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ECOLOGY OF SLOTH BEAR (*MELURSUS URSINUS*) IN PARAMBIKULAM WILDLIFE SANCTUARY

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ABSTRACT

A study on the food and feeding habits of sloth bear was carried out in Parambikulam Wildlife Sanctuary from 1994 to 1997. A total of 509 scat samples were collected from different areas within the sanctuary. Reference collections of fruits and seeds of various possible food plants were also made. Animal matter formed a higher proportion in the diet of bear. However, there were seasonal differences in the proportion of various food items, the plant matter being higher in the diet during May-June. There were seasonal differences in the distribution of sloth bear as evident from the seasonal distribution of scats. The sloth bear was found mostly in moist deciduous habitats and teak plantations. The phenological observations in selected plots indicated correlation between distribution of sloth bear and availability of fruits.

ABSTRACT OF PROJECT PROPOSAL

Code :KFRI 224/94

Title : Ecological Studies on Sloth Bear (*Melursus ursinus*) in Parambikulam Wildlife Sanctuary

Objectives : to study the food and feeding habit of the species in Parambikulam
- to study their role in dispersal of seeds
- to assess its status in Parambikulam

Date of Commencement : June 1994

Scheduled date of completion: June 1997

Funding Agency : Kerala Forest Department (Wildlife)

Project Team

Principal Investigator : P. S. Easa

Research Fellow : K. Prasanth (July 1994 to February 1996)

ACKNOWLEDGMENTS

The author is grateful to Shri. P. K. Surendranathan Asari, the then Chief Wildlife Warden for suggesting the problem and Dr. S. Chand Basha, the then Director, KFRI for the approval and guidance. The Kerala Forest Department was kind enough to fund the project and extend all possible help in the field. The Wildlife Warden, Asst. Wildlife Wardens of Parambikulam Wildlife Sanctuary were always helpful and assisted the programme in the field. Shri K. Prasanth did most of the field work and Dr. S. M. Vairavel helped in the completion of the project. Smt. K. R. Valsalakumari assisted in the laboratory work. Dr. N. Sasidharan, Scientist in the Division of NWFP, KFRI identified the plants and the seeds. Smt. Ranjana K. Menon helped in the preparation of the report in its final form.

1. Introduction

Ursidae, consisting of the bears originated from canid evolutionary path (Vaughan, 1978) and have achieved the climax in the Pleistocene era (Colbert, 1980). The structural and functional modifications clearly show its shift from carnivorous to omnivorous habit. *Melursus* genus has a distinct adaptive radiation of specialized feeding described as myrmecophagy. Since, it was unsuccessful to establish a predator niche in the trophic and sub-trophic levels, the sloth bear developed myrmecophagy and able to exploit termite and ant colonies efficiently as a part of omnivorous diet in a unique ecological niche in their ranges (Laurie and Seidensticker, 1977). Out of the six genera consisting of seven species in the family Ursidae, four species viz. *Melursus ursinus* (Sloth bear), *Ursus arctos* (Brown bear), *Selenarctos thibetanus* (Himalayan black bear) and *Helarctos malayanus* (Malayan sun bear) are distributed in India (Johnsingh, 1986). Among these, sloth bear is the only species widely distributed from the foot hills of Himalayas to Cape comerine. Distinct morphological features such as protrusible lips, mobile snout and nostrils adapted to voluntary movement make them efficient for feeding on insects. Prater (1965) and Zukerman (1974) have given detailed account on general morphological features of sloth bear.

Except for a few status survey and natural history observations, no long term ecological studies have been carried out in India. The status of sloth bear in Kaziranga National Park was reported by Spillet (1967) in his wildlife survey in Northern India. Krishnan (1972) mentioned sloth bears as a rare animal throughout its ranges in India. Jaffeson (1975), in his compilation of details collected from Indian forest officials estimated an average bear density of 1 per 16.5 Km^2 in Indian forest tracts. The abundance of sloth bear in forests of Kerala was estimated by Easa and Jayaraman (1998) from indirect evidences. A few short notes on the food habits have also been reported from various parts of its ranges (Prater, 1965; Prue and Napier, 1977; Davidar, 1983; Sanderson, 1983; Baskaran, 1990). Study by Schaller (1967) on the feeding habits of sloth bear in Kanha National Park is considered to be the pioneering work on the species.

The feeding strategy of this animal is highly adapted to the seasonal variation in the availability of the food items and this leads to successful survival in their ranges. Janzen (1967) reported that fruits, insects and nectar were the major components of sloth bear's diet and their availability were highly influenced by

monsoons (seasons). Information on the dietary composition of sloth bear from droppings was attempted in Royal Chitwan National Park, Nepal (Laurie and Seidensticker, 1977). Baskaran (1990) reported the and seasonality in food habits of bear in Mudumalai Wildlife Sanctuary in Tamil Nadu.

The number of sloth bear, which is endemic to Indian subcontinent and Sri Lanka is declining due to threats from various factors including habitat alterations (Laurie and Seidensticker, 1977). Forest fire, cattle grazing and fire wood collection were also reported to be responsible for the decline in the population (Johnsingh, 1986). Habitat destruction was emphasized as yet another reason for the decline (Davidar, 1987). Low population densities, large home range requirements and lower rate of reproduction are the limiting factors acting upon their populations (Herrero and Servheen, 1989). Minimum population size coupled with low breeding rate of sloth bear is highly susceptible to habitat alteration in Sri Lanka (Santiapillai and Santiapillai, 1990). Incidences of sloth bear attacks and mauling on human beings in the periphery of forest areas have increased in recent years. At least 20 to 30 cases of mauling by sloth bear on human beings occurred every year in Andhra Pradesh (Krishnaraju *et al.*, 1987).

The present study was carried out to assess the status of sloth bear in Parambikulam Wildlife Sanctuary, Kerala and to study their food and feeding habits along with their role in the dispersal of seeds.

2. Study Area

Parambikulam Wildlife Sanctuary is situated in Palakkad district, Kerala State, India (between 76 °35' and 76 °50 'E and between 10 ° 20' and 10 °26' N) (Fig. 1). The Sanctuary is bordered by the west flowing Karapara river in the west and the same river flowing easterly in part of the south. The Sanctuary is contiguous with the natural forests of Sholayar and Vazhachal. The boundary on the east is purely an administrative one with the forest clearance running throughout the area bordered by Indira Gandhi Wildlife Sanctuary of Tamil Nadu. The northern side is bordered by the southwest flowing Thekkady ar up to the central part of the area and the remaining portion by the forest clearance along the water divide between the northerly and southerly flowing streamlets. The Sanctuary is part of a larger area of forest comprising Anamalai's, Nelliampathis, Sholayar, High ranges and Palni Hills. Easa (1989), Uniyal and Easa (1990) and Uniyal (Undated) has given a detailed description of the Sanctuary.

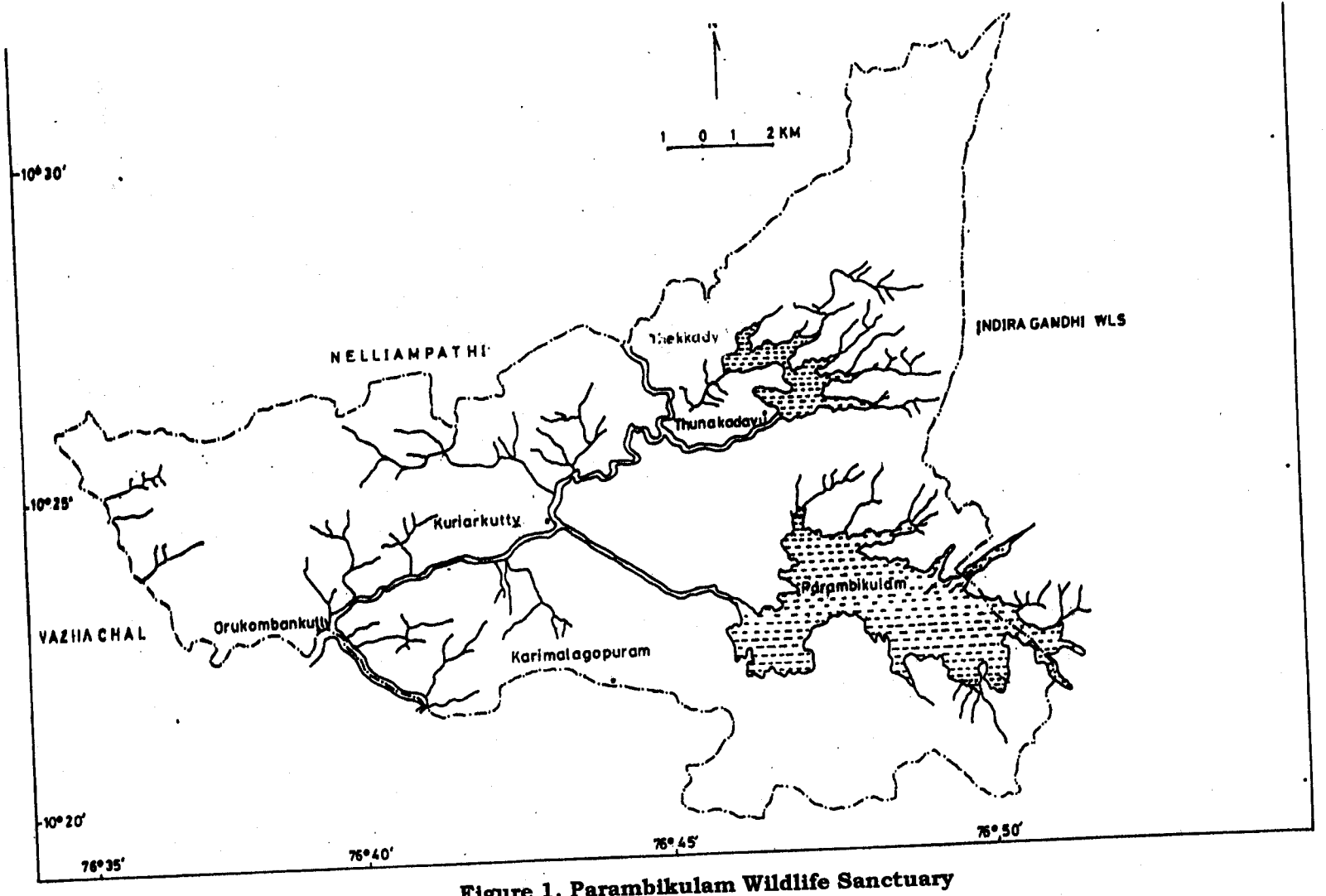

Figure 1. Parambikulam Wildlife Sanctuary

The area is drained by Thekkady ar, Parambikulam ar, Kuriarkutti ar, Thunacadavu ar, Thellickal ar, Karappara ar, Bagapallam ar, Vetti ar and Pulikkal ar. Of these, Thekkady ar, Thellickal ar and Bagapallam ar get dried up with stagnant pools during the summer season. There are three reservoirs of Parambikulam Aliyar project within the area: Parambikulam, Thunacadavu and Peruvarippalam. These three have a water spread area of about 28 km^2.

The monthly distribution of rainfall and temperature in the area indicates two sets of rainy seasons from both South-west and North-east monsoons. However, South-west monsoon is the more active one in this region. The first peak of rains occur between June and July and the second during October and November. Based on this rainfall pattern three seasons could be differentiated - Dry season (from Feb. to May), first wet season (from June to September) and second Wet season (from October to January).

2.1 Flora

Natural vegetation of the sanctuary is a combination of Malabar and Daccan elements (Sebastine and Ramamoorthy, 1966) and both natural and man-made vegetation types are met within the area. Menon (1991) gave a detailed description of the vegetation types of Parambikulam. The natural forests could be broadly classified on the basis of Champion and Seth (1968) into the Southern Tropical Wet Evergreen, Southern Tropical Semi Evergreen, Southern Tropical Moist Deciduous and Southern Tropical Dry Deciduous forests.

2.1.1 Southern tropical wet evergreen forests are distributed in higher slopes bordering Nelliampathy and Anamalai ranges. Small patches are also seen in depressions within moist deciduous forest localities such as, Thuthampara, Pulikkal, Orukomban, Kariyanshola, Vengolimala and Karimalagopuram. Tree species like, *Palaquium ellipticum, Calophyllum polyanthum, Mesua ferrea, Cullenia exarillata, Dipterocarpus indicus, Artocarpus hirsutus, Hopea parviflora, Vateria indica, Dysoxylum malabaricum, Myristica malabarica, Polyalthia fragrans, Canarium strictum, Schleichera oleosa*, etc. form the top storey of these type of forests. The lower storey is mainly of *Aporusa lindleyana, Vitex altissima, Elaeocarpus serratus, Cinnamomum vernum, Evodia lunu-ankenda, Holigarna arnottiana, Zanthoxylum rhetsa*, etc. *Calamus rotang, Dendrocnide sinuata, Nilgirianthus sp., Elettaria cardamomum* etc. form the ground vegetation. The evergreen forests are also rich in epiphytic orchids and ferns.

2.1.2 Southern tropical semi evergreen forests are transitional between evergreen and moist deciduous forests and are distributed unevenly throughout. They possess a mixture of both evergreen and deciduous elements.

2.1.3 Southern tropical moist deciduous forests are found along the ridges and lower slopes covering an area of about 60 km^2. Tree species observed in the area include *Haldina cordifolia, Albizia procera, Dalbergia sissoides, D. latifolia, Pterocarpus marsupium, Bauhinia racemosa, Tectona grandis, Dillenia pentagyna, Cassia fistula, Xylia xylocarpa, Pongamia pinnata, Careya arborea, Bombax ceiba, Terminalia paniculata, , T. bellirica, T. tomentosa, Emblica officinalis, Grewia tiliifolia, Lagerstroemia microcarpa.* Most of the deciduous forests of the sanctuary have been converted into teak plantations. This type of forest is distributed as large patches in Anapady, Elathodu, Poopara and Vengoli. They are also seen in small patches adjacent to teak plantations. The forests have thick regenerative ratio of bamboos as evident from areas such as Elathodu and Thellickal.

2.1.4 The southern tropical dry deciduous forests are confined to low rainfall areas around Thekkady and Keerapady and occupy about 15 km^2. The dry deciduous forests are dominated by *Anogeissus latifolia* along with other species of the moist deciduous forests. Extensive natural regeneration of *Bambusa arundinacea* are also found in the dry deciduous forests.

2.1.5 Grasslands and swamps (vayals) spread over an area of about 2 km^2 in a highly fragmented distributional pattern is one of the major characteristics of Parambikulam Wildlife Sanctuary. These vayals range from 5 ha. to 20 ha. in extent and are interspersed with plantations and natural forests at more than 30 locations. These have profuse growth of grasses and sedges and a few have extensive natural regeneration of *Bambusa arundinacea.* The vayals at Kannimara, Thellickal, Anakkal, Kothala and Poopara are the largest of these occupying contiguous area.

2.1.6 Teak plantations constitute about 90 km^2 and the eucalypts plantations near the northeast boundary about 3 km^2. The teak plantations of the area are of different age categories, since the plantation works were initiated in a phased manner. The area at present has plantations raised in 1916 to the recently regenerated 1982. Most of these plantations have a belt of natural forests and also a good undergrowth of shrub, herb and grass species. Natural regeneration of species such as *Cassia fistula, Dalbergia sissoides, Dillenia pentagyna, Xylia*

xylocarpa, etc. is the characteristic phenomenon of most of the plantations inParambikulam Wildlife Sanctuary.

2.2. Fauna

The diverse habitats and strategic locations of Parambikulam make it one of the faunistically richest areas in Kerala. Easa and Balakrishnan (1990) and Balakrishnan and Easa (1986) have described the mammals of Parambikulam Wildlife Sanctuary. The area has a good population of elephants, gaur, wild boar, sambar deer, spotted deer and mouse deer. The rodents include the Malabar giant squirrel and porcupine in addition to a number of smaller ones like rats and mice. All the four species of primates reported from the Western Ghats, *viz*, lion tailed macaque, bonnet macaque, Nilgiri langur and common langur are seen in the area. Carnivores such as tiger, leopard, sloth bear and wild dog are frequently sighted. Pangolin is of rare occurrence. Ruddy mangoose, common mangoose and stripe-necked mangoose, Nilgiri marten and bats are seen in the area. The lesser cats such as jungle cats and viverrids such as small Indian civet and toddy cat are also common. Nilgiri tahr is found in isolated places at Vengoli and Karimalagopuram. Otter is found in the reservoirs.

Three tribal communities in the sanctuary are located at Sungam (Malasar), Parambikulam and Kuriarkutty (Kadars) and Muduva colony (Muduvan).

3. Methods

Studies on the feeding habits of bear by direct observations of radio-collared animals are comparatively few (Phillips, 1987; Rogers, 1987; Unsworth *et al.*, 1989). Examination of the stomach contents was widely used to determine dietary composition (Landers *et al.*, 1979; Maehr and Brady, 1984; Ohdachi and Aoi, 1987). Fine grained method of scat analysis was used in the present study as suggested by Schaller (1967), Landers *et al.* (1979), Maehr and Brady (1984), Mace and Jonkel (1986), Cicnjak *et al.*, (1987), Ohdachi and Aoi (1987) and Manjrekar (1989).

Scat collections were made along the existing roads, forest tracks and fire lines. There are a few abandoned buildings in Thellickal, Anappady, Elathodu and Sungam watch tower area where bears regularly visit and rest during night hours. These were visited every month and scats collected. The segregated food items were oven dried and weighed.

3.1 Scat Analysis

The method of sub sampling and the quantity of sub samples to be taken from scat for analysis have not yet been standardised so for. Various authors used different methods of sub sampling. For example, Mace and Jonkel (1986) had taken sub sample from each scat of grizzly bear and Ohdachi and Aoi (1987) took 30g of mixed sample from the scats of brown bear for analysis. It poses many questions like i) What is the minimum proportion of sample to be taken? ii) What could be done if available scat quantity is less (less than the quantity of sub sample to be taken) iii) The scats may reflects food items in various proportion in relation to the food availability of the regions. So, conclusions drawn from the mixed sub sample from different individuals and from different regions lead to biased inference. Hence, in the present study, the entire scats were collected and analysed individually.

Reference collection of seeds and other parts of various species of plants available in Parambikulam Wildlife Sanctuary were made. Bear scats were collected every month from different parts of the sanctuary and analysed for seeds and animal matters. Analyses of the food species were made to determine the dominant food species in different seasons. The scats of sloth bear collected from August 1994 to July 1997 were thoroughly searched for seeds and remains of animal matter and the seeds were segregated individually and weighed. These were then oven dried and weighed. The values for the same months in different years were pooled and proportional weights of different food items were calculated. Twenty four plots of 50 m^2 were laid in different habitats for monthly phenological observation.

4. Results

A total of 509 scat samples were collected during the study period (Table 1). The number of scat samples collected was very low due to obvious reasons. However, the samples collected were representative of areas and seasons.

4.1 Food species

Analyses of proportional weights of different food items show that the animal matter was proportionately higher in all the months except during May - June when fruits were predominant (Fig. 2). The animal matter was never less than 35% of its food. A negligibly small proportion of food items was left unidentified in all the months.

Table 1. Number of bear scats collected in different months during the study period

Month	Year			
	1994	1995	1996	1997
January	-	17	04	05
February	-	20	73	-
March	-	18	31	23
April	-	21	29	14
May	-	03	31	12
June	-	01	24	05
July	-	08	06	07
August	-	09	18	-
September	11	03	8	-
October	18	04	13	-
November	27	12	06	-
December	19	05	04	-

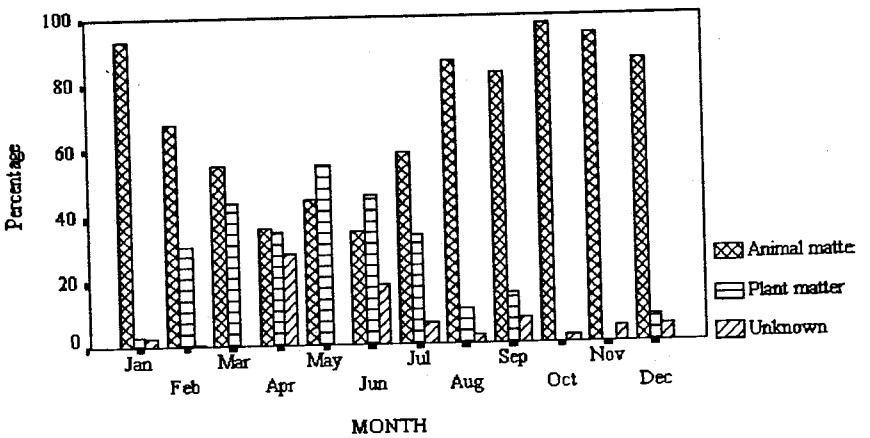

Figure 2. Different categories of food in sloth bear scats

Analyses for monthly variation in food items during different years showed a difference in the quantity of seeds. Animal matter formed the major food item in all the months except in June during the study period (Fig. 3). It increased or decreased depending on the feeding on fruits. February, March, April and June of 1995 showed an increase in feeding on fruits (Fig. 4).

A more or less same pattern was followed in subsequent years of 1996 and 1997. The unknown or unclassified food items were of less than 15% of its total food in all the months except September, 1995 and 1996 and April, May and June months of 1997 where the items were definitely of plant.

Percentages of seeds of various plant species in the diet of sloth bear in different months over the years are given in Table. 2. Seeds of *Cassia fistula, Cordia*

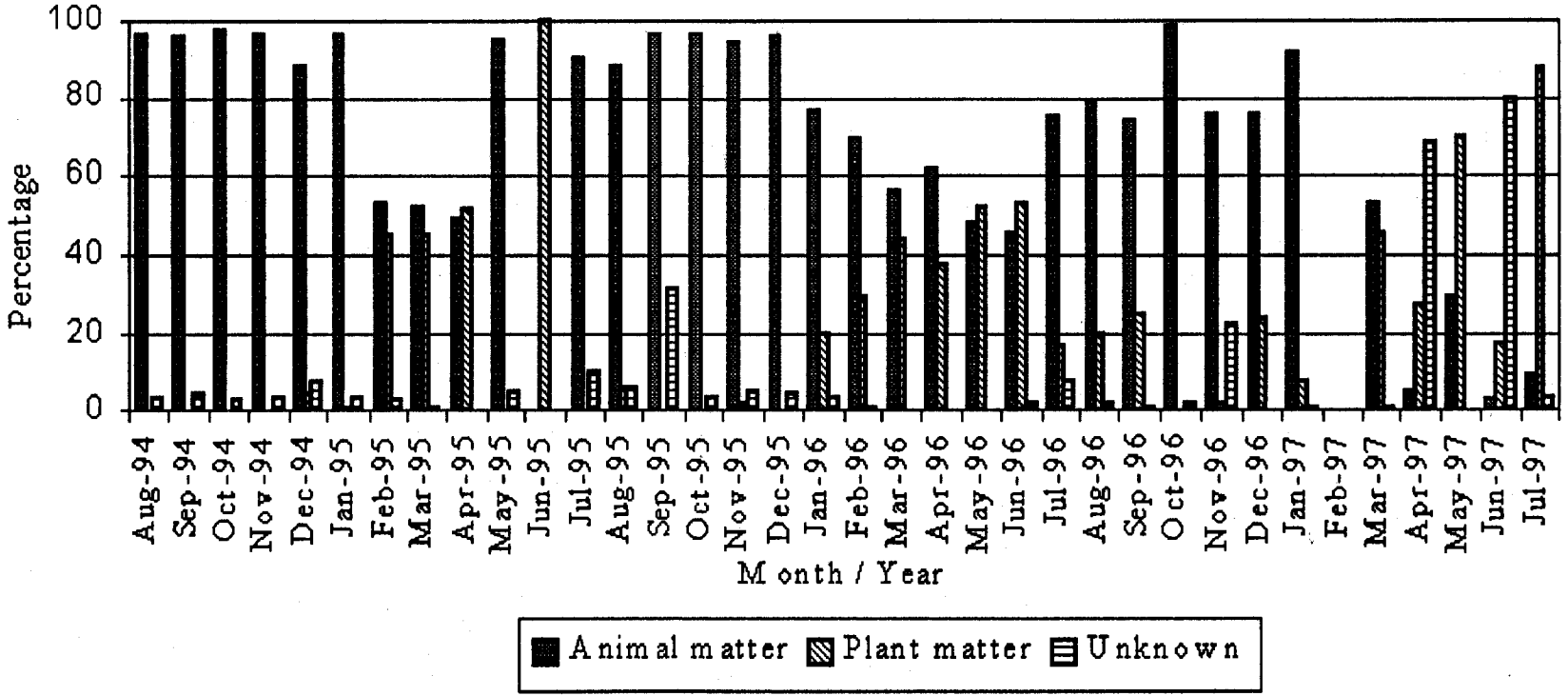

Fig. 3. Percentage of Sloth bear food items in different months

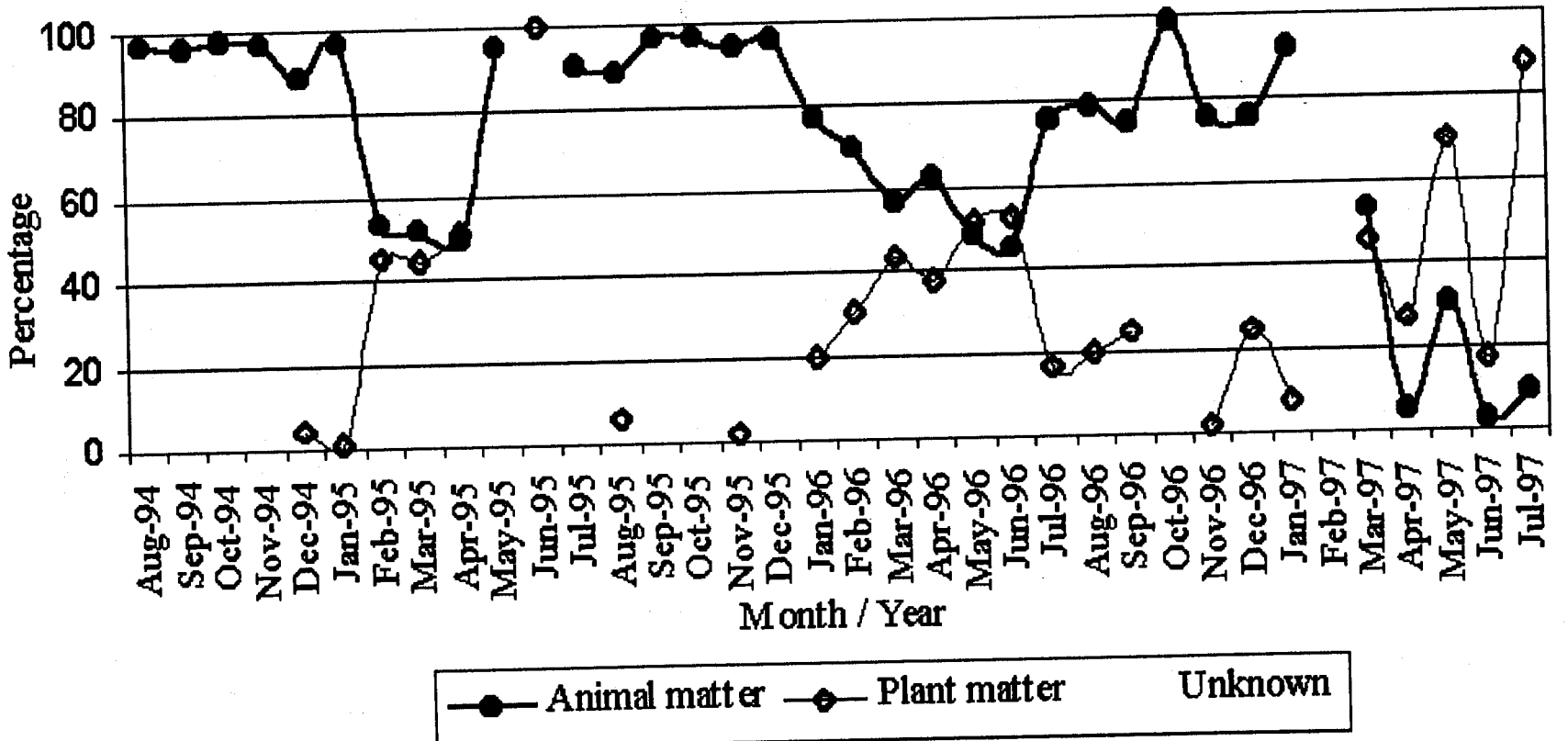

Fig. 4. Variations in the percentage of food items inthe bear scats

dichotoma and *Ziziphus* sp. were found in the scats in most of the months. Seeds of *Cassia fistula* was found in scats in all the months except in October and it was higher in the months of February to June and September. Feeding on *Cordia dichotoma* fruits was higher next to *Cassia fistula* during the months of May, June and August.

Fruits of *Ziziphus* species were fed more during February, July and December and it was highest in July. Seeds of *Glycosmis pentaphylla* were found in scats during February, March, April and June. Feeding on *Ficus* species fruits were observed during the months of February, March and June. Fruits of *Mangifera indica* were fed only in April.

Table 2. Percentage of seeds of different plant species in bear scats

Month	**Plant species**					
	Cassia fistuala	*Cordia dichotoma*	*Glycosmis sp.*	*Ficus sp.*	*Mangfera indica*	*Ziziphus sp.*
January	15.00	30.00	0.00	0.00	0.00	55.00
February	64.95	0.002	8.40	0.01	0.00	25.49
March	83.82	6.300	5.37	1.40	0.00	03.11
April	83.46	0.000	5.34	0.00	7.92	03.29
May	74.42	25.58	0.00	0.00	0.00	00.00
June	46.16	41.86	3.58	1.28	0.00	07.11
July	14.77	0.000	0.00	0.00	0.00	85.23
August	62.59	37.41	0.00	0.00	0.00	02.49
September	100.0	0.000	0.00	0.00	0.00	00.00
October	0.000	0.000	0.00	0.00	0.00	00.00
November	55.56	0.000	0.00	0.00	0.00	44.44
December	30.31	0.000	0.0	0.00	0.00	69.69

Percentage of *Cassia fistula* seeds in the diet of sloth bear in relation to its fruit availability is shown in Figure 5. Fruiting of *C.fistula* was observed during January to May in 1995 and January, February, March and June in 1996. But it was extended up to September in the year 1995. Percentage increase in feeding on *C. fistula* fruits well coincided with its fruiting season in the year 1995 and 1996. Though the plants in the plots were not in fruits, there were plants elsewhere in the area in fruit which have contributed to the increased feeding on *C. fistula* in April and May, 1996 and 1997. Fruiting of *Cordia dichotoma* varied considerably.

However, it was invariably between September and February with one observation in April, 1996 (Fig. 6). Phenology of *Ziziphus* sp. and percentage seed in the diet of sloth bear showed considerable variations (Fig. 7).

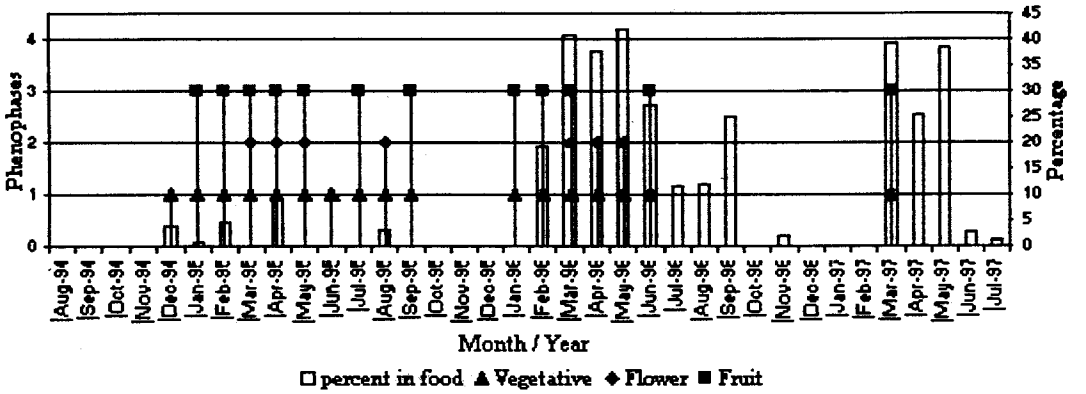

Figure 5. Percentage of *Cassia fistula* seeds in the diet of sloth bear in relation to its availability

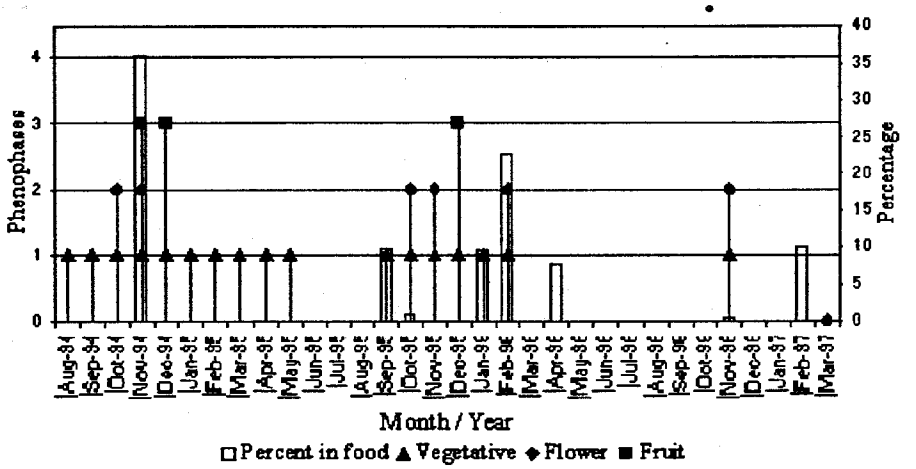

Figure 6. Percentage of *Cordia dichotoma* seeds in the diet of sloth bear in relation to its availability

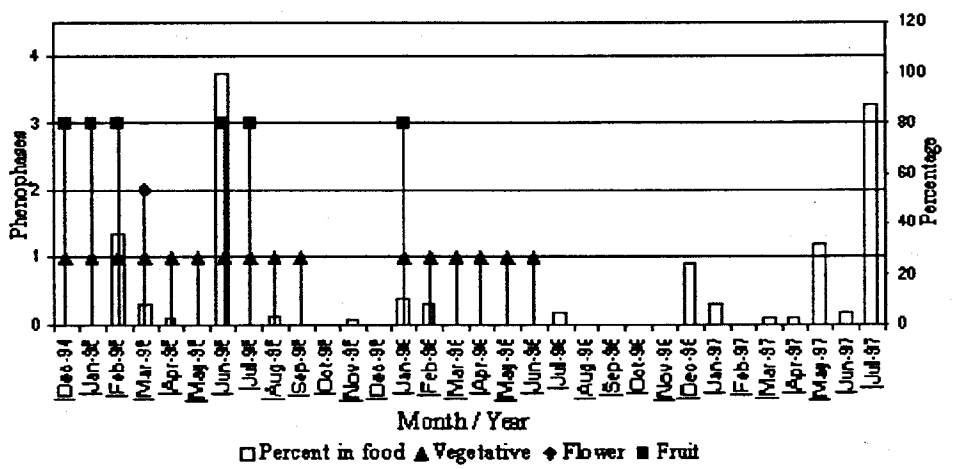

Figure 7. Percentage of *Ziziphus rugosa* seeds in the diet of sloth bear in relation to its availability

4.2 Seasonal variation

Analyses for seasonal variation in the composition of diet indicate higher percentage of animal matter throughout (Figs. 8-14). However, there was a reduction in the animal matter in dry season and the first wet season of 1996.

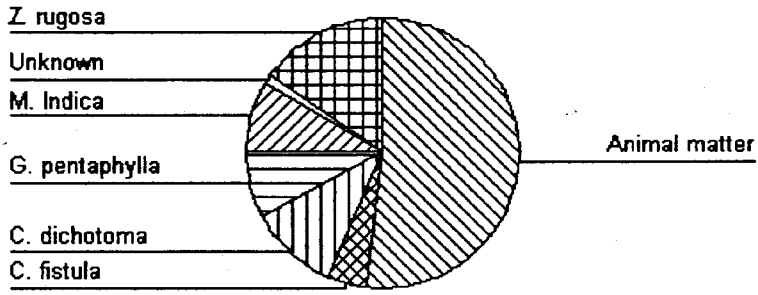

Figure 8. Percentage composition of food of bear during dry season 1995

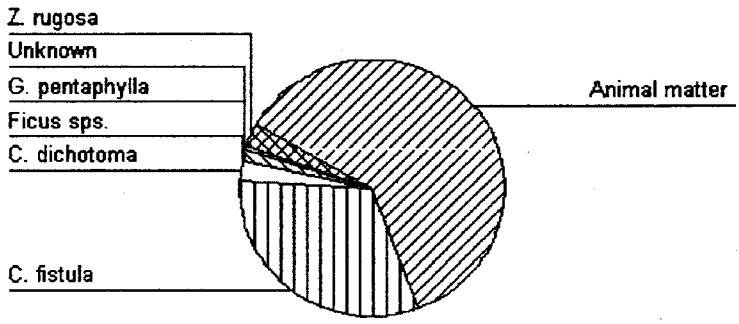

Figure 9. Percentage composition of food of bear during dry season 1996

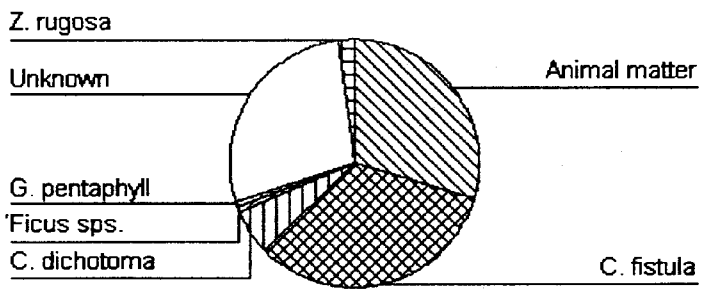

Figure 10. Percentage composition of food of bear during dry season 1997

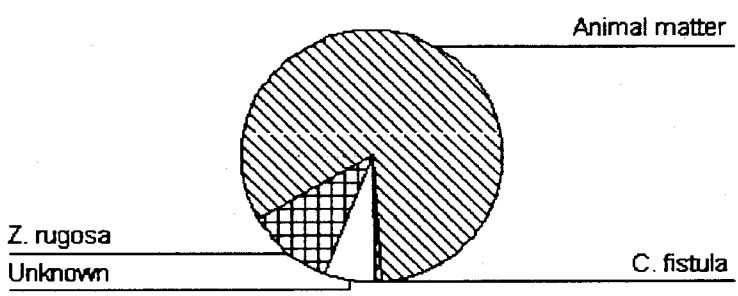

Figure 11. Percentage composition of food of bear during 1st wet season 1995

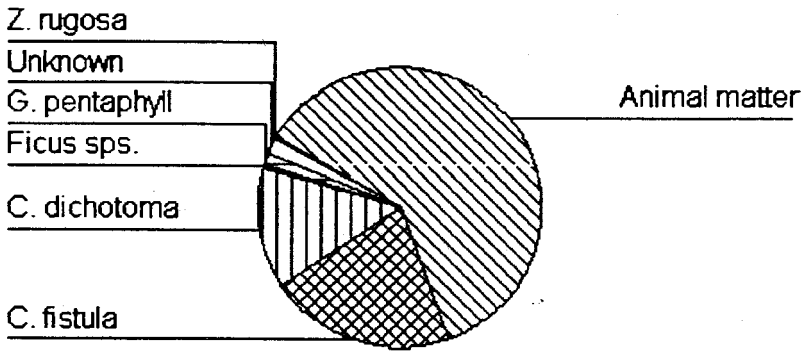

Figure 12. Percentage composition of food of bear during first wet season 1996

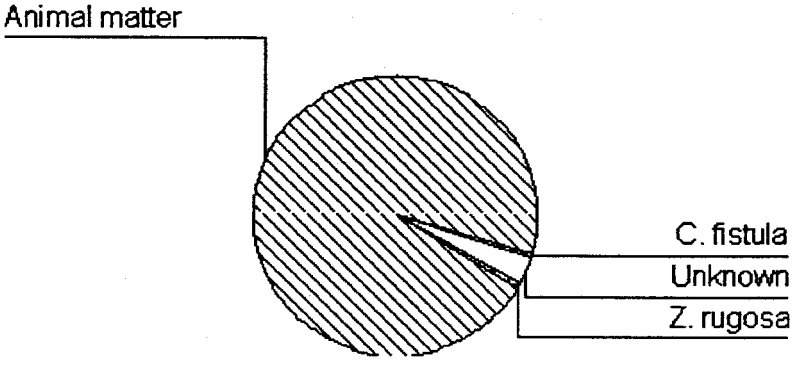

Figure 13. Percentage composition of food of bear during second wet season 1995

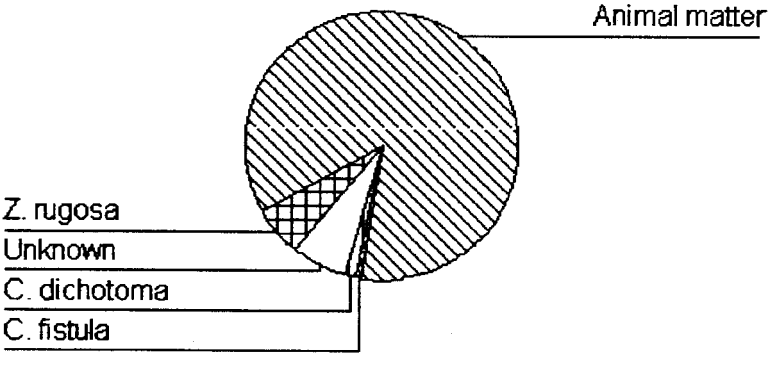

Figure 14. Percentage composition of food of bear during 2nd wet season 1996

4.3. Population

There were only very few direct sightings of the animal in Parambikulam. The sightings were confined Velayudhan kai near Parambikulam, Thellickal, Kannimara and Elathodu. There were incidences of bear attack at Kriarkutty during the period. There was no chance of estimating the population in the area based on direct sightings.

Hence, the indirect evidences were estimated for arriving at a value comparable to other areas. The estimated density of indirect evidences (1364/km^2) during the 1997 Statewide population estimation indicates that the area is next only to Trivandrum Wildlife Division, Periyar Tiger Reserve and Trivandrum Division. It is almost equal to the Wayanad Wildlife areas.

4.4 Distribution

The study area was divided into different zones to find out the spatial distribution of scats. There were 7 zones demarcated based on natural features such as rivers, streams and existing roads as 1. Kariyan shola, 2. Seechali, 3. Sungam-Amakkundu, 4. Padipara-Elathodu, 5. Peruvari -Thellickal, 6. Thunacadavu-Kanniamar and 7. Vengoli.

The scats collected from different locations were pooled for the distribution of animals in different seasons (Table 3). Out of the total 509 scats, the highest number (164) was during the dry season of 1996. Of these, the highest percentage of scats was from Seechali zone. The Thunacadavu-Kannimara zone which had the second highest of it. Of the scats collected during second wet season, maximum number of scats were from Sungam-Amakkundu zone. Collection of scats during first wet season in all the years (1995, 1996 & 1997) and second wet season in 1996 showed that scats were more or less evenly distributed among the zones. Lowest collection was found during first wet season of the year 1997. Twenty four scats were collected from out side of the zones.

Results of seasonal distribution of scats in different habitats are given in Table 4. The higher percentage of scats was collected from teak plantations followed by moist deciduous habitat. All other habitats have contributed less than 5% of total scats collected. Higher percentage of scats were observed in plantations in all the seasons except during first wet season in 1995 and 1997 and dry season of 1997. Moist deciduous habitat had higher number of scats compared to all other habitats during the first wet season of 1995 and 1997 and dry season of 1997. Evergreen and grassland habitat showed less number of scats in all the seasons and years.

4.5 Phenological observation

The observations on the phenology of trees in selected plots indicate a strong relation between the seeds in the scats (the food species) and the fruiting season.The

Table 3. Seasonal distribution of scats in different zones

Zones	Seasons								
	Wet2-94 (n=92)	Dry-95 (n = 62)	Wet1-95 (n = 21)	Wet2-95 (n = 25)	Dry-96 (n = 164)	Wet1-96 (n= 56)	Wet2-96 (n= 28)	Dry-97 (n= 49)	Wet1-97 (n= 14)
	Percentage of scats								
Kariyan Shola	04.35	09.88	00.00	04.00	02.44	01.79	03.57	02.04	00.00
Seechali	05.44	14.52	19.05	40.00	35.98	12.50	17.86	46.94	21.43
Sungam-Amakkundu	51.09	08.07	19.05	08.00	11.59	28.57	10.71	08.16	07.14
Padipara-Elathodu	13.05	01.61	19.05	08.00	05.49	03.57	14.29	02.04	14.29
Peruvari-Thellickal	18.48	27.42	04.76	08.00	06.10	10.71	10.71	10.20	14.29
Thunacadavu-Kannimara	03.26	17.74	19.05	16.00	18.29	12.50	21.43	06.12	00.00
Vengoli	01.07	19.36	19.05	16.00	15.24	17.86	17.86	20.41	07.14
Unknown	03.24	01.61	00 0.0	00.00	04.88	12.50	03.57	04.08	21.43

Table 4. Seasonal distribution of scats in different habitat

Habitat type	Seasons								
	Wet2-94 (n = 92)	Dry-95 (n = 62)	Wet1-95 (n = 21)	Wet2-95 (n = 25)	Dry-96 (n= 164)	Wet1-96 (n = 56)	Wet2-96 (n = 28)	Dry-97 (n = 49	Wet1-97 (n = 14)
	Percentage of scats								
Evergreen	4.35	09.68	00.00	04.00	03.66	1.76	03.57	04.08	00.00
Moist Deciduous	32.61	40.32	76.19	32.00	32.32	37.50	39.29	46.94	66.67
Dry Deciduous	00.00	00.00	00.00	00.00	00.00	00.00	03.57	00.00	00.00
Plantations	63.04	41.94	14.29	64.00	64.02	60.71	46.43	36.73	25.00
Grassland	00.00	08.07	09.52	00.00	00.00	00.00	00.00	04.08	00.00
Unknown	00.00	00.00	00.0	00.00	00.00	00.00	07.14	08.16	08.33

phenology of food plants has also influenced the distribution of animals, higher concentration of scats being in the zones with fruiting trees.

5. Discussion

Majority of the sightings of bear in Parambikulam was of single individuals indicating that sloth bears are mostly solitary except during breeding seasons. Reports of Laurie and Seidensticker (1977) that 72% of their total sightings in Royal Chitwan National Park, Nepal and that of Baskaran (1990) in Mudumalai support the present observation in Parambikulam. Black bears in Northeastern Minnesota were observed generally as solitary but exceptionally with mother-offspring relationship from birth to maturity (Rogers, 1987).

The bear family is unique among the carnivores with all the members being omnivores. Like other carnivores, the bears also have a short, unspecialised digestive tract without a complex structure and enzymes for digesting plant material. The peculiarity in the digestive structure led the animal to seek food with high nutrient and energy content. Thus, the diet of bear mostly consists of animal matter supplemented by fruits and seeds. According to Laurie and Seidensticker (1977), competitive pressure and temporal patterning of resource availability have lead the sloth bear to specialised feeding towards myrmecophagy

Eisenberg and Lockhart (1972) reported heavy feeding on termites and fruits in Wilpattu National Park, Sri Lanka. Schaller (1967) found termites to be the year round diet with occasional, seasonal fruits in the diet. Sanderson (1983) recorded bears scavenging on tiger kills. Hasted (1903) observed even a partially digested snake in the sloth bear scat.

The monsoonal climate in India results in restricted fruiting season and availability of many of the insects. The morphology and behaviour of an animal should contribute to the adaptation for hard times. Sloth bear, which depends more on the animal food supplement the diet with the seasonal fruits and also the animal products such as honey. Amstrup and Beecham (1976) suggested a possible correlation between plant phenological stage and the food species. Laurie and Seidensticker (1977), in their observations in Chitwan have also recorded seasonal differences in the diet of sloth bear. They have recorded 19 plant species in the diet. However , their observations also indicated that insects formed about 52% of the diet. Termites were the most important food item throughout the year. The present observations in Parambikulam also confirm these findings.

Fruits of *Cassia fistula, Cordia dichotoma, Glycosmis sp., Ficus sp., Mangifera sp.* and *Ziziphus* were the major plant food items found in their diet. Termites, ants and beetles were found to be common among their animal diet. Baskaran (1990) found fruits of 14 plant species and 5 insect species as food items of sloth bears in Mudumalai Wildlife Sanctuary, Tamil Nadu. Overall dietary composition of sloth bear in Parambikulam revealed that animal matter was higher in all the months except in May and June. Laurie and Seidensticker (1977) recorded 52% of insects and 47% of fruits in the bear diet in Royal Chitwan National Park, Nepal. Davidar (1983) mentioned that sloth bears were regularly hunting for termites during pre-monsoon showers in the Sigur forest areas. Proportion of insects in the diet of black bear increased in spring when other food resources deplete in Osceola National Park, Florida (Maher & Brady, 1984). Insects were common in the diet of black bear in northeastern Minnesota (Rogers, 1987). However, Baskaran (1990) reported that about 91% of sloth bear' s diet was of fruits and animal matter formed only 9% in the diet of sloth bear in Mudumalai Wildlife Sanctuary, Tamil Nadu. Schaller (1967) recorded 38% termite/insects remains and 62% fruits from 92 droppings of sloth bears in Kanha National Park, India. Percentage composition of plant and animal matter highly varies in different ranges of their geographical distribution.

In Parambikulam, animal matter dominate in the bear diet and its percentage contribution varied depending on the availability of fruits. The percentage of animal matter in the diet came down in dry season, when fruit availability increased. It was very conspicuous during May and June when fruits of *C. fistula, C. dichotoma* and *Ziziphus* were abundant. Laurie and Seidensticker (1977) also found that fruits of 17 different species contribute to the diet of sloth bear from March to June in Royal Chitwan National Park, Nepal. Maehr and Brady (1984) explained low occurrence of animal matter in the black bear diet due to the availability of more easily obtained soft mast.

The present study in Parambikulam revealed that diversity in food items were higher in dry season. Among the plant food, *C. fistula* and *Z. rugosa* contributed much to its food during dry and first wet seasons. Prater (1965), Janzen (1967), Schaller (1967), Prue and Napier (1977), Davidar (1983) and Sanderson (1983) have reported sloth bears feeding on diverse fruits. Schaller (1969) also recorded various fruits in the diet of Himalayan black bear in Dachigam National park.

In Chitwan, the sloth bears were primarily concentrating in areas with thick cover, coming out in the open at night. They did not move far from the forested or tall

grass areas. The association of bear with the fruiting of *Ficus* spp also tempted them to move up hills in summer. Baskaran (1990) in his studies in the deciduous forest of Mudumalai recorded considerable variation on the dietary composition. According to him, the selection of food was depending a lot on the availability of ripe fruits. He had observed direct correlation between diet and fruiting phenology of trees. Cicnjake *et.al.* (1987) opined that insects are the consistent source of high quality animal protein in brown bear.

Among the seven identified zones in the study area, highest number of sloth bear scats were collected from Seechali zone followed by Thunacadavu – Kannimara zone during dry season. Moist deciduous forests and old teak plantations dominated these zones. Thee zones are also characteristic with abundance of *C. fistula* dominated by *Ziziphus* undergrowth, which were in fruits during dry season. Since the animal matter was limited in the study area during dry season, sloth bear concentration in these zones for major food plant species of *C. fistula* and *Ziziphus sp* could be the reason for higher number of scats. Sungam - Amakkundu zone had the larger number of scats during second wet season indicating a shift in the habitat use. Though there is no quantitative information on the availability of insects and other groups of animals, observations indicate availability of diverse group of insects in the zone during the season. During the first wet season, there was no preference seen in the habitat use. Baskaran (1990) also reported seasonal differences in the use of various zones by sloth bear in Mudumalai Wildlife Sanctuary. Amstrup and Beecham (1976) and Unsworth *et al.,* (1989) reported that the availability and distribution of food seemed to influence the movements of black bear. Saberwal (1989) has also found spatial distribution and movement of black bear, which was mainly governed by the phenological trends of a few key fruit species in Dachigam National Park.

In the present study, higher percentage of scats collected were from teak plantations followed by moist deciduous habitat. Seasonal differences in the usage of different habitats were also observed. Moist deciduous habitat was used more during the first wet season. Radio-telemetry studies on American balck bear reported seasonal home range shifts in relation to habitat potentiality across habitats (Rogers, 1987; Unsworth *et al.,* 1989). Laurie and Seidensticker (1977) have also documented the spatio-temporal concentration of sloth bear, more regulated by availability of fruits of certain species in Royal Chitwan National Park, Nepal. The habitat usage by sloth bear was mostly found to be patchy, in relation to the availability of food

resources (Baskaran, 1990). The study in Parambikulam also indicates habitat usage in relation to season and food availability.

A large proportion of plants in most communities are dispersed by animal. At least 50-75% of the trees in tropical forests produce fleshy fruits adapted for vertebrate consumption (Howe and Smallwood, 1982). The extinct Neotropical megafauna is believed to have played an important role in the dispersal of woody flora (Janzen and Martin, 1982). Long co-existence between neotropical plants and large frugivores moulded the evolution of fruit and seed traits of some plants for consumption and dispersal by large mammals. Experiments with surrogate pleistocene frugivores suggested the evolutionary importance of large frugivores in the demography and micro distribution of Neotropical plants. (Janzen 1981 a, b, c, 1982 a, b).

Observations in Parambikulam suggest the dispersal of a large number of seeds of shrubs and trees by sloth bear. Six species dominate the list where *Cassia fistula* is the major food species. Whether bear is the only vertebrate responsible for the dispersal of *Cassia fistula* could be confirmed only through a long term study on the diet of vertebrates in the area. The germination success of the seeds from the scats and from the trees could also be interesting and rewarding.

RECOMMENDATIONS

The observations on the food habits of bear in Parambikulam Wildlife Sanctuary suggest that the seeds of a large number of shrubs and tree species, including those of *Cassia fistula*, *Cordia dichotoma* and *ziziphus sp.* are dispersed by bear. These observations indicate the necessity of maintaining the diversity of plant species in the sanctuary for the survival of the animals. The practice of weeding and similar forestry operations may be discontinued to maintain the plant species diversity which in turn would also maximise the insect diversity.

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