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STATUS, FOOD AND FEEDING OF LARGER MAMMALS IN IDUKKI WIDLIFE SANCTUARY

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ABSTRACT

A study was conducted in Idukki Wildlife Sanctuary, Kerala to estimate the population of larger mammals, their season wise density distribution and to record the food and feeding habits. Population was estimated through direct and indirect methods by following the transect method. Food species of animals were identified through direct observation and from the indirect method of evidences from the remains in dung/pellet/dropping.

Only twelve species of large sized mammals were recorded from the area. Elephants dominated them in number as well as biomass. The ecological density of elephants was estimated to be 1.34/Km^2. The proportion of males in the population was very low (2.75%) compared to the adult females (91%). Low proportion of juveniles (1.85%) and calves (0.92%) indicated a very unhealthy trend. There was no significant seasonal difference in the overall food availability in the Sanctuary. However, the distribution of elephants showed significant differences between seasons with highest density during the post monsoon period.

Sixty eight plant species belonging to twenty nine families were identified as food plants of elephants, grasses being the dominant ones. Sightings of sambar deer, barking deer, wild boar, porcupine, Malabar giant squirrel and bonnet macaque were very few indicating very low density. Sambar was found to feed on twenty four species of plants, barking deer on seven and wild boar on eight species.

The relevance of the findings are discussed and suggestions for management given.

INTRODUCTION

Western Ghats is considered to be one of the hotspots for biodiversity conservation due to habitat diversity and high degree of endemism. But, the forested areas in the region have been fragmented forming islands leading to isolation of wildlife population. Idukki Wildlife Sanctuary forms a part of an isolated patch of forests which was cut off from the adjacent areas due to developmental programmes and habitat destruction.

Knowledge on the diversity of an area is an important pre-requisite for management of a nature reserve. Attempts had been made to study the long term environmental and ecological impacts on Wildlife due to the river valley projects in Idukki areas (Nair and Balasubramanian, 1985). Idukki area had been the site of several studies related to environmental impact (Jain and Nair, 1982; Dikshit, 1983; Trisal and Ramanathan, 1983; Singh, 1983; Gopinath and Jayakrishnan, 1984; Wason, 1984; Cherian, 1985 a & b; Khatri, 1985; Prasad, 1985). The management plan for the Sanctuary gives a detailed description of the area (Ramesan, 1991). Vinod (1994) while working in association with this study, reported certain aspects of elephants in Idukki from one year observation. However, studies on the status, distribution and food and feeding of the mammals have not so far been attempted

STUDY AREA

Idukki Wildlife Sanctuary forms a part of a number of small islands of forests along the Western edge of the High Ranges. The area falls between Latitudes 9^{o} 45' and 9^{o}55' N and between Longitudes 76^{o} 50 and 77^{o} 05' E (Fig. 1). The area falls in Nagarampara Reserve Forests and forms the catchment area of ldukki Hydel Project. The Sanctuary with an area of about 77 Km^2 is contiguous with adjacent forested areas of Ayyappankoil and Nagarampara Forest Ranges of Kottayam Forest Division. Excluding the 33 Km^2 of water spread area of the reservoir, the actual area of the Sanctuary is about 44 km^2.

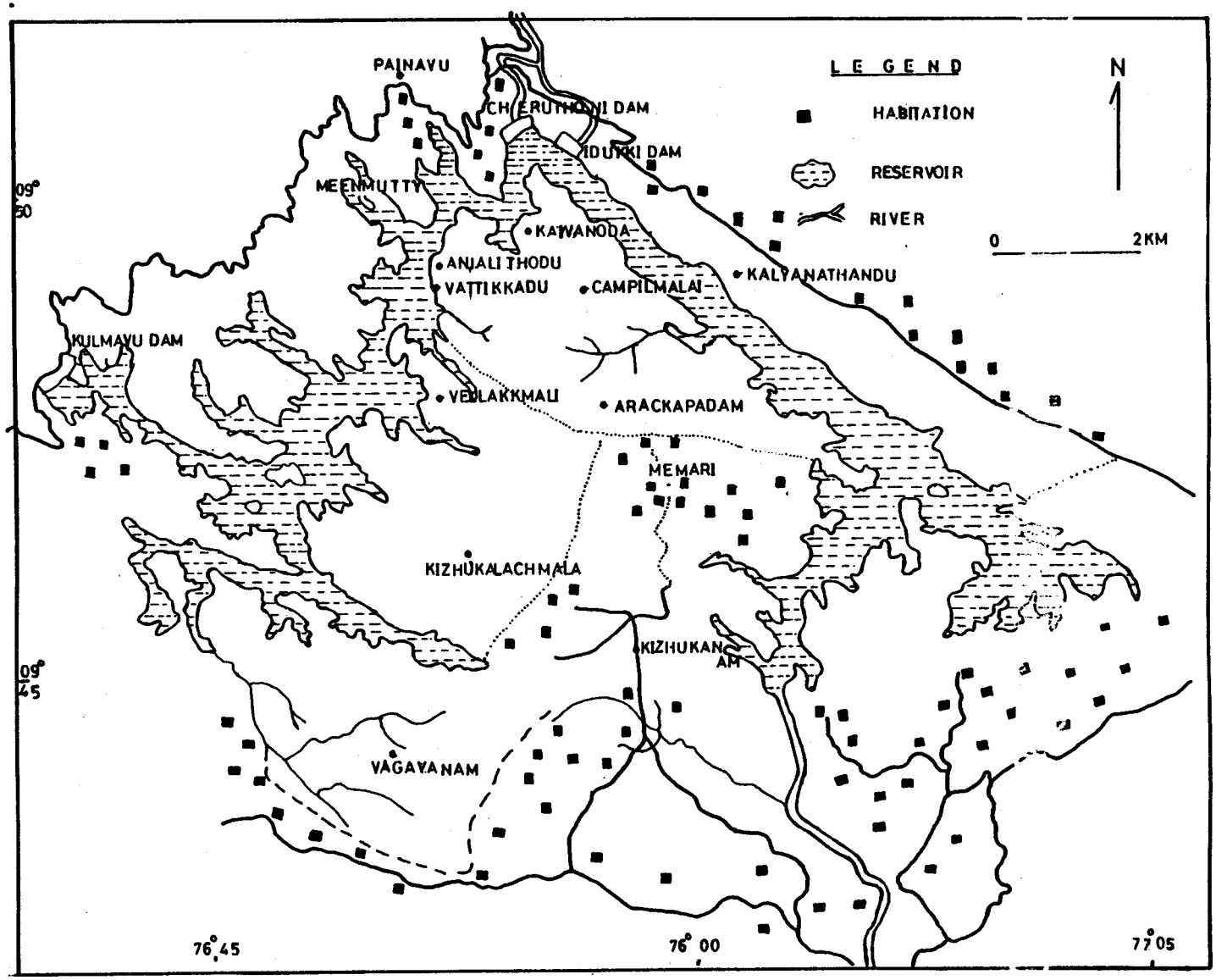


Fig. 1 Idukki Wildlife Sanctuary - the study area

The area is of undulating terrain with the elevation ranging from 800 to 1272 m. The highest peak in the Sanctuary is Kizhukalachimala (1272 m). Vegetation of the area could be classified into West Coast tropical evergreen forest, West Coast tropical semi-evergreen forest, South Indian moist deciduous forest and South Indian sub-tropical hill savanna.

West Coast Tropical Evergreen forests are mainly confined to Vagavanam and Kizhukalachimala areas. Pockets of such forest types occur at Vattikkadu, Vellakkamali and Chempakasseri areas also. The .evergreen patches are comparatively free from biotic pressures. Common tree species in the evergreen forests are *Cullenia exarillata, Artocarpus heterophyllus, Vateria indica, Dipterocarpus indicus, Paluquium ellipticum, Canarium strictum, Calophyllum apetalum, Dysoxylum malabaricum, Elacocarpus tuberculatus, Hopea parviflora, Holigarna arnottiana, Myristica dactyloides, Aporusa lindleyana* and *Cinnamomum zeylanicum.* Undergrowth is dominated by *Strobilanthus* sp., *Calamus* sp., *Pandanus, Curcuma* sp. and *Clerodendrum infortunatum.*

West Coast Tropical semi evergreen forests are found in the transitional zones of evergreen and deciduous forests and occupy only a very small area. South Indian Moist deciduous forests forms about sixty percent of the vegetation in Idukki Wildlife Sanctuary. They are distributed along the margins of the reservoir. *Tectona grandis, Dalbergia latifolia, Lagerstroemia microcarpa, Grewia tiliijolia, Vitex altissima. Xylia xylocarpa, Pterocarpus marsupium, Careya arborea, Dillenia pentagyna. Emblica officinalis, Haldina cordifolia, Schleichera oleosa* and *Randia brandisii* dominate the deciduous forests. Shrubs consists mainly of *Luntana camara, Eupatorium odoratum* and *Zizyphus* sp.

South Indian sub-tropical hill savanna type of forests dominated with grasslands and sparse tree growth occur mostly in the hill tops. A number of grass species with intermittent growth of trees like *Careya arborea,* and *Butea monosperma,* etc. is characteristic of this vegetation type in Idukki Wildlife Sanctuary.

The present study was formulated to estimate the population of large sized mammals, study their distribution in relation to season and food availability and identify the food Species.

METHODS

Population Studies

A direct simultaneous count of animals in the study area was organized in April-May 1993, as a part of the wildlife census organised by Kerala Forest Department with the assistance of trained volunteers and staff of the Kerala Forest Department. The study area was divided into 9 blocks of convenient size and all the blocks were simultaneously covered in a day on foot. The animal species sighted, the time and location of sightings and the group size and composition in the case of groups were recorded. The age and sex class were also recorded in the case of elephants.

Herd Size and Composition

A herd of elephant was defined as two or more elephants occurring together, the distance between the individuals being about 100 meters (Kurt, 1974). Elephants were classified into different age groups as described by Eisenberg and Lockhart (1972). However, the age group of sub-adult was combined with the adult as it was difficult for the investigators of the team to distinguish between adult and sub-adult.

The study area was also covered on foot every month recording the sightings of animals, group composition and classified them into different age and sex classes. Since the sightings of animals other than the elephants were very few, herd size frequency, herd composition and population structure of only elephants were analysed. Herd size frequency of elephants was computed by considering the total number of herds observed in the two year period. A solitary elephant was considered as herd for calculating the herd size frequency. A proportion of different age and sex classes in the population was also derived on the basis of all sightings.

Distribution of animals

Density distribution of animals in Idukki Wildlife Sanctuary area was also monitored through line transect method (Burnham *at al.,* 1980). Ten transects of 2 kms length were laid in the area covering different habitat types, almost proportionately (Table 1). These transects were covered on foot in two seasons viz. dry, (April-May) and Wet (July-August). The direct method (Burnham *et. al.,* 1980) of recording the animals sighted along with the sighting angle and distance was attempted once. However, since the number of direct sighting of animals were very few and inadequate for analysis, this was given up in the subsequent seasons.

Table 1. Details of transects in different zones followed for density distribution

Zone	Area
I.	Campilamali - Vattikkadu Chempakassery - Kaivanoda Anjilithandu - Vattikkadu
II.	Karukuttian - Chakkakolam Vallakkamali - Kizhukalachi
III	Charpamudi - Meenmutty Vadakkengopuram - Kuyilimala Kuyilimala - Mukkannampady
IV.	Vagavanam
V.	Kalyanathandu

Since the attempt was to know the season-wise abundance and distribution of animals in different parts of the Sanctuary, the indirect method as suggested by Barnes and Jensen (1987) was employed by covering the transects. In the case of elephants, the transects were covered and the number of dung boli on each side of the transect recorded. The perpendicular distance from the transect to the dung was measured and the stage of the dung was classified as fresh, old and very old and recorded. A fixed width of one metre on both sides of the transect was taken for other animals. The

indirect evidences (Pellet/ dropping scat/ hoof mark) of animals within one metre were recorded while covering the transects. The data were analysed using the Fourier Series analysis developed by Burnham *et al.,* (1980).

Studies on food plants

Information on food plants of elephants was collected by direct observation. Observation hours were distributed in proportion to habitat size as far as possible. The plants picked and consumed by elephants were noted from a distance through binoculars and the feeding site was visited soon after the animals moved away from the area. The specimens of plants fed were collected and compared with the herbarium for identification. The tree species debarked by elephants were also noted.

Considering the fewer number of sightings of other animal species, an indirect method was also employed to supplement information on food plants of sambar and barking deer. A technique for identification of plant materials had been used by Satakopan (1972) in Gir Forest. A similar technique with modification has been used in the present study. Possible food plants were collected from the field and identified. Plant parts were digested in a mixture of hydrogen peroxide and glacial acetic acid taken in equal proportion. The peelings of plants obtained after boiling were mounted on slides and the structure of epidermal cells such as trichomes, hairs, etc studied. The structure and distribution of stomata were also noted. These slides were later micro-photographed and the structure of the epidermal cells and stomata were compared between plant species for characteristic features. These were considered as reference slides/photographs.

Pellets/droppings/dung of animals were collected from the field, washed and digested in the mixture of hydrogen peroxide and acetic acid. The peelings of plant remains were separated and mounted on slides. The structure of epidermal cells, and the structure and distribution of stomata were studied. These were compared with the reference slides for identification of plant species fed by the animal.

Food availability

Biomass of plant species in different zones were estimated through clip and weigh method (Lehmkuhl, 1989). A number of plots were laid in different habitat types

(1 x 1 m for grass, 2 x 2 m for herbs and 5 x 5 m for shrubs). Plants from these sample plots were cut and weighed in the field. These were later brought to the laboratory, oven dried and weighed for biomass estimation. These were pooled zone-wise and analysed. The 5th zone, Kalyanathandu was not considered as no food availability estimation was done in the zone.

RESULTS

FOOD AND FEEDING

Reference slides

One hundred and eighty one species of plants from fifty families were collected and the parts treated with hydrogen peroxide-glacial acetic acid mixture (Table. 2). Reference slides of these were prepared for identification of food plants from the dung/pellets/droppings.

Table 2. List of plants for which reference slides were prepared

1) **Family: Ranunculaceae**
   1. *Naravelia zeylanica,* DC.
2) **Family: Polygalaceae**
   1. *Xanthophyllum flavescens* . Roxb.
3) **Family: Malvaceae**
   1. *Sida cordifolia,*L.
   2. *Abutilon,* Gaertn.
   3. *Bombax ceiba,* L.
4) **Family: Sterculaceae**
   1. *Helicteres isora*
5) **Family: Tiliaceae**
   1. *Grewia tiliifolia,*Vahl.
   2. *Triumfetta pilosa,* Roth.
6) **Family: Elaeocarpaceae**
   1. *Elaeocarpus glandulosum*
   2. *Elaeocarpus tuberculatus* ,Roxb.
7) **Family: Geraniaceae**
   1. *Biophytum candolleanum,* W.
   2. *Impatiens* sp.
8) **Family: Rutaceae**
   1. *Toddaiia asiatica,*Lam.
9) **Family: Burseraceae**
   1. *Garuga pinnata,* Roxb.
10) Family: Meliaceae
   1. *Cedrela* sp.
   2. *Naregamia alata,* W. & A.

11) **Family: Rhamnaceae**
1. *Zizyphus jujuba,* Lam.
2. *Zizyphus rugosa,* Lam.

12) **Family: Vitaceae**
1. *Tetrastigma sulcatum, Gamb.*
2. *Leea sp.*
3. *Leea wightii,* C.B.CI.

13) **Family: Sapindaceae**
1. *Harpullia arborea,* Roxb.
2. *Cardiospermum helicacabum,* L.
3. *Allophyllus rheedii,* Radlk.
4. *Allophyllus serratus,* Radlk.

14) **Family: Anacardiaceae**
1. *Solenocarpus indica,* W.& A.

15) **Family: Papilionaceae**
1. *Desmodium gyrans,* DC.
2. *Desmodium triangulare,* DC.
3. *Desmodium* sp.
4. *Desmodium triquetrum,* DC.
5. *Desmodium ormocarpoides.* DC.
6. *Crotalaria indica,* L.
7. *Croralaria walkeri,* Am.
8. *Erythrina stricta,* Roxb.
9. *Clittoria ternatea,* L.

16) **Family: Mimosaceae**
1. *Mimosa pudica,* L.
2. *Albizzia lebbeck, Benth.*
3. *Prosopis specigera,* L.
4. *Prosopis cinergria*

17) **Family: Combretaceae**
1. *Calycopterisfloribunda,* Lam.

18) **Family: Myrtaceae**
1. *Eugenia jambos,* L.
2. *Syzygium* sp.

19) **Family: Melastomaceae**
1. *Memecylon* sp.

20) **Family: Passifloraceae**
1. *Passiflora foetida,* L.

21) **Family: Rubiaceae**
1. *Ixora bracheata,* Roxb.
2. *Ixora coccinea,* L.
3. *Mussaenda glabrata,* Hk.f.
4. *Anotis wightiana,* B.& Hk.f.
5. *Knoxia sp.*
6. *Oldenlandia corymbosa,* L.
7. *Spermacocca latifolia*
8. *Psychotria sp.*
9. *Hedyotis auricularia, L.*
10. *Myrtacarpus*

11. *Xeromphis spinosa*

22) **Family: Compositae**

1. *Ageratum sp.,* R.
2. *Acanthospermum hispidum,* DC.
3. *Elephantopus scaber,* L.
4. *Eupatorium odoratum*
5. *Eupatorium glandulosum*
6. *Euparorium adenophorum*
7. *Synedrella nodijlora,* Gaertn.
8. *Tridax* sp.
9. *Bidens pilosa, L.*
10. *Vernonia sp.*
11. *Vernonia cinerea, Less.*
12. *Lactuca* sp.

23) **Family: Myrsinaceae**

1. *Maesa indica,* W.

24) *Family: Oleaceae*

1. *Olea dioica,* Roxb.

25) **Family: Apocynaceae**

1. *Alstonia scholaris,* R. Br.
2. *Rauwolfia* sp.
3. *Rauwolfia serpentina,* Benth.

26) **Family: Asclepiadaceae**

1. *Cosmostigma* sp.
2. *Hemidesmus indicus,* R. Br.

27) **Family: Convolvulaceae**

1. *lpomoea alba,* L.
2. *Ipomoea hederifolia,* Jacq.
3. *Evolvulus* sp.

28) **Family: Solanaceae**

1. *Solanum torvum,* Sw.
2. *Cestrum nocturnum*

29) **Family: Scrophulariaceae**

1. *Scoparia dulcis,* L.

30) **Family: Gesneriaceae**

1. *Rhyncoglossum notonianum,* Bl.

31) **Family: Acanthaceae**

1. *Strobilanthes* sp.
2. *Justicia procumbens,* L.
3. *Strobilanthes anceps,* Nees.

32) **Family: Verbenaceae**

1. *Clerodendron infortunatum.* L.
2. *Clerodendron thomsonae,* Balf.
3. *Lantana camara,* L.
4. *Duranta plumeri,* Jacq.
5. *Virex negundo,* L.
6. *Gmelina arborea,* Roxb.

33) **Family: Labiatae**
1. *Ocimum basilicum,* L.
2. *Hyptis* sp.

34) **Family: Amarantaceae**
1. *Gomphrena decumbens,* Jacq.
2. *Aerva lanata,* Juss.
3. *Banalia thyrsifolia,* Moq.

35) **Family: Polygonaceae**
1. *Polygonum chinense,* L.

36) **Family: Myristicaceae**
1. *Knema atfenuata,* Warb.

37) **Family: Lauraceae**
1. *Litsea* sp.
2. *Litsea coriacea,* Hk.f.
3. *Cinnamomum zeylanicum,* Bl.
4. *Cinnamomum riparium,* Gamb.

38) **Family: Euphorbiaceae**
1. *Macaranga peltata,* M. Arg.
2. *Macaranga subpeltata*
3. *Macaranga indica,* W.
4. *Euphorbia hirta,* L.
5. *Mallotus* sp.
6. *Ricinus communis,* L.
7. *Antidesma acidum,* L.
8. *Phyllanthus* sp.
9. *Mallotus indica*
10. *Bridelia scandens,* Gehrm.
11. *Drypetes* sp.
12. *Glochidion* sp.
13. *Souropus* sp.
14. *Brynia vitis-ideae,* Forst.

39) **Family: Moraceae**
1. *Ficus* sp.

40) **Family: Urticaceae**
1. *Laportea* sp.
2. *Pouzolzia indica,* Gaud.

41) **Family: Gnetaceae**
1. *Gnetum ula,* Brogn.

42) **Family: Cycadaceae**
1. *Cycas* sp.

43) **Family: Zingiberaceae**
1. *Costus speciosus,* Sm.
2. *Alpinia galanga,* Sw.
3. *Amomum* sp.
4. *Globba bulbifera,* L.
5. *Globba ophioglossa,* W.
6. *Zingiber* sp.
7. *Zingiber rnacrostachyum,* Dalz.

44) **Family: Dioscoriaceae**
1. *Dioscorea oppositifolia,* L.
2. *Dioscorea pentaphylla,* L.

45) **Family: Liliaceae**
1. *Asparagus* sp.
2. *Gloriosa superba,* L.

46) **Family: Commelinaceae**
1. *Commelina benghalensis,* L.

47) **Family: Palmaceae**
1. *Calamus rotang,* L.
2. *Caryota urens,* L.

48) **Family: Araceae**
1. *Pothos scandens,* L.

49) **Family: Cyperaceae**
1. *Cyperus pilosus,* Vahl.
2. *Cyperus kyllingia*
3. *Cyperus distans,* L.f.
4. *Mariscus pictus,* Nees.
5. *Fimbristylis dichotoma*
6. *Scleria corymbosa,* Roxb.

50) **Family: Poaceae**
1. *Cenchrus inhiri,* L.
2. *Briza minor,* L.
3. *Bambusa bambos* (L) Voss.
4. *Pennisetum polystachyon,* Sch.
5. *Sporobolus diander,* Beauv.
6. *Sorghum* sp.
7. *Chrysopogon* sp.
8. *Digitaria* sp.
9. *Digitaria ciliaris,* R. & T.
10. *Digitaria griffithii,* R. & T.
11. *Saccharum sp.*
12. *Apluda* sp.
13. *Eragrostis tenuifolia,* Hochst.
14. *Eragrostis unioloides,* Nees.
15. *Eragrostis riparia,* Stapf.
16. *Chloris* sp.
17. *Eleusine,* Gaertn.
18. *Paspalidium punctatum,* Stapf.
19. *Perotis indica,* O.Ktz.
20. *Saccharum officinarum, L.*
21. *Centotheca lappacea,* Desv.
22. *Ochlandra tmvancorica,* Gamb.
23. *Paspalum scrobiculatum,* L.
24. *Paspalum conjugatum,* Berg.
25. *Paspalidium flavidum.* A.Cam.
26. *Cyrtococcum oxyphyllum,* Stapf.
27. *Cyrtococcum patens,* A. Cam.

28. ***Cyrtococcum decarens***
29. ***Chloris dolichostachya***
30. ***Cymbopogon flexuosus,*** Hack.
31. ***Oplismenus compositus,*** Beauv.
32. ***Axonopus compressus***
33. ***Ischaemum rangacharianum,*** C. Fisch.
34. ***Chrysopogon zeylanicus,*** Thin.
35. ***Dactyloctenium aegyptium,*** Beauv.
36. ***Panicum*** sp.
37. ***Bothriochloa*** sp.
38. ***Cappillipedium*** sp.
39. ***Leersia hexandra,*** Sw.
40. ***Arundinella mesophylla,*** Nees.
41. ***Rottboellia cochinchinensis,*** L.f.

Microscopic characters such as stomata, trichomes and epidermal cells are used as diagnostic features of plant species. Identification of grasses were more or less easy compared to dicotyledons. The rate of digestion is more in the case of dicots leaving only a small portion of quadrangular shaped dicot materials after digestion. In the case of grasses, small linear pieces are available after digestion. These could be identified using the reference slides. The presence of trichomes, number of and distribution of stomata, nature of epidermal cells, etc. were taken as identifying characters.

Food availability

The significance test conducted revealed that there was no significant difference in the quantum of available food in the first four zones (Table 1) during the wet season (F= 1.28, p=0.31, df(3,20)). The values for the dry season turned out to be significant ((F=12.18, p=0.000l, df(3,20)) indicating differences in the available food in different zones. The Zone I (Kampilamali-Vattikkadu) had the highest value followed by Zone IV (Vagavanam) and Zone II (Karukuttian-Chakkakolam).

A comparison between the seasons combining all the zones turned out to be non-significant (t=0.94, p=0.35, df(46) indicating that there was no overall seasonal difference in food availability in Idukki Wildlife Sanctuary.

Elephant, *Elephas maximus*

Number and density

A total of 59 elephants were seen during the total count in bl cks. The cological density was estimated to be 1.34/ km2.

Population structure

The percentage frequency distribution of different age and sex classes of elephants, based on all the sighting records, in the area is given in Figure 2. The adult females constituted 91% of the population and the adult males only 2.75%. The subadult females (3.08%), juveniles (1.85%) and calves (0.92%) were of low proportion.

Herdsize of elephants

Herd size frequency distribution of elephants in Idukki Wildlife Sanctuary is given in Figure 3. The herd size frequency in dry and wet seasons are shown in Figures 4 and 5 respectively. A total of 87 herds were observed during the two year study period.

Herd size of 1,2,3 and 5 were the commonest throughout the year and constituted about 76% of the total sightings. Of the 87 herds, 37 were observed in dry season and 50 in wet. Twenty three percent of the total herds seen were of solitary animals and about half of these were males and others females. Percentage of solitary elephants were more during dry season compared to the wet season (18%).

However, there was no significant seasonal variation in the proportion of solitary elephants in the study area ($X^2(1, 0.01) = 2.71$). Herds of two individuals constituted about 20%, most of which during the wet season. All these were of female

Fig. 2 Age and Sex classes of elephants in Idukki WLS

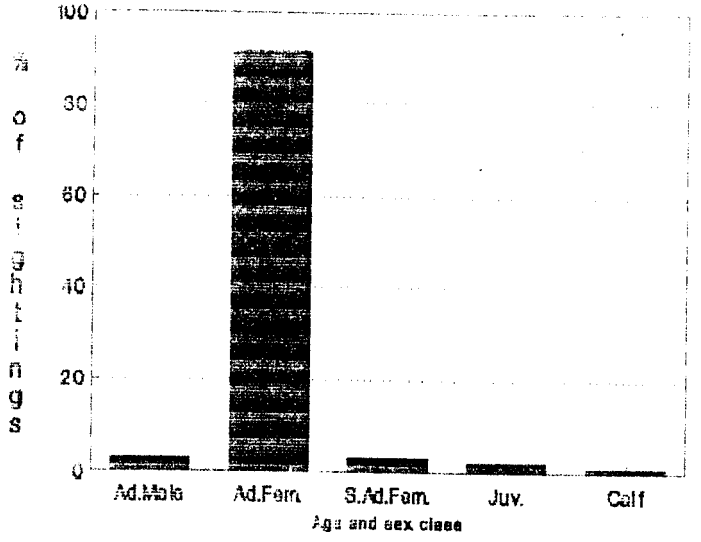


Fig 3 Herd size Frequency Distribution of Elephants in Idukki WLS

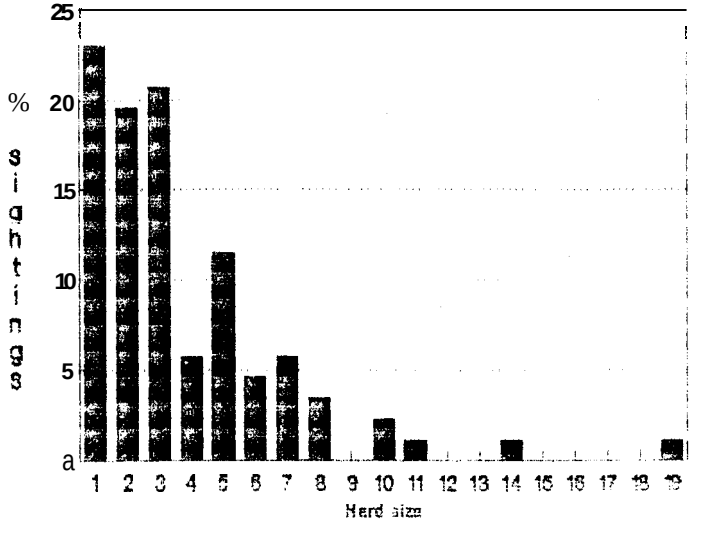


Fig. 4 Herdsize Frequency Distribution of Elephants in Idukki WLS - Dry season

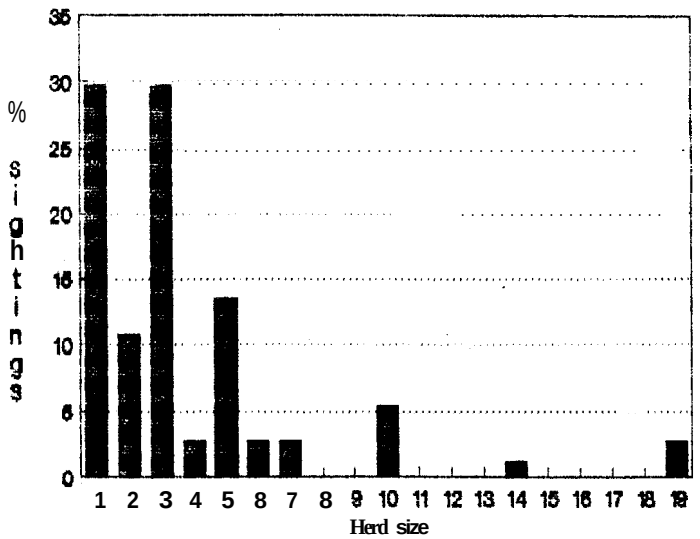
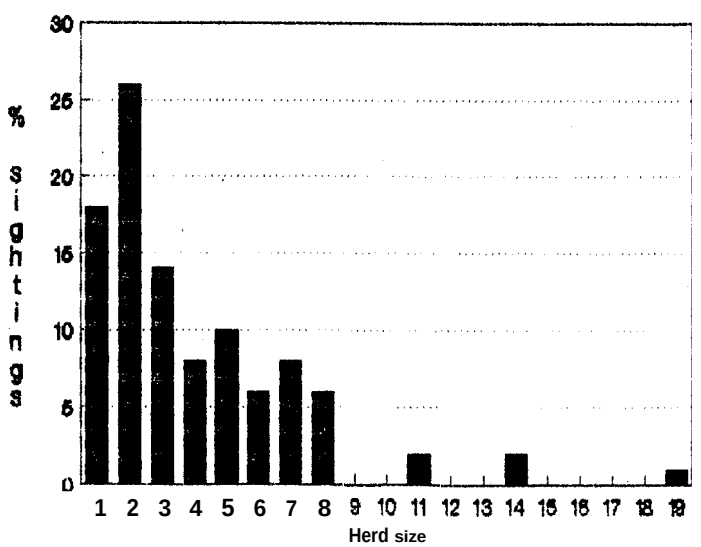


Fig.5 Herdsize Frequency Distribution of Elephants In Idukki WLS - Wet season



elephants. The two observations on herds with 10 elephants were during dry season. Herds with 11 and 14 were recorded only once during the wet season.

Seasonal variation in herd size

The variance in herd size in the dry and wet seasons, compared by F-test, were found to be equal.

	Dry season	Wet season
N	37.00	50.00
X	3.59	3.84
S^2	11.75	7.63

F=l.54 (ns) at 1% level.

The student's t-test carried out for computing the difference between average herd size turned out to be non-significant.

s^2 = 9.39
S = 3.06
t = 0.3767 (ns)

A comparison between food availability in dry and wet season was made using - test and was non significant (t=l.19, p=0.28, df=6) indicating that the food availability was equal in both the seasons.

Distribution of elephants

Dung density of elephants in different zones of the Sanctuary during dry and wet seasons is given in Table 3 and are represented in the Figures 6 and 7 respectively.

A comparison of density of elephant dung in dry, wet1 and wet2 seasons, combining all the zones, was attempted.

	Dry Season	Wet1 Season	Wet2 Season
Mean Density	577.88	1691.65	1759.99
Standard Error	144.31	303.51	345.07

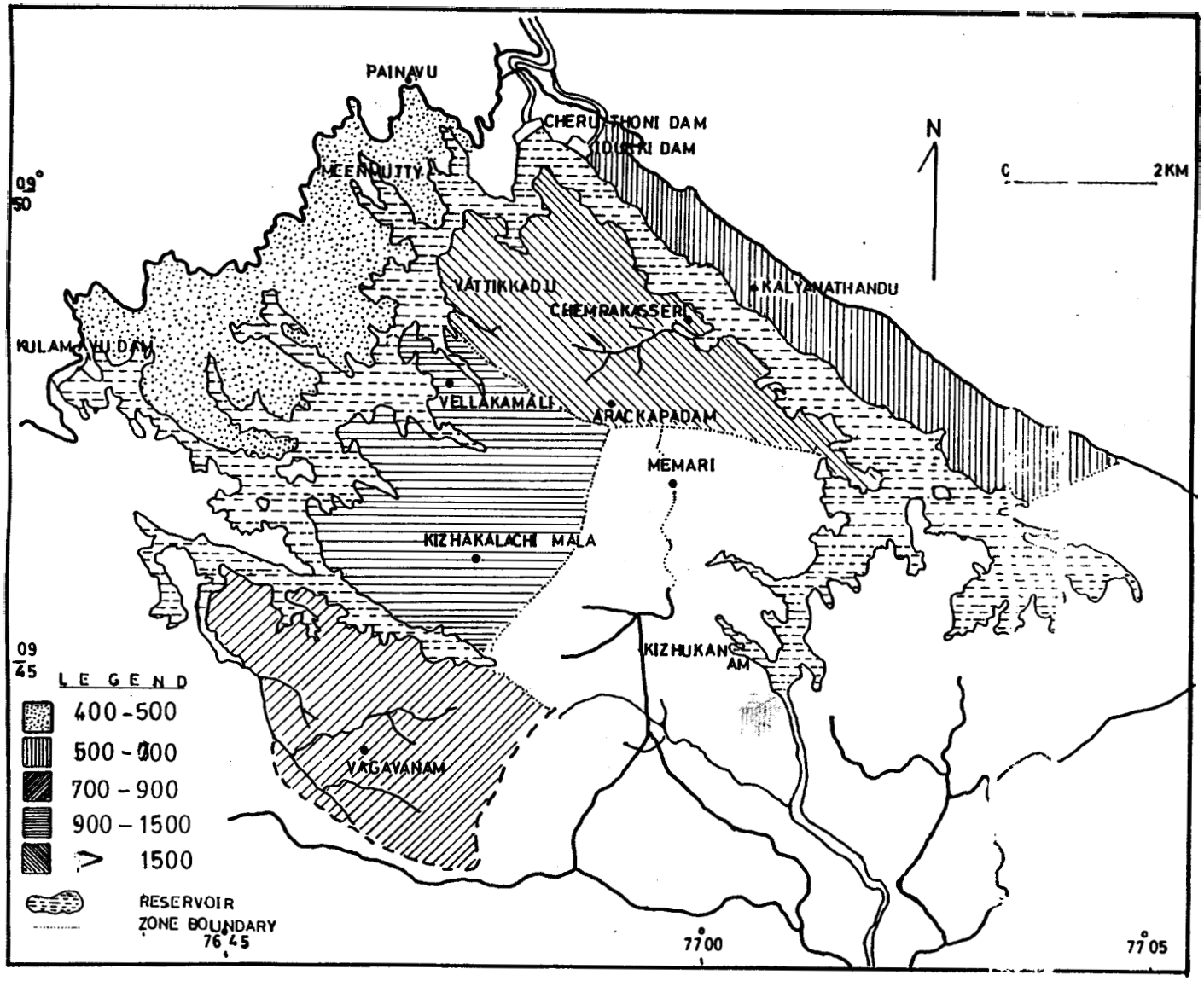


Fig. 6 Dry season distribution of elephants in Idukki Wildlife Sanctuary

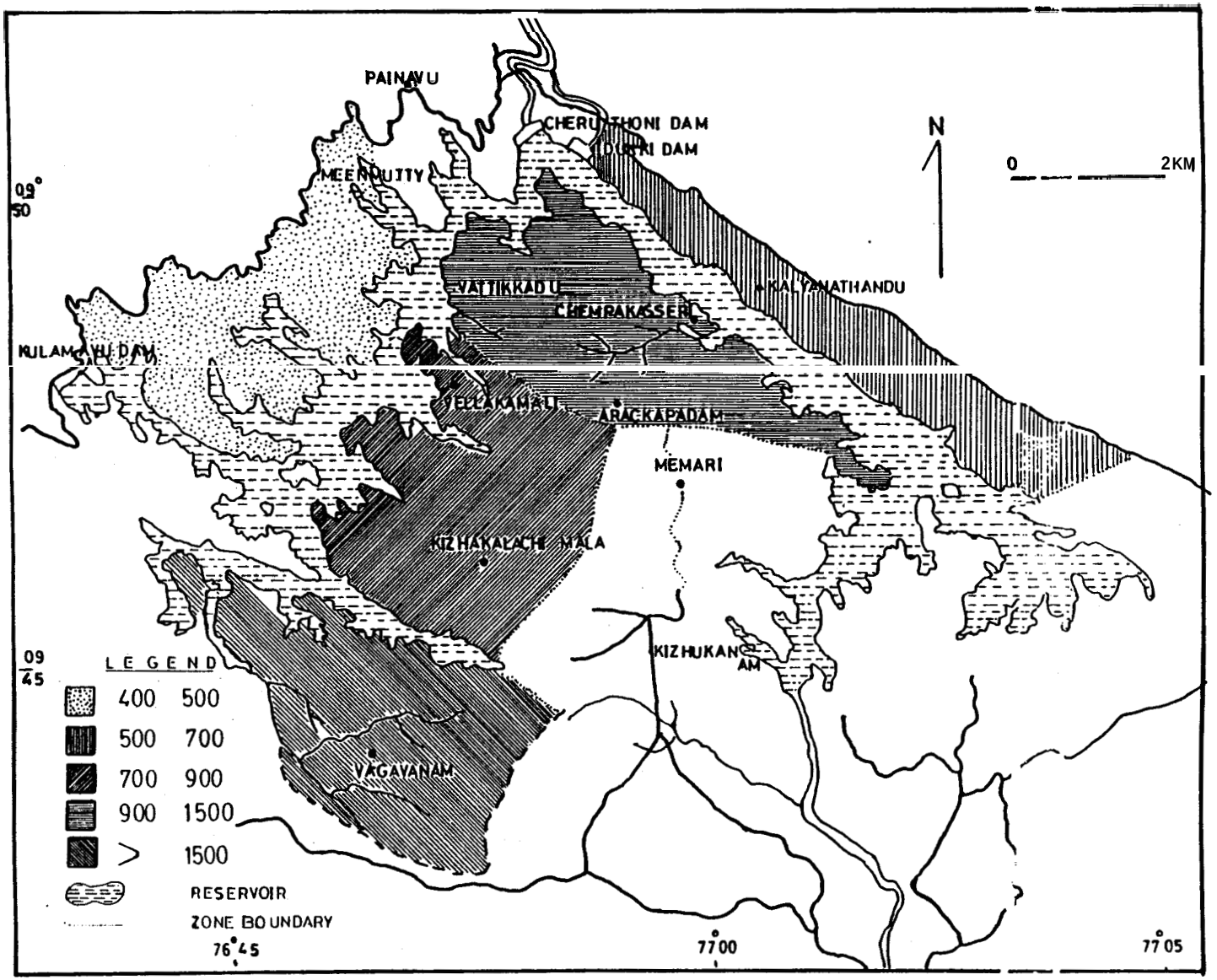


Fig. 7 Wet season distribution of elephants in Idukki wildlife Sanctuary

Comparisons between the three seasons were made using F-test. There was significant difference between the seasons (F=6.81, P=0.003, df (2,42).

Table 3. Density of elephant dung in dry and wet seasons

	Dry Season			Wet1 Season			Wet2 Season		
	Density	SE	CV	Density	SE	CV	Density	SE	CV
Zone I	2723.50	1020.95	26.45	1369.35	260.47	14.40	1844.00	572.00	31.00
Zone II	967.25	530.00	35.05	770.55	141.55	19.35	1573.00	378.30	24.10
Zone III	490.75	282.55	56.50	422.30	231.40	54.85	909.60	484.30	53.20
Zone IV	833.35	690.90	65.80	2124.50	774.70	37.50	2636.00	938.90	35.60
Zone V	529.05	307.23	57.70	590.50	432.00	78.85	882.40	509.40	57.70

Dry season differs significantly from the Wet1 and Wet2 seasons at 5% significance level (P=0.05). There was no significant difference in the density of dung between Wet1 and Wet2 seasons at 5% significance level (P=0.05) However, there was no statistically significant difference within the zones during dry (F=0.80, p=0.51, df(3,14)), and wet 1 seasons (F=0.52, p=0.68, df(3,14)). The test was not done for the Wet2 seasons as the sample size was low.

The density was comparatively higher in both the seasons in Zone I. However, Zone IV had the highest density in wet seasons. The Zones III and V had comparatively low densities in both the seasons.

Food species

Both the direct observations and indirect method indicated that 68 plant species belonging to 29 families formed the food plants of elephants (Table 4). Of these, grasses dominated with 13 species followed by 8 species under Papilionaceae and 6 under Moraceae.

Table 4. List of food plants fed by elephants in Idukki Wildlife Sanctuary

Plant Family and Species	Parts fed			
	Leaf	Bark	Root	whole
1) **Annonaceae**				
1. *Uvaria* sp.	+		-	-
2) **Malvaceae**				
1. *Urena lobata* L.	-		-	+
2. *Bombax ceiba* L. (sp. 511)	-	+	-	-
3) **Sterculiaceae**				
1. *Sterculia villosa* Roxb	-	+	-	-
2. *Helicteres isora* L.	-	-	-	+
4) **Tiliaceae**				
1. *Grewia disperma* Rottl.	-	+	-	-
2. *Grewia tiliifolia* Vahl.	-	+	-	-
3. *Grewia aspera* Roxb	-		-	+
5) **Meliaceae**				
1. *Dysoxylum beddomei* Hiern	-	+	-	-
6) **Rhamnaceae**				
1. *Zizyphus rugosa* Lamk	-	-	+	-
7) **Vitaceae**				
1. *Amplelocissus* sp.	-	+	-	-
2. *Tetrastigma sulcatum* (Lawson) Gamb.	-		-	+
8) **Sapindaceae**				
1. *Schleichera oleosa* (Lour) Oken	-	+	-	-
9) **Papilionaceae**				
1. *Desmodium triquetrum* DC	-	-	-	+
2. *Desmodium repandum* (Vahl) DC	-	-	-	+
3. *Desmodium zonatum* Miq.	-	-	-	+
4. *Desmodium triangulare* (Retz.) Morr.	-		-	+
5. *Desmodium motorium* (Houtt) meer	-		-	+
6. *Erythrina stricta* Roxb	-	+	-	-
7. *Pterocarpus marsupium* Roxb	-	+	-	-
8. *Dalbergia latifolia* Roxb	-	+	-	-
10) **Caesalpineaceae**				
1. *Bauhinia* sp.	-	+	-	-
11) **Mimosaceae**				
1. *Acacia sinuata* (Lour) meri.	-	+	-	-
12) **Combretaceae**				
1. *Terminalia paniculata* Roth	-	+	-	-
13) **Lecythidaceae**				
1. *Careya arborea* Roxb	-	+	-	-
14) **Datiscaceae**				
1. *Tetrameles nudiflora* Roxb	-	+	-	-

Plant Family and Species	Parts fed			
	Leaf	Bark	Root	whole
15) **Rubiaceae**				
1. *Haldina cordifolia* (Roxb) Ridsdale	-	+	-	-
2. *Mussaenda (f) belilla* Buch-Ham	-	-	-	+
16) **Compositae**				
1. *Acanthospermum hispidum* DC	-	-	-	+
17) **Acanthaceae**				
1. *Strobilanthes* sp.	+	-	-	-
18) **Verbenaceae**				
1. *Tectona grandis* L.f.	-	+	-	-
2. *Clerodendrum viscosum* Vent.	-	-	-	+
3. *Lantana camara* L.	-	-	-	+
19) **Polygonaceae**				
1. *Polygonum chinense* L.	-	-	-	+
20) **Myristicaceae**				
1. *Myristica malabarica*. Lam.	-	+	-	-
21) **Euphorbiaceae**				
1. *Mallotus ferrugineus* (Roxb) Muell-Arg	-	-	-	+
2. *Bridelia scandens*.(Roxb) Wild	+	+	-	-
22) **Ulmaceae**				
1. *Trema orientalis* Bl.	+	+	-	-
23) **Moraceae**				
1. *Ficus bengalensis* L.	+	+	-	-
2. *Ficus callosa*	-	-	-	+
3. *Ficus tsjahela* Burma .f.	-	+	-	-
4. *Artocarpus hirsutus* Lam.	+	+	-	-
5. *Ficus exasperata* Vahl.	-	+	-	-
6. *Artocarpus heterophyllus* Lamk.	+	+	-	-
24) **Zingiberaceae**				
1. *Amomum* **sp.**	-	-	-	+
25) **Musaceae**				
1. *Eusetesuperbum (Roxb)* Cheesman	-	-	-	+
26) **Marantaceae**				
1. *Schumannianthus virgatus* (Roxb) Rolfe.	-	-	-	+
27) **Palmaceae**				
1. *Phoenix loureirii* Kunth	-	-	-	+
28) **Pandanaceae**				
1. *Pandanus* sp.	-	-	-	+
29) **Cyperaceae**				
1. *Cyperus tenuiculmis* Boeck	-	-	-	+
2. *Cyperus kyllingia* Endl.	-	-	-	+

Plant Family and Species	Parts fed			
	Leaf	Bark	Root	whole
30) **Poaceae**				
1. ***Bambusa bambos*** (L) Voss.	-	-	-	+
2. ***Ochlandra travancorica*** Gamb.	-	-		+
3. ***Chrysopogon*** sp.		-	-	+
4. ***Themeda tremula*** Hack.	-	-	-	+
5. ***Themeda triandra*** Forsk.	-	-	-	+
6. ***Themeda cymbaria*** Hack.		-	-	+
7. ***Apluda mutica*** L.	-	-	-	+
8. ***Arundinella purpurea*** Rad.		-	-	+
9. ***Cymbopogon*** sp.	-	-	-	+
10. ***Ischaemum*** sp.			-	+
I 1. ***Sorghum*** sp.	-	-	-	+
12. ***Pennisetum polystachyon*** Sch.			-	+
13. ***Pennisetum hohenackeri*** Hochst.	-		-	+
14. ***Eleusine*** sp .	-	-	-	+
15. ***Eragrostis riparia***	-		-	+
16. ***Leersia hexandra***	-		-	+
17. ***Paspalum conjugatum.***	-	-	-	+

Sambar, *Cervus unicolor*

Number

Sightings of sambar deer were rather few in Idukki Wildlife Sanctuary. Only six animals were recorded in the total count. Of these, two were stags and three does and a fawn. The total number of sambar deer seen during the two year study period was only seven including a stag. The sightings were near Paramavu, Kaivanada, Chempakasseri and Keerimudi.

Distribution

Since the number of animals were very low; the attempt to know the abundance in different zones did not yield enough information for analyses. However, the number of indirect evidences such as pellets and hoof marks indicate the presence of sambar deer in Vagavanam, Kalyanathandu, Kuyilimala and Chempakasseri areas. Of these, Vagavanam harbours the maximum number followed equally by other areas.

Food Species

Twenty four plant species belonging to 15 families were identified as food plants of sambar deer (Table 5). These are based on the observations made during the rare sightings, the indirect evidences of biting marks obtained after the animal left the site and from the analyses of pellets for plant remains.

Table 5. List of food plants of Sambar deer

1) **Malvaceae**
   1. *Urena lobata* L.
2) **Sterculiaceae**
   1. *Helicteres isora* L.
3) **Burseraceae**
   1. *Boswellia serrata* Roxb. excoleb
4) **Meliaceae**
   1. *Soymida febrifuga* A. Juss.
5) **Rhamnaceae**
   1. *Zizyphus mauritiana* Lamk.
6) **Papilionaceae**
   1. *Centrosema pubescens* Benth
   2. *Erythrina stricta* Roxb.
7) **Caesalpineaceae**
   1. *Bauhinia racemosa* Lam.
8) **Mimosaceae**
   1. *Acacia leucophloea* (Roxb) Willd.
9) **Combretaceae**
   1. *Terminalia tomentosa* W & A.
   2. *Anogeissus latifolia* (Roxb exDC) Wallex. Guill & Perr
10) **Compositae**
   1. *Acanthospermum hispidum* DC
   2. *Ageratum conyzoides* L.
11) **Apocynaceae**
   1. *Wrightia tinctoria* R. Br.
12) **Convolvulaceae**
   1. *Ipomoea hederifolia* L.
   2. *Merremia umbellata* (L) Ha1l.f.
13) **Verbenaceae**
   1. *Lantana camara* L.
   2. *Clerodendrum viscosum* Vent
   3. *Tectona grandis* L.f.
14) **Polygonaceae**
   1. *Polygonum chinense* L.
15) **Poaceae**
   1. *Apluda mutica* L.
   2. *Cappillipedium huegelli* Stapf.

3. *Chionachne koenegii* Thw.
4. *Heteropogon insignis* Pers.

Barking deer, *Muntiacus muntjac*

Number and distribution

There were only six records of this shy animals in the total count. All of them were from Vattikkadu, Meenmutty and Vadakkangopuram areas. About 75 % of the fifteen sightings or recording from the calls during the study period were from the above areas. However, the indirect evidences indicate comparatively higher abundance in Vagavanam followed by Chempakasseri area in dry season (Table 6). It was evenly distributed in wet season.

Food plants

Seven species of plants were identified mainly from direct observation (Table 7).

Table 6. Season-wise Density of Barking deer pellets in Idukki in different zones

	Dry Season			Wet1 Season			Wet2 Season		
	Density	SE	CV	Density	SE	CV	Density	SE	CV
ZoneI	708.15	466.25	65.90	166.70	166.70	100.00	166.70	83.33	50.00
Zone II	250.00	125.00	66.65	187.50	187.50	175.00	250.00	00.00	00.00
Zone III	333.30	51.91	45.55	125.01	83.33	75.00	250.00	00.00	00.00
ZoneIV	1000.00	482.80	55.75	125.00	125.00	50.00	250.00	250.00	100.00
Zone V	125.00	125.00	125.00	125.00	125.00	50.00	250.00	250.00	100.00

Table 7. List of food plants of Barking deer

1) **Malvaceae**
   1. *Urena lobata* L.
2) **Papilionaceae**
   1. *Centrosema pubescens* Benth.
3) **Compositae**
   1. *Acanthospermum hispidum* DC.
   2. *Ageratum conyzoides* L.
4) **Convolvulaceae**
   1. *Merremia umbellata* (L) Hal1.f.
   2. *Ipomoea* L.

5) **Polygonaceae**
1. *Polygonum chinense* L. (Whole plant)

Wild Boar, *Sus scrofa*

Number and distribution

Only four sounders numbering about 34 animals were recorded in the total count. All these were from different areas. Seven sounders with a total number of 24 individuals were sighted in entirely different areas during the study period. However, there had been frequent records on the occurrence of the species in the habitations.

The results of the analyses of indirect evidences indicate its higher abundance in the second zone - Kizhukalachi followed by Meenmutty and Vagavanam areas in dry season (Table 8). The wet season abundance was high in Chempakasseri area followed by Kalyanathandu. No evidence was obtained from Meenmutty area in wet season.

The list of food plants identified mainly from the evidences at feeding sites is given in Table 9.

Table 8. Season-wise Density of Wild boar droppings in different zones in Idukki

	Dry Season			Wet1 Season			Wet2 Season		
	Density	SE	CV	Density	SE	CV	Density	SE	CV
Zone I	208.32	83.33	62.50	791.50	804.00	50.80	500.00	250.00	50.00
ZoneII	1062.50	812.50	87.50	125.00	125.00	50.00	0.00	0.00	0.00
ZoneIII	916.66	514.91	77.05	0.00	0.00	0.00	333.30	333.30	100.00
ZoneIV	875.00	456.30	57.70	250.00	250.00	100.00	500.00	353.60	70.70
ZoneV	500.00	341.50	78.85	500.00	353.60	70.70	500.00	353.60	70.70

Table 9. List of food plants of Wild boar

1) **Compositae**
1. *Acanthospermum hispidum* DC.
2. *Ageratum conyzoides* L.
2) **Convolvulaceae**
1. *Merremia umbellata* Hal1.f.
2. *Ipomoea hederifolia* L.

3) **Polygonaceae**
1. *Polygonum chinense* L. (Whole plant)

4) **Dioscoreaceae**
1. *Dioscorea spicata* Roth.
2. *Dioscorea pentaphylla* L
3. *Dioscorea wallichi* Hk.f.

Indian Porcupine, *Hystrix indica*

There was no direct sighting of this nocturnal rodent. Indirect evidences indicate that they were present in all the areas (Table 10). Vagavanam had the highest abundance followed by the Chempakasseri and Meenmutti areas in dry season. During wet season, abundance was more or less uniform in all but Vagavanam.

Table 10. Season-wise density of porcupine droppings in different zones in Idukki

	Dry Season			Wet1 Season			Wet2 Season		
	Density	SE	CV	Density	SE	CV	Density	SE	CV
Zone I	1416.85	986.75	60.05	333.35	182.40	55.30	416.70	83.33	20.00
Zone II	1750.00	969.00	43.70	250.00	250.00	100.00	250.00	250.00	100.00
Zone III	416.70	83.33	31.25	250.00	125.00	50.00	166.70	83.33	50.00
Zone IV	3000.00	809.00	36.20	750.00	404.50	72.35	500.00	353.60	70.70
Zone V	500.00	341.50	78.85	250.00	250.00	100.00	0.00	0.00	0.00

Giant Squirrel, *Ratufa indica*

A total of 12 squirrels were reported in total count from Vallakamali, Vattikkadu, Kampilamali, Chaparamudi, Chempakasseri and Vagavanam areas. Only six animals were recorded during the study period. However, the number of nests in Vagavanam and Meenmutty areas indicate that the number is not that low.

Bonnet Macaque, *Macaca radiata*

A total of 36 individuals in two troops were recorded in the total count. These were observed in Chaparamudi-Meenmutty area and Vagavanam. During the study

period, troops were observed in Meenmutty, Kodayurutty, Kuyilimala, Thottapura, Chempakasseri and Uppukuzhi areas. About 99 individuals were noted in these 6 troops.

Other animals

In addition to the animals described, indirect evidences indicate the presence of Mouse deer also. Common mongoose and Black-naped hare were also seen in the area.

DISCUSSION

A Nature Reserve is to maintain a highly complex system of ecological, genetic, behavioural, evolutionary and physical processes. It should also ensure maintenance of the co-evolved compatible populations which participate in these processes (Franklin, 1980). The size of the Reserve has a negative correlation with the rate of collapse in the number of species.

The effect of patchiness and island formation have been the topic of debate for a quite long time. It has been argued that extinction rates appeared to be too high in patchy habitats (Franklin, 1980). Ziswiler (1967) reported that 53 out of 77 or so species of birds and mammals that have gone extinct, were insular forms. Frankel and Soule (1981) lists biotic factors, isolation and habitat alterations as the major factors contributing to extinction. Considering the habitat preferences of every species (Balakrishnan and Easa, 1986), the alterations in the habitat has more relevance. Greenway (1967) presented evidences for overwhelming effect of habitat destruction and human interference in his exhaustive treatment of modern extinctions of birds.

Idukki Wildlife Sanctuary with the forests of adjacent Ayyappankoil and Nagarampara forms an island in the Western Ghats. This has been cut off from the nearby forests and a number of factors contributed to the alteration and degradation of the remaining forests. Wason (1984) mentions the records of Zoological Survey of India about the existence of 42 species of mammals in Idukki before the construction of the dam. The present observations indicate the presence of only 12 species viz. elephant, sambar deer, barking deer, mouse deer, wild boar, porcupine, bonnet macaque, black-naped hare, common mongoose, wild dog and Malabar giant squirrel. Gaur became extinct in the area at one stage during the process of separation with the adjacent area

and alteration of habitat. Eisenberg (1980) argues that large carnivores are sensitive indicators of the health of an ecological community. Idukki Wildlife Sanctuary and the adjacent forests holds only a remnant population of large carnivores.

Frankel and Soule (1981) established that the adaptation of species to environmental changes is not rapid and precise. The large organisms often lack ability to repopulate an area. Further, most large terrestrial organisms lack efficient dispersal mechanisms necessary to occupy empty habitat patches. Cherian (1985c) suggested re-introduction of the vanished species in one part of the area and convert it into an open zoo. This may lead in due course to the loss of importance of the area as a Sanctuary. Hence it is suggested here that attempt may be made to re-introduce gaur with proper monitoring system.

Elephants dominate the mammalian fauna of the Sanctuary in number as well as in biomass. However, the small number of elephants in the area (a total of about 100 in the whole forests) is alarming. The sex ratio is highly skewed, the tuskers constituting only 2.75% of the total observed, and juveniles and calves forming very low proportion is a matter of real concern. Earlier studies by Wason (1984) and Nair and Balasubramanian (1985) had also shown the fewer number of tuskers (three) and young ones in the population. Franklin (1980) argues that a genetically effective size of 500 animals is a satisfactory first approximation of the minimum size to accommodate the continuation of evolution. The most obvious correlate of a species' position on the demographic continuum is body size (Pianka, 1970). The larger the size, the lower the population growth. Further, variation in endangered species is likely to be more seriously depleted due to the very small numbers. The impact of genetic drift is directly related to the effective population size, not the census number of individuals (Greenway, 1967). The effective population size is extremely sensitive to unbalanced sex ratio among the breeding adults.

It has been shown that the large body size and the resource requirements of elephants necessitate a contiguous area of large size (Easa, 1989; Baskaran, *et. al.*, 1995). There is no possibility of establishing corridors to increase the size of the area in order to permit a continuous exchange of genes. Hence, it is suggested here that research and monitoring of genetic variation may be initiated to provide baseline data on the

attrition of variation in comparison with the Periyar population which once had continuity with the Idukki population. This is necessary for genetic management, alter sex ratio, alter age structure and for better resources for the population.

Early successional habitats are critical for the maintenance of diversity in tropical habitats (Pickett and Thompson, 1978). The most frequent cause for the disappearance of a successional habitat is reduced area. Further, the specialized tropical vertebrates are more susceptible to habitat disturbance and destruction (Janzen, 1972; Terborgh, 1975; Eisenberg, 1980). The evergreen forests in Idukki have undergone tremendous environmental degradation leading to formation of savanna and ultimately grasslands due to frequent fire (Singh, 1983). It is suggested that strict measures be taken to protect the habitats from fire and also to avoid planting of exotics.

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