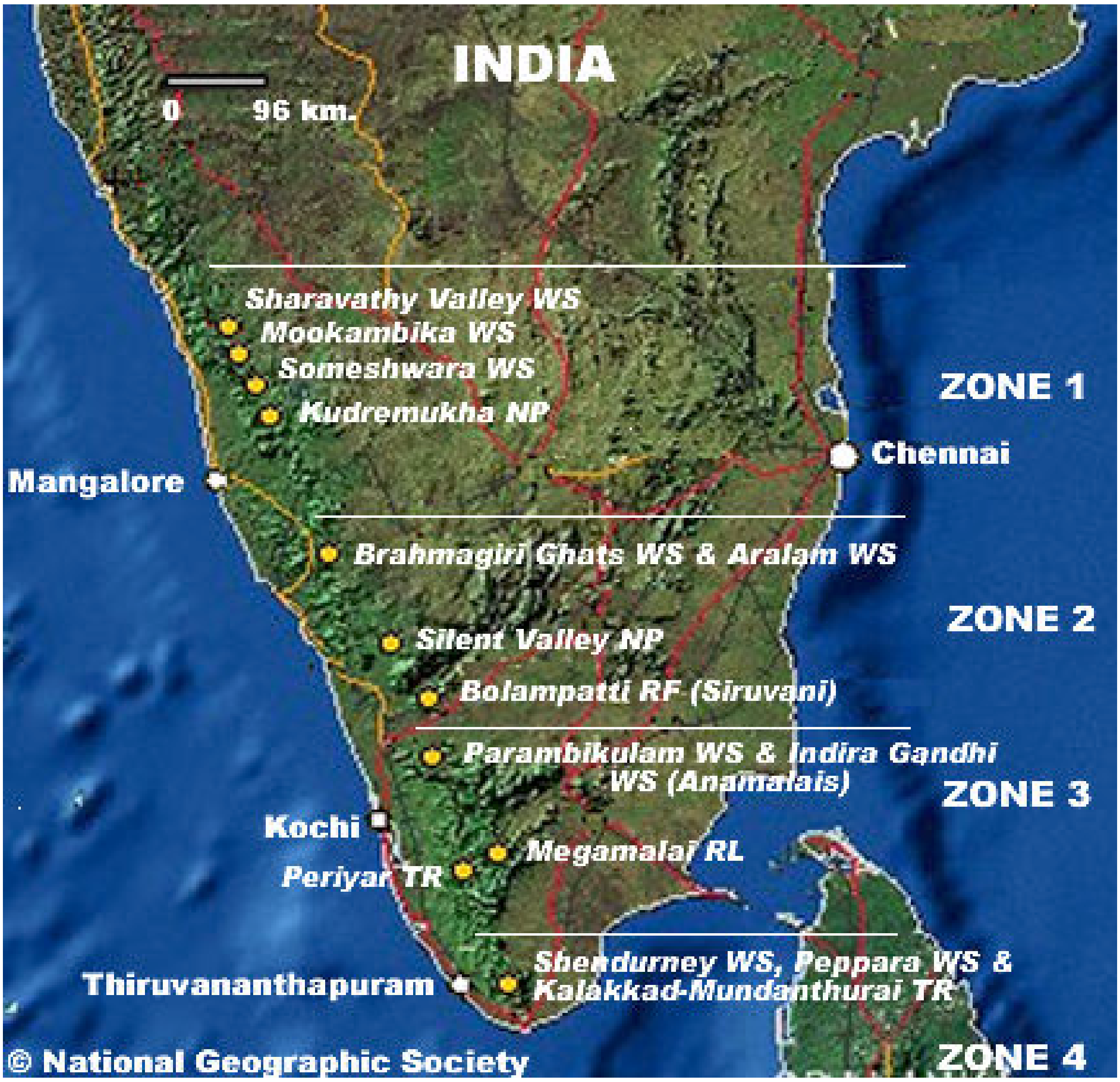


Figure 2.1. Map showing the study areas (the yellow dots when joined forms the habitat of the endangered Lion-tailed macaque (*Macaca silenus*). (WS = Wildlife Sanctuary; RL = Reserved Land; RF = Reserved Forest; NP = National Park; TR = Tiger Reserve).

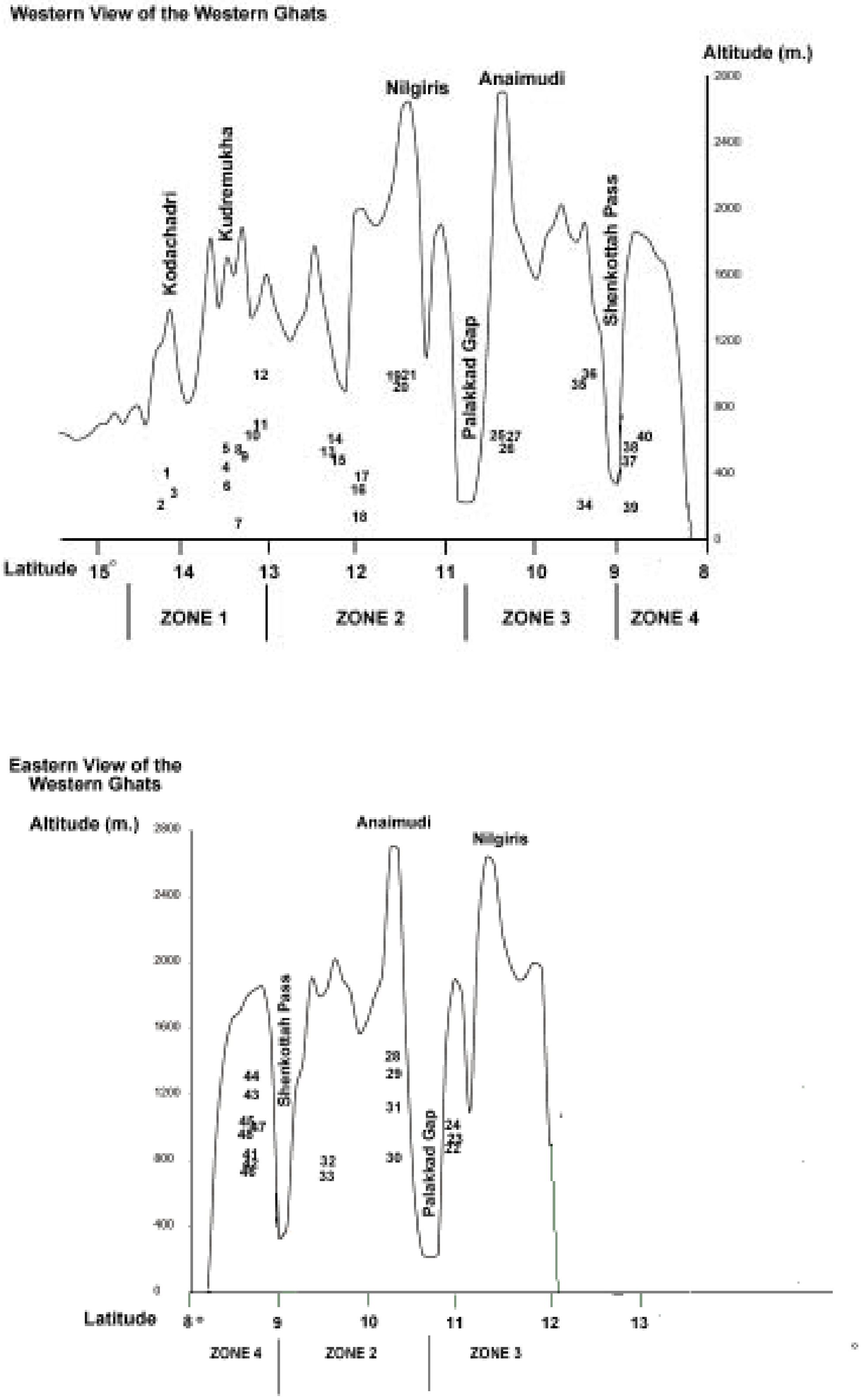


Figure 2.2. Profile view of the Western Ghats and the location of plots in each of the 4 Zones. The numbers are the location of the plots; details about the plots can be had from Table 2.1 (adapted from Ramesh and Pascal, 1997).

2.3. Methodology

Even though preliminary vegetation surveys were begun in Someshwara Wildlife Sanctuary in 1994, survey in other parts of the lion-tailed macaque habitats were initiated only in 1999. The array of methods for collecting vegetation data is seemingly endless and no consensus exists as to which should be accepted as a standard. For our purposes 1-8 belt transects were laid in each area, where the lion-tailed macaques were present. Each belt transect was 250x10 m (0.25 ha). Totally 48 belt transects (12 in each of the 4 Zones) were laid in the study areas, (12 ha). Each belt transect was divided into 10 sub-plots of 50x5 meters. All trees > 30 cm. and lianas > 10 cm. in gbh (girth at breast height: 1.2 m from the ground) within the belt transect were measured and identified. For buttressed trees measurements were made above the buttress and for multi-stemmed trees, bole girths were measured separately and basal area was calculated separately.

Voucher specimens were collected for species identification and confirmation. Some of the plant species were identified in the field with field keys (Beddome, 1869; Gamble, 1928; Pascal and Ramesh, 1988). Unidentified plant specimens were collected, tagged and pressed as herbarium specimens. These voucher specimens were identified at various herbaria in and around the study areas and later counter-checked and confirmed with the reference material available at Kerala Forest Research Institute's Herbarium, at Thrissur, Kerala. Detailed information on the methods used is given in the respective results chapters.

To analyze the vegetation characteristics, Importance Value Indices (IVI) were calculated for each species. The Important Value Index (IVI) of Curtis and McIntosh (1951) and Cottam and Curtis (1956) takes into consideration the number of individuals (density) belonging to each species, their basal area (dominance) and distribution (frequency) in the plot.

Relative Frequency (rF) = (Number of plots containing a species x 100)/ Sum of frequencies of all species.

Relative Density (rD) = (Number of individuals of a species x 100)/ Total number of individuals of all species.

Relative Dominance (rd) = (Basal Area of a species x 100)/ Total Basal Area of all species.

Thus importance Value Index (IVI) was calculated as follows:

$$\mathbf{IVI = rD + rd + rF}$$

and hence its value varies from 0 to 300.

2.4. Data analyses

Throughout the thesis, parametric tests were used whenever the quality of measurement met the criteria. Otherwise non-parametric tests were used (Sokal and Rohlf, 1981; Zar, 1984; Siegal and Castellan, 1988). All tests were 2-tailed and a probability level of ≤ 0.05 was considered statistically significant and ≤ 0.01 was considered highly significant. The statistical analyses were carried out using SPSS version 7.5. One-way ANOVA, Pearson's correlation, Spearman's rank correlation, Wilcoxon matched-pair signed ranks tests, Kruskal-Wallis one-way analysis of variance by ranks and chi-square tests were used. The variance to mean to ratio was used to assess the dispersion of the woody plant species in the lion-tailed macaque habitats using ***BioDiversity Pro 2*** (McAleece, 1997), a computer program. ***EstimateS 5*** (Colwell, 1997) was used to estimate total species richness. For β-diversity indices, Morisita-Horn Diveristy Index and Sorenson Index were calculated using ***EstimateS 5*** (Colwell, 1997) based on Magurran (1988) and Krebs (1989). The *Ficus* densities were calculated using ***Distance 3.5*** (Thomas *et al*., 1998).

Chapter 3

Species richness, density, basal area and girth-class frequencies of woody plant species

3.1. Introduction

One of the most conspicuous features of tropical rainforest is its very high species richness that has impressed scientists and naturalists alike. The way such very large numbers of species have evolved and are packed together has been the "driving force for endless speculation, constrained to varying degrees by observation and commonly involving massive extrapolation" (Whitmore, 1990). Extreme floristic richness involves the co-occurrence of a large number of species drawn from many genera and families. If we look at the floristic composition of an area we realize that it contains only those species that have survived as a result of evolution and immigration. This immigration is a form of 'rescue effect' whereby species in patches that do well supply individuals to patches which cannot maintain viable populations and this in turn produces greater local and regional species richness (Stevens, 1989).

A long evolutionary history with a relatively stable existence and constantly high temperatures are the two independent traits that illustrate species richness in the tropics. There is little doubt that tropics existed in the equatorial regions of the Earth throughout the Phanerozoic, although its area waxed and waned with the changing distribution of landmasses and seas and with variations in global climate (Walker, 1989). High temperatures encourage faster growth of organisms with less energy channeled to heat production. Faster growth, in turn, leads to more generations and more generations lead to mutations, which may result in the evolution of new species (Tokeshi, 1999).

The idea that the availability of resources or energy dictates species richness in an area has had frequent support form fellow ecologists (Hutchinson, 1959; Wright *et al*., 1993; Tokeshi, 1999). This comes from the intuitive perception that more species will require more energy. On the other hand, it is not immediately apparent that more energy will lead to more species (Tokeshi, 1999).

Furthermore, palaeontological evidence suggests that the temperate forests in Asia had considerably higher numbers of tree genera than those in North America and Europe long before late Tertiary global cooling (Latham and Ricklefs, 1993). This points to the possibility that the large-scale variation in tree species richness may be mainly due to the long period of time available for taxonomic diversification of tropical lineages. Thus, time remains a plausible explanation for the large-scale differences in species richness (Tokeshi, 1999).

Species richness generally decreases with an increase in latitude and altitude and the decrease in tree species richness with increasing latitude occurs primarily at the level of families (Ricklefs, 1989). Also, it is relatively easy to recognize altitudinal changes in floras and faunas, which parallel latitudinal changes. This is considered to result from lower temperatures, smaller areas with less habitat heterogeneity and increased isolation of habitats. The first point parallels the latitudinal patterns, whereas the second and third may be considered as the 'island biogeography' aspects of high-altitude habitats (Tokeshi, 1999). In particular, the last point relates to the fact that habitats at higher altitudes are more likely to be isolated from similar habitats, whereas low-altitude habitats are essentially continuous and unfragmented.

On a global level, the most diverse are the Indo-Malayan, Neotropical and African rainforests (not necessarily in that order). Some plots in the Neotropics are far more diverse than the Indo-Malayan, while some are also species poor (Whitmore, 1990) but Gentry and Dodson (1986) opine that the Neotropical rainforests are the richest, species wise, in the world. On two 50-ha plots in Malaysia the tree species richness was around 817 and 1171 respectively, whereas in the Barro Colorado Island, Panama, a similar area had only 305 tree species (Plotkin, *et al*., 2000). Hence taxonomic composition, habitat heterogeneity, habitat variability, exact species distribution and local species richness generally varies from place to place (Kolasa *et al*., 1998). Nevertheless African rainforests are species poor when compared to the other tropical rainforests (Whitmore, 1990).

In a plant community, the adult population consists of a small number of large plants and a large number of small ones (Hutchings, 1986). Many factors influence the variation in the sizes of plants. Seed-size, for example, varies from one species to another and the seedling size is often correlated with the size of the seed from which it emerged (Crawley and Nachapong, 1985). The growth rate of two seedlings may look similar in stem-diameter and height but may differ in their respective ages (Hutchings, 1986). The nearest neighborhood-distance will also have a role to play in regulating the size and population of an emerging seedling (cf. Janzen, 1970; Connell, 1971). Herbivorous animals can also have a dramatic impact on the size hierarchy of plants, if they preferentially attack smaller and already weakened plants. In fact, herbivores can accentuate the inequality in the sizes of the plants, whereas a preference for large plants would tend to reduce plant size variation (Crawley, 1983). To put it succinctly, plant population density, competition, herbivores, pathogens, weather, soil conditions and various hazards like fire or burial by sand are the factors that govern the abundance and size of a plant population (Atkinson, 1986).

3.2. Objectives

In this chapter, I examine the spatial variation in the woody plant community (trees and lianas) in the rainforest to test the following hypotheses:

1) Species richness show differences among plots (α-diversity) as well as regions, and such differences are related to altitudinal and latitudinal gradients.
2) Generic and family richness also show similar patterns.
3) Densities and basal area of the woody plant species show spatial differences.
4) The girth-class frequencies decrease monotonically with increasing girth-classes?

3.3. Methods

To analyze the vegetation characteristics, Importance Value Indices (IVI) were calculated for each species, which is described in detail in the Chapter 2.3. This parameter was calculated for genera and family richness also.

3.4. Results

3.4.1. Species, genera and family richness

3.4.1.1. Species richness

A total of 391 woody plant species (hereinafter referred to as species) were recorded from all the four zones together representing 210 genera and 64 families (Appendix 5). Trees accounted for 341 species (87.21%) representing 174 genera and 55 families and lianas accounted for 50 species (12.79%) representing 40 genera and 22 families.

Eleven species remained unidentified, of which 3 were lianas and 8 were tree species. The total number of species for all plots together increased from Zone 1 (164 species) to Zone 4 (210 species: Appendices 1-5 and Figure 3.1). The lianas decreased from Zone 1 (33 species) to Zone 4 (12 species), whereas the tree species increased from Zone 1 (131 species) to Zone 4 (198 species). Although there seemed to be a south-north gradation in total tree species richness in the 4 zones (Figure 3.1) there was no significant difference in the plots among zones in the species richness per plot (One-way ANOVA: F=0.66, df=3, p=0.58).

Figure 3.1. Species richness of trees and lianas in the 4 different Zones (in 12 plots of 0.25 ha each).

Species richness in plots ranged from 14 (Plot 33) to 51 (Plot 26) with a mean of 35.02 species (SE=1.20). The zonal maximum, minimum and means are given in Figure 3.2.

In Zone 1, *Poeciloneuron indicum* with an Importance Value Index (IVI) of 24.94 was the most dominant species, followed by *Myristica dactyloides* (20.26) and *Dimocarpus longan* (16.45) (Appendix 1). For Zone 2, *Palaquium ellipticum*, *Dry-petes wightii* and *Knema attenuata* were the top 3 rank-ordered species with an IVI of 12.66, 12.55 and 10.97 respectively (Appendix 2). *Palaquium ellipticum* again was in the top 3 rank-ordered list in Zone 3 with an IVI of 10.38 preceded by *Cullenia ex-*

arillata (12.19) and *Diospyros foliolosa* (14.02) (Appendix 3). *Cullenia exarillata* and *Palaquium ellipticum* continued its dominance in Zone 4 with an IVI value of 22.38 and 13.55 followed by *Gluta travancorica* (12.04) (Appendix 4).

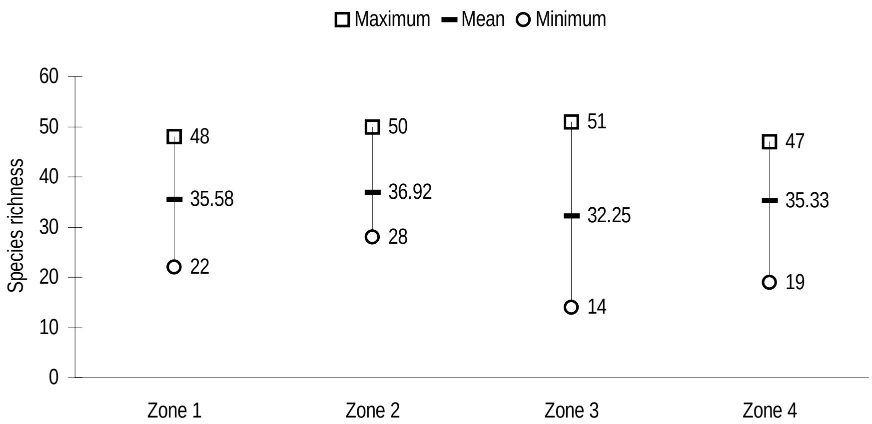


Figure 3.2. Species richness for each of the 4 Zones. — represents the mean species richness, □ represents the maximum number of species in a plot and ○ represents the minimum. The Standard Error (SE) for the 4 Zones is 2.35, 2.07, 2.82 and 2.42 respectively.

Zone 1	**Zone 2**	**Zone 3**	**Zone 4**	**Zone overall**
Poeciloneuron indicum	*Palaquium ellipticum*	*Diospyros foliolosa*	*Cullenia exarillata*	*Cullenia exarillata*
Myristica dactyloides	*Drypetes wightii*	*Cullenia exarillata*	*Palaquium ellipticum*	*Palaquium ellipticum*
Dimocarpus longan	*Knema attenuata*	*Palaquium ellipticum*	*Gluta travancorica*	*Myristica dactyloides*
Aglaia elaeagnoidea	*Myristica dactyloides*	*Reinwardtiodendron anamalaiense*	*Filicium decipiens*	*Aglaia elaeagnoidea*
Syzygium gardneri	*Toona ciliata*	*Agrostistachys borneensis*	*Neolitsea fischeri*	*Syzygium gardneri*
Olea dioica	*Elaeocarpus tuberculatus*	*Dipterocarpus indicus*	*Myristica dactyloides*	*Poeciloneuron indicum*
Lepisanthes tetraphylla	*Persea macrantha*	*Myristica dactyloides*	*Vateria indica*	*Knema attenuata*
Garcinia morella	*Syzygium gardneri*	*Aglaia elaeagnoidea*	*Cinnamomum malabatrum*	*Dimocarpus longan*
Palaquium ellipticum	*Cullenia exarillata*	*Baccaurea courtallensis*	*Myristica malabarica*	*Cinnamomum malabatrum*
Cinnamomum malabatrum	*Diospyros nilagirica*	*Polyalthia fragrans*	*Mangifera indica*	*Dipterocarpus indicus*

Table 3.1. Rank-order of top 10 species based on IVI values for Zones 1-4 and Zone overall (IVI values are given in Appendices 1-5).

For the Zones overall, *Cullenia exarillata* had the highest IVI (14.63) followed by *Palaquium ellipticum* (12.98) and *Myristica dactyloides* (11.91) (Appendix 5). It is interesting to note that though *Cullenia exarillata* was absent from Zone 1, it still had the highest IVI for the entire study area. The top 10 rank-ordered species in the 4 Zones and in the Zone overall contributed 133.32 (44.44%), 97.68 (32.56%), 69.68 (23.23%) and 108.85 (36.28%) of the IVI respectively. In the top 10 species (Table 3.1), based on the IVI, *Palaquium ellipticum* and *Myristica dactyloides* were present in all the 4 Zones. *Cullenia exarillata* was present in 3 Zones and *Syzygium gardneri* and *Cinnamomum malabatrum* were present in at least 2 Zones.

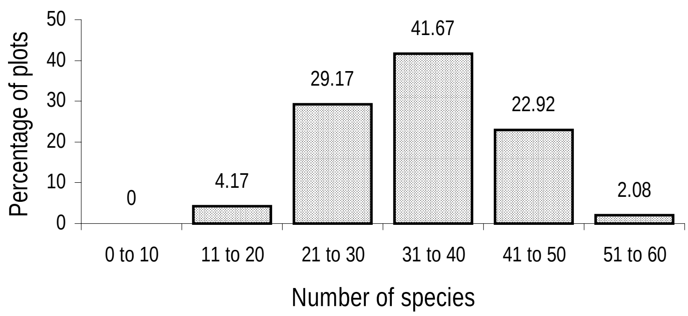


Figure 3.3. Class frequencies of species richness.

The species richness of 20 plots (41.67%) ranged from 31 to 40 (Figure 3.3). Though Zone 4 had 10 plots in the higher-class frequencies of 31 to 60 (Table 3.2) it was not significant (χ^2=3, df=3, *p*>0.05).

	11 to 20	21 to 30	31 to 40	41 to 50	51 to 60
Zone 1		4	5	3	
Zone 2		4	5	3	
Zone 3	1	5	4	1	1
Zone 4	1	1	6	4	
	2 plots	14 plots	20 plots	11 plots	1 plot

Table 3.2. The number of plots in five categories of species richness in 4 Zones.

The species richness per plot was negatively correlated with altitude, although weakly (r= -0.295, n=48, *p*=0.042) but not with latitude (r =0.170, n=48, *p*=0.249:

Figure 3.4). Species richness was negatively correlated with altitude in only Zones 2 and 4 (Figure 3.5).

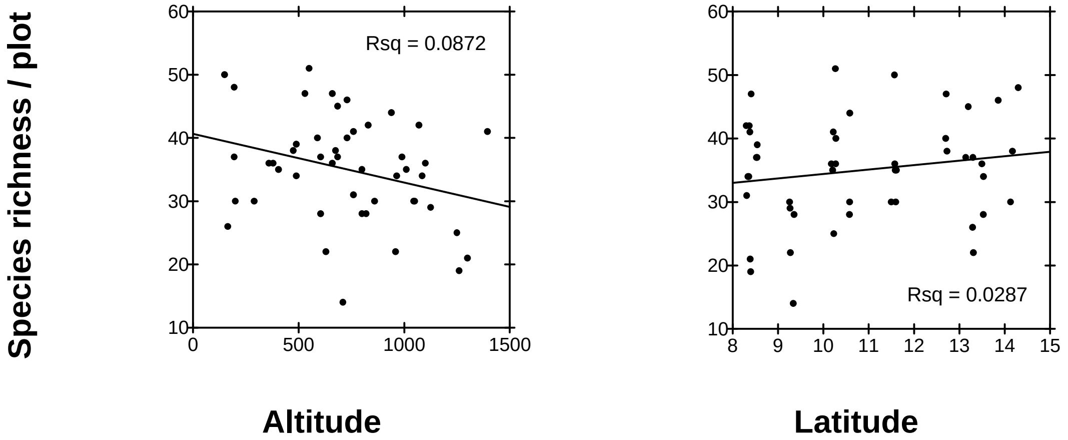


Figure 3.4. Species richness in 48 plots in the 4 zones, are plotted against altitude and latitude.

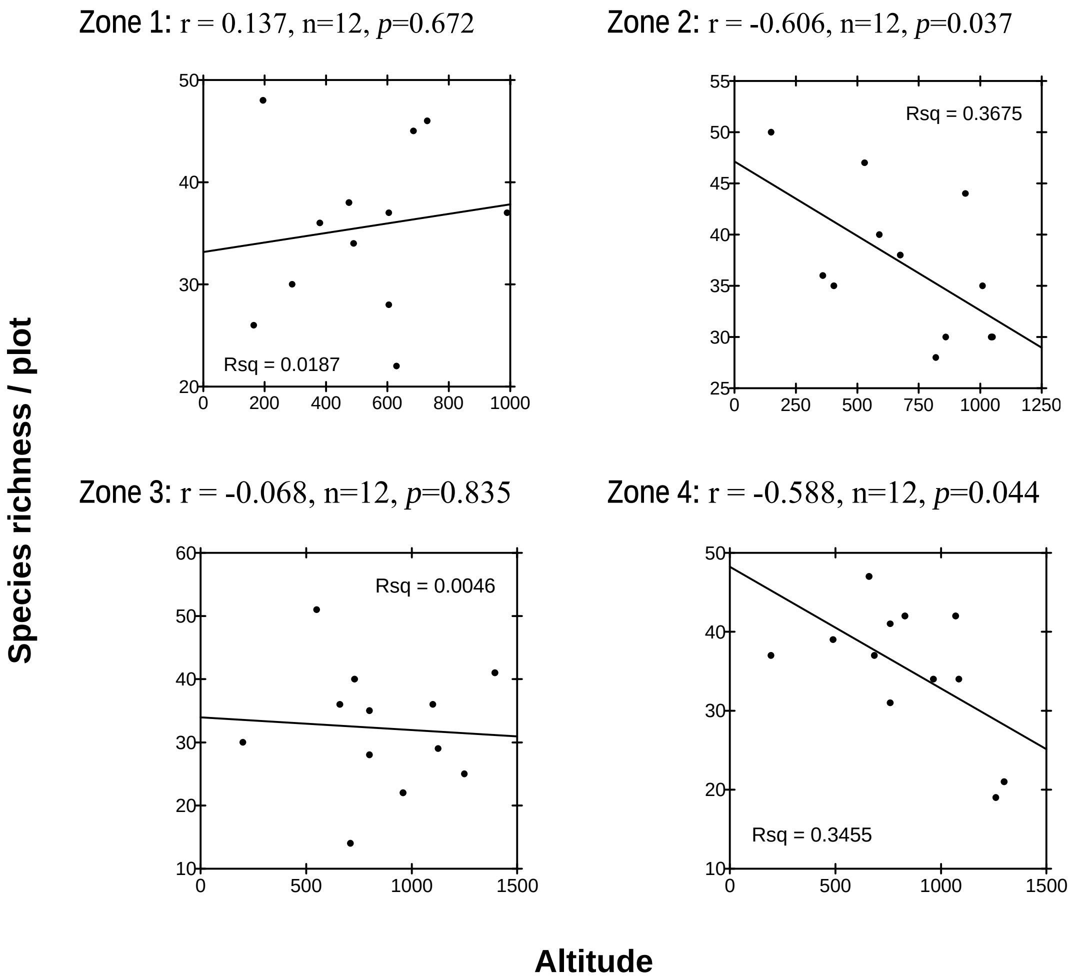


Figure 3.5. Species richness in 12 plots in each of the 4 zones, are plotted against altitude and latitude.

3.4.1.2. Generic richness

The generic richness (described as the number of genera) per plot did not vary significantly among zones (One-way ANOVA: F=0.28, df=3, *p*=0.84). It varied from 11 (in plot 33) to 49 (in plot 26) with a mean of 30.5 (SE=1.00). Generic richness was not correlated with either altitude (r = -0.252, n=48, *p*=0.084) or latitude (r=0.133, n=48, *p*=0.367). Like the species richness, overall generic richness also increased from Zone 1 to 4 (Figure 3.6).

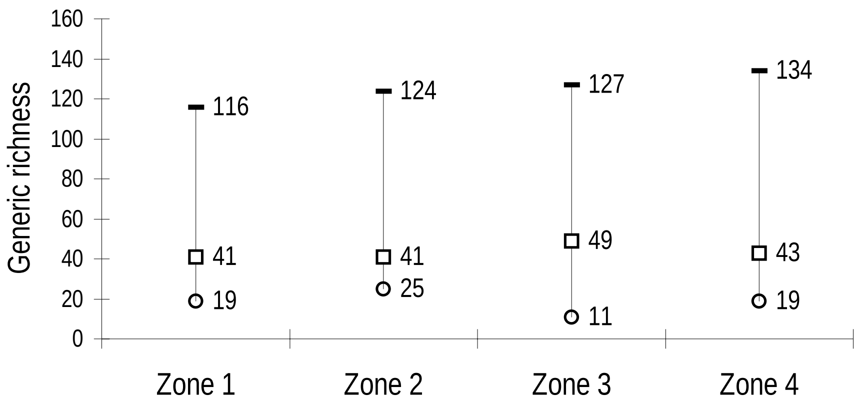


Figure 3.6. Generic richness for each of the 4 Zones. — represents the total number of genera, □ represents the maximum number of genera in a plot and ○ represents the minimum. The mean (and SE) for the 4 Zones is 30.42 (1.79), 31.92 (1.62), 29.25 (2.77) and 30.42 (1.82) respectively.

In Zone 1, *Myristica* was the top-ranking genus with a Generic Importance Value Index (GIVI) of 25.20 followed by *Poeciloneuron* (24.94) and *Syzygium* (18.12). In Zone 2 *Drypetes*, *Diospyros* and *Palaquium* were the top-ranking genera with a GIVI of 17.36, 12.88 and 12.66 respectively. Again, in Zone 3 *Diospyros* was the top-ranking genus with a GIVI of 23.74 followed by *Cullenia* (12.19) and *Palaquium* (10.38). *Cullenia* with a GIVI of 22.38 was the top-ranking genus in Zone 4 followed by *Myristica* (17.30) and *Syzygium* (15.20). The top 10 rank-ordered genera in the 4 Zones contributed 163.18 (54.39%), 116.35 (38.78%), 82.89 (27.63%) and 129.16 (43.05%) of the GIVI respectively (Table 3.3).

Zone 1	Zone 2	Zone 3	Zone 4
Myristica	*Drypetes*	*Diospyros*	*Cullenia*
Poeciloneuron	*Diospyros*	*Cullenia*	*Myristica*
Syzygium	*Palaquium*	*Palaquium*	*Syzygium*
Dimocarpus	*Myristica*	*Reinwardtiodendron*	*Palaquium*
Diospyros	*Syzygium*	*Myristica*	*Gluta*
Aglaia	*Knema*	*Dipterocarpus*	*Cinnamomum*
Olea	*Elaeocarpus*	*Agrostistachys*	*Filicium*
Garcinia	*Toona*	*Litsea*	*Neolitsea*
Holigarna	*Hopea*	*Syzygium*	*Vateria*
Lepisanthes	*Litsea*	*Aglaia*	*Hopea*

Table 3.3. Rank-order of top 10 genera based on GIVI values for Zones 1-4 (GIVI is derived from IVI given in Appendices 1-5).

Among the top 10 rank-ordered genera overall, only *Myristica* and *Syzygium* were present in all the 4 Zones. Two genera were found in at least 3 Zones, namely *Diospyros* and *Palaquium*. Four genera (*Cullenia*, *Hopea*, *Aglaia* and *Litsea*) were found in 2 Zones.

3.4.1.3. Family richness

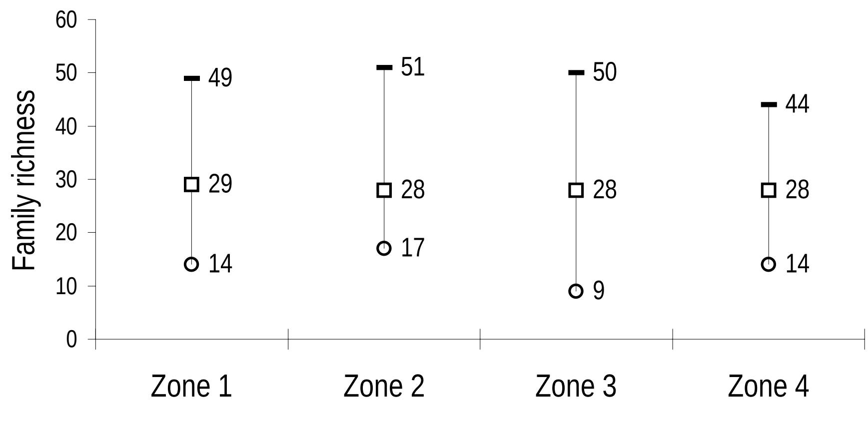


Figure 3.7. Family richness for each of the 4 Zones. . — represents the total number of families, ☐ represents the maximum number of species in a plot and ○ represents the minimum. The means (and SE) for the 4 Zones is 22.83 (1.19), 21.50 (1.00), 18.83 (1.43) and 20.42 (1.18) respectively.

The family richness per plot was also not different among zones (One-way ANOVA: F=1.95, df=3, *p*=0.14). It varied from 9 (in plot 33) to 29 (in plot 40) with a mean of 20.9 (SE=0.62). The family richness and altitude (r = -0.450, n=48, *p*=0.001) and latitude (r = 0.328, n=48, *p*=0.023) were correlated. The mean family-richness/plot, and overall for the zones did not follow any directional gradation (Figure 3.7).

In Zone 1, Clusiaceae was the top ranking family based on Family Importance Value Index (FIVI) followed by Myristicaceae (29.21) and Sapindaceae (24.86). Euphorbiaceae (37.41), Lauraceae (27.94) and Myristicaceae (23.44) were the top 3families for Zone 2 based on FIVI. In Zone 3, Euphorbiaceae (27.71), Ebenaceae (23.74) and Lauraceae (14.71) were the three top-ranking families and in Zone 4 it was Lauraceae (32.89), Anacardiaceae (25.63) and Euphorbiaceae (24.14) respectively. The top 10 rank-ordered families in the 4 Zones contributed 71.30%, 65.76%, 46.32% and 66.44% of the FIVI indices respectively (Table 3.4).

Zone 1	**Zone 2**	**Zone 3**	**Zone 4**	**Zone overall**
Clusiaceae	Euphorbiaceae	Euphorbiaceae	Lauraceae	Euphorbiaceae
Myristicaceae	Lauraceae	Ebenaceae	Anacardiaceae	Lauraceae
Sapindaceae	Myristicaceae	Lauraceae	Euphorbiaceae	Myristicaceae
Myrtaceae	Meliaceae	Meliaceae	Bombacaceae	Clusiaceae
Meliaceae	Fabaceae	Sapotaceae	Myristicaceae	Meliaceae
Oleaceae	Dipterocarpaceae	Bombacaceae	Myrtaceae	Sapotaceae
Lauraceae	Anacardiaceae	Myristicaceae	Sapindaceae	Ebenaceae
Ebenaceae	Sapotaceae	Dipterocarpaceae	Sapotaceae	Dipterocarpaceae
Moraceae	Ebenaceae	Sapindaceae	Dipterocarpaceae	Anacardiaceae
Anacardiaceae	Myrtaceae	Moraceae	Meliaceae	Bombacaceae

Table 3.4. Rank-order of top 10 genera based on FIVI values for Zones 1-4 and Zone overall (FIVI values are derived from IVI values, as given in Appendices 1-5).

Only three families, Myristicaceae, Meliaceae and Lauraceae, were present in all the 4 zones among the top ten families. In at least 3 zones, seven families were present and they were: Dipterocarpaceae, Sapotaceae, Sapindaceae, Myrtaceae, Euphorbiaceae, Ebenaceae and Anacardiaceae respectively. Bombacaceae and Moraceae were present in at least 2 zones.

A comprehensive list of the woody plant species distribution, based on this and other studies, is given in Appendix 6.

3.4.2. Density of woody plants

The number of trees and lianas per plot did not vary among the 4 zones (One-way ANOVA: F=0.854, df=3, p=0.472) and there was no clear south-north gradation (Figure 3.8). The density ranged from a minimum of 69 to 161 individuals with a mean of 108.94 (SE=2.78).

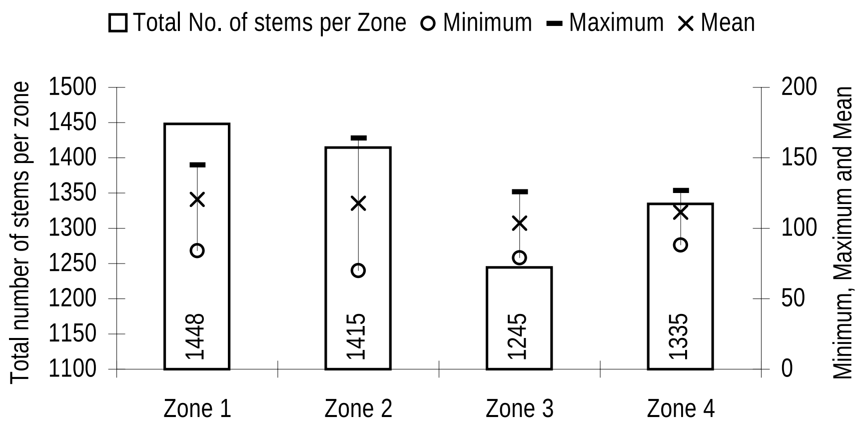


Figure. 3.8. Density of woody plants for the 4 zones. (SE for the plots= 5.17, 8.36, 4.13 and 3.24 respectively for Zones 1, 2, 3 and 4).

Zone 1 had 1448 stems in total and the top 10 ranked species contributed 46.2% of the total stems. The 3 top ranking species were, *Poeciloneuron indicum* (9.87%), *Myristica dactyloides* (7.53%) and *Dimocarpus longan* (5.39%). In Zone 2 the top 10 woody plant species contributed 33.14% of the total stems. The top 3 ranked woody plant species were *Drypetes wightii* (5.16%) followed by *Myristica dactyloides* (4.81%) and *Palaquium ellipticum* and *Knema attenuata* (4.03% each).

But in Zone 3, *Diospyros foliolosa* was the top ranking species (11.57%). It was followed by *Cullenia exarillata* (6.91%) and *Palaquium ellipticum* (5.14%) respectively. The 10 top-ranked species contributed to 40.16% of the density in Zone 3. In Zone 4, *Cullenia exarillata* contributed to 6.14% of the total density, followed by *Myristica dactyloides* (4.49%) and *Palaquium ellipticum* (4.34%). The top 10 woody plant species contributed to 35.80% of the density.

Zone 1	Zone 2	Zone 3	Zone 4	Zone overall
Poeciloneuron indicum	*Palaquium ellipticum*	*Diospyros foliolosa*	*Cullenia exarillata*	*Myristica dactyloides*
Myristica dactyloides	*Drypetes wightii*	*Cullenia exarillata*	*Myristica dactyloides*	*Palaquium ellipticum*
Dimocarpus longan	*Myristica dactyloides*	*Palaquium ellipticum*	*Palaquium ellipticum*	*Cullenia exarillata*
Aglaia elaeagnoidea	*Knema attenuata*	*Reinwardtiodendron anamalaiense*	*Filicium decipiens*	*Poeciloneuron indicum*
Olea dioica	*Diospyros nilagirica*	*Agrostistachys borneensis*	*Gluta travancorica*	*Diospyros foliolosa*
Garcinia morella	*Dipterocarpus indicus*	*Dipterocarpus indicus*	*Neolitsea fischeri*	*Aglaia elaeagnoidea*
Lepisanthes tetraphylla	*Xanthophyllum arnottianum*	*Myristica dactyloides*	*Agrostistachys borneensis*	*Reinwardtiodendron anamalaiense*
Syzygium gardneri	*Semecarpus auriculata*	*Polyalthia fragrans*	*Xanthophyllum arnottianum*	*Knema attenuata*
Palaquium ellipticum	*Humboldtia brunonis*	*Aglaia elaeagnoidea*	*Mangifera indica*	*Dimocarpus longan*
Reinwardtiodendron anamalaiense	*Reinwardtiodendron anamalaiense*	*Baccaurea courtallensis*	*Cinnamomum malabatrum*	*Cinnamomum malabatrum*

Table 3.5. Rank-order of top ten woody plant species from the 4 zones and zone overall based on densities.

But overall, with 5443 stems from the 4 Zones together, *Myristica dactyloides* with 261 stems contributed to 4.79% of the density followed by *Palaquium ellipticum* (209 individuals: 3.84%) and *Cullenia exarillata* (197 stems: 3.62%). The top 10 woody plant species contributed to 27.59% of the density with 1502 stems. *Myristica dactyloides* and *Palaquium ellipticum* were the only two species that was present in the top 10 rank-order of all 4 zones (Table 3.5). *Reinwardtiodendron anamalaiense* was present in 3 zones. Five species were in at least 2 zones and they were *Cullenia* *exarillata*, *Aglaia elaeagnoidea*, *Xanthophyllum arnottianum*, *Dipterocarpus indicus* and *Agrostistachys borneensis* (Table 3.5).

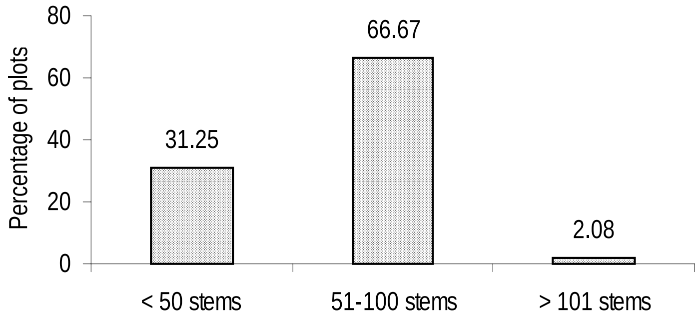


Figure. 3.9. Class frequencies of densities for 48 plots in the 4 Zones.

	More than 50 stems	More than 100 stems	More than 150 stems
Zone 1	3	9	
Zone 2	5	6	1
Zone 3	5	7	
Zone 4	2	10	
	15 plots	32 plots	1 plots

Table 3.6. The number of plots in three categories of woody plant species densities in 4 Zones.

Nearly 66.66% of the plots had a density of more than 100 stems (Figure 3.9) followed by 31.25% plots with a density of more than 50 stems. Only 1 plot from Zone 2 had a density of more than 150 stems (Table 3.6) and 10 plots from Zone 4 had more than 100 stems.

While density decreased with altitude (r = -0.371, n= 48, *p*=0.009) it increased with latitude (r = 0.317, n= 48, *p*=0.028), both relationships being weak however (Figure 3.10). When zones were examined separately, the density was negatively and more strongly correlated with altitude in Zones 2 and 3 (Table 3.11). In Zones 1 and 4 the relationship was not significant.

Altitude (a) r = -0.371, n=48, *p*=0.009 Latitude (b) r = 0.317, n=48, *p*=0.028

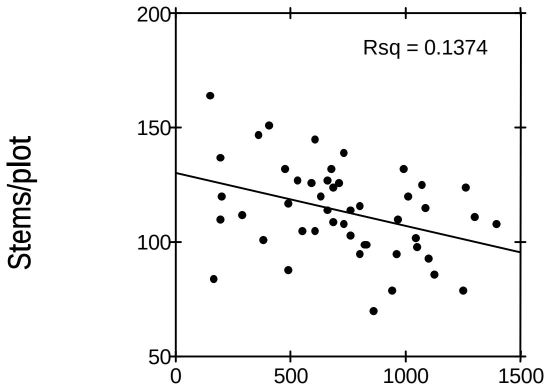


Figure 3.10. Densities of stems in 48 plots (0.25 ha each) in the 4 zones, are plotted against altitude and latitude.

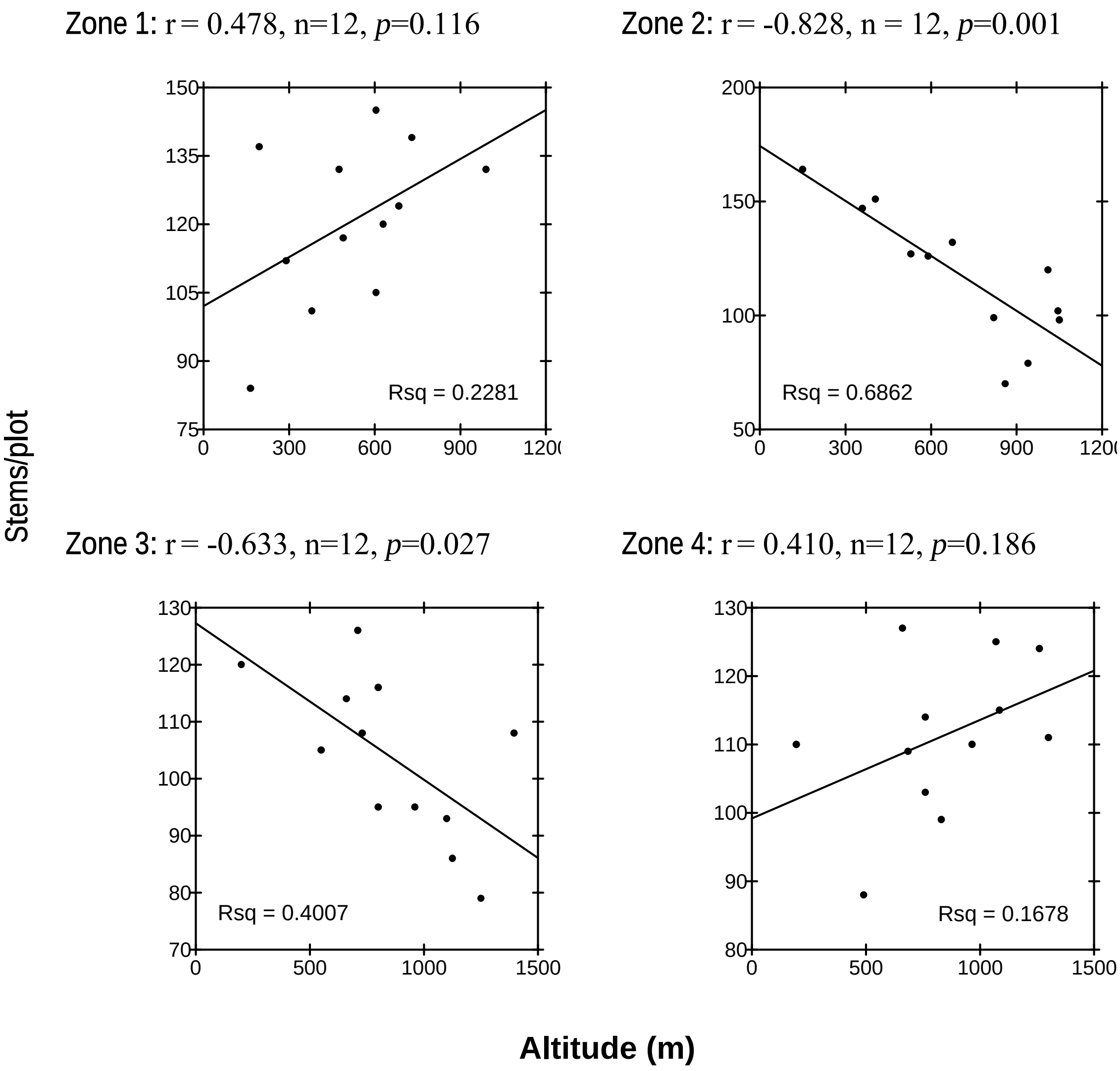


Figure 3.11. Densities in 12 plots in each of the 4 zones, are plotted against altitude and latitudes.

3.4.3. Basal area

The basal area, described as the area occupied by the species on the ground, was calculated for all the individuals and totaled for each of the 48 plots. The basal area per plot ranged from 6.47 m^2 (plot 33) to 16.77 m^2 (plot 38), with a mean of 11.48 m^2 (SE=0.34). There was a visible increase from south to north across the 4 different zones (Figure 3.12). The difference among zones was also statistically significant (One-way ANOVA: F=6.92, df=3, p=0.01).

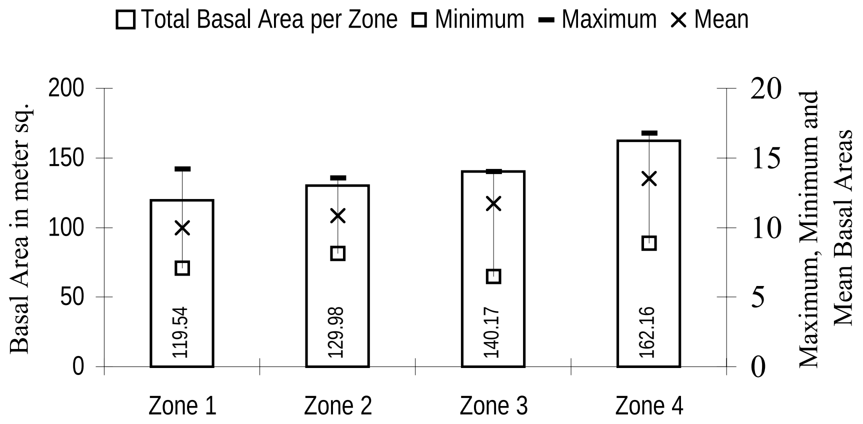


Figure 3.12. Basal area of woody plants in 12 plots together for the 4 zones (SE for plots= 0.530, 0.536, 0.590 and 0.667 respectively for Zones 1, 2, 3 and 4).

The total basal area for Zone 1 was 119.54 m^2 (Appendix 1). *Poeciloneuron indicum* was the top ranked contributing to 9.80% of the total basal area. This was followed by *Syzygium gardneri* (7.64%) and *Dimocarpus longan* (6.21%). The top 10 rank-ordered species contributed 58.75 m^2 of the total area (49.15%). In Zone 2 the total basal area was 129.98 m^2 with a mean of 10.83 m^2 per plot (Appendix 2). *Toona ciliata* was the dominant species with 6.57% of the total basal area. *Elaeocarpus tuberculatus* (5.32%) and *Palaquium ellipticum* (5.09%) were the 2nd and 3rd dominant species. The top 10 rank-ordered species contributed to 43.47% of the total basal area.

Cullenia exarillata was the most dominant species with a basal area of 14.35%, in Zone 3 (Appendix 3). *Palaquium ellipticum* (8.61%) and *Dipterocarpus* *indicus* (4.98%) occupied the second and third slots. The ten most dominant species contributed 47.98% of the basal area. *Cullenia exarillata* and *Palaquium ellipticum* were again the most dominant species, in Zone 4, and their contributions were 12.01% and 5.87% respectively (Appendix 4). *Gluta travancorica*, an endemic tree species to this zone, contributed to 5.21% of the total basal area. Zone 4 had the highest basal area of 162.16 m^2 with a mean of 13.53 m^2 and the top 10 species' contribution was 47.22%.

Zone 1	Zone 2	Zone 3	Zone 4	Zone overall
Poeciloneuron indicum	*Toona ciliata*	*Cullenia exarillata*	*Cullenia exarillata*	*Cullenia exarillata*
Syzygium gardneri	*Palaquium ellipticum*	*Palaquium ellipticum*	*Palaquium ellipticum*	*Palaquium ellipticum*
Dimocarpus longan	*Elaeocarpus tubercula-tus*	*Dipterocarpus indicus*	*Gluta travancorica*	*Myristica dactyloides*
Olea dioica	*Drypetes wightii*	*Diospyros foliolosa*	*Vateria indica*	*Syzygium gardneri*
Myristica dactyloides	*Persea macrantha*	*Stereospermum colais*	*Filicium decipiens*	*Elaeocarpus tubercula-tus*
Aglaia elaeagnoidea	*Cullenia exarillata*	*Syzygium cumini*	*Neolitsea fischeri*	*Dipterocarpus indicus*
Elaeocarpus tubercula-tus	*Dalbergia latifolia*	*Calophyllum polyan-thum*	*Myristica dactyloides*	*Poeciloneuron indicum*
Bischofia javanica	*Bischofia javanica*	*Aglaia elaeagnoidea*	*Mangifera indica*	*Vateria indica*
Lagerstroemia micro-carpa	*Syzygium gardneri*	*Myristica dactyloides*	*Syzygium cumini*	*Bischofia javanica*
Dipterocarpus indicus	*Hopea parviflora*	*Bischofia javanica*	*Hopea parviflora*	*Dimocarpus longan*

Table 3.7. The rank-order of the top 10 species in terms of basal area in the 4 zones and all the zones combined.

No species was dominant in all the 4 zones. Three were dominant in 3 zones (*Cullenia exarillata*, *Palaquium ellipticum* and *Myristica dactyloides*). *Elaeocarpus tuberculatus*, *Bischofia javanica*, *Hopea parviflora*, *Syzygium cumini*, *Syzygium gardneri* and *Aglaia elaeagnoidea* were the six species that were present in at least 2 zones (Table 3.7).

A majority of the plots were in the over 10 m^2 category (66.67%), with 29.17% in the over 5 m^2 category and followed 4.16% in the over 15 m^2 category (Figure 3.13). It is interesting to note that none of the plots were in the above 15 m^2 category, but for 2 plots belonging to Zone 4 (Table 3.8). Generally basal area decreased from Zone 4 to 1. Almost all the plots falling in the 1st category had been selectively felled in the recent past.

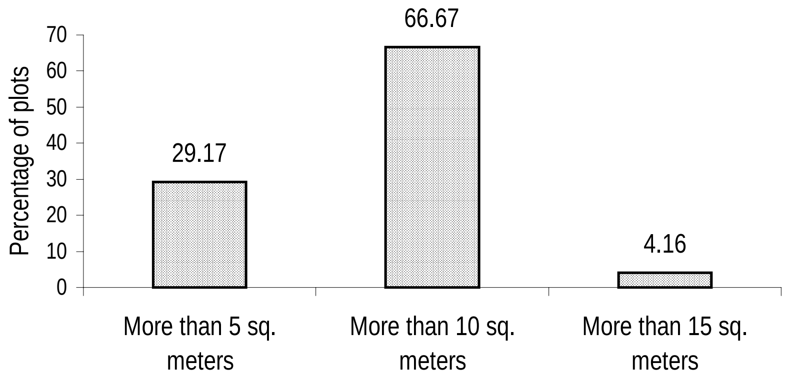


Figure. 3.13. Frequency distribution of basal area in 48 plots.

	More than 5 m^2	More than 10 m^2	More than 15 m^2
Zone 1	7	5	
Zone 2	4	8	
Zone 3	2	10	
Zone 4	1	9	2
	14 plots	32 plots	2 plots

Table 3.8. Categorization of the 48 plots based on their respective basal areas.

There was significant correlation between basal area per plot and altitude (r=0.431, n=48, *p*=0.002) and latitude (r= -0.558, n=48, *p*=0.000: Figure 3.14). The variation of the basal area at different latitudes was more pronounced than at various altitudes.

The correlation between basal area and altitude within the 4 zones is depicted in Figure 3.15. There was no significant relationship between basal area and altitude in any of the 4 zones.

Altitude (b) r =0.431, n=48, *p*=0.002 Latitude (c) r = -0.558, n = 48, *p*=0.000

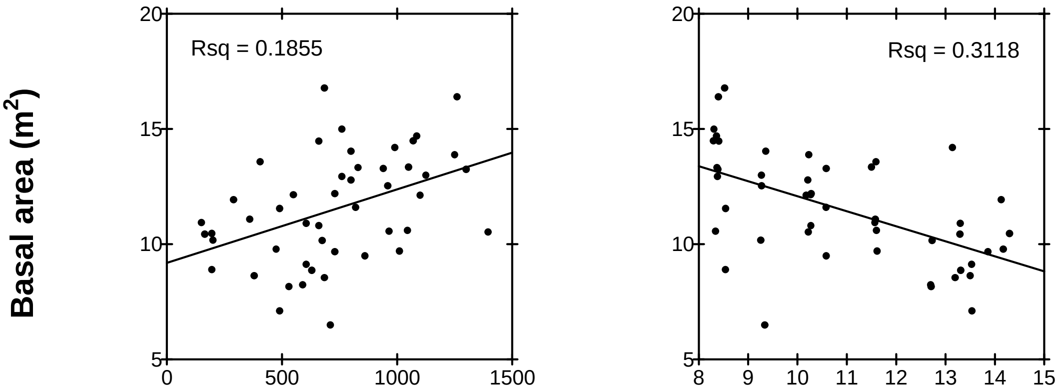


Figure 3.14. Basal areas in 48 plots in the 4 zones are plotted against altitude and latitude.

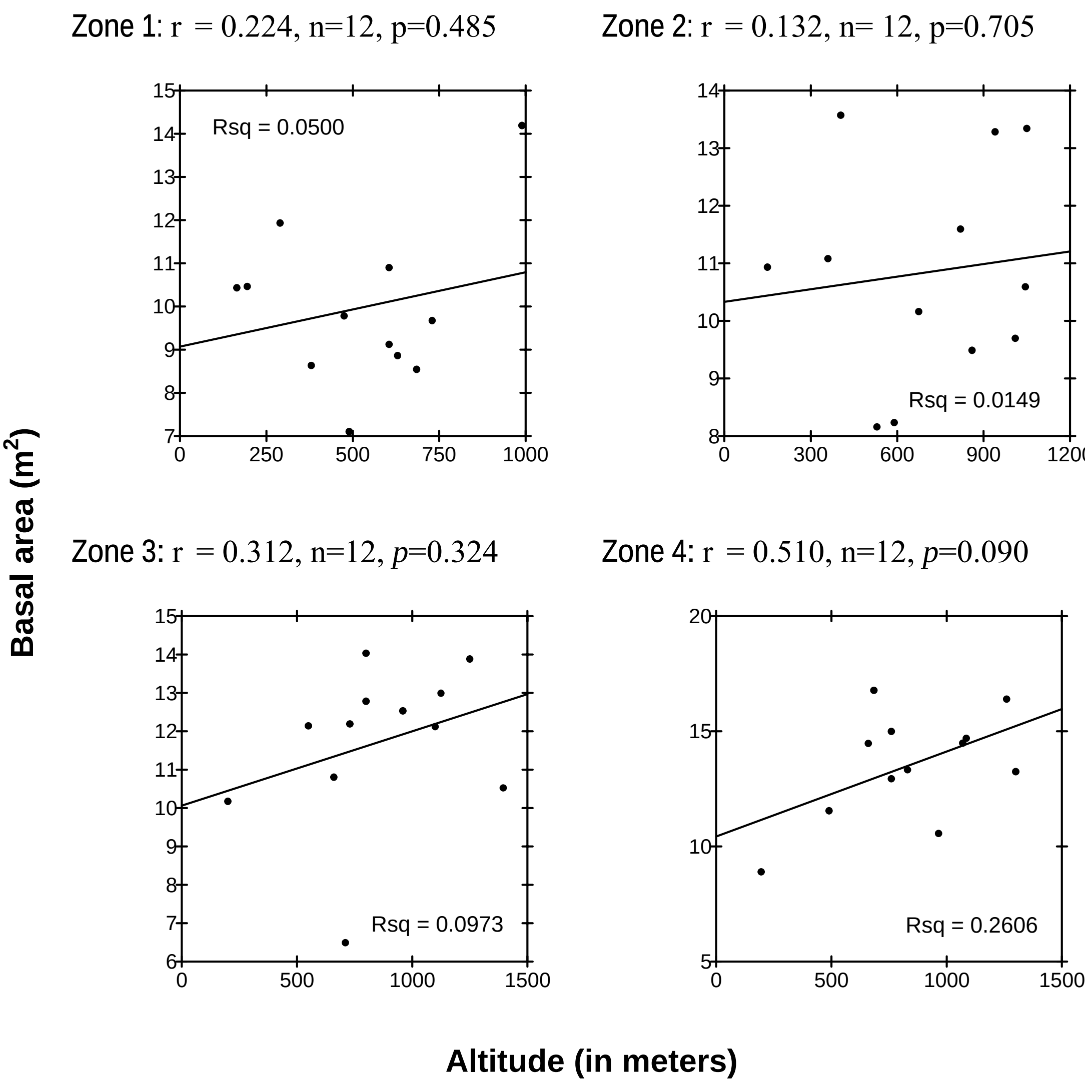


Figure 3.15. Basal areas in 12 plots in each of the 4 zones are plotted against altitude and latitude.

3.4.4. Girth-class frequency distribution

The maximum percentages of woody plants were in the 50 to 100 cm girth-class frequency, increasing initially, but decreasing almost monotonically with increasing girth-classes (Figures 3.16a). The lowest girth-class had a number of lianas. In contrast, most of the species had trees in the 30 to 50 cm. girth classes, closely followed by 51-100 cm girth class.

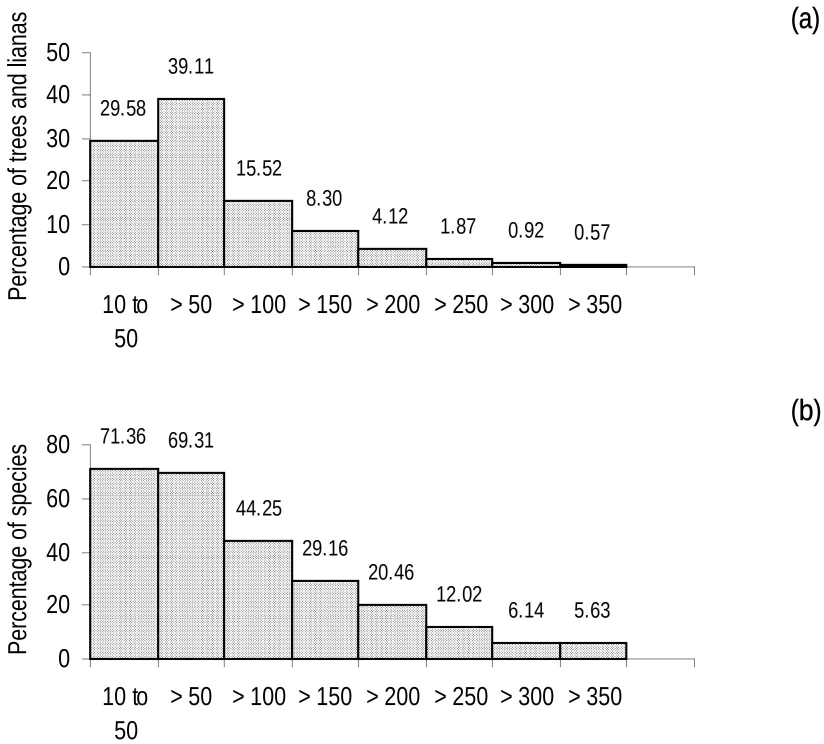


Figure 3.16. The percentage frequency distribution of individual woody plants (above) and species (below) in different girth classes, for all 4 Zones together.

However, Zone 1 had more trees in the lower girth classes, while trees in the higher girth classes increased in frequency from north to south (Figure 3.17a-d).

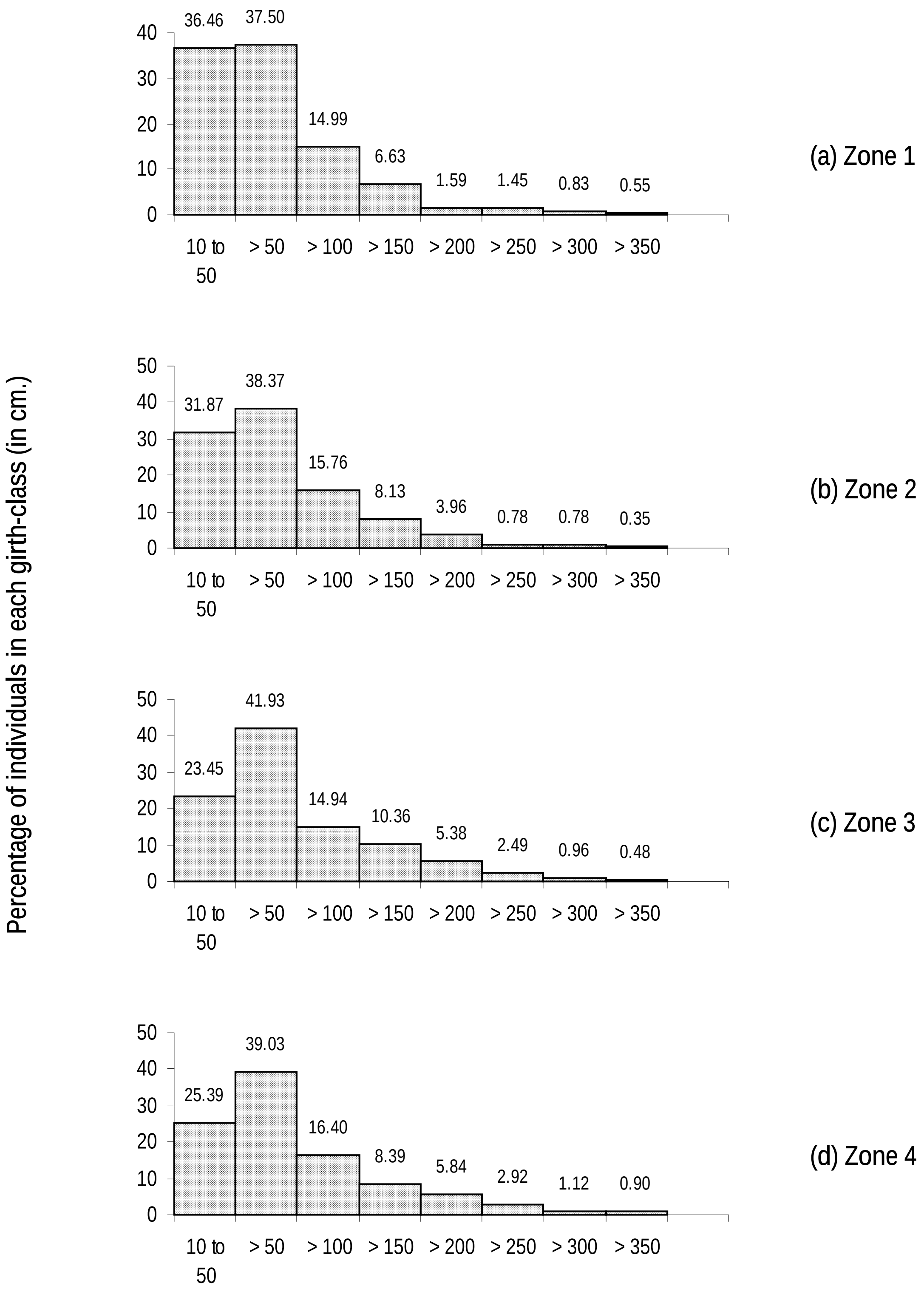


Figure 3.17. The frequency and distribution of trees and lianas in different girth classes (in cm.), in the 4 zones.

Nearly 90% of the individuals were < 200 cm in gbh in all the zones, but the percentages declined from north to south (χ^2 = 57.27, df=3, p<0.05: Figure 3.18).

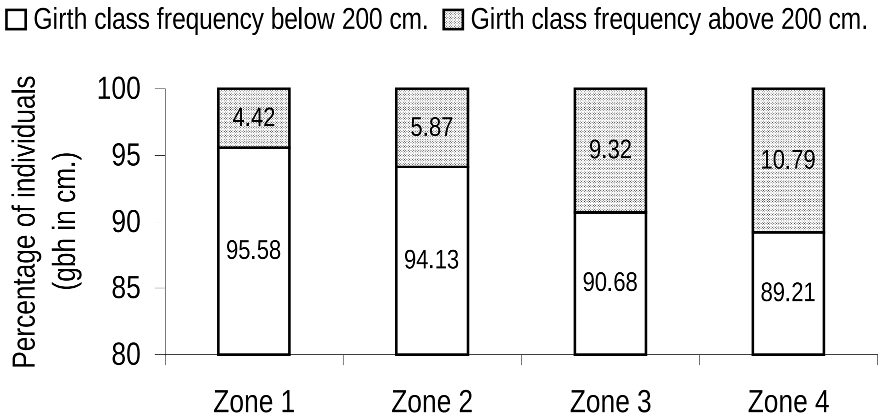


Figure 3.18. Percentage of individuals in the lower and higher girth-class frequencies, for each Zone.

Except for Zone 1 the maximum percentage of species were concentrated in the 51-100 cm. girth-class frequency (Table 3.19). The percentage of species in the higher girth classes increased from north to south (χ^2=3.21, df=3, p>0.05). The top rank-ordered species in each of the girth-class frequency is given in Table 3.9. As is evident most of the species given in Table 3.19 are in the top 10 ranking of each zone (Appendices 1-5) and are the food trees of the lion-tailed macaques. *Cullenia exarillata* is among the abundant in most girth-classes in Zones 3 and 4 and its dominance is apparent in the southern part of the Western Ghats. Like wise the most dominant plant in Zone 1, *Poeciloneuron indicum*, is present in many of the girth-classes. Of the 23 dominant species in different girth classes (some were in more than one girth class: (Table 3.9), 17 are food trees of the lion-tailed macaques.

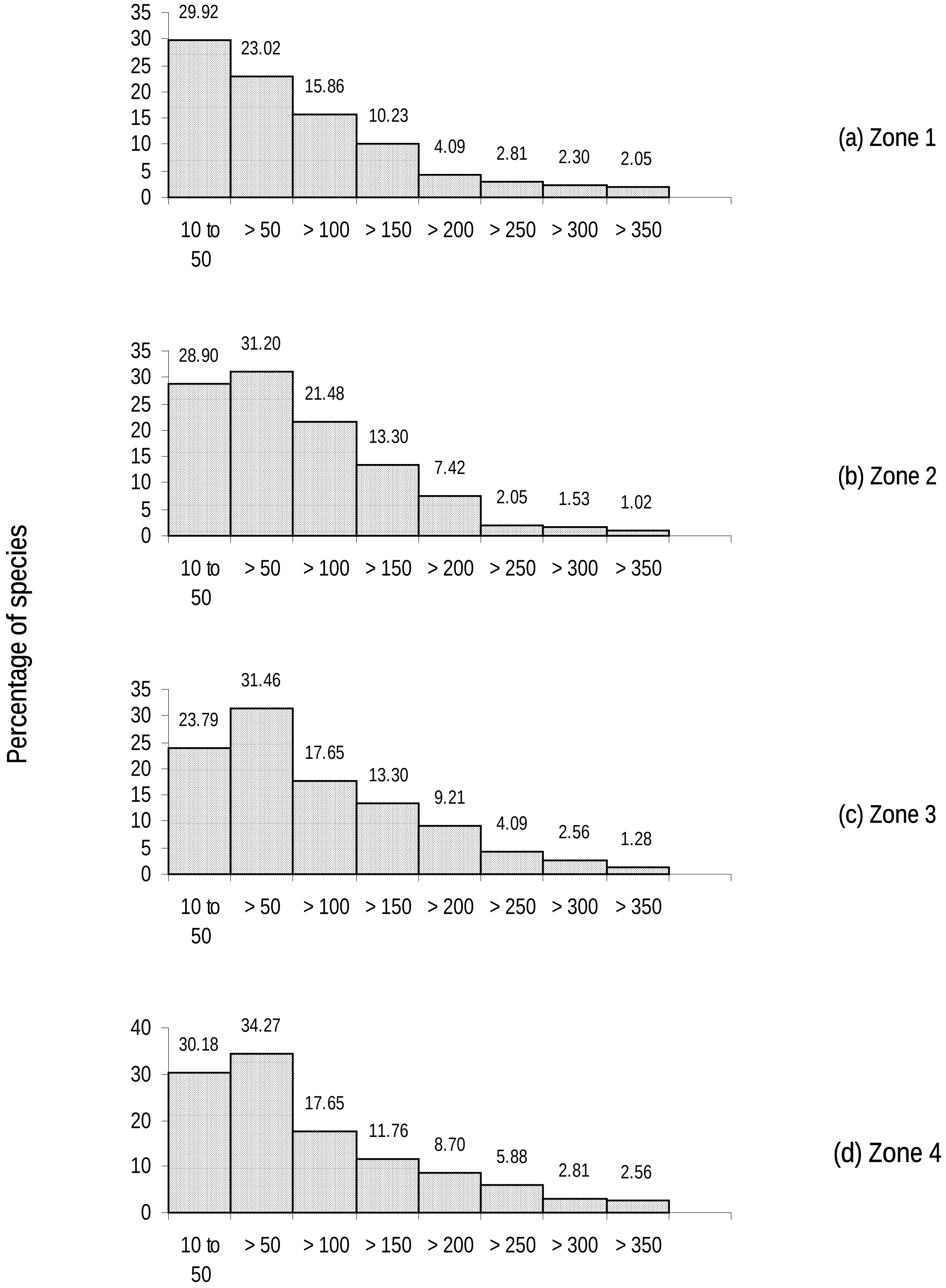


Figure 3.19. The percentage frequency distribution of species in different girth classes, in each of the 4 Zones.

Girth-class frequency	Zone 1	Zone 2	Zone 3	Zone 4	Zones overall
10 to 50 cm.	*Poeciloneuron indicum*	*Diospyros nilagirica*	*Diospyros foliolosa*	*Xanthophyllum arnottianum*	*Myristica dactyloides*
> 50 cm.	*Myristica dactyloides*	*Myristica dactyloides*	*Diospyros foliolosa*	*Cullenia exarillata*	*Myristica dactyloides*
> 100 cm.	*Poeciloneuron indicum*	*Palaquium ellipticum*	*Palaquium ellipticum*	*Myristica dactyloides*	*Palaquium ellipticum*
> 150cm.	*Poeciloneuron indicum* *Dimocarpus longan*	*Drypetes wightii*	*Cullenia exarillata*	*Cullenia exarillata* *Filicium decipiens* *Palaquium ellipticum*	*Cullenia exarillata*
> 200 cm.	*Dimocarpus longan*	*Dalbergia latifolia* *Palaquium ellipticum*	*Cullenia exarillata*	*Cullenia exarillata*	*Cullenia exarillata*
> 250 cm.	*Poeciloneuron indicum*	*Toona ciliata*	*Cullenia exarillata*	*Cullenia exarillata*	*Cullenia exarillata*
> 300 cm.	*Syzygium gardneri*	*Toona ciliata* *Bischofia javanica*	*Syzygium cumini*	*Cullenia exarillata*	*Cullenia exarillata*
> 350 cm.	*Antiaris toxicaria* *Bischofia javanica* *Calophyllum polyanthum* *Elaeocarpus tuberculatus* *Ficus nervosa* *Lophopetalum wightianum* *Stereospermum colais* *Syzygium gardneri*	*Persea macrantha*	*Stereospermum colais*	*Vateria indica*	*Elaeocarpus tuberculatus* *Stereospermum colais* *Vateria indica*

Table 3.9. The top rank-ordered plant species in each girth-class frequency for the 4 Zones and the Zone overall.

3.5. Discussion

3.5.1. Species richness

India has around 14,500 species of flowering plants (McNeely *et al*., 1990) and Western Ghats is home to some 3,500 of these (Subramanyam and Nayar, 1974). Of these about 823 are tree species (from Pascal, 1988; Sasidharan, 1997; Ramesh *et al*., 1997). In this study, I recorded 341 tree species and 50 lianas from 48 plots totaling an area of 12-ha. The only other study in the Western Ghats, with which this study is comparable in scope, is that of Pascal (1988). But has also sampled semi-evergreen and montane rainforests whereas mine was within the range of the lion-tailed macaques, which is in low- and mid-elevations. Also the plot size in that is smaller

(1000-1600 m^2) than this study and he has taken into consideration species of ≥ 10 cm. gbh.

Species richness was correlated with altitude but not with latitude. This is because lowland rainforests on the windward (western) side of the southern Western Ghats in Kerala were cleared long ago and much of the lowland rainforests at 100 m elevation still exist only in the South Canara, North Canara and Udipi Districts of Karnataka. Hence much of the intact rainforests in the south occur at higher altitudes. On the leeward (eastern) side of the Western Ghats in Tamil Nadu, rainforests had always occurred at higher altitudes due to the west-east gradient in rainfall (see Pascal, 1988).

Locality	Plot area (m^2)	No. of species
Silent Valley,Kerala	800	34
Silent Valley, Kerala	500	36
Attapadi, Kerala	1000	37
Attapadi, Kerala	2000	32
Nelliampathy, Kerala	10,000	30
Kadamakal, Karnataka	1600	70
Naravi, Karnataka	1600	35
New Someshwara, Karnataka	1400	25
Magod, Karnataka	1600	35
Suthanabi, Karnataka	1600	32
Bhagwathi, Karnataka	1000	12
Kankumbi, Karnataka	1600	44
Sengaltheri, TamilNadu	10,000	77
Sengaltheri, TamilNadu	10,000	64
Sengaltheri, TamilNadu	10,000	85
Sengaltheri, TamilNadu	10,000	84
Sengaltheri, TamilNadu	10,000	82
Sengaltheri, TamilNadu	10,000	80
Puthuthottam Estate, Tamil Nadu	1600	31
Varagaliyar, Tamil Nadu	1600	41
Kakkachi, Tamil Nadu	38,200	90
Lion-tailed macaque habitats, Western Ghats (Present study)	120,000	391

Table 3.10. Species richness in rainforest in various plot-sizes of various in the Western Ghats (data adapted from Ganesh *et al*., 1996). For references for individual plots, refer Ganesh *et al.* (ibid).

As mentioned earlier, there has been no study in the Western Ghats comparable to this, hence the species richness of various plots from the Western Ghats were compared with plot-size. It is interesting to note that there was a strong correlation between plot-size and species richness (r=0.934, n=21, $p<0.001$).

Neotropical	Southeast Asian	Australian & Papua New Guinea	This study
Fabaceae Moraceae Annonaceae Lauraceae Sapotaceae	Dipterocarpaceae Euphorbiaceae Fabaceae Myrtaceae Lauraceae Burseraceae Anacardiaceae	Lauraceae Sapotaceae Myrtaceae Elaeocarpaceae Meliaceae Clusiaceae Myristicaceae Rubiaceae Sapindaceae Moraceae	Euphorbiaceae Lauraceae Myristicaceae Clusiaceae Meliaceae Sapotaceae Ebenaceae Dipterocarpaceae Anacardiaceae Myrtaceae
Gentry, 1990	Whitmore, 1984 Proctor *et al*., 1988 Kochummen *et al*., 1990	Paijmans, 1970 Connell *et al*., 1984 Williams and Tracey, 1984 Wright *et al*., 1997	

Table 3.11. Dominant families from various tropical rainforest sites. Although Bombacaceae was one of the dominant families in my study it was not included because the dominance was due to a single species, *Cullenia exarillata*, and hence was not considered. Data adapted from Wright *et al*., (1997).

The plant families that are dominant in the rainforests of the Western Ghats are also dominant in other tropical rainforests sites (Table 3.11). Lauraceae was the dominant family with pantropical distribution. Moraceae that figure in the top 12 dominant families in my study is dominant in the Neotropical and the Australian rainforests. Dipterocarpaceae is the dominant family in Southeast Asia; this was because all the three studies were conducted in the lowland rainforests of Malaysia. But the Western Ghats was also Dipterocarpaceae rich. The fruits of Lauraceae and Euphorbiaceae are typically nutrient rich and the fruits of Moraceae (*Ficus*) are available throughout the year. Ebenaceae was conspicuous by its absence in other rainforest sites. Sapotaceae, one other family that was dominant in the Neotropical and Australian rainforests, has due representation in the rainforests of the Western Ghats.

3.5.2. Girth class frequencies, densities and basal area

In a plant assemblage, especially with respect to trees, a large number of individuals have small stem-diameter and this has been confirmed by several studies from the Western Ghats (Sukumar *et al*., 1992; Ganesh, *et al*., 1996; Pascal and Pelissier, 1996; Parthasarathy and Karthikeyan, 1997; Ayyappan and Parthasarathy, 1999; Parthasarathy, 1999; Srinivas and Parthasarathy, 2000) and in Sulawesi (O'Brien and Sinclair, unpublished data). This study also confirms this.

In this study I observed that trees with higher girth classes are from the Zone 4 and there is a steady decline towards Zone 1, which is the northern limit of this study area. In Zone 1, which is entirely in Karnataka, there has been large scale felling of tropical soft- and hard-wood in the distant- and near-past (Karanth, 1992; Kamath, 1981 cited in Swamy and Proctor, 1994). In fact selective felling was officially stopped only in 1989. The annual extraction of tropical soft-woods from the rainforests of Karnataka declined from 176,000 m^3 in 1976 to 80,956 m^3 in 1983 and subsequently to 36,482 m^3 in 1987 (Karanth, 1992). In spite of these large-scale disturbances, vast tracts of rainforests still exist in the coastal Karnataka plains, as moderate to large patches. One reason is that these 'production forests' have always been closer to or inside 'protected forests' (see van Schaik and Terborgh (1993) for more on this issue).

Huge trees like *Dipterocarpus indicus*, *Poeciloneuron indicum*, *Palaquium ellipticum*, *Vateria indica*, and *Ailanthus triphysa* (although this species is not native to these rainforests) were selectively felled to fuel the plywood and matchwood industries. In fact there has not been a single place in the Western Ghats that has been left untouched, but the degree varies from place to place (Pascal, 1988). This has resulted in an increase in the stem-density in Zone 1 when compared to other areas, but a decrease in basal area and girth.

This directional trend, such as an increase in stem-diameter and a decrease in basal area (which reflects the girth of trees) coupled with a lesser number of woody plant species may have a beneficial or detrimental effect on the frugivorous communities. In a study of the grassland ecosystem in the southern Western Ghats, Sankaran and McNaughton (1999) have disproved experimentally the popular belief that species rich and diverse habitats tend to be more resilient in the face of disturbance. They found that when subjected to controlled fire, demarcated plots that had high species richness responded no better than the species-poor plots. The plots came to be dominated by a single grass species, *Cymbopogon flexuosus*, which is not favored by the chital deer (*Axis axis*) and whose population is believed to be declining in the area (Kalakkad-Mundanthurai Tiger Reserve) where this study was done (Shahabuddin, 2001). This change in the species composition of the grasslands is having a cascading effect on the tiger (*Panthera tigris*) population, in Kalakkad-Mundanthurai Tiger Reserve, caused by the reduction of its ungulate prey (Ramakrishnan *et al*., 1999).

Although this sort of an experiment has not been done for the tree species, it is a fact that small- and large-scale disturbances could alter the floristic composition of these rainforests. In fact even 100 years after a patch has been clear-felled it will not have the species composition of a primary rainforest (Raman *et al*., 1998). This might be beneficial or otherwise for a frugivorous community depending on the plant species that might become dominant.

3.6. Summary

1) The goal of this study was to determine the species richness (α-diveristy) of the lion-tailed macaque habitats in Western Ghats from 8° N to 14.5° N (a distance of 720 km). Forty-eight belt-transects of 250x10 m (0.25 ha) were laid from the northernmost to the southernmost limit of the lion-tailed macaque.

2) There were totally 391 species, representing 210 genera and 64 plant families, with 5443 individual stems contributing to a basal area of 552.41 m^2 in an area of 12 ha. The species richness varied from 14 to 51 with a mean of 35.02 species per plot.

3) Species richness was correlated with altitude but not with latitude, but the density and basal area were correlated with altitude and latitude. The pristine rainforests in the Western Ghats are confined to the higher reaches and hence species richness is higher at higher altitude (< 1500 m msl). This could explain for the higher densities and basal areas also.

4) Many of the dominant plant families in the study area were dominant in other parts of the world.

5) The girth-class frequencies decreased monotonically with an increasing girth classes that were in concordance with other studies conducted in India and elsewhere.

6) The percentage of woody plant species in the higher girth classes had a directional gradient and increased from the north to south.

7) This study is the first of its kind in Western Ghats that looks into the vegetation-primate interaction. The findings will be useful for researchers interested in primate or rainforest ecology.

Chapter 4

Spatial distribution, β- and γ-diversity and estimation of species richness

4.1. Introduction

All natural environments are patchy (i.e., patchiness refers to distributional patterns of organisms, when individuals and or populations are aggregated on some spatial scales) in certain spatial or temporal contexts for all organisms (Tokeshi, 1999). Even when no physical boundaries exist, an environment can be regarded as a collection of habitat 'patches' for organisms with limited mobility, like plants. Further, organisms themselves often create a patchy landscape due to chance occurrence in an otherwise uniform environment. Where an organism occurs, its immediate local environment is modified, and a new set of microenvironments is created. Thus, habitat patchiness can result from both abiotic and biotic processes (Tokeshi, 1999). Random spatial patterns are rare and aggregated distributions are common in tree communities (Hutchings, 1986).

In any assembly of species the central paradigm is to estimate the "missing" species. Biological communities are not precisely defined, and so the richness of a community cannot be either. Often sampling is area based (quadrats, sampling distributed along transects, etc.) and so as sample size increases the area sampled does too. Ultimately this is a species-area phenomenon, and one expects species richness to be an ever-increasing function of sample area (Rosenzweig 1995). However, it may be appropriate to treat communities as though they were discrete, with biodiversity partitioned into two parts: the species richness of local communities, and the dissimilarity among these communities. Since it is not always possible to sample the entire area we want to estimate, certain techniques are used to extrapolate the species richness of a small subset.

4.2. Objectives

It was shown in Chapter 3 that despite a lack of differences in species richness/plot, species richness showed a south-north gradation at the zonal level. In this chapter, I examine whether patchiness is a factor causing this aspect.

The specific objectives are:

1) Assess the extent of patchiness in the distribution of woody plant species.
2) Evaluate the turnover of species, within (β-diversity) as well as between (γ-diversity) zones.
3) Estimate the overall woody plant species richness, of the lion-tailed macaque habitat, in the context of turnover of species.

4.3. Methods

4.3.1. Determining spatial distribution

The variance to mean ratio is the best indicator whether a species is generally clumped or spaced randomly. This was done using ***BioDiversity Pro 2***, a computer software.

4.3.2. Measuring β- and γ-diversity

The easiest way is to measure the β-diversity of pairs of sites or areas is by use of similarity coefficients that use both qualitative and quantitative techniques. This technique looks at the similarity of pairs of sites, either in terms of species presences and absences (qualitative data) or by taking species abundances into account (quantitative data: Magurran, 1998). I have used two similarity coefficients namely Sorenson's Measure (qualitative)

$$C_S = \frac{2j}{(a+b)}, \text{ (Magurran, 1988)}$$

where j=the number of species common to both sites

a=the number of species in site A, and

b=the number of species in site B.

The Morisita-Horn measure (quantitative) is calculated from the equation

$$C_{MH} = \frac{2\sum(an_i x bn_i)}{(da+db)aNxbN}, \text{ (Magurran, 1988)}$$

where aN = the number of individuals in site A,

bN = the number of individuals in site B,

an_i = the number of individuals in the *i*th species in site A,

bn_i = the number of individuals in the *i*th species in site B,

$$da = \frac{\sum an_i^2}{aN^2} \text{ and } db = \frac{\sum bn_i^2}{bN^2}$$

4.3.3. Estimating species richness

There are three general methods of estimating species richness: extrapolating species accumulation curves, fitting parametric models of relative abundance, and using non-parametric estimators. Species accumulation curves can be fit to equations that contain an asymptote, and the asymptote becomes the estimated species richness of the community. A difficulty with fitting asymptotic curves is that there are many different asymptotic equations, and multiple methods of fitting curves to them. This results in a plethora of different estimated richness values for the same observed species accumulation curve. Which of the different equations or curve-fitting methods is best is the subject of current investigation.

Before proceeding further, I would like to give a brief description about species accumulation curves. The rate of species accumulation is observed with a species accumulation curve. A species accumulation curve has some measure of effort, usually number of samples, on the horizontal axis, and cumulative number of species on the vertical axis. A particular ordering of samples produces a particular species accumulation curve. The last point on the curve will be the total number of species observed among all the samples. Changing the order of samples may change the shape of the curve, but not the endpoint. A smoothed or average species accumulation curve can be produced by repeatedly randomizing sample order, calculating a species accumulation curve for each randomization, and averaging the resultant curves. The curve for a highly under sampled fauna will be nearly linear, with each new sample adding many new species to the inventory. The curve for a thoroughly sampled fauna will reach a plateau, with few or no species being added with additional sampling.

I have used here Arrhenius (1921) power law, certain non-parametric estimators of Colwell (1997) and the Self-similarity model (Harte, 1997; 1999).

Arrhenius (1921) power law is:

$$S \cong cA^{z},$$

where S is the number of species found in a census area, A,

z is the slope and c is a constant.

For the non-parametric estimators I have used a computer program by Colwell (1997) ***EstimateS 5***. The following are the eight non-nonparametric estimators

1) Chao 1: An abundance-based estimator of species richness

$$S_{Chao1} = S_{obs} + \frac{F_1^{\,2}}{2F_2}$$

The variance estimator that ***EstimateS 5*** uses to compute the standard deviation for **Chao1** is

$$\mathrm{var}(S_{Chao1}) = F_2\left(\frac{G^4}{4} + G^3 + \frac{G^2}{2}\right)$$

$$\mathrm{var}(S_{Chao1}) = F_2\left(\frac{G^4}{4} + G^3 + \frac{G^2}{2}\right)$$

where, $G = \frac{F_1}{F_2}$

2) Chao 2: An incidence-based estimator of species richness

$$S_{Chao2} = S_{obs} + \frac{Q_1^{\,2}}{2Q_2}$$

The variance estimator that ***EstimateS 5*** uses to compute the standard deviation for Chao 1 is the same as for Chao1 (above), but with $G = \frac{Q_1}{Q_2}$

3) Jackknife 1: First-order jackknife estimator of species richness (incidence-based)

$$S_{jack1} = S_{obs} + Q_1\left(\frac{m-1}{m}\right)$$

4) Jackknife 2: Second-order jackknife estimator of species richness (incidence-based)

$$S_{jack2} = S_{obs} + \left[\frac{Q_1(2m-3)}{m} - \frac{Q_2(m-2)^2}{m(m-1)} \right]$$

5) Bootstrap: Bootstrap estimator of species richness (incidence-based) (Smith and van Belle, 1984)

$$S_{boot} = S_{obs} + \sum_{k=1}^{S_{obs}} (1 - p_k)^m$$

6) ACE: Abundance-based Coverage Estimator of species richness

First note that

$$S_{obs} = S_{rare} + S_{abund}$$

The sample coverage estimate based on abundance data is

$$C_{ace} = \frac{1 - F_1}{N_{rare}},$$

where, $N_{rare} = \sum_{i=1}^{10} iF_i$

Thus, this sample coverage estimate is the proportion of all individuals in rare species that are not singletons. Then the ACE estimator of species richness is

$$S_{ace} = S_{abund} + \frac{S_{rare}}{C_{ace}} + \frac{F_1}{C_{ace}} \gamma_{ace}^2$$

where γ_{ace}^2, which estimates the coefficient of variation of the F_i's, is

$$\gamma_{ace}^2 = \max \left\{ \frac{S_{rare}}{C_{ace}} \frac{\sum_{i=1}^{10} i(i-1)F_i}{(N_{rare})(N_{rare}-1)} - 1, 0 \right\}$$

7) ICE: Incidence-based Coverage Estimator of species richness: First note that

$$S_{obs} = S_{infr} + S_{freq}$$

The sample coverage estimate based on incidence data is

$$C_{ice} = 1 - Q_1 / N_{infr} \ ,$$

where, $N_{infr} = \sum_{j=1}^{10} jQ_j$

Thus, the sample coverage estimate is the proportion of all individuals in infrequent species that are not uniques. Then the ICE estimator of species richness is

$$S_{ice} = S_{freq} + \frac{S_{infr}}{C_{ice}} + \frac{Q_1}{C_{ice}} \gamma_{ice}^2$$

where γ_{ice}^2, which estimates the coefficient of variation of the Q_j's, is

$$\gamma_{ice}^2 = \max\left\{ \frac{S_{infr}}{C_{ice}} \frac{m_{infr}}{(m_{infr} - 1)} \frac{\sum_{j=1}^{10} j(j-1)Q_j}{(N_{infr})^2} - 1, 0 \right\} .$$

8) Michaelis-Menten Estimators: ***EstimateS 5*** computes two different Michaelis Menten (MM) richness estimators. In both, the data the program produces represent the estimated MM asymptote (see Colwell and Coddington 1994 cited in Colwell, 1997) based on one, two, three...QdMax samples (see Colwell and Coddington 1994 cited in Colwell, 1997, Fig. 1). The difference is that the first method (MMRuns) computes estimates for values for each pooling level, for each randomization run, then averages over randomization runs. If you have some samples that are much richer than other, randomization runs that, by chance, add a rich sample early in the curve are likely to produce enormous estimates of richness, since the rich sample "shoots" the fitted MM curve suddenly skyward. Thus, MMRuns data are often rather erratic for small numbers of samples, even when 100 runs are randomized.

The second method (MMMeans) computes the estimates for each sample pooling level just once, from the mean species accumulation curve. Since this curve becomes quite smooth when many randomizations are averaged, the MM estimates are much less erratic than for the MMRuns method. Because "outlier" runs are thus suppressed, the MMMeans estimates are usually somewhat lower than for the MMRuns method, for corresponding sample pooling levels, especially so at low sample pooling levels.

Definition of variables

V_{est}	Estimated number of species shared by samples *j* and *k*
V_{obs}	Observed number of species shared by samples *j* and k
$V_{jk(abund)}$	Observed number of shared, abundant species (>10 individuals in sample j, in sample k, or in both)
$V_{jk(rare)}$ or, in series or summations, **v**	Observed number of shared, rare species (≤ 10 individuals in sample j *and* ≤10 individuals in sample k)
$X_1 \ldots X_i \ldots X_v$	Number of individuals of rare, shared species i in sample j
$Y_1 \ldots Y_i \ldots Y_v$	Number of individuals of rare, shared species i in sample k
$f_{1\cdot}$	Total number of singletons ($X_i = 1$) among rare, shared species in sample j
$f_{\cdot 1}$	Total number of singletons ($Y_i = 1$) among rare, shared species in sample k
f_{1+}	Number of rare, shared species that are singletons in sample j but have $Y_i > 1$ in sample k
f_{+1}	Number of rare, shared species that are singletons in sample k but have $X_i > 1$ in sample j
f_{11}	Number of rare, shared species that are singletons in both samples j and k

N_{1+}	Number of individuals in sample k for rare, shared species that are singletons in sample j
N_{+1}	Number of individuals in sample j for rare, shared species that are singletons in sample k
C_{jk}	Sample coverage for rare, shared species

Some non-parametric methods show promise for richness estimation. These methods have been developed for the general problem of taking a sample of classifiable objects and estimating the true number of classes in the population. In ecology, such methods have been most frequently applied to estimating population size from mark recapture data. Estimating richness is essentially the same problem, with the abundance of a species in a sample equivalent to the number of captures of an individual in a mark recapture study (Longino and Colwell, 1997).

Harte's Self-similarity model is very simple in the sense that one has to calculate the Commonality Factor (C_f)

$$C_f = \frac{S}{\{(A + B)/2\}},$$

where, S is the number of shared species between plots 1 and 2 and

A and B are the species richness for plots 1 and plot 2 respectively. This can also be called Sorenson's measure.

Having calculated the commonality factor C_f, the logarithmic values of C_f and the geographical distances (G_d) are regressed to get the 'r' value (0.335). From the 'r' value we calculate the slope of the regression line (Figure 2a)

$$\text{Slope} = \frac{r * SD_{C_f}}{SD_{G_d}}, \text{ where}$$

SD_{Cf} and SD_{Gd} are the standard deviations of the commonality factor the geographical distances respectively. Since slope is equal to 2z, we also calculate the value for the constant 'z' (0.358). Having thus estimated z, we can now estimate the total species richness in an area **A** by taking the average number of species in the small censused plots, of area $\mathbf{A^1}$, and then using the species area law in the form:

$$S_A = S(A^1) * (A / A^1)^z$$

4.4. Results

4.4.1. Spatial distribution of species

Here I analyze the spatial distribution of the species using a χ^2 'Goodness of Fit' test using the software ***BioDiversity Pro 2***. χ^2 tests are used to measure patchiness in species populations or in whole communities (i.e. whether the organisms are distributed randomly through the samples or aggregated or uniformly distributed). The whole community analysis can also be used to assess whether individual species are randomly distributed with respect to each other, or aggregated together or aggregated in different samples. The variance to mean ratio of the density of a species, used by ***BioDiversity Pro 2***, is a simple yet reasonably robust measure of its dispersion pattern (Krebs, 1989). A ratio of 1.0 indicates a random dispersion, < 1.0 a uniform dispersion and > 1.0 an increasingly clumped dispersion. Based on this we see that for the entire community or cumulatively for the 48 plots the spatial distribution of the majority of the species (65.99%) were clumped, 22.25% were random and 11.76% were uniformly dispersed. Of the top 10 species with the highest IVI values (Appendix 5), five were randomly distributed, four were clumped and only one species was uniform in its dispersion.

A majority of the species belonging to top ten families was clumped and the percentage of aggregation was as follows: Ebenaceae (81.25%, n=16), Annonaceae (80.00%, n=15), Anacardiaceae (80.00%, n=15), Myrtaceae (65.00%, n=20), Fabaceae (63.64%, n=22), Euphorbiaceae (61.76%, n=34), Lauraceae (54.54%, n=33), Moraceae (53.86%, n=13), Meliaceae (53.86%, n=13) and Rubiaceae (43.75%, n=16). Some genera like *Elaeocarpus* (100%, N=5), *Garcinia* (100%, N=5) and *Syzygium* (64.29%, N=14) on which the lion-tailed macaques are dependent were clumped or aggregated. *Ficus* (55.55% aggregation, N=9) was also aggregated as per expectations (see Heithaus and Fleming, 1978; Gautier-Hion and Michaloud, 1989).

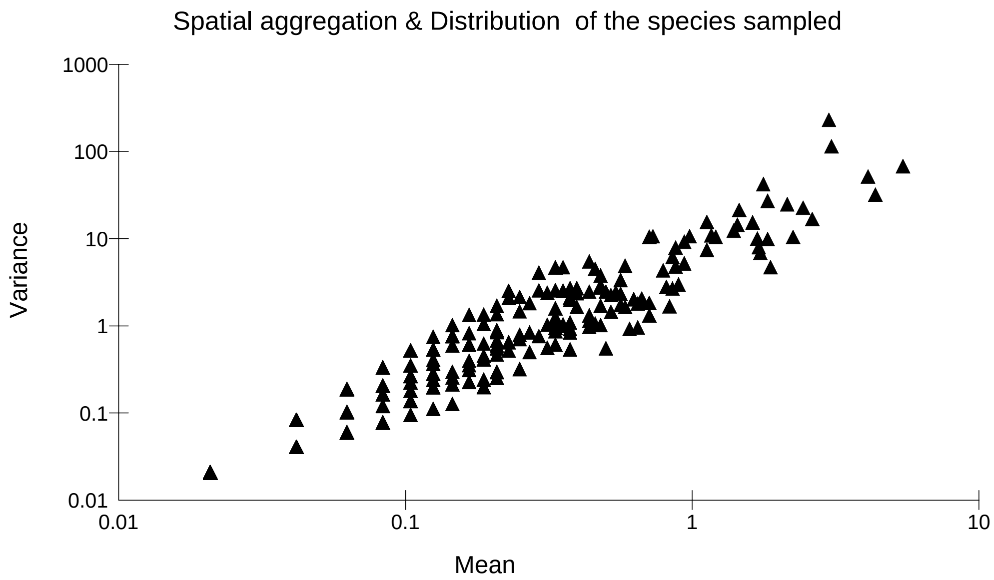


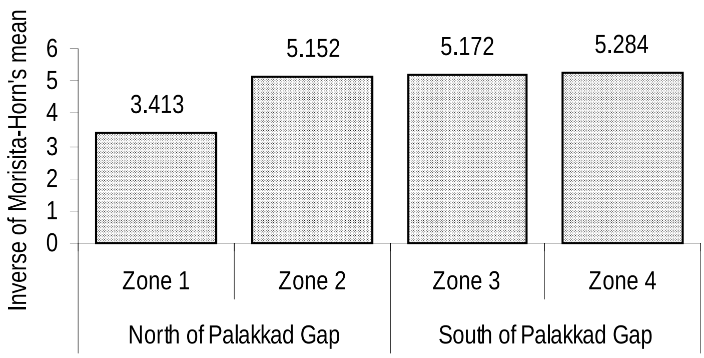
Figure 4.1. A variance-mean plot showing the spatial dispersion of all the species sampled (N=391). 65.99% of the species have variance-mean ratio > 1.0.

From Figure 4.1 we see that a majority of the species is aggregated between a mean of 0.1 and 1. We see that there is a clumped or aggregated distribution between each species.

4.4.2. β- and γ-diversity of the lion-tailed macaque habitats

4.4.2.1. β-diversity

The β-diversity was estimated as the inverse of the overlap between pairs of plots within the 4 zones. The β-diversity (the inverse of overlap) was significantly different among zones (Sorenson: K-W χ^2=39.45, df=3, p<0.001 and Morsita-Horn: K-W: χ^2=18.43, df=3, p<0.001). The southern zones had a greater turnover of species among plots, than the 2 northern zones (Figure 4.2). The β-diversity showed a south-north directional trend (Figure 4.2). The inverse of the means generated by the Morisita-Horn and Sorenson Indices were used so that the trend was clearly visible.



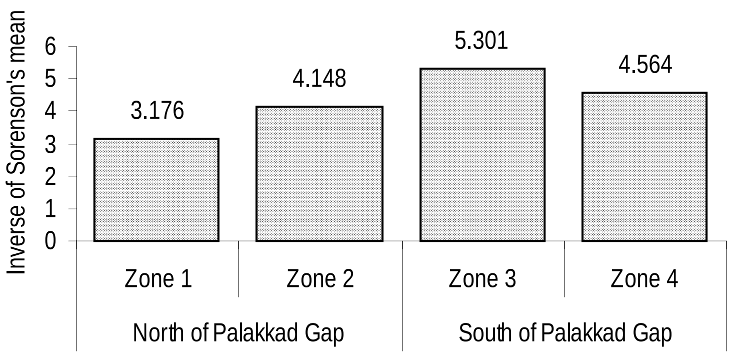
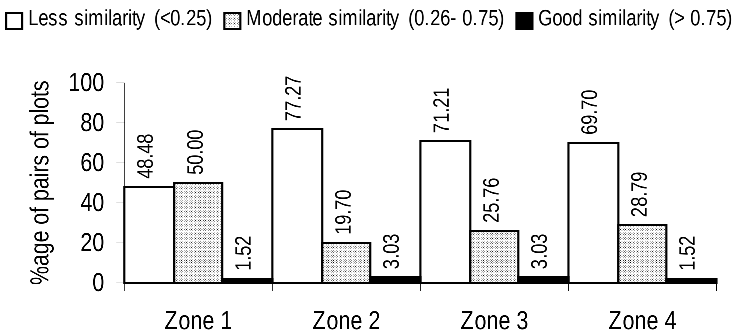


Figure 4.2. The β-diversity or species is higher in the south than north.

The high overlap between plots in the north (or conversely low β-diversity or turnover of species) is obvious when we examine Figure 4.3. In contrast the turnover or β-diversity increases towards the south, showing that turnover of species is a south-north declining gradient. This was obvious from both Sorenson and Morisita-Horn Indices. The plot-pair values generated by these two indices are given in Appendix 8 (Sorenson) and Appendix 9 (Morisita-Horn).



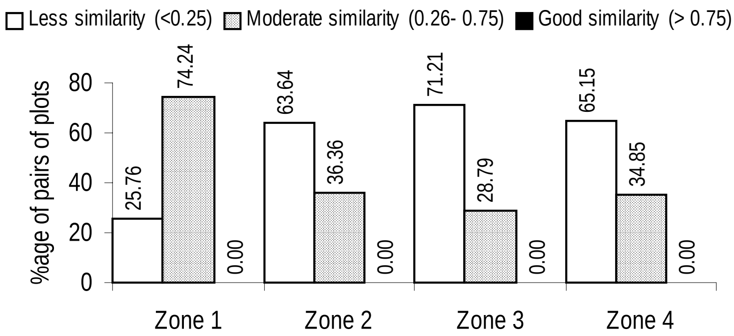


Figure 4.3. The frequency distribution of pairs of plots with the 4 zones, in different classes of overlap for Morisita-Horn (top) and Sorenson (bottom).

4.4.2.2. γ-diversity

γ-diversity here represents the turnover of species between pairs of plots from different zones. The species turnover was significant for both Sorenson (K-W: χ^2=50.83, df=5, p<0.001) and Morisita-Horn (K-W: χ^2=14.56, df=5, p<0.05). The species turnover was the highest between Zone 1 & 3 and Zones 1 & 4, and the lowest between Zones 1& 2 (for Morisita-Horn: Figure 4.4).

The γ-diversity based on the actual figures generated by the two indices also shows that the species turnover between Zones 2 and 3 are the highest (Figure 4.5).

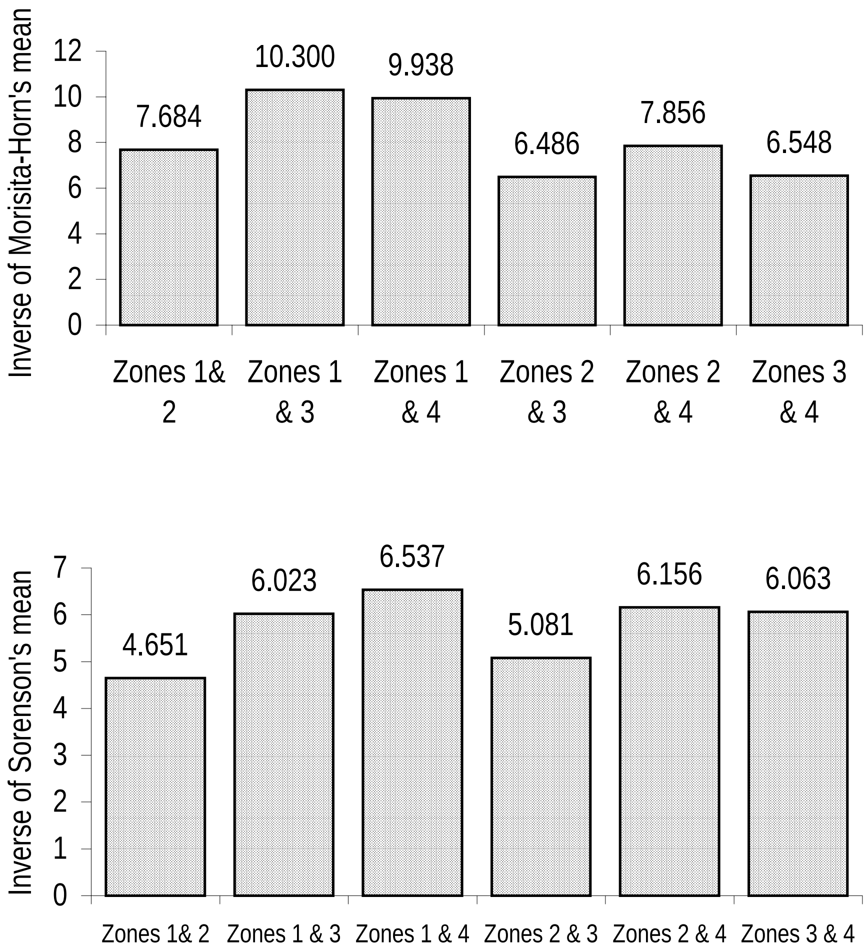
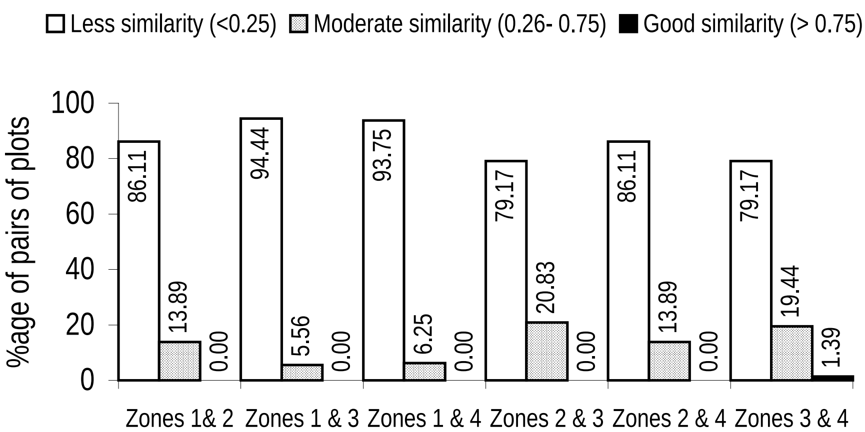


Figure 4.4. γ-diversity was the highest between Zone 1 and 4. These two zones are at the extremes of the lion-tailed macaque habitat.



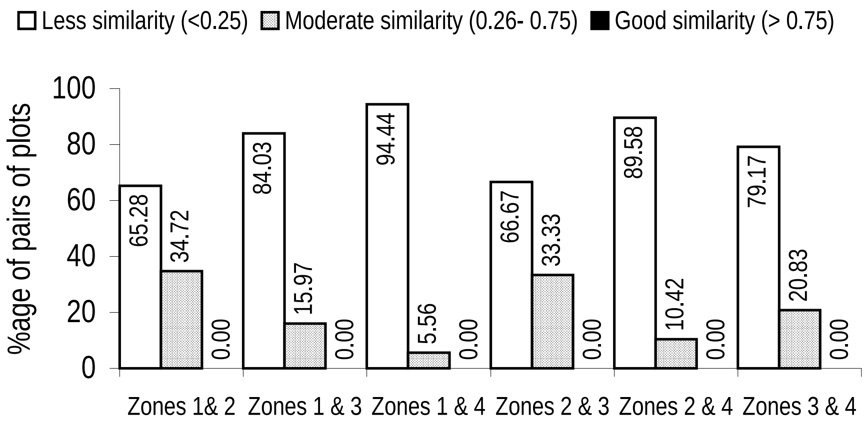


Figure 4.5. The frequency distribution of pairs of plots within the 6 zone-pairs, in different classes of overlap for Morisita-Horn (previous page) and Sorenson (this page).

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4.4.3. Species-richness estimation

4.4.3.1. Species area relationship

From the empirical data from 48 plots of 2500 m^2 each, the parameters of the Arrhenius equation were estimated as z=0.358 and c=5.94. Using this equation for the entire area of the lion-tailed macaque (720 km long, on the average 40 km wide: i.e., 28,800,000,000 m^2) we obtain an estimate of 32,980 species, clearly an over estimate. Hence we need models that will give us a realistic estimation of the number of tree species that could be present in the area we want to calculate approximately. I have used two models here: the first is based on the assumption that the 48 discrete plots are contiguous and the second model assumes that the 48 plots are randomly placed in a landscape (which is how the plots were).

4.4.3.2. Colwell's *EstimateS 5* model

Using a statistical package *EstimateS 5* (Version 5: Colwell, 1997) the species-richness was estimated from the 48 plots. In this model there are 8 methods to estimate the species richness using non-parametric statistics. In these methods, the assumption is that the species-area curves should reach the classic asymptotic form at sumption is that the species-area curves should reach the classic asymptotic form at a very early stage and forms a plateau (Chazdon *et al*., 1999).

The species-accumulation curve for the observed species did not reach the classic asymptotic form even after the 48th plot. For the complete data set the Jack-knife estimators (1 and 2) showed the highest estimate for species-richness with 504 and 475 species and Michaelis-Menton showed the lowest estimate with 412 species. The eight species-rich estimators were still increasing at the final sample sizes.

The ICE (Figure 4.6A), ACE estimator (Figure 4.6B), Bootstrap (Figure 4.6C), Chao 1 (Figure 4.6D), Jackknife 1 (Figure 4.6F) increased with sample size at a rate mirroring the increase in observed species richness. Except for Michaelis-Menten, these estimators are all based on incidence patterns of species within plots and require only presence/absence data. The equations for these calculations are given in the Methodology section (4.3.3).

However the data set did not satisfy all of the criteria for an ideal estimator from the above models, because the models are good for only contiguous areas (Chazdon *et al*., 1999; Colwell, pers. comm.) and not plots that are randomly placed in a large area like the Western Ghats. The latter is the reason for the species richness not reaching an asymptote even at the 48 plots. These estimators are not effective also because they mirror the observed species richness.

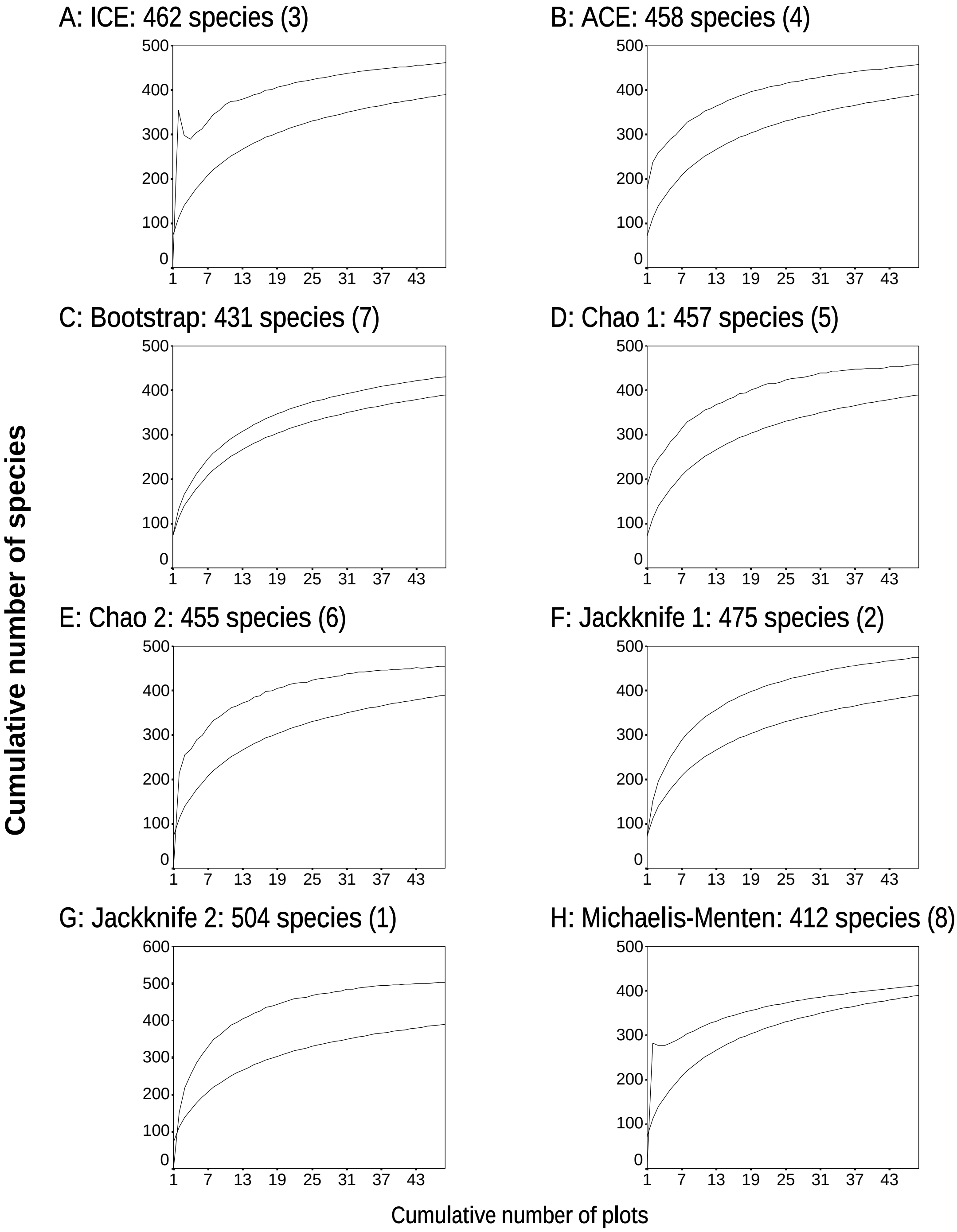


Figure 4.6. Performance of the eight species richness estimators for the 48 plots in the lion-tailed macaque habitats. The lower curve in each graph plots the observed number of species as a function of the number of pooled sampling plots as described in the Methodology section. The upper curve in each graph displays the estimated total species richness based on successively larger (estimated) numbers of pooled samples from the data set. The numbers are the estimated species richness for each of the 8 methods and the ranks are given within parenthesis.

4.4.3.3. Harte's Self-similarity model

Since the above models failed, we now turn to Harte's model based on the geographical distances between the randomly sample 48 plots. This model is based on the power law of Arrhenius (1921) and Harte *et al*. (1999) have shown that the power law is equivalent to self-similarity.

To estimate the species richness for the area in consideration i.e., the lion-tailed macaque habitat (720x40 km^2 or 2.88 x 10^{11} m^2) we need to know the number of species that are common and the geographical distance (either in kilometers or meters) between any plot-pair (say between plots 1 and 2 or plots 43 and 7 or plots 34 and 48 so on and so forth). For the 48 plots I have sampled, there are 1128 plot-pair combinations. From *EstimateS* ® I calculated the species that are common to any plot-pair combination. From this I calculated the commonality factor C_f using equation 2

$$C_f = \frac{S}{\{(A+B)/2\}},$$

where S is the number of shared species between plots 1 and 2 and A and B are the species richness for plots 1 and plot 2 respectively.

Having calculated the commonality factor C_f, the logarithmic values of C_f and the geographical distances (G_d) are regressed to get the 'r' value (0.335). From the 'r' value we calculate the slope of the regression line (Figure 4.7a)

$$\text{Slope} = \frac{r * SD_{C_f}}{SD_{G_d}}, \text{ where}$$

SD_{Cf} and SD_{Gd} are the standard deviations of the commonality factor the geographical distances respectively. Since slope is equal to 2z, we also calculate the value for the constant 'z' (0.358). Having thus estimated z, we can now estimate the total species richness in an area **A** by taking the average number of species in the small censused plots, of area $\mathbf{A^1}$, and then using the species area law in the form:

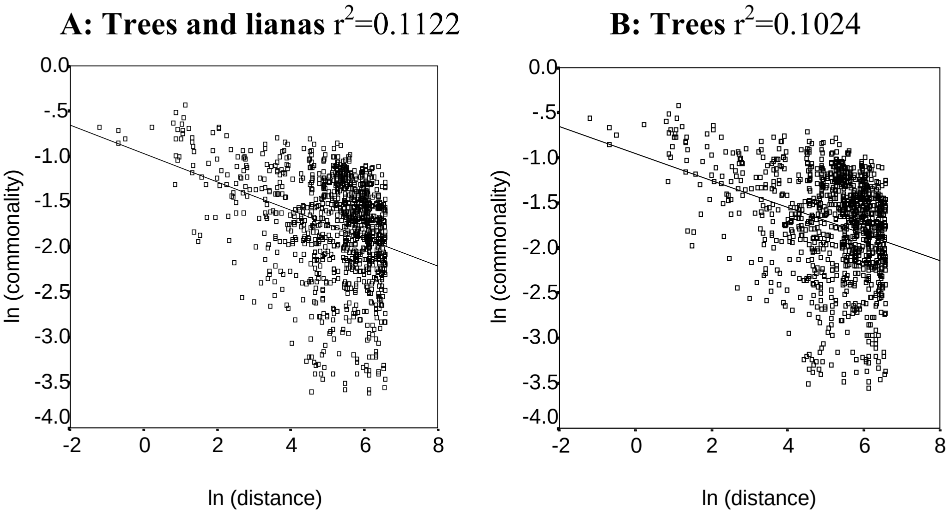


Figure 4.7. Dependence of ln (commonality: C_f) with ln (distance: G_d). The lianas are relatively less than the trees, hence the figures (a) and (b) look similar.

$$S_A = S(A^1) * (A / A^1)^z$$

$$S_A = (35.02) * (28{,}800{,}000{,}000\ m^2 / 2{,}500\ m^2)^{0.358} = \mathbf{1202}$$

Thus the estimated woody plant species richness for the area (28,800 km^2) is 1202. Now we have a problem, the woody plant species includes trees and lianas. We do not know the species richness of the lianas in the rainforests of the lion-tailed macaque habitats. But we have a reasonable figure for the tree species richness, which is around 823 species (data from Pascal, 1988; Sasidharan, 1997; Ramesh *et al.*, 1997 and this study). Hence if we apply the species area law for the estimated tree species richness, which is

$$S_A = (32.48) * (28{,}800{,}000{,}000\ m^2 / 2{,}500\ m^2)^{0.342} = \mathbf{853}$$

This figure of 853 tree species is perhaps more realistic being closer to the known species richness. But if we apply the same parameter to lianas we get an estimated species richness of 41,816. We know this figure is not realistic, but the reasons for this figure could be many. First of all, lianas are not present in 27.1% of the plots and nearly 86.6% of the plot-pair combinations had no species common between them. So the best option under the present situation is to find the difference between the estimated species richness between the woody plant species and trees. If we do this we get a figure of 349 for the liana species richness, which could be more realistic. Considering this, the self-similarity model gives us a reasonable prediction about the species richness in the lion-tailed macaque habitats.

4.5. Discussion

4.5.1. Spatial distribution

In my study nearly 65.99% of all the woody plant species were aggregated, 22.25% were random and 11.76% were uniformly dispersed (Appendix 7). Similarly rare species were also aggregated (55.09%). Similarly, 74.29% of the endemic species were aggregated, 16.43% were randomly dispersed and 9.29% were uniform. But the dispersion of the endemic woody plant species was more highly aggregated and patchy (74.29%) and the rest was either random or uniformly distributed. In my study nearly there were 216 (55.25%) species that could be termed rare, since these species had ≤ 5 individuals in the 48 plots or had a density of ≤ 0.42 individuals per hectare. Rarity or commonness is a term that has baffled ecologists for a long time and the criterion for choosing whether a species is rare also vague (see Kadavul and Parthasarathy, 1999; Krishnamani and Kumar, 2000; Pitman *et al*., 2001). 55.09% of these rare species were aggregated, 29.63% were uniform and 15.28% were uniformly dispersed.

In a study of six tropical forest sites, Condit *et al*., (2000) found that most of the tree species were aggregated, but at higher girth classes. They also found that the rare species (N < 50 individuals) were the most aggregated. Random distributions of plants have often been reported in desert perennial plant communities and it is the result of competition for water (Woodell *et al*., 1969).

4.5.2. β- and γ-diversity

In the Western Ghats, as one proceeds from south to north we notice that the species turnover. One reason is the vicarious species, closely related species which replace one another geographically, altitudinally or ecologically, at every degree increase in latitude (Pascal, 1988). Some of the vicarious species are found in the genera of *Diospyros*, *Microtropis*, *Garcinia*, *Humboldtia* and *Vateria* (Ramesh *et al*., 1997). This high species turnover is the reason why the rainforest are species rich. Endemic species also contribute to this high turnover. In fact there are endemics for each Zone (Table 2.1). This high species turnover has also contributed to different vegetation associations within these rainforests (see Pascal, 1998). The high turnover of species in the southern zones is also the reason for southern Western Ghats being more species rich. Thus β- and γ-diversity contribute significantly to the overall species richness in Western Ghats.

4.5.3. Species richness estimation

To attempt at such estimation I have used a non-parametric estimator software namely, *EstimateS*® (Colwell, 1997) and the Self-similarity model developed by Harte (Harte and Kinzig, 1997; Harte *et al*., 1999; Harte *et al*., 2001)). Both the models are based on Arrhenius' (1921) power-law function. The *EstimateS*® model is ideal only in conditions when the area in question is contiguous (Chazdon *et al*., 1998; Colwell, pers. comm.) and hence the estimated maximum species richness of 504 is a gross underestimate. But then *EstimateS*® model mirrors the species-area curves of the observed species richness. The species-area curve did not reach the asymptote even after the 48th plots, hence the 8 estimators in the *EstimateS*® model also did not reach the asymptote.

Syzygium makul Gaertn. f.	Range extension	Manilal and Sabu, 1984
Syzygium neesianum Arn.	Range extension	Manilal and Sabu, 1984
Cinnamomum nicolsonianum Manilal & Shylaja	New	Manilal and Shylaja, 1986
Syzygium parameswaranii Mohanan & Henry	New	Mohanan and Henry, 1987
Palaquium ravii Sasi. & Vink	New	Sasidharan and Vink, 1991
Cinnamomum chemungianum Mohan. & Henry	New	Mohanan and Henry, 1991
Cassine kedharnathii Sasi. & Swarup.	New	Sasidharan and Swarupanandan, 1992
Diospyros ghatensis Ramesh & De Franchechi	New	Ramesh and De Franceschi, 1993
Diospyros pyrrhocarpoides Ramesh & De Franchechi	New	Ramesh and De Franceschi, 1993
Polyalthia shendurunii Basha & Sasi.	New	Basha and Sasidharan, 1994
Nothopegia vajravelui Ravikumar & Lakshmanan	New	Ravikumar 1999
Syzygium sriganesanii Ravikumar & Lakshmanan	New	Ravikumar 1999
Syzygium zeylanicum var. *megamalayanum* Ravikumar & Lakshmanan	New	Ravikumar 1999
Ficus caulocarpa Miq.	Range extension	Sasidharan and Augustine, 1999a
Ficus costata Ait.	Range extension	Sasidharan and Augustine, 1999a
Syzygium periyarensis Jomy and Sasi.	New	Sasidharan and Augustine, 1999b
Dillenia suffruticosa (Griffith) Martelli in Becc.	Range extension	Murthy, 2000

Table 4.1. List of tree species that have been discovered in the past few years. Some are new to science and Western Ghats and some have an extended range. Range extension means tree species that are found elsewhere (like Sri Lanka, Malaysia etc) and whose distribution has been discovered in the Western Ghats.

Harte's model faired very well and we get an estimate of 853 tree species. From Pascal (1988), Sasidharan (1997) and Ramesh and Pascal (1997) we get a figure of 823 tree species. Now this is true only for the lion-tailed macaque habitats. What about the rest of the Western Ghats? We can look at it in two ways. Firstly, the study area covered the best remaining rainforest and since β-diversity declines with latitude, many additions to species are not likely. Secondly if we extend the sampling range we *might* get a figure of around 1000-1100 trees species. But then new tree species are being discovered that are either new to science or have an extended range (Table 4.1). In this case,a total species richness of 1000-1100 is likely!

There is also this scenario where the species turnover declines as one moves from south to north in the Western Ghats. There are several reasons for this change in floristic composition, the most distinct being the sudden appearance or disappearance of a species from one area to another. In Western Ghats some species do not disappear but lose their predominance to other and at times they are replaced by vicarious species (Pascal, 1988). This may be the case with other forest formations also.

4.6. Summary

In this chapter, I examined the spatial distribution and turnover of species within and between the four zones, using data from 48 plots.

1) Most of the woody plant species (65.99%) were spatially clumped or aggregated while 22.25% were randomly and 11.76% were uniformly dispersed. Clumping was greater among endemic and rare species.
2) The β-diversity was high in all zones and was especially higher in the southern rather than the northern part of the lion-tailed macaque habitat. This turnover is the major reason for the higher species richness in southern Western Ghats, since α-diversity does not seem to vary (Chapter 3).
3) The γ-diversity was the highest between Zones 1 and 4, which was expected because they both occupy the extremes of the lion-tailed macaque habitats.
4) The total species richness estimated for the lion-tailed macaque was fairly accurate with Harte's Self-Similarity model, compared to other non-parametric estimators. The estimated overall species richness of trees was 853 compared to 823 species that are currently known from the Western Ghats.

Chapter 5

Species richness, density and basal area of lion-tailed macaque food plants

5.1. Introduction

Studies of wildlife-vegetation relationships have generally focused on the development of models that predict animal presence or diversity or abundance. These models are based on assumed relationships between animal and its environment and are usually a compilation of simple correlations between animal and habitat attributes (Hamel *et al*., 1986; Schamberger and O'Neil, 1986). In primate studies, abundances or behavioral patterns have been related to habitat degradation (Struhsaker, 1976; Altmann *et al*., 1985), human land use (Johns, 1986; Skorupa, 1986), food resources (Struhsaker, 1975; Wrangham, 1977; Terborgh and Janson, 1986) or forest structure (Whitten, 1982; Skorupa, 1986). Primate habitat is defined in this study by forest structure, floristic composition and food-resource abundance. In the absence of data on the abundance or density of the lion-tailed macaque for most of the areas, the abundance of their food trees is used to depict potential habitat quality.

Although the modern primates and angiosperms appear to have a very tight coevolutionary relationship (Sussman, 1991), Howe (1986) opined that it was more of a co-occurrence than otherwise. Angiosperms made their appearance in the early Cretaceous (65 Million Years Ago: MYA) and the modern rainforests along with modern primates appeared around the same time in mid-Eocene (50 MYA: Sussman, 1991). The adaptive radiation and eventual dominance of angiosperms during the Cretaceous opened up a variety of dietary opportunities for the primates (Regal, 1977). If present-day primates are any indication, early primates appear to have taken strong advantage of arboreal plant foods since almost all potential food comes from dicotyledonous species using the C_3 carbon pathway and not from the monocotyledonous species (like grass) using the C_4 pathway (Milton, 1987).

The genus *Macaca* made its appearance around the mid-Miocene (10 MYA). The lion-tailed macaque is classified in the *silenus* or *silenus-sylvanus* subgroup (9 or 10 species) of the macaques (Delson, 1980; Fooden, 1980). Although there is a debate as to whether the lion-tailed macaque belongs to the *silenus* or *silenus-sylvanus* subgroup (see Fooden, 1975; 1980; Delson, 1980; Eudey, 1980) it is agreed that it is one the most primitive of the entire clade of Asian macaques (Hoelzer and Melnick, 1996). Its closest relatives are the seven Sulawesi macaques (*M. tonkeana*, *M. maura*, *M. ochreata*, *M. brunnescens*, *M. hecki*, *M. nigrescens* and *M. nigra*) and the pig-tailed macaque (*M. nemestrina*) that are distributed far away from the Western Ghats (Fooden, 1980). It is suggested that this strongly disjunct distribution of the *silenus-sylvanus* subgroup coupled with the male and female genital morphology (on which the classification is made) seen

Primate species	Mature leaves (%)	Fruits (%)	Source
Bonnet macaque, *Macaca radiata*	17.2	41	Krishnamani, 1994
	3.2	53.4	Ali, 1986
Crab eating macaque, *M. fascicularis*	1.6	87	Wheatly, 1980
Rhesus macaque, *M. mulatta*	NA	65-70	Lindburg, 1977
Pig-tailed macaque, *M. nemestrina* §	2.7	73.8	Caldecott, 1986
Lion-tailed macaque, *M. silenus* §	<1	60	Kumar, 1987
Sulawesi crested black macaque, *M. nigra* §	<2.4	60-70.7	O'Brien and Kinnaird, 1997
Barbary macaque, *M. sylvanus* §	37.7 *	<5.6 ¶	Ménard and Vallet, 1996

Table 5.1. The percentage of fruits in diet of the *silenus* subgroup (marked §) is very high, but the Barbary macaque's diet is dominated by leaves and seeds this maybe because of their subtropical distribution. * Indicates mean for two troops; ¶ indicates for "other items" which may include fruits. (Since not much information is available for the other 6 Sulawesi macaques only *Macaca nigra* is included here).

in this group is ancestral for the genus and hence suggests early radiation, as can be seen in Delson's (1980) phylogram of macaque evolution.

Having radiated this early, the niche the *silenus* group of macaques occupies is unique and a great majority of them are "indicator species" for the tropical rainforests they occupy. In the *silenus* subgroup certain common traits are visible. Almost all of them are rare and endangered and most of them are arboreal in nature and obligate frugivores (Groves, 1980; Crockett and Wilson, 1980: Table 5.1).

Ficus species (figs) are a common food for many tropical primate populations and often provide a reserve food supply during periods of general food scarcity (Leighton and Leighton, 1983; Terborgh, 1983). Most of the frugivorous animals, including primates, are dependent on *Ficus* species (Altmann, 1989) and *Ficus* fruits are considered to have high nutritional value (Janzen, 1979a; 1979b). This point has been validated by Vellayan (1981), Wrangham *et al.* (1993) and (Wendeln *et al*., 2000). However Milton *et al*. (1982) are of the opinion that the *Ficus* species on the Barro Colorado Island are lower in nutritional quality than most other fleshy fruits and few frugivores preferred *Ficus* species, like the howler monkeys (*Alouatta palliata*). Two main attributes determine *Ficus* species as an important food resource for primates during periods of fruit scarcity. Firstly, fruiting patterns of *Ficus* species exhibit spatio-temporal patchiness (Janzen, 1979b; Milton *et al*. 1982) ensuring that some individual *Ficus* species are in fruit throughout the year within the same habitat. Secondly, *Ficus* species are usually present at low densities in forest ecosystems and individual trees are usually clumped (Heithaus and Fleming, 1978; Gautier-Hion and Michaloud, 1989). Owing to these characteristics it appears that *Ficus* species can be exploited as a major fruit resource only by an animal with a relatively large home range (Borges, 1993).

There are more than 750 species of *Ficus* in this world (Berg, 1989) and southern India is home to 30 *Ficus* species (Sasidharan and Augustine, 1999a). Of this, 16 species are present within the range of the lion-tailed macaques. *Ficus* species form a major portion of lion-tailed macaques diet and a question is whether *Ficus* species set the limit for the lion-tailed macaque's rarity (Umapathy, 1998; Krishnamani and Kumar, 2000).

5.2. Objectives

In the previous chapters it was shown that total species richness of trees, their density and basal area show considerable variation among the four different zones in the Western Ghats. In this chapter, I examine whether a similar variation also is evident in the case of the food trees of the lion-tailed macaque, one of the major frugivore in its habitat. Such a variation, if it exists, would have major implications on the feeding ecology and population densities of the species in different areas in the Western Ghats. Ficus species is examined separately, considering its potential role as a keystone species. The following questions are specifically addressed:

1) What is the species richness, density and basal area of the food-trees of the lion-tailed macaques, in different zones of the Western Ghats?
2) What is the density of *Ficus* in the lion-tailed macaque's habitat and is it a limiting factor?
3) Which could be the best possible areas for the survival of the lion-tailed macaque, given the spatial variation of food trees?

5.3. Methods

The methods used to determine the species richness, density and dominance (basal area) of the food-trees of these macaques were discussed in Chapter 3. The *Ficus* densities were calculated using the software ***Distance* 3.5** (Thomas *et al*., 1998) following the methods described by Brockelman and Ali (1987) and van Schaik and Djojosudharmo (1992)

5.4. Results

5.4.1. Species richness in food trees and lianas

Studies in different parts of the Western Ghats show that a total of 218 food plants are used for food by the lion-tailed macaques from 61 plant families and two were bryophytes (ferns) (Appendix 10; Krishnamani and Kumar, 2000). Nearly 75% of the food plants are trees species (Figure 5.1). Although the lion-tailed macaques are highly arboreal, herbs formed 5.5% of their total diet because of their terrestrial habit in some of their degraded habitats like Puthuthottam Coffee Estate, Valparai (Menon, 1993; Umapathy, 1998). In my survey I encountered 114 lion-tailed macaque food species of which 10 (8.8%) were lianas and 104 were trees (91.2%). This formed 29.16% of the known food trees and lianas.

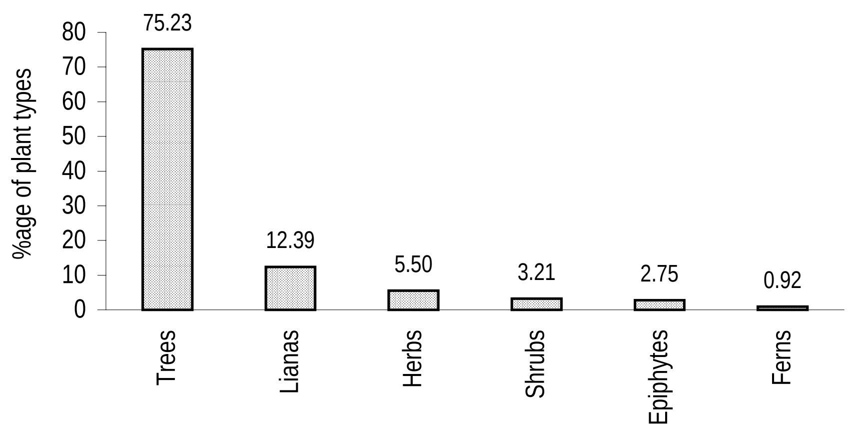


Figure 5.1. Percentage of food plant types in the diet of the lion-tailed macaques.

Although there seemed to be a south-north gradation in total tree species richness in the 4 zones (Figure 5.2) there was no significant difference among zones in food plant species richness per plot (One-Way Anova: F=0.151, df=3, p=0.928). Food plant species richness in a plot ranged from 4 (in Plot 33) to 30 (in Plot 31) with a mean of 18.83 species (SE=0.84). The zonal maximum, minimum and means are given in Table 5.2.

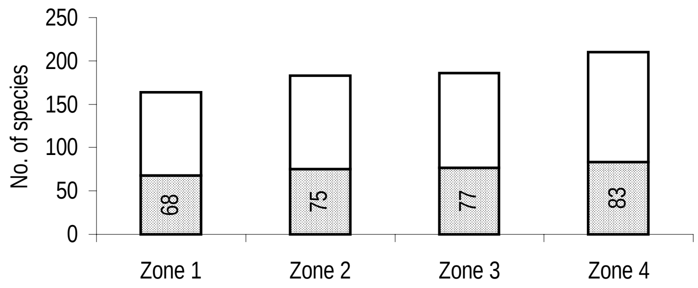


Figure 5.2. Species richness of woody plants and food species (shaded portion) of the lion-tailed macaque in the 4 zones. (n=12 plots of 0.25 ha for each zone)

Species richness	Zone 1	Zone 2	Zone 3	Zone 4	Zone Over-all
Total species richness	68	75	77	83	114
%age of LTM sp. richness	41.46%	40.98%	41.40%	39.52%	29.16%
Maximum per plot	27	29	30	28	30
Minimum per plot	11	7	4	12	4
Mean per plot	18.75	19.25	17.92	19.42	18.33
Standard Error	1.50	1.67	2.23	1.40	0.84

Table 5.2. Species richness of lion-tailed macaque food plants in four zones and overall. (n=12 plots of 0.25 ha for each zone)

In Zone 1, *Myristica dactyloides*, *Dimocarpus longan* and *Aglaia elaeagnoidea* were the most dominant food species with IVIs of 20.26, 16.45 and 14.55 respectively (Appendix 1). In Zone 2, the top 3 food species were *Palaquium ellipticum*, *Knema attenuata* and *Myristica dactyloides* with IVIs of 12.66, 10.97 and 10.35 respectively (Appendix 2). *Cullenia exarillata* occupied the top slot in Zone 3 with an IVI of 12.19. This was followed by *Palaquium ellipticum* (IVI: 10.38) and *Agrostistachys borneensis* (4.83) respectively (Appendix 3). *Cullenia exarillata* (IVI: 22.38) and *Palaquium ellipticum*

(13.55) continued its dominance in Zone 4 also followed by *Filicium decipiens* with an IVI of 10.74 (Appendix 4). For the zones overall, *Cullenia exarillata*, being a large tree, continued its dominance with an overall IVI of 14.63, followed by *Palaquium ellipticum* (12.98) and *Myristica dactyloides* (11.91; Appendix 5). The food species richness in plots were not correlated either with altitude (r=0.001, n=48, *p*=0.994) or latitude (r=0.099, n=48, *p*=0.505).

5.4.2. Density of food species

Out of 5443 stems encountered during the sampling of 48 plots, 3004 (55.19%) stems belonged to food species of the lion-tailed macaque. Their density varied from 10 individuals (in Plot 33: Megamalai Reserved Land) to 101 (in Plot 43: Kalakkad-Mundanthurai Tiger Reserve) with a mean of 62.58 stems/plot (SE=3.02). There was no south-north gradation among zones (Figure 5.3) and there was no significant difference among zones in food trees per plot (One-Way Anova: F=1.179, df=3, *p*=0.329). The zonal maximum, minimum and means are given in Table 5.3.

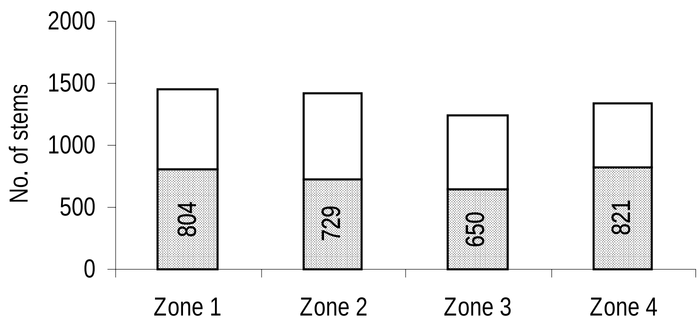


Figure 5.3. Density of woody plants and food species (shaded portion) of the lion-tailed macaque in the 4 zones. (n=12 plots of 0.25 ha for each zone)

The density of food species in Zone 1 was similar to that of the general pattern with *Myristica dactyloides* (7.53%), *Dimocarpus longan* (5.39%) and *Aglaia elaeag-*

noidea (5.25%) in the top 3 slots (Appendix 1). In Zone 2, *Myristica dactyloides* (4.81%), *Palaquium ellipticum* and *Knema attenuata* (4.03%) and *Diospyros nilagirica* (3.25%) occupied the first three slots respectively (Appendix 2).

Species density	Zone 1	Zone 2	Zone 3	Zone 4	Zone overall
Total no. individuals	804	729	650	821	2972
%age of LTM food species density	55.53%	51.52%	52.21%	61.50%	54.60%
Maximum	98	86	97	101	101
Minimum	28	18	10	48	10
Mean	67.00	60.75	54.17	68.42	62.58
Standard Error	5.88	6.27	6.04	5.83	3.02

Table 5.3. Density of lion-tailed macaque food plants in four zones and overall. (n=12 plots of 0.25 ha for each zone)

Zone 3 also mirrored the IVI pattern with *Cullenia exarillata* (6.91%) in the top slot. This was followed by *Palaquium ellipticum* (5.14%) and *Agrostistachys borneensis* (2.81%; Appendix 3). *Cullenia exarillata* (6.14%) and *Myristica dactyloides* (4.49%) were dominant in Zone 4 followed by *Palaquium ellipticum* (4.34%; Appendix 4). For zones overall, *Myristica dactyloides* (4.79%), *Palaquium ellipticum* (3.84%) and *Cullenia exarillata* (3.62%; Appendix 5), were the most common. The food tree density was not correlated either with altitude (r=0.099, n=48, p=0.505) or with latitude (r=0.124, n=48, p=0.403).

5.4.3. Basal area of food species

The 5443 stems that were sampled had a total basal area of 552.41 m^2. Of this, the lion-tailed macaque food species had a basal area of 347.00 m^2 (62.87%). The basal area of food trees varied from 1.90 m^2 (Plot 9: Someshwara Wildlife Sanctuary) to 13.10 m^2 (Plot 43: Kalakkad-Mundanthurai Tiger Reserve) with a mean of 7.28 m^2 per plot (SE=0.43).

The total basal area of food trees for all 12 plots in zone together, declined from south to north (Figure 5.4). Although, there was no significant difference among the zones in food tree basal area per plot, the probability level was much closer to significance than in the case of species richness and density (One-Way Anova: F=2.484, df=3, p=0.073). The zonal maximum, minimum and means are given in Table 5.4.

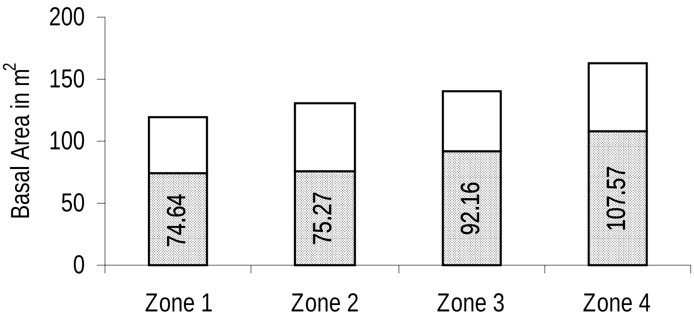


Figure 5.4. Basal area of woody plants and food species (shaded portion) of the lion-tailed macaque in the 4 zones. (n=12 plots of 0.25 ha for each zone)

Species Basal Area	Zone 1	Zone 2	Zone 3	Zone 4	Zone overall
Total	74.64 m^2	75.27 m^2	92.16 m^2	107.57 m^2	347.00 m^2
%age of LTM basal areas	62.44%	57.92%	65.55%	66.28%	62.81%
Maximum	8.77 m^2	11.40 m^2	12.87 m^2	13.10 m^2	13.10 m^2
Minimum	1.83 m^2	2.64 m^2	2.28 m^2	3.32 m^2	1.83 m^2
Mean	6.22 m^2	6.27 m^2	7.68 m^2	8.96 m^2	7.28 m^2
Standard Error	0.65	0.73	1.00	0.90	0.43

Table 5.4. Basal area of lion-tailed macaque food plants in four zones and overall. (n=12 plots of 0.25 ha for each zone)

In Zone 1, *Syzygium gardneri* (7.64%), *Olea dioica* (5.61%) and *Myristica dactyloides* (4.72%) were the top ranking lion-tailed macaque food species according to basal area (Appendix 1). *Elaeocarpus tuberculatus* (5.33%), *Palaquium ellipticum* (5.09%) and *Persea macrantha* (4.47%) dominated the top 3 slots in Zone 2 (Appendix 2). *Cullenia* exarillata (14.23%) and *Palaquium ellipticum* (8.61%) retained their dominance in this segment also followed by *Syzygium cumini* (2.92%) in so far as Zone 3 was concerned (Appendix 3). *Cullenia exarillata* (11.96%) and *Palaquium ellipticum* (5.85%) continued their dominance in Zone 4 also occupying the top 2 slots (Appendix 4). The third slot was occupied by *Vateria indica* (4.98%). For the zones overall, *Cullenia exarillata* (8.08%) was the top ranked food species followed by *Palaquium ellipticum* (5.46%) and *Myristica dactyloides* (2.96; Appendix 5). Unlike the species richness and density, the food species basal area was correlated with altitude and latitude, although the variance in basal area accounted for by these gradients was quite low (Figure 5.5).

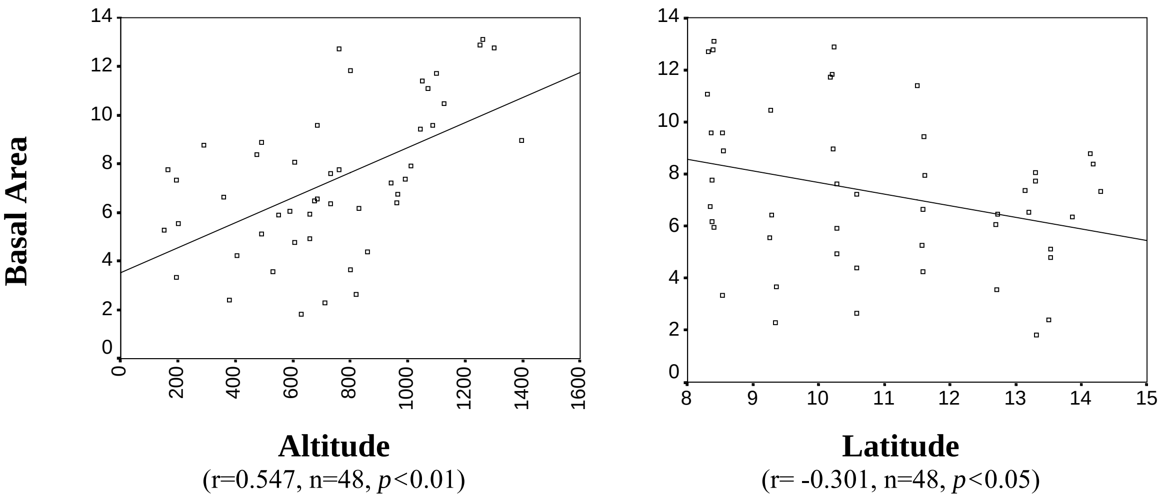


Figure 5.5. The relationship with food species' basal areas was associated with altitude and latitude.

Based on the basal areas of various places, potential areas for the conservation of the lion-tailed macaques can be identified. Some of the areas are given in Table 5.5.

Ranking	Areas	State	No. of plots	Basal area	
				Total	Mean
1	Indira Gandhi Wildlife Sanctuary	Tamil Nadu	4	45.36	11.34
2	Kalakkad-Mundanthurai Tiger Reserve	Tamil Nadu	8	79.85	9.98
3	Silent Valley National Park	Kerala	3	28.76	9.59
4	Sharavathy Valley Wildlife Sanctuary	Karnataka	3	24.46	8.15
5	Periyar Tiger Reserve	Kerala	3	22.42	7.47
6	Shendurney Wildlife Sanctuary	Kerala	3	21.78	7.26
7	Kudremukha National Park	Karnataka	3	20.26	6.75
8	Parambikulam Wildlife Sanctuary	Kerala	3	18.45	6.15
9	Someshwara Wildlife Sanctuary	Karnataka	3	17.62	5.87
10	Aralam Wildlife Sanctuary	Kerala	3	16.15	5.38
11	Brahmagiri Ghats Wildlife Sanctuary	Karnataka	3	16.10	5.37
12	Bolampatti Reserved Forest	Tamil Nadu	3	14.26	4.75
13	Mookambika Wildlife Sanctuary	Karnataka	3	12.30	4.10
14	Megamalai Reserved Land	Tamil Nadu	2	5.93	2.97
15	Peppara Wildlife Sanctuary *	Kerala	1	5.94	5.94

Table 5.5. The areas identified to be crucial for the survival of the lion-tailed macaques, based on the basal area of food trees. * Only one belt transect of 0.25 ha was laid in Peppara Wildlife Sanctuary, hence was not considered here.

5.4.4. *Ficus* species density

In the survey of *Ficus* densities, there were 48 line transects, one in each vegetation plot. I came across 11 *Ficus* species with 79 individuals. I did not encounter *Ficus* species on 13 transects and the maximum individuals encountered were six on the 23rd transect, with a mean of 1.65 individuals per transect (SE=0.243).

	Zone 1	**Zone 2**	**Zone 3**	**Zone 4**
Total no. of *Ficus* species	8	8	7	5
Total no. of individuals	31	25	13	10

Table 5.6. Summary report of the species richness and number of individuals of *Ficus* spp. in each of the 4 zones (n=12 plots of 0.25 ha in each zone).

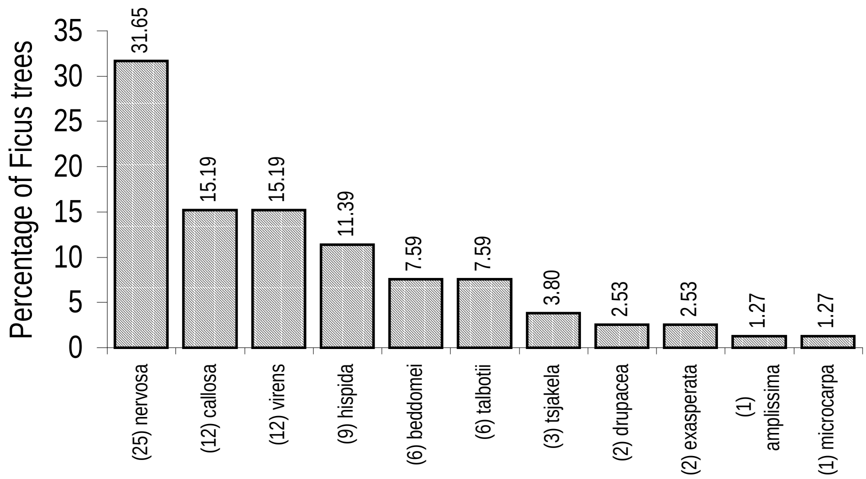


Figure 5.6. The frequency distribution of various *Ficus* species in 48 plots (n=79 trees). Numbers in parenthesis are the number of trees.

Ficus nervosa had the most number of individuals followed by *Ficus callosa* and *Ficus virens*. *Ficus amplissima* and *Ficus microcarpa* were represented by only one individual each (Figure 5.6). The species recorded from all four zones were *Ficus nervosa* and *Ficus virens*. Zone 1 had more *Ficus* species than the other 3 zones (Table 5.6).

The *Ficus* densities in different zones did not show any directional gradient. Density estimates for individual species were not done owing to small sample sizes. The overall density was 3.56 *Ficus* trees per hectare (Figure 5.7). The detection probabilities for Zones 1, 2, 3 and 4 and overall are shown in Figure 5.8. Since the sample data were small for Zones 3 and 4, the data were pooled. Truncating Zone 1 at 30 meters produced a 23% increase in the coefficient of variation and hence the perpendicular distances for the Zones were not truncated. The coefficients of variation (CVs) for the density estimates were between 16% and 33%, showing that the estimates were reasonable.

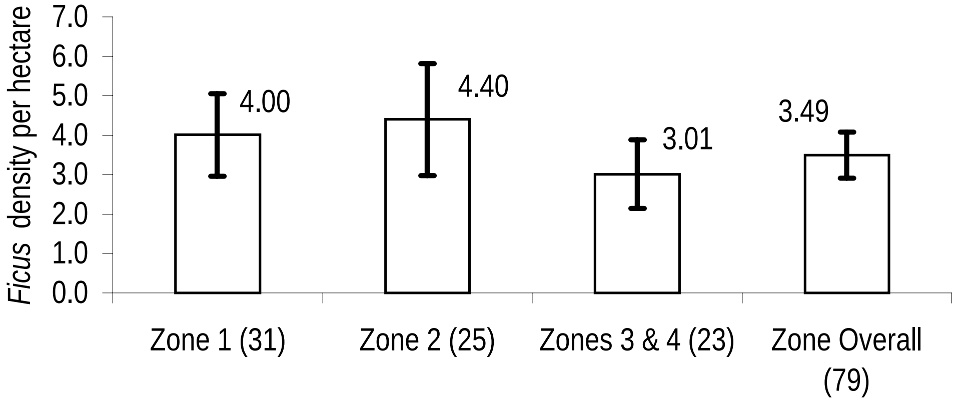


Figure 5.7. The density of Ficus trees in 4 zones, estimated from line transects. Numbers represent the *Ficus* density for each zone and the standard errors are 1.04, 1.42, 1.52 and 0.58 respectively. The number of trees recorded for each zone is given in parenthesis (n=12 transects of 250 m in each zone).

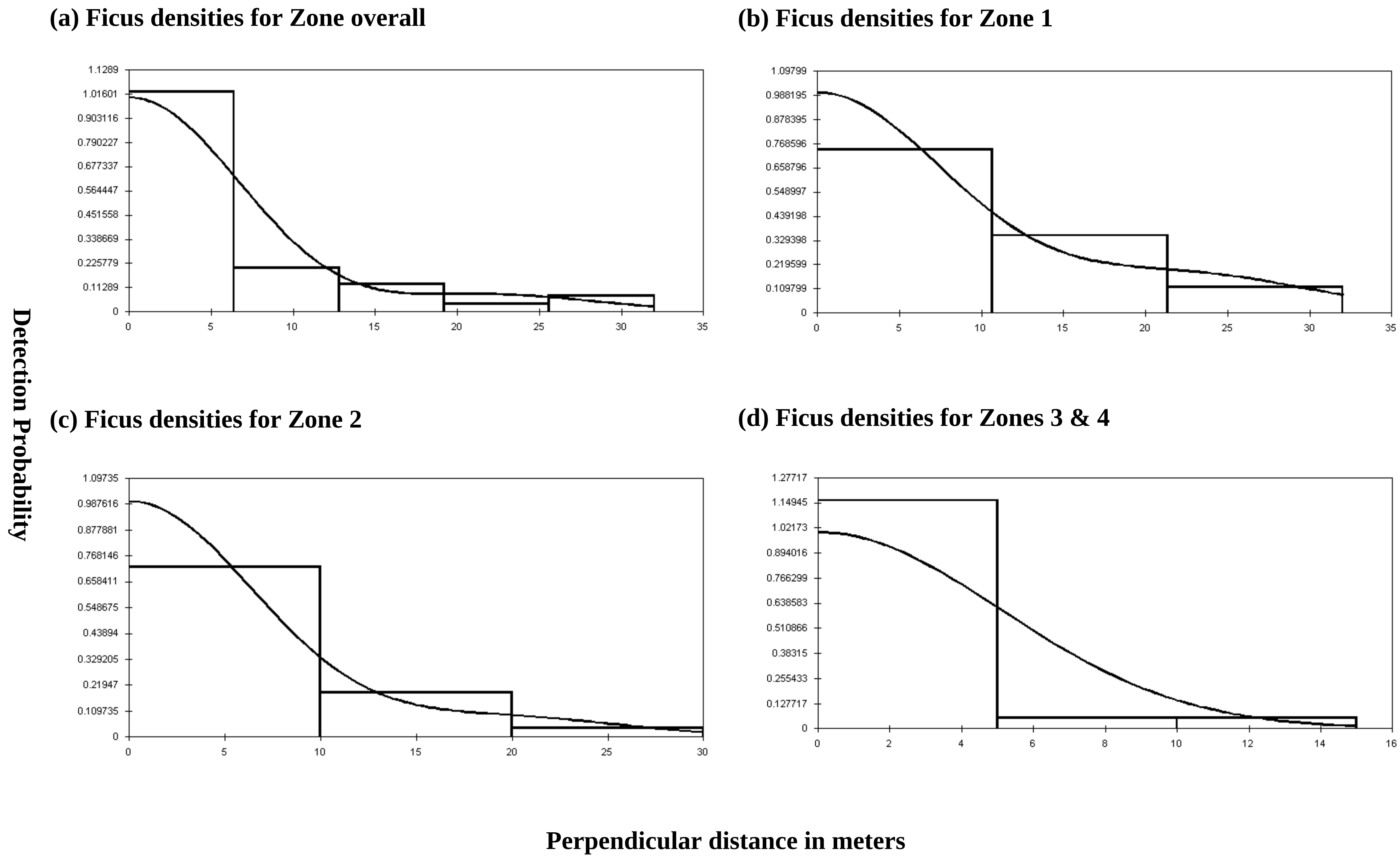


Figure 5.8. Detection probability curves for *Ficus* species.

5.5. Discussion

5.5.1. Food-species richness, density and basal areas

The food-species richness mirrored the general phyto-ecology of all species together, which was discussed in Chapter 1. For the lion-tailed macaque a food-species necessarily means a fruit-bearing tree since leaves constitute only less than 1% of its diet and nearly 60% of its food items are fruits (Table 5.7). Although fruits are often conspicuous and easily located, the availability of these food-items is generally variable in space and time and hence the ecological pressures operating on the frugivores are tremendous. Frugivores generally have a large home range because of the ephemeral and patchy nature of the availability of the fruits (Fleming, 1992). Kumar (1987) reported that of the 84 plant species used as food-plants, 23 species (27.38%) accounted for a whopping 70.9% (mean for 2 years, SE=1.7) of the lion-tailed macaque's annual diet. Other researchers have also observed the fact that a small percentage of the food-species contribute to a major portion of a primate's diet (Table 5.7).

Primate species	Top ranked food species (n)	%age of its diet	Source
Blue monkey, *Cercopithecus mitis stuhlmanni*	10	69.23	Rudran, 1978
	5	34.70	Struhsaker, 1978
Tana River red colobus, *Colobus badius rufomitratus*	10	>50	Medley, 1993
Red colobus, *Colobus badius tephrosceles*	5	34.3	Struhsaker, 1978
Black and white colobus, *Colobus guereza occidentalis*	5	59.8	Struhsaker, 1978
Mangabey, *Cercocebus albigena johnstoni*	5	50.9	Struhsaker, 1978
Red-tailed monkey, *Cercopithecus ascanius schmidti*	5	36.5	Struhsaker, 1978
Bonnet macaque, *Macaca radiata*	5	54.9	Krishnamani, 1994
Barbary macaque, *Macaca sylvanus*	8	≈65	Ménard and Vallet, 1996
Sulawesi crested black macaque, *Macaca nigra*	5	≈50	O'Brien and Kinnaird, 1997

Table 5.7. The top ranked food species (n=5-10) contribute to a major portion of a primate's diet.

		Zone 1	Zone 2	Zone 3	Zone 4	Zone overall
Species richness	Actual IVI	42.57	42.14	24.65	43.81	43.84
	Adjusted IVI value*	14.19	14.05	8.22	14.60	14.61
Density (Individuals)		9.60%	10.81%	12.29%	12.43%	11.23%
Dominance (Basal Area)		19.21%	17.87%	21.66%	21.23%	20.11%

Table 5.8. Species richness, density and dominance of the fifteen most important lion-tailed macaque food species in the Western Ghats mountains of peninsular India. (from Krishnamani and Kumar, 2000). * The total of all IVI is 300%, but for convenience the values are divided by 3 to bring it on par with the density and dominance of the species.

The fifteen most important species that contributed to a large portion of the lion-tailed macaques' diet had only 11.23% of the total density of the sampled trees and its basal area contributed to only 20.11% of the total (Table 5.8). Most of the studies on the rainforest primates have not quantified this aspect of measuring the density and basal area of food-trees present in a primate's habitat (studies not done include Struhsaker, 1978; Wheatley, 1980; Terborgh, 1983; Medley, 1993; O'Brien and Kinnaird, 1997), therefore, a comparison is not possible. A south-north gradient is visible, although much less than in case of all food species together.

Although food-trees like *Myristica dactyloides*, *Agrostistachys borneensis*, *Elaeocarpus tuberculatus* and *Vateria indica* figured among the top 10 rank-ordered food-species for the Zones (Appendices 1-5), for all categories of abundance, they formed a miniscule portion of the diet. The abundance of these food-species probably does not matter to these macaques since they were not the most sought after food-species.

Cullenia exarillata is a large, buttressed stenoaltitudinal and stenolatitudinal tree, which is distributed in the Western Ghats and in Sri Lanka at 600-1500 m elevation (Kadambi, 1954). It is an important food-tree of the lion-tailed macaque in the southern Western Ghats, rather south of Silent Valley National Park, but only above 700 or so meters altitude. It is totally absent from Zone 1, but the tree's dominance progressively increases towards the south and is the predominant tree in Zones 3 and 4. Despite this tree's absence from Zone 1 (which is entirely in Karnataka State) the lion-tailed macaques are present here. In fact the northern most limit of *Cullenia* is at 11°56' N (estimated from Pascal *et al*, 1982) that is 10 km south-east of Makut (which is in Kerti Reserved Forest) although Kadambi (1954) mentions it as 12°30' N which means the tree extends up to the Sampaji Ghat.

In the Brahmagiri Ghats Wildlife Sanctuary-Talacauvery Wildlife Sanctuary-Kerti Reserved Forest complex, the rainforests ideal for the lion-tailed macaque, is around 700 km^2, but the density of lion-tailed macaques are low (Ajith Kumar, unpublished data; Mewa Singh, pers. comm.) and so is *Cullenia* (a single tree was observed by the author in the Talacauvery Wildlife Sanctuary). It is an irony that for an area of this magnitude the density of the macaques is low. Then, is *Cullenia* a limiting factor for the lion-tailed macaques?

To the areas north of Pushpagiri Wildlife Sanctuary (12°36' N) the elevation of the Western Ghats at the crest averages around 700 m and only at Kudremukha National Park and at Kodachadri near Mookambika Wildlife Sanctuary does it overshoot 1400 m, that too as peaks. In the south *Cullenia is* associated with a lot of euryaltitudinal trees that are present in the forests of Karnataka like *Mesua ferrea*, *Palaquium ellipticum, Poeciloneuron indicum*, *Hopea parviflora* etc. (Kadambi, 1954). *Gordonia obtusa*, which is also a stenoaltitudinal tree, is present disjunctly at altitudes above 1000 m and hence is present in Karnataka at Kudremukha (1892 m) and Pushpagiri (1713 m) but not at Kodachadri (1343 m: Ramesh *et al*., 1997). Under the same currency *Cullenia should* have also had an extension in Karnataka, but is absent north of Madikeri (Mercara), but Pascal (1988) opines that the increased dry season north of Coorg could be a reason why *Cullenia* is absent in these areas.

The lion-tailed macaques feed on *Cullenia* flowers and seeds. Flowering in *Cullenia* occurs during periods of fruit scarcity (February-April) and also when most of the other plant species do not flower (Ganesh and Davidar, 1997). In Zone 4 *Ficus* trees are at low densities (Figure 5.7) and hence *Cullenia* could also be considered a keystone species (Ganesh and Davidar, 1997). In Karnataka, Zone 4 and partly Zone 3, *Ficus* densities are relatively higher and hence the lion-tailed macaques do not suffer during periods of fruit scarcity even in the absence of *Cullenia.* Hence the absence of *Cullenia* cannot be a limiting factor for the lion-tailed macaques. The only difference is that the densities of *Cullenia* far outweighs the densities of *Ficus*, but the asynchronous and year round fruiting pattern of the *Ficus* may compensate for the predictable flowering in *Cullenia*. It is also likely that *Ficus* is the key stone species for the lion-tailed macaque in the northern parts, and *Cullenia* in the southern parts.

5.5.2. *Ficus* densities do have a role in the lion-tailed macaque's rarity

Since plant genera evolve far more slowly than animal genera, 'keystone plant species' may act over evolutionary time as a decisive factor in the evolution of whole faunal assemblages (Terborgh, 1986a). *Ficus* is a keystone genus that supports a large number of frugivores during periods of fruit scarcity (Terborgh, 1983; Terborgh, 1986b) since their non-synchronous fruiting habit assures that crops will ripen at all times of the year (Morrison, 1978; Milton, 1980). Some non-*Ficus* fruits also act as keystone resources, but quantitatively they are of minor importance (Terborgh, 1986a). Even certain leaf-eating monkeys like *Colobus guereza* (Struhsaker, 1997), *Procolobus badius* (Struhsaker, 1997) and *Trachypithecus phayrei* (Gupta and Kumar, 1994) feed on them. Although carnivorous predators limit the population densities of primary consumers like primates (Terborgh *et al.*, 2001), it is these keystone food resources that regulate the carrying capacity of the frugivorous community during periods of food (fruit) scarcity (Terborgh, 1986b).

Of the 15 odd *Ficus* species supposedly eaten by the lion-tailed macaques two species (*F. callosa* and *F. nervosa*) form a very important component of the macaque's diet (Krishnamani and Kumar, 2000). *Ficus* species contain high amounts of amino acids, such as leucine, lysine, valine, and arginine and minerals, such as potassium, calcium, magnesium, sodium and phosphorous (Wendeln *et al*., 2000). A study on the nutritional value of some *Ficus* species supported the idea that no single species of *Ficus* may be sufficient to sustain frugivores; however, a mix of *Ficus* species can provide a complete set of nutrients (Wendeln *et al*., 2000).

The *Ficus* density in the lion-tailed macaque habitat is higher for areas north of Palakkad Gap compared to the southern part, (also see Ganesh and Davidar, 1999; Mudappa, 2001). The *Ficus* density in the Western Ghats (3.49 trees/ha) was comparable to other areas elsewhere (Table 5.9).

Place	*Ficus* trees per ha.	Source
Kibale National Park, Uganda	2.50-3.75	Struhsaker, 1997
Barro Colorado Island, Panama	5.68 *	Morrison, 1978
Gunung Leuser National Park, Sumatra	0.75-2.00	van Schaik and Djojosudharmo, 1992

Table 5.9. The *Ficus* densities at various sites in the rainforests of the world. * calculated from the given data.

van Schaik and Djojosudharmo (1992) opined that the density of fruit trees especially some *Ficus* species, regulated the overall density of the orangutans. Orangutans were rare at higher altitudes where *Ficus* densities were also low along with other soft-pulped fruit trees. Similarly, the rarity of a tamarin species (*Saguinas fuscicollis*) has been attributed to two keystone species. The flowers of *Combretum assimile* and *Quararibea cordata* provide them with nectar during periods of food scarcity (Terborgh and Stern, 1987). Keystone species are an extremely important member of a community and usually a species is considered to be a 'keystone' because its effect is large compared to its bio-mass or because of its large density (Jordán *et al*., 1999). Hence the two keystone species, *Ficus* species in the north and *Cullenia exarillata* in the south, could well be the limiting factors on which the densities of these macaques depend.

5.5.3. Forests with low density of lion-tailed macaques: a case study

Although close to 700 km^2 of contiguous rainforests exist in the Madikeri (Coorg) Forest Division (estimated from Pascal *et al*., 1982), which is fit enough for the survival of the lion-tailed macaques, the population densities are low (Karanth, 1985; Ajith Kumar, un-published data). As mentioned earlier this is northern most limit of *Cullenia* (Kadambi, 1954; Pascal, 1988) and the *Ficus* densities for this area, which is in Zone 2, is the highest (Figure 5.7). Hence technically the lion-tailed macaque is at a double advantage since both the keystone species are present in this area. Despite this advantage, Karanth (1985) mentioned that the "decline in abundance (of the lion-tailed macaque) seems to be severe in all the four ranges of the Madikeri Division".

If adequate conservation measures are enforced, in these areas, then the lion-tailed macaque might well continue to live into the 22nd century and beyond. One advantage these macaques have is that sanctuaries and tiger reserves on either side of Kerala and Tamil Nadu buffer these areas very well. For example, Parambikulam in Kerala buffers the Anamalais in Tamil Nadu, Kalakkad-Mundanthurai Tiger Reserve is adjacent to the sanctuaries of Peppara and Neyyar in Kerala, Silent Valley National Park is contiguous with the Mukkurthi National Park of Tamil Nadu and the entire Kudremukha National

Park is in Karnataka and hence needs no buffering. The same is not the case with the forests of Madikeri, although there are two wildlife sanctuaries (Talacauvery and Brhamagiri Ghats) and two Reserved Forests (Kerti and Urti) within its confines they border the adjoining state of Kerala. The forests of Kerala that could have buffered these areas in Karnataka vanished long ago due to anthropogenic pressures (Nair, 1991). In fact the northern districts of Kerala that border Karnataka like Kasargod and the northern parts of Kannur district do not have forest at all.

The most likely reason is hunting in recent years. Given the life history parameters of the lion-tailed macaque, it has a low intrinsic population growth rate. Therefore even low intensity hunting can suppress its population. It would also be very slow in recovering from severe hunting pressure.

5.5.4. Potential areas for their conservation and the future of these macaques

Based on basal area of its food species, the areas that are best suited for the macaques are the Anamalai Hills, Kalakkad-Mundanthurai Tiger Reserve (in Tamil Nadu side) Silent Valley National Park, Parambikulam Wildlife Sanctuary (in Kerala) and Sharavathy Valley Willdife Sanctuary Kudremukha National Park (in Karnataka: Table 5.5). Although these figures are based on field studies done in various parts of its habitat mention must be made that it has been extensively studied in the Indira Gandhi Wildlife Sanctuary. Some of the areas crucial to these macaques do not come under the purview of the Protected Area Network e.g., Reserved Forests of New Amrambalam, Kottiyur (in Kerala), Kerti, Urti, Andar, Agumbe, Gersoppa, Kodachadri (in Karnataka), Bolampatti (Siruvani) and Megamalai (in Tamil Nadu). Places like New Amarambalam, Andar, Agumbe, Kodachadri and Bolampatti are relatively pristine when compared to the other Reserved Forests and should be brought under the Protected Area Network. Unless Megamalai Reserved Land is gradually made into a Wildlife Sanctuary, the future of these macaques would bleak in the High Wavy Ranges of the Western Ghats. This move could also buffer Periyar Tiger Reserve in Kerala.

5.6. Summary

1) In this chapter, I assessed the density and abundance patterns of the food-species of the lion-tailed macaque.

2) While food species of the lion-tailed macaque formed 29.16% of all species recorded, the density and basal area were 54.60% and 62.18% respectively, of the overall density and basal area.

3) The species richness, density and basal area of food trees followed the same trends as that for all species. There was a south-north decline in species richness and basal area at eh zonal level, while the latter showed an altitudinal gradient.

4) The *Ficus* densities were the highest for Zone 2 followed by Zone 1. The *Ficus* densities were comparable with other sites in the world.

5) *Ficus* fruits (north of Palakkad Gap) and the flowers of *Cullenia exarillata* (in the south) are likely to act as a 'keystone food resource' and could be the limiting factors for these macaques.

6) Based on abundance of food sources, Anamalai Hills, Kalakkad-Mundanthurai Tiger Reserve (in Tamil Nadu side) Silent Valley National Park, Periyar Tiger Reserve (in Kerala) and Sharavathy Valley Wildlife Sanctuary, Kudremukha National Park (in Karnataka) are some of the potential places for the continued survival of these macaques.

Chapter 6

Phenological patterns in a tropical lowland rainforest of Karnataka, southern India

6.1. Introduction

“The term phenology is derived from the Greek word ‘*phaino*’ meaning to show or to appear. Hence phenology is defined as the study of the seasonal timing of life cycle events” (Rathcke and Lacey, 1985). In spite of its luxuriant look tropical forests undergo periods of abundance and scarcity in any plant’s reproductive and vegetative phenology (Leigh *et al*., 1993; Murali and Sukumar, 1993; 1994). All tropical forests studied to date show pronounced phenological variation between seasons and/or between years. The three phenophases (leafing, flowering and fruiting) are mutually dependent in individual woody plants (van Schaik *et al*., 1993). Individuals and populations of tropical plants display practically every possible phenological behavior from almost continuous activity to repeated brief bursts and from complete intra-specific synchrony to complete asynchrony (Medway, 1972; Frankie *et al*., 1974; Appanah, 1985; Newberry *et al*., 1998; Chapman *et al*., 1999).

This patterning suggests that phenological changes represent adaptations to either biotic or abiotic factors (van Schaik *et al*., 1993). Abiotic factors include rainfall, irradiance and temperature, and biotic factors encompass mode of seed dispersal, activities of pollinators and seed dispersers, variation in germination conditions, canopy position and the relative abundance of trees themselves (Chapman *et al*., 1999). Researchers have realized that there is a clearly defined seasonal pattern associated with marked change in rainfall and temperature. The continuous temperature and rainfall that characterize tropical lowland rainforests fosters plant growth throughout the year (Richards, 1975).

One generalization to emerge from phenological studies is that plant production of consumer resources (fruit, seeds, flowers and leaf-flush) undergoes variation in virtually all tropical forests (Frankie *et al*., 1974). Both intra- and inter-annual variation in resource production can be pronounced, but multi-year records are available only for a few sites like the Barro Colorado Island, Panama (Leigh *et al*., 1982). Periodic and prolonged resource scarcity has presumably led to the evolution of a wide range of morphological, behavioral and physiological adaptations in primary and secondary consumers. These adaptations confer the flexibility needed to survive in environments characterized by fluctuating or unpredictable food supplies (Terborgh and van Schaik, 1987). Also, during periods of scarcity, certain plant products, called “keystone plant resources” assume major importance as sustenance for the primary consumer community (Terborgh, 1986a; 1986b).

The abundance of these ‘keystone plant resources’ may set the carrying capacity of the community, while the physical and nutritional properties of these keystone resources appear to determine some morphological features of the consumer species (van Schaik *et al*., 1993). In fact natural selection is expected to favor such a timing of reproduction with the availability of food thereby resulting in the greatest number of surviving offspring (van Schaik, 1986). In primates, although field studies combining records of births with phenological observations are scarce, it appears that these two coincide (see Kummer, 1968; Fooden, 1981; Terborgh, 1983; an excellent review on this subject is given by Lindburgh, 1987). In fact Gevaerts (1992) showed experimentally that in certain *Cercopithecus*, *Colobus* and *Cercocebus* spp. the birth of infants coincided with rainfall.

It has been shown that in highly seasonal environments where plant phenology exerts a major influence on primate diets the consumption of seasonally fluctuating resources such as fruits, flowers and young leaves is the norm rather than perennial ones such as mature leaves and bark (Milton, 1980; Leighton and Leighton, 1983; Terborgh, 1983; Lucas and Corlett, 1991). For frugivores like many primates the fruiting or flowering phenology of a forest is so important that their very existence depends on it. In fact the flowers or fruits of a particular or a few plant species could be a limiting factor as been proved for many primates (Milton, 1980; Terborgh, 1983; van Schaik and Noordwijk, 1985; Terborgh and Stern, 1987; Kumar, 1987; Lucas and Corlett, 1991; Ganesh and Davidar, 1997; 1999).

Considering all these it was decided to study the general phenological patterns in a tropical lowland rainforest in Karnataka, India, where lion-tailed macaques are present.

6.2. Objectives

The main objectives of the phenological study were:

1) to identify the intra- and inter-annual phenological patterns of the 4 phenophases (leaf-fall, leaf-flush, flowering and fruiting) in individuals and species, in the lowland rainforests of Someshwara Wildlife Sanctuary, Karnataka, India.
2) to assess the fruiting phenology of this area and try to understand how the lion-tailed macaques undergo the vagaries of seasonal changes.
3) to ascertain whether the *Ficus* species, present in this area, have an aseasonal fruiting pattern and thus serve as a ‘keystone’ food resource.

6.3. Study area

The phenological studies were carried out in Someshwara Wildlife Sanctuary, Udupi District, Karnataka (13°35' N, 75°0' E: Figure 2.1). The Sanctuary is around 88 km^2 in area and has an altitudinal range of 120-650 m. The forest can be classified as a tropical lowland rainforest and the main association is *Dipterocarpus indicus-Diospyros candolleana-Diospyros oocarpa* (Pascal, 1988). The upper reaches of the Sanctuary have *Poeciloneuron indicum* facies. The perennial river Sitanadi flows through the Sanctuary. The soil type is laterite capped with mesas with granites and gneisses (Bourgeon, 1989). The area receives bulk of the rainfall between June-September from the southwest monsoon. The average annual rainfall is around 6,500 mm and the mean number of rainy days is around 130. The day temperature ranges between 28°-37° C with a mean of 31.89° C (SE=0.66) and the night temperature ranges from 18.5°-25° C with a mean of 22° C (SE=0.42). The dry season for this area varies from 4 to 4.5 months.

There are several houses scattered (> 1500) inside the Sanctuary and the nearest township is Hebri, which borders the Sanctuary. The anthropogenic pressure exerted on this Sanctuary is enormous since fuel wood and litter fall are collected throughout the year except during the rainy season. The lion-tailed macaques live on the eastern boundary of this Sanctuary and are sympatric with langurs (*Semnopitheus entellus* (?): see Groves (2001) for a recent taxonomic revision on the genus *Semnopithecus*) and bonnet macaques (*Macaca radiata radiata*).

6.4. Methods

The leaf-fall, leaf-flush, flowering and fruiting phenology were monitored from January 1997 to December 1998 in Someshwara Wildlife Sanctuary. Totally 584 individuals (554 trees: GBH ≥ 30 cm and 30 lianas: GBH ≥ 10 cm) were tagged for phenological observations and it comprised of 129 species (121 tree species and 8 lianas: Appendix 11). Easy visibility of the tree crown was a criteria used in selecting a woody plant species. These woody plants ranged from 2 to 12 per species with a mean of 4.53 individuals (SE=0.19).

This was inclusive of 48 woody plants reported as food-species of the lion-tailed macaque. Presence/absence of trees for mature leaves, leaf-flush, flowers and fruits were recorded during the 1st week of every month. These woody plant species were permanently tagged and were present in two trails, 4 km and 12 km in length.

While analyzing this data, similarity between years in phenological pattern (percentage of individuals and percentage of species) was tested using Spearman rank correlation. Significance of difference between two years (1997-19980 was tested using Wilcoxon matched pairs signed rank test (Z value in Table 6.1) thus controlling for monthly variations.

6.5. Results

6.5.1. Leaf-fall and leaf-flush phenology

The leaf-fall (the percentage of woody plant species without leaves), leaf-flush (the percenatge of species with young leaves), flowering and fruiting phenologies were similar with respect to the individuals and species (Figures 6.1a-d). The leaf-fall and the leaf-flush period more or less coincided with the hottest part of the year and the patterns were similar for both the individual stems and species (r_s=0.949, 0.914, n=24, p<0.01). There was no difference between the years for both leaf-fall and leaf-flush (Table 6.1 and Figures 6.1a and 6.1b).

The variation in months between years, in individuals and species leaf-fall (Z= -2.666, -2.257, n=12, p>0.05: Table 6.1) and in individuals and species leaf-flush (Z= -2.934, -2.198, n=12, p<0.05: Table 6.1). Most of the deciduous species lost their leaves in April and leaf-flush occurred in May-June. The leaf-fall patterns were more predictable for some of the obligate leaf-shedders like *Tetrameles nudiflora*, *Caraya arborea*, *Termi-*

nalia spp. etc., whereas some facultative leaf-shedders like *Ficus racemosa* lost their leaves only in December 1998 when all the other plants had their leaves intact. Some of the species like *Tetrameles nudiflora*, *Bombax ceiba*, *Erythrina indica*, *Oroxylum indicum* and *Pajanelia longifolia* had relatively longer spells of leaflessness, while many of the leaf-shedders had leaf-flush and leaf-fall simultaneously.

Parameter	**Mean (SE)**		**Wilcoxon**	**Rank correlation**
	1997	**1998**	**Z**	**r_s (*P*)**
Climate				
Total rainfall (cm)	579.26	684.30		
Mean monthly rainfall (cm)	48.27 (22.28)	57.02 (21.36)	-0.27 (0.790)	**0.854 (0.000)**
Total no. of rainy days	126	132		
Mean no. of rainy days/ month	10.50 (3.42)	11.00 (3.41)	-0.05 (0.964)	**0.840 (0.001)**
Min. temperature (º C)	22.12 (0.60)	21.90 (0.60)	**-3.059 (0.002)**	**0.902 (0.000)**
Max. temperature (º C)	32.03 (0.94)	31.75 (0.98)	**-3.059 (0.002**	**0.972 (0.000)**
Mature leaves				
Individuals/month (n=584)	558.33 (10.54)	577.42 (5.62)	**-2.666 (0.008)**	**0.647 (0.023)**
Species/month (n=129)	119.33 (4.51)	126.75 (1.99)	**-2.257 (0.012)**	**0.661 (0.019)**
Young leaves				
Individuals/month (n=584)	227.42 (11.08)	179.25 (9.60)	**-2.934 (0.003)**	**0.636 (0.026)**
Species/month (n=129)	82.75 (4.08)	72.08 (2.94)	**-2.198 (0.028)**	**0.652 (0.022)**
Flowers				
Individuals/month (n=584)	56.25 (10.46)	45.67 (12.56)	-1.490 (0.136)	**0.925 (0.000)**
Species/month (n=129)	25.25 (4.75)	17.50 (4.74)	**-2.435 (0.015)**	**0.937 (0.000)**
Fruits				
Individuals/month (n=584)	132.17 (12.21)	135.25 (9.78)	-0.432 (0.666)	**0.662 (0.031)**
Species/month (n=129)	51.50 (4.92)	46.67 (2.82)	-0.981 (0.327)	0.497 (0.100)
LTM Food plants - Fruits				
Food tree-species/month (n=49)	21.17 (2.19)	16.67 (1.71)	**-2.084 (0.037)**	0.556 (0.060)
Ficus individuals/month (n=47)	10.16 (0.85)	7.50 (1.14)	**-2.057 (0.040)**	0.353 (0.261)

Table 6.1. A comparison of climatic and phenological variations between the years 1997 and 1998 in Someshwara Wildlife Sanctuary, Karnataka. (Significant values are in **bold**). Wilcoxon Z is for significance of difference between years and Spearman rank correlation is for similarity in monthly pattern between years.

6.5.2. Flowering Phenology

The flowering, of individuals and species, was at its maximum in March and April and minimum in September for both the years, and the monthly variation was similar between them (r_s=0.925, n=24, p<0.01: Table 6.1 and Figure 6.1c). The pattern in the flowering phenology of the plant species mirrored that of the individuals (r_s=0.958, n=24, p<0.01:

Figure 6.1). There was a predictable pattern between the 2 years (r_s=0.925, n=12, p<0.01) but there was no significant difference between years in the monthly number of individuals flowering (Z= -1.490, n=12, p>0.05: Table 6.1). There seemed to be an inverse relationship between the flowering phenology and leaf fall. The flowering season was at its zenith when the plants were losing their leaves (March-April). In fact the relationship was significant for both the individual and species flowering and leaf fall (r_s= -0.801, -0.730 respectively, n=24, p<0.001). There was no correlation between individuals flowering and individuals leaf-flush phenology (r_s=0.236, n=24, p>0.05) and species flowering and species leaf-flush (r_s=0.161, n=-24, p>0.05).

Flowers of some species like *Mangifera indica* and *Glochidion johnstonei* did not fructify or were aborted during April 1997. Flowering began in October, increasing in succeeding months and reaching a peak in March-April before drastically declining in subsequent months. Almost all species had flowers by June, just before the onset of monsoon. Only *Callicarpa tomentosa* flowered later. The flowers of *Cinnamomum malabatrum* were not allowed to fructify since they were being collected as non-timber forest produce and hence the fruits of this species were seldom seen.

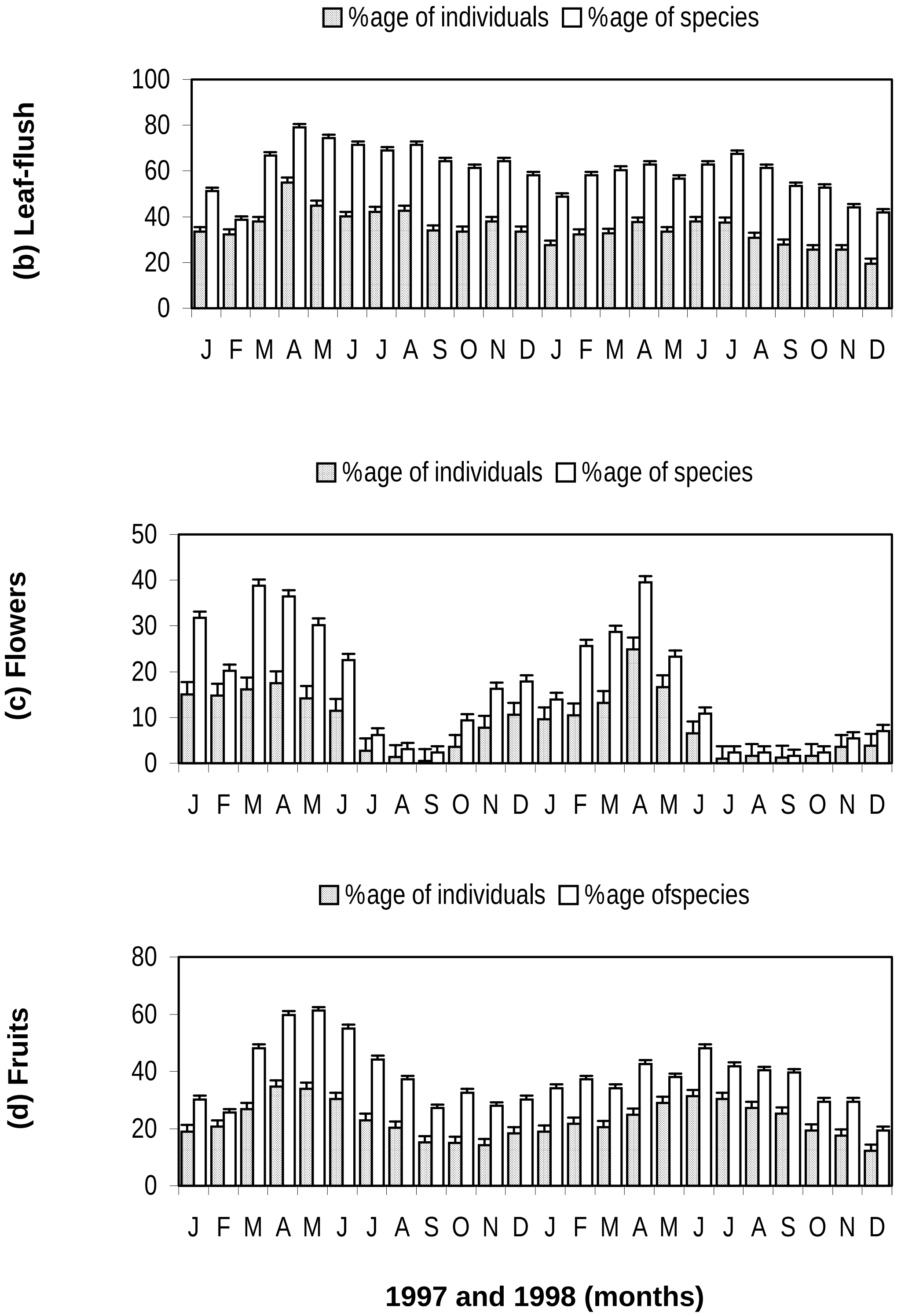


Figure6.1. The leaf-fall, leaf-flush, flowering and fruiting patterns observed in Someshwara Wildlife Sanctaury.

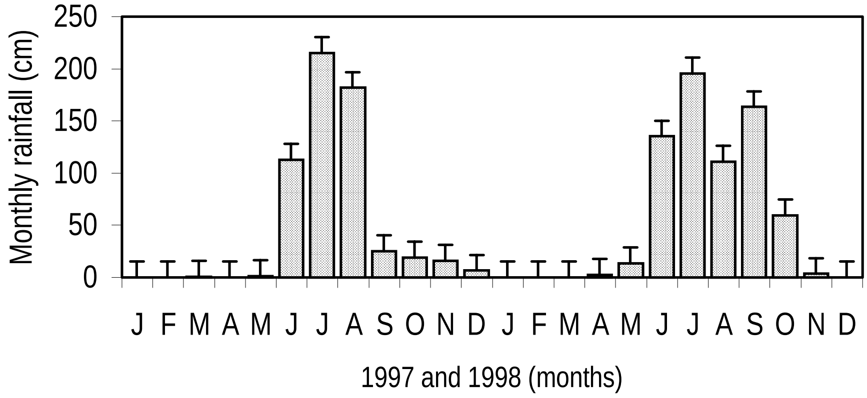
6.5.3. Fruiting phenology

The inter-annual fruiting pattern for the individuals was significantly correlated (r_s=0.622, n=12, p<0.05) between the two years whereas it was not the case for species (r_s=0.497, n=12, p>0.05: Table 1 and Figure 1d). There was no significant difference between years in the monthly number of individuals and species fruiting (Z= -0.432, -0.981, n=12, *p*>0.05: Table 6.1). The fruiting pattern for the individuals and species for the two years were similar (r_s=0.882, n=24, *p*<0.01). The percentage species fruiting was negatively correlated with individual and species leaf-fall (r_s= -0.681, -0.703, n=24, *p*<0.01). There again was a relationship between individual fruiting and individual and species leaf-flush (r_s=0.484, 0.523, n=24, *p*<0.05, *p*<0.01) and species fruiting and individual and species leaf-flush (r_s=0.645, 0.705, n=24, *p*<0.01).

It is interesting to note that fleshy fruits were removed or consumed immediately after fruiting but the dehiscent pods and capsules were seen on the plants for a longer time. Examples of the latter include the pods of *Entada pursaetha*, *Oroxylum indicum, Pajanelia longifolia*, *Albizia amara, A. chinensis, A. lebbeck*, *Hydnocarpus pentandra* and *H. macrocarpa*. There was competition between the animal frugivores and human beings for the fruits of *Garcinia indica*, *G. gummi-gutta*, *Artocarpus gomezianus* ssp. *zey-lanicus*, *A. heterophyllus*, *Myristica malabarica* and *Mangifera indica* and hence the fruits were harvested much faster than they would have been normally.

6.5.4. Effect of rainfall and temperature on plant phenology

The monthly variations in rainfall, rainy days, mean minimum and maximum tempera-tures were significantly correlated between the two years (r_s=0.854, 0.840, 0.902, 0.972 respectively, n=12, *p*<0.001: Table 6.1 and Figure 6.2). There was no difference between the years with respect to rainfall and rainy days (Z= -0.27, -0.05, n=12, *p*>0.05) but the differences in the daytime and nighttime temperatures were significant (Z= -3.059, -3.059, n=12, p<0.01). However, the mean monthly rainfall was lower in 1997 than 1998 and so were the mean rainy days (Table 6.2). The day and night temperatures were lower in 1998 compared to 1997 (Table 6.2).



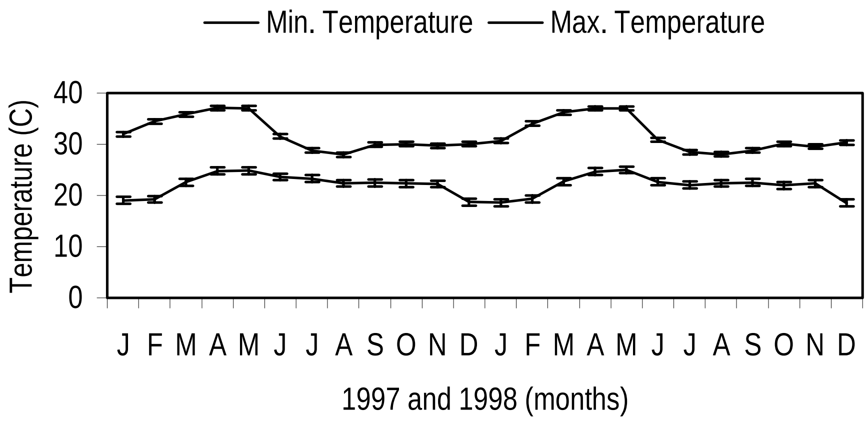


Figure 6.2. The monthly rainfall and minimum and maximum temperatures for Someshwara Wildlife Sanctuary, Karnataka (1997-1998). Source: Forest Rest House, Sitanadi.

The flowering phenology of individuals was inversely correlated with rainfall and the number of rainy days (r_s= -0.654, -0.650 respectively, n=24, p<0.01) and positively associated with the daytime (maximum) temperature (r_s=0.862, n=24, p<0.01) whereas the fruiting and leaf-flush phenology was highly correlated with nighttime (minimum) temperatures (r_s=0.725, 0.634 respectively, n=24, p<0.01). The leaf-fall phenology for the individuals was positively correlated with maximum temperatures (r_s= -0.704, n=24, p<0.01), but not with minimum temperatures (r_s= -0.326, n=24, p>0.05).

6.5.5. Phenology of lion-tailed macaque food-trees

Among the 129 species tagged for phenological observations, the lion-tailed macaques use forty-nine species (37.98%) as food resources. Since the macaques are obligate frugivores and also consume some amount of flowers, the leaf-fall and leaf-flush phenology for these species were not taken into consideration. The food-species flowering and fruiting phenology of food species together was similar to the general species flowering and fruiting (r_s=0.924, 0.791, n=24, p<0.01). However, the inter-annual fruiting patterns (for the food species) were marginally significant (r_s=0.556, n=12, p=0.060: Figure 6.3), and the number of species in fruit in each month was greater in 1997 than in 1998 (Z= -2.084, n=24, p<0.05: Table 6.1). . The supply of fruits had a peak in April-May and a trough during September to December in 1997 and 1998

Some of the most important food species like *Syzygium gardneri* (n=7) did not fruit at all (although one tree did fruit for around 15 days with few fruits). Among the non-*Ficus* fruits, *Elaeocarpus serratus* and *E. tuberculatus* fruits were available for the longest period (Appendix 11). *Bombax ceiba* and *Tetrameles nudiflora* flowered with unfailing accuracy, and provided food for 2-3 months. The fruits of *Hydnocarpus macrocarpa* and *H. pentandra* were persistent on the tree branches for most of the months, but becoming inedible after a period of time.

The fruits of *Mimusops elengi* were available only during the rainy months of July and August (Table 6.2). Of the 9 individuals of *Antiaris toxicaria* only 2 fruited during the months of January to March (Table 6.2) and that too only one individual had a consistent and sumptuous supply of the fruits on which the macaques fed continuously during the morning hours. Overall the fruits of the plant family Moraceae proved to be the most important for the very sustenance of these macaques.

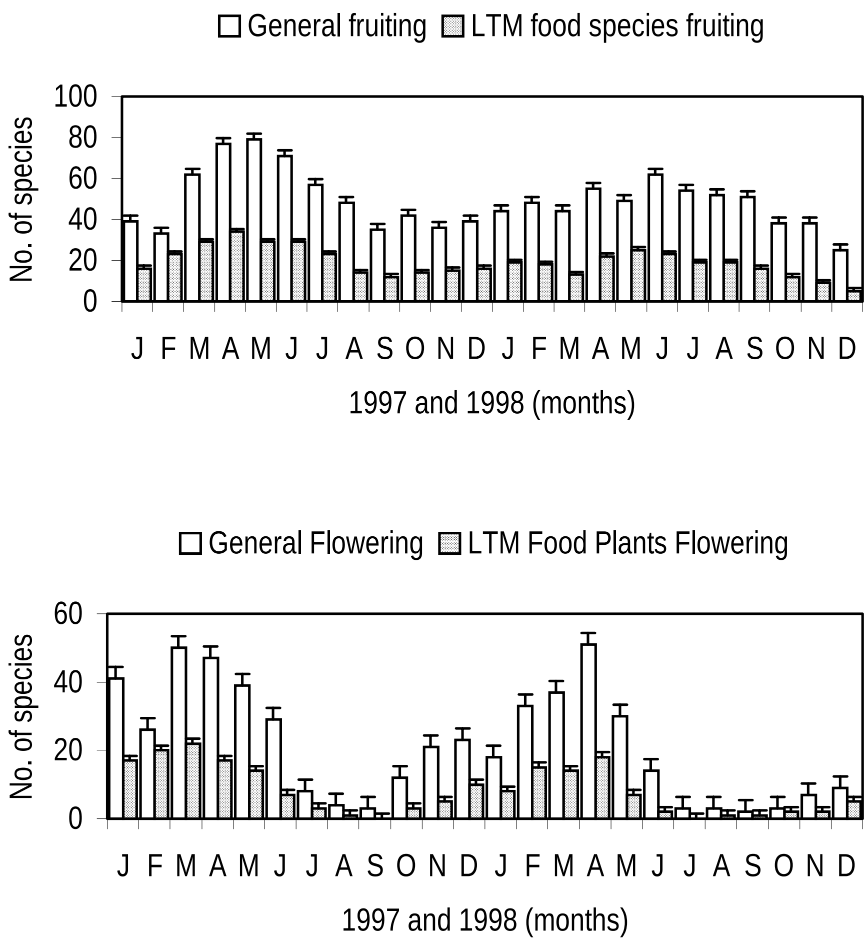


Figure 6.3. A comparison of the fruiting and flowering phenology of all the tagged species and the food-species of the lion-tailed macaques

6.5.6. *Ficus* fruiting phenology

There were 8 species of *Ficus* with 47 individuals in the phenological sample with a mean of 5.22 individuals/species (SE=1.09). These *Ficus* species provided fruits throughout the 24-month period of monitoring barring one month (Figure 6.4) with a mean of 8.83 individuals per month (SE=0.75). The *Ficus* fruiting phenology was not correlated with rainfall (r_s=0.166, n=24, p>0.05) but was correlated with the nighttime temperature (r_s=0.520,

	Lion-tailed macaque food species	1997												1998											
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
1	*Antiaris toxicaria*	*	*	*										*	*	*									
2	*Aporusa lindleyana*			*	*	*	*	*	*					*			*	*	*	*	*				
3	*Arenga wightii*																								
4	*Artocarpus gomezianus* [A]	*	*	*	*	*						*	*	*	*	*	*	*	*						
5	*Artocarpus heterophyllus*		*	*	*	*	*						*	*	*		*								
6	*Artocarpus hirsutus*		*	*	*	*											*								
7	*Bombax ceiba*		*	*	*	*								*			*	*							
8	*Calophyllum polyanthum*	*										*	*	*	*		*								
9	*Carallia brachiata*	*		*	*	*	*	*						*						*					
10	*Caryota urens*	*	*	*	*	*	*	*		*	*	*	*	*	*	*		*	*	*	*	*	*		
11	*Cinnamomum malabatrum*			*		*	*																		
12	*Clausena dentata*						*	*	*	*								*							
13	*Dillenia pentagyna*				*	*	*	*										*	*						
14	*Dimocarpus longan*	*		*	*	*					*	*	*	*	*	*	*		*	*		*	*		*
15	*Diospyros buxifolia*																								
16	*Elaeocarpus serratus*	*	*	*	*	*	*	*	*	*			*	*	*	*	*	*	*	*	*	*			
17	*Elaeocarpus tuberculatus*		*	*	*	*	*	*						*	*	*	*	*	*	*	*	*	*	*	*
18	*Ficus callosa*		*	*	*						*	*					*	*	*	*	*	*			
19	*Ficus drupacea*		*	*	*	*	*					*			*		*								
20	*Ficus hispida*				*			*	*		*		*	*			*	*	*	*	*	*	*	*	
21	*Ficus nervosa*						*	*	*		*	*							*		*	*			
22	*Ficus racemosa*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
23	*Ficus talbotii*		*		*														*		*				
24	*Ficus tsjahela*		*	*	*	*	*		*	*		*		*	*	*	*	*	*	*		*	*		
25	*Ficus virens*	*	*	*	*		*				*	*	*		*										
26	*Flacourtia montana*	*	*	*	*																				
27	*Garcinia gummi-gutta*				*	*	*	*										*							
28	*Garcinia indica*		*	*	*	*	*	*	*		*				*	*	*								
29	*Garcinia morella*	*			*	*	*						*	*				*							
30	*Gnetum ula (L)*		*	*	*	*	*	*	*	*							*		*	*	*	*			
31	*Grewia tiliifolia*					*	*	*	*	*								*			*				
32	*Holigarna grahamii*			*								*					*								
33	*Hydnocarpus macrocarpa*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			*	*	*	*	*	*	*	*
34	*Hydnocarpus pentandra*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
35	*Macaranga peltata*			*														*							
36	*Mangifera indica*			*	*	*									*			*							
37	*Mimusops elengi*		*				*	*	*	*	*	*	*	*											
38	*Myristica dactyloides*				*	*												*							
39	*Myristica malabarica*		*	*	*		*	*								*	*		*	*	*	*	*	*	*
40	*Olea dioica*			*	*												*	*	*						
41	*Oroxylum indicum*	*	*	*	*	*	*	*	*		*	*	*	*		*	*	*	*	*	*	*	*	*	
42	*Persea macrantha*		*	*	*	*														*	*	*	*		
43	*Sterculia guttata*	*	*		*	*	*				*	*	*	*		*	*	*	*	*	*	*	*	*	
44	*Syzygium cumini*				*	*	*											*	*						
45	*Syzygium gardneri*														*										
46	*Syzygium hemisphericum*						*	*							*										
47	*Tetrameles nudiflora*				*	*	*												*	*					
48	*Vateria indica*						*	*	*	*								*	*	*	*	*			
49	*Vepris bilocularis*							*		*															

Table 6.2. The fruiting patterns of the lion-tailed macaque food species. [A] ssp. zeylanicus

n=24, *p*<0.01). One *Ficus racemosa* individual was in fruiting for 23 months continuously, except during the December of 1998, when the other *Ficus* species were also not fruiting (Table 6.2). The fruiting of *F. religiosa* was not as reliable as the *F. racemosa* but was fruiting every now and then.

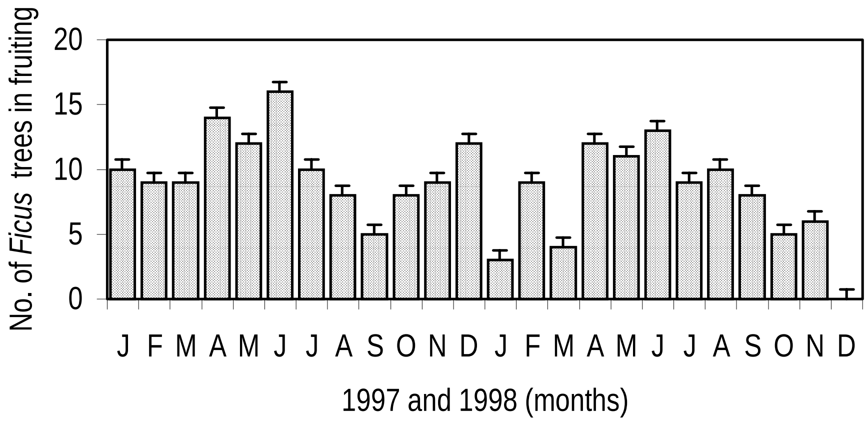


Figure 6.4. The fruiting patterns for the *Ficus* individuals for the years 1997 and 1998 in Someshwara Wildlife Sanctuary, Karnataka.

6.6. Discussion

6.6.1. Plant phenology – a background scenario

Knowledge about the patterns of leafing, flowering and fruiting phenology of tropical forest plants, both at the level of communities and of individuals species, has been developed during the past few years and this information has revealed considerable spatial and temporal variation in phenological patterns (Janzen, 1967; Medway, 1972; Frankie *et al*., 1974; Appanah, 1985; Newberry *et al*., 1998; Chapman *et al*., 1999; Murali and Sukumar, 1993; 1994; Ganesh and Davidar, 1997; Bhat and Murali, 2001; Mudappa, 2001). Understanding of the factors that regulate initiation, periodicity and frequency of flowering and/or fruiting remains obscure and therefore it is not surprising that in spite of 20-30 years of phenological research in the tropics, researchers have not had any success in developing predictive models of phenological events (Bawa *et al*., 1990).

Although some attempt is being made in this direction to understand the effect of certain abiotic factors like irradiance, rainfall, water stress and temperature (Ashton *et al*., 1988; Wright and Cornejo, 1990; Wright and van Schaik, 1994; Sun *et al*., 1996; Newberry *et al*., 1998), biotic factors like mode of seed dispersal, activity of pollinators or seed dispersers, variations in germination conditions and relative abundance of tree themselves are also important factors governing phenology (Snow, 1965; Janzen, 1967; Frankie *et al*., 1974; Wheelwright, 1985; Rathche and Lacey, 1985; van Schaik *et al*., 1993; Newstrom *et al*., 1994; Chapman *et al*., 1999).

An understanding of the phenological patterns in different geographical regions and of factors underlying these patterns is important for a number of reasons. First, frugivores are a dominant group of vertebrates in most tropical forests and regional differences in their abundance may be caused by differences in food availability (Terborgh, 1986a; Terborgh and van Schaik, 1987). Second, phenological patterns are linked to many processes governing forest function and structure including the population biology of pollinators, seed dispersers and predators, herbivores etc. (van Schaik *et al*., 1993; Newstrom *et al*., 1994). Thus an understanding of what regulates phenological processes is valuable in understanding forest function and structure and in providing the basis for developing conservation options for the flora and fauna.

6.6.2. Leaf-fall and leaf-flush (vegetative) phenology

Rates of leaf fall in tropical forest communities almost always peak during seasonal drought and it is frequently inferred that avoidance of water stress is the ultimate cause of leaf abscission (Frankie *et al*., 1974; Wright and Cornejo, 1990; Murali and Sukumar, 1993). In fact leaf-fall is often concentrated during the dry seasons in Central America (Janzen, 1967; Frankie *et al*., 1974; Wright and Cornejo, 1990). The leaf-fall phenology in Someshwara Wildlife Sanctuary showed clear peaks (when mature leaves start falling) during the dry months of 1997-1998 when there was physiological water stress on the plants. In Someshwara Wildlife Sanctuary the leaf-fall starts in February and all deciduous trees regain their mature leaves by mid-June when the south-west monsoon is very active. Generally the quantum of litter-fall starts building up when the trees start losing their leaves. From a study in the Sringeri region (30 km south-east of Someshwara Wildlife Sanctuary) of the Western Ghats it is confirmed that peak litter-fall is around January-March (Swamy and Proctor, 1994b) whereas the leaf-fall reaches its zenith during April for Someshwara Wildlife Sanctuary. The litter-fall pattern observed by Swamy and Proctor (1994b) has also been confirmed by Pascal (1988) for Attapadi.

Leaf-flushing in plants is a seasonal phenomenon that coincides with the onset of rainfall or when there is no moisture stress and hence most of the species may flush synchronously (Frankie *et al*., 1974; Lieberman and Lieberman, 1984; Murali and Sukumar, 1993). In Someshwara Wildlife Sanctuary, leaf-flush was noticed during the pre-monsoon showers and during the rainy season. Leaf-flush for the deciduous species were noticed only after the onset of the monsoons, whereas in the evergreen species it was noticed throughout the year and was more pronounced during the time of pre-monsoon showers. Leaf-flush in the *Ficus* species was immediately after all the mature leaves had fallen but the trees were leaf-less only for a few days. In fact, this phenomenon of leaflessness is the rule for all the *Ficus* species around the world (van Schaik *et al*., 1993).

The pattern observed at Someshwara Wildlife Sanctuary is similar to what has been observed in a dry deciduous forest, in Mudumalai Wildlife Sanctuary: leaf-flush peaks around March-April and dips around July-August (Murali and Sukumar, 1993). Both areas receive bulk of the rainfall during July and both experience a dry season of around 4.5-5 months. The only difference in the evergreen nature of Someshwara Wildlife Sanctuary could be its average annual rainfall that is 6 times more than Mudumalai Wildlife Sanctuary.

6.6.3. Flowering and fruiting (reproductive) phenology

Reproductive phenology of a forest is more important to a frugivorous guild and since the lion-tailed macaque is an obligate frugivore it gains more importance than the vegetative phenology. It is believed that the flowering (and also fruiting) phenology in the rainforests of southern Western Ghats is bi-modal whereas the northern part may exhibit a uni-modal pattern (Pascal, 1988). A study on flowering phenology conducted at Kalakkad-Mundanthurai Tiger Reserve (in the southern most limit of the Western Ghats) confirms this (Mudappa, 2001). Areas where the rainfall is spread out (or exhibit a bi-modal pattern), exhibit a bi-modal fruiting pattern (Cocha-Cashu: Terborgh, 1986a; Barro Colorado Island: Wright and Cornejo, 1990; Kibale: Struhsaker, 1997; Kalakkad-Mundanthurai Tiger Reserve: Mudappa, 2001). In the northern part of the Western Ghats the reproductive phenology exhibits a uni-modal pattern with only one peak (Bhat and Murali, 2001; this study). In Pakhui Wildlife Sanctuary (Arunachal Pradesh, northeastern India), where the rainfall pattern is similar to Someshwara Wildlife Sanctuary the flowering phenology is also uni-modal (Datta and Rawat, unpublished data).

Some of the deciduous species like *Tetrameles nudiflora*, *Bombax ceiba* and *Erythrina indica* flowered when there were no mature leaves or leaf-flush. It has been suggested that it may not be possible for a plant to allocate energy for both leaf flushing and flowering at the same time when resources such as moisture are scarce (Janzen, 1967). This is true of plants in dry deciduous forests or with respect to deciduous species (Murali and Sukumar, 1993; 1994). The flowering patterns showed sharp peaks compared to the fruiting patterns, probably due to the turnover of species from month to month and also because flowers are short-lived compared to fruits.

6.6.4. Phenology of lion-tailed macaque food-trees and some *Ficus* species

Plants of the humid tropics depend upon animals for the dispersal of their seeds and fruit is an important food item for many tropical animals (van der Pijl, 1972; Estrada and Fleming, 1986). For a mono-gastric primate like the lion-tailed macaque, tropical rainforests present a paradox in that much of the enormous biomass is chemically hostile, the digestible parts being fruits. Even though there is year round availability of fruits for a frugivorous community, the reproductive phenology of the preferred food-items vary in space and time. Hence a frugivorous primate like the lion-tailed macaques adapts itself to an eclectic diet, which includes a diversity of fruits and animal matter in varying proportion. In fact this aspect of meat eating has been observed in certain fruit-eating bats (Fleming, 1986). When preferred food resources become scarce competing sympatric frugivores switchover to exclusive diets (Stevenson *et al*., 2000).

The fruiting patterns of the 49 plant species of the lion-tailed macaque species were similar to that of the general fruiting. There was a peak in fruit availability during April-May and the fruit resources dwindled during December-January. For the macaques *Ficus* fruits were available throughout the year. The yield of some of the preferred fruits like *Syzygium gardneri*, *Mangifera indica* etc. were not promising, while some like *Elaeocarpus serratus* was fruiting for most part of the year.

The difference between years in the percentage of food specie which fruited was significant considering that may thus there was no such pattern in the general species fruiting. Overall fruiting patterns hide the problems faced by the frugivores. Availability of fruits throughout the year in a predictable fashion is very crucial for the survival of these macaques. More detailed studies are required in many part of the lion-tailed macaque habitats so that we would be able to understand the ecological pressures these macaques are facing.

6.7. Summary

1) In this chapter I examined the phenology of 129 species woody plant species including the food species of the lion-tailed macaque from 584 trees and lianas. The reproductive and vegetative phenologies of the woody plant species observed showed a uni-modal pattern, which is the norm for the rainforests of the northern part of the Western Ghats.
2) Although the fruits were not quantified it was apparent that the plant species exhibited a fruiting pattern that was similar to the flowering phenology.
3) The leaf-fall and leaf-flush phenology followed that of what has been observed by other researchers.
4) The fruiting pattern of the food species of the lion-tailed macaque was similar to that of the general fruiting. The lion-tailed macaques did face a period of fruit scarcity in September to December in both years.
5) *Ficus* species may be important in this context, since they were fruiting through out the year, thus buffering for seasonal and probably inter-annual variation.

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Appendix 1: Floristic composition, frequency, density and Importance Value Index (IVI) of all species sampled from **Zone 1**. The subspecies names are given as a footnote. IVI values for Lianas are not given since its total basal area is negligible. Species names that are in *italics* are food-plants of the lion-tailed macaques.

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm^2)	IVI
1	Poeciloneuron indicum	Clusiaceae	143	38	117065.16	24.94
2	*Myristica dactyloides*	Myristicaceae	109	64	56407.48	20.26
3	*Dimocarpus longan*	Sapindaceae	78	38	74245.34	16.45
4	*Aglaia elaeagnoidea*	Meliaceae	76	47	41203.52	14.55
5	*Syzygium gardneri*	Myrtaceae	41	31	91288.12	14.30
6	*Olea dioica*	Oleaceae	60	33	66951.83	13.91
7	Lepisanthes tetraphylla	Sapindaceae	46	29	19474.28	8.41
8	*Garcinia morella*	Clusiaceae	57	26	12482.56	8.31
9	*Palaquium ellipticum*	Sapotaceae	30	21	18930.20	6.25
10	*Cinnamomum malabatrum*	Lauraceae	21	20	24674.13	5.94
11	Holigarna arnottiana	Anacardiaceae	25	20	15041.31	5.43
12	*Holigarna grahamii*	Anacardiaceae	23	16	21743.00	5.39
13	Hopea ponga	Dipterocarpaceae	27	16	15276.13	5.14
14	Dipterocarpus indicus	Dipterocarpaceae	17	9	33326.14	5.11
15	*Elaeocarpus tuberculatus*	Elaeocarpaceae	11	9	37295.08	4.99
16	*Myristica malabarica*	Myristicaceae	28	15	13403.21	4.95
17	*Ficus nervosa*	Moraceae	11	9	32874.54	4.62
18	*Artocarpus hirsutus*	Moraceae	16	13	22425.43	4.58
19	*Bischofia javanica*	Euphorbiaceae	8	8	36359.33	4.57
20	Lagerstroemia microcarpa	Lythraceae	9	9	33327.09	4.51
21	Reinwardtiodendron anamalaiense	Meliaceae	29	13	8160.46	4.35
22	*Knema attenuata*	Myristicaceae	21	15	8495.01	4.01
23	Diospyros candolleana	Ebenaceae	16	11	8166.36	3.15
24	*Canthium dicoccum*	Rubiaceae	20	9	6030.32	3.04
25	*Litsea insignis*	Lauraceae	15	12	6126.21	3.02
26	Lophopetalum wightianum	Celastraceae	6	6	21596.15	2.95
27	*Garcinia indica*	Clusiaceae	12	11	7792.35	2.82
28	*Gordonia obtusa*	Ternstroemiaceae	6	4	22342.59	2.79
29	Diospyros paniculata	Ebenaceae	12	11	7235.17	2.77
30	Chionanthus mala-elengi	Oleaceae	15	9	6683.40	2.72
31	Diospyros oocarpa	Ebenaceae	9	7	13707.90	2.63
32	*Calophyllum polyanthum*	Clusiaceae	5	5	18496.40	2.50
33	Diospyros crumenata	Ebenaceae	12	10	4597.27	2.43
34	*Persea macrantha*	Lauraceae	6	6	15171.66	2.41
35	Terminalia paniculata	Combretaceae	5	4	18093.85	2.35
36	Polyalthia fragrans	Annonaceae	8	8	6546.36	2.07

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm²)	IVI
37	Garcinia spicata	Clusiaceae	8	6	8661.39	2.02
38	*Nothopegia beddomei*	Anacardiaceae	9	9	2765.84	1.94
39	*Antiaris toxicaria*	Moraceae	3	3	16082.59	1.92
40	Ixora brachiata	Rubiaceae	10	8	2560.88	1.88
41	Diospyros sp.	Ebenaceae	11	6	2987.12	1.76
42	*Caryota urens*	Arecaceae	8	7	4094.21	1.75
43	Stereospermum colais	Bignoniaceae	4	3	12834.31	1.72
44	*Ficus virens*	Moraceae	2	2	15964.78	1.72
45	Diospyros saldanhae	Ebenaceae	11	6	2342.09	1.71
46	*Arenga wightii*	Arecaceae	9	7	2520.72	1.69
47	*Fahrenheitia zeylanica*	Euphorbiaceae	6	6	4565.74	1.52
48	*Litsea floribunda*	Lauraceae	6	5	5692.77	1.50
49	*Hydnocarpus pentandra*	Flacourtiaceae	7	7	1112.86	1.42
50	Mastixia arborea	Cornaceae	6	5	4513.33	1.40
51	*Macaranga peltata*	Euphorbiaceae	8	5	2199.78	1.36
52	*Vateria indica*	Dipterocarpaceae	5	5	4585.31	1.33
53	Litsea mysorensis	Lauraceae	7	5	2055.73	1.27
54	Actinodaphne bourdillonii	Lauraceae	6	6	1536.15	1.27
55	Pterospermum diversifolium	Sterculiaceae	6	6	1376.39	1.25
56	Alstonia scholaris	Apocynaceae	3	2	9158.14	1.22
57	Eugenia macrosepala	Myrtaceae	6	6	914.82	1.21
58	Donella roxburghii	Sapotaceae	4	3	6458.16	1.19
59	*Ficus callosa*	Moraceae	4	4	4630.22	1.15
60	Mallotus philippensis	Euphorbiaceae	5	5	1664.78	1.09
61	*Mangifera indica*	Anacardiaceae	5	5	1613.66	1.08
62	Mesua ferrea	Clusiaceae	4	3	5127.20	1.07
63	Syzygium rubicundam	Myrtaceae	4	4	3165.31	1.02
64	*Carallia brachiata*	Rhizophoraceae	2	1	8639.60	0.99
65	*Hydnocarpus macrocarpa*	Flacourtiaceae	5	4	1722.35	0.98
66	Hopea canarensis	Dipterocarpaceae	5	4	1458.02	0.96
67	Acrocarpus fraxinifolius	Fabaceae	1	1	8150.55	0.87
68	Syzygium zeylanicum	Myrtaceae	4	4	1040.08	0.85
69	Archidendron monadelphum	Fabaceae	4	3	2357.56	0.84
70	*Artocarpus heterophyllus*	Moraceae	3	3	3068.59	0.83
71	*Canarium strictum*	Burseraceae	3	3	2643.71	0.79
72	*Sterculia guttata*	Sterculiaceae	2	2	4713.68	0.78
73	*Vepris bilocularis*	Rutaceae	3	3	2429.70	0.77
74	*Syzygium hemisphericum*	Myrtaceae	3	3	2291.09	0.76
75	*Mimusops elengi*	Sapotaceae	4	3	1254.77	0.75
76	Goniothalamus cardiopetalus	Annonaceae	3	3	2054.27	0.74
77	Hopea parviflora	Dipterocarpaceae	3	3	1852.33	0.72
78	*Diospyros malabarica*	Ebenaceae	4	3	880.26	0.72

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm^2)	IVI
79	Holoptelea integrifolia	Ulmaceae	1	1	6236.36	0.71
80	Madhuca neriifolia	Sapotaceae	3	3	1717.45	0.71
81	Nothapodytes nimmoniana	Icacinaceae	4	3	643.83	0.70
82	Schefflera racemosa	Araliaceae	2	2	3668.18	0.69
83	*Clausena dentata*	Rutaceae	3	3	1209.43	0.67
84	Terminalia bellirica	Combretaceae	1	1	5393.83	0.64
85	Grewia serrulata	Tiliaceae	3	3	804.17	0.64
86	*Syzygium laetum*	Myrtaceae	3	3	507.14	0.61
87	*Syzygium cumini*	Myrtaceae	2	2	2329.75	0.58
88	Maytenus rothiana	Celastraceae	2	2	1472.53	0.50
89	Blachia denudata	Euphorbiaceae	3	2	297.54	0.48
90	*Elaeocarpus serratus*	Elaeocarpaceae	2	2	1136.01	0.47
91	*Diospyros buxifolia*	Ebenaceae	2	2	1119.74	0.47
92	*Aporusa lindleyana*	Euphorbiaceae	2	2	1042.00	0.47
93	Trewia polycarpa	Euphorbiaceae	2	2	932.98	0.46
94	Holigarna beddomei	Anacardiaceae	2	2	636.88	0.43
95	Xantolis tomentosa	Sapotaceae	2	2	522.63	0.42
96	*Litsea laevigata*	Lauraceae	2	2	513.19	0.42
97	Unidentified Species 38		1	1	2731.28	0.42
98	*Antidesma menasu*	Euphorbiaceae	2	2	381.16	0.41
99	Homalium zeylanicum	Flacourtiaceae	1	1	2634.86	0.41
100	Callicarpa tomentosa	Verbenaceae	2	2	338.23	0.41
101	Unidentified species 27		2	2	315.90	0.41
102	Unidentified species 85		2	2	301.72	0.40
103	Unidentified species 57		2	2	280.72	0.40
104	Memecylon umbellatum	Melastomataceae	2	2	271.93	0.40
105	*Garcinia gummi-gutta*	Clusiaceae	1	1	2023.66	0.36
106	Vitex altissima	Verbenaceae	1	1	1813.72	0.34
107	Lagerstroemia parviflora	Lythraceae	1	1	1295.14	0.30
108	Celtis philippensis	Ulmaceae	1	1	1242.90	0.29
109	Haldina cordifolia	Rubiaceae	1	1	1174.27	0.29
110	Ficus exasperata	Moraceae	1	1	917.54	0.27
111	Chionanthus ramiflorus	Oleaceae	1	1	843.90	0.26
112	*Cryptocarya bourdillonii*	Lauraceae	1	1	509.09	0.23
113	Symplocos racemosa [A]	Symplocaceae	1	1	418.11	0.22
114	Rubiaceae member	Rubiaceae	1	1	336.08	0.22
115	*Artocarpus gomezianus* [B]	Moraceae	1	1	328.88	0.22
116	*Neolitsea scrobiculata*	Lauraceae	1	1	319.74	0.22
117	Toona ciliata	Meliaceae	1	1	249.45	0.21
118	Symplocos macrophylla [C]	Symplocaceae	1	1	172.00	0.20
119	*Tetrameles nudiflora*	Datiscaceae	1	1	156.11	0.20

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm^2)	IVI
120	Tabernaemontana heyneana	Apocynaceae	1	1	142.33	0.20
121	Eurya nitida	Ternstroemiaceae	1	1	135.02	0.20
122	*Holigarna nigra*	Anacardiaceae	1	1	122.86	0.20
123	*Cinnamomum sulphuratum*	Lauraceae	1	1	98.56	0.20
124	Beilschmiedia wightii	Lauraceae	1	1	97.44	0.20
125	*Flacourtia montana*	Flacourtiaceae	1	1	97.44	0.20
126	Casearia bourdillonii	Flacourtiaceae	1	1	86.63	0.20
127	*Meiogyne pannosa*	Annonaceae	1	1	81.45	0.20
128	Saraca asoca	Fabaceae	1	1	72.55	0.20
129	*Ardisia pauciflora*	Myrsinaceae	1	1	71.59	0.20
130	*Ficus hispida*	Moraceae	1	1	71.59	0.20
131	Litsea glabarata	Lauraceae	1	1	71.59	0.20
			1331	**874**	**1189165.26**	**300**
	SPECIES (Lianas)					
1	Ventilago maderaspatana	Rhamnaceae	21	19	1304.76	
2	Grewia umbellifera	Tiliaceae	8	5	862.50	
3	Calycopteris floribunda	Combretaceae	9	8	258.15	
4	Strychnos colubrina	Loganiaceae	8	6	380.23	
5	*Chilocarpus denudatus*	Apocynaceae	5	5	356.83	
6	Ancistrocladus heyneanus	Ancistrocladaceae	5	5	257.49	
7	Moullava spicata	Fabaceae	6	3	161.31	
8	Loeseneriella arnottiana	Hippocrataceae	5	3	213.10	
9	Tetrastigma muricatum	Vitaceae	5	4	143.12	
10	*Randia rugulosa*	Rubiaceae	4	3	233.21	
11	Ventilago bombaiensis	Rhamnaceae	4	3	223.52	
12	Bauhinia phoenicea	Fabaceae	3	3	250.71	
13	*Gnetum ula*	Gnetaceae	3	3	199.53	
14	Schefflera venulosa	Araliaceae	3	3	157.66	
15	Gardneria ovata	Loganiaceae	2	2	135.94	
16	Luvunga sarmentosa	Rutaceae	2	2	84.00	
17	*Erycibe paniculata*	Convolvulaceae	1	1	200.46	
18	Kunstleria keralensis	Fabaceae	2	2	81.84	
19	Combretum latifolium	Combretaceae	2	2	42.19	
20	Leptadenia reticulata	Asclepiadaceae	2	1	103.41	
21	Meiogyne lawii	Annonaceae	2	2	26.35	
22	Unidentified species 22		1	1	117.91	
23	Jasminum malabaricum	Oleaceae	2	1	63.70	
24	*Artabotrys zeylanicus*	Annonaceae	2	1	63.18	
25	Rourea minor	Connaraceae	1	1	84.02	
26	Entada pursaetha	Fabaceae	2	1	17.90	

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm^2)	IVI
27	Desmos sp.	Fabaceae	1	1	51.32	
28	*Sarcostigma kleinii*	Icacinaceae	1	1	42.08	
29	Carissa inermis	Apocynaceae	1	1	35.75	
30	Unidentified species 92		1	1	27.82	
31	Derris sp.	Fabaceae	1	1	14.5	
32	*Calamus pseudo-tenuis*	Arecaceae	1	1	8.44	
33	Premna coriacea	Verbenaceae	1	1	8.28	
			117	**97**	**6211.21**	

[A] ssp. *macrophylla*, [B] ssp. *zeylanicus*, [C] ssp. *rosea*.

Appendix 2: Floristic composition, frequency, density and Importance Value Index (IVI) of all species sampled from **Zone 2**. The subspecies names are given as a footnote. IVI values for Lianas are not given since its total basal area is negligible. Species names that are in *italics* are food-plants of the lion-tailed macaques.

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm^2)	IVI
1	*Palaquium ellipticum*	Sapotaceae	57	34	66134.77	12.66
2	Drypetes wightii	Euphorbiaceae	73	25	61591.14	12.55
3	*Knema attenuata*	Myristicaceae	57	39	37562.75	10.97
4	*Myristica dactyloides*	Myristicaceae	68	31	29819.77	10.35
5	Toona ciliata	Meliaceae	26	17	85402.37	10.18
6	*Elaeocarpus tuberculatus*	Elaeocarpaceae	22	16	69176.49	8.54
7	*Persea macrantha*	Lauraceae	23	21	58085.03	8.27
8	*Syzygium gardneri*	Myrtaceae	31	26	41839.46	8.10
9	*Cullenia exarillata*	Bombacaceae	29	20	51147.67	8.07
10	*Diospyros nilagirica*	Ebenaceae	46	32	18391.9	7.99
11	Hopea parviflora	Dipterocarpaceae	21	16	40479.18	6.26
12	Dalbergia latifolia	Fabaceae	18	12	48301.96	6.24
13	Dipterocarpus indicus	Dipterocarpaceae	34	20	22739.25	6.24
14	*Bischofia javanica*	Euphorbiaceae	15	15	42747.08	5.90
15	*Xanthophyllum arnottianum*	Xanthophyllaceae	34	24	8449.53	5.54
16	Reinwardtiodendron anamalaiense	Meliaceae	32	22	11130.66	5.40
17	Semecarpus auriculata	Anacardiaceae	34	16	14854.93	5.22
18	Humboldtia brunonis	Fabaceae	34	18	5101.24	4.67
19	*Mesua ferrea*	Clusiaceae	15	15	25491.48	4.57
20	*Drypetes elata*	Euphorbiaceae	16	14	17829.15	3.95
21	Chionanthus mala-elengi	Oleaceae	22	15	8578.72	3.77
22	*Calophyllum polyanthum*	Clusiaceae	13	13	16508.75	3.53
23	*Cinnamomum malabatrum*	Lauraceae	16	15	10177.90	3.46
24	Lepisanthes tetraphylla	Sapindaceae	22	13	6083.33	3.38
25	*Artocarpus hirsutus*	Moraceae	13	11	16150.13	3.30
26	Lophopetalum wightianum	Celastraceae	14	9	17636.00	3.28
27	Vitex altissima	Verbenaceae	9	9	20668.57	3.16
28	*Mangifera indica*	Anacardiaceae	11	10	17159.88	3.13
29	Litsea mysorensis	Lauraceae	15	14	4969.95	2.89
30	*Vateria indica*	Dipterocarpaceae	21	5	10942.29	2.86
31	*Litsea floribunda*	Lauraceae	12	11	11308.13	2.85
32	*Dimocarpus longan*	Sapindaceae	11	11	10370.90	2.71
33	Hopea ponga	Dipterocarpaceae	14	9	10151.52	2.71
34	*Baccaurea courtallensis*	Euphorbiaceae	16	12	2901.02	2.60
35	*Agrostistachys borneensis*	Euphorbiaceae	15	12	3561.75	2.58
36	Phoebe lanceolata	Lauraceae	14	10	4447.52	2.37
37	*Macaranga indica*	Anacardiaceae	14	7	6175.29	2.20
38	*Macaranga peltata*	Euphorbiaceae	10	7	9170.91	2.14
39	*Myristica malabarica*	Myristicaceae	12	9	4436.99	2.12
40	Lagerstroemia parviflora	Lythraceae	9	8	7022.39	2.00
41	*Elaeocarpus serratus*	Elaeocarpaceae	9	7	8087.32	1.98
42	*Ficus nervosa*	Moraceae	5	5	13867.90	1.94

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm²)	IVI
43	*Prunus ceylanica*	Rosaceae	9	8	5192.38	1.86
44	*Canarium strictum*	Burseraceae	7	7	8324.05	1.86
45	*Litsea insignis*	Lauraceae	10	7	5281.33	1.84
46	Acrocarpus fraxinifolius	Fabaceae	3	3	16692.05	1.81
47	*Garcinia gummi-gutta*	Clusiaceae	7	7	7666.27	1.81
48	Mastixia arborea	Cornaceae	12	7	2696.69	1.78
49	Casearia wynadensis	Flacourtiaceae	14	4	4659.21	1.77
50	Casearia rubescens	Flacourtiaceae	12	5	4804.40	1.74
51	*Ficus virens*	Moraceae	2	2	16966.84	1.65
52	Polyalthia fragrans	Annonaceae	7	6	6585.01	1.62
53	Diospyros humilis	Ebenaceae	9	7	3332.49	1.62
54	*Ficus beddomei*	Moraceae	3	3	13910.98	1.59
55	*Olea dioica*	Oleaceae	8	6	4241.98	1.51
56	Diospyros paniculata	Ebenaceae	7	7	3499.40	1.49
57	Albizia chinensis	Fabaceae	5	2	11961.40	1.49
58	Kingiodendron pinnatum	Fabaceae	11	5	1867.44	1.45
59	Trichilia connaroides	Meliaceae	5	4	7738.53	1.36
60	*Holigarna grahamii*	Anacardiaceae	5	5	6175.28	1.34
61	Lagerstroemia microcarpa	Lythraceae	3	3	10487.87	1.33
62	*Hydnocarpus pentandra*	Flacourtiaceae	7	7	1464.66	1.33
63	*Symplocos cochinchinensis* [A]	Symplocaceae	7	6	2668.79	1.32
64	Oreocnide integrifolia	Urticaceae	8	5	2316.09	1.26
65	Callicarpa tomentosa	Verbenaceae	7	6	994.61	1.19
66	Glochidion malabaricum	Euphorbiaceae	6	4	4321.59	1.17
67	Archidendron monadelphum	Fabaceae	9	3	2746.29	1.17
68	Sapindus trifoliata	Sapindaceae	5	4	4994.22	1.15
69	Syzygium palghatense	Myrtaceae	7	5	1542.23	1.13
70	Gomphandra tetrandra	Icacinaceae	7	5	1214.09	1.11
71	*Ficus hispida*	Moraceae	7	5	1153.43	1.10
72	*Turpinia malabarica*	Staphyleaceae	4	4	5198.43	1.10
73	*Fahrenheitia zeylanica*	Euphorbiaceae	5	5	2721.1	1.08
74	*Cryptocarya bourdillonii*	Lauraceae	5	4	3767.74	1.06
75	Donella roxburghii	Sapotaceae	5	5	2088.99	1.03
76	*Artocarpus heterophyllus*	Moraceae	3	3	6401.27	1.01
77	Tabernaemontana heyneana	Apocynaceae	5	5	1749.29	1.00
78	*Syzygium hemisphericum*	Myrtaceae	4	3	5227.31	1.00
79	*Holigarna nigra*	Anacardiaceae	4	4	3125.60	0.94
80	*Garcinia morella*	Clusiaceae	5	4	1768.33	0.90
81	Ixora brachiata	Rubiaceae	6	4	769.14	0.90
82	Trewia polycarpa	Euphorbiaceae	3	3	4808.36	0.89
83	Epiprinus mallotiformis	Euphorbiaceae	5	3	2524.13	0.86
84	Chukrasia tabularis	Meliaceae	2	2	6343.90	0.84
85	Diospyros bourdillonii	Ebenaceae	4	3	3043.95	0.83
86	Mallotus philippensis	Euphorbiaceae	4	4	1450.24	0.81
87	*Aglaia elaeagnoidea*	Meliaceae	4	3	2624.31	0.80
88	Diospyros oocarpa	Ebenaceae	3	3	3295.09	0.78
89	*Grewia tiliifolia*	Tiliaceae	2	2	5340.06	0.76

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm^2)	IVI
90	Otonephelium stipulaceum	Sapindaceae	4	3	2044.21	0.75
91	Actinodaphne malabarica	Lauraceae	4	4	692.71	0.75
92	Nothopegia racemosa	Anacardiaceae	4	4	556.49	0.74
93	*Meliosma pinnata* [B]	Sabiaceae	3	1	5368.50	0.73
94	Alstonia scholaris	Apocynaceae	3	3	2337.82	0.70
95	Drypetes confertiflora	Euphorbiaceae	3	3	1974.93	0.67
96	Croton malabaricus	Euphorbiaceae	3	3	1250.73	0.62
97	Pajanelia longifolia	Bignoniaceae	3	3	1230.78	0.62
98	Lagerstroemia reginae	Lythraceae	1	1	5518.83	0.60
99	Glochidion velutinum	Euphorbiaceae	3	3	958.27	0.60
100	*Syzygium cumini*	Myrtaceae	2	1	4013.81	0.56
101	*Carallia brachiata*	Rhizophoraceae	2	2	2479.41	0.54
102	Cinnamomum keralaense	Lauraceae	2	2	2410.68	0.53
103	*Bombax ceiba*	Bombacaceae	1	1	4627.75	0.53
104	*Cassine kedharnathii*	Celastraceae	1	1	4581.82	0.53
105	Blepharistemma membranifolia	Rhizophoraceae	3	2	1199.04	0.51
106	Stereospermum colais	Bignoniaceae	2	2	1875.07	0.49
107	Pterospermum diversifolium	Sterculiaceae	2	2	1757.32	0.48
108	Cinnamomum verum	Lauraceae	1	1	3864.01	0.47
109	Beilschmiedia wightii	Lauraceae	2	2	1468.65	0.46
110	Cassine glauca	Celastraceae	2	2	1192.69	0.44
111	*Litsea oleoides*	Lauraceae	2	2	1160.39	0.44
112	*Antidesma menasu*	Euphorbiaceae	2	2	1012.38	0.43
113	Actinodaphne bourdillonii	Lauraceae	2	2	917.65	0.42
114	Cynometra travancorica	Fabaceae	2	2	863.90	0.41
115	Celtis timorensis	Ulmaceae	2	2	583.10	0.39
116	*Ormosia travancorica*	Fabaceae	1	1	2829.43	0.39
117	*Cinnamomum sulphuratum*	Lauraceae	1	1	2781.63	0.39
118	*Syzygium laetum*	Myrtaceae	2	2	499.49	0.39
119	*Nothopegia beddomei*	Anacardiaceae	2	2	361.94	0.38
120	Nothapodytes nimmoniana	Icacinaceae	2	2	352.15	0.37
121	*Garcinia indica*	Lauraceae	2	1	1610.55	0.37
122	Syzygium munronii	Myrtaceae	2	2	270.15	0.37
123	Pterygota alata	Sterculiaceae	2	2	193.74	0.36
124	Holoptelea integrifolia	Ulmaceae	1	1	2416.63	0.36
125	Dendrocnide sinuata	Urticaceae	2	2	149.02	0.36
126	Litsea ghatica	Lauraceae	2	1	1414.26	0.35
127	Terminalia bellirica	Combretaceae	1	1	2325.99	0.35
128	Terminalia paniculata	Combretaceae	1	1	2144.68	0.34
129	Albizia lebbeck	Fabaceae	1	1	1432.59	0.28
130	Olea glandulifera	Oleaceae	1	1	1415.56	0.28
131	Garcinia spicata	Clusiaceae	2	1	327.66	0.27
132	*Vepris bilocularis*	Rutaceae	1	1	1223.09	0.27
133	*Artocarpus gomezianus* [C]	Moraceae	1	1	1048.33	0.25
134	Madhuca longifolia	Sapotaceae	1	1	919.25	0.24
135	Rinorea zeylanica	Violaceae	1	1	883.68	0.24

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm²)	IVI
136	Memecylon umbellatum	Melastomataceae	1	1	863.68	0.24
137	Dysoxylum binectariferum	Meliaceae	1	1	822.44	0.24
138	Clerodendrum viscosum	Verbenaceae	1	1	817.88	0.24
139	*Scolopia crenata*	Flacourtiaceae	1	1	816.27	0.24
140	Neolitsea zeylanica	Lauraceae	1	1	673.27	0.23
141	*Tetrameles nudiflora*	Datiscaceae	1	1	673.27	0.23
142	*Acronychia pedunculata*	Rutaceae	1	1	638.60	0.22
143	*Syzygium mundagam*	Myrtaceae	1	1	563.95	0.22
144	*Flacourtia montana*	Flacourtiaceae	1	1	514.19	0.21
145	*Dillenia pentagyna*	Dilleniaceae	1	1	488.93	0.21
146	*Clausena dentata*	Rutaceae	1	1	464.30	0.21
147	*Ficus exasperata*	Moraceae	1	1	439.13	0.21
148	Actinodaphne lawsonii	Lauraceae	1	1	394.24	0.20
149	*Ficus talbotii*	Lauraceae	1	1	394.24	0.20
150	*Mimusops elengi*	Sapotaceae	1	1	394.24	0.20
151	*Aglaia lawii*	Meliaceae	1	1	389.77	0.20
152	Holigarna ferruginea	Anacardiaceae	1	1	351.77	0.20
153	Glochidion ellipticum	Euphorbiaceae	1	1	325.82	0.20
154	Aglaia perviridis	Meliaceae	1	1	299.88	0.20
155	*Litsea deccanensis*	Lauraceae	1	1	295.99	0.20
156	Cassia fistula	Fabaceae	1	1	290.19	0.20
157	Schefflera rostrata	Araliaceae	1	1	258.44	0.19
158	Mallotus ferrugineus	Euphorbiaceae	1	1	203.67	0.19
159	*Diospyros buxifolia*	Ebenaceae	1	1	194.12	0.19
160	Holigarna arnottiana	Anacardiaceae	1	1	184.80	0.19
161	Annonaceae Member	Annonaceae	1	1	177.97	0.19
162	*Casearia ovata*	Flacourtiaceae	1	1	155.40	0.19
163	Drypetes roxburghii	Euphorbiaceae	1	1	152.60	0.19
164	*Polyalthia coffeoides*	Annonaceae	1	1	140.32	0.18
165	Canthium sp.	Rubiaceae	1	1	133.72	0.18
166	Alseodaphne semecarpifolia	Lauraceae	1	1	108.9	0.18
167	Atalantia racemosa	Rutaceae	1	1	77.43	0.18
168	*Caryota urens*	Arecaceae	1	1	71.59	0.18
169	Fagraea ceylanica	Loganiaceae	1	1	71.59	0.18
			1388	**983**	**1297783.17**	**300**

	SPECIES (Lianas)					
1	Strychnos wallichiana	Loganiaceae	8	6	511.61	
2	Ventilago maderaspatana	Rhamnaceae	2	2	319.90	
3	Ancistrocladus heyneanus	Ancistrocladaceae	1	1	162.51	
4	Tetrastigma muricatum	Vitaceae	2	2	160.23	
5	*Tetrastigma sulcatum*	Vitaceae	2	2	130.92	
6	Desmos sp.	Fabaceae	3	3	121.59	
7	Thunbergia mysorensis	Acanthaceae	1	1	116.08	
8	Entada pursaetha	Fabaceae	1	1	94.68	
9	Uvaria narum	Annonaceae	1	1	70.58	

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm^2)	IVI
10	Calycopteris floribunda	Combretaceae	1	1	49.72	
11	Bauhinia phoenicea	Fabaceae	1	1	45.82	
12	Strychnos colubrina	Loganiaceae	1	1	26.35	
13	Mezoneuron cucullatum	Fabaceae	2	2	24.44	
14	Canthium angustifolium	Rubiaceae	1	1	9.63	
			27	**25**	**1844.06**	

[A] ssp. laurina [B] ssp. arnottiana [C] ssp. zeylanicus

Appendix 3: Floristic composition, frequency, density and Importance Value Index (IVI) of all species sampled from **Zone 3**. The subspecies names are given as a footnote. IVI values for Lianas are not given since its total basal area is negligible. Species names that are in *italics* are food-plants of the lion-tailed macaques.

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm^2)	IVI
1	Diospyros foliolosa	Ebenaceae	144	18	59641.25	14.02
2	*Cullenia exarillata*	Bombacaceae	86	42	200165.40	12.19
3	*Palaquium ellipticum*	Sapotaceae	64	42	120991.51	10.38
4	Reinwardtiodendron anamalaiense	Meliaceae	52	22	23018.97	6.96
5	*Agrostistachys borneensis*	Euphorbiaceae	35	16	10237.22	4.83
6	Dipterocarpus indicus	Dipterocarpaceae	27	21	70002.27	4.78
7	*Myristica dactyloides*	Myristicaceae	24	22	30051.92	4.66
8	*Aglaia elaeagnoidea*	Meliaceae	22	19	32547.17	4.13
9	*Baccaurea courtallensis*	Euphorbiaceae	22	16	3803.41	3.76
10	Polyalthia fragrans	Annonaceae	24	14	16442.54	3.68
11	*Cinnamomum malabatrum*	Lauraceae	21	16	13983.18	3.68
12	*Knema attenuata*	Myristicaceae	19	17	13550.05	3.64
13	*Vateria indica*	Dipterocarpaceae	20	16	24247.69	3.60
14	Diospyros assimilis	Ebenaceae	13	13	10669.85	2.65
15	Diospyros bourdillonii	Ebenaceae	14	11	10079.72	2.49
16	Oreocnide integrifolia	Urticaceae	15	10	3188.23	2.45
17	*Aphananthe cuspidata*	Ulmaceae	17	8	3544.94	2.37
18	*Dimocarpus longan*	Sapindaceae	12	11	15328.84	2.33
19	*Diospyros nilagirica*	Ebenaceae	12	11	3801.31	2.33
20	Otonephelium stipulaceum	Sapindaceae	12	11	8342.24	2.33
21	Croton malabaricus	Euphorbiaceae	12	10	3283.55	2.21
22	*Xanthophyllum arnottianum*	Xanthophyllaceae	12	10	3925.11	2.21
23	*Antidesma menasu*	Euphorbiaceae	13	9	3944.86	2.17
24	*Macaranga peltata*	Euphorbiaceae	13	9	14120.51	2.17
25	*Mesua ferrea*	Clusiaceae	11	10	21491.75	2.12
26	Drypetes wightii	Euphorbiaceae	12	9	11623.15	2.08
27	*Fahrenheitia zeylanica*	Euphorbiaceae	11	9	8505.35	2.00
28	*Myristica malabarica*	Myristicaceae	11	9	5699.46	2.00
29	*Calophyllum polyanthum*	Clusiaceae	10	8	32705.31	1.80
30	Donella roxburghii	Sapotaceae	10	8	11801.17	1.80
31	*Macaranga indica*	Euphorbiaceae	10	8	3743.98	1.80
32	Strombosia ceylanica	Olacaceae	12	6	17307.74	1.72
33	*Bischofia javanica*	Euphorbiaceae	9	8	29797.83	1.72
34	*Hydnocarpus pentandra*	Flacourtiaceae	11	6	9930.77	1.64
35	*Artocarpus heterophyllus*	Moraceae	8	8	16332.12	1.63
36	Gomphandra tetrandra	Icacinaceae	10	6	3079.69	1.55
37	*Litsea floribunda*	Lauraceae	8	7	5442.36	1.51
38	Callicarpa tomentosa	Verbenaceae	7	7	1167.45	1.43
39	*Mimusops elengi*	Sapotaceae	7	7	18240.48	1.43
40	*Syzygium cumini*	Myrtaceae	7	7	41129.16	1.43
41	Stereospermum colais	Bignoniaceae	11	4	57527.26	1.39

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm^2)	IVI
42	Aphanamixis polystachya	Meliaceae	7	6	4211.96	1.31
43	Harpullia arborea	Sapindaceae	7	6	7266.05	1.31
44	Hunteria zeylanica	Apocynaceae	7	6	4049.94	1.31
45	*Persea macrantha*	Lauraceae	7	6	6572.97	1.31
46	Celtis timorensis	Ulmaceae	8	5	7658.4	1.27
47	Syzygium neesianum	Myrtaceae	8	5	5764.53	1.27
48	Elaeocarpus tuberculatus	Elaeocarpaceae	6	6	24374.25	1.23
49	Actinodaphne malabarica	Lauraceae	7	5	3074.69	1.19
50	*Nothopegia heyneana*	Anacardiaceae	8	4	8056.23	1.15
51	*Canarium strictum*	Burseraceae	6	5	13706.73	1.10
52	*Mangifera indica*	Anacardiaceae	6	5	16725.00	1.10
53	*Antiaris toxicaria*	Moraceae	5	5	17907.15	1.02
54	*Elaeocarpus serratus*	Elaeocarpaceae	5	5	2232.25	1.02
55	*Litsea oleoides*	Lauraceae	5	5	8152.73	1.02
56	*Ormosia travancorica*	Fabaceae	5	5	5377.49	1.02
57	Vitex altissima	Verbenaceae	5	5	27907.05	1.02
58	Croton laccifer	Euphorbiaceae	6	4	952.97	0.98
59	Filicium decipiens	Sapindaceae	6	4	4126.72	0.98
60	Mallotus intermedius	Euphorbiaceae	6	4	494.03	0.98
61	Pterygota alata	Sterculiaceae	6	4	3067.94	0.98
62	*Elaeocarpus munroii*	Elaeocarpaceae	7	3	9353.83	0.94
63	Atalantia monophylla	Rutaceae	4	4	543.53	0.82
64	Cleidion javanicum	Euphorbiaceae	4	4	1474.90	0.82
65	Leea indica	Leeaceae	4	4	395.95	0.82
66	Nothopegia racemosa	Anacardiaceae	4	4	1134.04	0.82
67	Bhesa indica	Celastraceae	5	3	6822.55	0.78
68	Chionanthus mala-elengi	Oleaceae	5	3	1799.00	0.78
69	*Syzygium laetum*	Myrtaceae	5	3	706.35	0.78
70	*Grewia tiliifolia*	Tiliaceae	4	3	1308.02	0.69
71	*Syzygium gardneri*	Myrtaceae	4	3	6046.04	0.69
72	Actinodaphne lawsonii	Lauraceae	3	3	4719.99	0.61
73	Cassine glauca	Celastraceae	3	3	2588.91	0.61
74	Clerodendrum viscosum	Verbenaceae	3	3	1455.30	0.61
75	Diospyros insignis	Ebenaceae	3	3	5526.46	0.61
76	Dysoxylum malabaricum	Meliaceae	3	3	6500.85	0.61
77	Eugenia thwaitesii	Myrtaceae	3	3	581.03	0.61
78	Euonymus paniculatus	Celastraceae	3	3	1415.52	0.61
79	*Ficus beddomei*	Moraceae	3	3	15984.38	0.61
80	*Ficus nervosa*	Moraceae	3	3	3998.11	0.61
81	*Ficus virens*	Moraceae	3	3	13061.04	0.61
82	*Flacourtia montana*	Flacourtiaceae	3	3	1480.64	0.61
83	Lagerstroemia microcarpa	Lythraceae	3	3	4794.50	0.61
84	*Litsea laevigata*	Lauraceae	3	3	1891.22	0.61
85	*Neolitsea cassia*	Lauraceae	3	3	1205.24	0.61
86	Phoebe lanceolata	Lauraceae	3	3	2032.93	0.61
87	*Polyalthia coffeoides*	Annonaceae	3	3	3495.79	0.61
88	Unidentified Species 139		3	3	1095.07	0.61

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm^2)	IVI
89	*Vepris bilocularis*	Rutaceae	3	3	4147.61	0.61
90	Ixora brachiata	Rubiaceae	4	2	1311.90	0.57
91	Poeciloneuron indicum	Clusiaceae	4	2	6723.9	0.57
92	*Garcinia morella*	Clusiaceae	3	2	988.01	0.49
93	Litsea stocksii	Lauraceae	3	2	667.11	0.49
94	Mitrephora heyneana	Annonaceae	3	2	972.87	0.49
95	*Prunus ceylanica*	Rosaceae	3	2	2020.75	0.49
96	Actinodaphne bourdillonii	Lauraceae	2	2	2033.24	0.41
97	*Apodytes dimidiata*	Icacinaceae	2	2	1247.91	0.41
98	*Apollonias arnottii*	Lauraceae	2	2	714.34	0.41
99	*Artocarpus hirsutus*	Moraceae	2	2	1362.63	0.41
100	Beilschmiedia wightii	Lauraceae	2	2	1298.34	0.41
101	*Diospyros buxifolia*	Ebenaceae	2	2	501.63	0.41
102	*Diospyros malabarica*	Ebenaceae	2	2	1567.70	0.41
103	*Elaeocarpus glandulosus*	Elaeocarpaceae	2	2	1525.67	0.41
104	Euodia lunu-ankenda	Rutaceae	2	2	435.23	0.41
105	Euonymus indicus	Celastraceae	2	2	316.97	0.41
106	*Ficus callosa*	Moraceae	2	2	4696.53	0.41
107	*Ficus talbotii*	Moraceae	2	2	4893.64	0.41
108	*Gordonia obtusa*	Ternstroemiaceae	2	2	14039.77	0.41
109	*Holigarna grahamii*	Anacardiaceae	2	2	2913.35	0.41
110	Hopea parviflora	Dipterocarpaceae	2	2	3745.04	0.41
111	Lepisanthes erecta	Sapindaceae	2	2	728.14	0.41
112	Mallotus philippensis	Euphorbiaceae	2	2	263.64	0.41
113	Mitrephora grandiflora	Annonaceae	2	2	3411.17	0.41
114	Nageia wallichiana	Podocarpaceae	2	2	237.99	0.41
115	Prismatomeris albidiflora	Rubiaceae	2	2	197.76	0.41
116	Symplocos macrophylla [A]	Symplocaceae	2	2	1703.26	0.41
117	Trewia polycarpa	Euphorbiaceae	2	2	692.98	0.41
118	Tricalysia sphaerocarpa	Rubiaceae	2	2	1143.94	0.41
119	Zanthoxylum rhetsa	Rutaceae	2	2	7359.39	0.41
120	Glochidion malabaricum	Euphorbiaceae	3	1	1690.72	0.37
121	*Garcinia indica*	Clusiaceae	2	1	740.22	0.29
122	*Hydnocarpus alpina*	Flacourtiaceae	2	1	1388.09	0.29
123	*Aglaia lawii*	Meliaceae	1	1	245.90	0.20
124	Alseodaphne semecarpifolia	Lauraceae	1	1	305.77	0.20
125	Alstonia scholaris	Apocynaceae	1	1	4581.82	0.20
126	Aporusa acuminata	Euphorbiaceae	1	1	76.44	0.20
127	*Ardisia pauciflora*	Myrsinaceae	1	1	97.44	0.20
128	*Artocarpus gomezianus* [B]	Moraceae	1	1	2772.71	0.20
129	Atalantia racemosa	Rutaceae	1	1	93.04	0.20
130	Casearia graveolens	Flacourtiaceae	1	1	394.24	0.20
131	*Canthium dicoccum*	Rubiaceae	1	1	474.99	0.20
132	*Carallia brachiata*	Rhizophoraceae	1	1	1658.63	0.20
133	Chukrasia tabularis	Meliaceae	1	1	767.08	0.20
134	Cinnamomum macrocarpum	Lauraceae	1	1	443.87	0.20

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm^2)	IVI
135	Cryptocarya anamalayana	Lauraceae	1	1	394.24	0.20
136	Diospyros chloroxylon	Ebenaceae	1	1	1458.32	0.20
137	Diospyros cordifolia	Ebenaceae	1	1	3355.96	0.20
138	Diospyros oocarpa	Ebenaceae	1	1	2271.90	0.20
139	Diospyros paniculata	Ebenaceae	1	1	967.76	0.20
140	Dipterocarpus bourdillonii	Dipterocarpaceae	1	1	3885.08	0.20
141	Drypetes malabarica	Euphorbiaceae	1	1	3137.43	0.20
142	Dysoxylum ficiforme	Meliaceae	1	1	863.68	0.20
143	Epiprinus mallotiformis	Euphorbiaceae	1	1	225.13	0.20
144	*Ficus hispida*	Moraceae	1	1	151.91	0.20
145	Glochidion velutinum	Euphorbiaceae	1	1	400.99	0.20
146	Gnidia glauca	Thymeleaceae	1	1	635.76	0.20
147	Haldina cordifolia	Rubiaceae	1	1	1164.63	0.20
148	Holigarna arnottiana	Anacardiaceae	1	1	987.16	0.20
149	Holigarna beddomei	Anacardiaceae	1	1	578.78	0.20
150	*Holigarna nigra*	Anacardiaceae	1	1	563.95	0.20
151	Litsea bourdillonii	Lauraceae	1	1	83.50	0.20
152	*Litsea deccanensis*	Lauraceae	1	1	795.45	0.20
153	*Litsea insignis*	Lauraceae	1	1	3342.90	0.20
154	Litsea mysorensis	Lauraceae	1	1	124.74	0.20
155	Madhuca latifolia	Sapotaceae	1	1	5027.43	0.20
156	Murraya paniculata	Rutaceae	1	1	208.52	0.20
157	Neolitsea fischeri	Lauraceae	1	1	299.88	0.20
158	*Neolitsea scrobiculata*	Lauraceae	1	1	286.36	0.20
159	Phyllanthus polyphyllus	Euphorbiaceae	1	1	328.88	0.20
160	Pterospermum reticulatum	Sterculiaceae	1	1	754.40	0.20
161	Sapindus trifoliata	Sapindaceae	1	1	637.18	0.20
162	Schefflera rostrata	Araliaceae	1	1	97.44	0.20
163	Semecarpus auriculata	Anacardiaceae	1	1	3105.91	0.20
164	*Sterculia guttata*	Sterculiaceae	1	1	860.36	0.20
165	Syzygium makul	Myrtaceae	1	1	5586.08	0.20
166	Terminalia bellirica	Combretaceae	1	1	501.48	0.20
167	Toona ciliata	Meliaceae	1	1	1074.06	0.20
168	*Turpinia malabarica*	Staphyleaceae	1	1	620.21	0.20
169	Unidentified Species 132		1	1	97.44	0.20
			1218	**819**	**1401995.31**	**300**

	SPECIES (Lianas)					
1	Grewia umbellifera	Tiliaceae	2	2	790.95	
2	*Gnetum ula*	Gnetaceae	2	2	697.45	
3	Calycopteris floribunda	Combretaceae	5	3	494.79	
4	Uniden. Liana (Adhumbhu valli)		2	2	447.02	
5	Tetrastigma muricatum	Vitaceae	1	1	394.24	
6	Ancistrocladus heyneanus	Ancistrocladaceae	2	2	364.99	
7	*Chilocarpus denudatus*	Apocynaceae	2	2	216.29	

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm^2)	IVI
8	Strychnos wallichiana	Loganiaceae	2	2	180.83	
9	Jasminum sp.	Oleaceae	1	1	95.23	
10	Connarus wightii	Connaraceae	1	1	78.93	
11	Kunstleria keralensis	Fabaceae	1	1	78.43	
12	Derris brevipes	Fabaceae	1	1	62.36	
13	Thunbergia mysorensis	Acanthaceae	1	1	51.32	
14	Uvaria narum	Annonaceae	1	1	42.08	
15	*Toddalia asiatica*	Rutaceae	1	1	27.22	
16	Raphidophora laciniata	Araliaceae	1	1	9.63	
17	Luvunga sarmentosa	Rutaceae	1	1	8.11	
			27	**25**	**4039.87**	

[A] ssp. rosea

[B] ssp. zeylanicus

Appendix 4: Floristic composition, frequency, density and Importance Value Index (IVI) of all species sampled from **Zone 4**. The subspecies names are given as a footnote. IVI values for Lianas are not given since its total basal area is negligible. Species names that are in *italics* are food-plants of the lion-tailed macaques.

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm^2)	IVI
1	*Cullenia exarillata*	Bombacaceae	82	38	194904.41	22.38
2	*Palaquium ellipticum*	Sapotaceae	58	30	95345.37	13.55
3	Gluta travancorica	Anacardiaceae	47	30	84460.44	12.04
4	*Filicium decipiens*	Sapindaceae	48	23	74460.04	10.74
5	Neolitsea fischeri	Lauraceae	44	28	64595.29	10.37
6	*Myristica dactyloides*	Myristicaceae	60	26	47191.47	10.29
7	*Vateria indica*	Dipterocarpaceae	21	17	81133.37	8.45
8	*Cinnamomum malabatrum*	Lauraceae	32	27	34607.05	7.51
9	*Myristica malabarica*	Myristicaceae	32	25	29959.98	7.00
10	*Mangifera indica*	Anacardiaceae	34	11	44450.06	6.52
11	*Xanthophyllum arnottianum*	Xanthophyllaceae	35	22	11964.72	5.79
12	Vitex altissima	Verbenaceae	24	19	23322.90	5.33
13	*Syzygium cumini*	Myrtaceae	16	14	41982.07	5.33
14	*Agrostistachys borneensis*	Euphorbiaceae	38	15	10406.55	5.16
15	Hopea parviflora	Dipterocarpaceae	16	9	37878.41	4.53
16	*Aglaia elaeagnoidea*	Meliaceae	24	15	10680.88	4.11
17	Lepisanthes tetraphylla	Sapindaceae	20	13	7636.66	3.41
18	Heritiera papilio	Sterculiaceae	15	8	22142.68	3.38
19	Calophyllum austroindicum	Clusiaceae	6	6	36683.73	3.37
20	*Antidesma menasu*	Euphorbiaceae	21	13	3672.17	3.24
21	*Litsea oleoides*	Lauraceae	16	10	14293.23	3.19
22	*Acronychia pedunculata*	Rutaceae	20	12	5712.03	3.18
23	*Artocarpus heterophyllus*	Moraceae	11	7	22156.96	2.96
24	*Syzygium mundagam*	Myrtaceae	15	12	7199.88	2.89
25	*Knema attenuata*	Myristicaceae	11	10	15024.94	2.85
26	*Dysoxylum malabaricum*	Meliaceae	9	8	20099.87	2.79
27	*Gomphandra coriacea*	Icacinaceae	16	12	4127.38	2.78
28	Anacolosa densiflora	Olacaceae	12	11	10105.91	2.73
29	*Elaeocarpus serratus*	Elaeocarpaceae	6	6	23810.83	2.58
30	*Fahrenheitia zeylanica*	Euphorbiaceae	10	9	13015.45	2.54
31	*Flacourtia montana*	Flacourtiaceae	12	11	5788.56	2.47
32	Kingiodendron pinnatum	Fabaceae	11	7	13931.26	2.46
33	*Macaranga peltata*	Euphorbiaceae	12	9	9022.80	2.45
34	Lannea coromandelica	Anacardiaceae	6	5	20890.27	2.29
35	*Cyathocalyx zeylanica*	Annonaceae	16	6	4815.30	2.16
36	Cynometra bourdillonii	Fabaceae	7	7	14085.04	2.16
37	*Cryptocarya bourdillonii*	Lauraceae	10	9	6785.31	2.16
38	Memecylon malabaricum	Melastomataceae	8	7	12188.78	2.12
39	Syzygium benthamianum	Myrtaceae	13	9	2363.32	2.11
40	*Syzygium gardneri*	Myrtaceae	6	6	15002.99	2.03
41	Diospyros malabarica	Ebenaceae	12	8	3782.49	2.02
42	Chionanthus mala-elengi	Oleaceae	12	5	8666.90	1.99
43	Epiprinus mallotiformis	Euphorbiaceae	12	7	3442.20	1.89

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm²)	IVI
44	*Artocarpus hirsutus*	Moraceae	3	3	20736.23	1.83
45	Canthium travancoricum	Rubiaceae	11	6	3636.42	1.71
46	Psilanthus wightianus	Rubiaceae	7	7	6497.33	1.70
47	*Calophyllum polyanthum*	Clusiaceae	3	3	18004.50	1.67
48	Cinnamomum macrocarpum	Lauraceae	4	4	14702.83	1.65
49	*Holigarna nigra*	Anacardiaceae	6	6	8170.78	1.61
50	*Prunus ceylanica*	Rosaceae	5	5	10951.94	1.60
51	*Canarium strictum*	Burseraceae	8	7	3700.35	1.60
52	Lophopetalum wightianum	Celastraceae	6	4	9721.98	1.49
53	*Litsea insignis*	Lauraceae	6	5	6657.68	1.41
54	Mallotus philippensis	Euphorbiaceae	7	7	1747.29	1.40
55	*Baccaurea courtallensis*	Euphorbiaceae	7	7	1192.10	1.37
56	Nothopegia travancorica	Anacardiaceae	7	6	2161.31	1.32
57	*Elaeocarpus munroii*	Elaeocarpaceae	2	2	15199.70	1.31
58	Ixora brachiata	Rubiaceae	7	5	2996.71	1.26
59	Syzygium travancoricum	Myrtaceae	2	2	14203.68	1.25
60	*Casearia ovata*	Flacourtiaceae	7	5	2133.89	1.21
61	*Elaeocarpus tuberculatus*	Elaeocarpaceae	2	2	13386.36	1.20
62	*Ficus callosa*	Moraceae	4	4	6856.16	1.16
63	Vernonia travancorica	Asteraceae	6	5	2332.78	1.14
64	*Elaeocarpus venustus*	Elaeocarpaceae	4	4	6385.69	1.13
65	*Persea macrantha*	Lauraceae	4	4	6086.86	1.12
66	Cinnamomum keralaense	Lauraceae	4	3	7547.40	1.10
67	Croton malabaricus	Euphorbiaceae	6	5	1259.45	1.08
68	Eugenia singampattiana	Myrtaceae	6	5	1004.45	1.06
69	*Mimusops elengi*	Sapotaceae	3	2	9915.17	1.06
70	Aporusa acuminata	Euphorbiaceae	5	5	1733.17	1.03
71	Diospyros insignis	Ebenaceae	5	5	1699.16	1.03
72	*Cinnamomum sulphuratum*	Lauraceae	4	3	6169.46	1.01
73	Donella roxburghii	Sapindaceae	6	4	1740.08	1.00
74	Eugenia floccosa	Myrtaceae	2	2	10020.74	0.99
75	*Vepris bilocularis*	Rutaceae	3	3	7013.33	0.99
76	Terminalia paniculata	Combretaceae	4	3	5681.57	0.98
77	*Garcinia morella*	Clusiaceae	5	5	903.44	0.98
78	Garcinia rubro-echinata	Clusiaceae	5	3	4101.10	0.96
79	Aglaia jainii	Meliaceae	4	4	3208.82	0.94
80	Eugenia maboides	Myrtaceae	5	4	1758.65	0.92
81	Psychotria connata	Rubiaceae	5	4	1230.96	0.89
82	Mastixia arborea	Cornaceae	5	1	6339.93	0.88
83	*Litsea floribunda*	Lauraceae	3	3	4983.69	0.86
84	Erythroxylum obtusifolium	Erythroxylaceae	5	3	2478.20	0.86
85	Terminalia chebula	Combretaceae	5	3	2320.65	0.85
86	*Hydnocarpus alpina*	Flacourtiaceae	3	3	4349.45	0.82
87	*Antiaris toxicaria*	Moraceae	1	1	10309.09	0.82
88	Diospyros oocarpa	Ebenaceae	5	3	1574.14	0.80
89	*Ficus virens*	Moraceae	2	2	6967.70	0.80
90	Nageia wallichiana	Podocarpaceae	4	4	803.32	0.79

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm^2)	IVI
91	Reinwardtiodendron anamalaiense	Meliaceae	4	4	656.02	0.78
92	*Semecarpus travancorica*	Anacardiaceae	3	3	2310.40	0.70
93	Memecylon umbellatum	Melastomataceae	3	3	2230.42	0.69
94	Mallotus beddomei	Euphorbiaceae	4	2	1936.18	0.64
95	Aglaia indica	Meliaceae	3	3	991.82	0.62
96	Eurya nitida	Ternstroemiaceae	3	2	2150.33	0.58
97	*Ficus tsjahela*	Moraceae	1	1	6236.36	0.57
98	*Ormosia travancorica*	Fabaceae	1	1	6236.36	0.57
99	Syzygium rubicundam	Myrtaceae	2	2	3219.00	0.57
100	Hopea erosa	Dipterocarpaceae	3	2	1829.33	0.56
101	*Hydnocarpus macrocarpa*	Flacourtiaceae	3	2	1653.87	0.55
102	Memecylon talbotianum	Melastomataceae	3	2	1187.16	0.52
103	Litsea bourdillonii	Lauraceae	2	2	2375.56	0.52
104	*Bischofia javanica*	Euphorbiaceae	2	2	2348.89	0.51
105	Canthium coromandelicum	Rubiaceae	3	2	1118.39	0.51
106	*Nothopegia beddomei*	Anacardiaceae	2	2	2342.03	0.51
107	Hunteria zeylanica	Apocynaceae	2	2	2249.08	0.51
108	*Gordonia obtusa*	Ternstroemiaceae	3	2	771.70	0.49
109	*Hydnocarpus pentandra*	Flacourtiaceae	3	2	674.21	0.49
110	*Syzygium hemisphericum*	Myrtaceae	2	2	1875.77	0.49
111	*Dimocarpus longan*	Sapindaceae	2	2	1872.98	0.49
112	*Clausena dentata*	Rutaceae	2	2	1854.04	0.48
113	Alstonia scholaris	Apocynaceae	1	1	4445.39	0.46
114	Stereospermum colais	Bignoniaceae	2	2	1385.29	0.46
115	*Artocarpus gomezianus* [A]	Moraceae	1	1	4207.95	0.44
116	Spondias indica	Anacardiaceae	1	1	4207.95	0.44
117	Dysoxylum ficiforme	Meliaceae	2	2	1124.16	0.44
118	Microtropis latifolia	Celastraceae	2	2	1047.83	0.43
119	*Garcinia indica*	Clusiaceae	2	1	2688.33	0.43
120	*Diospyros buxifolia*	Ebenaceae	1	1	3850.00	0.42
121	Alphonsea sclerocarpa	Annonaceae	2	2	839.12	0.42
122	Glochidion malabaricum	Euphorbiaceae	2	2	827.59	0.42
123	*Ficus microcarpa*	Moraceae	1	1	3676.99	0.41
124	Isonandra perrottetiana	Sapotaceae	2	2	587.85	0.41
125	Mitrephora grandiflora	Annonaceae	1	1	3534.73	0.40
126	Callicarpa tomentosa	Verbenaceae	2	2	433.01	0.40
127	*Scolopia crenata*	Flacourtiaceae	2	2	392.23	0.39
128	Goniothalamus wightii	Annonaceae	2	2	382.85	0.39
129	*Aporusa lindleyana*	Euphorbiaceae	2	2	346.97	0.39
130	Phoebe lanceolata	Lauraceae	2	2	316.99	0.39
131	Diospyros bourdillonii	Ebenaceae	1	1	3303.88	0.39
132	Polyalthia fragrans	Annonaceae	2	2	262.95	0.39
133	Strombosia ceylanica	Olacaceae	2	2	249.22	0.39
134	*Ficus nervosa*	Moraceae	2	2	234.21	0.38
135	Euonymus indicus	Celastraceae	2	2	221.65	0.38
136	Glochidion fagifolium	Euphorbiaceae	1	1	3034.03	0.37
137	Palaquium bourdillonii	Sapotaceae	1	1	2877.64	0.36

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm^2)	IVI
138	*Schleichera oleosa*	Oleaceae	2	1	1065.70	0.33
139	Euonymus dichotomous	Celastraceae	2	1	1039.35	0.32
140	*Syzygium lanceolatum*	Myrtaceae	1	1	2239.75	0.32
141	*Sterculia guttata*	Sterculiaceae	1	1	2144.68	0.32
142	Beilschmiedia gemmiflora	Lauraceae	1	1	2118.63	0.32
143	*Bombax ceiba*	Bombacaceae	1	1	2036.36	0.31
144	Mitragyna parviflora	Rubiaceae	2	1	752.04	0.31
145	*Meiogyne pannosa*	Annonaceae	1	1	1272.91	0.26
146	Chukrasia tabularis	Meliaceae	1	1	1262.86	0.26
147	Murraya paniculata	Rutaceae	1	1	1246.88	0.26
148	Canthium pergracile	Rubiaceae	1	1	1155.02	0.26
149	Croton klotzschianus	Euphorbiaceae	1	1	931.26	0.24
150	Albizia lebbeck	Fabaceae	1	1	814.66	0.24
151	Litsea glabarata	Lauraceae	1	1	795.45	0.23
152	Vitex pubescens	Verbenaceae	1	1	785.94	0.23
153	Anogeissus latifolia	Combretaceae	1	1	770.20	0.23
154	Pterospermum diversifolium	Sterculiaceae	1	1	677.67	0.23
155	Rapanea wightiana	Myrsinaceae	1	1	670.35	0.23
156	Breynia vitis-idaea	Euphorbiaceae	1	1	616.00	0.22
157	Zanthoxylum rhetsa	Rutaceae	1	1	538.78	0.22
158	Alseodaphne semecarpifolia	Lauraceae	1	1	515.47	0.22
159	*Litsea wightiana*	Lauraceae	1	1	511.64	0.22
160	Neolitsea zeylanica	Lauraceae	1	1	509.09	0.22
161	Litsea ligustrina	Lauraceae	1	1	490.18	0.22
162	Scleropyrum pentandrum	Santalaceae	1	1	488.93	0.22
163	Cleidion javanicum	Euphorbiaceae	1	1	465.52	0.21
164	Polyalthia shendurunii	Annonaceae	1	1	447.44	0.21
165	Diospyros assimilis	Ebenaceae	1	1	380.91	0.21
166	Actinodaphne angustifolia	Lauraceae	1	1	377.62	0.21
167	*Mesua ferrea*	Clusiaceae	1	1	373.25	0.21
168	Syzygium munronii	Myrtaceae	1	1	349.66	0.21
169	Pterospermum reticulatum	Sterculiaceae	1	1	319.74	0.20
170	*Hopea glabra*	Dipterocarpaceae	1	1	280.67	0.20
171	Diospyros humilis	Ebenaceae	1	1	276.9	0.20
172	Eugenia rottleriana	Myrtaceae	1	1	238.35	0.20
173	Mallotus intermedius	Euphorbiaceae	1	1	231.95	0.20
174	*Olea dioica*	Oleaceae	1	1	226.83	0.20
175	Erythrina stricta	Fabaceae	1	1	219.25	0.20
176	Eugenia thwaitesii	Myrtaceae	1	1	210.97	0.20
177	Drypetes malabarica	Euphorbiaceae	1	1	208.52	0.20
178	Cassine glauca	Celastraceae	1	1	187.88	0.20
179	Chionanthus courtallensis	Oleaceae	1	1	177.97	0.20
180	Diospyros paniculata	Ebenaceae	1	1	148.45	0.19
181	Dodonaea angustifolia	Sapindaceae	1	1	148.45	0.19
182	Pavetta thomsonii [B]	Rubiaceae	1	1	144.36	0.19
183	Tabernaemontana heyneana	Apocynaceae	1	1	143.00	0.19
184	Erythroxylum monogynum	Erythroxylaceae	1	1	142.33	0.19

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm²)	IVI
185	*Garcinia gummi-gutta*	Clusiaceae	1	1	130.47	0.19
186	Hopea ponga	Dipterocarpaceae	1	1	130.47	0.19
187	*Nothopegia heyneana*	Anacardiaceae	1	1	130.47	0.19
188	Hopea utilis	Dipterocarpaceae	1	1	123.48	0.19
189	Chionanthus linocieroides	Oleaceae	1	1	117.29	0.19
190	*Ligustrum perrottetii*	Oleaceae	1	1	116.08	0.19
191	Excoecaria robusta	Euphorbiaceae	1	1	114.86	0.19
192	Mallotus resinosus	Euphorbiaceae	1	1	114.86	0.19
193	Drypetes longifolia	Euphorbiaceae	1	1	97.44	0.19
194	Memecylon heyneanum	Melastomataceae	1	1	95.23	0.19
195	Cassia fistula	Fabaceae	1	1	93.04	0.19
196	*Ardisia rhomboidea*	Myrsinaceae	1	1	91.95	0.19
197	Murraya koenigii	Rutaceae	1	1	72.55	0.19
198	*Arenga wightii*	Arecaceae	1	1	71.59	0.19
			1320	916	1621613.95	300
	Lianas					
1	Dalbergia horrida	Fabaceae	3	2	420.35	
2	*Gnetum ula*	Gnetaceae	2	2	157.09	
3	Beaumontia jerdoniana	Apocynaceae	1	1	262.08	
4	Derris benthamii	Fabaceae	1	1	180.23	
5	Calycopteris floribunda	Combretaceae	1	1	127.43	
6	Strychnos colubrina	Loganiaceae	1	1	104.24	
7	Uvaria narum	Annonaceae	1	1	71.59	
8	*Zizyphus oenoplia*	Rhamnaceae	1	1	36.09	
9	Schefflera wallichiana	Araliaceae	1	1	23.11	
10	Entada pursaetha	Fabaceae	1	1	18.87	
11	Kunstleria keralensis	Fabaceae	1	1	13.86	
12	*Toddalia asiatica*	Rutaceae	1	1	9.98	
			15	14	1424.92	

[A] ssp. *zeylanicus*, [B] var. *puberula*

Appendix 5: Floristic composition, frequency, density and Importance Value Index (IVI) of all species sampled for the **Zone overall**. The subspecies names are given as a footnote. IVI values for Lianas are not given since its total basal area is negligible. Species names that are in **bold** are food-plants of the lion-tailed macaques. Nomenclature and Author Citation follows Sasidharan (1997).

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm^2)	IVI
1	***Cullenia exarillata* Robyns**	Bombacaceae	197	100	446217.48	14.63
2	***Palaquium ellipticum* (Dalz.) Baillon**	Sapotaceae	209	127	301401.85	12.98
3	***Myristica dactyloides* Gaertn.**	Myristicaceae	261	143	163470.64	11.91
4	***Aglaia elaeagnoidea* (Juss.) Benth**	Meliaceae	126	84	87055.88	6.32
5	***Syzygium gardneri* Thw.**	Myrtaceae	82	66	154176.61	6.20
6	*Poeciloneuron indicum* Bedd.	Clusiaceae	147	40	123789.06	6.16
7	***Knema attenuata* (Wall. ex Hk.f. & Thoms.) Warb.**	Myristicaceae	108	81	74632.75	5.66
8	***Dimocarpus longan* Lour.**	Sapindaceae	103	62	101818.06	5.53
9	***Cinnamomum malabatrum* (Burm.f.) Bl.**	Lauraceae	90	78	83442.26	5.40
10	*Dipterocarpus indicus* Bedd.	Dipterocarpaceae	78	50	126067.66	5.16
11	*Reinwardtiodendron anamalaiense* (Bedd.) Mabber.	Meliaceae	117	61	42966.11	4.70
12	***Vateria indica* L.**	Dipterocarpaceae	67	43	120908.66	4.67
13	*Diospyros foliosa* Wall.	Ebenaceae	144	18	59641.25	4.32
14	***Elaeocarpus tuberculatus* Roxb.**	Elaeocarpaceae	41	33	144232.18	4.32
15	***Myristica malabarica* Lamk.**	Myristicaceae	83	58	53499.64	4.16
16	*Drypetes wightii* (Hk.f.) Pax & Hoffm.	Euphorbiaceae	85	34	73214.29	3.89
17	*Lepisanthes tetraphylla* (Vahl) Radlk.	Sapindaceae	88	55	33194.27	3.81
18	***Olea dioica* Roxb**	Oleaceae	69	40	71420.64	3.72
19	***Bischofia javanica* Bl.**	Euphorbiaceae	34	33	111253.13	3.58
20	***Xanthophyllum arnottianum* Wt.**	Xanthophyllaceae	81	56	24339.36	3.54
21	***Mangifera indica* L.**	Anacardiaceae	56	31	79948.60	3.38
22	***Persea macrantha* Nees**	Lauraceae	40	37	85916.52	3.35
23	***Agrostistachys borneensis* Becc.**	Euphorbiaceae	88	43	24205.52	3.31
24	*Gluta travancorica* Bedd.	Anacardiaceae	47	30	84460.44	3.26
25	***Filicium decipiens* Thw.**	Sapindaceae	54	27	78586.76	3.20
26	*Hopea parviflora* Bedd.	Dipterocarpaceae	42	30	83954.96	3.16
27	*Vitex altissima* L.	Verbenaceae	39	34	73712.24	3.03
28	***Calophyllum polyanthum* Wall. ex Choisy**	Clusiaceae	31	29	85714.96	2.95
29	*Neolitsea fischeri* Gamble	Lauraceae	45	29	64895.17	2.84
30	***Syzygium cumini* L.**	Myrtaceae	27	24	89454.79	2.81
31	***Diospyros nilagirica* Bedd.**	Ebenaceae	58	43	22193.21	2.70
32	***Garcinia morella* (Gaertn.) Desr.**	Clusiaceae	70	37	16142.34	2.65
33	*Toona ciliata* Roem.	Meliaceae	28	19	86725.88	2.64
34	***Artocarpus hirsutus* Lamk.**	Moraceae	34	29	60674.42	2.56
35	*Chionanthus mala-elengi* (Dennst.) P.S. Green	Oleaceae	54	32	25728.02	2.38
36	***Mesua ferrea* L.**	Clusiaceae	31	29	52483.68	2.35
37	***Macaranga peltata* (Roxb.) M.-A.**	Euphorbiaceae	43	30	34514.00	2.28
38	*Polyalthia fragrans* (Dalz.) Bedd.	Annonaceae	41	30	29836.86	2.16
39	*Stereospermum colais* (L.f.) DC.	Bignoniaceae	19	11	73621.93	2.00
40	*Hopea ponga* (Dennst.) Mabber.	Dipterocarpaceae	42	26	25558.12	1.99

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm^2)	IVI
41	***Baccaurea courtallensis* (Wt.) M.-A.**	Euphorbiaceae	45	35	7896.53	1.97
42	***Fahrenheitia zeylanica* (Thw.) Airy Shaw x**	Euphorbiaceae	32	29	28807.64	1.94
43	***Artocarpus heterophyllus* Lamk.**	Moraceae	25	21	47958.94	1.93
44	*Lophopetalum wightianum* Ar.	Celastraceae	26	19	48954.13	1.91
45	***Ficus nervosa* L.**	Moraceae	21	19	50974.76	1.85
46	***Litsea floribunda* (Bl.) Gamble**	Lauraceae	29	26	27426.95	1.77
47	***Holigarna grahamii* (Wt.) Kurz**	Anacardiaceae	30	23	30831.63	1.77
48	***Litsea insignis* Gamble**	Lauraceae	32	25	21408.12	1.69
49	***Elaeocarpus serratus* L.**	Elaeocarpaceae	22	20	35266.41	1.62
50	***Antidesma menasu* Miq.**	Euphorbiaceae	38	26	9010.57	1.61
51	*Lagerstroemia microcarpa* Wt.	Lythraceae	15	15	48609.46	1.59
52	***Canarium strictum* Roxb.**	Burseraceae	24	22	28374.84	1.58
53	*Dalbergia latifolia* Roxb.	Fabaceae	18	12	48301.96	1.55
54	*Semecarpus auriculata* Bedd.	Anacardiaceae	35	17	17960.84	1.46
55	*Donella roxburghii* (G. Don) Pierre ex Lecomte	Sapotaceae	25	20	22088.40	1.43
56	*Holigarna arnottiana* Hk.f.	Anacardiaceae	27	22	16213.27	1.42
57	***Hydnocarpus pentandra* (Buch.-Ham.) Oken**	Flacourtiaceae	28	22	13182.50	1.38
58	***Ficus virens* Ait.**	Moraceae	9	9	52960.36	1.38
59	***Litsea oleoides* (Meissn.) Hk.f.**	Lauraceae	23	17	23606.35	1.34
60	*Humboldtia brunonis* Wall.	Fabaceae	34	18	5101.24	1.24
61	***Antiaris toxicaria* (Pers.) Lesch.**	Moraceae	9	9	44298.83	1.23
62	***Mimusops elengi* L.**	Sapotaceae	15	13	29804.66	1.19
63	*Ixora brachiata* Roxb. ex DC	Rubiaceae	27	19	7638.63	1.18
64	*Diospyros paniculata* Dalz.	Ebenaceae	21	20	11850.78	1.17
65	*Litsea mysorensis* Gamble	Lauraceae	23	20	7150.42	1.12
66	*Diospyros oocarpa* Thw.	Ebenaceae	18	14	20849.03	1.11
67	***Gordonia obtusa* (Wall.**	Ternstroemiaceae	11	8	37154.06	1.11
68	*Diospyros bourdillonii* Brand.	Ebenaceae	19	15	16427.55	1.08
69	***Prunus ceylanica* (Wt.) Miq.**	Rosaceae	17	15	18165.07	1.07
70	***Macaranga indica* Wt.**	Euphorbiaceae	24	15	9919.27	1.05
71	*Mastixia arborea* (Wt.) Bedd.	Cornaceae	23	13	13549.95	1.05
72	*Kingiodendron pinnatum* (Roxb. ex DC.) Harms	Fabaceae	22	12	15798.70	1.04
73	***Drypetes elata* Bedd.**	Euphorbiaceae	16	14	17829.15	1.02
74	***Dysoxylum malabaricum* Bedd. ex Hiern**	Meliaceae	12	11	26600.72	1.02
75	*Croton malabaricus* Bedd.	Euphorbiaceae	21	18	5793.73	1.01
76	***Garcinia indica* Choisy**	Clusiaceae	18	14	12831.45	0.97
77	*Oreocnide integrifolia* (Gaud.) Miq.	Urticaceae	23	15	5504.32	0.95
78	*Calophyllum austroindicum* Kosterm.	Clusiaceae	6	6	36683.73	0.95
79	*Mallotus philippensis* (Lamk.) M.-A.	Euphorbiaceae	18	18	5125.95	0.94
80	***Flacourtia montana* Grah.**	Flacourtiaceae	17	16	7880.83	0.91
81	*Heritiera papilio* Bedd.	Sterculiaceae	15	8	22142.68	0.91
82	*Phoebe lanceolata* Nees	Lauraceae	19	15	6797.44	0.90
83	***Cryptocarya bourdillonii* Gamble**	Lauraceae	16	14	11062.14	0.89
84	*Terminalia paniculata* Roth	Combretaceae	10	8	25920.10	0.88
85	*Otonephelium stipulaceum* (Bedd.) Radlk.	Sapindaceae	16	14	10386.45	0.88

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm^2)	IVI
86	***Acronychia pedunculata* (L.) Miq.**	Rutaceae	21	13	6350.63	0.88
87	*Callicarpa tomentosa* (L.) Murray	Verbenaceae	18	17	2933.30	0.87
88	*Diospyros assimilis* Bedd.	Ebenaceae	14	14	11050.76	0.86
89	***Ficus beddomei* King**	Moraceae	6	6	29895.36	0.82
90	*Diospyros malabarica* (Desr.) Kostel.	Ebenaceae	18	13	6230.45	0.82
91	*Strombosia ceylanica* Gardn.	Olacaceae	14	8	17556.96	0.81
92	***Syzygium mundagam* (Bourd.) Chitra**	Myrtaceae	16	13	7763.83	0.81
93	***Canthium dicoccum* (Gaertn.) Merr.**	Rubiaceae	21	10	6505.31	0.80
94	***Holigarna nigra* Bourd.**	Anacardiaceae	12	12	11983.19	0.78
95	***Ficus callosa* Willd.**	Moraceae	10	10	16182.91	0.76
96	*Epiprinus mallotiformis* (M.-A.) Croizat	Euphorbiaceae	18	11	6191.46	0.76
97	*Diospyros candolleana* Wt.	Ebenaceae	16	11	8166.36	0.76
98	***Elaeocarpus munroii* (Wt.) Mast.**	Elaeocarpaceae	9	5	24553.53	0.76
99	***Vepris bilocularis* (Wt. & Arn.) Engl.**	Rutaceae	10	10	14813.73	0.74
100	*Alstonia scholaris* (L.) R. Br.	Apocynaceae	8	7	20523.17	0.72
101	*Anacolosa densiflora* Bedd.	Olacaceae	12	11	10105.91	0.72
102	***Gomphandra coriacea* Wt.**	Icacinaceae	16	12	4127.38	0.71
103	***Nothopegia beddomei* Gamble**	Anacardiaceae	13	13	5469.81	0.71
104	*Gomphandra tetrandra* (Wall.) Sleumer	Icacinaceae	17	11	4293.78	0.71
105	*Acrocarpus fraxinifolius* Wt. & Arn.	Fabaceae	4	4	24842.60	0.64
106	*Lannea coromandelica* (Houtt.) Merr.	Anacardiaceae	6	5	20890.27	0.63
107	***Aphananthe cuspidata* (Bl.) Planch.**	Ulmaceae	17	8	3544.94	0.61
108	***Garcinia gummi-gutta* (L.) Robs.**	Clusiaceae	9	9	9820.40	0.60
109	*Lagerstroemia parviflora* Roxb.	Lythraceae	10	9	8317.53	0.59
110	***Ormosia travancorica* Bedd.**	Fabaceae	7	7	14443.28	0.59
111	*Diospyros crumenata* Thw.	Ebenaceae	12	10	4597.27	0.59
112	*Cynometra bourdillonii* Gamble	Fabaceae	7	7	14085.04	0.58
113	*Memecylon malabaricum* (Cl.) Cogn.	Melastomataceae	8	7	12188.78	0.57
114	***Syzygium hemisphericum* (Walp.) Alston**	Myrtaceae	9	8	9394.17	0.56
115	***Cyathocalyx zeylanica* Champ. ex Hk.f. & Thoms.**	Annonaceae	16	6	4815.30	0.56
116	*Actinodaphne bourdillonii* Gamble	Lauraceae	10	10	4487.04	0.55
117	*Garcinia spicata* (Wt. & Arn.) Hk.f.	Clusiaceae	10	7	8989.05	0.55
118	*Syzygium benthamianum* (Wt. ex Duthie) Gamble	Myrtaceae	13	9	2363.32	0.54
119	*Celtis timorensis* Spanoghe	Ulmaceae	10	7	8241.50	0.53
120	*Glochidion malabaricum* Bedd.	Euphorbiaceae	11	7	6839.90	0.53
121	*Actinodaphne malabarica* Balak.	Lauraceae	11	9	3767.40	0.53
122	*Cinnamomum macrocarpum* Hk.f.	Lauraceae	5	5	15146.70	0.51
123	*Hunteria zeylanica* (Retz.) Gard. ex Thw.	Apocynaceae	9	8	6299.02	0.51
124	*Archidendron monadelphum* (Roxb.) Neilson	Fabaceae	13	6	5103.85	0.51
125	*Diospyros insignis* Thw.	Ebenaceae	8	8	7225.62	0.51
126	*Pterospermum diversifolium* Bl.	Sterculiaceae	9	9	3811.38	0.49
127	*Diospyros humilis* Bourd.	Ebenaceae	10	8	3609.39	0.48
128	***Caryota urens* L.**	Arecaceae	9	8	4165.80	0.47
129	*Casearia wynadensis* Bedd.	Flacourtiaceae	14	4	4659.21	0.46
130	***Arenga wightii* Griff.**	Arecaceae	10	8	2592.31	0.46

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm^2)	IVI
131	*Nothopegia heyneana* (Hk.f.) Gamble	Anacardiaceae	9	5	8186.70	0.46
132	*Casearia rubescens* Dalz.	Flacourtiaceae	12	5	4804.40	0.45
133	*Psilanthus wightianus* (Wt. & Arn.) J. Leroy	Rubiaceae	7	7	6497.33	0.45
134	*Trewia polycarpa* Bemth.	Euphorbiaceae	7	7	6434.32	0.44
135	***Syzygium laetum* (Ham.) Gandhi**	Myrtaceae	10	8	1712.98	0.44
136	*Canthium travancoricum* (Bedd.) Hk.f.	Rubiaceae	11	6	3636.42	0.44
137	***Carallia brachiata* (Lour.) Merr.**	Rhizophoraceae	5	4	12777.64	0.44
138	*Cinnamomum keralaense* Kosterm.	Lauraceae	6	5	9958.08	0.43
139	*Harpullia arborea* (Blanco) Radlk.	Sapindaceae	7	6	7266.05	0.43
140	*Diospyros* sp.	Ebenaceae	11	6	2987.12	0.43
141	*Diospyros saldanhae* Kosterm.	Ebenaceae	11	6	2342.09	0.42
142	***Cinnamomum sulphuratum* Nees**	Lauraceae	6	5	9049.65	0.42
143	*Nothopegia racemosa* (Dalz.) Ramam.	Anacardiaceae	8	8	1690.53	0.41
144	*Syzygium rubicundam* Wt. & Arn.	Myrtaceae	6	6	6384.31	0.40
145	*Syzygium neesianum* Arn.	Myrtaceae	8	5	5764.53	0.40
146	*Ficus hispida* L.f.	Moraceae	9	7	1376.93	0.39
147	***Diospyros buxifolia* (Bl.) Hiern**	Ebenaceae	6	6	5665.49	0.38
148	***Hydnocarpus macrocarpa* (Bedd.) Warb.**	Flacourtiaceae	8	6	3376.22	0.38
149	*Pterygota alata* (Roxb.) R.Br.	Sterculiaceae	8	6	3261.68	0.38
150	*Aphanamixis polystachya* (Wall.) Parker	Meliaceae	7	6	4211.96	0.38
151	***Grewia tiliifolia* Vahl**	Tiliaceae	6	5	6648.08	0.37
152	*Albizia chinensis* (Osb.) Merr.	Fabaceae	5	2	11961.40	0.37
153	*Tabernaemontana heyneana* Wall.	Apocynaceae	7	7	2034.62	0.36
154	***Casearia ovata* (Lamk.) Willd.**	Flacourtiaceae	8	6	2289.29	0.36
155	*Sapindus trifoliata* L.	Sapindaceae	6	5	5631.40	0.36
156	*Cassine glauca* (Rottb.) O.Ktze.	Celastraceae	6	6	3969.48	0.35
157	*Syzygium travancoricum* Gamble	Myrtaceae	2	2	14203.68	0.35
158	***Symplocos cochinchinensis* (Lour.) S.Moore** [A]	Symplocaceae	7	6	2668.79	0.35
159	*Trichilia connaroides* (Wt. & Arn.) Bentv.	Meliaceae	5	4	7738.53	0.35
160	***Clausena dentata* (Willd.) Roem.**	Rutaceae	6	6	3527.77	0.35
161	*Memecylon umbellatum* Burm.f.	Melastomataceae	6	6	3366.03	0.34
162	***Turpinia malabarica* Gamble**	Staphyleaceae	5	5	5818.64	0.34
163	*Nothopegia travancorica* Bedd. ex Wt. & Arn.	Anacardiaceae	7	6	2161.31	0.34
164	*Chukrasia tabularis* A.Juss.	Meliaceae	4	4	8373.84	0.34
165	***Artocarpus gomezianus* Wall. ex Trec.** [B]	Moraceae	4	4	8357.87	0.34
166	***Sterculia guttata* Roxb.**	Sterculiaceae	4	4	7718.72	0.33
167	*Aporusa acuminata* Thw.	Euphorbiaceae	6	6	1809.61	0.31
168	***Hydnocarpus alpina* Wt.**	Flacourtiaceae	5	4	5737.54	0.31
169	***Elaeocarpus venustus* Bedd.**	Elaeocarpaceae	4	4	6385.69	0.30
170	*Bhesa indica* (Bedd.) Ding Hou	Celastraceae	5	3	6822.55	0.30
171	*Syzygium palghatense* Gamble	Myrtaceae	7	5	1542.23	0.30
172	*Nageia wallichiana* (Presl.) Kuntze.	Podocarpaceae	6	6	1041.31	0.30
173	*Eugenia macrosepala* Duthie	Myrtaceae	6	6	914.82	0.30
174	*Vernonia travancorica* Hk.f.	Asteraceae	6	5	2332.78	0.30
175	*Terminalia bellirica* (Gaertn.) Roxb.	Combretaceae	3	3	8221.30	0.29

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm^2)	IVI
176	*Beilschmiedia wightii* (Nees) Benth.	Lauraceae	5	5	2864.43	0.29
177	*Mallotus intermedius* (Baill.) Balak.	Euphorbiaceae	7	5	725.98	0.29
178	*Zanthoxylum rhetsa* (Roxb.) DC.	Rutaceae	3	3	7898.17	0.28
179	*Actinodaphne lawsonii* Gamble	Lauraceae	4	4	5114.23	0.28
180	***Litsea laevigata* (Nees) Gamble**	Lauraceae	5	5	2404.41	0.28
181	*Eugenia floccosa* Bedd.	Myrtaceae	2	2	10020.74	0.28
182	*Eugenia singampattiana* Bedd.	Myrtaceae	6	5	1004.45	0.27
183	*Nothapodytes nimmoniana* (Grah.) Mabber.	Icacinaceae	6	5	995.98	0.27
184	*Cleidion javanicum* Bl.	Euphorbiaceae	5	5	1940.42	0.27
185	*Mitrephora grandiflora* Bedd.	Annonaceae	3	3	6945.90	0.27
186	***Polyalthia coffeoides* (Thw.) Benth. ex Hk.f. & Thoms.**	Annonaceae	4	4	3636.11	0.25
187	*Garcinia rubro-echinata* Kosterm.	Clusiaceae	5	3	4101.10	0.25
188	*Holoptelea integrifolia* ((Roxb.) Planch.	Ulmaceae	2	2	8652.99	0.25
189	*Aglaia jainii* Viswa. & Ramachan.	Meliaceae	4	4	3208.82	0.25
190	*Croton laccifer* L.	Euphorbiaceae	6	4	952.97	0.24
191	*Eugenia maboides* Wt.	Myrtaceae	5	4	1758.65	0.24
192	*Ficus talbotii* King	Moraceae	3	3	5287.88	0.24
193	*Hopea canarensis* Hole	Dipterocarpaceae	5	4	1458.02	0.23
194	*Psychotria connata* Wall.	Rubiaceae	5	4	1230.96	0.23
195	*Clerodendrum viscosum* Vent.	Verbenaceae	4	4	2273.18	0.23
196	*Erythroxylum obtusifolium* Hk.f.	Erythroxylaceae	5	3	2478.20	0.22
197	*Terminalia chebula* Retz.	Combretaceae	5	3	2320.65	0.22
198	*Bombax ceiba* L.	Bombacaceae	2	2	6664.11	0.21
199	*Aporusa lindleyana* (Wt.) Baill.	Euphorbiaceae	4	4	1388.97	0.21
200	*Glochidion velutinum* Wt.	Euphorbiaceae	4	4	1359.26	0.21
201	*Syzygium zeylanicum* (L.) DC.	Myrtaceae	4	4	1040.08	0.21
202	*Eugenia thwaitesii* Duthie	Myrtaceae	4	4	792.00	0.20
203	*Eurya nitida* Korth.	Ternstroemiaceae	4	3	2285.35	0.20
204	*Atalantia monophylla* (L.) Correa	Rutaceae	4	4	543.53	0.20
205	*Euonymus indicus* Heyne ex Roxb.	Celastraceae	4	4	538.62	0.20
206	*Leea indica* (Burm.f.) Merr.	Leeaceae	4	4	395.95	0.19
207	*Litsea bourdillonii* Gamble	Lauraceae	3	3	2459.06	0.19
208	*Semecarpus travancorica* Bedd.	Anacardiaceae	3	3	2310.40	0.18
209	***Meliosma pinnata* (Roxb.) Maxim.** [C]	Sabiaceae	3	1	5368.50	0.18
210	*Goniothalamus cardiopetalus* (Dalz.) Hk.f. & Thoms.	Annonaceae	3	3	2054.27	0.18
211	*Dysoxylum ficiforme* (Wt.) Gamble	Meliaceae	3	3	1987.84	0.18
212	*Drypetes confertiflora* (Hk.f.) Pax & Hoffm.	Euphorbiaceae	3	3	1974.93	0.18
213	*Madhuca neriifolia* (Moon) H.J. Lam	Sapotaceae	3	3	1717.45	0.17
214	*Mallotus beddomei* J.Hk.	Euphorbiaceae	4	2	1936.18	0.17
215	*Euonymus paniculatus* Wt. ex Laws.	Celastraceae	3	3	1415.52	0.17
216	*Pajanelia longifolia* (Willd.) K.Schum.	Bignoniaceae	3	3	1230.78	0.16
217	*Holigarna beddomei* Hk.f.	Anacardiaceae	3	3	1215.66	0.16
218	***Scolopia crenata* (Wt. & Arn.) Clos.**	Flacourtiaceae	3	3	1208.50	0.16
219	***Neolitsea cassia* (L.) Kosterm.**	Lauraceae	3	3	1205.24	0.16
220	Unidentified Species 139		3	3	1095.07	0.16

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm^2)	IVI
221	*Schefflera racemosa* (Wt.) Harms	Araliaceae	2	2	3668.18	0.16
222	***Ficus tsjahela* Burm.f.**	Moraceae	1	1	6236.36	0.16
223	*Aglaia indica* (J.Hk.) Harms	Meliaceae	3	3	991.82	0.16
224	*Alseodaphne semecarpifolia* Nees	Lauraceae	3	3	930.14	0.16
225	*Grewia serrulata* DC.	Tiliaceae	3	3	804.17	0.16
226	*Drypetes malabarica* (Bedd.) Airy Shaw	Euphorbiaceae	2	2	3345.95	0.15
227	*Syzygium munronii* (Wt.) Chandr.	Myrtaceae	3	3	619.81	0.15
228	*Syzygium makul* Gaertn.	Myrtaceae	1	1	5586.08	0.15
229	*Lagerstroemia reginae* Roxb.	Lythraceae	1	1	5518.83	0.15
230	*Hopea erosa* (Bedd.) van Sloot.	Dipterocarpaceae	3	2	1829.33	0.15
231	*Madhuca longifolia* [D]	Sapotaceae	1	1	5027.43	0.14
232	*Haldina cordifolia* (Roxb.) Ridsd.	Rubiaceae	2	2	2338.90	0.14
233	*Blepharistemma membranifolia* (Miq.) Ding Hou	Rhizophoraceae	3	2	1199.04	0.13
234	*Albizia lebbeck* (L.) Willd.	Fabaceae	2	2	2247.25	0.13
235	*Memecylon talbotianum* Brand.	Melastomataceae	3	2	1187.16	0.13
236	*Canthium coromandelicum* (Burmf.) Alston	Rubiaceae	3	2	1118.39	0.13
237	*Mitrephora heyneana* (Hk.f. & Thoms.) Thw.	Annonaceae	3	2	972.87	0.13
238	***Cassine kedharnathii* Sasi. & Swarup.**	Celastraceae	1	1	4581.82	0.13
239	*Litsea stocksii* (Hk.f.	Lauraceae	3	2	667.11	0.12
240	*Symplocos macrophylla* Wall. ex DC. [E]	Symplocaceae	2	2	1703.26	0.12
241	*Spondias indica* (Wt. & Arn.) Airy Shaw & Forman	Anacardiaceae	1	1	4207.95	0.12
242	***Elaeocarpus glandulosus* Wall. ex Merr.**	Elaeocarpaceae	2	2	1525.67	0.12
243	*Maytenus rothiana* (Walp.) Ramam.	Celastraceae	2	2	1472.53	0.12
244	*Murraya paniculata* (L.) Jack.	Rutaceae	2	2	1455.40	0.12
245	*Ficus exasperata* Vahl.	Moraceae	2	2	1356.67	0.12
246	***Meiogyne pannosa* (Dalz.) Sinclair**	Annonaceae	2	2	1354.36	0.12
247	*Blachia denudata* Benth.	Euphorbiaceae	3	2	297.54	0.12
248	*Dipterocarpus bourdillonii* Brand.	Dipterocarpaceae	1	1	3885.08	0.12
249	*Cinnamomum verum* J.S.Presl.	Lauraceae	1	1	3864.01	0.12
250	***Apodytes dimidiata* E.Meyer ex Arn.**	Icacinaceae	2	2	1247.91	0.12
251	*Neolitsea zeylanica* (Nees) Merr.	Lauraceae	2	2	1182.36	0.12
252	*Tricalysia sphaerocarpa* (Dalz.) Gamble	Rubiaceae	2	2	1143.94	0.11
253	***Ficus microcarpa* L.f.**	Moraceae	1	1	3676.99	0.11
254	***Litsea deccanensis* Gamble**	Lauraceae	2	2	1091.44	0.11
255	*Pterospermum reticulatum* Wt. & Arn.	Sterculiaceae	2	2	1074.14	0.11
256	*Microtropis latifolia* Wt. ex Laws.	Celastraceae	2	2	1047.83	0.11
257	*Litsea glabarata* (Wall. ex Nees) Hk.f.	Lauraceae	2	2	867.04	0.11
258	*Cynometra travancorica* Bedd.	Fabaceae	2	2	863.90	0.11
259	*Alphonsea sclerocarpa* Thw.	Annonaceae	2	2	839.12	0.11
260	*Tetrameles nudiflora* R. Br.	Datiscaceae	2	2	829.38	0.11
261	*Diospyros cordifolia* Roxb.	Ebenaceae	1	1	3355.96	0.11
262	*Lepisanthes erecta* (Thw.) Leenh.	Sapindaceae	2	2	728.14	0.11
263	***Apollonias arnottii* Nees**	Lauraceae	2	2	714.34	0.11
264	***Aglaia lawii* (Wt.) Sald.**	Meliaceae	2	2	635.67	0.11
265	***Neolitsea scrobiculata* (Meissn.) Gamble**	Lauraceae	2	2	606.10	0.10

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm^2)	IVI
266	*Isonandra perrottetiana* A. DC.	Sapotaceae	2	2	587.85	0.10
267	*Xantolis tomentosa* (Roxb.) Raf.	Sapotaceae	2	2	522.63	0.10
268	*Glochidion fagifolium* Bedd.	Euphorbiaceae	1	1	3034.03	0.10
269	*Euodia lunu-ankenda* (Gaertn.) Merr.	Rutaceae	2	2	435.23	0.10
270	*Cassia fistula* L.	Fabaceae	2	2	383.23	0.10
271	*Goniothalamus wightii* Hk.f. & Thoms.	Annonaceae	2	2	382.85	0.10
272	*Schefflera rostrata* Harms	Araliaceae	2	2	355.88	0.10
273	Unidentified species 27		2	2	315.90	0.10
274	Unidentified species 85		2	2	301.72	0.10
275	*Palaquium bourdillonii* Brand.	Sapotaceae	1	1	2877.64	0.10
276	Unidentified species 57		2	2	280.72	0.10
277	*Prismatomeris albidiflora* Thw.	Rubiaceae	2	2	197.76	0.10
278	*Atalantia racemosa* Wt. & Arn.	Rutaceae	2	2	170.47	0.10
279	***Ardisia pauciflora* Heyne ex. Wall.**	Myrsinaceae	2	2	169.03	0.10
280	*Dendrocnide sinuata* (Bl.) Chew.	Urticaceae	2	2	149.02	0.10
281	Unidentified Species 38		1	1	2731.28	0.10
282	*Homalium zeylanicum* (Gard.) Benth.	Flacourtiaceae	1	1	2634.86	0.09
283	*Litsea ghatica* Subram. *et al*.	Lauraceae	2	1	1414.26	0.09
284	***Syzygium lanceolatum* (Lamk.) Wt. & Arn.**	Myrtaceae	1	1	2239.75	0.09
285	*Beilschmiedia gemmiflora* (Bl.) Kosterm.	Lauraceae	1	1	2118.63	0.09
286	***Schleichera oleosa* (Lour.) Oken**	Sapindaceae	2	1	1065.70	0.09
287	*Euonymus dichotomous* Heyne ex Roxb.	Celastraceae	2	1	1039.35	0.08
288	*Mitragyna parviflora* (Roxb.) Kunth	Rubiaceae	2	1	752.04	0.08
289	*Diospyros chloroxylon* Roxb.	Ebenaceae	1	1	1458.32	0.07
290	*Olea glandulifera* Wall.	Oleaceae	1	1	1415.56	0.07
291	*Celtis philippensis* Blanco.	Ulmaceae	1	1	1242.90	0.07
292	*Canthium pergracile* Bourd.	Rubiaceae	1	1	1155.02	0.07
293	*Croton klotzschianus* (Wt.) Thw.	Euphorbiaceae	1	1	931.26	0.06
294	*Madhuca longifolia* (Koenig) Macbride [F]	Sapotaceae	1	1	919.25	0.06
295	*Rinorea zeylanica* (Thw.) O.Ktze.	Violaceae	1	1	883.68	0.06
296	*Chionanthus ramiflorus* Roxb.	Oleaceae	1	1	843.90	0.06
297	*Dysoxylum binectariferum* (Roxb.) Hk.f. ex Bedd.	Meliaceae	1	1	822.44	0.06
298	*Vitex pubescens* Vahl	Verbenaceae	1	1	785.94	0.06
299	*Anogeissus latifolia* (Roxb. ex DC.) Wall. ex Guill. & Perr.	Combretaceae	1	1	770.20	0.06
300	*Rapanea wightiana* (Wall. ex DC.) Mez	Myrsinaceae	1	1	670.35	0.06
301	*Gnidia glauca* (Fresen.) Gilg	Thymeleaceae	1	1	635.76	0.06
302	*Breynia vitis-idaea* (Burm.f.) Fischer	Euphorbiaceae	1	1	616.00	0.06
303	***Litsea wightiana* (Nees) Hk.f.**	Lauraceae	1	1	511.64	0.06
304	*Litsea ligustrina* (Nees) Hk.f.	Lauraceae	1	1	490.18	0.06
305	***Dillenia pentagyna* Roxb.**	Dilleniaceae	1	1	488.93	0.06
306	*Scleropyrum pentandrum* (Dennst.) Mabber.	Santalaceae	1	1	488.93	0.06
307	*Polyalthia shendurunii* Basha & Sasi.	Annonaceae	1	1	447.44	0.05
308	*Symplocos racemosa* Roxb.	Symplocaceae	1	1	418.11	0.05
309	*Casearia graveolens* Dalz.	Flacourtiaceae	1	1	394.24	0.05
310	*Cryptocarya anamalayana* Gamble	Lauraceae	1	1	394.24	0.05

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm^2)	IVI
311	*Actinodaphne angustifolia* (Bl.) Nees	Lauraceae	1	1	377.62	0.05
312	*Holigarna ferruginea* March.	Anacardiaceae	1	1	351.77	0.05
313	Rubiaceae member	Rubiaceae	1	1	336.08	0.05
314	*Phyllanthus polyphyllus* Willd.	Euphorbiaceae	1	1	328.88	0.05
315	*Glochidion ellipticum* Wt.	Euphorbiaceae	1	1	325.82	0.05
316	*Aglaia perviridis* Hiern	Meliaceae	1	1	299.88	0.05
317	***Hopea glabra* Wt. & Arn.**	Dipterocarpaceae	1	1	280.67	0.05
318	*Eugenia rottleriana* Wt. & Arn.	Myrtaceae	1	1	238.35	0.05
319	*Erythrina stricta* Roxb.	Fabaceae	1	1	219.25	0.05
320	*Mallotus ferrugineus* (Roxb.) M.-A.	Euphorbiaceae	1	1	203.67	0.05
321	Annonaceae Member	Annonaceae	1	1	177.97	0.05
322	*Chionanthus courtallensis* Bedd.	Oleaceae	1	1	177.97	0.05
323	*Symplocos macrophylla* Wall. ex DC. [G]	Symplocaceae	1	1	172.00	0.05
324	*Drypetes roxburghii* (Wall.) Hurusawa	Euphorbiaceae	1	1	152.60	0.05
325	*Dodonaea angustifolia* L.	Sapindaceae	1	1	148.45	0.05
326	*Pavetta thomsonii* Bremek [H]	Rubiaceae	1	1	144.36	0.05
327	*Erythroxylum monogynum* Roxb.	Erythroxylaceae	1	1	142.33	0.05
328	*Canthium* sp.	Rubiaceae	1	1	133.72	0.05
329	*Hopea utilis* (Bedd.) Bole	Dipterocarpaceae	1	1	123.48	0.05
330	*Chionanthus linocieroides* (Wt.) Bennet & Raizada	Oleaceae	1	1	117.29	0.05
331	***Ligustrum perrottetii* A. DC. ex DC.**	Oleaceae	1	1	116.08	0.05
332	*Excoecaria robusta* Hk.f.	Euphorbiaceae	1	1	114.86	0.05
333	*Mallotus resinosus* (Blanco) Merr.	Euphorbiaceae	1	1	114.86	0.05
334	*Drypetes longifolia* (Bl.) Pax & Hoffm.	Euphorbiaceae	1	1	97.44	0.05
335	Unidentified Species 132		1	1	97.44	0.05
336	*Memecylon heyneanum* Benth. ex Wt.	Melastomataceae	1	1	95.23	0.05
337	***Ardisia rhomboidea* Wt.**	Myrsinaceae	1	1	91.95	0.05
338	*Casearia bourdillonii* Mukherjee	Flacourtiaceae	1	1	86.63	0.05
339	*Murraya koenigii* Spr.	Rutaceae	1	1	72.55	0.05
340	*Saraca asoca* (Roxb.) de Wilde	Fabaceae	1	1	72.55	0.05
341	*Fagraea ceylanica* Thunb.	Loganiaceae	1	1	71.59	0.05
			5257	3592	5510557.69	300.00

SPECIES (Lianas)

No.	SPECIES (Lianas)	Family	Density	Frequency	Basal Area (cm^2)
1	*Grewia umbellifera* Bedd.	Tiliaceae	10	7	1653.45
2	*Ventilago maderaspatana* Gaertn.	Rhamnaceae	23	21	1624.66
3	***Gnetum ula* Brogn.**	Gnetaceae	7	7	1054.07
4	*Calycopteris floribunda* (Roxb.) Poir.	Combretaceae	16	13	930.09
5	*Ancistrocladus heyneanus* Wall.	Ancistrocladaceae	8	8	784.99
6	*Tetrastigma muricatum* Gamble	Vitaceae	8	7	697.59
7	*Strychnos wallichiana* Steud ex DC.	Loganiaceae	10	8	692.44
8	***Chilocarpus denudatus* Bl.**	Apocynaceae	7	7	573.12
9	*Strychnos colubrina* L.	Loganiaceae	10	8	510.82

No.	SPECIES (Trees)	Family	Density	Frequency	Basal Area (cm²)	IVI
10	*Spatholobus roxburghii* Benth.	Fabaceae	2	2	447.02	
11	*Dalbergia horrida* (Dennst.) Mabber.	Fabaceae	3	2	420.35	
12	*Bauhinia phoenicea* Heyne ex Wt. & Arn.	Fabaceae	4	4	296.53	
13	*Beaumontia jerdoniana* Wt.	Apocynaceae	1	1	262.08	
14	***Randia rugulosa* (Thw.) J.Hk.**	Rubiaceae	4	3	233.21	
15	*Ventilago bombaiensis* Dalz.	Rhamnaceae	4	3	223.52	
16	*Loeseneriella arnottiana* (Gamble) Ramam.	Hippocrataceae	5	3	213.10	
17	***Erycibe paniculata* Roxb.**	Convolvulaceae	1	1	200.46	
18	*Uvaria narum* (Dunal) Wt. & Arn.	Annonaceae	3	3	184.24	
19	*Derris benthamii* (Thw.) Thw.	Fabaceae	1	1	180.23	
20	*Kunstleria keralensis* Mohanan & N. C. Nair	Fabaceae	4	4	174.13	
21	*Desmos* sp.	Annonaceae	4	4	172.91	
22	*Thunbergia mysorensis* T. And.	Acanthaceae	2	2	167.40	
23	*Moullava spicata* (Dalz.) Nicolson	Fabaceae	6	3	161.31	
24	*Schefflera venulosa* Harms	Araliaceae	3	3	157.66	
25	*Gardneria ovata* Wall.	Loganiaceae	2	2	135.94	
26	*Entada pursaetha* DC. (Fabaceae)	Fabaceae	4	3	131.45	
27	***Tetrastigma sulcatum* Gamble**	Vitaceae	2	2	130.92	
28	Unidentified species 22		1	1	117.91	
29	*Leptadenia reticulata* Wt. & Arn.	Asclepiadaceae	2	1	103.41	
30	*Jasminum* sp.	Oleaceae	1	1	95.23	
31	*Luvunga sarmentosa* `(Bl.) Kurz.	Rutaceae	3	3	92.11	
32	*Rourea minor* (Gaertn.) Alston	Connaraceae	1	1	84.02	
33	*Connarus wightii* Hk.f.	Connaraceae	1	1	78.93	
34	*Jasminum malabaricum* Wt.	Oleaceae	2	1	63.70	
35	***Artabotrys zeylanicus* Hk.f.**	Annonaceae	2	1	63.18	
36	*Derris brevipes* Baker (Fabaceae)	Fabaceae	1	1	62.36	
37	*Combretum latifolium* Bl.	Combretaceae	2	2	42.19	
38	***Sarcostigma kleinii* Wt. & Arn.**	Icacinaceae	1	1	42.08	
39	***Toddalia asiatica* (L.) Lam.**	Rutaceae	2	2	37.2	
40	***Zizyphus oenoplia* (L.) Mill.**	Rhamnaceae	1	1	36.09	
41	*Carissa inermis* Vahl.	Vitaceae	1	1	35.75	
42	Unidentified species 92		1	1	27.82	
43	***Meiogyne lawii***	Annonaceae	2	2	26.35	
44	*Mezoneuron cucullatum* (Roxb.) Wt. & Arn.	Fabaceae	2	2	24.44	
45	*Schefflera wallichiana* Harms	Araliaceae	1	1	23.11	
46	*Derris* sp.	Fabaceae	1	1	14.5	
47	*Canthium angustifolium* Roxb.	Rubiaceae	1	1	9.63	
48	*Raphidophora laciniata* (N. Burm.) Merrill	Araliaceae	1	1	9.63	
49	***Calamus pseudo-tenuis*** Becc. ex Becc & Hk.f.	Arecaceae	1	1	8.44	
50	*Premna coriacea* Cl.	Verbenaceae	1	1	8.28	
			186	161	13520.05	

[A] ssp. *laurina* (Retz.) Nooteb., [B] ssp. *zeylanicus* Jarett, [C] ssp. *arnottiana* (Wt.) Beus., [D] var. *latifolia* (Roxb.) A. Cheval
[E] ssp. *rosea* (Bedd.) Nooteb., [F] var. *longifolia*, [G] ssp. *macrophylla*, [H] var. *puberula* Bremek

Appendix 6. Latitudinal and altitudinal distribution of all the woody plant species sampled in the lion-tailed macaque habitats. ● Distribution of woody plant species from this study; ◆ Distribution of woody plant species from literature, ▲ Distribution of woody plant species from this study & literature. Species in *italics* are the food-plants of the lion-tailed macaques.

			1	2	3	4	5	6	7	8	9	10	11	12	13
		Altitudinal	Zone 1					Zone 2			Zone 3			Zone 4	
	North Latitude >	Range (m.)	14º30	14º	13º30	13º	12º30	12º	11º30	11º	10º30	10º	9º30	9º	8º30
		▽													
1	Acrocarpus fraxinifolius	160-900			●		●	●						◆	
2	Acronychia pedunculata	120-1300						●			◆			▲	
3	Actinodaphne angustifolium	500-840												●	
4	Actinodaphne bourdillonii	190-1430	●	●	▲		●				●				
5	Actinodaphne lawsonii	760-1140								●			●		
6	Actinodaphne malabarica	1000-1140							●		●		●	◆	
7	*Aglaia elaeagnoidea*	120-1300	●	●	▲		●	●			▲		●	▲	
8	Aglaia indica	630-690												●	
9	Aglaia jainii	600-1200									◆			▲	
10	*Aglaia lawii*	400-1000						●					●		
11	Aglaia perviridis	500-560					●								
12	*Agrostistachys borneensis*	500-1400				◆	●		▲		▲		●	▲	
13	Albizia chinensis	100-900								●				◆	
14	Albizia lebbeck	100-900								●				●	
15	Alphonsea sclerocarpa	1040-1100												●	
16	Alseodaphne semecarpifolia	100-1300							●			●		▲	
17	Alstonia scholaris	100-600		●	●					●	◆			▲	
18	Anacolosa densiflora	170-520												●	
19	Ancistrocladus heyneanus	120-1100		●	●				◆	●	●		●		
20	Anogeissus latifolia	900-1100												●	
21	*Antiaris toxicaria*	100-700	●	●		◆					▲		●	●	
22	*Antidesma menasu*	100-1300			●	◆				●	▲			▲	
23	Aphanamixis polystachya	540-1200									▲		●	◆	
24	*Aphananthe cuspidata*	700-1000									▲		●		
25	*Apodytes dimidiata*	500-1000			◆						◆		●		
26	*Apollonias arnottii*	1000-1300									●			◆	
27	Aporusa acuminata	630									●			●	
28	*Aporusa lindleyana*	100-700		●							◆			●	
29	Archidendron monadelphum	100-1100	●		●			●							
30	Ardisia pauciflora	720-1300			●						◆		●	◆	
31	*Ardisia rhomboidea*	1100												▲	
32	*Arenga wightii*	200-710	●		◆									●	
33	*Artabotrys zeylanicus*	120-420		●											
34	*Artocarpus gomezianus* [A]	100-700		●						●	▲			▲	
35	*Artocarpus heterophyllus*	100-1300			●	◆	●		●	●	▲			▲	
36	*Artocarpus hirsutus*	100-800	●		●	◆	●	●		●	▲			●	
37	Atalantia monophylla	540-800									●	●			
38	Atalantia racemosa	500-540					●				●				
39	*Baccaurea courtallensis*	500-1400				◆	●	●			▲		●	▲	
40	Bauhinia phoenicea	120-610			●			●							

			1	2	3	4	5	6	7	8	9	10	11	12	13
	North Latitude >	Altitudinal	**Zone 1**					**Zone 2**			**Zone 3**			**Zone 4**	
		Range (m.) ▽	**14º30**	**14º**	**13º30**	**13º**	**12º30**	**12º**	**11º30**	**11º**	**10º30**	**10º**	**9º30**	**9º**	**8º30**
41	Beaumontia jerdoniana	1100-1300												▲	
42	Beilschmiedia gemmiflora	1100-1300												▲	
43	Beilschmiedia wightii	120-1300			●	◆	●				▲			◆	
44	Bhesa indica	900 >											●		
45	*Bischofia javanica*	190-1100	●	●	●		●		●	●	▲			▲	
46	Blachia denudata	190-600	●			◆									
47	Blepharistemma membranifolia	*ca.* 500				◆	●								
48	*Bombax ceiba*	100-660								●	◆			●	
49	Breynia vitis-idaea	1000-1300												▲	
50	*Calamus pseudo-tenuis*	340-1300		●										◆	
51	Callicarpa tomentosa	100-600	●			◆		●		●	●			▲	
52	Calophyllum austroindicum	1000-1300												▲	
53	*Calophyllum polyanthum*	100-1400	●		●	◆	●	●	▲		▲		●	●	
54	Calycopteris floribunda	100-800	●	●				●			●		●	●	
55	*Canarium strictum*	250-1400		●	●	◆	●	●	▲	●	▲			▲	
56	Canthium angustifolium	200-1100					●							◆	
57	Canthium coromandelicum	*ca.* 1200												●	
58	*Canthium dicoccum*	100-800		●	●						▲			◆	
59	Canthium pergracile	400-600												●	
60	Canthium sp.	NA					●								
61	Canthium travancoricum	1000-1300												▲	
62	*Carallia brachiata*	100-900			●					●	▲				
63	Carissa inermis	*ca.* 700			●										
64	*Caryota urens*	100-700	●	●	●	◆		●							
65	Casearia bourdillonii	400-1400			●										
66	Casearia graveolens	400-1400									▲				
67	*Casearia ovata*	400-1400				◆				●	◆			▲	
68	Casearia rubescens	400-1400								●				◆	
69	Casearia wynadensis	400-1400								●					
70	Cassia fistula	100-700								●	◆			●	
71	Cassine glauca	200-1100								●	◆		●	▲	
72	*Cassine kedharnathii*	*ca.* 1000							●						
73	Celtis philippensis	250-1100		●							◆			◆	
74	Celtis timorensis	700-1400								●		●		◆	
75	*Chilocarpus denudatus*	200-800		●	●						●				
76	Chionanthus courtallensis	*ca.* 700												●	
77	Chionanthus linocieroides	*ca.* 700												●	
78	Chionanthus mala-elengi	120-1100			●			●		●	▲			▲	
79	Chionanthus ramiflorus	120-1100			●										
80	Chukrasia tabularis	700 >							●		◆		●	▲	
81	Cinnamomum keralaense	700 >							●					▲	
82	Cinnamomum macrocarpum	700 >							◆		◆		●	●	
83	*Cinnamomum malabatrum*	100-1400	●	●	▲		●	●	●		▲		●	▲	
84	*Cinnamomum sulphuratum*	100-1400			●			●						▲	

North Latitude >	Altitudinal	1	2	3	4	5	6	7	8	9	10	11	12	13
		Zone 1					**Zone 2**			**Zone 3**			**Zone 4**	
	Range (m.) ▽	**14º30**	**14º**	**13º30**	**13º**	**12º30**	**12º**	**11º30**	**11º**	**10º30**	**10º**	**9º30**	**9º**	**8º30**
85 Cinnamomum verum	400-1000						●							
86 *Clausena dentata*	100-700	●	●	●					●				●	
87 Cleidion javanicum	400-800									▲			●	
88 Clerodendrum viscosum	200-1200							◆	●	●	●		◆	
89 Combretum latifolium	100-700	●		●										
90 Connarus wightii	500-1300									●			◆	
91 Croton klotzschianus	*ca.* 600												●	
92 Croton laccifer	*ca. 1000*									●			◆	
93 Croton malabaricus	500-1300				◆		●			▲		●	●	
94 Cryptocarya anamalayana	*ca.* 1000									●				
95 *Cryptocarya bourdillonii*	660-1100			●	◆		●			◆			▲	
96 *Cullenia exarillata*	600-1400					·	·	▲	●	▲		●	▲	
97 *Cyathocalyx zeylanica*	500-1300				◆					◆			●	
98 Cynometra bourdillonii	*ca.* 600												●	
99 Cynometra travancorica	*ca.* 600					●								
100 Dalbergia horrida	200-800												●	
101 Dalbergia latifolia	200-1000								●					
102 Dendrocnide sinuata	500-1300				◆			▲						
103 Derris benthamii	800-1300												▲	
104 Derris brevipes	*ca.* 600									●				
105 Derris sp.	NA	●												
106 Desmos sp.	NA			●			●							
107 *Dillenia pentagyna*	100-800								●	◆				
108 *Dimocarpus longan*	100-1300	●	●	▲	◆	●	●	◆	●	▲		●	▲	
109 Diospyros assimilis	500-1100				◆					●	●	●	▲	
110 Diospyros bourdillonii	400-900				◆		●			▲	●		●	
111 *Diospyros buxifolia*	100-700	●			◆				●	▲			●	
112 Diospyros candolleana	200-800	●	●	●										
113 Diospyros chloroxylon	*ca.* 800										●			
114 Diospyros cordifolia	*ca.*500									●				
115 Diospyros crumenata	200-700	●	●	●										
116 Diospyros foliolosa	500-900										●			
117 Diospyros humilis	400-800								●				●	
118 Diospyros insignis	400-1000											●	●	
119 *Diospyros malabarica*	400-1300	●								●			▲	
120 *Diospyros nilagirica*	400-900					●	●				●	●		
121 Diospyros oocarpa	200-1100	●		●		●				●			▲	
122 Diospyros paniculata	100-800	●		●			●					●	●	
123 Diospyros saldanhae	100-600		●											
124 Diospyros sp.	NA		●											
125 Dipterocarpus bourdillonii	200-1000				◆							●		
126 Dipterocarpus indicus	200-1000		●	●	◆	●	●			▲		●		
127 Dodonaea angustifolia	*ca.* 1000												●	
128 Donella roxburghii	200-1300		●	▲	◆	●	●		●	▲		●	▲	

North Latitude >	Altitudinal Range (m.) ▽	1	2	3	4	5	6	7	8	9	10	11	12	13
		Zone 1				Zone 2				Zone 3			Zone 4	
		14º30	14º	13º30	13º	12º30	12º	11º30	11º	10º30	10º	9º30	9º	8º30
129 Drypetes confertiflora	400-800					●	●							
130 *Drypetes elata*	300-900				◆	●	●	▲						
131 Drypetes longifolia	900-1300												▲	
132 Drypetes malabarica	200-800									●			●	
133 Drypetes roxburghii	*ca.* 500					●								
134 Drypetes wightii	400-900						●			◆		●	◆	
135 Dysoxylum binectariferum	300-1300								●					
136 Dysoxylum ficiforme	300-1300									▲			●	
137 *Dysoxylum malabaricum*	300-1300									▲		●	▲	
138 *Elaeocarpus glandulosus*	*ca.* 700										●			
139 *Elaeocarpus munroii*	1000 >									●			▲	
140 *Elaeocarpus serratus*	100-	●			◆	●	●	●		▲			▲	
141 *Elaeocarpus tuberculatus*	140-1300	●	●	▲		●	●	▲	●	●			▲	
142 *Elaeocarpus venustus*	*ca.* 900												▲	
143 Entada pursaetha	100-800	●							●				●	
144 Epiprinus mallotiformis	600-1300							●			●		▲	
145 *Erycibe paniculata*	300-800		●	●										
146 Erythrina stricta	100-700												●	
147 Erythroxylum monogynum	*ca.* 900												●	
148 Erythroxylum obtusifolium	*ca.* 900												▲	
149 Eugenia floccosa	*ca.* 1100												▲	
150 Eugenia maboides	*ca.* 1100												▲	
151 Eugenia macrosepala	140-800		●	●										
152 Eugenia rottleriana	*ca.* 1100												▲	
153 Eugenia singampattiana	*ca.* 1100												●	
154 Eugenia thwaitesii	700-1200											●	▲	
155 Euodia lunu-ankenda	100-1000			◆						▲				
156 Euonymus dichotomous	*ca.* 600												●	
157 Euonymus indicus	400-900				◆							●	●	
158 Euonymus paniculatus	400-900									●				
159 Eurya nitida	600-1300			●									●	
160 Excoecaria robusta	600-1300									◆			▲	
161 Fagraea ceylanica	100-						●			●				
162 *Fahrenheitia zeylanica*	500-1000			●	◆	●			●	▲			●	
163 *Ficus beddomei*	600-900							●		▲				
164 *Ficus callosa*	150-800	●		◆						▲			●	
165 Ficus exasperata	100-600		●						●					
166 *Ficus hispida*	100-800			●					●		●		◆	
167 *Ficus microcarpa*	800 >												▲	
168 *Ficus nervosa*	100-1200	●	●	▲	◆	●	●	●	●	▲	●		▲	
169 *Ficus talbotii*	100-800								●	▲	●			
170 *Ficus tsjahela*	100-700									◆			▲	
171 *Ficus virens*	100-1000			●			●	●		●	●		▲	
172 *Filicium decipiens*	500-1200									▲	●		▲	

North Latitude >	Altitudinal	1	2	3	4	5	6	7	8	9	10	11	12	13
		Zone 1				Zone 2				Zone 3			Zone 4	
	Range (m.) ▽	14º30	14º	13º30	13º	12º30	12º	11º30	11º	10º30	10º	9º30	9º	8º30
173 *Flacourtia montana*	100-800		●		◆				●	▲			●	
174 *Garcinia gummi-gutta*	100-900			●	◆	●	●		●	◆			▲	
175 *Garcinia indica*	100-900	●	●	●					●	●			●	
176 *Garcinia morella*	100-1300	●	●	▲	◆	●		▲	●	▲		●	●	
177 Garcinia rubro-echinata	600-900												●	
178 Garcinia spicata	450-850		●	●		●								
179 Gardneria ovata	200-600		●											
180 Glochidion ellipticum	200-1000							●		▲				
181 Glochidion fagifolium	200-1000												▲	
182 Glochidion malabaricum	200-1000				◆				●	●			▲	
183 Glochidion velutinum	200-1000						●			●				
184 Gluta travancorica	500-1400												●	
185 *Gnetum ula*	100-1100	●	●	●						●		●	▲	
186 Gnidia glauca	*ca*. 600									●				
187 *Gomphandra coriacea*	*ca.* 1300												▲	
188 Gomphandra tetrandra	500-1000				◆			●				●		
189 Goniothalamus cardiopetalus	400-800		●											
190 Goniothalamus wightii	600-1300												▲	
191 *Gordonia obtusa*	1000 >			●				◆				●	▲	
192 Grewia serrulata	400-960			●										
193 *Grewia tiliifolia*	100-800								●	▲	●			
194 Grewia umbellifera	200-750			●								●		
195 Haldina cordifolia	100-700		●							●				
196 Harpullia arborea	300-900				◆					▲			◆	
197 Heritiera papilio	500-1200				◆								▲	
198 Holigarna arnottiana	100-1100	●		▲	◆	●				●			◆	
199 Holigarna beddomei	120-800	●								▲				
200 Holigarna ferruginea	400-900				◆		●			·				
201 *Holigarna grahamii*	120-1200	●	●	▲	◆	●				●				
202 *Holigarna nigra*	250-1300			▲	◆		●	▲		▲			▲	
203 Holoptelea integrifolia	100-800		●			●								
204 Homalium zeylanicum	300-900			●						◆			◆	
205 Hopea canarensis	720-740			●										
206 Hopea erosa	600-900												●	
207 *Hopea glabra*	600-900												●	
208 Hopea parviflora	100-			●	◆	●	●			▲			●	
209 Hopea ponga	100-	●		◆	◆	●		●					●	
210 Hopea utilis	600-900												●	
211 Humboldtia brunonis	140-800			◆	◆	●	●							
212 Hunteria zeylanica	600-900									●			●	
213 *Hydnocarpus alpina*	120-1300				◆						●		▲	
214 *Hydnocarpus macrocarpa*	120-1100			●									▲	
215 *Hydnocarpus pentandra*	120-1100		●	●	◆		●		●	▲			●	
216 Isonandra perrottetiana	600-1300									◆			▲	

North Latitude >	Altitudinal Range (m.) ▽	1	2	3	4	5	6	7	8	9	10	11	12	13
		Zone 1				Zone 2				Zone 3			Zone 4	
		14º30	14º	13º30	13º	12º30	12º	11º30	11º	10º30	10º	9º30	9º	8º30
217 Ixora brachiata	100-800	●	●	●		●	●			●			●	
218 Jasminum malabaricum	120-500			●									◆	
219 Jasminum sp.	NA											●		
220 Kingiodendron pinnatum	120-800				◆	●							●	
221 *Knema attenuata*	100-1300	●	●	▲	◆	●	●	▲		▲		●	●	
222 Kunstleria keralensis	140-1200		●	●						●			●	
223 Lagerstroemia microcarpa	100-700	●	●	●		●	●			▲				
224 Lagerstroemia parviflora	100-700			●		●								
225 Lagerstroemia reginae	100-650						●							
226 Lannea coromandelica	100-1200												●	
227 Leea indica	100-800							◆		●				
228 Lepisanthes erecta	*ca.* 700											●		
229 Lepisanthes tetraphylla	120-1200	●	●	▲				●					▲	
230 Leptadenia reticulata	400-800			●										
231 *Ligustrum perrottetii*	600-1100											●	▲	
232 Litsea bourdillonii	200-1300											●	●	
233 *Litsea deccanensis*	200-1300					●				●				
234 *Litsea floribunda*	200-1300	●		●	◆	●		●		▲		●	●	
235 Litsea ghatica	800-1200							●						
236 Litsea glabarata	200-1300			●									▲	
237 *Litsea insignis*	200-1300	●	●	●		●	●						▲	
238 *Litsea laevigata*	200-1300			●						●		●	◆	
239 Litsea ligustrina	200-1300												▲	
240 Litsea mysorensis	200-1300		●	●			●	●	●		●			
241 *Litsea oleoides*	200-1300							●	●	▲			●	
242 Litsea stocksii	200-1300									●			◆	
243 *Litsea wightiana*	200-1300							◆					▲	
244 Loeseneriella arnottiana	200-800	●												
245 Lophopetalum wightianum	100-800	●	●	◆	◆	●	●						●	
246 Luvunga sarmentosa	120-800			●										
247 *Macaranga indica*	1000 >							●		●			●	
248 *Macaranga peltata*	100-1000	●	●		◆		●	◆	●	▲			▲	
249 Madhuca longifolia [F]	100-900										●			
250 Madhuca longifolia [G]	100-900					●								
251 Madhuca neriifolia	100-800	●		●										
252 Mallotus beddomei	500-1000									◆			●	
253 Mallotus ferrugineus	500-1000								●					
254 Mallotus intermedius	500-1000										●		●	
255 Mallotus philippensis	100-	●	●		◆				●	▲			▲	
256 Mallotus resinosus	500-1000												▲	
257 *Mangifera indica*	100-1100	●	●		◆	●		●	●	▲	●	●	▲	
258 Mastixia arborea	400-1300		●	●	◆	●		●		◆			▲	
259 Maytenus rothiana	580-630		●											
260 Meiogyne lawii	*ca.* 400	●												

North Latitude >	Altitudinal Range (m.) ▽	1	2	3	4	5	6	7	8	9	10	11	12	13
		Zone 1					**Zone 2**			**Zone 3**			**Zone 4**	
		14º30	**14º**	**13º30**	**13º**	**12º30**	**12º**	**11º30**	**11º**	**10º30**	**10º**	**9º30**	**9º**	**8º30**
261 *Meiogyne pannosa*	300-900			●									▲	
262 *Meliosma pinnata* [B]	500-1200							●		◆				
263 Memecylon heyneanum	500-900												●	
264 Memecylon malabaricum	500-1000									◆			▲	
265 Memecylon talbotianum	500-1000												▲	
266 Memecylon umbellatum	200-900			●		●							▲	
267 *Mesua ferrea*	400-1300			▲	◆	●		▲		▲			▲	
268 Mezoneuron cucullatum	300-800						●	●						
269 Microtropis latifolia	500-1200							◆					●	
270 *Mimusops elengi*	100-1100	●	●		◆				●	◆	●		▲	
271 Mitragyna parviflora	100-1200									◆			●	
272 Mitrephora grandiflora	600-1000									●			●	
273 Mitrephora heyneana	500-1100										●			
274 Moullava spicata	200-800		●	●										
275 Murraya koenigii	400-1200												▲	
276 Murraya paniculata	400-1200										●		●	
277 *Myristica dactyloides*	100-1400	●	●	▲	◆	●	●	◆	●	▲		●	▲	
278 *Myristica malabarica*	100-1400	●		●	◆	●	●	●		●		●	●	
279 Nageia wallichiana	800 >									●			▲	
280 *Neolitsea cassia*	400-1200									●			◆	
281 Neolitsea fischeri	400-1200									●			▲	
282 *Neolitsea scrobiculata*	300-1300		●							▲			◆	
283 Neolitsea zeylanica	400-1200							●					●	
284 Nothapodytes nimmoniana	140-800	●	●					◆	●				◆	
285 *Nothopegia beddomei*	200-1100	●		●	◆	●							▲	
286 *Nothopegia heyneana*	200-1100										●		●	
287 Nothopegia racemosa	200-1100					●	●			▲				
288 Nothopegia travancorica	500-1300												▲	
289 *Olea dioica*	100-1100	●	●	▲	◆	●	●	◆	●	◆			▲	
290 Olea glandulifera	*ca.* 700							●						
291 Oreocnide integrifolia	600-1300							●	●	▲			◆	
292 *Ormosia travancorica*	500-1200					●				▲	●		▲	
293 Otonephelium stipulaceum	500-1000				◆	●	●			▲				
294 Pajanelia longifolia	100-800				◆	●	●			◆				
295 Palaquium bourdillonii	200-700												●	
296 *Palaquium ellipticum*	200-1400	●	●	▲	◆	●		▲	●	▲		●	▲	
297 Pavetta thomsonii [H]	*ca.* 1200												▲	
298 *Persea macrantha*	200-1300	●		▲	◆	●		▲	●	▲	●	●	▲	
299 Phoebe lanceolata	500-1200							●		◆		●	▲	
300 Phyllanthus polyphyllus	*ca.* 700										●			
301 Poeciloneuron indicum	600-1300		●	▲				◆		▲				
302 *Polyalthia coffeoides*	500-1200				◆			●		●		●		
303 Polyalthia fragrans	100-1100	●	●	●	◆		●			▲		●	●	
304 Polyalthia shendurunii	400-800												●	

North Latitude >	Altitudinal Range (m.) ▽	1	2	3	4	5	6	7	8	9	10	11	12	13
		Zone 1					Zone 2			Zone 3			Zone 4	
		14º30	14º	13º30	13º	12º30	12º	11º30	11º	10º30	10º	9º30	9º	8º30
305 Premna coriacea	120-500		●											
306 Prismatomeris albidiflora	*ca.* 500									●				
307 *Prunus ceylanica*	150-1200						●	●	●	▲			▲	
308 Psilanthus wightianus	800-1300												●	
309 Psychotria connata	800-1300												▲	
310 Pterospermum diversifolium	200-900	●	●		◆		●						●	
311 Pterospermum reticulatum	400-1100									▲			▲	
312 Pterygota alata	200-900						●			◆		●		
313 *Randia rugulosa*	100-800			●										
314 Rapanea wightiana	900-1300												▲	
315 Raphidophora laciniata	100-1000											●		
316 Reinwardtiodendron anamalaiense	200-1400	●	●	●			●	●		▲		●	●	
317 Rinorea zeylanica	*ca.* 500				◆		●							
318 Rourea minor	*ca.* 400		●										◆	
319 Sapindus trifoliata	100-900								●	●				
320 Saraca asoca	140-800	●												
321 *Sarcostigma kleinii*	200-700		●											
322 Schefflera racemosa	500-900			●										
323 Schefflera rostrata	600-1400			◆		●				●				
324 Schefflera venulosa	600-1400			●										
325 Schefflera wallichiana	600-1400												▲	
326 *Schleichera oleosa*	100-900									◆			●	
327 Scleropyrum pentandrum	100-1000												●	
328 *Scolopia crenata*	400-900								●				▲	
329 Semecarpus auriculata	500-1200				◆	●						●		
330 *Semecarpus travancorica*	600-1300												●	
331 Spondias indica	100-800												●	
332 *Sterculia guttata*	100-1300	●		●						◆		●	●	
333 Stereospermum colais	100-1000	●	●	◆			●		●	◆	●		●	
334 Strombosia ceylanica	100-700				◆							●	●	
335 Strychnos colubrina	100-800			●		●							●	
336 Strychnos wallichiana	300-800						●					●		
337 *Symplocos cochinchinensis* [C]	600-1300					●		●		◆				
338 Symplocos macrophylla [D]	400-1100			●										
339 Symplocos macrophylla [E]	500-1100									▲				
340 Symplocos racemosa	500-900			▲	◆									
341 Syzygium benthamianum	600-1300												▲	
342 *Syzygium cumini*	100-1300			●					●	●		●	▲	
343 *Syzygium gardneri*	140-1000	●	●	●	◆	●	●		●	●	●		▲	
344 *Syzygium hemisphericum*	100-1200	●	●	◆	◆	●	●			◆			▲	
345 *Syzygium laetum*	200-1100			●	◆	●	●	◆		●				
346 *Syzygium lanceolatum*	600-1100												▲	
347 Syzygium makul	600-1000									●				
348 *Syzygium mundagam*	400-1300								●				▲	

North Latitude >	Altitudinal Range (m.) ▽	1	2	3	4	5	6	7	8	9	10	11	12	13
		Zone 1					Zone 2			Zone 3			Zone 4	
		14º30	14º	13º30	13º	12º30	12º	11º30	11º	10º30	10º	9º30	9º	8º30
349 Syzygium munronii	600-1300							●					●	
350 Syzygium neesianum	700 >											●		
351 Syzygium palghatense	*ca.* 1000							●						
352 Syzygium rubicundam	400-900			▲									●	
353 Syzygium travancoricum	600-1200												●	
354 Syzygium zeylanicum	100-1100			●									◆	
355 Tabernaemontana heyneana	100-800	●				●			●	◆			●	
356 Terminalia bellirica	100-900		●			●				▲				
357 Terminalia chebula	500-1100												▲	
358 Terminalia paniculata	100-800		●						●	◆			●	
359 *Tetrameles nudiflora*	100-800		●				●			◆				
360 Tetrastigma muricatum	200-800	●					●			●				
361 *Tetrastigma sulcatum*	600-900							●	●					
362 Thunbergia mysorensis	300-800							●						
363 *Toddalia asiatica*	200-1300												▲	
364 Toona ciliata	120-1300		●	◆			●	◆	●	▲				
365 Trewia polycarpa	120-800	●	●						●	●				
366 Tricalysia sphaerocarpa	600-1300										●			
367 Trichilia connaroides	600-1200			◆				●		◆			◆	
368 *Turpinia malabarica*	500-1400							●		◆		●		
369 Uvaria narum	100-900					●				●			●	
370 *Vateria indica*	100-900	●		●	◆		●	●		▲		●	●	
371 Ventilago bombaiensis	100-900		●											
372 Ventilago maderaspatana	100-1300	●	●	●			●						◆	
373 *Vepris bilocularis*	140-1300	●			◆	●				▲			▲	
374 Vernonia travancorica	*ca.* 1200												●	
375 Vitex altissima	100-1100	●				●	●			▲	●	●	▲	
376 Vitex pubescens	100-1100												●	
377 *Xanthophyllum arnottianum*	400-1300						●	▲	●	▲			▲	
378 Xantolis tomentosa	450-500	●												
379 Zanthoxylum rhetsa	100-800									▲			●	
380 *Zizyphus oenoplia*	100-900												●	
381 Annonaceae Member	NA					●								
382 Rubiaceae member	NA		●											
383 Unidentified Species 132	NA									●				
384 Unidentified Species 139	NA											●		
385 Unidentified species 22	NA			●										
386 Unidentified species 27	NA			●										
387 Unidentified Species 38	NA			●										
388 Unidentified species 57	NA			●										
389 Unidentified species 85	NA	●												
390 Unidentified species 92	NA	●												
391 Adhumbhu valli - Liana	NA											●		

		1	2	3	4	5	6	7	8	9	10	11	12	13
	Altitudinal	**Zone 1**				**Zone 2**				**Zone 3**			**Zone 4**	
North Latitude >	Range (m.)	**14º30**	**14º**	**13º30**	**13º**	**12º30**	**12º**	**11º30**	**11º**	**10º30**	**10º**	**9º30**	**9º**	**8º30**
	▽													
Source				f	c			g		b			a,d,e	

A) ssp. *zeylanicus*; B) ssp. *arnottiana*; C) ssp. *laurina*; D) ssp. *macrophylla*; E) ssp. *rosea*
F) var. *latifolia*; G) var. *longifolia*; H) var. *puberula*

1 Sharavathy Valley WS, Gersoppa RF
2 Mookambika WS
3 Someshwara WS, Kudremukha NP, Agumbe State Forest
4 Subramanya RF, Kadamakal RF, Pushpagiri WS
5 Brahmagiri Ghats WS, Kerti RF
6 Aralam WS, Kottiyur RF
7 Silent Valley NP, New Amarambalam RF
8 Siruvani (Bolampatti RF)
9 Parambikulam WS, Anamalais (Indira Gandhi WS), Nelliampathi
10 Megamalai Reserved Land
11 Periyar TR
12 Shendurney WS, Peppara WS, Neyyar WS, Kalakkad-Mundanthurai TR, Courtallum RF

a) Parthasarathy and Karthikeyan, 1997; b) Ayyappan and Parthasarathy, 1999;
c) Pascal and Pelissier, 1996; d) Ganesh *et al*., 1996; e) Parthasarathy, 1999
f) Swamy and Proctor, 1997; g) Singh *et al*., 1981

Appendix 7. Spatial distribution of all the species sampled in the lion-tailed macaque habitats (n=391).

No.	Species	Variance	Mean	Chi-sq	d.f.	Probability	Distribution
1	*Acrocarpus fraxinifolius*	0.08	0.08	44.00	47	0.59773620	Scattered
2	*Acronychia pedunculata*	2.46	0.44	264.71	47	0.00000000	Clumped
3	*Actinodaphne angustifolium*	0.02	0.02	47.00	47	0.47258980	Scattered
4	*Actinodaphne bourdillonii*	0.25	0.21	57.20	47	0.14623130	Scattered
5	*Actinodaphne lawsonii*	0.21	0.08	116.00	47	0.00000010	Clumped
6	*Actinodaphne malabarica*	0.52	0.23	106.82	47	0.00000170	Clumped
7	*Aglaia elaeagnoidea*	16.75	2.63	299.90	47	0.00000000	Clumped
8	*Aglaia indica*	0.19	0.06	141.00	47	0.00000000	Clumped
9	*Aglaia jainii*	0.16	0.08	92.00	47	0.00010050	Clumped
10	*Aglaia lawii*	0.04	0.04	46.00	47	0.51400830	Scattered
11	*Aglaia perviridis*	0.02	0.02	47.00	47	0.47258980	Scattered
12	*Agrostistachys borneensis*	27.16	1.83	696.36	47	0.00000000	Clumped
13	*Albizia chinensis*	0.27	0.10	119.80	47	0.00000000	Clumped
14	*Albizia lebbeck*	0.04	0.04	46.00	47	0.51400830	Scattered
15	*Alphonsea sclerocarpa*	0.04	0.04	46.00	47	0.51400830	Scattered
16	*Alseodaphne semecarpifolia*	0.06	0.06	45.00	47	0.55587550	Scattered
17	*Alstonia scholaris*	0.23	0.17	64.00	47	0.04997100	Scattered
18	*Anacolosa densiflora*	1.47	0.25	276.00	47	0.00000000	Clumped
19	*Ancistrocladus heyneanus*	0.23	0.17	64.00	47	0.04997100	Scattered
20	Annonaceae Member	0.02	0.02	47.00	47	0.47258980	Scattered
21	*Anogeissus latifolia*	0.02	0.02	47.00	47	0.47258980	Scattered
22	*Antiaris toxicaria*	0.24	0.19	60.33	47	0.09155750	Scattered
23	*Antidesma menasu*	4.34	0.79	257.58	47	0.00000000	Clumped
24	*Aphanamixis polystachya*	0.77	0.15	246.71	47	0.00000000	Clumped
25	*Aphananthe cuspidata*	4.70	0.35	623.94	47	0.00000000	Clumped
26	*Apodytes dimidiata*	0.04	0.04	46.00	47	0.51400830	Scattered
27	*Apollonias arnottii*	0.08	0.04	94.00	47	0.00005940	Clumped
28	*Aporusa acuminata*	0.24	0.13	90.00	47	0.00016850	Clumped
29	*Aporusa lindleyana*	0.16	0.08	92.00	47	0.00010050	Clumped
30	*Archidendron monadelphum*	1.82	0.27	315.62	47	0.00000000	Clumped
31	*Ardisia pauciflora*	0.04	0.04	46.00	47	0.51400830	Scattered
32	*Ardisia rhomboidea*	0.02	0.02	47.00	47	0.47258980	Scattered
33	*Arenga wightii*	0.85	0.21	191.60	47	0.00000000	Clumped
34	*Artabotrys zeylanicus*	0.08	0.04	94.00	47	0.00005940	Clumped
35	*Artocarpus gomezianus* [A]	0.08	0.08	44.00	47	0.59773620	Scattered
36	*Artocarpus heterophyllus*	1.45	0.52	130.52	47	0.00000000	Clumped
37	*Artocarpus hirsutus*	1.83	0.71	121.29	47	0.00000000	Clumped
38	*Atalantia monophylla*	0.21	0.08	116.00	47	0.00000010	Clumped
39	*Atalantia racemosa*	0.04	0.04	46.00	47	0.51400830	Scattered
40	*Baccaurea courtallensis*	5.21	0.94	261.13	47	0.00000000	Clumped
41	*Bauhinia phoenicea*	0.21	0.08	116.00	47	0.00000010	Clumped
42	*Beaumontia jerdoniana*	0.02	0.02	47.00	47	0.47258980	Scattered
43	*Beilschmiedia gemmiflora*	0.02	0.02	47.00	47	0.47258980	Scattered
44	*Beilschmiedia wightii*	0.14	0.10	62.20	47	0.06777410	Scattered
45	*Bhesa indica*	0.52	0.10	235.00	47	0.00000000	Clumped

No.	Species	Variance	Mean	Chi-sq	d.f.	Probability	Distribution
46	*Bischofia javanica*	1.32	0.71	87.41	47	0.00032450	Clumped
47	*Blachia denudata*	0.19	0.06	141.00	47	0.00000000	Clumped
48	*Blepharistemma membranifolia*	0.19	0.06	141.00	47	0.00000000	Clumped
49	*Bombax ceiba*	0.04	0.04	46.00	47	0.51400830	Scattered
50	*Breynia vitis-idaea*	0.02	0.02	47.00	47	0.47258980	Scattered
51	*Calamus pseudo-tenuis*	0.02	0.02	47.00	47	0.47258980	Scattered
52	*Callicarpa tomentosa*	0.92	0.38	115.33	47	0.00000010	Clumped
53	*Calophyllum austroindicum*	0.28	0.13	106.00	47	0.00000210	Clumped
54	*Calophyllum polyanthum*	0.96	0.65	69.65	47	0.01761140	Clumped
55	*Calycopteris floribunda*	1.16	0.33	164.00	47	0.00000000	Clumped
56	*Canarium strictum*	0.55	0.50	52.00	47	0.28529110	Scattered
57	*Canthium angustifolium*	0.02	0.02	47.00	47	0.47258980	Scattered
58	*Canthium coromandelicum*	5.49	0.44	589.29	47	0.00000000	Clumped
59	*Canthium dicoccum*	0.02	0.02	47.00	47	0.47258980	Scattered
60	*Canthium pergracile*	0.02	0.02	47.00	47	0.47258980	Scattered
61	*Canthium* sp.	2.10	0.23	429.73	47	0.00000000	Clumped
62	*Canthium travancoricum*	0.18	0.10	81.40	47	0.00139250	Clumped
63	*Carallia brachiata*	0.02	0.02	47.00	47	0.47258980	Scattered
64	*Carissa inermis*	0.41	0.19	103.00	47	0.00000500	Clumped
65	*Caryota urens*	0.02	0.02	47.00	47	0.47258980	Scattered
66	*Casearia bourdillonii*	0.02	0.02	47.00	47	0.47258980	Scattered
67	*Casearia graveolens*	0.61	0.17	172.00	47	0.00000000	Clumped
68	*Casearia ovata*	2.15	0.25	404.00	47	0.00000000	Clumped
69	*Casearia rubescens*	4.08	0.29	658.00	47	0.00000000	Clumped
70	*Casearia wynadensis*	0.04	0.04	46.00	47	0.51400830	Scattered
71	*Cassia fistula*	0.24	0.13	90.00	47	0.00016850	Clumped
72	*Cassine glauca*	0.02	0.02	47.00	47	0.47258980	Scattered
73	*Cassine kedharnathii*	0.02	0.02	47.00	47	0.47258980	Scattered
74	*Celtis philippensis*	1.36	0.21	306.80	47	0.00000000	Clumped
75	*Celtis timorensis*	0.21	0.15	68.43	47	0.02228570	Clumped
76	*Chilocarpus denudatus*	0.02	0.02	47.00	47	0.47258980	Scattered
77	*Chionanthus courtallensis*	0.02	0.02	47.00	47	0.47258980	Scattered
78	*Chionanthus linocieroides*	7.43	1.13	310.44	47	0.00000000	Clumped
79	*Chionanthus mala-elengi*	0.02	0.02	47.00	47	0.47258980	Scattered
80	*Chionanthus ramiflorus*	0.08	0.08	44.00	47	0.59773620	Scattered
81	*Chukrasia tabularis*	0.41	0.13	154.00	47	0.00000000	Clumped
82	*Cinnamomum keralaense*	0.22	0.10	100.60	47	0.00000990	Clumped
83	*Cinnamomum macrocarpum*	4.71	1.88	118.00	47	0.00000010	Clumped
84	*Cinnamomum malabatrum*	0.24	0.13	90.00	47	0.00016850	Clumped
85	*Cinnamomum sulphuratum*	0.02	0.02	47.00	47	0.47258980	Scattered
86	*Cinnamomum verum*	0.11	0.13	42.00	47	0.67953560	Scattered
87	*Clausena dentata*	0.22	0.10	100.60	47	0.00000990	Clumped
88	*Cleidion javanicum*	0.12	0.08	68.00	47	0.02417980	Clumped
89	*Clerodendrum viscosum*	0.16	0.08	92.00	47	0.00010050	Clumped
90	*Combretum latifolium*	0.04	0.04	46.00	47	0.51400830	Scattered
91	*Connarus wightii*	0.02	0.02	47.00	47	0.47258980	Scattered
92	*Croton klotzschianus*	0.02	0.02	47.00	47	0.47258980	Scattered
93	*Croton laccifer*	0.54	0.13	202.00	47	0.00000000	Clumped

No.	Species	Variance	Mean	Chi-sq	d.f.	Probability	Distribution
94	*Croton malabaricus*	1.32	0.44	141.29	47	0.00000000	Clumped
95	*Cryptocarya anamalayana*	0.02	0.02	47.00	47	0.47258980	Scattered
96	*Cryptocarya bourdillonii*	0.61	0.33	86.00	47	0.00046070	Clumped
97	*Cullenia exarillata*	51.75	4.10	592.69	47	0.00000000	Clumped
98	*Cyathocalyx zeylanica*	4.70	0.33	662.00	47	0.00000000	Clumped
99	*Cynometra bourdillonii*	1.02	0.15	329.00	47	0.00000000	Clumped
100	*Cynometra travancorica*	0.08	0.04	94.00	47	0.00005940	Clumped
101	*Dalbergia horrida*	0.10	0.06	77.00	47	0.00379250	Clumped
102	*Dalbergia latifolia*	2.71	0.38	339.33	47	0.00000000	Clumped
103	*Dendrocnide sinuata*	0.08	0.04	94.00	47	0.00005940	Clumped
104	*Derris benthamii*	0.02	0.02	47.00	47	0.47258980	Scattered
105	*Derris brevipes*	0.02	0.02	47.00	47	0.47258980	Scattered
106	*Derris* sp.	0.02	0.02	47.00	47	0.47258980	Scattered
107	*Desmos* sp.	0.12	0.08	68.00	47	0.02417980	Clumped
108	*Dillenia pentagyna*	0.02	0.02	47.00	47	0.47258980	Scattered
109	*Dimocarpus longan*	24.85	2.15	544.30	47	0.00000000	Clumped
110	*Diospyros assimilis*	0.76	0.29	123.14	47	0.00000000	Clumped
111	*Diospyros bourdillonii*	1.65	0.40	195.74	47	0.00000000	Clumped
112	*Diospyros buxifolia*	0.11	0.13	42.00	47	0.67953560	Scattered
113	*Diospyros candolleana*	1.59	0.33	224.00	47	0.00000000	Clumped
114	*Diospyros chloroxylon*	0.02	0.02	47.00	47	0.47258980	Scattered
115	*Diospyros cordifolia*	0.02	0.02	47.00	47	0.47258980	Scattered
116	*Diospyros crumenata*	0.79	0.25	148.00	47	0.00000000	Clumped
117	*Diospyros foliolosa*	232.00	3.00	3634.67	47	0.00000000	Clumped
118	*Diospyros humilis*	1.70	0.21	383.60	47	0.00000000	Clumped
119	*Diospyros insignis*	0.61	0.17	172.00	47	0.00000000	Clumped
120	*Diospyros malabarica*	2.11	0.38	264.67	47	0.00000000	Clumped
121	*Diospyros nilagirica*	10.51	1.21	408.76	47	0.00000000	Clumped
122	*Diospyros oocarpa*	1.09	0.38	136.67	47	0.00000000	Clumped
123	*Diospyros paniculata*	1.14	0.44	123.00	47	0.00000000	Clumped
124	*Diospyros saldanhae*	2.52	0.23	517.00	47	0.00000000	Clumped
125	*Diospyros* sp.	2.52	0.23	517.00	47	0.00000000	Clumped
126	*Dipterocarpus bourdillonii*	0.02	0.02	47.00	47	0.47258980	Scattered
127	*Dipterocarpus indicus*	15.39	1.63	445.08	47	0.00000000	Clumped
128	*Dodonaea angustifolia*	0.02	0.02	47.00	47	0.47258980	Scattered
129	*Donella roxburghii*	2.25	0.52	203.48	47	0.00000000	Clumped
130	*Drypetes confertiflora*	0.06	0.06	45.00	47	0.55587550	Scattered
131	*Drypetes elata*	0.87	0.33	122.00	47	0.00000000	Clumped
132	*Drypetes longifolia*	0.04	0.04	46.00	47	0.51400830	Scattered
133	*Drypetes malabarica*	0.02	0.02	47.00	47	0.47258980	Scattered
134	*Drypetes roxburghii*	42.44	1.77	1126.29	47	0.00000000	Clumped
135	*Drypetes wightii*	0.02	0.02	47.00	47	0.47258980	Scattered
136	*Dysoxylum binectariferum*	0.10	0.06	77.00	47	0.00379250	Clumped
137	*Dysoxylum ficiforme*	0.70	0.25	132.00	47	0.00000000	Clumped
138	*Dysoxylum malabaricum*	0.08	0.04	94.00	47	0.00005940	Clumped
139	*Elaeocarpus glandulosus*	1.05	0.19	263.00	47	0.00000000	Clumped
140	*Elaeocarpus munroii*	1.06	0.46	108.91	47	0.00000090	Clumped
141	*Elaeocarpus serratus*	2.68	0.85	147.49	47	0.00000000	Clumped

No.	Species	Variance	Mean	Chi-sq	d.f.	Probability	Distribution
142	*Elaeocarpus tuberculatus*	0.12	0.08	68.00	47	0.02417980	Clumped
143	*Elaeocarpus venustus*	0.12	0.08	68.00	47	0.02417980	Clumped
144	*Entada pursaetha*	1.98	0.38	248.67	47	0.00000000	Clumped
145	*Epiprinus mallotiformis*	0.02	0.02	47.00	47	0.47258980	Scattered
146	*Erycibe paniculata*	0.02	0.02	47.00	47	0.47258980	Scattered
147	*Erythrina stricta*	0.02	0.02	47.00	47	0.47258980	Scattered
148	*Erythroxylum monogynum*	0.52	0.10	235.00	47	0.00000000	Clumped
149	*Erythroxylum obtusifolium*	0.08	0.04	94.00	47	0.00005940	Clumped
150	*Eugenia floccosa*	0.52	0.10	235.00	47	0.00000000	Clumped
151	*Eugenia maboides*	0.28	0.13	106.00	47	0.00000210	Clumped
152	*Eugenia macrosepala*	0.02	0.02	47.00	47	0.47258980	Scattered
153	*Eugenia rottleriana*	0.37	0.13	138.00	47	0.00000000	Clumped
154	*Eugenia singampattiana*	0.08	0.08	44.00	47	0.59773620	Scattered
155	*Eugenia thwaitesii*	0.08	0.04	94.00	47	0.00005940	Clumped
156	*Euodia lunu-ankenda*	0.08	0.04	94.00	47	0.00005940	Clumped
157	*Euonymus dichotomous*	0.16	0.08	92.00	47	0.00010050	Clumped
158	*Euonymus indicus*	0.10	0.06	77.00	47	0.00379250	Clumped
159	*Euonymus paniculatus*	0.12	0.08	68.00	47	0.02417980	Clumped
160	*Eurya nitida*	0.02	0.02	47.00	47	0.47258980	Scattered
161	*Excoecaria robusta*	0.02	0.02	47.00	47	0.47258980	Scattered
162	*Fagraea ceylanica*	1.89	0.67	133.00	47	0.00000000	Clumped
163	*Fahrenheitia zeylanica*	0.20	0.13	74.00	47	0.00725460	Clumped
164	*Ficus beddomei*	0.30	0.21	66.80	47	0.03026840	Scattered
165	*Ficus callosa*	0.04	0.04	46.00	47	0.51400830	Scattered
166	*Ficus exasperata*	0.62	0.19	156.33	47	0.00000000	Clumped
167	*Ficus hispida*	0.02	0.02	47.00	47	0.47258980	Scattered
168	*Ficus microcarpa*	0.97	0.44	104.71	47	0.00000310	Clumped
169	*Ficus nervosa*	0.06	0.06	45.00	47	0.55587550	Scattered
170	*Ficus talbotii*	0.02	0.02	47.00	47	0.47258980	Scattered
171	*Ficus tsjahela*	0.20	0.19	49.67	47	0.36739390	Scattered
172	*Ficus virens*	15.56	1.13	650.00	47	0.00000000	Clumped
173	*Filicium decipiens*	1.04	0.35	138.29	47	0.00000000	Clumped
174	*Flacourtia montana*	0.24	0.19	60.33	47	0.09155750	Scattered
175	*Garcinia gummi-gutta*	0.84	0.38	104.67	47	0.00000310	Clumped
176	*Garcinia indica*	21.40	1.46	689.77	47	0.00000000	Clumped
177	*Garcinia morella*	0.52	0.10	235.00	47	0.00000000	Clumped
178	*Garcinia rubro-echinata*	0.59	0.21	134.00	47	0.00000000	Clumped
179	*Garcinia spicata*	0.08	0.04	94.00	47	0.00005940	Clumped
180	*Gardneria ovata*	0.02	0.02	47.00	47	0.47258980	Scattered
181	*Glochidion ellipticum*	0.02	0.02	47.00	47	0.47258980	Scattered
182	*Glochidion fagifolium*	0.65	0.23	133.00	47	0.00000000	Clumped
183	*Glochidion malabaricum*	0.21	0.08	116.00	47	0.00000010	Clumped
184	*Glochidion velutinum*	10.70	0.98	513.68	47	0.00000000	Clumped
185	*Gluta travancorica*	0.13	0.15	41.00	47	0.71852610	Scattered
186	*Gnetum ula*	0.02	0.02	47.00	47	0.47258980	Scattered
187	*Gnidia glauca*	2.57	0.33	362.00	47	0.00000000	Clumped
188	*Gomphandra coriacea*	2.53	0.35	335.94	47	0.00000000	Clumped
189	*Gomphandra tetrandra*	0.19	0.06	141.00	47	0.00000000	Clumped

No.	Species	Variance	Mean	Chi-sq	d.f.	Probability	Distribution
190	*Goniothalamus cardiopetalus*	0.08	0.04	94.00	47	0.00005940	Clumped
191	*Goniothalamus wightii*	0.89	0.21	201.20	47	0.00000000	Clumped
192	*Gordonia obtusa*	0.19	0.06	141.00	47	0.00000000	Clumped
193	*Grewia serrulata*	0.28	0.13	106.00	47	0.00000210	Clumped
194	*Grewia tiliifolia*	0.55	0.21	124.40	47	0.00000000	Clumped
195	*Grewia umbellifera*	0.04	0.04	46.00	47	0.51400830	Scattered
196	*Haldina cordifolia*	0.60	0.15	191.86	47	0.00000000	Clumped
197	*Harpullia arborea*	2.39	0.31	359.40	47	0.00000000	Clumped
198	*Heritiera papilio*	3.36	0.56	280.56	47	0.00000000	Clumped
199	*Holigarna arnottiana*	0.10	0.06	77.00	47	0.00379250	Clumped
200	*Holigarna beddomei*	0.02	0.02	47.00	47	0.47258980	Scattered
201	*Holigarna ferruginea*	2.03	0.63	152.40	47	0.00000000	Clumped
202	*Holigarna grahamii*	0.32	0.25	60.00	47	0.09644730	Scattered
203	*Holigarna nigra*	0.04	0.04	46.00	47	0.51400830	Scattered
204	*Holoptelea integrifolia*	0.02	0.02	47.00	47	0.47258980	Scattered
205	*Homalium zeylanicum*	0.35	0.10	158.20	47	0.00000000	Clumped
206	*Hopea canarensis*	0.19	0.06	141.00	47	0.00000000	Clumped
207	*Hopea erosa*	0.02	0.02	47.00	47	0.47258980	Scattered
208	*Hopea glabra*	4.79	0.88	257.43	47	0.00000000	Clumped
209	*Hopea parviflora*	7.90	0.88	424.29	47	0.00000000	Clumped
210	*Hopea ponga*	0.02	0.02	47.00	47	0.47258980	Scattered
211	*Hopea utilis*	10.51	0.71	697.29	47	0.00000000	Clumped
212	*Humboldtia brunonis*	0.45	0.19	113.67	47	0.00000020	Clumped
213	*Hunteria zeylanica*	0.14	0.10	62.20	47	0.06777410	Scattered
214	*Hydnocarpus alpina*	0.40	0.17	112.00	47	0.00000040	Clumped
215	*Hydnocarpus macrocarpa*	1.65	0.58	133.14	47	0.00000000	Clumped
216	*Hydnocarpus pentandra*	0.08	0.04	94.00	47	0.00005940	Clumped
217	*Isonandra perrottetiana*	2.34	0.56	195.22	47	0.00000000	Clumped
218	*Ixora brachiata*	0.08	0.04	94.00	47	0.00005940	Clumped
219	*Jasminum malabaricum*	0.02	0.02	47.00	47	0.47258980	Scattered
220	*Jasminum* sp.	4.51	0.46	462.36	47	0.00000000	Clumped
221	*Kingiodendron pinnatum*	10.45	2.25	218.22	47	0.00000000	Clumped
222	*Knema attenuata*	0.08	0.08	44.00	47	0.59773620	Scattered
223	*Kunstleria keralensis*	0.56	0.31	84.20	47	0.00071500	Clumped
224	*Lagerstroemia microcarpa*	0.68	0.21	153.20	47	0.00000000	Clumped
225	*Lagerstroemia parviflora*	0.02	0.02	47.00	47	0.47258980	Scattered
226	*Lagerstroemia reginae*	0.54	0.13	202.00	47	0.00000000	Clumped
227	*Lannea coromandelica*	0.33	0.08	188.00	47	0.00000000	Clumped
228	*Leea indica*	0.08	0.04	94.00	47	0.00005940	Clumped
229	*Lepisanthes erecta*	9.89	1.83	253.45	47	0.00000000	Clumped
230	*Lepisanthes tetraphylla*	0.08	0.04	94.00	47	0.00005940	Clumped
231	*Leptadenia reticulata*	0.02	0.02	47.00	47	0.47258980	Scattered
232	*Ligustrum perrottetii*	0.06	0.06	45.00	47	0.55587550	Scattered
233	*Litsea bourdillonii*	0.04	0.04	46.00	47	0.51400830	Scattered
234	*Litsea deccanensis*	0.93	0.60	71.97	47	0.01107130	Clumped
235	*Litsea floribunda*	0.08	0.04	94.00	47	0.00005940	Clumped
236	*Litsea ghatica*	0.04	0.04	46.00	47	0.51400830	Scattered
237	*Litsea glabarata*	2.06	0.67	145.00	47	0.00000000	Clumped

No.	Species	Variance	Mean	Chi-sq	d.f.	Probability	Distribution
238	*Litsea insignis*	0.10	0.10	43.00	47	0.63911630	Scattered
239	*Litsea laevigata*	0.02	0.02	47.00	47	0.47258980	Scattered
240	*Litsea ligustrina*	1.02	0.48	100.13	47	0.00001120	Clumped
241	*Litsea mysorensis*	3.79	0.48	371.43	47	0.00000000	Clumped
242	*Litsea oleoides*	0.19	0.06	141.00	47	0.00000000	Clumped
243	*Litsea stocksii*	0.02	0.02	47.00	47	0.47258980	Scattered
244	*Litsea wightiana*	0.35	0.10	158.20	47	0.00000000	Clumped
245	*Loeseneriella arnottiana*	2.42	0.54	210.31	47	0.00000000	Clumped
246	*Lophopetalum wightianum*	0.06	0.06	45.00	47	0.55587550	Scattered
247	*Luvunga sarmentosa*	2.47	0.50	232.00	47	0.00000000	Clumped
248	*Macaranga indica*	2.99	0.90	156.81	47	0.00000000	Clumped
249	*Macaranga peltata*	0.02	0.02	47.00	47	0.47258980	Scattered
250	*Madhuca longifolia* [F]	0.02	0.02	47.00	47	0.47258980	Scattered
251	*Madhuca longifolia* [G]	0.10	0.06	77.00	47	0.00379250	Clumped
252	*Madhuca neriifolia*	0.33	0.08	188.00	47	0.00000000	Clumped
253	*Mallotus beddomei*	0.02	0.02	47.00	47	0.47258980	Scattered
254	*Mallotus ferrugineus*	0.77	0.15	246.71	47	0.00000000	Clumped
255	*Mallotus intermedius*	0.54	0.38	67.33	47	0.02741220	Scattered
256	*Mallotus philippensis*	0.02	0.02	47.00	47	0.47258980	Scattered
257	*Mallotus resinosus*	10.95	1.17	441.14	47	0.00000000	Clumped
258	*Mangifera indica*	2.77	0.48	271.26	47	0.00000000	Clumped
259	*Mastixia arborea*	0.08	0.04	94.00	47	0.00005940	Clumped
260	*Maytenus rothiana*	0.08	0.04	94.00	47	0.00005940	Clumped
261	*Meiogyne lawii*	0.10	0.06	77.00	47	0.00379250	Clumped
262	*Meiogyne pannosa*	0.19	0.06	141.00	47	0.00000000	Clumped
263	*Meliosma pinnata* [B]	0.02	0.02	47.00	47	0.47258980	Scattered
264	*Memecylon heyneanum*	0.35	0.17	100.00	47	0.00001170	Clumped
265	*Memecylon malabaricum*	0.19	0.06	141.00	47	0.00000000	Clumped
266	*Memecylon talbotianum*	0.54	0.13	202.00	47	0.00000000	Clumped
267	*Memecylon umbellatum*	0.20	0.13	74.00	47	0.00725460	Clumped
268	*Mesua ferrea*	1.81	0.65	131.58	47	0.00000000	Clumped
269	*Mezoneuron cucullatum*	0.04	0.04	46.00	47	0.51400830	Scattered
270	*Microtropis latifolia*	0.08	0.04	94.00	47	0.00005940	Clumped
271	*Mimusops elengi*	1.03	0.31	154.60	47	0.00000000	Clumped
272	*Mitragyna parviflora*	0.08	0.04	94.00	47	0.00005940	Clumped
273	*Mitrephora grandiflora*	0.10	0.06	77.00	47	0.00379250	Clumped
274	*Mitrephora heyneana*	0.19	0.06	141.00	47	0.00000000	Clumped
275	*Moullava spicata*	0.54	0.13	202.00	47	0.00000000	Clumped
276	*Murraya koenigii*	0.02	0.02	47.00	47	0.47258980	Scattered
277	*Murraya paniculata*	0.04	0.04	46.00	47	0.51400830	Scattered
278	*Myristica dactyloides*	68.00	5.44	587.74	47	0.00000000	Clumped
279	*Myristica malabarica*	6.93	1.73	188.23	47	0.00000000	Clumped
280	*Nageia wallichiana*	0.37	0.13	138.00	47	0.00000000	Clumped
281	*Neolitsea cassia*	0.19	0.06	141.00	47	0.00000000	Clumped
282	*Neolitsea fischeri*	9.25	0.94	463.80	47	0.00000000	Clumped
283	*Neolitsea scrobiculata*	0.04	0.04	46.00	47	0.51400830	Scattered
284	*Neolitsea zeylanica*	0.04	0.04	46.00	47	0.51400830	Scattered
285	*Nothapodytes nimmoniana*	0.28	0.13	106.00	47	0.00000210	Clumped

No.	Species	Variance	Mean	Chi-sq	d.f.	Probability	Distribution
286	*Nothopegia beddomei*	0.50	0.27	86.69	47	0.00038820	Clumped
287	*Nothopegia heyneana*	1.35	0.19	337.67	47	0.00000000	Clumped
288	*Nothopegia racemosa*	0.31	0.17	88.00	47	0.00028000	Clumped
289	*Nothopegia travancorica*	0.30	0.15	95.86	47	0.00003620	Clumped
290	*Olea dioica*	14.46	1.44	472.91	47	0.00000000	Clumped
291	*Olea glandulifera*	0.02	0.02	47.00	47	0.47258980	Scattered
292	*Oreocnide integrifolia*	2.89	0.48	283.78	47	0.00000000	Clumped
293	*Ormosia travancorica*	0.25	0.15	82.14	47	0.00116930	Clumped
294	*Otonephelium stipulaceum*	1.25	0.33	176.00	47	0.00000000	Clumped
295	*Pajanelia longifolia*	0.06	0.06	45.00	47	0.55587550	Scattered
296	*Palaquium bourdillonii*	0.02	0.02	47.00	47	0.47258980	Scattered
297	*Palaquium ellipticum*	32.02	4.35	345.64	47	0.00000000	Clumped
298	*Pavetta thomsonii* [H]	0.02	0.02	47.00	47	0.47258980	Scattered
299	*Persea macrantha*	1.67	0.83	94.40	47	0.00005340	Clumped
300	*Phoebe lanceolata*	2.37	0.40	281.63	47	0.00000000	Clumped
301	*Phyllanthus polyphyllus*	0.02	0.02	47.00	47	0.47258980	Scattered
302	*Poeciloneuron indicum*	0.19	0.06	141.00	47	0.00000000	Clumped
303	*Polyalthia coffeoides*	114.66	3.06	1759.61	47	0.00000000	Clumped
304	*Polyalthia fragrans*	0.12	0.08	68.00	47	0.02417980	Clumped
305	*Polyalthia shendurunii*	6.17	0.85	339.49	47	0.00000000	Clumped
306	*Premna coriacea*	0.02	0.02	47.00	47	0.47258980	Scattered
307	*Prismatomeris albidiflora*	0.02	0.02	47.00	47	0.47258980	Scattered
308	*Prunus ceylanica*	0.02	0.02	47.00	47	0.47258980	Scattered
309	*Psilanthus wightianus*	0.04	0.04	46.00	47	0.51400830	Scattered
310	*Psychotria connata*	1.00	0.35	132.65	47	0.00000000	Clumped
311	*Pterospermum diversifolium*	0.35	0.10	158.20	47	0.00000000	Clumped
312	*Pterospermum reticulatum*	0.41	0.19	103.00	47	0.00000500	Clumped
313	*Pterygota alata*	0.04	0.04	46.00	47	0.51400830	Scattered
314	*Randia rugulosa*	0.82	0.17	232.00	47	0.00000000	Clumped
315	*Rapanea wightiana*	0.16	0.08	92.00	47	0.00010050	Clumped
316	*Raphidophora laciniata*	0.02	0.02	47.00	47	0.47258980	Scattered
317	*Reinwardtiodendron anamalaiense*	0.02	0.02	47.00	47	0.47258980	Scattered
318	*Rinorea zeylanica*	22.63	2.44	436.44	47	0.00000000	Clumped
319	*Rourea minor*	0.02	0.02	47.00	47	0.47258980	Scattered
320	*Sapindus trifoliata*	0.02	0.02	47.00	47	0.47258980	Scattered
321	*Saraca asoca*	0.02	0.02	47.00	47	0.47258980	Scattered
322	*Sarcostigma kleinii*	0.37	0.13	138.00	47	0.00000000	Clumped
323	*Schefflera racemosa*	0.02	0.02	47.00	47	0.47258980	Scattered
324	*Schefflera rostrata*	0.02	0.02	47.00	47	0.47258980	Scattered
325	*Schefflera venulosa*	0.08	0.04	94.00	47	0.00005940	Clumped
326	*Schefflera wallichiana*	0.04	0.04	46.00	47	0.51400830	Scattered
327	*Schleichera oleosa*	0.08	0.04	94.00	47	0.00005940	Clumped
328	*Scleropyrum pentandrum*	0.02	0.02	47.00	47	0.47258980	Scattered
329	*Scolopia crenata*	0.08	0.04	94.00	47	0.00005940	Clumped
330	*Semecarpus auriculata*	0.02	0.02	47.00	47	0.47258980	Scattered
331	*Semecarpus travancorica*	0.06	0.06	45.00	47	0.55587550	Scattered
332	*Spondias indica*	10.67	0.73	687.74	47	0.00000000	Clumped
333	*Sterculia guttata*	0.19	0.06	141.00	47	0.00000000	Clumped

No.	Species	Variance	Mean	Chi-sq	d.f.	Probability	Distribution
334	*Stereospermum colais*	0.02	0.02	47.00	47	0.47258980	Scattered
335	*Strombosia ceylanica*	0.08	0.08	44.00	47	0.59773620	Scattered
336	*Strychnos colubrina*	2.71	0.40	322.05	47	0.00000000	Clumped
337	*Strychnos wallichiana*	2.55	0.29	411.14	47	0.00000000	Clumped
338	*Symplocos cochinchinensis* [C]	0.47	0.21	105.20	47	0.00000270	Clumped
339	*Symplocos macrophylla* [D]	0.55	0.21	124.40	47	0.00000000	Clumped
340	*Symplocos macrophylla* [E]	0.77	0.15	246.71	47	0.00000000	Clumped
341	*Symplocos racemosa*	0.02	0.02	47.00	47	0.47258980	Scattered
342	*Syzygium benthamianum*	0.08	0.04	94.00	47	0.00005940	Clumped
343	*Syzygium cumini*	0.02	0.02	47.00	47	0.47258980	Scattered
344	*Syzygium gardneri*	0.84	0.27	145.77	47	0.00000000	Clumped
345	*Syzygium hemisphericum*	1.74	0.56	145.44	47	0.00000000	Clumped
346	*Syzygium laetum*	8.00	1.71	220.05	47	0.00000000	Clumped
347	*Syzygium lanceolatum*	0.20	0.19	49.67	47	0.36739390	Scattered
348	*Syzygium makul*	0.30	0.21	66.80	47	0.03026840	Scattered
349	*Syzygium mundagam*	0.02	0.02	47.00	47	0.47258980	Scattered
350	*Syzygium munronii*	0.02	0.02	47.00	47	0.47258980	Scattered
351	*Syzygium neesianum*	0.95	0.33	134.00	47	0.00000000	Clumped
352	*Syzygium palghatense*	0.06	0.06	45.00	47	0.55587550	Scattered
353	*Syzygium rubicundam*	1.33	0.17	376.00	47	0.00000000	Clumped
354	*Syzygium travancoricum*	0.77	0.15	246.71	47	0.00000000	Clumped
355	*Syzygium zeylanicum*	0.20	0.13	74.00	47	0.00725460	Clumped
356	*Tabernaemontana heyneana*	0.08	0.04	94.00	47	0.00005940	Clumped
357	*Terminalia bellirica*	0.21	0.08	116.00	47	0.00000010	Clumped
358	*Terminalia chebula*	0.21	0.15	68.43	47	0.02228570	Clumped
359	*Terminalia paniculata*	0.06	0.06	45.00	47	0.55587550	Scattered
360	*Tetrameles nudiflora*	0.52	0.10	235.00	47	0.00000000	Clumped
361	*Tetrastigma muricatum*	0.85	0.21	191.60	47	0.00000000	Clumped
362	*Tetrastigma sulcatum*	0.04	0.04	46.00	47	0.51400830	Scattered
363	*Thunbergia mysorensis*	0.31	0.17	88.00	47	0.00028000	Clumped
364	*Toddalia asiatica*	0.04	0.04	46.00	47	0.51400830	Scattered
365	*Toona ciliata*	0.04	0.04	46.00	47	0.51400830	Scattered
366	*Trewia polycarpa*	0.04	0.04	46.00	47	0.51400830	Scattered
367	*Tricalysia sphaerocarpa*	4.89	0.58	393.71	47	0.00000000	Clumped
368	*Trichilia connaroides*	0.21	0.15	68.43	47	0.02228570	Clumped
369	*Turpinia malabarica*	0.04	0.04	46.00	47	0.51400830	Scattered
370	*Uvaria narum*	0.27	0.10	119.80	47	0.00000000	Clumped
371	*Vateria indica*	0.14	0.10	62.20	47	0.06777410	Scattered
372	*Ventilago bombaiensis*	0.02	0.02	47.00	47	0.47258980	Scattered
373	*Ventilago maderaspatana*	12.41	1.40	418.01	47	0.00000000	Clumped
374	*Vepris bilocularis*	0.33	0.08	188.00	47	0.00000000	Clumped
375	*Vernonia travancorica*	1.70	0.48	166.91	47	0.00000000	Clumped
376	*Vitex altissima*	0.25	0.21	57.20	47	0.14623130	Scattered
377	*Vitex pubescens*	0.75	0.13	282.00	47	0.00000000	Clumped
378	*Xanthophyllum arnottianum*	2.79	0.81	161.62	47	0.00000000	Clumped
379	*Xantolis tomentosa*	0.02	0.02	47.00	47	0.47258980	Scattered
380	*Zanthoxylum rhetsa*	10.05	1.69	279.89	47	0.00000000	Clumped
381	*Zizyphus oenoplia*	0.08	0.04	94.00	47	0.00005940	Clumped

No.	Species	Variance	Mean	Chi-sq	d.f.	Probability	Distribution
382	Rubiaceae member	0.10	0.06	77.00	47	0.00379250	Clumped
383	Unidentified Species 132	0.02	0.02	47.00	47	0.47258980	Scattered
384	Unidentified Species 139	0.02	0.02	47.00	47	0.47258980	Scattered
385	Unidentified species 22	0.19	0.06	141.00	47	0.00000000	Clumped
386	Unidentified species 27	0.02	0.02	47.00	47	0.47258980	Scattered
387	Unidentified Species 38	0.08	0.04	94.00	47	0.00005940	Clumped
388	Unidentified species 57	0.02	0.02	47.00	47	0.47258980	Scattered
389	Unidentified species 85	0.08	0.04	94.00	47	0.00005940	Clumped
390	Unidentified species 92	0.08	0.04	94.00	47	0.00005940	Clumped
391	Adhumbhu valli - Liana	0.10	0.06	77.00	47	0.00379250	Clumped

Appendix 8. Sorenson Diversity Index values for the plot-pairs in the 4 zones (48 plots of 0.25 ha each).

	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9	Plot 10	Plot 11	Plot 12
Plot 1												
Plot 2	0.36											
Plot 3	0.50	0.47										
Plot 4	0.31	0.45	0.31									
Plot 5	0.39	0.24	0.34	0.35								
Plot 6	0.24	0.24	0.24	0.14	0.19							
Plot 7	0.38	0.44	0.36	0.37	0.33	0.16						
Plot 8	0.35	0.39	0.27	0.42	0.34	0.19	0.41					
Plot 9	0.20	0.32	0.19	0.32	0.36	0.10	0.33	0.51				
Plot 10	0.29	0.35	0.27	0.35	0.36	0.15	0.31	0.37	0.30			
Plot 11	0.26	0.28	0.24	0.33	0.32	0.05	0.28	0.39	0.26	0.53		
Plot 12	0.37	0.24	0.27	0.39	0.25	0.03	0.32	0.43	0.31	0.46	0.51	
Plot 13	0.36	0.35	0.26	0.30	0.32	0.05	0.33	0.36	0.32	0.40	0.35	0.31
Plot 14	0.29	0.19	0.18	0.19	0.33	0.05	0.28	0.40	0.37	0.29	0.36	0.24
Plot 15	0.38	0.30	0.36	0.20	0.29	0.12	0.33	0.24	0.23	0.28	0.26	0.24
Plot 16	0.27	0.27	0.24	0.26	0.19	0.03	0.32	0.22	0.21	0.17	0.17	0.22
Plot 17	0.27	0.30	0.31	0.32	0.22	0.17	0.43	0.31	0.32	0.25	0.20	0.28
Plot 18	0.28	0.29	0.23	0.29	0.31	0.07	0.35	0.30	0.25	0.28	0.29	0.28
Plot 19	0.15	0.13	0.07	0.19	0.10	0.06	0.18	0.21	0.27	0.19	0.18	0.24
Plot 20	0.22	0.17	0.09	0.12	0.13	0.11	0.23	0.19	0.21	0.18	0.17	0.19
Plot 21	0.21	0.16	0.10	0.13	0.10	0.06	0.18	0.21	0.19	0.13	0.16	0.21
Plot 22	0.15	0.22	0.03	0.26	0.04	0.19	0.15	0.15	0.16	0.22	0.11	0.18
Plot 23	0.12	0.21	0.07	0.19	0.10	0.21	0.07	0.09	0.12	0.16	0.11	0.12
Plot 24	0.27	0.24	0.11	0.23	0.19	0.15	0.20	0.17	0.18	0.29	0.20	0.20
Plot 25	0.21	0.30	0.14	0.24	0.18	0.13	0.27	0.23	0.23	0.21	0.19	0.21
Plot 26	0.27	0.31	0.27	0.24	0.20	0.25	0.29	0.23	0.16	0.25	0.16	0.16
Plot 27	0.19	0.22	0.18	0.26	0.16	0.08	0.19	0.27	0.31	0.22	0.17	0.22
Plot 28	0.15	0.18	0.08	0.11	0.12	0.05	0.18	0.18	0.19	0.21	0.23	0.15
Plot 29	0.16	0.14	0.07	0.14	0.23	0.03	0.12	0.23	0.21	0.17	0.25	0.19
Plot 30	0.16	0.32	0.18	0.29	0.22	0.14	0.30	0.33	0.28	0.30	0.32	0.25
Plot 31	0.32	0.29	0.27	0.20	0.19	0.14	0.19	0.27	0.24	0.30	0.32	0.30
Plot 32	0.12	0.08	0.10	0.06	0.07	0.09	0.11	0.09	0.16	0.08	0.03	0.09
Plot 33	0.08	0.03	0.05	0.04	0.05	0.04	0.05	0.04	0.06	0.03	0.00	0.04
Plot 34	0.15	0.24	0.23	0.13	0.07	0.12	0.21	0.09	0.12	0.13	0.11	0.15
Plot 35	0.03	0.12	0.00	0.14	0.04	0.07	0.13	0.17	0.18	0.12	0.15	0.10
Plot 36	0.15	0.13	0.00	0.10	0.11	0.06	0.18	0.21	0.24	0.14	0.16	0.15
Plot 37	0.21	0.21	0.12	0.16	0.18	0.11	0.28	0.18	0.13	0.19	0.12	0.16
Plot 38	0.21	0.19	0.15	0.14	0.09	0.05	0.25	0.16	0.17	0.29	0.24	0.19
Plot 39	0.19	0.27	0.30	0.14	0.15	0.22	0.22	0.14	0.10	0.15	0.10	0.05
Plot 40	0.21	0.22	0.18	0.15	0.16	0.10	0.33	0.24	0.17	0.22	0.22	0.12
Plot 41	0.13	0.20	0.11	0.13	0.14	0.10	0.21	0.18	0.19	0.18	0.18	0.13
Plot 42	0.20	0.23	0.11	0.11	0.12	0.08	0.15	0.21	0.22	0.21	0.16	0.21
Plot 43	0.14	0.15	0.12	0.11	0.13	0.04	0.18	0.18	0.15	0.13	0.15	0.14
Plot 44	0.17	0.15	0.12	0.18	0.20	0.04	0.21	0.21	0.19	0.21	0.21	0.24
Plot 45	0.08	0.10	0.03	0.06	0.00	0.03	0.10	0.08	0.07	0.08	0.08	0.11
Plot 46	0.26	0.21	0.26	0.12	0.17	0.18	0.11	0.06	0.08	0.18	0.16	0.09
Plot 47	0.28	0.16	0.11	0.11	0.14	0.10	0.09	0.15	0.09	0.07	0.11	0.13
Plot 48	0.19	0.15	0.13	0.06	0.06	0.20	0.17	0.14	0.07	0.13	0.18	0.14

	Plot 13	Plot 14	Plot 15	Plot 16	Plot 17	Plot 18	Plot 19	Plot 20	Plot 21	Plot 22	Plot 23	Plot 24
Plot 1												
Plot 2												
Plot 3												
Plot 4												
Plot 5												
Plot 6												
Plot 7												
Plot 8												
Plot 9												
Plot 10												
Plot 11												
Plot 12												
Plot 13												
Plot 14	0.49											
Plot 15	0.53	0.49										
Plot 16	0.32	0.32	0.36									
Plot 17	0.29	0.25	0.37	0.56								
Plot 18	0.29	0.39	0.33	0.45	0.45							
Plot 19	0.26	0.26	0.23	0.15	0.15	0.10						
Plot 20	0.19	0.22	0.15	0.14	0.17	0.21	0.49					
Plot 21	0.23	0.21	0.21	0.21	0.09	0.10	0.50	0.65				
Plot 22	0.15	0.09	0.05	0.06	0.06	0.18	0.14	0.10	0.10			
Plot 23	0.14	0.12	0.05	0.09	0.09	0.20	0.13	0.18	0.10	0.45		
Plot 24	0.24	0.29	0.15	0.15	0.13	0.28	0.19	0.23	0.22	0.31	0.43	
Plot 25	0.33	0.28	0.21	0.29	0.27	0.34	0.20	0.21	0.20	0.15	0.14	0.29
Plot 26	0.29	0.20	0.31	0.30	0.30	0.32	0.17	0.16	0.15	0.18	0.17	0.19
Plot 27	0.26	0.30	0.31	0.31	0.37	0.26	0.18	0.14	0.15	0.13	0.06	0.15
Plot 28	0.22	0.30	0.27	0.18	0.16	0.20	0.28	0.29	0.25	0.12	0.17	0.28
Plot 29	0.22	0.29	0.22	0.13	0.13	0.19	0.29	0.30	0.33	0.08	0.15	0.29
Plot 30	0.32	0.30	0.29	0.23	0.26	0.33	0.28	0.26	0.22	0.19	0.18	0.30
Plot 31	0.32	0.32	0.27	0.19	0.23	0.35	0.33	0.42	0.33	0.13	0.21	0.40
Plot 32	0.12	0.12	0.11	0.16	0.19	0.10	0.14	0.10	0.10	0.14	0.21	0.17
Plot 33	0.04	0.04	0.03	0.08	0.08	0.06	0.00	0.04	0.00	0.05	0.09	0.11
Plot 34	0.11	0.09	0.16	0.21	0.28	0.23	0.07	0.15	0.07	0.07	0.03	0.05
Plot 35	0.16	0.20	0.12	0.14	0.14	0.11	0.27	0.25	0.23	0.12	0.00	0.06
Plot 36	0.20	0.24	0.18	0.22	0.25	0.18	0.27	0.34	0.27	0.11	0.07	0.14
Plot 37	0.23	0.13	0.19	0.29	0.27	0.25	0.12	0.16	0.12	0.09	0.09	0.17
Plot 38	0.31	0.19	0.24	0.22	0.22	0.23	0.21	0.22	0.15	0.09	0.03	0.15
Plot 39	0.18	0.13	0.31	0.25	0.31	0.23	0.06	0.14	0.09	0.06	0.12	0.22
Plot 40	0.28	0.33	0.32	0.22	0.24	0.27	0.23	0.20	0.18	0.11	0.05	0.22
Plot 41	0.17	0.18	0.16	0.15	0.21	0.20	0.17	0.23	0.19	0.09	0.14	0.30
Plot 42	0.20	0.23	0.18	0.21	0.18	0.24	0.25	0.32	0.23	0.14	0.11	0.26
Plot 43	0.14	0.14	0.15	0.04	0.15	0.09	0.12	0.30	0.12	0.00	0.00	0.13
Plot 44	0.16	0.17	0.18	0.11	0.25	0.14	0.16	0.29	0.12	0.04	0.00	0.15
Plot 45	0.08	0.03	0.05	0.06	0.09	0.05	0.13	0.20	0.13	0.06	0.06	0.13
Plot 46	0.11	0.12	0.15	0.21	0.24	0.20	0.07	0.15	0.07	0.07	0.13	0.24
Plot 47	0.12	0.13	0.11	0.13	0.13	0.15	0.22	0.23	0.22	0.17	0.19	0.26
Plot 48	0.08	0.00	0.07	0.11	0.20	0.17	0.09	0.20	0.13	0.13	0.13	0.18

	Plot 25	Plot 26	Plot 27	Plot 28	Plot 29	Plot 30	Plot 31	Plot 32	Plot 33	Plot 34	Plot 35	Plot 36
Plot 1												
Plot 2												
Plot 3												
Plot 4												
Plot 5												
Plot 6												
Plot 7												
Plot 8												
Plot 9												
Plot 10												
Plot 11												
Plot 12												
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Plot 14												
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Plot 16												
Plot 17												
Plot 18												
Plot 19												
Plot 20												
Plot 21												
Plot 22												
Plot 23												
Plot 24												
Plot 25												
Plot 26	0.51											
Plot 27	0.45	0.37										
Plot 28	0.20	0.15	0.26									
Plot 29	0.09	0.08	0.20	0.42								
Plot 30	0.40	0.42	0.34	0.39	0.30							
Plot 31	0.32	0.25	0.25	0.36	0.39	0.48						
Plot 32	0.12	0.08	0.16	0.12	0.04	0.00	0.06					
Plot 33	0.08	0.03	0.12	0.07	0.00	0.00	0.00	0.29				
Plot 34	0.29	0.27	0.30	0.14	0.07	0.12	0.21	0.14	0.05			
Plot 35	0.13	0.11	0.17	0.13	0.13	0.18	0.14	0.00	0.00	0.08		
Plot 36	0.23	0.15	0.18	0.23	0.19	0.19	0.22	0.07	0.00	0.14	0.39	
Plot 37	0.33	0.27	0.21	0.20	0.13	0.22	0.24	0.09	0.04	0.20	0.10	0.15
Plot 38	0.29	0.30	0.27	0.23	0.23	0.31	0.30	0.09	0.04	0.21	0.20	0.18
Plot 39	0.18	0.25	0.19	0.10	0.06	0.25	0.14	0.09	0.04	0.18	0.00	0.09
Plot 40	0.25	0.31	0.29	0.14	0.17	0.32	0.22	0.11	0.03	0.21	0.14	0.16
Plot 41	0.27	0.26	0.21	0.22	0.21	0.34	0.28	0.09	0.04	0.17	0.09	0.11
Plot 42	0.22	0.22	0.23	0.29	0.30	0.29	0.42	0.12	0.04	0.17	0.16	0.17
Plot 43	0.10	0.09	0.15	0.27	0.27	0.30	0.29	0.00	0.06	0.08	0.15	0.21
Plot 44	0.13	0.11	0.18	0.29	0.30	0.29	0.35	0.04	0.06	0.12	0.14	0.16
Plot 45	0.08	0.00	0.09	0.13	0.14	0.12	0.20	0.06	0.04	0.06	0.14	0.10
Plot 46	0.20	0.29	0.09	0.14	0.14	0.24	0.33	0.14	0.05	0.20	0.00	0.03
Plot 47	0.07	0.17	0.13	0.19	0.27	0.16	0.28	0.17	0.00	0.08	0.00	0.08
Plot 48	0.11	0.19	0.11	0.11	0.07	0.14	0.20	0.13	0.00	0.13	0.04	0.10

	Plot 37	Plot 38	Plot 39	Plot 40	Plot 41	Plot 42	Plot 43	Plot 44	Plot 45	Plot 46	Plot 47	Plot 48
Plot 1												
Plot 2												
Plot 3												
Plot 4												
Plot 5												
Plot 6												
Plot 7												
Plot 8												
Plot 9												
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Plot 11												
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Plot 30												
Plot 31												
Plot 32												
Plot 33												
Plot 34												
Plot 35												
Plot 36												
Plot 37												
Plot 38	0.34											
Plot 39	0.32	0.27										
Plot 40	0.26	0.38	0.29									
Plot 41	0.20	0.33	0.20	0.27								
Plot 42	0.20	0.33	0.13	0.27	0.39							
Plot 43	0.10	0.14	0.07	0.09	0.20	0.23						
Plot 44	0.10	0.17	0.07	0.12	0.25	0.29	0.60					
Plot 45	0.11	0.20	0.08	0.07	0.24	0.27	0.19	0.29				
Plot 46	0.14	0.24	0.24	0.26	0.36	0.22	0.16	0.27	0.15			
Plot 47	0.17	0.18	0.18	0.18	0.26	0.29	0.20	0.19	0.24	0.33		
Plot 48	0.16	0.14	0.20	0.15	0.16	0.19	0.11	0.15	0.26	0.25	0.37	

Appendix 9. Morisita-Horn Diversity Index values for the plot-pairs in the 4 zones (48 plots of 0.25 ha each).

	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9	Plot 10	Plot 11	Plot 12
Plot 1												
Plot 2	0.51											
Plot 3	0.86	0.46										
Plot 4	0.37	0.31	0.21									
Plot 5	0.42	0.29	0.34	0.38								
Plot 6	0.28	0.17	0.34	0.05	0.23							
Plot 7	0.71	0.56	0.53	0.42	0.36	0.13						
Plot 8	0.30	0.44	0.24	0.48	0.49	0.07	0.37					
Plot 9	0.06	0.06	0.04	0.55	0.08	0.00	0.07	0.33				
Plot 10	0.20	0.22	0.14	0.30	0.65	0.10	0.25	0.60	0.07			
Plot 11	0.16	0.20	0.16	0.41	0.20	0.02	0.17	0.54	0.33	0.37		
Plot 12	0.07	0.13	0.08	0.52	0.03	0.01	0.09	0.55	0.68	0.08	0.50	
Plot 13	0.24	0.17	0.20	0.11	0.15	0.01	0.24	0.25	0.12	0.15	0.23	0.10
Plot 14	0.18	0.09	0.18	0.06	0.14	0.06	0.24	0.18	0.09	0.13	0.23	0.05
Plot 15	0.27	0.14	0.29	0.03	0.13	0.13	0.13	0.09	0.03	0.11	0.09	0.02
Plot 16	0.33	0.22	0.33	0.11	0.12	0.01	0.36	0.16	0.05	0.07	0.08	0.05
Plot 17	0.45	0.38	0.42	0.16	0.19	0.03	0.46	0.26	0.04	0.10	0.10	0.04
Plot 18	0.30	0.36	0.26	0.16	0.18	0.03	0.33	0.19	0.03	0.12	0.16	0.06
Plot 19	0.04	0.21	0.01	0.06	0.04	0.06	0.23	0.22	0.05	0.08	0.33	0.13
Plot 20	0.04	0.29	0.02	0.05	0.04	0.07	0.28	0.20	0.03	0.09	0.18	0.07
Plot 21	0.07	0.26	0.03	0.07	0.06	0.09	0.29	0.21	0.03	0.10	0.25	0.08
Plot 22	0.06	0.05	0.06	0.04	0.00	0.03	0.09	0.04	0.01	0.06	0.13	0.05
Plot 23	0.02	0.03	0.01	0.06	0.06	0.03	0.02	0.05	0.01	0.09	0.16	0.03
Plot 24	0.10	0.10	0.09	0.14	0.12	0.09	0.07	0.15	0.02	0.18	0.32	0.05
Plot 25	0.20	0.61	0.12	0.21	0.12	0.04	0.28	0.25	0.07	0.08	0.14	0.04
Plot 26	0.15	0.21	0.09	0.17	0.12	0.09	0.28	0.12	0.04	0.14	0.07	0.03
Plot 27	0.16	0.48	0.11	0.10	0.12	0.03	0.22	0.24	0.12	0.11	0.11	0.04
Plot 28	0.05	0.09	0.06	0.03	0.08	0.01	0.06	0.13	0.02	0.08	0.18	0.05
Plot 29	0.05	0.06	0.03	0.04	0.14	0.01	0.04	0.15	0.02	0.16	0.20	0.03
Plot 30	0.14	0.20	0.08	0.24	0.11	0.01	0.18	0.26	0.17	0.11	0.39	0.23
Plot 31	0.09	0.10	0.06	0.10	0.11	0.02	0.09	0.14	0.04	0.13	0.18	0.06
Plot 32	0.01	0.00	0.02	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Plot 33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plot 34	0.24	0.25	0.22	0.14	0.11	0.04	0.35	0.10	0.02	0.05	0.07	0.05
Plot 35	0.00	0.07	0.00	0.02	0.01	0.01	0.04	0.10	0.07	0.02	0.12	0.06
Plot 36	0.02	0.28	0.00	0.04	0.07	0.02	0.08	0.23	0.07	0.11	0.24	0.09
Plot 37	0.33	0.28	0.26	0.16	0.16	0.04	0.46	0.20	0.02	0.11	0.09	0.03
Plot 38	0.11	0.11	0.11	0.04	0.04	0.00	0.16	0.10	0.01	0.05	0.12	0.07
Plot 39	0.05	0.07	0.08	0.04	0.10	0.12	0.09	0.07	0.01	0.09	0.02	0.01
Plot 40	0.07	0.07	0.06	0.03	0.05	0.05	0.18	0.08	0.01	0.04	0.09	0.01
Plot 41	0.07	0.10	0.07	0.07	0.04	0.01	0.08	0.07	0.01	0.05	0.10	0.02
Plot 42	0.12	0.13	0.11	0.04	0.05	0.02	0.12	0.10	0.02	0.07	0.13	0.05
Plot 43	0.13	0.14	0.08	0.16	0.10	0.00	0.17	0.11	0.05	0.08	0.21	0.10
Plot 44	0.16	0.15	0.11	0.15	0.11	0.00	0.19	0.14	0.05	0.08	0.22	0.10
Plot 45	0.05	0.06	0.02	0.02	0.00	0.08	0.02	0.10	0.02	0.02	0.17	0.12
Plot 46	0.62	0.39	0.60	0.21	0.25	0.02	0.52	0.27	0.04	0.08	0.15	0.06
Plot 47	0.04	0.06	0.01	0.02	0.05	0.03	0.05	0.08	0.01	0.05	0.03	0.01
Plot 48	0.06	0.23	0.03	0.04	0.06	0.17	0.18	0.07	0.01	0.09	0.20	0.03

	Plot 13	Plot 14	Plot 15	Plot 16	Plot 17	Plot 18	Plot 19	Plot 20	Plot 21	Plot 22	Plot 23	Plot 24
Plot 1												
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Plot 3												
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Plot 5												
Plot 6												
Plot 7												
Plot 8												
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Plot 13												
Plot 14	0.55											
Plot 15	0.30	0.40										
Plot 16	0.20	0.19	0.16									
Plot 17	0.17	0.15	0.25	0.85								
Plot 18	0.27	0.12	0.20	0.50	0.55							
Plot 19	0.24	0.28	0.09	0.09	0.07	0.05						
Plot 20	0.16	0.26	0.08	0.12	0.10	0.13	0.69					
Plot 21	0.18	0.22	0.12	0.10	0.07	0.08	0.70	0.80				
Plot 22	0.04	0.05	0.02	0.04	0.03	0.07	0.02	0.03	0.05			
Plot 23	0.02	0.03	0.01	0.01	0.00	0.10	0.02	0.06	0.14	0.40		
Plot 24	0.12	0.10	0.06	0.05	0.06	0.16	0.19	0.14	0.22	0.40	0.68	
Plot 25	0.21	0.16	0.06	0.17	0.25	0.40	0.26	0.32	0.26	0.03	0.07	0.18
Plot 26	0.17	0.15	0.24	0.16	0.18	0.30	0.10	0.18	0.15	0.05	0.05	0.12
Plot 27	0.31	0.27	0.09	0.21	0.23	0.23	0.28	0.32	0.25	0.02	0.01	0.06
Plot 28	0.12	0.11	0.10	0.05	0.06	0.06	0.45	0.42	0.41	0.05	0.09	0.22
Plot 29	0.11	0.10	0.08	0.03	0.05	0.07	0.36	0.35	0.45	0.04	0.11	0.18
Plot 30	0.18	0.15	0.06	0.06	0.11	0.12	0.69	0.49	0.46	0.07	0.06	0.25
Plot 31	0.12	0.13	0.06	0.07	0.07	0.10	0.57	0.51	0.43	0.03	0.06	0.21
Plot 32	0.01	0.02	0.04	0.03	0.06	0.03	0.00	0.00	0.00	0.01	0.02	0.01
Plot 33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Plot 34	0.09	0.04	0.10	0.24	0.29	0.38	0.00	0.02	0.01	0.01	0.00	0.02
Plot 35	0.17	0.31	0.04	0.32	0.22	0.15	0.39	0.44	0.24	0.01	0.00	0.07
Plot 36	0.19	0.24	0.08	0.05	0.10	0.12	0.62	0.66	0.53	0.02	0.01	0.15
Plot 37	0.16	0.10	0.10	0.38	0.39	0.41	0.16	0.21	0.19	0.02	0.01	0.08
Plot 38	0.10	0.08	0.04	0.10	0.10	0.15	0.36	0.38	0.30	0.01	0.00	0.09
Plot 39	0.04	0.05	0.43	0.11	0.16	0.14	0.03	0.04	0.04	0.02	0.01	0.07
Plot 40	0.07	0.15	0.16	0.19	0.20	0.24	0.16	0.17	0.16	0.02	0.01	0.08
Plot 41	0.07	0.04	0.07	0.05	0.10	0.10	0.10	0.09	0.08	0.02	0.04	0.12
Plot 42	0.10	0.10	0.06	0.10	0.12	0.10	0.31	0.29	0.25	0.05	0.02	0.14
Plot 43	0.10	0.20	0.03	0.03	0.02	0.04	0.52	0.50	0.32	0.00	0.00	0.12
Plot 44	0.12	0.19	0.03	0.06	0.07	0.07	0.55	0.52	0.34	0.01	0.00	0.16
Plot 45	0.15	0.08	0.02	0.02	0.01	0.01	0.39	0.27	0.25	0.08	0.04	0.22
Plot 46	0.21	0.09	0.08	0.37	0.56	0.30	0.00	0.02	0.00	0.01	0.01	0.09
Plot 47	0.05	0.03	0.10	0.01	0.05	0.04	0.05	0.05	0.07	0.02	0.04	0.09
Plot 48	0.05	0.00	0.04	0.02	0.04	0.07	0.12	0.15	0.17	0.21	0.14	0.25

	Plot 25	Plot 26	Plot 27	Plot 28	Plot 29	Plot 30	Plot 31	Plot 32	Plot 33	Plot 34	Plot 35	Plot 36
Plot 1												
Plot 2												
Plot 3												
Plot 4												
Plot 5												
Plot 6												
Plot 7												
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Plot 23												
Plot 24												
Plot 25												
Plot 26	0.44											
Plot 27	0.67	0.23										
Plot 28	0.07	0.12	0.08									
Plot 29	0.03	0.06	0.05	0.60								
Plot 30	0.25	0.13	0.19	0.63	0.45							
Plot 31	0.12	0.07	0.10	0.66	0.51	0.86						
Plot 32	0.01	0.00	0.01	0.01	0.00	0.00	0.01					
Plot 33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83				
Plot 34	0.29	0.24	0.17	0.05	0.02	0.06	0.07	0.02	0.00			
Plot 35	0.13	0.04	0.20	0.26	0.17	0.40	0.46	0.00	0.00	0.01		
Plot 36	0.39	0.10	0.40	0.35	0.25	0.54	0.46	0.01	0.00	0.01	0.47	
Plot 37	0.28	0.32	0.21	0.08	0.03	0.10	0.13	0.01	0.00	0.37	0.01	0.05
Plot 38	0.10	0.10	0.08	0.53	0.36	0.63	0.70	0.02	0.00	0.13	0.24	0.27
Plot 39	0.06	0.22	0.05	0.04	0.03	0.04	0.05	0.01	0.00	0.06	0.00	0.02
Plot 40	0.11	0.21	0.12	0.05	0.03	0.09	0.09	0.00	0.00	0.14	0.07	0.05
Plot 41	0.15	0.17	0.08	0.15	0.10	0.19	0.13	0.00	0.00	0.06	0.05	0.10
Plot 42	0.12	0.13	0.10	0.41	0.28	0.46	0.46	0.01	0.00	0.06	0.20	0.27
Plot 43	0.12	0.04	0.09	0.46	0.29	0.66	0.69	0.00	0.00	0.09	0.67	0.49
Plot 44	0.13	0.06	0.11	0.59	0.36	0.74	0.76	0.00	0.00	0.09	0.62	0.49
Plot 45	0.06	0.00	0.07	0.31	0.20	0.43	0.44	0.02	0.00	0.04	0.21	0.30
Plot 46	0.16	0.17	0.12	0.08	0.10	0.12	0.07	0.02	0.00	0.26	0.00	0.01
Plot 47	0.02	0.15	0.02	0.21	0.13	0.04	0.09	0.05	0.00	0.01	0.00	0.04
Plot 48	0.06	0.07	0.06	0.04	0.01	0.08	0.08	0.04	0.00	0.03	0.01	0.04

	Plot 37	Plot 38	Plot 39	Plot 40	Plot 41	Plot 42	Plot 43	Plot 44	Plot 45	Plot 46	Plot 47	Plot 48
Plot 1												
Plot 2												
Plot 3												
Plot 4												
Plot 5												
Plot 6												
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Plot 33												
Plot 34												
Plot 35												
Plot 36												
Plot 37												
Plot 38	0.19											
Plot 39	0.28	0.04										
Plot 40	0.44	0.23	0.28									
Plot 41	0.09	0.49	0.08	0.34								
Plot 42	0.17	0.73	0.06	0.29	0.69							
Plot 43	0.03	0.40	0.01	0.02	0.10	0.32						
Plot 44	0.06	0.48	0.01	0.02	0.13	0.37	0.92					
Plot 45	0.02	0.36	0.02	0.03	0.23	0.38	0.34	0.39				
Plot 46	0.35	0.17	0.06	0.07	0.14	0.14	0.05	0.12	0.05			
Plot 47	0.05	0.14	0.09	0.06	0.12	0.12	0.03	0.08	0.05	0.17		
Plot 48	0.10	0.08	0.09	0.10	0.07	0.06	0.01	0.02	0.31	0.12	0.43	

Appendix 10. Food plants of the lion-tailed macaque. Compiled from studies in different areas. Important species are given in **bold**.

Family	Species	Part eaten	Source
Anacardiaceae	**Holigarna nigra** Bourd**.**		2, 6
	H. grahamii (Wt.)	F	4
	Mangifera indica L.	F	1, 3, 4, 6
	Nothopegia beddomei Gamble	F	1
	N. heyneana (Hook.f.)		3
	Semecarpus travancorica Bedd.	F	1, 3, 5
Annonaceae	Annona cherimola Miller ‡	F	1
	Artabotrys zeylanicus Hk. f. †	F	1
	Cyathocalyx zeylanicas Champ	F	1
	Meiogyne viridiflora ?	F	1
	M. pannosa (Dalz.)	F	1
	Miliusa wightiana J. Hk. & Thw.	x	2
	M. tomentosa (Roxb.)	F	1
	Polyalthia coffeoides (Thw.)	F	1
Apocynaceae	Aganosma cymosa (Roxb.)	F	1
	Carissa spinarum L. **	S	1
	Chilocarpus denudatus Bl. †(=Chilocarpus atroviridis)	S	1
	Cryptostegia grandiflora R. Br. †	F	1
Areaceae	Arenga wightii Griff.	F	4
	Bentinckia condapanna Bl.		2
	Calamus pseudo-tenuis Becc. †	S	1, 4
	C. rotang L. †	S	1, 3
	C. travancoricus Bedd. †		2
	Calamus sp.		6
	Caryota urens L.	F	4, 6
Aristolochiaceae	Aristolochia tagala Cham. †		2, 6
Bignoniaceae	Oroxylum indicum (L.).	F	5
Bombacaceae	**Bombax ceiba** L. (=B.malabaricum, Salmalia malabarica)	N	1, 3, 4
	Cullenia exarillata A. Robyns	S N	1, 2, 5, 6
Boraginaceae	**Cordia dichotama** Forst.f. (=Cordia myxa)	F	1
Burseraceae	Canarium strictum Roxb.		6
Celestraceae	**Cassine kedarnathii** Sasi. & Swarup.		6
Chloranthaceae	Sarcandra chloranthoides Gard. (=Chloranthus brachystachys)		2
Clusiaceae	Calophyllum polyanthum Wall. (= C. elatum)		6
	Garcinia gummi-gutta (L.) (= G. cambogia)	F	1, 4, 6
	G. indica (Thouras)	F	4
	G. morella (Gaertn.) Desr.		6

Family	Species	Part eaten	Source
	Mesua ferrea L.	F	1, 3, 5, 6
Convolvulaceae	**Erycibe paniculata** Roxb. †(=E. wightiana)	F	1
Cyperaceae	Scleria terrestris (L.) Fassett ***(=S. cochinchinensis)		2
Datiscaceae	Tetrameles nudiflora R. Br.	N	1
Dilleniaceae	**Dillenia pentagyna** Roxb**.**	F	1, 4
Dioscoreaceae	Dioscorea pentaphylla L. †(=D. belophylla)		2
	Dioscorea sp.		6
Dipterocarpaceae	Hopea glabra Wt. & Arn.		6
	Vateria indica L.	S	1
Ebenaceae	**Diospyros buxifolia** (Bl.) (=D. microphylla)	S	1, 4
	D. montana Roxb.	S	1
	D. nilagirica Bedd.		2
	D. malabarica (Desr.) (=D. peregrina)		2
	D. sylvatica Roxb.	S	1, 3, 5
Elaeagnaceae	**Elaeagnus conferta** Roxb. †	F	1, 3
	E. kologa D. F. K. Schldl. †	F	3
	Elaeagnus sp. †	F	1
Elaeocarpaceae	Elaeocarpus glandulosus Wall.		6
	E. munronii (Wt.)	S	2, 3, 5, 6
	E. recurvatus Corner (=E ferrugineus)	N F	1, 3
	E. serratus L.	F	4
	E. tuberculatus Roxb.	F	2, 4, 6
	E. venustus Bedd.		2
Euphorbiaceae	Agrostistachys borneensis Becc. (=A. meeboldii)		6
	Antidesma menasu Miq.	F B	1, 2, 3, 6
	Aporusa lindleyana Baill.	F	1, 4
	Baccaurea courtallensis (Wt.)	F	1
	Bischofia javanica Bl.	F	1, 3, 4, 6
	Croton sp.	R	1
	Drypetes elata (Bedd.) (=Hemicyclia elata)		2, 6
	D. oblongifolia (Bedd.)		2
	Fahrenheitia zeylanica (Thw.)		6
	Glochidion arboreum Wt.		6
	Glochidion bourdillonii Gamble		3
	Macaranga indica Wt.		6
	M. peltata (Roxb.) (=M. roxburghii)	F B	1, 2, 3, 4, 5
	Mallotus tetracoccus (Roxb.)		3, 5
Fabaceae	Cassia sp.	F	3
	Caesalpinia bonduc (L.) ‡	S	1

Family	Species	Part eaten	Source
	Dalbergia sissoides Grah. ‡	S	1
	Erythrina subumbrans (Hassk.) ‡(=E. lithosperma)	N	3, 5
	Flemingia macrophylla ?		6
	Mucuna prurita Hk. †		6
	Ormosia travancorica Bedd.		2
Flacourtiaceae	Casearia ovata (Lam.) (=C. esculenta)	S	1, 6
	Flacourtia montana Graham	F N	1, 4, 5
	Hydnocarpus alpina Wt.		6
	H. pentandra (Buch.- Ham.) (=H. laurifolia)	F	4
	H. macrocarpa (Bedd.) (= Taraktogenos macrocarpa)	F	4
	Scolopia crenata (Wight & Arn.)		2
Gnetaceae	**Gnetum ula** Brogn. †	F R	1, 4
Hippocrataceae	Salacia fruticosa Lawson †		6
Icacinaceae	Apodytes dimidiata E.Meyer		6
	Gomphandra coriacea Wt.		2, 6
	G. polymorpha Wt.		5
	Sarcostigma kleinii Wt. & Arn. †	F	1, 4
Lauraceae	Actinodaphne tadulingami Gamble	F	1, 2
	Apollonias arnottii Nees		6
	Cinnamomum sulphuratum Nees		2, 4
	C. malabatrum (Burm.f.)		6
	Cryptocarya bourdillonii Gamble		6
	Litsea beddomei Hk.		2
	L. coriacea J. Hk.	F	1
	L. deccanensis Gamble	F	3, 5
	L. floribunda (Bl.)	F	1, 6
	L. insignis Gamble	F	2, 3, 5
	L. laevigata (Nees)		6
	L. oleoides J. Hk.	F	2, 3, 5, 6
	L. wightiana Hk. f.		2
	Neolitsea scrobiculata (Meissn.)		6
	N. cassia (L.) (=N. zeylanica)		5
	Persea macrantha (Nees) (=Machilus macrantha)	F	1, 4, 6
Liliaceae	Smilax zeylanica L. †	F	1
Loranthaceae	Dendropthoë falcata (L.f.) (=Loranthus longiflorus)	F	1, 4
	Helicanthus elastica (Desr.) (=Loranthus elasticus)		2
	Loranthus tomentosus Heyne	F	3, 5
Meliaceae	**Aglaia bourdilloni** Gamble		2
	A. elaeagnoidea (Juss.) (=A. roxburghiana)	F	1, 4
	A. lawii (Wt.)		6

Family	Species	Part eaten	Source
	Dysoxylum malabaricum Bedd.	A	1
	Dysoxylum sp.		6
Moraceae	**Antiaris toxicaria** Lesch.	F	4
	Artocarpus gomezianus Wall. (=A. lakoocha)	F S	1, 4
	A. heterophyllus Lam.	F S	1, 2, 3, 4, 5, 6
	A. hirsutus Lam.	F S	1, 3, 4, 5
	Ficus amplissima J.E. Sm. (=F. tsiela)	F	1, 2
	F. beddomei King		6
	F. callosa Willd.	F	4
	F. drupacea Thunb. (= F. mysorensis.)	F	4
	F. hispida L.f.	F	3, 5
	F. integrifolia ?	F	3
	F. jerdonii ?	F	1
	F. macrocarpa Wight	F	3, 5
	F. microcarpa L.f. (=F. retusa L.)	F	3, 5, 6
	F. nervosa Roth.	F	1, 3, 4, 5, 6
	F. racemosa L. (=F. glomerata)	F	3, 4, 5
	F. rigida Jack. (= F. glaberrima) (= F. travancorica)		3, 5
	F. tsjahela N. Burman	F	1, 4, 5, 6
	F. talbotii King.	F	2, 4
	F. virens Aiton (=F. infectoria)	F	1, 3, 4
Myristicaceae	Knema attenuata (J. Hk. & Thw.)	F	1, 3, 5, 6
	Myristica dactyloides Gaertn. (=M. beddomei)	A	1, 2, 3, 4, 6
	M. malabarica Lam.	A	4
Myrsinaceae	Ardisia pauciflora Heyne		2
	A. rhomboidea Wt.		1
	A. stonii ?		6
	Embelia adnata Bedd.		2
	E. ribes Burm.		6
	Maesa indica (Roxb.)	F	3, 6
	M. perottetiana A. DC.		5
	Rapanea daphnoides Mez. **		2
Myrtaceae	Eugenia sp.		2
	Psidium guajava L. ‡	F	3
	Syzygium cumini (L.)	F	1, 6
	S. gardneri Thw.	F	4, 6
	S. hemisphericum (Walp.)	F	4
	S. laetum (Buch.-Ham.) (= Eugenia laeta)	F	1, 3, 5, 6
	S. lanceolatum (Lam.) (= S. wightianum)	F	1, 3

Family	Species	Part eaten	Source
	S. mundagam (Bourd.)	F	2, 6
	Syzygium sp.	F	3
Oleaceae	Chionanthus sp.		6
	Ligustrum perrottetii A. DC.		6
	Olea dioica Roxb.		6
Orchidaceae	Luisia birchea Blume (=L. tenuifolia)		2
Pandanaceae	Pandanus thwaitesii Mart.	F	3
Piperaceae	Piper hymenophyllum Miq. †	Shoot	1
	P. pseudotenuis ? †	S	3
Poaceae	Arthraxon sp.	L	1
	Bambusa bambos (L.) (=Bambusa arundinacea.)	S	1
	Isachne gardneri Benth.		2
	Ochlandra scriptoria C. Fisch.		2
	Oplismenus compositus (L.)		2
Polygonaceae	Polygonum chinense L. †		6
Rhamancaeae	**Maesopsis eminii** Engl. ‡	F	3
	Zizyphus oenoplia Mill. †	F	4
	Z. rugosa Lam. †		6
Rhizophoraceae	**Carallia brachiata** (Lour.) (=C. integerrima)	F	1
Rosaceae	Prunus ceylanica (Wt.). (=Pygeum acuminatum)	F	4
Rubiaceae	Canthium dicoccum (Gaertn.) Merr.		2, 6
	C. umbellatum W. S		1, 2
	Coffea arabica L. [1]	F	3, 5
	Lasianthus cinereus Gamble		2
	L. jackianus Wt.		6
	Octotropis travancorica Bedd.		2
	Psychotria congesta Hk. f.		2
	P. flavida Talb.	S	1
	P. octosulcata Talb.		2
	Randia rugulosa (Thw.) J. Hk. †		2
	Saprosma corymbosum Bedd. **		2
Rutaceae	Acronychia pedunculata (L.) (=A. barberi)	F	1, 4, 6
	Clausena dentata (Willd.)		6
	Glycosmis mauritiania (Lam.)	F	1
	Glycosmis sp.		3
	Toddalia asiatica Lamk. † (= T. aculeata)	F	1, 2, 3, 6
	Vepris bilocularis (Wt. & Arn.)	F	1, 2, 3, 4, 5
Sabiaceae	**Meliosma pinnata** (Roxb.)		6
Sapindaceae	Allophyllus rheedii Radlk.		6

Family	Species	Part eaten	Source
	Filicium decipiens (Wt. & Arn.)	F	1
	Dimocarpus longan Lour. (=Nephalium longana)	F N	1, 6
	Schleichera oleosa (Lour.) (=S. trijuga)	F	1, 3
Sapotaceae	**Mimusops elangi** L.	F	3, 5
	Palaquium ellipticum (Dalz.)	F	2, 3, 4, 5, 6
Solanaceae	Solanum sp.		6
Staphyleaceae	Turpinia malabarica Gamble		6
Sterculiaceae	Sterculia guttata Roxb.	S	3, 5
Symplocaceae	Symplocos cochinchinensis (Lour.)	F	3, 6
	Symplocos sessilis Cl.		2
Ternstromiaceae	Gordonia obtusa Wall.		2
Tiliaceae	**Grewia tiliifolia** Vahl.	F S	1, 3
	G. disperma Rottler	F	1
	Grewia sp.	R	1
Ulmaceae	**Aphananthe cuspidata** (Bl.) (=Gironniera reticulata)	S	1
Verbenaceae	**Lantana camara** L. ‡	F	3, 5, 6
Viscaceae	Viscum angulatum Heyne		6
	V. ramosissimum Wall.		2
Vitaceae	Cayratia pedata (Lour.)	F	3
	Tetrastigma sulcatum (M. Lawson)		2, 6
Xanthophyllaceae	**Xanthophyllum arnottianum** Wt. (=X. flavescens)	B	1, 6
Zingiberaceae	Elettaria cardamomum (L.) ***	Pith	3, 5, 6
Bryophytes	Asplinium nidus avis	L	1
	Microsporium punctatum	L	1

F = Fruits; S = Seeds; B = Blossoms/Flowers; N = Nectar; L = Leaves; R = Resin/Gum; A = Aril; x = Information not available.

[1] Plant Species not native to these forests; **†** = Liana/Vines; ** = Shrub; *** = Herbs.

Source: 1) Green and Minkowski, 1977; 2) Kumar, 1987; 3) Menon, 1993; 4) Umapathy, 1998; 5) Joseph, 1998; 6) Krishnamani and Kumar, 2000.

Appendix 11. Phenological patterns in Someshwara Wildlife Sanctuary, Karnataka, India.
(■ = Mature leaves, □ = Leaf flush, ● = Flowers, * = Fruits). The species in *italics* are the food species of the lion-tailed macaques. (L) indicates a Liana.

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		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
1	Acrocarpus fraxinifolius	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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2	Ailanthus triphysa	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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3	Alangium salvifolium (L)	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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4	Albizia amara	■	■	■		■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■
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5	Albizia chinensis	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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6	Albizia lebbeck	■	■			■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■
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7	Alseodaphne semecarpifolia	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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8	Alstonia scholaris	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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9	*Antiaris toxicaria*	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■
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10	*Aporusa lindleyana*	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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11 Archidendron monadelphum	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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12 *Arenga wightii*	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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13 *Artocarpus gomezianus*	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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14 *Artocarpus heterophyllus*	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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15 *Artocarpus hirsutus*	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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16 Bauhinia phoenicea (L)	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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17 *Bombax ceiba*	■						■	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■
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18 Butea monosperma	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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19 Butea parviflora (L)	■	■	■	■			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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20 Callicarpa tomentosa	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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21 *Calophyllum polyanthum*	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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22	*Carallia brachiata*	□	□	□	□			□					□		□					□			□		
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23	Caraya arborea			□	□	□	□		□																
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24	*Caryota urens*	□	□	□	□	□	□	□	□	□		□	□	□				□	□	□	□	□	□		
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25	Cassia fistula				□	□	□		□							□	□		□	□					□
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26	Catunaregam spinosa				□	□	□	□	□				□					□	□		□	□		□	
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27	Celtis philippensis	□	□	□	□	□		□	□		□	□	□		□		□	□	□	□	□		□	□	
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28	Chionanthus mala-elengi										□	□													
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29	*Cinnamomum malabatrum*	□	□	□	□	□	□	□		□	□	□	□	□	□	□		□	□	□	□	□	□	□	□
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30	Cinnamomum sulphuratum			□	□	□					□	□		□	□	□			□		□		□	□	□
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31	*Clausena dentata*				□	□		□	□														□		
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32	Combretum latifolium (L)	□				□		□	□	□	□	□		□	□	□	□	□	□	□	□	□			
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33	Dalbergia latifolia	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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34	Dalbergia sp. (L)	■	■	■				■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■
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35	*Dillenia pentagyna*	■	■	■				■	■	■	■	■	■	■	■	■			■	■	■	■	■	■	■
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36	*Dimocarpus longan*	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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37	*Diospyros buxifolia*	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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38	Diospyros oocarpa	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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39	Diospyros paniculata	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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40	Diospyros saldanhae	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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41	*Elaeocarpus serratus*	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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42	*Elaeocarpus tuberculatus*	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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43	Entada pursaetha (L)	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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44	Erythrina indica	■						■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■
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45	Fagraea ceylanica	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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46	*Ficus callosa*	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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47	*Ficus drupacea*	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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48	*Ficus hispida*	■	■	■		■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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49	*Ficus nervosa*	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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50	*Ficus racemosa*	■	■	■	■	■	■	■	■	■			■	■	■	■	■	■	■	■	■	■	■	■	■
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51	Ficus religiosa	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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52	*Ficus talbotii*	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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53	*Ficus tsjahela*	■	■		■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
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54	*Ficus virens*	■	■	■			■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■
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55	Flacourtia indica	■	■	■				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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56	*Flacourtia montana*	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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57	*Garcinia gummi-gutta*	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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58	*Garcinia indica*	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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59	*Garcinia morella*	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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60	Glochidion johnstonei	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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61	*Gnetum ula (L)*	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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62	*Grewia tiliifolia*	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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63	Haldina cordifolia	■	■	■				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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64	Harpullia arborea	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■
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65	Holarrhena pubescens	■	■	■				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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66	Holigarna arnottiana	□	□	□	□	□	□	□	□	□	□	□	□	□	□		□	□	□	□	□	□	□	□	□
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67	*Holigarna grahamii*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
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68	Holoptelea integrifolia			□	□		□	□	□	□	□		□	□		□	□	□	□	□	□	□	□		□
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69	Homalium zeylanicum	□	□	□	□	□	□	□	□		□	□	□		□	□		□			□				
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70	Hopea parviflora	□	□	□	□		□	□	□	□		□	□	□	□		□		□	□		□			□
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71	Hopea ponga	□	□		□		□			□		□		□	□	□	□		□		□	□			
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72	Humboldtia brunonis					□			□	□	□	□	□				□	□	□	□		□	□	□	
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73	*Hydnocarpus macrocarpa*	□	□	□	□	□	□	□	□	□	□	□	□		□	□		□	□	□	□	□	□	□	□
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74	*Hydnocarpus pentandra*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	
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75	Ixora brachiata	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□		□	□	□	□	□	□	□
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76	Lagerstroemia microcarpa				□	□	□									□	□								
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77	Lagerstroemia parviflora				□			□	□	□		□	□		□				□						
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78	Lagerstroemia reginae				□	□	□	□	□	□	□					□	□	□	□	□	□		□		
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79	Lannea coromandelica	□	□	□	□	□	□	□	□	□					□		□	□	□	□	□				
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80	Leea indica				□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
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81	Litsea malabarica	□	□	□	□	□	□		□	□	□	□	□	□	□	□	□	□	□			□	□	□	
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82	Lophopetalum wightianum	□	□	□	□	□	□				□	□	□			□	□		□	□	□	□		□	
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83	*Macaranga peltata*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□									
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84	Madhuca longifolia				□	□	□	□	□	□					□			□		□	□				
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85	Madhuca neriifolia	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
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86	*Mangifera indica*		□		□	□	□	□							□	□	□			□	□	□	□		
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87	Melia dubia	□	□	□	□	□		□	□		□	□	□		□			□		□		□			
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88	*Mimusops elengi*	□	□	□	□	□	□			□	□	□		□	□					□	□	□	□		
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89	*Myristica dactyloides*	□	□	□	□	□						□	□	□			□		□		□			□	□
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90	*Myristica malabarica*	□	□	□	□							□	□	□		□				□					
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91	Naringi crenulata	□	□	□	□	□	□	□	□			□			□			□						□	
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92	Neolamarckia cadamba		□	□	□	□	□	□	□	□	□	□		□	□		□	□	□	□	□	□	□	□	□
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93	Nothopegia racemosa	□	□	□		□	□					□	□	□		□				□	□			□	
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94	*Olea dioica*	□	□					□	□						□		□	□	□	□		□			
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95	*Oroxylum indicum*					□	□	□	□	□	□			□	□	□		□	□	□	□	□	□	□	□
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96	Pajanelia longifolia			□	□	□	□	□	□	□	□	□	□	□		□	□	□	□	□	□	□	□		□
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97	*Persea macrantha*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	
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98	Polyalthia fragrans			□	□	□	□		□	□	□	□	□			□	□		□	□	□	□	□	□	□
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No.	Species	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
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99	Prunus ceylanica	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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100	Pterocarpus marsupium	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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101	Pterospermum diversifolium	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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102	Pterygota alata	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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103	Sapindus trifoliata	■	■			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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104	Saraca asoca	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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105	Schleichera oleosa	■	■	■		■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■
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106	Scleropyrum pentandrum	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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107	Spondias indica	■	■			■	■	■	■	■	■		■	■	■	■		■	■	■	■	■	■	■	■
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108	*Sterculia guttata*	■	■			■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■
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109	Stereospermum colais	■	■	■			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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110	Strychnos nux-vomica	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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111	Syzygium caryophyllatum	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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112	*Syzygium cumini*	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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113	*Syzygium gardneri*	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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114	*Syzygium hemisphericum*	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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115	Tabernaemontana heyneana	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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116	Terminalia alata	■	■	■			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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117	Terminalia bellirica	■	■	■		■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■
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118	Terminalia paniculata	■	■	■		■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■
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119	Terminalia travancorensis	■	■	■		■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■
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120	*Tetrameles nudiflora*	■	■					■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■
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121	Trewia polycarpa	■	■			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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122	*Vateria indica*	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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123	Ventilago maderaspatana (L)	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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124	*Vepris bilocularis*	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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125	Vitex altissima	■	■	■			■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■
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126	Vitex leucoxylon	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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127	Walsura trifolia	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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128	Xylia xylocarpa	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
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129	Zanthoxylum rhetsa	■	■	■				■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■
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[A] var. hexapetalum, [B] ssp. zeylanicus, [C] var pubescens