Stand structure of a primate rich rainforest region in the central Western Ghats of southern India

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Date of publication (online): 26 June 2010
Date of publication (print): 26 June 2010
ISSN 0974-7907 (online) | 0974-7893 (print)

Editor: Werner Kaumanns

Manuscript details:
Ms # o2415
Received 02 March 2010
Final revised received 08 May 2010
Finally accepted 20 May 2010

Citation: Roy, K., M. Singh, H.S. Sushma & M. Singh (2010). Stand structure of a primate rich rainforest region in the central Western Ghats of southern India. *Journal of Threatened Taxa* 2(6): 930-939.

Author Details: See end of this article.

Author Contribution: Kuladeep Roy is a research scholar and collected major part of the data. Dr. H.S. Sushma was involved in data collection and sampling in the earlier stages of the project. Prof. Mewa Singh and Dr. Mridula Singh are PI and Co-PI of the project and are responsible for planning the study, obtaining the grants and analysis and write up.

Acknowledgements: The financial grants for the present study were received by Mewa Singh and Mridula Singh from the Department of Science and Technology, Government of India. We thank the Chief Wildlife Warden, Bangalore, Deputy Conservator of Forests, Honnavara Forest Division, Range Forest Officer, Gerusoppa Forest Range and the forest staff at Gerusoppa range for research permits and field assistance. We thank Karnataka Power Corporation Limited for providing accommodation at Gerusoppa. Our special thanks to Krishna and other villagers at Matnigadde for their help during field work.

Abstract: The Western Ghats of southern India are one of the most important biodiversity regions in the world, not only due to their faunal diversity and abundance but also due to different habitat types, floral diversity and the presence of several endemic plant species. The rainforests in the central Western Ghats are inhabited by several primate species. We investigated the vegetation pattern and tree species occupancy of one of the prime primate habitats in the central Western Ghats. Lion-tailed Macaque (*Macaca silenus*), Bonnet Macaque (*Macaca radiata*), Hanuman Langur (*Semnopithecus entellus achates*) and Malabar Slender Loris (*Loris lydekkerianus malabaricus*) inhabit the study area. We studied the density, dominance, frequency and Importance Value Index (IVI) of different tree species, using the belt transect method on randomly selected plots covering 4.1ha. We found that all the plant species that emerged to be the most dominant species with high IVI in the forest were also used by the diurnal primates for foraging. *Knema attenuata* and *Syzygium gardneri* were found to be the 'keystone' species. Since the forests of the study area do not come under the 'protected area network' for wildlife, the data obtained during this study will be helpful in the forestry management practices with a view for wildlife conservation of the region.

Keywords: Keystone species, *Knema attenuata*, primates, *Syzygium gardneri*, Western Ghats.

INTRODUCTION

Although ranging up to the snowy region of Japan and Himalayan mountains, most primates live in warm tropical and subtropical climates. Further, though some of the primate species have adapted to live on ground, most of the primates live in trees. Therefore, the tropical regions with a wide diversity of vegetation harbor variety of primate species. In India, the Western Ghats of southern India and the northeastern Himalayan region are characterized by rainforests as well as deciduous forests. This floral diversity in these hills has provided several habitat types and many primate species inhabit these forests including some of the species even being sympatric (Molur et al. 2003).

The Western Ghats of southern India range along the west coast covering a north-south length of about 1600km. Because of the monsoons, the ridge and the western slopes of the Ghats receive high rain fall resulting in tropical evergreen rainforests. The eastern slopes of these hills are rain shadow and dominated by deciduous and scrub forests. Due to the diversity of habitat types, faunal diversity and a high degree of endemism, the Western Ghats have been considered as one of the 'hottest hotspots' of global biodiversity (Myers et al. 2000). The Western Ghats harbor several primate taxa including the Mysore Slender Loris (*Loris lydekkerianus lydekkerianus*) and Malabar Slender Loris (*L. l. malabaricus*), endemic and Endangered Lion-tailed Macaque (*Macaca silenus*), endemic and Vulnerable Nilgiri Langur (*Trachypithecus johnii*), Dark-bellied Bonnet Macaque (*Macaca radiata radiata*) and Pale-bellied Bonnet Macaque (*M. r. diluta*), and several taxa of Hanuman Langurs (*Semnopithecus achates*, *S. priam*, *S. hypoleucos, S. thersites*).

In order to understand the feeding ecology of a species, it is important

that the habitat is described in terms of its stand structure, species' distribution, richness and abundance, and importance value of each plant species. This may also help identify keystone species (Paine 1969; Stiling 2004). A few studies in the past have provided description of primate habitats in the Western Ghats. Ramachandran & Joseph (2000) described the stand structure in Silent Valley, an important habitat of the rainforest primates in the Western Ghats. Primates were mostly found in areas with tree associations of *Cullenia-Palaquium*, *Mesua-Palaquium* and *Mesua-Calophyllum*. Lion-tailed Macaques were absent in areas with associations of *Poeciloneuron-Palaquium*, *Poeciloneuron-Ochlandra* and *Calophyllum-Ochlandra*. In the Anaimalai Hills of the Western Ghats, primates inhabited the rainforest regions dominated by *Cullenia exarillata*, *Ficus microcarpa*, *Ficus exasperata* and *Melisoma pinnata* (Sushma & Singh 2006). Krishnamani & Kumar (2000) studied several rainforest primate habitats in Karnataka and found that five tree species including *Poeciloneuron indicum*, *Myristica dactyloides*, *Dimocarpus longan*, *Olea dioica* and *Aglaia elaegnoidea* had the highest number of individuals. However, large areas inhabited by primates in the Western Ghats have not yet been quantitatively described for the vegetation characteristics.

In most of the places in the Western Ghats, Lion-tailed Macaques, Nilgiri Langurs and Malabar Slender Loris are sympatric in the rainforests of the ridge and the Western slopes, and Bonnet Macaques, Hanuman Langurs and Mysore Slender Loris are sympatric in relatively drier forests of the eastern slopes (Singh et al. 1997; Kumara & Singh 2004). However, north of Brahmagiri Hills in the Coorg District of the state of Karnataka, Lion-tailed Macaques, Bonnet Macaques, Hanuman Langurs and Malabar Slender Loris are found as sympatric species in several ranges of rainforests. The rainforest region to the north of Sharavathy River and south of Aghnashini River is one such region which, due to the high abundance of primates, has been regarded as one of the most potential regions for long-term primate conservation (Kumara & Singh 2004). In this article, we describe the vegetation structure of this prime primate habitat.

METHODS

Study site: We carried out the present study in the rainforests of the Western Ghats lying between 14^{0}15'-14^{0}25'N & 74^{0}35'-74^{0}47'E in the Gerusoppa Forest Range of Honnavara Forest Division in the State of Karnataka, India (Fig. 1). This forest region constitutes the northern limit of the evergreen forests of the plains and low elevations of southern India (Pascal 1988). Champion & Seth (1968) broadly classify this forest as 'west coast tropical evergreen forest'. The forest is primarily distinguished as *Persea macrantha-Diospyros* spp.-*Holigarna* spp. type with abundance of heleiophilic or light tolerant species. The official status of the forest is a Reserve Forest with interspersed revenue lands (Kumara & Singh 2004). Four primate species including the Endangered Lion-tailed Macaque (*Macaca silenus*) (Kumar et al. 2008), Bonnet Macaque (*Macaca radiata*), taxonomically controversial Hanuman Langur (*Semnopithecus entellus achates*) (Molur et al. 2003) and Malabar Slender Loris (*Loris lydekkerianus malabaricus*) inhabit the study area. This place is one of the few places in the Western Ghats of India where four primate species are sympatric.

Data collection: Between April 2006 and March 2007, we laid 10 belt transects traversing through the study site covering almost all vegetation types of the study area. The length of transects varied from 150 to 300 m covering a total length of 2050m. On each side of a belt transect, we included 10m width as vegetation sampling plots amounting to a total sampling area of 4.1ha. Inside each sampling plot, all plants (excluding climbers, lianas and herbs) with a girth more than 12cm were numbered with aluminum tags. However, we sorted the trees with a girth of >30cm for vegetation analysis. We identified the plant species with the help of field guide books (Gamble 1935; Pascal & Ramesh 1997). In most of the cases, we preserved sample plant parts including leaf, flower and fruit for confirmation of identification by plant taxonomists. We identified most of the plants up to the species level.

The vegetation analysis including density, dominance and frequency (Curtis & McIntosh 1950) and importance value index (Curtis 1959) of different tree species were estimated using the following methods:

Basal area = πr^2 (where r is radius of the plant girth at breast height) (Basal area represents dominance of a plant species)

Density = total number of plants of any species/ number of plots

Frequency = (number of plots with the presence of a species/number of plots) x 100

Relative dominance = (dominance of a plant species/ total dominance of all plant species) x 100

Relative frequency = (frequency of a plant species/ total frequency of all plant species) x 100

Relative density = (density of a plant species/ total density of all plant species) x 100

Importance Value Index (IVI) = Relative dominance+Relative frequency+Relative density

We recorded the data on feeding by primates through instantaneous scan sampling (Altmann 1974). On the basis of feeding records, we identified the use of high IVI plant species by the three diurnal primates including Lion-tailed Macaque, Bonnet Macaque and Hanuman Langur.

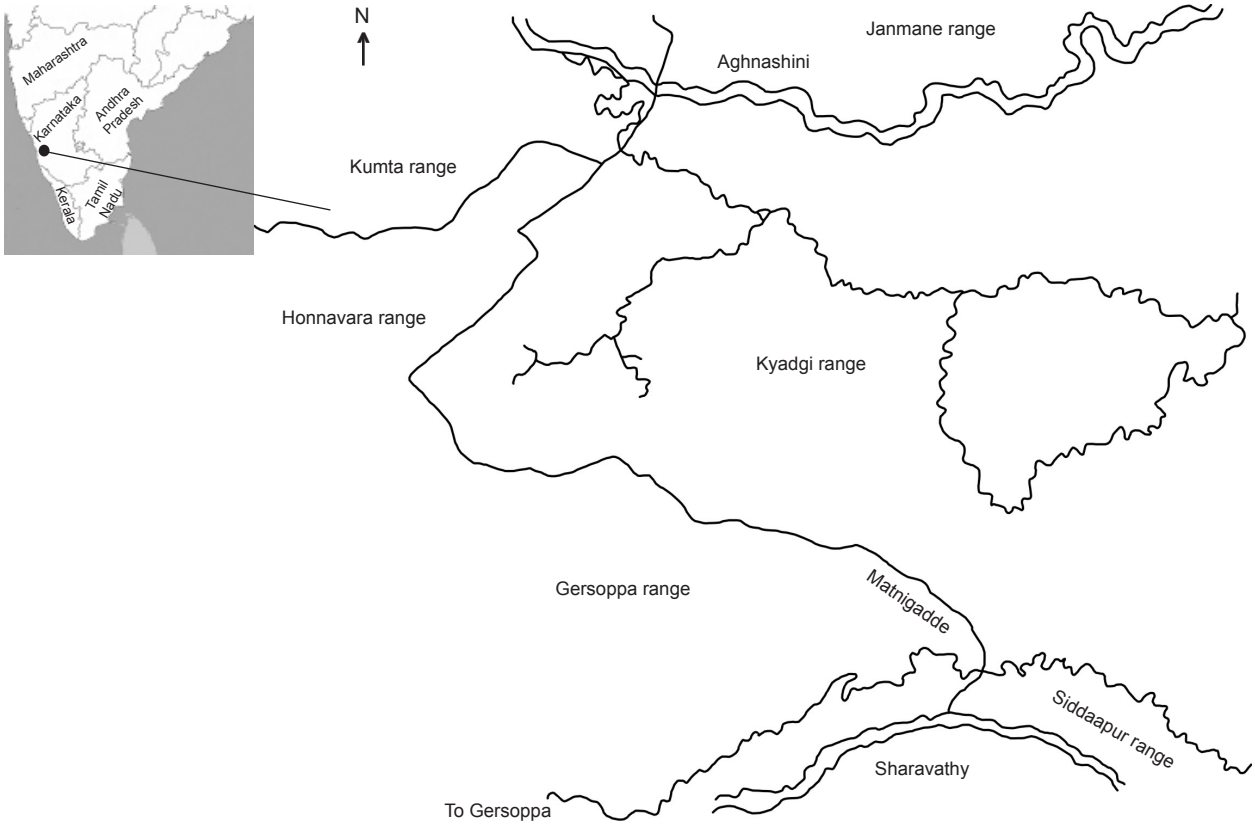

Figure 1. Map of the study area. Aghnashini and Sharavathy are the major rivers and other place names indicate forest ranges

RESULTS

In this section, we present the data on tree species, their abundance and IVI, and their use by the primate species.

Table 1 presents the data on tree species, their density, dominance and percent frequency in the study area. We recorded a total of 81 tree species belonging to 33 families in the sampled area. All species were almost randomly distributed in all sample plots.

In the study area, *Knema attenuata* had the highest density (29.5) followed by *Aglaia roxburghii* (20.4), *Hopea ponga* (15.6), *Dimocarpus longan* (10.8), *Holigarna grahamii* (10.4), *Olea dioica* (10.3), *Syzygium gardneri* (8.3) and *Garcinia gummigutta* (5.7). However, when dominance was calculated, *Syzygium gardneri* had the highest ground cover (20.02) followed by *Knema attenuata* (14.34), *Olea dioica* (13.30), *Aglaia roxburghii* (12.43), *Hopea ponga* (9.70), *Holigarna grahamii* (8.22), *Dimocarpus longan* (7.99), *Ficus nervosa* (7.37) and *Diospyros crumenata* (6.88). These important tree species had 100 percent frequency as they were distributed throughout the study area. In addition, some other tree species including *Garcinia gummigutta*, *Diospyros* sp., *Litsea* sp., also had 100 percent frequency of presence.

Table 2 presents the data on relative density, relative abundance, relative frequency and IVI (arranged in a descending order) of the tree species in the study area. *Knema attenuata* had the highest IVI followed by *Aglaia roxburghii*, *Syzygium gardneri*, *Hopea ponga*, *Olea dioica*, *Dimocarpus longan* and *Holigarna grahamii*. All other tree species had an IVI value smaller than 8.00.

Table 3 presents the data on the proportion of consumption (of total diet) of items from the top ten tree species by the primates. *Knema attenuata* and *Holigarna grahamii* were used by all primate species. Rest of the tree species were foraged by some primate species or the other. Only *Olea dioica* and *Ficus nervosa* were used by a single primate species.

Table 4 lists the common tree species used by different primate species' pairs. Almost all of the high IVI tree species were used by more than one primate species. There were also several tree species that were used exclusively by one primate species or the other (Table 5).

DISCUSSION

The study of stand structure helps in not only describing the vegetation type and the abundance of various tree species etc., but also in identification of keystone species in a forest. The Western Ghats are characterized by several ecozones. The present study

Table 1. Density, dominance and frequency of all sampled tree species

Species	Family	Density	Dominance	Frequency (in %)
Artocarpus hirsutus (WG)	Moraceae	1.8	0.87	60
Actinodaphne hookeri (WG)	Lauraceae	2.6	0.62	60
Aglaia roxburghii	Meliaceae	20.4	12.43	100
Alstonia scholaris	Apocynaceae	0.1	0.04	10
Aporosa lindleyana	Euphorbeaceae	0.6	0.19	30
Archidendron monadelphum	Fabaceae	1.5	0.25	40
Atalantia racemosa	Rutaceae	2.2	0.36	30
Canthium dicoccum	Rubiaceae	0.1	0.09	10
Callicarpa tomentosa	Verbenaceae	1.6	0.17	50
Calophyllum polyanthum	Clusiaceae	1.1	1.37	50
Canarium strictum (WG)	Burseraceae	0.2	0.08	20
Caryota urens	Arecaceae	4.1	2.20	90
Cassine glauca	Celastraceae	3.2	2.78	80
Chionanthus malabarica	Oleaceae	0.3	0.05	30
Chrysophyllum lanceolatum	Sapotaceae	0.4	0.82	30
Cinnamomum malabathrum (WG)	Lauraceae	1.3	0.72	50
Clausena indica	Rutaceae	0.2	0.03	20
Cleidion spiciflorum	Euphorbeaceae	1.3	0.40	50
Drypetes confertiflora	Euphorbeaceae	0.3	0.05	20
Dipterocarpus indicus (WG)	Dipterocarpaceae	2.3	0.74	30
Diospyros pruriens	Ebenaceae	1.2	0.20	50
Diospyros crumenata	Ebenaceae	2.2	6.88	40
Dimocarpus longan	Sapindaceae	10.8	7.99	100
Diospyros paniculata (WG)	Ebenaceae	3.8	0.80	50
Diospyros sp.	Ebenaceae	4.1	1.83	100
Drypetes venusta	Euphorbeaceae	3.6	2.28	30
Dysoxylum malabaricum (WG)	Meliaceae	0.3	0.15	20
Elaeocarpus serratus	Elaeocarpaceae	2.2	0.72	60
Eugenia macrocepala	Myrtaceae	1.3	0.25	70
Ficus callosa	Moraceae	0.4	3.11	30
Ficus nervosa	Moraceae	1.2	7.37	60
Flacourtia Montana	Flacourtiaceae	0.8	0.28	60
Garcinia gummigutta	Clusiaceae	5.7	4.43	100
Garcinia morella	Clusiaceae	2.4	0.89	80
Garcinia talbotii (WG)	Clusiaceae	3.7	1.48	40
Glochidion sp.	Euphorbiaceae	0.6	0.19	40
Holigarna arnottiana (WG)	Anacardiaceae	0.2	0.32	20
Hemigyrosa canescens	Sapindaceae	0.3	0.07	30
Holigarna grahamii (WG)	Anacardiaceae	10.4	8.22	100
Hopea ponga (WG)	Dipterocarpaceae	15.6	9.70	100
Hydnocarpus pentandra	Flacourtiaceae	0.3	0.09	30
Ixora brachiata (WG)	Rubiaceae	1.6	0.37	70
Knema attenuata (WG)	Myristicaceae	29.5	14.34	100
Litsea floribunda (WG)	Lauraceae	0.9	0.23	20
Litsea laevigata (WG)	Lauraceae	2.5	0.99	40

Species	Family	Density	Dominance	Frequency (in %)
Litsea mysorensis	Lauraceae	0.4	0.10	40
Litsea stocksii (WG)	Lauraceae	2.9	1.23	40
Lagerstroemia lanceolata	Lythraceae	0.9	2.27	30
Lansium anamalayanum	Meliaceae	4.9	1.27	50
Leea indica	Leeaceae	0.4	0.03	20
Litsea sp.	Lauraceae	5.6	1.57	100
Lophopetalum wightianum	Celastraceae	1	1.97	30
Myristica dactyloides	Myristicaceae	1.2	0.71	70
Myristica malabarica (WG)	Myristicaceae	1.1	0.92	60
Mallotus phillipensis	Euphorbeaceae	0.2	0.11	20
Macaranga peltata	Euphorbiaceae	3.6	0.91	70
Madhuca neriifolia	Sapotaceae	1.2	2.52	30
Mangifera indica	Anacardiaceae	0.9	0.36	60
Mappia sp.	Icacinaceae	0.1	0.01	10
Maytenus rothiana (WG)	Celastraceae	0.4	0.07	20
Mimusops elengi	Sapotaceae	2.1	0.89	80
Nothopegia racemosa	Anacardiaceae	2.1	0.42	80
Olea dioica	Oleaceae	10.3	13.30	100
Pterospermum diversifolium	Sterculiaceae	0.9	0.72	40
Pterospermum reticulatum	Sterculiaceae	0.8	0.50	40
Persea macrantha	Lauraceae	1.4	2.06	60
Polyalthia fragrans (WG)	Annonaceae	0.9	1.02	60
Syzygium cumini	Myrtaceae	0.2	0.61	10
Syzygium gardneri	Myrtaceae	8.3	20.02	100
Sterculia guttata	Sterculiaceae	0.5	0.78	20
Stereospermum personatum	Bignoniaceae	1.5	1.99	50
Strombosia ceylanica	Olacaceae	1.2	0.67	40
Symplocos racemosa	Symplocaceae	1.8	1.19	50
Syzygium sp.	Myrtaceae	1.3	2.23	50
Tabernaemontana heyneana	Apocynaceae	1.4	0.25	40
Terminalia bellirica	Combretaceae	0.2	0.98	20
Trewia nudiflora	Euphorbeaceae	1.1	0.45	40
Vateria indica (WG)	Dipterocarpaceae	1	0.22	30
Vepris bilocularis (WG)	Rutaceae	1.1	0.80	40
Vitex altissima	Verbenaceae	0.7	1.22	30
Xantolis tomentosa	Sapotaceae	0.3	0.17	20

WG - Endemic to the Western Ghats

Table 2. Importance Value Index (IVI) of different plant species inside the study area

Species	Relative density	Relative dominance	Relative frequency	IVI
Knema attenuata	13.715	8.855	2.532	25.101*
Aglaia roxburghii	9.484	7.674	2.532	19.690*
Syzygium gardneri	3.859	12.358	2.532	18.748*
Hopea ponga	7.252	5.990	2.532	15.774*
Olea dioica	4.788	8.211	2.532	15.531*
Dimocarpus longan	5.021	4.934	2.532	12.487*
Holigarna grahamii	4.835	5.072	2.532	12.439*
Garcinia gummigutta	2.650	2.736	2.532	7.917
Ficus nervosa	0.558	4.551	1.519	6.628
Diospyros crumenata	1.023	4.249	1.013	6.284
Litsea sp.	2.603	0.971	2.532	6.106
Diospyros sp.	1.906	1.128	2.532	5.566
Caryota urens	1.906	1.360	2.278	5.545
Cassine glauca	1.488	1.715	2.025	5.228
Lansium anamalayanum	2.278	0.784	1.266	4.327
Macaranga peltata	1.674	0.561	1.772	4.007
Drypetes venusta	1.674	1.408	0.759	3.841
Garcinia morella	1.116	0.549	2.025	3.690
Garcinia talbotii	1.720	0.914	1.013	3.647
Mimusops elengi	0.976	0.547	2.025	3.549
Diospyros paniculata	1.767	0.493	1.266	3.526
Persea macrantha	0.651	1.275	1.519	3.445
Nothopegia racemosa	0.976	0.257	2.025	3.258
Syzygium sp.	0.604	1.376	1.266	3.246
Stereospermum personatum	0.697	1.230	1.266	3.193
Litsea stocksii	1.348	0.759	1.013	3.119
Actinodaphne hookeri	1.209	0.383	1.519	3.110
Elaeocarpus serratus	1.023	0.447	1.519	2.988
Artocarpus hirsutus	0.837	0.536	1.519	2.891
Madhuca neriifolia	0.558	1.557	0.759	2.874
Ficus callosa	0.186	1.917	0.759	2.863
Symplocos racemosa	0.837	0.735	1.266	2.838
Litsea laevigata	1.162	0.612	1.013	2.787
Myristica dactyloides	0.558	0.440	1.772	2.770
Ixora brachiata	0.744	0.226	1.772	2.742
Calophyllum polyanthum	0.511	0.844	1.266	2.621
Myristica malabarica	0.511	0.567	1.519	2.598
Lagerstroemia lanceolata	0.418	1.402	0.759	2.580
Polyalthia fragrans	0.418	0.631	1.519	2.568
Eugenia macrocepala	0.604	0.152	1.772	2.529
Lophopetalum wightianum	0.465	1.213	0.759	2.438
Cinnamomum malabathrum	0.604	0.442	1.266	2.312
Dipterocarpus indicus	1.069	0.455	0.759	2.284
Mangifera indica	0.418	0.222	1.519	2.159

Species	Relative density	Relative dominance	Relative frequency	IVI
Cleidion spiciflorum	0.604	0.250	1.266	2.120
Callicarpa tomentosa	0.744	0.105	1.266	2.115
Flacourtia montana	0.372	0.172	1.519	2.063
Vepris bilocularis	0.511	0.495	1.013	2.019
Atalantia racemosa	1.023	0.222	0.759	2.004
Strombosia ceylanica	0.558	0.415	1.013	1.985
Diospyros pruriens	0.558	0.123	1.266	1.946
Pterospermum diversifolium	0.418	0.442	1.013	1.873
Archidendron monadelphum	0.697	0.157	1.013	1.867
Vitex altissima	0.325	0.755	0.759	1.840
Tabernaemontana heyneana	0.651	0.156	1.013	1.820
Trewia nudiflora	0.511	0.278	1.013	1.802
Pterospermum reticulatum	0.372	0.306	1.013	1.690
Chrysophyllum lanceolatum	0.186	0.503	0.759	1.449
Glochidion sp.	0.279	0.119	1.013	1.411
Vateria indica	0.465	0.137	0.759	1.362
Litsea mysorensis	0.186	0.059	1.013	1.257
Sterculia guttata	0.232	0.482	0.506	1.221
Terminalia bellirica	0.093	0.607	0.506	1.206
Aporosa lindleyana	0.279	0.120	0.759	1.159
Litsea floribunda	0.418	0.142	0.506	1.067
Hydnocarpus pentandra	0.139	0.055	0.759	0.954
Hemigyrosa canescens	0.139	0.046	0.759	0.945
Chionanthus malabarica	0.139	0.028	0.759	0.927
Holigarna arnottiana	0.093	0.195	0.506	0.794
Xantolis tomentosa	0.139	0.106	0.506	0.752
Dysoxylum malabaricum	0.139	0.091	0.506	0.736
Maytenus rothiana	0.186	0.043	0.506	0.736
Syzygium cumini	0.093	0.378	0.253	0.725
Leea indica	0.186	0.020	0.506	0.712
Drypetes confertiflora	0.139	0.032	0.506	0.678
Mallotus phillipensis	0.093	0.067	0.506	0.667
Canarium strictum	0.093	0.050	0.506	0.649
Clausena indica	0.093	0.017	0.506	0.616
Canthium dicoccum	0.046	0.058	0.253	0.358
Alstonia scholaris	0.046	0.028	0.253	0.327
Mappia sp.	0.046	0.007	0.253	0.306

* - High IVI species

Table 3. Use of important tree species as major resources by different primates

Important tree species	Mostly used by different primate species		
	Hanuman Langur	Lion-tailed Macaque	Bonnet Macaque
Knema attenuata	0.034	0.027	0.022
Aglaia roxburghii	-	0.069	0.064
Syzygium gardneri	0.049	0.055	0.027
Hopea ponga	0.013	-	0.127
Olea dioica	0.252	0	0
Dimocarpus longan	0.152	-	-
Holigarna grahamii	0.019	0.033	0.051
Garcinia gummigutta	-	0.064	0.023
Ficus nervosa	-	-	0.027
Diospyros crumenata	0	0.202	0.012

Table 4. Common fodder plants used by different species-pairs

Hanuman Langur & Lion-tailed Macaque	Hanuman Langur & Bonnet Macaque	Lion-tailed Macaque & Bonnet Macaque
*Hopea ponga**	*Pothos scandens*^*	*Hopea ponga**
Persea macrantha	*Hopea ponga**	*Persea macrantha*
*Knema attenuata**	*Calophyllum polyanthum*	*Knema attenuata**
*Dimocarpus longan**	*Diospyros paniculata*	*Dimocarpus longan**
Ficus callosa	*Garcinia talbotii*	*Ficus callosa*
*Syzygium gardneri**	*Lophopetalum wightianum*	*Syzygium gardneri**
Cassine glauca	Unidentified	*Cassine glauca*
*Garcinia gummigutta**	*Persea macrantha*	*Garcinia gummigutta**
Artocarpus hirsutus	*Knema attenuata**	*Artocarpus hirsutus*
Callicarpa tomentosa	*Dimocarpus longan**	*Holigarna grahamii**
*Holigarna grahamii**	*Ficus callosa*	Climber
Climber	*Syzygium gardneri**	*Aglaia roxburghii**
Macaranga peltata	*Cassine glauca*	*Diospyros pruriens*
Mangifera indica	*Garcinia gummigutta**	*Caryota urens*
*Aglaia roxburghii**	*Artocarpus hirsutus*	*Diospyros crumenata**
Dipterocarpus indicus	*Holigarna grahamii**	*Cayratia auriculata*^*
Diospyros pruriens	*Chionanthus malabarica*	
Litsea stocksii	*Litsea laevigata*	
Syzygium cuminii	Climber	
	Ficus racemosa	
	Madhuca neriifolia	
	Vepris bilocularis	
	Trewia nudiflora	
	*Aglaia roxburghii**	
	*Ficus nervosa**	
	Cleidion spiciflorum	
	Polyalthia fragrans	
	Litsea floribunda	
	Diospyros pruriens	

* - High IVI species; ^ - Vegetation other than trees

Table 5. Different fodder plants exclusively used by different study groups

Hanuman Langur	Lion-tailed Macaque	Bonnet Macaque
Litsea sp., *Olea dioica**, *Elaeocarpus serratus, Symplocos racemosa, Diospyros* sp., *Sterculia guttata, Cinnamomum malabathrum, Eupatorium* sp.^, *Terminalia bellirica, Lagerstroemia lanceolata, Xantolis tomentosa, Dysoxylum malabaricum, Tabernaemontana heyneana, Carallia brachiata, Archidendron monadelphum, Hydnocarpus pentandra, Piper nigrum^, Psychotria nigra^, Canthium angustifolium^, Dillenia pentagyna, Actinodaphne hookeri, Vitex altissima, Clausena indica, Anthocephalus cadamba, Dalbergia volubilis^, Vitis canarensis^, Ochlandra redii^, Randia rugulosa^, Leea indica^, Garcinia morella, Pinanga dicksonii^, Flacourtia montana, Eugenia macrocepala, Vateria indica, Myristica dactyloides, Strombosia ceylanica*	*Drypetes venusta, Chrysophyllum lanceolatum*	*Diospyros oocarpa, Mimusops elengi, Artocarpus heterophyllus, Ficus tsjakela,* Paddy^

* - High IVI species; ^ - Vegetation other than trees

area marks the northern end of the distribution of low and medium elevation dipterocarp forests (Pascal 1998). This region is also the northern end of the distribution of the threatened Lion-tailed Macaques (Kumara & Singh 2004). The results of the present study reveal that the rainforests to the north and south of Sharavathy and Aghnashini rivers respectively in the Western Ghats are characterized by a high diversity of vegetation including lianas, shrubs and trees. Many tree species were distributed throughout the study area, but these might not be considered as important trees species. Only a few tree species were important by dominance, density and frequency. High IVI value is considered only for those species which have a major impact on community and are defined as major vegetation type. Some tree species such as *Garcinia gummigutta*, *Litsea* sp., *Diospyros* sp., *Caryota urens*, *Cassine glauca*, *Garcinia morella*, *Mimusops elengi* etc were also distributed almost throughout the study site, but these were poor in density or dominance. Even important tree species such as *Syzygium gardneri* and *Olea dioica* were poor in their overall density compared to the other important tree species. However, they had a large ground cover with high basal area.

Of the 81 plant species recorded in the study area, 62 (76.54%) were used for feeding by one primate species or the other. The primarily folivorous langurs used the largest number of plant species followed by the primarily frugivorous macaques. All of the high IVI tree species were used by the primates indicating that the characteristic vegetation of the region is also a major food resource for the primates.

In the present study, the important tree species might be considered as the keystone species. Keystone species may not necessarily be the dominant species, though a dominant species has an effect on community because it is common (Paine 1966, 1969; Stiling 2004). Generally, keystone species are those whose absence has an effect on overall foodchain of the community. However, producers are also considered as keystone prey in some cases as those are mostly used by maximum number of consumers; palm-nuts, figs and nectar could be keystone prey because they are critical to tropical forest fruit-eating guilds including primates, rodents and many birds (Terborgh 1983). In the present study area, the important tree species were also important fodder plants for different primate species. Out of the major resource trees of primates, more than 50 percent were the important tree species in the present study area, and some important trees were also used as minor diet by the primates. In the rainforests of the Western Ghats south of the Palghat Gap, *Cullenia exarillata* is the keystone species for primates as it constitutes a major food resource in the Anaimalai Hills (Sushma & Singh 2004) and in the forests of the Silent Valley (Joseph & Ramachandran 2001). *Knema attenuata* and *Syzygium gardneri* could be considered as the keystone tree species in the present study area according to their presence as well as their use as major resource items. All three primate species used different plant part of these two trees as major food items and some resource items were also shared by different species-pairs. Retention of such tree species, therefore, is a key element in the forest management of this primate rich region which, at present, does not form a part of the 'protected area' network for wildlife conservation.

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