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ECOLOGY AND POPULATION DYNAMICS OF ENDANGERED PRIMATES IN SILENT VALLEY NATIONAL PARK

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ABSTRACT

The endemic and endangered primates of Western Ghats namely lion-tailed macaque ***(Macaca silenus)*** *and Nilgiri langur* ***(Trachypithecus johnii)*** *were studied in Silent Valley National Park and adjacent areas, for a period of three years from 1993. Fourteen lion-tailed macaque troops constituting 275 individuals were identiid. Eight lion-tailed macaque troops having 147 individuals were found to inhabit east of Kunthipuzha river. The population west of Kunthipuzha river constituted six troops having 128 individuals; average troop size was 19.2 individuals. Among the 275 individuals observed, 8% were adult males and 45% adult females: subadult males constituted 6%. Subadult females, juveniles, infants and cradled infants constituted the immature class with 41%. Adult male-female ratio was estimated as 1:5.6. During the study period two lion-tailed macaque troops fissioned.*

Ninety two plant species were utilized by the lion-tailed macaque for food which included 62 trees, 10 lianas, eight shrubs, six species of mushroom, three species of lichens and three parasitic plants. Among the food species, ***Cullenia exarillata*** *used both for seeds and flowers, was favoured the most. An average of 21 plant species were used for food every month. The average home range size of lion-tailed macaque in the rainforest habitats of Silent Valley was estimated as 2.41 km^2.*

Nilgiri langur was commonly seen in the entire stretch of evergreen forests inside the National Park and semi-evergreen and moist deciduous forests along the fringes. Eighty five Nilgiri langur troops were identiied. Among the 85 troops, 69 were ranging well inside the boundaries of the National Park, of which, Sairandri and Puchappara sections hold the majority of population. The remaining 16 troops were located from adjacent forest areas mainly in the Attappady Reserved Forest. Seventy nine troops were confined only to the evergreen forests. Nilgiri langur troops residing in the evergreen forests of Nilikkal border areas occasionally foraged to the adjacent moist deciduous forests. Average troop size was estimated as 5.89. The adult male-female ratio was estimated to be 1 :2.

Eighty nine plant species, utilized as food by Nilgiri langur, included 72 trees, 7 shrubs, 7 lianas, one herb, one reed, a parasitic plant and mushroom species. Home range of Nilgiri langur was estimated as 0.47 km^2.

1. INTRODUCTION

India is well known for its rich primate diversity with as many as 15 living primate species. These include two lorises, seven macaques, five langurs and one ape species *(Hylobates hoolock).* The highest primate diversity in India is localized towards the north-eastern states of India where, as many as 10 species occur in sympatry. The distributional range of these primates very often extends up to the south-east Asian countries like Bangladesh, Myanmar, Indonesia, Thailand, South China, Malesia etc. The two most common macaques of India are rhesus macaque *(Macaca mulatta)* and bonnet macaque (Macacaradiata). The former ranges in the northern India extending south up to Godavari river. The latter is a common endemic Indian species confined to the southern Peninsular India extending north up to the Godavari river. A critically endangered subspecies of crab eating macaque *(Macaca fascicularis umbrosa)* is inhabiting the Nicobar Islands (ZSI. 1994). The common langur (Semnopithecus entellus) has a wide distribution all over India extending from Himalayas to the southernmost Western Ghats (Roonwaland Mohnot, 1977). Distribution of this species ranges upto Pakistan in the north and Sri Lanka in south. Slender loris (Loris tardigradus) existing in various states of Peninsular India also shares its distribution range with Sri Lanka. Among the Indian primates two of them are endemic and endangered to the Westem Ghats namely lion-tailed macaque *(Macaca* silenus) and Nilgiri langur (Trachypithecus johnii). A few field surveys and studies were carried out to estimate the status, distribution and ecology of these endangered primates (Pocock, 1928, 1939; Hutton, 1949; Poirier, 1969; Kurup, 1975, 1978, 1979; Green and Minkowski, 1977; Balakrishnan, 1984 Ali et *al.*, 1985; Karanth, 1985; Ramachandran et *al.*, 1986; Balakrishnan and Easa, 1986; Kumar, 1987; Menon and Poirier. 1996; Easa et *al.*, 1997).

Lion-tailed macaque inhabits the more elevated tropical wet evergreen forests of the Western Ghats from 14°2 1'N to extreme south of Kanyakumari district in Tamil Nadu; but they are mostly abundant in erstwhile states of Cochin and Travancore (Jerdon, 1874). Hutton (1949) dealt with the status of lion-tailed macaque in the High Wavy mountains and Sugiyama (1968) made a two month study on the status and ecology of the species at Panniyar near Munnar. Kurup (1978) reported the distributional range of lion-tailed macaque between 8° 21' and 11° 30' N *ie.*; from southwestern face of Nilgiri down to Kalakkad slopes in the Agasthyamala ranges of the southern spurs. Green and Minkowski (1977) reported that the lion-tailed monkey occurs in the undisturbed rainforests in south India. Johnson (1980) reported their status, ecology and behaviour in Thirunelveli forests. Karanth (1985) studied the ecology and it's rain forest habitat in Karnataka. Kumar (1987) reported

that the viable populations of lion-tailed macaque occurs only in Ashambu Hills and Silent Valley areas. Menon and Poirier (1996) studied the activity pattern of this macaque in one of its disturbed habitats. Easa *et al.* (1997) made a survey in the entire stretch of Kerala forests to assess their population status.

Nilgiri langur generally inhabit the sholas. To a lesser extent it occupies the evergreen forests at about 900-1200 m altitude with trees growing upto about 40 m in height (Roonwal and Mohnot, 1977). Some ecological and status studies were carried out on this species (Pocock, 1939; Hutton, 1949; Poirier, 1968; Krishnan, 1971: Hohmann and Sunderraj, 1992: KFRI, 1993; Ramachandran, 1995).This arboreal species is threatened by the destruction of its natural habitat for cultivation and other agricultural needs. Moreover, these langurs are poached in large-scale throughout the Kerala part of the Western Ghats for their supposed medicinal qualities. However, recently its population is gradually recouping at least in protected areas like, sanctuaries and National Parks (Ramachandran *et al.,* 1986; KFRI, 1993; Ramachandran, 1995).

Lion-tailed macaque and Nilgiri langur are of considerable significance in the forest ecosystem of Silent Valley. In an earlier study, eight troops of lion-tailed macaque and about eighty troops of Nilgiri langur were reported from the area (Vijayan and Balakrishnan, 1977).Ramachandran (1990) reported 13 lion-tailed macaque troops with a total of 171 individuals in an effective area of 2000 ha of evergreen forests in Silent Valley and adjacent areas. Recently, Ramachandran and Joseph (1997)provided some information regarding the status and distribution of this endangered primates. A detailed study on the ecology and population dynamics of these primates were not attempted in its rain forest habitat of Kerala. Hence, the present study conducted in Silent Valley area focussed on the demography and ecology of these primates.

SILENT VALLEY NATIONAL PARK

Silent Valley National Park is situated in Palghat district of Kerala State and located at 11° 3' to 11° 13 N latitude and 76° 21' to 76° 35' E longitude. The National Park area is 89.52 km2 and forms part of the westerly sloping Silent Valley-New Amarambalam basin (Fig. 1).The altitude varies between 658 to 2383 m. The vegetation is of west coast tropical evergreen type. The Park is designated as one of the core areas of Nilgiri Biosphere Reserve.

The highly diverse flora of Silent Valley consists of 966 species belonging to 134 families and 559 genera (Manilal, 1988).This comprises 701 dicotyledons and 265 monocotyledons. The five dominant families recorded are: Orchidaceae, Poaceae, Fabaceae, Rubiaceae, and Asteraceae. Relative abundance

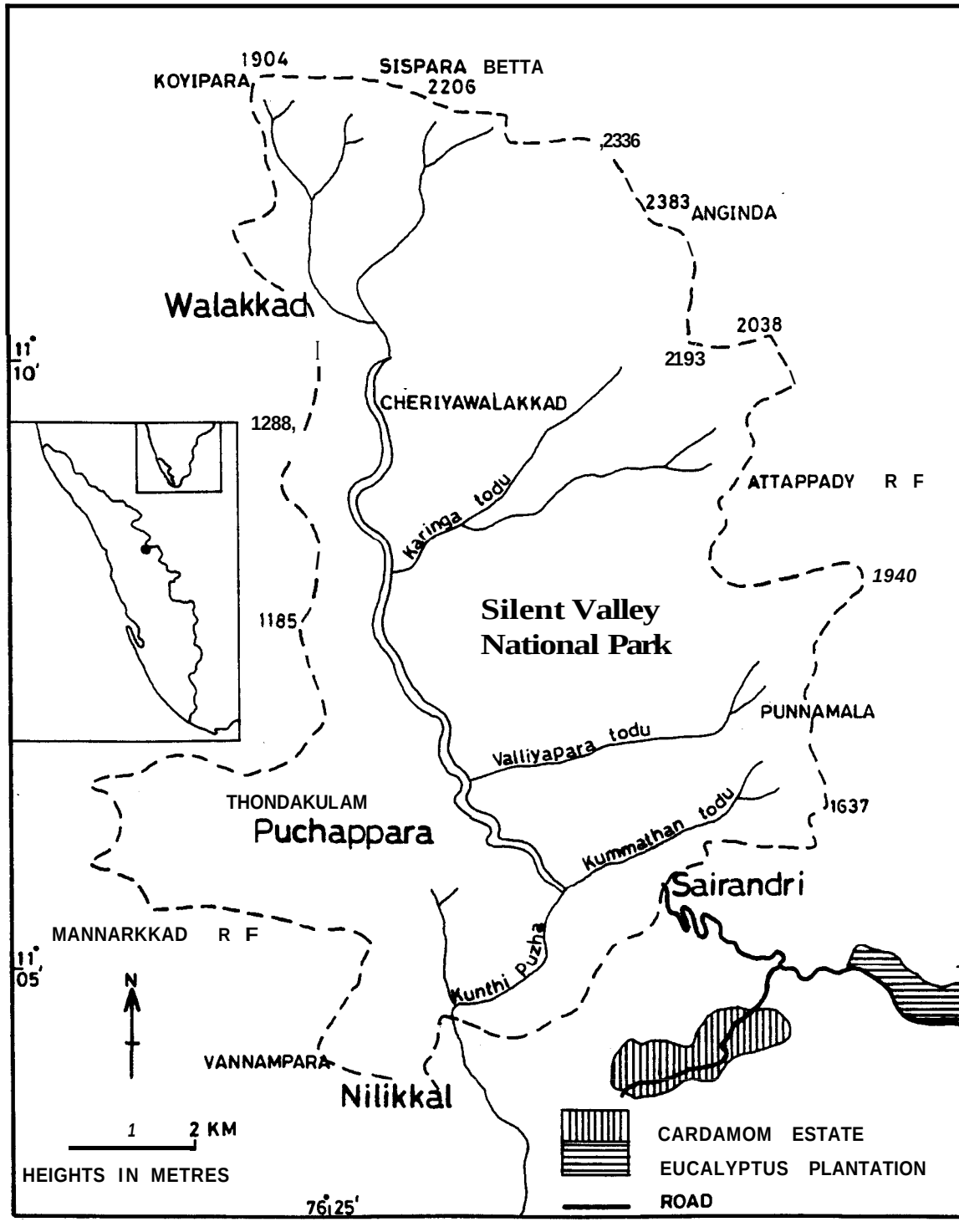


Fig. 1 Silent Valley National Park and adjacent areas

of certain species in specific patches has resulted in the formation of certain tree association which is a unique feature of the Silent Valley ecosystem. Six distinct tree associations can be distinguished in the Valley (Aiyar, 1932)and they are:- i) *Cullenia exarillata-Palaquium ellipticum* ii) *Palaquium ellipticum-Mesua ferrea* iii) *Mesua ferrea-Calophyllum elatum* iv) *Palaquium ellipticum-Poeciloneuron indicum* v) *Calophyllum elatum-Ochlandra* sp. vi) *Poeciloneuron indicum-Ochlandra* sp. Among these, first three tree associations are more concentrated in the southern sector whereas the rest of them are confined to the central and northern parts of the National Park.

CLIMATE

Rainfall

Rainfall was recorded from all the four sections of the Park (Sairandri, Nilikkal, Puchappara, Walakkad) by the Kerala Forest Department from the rain gauges installed within each section. During the study period the study area had rains in all months except December (Fig. 2). The area extensively experienced the south-west and the comparatively less north-east monsoon.

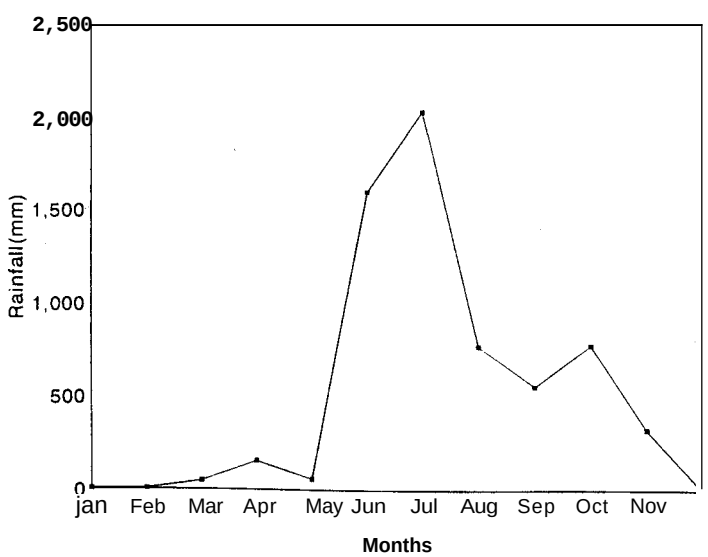


Fig. 2 Mean monthly rainfall in Silent Valley

The southwest monsoon starts in the last week of May and ends in the first week of September. Northeast monsoon starts from the last week of September and ends by first week of November. The cumulative rainfall data measured for a period of 12 months was 6329 mm. The highest rainfall was recorded in July (2035 mm) followed by June (1601 mm).

Temperature

Temperature was measured in all the four sections with the maximum-minimum thermometers and the data provided by the Kerala Forest Department. Maximum, minimum and mean temperatures were estimated. Monthly mean for maximum and minimum temperatures are shown in Fig. 3. Maximum temperature was observed in the month of May and the lowest in December. Similarly the highest minimum temperature was recorded in May and the lowest in December.

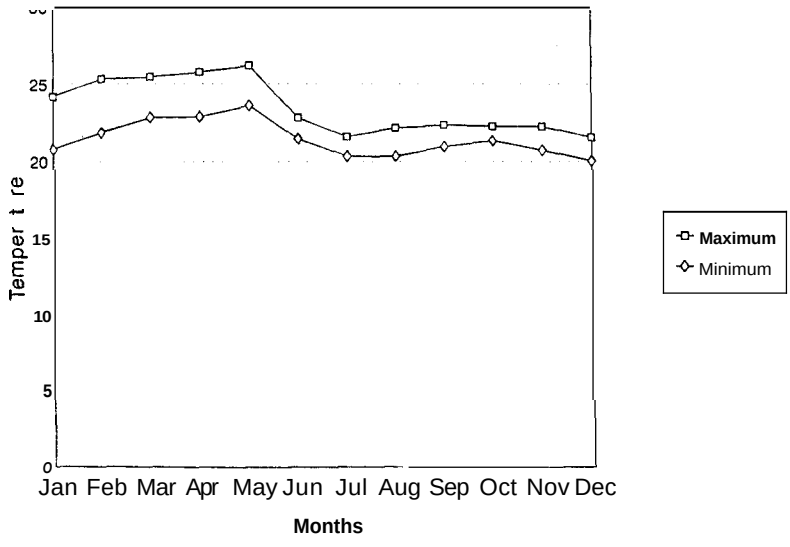


Fig. 3 Maximum-minimum temperature in Silent Valley

Seasons

Months were classified into four seasons based on the combination of temperature and rainfall. December, January and February months are identified as winter season having least rainfall (9.12 mm) and low temperature. March, April, May are having high temperature (25.8^{o}C) and with relatively low rainfall (2.59 mm). These driest and warmest months constituted the summer. June, July, August months are extremely different from all other months having highest rainfall (4407 mm). They form the monsoon season. September, October, November months were marked with moderate rainfall (1654 mm) and moderate temperature (22.29^{o}C). These months together constitute the post-monsoon season.

Objectives of the present study

Objectives of the study were a) To map the distribution of the primates in the area b) To study the habitat continuity of the endangered primates. c) To study the food and feeding habits d) To monitor the population of primates and to establish a database.

2. METHODS

The lion-tailed macaque and Nilgiri langur were studied over a period of three years from March 1993 to March 1996. The study area was stratified according to the habitat and the primate population was estimated using the total count method NRC, 1981; and Whitesides, *etal.*, 1988). The entire area was repeatedly surveyed on foot for the presence of primate troops. The adjacent semi-evergreen and moist deciduous forests were also occasionally surveyed to know their general status and distribution. On an average twenty days in a month were spent in the field for the entire study period.

Lion-tailed macaque troops were located by contact calls audible upto 100 m, and once located troops were followed and continuous observations were made until it was reliably censused or until the troop could not be followed. Such repeated surveys were made in different areas to collect data on troop size and troop composition from as many troops as possible. Often the total number of individuals in a troop could be counted, when they were crossing the slightly opened canopy spots like trek paths, streams, regeneration gaps. etc. The fully known troops were monitored periodically to assess the demographic fluctuations in the population.

Animals were classified into different age/sex classes. They were adult males, adult females, subadults, juveniles and infants (Kumar, 1987). Adult males were easily identified with stouter body and longer canines. The tail tufts having a slightly lifted tail carriage (more than 8 years). Adult females were identified by the presence of elongated nipples and baggy breasts (more than 6 years). Subadults were classified arbitrarily as those having more than five years of age and subadulthood for males could prolong for five to eight years and they were indicated by less developed musculature and comparatively shorter canines. Tail tufts might be fully developed. Subadult females were classified as those animals having more than five years of age to the first birth. They were characterized by prominent nipples but not so elongated when compared to the adult females. Animals having one to five years of age were categorized as juveniles and between third and fourth year, nipples would be differentiated in females. All the individuals having less than one year old were grouped as infants. Young infants less than eight to ten weeks old, were often cradled by adult females most probably by their mother. While censusing, the number of cradling pairs in a troop helped to distinguish the troop in the initial phases of the study.

Number of births, death or missing, successive recruitment, immigrations and emigrations in the troops were recorded. Nine troops of lion-tailed macaque were monitored for troop composition from 1993 to 1996. Another three more troops were located, two in 1994 and one in 1995, which were also monitored up to 1996. Of the twelve troops monitored, in a couple of troops fission occurred, resulting the number of troops to fourteen towards the end of the study period.

Studies like feeding and ranging behaviour of the lion-tailed macaque and Nilgiri langur were confined to the intensive study area in Nilikkal. The troops were followed for habituation and to get an approximate estimate of its home range. After knowing the approximate home range trails were cut in the undergrowth at 100 m intervals ranging north-south and east-west directions. A total of twenty one north south and twenty three east west grids were made making a total of 440 quadrats, which covered an area of 4.4 km^2. Grid usage by the primates was taken as an indication of the home range. Sampling method used for data collection was the Instantaneous Scan Method (Altmann, 1974) with some modifications (Kumar, 1987).

INSTANTANEOUS SCAN METHOD

This method envisages recording of different activities of all the individuals of the troop seen within a period of about 5 minutes at every fifteen minutes. In each group scan, other details like time, grid used, number of individuals, age-sex category, nearest neighbour, type of activity, height of occupation, tree height and food species were noted. Inter, intra troop interactions and inter species relations such as the presence of *Macaca radiata,* and Ratufa indica in the vicinity were also recorded. Five days of group scan were carried out in each month over a period of two years starting from April 1994 to March 1996.

VEGETATIONAL STUDIES

Vegetation studies were carried out in 1993. Almost all flowering trees and shrubs from the intensive study area were collected and specimens preserved as herbarium for identification of species. Floristic composition, density of plant species, extent of canopy cover and vertical stratification were studied in detail. A total of fifty plots of 10 x 10 m each were taken at random in five different locations in an effective area of 4 km^2 (APPENDIXIV). All the trees with more than 30 cm GBH were identified and its GBH and height were measured. Height was measured by visual approximation and in comparison with measured ones.

The periodicity of leaf flushing, leaf maturing, flowering and fruiting varies between species, and there is considerable difference even among the individuals of the same species. Five members of forty tree species were selected from the main study area and monitored regularly every month from January 1994 to March 1996.

3. RESULTS

LION-TAILED MACAQUE *(Macaca silenus)*

Distribution

Lion-tailed macaque population was exclusively confined to the tropical wet evergreen forests. They showed an altitude preference of 650 m to 1500 m in Silent Valley and adjacent areas. More specifically, their distribution was restricted to specific tree associations like *Cullenia-Palaquium, Mesua-Palaquium* and *Mesua-Calophyllum* existing within the evergreen forests. These tree associations are distributed more towards the southern region of the National Park and the adjoining Attappady Reserve Forest. Among the three tree associations, the troops were more common in *Cullenia-Palaquium* areas. This resulted a southward shift in their distribution pattern rather than random in the National Park. Their distribution extended upto Valiyaparathod in the north, where the *Cullenia-Palaquium* gradually merged with *Poeciloneuron-Palaquium* tree association. The distributional range towards south of Valiyaparathod included, the entire Sairandri section constituting Punnamala region in the east and Aruvampara region in the south. Lion-tailed macaques were also distributed to the adjoining Panthanthod beat of the Attappady Reserve Forest. The distribution in the southern most part of Panthanthod forest abruptly ended towards the eucalyptus plantation adjoining the evergreen forests. Lion-tailed macaque troops were found ranging in the entire south western region of the National Park like, Nilikkal section and the major part of the Puchapara section. However, their distribution in the north-western sector was restricted upto the *Calophyllum-Ochlandra* association in the northern region of the Puchapara section. No troops could be sighted further north especially in the Walakkad section of the National Park. Eucalyptus and teak plantations contiguous with the evergreen belt in the Panthanthod restricts the range of these macaques in the south. Lion-tailed macaque troops were found ranging in the entire south western border of the National Park upto reed brakes in Thondakkulam region of the Puchappara section in the north.

Two distinct sub populations were identified on either side of Kunthipuzha river. Individuals were not observed crossing the river during the entire study period as there was no canopy continuity over the river. During the present study, 598 separate sightings of 2456 lion-tailed macaques were observed. Fourteen lion-tailed macaque troops were identified from the sub populations. They constituted 275 individuals when the field study was terminated

in 1996 (Table 1 & Fig 4). Two troops (AV and CHEI) had fissioned before the termination of the field study. There were eight troops inhabiting east of Kunthipuzha river having 147 individuals. Among the eight troops, two of them ranged outside the boundary of National Park in the Panthanthod beat of Attappady RJ?. The rest were distributed in Aruvampara, Sairandri, Punnamala and Valiyaparathod regions. The population residing west of Kunthipuzha river constituted 6 troops having 128 individuals. Their distributional range extended to Nilikkal, Chembotti and Puchappara areas. No troops could be located in the northern belt of evergreen forests especially in the north-eastern portion of the National Park.

Troop size

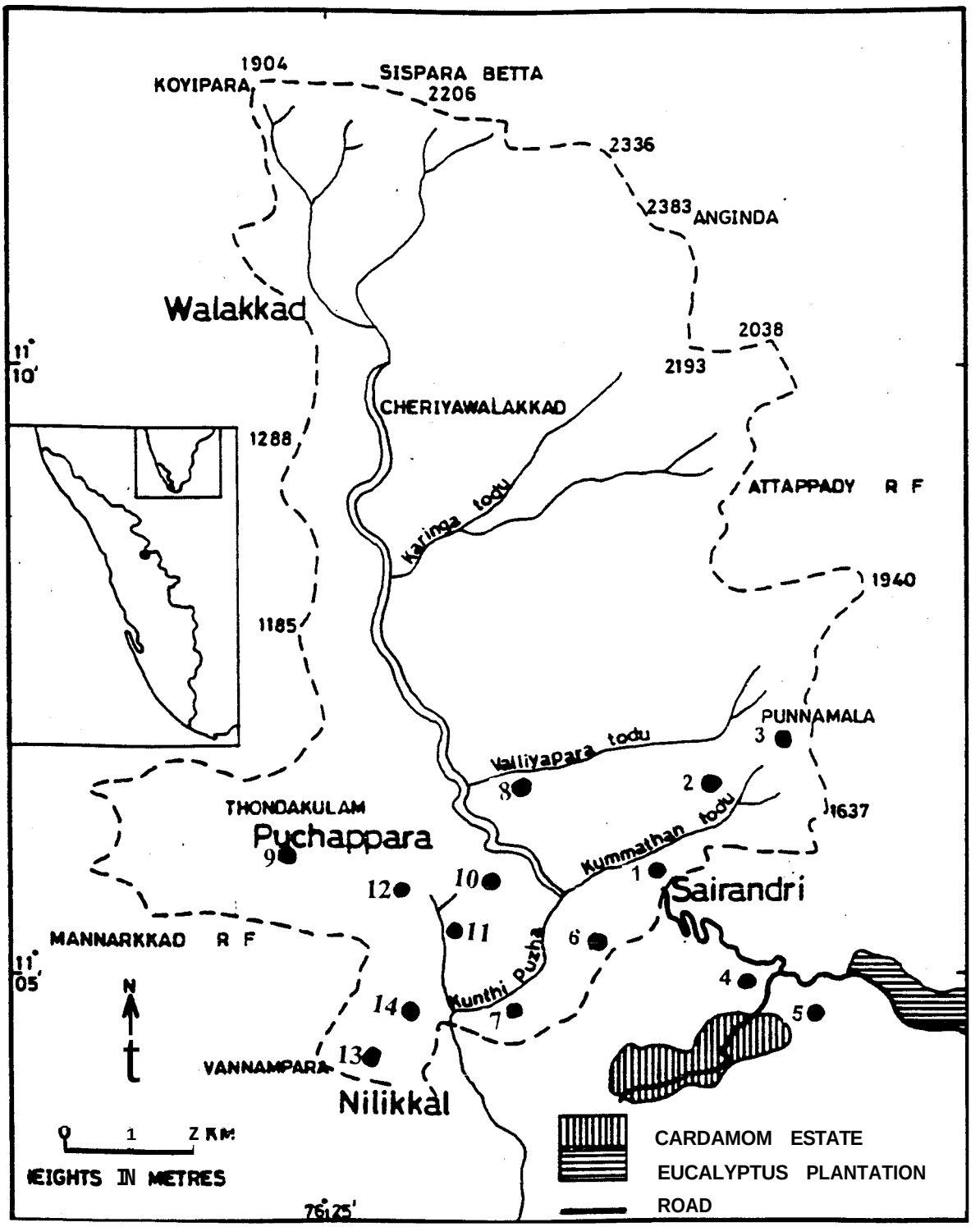
Data on troop size of lion-tailed macaque were generated from 14 troops monitored in the study period (Table 1). Continuously monitored troops showed variation in number within the troops. Troop size of main study troop (NKL I) increased from 28 in 1993 to 36 in 1996. A troop ranging mainly in the Sairandri section (SAI) increased from 29 in 1993 to 34 in 1996. A total of 6 troops (SAI, NKL I, PUN I. PAN I, PAR and PUC) increased their size considerably during the period referred (1993-1996). In two troops (AV, CHEI), one ranging in Aruvampara and the other in southern part of Chembotti regions, fission occurred towards the end of the study resulting the formation of 4 troops (AVI, AVII, CHE Ia and CHE Ib), Table 1. Demography of lion-tailed macaque troops in Silent Valley National Park

Troop size had increased in both of the parental troops from 1993 up to 1995. Two other troops were first located in 1994 (CHE II and NKL. II) and both troops showed an initial increase of two individuals each and remain unchanged in the gross troop size. One troop (PUN 11), located in Punnamala in 1995 with a troop size of 21 individuals also remained same till the termination of the study. A comparatively large troop (PAN II) with 21 individuals was observed in the Panthanthod beat of Attappady RF in 1993. A total of nine individuals from that troop were trapped and killed by tribals living in the nearby Karuvara settlement. This mishap occurred only once in the entire study period and the troops residing inside the National Park were completely free from any kind of poaching activities. The Panthanthod troop increased from 12 to 16 by 1996. The mean troop size of different troops varied from 7.5 to 31.5 individuals (Table 2). The least troop size was observed in the Parathod troop (PAR) and the highest in Chembotti (CHEI) troop. Towards the end of the study the latter fissioned to two troops. Average troop size computed for all the troops monitored was 19.24 individuals. The least number of individuals (6) were recorded form Parathod (PAR) troop in 1993 and the highest number of individuals (36) were recorded from the main study troop (NKL I) in 1996.

Table 1. Demography of lion-tailed macaque troops in Silent Valley National Park

Sl. No.	Troop name (Location)	AM	SAM	AF	SAF	J	I	CF	CI	Total
1.	SAI (Sairandri)	2	3	14	3	3	5	2	2	34
2.	PUN I (Punnamala)	2	2	9	-	3	2	1	1	20
3.	PUN II (Punnamala top)	1	1	6	1	6	4	1	1	21
4.	PAN I (Panthanthod)	2	1	8	1	3	3	1	1	20
5.	PAN II (Panthanthod)	1	1	4	-	4	2	2	2	16
6.	AV I (Aruvampara)	1	2	6	-	1	2	1	1	14
7.	AV II (Aruvampara)	1	-	2	-	3	1	3	3	13
8.	PAR I (Parathod)	1	-	2	1	1	-	2	2	9
9.	PUC (Puchappara)	1	1	6	2	4	2	-	-	16
10.	CHE Ia (Chembotti)	2	1	6	1	2	2	1	1	16
11.	CHE Ib (Chembotti)	2	1	10	1	4	2	-	-	20
12.	CHE II (Chembotti)	2	1	10	-	4	2	1	1	21
13.	NKL I (Nilikkal)	2	3	15	1	8	3	2	2	36
14.	NKL II (Nilikkal)	2	-	8	1	3	3	1	1	19
		22	17	106	12	49	33	18	18	275

SAM = Subadult male
AF = Adult female
SAF = Subadult female
J = Juvenile
I = Infant
CF = Cradling female
CI = Cradled infant



o Indicates location of lion-tailed macaque troops
Number given near location denote troop serial number given in Table 1

Fig. 4 Distribution of lion-tailed macaque troops in Silent Valley and adjacent areas

Table 2. Yearly variation in troop size and mean troop size of lion-tailed macaque

Troop	1993	1994	1995	1996	Mean
SAI	29	29	31	34	30.75
PUN I	15	15	17	20	16.75
PUN II	-	-	21	21	21.00
PAN I	12	14	18	20	16.00
PAN II	21	13	15	16	16.25
AV	20	20	22	-	20.70
PAR	6	7	8	9	7.50
PUC	12	15	16	16	14.75
CHE I	29	31	33	-	31.00
CHE II	-	19	21	21	20.30
NKL I	28	30	32	36	31.50
NKL II	-	17	19	19	18.30
AV I	-	-	-	14	14.00
AV II	-	-	-	13	13.00
CHE Ia	-	-	-	16	16.00
CHE Ib	-	-	-	20	20.00
	172	210	253	275	19.24

Troop composition

Proportion of different age and sex classes in a troop make the troop composition. Data for the troop composition come from 14 troops censused in the final year of the study (1996).Troop composition for different age and sex classes are shown in Figure 5. Among the 275 individuals observed 8% were adult males. A total of 45% were adult females. Subadult males constituted 6%. Subadult females, juveniles, infants and cradled infants were grouped under immature class, and their proportion shared 41% of the total population.

Sex ratio

Sex ratio of the sexually mature individuals showed a higher number of females for all the troop studied. The sex ratio varied form 3.50 (PAR, CHE Ia) to 8.38 in the main study troop (NKL I). Average male-female ratio for all the troops were estimated as

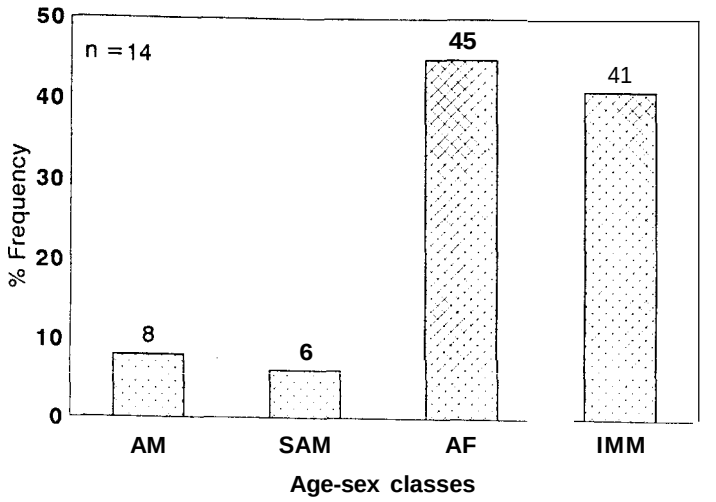


Fig. 5 Troop composition of lion-tailed macaque

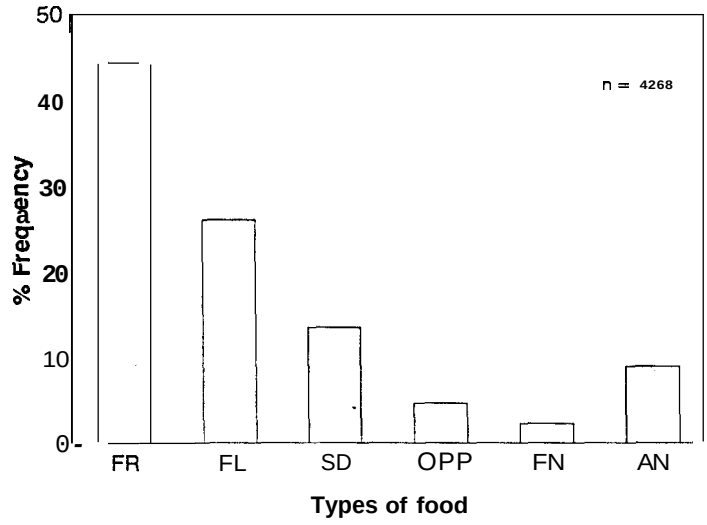
Food and feeding

Elements of the diet

The lion-tailed macaque feeds on a variety of food items both plant and animal origin. The main food types identified are fruits (fruit, pulp and mesocarp) seeds, flowers, other plant parts such as leaves, bark, nectar, resins, and arthropods comprising mainly insects. Occasionally the diet includes fungi and lichen species. Figure 6 shows the proportion of different types of food eaten from observations made using the instantaneous scan sampling.

Monthly variation in diet

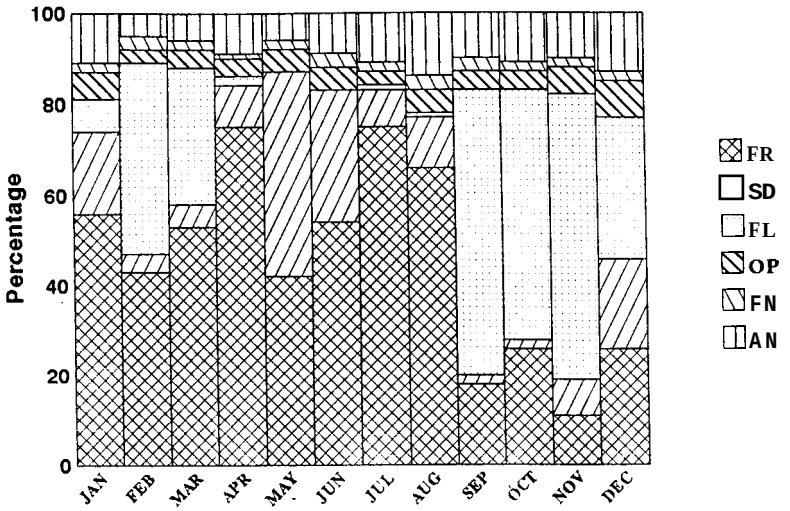
Diet of lion-tailed macaque varied considerably between months. Monthly variation in type of food consumed is shown in Figure 7. Fruit feeding was higher than all other items from January to August except the month of May.



FR=Fruit, FL= Flower, SD= Seed, OPP=Other plant parts, FN= Fungi, AN= Animal matter

Fig. 6 Dietic composition of lion-tailed macaque

Highest proportion of fruit feeding was observed in April (74.9%) followed by July (74.55%). In September, there was a decline in fruit feeding and remained less up to December. The variation in fruit feeding between the months was statistically significant (X^2 = 570; df = 11; p <.001).Two peaks for flower feeding, one in February (42%) and other one in November (64%) were observed. Flower feeding was not observed during May and June but dominated over all other food items from September to December. Monthly variation was found statistically significant (X^2 = 361; df = 11; p <.001). Seed feeding recorded highest in May (45%) and least in October (1.94%). Even-though seed feeding occurred in all months significant variation (X^2 = 712; df = 11; p < .001)was noticed between months. Proportion of other plant parts were found more or less uniform in the diet. Their proportion vaned from 3% to 8% (December) in the diet. However, the variation was statistically signifi-cant(X^2 = 29; df = 11; p <.01).There occurred little variation in feeding fungi



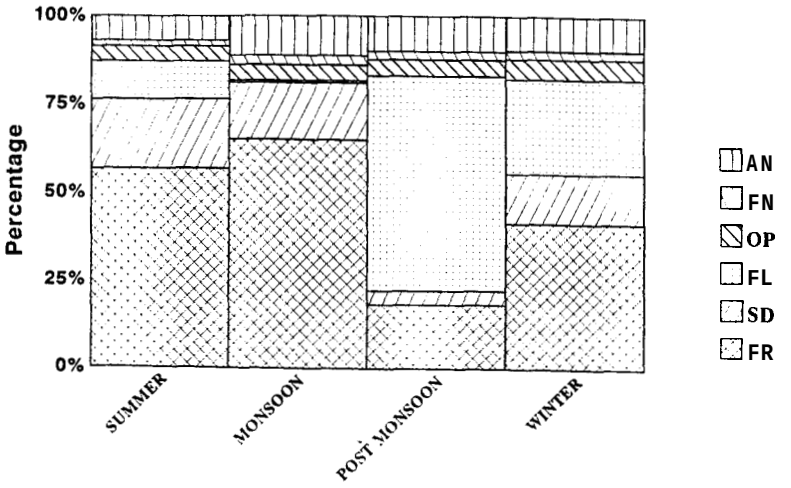
FR=fruit, SD=seed, FL=flower, OP=other plant parts, FN=fungi, AN=animal mailer

Fig. 7 Monthly variation of different food types of LTM

(mushroom) and lichen species in various months. No significant variation was noticed between the months. Animal matter in the diet of lion-tailed macaque varied from 5% to 14% in various months. The highest proportion was recorded in August, followed by December (13%) and the least in February. However, the variation was statistically significant ($X^2 = 29$; df = 11: $p < .01$).

Seasonal variation in diet

Variation was observed in the dietic elements between different seasons (Fig. 8). Fruit feeding was observed higher in all seasons except in post monsoon season (18.33%).The highest proportion of fruit feeding was noticed in monsoon season (65%).Variation between the seasons was statistically



FR=fruit, SD=seed, FL=flower, OP=other plant parts, FN=fungi, AN=Animal matter

Fig. 8 Seasonal variation of different food types of LTM

significant (X^2 = 398; df = 3; p <.001).Seed feeding was found moderate in all seasons except in post monsoon. The post monsoon season had the lowest proportion (4%) and the highest in summer (19.67%). However, significant variation (X^2 = 200; df = 3; p <.001)was observed between different seasons. Flower feeding varied considerably among different seasons ranging from 0.67% to 60.67% (post-monsoon) in the total diet. A remarkably higher proportion of flower feeding was observed in the post monsoon season when compared to all other seasons. The variation was statistically significant (X^2 = 344; df = 3; p <.001).The frequency of other plant parts also exhibited significant variation in different seasons (X^2 = 15; df = 3; p <.05). However, the proportion of mushrooms and lichens in the diet of lion-tailed macaque was found lesser when compared to all other food items and the seasonal difference was not significant. Animal feeding ranged from 7% (summer) to 11.33% (winter) in the diet, and the variation was statistically significant (X^2 = 8; df = 3; p < 0.05).

Food plants

Plant foods relatively dominated over animal foods in the diet of lion-tailed macaque. The former included the products of trees, shrubs, lianas, fungi and lichens. Mostly the reproductive parts of the plant species were used in the diet rather than the vegetative parts. Ninety two plant species were utilized for food including 62 trees, 10 lianas, eight shrubs, six fungi three lichen and three parasitic plant species (Table 3). Among the trees *Cullenia exarillata* was the most extensively used species both for seeds and flowers. Half matured seeds were preferred by the macaques.

The diet included four Ficus species namely *Ficus beddomei*, Ficus nervosa, Ficus *microcarpa* and *Ficus tsjahela* Of which, the first three species were extensively used in the diet and ranked in the top ten food species (APPENDIX I). The other high ranking food species included *Palaquium ellipticum, Drypetes elata, Macaranga indica, Elaeocarpus tuberculatus, Turpinia malabarica*, and *Syzygium cumini* . Among the ten lianas, *Tetrastigma solcatum, Calamus sp. Toddalia asiatica, Embelia ribes* and *Salacia fruticosa* were rather highly preferred when compared with other lianas. Major feeding shrubs included *Maesa indica, Lantana camara, Polygonum chinensis, Solanum* sp. and *Flemingia* sp. Lion-tailed macaques were observed to feed on the fruits of three parasitic species namely *Helixanthera obtusata, Helixanthera wallichiana* and *Viscum angulatum.*

Monthly variation in the number of food species

Lion-tailed macaque thrives on a variety of plant species in its rainforest habitat. There occurred monthly variation in the number of food species. It varied from twelve in September to twentyeight in the month of April (Table4). An average of 21 species were used in every month during the period of observation.

Seasonal variation in the number of food species

Greater number of plant species were utilized in monsoon season (23.34). followed by winter (22.00).The least number of food species (17.34)were used in post monsoon season (Table 5). Mean number of plant species in 1994-95 (22.25) was higher than the following year (19.75).

Table 3. Food species and their relative frequency in the diet of lion-tailed macaque

sl. No.	Species	Family	Feeding records	Per-
1.	*Cullenia exarillata*	Bombacaceae	822	20.74
2.	*Palaquium ellipticum*	Sapotaceae	308	7.40
3.	*Ficus beddomei*	Moraceae	230	5.52
4.	*Drypetes elata*	Euphorbiaceae	166	3.99
5.	*Macaranga indica*	Euphorbiaceae	151	3.63
6.	*Elaeocarpus tuberculatus*	Elaeocarpaceae	122	2.93
7.	*Ficus microcarpa*	Moraceae	114	2.74
8.	*Turpinia malabarica*	Staphyleaceae	110	2.64
9.	*Syzygium cumini*	Myrtaceae	106	2.55
10.	*Ficus nervosa*	Moraceae	103	2.47
11.	*Artocarpus heterophyllus*	Moraceae	98	2.35
12.	*Syzygium gardineri*	Myrtaceae	93	2.23
13.	*Mangifera indica*	Anacardiaceae	84	2.02
14.	*Tetrastigma sulcatum*	Vitaceae	79	1.90
15.	*Persea macrantha*	Lauraceae	52	1.25
16.	*Litsea floribunda*	Lauraceae	49	1.18
17.	*Aglaia lawii*	Meliaceae	44	1.06
18.	*Mesua ferrea*	Clusiaceae	35	0.84
19.	*Xanthophyllum flavescens*	Xanthophyllaceae	32	0.77
20.	*Myristica dactyloides*	Myristicaceae	28	0.67
21.	*Hopea glabra*	Dipterocarpaceae	28	0.67
22.	*Bischofia javanica*	Euphorbiaceaze	28	0.67
23.	*Elaeocarpus glandulosus*	Elaeocarpaceae	27	0.64
24.	*Syzygium laetum*	Myrtaceae	23	0.55
25.	*Elaeocarpus munronii*	Elaeocarpaceae	23	0.55
26.	*Calophyllum polyanthum*	Clusiaceae	23	0.55
27.	*Apodytes dimidiata*	Icacinaceae	23	0.55
28.	*Calamus* sp.	Palmae	22	0.53

Tab3contd...

Tab 3 contd ...

sl. No.	Species	Family	Feeding records	Per-centage
29.	*Dimocarpus longan*	Sapindaceae	20	0.48
30.	*Canarium strictum*	Burseraceae	19	0.46
31.	*Caryota urens*	Palmae	18	0.43
32.	*Lantana camara*	Verbenaceae	18	0.43
33.	*Apobnias arnotii*	Laurac eae	18	0.43
34.	*Helixanthera obtusata*	Loranthaceae	18	0.43
35.	*Antidesma menasu*	Euphorbiaceae	18	0.43
36.	*Measa indica*	Myrsinaceae	18	0.43
37.	*Cinnamomum malabatrum*	Lauraceae	18	0.43
38.	*Allophyllus rheedi*	Sapindaceae	18	0.43
39.	*Cassine kedharnathi*	Celastraceae	17	0.41
40.	*Garciniamorella*	Clusiaceae	16	0.38
41.	*Agrostistachys meeboldi*	Euphorbiaceae	14	0.33
42.	*Symplocos cochinchinensis*	Symplocaceae	14	0.33
43.	*Glochidion arboreum*	Euphorbiaceae	13	0.31
44.	*Toddalia asiatica*	Rutaceae	12	0.29
45.	*Embelia ribes*	Myrsinaceae	12	0.29
46.	*Polygonum chinensis*	Polygonaceae	12	0.29
47.	*Holigama nigra*	Anacardiaceae	12	0.29
48.	*Gomphandra coriacea*	Icacinaceae	11	0.26
49.	*Salacia-fructicosa*	Hippocarateaceae	11	0.26
50.	*Cryptocarya bourdiloni*	Lauraceae	10	0.24
51.	*Casearia esculenta*	Flacourteaceae	10	0.24
52.	*Zizyphus rugosa*	Rhamnaceae	10	0.24
53.	*Ficus tsjahela*	Moraceae	10	0.24
54.	*Olea dweca*	Oleaceae	9	0.22
55.	*Hydnocarpus alpina*	Flacourtaceae	9	0.22
56.	*Solanum* sp.	Solanaceae	8	0.19
57.	*Mucuna pruriens*	Fabaceae	8	0.19
58.	*Flemingia* sp.	Fabaceae	8	0.19

*Tab **3 contd...***

Tab 3 contd...

Sl. No.	Species	Family	Feeding records	Per-centage
59.	*Litsea laevigata*	Lauraceae	7	0.17
60.	*Viscum angulatum*	Viscaceae	7	0.17
61.	*Garcinia gummi-gutta*	Clusiaceae	6	0.14
62.	*Achronychia pedunculata*	Rutaceae	5	0.12
63.	*Helixanthera wallichiana*	Loranthaceae	5	0.12
64.	*Meliosma pinnata*	Sabiaceae	5	0.12
65.	*Knema attenuata*	Myristicaceae	5	0.12
66.	*Syzygium mundagam*	Myrtaceae	5	0.12
67.	*Eletteria cardamomum*	Zingiberaceae	4	0.10
68.	*Canthium dicoccum*	Rubiaceae	4	0.10
69.	*Ligustrum perrottetii*	Oleaceae	3	0.07
70.	*Ardisia stonii*	Myrsinaceae	2	0.05
71.	*Lasianthus jackianus*	Rubiaceae	2	0.05
72.	*Fahrenheitia zeylanica*	Euphorbiaceae	2	0.05
73.	*Litsea oleodes*	Lauraceae	2	0.05
74.	*Chaionathes* sp.	Oleaceae	2	0.05
75.	*Dysoxylum* sp.	Meliaceae	2	0.05
76.	*Dioscorea* sp.	Dioscoraceae	2	0.05
77.	*Clausena dentata*	Rutaceae	1	0.02
78.	*Aristolochia* sp.	Aristolochiaceae	1	0.02
79.	*Neolitsea scrobiculata*	Lauraceae	1	0.02
	Unidentified (4 species)	--	6	0.14
	Mushroom (6 species)	--	88	2.11
	Lichens (3 species)	--	4	0.10
	Moss plant	--	7	0.17
	Other plant parts	--	166	3.99
	Animal foods	--	388	9.09
			4164	100.00

Table 4. Monthly variation in the number of food species of lion-tailed macaque

Months	Number of plant species used			Mean
	1994	1995	1996	
January	nd	18	23	20.5
February	nd	27	21	24.0
March	nd	23	24	23.5
April	18	28	nd	23.0
May	17	18	nd	17.5
June	21	19	nd	20.0
July	28	23	nd	25.5
August	26	23	nd	24.5
September	18	12	nd	15.0
October	18	12	nd	18.5
November	16	21	nd	18.5
December	25	18	nd	21.5
Mean	20.89	20.67	22.67	21.00

nd = no data

Table 5. Seasonal variation in the number of food species of lion-tailed mecaque

Season	Number of plant species used		Mean
	1994-95	1995-96	
Monsoon	25.00	21.67	23.34
Postmonsoon	17.67	17.00	17.34
Winter	23.33	20.67	22.00
Mean	22.25	19.75	21.00

Home range size

Home range size of lion-tailed macaque in Silent Valley National Park was estimated from the date taken along with instantaneous scan observations from the main study troop I) at Nilikkal. In 1994-95 the study group entered 240 different quadrats. In the following year the study group utilized

29 new quadrats. However, they did not enter 27 quadrats in which they had ranged in the previous year. Thus the average home range size of lion-tailed macaque in the rainforest habitats of Silent Valley was estimated as 2.41 km^2.

Monthly variations in the home range use

Monthly variation in the usage of quadrats were given in Table 6. The number of quadrats varied considerably among months. The variation was statistically significant ($X^2 = 82$, df = 11, $P < 0.001$) in 1994-95, whereas in the following year it was not significant. However, the mean monthly variation of the number of quadrats was found statistically significant ($X^2 = 28$, df = 11, $P < 0.001$). The number of quadrats used varied from 38 (June) to 109 (February) in 1994-95, whereas in 1995-96, it was ranging from 63 (September) to 100 (November). Monthly average of the number of quadrats entered by the study group varied from 68.67 quadrats in 1994-95 to 83.58 quadrats in 1995-96 with an absolute average of 76.13 quadrats per month.

Table 6. Monthly variation in the total quadrats used

Month	No. of quadrats used		Mean
	1994-95	1995-96	
January	104.0	91.0	97.5
February	109.0	81.0	95.0
March	81.0	99.0	90.0
April	65.0	71.0	68.0
May	50.0	71.0	60.5
June	38.0	88.0	63.0
July	54.0	81.0	67.5
August	57.0	80.0	68.5
September	57.0	63.0	60.0
October	58.0	87.0	72.5
November	58.0	100.0	79.0
December	93.0	91.0	92.0
Mean	68.7	83.6	76.2

Seasonal variation in the home range use

Table 7 shows the difference in the number of quadrats used in different seasons. Significant variation was noticed between the season in 1994-95, ($X^2 = 71$, df = 3, $P < 0.001$) in 1995-96 ($X^2 = 19$, df = 3, $P < 0.001$) as well as

in the average number ($X^2 = 34$, df = 3, $P < 0.001$). Number of quadrats used were greater in winter and lesser in summer season in both the years. An average of 184 quadrats were utilized in winter while in summer only 92 quadrats were utilized.

Table 7. Seasonal variation in the total quadrats used

Season	No. of quadrats used		Mean
	1994-95	1995-96	
Summer	87.0	97.0	92.0
Monsoon	101.0	153.0	127.0
PostMonsoon	97.0	140.0	118.5
Winter	202.0	166.0	184.0
Mean	121.8	139.0	130.4

Day Range length

Day range length of lion-tailed macaques varied from 1.41 km to 3.43 km in 1994-95 having a mean of 2.28 km (Table 8). In the following year (1995-96) it varied from 1.65 km to 3.55 km with an average distance of 2.68 km (Table 9). The overall mean of day range length estimated was 2.48 km per day in its contiguous habitat.

Table 8. Monthly variation in day range length during 1994-95

Month	Day range length (km)		Mean
	Maximum	Minimum	
January	3.16	2.45	2.80
February	3.43	2.59	3.17
March	3.25	2.40	2.98
April	3.11	1.52	2.44
May	2.29	1.72	2.00
June	1.62	1.41	1.53
July	1.91	1.52	1.80
August	2.15	1.32	1.86
September	2.31	1.75	2.01
October	2.43	1.41	1.89
November	2.87	1.82	2.26
December	2.77	2.51	2.69

Table 9. Monthly variation in day range length during 1995-96

Month	Day range length (km)		Mean
	Maximum	Minimum	
January	3.39	1.86	2.71
February	3.31	2.56	2.94
March	3.35	2.77	3.04
April	2.99	2.24	2.67
May	2.90	2.43	2.70
June	2.80	1.65	2.42
July	2.73	1.83	2.35
August	3.01	1.85	2.48
September	3.01	1.75	2.31
October	3.11	1.81	2.54
November	3.13	2.56	2.94
December	3.55	2.15	3.10

Monthly variation in day range length

Monthly variation occurred in day range length in both of the study years. Highest mean day range length was recorded in February (3.17 km) in 1994-95 and minimum in June (1.53 km). While in 1995-96, maximum was recorded in December (3.10 km) and minimum in September (2.31 km). Day range length was estimated higher in all the months in 1995-96 except in January and February.

Seasonal variation in day range length

Day range length vaned in different seasons in both of the years under study. Maximum mean day range length estimated in 1994-95 was 2.92 km in winter season and minimum in monsoon (1.73 km). In 1995-96 also maximum day range length was found in winter season (2.92 km) followed by summer (2.78 km) and minimum in monsoon (2.42 km).

NILGIRI LANGUR (*Trachypithecus johnii*)

Distribution

The Nilgiri langur was distributed in the entire stretch of evergreen forests, semi-evergreen forests and moist deciduous forests in the fringes of the

National Park. They were distributed all over the forested areas irrespective of the different tree associations in the rainforest ecosystems of Silent Valley National Park. The langur was observed in the montane shola at 2150 m altitude. They were adapted to thrive well in the sholas and evergreen forests. Most of the troops were sighted between 700 m to 1600 m elevation. These altitudinal range include areas like Sairandri, Nilikkal, Puchappara and Walakkad. Apart from these areas Panthanthod beat of the Attappady Reserved Forest having evergreen, semi-evergreen and moist deciduous patches hold a very good population of this primate. The troops were also sighted in the moist deciduous forest patches of Mannarkkad Forest Division in the southwestern region bordering the National Park. They were found along with common langur *(Semnopithecus entellus)* troops ranging in the steep gorges having deciduous vegetation adjacent to the southwestern border of the National Park. Frequent whooping calls of Nilgiri langur were heard from the forests of the Nilambur South forest division bordering the northwestern region of the National Park.

Figure 9 shows the distribution of Nilgiri langur troops in Silent Valley and adjacent areas. Eighty five different troops were identified. Among the 85 troops, 69 were ranging well inside the boundaries of the National Park, while the rest of the troops (16 nos.) were sighted from adjacent forest areas. Five troops were observed from the high altitude regions in Sispara having more than 2000 m elevation. Of which, two troops were found ranging in the montane sholas.

A total of 501 individuals were recorded form 85 troops surveyed in the final census. Of which, Sairandri and Puchappara sections hold the majority of the population. The former area hold 27 troops with 154 individuals, while the latter had 18 troops with 124 individuals (Table 10). Twelve different troops including the two troops in the border areas were observed in the Nilikkal section. They constitute 78 individuals. Fifteen troops having 72 individuals were observed in Walakkad section. A total of 13 troops having

Table 10. Distribution of Nilgiri langur troops in Silent Valley and adjacent areas

Sl. No.	Location	No. of troops	No. of individuals
1.	Sairandri	27	154
2.	Puchappara	18	124
3.	Nilikkal	12	78
4.	Walakkad	15	72
5.	Panthanthod	13	73
	Total	85	501

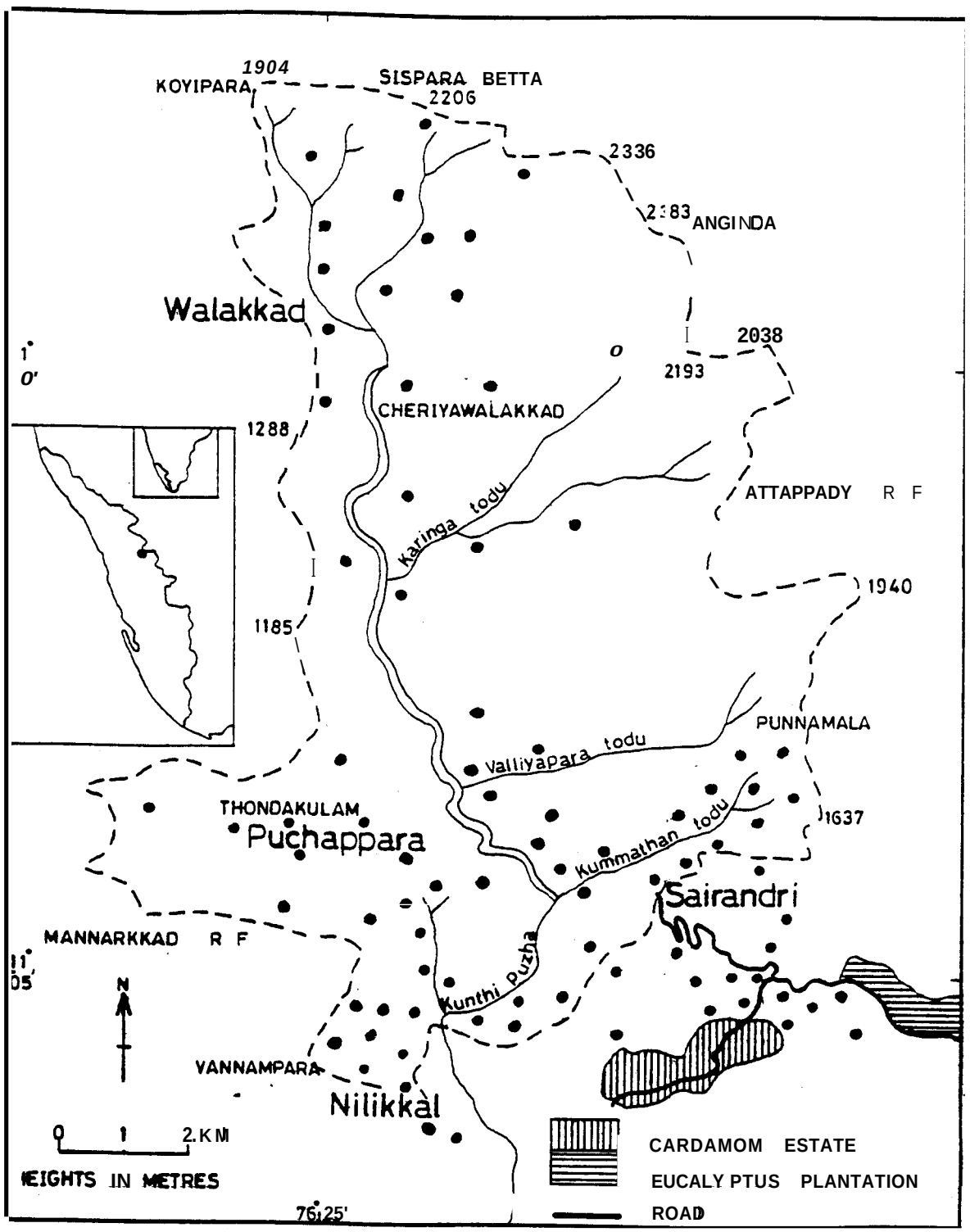


Fig. 9 Distribution of Nilgiri troops in Silent Valley and adjacent areas

73 individuals were found in the Panthanthod beat of the Attappadi RF bordering the south-eastem portion of the National Park.

Troop size

Troop size varied form one individual to 12. Average troop size estimated was 5.89 individuals in Silent Valley forests. Seven troops were having more than 10 individuals. Two troops, one ranging in Nilikkal section and the other one in Puchappara section, were having 12 individuals. Figure 10 shows the frequency of different troop size classes. Eight solitary individuals were frequently sighted in different areas. Majority of the troops (50.59%) were having 6 to 9 individuals.

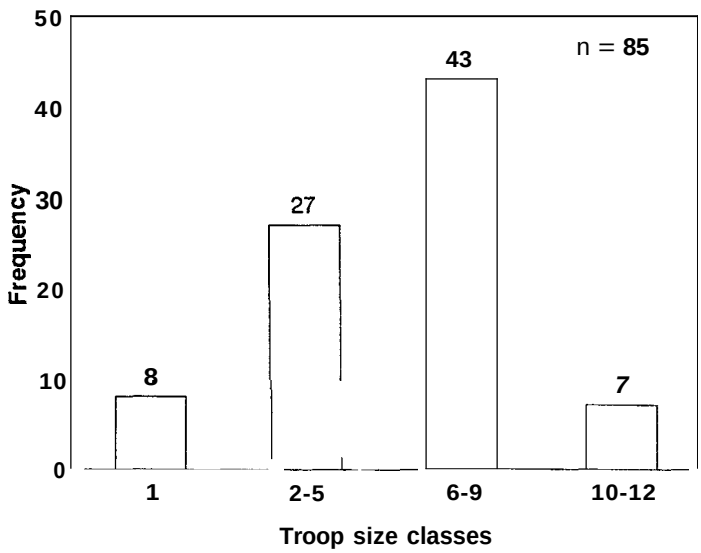
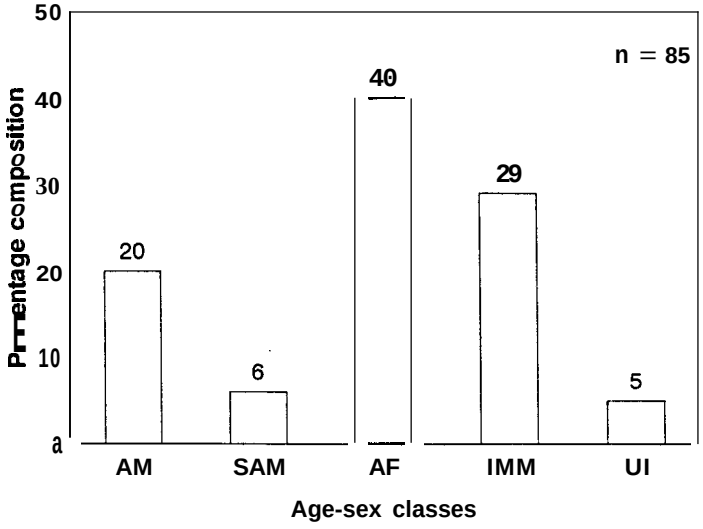


Fig. 10 Troop size of Nilgiri

Troop composition

Data for the troop composition was taken form 85 troops censused before the termination of the field study in 1996. Figure 11 shows the proportion of

different age-sex classes in the population. Proportion of adult females dominated over other age-sex classes. They contributed 40% of the total population. Adult males constituted 20% and subadult males 6%. Subadult females, juveniles, infants and cradled infants together formed the immature class and their proportion was 29%. Five percent of the individuals could not reliably be sexed during the census and have been clubbed under unidentified class.



AM = Adult male; AF = Adult female: SAM = Sub adult male; IMM = immature; UI = Unidentified

Fig. 11 Troop composition of Nilgiri langur

Sex ratio

Data for the estimation of sex ratio was taken from the 85 monitored troops. Among the sexually identified 302 individuals, 33% were adult males and 67% were adult females. The adult male-female ratio estimated was 1:2. While combining the sexually known subadult male and subadult female to their respective sex classes the male-female ratio fluctuated to 1:1.62.

Food and feeding behaviour

Elements of the diet

Nilgiri langur is a folivore feeding mainly on foliage (Appendix II). They feed on a variety of other food items such as fruits, seeds, flowers, bark, mushrooms etc. Rarely Nilgiri langur feeds on animal matter. Figure 12 shows the proportion of different food items observed in the diet of Nilgiri langur. Proportion of leaves dominated (62%) over other food items. Flowers constituted 10% of the diet. Fruits and seeds shared 14% each. Occasionally they were found feeding on petioles, bark and small twigs. Rarely, the langurs fed on insects under the dry bark of dead trees. They were also found to feed on mushrooms from the dry branches. On three occasions, they descended down and fed soil from the ground.

Fig. 12 Proportion of different food types in the diet of Nilgiri langur

Monthly variation in diet

There occurred monthly variation in the dietic composition of Nilgiri langur. Leaf feeding was observed higher in almost all months except in the month ofApril and June (Figure 13).The highest proportion of foliage in the diet was recorded for the month of January (83%), followed by November (72%)and the lowest was in June (30%).The monthly variation in the frequency of foliage feeding was statically significant (X^2 = 85, df = 11 p < 0.001). Significant variation occurred also in the frequency of flowers in the diet (X^2 = 68, df = 11 p < 0.001).

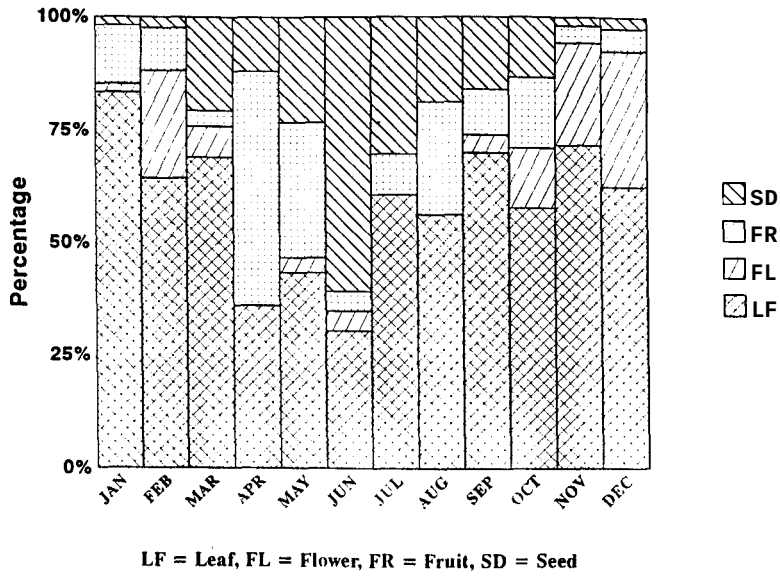


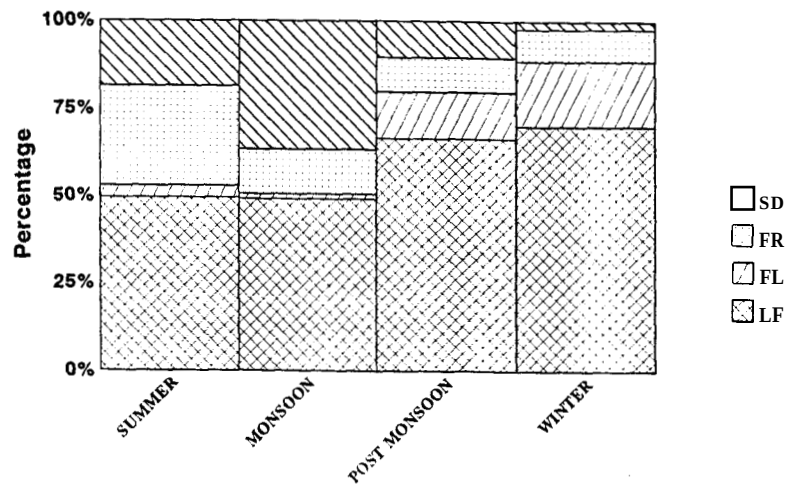
Fig. 13 Monthly variation in dietic composition of Nilgiri langur

The highest percentage composition of flower in the diet was noticed in December (30%) followed by February (24%). Flower feeding was not observed in April, July and August. Fruit feeding occurred in all the months. In April, fruits dominated (52%) in the diet. The proportion of fruits in the diet ranged

from 3.45% (March)to 52% in various months. The variation was statistically significant ($X^2 = 42$, df = 11 $p < 0.001$).Dietic elements included seeds in all the months. Monthly variation in the proportion of the seeds in the diet was notable. It varied from 2% in January, to 61% in June. The variation was statistically significant ($X^2 = 42$. df = 11 $p < 0.001$).

Seasonal variation in the diet

Figure 14 shows the pattern of seasonal variation in the diet of Nilgiri langur. When months were combined into seasons the various elements of the diet showed variation in different seasons. Percentage composition of foliage had a dominance on other food types in all seasons. Its proportion varied from 49% in monsoon season to 70% in winter season. The variation was statistically significant ($X^2 = 56$, df = 3, $p < 0.001$)) Flower feeding showed significant variation ($X^2 = 38$, df = 3, $p < 0.001$) over different seasons. Proportion of



LF = Leaf, FL = Flower, FR = Fruit, SD = Seed

Fig. 14 Seasonal variation in dietic composition of Nilgiri langur

flowers in the diet varied from 1.46% in monsoon to 19% in winter. The post monsoon season also had a fairly good proportion (13%) of flowers in the diet. Fruit feeding was more in summer season (28%) and less in winter (9%). The variation was found not significant ($X^2 = 3$, df = 3, $p > 0.05$). The proportion of fruits in the diet gradually decreased from summer season to winter. Seed feeding was maximum in monsoon season (37%) followed by summer (19%). The proportion of seeds in the diet was minimum in winter season (2%). Seasonal variation in the frequency of seed feeding was found statistically significant ($X^2 = 25$, df = 3, $p < 0.001$).

Food plants of Nilgiri langur

Nilgiri langur was observed feeding on a variety of plant species during the study period. Table 11 shows the various food species and their relative frequency in the diet. Eighty nine food species were identified from the *ad-libitum* observations for a period of three years. They include 72 tree species, 7 shrubs, 7 lianas, one herb *(Impatiens* sp.), one reed *(Ochlandrasp.)* one plant parasite *(Helixanthera obtusata)* and a mushroom species.

The major food species of Nilgiri langur were *Cullenia exarillata, Palaquium ellipticum, Myristica dactyloides, Syzygium laetum, Bischofia javanica, Garcinia morella, Mesua ferrea,* Ficus *beddomei, Drypetes elata* and *Elaeocarpus tuberculatus.* The shrubs utilized for food include *Nilgirianthus* sp., *Leea indica, Ardisia stonii, Polygonum chinensis, Zizyphus rugosa, Ixora* sp. and *Lasianthus jackianus. Thunbergia mysorensis, Polyscias acuminata, Aristolochia tagala, Salacia fruticosa, Erythropalum populifolium, Piper nigrum,* and *Tetrastigma sulcatum* were the lianas utilized.

A total of 45 plant families were represented in the diet. Euphorbiaceae was the most widely used (eight species) followed by Lauraceae (seven species), Clusiaceae and Myrtaceae (five species each). However, 27 families were represented with a single species.

Monthly variation

Monthly variation in the different food species of Nilgiri langur is given in Appendix 11. Utilization of different species overlapped between months. Variation was noticed in the number of food species in various months (Table 12). It varied from two in 1993 (June) to 28 in 1995 (August). The average number of food species varied from 5.00 (June) to 14.67 (September) in different years. The overall mean number of food species recorded was 10.74 species per month.

Table 11. Food species and their relative frequency in the diet of Nilgiri langur

Sl. No.	Species	Family	Feeding records	Per-centage
1.	*Cullenia exarillata*	Bombacaceae	67	13.40
2.	*Palaquium ellipticum*	Sapotaceae	35	7.00
3.	*Myristica dactyloides*	Myristicaceae	26	5.20
4.	*Syzygium laetum*	Myrtaceae	24	4.80
5.	*Bischofia javanica*	Euphorbiaceae	19	3.80
6.	*Garcinia morella*	Clusiaceae	14	2.80
7.	*Mesua ferrea*	Clusiaceae	12	2.40
8.	*Ficus beddomei*	Moraceae	12	2.40
9.	*Drypetes elata*	Euphorbiaceae	12	2.40
10.	*Elaeocarpus tuberculatus*	Elaeocarpaceae	11	2.20
11.	*Litsea floribunda*	Lauraceae	11	2.20
12.	*Calophyllum polyanthum*	Clusiaceae	10	2.00
13.	*Cinnamomum malabatrum*	Lauraceae	10	2.00
14.	*Macaranga indica*	Euphorbiaceae	10	2.00
15.	*Syzygium cumini*	Myrtaceae	10	2.00
16.	*Xanthophyllum flavescens*	Xanthophyllaceae	9	1.80
17.	*Ficus nervosa*	Moraceae	8	1.60
18.	*Syzygium mundagam*	Myrtaceae	8	1.60
19.	*Olea dioica*	Oleaceae	8	1.60
20.	*Dimocarpus longan*	Sapindaceae	8	1.60
21.	*Symplocos cochinchinensis*	Symplococeae	8	1.60
22.	*Turpenia malabarica*	Staphyleaceae	8	1.60
23.	*Apodytes dimidiata*	Icacinaceae	6	1.20
24.	*Gomphandra coriacea*	Icacinaceae	6	1.20
25.	*Mangifera indica*	Anacaradiaceae	6	1.20
26.	*Canarium strictum*	Bursaraceae	5	1.00
27.	*Antedesma menasu*	Euphorbiaceae	5	1.00
28.	*Ficus microcarpa*	Moraceae	5	1.00
29.	*Ochlandra* sp.	Poaceae	5	1.00
30.	*Thunbergia mysorensis*	Acanthaceae	5	1.00

Tab ***11 contd....***

Tab 11 contd....

Sl. No.	Species	Family	Feeding records	Per-centage
31.	*Garcinia gummi-gutta*	Clusiaceae	4	0.80
32.	*Actinodaphne bourdilloni*	Lauraceae	4	0.80
33.	*Clerodendrum viscosum*	Verbanaceae	4	0.80
34.	*Elaeocarpus munroni*	Elaeocarpaceae	4	0.80
35.	*Persea macrantha*	Lauraceae	4	0.80
36.	*Litsea laevigata*	Lauraceae	4	0.80
37.	*Syzygium munroni*	Myrtaceae	4	0.80
38.	*Clausena indica*	Rutaceae	3	0.60
39.	*Acronychia pedunculata*	Rutaceae	3	0.60
40.	*Elaeocarpus glandulosus*	Elaeocarpaeae	3	0.60
41.	*Fahrenheitia zeylanica*	Euphorbiaceae	3	0.60
42.	*Maesa indica*	Myrsinaceae	3	0.60
43.	*Neolitsea scrobiculata*	Lauraceae	3	0.60
44.	*Nothopodytes nimmoniana*	Icacinaceae	3	0.60
45.	*Salacia fructicosa*	Hippocrateaceae	3	0.60
46.	*Terminalia bellirica*	Combretaceae	3	0.60
47.	*Debregeasia longifolia*	Urticaceae	2	0.40
48.	*Casearia esculenta*	Flacourteaceae	2	0.40
49.	*Aphanamyxis polystachya*	Meliaceae	2	0.40
50.	*Apollonias arnottii*	Lauraceae	2	0.40
51.	*Cassine kedamathi*	Celastraceae	2	0.40
52.	*Eurya nitida*	Theaceae	2	0.40
53.	*Holigarna nigra*	Anacardiaceae	2	0.40
54.	*Impatiens* sp.	Balasaminaceae	2	0.40
55.	*Drypetes oblongifolia*	Euphorbiaceae	2	0.40
56.	*Knema attenuata*	Myristicaceae	2	0.40
57.	*Lasianthes jackianus*	Rubiaceae	2	0.40
58.	*Ligustrum perrottetii*	Oleaceae	2	0.40
59.	*Piper nigrum*	Piperaceae	2	0.40
60.	*Prunus zeylanicus*	Rosaceae	2	0.40
61.	*Nilgirianthus* sp.	Acanthaceae	2	0.40
62.	*Syzygium gardneri*	Myrtaceae	2	0.40

Tab 11 contd....

Tab 11 ***contd....***

Sl. No.	Species	Family	Feeding records	Per-centage
63.	*Tetrastigma sulcatum*	Vitaeceae	2	0.40
64.	*Vernonia arborea*	Asteraceae	2	0.40
65.	*Zizyphus rugosa*	Rhamnaceae	2	0.40
66.	*Ardisia stoni*	Myrsinaceae	1	0.20
67.	*Aristolochia tagala*	Aristolochaceae	1	0.20
68.	*Aglaia lawii*	Meliaceae	1	0.20
69.	*Agrostistachys meeboldi*	Euphorbiaceae	1	0.20
70.	*Allophyllus rheedi*	Sapindaceae	1	0.20
71.	*Callicarpa tomentosa*	Verbenaceae	1	0.20
72.	*Canthium dicoccum*	Rubiaceae	1	0.20
73.	*Chionanthes intermedia*	Oleaceae	1	0.20
74.	*Dysoxylum* sp.	Meliaceae	1	0.20
75.	*Erythropalum populifolium*	Olacaceae	1	0.20
76.	*Erythroxylum monogynum*	Erythroxylaceae	1	0.20
77.	*Ficus tsjahela*	Moraceae	1	0.20
78.	*Glochidion fagifolium*	Euphorbiaceae	1	0.20
79.	*Hopea glabra*	Dipterocarpaceae	1	0.20
80.	*Hydnocarpus alpina*	Flacourtaceae	1	0.20
81.	*Ixora* sp.	Rubiaceae	1	0.20
82.	*Leea indica*	Leeaceae	1	0.20
83.	*Helixanthera obtusata*	Loranthaceae	1	0.20
84.	*Meliosma pinnata*	Sabiaceae	1	0.20
85.	*Poeciloneuron indicum*	Clusiaceae	1	0.20
86.	*Polycyas acuminata*	Araleaceae	1	0.20
87.	*Polygonum chinensis*	Polygonaceae	1	0.20
88.	*Catunaregam spinosa*	Rubiaceae	1	0.20
89.	Mushroom	--	1	0.20
	Total		500	100.00

Table 12. Monthly variation in the number of food species used by Nilgiri langur in different years

Month	Number of food species				
	1993	1994	1995	1996	Mean
January	nd	6	17	19	14.00
February	nd	8	12	14	11.33
March	nd	3	19	4	8.67
April	nd	21	6	nd	13.50
May	nd	5	14	nd	9.50
June	2	4	9	nd	5.00
July	7	8	16	nd	10.33
August	9	6	28	nd	14.33
September	10	10	24	nd	14.67
October	9	9	13	nd	10.33
November	10	9	15	nd	11.33
December	9	6	16	nd	10.33

nd = no data

Seasonal variation in the number of food species

Data for the seasonal variation in the number of food species was estimated from monsoon season 1993 onwards to winter in 1995-96 (Table 13). The number of food species varied from 6.00 (during monsoon 1993 and 1994) to 17.67 (during monsoon 1995) in various seasons. The number of species used for feeding was maximum in post monsoon season (12.11) followed by winter season (11.89) and minimum in summer (9.83).

Table 13. Seasonal variation in the number of plant species used by langur

Season	Number of food species			
	1993	1994	1995	Mean
Summer	nd	3.33	16.30	9.83
Monsoon	6.00	6.00	17.67	9.89
Post monsoon	9.67	9.33	17.33	12.11
Winter	7.67	11.67	16.33	11.89

nd = no data

Ranging of Nilgiri langur troops

Nilgiri langur troops were observed ranging in sholas, wet evergreen, semi-evergreen and moist deciduous forests of Silent Valley and adjacent areas. Among the 85 different troops the home range use of 79 troops were confined only to the evergreen forests. Three troops inhabiting the southernmost part of Panthanthod areas extend their home range to the adjacent teak plantations. Home range of another three troops were observed confined only to the moist deciduous areas in the Mannarkad Reserved Forest. Members of another troop residing in the evergreen forests of Nilikkal border areas was observed eight times criss-crossing the cliff areas in the boundary to the moist deciduous forests down and returned to the evergreen forests by dusk. Five individuals were observed ranging along with these three troops of common langur (Semnopithecus entellus) in the Mannarkad Forest Division. A couple of troops were observed ranging only in the high altitude montane sholas. Unlike the lion-tailed macaque, Nilgiri langurs were observed five times crossing the grassland patches in between the evergreen forests.

Home range size

Home range size of Nilgiri langur is estimated from a troop, with five individuals, ranging extreme south of Nilikkal section. The home range area of the troop fell within the home range of the main study troop of lion-tailed macaque. A total of 47 quadrats were used by the troop in the intensive study area. The home range size of Nilgiri langur troop was estimated as 0.47 km^2. There occurred variation in the usage of number of quadrats in various months as well as seasons. A total of 43 quadrats were used in April 1994 to March 1995, while 4 more quadrats were used in the following year (1995-96). All quadrats ranged in the previous year (1994-95) were also used in the successive year (1995-96).

Canopy use

Nilgiri langur utilized different canopy levels for various activities. Data for the analysis of canopy use by Nilgiri langur is taken from the ad-libitum records from 1993 March onwards to 1996 March (n = 1409). The data revealed the arboreal nature of these langurs. Figure 15 shows the variation in the usage of different canopy levels. They preferred medium canopy levels between 11 to 20 m for their activities. Majority of the observations (57.70%) were at the medium canopy level, followed by 1 - 10 m canopy level (19.87%). The percentage frequency of records at 21 to 30 m canopy level was 16.82%. Nilgiri langurs utilized 4.97% of their time in the upper most canopy level having more than 30 m height. On very few occasions they came down to the

ground for various activities. They spent less than one percent of their time (0.85%) in the ground. In majority of the instances they came down to the ground for crossing grassland patches or roads where there was canopy discontinuity. In three instances they came down and fed soil from the ground.

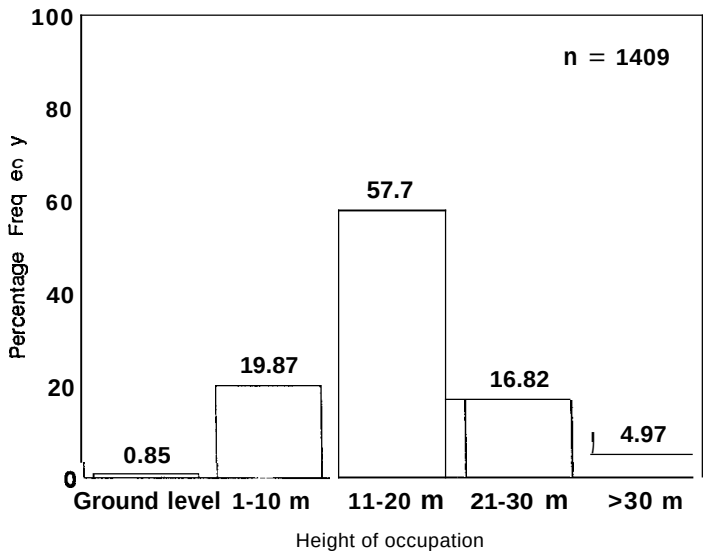


Fig. 15 Canopy use of Nilgiri langur in different heights

Age sex difference in the canopy use

Variation was noticed in the canopy usage between adult males and adult females. Both sexes utilized all the canopy levels. Compared to adult females, adult males dominated in spending their time in the medium (11-20 m , 2 1-30 m) and upper canopy (30m) levels (n = 625). Adult male shared 4.96% of their time in the upper most canopy level (30m), whereas the adult females utilized only 3.75% of their total time. In the ground and the lower canopy levels (1-10 m), adult female had a marginally greater proportion over adult male.

4. DISCUSSION

LION-TAILED MACAQUE

Lion-tailed macaque, one of the most endangered primates in India is endemic to the Western Ghats, is exclusively an arboreal denizen of south Indian rainforests (Green and Minkowski, 1977).Kurup (1978)estimates the altitudinal variation in its occurrence ranging from 300 m (Anshighat)to 1350 m (Munnar). The habitat of lion-tailed macaque is highly fragmented leaving only two viable populations, one in Ashambu hills and the other one in Silent Valley forests (Kumar, 1987).The present study reveals the macaque distribution exclusively in the wet evergreen forests, between 650 m to 1500 m elevation in Silent Valley and also throws light on the preference of the species to certain tree associations in evergreen forests. The distribution of lion-tailed macaque is more predominant in the three tree associations in the evergreen forests, namely i) *Cullenia exarillata-Palaquium ellipticum* ii) *Palaquium ellipticum-Mesua ferrea* iii) *Mesua ferrea-Calophyllum elatum*. Random distribution of the major food species like *Cullenia, Palaquium,* Ficus, *Syzygium* etc., occur in these associations which provide ample food supply through out the year. The *Poeciloneuron-Ochlandra* association in the higher elevations are lacking many of the food species for this highly arboreal macaque. The reed brakes permit very few trees to grow randomly and prevent the occurrence of multilayered canopy conditions which is essential for lion-tailed macaque to survive. Probably this may be the reason for the absence of lion-tailed macaque in the upper reaches of Silent Valley National Park.This localised distribution pattern of the species highlights the importance of knowing the potential lion-tailed macaque habitat, which may be much lesser than the total extent of evergreen forests put together, for estimating the population.

Even though, various surveys were conducted for estimating lion-tailed macaque population elsewhere (Hutton, 1949; Krishnan, 1971: Kurup, 1978. 1988; Karanth, 1985 and Easa, *et al.,* 1997) very few detailed studies regarding the demography are carriedout (Johnson, 1980; Kumar, 1987). Johnson (1980)estimated the troop size of lion-tailed macaque and it vaned from 7 to 25 individuals. Kumar (1987)studied ten lion-tailed macaque troops and estimated the average troop size as 19.9 individuals per troop, where the troop size varied from 12 to 31. The present study corroborates the former estimation (Kumar, 1987) with a mean troop size of 19.24 individuals in the fourteen troops studied. Menon (1993)studied a single large troop having 43 individuals in the highly fragmented forest habitat existing in Puthuthottam cardamom estate area in Tamil Nadu. Troop fission is a general phenomenon

among free ranging social primates in its true habitat conditions. The present study reports two instances of troop fission.

The present study in the continuous habitat reveals the unequal sex ratio favouring more females in the population. The present observation corroborates similar findings (1:5 females) in the Varagaliar forests (Kumar, 1987). The adult sex ratio is greater in all the other macaques except in pig-tailed macaques (Caldecott, 1986; Fooden, 1980). Johnson (1980) recorded five single adult male troops in the Kalakkad Mundanthurai forests. According to Kumar (1987) most of the lion-tailed macaque troops have only one adult male per troop though he recorded 1-3 adult males in various troops. In the present study, eight troops were having two adult males each and the rest of them were with single adult male. It is found that the number of adult males are directly related to the increasing troop size.

Macaques are generally frugivorous. They depend on the reproductive parts of various plant species than the vegetative parts (Lindburg, 1977). Faunivory is rather common among many macaques (Crocket and Wilson, 1980). Lion-tailed macaque is considered as an omnivore feeding on a variety of food items of both animal and plant origin (Green and Minkowski, 1977). Kumar (1987) described the diet of lion-tailed macaque, consisting of 58% fruits and seeds, 37% animal matter and *5%* other plant parts such as nectar, resins and flowers. The present study differs mainly in the lesser animal matter (9%) in the dietic composition. The diet contained 26.1% of flowers in the current study while in the former study flower intake was found minimal (Kumar, 1987). According to Milton (1979), the flowers have greater protein contents than the fruits, and may supplement the protein requirements to certain extent. Moreover, protein rich mushrooms may help to maintain the nutrient balance in the diet. The comparitively low animal matter in the diet of the lion-tailed macaque is thus balanced with higher intake of flowers and mushrooms. Foliage forms a negligible proportion in the diet of lion-tailed macaques in the present study though Green and Minkowski (1977) reported leaves of reeds, grasses, sedges in their diet in the Kalakkad forests.

Various factors like climate, fruiting seasonality and other phenological conditions and troop size influence the dietic variations over different months (Milton, 1979; Green, 1978). Monthly variation in the diet has been observed in many ecological studies of primates (Klein and Klein, 1977; Pollock, 1977, Smith, 1977; Fossy and Harcourt, 1977; Menon, 1993). Lion-tailed macaque exhibit monthly variation in the diet during the months in the contiguous habitat. Eventhough *Cullenia exarillata* is the most important food species in many months, from January to March these macaques are depending totally on other food species. Gregarious flowering of *Palaquium* and simultaneous switching over to flower feeding in February and March balances the diet in these months. Intensive feeding of *Syzygium cumini* and *Syzygium*

fruits in April is remarkable when compared to all other food items. In May, they switch over to immature seeds of *Cullenia* and when they fully mature in July and August the macaques prefer other fruits rather than *Cullenia*. Flower feeding reaches its maximum in November. In December, flower availability is very less and the macaques are tempted to range over regenerating areas and they thrive mainly on the seeds of *Macaranga* and other ecotone species. In September and October, least food availability was noticed in fragmented areas (Kumar, 1987) while in the present study no shortage of food availability was noticed as there was high intake of *Cullenia* flowers.

The present study revealed that fruits dominated in the diet of lion-tailed macaques in all seasons except in post monsoon season. This might be related to the specific phenological conditions of the tree species found in the Valley (Appendix III) Most of the tree species are devoid of fruits in the post monsoon season. Seed feeding is also brought to the minimum in post monsoon season. Menon (1993) estimates high intake of *Cullenia* flower in post monsoon season. The present study corroborates the high intake of *Cullenia* flower.

Primates are dependent mainly on plant species rather than animal foods (Simmen and Sabatier. 1996). Composition of food species vary considerably among different species of primates even in the same ecological conditions (Aldrich-Blake. 1980). The dietic diversity of macaques are very high and the intake of fruits, seeds, flowers, leaves, bark, grasses and herbs make it more flexible (Lindburg, 1977). A total of 66 plant species including top most canopy trees, second storey trees, small trees, shrubs, woody climbers, parasites and epiphytic orchids were utilized as food species in the diet of lion-tailed macaque in Kalakkad-Mundanthurai forests (Green and Minkowski. 1977). Johnson described the importance of *Cullenia exarillata* in the dietic diversity of this arboreal macaque. Kumar (1987) listed 93 food species in Varagaliar forests. Later, in Puthuthottam Cardamom forests Menon (1993) estimated 42 food species in one year. In the present study a total of 92 species were estimated in the diet for a period of two years. *Cullenia exarillata*, *Palaquium ellipticum* and three *Ficus* species were extensively used. Except in the Varagaliar study (Kumar, 1987) *Cullenia* formed the major food species for lion-tailed macaque. Figs of *Ficus* species were considered as a preferred food item in all the ecological studies of the species. Mushrooms were rather commonly used in the study area. The same was noticed in the Mundanthurai-Kalakkad areas also (Green and Minkowski, 1977).

Eventhough, Menon (1993) reported that *Cullenia* is the major food species for lion-tailed macaque, the fully mature fruits were eaten by the macaques. The present study contradicts this observation as these monkeys prefer the half mature seeds of *Cullenia* with more water content, in April-May-June than the fully mature seeds in the following months.

Social animals like, primates have a specific pattern of movement within its home range. Burt (1943) defined a mammal's home range as the area traversed by the animal in order to perform normal activities like, food gathering, mating and caring for the young. The extent of this range greatly varied in each primate species. John and Mackinnon (1980) state that leaf monkeys have smaller home ranges than macaques *(Macaca fascicularis)* and gibbons (*Hylobates lar, H. syndactylus*) in the same habitat. Remarkable intraspecies variation also occurs in the size of its home range in different months and seasons. Several factors like, troop size, social organization, population density, food availability, phenological states and type of habitat may affect the ranging pattern of primates (Lindburg, 1977; Kumar, 1987; Wheatley, 1980).

Macaque troops have a tendency to have larger home ranges ranging from 10 to 15 km^2 to less than 1 km^2 (Clutton-Brock and Harvey, 1977: Lindburg, 1977). Home range size of Bonnet macaque is estimated to be about 5 km^2 on the edge of a sandal wood forest. (Simonds, 1965). Wheatley (1980) described the home range size of crab eating macaque *(Macaca fascicularis)* in East Borneo as 1.25 km^2. Aldrich-Blake (1980) estimated the home range size of the same species as 80 ha in Kutai Reserve. The home range size of lion-tailed macaques was estimated as 5 km2 in Mundanthurai - Kalakkad areas (Green and Minkowski 1977). The present study estimates the home range size as 2.41 km^2 in the contiguous evergreen forests. In Silent Valley, the higher elevation evergreen forests with multistratum canopy conditions provide good habitat for lion-tailed macaques to survive. The phenological data (APPENDIX III) of the major food species suggest that the resource availability in Silent Valley is good enough to provide continuous food supply throughout the year. This would be the reason why these macaques have lesser home range when compared to one of the former studies (Green and Minkowski, 1977) in the higher elevation forests where the home range was extending to the cardamom estates, lacking multi-tier canopy systems. However, in the lower elevation forests of Varagaliar the home range was estimated much lower (Kumar, 1987). Home range size may vary according to the specific phenological phases and related food availability in various months. (Chivers and Hladik, 1978). The smaller home range size in June (1994-95) and September (1995-96) may be due to the occurrence of higher food availability in the core area of the troop. Phenological data shows that as many as seventeen trees are having fruits on the onset of monsoon in June (APPENDIX III). In September, gregarious flowering of *Cullenia* trees in the core areas of the macaque troop and the heavy dependence on that resource restricted the home range. While in November, the frequency of flowering of *Cullenia* trees in the core area diminishes and the troop had to range extensive areas. By the end of November the macaques had to switch over to other species on the onset of winter months. This would further extend the extent of home range in its habitat. According to Gittins and Raemaekers 1980) the

ranging strategy of primates are related with the phenological conditions of their feeding niche.

The summer season is characteristic in having abundant food supply of the fruits of *Drypetes elata*, Syzygium, flowers of *Palaquium* and half mature seeds of *Cullenia* in the core area of the troop. This high resource availability in turn helps the macaques to sustain mainly in the core areas and thereby having lesser home range. Seasonal variation in the home range size is a characteristic feature among primate populations (Clutton-Brock, 1977a). Struhsaker (1975) state that intergroup interactions may be more important than food dispersion in determining movement patterns. However, in the present study the food dispersion plays a major role in movement patterns and related to the home range size in different seasons. Clutton-Brock (1977b) also supported this view that ranging pattern of primates might be significantly related to the mean rank of dietic diversity and abundance of the top ranking food species.

The present study estimated an -overall mean day range length of lion-tailed macaque as 2.48 km. Kumar (1987) estimated the mean day range length to be 2.19 km in 1982-83 in the Varagaliar forests. Day range length has been studied in many primates (Clutton-Brock and Harvey, 1977; Goodall, 1977). Pattern of day range length varies among different primate species and the daily travel patterns were determined by the location of food items within the patch being exploited at a given time (Lindburg, 1977).The variation of day range length has been recorded in many primates. The monthly variation in day range length was also observed in the present study. The highest mean day range length recorded was in the month of February (3.18 km) in 1994-95 and (3.10 km) in December in the succeeding year (1995-96). Both these winter months had greater home range size probably due to less availability of food in the core areas. Kumar (1987) also recorded monthly variation in the day range patterns and the highest mean day range length was observed in August (2.46 km) in 1982-83. Climate, phenological status and food availability may influence day range length over different seasons (Clutton-Brock, 1977a). MacKinnon (1974) reported that feeding time decreased and travel increased in months having lesser fruit proportion in the diet of an orangutan population. Thus dispersion of mature fruits across their home range would be very crucial for determining the day range length of a frugivorous macaque.

NILGIRI LANGUR

Compared to lion-tailed macaque, Nilgiri langur troops have a random distribution, irrespective of the different tree association in the evergreen areas of the National Park. In addition to the entire evergreen stretch in the

National Park, the troops are distributed in semi-evergreen and moist deciduous forests outside the National Park. As the latter is mainly a folivore (APPENDIX II) the food availability will not be a limiting factor to the species irrespective of the different habitats. The results of the present study shows that most of the Nilgiri langur troops are found in the evergreen forests between 600 m to 1600 m elevation, though the upper altitude limit was 2200 m. According to Horwich (1972), a relatively constant volume of evergreen forest is necessary for this arboreal langur.

The present study estimates the mean troop size as 5.89, is comparable to 5.68 in Shendurney Wildlife Sanctuary (Ramachandran, 1995). Daniel and Kannan (1967) described the range of troop size from 1 to 30 individuals. Poirier (1969) estimated an average troop size of 8.9 individuals from the more accurately monitored troops in the sholas. Another survey (KFRI, 1993) in Kerala part of Western Ghats revealed the existence of 348 troops with an average troop size of 11.65 individuals. Variation in troop size in different habitats may be due to the difference in the quality of their habitat and the population density. According to Poirier (1968) troops inhabiting in high population density areas have smaller home ranges and in turn smaller troop size when compared to other areas as the bigger troops have greater home range and the chance of range overlap may be more and the same will directly lead to greater agonistic activities between the troops. Hohmann and Sunderraj (1992) also described lesser mean troop size of 4.36 individuals in contiguous evergreen forests in Mundanthurai-Kalakkad areas.

The size and composition of the social group may vary in various primate societies (Chivers and Raemakers, 1980). Poirier (1969) observed larger proportion of adults than immatures in the population. Present study also reveals greater proportion of adults. Roonwal and Mohnot (1977) described the existence of all male and female Nilgiri langur troops, whereas the present study could reveal the existence of solitary males, apart from the bisexual troops. However, the occurrence of solitary males are probably for a brief period and may join bisexual troops. Sunderraj and Johnsingh (1993) reported higher proportion of immatures including subadults, juveniles and infants in a Nilgiri langur population in Servalar gallery forest in Tamil Nadu. Proportion of adult females exceeded adult males in all the demographic studies (Poirier, 1969; Hohmann and Sunderraj, 1992). The present study estimated the adult sex ratio as 1:1.99 which comparatively closer to the previous observation of 1:1.2 by Poirier (1969). The unequal sex ratio may be due to the existence of all male bands and solitary males in the population.

Langurs are generally folivorous, feeding mainly on foliage. Stanford (1992) compared the feeding ecology of two sympatric langurs in northeast India, in which he described that *Trachypithecus phayrei* (Phayre'sleaf monkey) more folivorous than *Trachypithecus pileata* (capped langur). However, populations

of the latter in a deciduous forest has been observed more folivorous than in the wetter semi evergreen forest. Horwich (1972) studied the feeding ecology of Nilgiri langur in Periyar and observed young leaves, mature leaves, flowers and fruits in the diet. Roonwal and Mohnot stated that out of the leaves, flowers, buds, seeds, bark and stems of various plants, the most preferred elements in the diet was leaves. Ramachandran (1995) observed leaf buds, mature leaves, flowers, and fruits in the diet of Nilgiri langur in Shendurney Wildlife Sanctuary. However, Srivastava, *et al.* (1996) described 19 tree species utilized for fruits and seeds while only three species were utilized for tender leaves during monsoon season in Periyar. The present study revealed the dominance of foliage over all other items in the diet. Eventhough Roonwal and Mohnot (1977) considered Nilgiri langur as a strict vegetarian, an adult female Nilgiri langur was observed removing dry bark from a dead wood and picking insects four times and directly placing in the mouth. Rarely they were observed feeding on soil in the present study on parallel to the previous observations (Roonwal and Mohnot, 1977).

Proportion of dietic elements of primates may vary in different months according to the food availability, phenological status and type of habitat. Stanford (1992) reported the monthly variation in the diet of Capped langur (*Trachypithecus pileata*) and in which he described the dominance of mature leaves in the diet during winter months. Later in May to September the same troop switched on to fruits in the same habitat. Horwich (1972) observed a change in the diet of Nilgiri langur over different months. During March and early April, the diet contained tender leaves and fruits, while with the advent of mid April mature leaves dominated in the diet. The present study reveals a marked difference in the proportion of various dietic elements in different months. Highest proportion of foliage in the diet was observed in January, probably due to the greater availability of young leaves (APPENDIX III). Higher proportion of seeds in the diet observed in June may be related to the abundance of mature seeds of *Cullenia exarillata.* Fruit feeding exceeded in April over other food items. Greater availability of Ficus and *Syzygium* fruits and less availability of the most preferred young foliage may result higher fruit feeding in April. Other folivorous langurs also used to feed heavily on fruits in summer months (Roonwal and Mohnot, 1977; Stanford, 1992).

Wet evergreen forests are characteristic in having year round foliage in different phases. However, they exploited greater proportion of leaves in the winter season which was exceptional in having young shoots and foliage. Nilgiri langurs are highly preferred to feed young leaves rather than the old ones (Horwich. 1972). Flower feeding was also recorded high in the winter season. Flower feeding in winter season was pronounced with the intensive flowering of *Palaquium ellipticum* in February. Highest fruit feeding in summer season was due to the high availability of *Syzygium* fruits which was heavily fed by langurs. The adaptive success of Asian colobines lies in their

sion of a sacculated stomach which digests cellulose by bacterial fermentation and thereby allows the exploitation of vegetation parts (Curtin, 1980). Nilgiri langurs. which has got a wider threshold of adaptation to different type of habitats consume the products of a variety of plant species (Kurup, 1975; Roonwal and Mohnot, 1977). Horwich (1972) listed 39 food plants in the diet of Nilgiri langur for a period of three months in Periyar. Major food species included moist deciduous species like *Pterocarpus marsupium, Grewia tiliifolia, Dalbergia latifolia, Tectona grandis* etc. Sunderraj and Johnsingh (1993) reported 54 food species during their study in Servalar gallery forests in Mundanthurai Wildlife Sanctuary. They included species like, *Hopea parviflora, Terminalia bellirica, Albizia amara, Tamarindus indica, Syzygium cumini, Garcinia cambogia* etc. Ramachandran (1995) reported 13 food species like, *Myristica malabarica, Knema attenuata, Garcinia* sp., *Mesua ferrea, Vateria indica* etc. from Shendurney Wildlife Sanctuary. However, the present study reveals a highly vaned dietic diversity of Nilgiri langur having 89 food species, most of the them are typical evergreen species. However, the present study estimates an average utilization of 10.74 food species per month. Relatively high abundance of mature *Cullenia* seeds in the habitat in June may be the reason for the least dietic diversity in that month. Followed by the monsoon months, Nilgiri langur were observed feeding on a variety of species and the dietic diversity remained high in August and September months. However, there was no specific shift to the deciduous tree species in the study as in the Periyar troops (Horwich. 1972).

Seasonal variation in the number of food species in the diet of primates may occur mainly due to the resource availability in their respective habitats (Lindburg, 1977). Horwich (1972) reported the preference of deciduous tree species in the diet of Nilgiri langur in summer season. However, the present study describes no such preference in any season. Post monsoon season is marked by greater food species diversity followed by winter. This is probably due to greater availability of tree species with young foliage after the two monsoons. According to Horwich (1972) the tender leaves are the most preferred parts of the plant for Nilgiri langur. In summer season fruits of the food plants like *Syzygiwn cumini, Cinnamomum malabatrum, Palaquium ellipticum,* figs of *Ficus nervosa,* and *Ficus beddomei* are common and the langurs thrive mainly on these species. According to Stanford (1992) when fruits are available langurs switched on to fruits rather than leaves.

Poirier (1968) reports that the size and composition of Nilgiri langur troop is related to the size of its home range. Increased nutritional requirements of the larger troops may forced to extend their home range size. He described the home range size of Nilgiri langur as one quarter square mile in the Nilgiris. Horwich (1972) analyzed the home range sizes of three Nilgiri langur troops, estimated 2.3-3.9 hectares per troop. Kurup (1975) reported small home range size of Nilgiri langur when compared to the home range size of the

lion-tailed macaques. The present study estimated a home range of 0.47km^2. This is small when compared to the home range size of lion-tailed macaque in the same habitat (2.41km^2).According to Poirier (1968)the concentration and type of food plants in the home range, can play a major role in determining the home range size. The size and proximity of neighbouring troops can also influence the size of the home range. The home range of the main study troop overlapped between the home ranges of two other troops. Presence of these two troops in the vicinity may restrict the further expansion of its home range. Territorial behaviour and defending the core areas were observed among Nilgiri langur troops (Poirier, 1968). However, Horwich (1972) recorded the change of core areas depending on the availability of preferred food in different seasons.

Though in very few occasions (0.85%)Nilgiri langurs were observed in ground level, their activities were mostly limited in the higher canopy levels. In evergreen areas, foliage and vegetation in the ground level are limited and this may be reason why these folivorous monkeys rarely visited the ground stratum for their various activities. Unlike the lion-tailed macaque, if the canopy continuity is lacking somewhere, Nilgiri langurs may come down and cross through the ground level to neighboring sholas (Poirier, 1968).Nilgiri langur preferred the medium canopy heights for performing their various activities. Choudhury (1994) observed Phayre's leaf monkey mostly in 2 m to more than 13 m above the ground. Leaves and foliage of small to medium sized trees were extensively used by Nilgiri langur in all the seasons which may be the reason for their preference in the medium canopy levels.

Adult males of Nilgiri langur showed greater preferences in higher canopy levels than the adult females. This may aid the more vigilant nature of males than the females. Many a time the adult males readily sight the predators, other troops or human intruder in their habitat and give continuous alarm calls.

5. CONCLUSIONS AND SUGGESTIONS FOR MANAGEMENT

The study reveals the existence of a good population of lion-tailed macaque and Nilgiri langur, both endemic and endangered primates, in the area. Thus Silent Valley and neighbouring evergreen areas of the Attappady Reserved Forest provide a large and extensive habitat for an interbreeding and dynamic lion-tailed macaque population. The conservation of these areas would definitely assure the long-term survival of the species.

The distribution of lion-tailed macaque is more predominant in the three tree associations in the evergreen forests, namely i) *Cullenia exarillata-Palaquium ellipticum* ii) *Palaquium ellipticum-Mesuaferrea* iii) *Mesuaferrea-Calophyllum elatum*. These associations provide ample food supply throughout the year. The Poeciloneuron-Ochlandra association in the higher elevations are lacking many of the food species for this highly arboreal macaque. Probably this may be the reason for the absence of lion-tailed macaque in the upper reaches of Silent Valley National Park. Another tree association found outside the National Park is the *Mesua ferrea-Cullenia exarillata* which is also equally important for the primates and lion-tailed macaque in particular.

The Nilgiri langur is distributed in montane shola, in the low altitude evergreen, semi evergreen and even moist deciduous forests adjoining the National Park. This folivorous primate is distributed throughout the Park irrespective of the various tree associations.

As the management strategies are concerned the whole area of Silent Valley National Park is treated as 'corezone' and there is no separate 'bufferzone' demarcated. There is need for designating a suitable buffer zone for the National Park which should include the entire stretch of adjoining rainforest and the floristically and faunistically rich Attappady RF, particularly the Panthenthod area.

Existing road through the lion-tailed macaque habitat should not be widened as it would degrade the canopy continuity which is very crucial for this highly arboreal species. Atourism zone should be demarcated outside the National Park and the anthropogenic pressure should be minimized in the core zone.

The monitoring of the endangered primates should be continued so that the effectiveness of the management actions on conservation of existing rainforest fragments can be studied.

Firelines should be made effective for protecting the continuous stretch of rainforests, as there is possibility of occasional fire from the adjacent forests devastating the rainforest continuity. Fire affected areas adjacent to the National Park should be monitored and maximum care be taken for the regeneration process to progress. Planting of the seedlings of food species of primates in these areas are suggested.

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APPENDIX -I

Proportion of time spent on feeding major food species of lion-tailed macaque in different months at Nilikkal study area

April 1994

No.	Species	Plant part	% Composition
1	*Ficus beddomei*	fruit	15.77
2	*Syzygium cumini*	mesocarp	11.71
3	*Palaquium ellipticum*	mesocarp	10.81
4	*Elaeocarpus tuberculatus*	mesocarp	10.36
5	*Syzygium gardneri*	mesocarp	9.91
6	*Ficus nervosa*	Fig	9.91
7	*Mesua ferrea*	seed	9.01
8	*Artocarpus heterophyllus*	mesocarp	2.70
9	*Cullenia exarillata*	seed	1.80
10	*Mangifera indica*	mesocarp	1.35
11	*Xanthophyllum flavescens*	flower	1.35
12	*Hopea glabra*	flower	0.90
13	*Symplocos cochinchinensis*	mesocarp	0.90
14	*Drypetes elata*	mesocarp	0.45
15	*Myristica dactyloides*	mesocarp	0.45
	Other plants (2 species)	-	0.90
	Other plant parts	-	1.80
	Animal matter	-	9.92
			100.00

May 1994

No.	Species	Plant part	% Composition
1	*Cullenia exarillata*	seed	46.76
2	*Ficus beddomei*	fig	8.80
3	*Syzygium cumini*	mesocarp	4.17
4	*Artocarpus heterophyllus*	mesocarp	4.16
5	*Turpinia malabarica*	mesocarp	3.70
6	*Ficus nervosa*	fig	3.24
7	*Listea floribunda*	mesocarp	3.24
8	*Tetrastigma sulcatum*	mesocarp	2.31
9	*Elaeocarpus tuberculatus*	mesocarp	2.31
10	*Myristica dactyloides*	mesocarp	2.31
11	*Apollonias arnottii*	mesocarp	1.39
12	*Garcinia morella*	mesocarp	1.39
13	*Holigarna nigra*	mesocarp	1.39
14	*Dimocarpus longan*	seed	0.93
15	*Mesua ferrea*	seed	0.93
16	*Hydnocarpus alpina*	mesocarp	0.46
	Mushroom (unidentified)	-	2.31
	Other plant parts	-	2.78
	Animal matter	-	7.42
			100.00

Appendix I contd..

June 1994

No.	Species	Plant part	% Composition
1	*Cullenia exarillata*	seed	25.00
2	*Aglaia lawii*	mesocarp	13.89
3	*Tetrastigma sulcatum*	mesocarp	8.33
4	*Ficus beddornei*	fig	5.56
5	*Elaeocarpus glandulosus*	mesocarp	4.17
6	Mushroom (unidentified)		4.17
7	*Calophyllum polyanthum*	mesocarp	2.78
8	*Turpinia malabarica*	mesocarp	2.78
9	*Garciniagummi-gutta*	mesocarp	2.78
10	*Bischofia javanica*	mesocarp	2.78
11	*Apollonias arnottii*	mesocarp	1.39
12	*Artocarpus heterophyllus*	mesocarp	1.39
13	*Litsea laevigata*	mesocarp	1.39
14	*Toddalia asiatica*	mesocarp	1.39
15	*Knema attenuata*	mesocam	1.39
	Other plants (6species)		8.3 1
	Other plant parts		1.39
	Animal matter		11.11
			100.00

July 1994

No.	Species	Plant part	% Composition
1	*Ficus microcarpa*	fig	11.48
2	*Ficus nervosa*	fig	7.38
3	*Turpinia malabarica*	mesocarp	5.74
4	*Bischofia javanica*	mesocarp	5.74
5	*Cullenia exarillata*	seed	5.74
6	*Aglaia lawii*	mesocarp	4.92
7	*Apollonias arnotti*	mesocarp	4.92
8	*Tetrastigma sulcatum*	mesocarp	4.10
9	*Apodytes dimidiata*	mesocarp	4.10
10	*Antidesma menasu*	mesocarp	4.10
11	*Aristolochia tagala*	seed	2.46
12	*Elaeocarpus tuberculatus*	mesocarp	2.46
13	Mushroom (unidentified)	-	2.46
14	*Artocarpus heterophyllus*	mesocarp	1.64
15	*Calophyllum polyanthum*	seed	1.64
	Other plants (14 species)	-	15.54
	Other plant parts	-	2.46
			13.12
			100.00

August 1994

No.	Species	Plant part	% Composition
1	*Ficus beddomei*	fig	10.10
2	*Ficus microcarpa*	fig	6.06
3	*Turpinia malabarica*	seed	6.06
4	*Tetrastigma sulcatum*	mesocarp	6.06
5	*Bischofia javanica*	seed	5.05
6	*Cassine kedarnathii*	mesocarp	5.05
7	*Calophyllum polyanthum*	seed	4.04
8	*Salacia fruticosa*	mesocarp	4.04
9	*Aglaia lawii*	mesocarp	3.03
10	*Antidesma menasu*	mesocarp	3.03
11	*Aristolochia tagala*	seed	3.03
12	*Agrostistachys meeboldii*	mesocarp	2.02
13	*Embelia ribes*	mesocarp	2.02
14	*Ficus nervosa*	fig	2.02
15	*Garcinia morella*	mesocarp	2.02
	Other plants (10 species)	-	15.16
	Other plant parts	-	5.05
	Animal matter	-	16.16
			100.00

September 1994

No.	Species	Plant part	% Composition
1	*Cullenia exarillata*	flower	65.34
2	*Ficus beddomei*	fig	5.11
3	Mushroom (Unidentified)	--	2.84
4	*Elaeocarpus glandulosus*	mesocarp	2.27
5	*Unidentifed species*	mesocarp	2.27
6	*Helixanthera* sp.	mesocarp	1.70
7	*Cassine kedharnathii*	mesocarp	1.14
8	*Canarium strictum*	mesocarp	1.14
9	*Casearia esculenta*	mesocarp	1.14
10	*Garcinia morella*	mesocarp	1.14
11	*Myristica dactyloides*	mesocarp	1.14
12	*Agrostistachys meeboldii*	seed	0.57
13	*Calophyllum polyanthum*	seed	0.57
14	*Knema attenuata*	mesocarp	0.57
15	*Lantana camara*	seed	0.57
	Other plants (2 species)	-	1.14
	Other plant parts	-	3.98
	Animal matter	-	7.38
			100.00

October 1994

No.	Species	Plant part	% Composition
1	*Cullenia exarillata*	flower	50.00
2	*Ficus microcarpa*	fig	6.32
3	*Ficus beddomei*	fig	5.79
4	*Turpinia malabarica*	seed	4.74
5	*Macaranga indica*	flower	3.16
6	*Elaeocarpus glandulosus*	mesocarp	2.11
7	*Agrostistachys meeboldi*	seed	2.11
8	*Helixanthera sp.*	mesocarp	2.11
9	*Gomphandra coriacea*	seed	1.58
10	*Calophyllum polyanthum*	seed	1.05
11	Mushroom (unidentified)	-	1.05
12	*Garcinia morella*	mesocarp	1.05
13	*Hopea glabra*	seed	1.05
14	*Myristica dactyloides*	mesocarp	1.05
15	*Mesua ferrea*	seed	0.53
	Other plants (4 species)	-	2.09
	Other plant parts	-	5.79
	Animal matter	-	8.42
			100.00

November 1994

No.	Species	Plant part	% Composition
1	*Cullenia exarillata*	flower	52.91
2	*Macaranga indica*	seed	8.14
3	*Turpinia malabarica*	flower	7.56
4	*Xanthophyllum flavescens*	flower	2.91
5	*Syzygium laetum*	mesocarp	2.91
6	*Litsea floribunda*	mesocarp	2.91
7	*Canarium strictum*	mesocarp	2.91
8	Mushroom (unidentified)	-	1.74
9	*Gomphandra coriacea*	seed	1.74
10	*Caryota urens*	mesocarp	1.16
11	*Hopea glabra*	seed	1.16
12	*Fahrenheitia zeylanica*	mesocarp	0.58
13	*Garcinia morella*	mesocarp	0.58
14	*Litsea laevigata*	mesocarp	0.58
15	*Maesa indica*	mesocarp	0.58
	Other plant parts	-	6.29
	Animal matter	-	5.81
			100.00

December 1994

No.	Species	Plant part	% Composition
1	*Cullenia exarillata*	flower	21.21
2	*Macaranga indica*	seed	18.69
3	*Drypetes elata*	mesocarp	5.56
4	*Lantana camara*	mesocarp	5.05
5	*Glochidion* sp.	seed	4.04
6	*Turpinia malabarica*	flower	3.54
7	*Polygonum chinensis*	mesocarp	3.54
8	*Flemingia* sp.	seed	3.03
9	*Solanum* sp.	mesocarp	3.03
10	*Mucuna pruriens*	seed	2.53
11	*Elaeocarpus tuberculatus*	flower	2.53
12	Mushroom (unidentified)	-	2.02
13	*Caryota urens*	mesocarp	1.52
14	*Syzygium laetum*	mesocarp	1.52
15	*Myristica dactyloides*	mesocarp	1.52
	Other plants (9 species)	-	4.49
	Other plant part	-	6.07
	Animal matter	-	10.11
			100.00

January 1995

No.	Species	Plant part	% Composition
1	*Drypetes elata*	mesocarp	26.18
2	*Macaranga indica*	seed	18.32
3	*Ficus microcarpa*	fig	9.95
4	*Elaeocarpus tuberculatus*	flower	6.81
5	*Artocarpus heterophyllus*	mesocarp	4.71
6	*Calamus* sp.	mesocarp	2.09
7	*Cassine kedarnathi*	mesocarp	2.09
8	*Canarium strictum*	mesocarp	2.09
9	*Hopea glabra*	seed	2.09
10	*Polygonum chinensis*	mesocarp	2.09
11	*Toddalia asiatica*	mesocarp	2.09
12	*Mucuna pruriens*	seed	1.57
13	Mushroom (unidentified)	-	1.05
14	*Maesa indica*	mesocarp	1.05
15	*Syzygium mundagam*	flower	0.52
	Other plants (2 species)	-	2.12
	Other plant parts	-	5.76
	Animal matter	-	9.42
			100.00

February 1995

No.	Species	Plant part	% Composition
1	*Palaquium ellipticum*	flower	39.76
2	*Drypetes elata*	mesocarp	10.24
3	*Ficus nervosa*	fig	7.09
4	*Ficus beddomei*	fig	6.69
5	*Artocarpus heterophyllus*	mesocarp	4.71
6	*Persea macrantha*	mesocarp	3.15
7	*Mangifera indica*	mesocarp	2.76
8	*Hopea glabra*	seed	2.76
9	Mushroom (unidentified)	-	2.36
10	*Calamus* sp.	mesocarp	1.97
11	*Ficus microcarpa*	fig	1.97
12	*Syzygium laetum*	mesocarp	1.57
13	*Macaranga indica*	seed	1.57
14	*Embelia ribes*	flower	1.18
15	*Elaeocarpus tuberculatus*	mesocarp	1.57
	Other plants (9 species)	-	5.16
	Other plant parts	-	2.74
	Animal matter	-	2.74
			100.00

March 1995

No.	Species	Plant part	% Composition
1	*Palaquium ellipticum*	flower	18.80
2	*Ficus beddomei*	fig	13.60
3	*Drypetes elata*	mesocarp	8.80
4	*Ficus nervosa*	fig	7.20
5	*Syzygium gardneri*	mesocarp	6.80
6	*Persea macrantha*	mesocarp	6.00
7	*Tetrastigma sulcatum*	mesocarp	5.20
8	*Mangifera indica*	mesocarp	5.20
9	*Elaeocarpus tubercalatus*	mesocarp	5.20
10	*Artocarpus heterophyllus*	mesocarp	4.80
11	*Dimocarpus longan*	seed	2.80
12	*Cryptocarya bourdillonii*	mesocarp	1.60
13	*Elaeocarpus munroni*	mesocarp	1.60
14	Mushroom (unidentified)	-	1.60
15	*Symplocos cochinchinensis*	seed	1.20
	Other plants (8 species)	-	5.20
	Other plant parts	-	1.60
	Animal matter	-	2.80
			100.00

April 1995

No.	Species	Plant part	% Composition
1	*Syzygium gardneri*	mesocarp	12.83
2	*Syzygium cumini*	mesocarp	12.08
3	*Ficus beddomei*	fig	12.08
4	*Mangifera indica*	mesocarp	9.81
5	*Cullenia exarillata*	seed	4.91
6	*Tetrastigma sulcatum*	mesocarp	3.77
7	*Zizyphus rugosa*	mesocarp	3.77
8	*Elaeocarpus tuberculatus*	mesocarp	5.28
9	*Elaeocarpus munronii*	mesocarp	3.02
10	*Artocarpus heterophyllus*	mesocarp	3.02
11	Mushroom (unidentified)	-	2.64
12	*Xanthophyllum flavescens*	flower	2.64
13	*Ficus nervosa*	fig	1.89
14	*Calamus* sp.	mesocarp	1.51
15	*Hopea glabra*	seed	1.51
	Other plants (12 species)	-	7.92
	Other plant parts	-	3.40
	Animal matter	-	7.92
			100.00

May 1995

No.	Species	Plant part	% Composition
1	*Cullenia exarillata*	seed	36.40
2	*Syzygium cumini*	mesocarp	15.06
3	*Cinnamomum malabatrum*	mesocarp	6.69
4	*Mangifera indica*	mesocarp	5.44
5	*Artocarpus heterophyllus*	mesocarp	3.77
6	*Elaeocapus tuberculatus*	mesocarp	3.77
7	*Holigarna nigra*	mesocarp	3.77
8	*Tetrastigma sulcatum*	mesocarp	2.93
9	*Elaeocarpus munronii*	mesocarp	2.93
10	Mushroom (unidentified)	-	2.93
11	*Palaquium ellipticum*	mesocarp	2.09
12	*Dimocarpus longan*	seed	1.26
13	*Litsea floribuda*	mesocarp	1.26
14	*Myristica dactyloides*	mesocarp	0.84
15	*Garcinia morella*	mesocarp	0.42
	Other plants (3 species)	-	1.64
	Other plant parts	-	4.19
	Animal matter	-	4.61
			100.00

June 1995

No.	Species	Plant part	% Composition
1	*Cullenia exarillata*	seed	22.06
2	*Aglaia lawii*	mesocarp	14.71
3	*Turpinia malabarica*	mesocarp	8.82
4	*Artocarpus heterophyllus*	mesocarp	5.88
5	*Mangifera indica*	mesocarp	5.15
6	*Antidesma menasu*	mesocarp	5.15
7	*Tetrastigma sulcatum*	mesocarp	4.41
8	*Elaeocarpus tuberculatus*	mesocarp	3.68
9	*Embelia ribes*	mesocarp	2.21
10	Mushroom (unidentified)	-	2.94
11	*Garcinia gumi-gutta*	mesocarp	2.21
12	*Toddalia asiatica*	mesocarp	2.21
13	*Garcinia morella*	mesocarp	1.47
14	*Unidentified species*	mesocarp	1.47
15	*Elaeocarpus glandulosus*	mesocarp	1.47
	Other plants (4 species)	-	2.91
	Other plant parts	-	5.15
	Animal matter	-	8.10
			100.00

July 1995

No.	Species	Plant part	% Composition
1	*Ficus nervosa*	fig	11.25
2	*Mangifera indica*	mesocarp	8.75
3	*Apodytes dimidiata*	mesocarp	8.75
4	*Apollonias arnottii*	mesocarp	8.75
5	*Turpinia malabarica*	mesocarp	8.75
6	*Aglaia lawii*	mesocarp	6.25
7	*Tetrastigma sulcatum*	mesocarp	3.75
8	*Artocarpus heterophyllus*	mesocarp	2.50
9	*Antidesma menasu*	mesocarp	2.50
10	*Achronychia pedunculata*	mesocarp	2.50
11	*Bischofia javanica*	mesocarp	2.50
12	*Cullenia exarillata*	seed	2.50
13	*Cassine kedarnathii*	mesocarp	2.50
14	Mushroom (unidentified)	-	2.50
15	*Palaquium ellipticum*	mesocarp	2.50
	Other plants (8 species)	-	10.00
	Other plant parts	-	3.75
	Animal matter	-	10.00
			100.00

August 1995

No.	Species	Plant part	% Composition
1	*Ficus beddomei*	fig	10.28
2	*Turpinia malabarica*	mesocarp	10.28
3	*Apodytes dimidiata*	mesocarp	9.35
4	*Calophyllum polyanthum*	seed	7.48
5	*Bischofia javanica*	mesocarp	6.54
6	*Elaeocarpus glandulosus*	mesocarp	6.54
7	*Agrostistachys meeboldi*	seed	5.61
8	*Ficus nervosa*	fig	5.61
9	*Casearia esculenta*	seed	2.80
10	*Cassine kedarnathi*	mesocarp	2.80
11	*Aristolachia tagala*	seed	5.61
12	*Salacia fruticosa*	mesocarp	1.87
13	*Antidesma menasu*	mesocarp	0.93
14	*Garcinia morella*	mesocarp	0.93
15	Mushroom (unidentified)	-	0.93
	Other plants (8 species)	-	7.48
	Other plant parts	-	3.74
	Animal matter	-	11.22
			100.00

September 1995

No.	Species	Plant part	% Composition
1	*Cullenia exarillata*	flower	53.23
2	*Ficus beddomei*	fig	8.87
3	*Elaeocarpus glandulosus*	mesocarp	4.03
4	*Mesua ferrea*	seed	5.65
5	Mushroom (unidentified)	-	4.03
6	*Canarium strictum*	flower	1.61
7	*Cardomomum* sp.	seed	1.61
8	*Calophyllum polyanthum*	seed	1.61
9	*Casearia esculenta*	seed	1.61
10	*Helixanthera* sp.	mesocarp	1.61
11	*Maesa indica*	mesocarp	1.61
12	*Caryota urens*	mesocarp	0.81
	Other plant parts	-	3.23
	Animal matter	-	10.49
			100.00

October 1995

No.	Species	Plant part	% Composition
1	*Cullenia exarillata*	flower	47.34
2	*Ficus beddomei*	fig	13.02
3	*Ficus microcarpa*	fig	7.10
4	*Bischofia javanica*	mesocarp	2.96
5	*Maesa indica*	mesocarp	2.96
6	*Ficus tsjahela*	fig	1.78
7	*Litsea laevigata*	mesocarp	1.18
8	*Helixanthera* sp.	mesocarp	1.18
9	*Myristica dactyloides*	mesocarp	1.18
10	*Unidentified species*	mesocarp	1.18
11	Mushroom (unidentified)	-	0.59
12	*Apollonias arnottii*	mesocarp	0.59
13	*Acronychia pedunculata*	mesocarp	0.59
14	*Cardamomum* sp.	seed	0.59
15	*Viscum* sp.	mesocarp	0.59
	Other plants (5 species)	-	1.78
	Other plant parts	-	2.95
	Animal matter	-	12.43
			100.00

November 1995

No.	Species	Plant part	% Composition
1	*Cullenia exarillata*	flower	32.58
2	*Turpinia malabarica*	flower	14.04
3	*Ficus microcarpa*	fig	9.55
4	*Xanthophyllum flavescens*	flower	5.06
5	*Mesua ferrea*	seed	2.82
6	*Mystistica dactyloides*	mesocarp	2.25
7	Mushroom (unidentified)	-	2.25
8	*Syzygium laetum*	mesocarp	1.69
9	*Litsea floribunda*	mesocarp	1.12
10	*Gomphandra coriacea*	seed	1.12
11	*Ficus tsjahela*	fig	1.12
12	*Dysoxylam* sp.	seed	1.12
13	*Agrostistachys meeboldi*	seed	0.56
14	*Calophyllum polyanthum*	seed	0.56
15	*Fahrenheitia zeylanica*	mesocarp	0.56
	Other plant (5 species)	-	2.82
	Other plant parts	-	6.74
	Animal matter	-	14.04

December 1995			
No.	Species	Plant part	% Composition
1	*Macaranga indica*	seed	16.03
2	*Litsea floribunda*	mesocarp	12.82
3	*Elaeocarpus tuberculatus*	flower	9.62
4	*Cullenia exarillata*	flower	8.33
5	*Xanthophyllum flavescens*	flower	5.13
6	*Canarium strictum*	mesocarp	3.85
7	Mushroom (unidentified)	-	3.21
8	*Meliosma pinnata*	seed	2.56
9	*Myristica dactyloides*	mesocarp	2.56
10	*Lantana camara*	seed	1.92
11	*Caryota urens*	mesocarp	1.92
12	*Ligustrum perrottetii*	flower	1.28
13	*Unidentified species*	mesocarp	1.28
14	*Syzygium laetum*	mesocarp	1.28
15	*Solanum* sp.	mesocarp	1.28
	Other plants (2 species)	-	1.28
	Other plant parts	-	8.33
	Animal matter	-	17.30
			100.00
January 1996			
No.	Species	Plant part	% Composition
1	*Drypetes elata*	mesocarp	16.84
2	*Macaranga indica*	seed	15.26
3	*Persea macrantha*	mesocarp	12.11
4	*Ficus microcarpa*	fig	11.58
5	*Artocarpus heterophyllus*	mesocarp	4.21
6	*Litsea floribunda*	mesocarp	3.16
7	*Elaeocarpus tuberculatus*	flower	3.16
8	*Calamus* sp.	mesocarp	2.63
9	Mushroom (unidentified)	-	2.63
10	*Caryota urens*	mesocarp	1.58
11	*Cinnamomum malabatrum*	flower	1.05
12	*Unidentified species*	mesocarp	1.05
13	*Myristica dactyloides*	mesocarp	1.05
14	*Ligustrum perrottetii*	flower	0.53
15	*Flemingia* sp.	seed	0.53
	Other plant (9 species)	-	4.74
	Other plant parts	-	5.26
	Animal matter	-	12.63
			100.00

February 1996

No.	Species	Plant part	% Composition
1	*Palaquium ellipticum*	flower	33.54
2	*Drypetes elata*	mesocarp	13.29
3	*Artocarpus heterophyllus*	mesocarp	5.06
4	*Ficus microcarpa*	fig	4.43
5	*Tetrastigma sulcatum*	mesocarp	4.43
6	*Persea macrantha*	mesocarp	3.80
7	*Elaeocarpus tuberculatus*	mesocarp	3.80
8	*Ficus tsjahela*	fig	3.16
9	Mushroom (unidentified)	-	2.53
10	*Hopea glabra*	flower	2.53
11	*Calamus* sp.	mesocarp	1.27
12	*Glochidion* sp.	seed	1.27
13	*Lantana camara*	seed	1.27
14	*Litsea floribunda*	mesocarp	1.27
15	*Maesa indica*	mesocarp	1.27
	Other plants (8 species)	-	5.69
	Other plant parts	-	2.53
	Animal matter	-	8.86
			100.00

March 1996

No.	Species	Plant part	% Composition
1	*Palaquium ellipticum*	flower	35.32
2	*Syzygium gardneri*	mesocarp	8.96
3	*Ficus beddomei*	fig	6.47
4	*Tetrastigma sulcatum*	mesocarp	5.47
5	*Mangifera indica*	mesocarp	3.98
6	*Ficus nervosa*	fig	3.48
7	*Cryptocarya bourdillonii*	mesocarp	3.00
8	*Symplocos cochinchinensis*	seed	2.50
9	*Artocarpus heterophyllus*	mesocarp	2.00
10	*Elaeocarpus monronii*	mesocarp	2.00
11	Mushroom (unidentified)	-	1.50
12	*Viscum* sp.	mesocarp	1.50
13	*Olea dioica*	seed	1.00
14	*Drypetes elata*	mesocarp	1.00
15	*Hopea glabra*	flower	1.00
	Other plants (8 species)	-	5.00
	Other plant parts	-	5.47
	Animal matter	-	10.46
			100.00

APPENDIX -II

Monthly variation in dietic diversity of Nilgiri langur*

Species	Parts eaten			
	leaf	flower	fruit	seed
January				
Actinodaphne bourdilloni	+			
Ardisia stoni			+	
Calophyllum polyanthum	+			
Canarium strictum	+			
Clausena indica	+			
Dimocarpus longan	+			
Drypetes elata	+		+	
Elaeocarpus glandulosus	+			
Elaeocarpus tuberculatus		+		
Elaeocarpus munroni	+			
Erythropalum populifolium	+			
Eurya nitida	+			
Fahrenheitia zeylanica	+			
Ficus beddomei	+			
Garcinia gummi-gutta	+			
Garcinia morella	+			
Lasianthus jackianus	+			
Litsea laevigata	+			
Litsea floribunda	+			
Mangifera indica	+			
Mesua ferrea				+
Mushroom sp.				
Myristica dactyloides	+			
Nilgirianthus sp.	+			
Ochlandra sp.	+			
Olea dioica			+	
Palaquium ellipticum	+			
Persea macrantha			+	
Poeciloneuron indicum	+			
Symplocos cochinchinensis			+	
Syzygium laetum	+			

Appendu contd..

Species	Parts eaten			
	leaf	flower	fruit	seed
Thunbergia mysorensis	+			
Turpinia malabarica	+		+	
Xanthophyllum_flavescens	+			
February				
Apodytes dimidiata	+			
Apollonias arnottii	+			
Aristolochia tagala	+			
Bischofia javanica	+	+		
Canthium dicoccum		+		
Cinnamomum malabatrum	+			
Dimocarpus longan	+			
Drypetes elata	+			
Ficus beddomei	+			
Ficus microcarpa			+	
Garcinia morella	+			
Hopea glabra				+
Litsea floribunda	+			
Mesua ferrea	+			
Myristica dactyloides	+			
Nothopodytes nimmoniana	+			
Palaquium ellipticum		+		
Piver nigrum	+			
Polygonum chinensis	+			
Symplocos cochinchinensis			+	
Syzygium cumini		+		
Syzygium laetum	+			
Syzygium mundagam	+			
Terminalia bellirica			+	
Xanthophyllum flavescens	+			
March				
Actinodaphne bourdilloni	+			
Antidesma menasu	+			
Apodytes dimidiata	+			
Bischofia javanica	+			
Casearia esculenta				+

Appendix IIcontd..

Species	Parts eaten			
	leaf	flower	fruit	seed
Cinnamommum malabatrum	+			
Clausena indica	+			
Dimocarpus longan	+	+		
Drypetes elata	+			
Ficus beddomei			+	
Holigarna nigra	+			
Hydnocarpus alpina	+			
Litsea floribunda	+			
Myristica dactyloides	+			
Neolitsea scrobiculata	+			
Olea dioica			+	+
Palaquium ellipticum	+	+		
Prunus zeylanicus	+			
Salacia fructicosa			+	
Symplocos cochinchinensis			+	+
Syzygium laetum	+			
Thunbergia mysorensis	+			
April				
Antidesma menasu	+			
Apodytes dimidiata	+			
Apollonias arnottii	+			
Erythropalum populifolium	+			
Ficus nervosa			+	
Ficus beddomei			+	
Garcinia morella	+			
Gomphandra coriacea	+			
Knema attenuata	+			
Lasianthus	+			
Litsea floribunda	+			
Palaquium ellipticum			+	
Symplocos cochinchinensis			+	
Syzygium laetum			+	
Syzygium cumini			+	
Terminalia bellirica				+
Thunbergia mysorensis	+			
Xanthophyllum flavescens	+			

Appendix IIcontd..

Species	Parts eaten			
	leaf	flower	fruit	seed
Zizyphus rugosa			+	
May				
Aphanamyxis polystachya	+			
Apodytes dimidiata	+	+		
Catunaragam spinosa	+			
Cinnamommum malabatrum			+	
Cullenia exarillata				+
Drypetes oblongifolia	+			
Eurya nitida	+			
Garcinia morella	+			
Holigarna nigra			+	
Impatiens sp.	+			
Lasianthus jackianus	+			
Mesua ferrea				+
Nothopodytes	+			
Olea dioica			+	
Palaquium ellipticum	+		+	
Persea macrantha	+			
Syzygium mundagam	+			
Syzygium cumini			+	
Syzygium munroni	+			
Thumbergia mysorensis	+			
Xanthophyllum flavescens	+			
June				
Acronychia pedunculata		+		
Bischofia javanica			+	
Casearia esculenta	+			
Cullenia exarillata				+
Drypetes elata	+			
Elaeocarpus glandulosus			+	
Fahrenheitia zeylanica	+			
Litsea floribunda	+		+	
Macaranga indiaca	+			
Salacia fruticosa			+	
syzygium laetum	+			

Species	Parts eaten			
	leaf	flower	fruit	seed
July				
Aglaia lawii	+			
Antidesma menasu	+			
Bischofia javanica	+			
Casearia esculenta	+			
Calophyllum polyanthum			+	
Canarium strictum	+			
Cinnamomum malabatrum	+			
Cullenia exarillata				+
Debregeasia longifolia	+			
Ficus *beddomei*	+			
Glochidion sp.	+			
Impatiens Sp.	+			
Leea indica	+			
Litsea floribunda	+			
Litsea laevigata	+			
Macaranga indica	+			
Myristica dactyloides	+			
Ochlandra sp.	+			
Palaquium ellipticum			+	
Piper nigrum	+			
Syzygium mundagam	+			
Syzygium cumini	+			
Tetrastigma sulcatum			+	
Thunberbia mysorensis	+			
August				
Acronychia pedunculata	+			
Actinodaphne bourdilloni	+			
Agrostistachys meeboldi				+
Allophyllus rheedi			+	
Calophyllum polyanthum			+	
Canarium strictum	+			
Casearia esculenta	+			
Chaionanthes sp.	+			
Cinnamomum malabatrum	+			

Species	Parts eaten			
	leaf	flower	fruit	seed
Cullenia exarillata				+
Dimocarpus longan				+
Drypetes oblongifolia	+			
Elaeocarpus munroni	+			
Elaeocarpus tuberculatus			+	
Elaeocarpus glandulosus	+		+	
Fahrenheitia zeylanica	+			
Ficus beddomei	+			
Garcinia morella	+			
Gomphandra coreacea	+			
Helixanthera sp.			+	
Knema attenuata	+			
Ligustrum perrottetii	+			
Macaranga indica	+			
Mesua ferrea	+			
Myristica dactyloides	+			
Palaquium ellipticum	+			
Polyscias acuminata	+			
Salacia fructicosa			+	
Syzygium cumini	+			
Syzygium munroni	+			
Syzygium laetum	+			
Turpinia malabarica			+	
Xanthophyllum flavescens	+			
September				
Actinodaphne bourdilloni	+			
Antidesma menasu	+			
Bischofia javanica	+			
Callicarpa tomentosa	+			
Casearia esculenta				+
Clerodendrum viscosum	+			
Cullenia exarillata		+		+
Drypetes elata	+			
Dysoxylum sp.				+
Elaeocarpus tuberculatus	+			
Elaeocarpus munroni	+			

Species	Parts eaten			
	leaf	flower	fruit	seed
Elaeocarpus glandulosus			+	
Ficus tsjahela	+			
Ficus beddomei	+		+	
Garcinia gummi-gutta	+			
Garcinia morella	+			
Glochidion fagifolium	+			
Litsea laevigata	+			
Litsea floribunda	+			
Macaranga indica	+			
Meliosma pinnata	+			
Mesua ferrea	+			
Myristica dactyloides	+			
Nothopodytes nimmoniana	+			
Ochlandra Sp .	+			
Olela dioica	+			
Palaquium ellipticum	+			
Salacia fructicosa			+	
Syzygium laetum	+			
Syzygium cumini	+			
Syzygium munroni	+			
Syzygium gardneri	+			
Thunbergia mysorensis	+			
Turpinia malabarica				+
Vemonia arborea	+			
October				
Acronychia pedunculata			+	
Apodytes dimidiata	+			
Bischofia javanica	+			
Casearia esculenta				+
Calophyllum polyanthum	+			+
Clausena dentata	+			
Cullenia exarillata	+	+		+
Elaeocarpus tuberculatus	+			
Ficus *beddomei*	+		+	
Garcinia morella	+			
Gomphandra coriacea				+

Appendix contd..

Species	Parts eaten			
	leaf	flower	fruit	seed
Litsea laevigata		+		
Litsea floribunda	+			
Macaranga indica			+	
Maesa indica			+	
Mesua. ferrea	+			
Myristica dactyloides	+		+	
Ochlandra sp.	+			
Palaquium ellipticum	+			
Symplocos cochinchinensis	+			
Syzygium laetum	+			
Syzygium mundagam	+			
Turpinia malabarica	+	+		
Vernonia arborea	+			
November				
Antedesma menasu	+			
Aphanamyxis polystachya			+	
Bischofia javanica	+			
Calophyllumpolyanthum	+			
Canarium strictum	+			
Cassine kedarnathii	+			
Cinnamomum malabatrum	+			
Clerodendrum viscosum	+			
Cullenia exarillata		+		
Elaeocarpus tuberculatus	+			
Ficus beddomei	+			
Gomphandra coreacea				+
Litsea floribunda	+			
Macaranga indica	+			
Myristica dactyloides	+			
Neolitsea scrobiculata	+			
Nilgirianthus sp.	+			
Palaquium ellipticum	+			
Persea macrantha	+			
Syzygium gardneri	+			
Syzygium laetum	+			
Syzygium munroni		+		

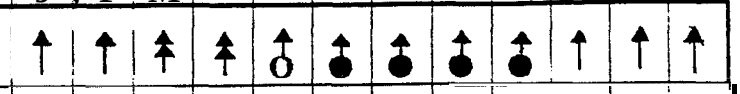
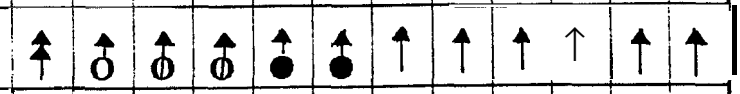
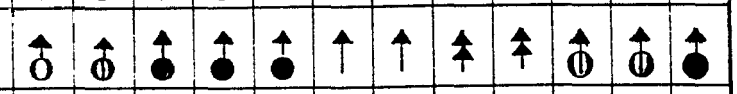
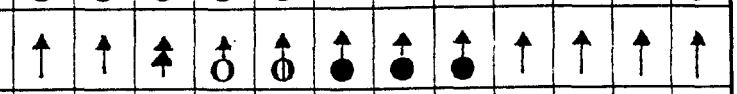
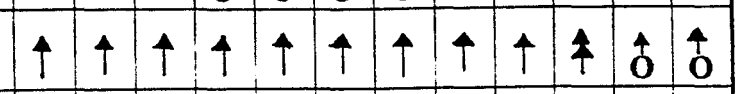
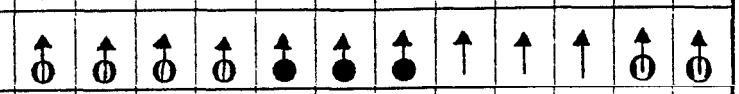
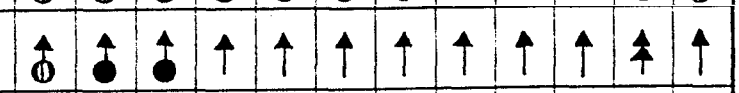
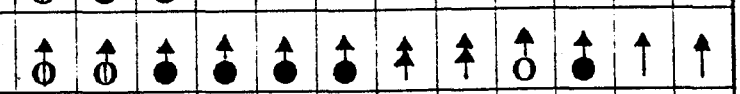
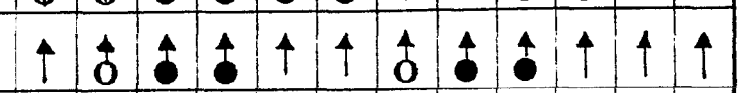
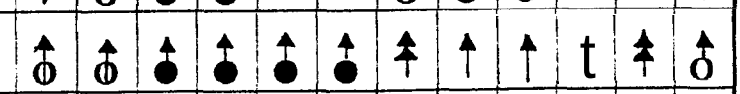
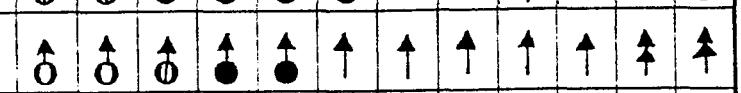
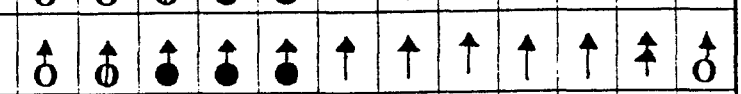
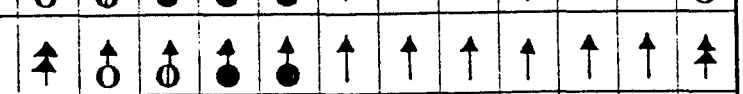
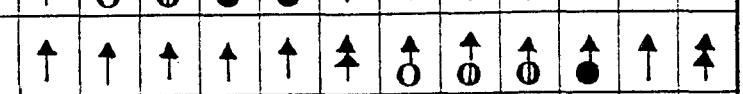
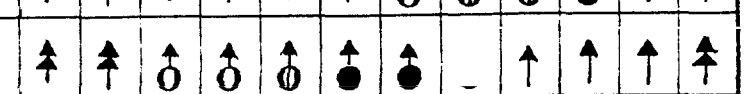
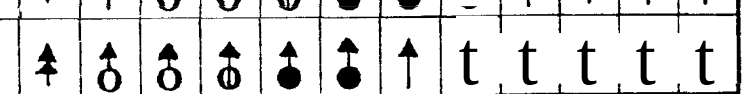
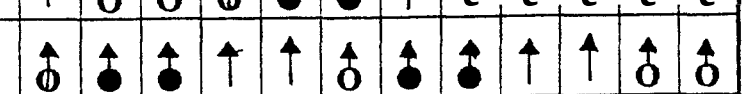
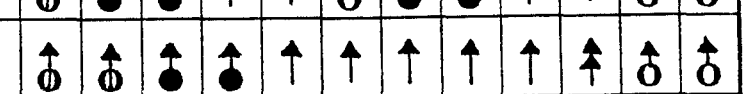
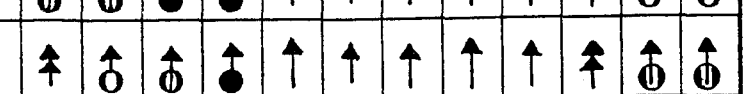
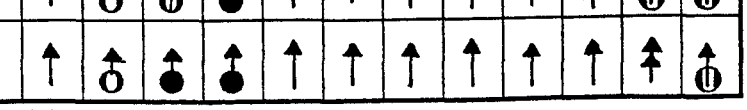
Species	Parts eaten			
	leaf	flower	fruit	seed
Syzygium mundagam	+			
Terminalia bellirica			+	
Turpinia malabarica		+		
Unknown climber	+			
Xanthophyllum flavescens		+		
December				
Bischofia javanica	+			
Calophyllum polyanthum	+			
Cassine kedharnathii	+			
Cinnamomum malabatrum	+			
Cullenia exarillata		+		
Debregesia longifolia		+		
Dimocarpus longan		+		
Drypetes elata	+			
Elaeocarpus tuberculatus		+		
Elaeocarpus munroni		+	+	
Erythroxylum monogynum	+			
Ixora sp.	+			
Ligustrum perrottetii		+		
Macaranga indica	+			+
Mesua ferrea	+			
Myristica dactyloides	+			
Neolitsea scrobiculata	+			
Olea dioica	+			
Persea macrantha		+		
Prunus zeylanicus	+			
Syzygium mundagam	+			
Xanthophyllum flavescens	+	+		

• Based on *ad libitum* records pooled for the whole study period.

APPENDIX -III

Phenological phases of forty tree species in Silent Valley during different months

No	Species	J	F	M	A	M	J	J	A	S	O	N	D
1	Holigarna nigra												
2	Mangifera indica												
3	Vernonia arborea												
4	Cullenia exarillata												
5	Cassine kedarnathii												
6	**Calophyllum polyanthum**												
7	Garcinia morella												
8	Mesua ferrea												
9	Elaeocarpus glandulosus												
10	Elaeocarpus munroni												
11	Elaeocarpus tuberculatus												
12	Antidesma menasu												
13	Agrostistachys meeboldi												
14	Bischofia javanica												
15	Drypetes elata												
16	Fahrenheitia zeylanica												
17	Glochidion fagifolium												
18	Macaranga indica												
19	Mallotus tetracoccus												
20	Casearia esculenta												

No	Species	J	F	M	A	M	J	J	A	S	O	N	D
21	Apodytes dimidiata												
22	Cinnamomum malabatrum												
23	Litsea floribunda												
24	Aglaia lawii												
25	Aphanamixis polystachya												
26	Artocarpus heterophyllus												
27	Ficus microcarpa												
28	Ficus beddomei												
29	Ficus nervosa												
30	Myristica dactyloides												
31	Syzygium cumini												
32	Syzygium laetum												
33	**Olea dioica**												
34	**Acronychia pedunculata**												
35	Dimocarpus longan												
36	Palaquium ellipticum												
37	Turpinia malabarica												
38	**Symplocos cochinchinensis**												
39	**Xanthophyllum flavescens**												
40	Persea macrantha												

Key: Young leaves Mature leaves Young fruit Mature fruit

APPENDIX -IV

Synthesis table for the Vegetation plots in Silent Valley National Park

SPECIES	Plots					Total Occurrence	% Consult-ancy
	P1	P2	P3	P4	P5		
Agrostistachys meeboldi	4	5	4	1	1	15	100.0
Dimocarpus longan	5	3	5	2	1	16	100.0
Garcinia morella	3	3	8	1	2	17	100.0
Myristica dactyloides	3	2	10	1	2	18	100.0
Palaquium ellipticum	18	8	10	1	4	41	100.0
Achronychia pedunculata	1	1		1	1	4	80.0
Mesua ferrea	4	2	3	6	-	15	80.0
Persea macrantha	1	1		5	4	11	80.0
Syzygium gardneri	-	1	1	3	2	7	80.0
Syzygium laetum	2	1	6		1	10	80.0
Cassine kedarnathi		1		2	1	4	60.0
Casearia Sp.	2		1	-	3	6	60.0
Drypetes elata	2	29		-	2	33	60.0
Ficus microcarpa			1	2	2	5	60.0
Ficus beddomei	-	1	1	-	1	3	60.0
Litsea laevigata	-	-	1	1	1	3	60.0

AppendixIV contd..

Appendix IVcontd..

Meliosma pinnata	-	-	1	3	5	9	60.0
Artocarpus heterophyllus	1	-	1	-	-	2	40.0
Aglaia lawii	-	1	4	-	-	5	40.0
Allophyllus rheedi	-	1	7	-	-	8	40.0
Bischofia javanica	-	-	-	2	5	7	40.0
Cullenia exarillata	23	2	-	-	-	25	40.0
Cinnamomum malabatrum	-	2	-	1	-	3	40.0
Canarium strictum	-	-	1	-	1	2	40.0
Calophyllum polyanthum	-	3	8	-	-	11	40.0
Cryptocarya bourdilloni	-	-	7	-	1	8	40.0
Elaeocarpus glandulosus	-	-	1	-	1	2	40.0
Ficus tsjahela	-	-	1	-	1	2	40.0
Fahrenheitia zeylanica	6	1	-	-	-	7	40.0
Hydnocarpus alpina	5	1	-	-	-	6	40.0
Heritieria papilio	1	-	6	-	-	7	40.0
Litsea oleodes	-	-	1	-	1	2	40.0
Ligustrum perrottetii	-	-	1	1	-	2	40.0
Macaranga indica	-	-	-	1	17	18	40.0
Mangifera indica	-	1	3	-	-	4	40.0
Neolitsea scrobiculata	1	-	-	-	4	5	40.0
Olea dioica	-	-	-	6	2	8	40.0
Syzygium lanceolatum	-	-	8	1	-	9	40.0

Appendix IVcontd..

Appendix IVcontd..

Scolopia crenata	-	-	1	2	-	3	40.0
Syzygium cumini	-	-	-	19	1	20	40.0
Unidentified species	2	-	3	-	-	5	40.0
Apollonias arnottii	1	-	-	-	-	1	20.0
Antidesma menasu	-		12	-	-	12	20.0
Canthium sp.	-	-	1	-	-	1	20.0
Chionanthes sp.				5		5	20.0
Clausena sp.			3	-		3	20.0
Clerodendrum viscosum				-	4	4	20.0
Eurua nitida			1	-	-	1	20.0
Elaeocarpus tuberculatus			-		1	1	20.0
Gomphandra corea	1	-				1	20.0
Glochidion flagifolium				4		4	20.0
Hopea glabra		1		-		1	20.0
Holigarna nigra	1	-	-	-	-	1	20.0
Knema attenuata			1			1	20.0
Litseafloribunda					1	1	20.0
Mallotus sp.		-		6		6	20.0
Symplocos cochinchinensis	-	-	8	-	-	8	20.0
Caryota urens					1	1	20.0
Xanthophyllum flavescens	3					3	20.0
Total	90	71	131	77	74	443	100.0