FOOD AVAILABILITY AND RANGE USE BY THE COMMON LANGUR (*Presbytis entellus*, DUFRESNE 1797) IN RAJAJI NATIONAL PARK, U.P., INDIA

DISSERTATION SUBMITTED TO THE SAURASHTRA UNIVERSITY, RAJKOT IN PARTIAL FULFILLMENT OF MASTER'S DEGREE IN WILDLIFE SCIENCE (1991)

BY

GEETANJALI TIWARI

SUPERVISOR

DR. AJITH KUMAR, ASSISTANT PROFESSOR, WILDLIFE INSTITUTE OF INDIA, DEHRA DUN.

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भारतीय वन्यजीव संस्थान
न्यू फॉरेस्ट, देहरादून-248 006
WILDLIFE INSTITUTE OF INDIA
NEW FOREST, DEHRA DUN-248 006

CERTIFICATE

This is to certify that Miss Geetanjali Tiwari has carried out an original piece of research in partial fulfillment of her M.Sc. (Wildlife) Degree of the Saurashtra University, Rajkot. The topic of her dissertation is "Food availability and range use by the Common langur (*Presbytis entellus*, Dufresne 1797) in Rajaji National Park, U.P., India". The investigations were carried out at the Wildlife Institute of India, Dehra Dun under my supervision from November 1990 to June 1991. I hereby certify that this work has not been submitted for any degree of any University.

(AJITH KUMAR)

ASSISTANT PROFESSOR

JULY 1991

Phone : 27021 to 27028 (Ext. 334); 28760 Gram : WILDLIFE Telex : 595/258 FRI IN

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SUMMARY

A bisexual group of Common langur (*P.entellus*) was chosen in Rajaji National Park, (U.P. India) to test my hypothesis that spatial variation in the intensity of use of home range is correlated with food availability. During the study period I collected data at three levels:

(i) 6-day group scan for activity patterns, occupational density and frequency of use of major food species items.

(ii) Circular plots, covering 6 percent of the area for estimating availability of tree species.

(iii) Phenological data for estimating monthly variation in food items.

Using the latter two I calculated the availability of major food species item spatially and temporally.

I found that occupational density was significantly correlated with the availability of major food items in only two months. When analyzed for five months correlation increased as more major food items were added. The correlation was not significant for December, February and March because of constraints in the estimation of food availability added to the problem of clumpiness and rarity in the distribution of food species. A linear correlation is however, unlikely because availability of most foliage is often in excess of immediate requirement. Moreover, as summer progressed water increasingly became limiting factor. This, in combination with other factors like inter-group interactions might further decrease the possibility of getting a linear correlation.

1. INTRODUCTION

Ranging behaviour includes the differential use of a single or a group of animals' home range (Jewell 1966) for the acquisition of various resources like food, water, shelter, roosting sites (Altmann and Altmann 1970; Gautier-Hion et al. 1981; Raemaekers 1980). Thus, the distribution of one or more of the above resources should influence range use. Moreover the proportion of time devoted by the animals to the use of a resource would increase the influence of that resource in the use of home range (Rasmussen 1980).

Patterns of range use are maps of occupational densities of areas within the range of a group or an individual aggregated over some time (Rasmussen 1980). He emphasis that 'ranging behaviour' is an imprecise yet frequently used term and is to be differentiated from patterns of range use which are composed of observations of locations of the subject animal without respect to behaviour.

Major constraints in movement activity at interspecific level can be subdivided into a) Between sites - For example the overall quality of a habitat and distribution of food within it would vary from site to site and b) Within a site - An animal's movement will be affected by two factors i) group size (Waser 1977). Larger groups require more food and so need to forage over large areas (Marsh 1981). In case of primates the number of females rather than group size alone influences ranging patterns (Marsh 1981; Rasmussen 1979). b) the temporal variation in habitat quality mostly relating to phenological changes and water availability (Clutton-Brock.1975: Red Colobus; Wrangham 1981:Vervet monkeys).

Infact a recurrent aim of studies on primate ecology is to understand the factors affecting range use at intraspecific level Clutton-Brock (1975), Homewood (1976) and Goodall (1977) correlated range use with the distribution of preferred food. Struhsaker (1974) Oates (1977) and Wrangham (1977) correlated seasonal variation in range use with changes in animals diet and availability of food. There is a lack of literature on quantification of factors influencing patterns of range use *by P.entellus*.

Apart from food factors like distribution of water and sleeping sites (Altmann and Altmann 1970); habitat structure (Gautier-Hion et al 1981); predators (Altmann and Altmann 1970); weather (Chivers 1979) and social factors (Rasmussen 1979) often in combination also strongly influence the range use. It is difficult to isolate any one of the above factors.

1.1. Objective

The objective of the study was to quantify the extent of influence of food availability on range use and its seasonal variation.

More specifically, I tested the hypothesis that spatial intensity of use is positively correlated to the availability of major food sources. This hypothesis was tested for five months separately as well as together.

1.2. General Information on the Common Langur

P.entellus is the most abundant of six species of colobine monkeys found in S.Asia (Newton 1988). Studies in India on this species have concentrated on semi-wild groups living near temples or human habitation in open country habitats or dry woodlands of India (Sugiyama 1966, 1967; Ripley 1967, 1970; Rudran 1973; Struhsaker 1975).

One of the few and early studies on *Presbytis entellus* was done by Jay from 1958 to 1960 in Madhya Pradesh. *P.entellus* of South India are known to differ from their counter parts of North India. The latter are probably the most ground living of langurs and have a larger home range (from 1.3 to 13km^2) than those of Sri Lanka and South India. The home ranges of *P. entellus* may overlap extensively, but core areas do not (Sugiyama et. al. 1965). Langur groups seldom come together, since they are separated very effectively by their daily routes and patterns of range use (Jay 1965). *P.entellus* is noted for its highly variable pattern of social organization, regularly forming both bisexual troops and all-male bands (Winkler et al 1984; Mohnot 1968; Yoshiba 1968; Vogel 1971). At Rajaji National Park, social change appeared to be of the gradual type and extra troop males immigrated into the troop during breeding season. The average density of langurs was estimated to be 90 individuals/km^2 while about 75% of the population formed multimale groups (Newton 1988). Laws and Laws (1984) reported that at Rajaji National Park the extra group males have an equal mating success as bisexual group males. Horwich (1972) observed that *P.johnii* shows localized movements around certain preferred feeding and resting areas ('core area' Kaufmann 1962), although these probably change seasonally. Apart from the above aspects the phenomenon of infanticide unique to *P.entellus has been reported by Mohnot (1971) and Hrdy (1974)* in Rajasthan.

2. STUDY AREA AND METHODS

2.1. Study Area

The study was conducted in Dholkhand range of Rajaji National Park. The Park is situated at the interface of Lesser-Himalayan foothills and Indo-Gangetic plains (Fig 2.1). The latitudes and longitudes are between 29' 52'N to 30' 15'N and 77' 55'E to 78' 19'E, respectively.

Champion and Seth (1968) classify Rajaji National Park as moist deciduous forest. The mean annual rainfall varies from 1400 mm to 2,800 mm which is mainly restricted to two seasons summer and to a lesser extent winter. Temperature varies from 45' C in May to 3' C in January. The altitude varies from 300 m to 1000 m. The highest peak in the intensive study area is 741m.

The intensive study area or the home range of the study group (219 ha) encompasses two broad terrain types (1) Plains (2) Hills in almost equal proportions (Fig 2.2). Plains are further subdivided into i) Plantation ii) Open mix iii) Sal dominated mix (iv) Dense mix and v) Broad dry river beds locally called `Raos'. Hills are subdivided into i) Dry open mix on higher areas ii) Riverine mix along the 'raos' and perennial streams.

Amongst the fauna present at Dholkhand I mention the ones concerned with my study group. Sambar (*Cervus unicolor*), Cheetal (*Cervus axis*), Wild boar (*Sus scrofa*), Barking deer (*Muntiacus muntjac*), Ghoral (*Nemorhaedus goral*) and Common Langur (*Presbytis entellus*) form the large mammal prey base. Langurs were most often seen in association with chital and sometimes with Sambar.

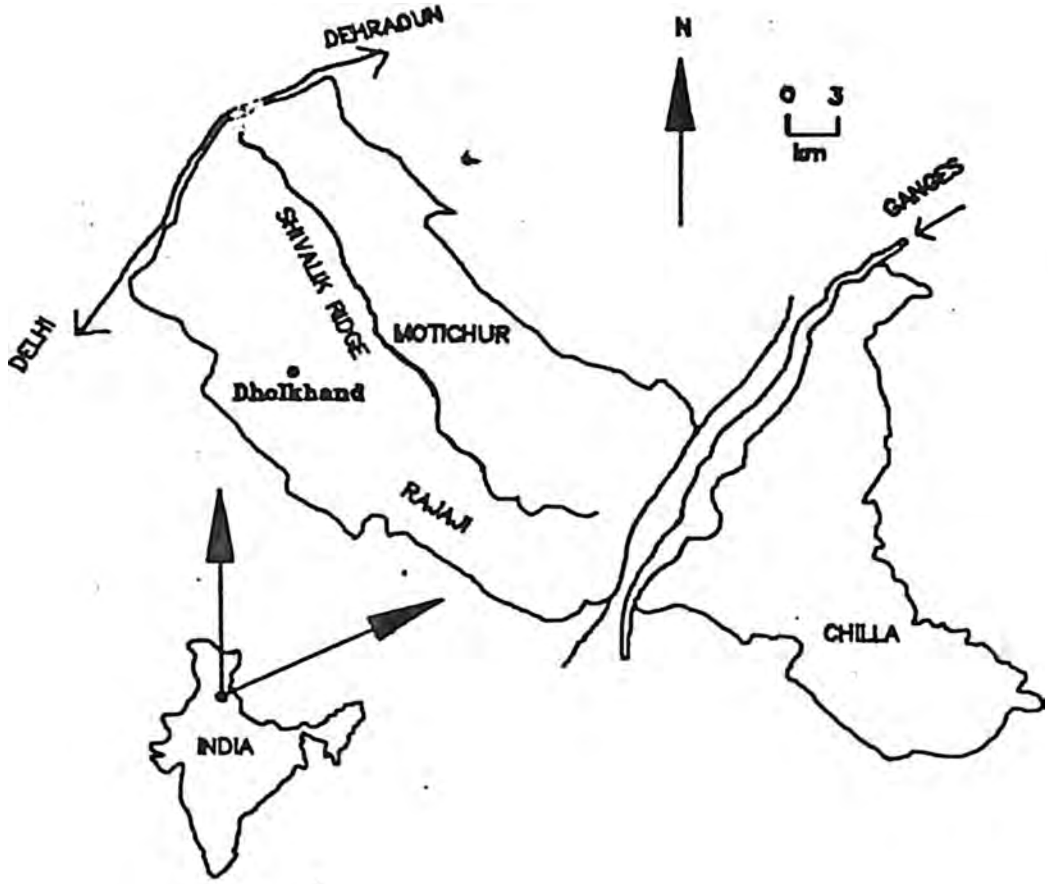


Fig.2.1 Rajaji National Park

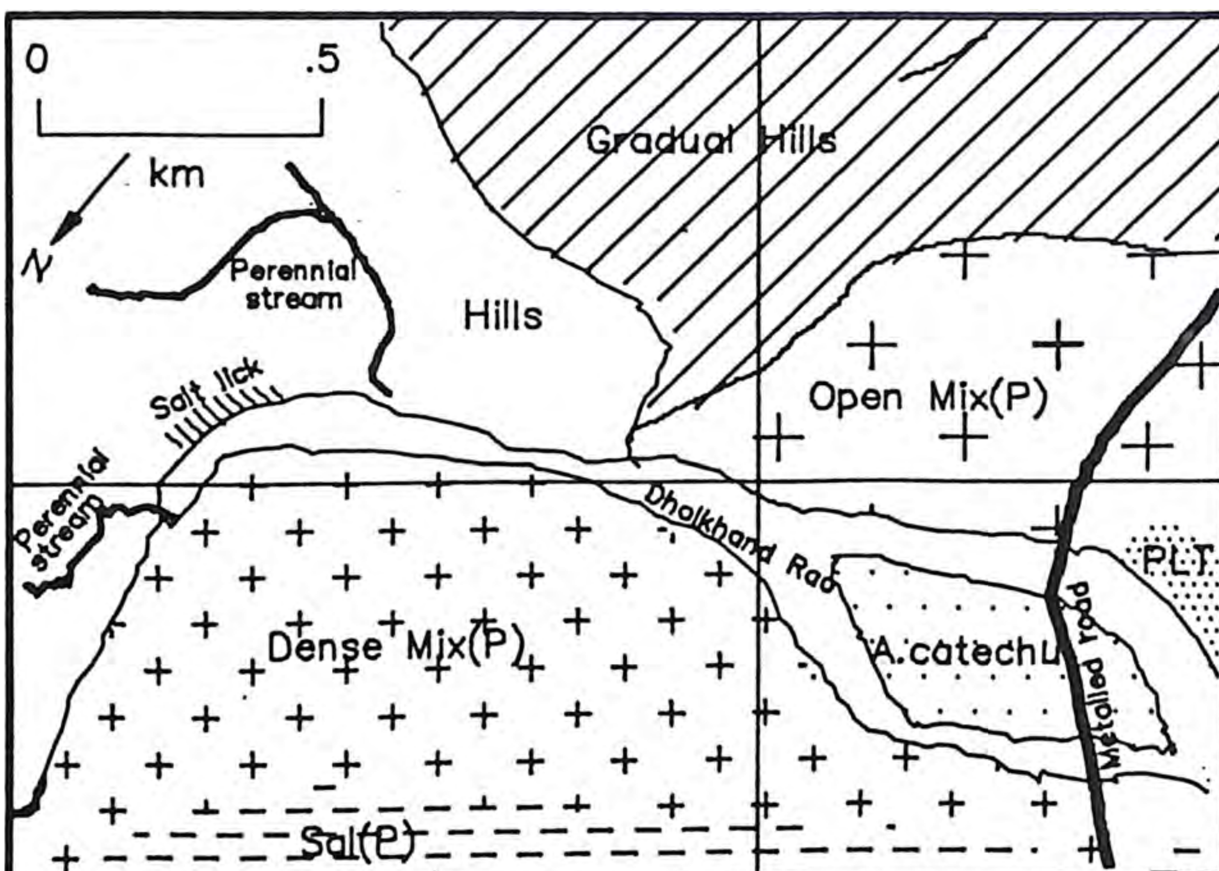


Fig.2.2 Home range of study group

The potential predators for Common Langurs are:

Crested Hawk eagle	(*Spizeatus cirrhatus*)
Crested serpent eagle	(*Spilornis cheela*)
Jackal	(*Canis aureus*)
Leopard	(*Panthera pardus*)
Tiger	(*Panthera tigris*)
Himalayan Yellow Throated Martin	(*Martes flavigula*)

2.2. Methods

The study extended from 1st November, 1990 to 30th June, 1991 of which the first month was spent in identifying and familiarizing a bisexual langur group in a natural mixed forest area. Actual data collection extended from 1st December, 1990 till 30th April, 1991. The study group was very large and thus censusing it was difficult. Only on two occasions was it possible to count them as they crossed the 'rao'. The figures in Table.2.1 are only rough estimates of the group size and composition.

TABLE 2.1 Group size and composition of the study group in December 1990 and March 1991.

Month	Adult male	Adult femal	Subad male	Subad femal	Juven -ile	Infan	Unid	Total
DEC	8	36	17	16	25	25	16	143
MAR	12	40	9	26	26	35		148

The study group was observed for 310 hours during 620 group scans over five months. I conducted an average of 124 group scans/month or 20.66 group scans/day with a mean of 7.44 animals recorded/ scan (Table 2.2).

For age-classification either give details or some reference!

sub-ad ♀?

Table 2.2 Distribution of records in time from December to April.

	Dec.	Jan.	Feb.	Mar.	Apr.
Total No. of obs.	1110	929	952	928	692
Total No. of scans	116	118	129	129	125
Ave No. of obs/scan	9.57	7.87	7.38	7.19	5.54

Field methods aimed at the collection of data to estimate:

(1) Time spent on various activities - Activity pattern.

(2) Intensity of use of different parts of the groups home range.

(3) Availability of food in the home range.

2.2.1. Activity Pattern

Percent time spent in various activities was estimated through group scan (Altmann 1974). Group scan was carried out at 30 minute interval from dawn to dusk for six consecutive days in the latter half of each month. The following records were made for each animal sighted during a scan.

1. Date
2. Time
3. Weather
4. Group spread :the distance between two farthest langurs.
5. Associated species:like chital (*Cervus axis*) and rhesus monkeys (*Macaqua mulata*).
6. Individual: Adult male, Adult female, Subadult male, Subadult female, Juvenile, Infant and Unidentified.
7. Location: Grids of 50mx50m were laid in the home range and numbered as per X, Y coordinates. Also a self made

map showing the characteristic trees and other features was used for easy identification of grids.

8. Height above: vegetation above the langur.

9. Height below: vegetation below the langur.

10. Canopy cover: as a score of light falling on the animal

11. Activity: recorded in as much detail as possible, but for analysis I used the following six categories: feeding, moving, resting, drinking, salt licking, and others.

Feeding included activities from searching of food items to swallowing them Oates (1986).

Moving included travel within trees as well as on ground (Newton 1984 ; Kumar 1987).

Resting was recorded when the animal was stationary, or sleeping or looking around (Newton 1984).

Drinking involved actual drinking as well as short breaks while drinking.

Licking was recorded when either stones or earth was licked.

The category 'others' includes all those which do not fit in with any of the above; social activities, teeth grinding, playing, mounting etc.

12. Species: the plant used for feeding or resting

13. Plant part: as young leaf, mature leaf, floral bud, flower, unripe fruit, ripe fruit, new shoots, stem, bark and petiole (Newton 1984 ; Marsh 1981).

Of the above only date, time, indiv, grid, act, species and part were used for the major part of the analysis.

Time spent on various activities was estimated from group scan data using:

$$P_i = 1/S \sum_{i=1}^{S} ni/n$$

where P_i = % time on activity i,
ni = no. of records for activity i,
n = no. of records in a scan,
S = no. of scans over the time period under consideration.

Similarly time spent feeding on various plant items was estimated using the above formula but with,

Pi = % time spent feeding on species,
ni = no. of records feeding on food item,
n = no. of feeding records in the scan,
S = no. of scans over the time period under consideration.

2.2.2. Estimation of Occupational Density (OD)

This was done using the locations of animals recorded during group scan: O.D. for each quadrat was estimated as follows:

$$ODj = 1/S \sum_{i=1}^{S} n_{ji} / n_i$$

where n_{ji} = no. of records in quadrat j in i^{th} scan.
n_i = no. of records for i^{th} scan.
S = no. of scans for the period under consideration.

The home range was divided into 48 blocks on the basis of gross habitat features like dominant tree species, terrain, distance to water, tree density etc. The blocks varied in size from .75 ha to 13 ha subject to above parameters.

The mean OD for a quadrat in a block was estimated using:

$$OD_b = 1/n \sum_{i=1}^{n} OD_i$$

where OD_b = OD for block b.
n = no. of used quadrats in the block for the period under consideration
OD_i = OD of quadrat *i* in the block.

2.2.3. Food availability

Estimation of food availability consisted of vegetation sampling and phenological studies.

For vegetation study 465 plots of 10 m^2 radius covering 6 % of the home range were laid. In each plot the details recorded for each plant with GBH>10cm were: species name, GBH, crown width, crown height and diameter. Presence of the parasites *Cuscuta radiata* and *Dendrophthoe fulcata* was also recorded.

Availability of various plant food parts was estimated by taking phenology data of almost all food species on a monthly basis between fixed dates. Trees were randomly sampled throughout the home range. The sample size ranged from 9 to 21 subject to availability of the species. For each tree the percentage of the crown surface covered by each of the followings: phenophases was visually assessed: Young leaves, Mature leaves, Floral buds, Flowers, Unripe fruits, Ripe fruits, and New shoots. For example, young leaves were estimated in terms of proportion of young leaves present out of total potential crown volume. In addition, the intensity of lopping was also assessed as percentage loss of crown volume.

Although canopy dimension data were collected for all trees in sampled area, this measure was not used because of the established high correlations between canopy volume and basal area under natural conditions (Davis et al. 1988 ; Oates et al. 1980; McKey et al. 1981; Struhsaker 1991). Lopping as a whole was very insignificant and so was ignored. Vegetation data of all plots within one block were pooled and calculated as cm^2/ha for each species.

It was assumed that phenology would not vary significantly between habitat types within the study area. Phenology data were pooled for all individuals of a species per month to get an average of percent item available. Availability of each food item was estimated using the following formula:

$$P_{ij} = P_{ij} \times b_i$$

where b_i = basal area in cm^2 / ha. for species i

$$P_{ij} = 1/S \sum_{k=1}^{S} P_{ijk}$$

where P_{ij} = mean phenology score for item j of species i.
S = number of samples taken for species i.
P_{ijk} = phenological score for sample k of item j of species i.

2.3. Statistical Analysis

Statistical Program for Social Sciences (SPSSinc.) was used for all the statistical analysis and estimations. Pearsons correlation was used when there was only one independent variable; with more than one, a stepwise regression was carried out to get multiple correlation. All tests of significance are at P=0.05.

3. RESULTS

3.1. *Introduction*

This chapter is divided into three sections. The first deals with results from group scan data and includes activity pattern and feeding. In the second section I describe home range and the variation in occupational densities and in the third section, the availability of major food items within months and amongst blocks. In the last section I combine food availability with occupational densities to test the hypothesis that these should be correlated.

3.2. Activity Pattern and Feeding

3.2.1. *Activity Pattern*

Fig.3.1 shows the percent time spent on six major activities monthwise. The pattern observed is similar for all the months. Resting and feeding are the most performed activities while drinking water and salt licking tend to increase as summer progresses. March is seen to have maximum percent time spent in moving and drinking.

3.2.2. *Feeding*

As the number of species fed on increased, those forming 80 % of diet also increased (r_s=0.8, n=4). The least species-item forming 80% of diet are in December (7), followed by April (12), January (14), March (16) and the maximum in February (19). Overall only 51 species were fed on, with only 23 species-item forming up to 80% of diet.

Fig.3.1 Time spent on major activities

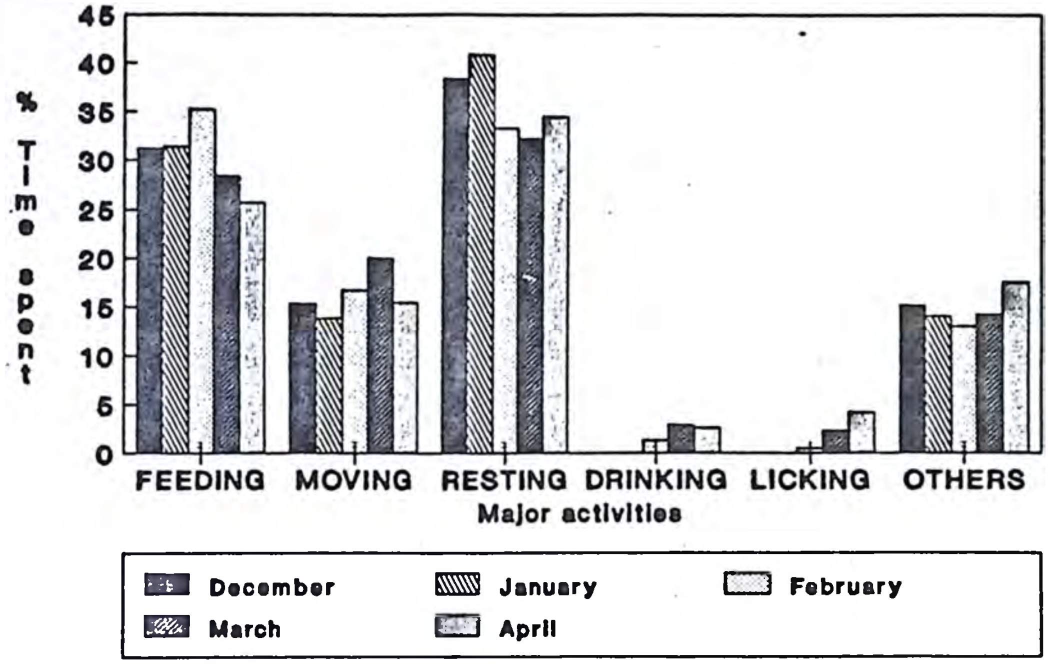


Fig.3.2 Number of quadrats used each month

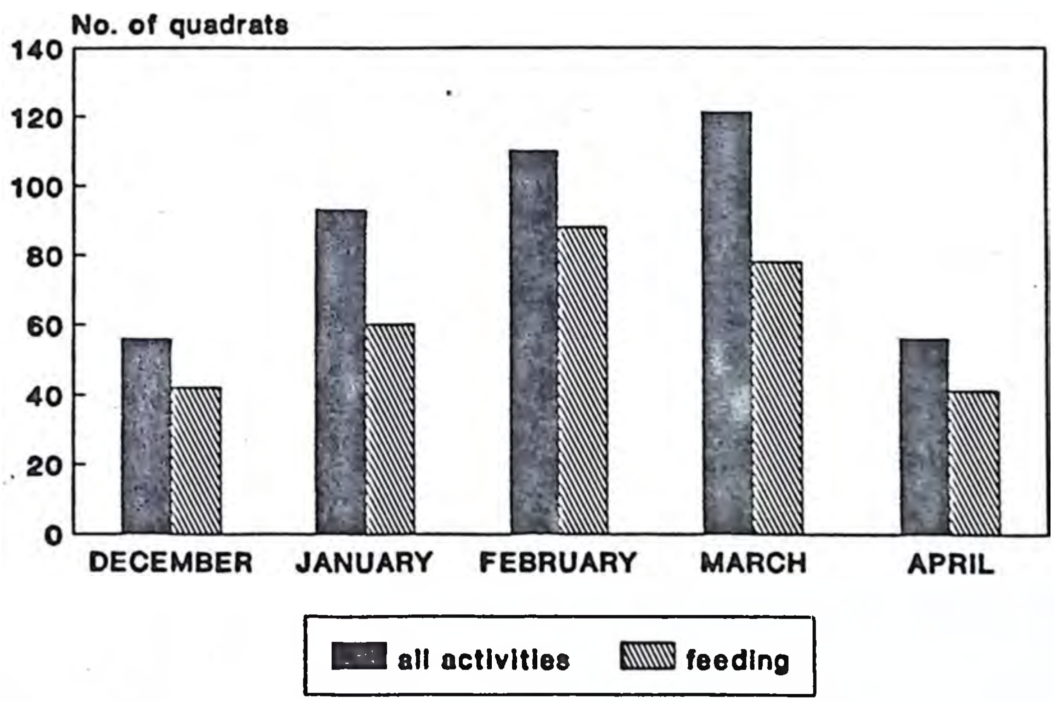


Table 3.1 The total number of species and species-item used per month with those forming up to 80% of diet.

	Dec	Jan	Feb.	Mar	Apr	5 months
Total species	21	26	30	30	51	51
Total spp-item	29(+4)	38	50(+5)	40	106	106
Spp.in 80% diet	6	9	14	14	12	18
Spp-item in 80% diet	7	14	19	16	12	23

(The number following `+' are unknown spp-item)

Fruits formed a large part of the diet in December (56.9%) and January (24.9%) while in other months it varied from 2.28% in March to 15.38% in February (Table 3.2). Foliage, particularly young leaves, dominated in March (71.22%) and April (62.35%), while in other months it formed lesser than 32% of the diet. February has the maximum percent of floral buds and flowers (20.63%) while the all other months have below 8 percent.

In December and April diet was dominated by one species-item each; *A.catechu* seeds in December (38.16%) and *D.sissoo* young leaves in April (37.64%). In the other months the dominance of a single food species-item was not as prominent.

Over five months, 18 species and 23 species_item form 80% of diet. Only *A.catechu* seeds dominate with 16.83%. All other species items form below 6 percent of the diet.

Table 3.2a: Food species item forming upto 80% of diet in December.

Species*	Item	Percent Feeding	Cumulative Percent
A.catechu	seed	38.16	
T.bellerica	unripe fruit	13.63	51.79
Cuscuta		8.58	60.37
E.laevis	leaves	5.76	66.13
L.acidissima	leaves	5.17	71.30
Z.mauritiana	unripe fruit	5.11	76.41
Z.mauritiana	leaves	4.16	80.57

Table 3.2b: Food species item forming up to 80% of diet in January.

Species*	Item	Percent Feeding	Cumulative Percent
T.bellerica	unripe fruit	9.59	
W.tomentosa	leaves	8.56	18.15
B.ceiba	bud	7.87	26.02
P.latifolia	leaves	7.53	33.55
T.bellerica	debarked stem	7.53	41.08
A.catechu	seed	7.19	48.27
Z.mauritiana	leaves	6.51	54.78
W.tomentosa	unripe fruit	6.16	60.94
Cuscuta		5.82	66.76
D.fulcata	leaves	4.45	71.21
E.laevis	leaves	3.08	74.29
P.emblica	unripe fruit	2.05	76.34
L.acidissima	leaves	2.05	78.39
T.bellerica	unknown	2.05	80.44

(* See Appendix 1 for abbreviations.)

Table 3.2c: Food species item forming up to 80% of diet in February.

Species*	Item	Percent Feeding	Cumulative Percent
A.catechu	leaves	12.07	
S.villosa	flowers	10.25	22.32
H.antidysenterica	unripe fruit	8.86	31.18
T.bellerica	debarked stem	6.07	37.25
B.ceiba	flowers	5.19	42.44
B.ceiba	bud	5.19	47.63
A.catechu	seed	5.17	52.80
C.opeca	young leaves	4.11	56.91
E.laevis	flowers	3.22	60.13
O.oogeinensis	flowers	2.98	63.11
F.indica	leaves	2.62	65.73
L.parviflora	unknown	2.38	68.11
E.laevis	leaves	2.33	70.44
C.opeca	mature leaves	2.32	72.76
L.acidissima	leaves	2.14	74.90
A.catechu	leaves	2.03	76.93
Z.xylopyra	leaves	1.43	78.36
E.laevis	unknown	1.37	79.73
G.turgida	fruits	1.35	81.08

Table 3.2d: Food species item forming up to 80% of diet in March.

Species*	Item	Percent Feeding	Cumulative Percent
D.sissoo	young leaves	18.15	
E.laevis	young leaves	11.39	29.54
C.opeca	young leaves	11.36	40.90
F.indica	young leaves	8.71	49.61
A.latifolia	young leaves	8.33	57.94
A.catechu	leaves	6.44	64.38
S.cumini	young leaves	2.28	66.66
S.robusta	flowers	2.27	68.93
B.monosperma	bud	1.90	70.83
T.bellerica	debarked stem	1.89	72.72
F.indica	new shoots	1.52	74.24
L.acidissima	young leaves	1.52	75.76
W.fruticosa	leaves	1.52	77.28
H.antidysenterica	unripe fruit	1.14	78.42
A.catechu	seed	1.14	79.56
P.emblica	fruits	1.14	80.70

(* See Appendix 1 for abbreviations)

Table 3.2e: Food species item forming upto 80% of diet in April.

Species*	Item	Percent Feeding	Cumulative Percent
D.sissoo	young leaves	37.64	
A.lebbek	young leaves	7.86	45.5
S.robusta	flowers	6.18	51.68
F.indica	young leaves	5.06	56.74
S.villosa	unripe fruit	5.05	61.79
H.antidysenterica	young leaves	4.49	66.28
M.philippinensis	unripe fruit	3.93	70.21
E.laevis	young leaves	3.37	73.58
C.opeca	young leaves	2.25	75.83
A.latifolia	leaves	1.69	77.52
A.odoratissima	seed	1.69	79.21
Ficus spp.	young leaves	1.68	80.89

Table 3.3: Food species item in five months forming up to 80% of diet.

Species*	Item	Percent Feeding	Cumulative Percent
A.catechu	seed	16.83	
D.sissoo	young leaves	6.02	22.85
A.catechu	mature leaves	5.77	28.62
E.laevis	leaves	4.86	33.48
T.bellerica	fruits	4.07	37.55
B.ceiba	bud	3.58	41.13
T.bellerica	debarked stem	3.58	44.71
C.opeca	leaves	3.25	47.96
D.sissoo	new shoots	3.17	51.13
Cuscuta		3.16	54.29
Z.mauritiana	mature leaves	2.68	56.97
A.latifolia	mature leaves	2.52	59.49
H.antidysenterica	fruits	2.52	62.01
P.latifolia	mature leaves	2.52	64.53
W.tomentosa	mature leaves	2.94	66.97
Ficus spp.	young leaves	2.26	69.23
W.tomentosa	fruits	2.02	71.25
D.fulcata	leaves	1.94	73.19
B.ceiba	fruits	1.78	74.98
S.villosa	fruits	1.60	76.59
S.robusta	fruits	1.46	78.05
L.acidissima	mature leaves	1.05	79.12
A.lebbek	young leaves	.89	80.00

(* See Appendix 1 for abbreviations)

3.3. Pattern of Range Use

3.3.1. *Home Range*

When all sightings are considered the home range for five months was 875 quadrats (219 ha.) (Fig.3.2a). But if only 6-day samples of all the months are considered, then 436 quadrats (109 ha) forms the home range. If feeding alone is taken then only 309 quadrats (77.7 ha) were used.

The number of quadrats used for feeding was least in December and April (41) followed by January (60), March (78) and February (88) with the most (Fig. 3.3). These diagrams also reveal that the home range of the study group was not used uniformly over time. April alone has no new block being used.

3.3.2. *Occupational Density (OD)*

Two measures of OD were calculated:

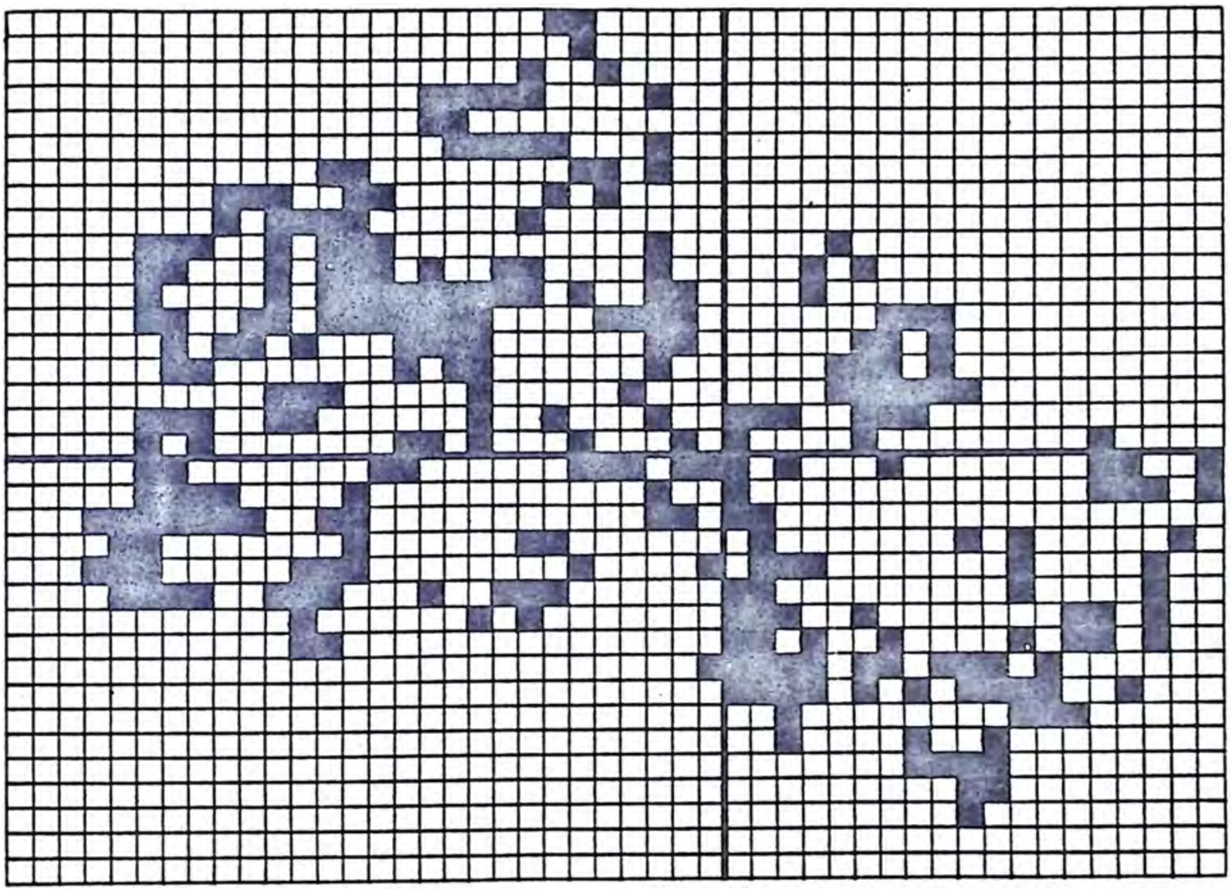
i) WOD (Weighted occupational density) is the mean OD of a grid used for all activities.

ii) WODF is the weighted OD of a grid used for feeding.

Of these I used mostly WODF since it relates more closely with my objective. As expected WOD and WODF are highly correlated (r=>.8), which reflects that feeding is the most important activity.

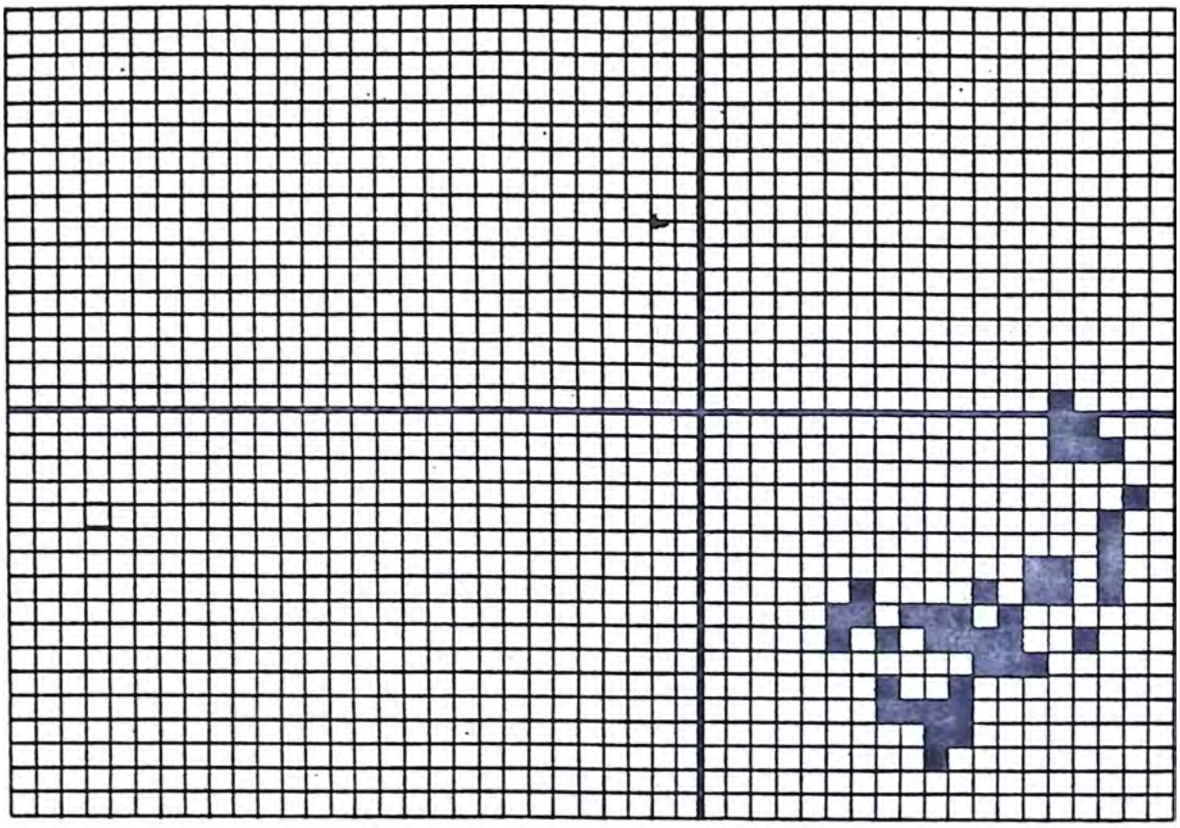
Initially the quadrats were divided into 48 blocks, but this caused problems during analysis. Many species were not represented in the blocks (i.e. had zero densities). Therefore, for analysis of data over five months the 48 blocks were regrouped into 10 larger blocks and correlation test performed. However this created problems during analysis on a monthly basis because very few blocks

Fig. 3.2a Quadrats used for feeding



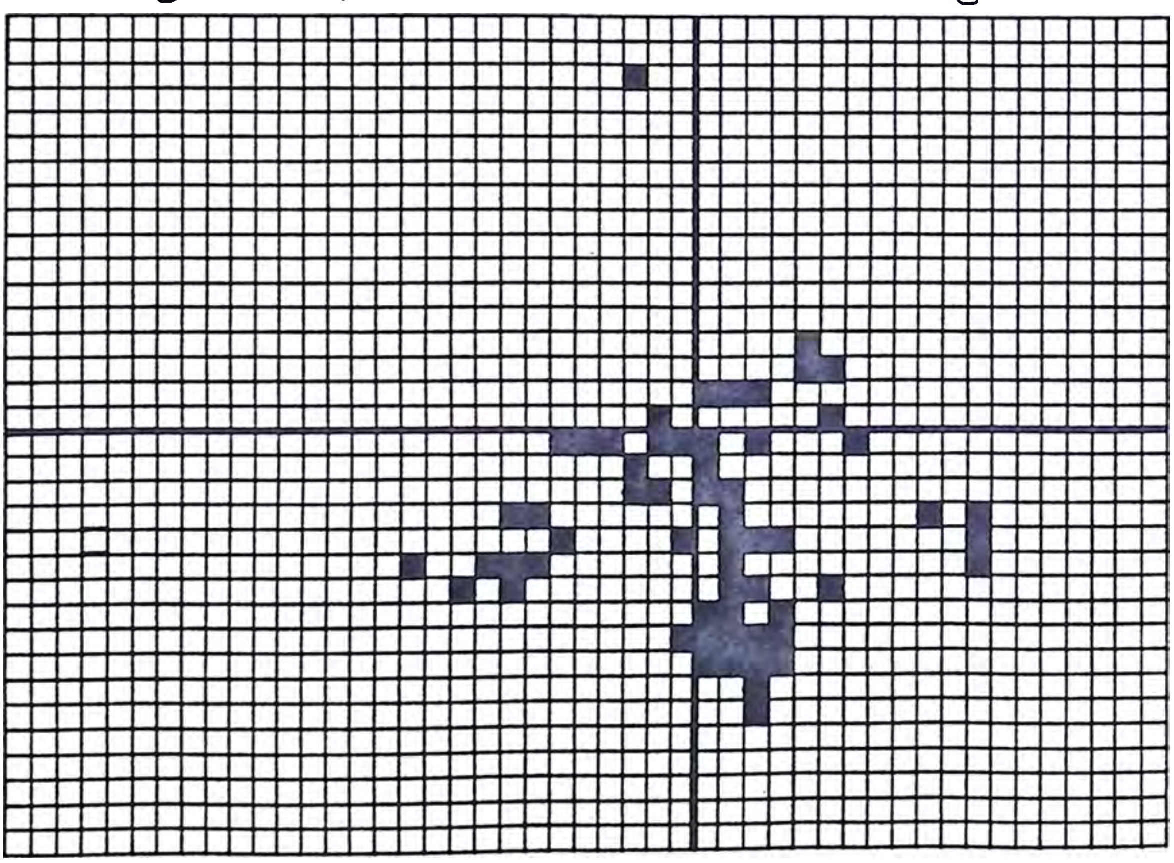
December 1990 to April 1991

Fig.3.3a Quadrats used for feeding



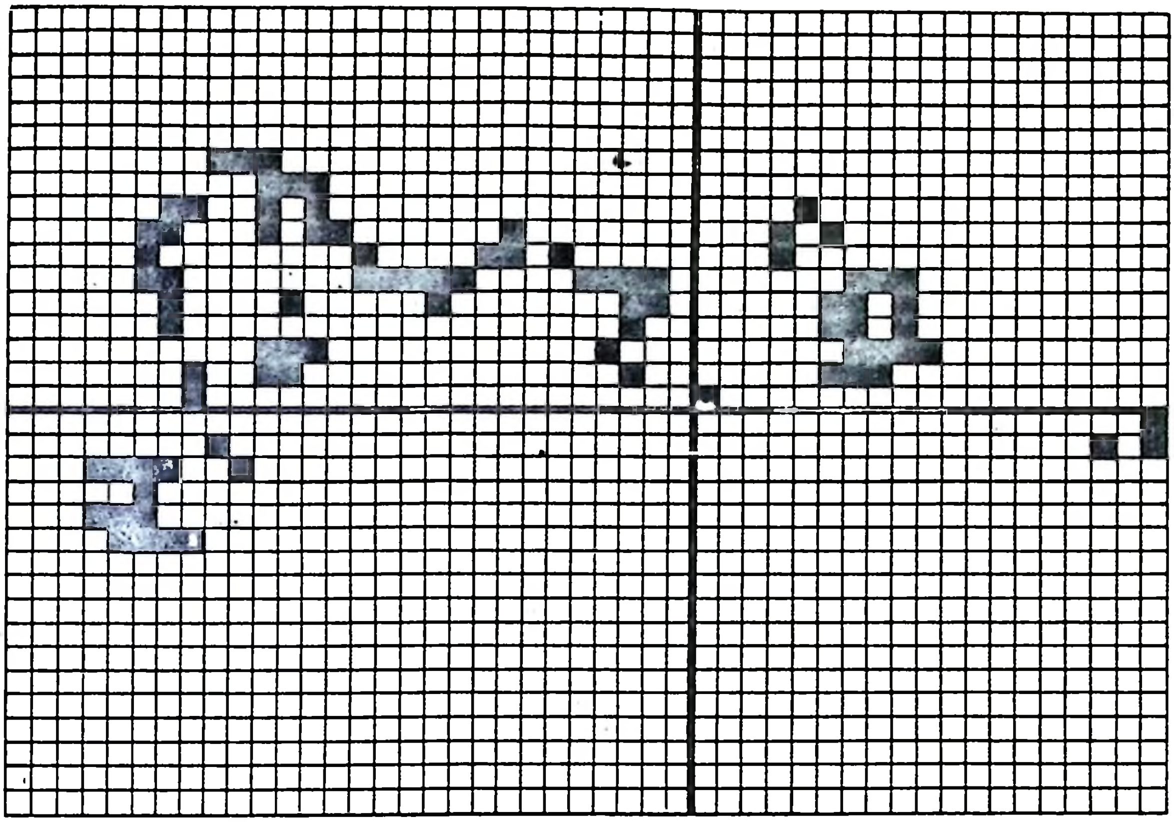
December 1990

Fig.3.3b Quadrats used for feeding



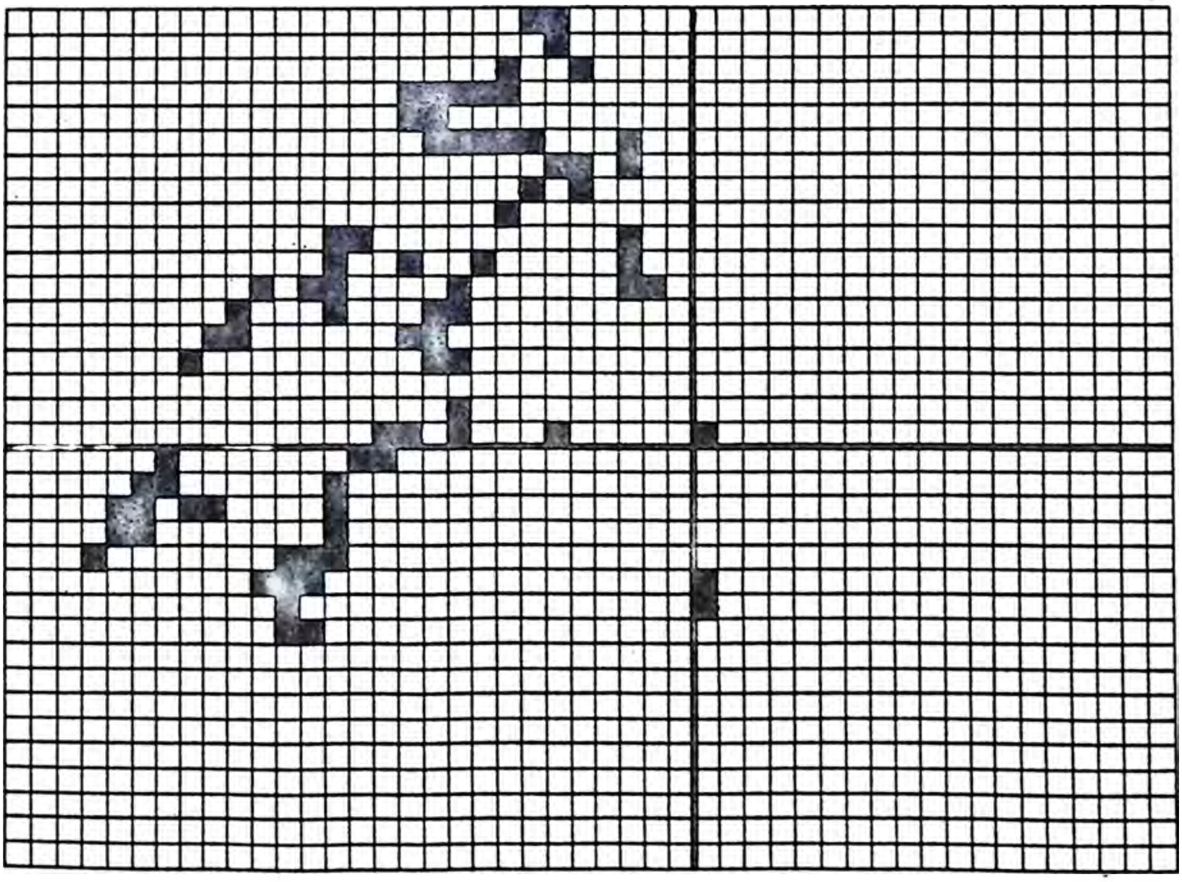
January 1991

Fig.3.3c Quadrats used for feeding



February 1991

Fig.3.3d Quadrats used for feeding



March 1991

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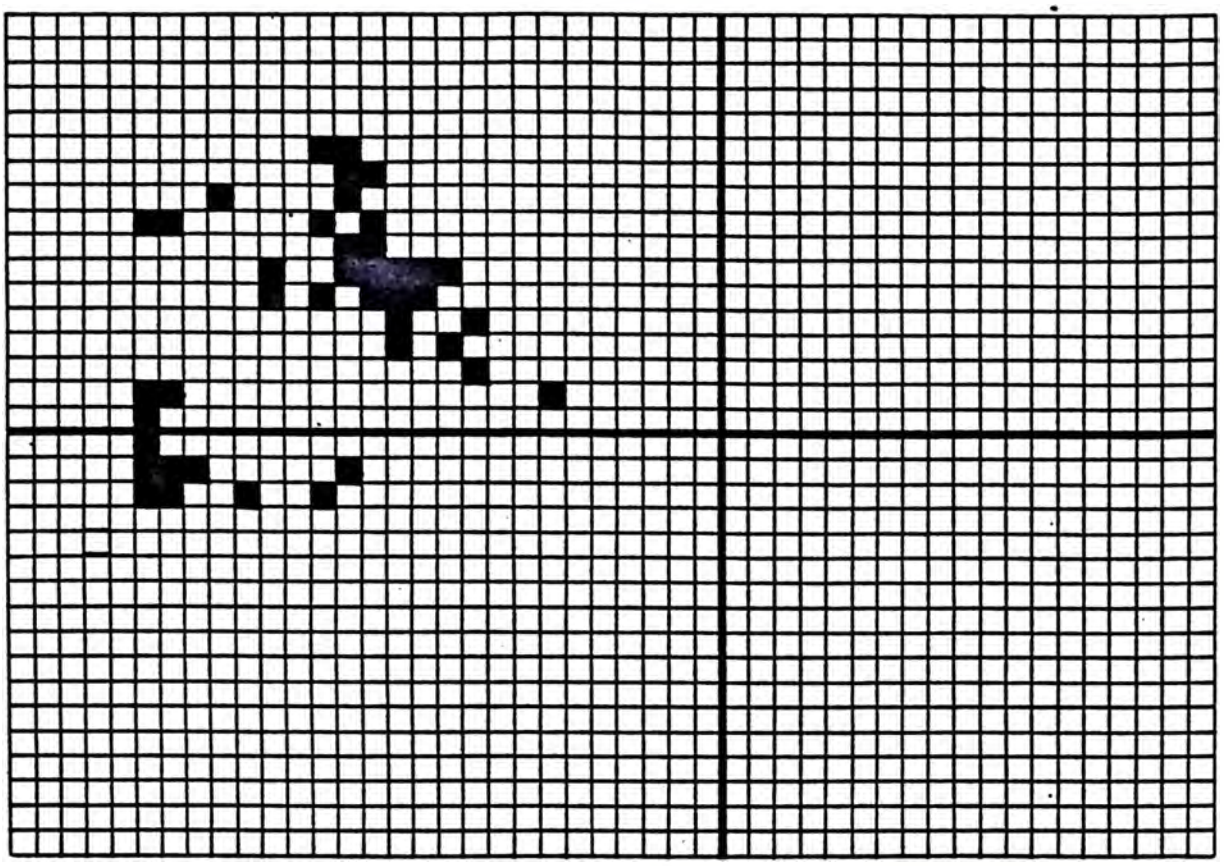
Fig.3.3e Quadrats used for feeding



April 1991

had non-zero occupational densities. So analysis of monthwise data is based on 48 blocks while that of five months is based on 10 blocks.

Variation in block occupancy between months

Both WOD and WODF have a more clumped distribution in December and April as compared to other months, since few blocks were used (Table 3.4). Most of them had higher OD in comparison to other months especially March. Blocks 5, 3 and 10 in December have a WODF value of 6.45, 3.69 and 3.33 respectively. In April blocks 43 and 29 have WODF values of 4.9 and 2.26, respectively, whereas the highest WODF values in January, February and March are 3.16, 3.64 and 2.03, respectively.

December and April have blocks with extremely high WODF values (Table 3.5). This exemplifies that in these two months the blocks were most disproportionately used. On the contrary in January, February and March most blocks had WODF values ranging from 0.01 to 1.99. Thus, in these months the blocks were more evenly used.

Table 3.5: Distribution of blocks used in each in six WODF classes.

WODF class intervals	Dec.	Jan.	Feb.	Mar.	Apr.
0.01-0.99	1	5	9	6	1
1.0-1.99	5	7	7	8	1
2.0-2.99	0	5	0	2	1
3.0-3.99	2	1	2	0	0
4.0-4.99	0	0	0	0	1
> 5.0	1	0	0	0	0

Table 3.4 Variation in Block occupancy between months for all activities (WOD) and feeding (WODF).

Block No.	Dec.		Jan.		Feb.		March		April	
	WOD	WODF	WOD	WODF	WOD	WODF	WOD	WODF	WOD	WODF
1.	1.11	1.35	.62	.88						
2.	1.84	1.63								
3.	3.77	3.69								
4.	.46	0	.44	.98						
5.	3.46	6.45								
6.	.17	0	.49	2.2	1.75	1.62				
7.	1.19	1.05	.86	1.32						
8.	.78	1.00								
9.	.42	.85	.13	.46						
10.	2.82	3.33								
11.	1.16	1.68								
12.			1.06	1.32						
13.			1.69	2.27						
14.			1.94	3.16			.56	.61	.26	0
15.			1.73	2.84	1.42	.91				
16.			.43	1.1	.26	.55	.16	0		
17.			1.17	.37	1.12	1.33	.26	0		
18.			1.45	1.6						
19.			1.36	2.2						
20.			.27	.46						
21.			.79	2.04						
22.			.89	1.71	.39	.91				
23.			1.33	1.1			.67	1.13		
24.			1.86	1.47						
25.			.07	0	.69	.84				
26.			.88	0						
27.					.98	1.1	.83	1.32	.7	
28.					.26	.45				
29.					.36	.60	.89	1.73	.59	.26
30.					.26	0				
31.					.7	1.21	.26	.45	.76	.63
32.					3.08	3.25	.22	0		
33.					1.17	3.64	.4	2.4		
34.					.95	1.32	.18	1.61	.53	0
35.					1.54	0				
36.					1.13	1.21	.44	2.03	.81	0
37.					.84	1.11	.61	1.78	.42	.65
38.					.65	.84	.46	.8		
39.					.49	.66				
40.					.52	0				
41.					.37	.68				
42.					.16	0	.71	.88		
43.							.27	1.0	.40	
44.							.33	.46		
45.							.73	1.45		
46.							.70	1.0		
47.							.79	1.1		

3.4. *Food Availability*

Food availability was estimated for the major food species-item, for blocks used in each month (Appendix 2a to 2e). For monthly estimations 47 blocks were used while for the overall estimation the larger 10 blocks were used.

It is evident that though *A.catechu* and *E.laevis* were important food species in all months, *A.catechu* was present in only a quarter of the blocks, while *E.laevis* was present in almost all (Table 3.6). Rare species like *B.ceiba, T.bellerica and S.cumini* are absent in >93% of the blocks. *S.villosa* has no representation in February. *D.sissoo* is present in only 48% of the blocks for the months March and April.

3.5. *Food Availability and Occupational Density*

The hypothesis that occupational density is related to availability of major food species was tested for each month as well as for five months using regression analysis. For monthly estimations 47 blocks were used while for the overall estimation the larger 10 blocks were used. The blocks used each month alone were included in the analysis. The species-items which were present in very few blocks have been deleted since they would have otherwise masked a possible relationship.

Significant correlation was found in January with *W.tomentosa* mature leaves and in April with *C.opaca* young leaves and *D.sissoo* young leaves (Table 3.7). No significant correlation was found in the remaining months. When looked at 5 months altogether again no significant correlation was obtained in regression analysis.

Table 3.5: Distribution of blocks used in each in six WODF classes.

WODF class intervals	Dec.	Jan.	Feb.	Mar.	Apr.
0.01-0.99	1	5	9	6	1
1.0-1.99	5	7	7	8	1
2.0-2.99	0	5	0	2	1
3.0-3.99	2	1	2	0	0
4.0-4.99	0	0	0	0	1
> 5.0	1	0	0	0	0

Table 3.6: Proportion of blocks having the major species within the months used (Months in which the species were used are marked with 'X'.)

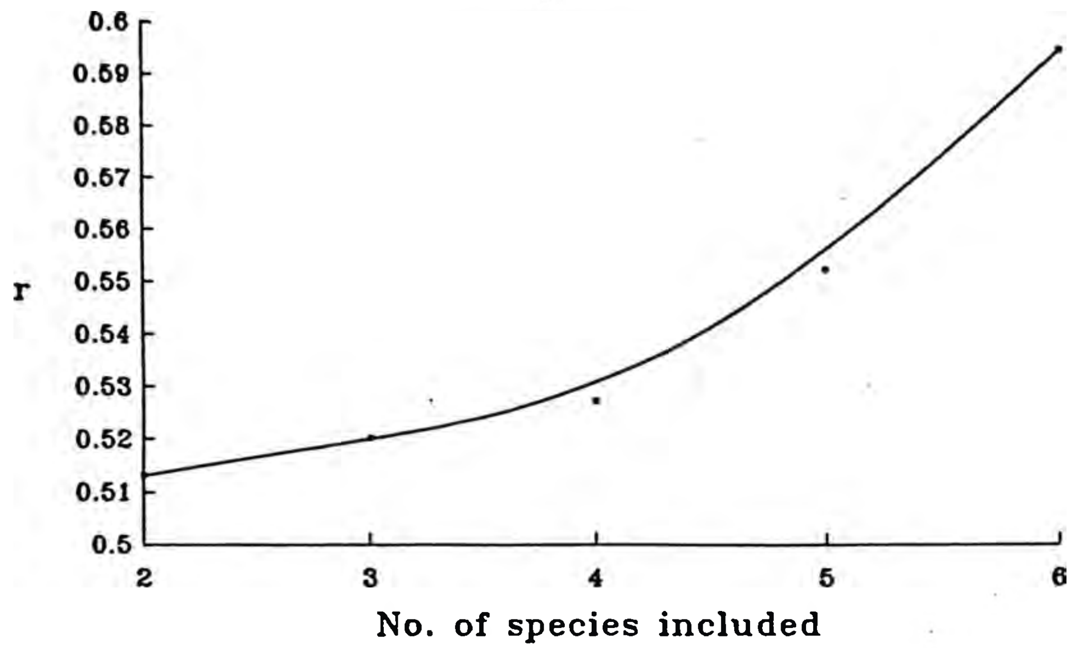
Species	Prop. blocks	Dec	Jan	Feb	Mar	Apr
S.villosa	0.00			x		
B.ceiba	0.025		x	x		
S.cumini	0.05				x	
T.bellerica	0.075	x	x	x		
S.robusta	0.245				x	x
A.catechu	0.25	x	x	x	x	x
A.lebbek	0.25					x
F.indica	0.25			x	x	x
W.tomentosa	0.475	x	x			
D.sissoo	0.48				x	x
P.latifolia	0.575	x	x			
C.opeca	0.635			x	x	x
Z.mauritiana	0.725	x	x			
M.philippin.	0.75					x
H.antidysent.	0.78			x	x	
E.laevis	0.92	x	x	x	x	x

Table 3.7: Result from regression analysis of WODF with availability of major food item in five months separately and together.

Month	r value	p	Species-item included
December	No corr.		
January	0.611	0.0042	*W. tomentosa* (mature leaves)
February	No corr.		
March	No corr		
April	0.856	0.01	*C. opaca* (young leaves)
	0.986	0.0001	*D. sissoo* (young leaves)
Overall	No corr.		

Availability of major food species were summed up and tested for correlation with occupational densities over the 5 month period. This showed that correlation increased with the addition of major food items from 0.513 to 0.594, up till the seventh most fed species item (Fig 3.4). Maximum level of significance achieved was only P=.07.

Fig 3.4 Correlation coefficient versus number of species



4. DISCUSSION

Is occupational density positively related with availability of major food items? When looked at monthwise, results reveal a significant positive correlation only for January and April. No correlation is seen for December, February and March. Similarly, results of 5 months together do not show a significant correlation, but it increases as the number of major food items on the analysis are increased.

There is no single answer to my hypotheses, particularly because even if a relationship between ranging patterns and food availability exists, the nature of it is not readily predictable (Struhsaker 1974).

Many primates show restricted and heavy use of certain areas. This could result from:

a) feeding on a rare species with a clumped distribution but having a high density of food per tree.

b) feeding on a common and widely dispersed species also having a high density of food per tree (Struhsaker 1974).

c) In many Colobines, young and mature leaves form a significant part of the diet. These plant parts, when they are present are often available in sufficient quantities for the folivores not to be restricted by it. If this is so, then a linear relationship between feeding and availability might not exist. The result would be that occupational density might not show a linear relationship with availability of many species.

Rare and clumped species are major complicating factors because of difficulties encountered in representing them adequately while correlating range use with food availability (Rasmussen 1980). The two methodological constraints I encountered in the estimation of food availability which have masked this potential correlation are inadequate estimation of food availability and extreme patchiness of food distribution. The former was mainly due to four causes:

a) Rarity : The more rare a species is the greater is the necessity to increase the percent of area sampled failing which the chances of missing the species altogether increases. In my case *Sterculia villosa*, was not represented at all in the vegetation sample while *Terminalia bellerica, Albizzia lebbek* and *Bombax ceiba* were under represented.

b) Errors in the collection of phenological data: An example of this was my inability to spot unripe fruits of *Terminalia bellerica* in December. This item was wrongly recorded as absent.

c) Depletion of certain items by langurs: Another problem which affected results was that in January and February, the langurs were observed to deplete all the flowers and floral birds of the *B.ceiba* trees. So when phenological data was collected, soon after scan sampling, no buds or flowers could be recorded in those areas. This resulted in under-estimation of the availability of *B.ceiba* buds and flowers.

d) Recording of individual species with GBH>10cm: There were a large number of *Dalbergia sissoo* saplings having GBH's much below

10cm. This items' availability got significantly underestimated, which particularly affected correlation values of March and April when it was most fed on.

Extremely patchy distribution of certain species all affected the estimation of food availability *A. catechu* was restricted to old plantations mainly in three blocks (total 5.2 ha) in the home range, where it was abundant (>2500cm² /ha). These three blocks had high feeding occupational densities too (34.71, 18.36 and 10.62) in December. Also the highest percent time fed for any single item for the five months is for *A. catechu* seeds in December. Thus, high abundance, high WODF coupled with largest amount of time spent indicate that it is very likely that the monkeys were going specifically for *A.catechu* seeds. It can be safely assumed that the monkeys were not going for other species in those blocks. Recall that percent time spent on food other items i.e. *Ehretia laevis* mature leaves, *Zizyphus mauritiana* mature leaves and unripe fruits present in those blocks is relatively very low). The superabundance of *A. catechu* in a very few blocks and its absence in others mask any correlation between *A. catechu* and WODF.

Availability of water is a major factor which restricts the movement of primates especially in dry habitats (Harrison 1983). This was true for the study group in summer (March-April). In these months, the primary factor affecting occupational density was water rather than food availability and the langurs were seen to move only along streams which had water. Availability of salt lick also seemed to act in a similar way, though to a lesser extent. Recall that these months had the highest percent time spent licking salt. Intergroup encounters (Waser 1982: in *Cercocebus albegia*). and presence of neighbouring groups (Clutton-Brock 1975: in *Colobus guereza*; Harrison 1983: *in Cercocebus sabaeus*) also affect the relationship between food availability and ranging patterns. Although no other group of *P. entellus* was sighted near our study group at any time, I cannot rule out this point.

I will now try to put the above factors together and reason out why only in certain months is a significant positive correlation seen.

In January a significant positive correlation was seen with *T.bellerica* unripe fruits and *W.tomentosa* mature leaves, yet 67% of variation in WODF was left unaccounted for. This is probably because of wrong estimation of the availability of the most used food species; *B.ceiba* flowers which could have been under estimated and leaves of *Premna latifolia* which could have been over estimated as a result of extensive lopping.

In April it was expected that *D.sissoo* would correlate significantly with occupational densities, since it was one of the major food species and also with a non-patchy distribution. However, as discussed earlier, the availability of large numbers of saplings, (below 10 cm GBH) on which the group fed extensively, could not be estimated. Availability estimate for *D.sissoo*, therefore, did not reflect this. The next important food species like *Albizzia lebbek* and *Sterculia villosa* are rare and thus underestimated, while *Shorea robusta* and *Flacourtia indica* availability estimates suffer from consequences of patchiness. *Carissa opaca* however shows a significant correlation amongst the remaining species. An abrupt change in habitat caused by a sudden altitude difference can result in a drastic change in species composition (Rawat pers. comm.). Thus, although *C.opaca* is mostly restricted to drier patches, the langurs might have fed on it while moving from one water patch to another.

It should be remembered also that the above factors are all probably secondary to the consequences of decreased water availability.

In December two major causes for masking of a possible correlation related to the top two food species.

i) Extreme patchiness of A.catechu.

ii) Under estimation of availability of *T.bellerica* unripe fruits, when they were very difficult to see.

The lack of correlation in February and March can perhaps be explained in the following way. One of the strategies employed by primates in the dry season is to become lees selective contrary to winter months when high food availability allows them to be selective (Curtin 1975). This is what seems to have caused the highest diversity of food species in these months. In such cases no single item predominates resulting in no correlation. So theoretically if the top few species are summed up a correlation should be expected. But of the top ten species in February only *H.antidysenterica* and *E.laevis* are uniformly distributed (see results Table 3.6). All others are either rare or clumped. In March similar to April D.sissoo has been underestimated. The other species suffered from similar estimation problems as in February.

Finally I would like to discuss the result obtained over all the 5 months. Although the correlation is insignificant, yet addition of the next most fed item increased the correlation. Marsh (1981) got a significant correlation when the top four food species were added. But if any more were added to them then again the correlation decreased, because decreasing time spent on species is a measure of decreasing selectiveness (Marsh 1981). His work, however, has to be contrasted with mine. He quantified food availability using crown volume of all the individual food species within the home range of his Red Colobus group. This obviously eliminated the shortcomings I encountered by sampling only about 6% of the home range. This lacunae probably got exaggerated when I multiplied the species availability by item availability for all months.

Most workers in this field have tried to correlate day range length or quadrat utilization diversity with food availability . I am unable to compare my findings with theirs because the their analysis involves a different level of focus (Rasmussen 1980).

CONCLUSION

Several complicating factors influenced the analysis at various stages like patchiness and rarity of food species, methodological problems, availability of water and equally important, lack of time for sampling a greater percentage of area.

The picture that emerges is that there is a positive relationship between food availability, and distribution, and occupational densities of different parts of the home range. But it is only a trend since each month seems to have a different set of conditions influencing it. Also it must be emphasized that in the case of folivores particularly, a strong correlation should not be expected since foliage is likely to be in excess of a folivores immediate requirement.

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* Originals not seen.

Appendix 1. **Plant species fed on during study period.**

<u>Species Name</u>

Acacia catechu
Albizzia lebbek
Albizzia odoratissima
Anogeissus latifolia
Bombax ceiba
Butea monosperma
Carissa opaca
Cuscuta radiata
Dalbergia sissoo
Dendrophthoe fulcata
Ehretia laevis
Ficus bengalensis
Ficus religiosa
Ficus ramphii
Flacourtia indica
Gardenia turgida
Holarrhaena antidysenterica
Lagerstroemia parviflora
Mallotus philippinensis
Ougeinia ooginensis
Phyllanthus emblica
Premna latifolia
Shorea robusta
Sterculia villosa
Syzygium cumini
Terminalia bellerica
Woodfordia fruticosa
Wrightia tomentosa
Zizyphus mauritiana
Zizyphus xylopyra
[Unknown (UK)]

Appendix 2a. Occupational densities WOD, WODF and availability of food species item for all blocks used in December.

BLOCK	WOD	WODF	ELM	HAUF	ACM	ACP	ZMM	WTM	WTUF	PLM
S4	1.11	1.35	5100	1629	0	0	493	0	0	0
S5	1.84	1.63	4072	3480	0	0	4405	1464	1127	2164
S6	3.77	3.69	2588	1112	0	0	0	0	0	0
ISL3	0.46	0.00	3493	0	1129	3104	4529	8486	6528	4196
AC	3.46	6.45	1603	388	2825	7768	5289	0	0	1619
HOME	0.17	0.00	2997	2221	1013	2787	10708	17604	1 3543	1791
ISL1	1.18	1.05	2151	526	0	0	1489	784	603	1540
DERA	0.78	1.00	0	0	0	0	0	0	0	0
DRAO	0.42	0.85	876	0	0	0	2346	0	0	0
PLT2	2.82	3.33	8870	569	16719	45979	0	0	0	464
PLT1	1.16	1.68	6237	61	6116	16819	0	0	0	542

ACP - A.catechu seeds; ELM - E.laevis mature leaves; ACM - A.catechu mature leaves; HAUF - H.antidysenterica fruits; PLM - P.latifolia mature leaves; WTM - W.tomentosa mature leaves; WTUF - W.tomentosa unripe fruits; ZMM - Z.mauritiana mature leaves;

Appendix 2b. Occupational densities WOD, WODF and availability of food species item for all blocks used in January.

BLOCK	WOD	WODF	ZML	PLL	WTL	ELL	TBUF
BPATH	1.060	1.320	760	0	3446	2296	115
S1	1.690	2.270	1054	0	3748	4000	143
MAC	1.940	3.160	724	172	793	465	151
DAS	1.730	2.838	1562	0	5949	3008	300
S2	0.425	1.100	447	0	0	866	44
Y21	1.170	0.370	0	0	0	457	0
S3	1.450	1.598	0	426	760	2547	0
WELL	1.360	2.200	1920	885	7228	457	163
ISL1	0.862	1.320	800	97	363	1085	380
DRAOX	0.270	0.460	0	0	0	0	0
TB	0.794	2.040	5364	0	9022	1148	183
S4	0.620	0.880	265	0	0	2573	215
GP	0.894	1.710	602	36	5945	1150	166
B1	1.330	1.100	0	0	0	589	0
M4	1.860	1.470	0	76	0	2044	0
M3	0.070	0.000	0	0	0	3294	0
ISL2	0.885	0.000	91	40	0	1292	0
HOME	0.490	2.200	5756	113	8142	1513	221
DRAO	0.130	0.460	1261	0	0	442	0
ISL3	0.435	0.976	2435	265	3425	1762	0

ELL - E.laevis leaves; PLL - P.latifolia leaves; WTL - W.tomentosa leaves; TBUF - T.bellerica unripe fruits; ZML - Z.mauritiana leaves

Appendix 2c. Occupational densities WOD, WODF and availability of food species item for all blocks used in February.

BLOCK	WOD	WODF	ACL	ACP	COM	COY	ELL	FINDL	HAFR
NHILL	0.98	1.11	0	0	0	0	232	0	6
MPH	0.26	0.45	0	0	152	73	2272	2293	413
GS	0.36	0.60	0	0	0	0	104	0	162
GRAS2	0.26	0.00	0	0	0	0	656	0	105
ANNRD	0.70	1.21	0	0	124	61	76	0	9
GRAS1	3.08	3.25	0	0	0	0	0	0	0
ANN	1.17	3.64	0	0	0	87	0	2504	0
DRYHI	0.95	1.32	1134	484	178	26	619	0	33
ACLIF	1.54	0.00	0	0	53	0	0	0	0
KSOT	1.13	1.21	249	106	0	5	1222	0	383
LIK	0.84	1.11	0	0	11	51	377	0	154
GSAL	0.65	0.84	0	0	104	95	1249	0	81
GH	0.49	0.66	620	265	194	51	183	347	106
Y21	1.12	1.33	0	0	104	0	154	0	0
TH	0.52	0.00	0	0	0	152	760	94	33
M5	0.37	0.68	0	0	311	0	1301	0	206
GP	0.39	0.91	2013	859	0	32	394	0	120
M3	0.69	0.84	0	0	65	0	1127	529	157
HOME	1.75	1.62	1165	497	0	0	517	0	124
Y11	0.16	0.00	0	0	0	537	328	0	17
S2	0.26	0.55	0	0	1097	15	296	0	51
DAS	1.42	0.91	0	0	43	21	1030	0	8

ACL - A.catechu leaves; ACP - A.catechu seeds; COM - C.opeca mature leaves; COY - C.opeca young leaves; ELL - E.laevis leaves; FINDL - F.indica leaves; HAFR - H.antidysenterica fruits;

Appendix 2d. Occupational densities WOD, WODF and availability of food species item for all blocks used in March.

BLOCK	WOD	WODF	ACM	DSY	COY	ELY	FINY	SYCY	HAUF
NHIL	0.832	1.320	0	0	0	966	0	0	2
GS	0.895	1.725	0	9780	0	432	0	1384	58
DHIL	1.175	1.610	789	319	114	2577	0	0	12
ANN	2.400	2.400	0	0	381	0	4521	0	0
ANNRD	0.255	0.450	0	1636	266	316	0	0	3
KSOT	1.438	2.030	173	270	23	5080	0	2181	137
MDRD	0.270	1.000	0	137	852	1995	67	0	5
GRAS1	0.220	0.000	0	0	0	0	0	0	0
MAC	0.560	0.610	0	0	0	662	1065	0	33
ACORD	0.332	0.457	1313	0	132	3391	0	0	79
LIK	0.610	0.780	0	0	222	1567	0	0	55
Y21	0.260	0.000	0	67709	69556	651	7732	5799	0
GSAL	0.460	0.800	0	0	415	5196	0	1083	29
Y11	0.710	0.880	0	0	2351	1364	0	0	6
CO	0.734	1.450	0	0	589	141	0	0	1
B1	0.673	1.134	0	0	129	839	0	0	3
GH	0.160	0.000	431	0	222	1000	626	7312	38
B2	0.696	1.000	0	0	1762	0	0	842	0
SRAOX	0.788	1.100	99	99	99	99	99	99	99

ACL - A.catechu mature leaves; COY - C.opeca young leaves;
DSY - D.sissoo young leaves; ELY - E.laevis young leaves;
FINY - F.indica young leaves; HAUF - H.antidysenterica fruits;
SYCY - S.cumini young leaves;

Appendix 2e. Occupational densities WOD, WODF and availability of food species item for all blocks used in April.

BLOCK	WOD	WODF	COY	DSY	MPHRF	ELL
NHILL	1.70	0.00	0	0	0	952
GS	4.59	2.26	0	5568	1152	426
DRYHI	0.53	0.00	116	182	0	2540
KSOT	1.81	0.00	23	154	1181	5008
ANNRD	0.76	1.63	270	931	353	312
MDRD	0.40	4.90	866	78	298	1967
LIK	1.42	0.65	226	0	953	1545
MAC	0.26	0.00	0	0	684	652

COY - C.opeca young leaves; DSY - D.sissoo young leaves;
ELL - E.laevis leaves; MPHRF - M.philippinensis ripe fruits;

Appendix 2f Occupational densities WBOD and average availability of food species item for five months within the ten large blocks.

BLOCK	WBOD	ACP	DSY	ELM	TBUF	BCB	COY
1	0.12	0.0	0.0	9489.0	0.0	0.0	564.5
2	0.26	3653.5	0.0	3566.8	0.0	0.0	118.8
3	0.44	60443.0	21088.5	12738.0	0.0	10057.0	0.0
4	0.33	4215.8	11286.4	3603.2	304.6	0.0	195.6
5	0.38	0.0	8477.0	7087.5	269.2	0.0	0.0
6	0.22	0.0	554.0	6159.3	0.0	4249.5	570.7
7	0.30	2122.0	349.7	7249.7	704.7	0.0	406.0
8	0.14	574.0	24765.2	3809.2	143.2	0.0	2426.2
9	0.13	2896.0	0.0	3311.3	0.0	0.0	2287.3
10	0.34	0.0	2903.3	4659.6	1047.7	7713.2	471.7

ACP - A.catechu seeds; BCB - B.ceiba buds; COY - C.opeca young leaves; DSY - D.sissoo young leaves; ELM - E.laevis mature leaves; TBUF - T.bellerica unripe fruits

Appendix 2f (continued)

BLOCK	WBOD	ZMM	PLY	HAUF	WTM	FINY	SALFL
1	0.12	98.3	386.8	3702.0	0.0	751.5	77461.8
2	0.26	17706.3	5285.0	2332.5	27615.8	0.0	0.0
3	0.44	0.0	649.5	426.5	0.0	376.0	0.0
4	0.33	7769.2	2063.0	282.6	3122.2	0.0	0.0
5	0.38	346.5	2877.8	2606.0	1308.3	0.0	64086.0
6	0.22	7163.8	1189.8	1919.3	7533.8	504.3	0.0
7	0.30	364.3	0.0	4603.7	0.0	0.0	7456.3
8	0.14	3386.0	0.0	1165.6	0.0	4466.4	71946.6
9	0.13	0.0	0.0	1852.7	0.0	0.0	70182.7
10	0.34	9976.3	626.6	2409.6	1047.1	3304.1	0.0

FINY - F.indica young leaves; HAUF - H.antidysenterica unripe fruits; PLY - P.latifolia young leaves; SALFL - S.robusta flowers; WTM - W.tomentosa mature leaves; ZMM - Z.mauritiana mature leaves