Asian Journal of Conservation Biology, December 2012. Vol. 1 No. 2, pp. 92-102 AJCB: FP0012
ISSN 2278-7666 ©*TCRP* 2012

Foraging ecology of Nilgiri Langur (*Trachypithecus Johnii)* in Parimbikulam Tiger Reserve, Kerala, India

Debahutee Roy[1*], M. Ashokkumar[2,] and Ajay A Desai[3]
[1]*PG and Research Department of Zoology and Wildlife Biology, A.V.C. College, Mannampandal – 609 305, Mayiladuthurai, India*
[2]*WWF-India,Western Ghats landscape, Coimbatore, India*
[3] *WWF-Indonesia, Asian Elephant Specialist Group-India*

(Accepted November 25, 2012)

ABSTRACT

We studied the foraging ecology of *Trachypithecus johnii* from December 2011 to march 2012 in Parambikulam tiger reserve, kerala, India.We collected phenology of food plant species and food consumed by langurs living in two habitats. Feeding records showed that Nilgiri Langur (*Trachypithecus johnii*) feeds on 97 species of plants belonging to 44 families. The food plants species composed of trees, shrubs and climbers which were constituted 78, 6, and 7 species respectively. Among the different plant categories trees accounts for 83.87%, followed by climber 7.53%, shrub 6.45%, herb 1.08% and grass 1.08%. Thus trees and shrub were constituted about 90% of overall composition of food plant species. Food plant species composed of 44 different families, in which Fabaceae was constituted by 16 species with greatest percent (16%), followed by Euphorbiaceae (8 sp.) Moraceae (5sp.) and other families represented less than 3% .The diet species of Nilgiri Langurr was compared with other areas and discussed.

Key words: Nilgiri Langur; Foraging ecology; habitat; food availability; conservation.

INTRODUCTION

Food and shelter are the vital needs of all living organisms. The appraisal of feeding habits of an animal is of the outmost significance for the correct determination of the carrying capacity of their habitat and for the study of their population dynamics (Ashokkumar, 2011). To endure and reproduce successfully every animal needs food. The food habit of a species is one of the most basic aspects of its ecology and needs to be understood not only to determine the species' nutritional requirements, but also to understand how distribution of food resources could determine the density, local distribution and social interactions (Swapna, 2008).

The study of feeding behavior is essential to understand a species' ecological adaptation to the environment, and is also an important factor to be considered when examining the relationship between ecology and sociological problems (troop size, inter and intra-troop relations and social changes) (Maruhashi, 1980).Animals which exhibit extreme selection in their food components particularly vulnerable to nutritional deficiencies (Swapna, 2008).Primate feeding Ecology addresses questions concerning the interrelations between primates and their environment via feeding behaviours of the Primates within constrains of their morphology and physiology (Nakagawa, 2009).

Nilgiri Langur (*Trachypithicus johnii)* a black leaf monkey is an endangered species and is endemic to the rainforests of the Western Ghats of India. Within the Western Ghats Nilgiri langur's distribution is pocketed among Tamilnadu, Kerala and Coorg of Karnataka, India. Nilgiri langur is confined to evergreen forests. It commonly occurs in Dry deciduous forests and moist deciduous forests of Western Ghats. Moreover, it also acclimatized to live in anthropogenised habitats including eucalyptus plantations, and teak plantations. The species has been listed under Appendix II of CITES. They are also protected under the Schedule I, Part I of Indian Wildlife Protection Act, 1972 and are listed as Vulnerable C2a (i) under IUCN Red data list (Malviya *et al*., 2011).

As it is not a habitat specialized, Nilgiri Langur thrives on a variety of plant species occurring in different types of habitats (Ramachandran and Joseph, 2001b). The species has been listed under Appendix II of CITES. They are also protected under the Schedule I, Part I of Indian Wildlife Protection Act, 1972 and are listed as Vulnerable C2a (i) under IUCN Red data list (Malviya *et al.,* 2011).

Even though number of studies is available in Western Ghats, till date there is a lacuna about the species in Parambikulam Tiger reserve.

The study of diet can help to understand the role of a species in the energy flow and nutrient cycle of an ecosystem. It also sets a foundation for understanding of foraging behaviour, population dynamics, habitat use and social organization of a species (Mills, 1992). Preference for a given habitat type is largely determined by the available vegetation within the area, providing food, water, minerals, shelter from climatic extremes

***Corresponding Author's E-mail:** moni.roy8@gmail.com*

and cover from predators (Jarman & Sinclair, 1979). Food resources, however, not only vary between different habitat types, but also show marked seasonal variations within a given habitat, in response to changes in rainfall patterns (Phillipson, 1975; Sinclair, 1975). Knowledge on feeding preferences and nutritive requirements is essential in planning habitat management. It would be advantageous to have information on the habitat requirements of a species in order to protect and improve these attributes. The present study aims to provide such information for Nilgiri Langur and also aims at increasing our knowledge of the species. Hence the current study is designed to investigate the food composition, food selection and the availability of food in the selected two habitats viz. Moist deciduous forest (MDF) and Evergreen forest (EF) of Parambikulam Tiger Reserve.

MATERIALS AND METHODS

Study area

Parimbukulam Tiger reserve (Figure 1) is situated in Palakkad district of Kerala state, India. The sanctuary is located between 76°35'- 76°50' E, Longitude and 10° 20' – 10°26' N Latitude . Parimbukulam Wildlife Sanctuary was declared as part of the 390.88 square kilometers (150.9 sq mi) Parambikulam Tiger Reserve on February 19, 2010. It is in the Sungam range of hills between the Anaimalai Hills and Nelliampathy Hills. It is 135 km from Palakkad town and adjacent to the Anaimalai Wildlife Sanctuary to the east in Tamil Nadu.The altitude ranges between 300 m and 1438 m. The natural vegetation in the sanctuary has been classified into 7 types (Vairavel, 1998), they are-

1. West coast tropical evergreen forests
2. West coast tropical semi-evergreen forests
3. Southern moist mixed deciduous forest
4. Southern dry mixed deciduous forests
5. Moist bamboo brakes
6. Reed brakes
7. Southern montane wet temperate forests (Sholas)

In addition, this sanctuary harbors three major vegetation types of which two are man- made. They are

1. Low altitude marshy grass lands known locally as vayals
2. Teak plantations
3. Eucalyptus plantations

The evergreen and moist deciduous forests are the most important natural vegetation types. Sholas are confined to small areas in the hilltops of Karimala Gopuram and in the foothills of Pandaravara peak which is known by the name Karian Shola (Vairavel, 1998). Parambikulam supports 1432 of plants falling under 753 genera and 140 families. The oldest teak tree, Kannimara Teak exists here. It is about 450 years old and has girth of 6.8 meters and a height of 49.5 meters. It won the Mahavriksha Puraskar given by the Indian Government during the year 1994-1995.The larger herbivores include elephant (*Elephus maximus*), chital (*Axis axis*), sambar deer (*Cervus unicolor*), barking deer (*Muntiacus muntjak*). Predators like tiger (*Panthera tigiris*), leopard (*Panthera pardus*) and wild dog (*Cuon alpinus*). The Nilgiri langur is threatened by habitat fragmentation, poaching and human disturbance.

Study animal

Like other Colobine monkeys Nilgiri Langur have complex foregut with microbial fermentation and enlarged salivary gland. This species is sexually dimorphic in the canine teeth, where adult males have larger

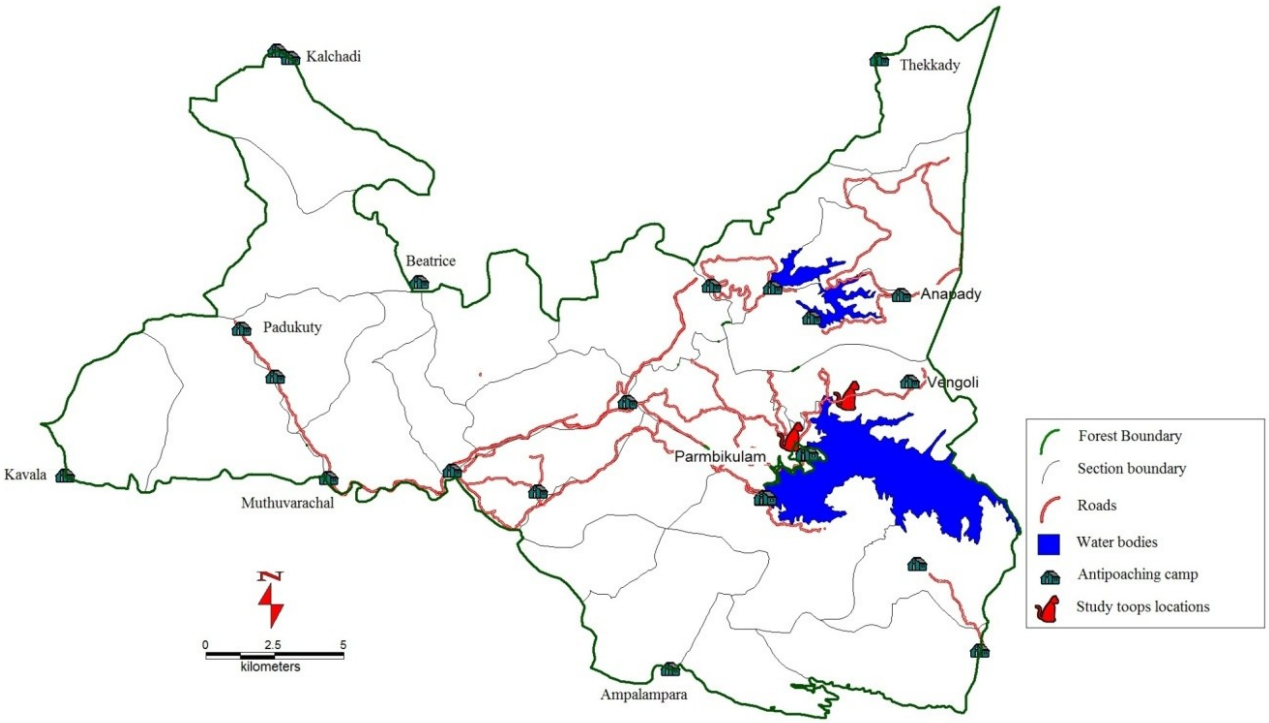

Figure 1. Map of the Study area (Parambikulam Tiger Reserve).

canines than adult females. Females have a white patch of fur on the inner thigh region. The Nilgiri langur is a folivorous species, but the diet also includes flowers, buds, seeds, bark, stems, insects, and mud (Horwich, 1980). Nilgiri langur's distribution is pocketed among Tamilnadu, Kerala and Coorg of Karnataka. They are found between 8° N and 12° N Latitude and 76°E and 77.5°E Longitude (Malviya *et al.*, 2011).The Nilgiri Langur is strictly arboreal in habit. This species is mainly found in sholas, which are narrow tracts of forest with streams running through it. This species also lives in semi-evergreen, moist deciduous forests, and montane temperate evergreen forests of Western Ghats (Malviy *et al.*, 2011). Nilgiri Langur has been recorded to occur mostly as uni-male-multifemale troops sometimes multi male troops. The uni-male troop has many females which has a well defined dominance hierarchy. Group size ranges from 2-29 (6-8 in deciduous) and (18 -20 in Evergreen). A linear hierarchy exists amongst the females in the group. Males also show a linear dominance hierarchy, and most dominance disputes are between the adult males. However, multi male and all female groups are not common in Nilgiri Langurs (Sunderaj, 1998).

The recent census report revealed that the Nilgiri langur population in the wild is 5000-15,000 (Malviya *et al.*, 2011). Habitat destruction, fragmentation (large scale developmental projects like dams and hydro electric projects) and loss of food plant species (for timber production, teak plantation and fuel wood) are the main cause for the decline (Ram, 2007; Malviya *et al*., 2011). Apart from the above, poaching for pelt, flesh, blood and organs to produce medicines are the other threats to the Nilgiri Langur in the study area.

The species has been listed under Appendix II of CITES. They are also protected under the Schedule I, Part I of Indian Wildlife Protection Act, 1972 and are listed as Vulnerable C2a (i) under IUCN Red data list (Malviya *et al*., 2011).

Behavioural study and data collection

Diet

Foraging ecology of Nilgiri langur was studied from Dec-2011 to Mar-2012. One male-multi female troops of Nilgiri Langurs were chosen in the two habitats to record the food plant species and on the allotment of time to different activities in their natural habitat. The composition of the study troop was one adult male, two adult females, two sub adult females and four juveniles in Evergreen forest (EF) and one adult male, two adult females, two sub adult females and one infant in Moist Deciduous Forest (MDF).

The troops were observed from December 2011 to the end of March 2012. On the day prior to the beginning of the scan period the roosting site of the troop was located. Observations were recorded from the activity started (morning 6:00 am) until roosting (evening 6:00 pm) had set down.

Feeding data of the troops were collected by adopting the scan sampling method of Altmann (1974).The scans each of five minutes were made at every five minutes interval. The activities of Nilgiri Langurs were categorized into six major categories: Feeding, and resting, moving, vigilance, agonistic and social behavior. Activities of individual Langurs were recorded which sustained for at least five seconds during the scan (Sunderraj, 1984). No individual langur was sampled more than once in each scan. Additional information like the height of the tree, height at which the animal is seen, the distance from its neighbor individual was also recorded. When the feeding activity was recorded, the name of the plant species and the part of the plant eaten and discarded were noted. The plants species were identified with the help of preserved specimens (herbariums) in Fischer's herbarium (Biodiversity division), Institute of Forest Genetics and Tree Breeding, Coimbatore and from Nilgiri Biosphere Nature Park (nbnp), Pappanaickenpalayam, Coimbatore, India.

Vegetation and phenology

The density and relative abundance of food plant species, species diversity, and richness in the two habitats, viz., Evergreen and MDF was estimated by belt transects (eight in MDF and ten in Evergreen) within the Nilgiri Langur ranging area. Each transect was in the dimension of 50x2 m, separated by at least 100m (distance between adjacent transects) based on the distance moved by the Langurs in each habitat. In each transects the variables such as name of the tree species, GBH (Girth at Breast Height) of the tree, vegetative phenology (Percent of young and mature leaves), length and breadth of the canopy cover, reproductive phenology (presence and absence of flowers and fruits).

Data analysis

Shannon-Weiner Diversity index (H') of food species was estimated Using the following formula

$$H' = -\sum_{i=1}^{s} p_i \log_2 p_i$$

Where H′= index of species diversity; s=number of species.

P_i = the proportion of the each species in the sample

Food preference index

To investigate the preference of food plant species for different forage categories, Jacobs' index of preference (D) was calculated

$$D = \frac{r - p}{r + p} - 2rp$$

Where r *is* the proportion of a particular category in the diet and *p* is the proportion of that category in the population. Proportions were calculated in terms of relative density of plant species. The index varies from -1 to +1 with -1representing total avoidance, 0 no preference and +1 absolute preference for that category, i.e., no other category was consumed.

Statistical Analysis

Basic statistics viz. mean, standard deviation and standard error were calculated for all the replicative variables and are given as X±SD or X±SE. Statistical

analysis were performed by using Windows based statistical package viz. Microsoft Excel, and SPSS (Statistical Package for Social Science: Nie *et al*., 1975). Mainly parametric test *viz*. Cluster analysis, Analysis of Variance (ANOVA) and Multiple regression equation were used to test different hypothesis. The non-parametric test used was chi-square test for testing the association between variables. For hypothesis testing $P < 0.05$ and $P < 0.01$ were considered and these level of significance were indicated at appropriate places.

The chi-square test was used to investigate the association between variables where the data were in frequencies.

RESULTS

Diet

Nilgiri Langur consumed different plant species from different various physiognomic categories. The details of food plants, parts eaten (based on scan sampling) of Nilgiri Langur in Parambikulam Tiger Reserve is given in the Table 1 During the study period it was observed that Nilgiri Langur consumed 97 different plant species. The food plant species composed of trees, shrubs and climbers which were constituted 78, 6, and 7 species respectively. Among the different plant categories, trees accounts for 84%, followed by climber 8%, shrub 6%, herb 1% and grass 1%. (Figure 2). Thus trees and climber were constituted over 90% of overall composition of food plant species. Food plant species composed of 44 different families, in which Fabaceae contributed 16 species with greatest percent (16%), followed by Euphorbiaceae (8%.) Moraceae (5%.) and other families represented less than 3% (Figure 3).

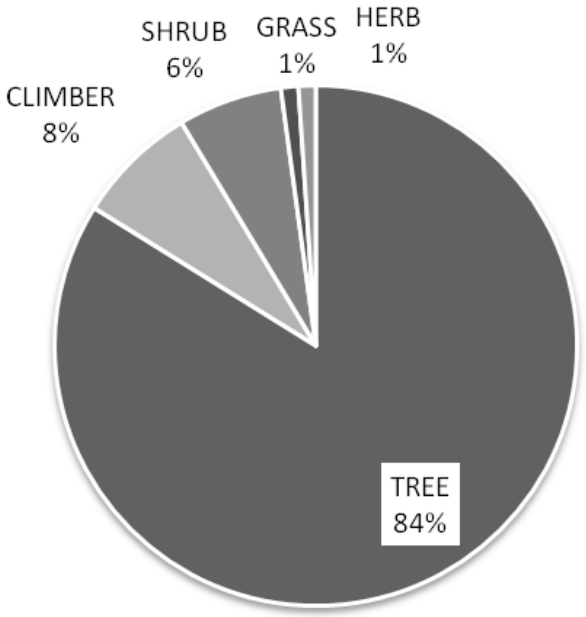

Figure 2. Proportion of different plant categories constitutes food species of Nilgiri Langur in Parambikulam Tiger Reserve during the study period (Dec-2011 to Mar-2012).

The major tree food species of Nilgiri Langur were *Macaranga indica, Dalbergia latifolia, Terminalia tomentosa, Melia,dubia, Tectona grandis, Grewia tiliifolia, Lagerstroemia microcarpa, Delonix regia* and *Terminalia paniculata*. The major climber species consumed were *Spatholobus pariviflorus, Toddalia asiatica* and *Piper nigrum*. Endemic plant species namely *Tabernaemontana alternifolia, Capparis rheedei, Baccurea courtallensis, Drypetes malabariaca, Bauhinia malabarica, Vateria indica* and *Cinnamomum malabathrum* were also eaten by Nilgiri Langur.

It was obvious that foliage dominated in the diet of Nilgiri Langur, but other plant parts like fruits, seeds, stems and flowers were also foraged. The percent of mature leaves is 45.4% followed by young leaves 25.65%, fruits 10.30%, flower buds 2.95%, flower 8.65%, stem, 5.26%, seeds 1.37%, bark 0.29% and nodes 0.07% in the diet of Nilgiri Langur were shown in the figure 4. In addition to the food plant species on two occasions they were found to feed on mud from termite mound and soil from the decayed logs and ground.

Food preference

Jacob's preference index (D) of forage categories in different habitats during the study period are given in the Table 2. The food plants species which were recorded in the diet and environment are only listed out in the given table and the remaining food plants which have low density in the environment and not listed. Among the plant categories grass was preferred in EF but not eaten in MDF. All the species of herb, shrub and climbers were preferred except shrub species such as *Michelia nilagirica* and *Glycosmis mauritiana* were less prefered. Among the tree species *Xylia xylocarpa, Melia dubia, Tectona grandis, Acacia concinna, Ficus bengalensis, Emblica officinalis, Terminalia tomentosa, Albizia lebbeck, Trewia nudiflora, Acrocarpus fraxinifollius*, *etc* were preferred in both habitats. The tree species such as *Rademochera xylocarpa, Polyalthia rufescens* and *Tabernaemontana alternifolia* were the least preferred (-.83 to -0.94) in different habitats.

Food plant abundance, species richness and diversity

Tree species richness and diversity, tree characteristics, phenology and shrub richness in different habitats (EF and MDF) of Parambikulam Tiger reserve during the study period are given in Table 3.

Among the two habitats, tree species richness and diversity was higher in the EF (12.0±2.91) and (2.8±0.44) than in MDF (8.6±1.19) and (2.4±0.27). Tree species height, Girth at Breast Height (GBH) was higher in MDF. The mean canopy area was highest in the EF (549m^2).

In tree vegetative phenology the percent young leaves was significantly more in the EF (11.8±4.39%) than in MDF (8.3±6.05%). On the contrary percent mature leaves was more in MDF (91.7±6.05) than in the evergreen (88.2±4.39). Shrub richness and density is more in the EF (1.2±0.63) and (2.4±1.65) than in MDF (0.9±0.99) and (2.1±2.36) respectively. The number of trees in fruit was higher in

Table 1. Details of food plants of Nilgiri Langur, Parts eaten (based on direct observation) in Parambikulam Tiger Reserve during the study period from Dec-2011 to Mar 2012 [[a]-Classification is based on Bentham and Hooker (1962-63); Gamble, 1953); Sasidharan, 2004)].

Sl. No.	CATEGORY	FAMILY[a]	SPECIES[a]	PARTS EATEN*	STATUS
1	CLIMBER	CONVOLVULACEAE	*Argyreia elliptica*	L	
2	CLIMBER	PIPERACEAE	*Piper nigrum*	L	
3	CLIMBER	FABACEAE	*Canavalia ensiformis*	L	
4	CLIMBER	ERYTHROPALLACEAE	*Erythropalum scandens*	L	
5	CLIMBER	ASCEPIADACEAE	*Cryptolepis buchananii*	L	
6	CLIMBER	FABACEAE	*Spatholobus pariviflorus*	L	
7	CLIMBER	RUTACEAE	*Toddalia asiatica*	L	
8	CLIMBING SHRUB	CAESALPONIACEAE	*Acacia concinna*	L & FR	
9	CLIMBING SHRUB	COMBRETACEAE	*Calycopteris floribunda*	L	
10	CREEPER	FABACEAE	*Centrosema virginianum*	L	
11	CREEPER	MENINSPERMACEAE	*Cyclea peltata*	L	
12	GRASS	POACEAE	*Bambusa bambos*	L	
13	HERB	FABACEAE	*Mimosa pudica*	L	
14	ORCHID	ORCHIDACEAE	*Orchid* sp.	L	
15	SHRUB	MAGNOLIACEAE	*Michelia nilagirica*	L	
16	SHRUB	RUTACEAE	*Glycosmis mauritiana*	FR	
17	SHRUB	VERBENACEAE	*Lantana camara*	L & FL	Weed
18	SHRUB TO SMALL TREE	RHAMNACEAE	*Zizyphus oenoplia*	FR	
19	SMALL PLANT	APOCYNACEAE	*Tabernaemontana alternifolia*	L & FL	Endemic
20	SMALL PLANT	CAPPARIDACEAE	*Capparis rheedii*	L	rare and endemic
21	SMALL PLANT	ELAEAGNACEAE	*Elaeagnus conferata*	L	
22	SMALL PLANT	OLEACEAE	*Jasminum malabaricum*	L & FL	
23	SHRUB TO SMALL TREE	RHAMNACEAE	*Zizyphus mauritiana*	FR	
24	TREE	AMMONACEAE	*Polyalthia rufescens*	L	Rare
25	TREE	ANACARDIACEAE	*Anacardium occidentale*	L	
26	TREE	ANACARDIACEAE	*Mangifera indica*	L,FL&FR	
27	TREE	ANACARDIACEAE	*Spondias pinnata*	L	
28	TREE	ALLANGIACEAE	*Alangium salvifolium*	L	
29	TREE	ANNONACEAE	*Guatteria fragrans*	L	
30	TREE	APOCYNACEAE	*Alstonia scholaris*	L & FL	
31	TREE	BIGNONIACEAE	*Jacarandha mimosifolia*	L	
32	TREE	BIGNONIACEAE	*Radermachera xylocarpa*	L	
33	TREE	BOMBACACEAE	*Bombax malabarica*	L & FL	
34	TREE	BOMBACACEAE	*Ceiba pentandra*	L & FR	
35	TREE	BOMBACACEAE	*Cullenia exarillata*	L	
36	TREE	COMBRETACEAE	*Terminalia bellerica*	L & FR	
37	TREE	COMBRETACEAE	*Terminalia paniculata*	L & FL	
38	TREE	COMBRETACEAE	*Terminalia tomentosa*	L	
39	TREE	CONVOLVULACEAE	*Breweria cordata*	L	
40	TREE	DATISCACEAE	*Tetrameles nudiflora*	L	
41	TREE	DELLENIACEAE	*Dillenia pentagyna*	L & FR	
42	TREE	EUPHORBIACEAE	*Baccaurea courtallensis*	L	Endemic
43	TREE	EUPHORBIACEAE	*Bischofia javanica*	L	
44	TREE	EUPHORBIACEAE	*Bridelia retusa*	L	
45	TREE	EUPHORBIACEAE	*Drypetes malabarica*	L	Endemic
46	TREE	EUPHORBIACEAE	*Emblica officinalis*	L & FR	
47	TREE	EUPHORBIACEAE	*Macaranga indica*	stem & FL	

Table 1 Cond.

48	TREE	EUPHORBIACEAE	*Mallotus ferrugineus*	L	
49	TREE	EUPHORBIACEAE	*Trewia nudiflora*	L & FL	
50	TREE	FABACEAE	*Acrocarpus fraxinifolius*	L	
51	TREE	FABACEAE	*Anogeissus latifolia*	L	
52	TREE	FABACEAE	*Bauhinia malabarica*	L	*Endemic*
53	TREE	FABACEAE	*Bauhinia racemosa*	L	
54	TREE	FABACEAE	*Cassia fistula*	L	
55	TREE	FABACEAE	*Dalbergia latifolia*	L	
56	TREE	FABACEAE	*Dalbergia sissoides*	L	
57	TREE	FABACEAE	*Pongamia pinnata*	L	
58	TREE	FABACEAE	*Pterocarpus marsupium*	L	
59	TREE	FABACEAE	*Derris* sp.	L&FL	
60	TREE	FABACEAE	*Tamarindus indicus*	L & FR	
61	TREE	MORACEAE	*Ficus religiosa*	L	
62	TREE	FLACOURTIACEAE	*Hydnocarpus pentandra*	L & FL	
63	TREE	FLACOURTIACEAE	*Scolopia crenata*	L	
64	TREE	VERBENACEAE	*Vitex altissima*	L	
65	TREE	LAURACEAE	*Cinnamomum malabathrum*	L	Endemic
66	TREE	LAURACEAE	*Cryptocarya stocksii*	L	
67	TREE	LAURACEAE	*Litsea* sp.	L	
68	TREE	LAURACEAE	*Tetranthera coriacea*	L	
69	TREE	LEGUMINOSAE	*Delonix regia*	L & FL	
70	TREE	LEGUMINOSAE	*Samanea saman*	L,FL& FR	
71	TREE	LYTHRACEAE	*Lagerstroemia microcarpa*	L	
72	TREE	MELIACEAE	*Dysoxylum beddomei*	L	
73	TREE	MELIACEAE	*Melia dubia*	L & FR	
74	TREE	MIMOSOIDEAE	*Albizia lebbeck*	L	
75	TREE	MORACEAE	*Artocarpus heterophyllus*	L	
76	TREE	MORACEAE	*Ficus asperrima*	L	
77	TREE	MORACEAE	*Ficus bengalensis*	L & FR	
78	TREE	MORACEAE	*Ficus glomerata*	L	
79	TREE	MORACEAE	*Ficus microcarpa*	L & FR	
80	TREE	MYRISTICACEAE	*Knema attenuate*	L	
81	TREE	MYRTACEAE	*Psidium guajava*	L & FR	
82	TREE	MYRTACEAE	*Syzygium cumini*	L & FR	
83	TREE	MYRTACEAE	*Syzygium gardneri*	FR	
84	TREE	RHIZOPHORACEAE	*Carallia integerrima*	L	
85	TREE	RUBIACEAE	*Ixora brachiata*	L	
86	TREE	RUBIACEAE	*Randia dumetorum*	FR	
87	TREE	RUTACEAE	*Euodia rouburghiona*	L	
88	TREE	RUTACEAE	*Murraya koenigii*	L	
89	TREE	SAPINDACEAE	*Schleichera oleosa*	L	
90	TREE	SAPOTACEAE	*Palaquium ravii*	L	
91	TREE	STERCULIACEAE	*Heritiera papilio*	L	
92	TREE	TILIACEAE	*Grewia tiliifolia*	L	
93	TREE	VERBENACEAE	*Gmelina arborea*	L & FL	
94	TREE	VERBENACEAE	*Tectona grandis*	L & stem	
95	TREE	FABACEAE	*Xylia xylocarpa*	L & FR	
96	TREE	DIPTEROCAR-PACEAE	*Vateria indica*	L & FL	Endemic &Threatened
97	TREE	MYRSINACEAE	*Aegiceras pauciflora*	L	

*L=LEAVES; FL=FLOWER; FR=FRUITS

the MDF whereas number of trees is the flowering stage was higher in Evergreen.

Overall, the two habitats differ in tree species richness, diversity and phenology was higher in EF.

and Joseph,G.K.,2001b) Another study carried out in Silent Valley for 3 years again by Ramachandran and Gigi in 2001 recorded 90 species of food plants of Nilgiri Langur with 45 families. These informations

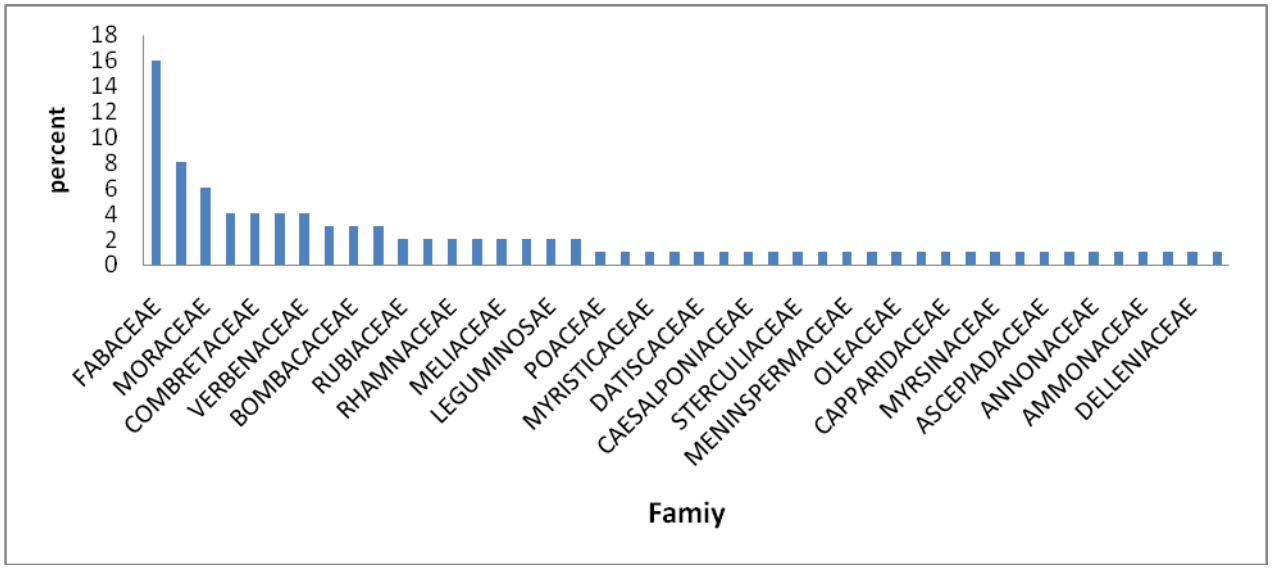

Figure 3. Percent composition of different food plants of Nilgiri Langur belonging to different families in Parambikulam Tiger reserve during the study period (Families of different plants arranged based on ranking).

Variation in Foraging and non-foraging areas:

Evergreen Forest and Moist Deciduous Forest habitats differed in terms of species richness, diversity and composition. The differences in species composition and characteristics were tested within each habitat in Nilgiri Langur foraging and non-foraging areas and the results are given in Table 4. Tree species diversity (2.9), percent of young leaves (13%), shrub density ($2.9/5m^2$) was higher in the foraging areas of the EF. The density of trees with non-flowering stage was higher in non-foraging areas of EF.

Tree species richness, diversity, and the canopy area was marginally higher in foraging areas than non-foraging in MDF. The percent availability of young and mature leaves were similar in both foraging and non -foraging areas. Density of trees in fruit was significantly higher in foraging area of MDF.

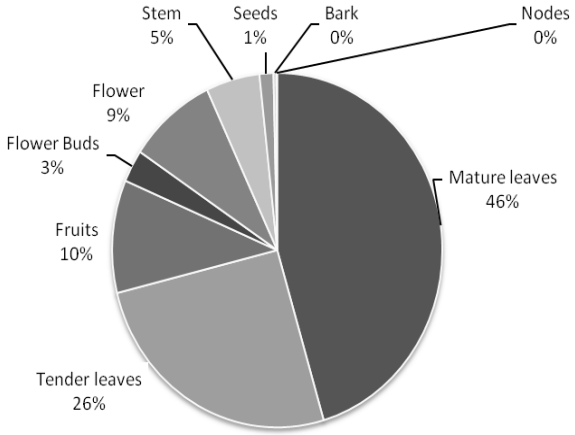

Figure 4. Proportion of different parts of food plants eaten Nilgiri Langur in Parambikulam Tiger Reserve during the study period (Dec-2011 to Mar-2012).

DISCUSSION

Diet

Nilgiri langur's diet consisted of 97 plant species of 44 families during the study period from December, 2011 to March, 2012. Among different physiognomic categories tree species is more consumed (83.87%) followed by climber (7.53%), shrub (6.45%), grass and herb (1.08%) respectively.

In earlier studies, Horwich (1972) listed 39 food plants in the diet of Nilgiri Langur for a period of three months of period in Periyar. Sunderraj and Johnsingh (1993) reported 54 food species in Servalar gallery forests in Mundanthurai wildlife sanctuary. Srivastava *et al*. (1996) conducted a month study in Periyar and described 29 food species . (Source-Ramachandran,K.K. indicates that Nilgiri Langur has access to different types Another study carried out in Silent Valley for 3 years again by Ramachandran and Gigi in 2001 recorded 90 species of food plants of food plants in different forest type and feeds on a greater variety of food plants in Parambikulam Tiger Reserve.

The number of food species varied greatly with forest type, duration of study period and method of foraging data collection .In the present study the two vegetation types showed differences.

Adaptive success of Asian Colobines lies in their possession of a sacculated stomach which digests cellulose by bacterial fermentation, thereby allowing the exploitation of vegetation parts (Ramachandran, 1998)

Table 2. Jacob's preference index of plant species (Data sorted in descending order based on total preference) of Nilgiri Langur in different habitats of Parambikulam Tiger Reserve during the study period (Dec 2011 to Mar 2012).

Sl. No.	Category	Species	EF	MDF	Total
1	Grass	*Bambusa bambos*	1.00	-0.52	-0.37
2	Shrub	*Zizyphus mauritiana*	0.40	-1.00	0.02
3	Shrub	*Michelia nilagirica*	-0.94		-0.95
4	Shrub	*Glycosmis mauritiana*	-0.98	-0.97	-0.97
5	Tree	*Melia dubia*	0.90	1.00	0.91
6	Tree	*Delonix regia*	0.84		0.82
7	Tree	*Tectona grandis*	1.00	0.61	0.78
8	Tree	*Acacia concinna*	0.82	0.36	0.70
9	Tree	*Ficus bengalensis*	0.53	1.00	0.59
10	Tree	*Emblica officinalis*	1.00	0.43	0.56
11	Tree	*Terminalia tomentosa*	0.29	0.57	0.53
12	Tree	*Albizia lebbeck*	1.00	0.23	0.52
13	Tree	*Trewia nudiflora*	1.00	0.30	0.46
14	Tree	*Acrocarpus fraxinifolius*	0.33	1.00	0.41
15	Tree	*Vateria indica*	0.37		0.31
16	Tree	*Syzygium cumini*	0.33		0.27
17	Tree	*Terminalia bellarica*	0.33		0.27
18	Tree	*Wrightia tinctoria*		0.19	0.27
19	Tree	*Macaranga indica*	0.02	1.00	0.23
20	Tree	*Cinnamomum malabathrum*	-0.38	1.00	-0.02
21	Tree	*Ixora brachiata*	0.04		-0.02
22	Tree	*Gmelina arborea*	-0.05		-0.11
23	Tree	*Terminalia paniculata*	0.40	-0.43	-0.11
24	Tree	*Hydrocarpus pentandra*	-0.12	-0.11	-0.15
25	Tree	*Grewia tillifolia*	-0.05	-0.27	-0.15
26	Tree	*Dillenia pentagyna*	-1.00	-0.23	-0.24
27	Tree	*Heritiera papilio*	-0.23	1.00	-0.25
28	Tree	*Cullenia exarillata*		-0.36	-0.28
29	Tree	*Anogeissus latifolia*		-0.38	-0.30
30	Tree	*Randia dumetorum*		-0.43	-0.35
31	Tree	*Lagerstroemia microcarpa*	-0.47	-0.28	-0.35
32	Tree	*Cryptocarya stocksii*	-0.34		-0.39
33	Tree	*Elaeagnus conferata*	-0.30	-1.00	-0.61
34	Tree	*Vitex altissima*	-0.83	1.00	-0.61
35	Tree	*Palaquium ravii*	-0.70	1.00	-0.64
36	Tree	*Schleichera oleosa*	-0.89	1.00	-0.69
37	Tree	*Calycopteris floribunda*	-0.54	-0.92	-0.72
38	Tree	*Alangium salvifolium*	-0.83		-0.85
39	Tree	*Carallia integerrima*	-1.00	-0.77	-0.85
40	Tree	*Euodia rouburghiona*	-0.89		-0.90
41	Tree	*Cassia fistula*	-1.00	-0.89	-0.91
42	Tree	*Rademochera xylocarpa*	-0.83	-1.00	-0.94
43	Tree	*Polyalthia rufescens*	-0.93	-1.00	-0.94
44	Tree	*Tabernaemontana alternifolia*	-1.00	-0.84	-0.94

Table 3. Tree species richness, diversity, tree characteristics, phenology and shrub richness in different habitats (Evergreen forest and Moist deciduous forests) of Parambikulam Tiger Reserve during the study period (Dec 2011-Mar-2012).

Variables	Evergreen Forest		Moist deciduous forest		F	p
	Mean	SD	Mean	SD		
Tree richness	12.0	2.91	8.6	1.19	**9.43**	**0.01**
Tree Diversity	2.8	0.44	2.4	0.27	**4.59**	**0.05**
Tree GBH (cm)	30.5	9.08	35.8	12.39	1.10	0.31
Tree Height (m)	36.1	5.92	43.8	7.75	**5.70**	**0.03**
Canopy length (m)	12.9	3.59	13.3	2.04	0.08	0.77
Canopy width (m)	8.3	2.30	8.6	1.84	0.10	0.76
Canopy area (m^2)	549.3	289.67	483.9	138.40	0.34	0.57
Young leaves (%)	11.8	4.39	8.3	6.05	1.98	0.18
Mature leaves (%)	88.2	4.39	91.7	6.05	1.98	0.18
Shurb richness	1.2	0.63	0.9	0.99	0.72	0.41
Shurb density (/5m^2)	2.4	1.65	2.1	2.36	0.08	0.77
Number of trees without fruits	11.1	3.25	7.5	1.60	**8.16**	**0.01**
Number of trees with fruits	0.8	0.79	1.1	0.99	0.60	0.45
Number of trees without flower	10.7	2.79	7.6	1.51	7.82	0.01
Number of trees with flower	1.3	1.25	1.0	1.07	0.29	0.60

Table 4. Tree species richness, diversity, tree characteristics, phenology and shrub richness in Nilgiri Langur foraged and non-foraged areas of Evergreen forest and Moist deciduous forests of Parambikulam Tiger Reserve during the study period (Nov-2011 to Dec 2012).

Variables	Evergreen Forest				F	P	Moist Deciduous Forest				F	p
	Non-foraged		Foraged				Non-foraged		Foraged			
	Mean	SD	Mean	SD			Mean	SD	Mean	SD		
Tree richness	12.50	3.54	11.88	3.00	0.07	0.80	8.50	1.29	8.75	1.26	0.08	0.79
Tree Diversity	2.34	0.30	2.94	0.38	4.11	0.08	2.41	0.29	2.48	0.28	0.13	0.73
Tree GBH (cm)	30.27	3.02	30.51	10.23	0.00	0.98	37.20	13.91	34.33	12.61	0.09	0.77
Tree Height (m)	39.98	10.63	35.17	4.86	1.06	0.33	43.98	9.08	43.65	7.59	0.00	0.96
Canopy length (m)	13.15	5.59	12.78	3.47	0.01	0.91	12.83	2.20	13.71	2.09	0.33	0.59
Canopy width (m)	7.83	3.35	8.42	2.27	0.09	0.77	8.46	1.63	8.77	2.27	0.05	0.83
Canopy area (m^2)	495.66	326.92	562.76	302.63	0.08	0.79	455.87	136.20	511.97	155.07	0.30	0.61
Young leaves (%)	6.00	0.00	13.19	3.61	7.26	0.03	8.04	6.00	8.55	7.02	0.01	0.92
Mature leaves (%)	94.00	0.00	86.81	3.61	7.26	0.03	91.96	6.00	91.45	7.02	0.01	0.92
Shurb richness	0.50	0.71	1.38	0.52	4.13	0.08	1.25	1.26	0.50	0.58	1.17	0.32
Shurb density (/5m^2)	0.50	0.71	2.88	1.46	4.70	0.06	3.00	2.94	1.25	1.50	1.12	0.33
Densityof trees without fruit (100m^2)	11.00	2.83	11.13	3.52	0.00	0.96	8.00	1.83	7.00	1.41	0.75	0.42
Density of trees with fruit (100m^2)	1.50	0.71	0.63	0.74	2.24	0.17	0.50	1.00	1.75	0.50	5.00	0.07
Density of trees without flower(100 m^2)	9.50	4.95	11.00	2.45	0.43	0.53	7.00	1.41	8.25	1.50	1.47	0.27
Density of trees with flower (100m^2)	3.00	1.41	0.88	0.83	8.41	0.02	1.50	1.29	0.50	0.58	2.00	0.21

Almost all workers have virtually pointed out the folivorous nature of Nilgiri Langur (Ramachandran, 2001a).

Nilgiri Langur was found to prefer young leaf in Evergreen forest since young leaves contain more protein and less fiber and it preferred mature leaves in MDF. But an earlier study on the leaf chemistry of Nilgiri Langur's diet showed the preference for mature leaves over young leaves (Sunderraj, 2001) The difference is mainly due to variation in plant species diversity between the habitats. It has been stated that, where diversity is higher, a large number of species may produce acceptable mature leaves, permitting greater use of those most common items in the plant (Sunderraj, 2001).Apart from this, there are some other studies which support that Colobines in different habitats vary the proportions of leaf and non-leaf foods in their diets according to plant species diversity, seasonality, and the nutritional quality of the leaves available (Li *et al.,* 2006).

Food Preference

The plant species preference and avoidance varied according to species in different habitats. Among different species, five climbers, one herb (*Mimosa pudica*) and one grass (*Bambusa bambos*) species were positively preferred in the evergreen habitat and avoided in MDF by Nilgiri Langur. Nilgiri Langur showed clear preference to some species of trees. Trees like *Melia dubia, Acacia concinna, Ficus bengaensis, Emblica officinalis, Terminalia tomentosa, Trewia nudiflora, and Macaranga indica* were highly preferred in both the habitats with positive preference value. Tree species such as *Schleichera oleosa, Palaquium ravii, Heritiera papilio* were positively preferred in MDF. *Radermachera xylocarpa, Polyalthia rufescens and Tabernaemontana alternifolia* were highly avoided (-0.83 to -0.94) in both the habitats. Preffered food plants, feeding by Nilgiri Langur was therefore not random but was very selective. The choice of diet for folivorous animals may be constrained by the need to avoid too much of particular secondary compounds and also a plant or a part of that plant is rich in one essential nutrient may be deficient in other.

Plant species composition in Nilgiri Langur foraging and non-foraging areas were compared, where the number of species is higher in the non-foraged area but diversity is more in the foraged area with higher percentage of young leaves in the Evergreen forest, whereas, the number of species is more in foraged area for MDF with a higher percentage of mature leaves in the non-foraged area. In addition to that the density of trees in fruiting stage is more in the foraged area of MDF when compared to the foraged area of Evergreen forest. Also the shrub density is more in foraged area of Evergreen forest whereas less in the foraged area of MDF. Though it is not a habitat specialist, yet the Nilgiri Langur has the tendency to exploit the maximum resource available within its home range for its food (Sunderraj, 2001). In other words, Nilgiri Langur selectively foraged in the areas with preferred plant species and its parts. Feeding on diverse food plants by Nilgiri Langur clearly indicates its high adaptability to a given habitat (Sunderraj, 2001).

Factors influencing foraging

There are number of factors known to influence the foraging area selection of Nilgiri Langur, their forage availability, vegetation height, percent cover, presence and absence of young, palatable and nutritious leaves, Density of trees in fruiting stage was significantly higher in foraged areas of MDF. Nilgiri Langur preferred young leaves in MDF and mature leaves in EF.The percent of young leaves were more in the foraged areas of EF. Young leaves were the preferred staple food for langurs, whereas mature leaves and fruits may serve as emergency foods in response to seasonal shortage in the abundance of young leaves species composition of the diets. The Colobine represent a group of Old World Primates that exhibit a number of anatomical and behaviour adaptations associated with leaf eating. These include dental crests and gut specializations (expanded and segmented forestomach) that initiate the mechanical and chemical breakdown of fibrous materials (Garber, 1987).In this way coarse plant material is broken down mechanically and made available to digest properly. The proximal Section of the stomach in Presbytis has a high ph (5.0-7.0) and provides an environment capable of supporting a large and diversified micro bacterial flora (Garber, 1987). Presbytis johnii, also exhibits a highly selective dietary pattern. When feeding on mature leaves, the lamina were frequently discarded and only the petioles injested. A preference for leaf petiole has also been reported in other Colobines and may reflect the fact that the resources is lower in nonstructural carbohydrates and higher in available nutrients than leaf blades (Garber, 1987).Mature leaves of some species were of higher nutritional quality (less fibers) than the young leaves of others. Although P. johnii ingested young leaves with high concentrations of secondary compounds, (Oates *et al*., 1977) caution that tannins found in young leaves "tend to be much less effective in combining with proteins than those of corresponding mature leaves" These authors conclude that fiber content is likely to be the most important factor influencing food choice in Asian Colobines(Garber, 1987) .

Final Considerations

The above results indicate that Nilgiri Langur consumed variety of plants. The number of food species listed varied greatly with forest type, duration of study period and method of foraging data collection. The present study reveals marked differences in the proportion of various dietic elements in the two habitats. The various food preferences by Nilgiri Langur showed was therefore not random but very selective. As among the 97 food plants recorded, eight no. of plants species are endemic, rare and threatened to Western Ghats. Therefore, these middle elevation evergreen forests needs the utmost protection and management for the long term survival of the species.

ACKNOWLEDGEMENT

We thank Kerala Forest Department for permission to conduct research in Parambikulam Tiger Reserve. I thank World Wildlife Fund (WWF) for nature and natural resources, Western Ghats for providing financial assistance. I am grateful to K. Thiyagesan, principal of A.V.C College for his constant encourage and help, S. Sandilyan of being my guide and J. Pandian, G. Sharmila, R. Nagarajan, S. Shankari and M. Kartikiyan of A.V.C College, Department of Zoology and Wildlife Biology for their support. I would like to thank Ajay Desai, co-chairman Asian Elephant Specialist Group IUCN for designing the study.

REFERENCES

Altmann, J. 1974. Observational study of behaviour: Sampling methods. *Behaviour* 49: 227-267.

Ashokkumar, M. 2011. Population, Foraging, And Activity Pattern of Gaur (Bos gaurus H.Smith,1827) In Mudumalai Tiger Reserve, Southern India. Ph.D. Thesis. Bharathidasan University. Trichy.

Gamble, J.S. 1935. Flora of the presidency of madras 3 vols (1979 edn) Bishen Singh Mahendra Pal Singh, Dehra Dun, India.

Garber , P.A. 1987. Foraging strategies of among Living Primates. *Annual Review of Antropology* 16:339-364.

Horwich, R.H. 1972. Home range and food habits of Nilgiri Langur Presbytis johnii. Journal of Bombay Natural History society,69:255-267.

Horwich, R.H. 1980. Behavioural Rhythms in the Nilgiri Langur,Presbytis johnii. *Primates* 21 (2):220-229..

Jarman, P.J. and Sinclair, A.R.E. 1979. Feeding strategy and the pattern of resource- partitioning in ungulates. In (Eds.) Sinclair, A.R. E. and M. Norton- Griffiths. Serengeti, Dynamics of an ecosystem, University of Chicago Press, Chicago.

Li Z, Rogers, M.E. 2006. Food Items Consumed by White-headed Langurs in Fusui, China. *International Journal of Primatology* 27(6):1551-1567.

Malviya, M., Srivastava, A.,Nigam, P. and Tyagi, P.C. 2011. National Studbook of Nilgiri langur (Trachypithecus johnii).Wildlife Institute of India, Central Zoo Authority.

Maruhashi, T. 1980. Feeding Behaviour and Diet of the Japanese Monkey (Macaca fuscata yakui) on Yakushima Island,Japan. Primates 21(2):141-160.

Mills, M.G. L. 1992. A comparison of methods used to study food habits of large African Carnivores. In Wildlife 2001: Population 1112-1124. (Eds) McCullough, D. R. and Barrett, R. H. London, Elsevier Science Publisher.

Nakagawa, N. 2009. Feeding Rate as Valuable Information in Primate Feeding Ecology. *Primates* 50:131-141

Nie , N.H., Hull, C.H., Jenkins, J.G., Steinbrenner, K. and Bent, D.H. 1975. SPSS: Statistical Package for the Social Sciences (2nd edition), McGraw -Hill, New York.

Oates, J.F., Swain, T.and Zantovska, T. 1977. Secondary compounds and food selection by colobus monkeys. *Biochemical Systematics and Ecology* 5:317-321.

Phillipson, J. 1975. Rainfall, Primary production and carrying capacity of Tsavo National park (East), Kenya, East African Wildlife Journal, 13: 171-201.

Ram, S. 2007. Distribution and Status of the Nilgiri Langur (Semnopithecus johnii) in the Western Ghats of India. Final Technical Report FERAL (Foundation for Ecological Research, Advocacy and Learning.

Ramachandran, K.K. 1998. Ecology and Population Dynamics of Endangered Primates in Silent Valley National Park. KFRI Research Report 143. Kerala Forest Research Institute, Peehi, Thrissur.

Ramachandran, K.K. and Joseph , G. K. 2000. Habitat Utilization of Lion Tailed Macaque (Macaca silenus.) in Silent valley National Park, Kerala, India. Primate Report, 58:pp.17-25.

Ramachandran , K.K., Joseph , G. K 2001 (a). Distribution and Demography of Diurnal Primates in Silent Valley National Park and adjacent areas, Kerala, India. Journal of Bombay Natural History Society,98(2):191-196.

Ramachandran , K.K, Joseph, G. K. 2001(b). Feeding Ecology Of Nilgiri Langur (Trachypithecus johnii) In Silent Valley National Park, Kerala, India. *Indian Forester* 1155-1164.

Sasidharan , N. 2004. Forest Trees of Kerala. Kerala Forest Research Institute, Peechi, Thrissur.

Srivastava, K.K., Zachavias, V.J., Bhaedwaj, A.K., Joseph. P., Joseph, S. 1996. Some observation on troop structure, activity budgets and food habits of the Nilgiri Langur (Presbytes johnii) in Periyar during monsoon (June-August). *Indian Forester* 122 (10): 946-950.

Sunderraj, S.F.W. 1984. Foraging Ecology and Ranging Pattern of Nilgiri Langur, Presbytis Johnii. M.sc., thesis, Bharathidasan University,Trichy.

Sunderraj, S.F.W. and Johnsingh. A.J.T. 1993. Impact of flash flood on the gallery forest and arboreal mammals of River Servalar. Mundanthurai Pllateau South India.Wildlife Institute of India:1-9.

Sunderraj, S.F.W. 2001. Ecology and conservation of Nilgiri Langur (Trachypithecus johnii). Envis Bulletin: Wildlfe and Protected Areas, 1(1),49-59.

Swapna, N. 2008. Assessing the feeding ecology of the Bengal Slow Loris (Nycticebus bengalensis) in Trishna wildlife sanctuary, Tripura. M.sc., thesis submitted to Manipal University, India.

Vairavel. S.M. 1998. Ecology of gaur (Bos gaurus) with special reference to habitat utilization in Parambikulam Wildlife Sanctuary, Kerala, India. Ph.D., Thesis. Forest Research Institute, Peechi, Kerala, 155pp.