LEAF CHEMISTRY AND FOOD SELECTION BY THE COMMON LANGUR (*Presbytis entellus*, DUFRESNE 1797) IN RAJAJI NATIONAL PARK, U.P., INDIA

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CERTIFICATE

This is to certify that Kaberi Kar Gupta has carried o
original piece of research in partial fulfillment of her
(Wildlife) degree of the Saurashtra University, Rajkot. The
of the dissertation is "Leaf chemistry and Food selecti
Presbytis entellus in Rajaji National Park". The investiga
were carried out at the Wildlife Institute of India, Dehradun
my supervision from November 1990 to June 1991. I hereby ce
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CONTENTS

SUMMARY

Food selection in folivorous primates has been hypothesised to be correlated with leaf chemistry. To test this hypothesis, a 5-month study on *Presbytis entellus* was carried out in a moist deciduous forest in the Rajaji National Park, U.P.

Two indices of food selection were estimated: percent time spent feeding on the food item, and selection ratio. The former was estimated from group scan data collected from one study group for six days each month. The selection ratio for each item was estimated as a ratio of time spent feeding to availability. Food availability was estimated from vegetation sampling, which covered 6% of the home range of the study group, and phenology data in the study area. Crude Protein (*CP*), Acid Detergent Fibre (*ADF*) and Tannins in mature and young leaves of 12 major food species were estimated in the laboratory.

Food selection was positively correlated with *CP* in winter and with *ADF* in both seasons. It was also correlated with *CP/ADF* ratio, but to a lesser extent than the best predictor in winter and spring. Selection ratio did not have any correlation with *CP* in two seasons and only a weak correlation with *ADF*. It is very likely that the inclusion of other factors such as micro-nutrients, condensed tannins and digestibility might give a better prediction of food selection.

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CHAPTER I: INTRODUCTION

1.1 Leaf Chemistry and Food Selection

Feeding behaviour includes searching, selection and ingestion of food. In primates the relative importance of searching and selection varies with taxa. Insectivorous and frugivorous primates (e.g., Cercopithecines) feed primarily on high quality, readily digestible food which are less abundant. Searching for food, therefore, plays an important role in feeding behaviour. On the contrary, folivorous primates (e.g., Colobines) feed mostly on leaves, which are often very abundant and diverse. Food selection, therefore, forms an important component in their feeding behaviour. All folivorous primates have been found to be very selective while they feed on foliage (Hladik 1977, McKey *et al.* 1981). Therefore, feeding behaviour, especially food selection, has an important role in the ecology of folivorous primates and it has been the focus of several recent studies (Struhsaker 1975, Oates *et al.* 1977, Glander 1981, Milton 1979, Oates *et al.* 1980, McKey *et al.* 1981, Davies *et al.* 1988, Oates 1988). These studies reveal that a number of structural and chemical attributes of plant materials affect food selection. These could be divided into 2 groups: nutrient content and secondary compounds (Freeland and Janzen 1974, Milton 1979). The former increases the selection value of a food item while latter decrease it.

Among nutrients, protein and non-structural carbohydrate are the major factors. Studies in rain forests of Africa, Central America and Asia (Hladik 1977, Glander 1978, Milton 1979, Oates *et al.* 1980, Davies *et al.* 1988) confirm that protein level or crude protein content is a good predictor of food selection. Among foliage, protein level [measured as crude protein (*CP*)] is highest in immature leaves (Milton 1979, Glander 1981, Oates et al. 1980, McKey *et al.* 1981). Hladik (1977) recorded a constant level of protein in the diet of *P.senex* (11%) where as in case of *P.entellus* it fluctuated (10-15%).

Micro-nutrients, such as sodium, influence the food selection in herbivores (Belovsky 1978, Oates 1978). Similarly, calcium has an influence on the diet selection of *Ratufa indica* (Giant squirrel) another herbivorous animal (Borges 1990).

Plants produce a vast array of secondary metabolites to protect themselves from herbivores (Janzen 1973, 1978, Freeland and Janzen 1974, Rosenthal and Janzen 1979). These act as antifeedants in two ways (Rhoades and Cates 1976) - as digestion inhibitors and as toxins (Table 1.1).

Digestion inhibitors consist of fibres and tannin. There is no doubt that fibre (often measured as acid detergent fibre, *ADF*) is a major deterrent of food selection (Waterman 1983, 1984). Among fibre, lignin is the primary factor causing decline in digestibility. Apart from presenting a physical barrier to digestive enzymes, it interferes with digestion by binding to both

carbohydrate substrate and digestive enzymes in the gut (Van Soest 1982, Waterman *et al.* 1980).

Table 1.1: Mode of action of toxins and digestion inhibitors (From Waterman 1983)

Toxins	Digestion inhibitors
Qualitative, active in small amounts and cheap to produce	Quantitative, usually the effect is proportional
Usually small lipophilic molecules which can cross membrane barrier to reach specific sites	Act in the gut and do not need to cross the membrane; usually large, often highly polar, molecules
It can act at a specific target site within target organism	Interfere with some aspects of the digestive process
Predators can detoxify completely	Predators cannot detoxify but the degree of activity may be influenced by physical factors like pH, fibre (mainly lignins and tannins).
Several toxic compounds are alkaloids, terpenoids, flavonoids, saponins.	

Tannins are a group of polyphenols such as condensed tannins, total phenolics, oxytannins and prototannins (Swain 1979). They form insoluble complexes with proteins in food and with digestive enzymes, thereby preventing digestion (Swain 1979). Young leaves contain more tannins than mature leaves of the same species (Waterman 1983). Analysis of foliage available to 3 colobines showed that tannin had a weak negative correlation with food selection (Waterman and Choo 1981). Oates *et al.* (1977) found strong correlation between procyanidin tannin and food preference

of *C.guereza*. Selection of two *Acacia* species by vervet monkeys was negatively correlated with both total phenolics and condensed tannins (Wrangham and Waterman 1981).

Toxins include a vast array of compounds like alkaloids and terpenes (Table 1.1). Their analysis is difficult because of absence of appropriate assay techniques (Waterman 1984). McKey (1974) suggested that alkaloids are higher in young leaves. Hladik (1977) reported *P.entellus* at Polonnaruwa feeding on fruits of *Strychnos nuxvomica* which contain an alkaloid, strychnine, which is highly toxic to other animals. *Gomphandra coriacea* mature leaves, which form *P.johnii*'s staple diet contain some unidentified alkaloids (Oates et al. 1980).

Many primates have evolved mechanisms for detoxification of the above compounds by gut microflora (Freeland and Janzen 1974, Bauchop 1978). Glander *et al.* (1989) reported that among 3 sympatric species of bamboo lemurs, one feeds on bamboo shoots which contain high level of cyanides, while the other two do not feed on them.

In some colobines *CP/ADF* ratio is a better predictor of food selection (Waterman and Choo 1981, Waterman 1984). McKey et al. (1981) reported that a combination of several parameters, for e.g. (*N*+10*P*+Ash)x*CDIG/ADF+CT*, gave best correlation with food selection in *C.satanus*.

1.2 Objectives

The objective of this study was to test the hypotheses that *CP*, *ADF* and tannin, either alone or in combination would give a good prediction of food selection by the common langur *P.entellus*. Toxic secondary compounds and micro-nutrients were not considered because of logistic limitations. Moreover, the analysis was restricted to foliage because of several reasons:

- Foliage is the major part of the diet of folivores and, therefore, previous studies on folivorous primates (Colobines and Cebids) have concentrated on foliage.
- Seeds and fruits mostly have high *CP* and low *ADF*, and hence, their selection is relatively simple.
- In most of the studies % time spent feeding on different items from group scan data is used as an index of food selectivity or preference. This gives a good estimation of relative intake of foliage biomass of different plant species, but either under-estimates or over-estimates the intake of seeds and fruits (Iwamoto 1978). A comparison of percentage time spent feeding between foliage and fruits or seeds, therefore, would have been incorrect.

Hypotheses

The general hypothesis is that preference by *P.entellus* for foliage from different species should be correlated with leaf chemistry, especially *CP*, *ADF* and tannins. This study was planned to test the following specific hypotheses:

1. % time spent feeding should be positively correlated with *CP*.
2. % time spent feeding should be negatively correlated with *ADF*.
3. % time spent feeding should be negatively correlated with tannins.
4. *CP/ADF* ratio should be a better predictor of food selection.

P.entellus was selected for study as, in spite of being the most widely distributed colobine, no studies on food selection have been carried out. Food selection by folivores in deciduous forest has also not been studied. Moreover, *P.entellus* was a logistically convenient species since resources at my disposal for the study were limited.

1.3 Study animal

P.entellus is a leaf monkey belonging to the Subfamily Colobinae (Family Cercopithecidae, Order Primates). It is one of the most widely distributed leaf monkeys, occupying a wide variety of habitats such as deciduous forests, scrublands and rain forests of South Asia. About 16 subspecies (Napier and Napier 1967, Prater 1988) have been recorded, ranging from the snowy regions of the Himalayas in India and Nepal, to the forests of Sri Lanka, and from open scrublands of western India to the evergreen forest of north-east India (Roonwal and Mohnot 1977). They are found from sea level up to 3600m. (Prater 1988).

P.entellus is perhaps one of the most widely studied primates in the Indian subcontinent (Jay 1965, Sugiyama 1964, Yoshiba 1967,

Newton 1984). Only one study has been carried out in Rajaji National Park (Laws and Laws 1984). Most of the above studies have concentrated on the social organisation. These reveal that there is considerable geographic variation in group size and composition. The most common organisation is multimale groups, in deciduous forest (Jay 1965, Ripley 1970). In Gir, both multimale and one male groups have been reported (Rahman 1974), while one male groups are reported from Dharwar (Sugiyama 1964), Jodhpur (Mohnot 1971) and Mount Abu (Hrdy 1977). In the Himalayan region, multimale groups have been reported (Curtin 1975). A subject of considerable debate is the occurrence of infanticide in *P.entellus*, reported mostly from the arid zone (Sugiyama 1964, Mohnot 1971, Hrdy, 1977).

Comparatively few studies have been conducted on the feeding ecology of *P.entellus* (Curtin 1975, Newton 1984, Hladik 1977). Hladik (1977) suggested that *P.entellus* is a more generalist herbivore than other *Presbytis* species.

CHAPTER II: STUDY AREA AND METHODS

2.1 Study Area

The field study was conducted at the Rajaji National Park, U.P. (824 km^2). It is a forest stretch of the Siwalik ecosystem. Intensive study was conducted at Dholkhand range (30'E; 78'N) in the south-west part of Rajaji National Park (Map 1). Biogeographically this area is at the boundary of the Gangetic Plains and the Himalayan region, and consists of flora and fauna of both the regions (Rodgers and Panwar 1988). The Siwalik mountain ranges run through the park, with a maximum altitude of 1200m. above sea level (Osmaston and Sale 1988).

2.1.1 Climate

The study area has a continental monsoonal climate. There are three distinct seasons (Rodgers *et al.* in prep.): Monsoon rains (July to September), Post-monsoon winter (November to February), Summer (April to June). Annual rainfall at Dholkhand is about 1500 mm. Temperature ranges from 3°C in winter to 45°C in summer. Temperature recorded during study period is shown in Fig.2.1.

2.1.2 Vegetation

Champion and Seth (1968) classified the vegetation in the area as moist deciduous Sal forest. Rodgers *et al.* (in prep.) identified six vegetation categories in the area. Of these only 3 are represented in the study area at Dholkhand:

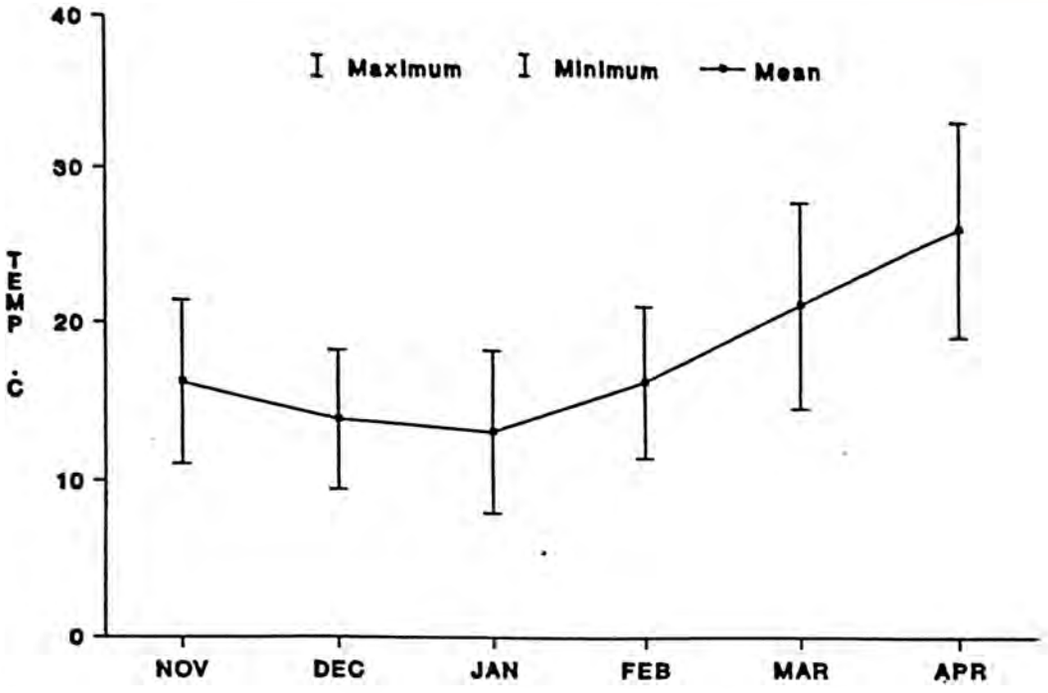
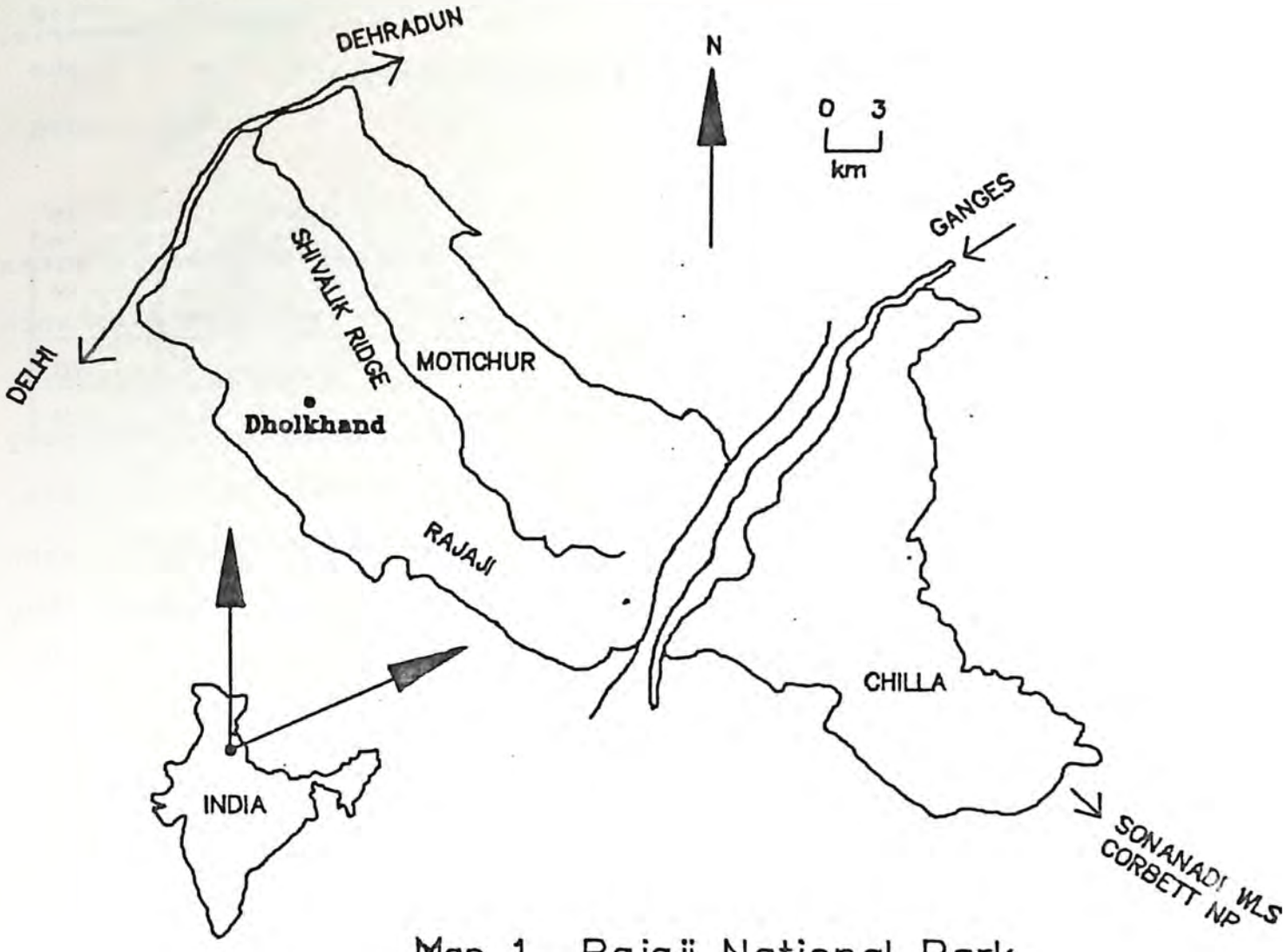


Fig.1. Temperature variation in six months.

1. Sal (*Shorea robusta*) forest; 2. Mixed deciduous forest; and 3. River banks and alluvial soils.

Both Sal and mixed deciduous are further subdivided into hill and plain types (Champion and Seth 1968). The composition of plain Sal forest further varies between dry and moist areas with *Lagerstroemia, Ehretia, Mellittia and Murraya* in the dry parts and *Syzygium* and *Terminalia tomentosa* in the moist parts.

Rodgers *et al.* (1986) describe woodland forest as represented by *Bauhinia, Cassia, Carissa, Grewia* and *Zizyphus*, while hills contain *Acacia catechu, Lannea, Buchnania, Anogeissus* and *Shorea robusta*.



Map 1 Rajaji National Park

River banks and alluvial terraces have characteristic *Acacia-Dalbergia* type (Rodgers *et al.* in prep.). But in Dholkhand, *Acacia* is planted. River banks have scattered trees of *Bombax, Casseria, Terminalia, Ficus* and *Erythrina* (Rodgers 1985).

2.1.3 Fauna

Dholkhand is rich in the diversity of fauna. Apart from primates (*Presbytis entellus* and *Macaca mullata*), there are Asian elephants (*Elephas maximus*), chital (*Axis axis*), sambar (*Cervus unicolor*), barking deer (*Muntiacus muntjac*), wild boar (*Sus scrofa*) and grey goral (*Nemorrhaedus goral*). Carnivores include two big cats, *Panthera tigris* and *P.pardus*, jackal (*Canis aureus*) and Himalayan yellow-throated marten (*Martes flavigula*). Approximately 230 species of birds have been recorded (unpubl. species list).

2.2 Methods

A test of the hypotheses proposed in chapter I required the estimation of intake of foliage of various plant species, estimation of relative abundance of foliage of major food species and the analysis of foliage for estimation of *CP, ADF* and *CT*.

2.2.1 Estimation of time spent feeding

A group of *P. entellus* was identified as the main study group in the first week of November 1990. This group was followed for about a month to habituate them. This period was also spent on estimating the group size and composition (Table 2.1), to get a

preliminary idea of home range, and mapping of the study area. The study area was divided into 50 x 50 m. quadrats, by a number of grids. Although this was begun in November, more grids had to be added since the group expanded its home range, as the study progressed.

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

Month	Adult Male	Adult Fem.	Subad male	Subad fem.	Juve-nile	Inf.	Unid	Total
DEC	8	36	17	16	25	25	16	143
MAR	12	40	9	26	26	35		148

Data collection from the group started in December 1990 and lasted until 30th April 1991. Percent time spent feeding on various plant parts and species were estimated by group scan (Altman 1974). I followed the study group for six consecutive days at the end of every month, from dawn to dusk each day. Instantaneous scan samples were made at 15-minute intervals and the activities of all animals visible at that time were recorded. In each scan, age and sex class of the animal, activity, and plant species and plant part used if they were feeding, were recorded. Each animal's activity was counted as an activity record. Although activities were classified into many categories in the field, for the purpose of analysis here, they were grouped into four:

Feeding: active searching and plucking of food, bringing it to the mouth, chewing and swallowing (Milton 1978).

Resting: sitting inactive or sleeping.

Moving: movement of individual or movement of the group.

Others: activities not included in the above: *e.g.* grooming, playing, fighting licking of stones, eating of soil and drinking.

Percentage time spent on each activity was calculated as follows (Kumar 1987):

$$P_i = \frac{n_i}{N} \times 100$$

where P_i = % time spent on activity 'i'
n_i = number of records of activity 'i'
N = number of total activity records

Percent time spent feeding on a food item out of the total time spent feeding was estimated from the same formula, but with:

n_i = number of records of feeding on item 'i'
N = total number of feeding records.

2.2.2 Estimation of food availability

Food availability was estimated from a combination of vegetational and phenological data collected during the study period within the home range of the study group.

Estimation of Species Abundance

The vegetation sampling was conducted at the end of the study period by when the food plant species were known. Circular plots of 10-metre radius were laid in most of the 50 x 50 m. quadrats which covered almost the entire home range of the study group. Within each plot, the species, girth at breast height (GBH), depth and diameter of the crown, and height were recorded for all trees with GBH greater than 10 cm. A total of 465 plots were sampled

covering nearly 6% of the home range of the group. Crown volume strongly correlates with basal area (Oates *et al.*1980, Oates *et al.* 1990, McKey *et al.* 1981) and with GBH (Strier 1991).

Phenology

Randomly selected trees (2 to 10) of 52 species were visited each month for estimation of availability of various phytophases. Out of these, 14 species contributed more than 70% of the diet. A visual assessment of the percentage cover was made independently for each phytophase (flower, mature leaves, etc.) out of the crown surface.

Availability index

Relative availability of mature and young leaves was estimated for each, as follows:

$$A_i = \frac{\bar{P}_i \times b_i}{\sum_{i=1}^{N} \bar{P}_i \cdot b_i} \times 100$$

where $\bar{P}_i = \frac{1}{S} \sum_{j=1}^{S} P_{ij}$

Where A_i = availability of species 'i'
P_i = % of phytophase 'i'
b_i = basal area of species 'i'
N = total number of species
P_{ij} = proportion of coverage of phytophase on sample 'j' of species 'i'
s = number of samples for species 'i'

2.2.3 Estimation of Selection Ratio

Selection ratio was estimated for mature and young leaves for each species from:

$$SR = \frac{P_i}{A_i}$$

where P_i = percent time spent feeding on food item 'i'.
A_i = relative availability of the item 'i'

2.2.4 Leaf chemistry

Collection of samples

Foliage from more than 20 food plant species were collected during the study period from the home range of the study group. One to three samples each of 50 to 200 gms. fresh weight were collected for each item (mature and young leaves) of a species from one tree. Diseased leaves or those eaten by insects were avoided during collection. Samples of fruits and flowers eaten by langurs, and foliage from some uneaten plant species were also collected.

Preparation of samples

Fresh samples were collected in plastic bags, then placed in paper bags and weighed. These samples were brought to the laboratory within 48 hours and kept in an oven at 60°C for drying for a period of six days or till the dry weight became consistent. Oven-dried plant samples were finely ground in Cyclote's grinding mill and kept in sample packets for further analysis. Chemical analyses were carried out for protein, acid detergent fibre and tannin in the Wildlife Institute of India's laboratory.

Estimation of Crude Protein (*CP*):

Crude protein was quantified by Kjeldahl method. 0.5 gm. of oven-dried sample was taken and mixed with a catalyst ($CuSO_4$ + K_2SO_4) and 5 ml. of concentrated sulphuric acid, and then left for digestion on a heater for 5 to 6 hours. Ammonia generated during distillation was absorbed in 2% Boric acid, which was then titrated against N/10 sulphuric acid. Percent crude protein was estimated from:

$$CP = N \times 6.25 \times 100$$

where CP = percent crude protein
N = nitrogen in the sample
= $X \times 0.0014 \times 2$,
X = volume of acid used for titration

Estimation of Acid Detergent Fibre (*ADF*)

ADF was estimated according to Van Soest's (1963) method:
0.5 gm. oven-dried sample was refluxed with 50 ml. of acid detergent solution (ADS) and boiled vigourously at first and then more evenly. After an hour of reflux distillation, the contents were transferred to Grade 1 (G_1) sintered crucibles and allowed to percolate. The residue was washed with boiling water and then with 20 ml. acetone thrice. The crucibles were kept overnight in an oven at 100°C and then cooled in a desiccator and weighed. The residue which remained insoluble in the hot ADS was the amount of *ADF*, percentage of which was calculated.

Qualitative assay for Tannin estimation

The assay was based on the formation of coloured phenolic metal ion complexes (Hagerman and Butler 1989). Hot 50% ethanol was used as the solvent to extract tannin (Swain 1979). 100 mg of dried leaf material was taken and kept in 10 ml of the solvent for two hours. The extract was filtered and one ml of freshly prepared neutral ferric chloride solution was added to the filtrate. Greenish blue color indicated the presence of tannin. Intensity of the colour varies depending on the amount of tannin present in the sample. The intensity of colour was ranked 0 (absent) to 9 (maximum) for all samples.

There are a number of assays to estimate condensed tannins and total phenolics quantitatively (Mole and Waterman 1987 a, b, Hagerman and Butler 1989). Standardisation of these methods is, however very lengthy, and therefore was not possible within this study.

2.2.5 Statistical analysis:

Non-parametric statistics were preferred over parametric statistics for a number of reasons (Siegel and Castellan 1988):

a) Distribution of data was unknown,

b) Most of the data were as percentages,

c) Sample sizes were often small.

Spearman's rank correlation was used as correlation test. A level of significance of 0.05 was applied in all statistical tests.

The five months of study were divided into two seasons, winter (December, January and February) and spring (March and April). There were substantial changes in temperature between these two seasons, and these were reflected on the phenology. Most of the analyses are, therefore, done with reference to these two seasons.

CHAPTER III: RESULTS

3.1 Introduction

In this chapter, the analysis of data collected is presented. Following a brief description of the general activity pattern, feeding is discussed in detail with reference to diet composition. This is followed by discussion of food availability, selection ratios, leaf chemistry and finally an analysis of the correlation between leaf chemistry and food selection.

3.2 Activity pattern

I sampled the group for a total of 30 days, 6 consecutive days in each of the five months (Table 3.1). The number of scans in a day varied from 38 to 40 in winter and from 34 to 44 in summer. The number of records made each day varied from 199 to 398, with number of individuals recorded in each scan varying from 5 to 9. A total of 8357 records were made over 5 months. Time spent on different activities in each day are given in Appendix I.

Table 3.1: Data collected through group scan in five months.

Month	No. days	No.hrs.	No. Scan	Total Recs.	Av.Ind./ Scan
December	6	58.25	233	1585	6.80
January	6	56.00	225	1490	6.62
February	6	63.00	252	1722	6.83
March	6	62.75	251	2192	8.73
April	6	59.75	239	1368	5.72

Table 3.2: Percent time spent on various activities in 2 seasons and over the study period (5 months).

Season	Feed	Rest	Move	Others	Total records
Winter					
X	41.71	36.79	12.79	8.63	4797
o-	10.37	8.22	4.74	3.38	
Spring					
X	38.55	37.94	15.22	7.85	3561
o-	5.75	5.40	5.08	2.96	
5 months					
X	40.44	37.28	13.77	8.32	8357
o-	8.96	7.24	5.02	3.24	

Over the five month study period 40.44% of time was spent on feeding, 37.28% on resting, 13.77% on moving and 8.32% on other activities (Table 3.2). There were no pronounced differences between months or seasons in the time spent on the various activities. Thus, feeding in the two seasons varied only between 41.71% in winter and 38.55% in spring, and resting from 36.79% in winter to 37.90% in spring. Similarly time spent moving and on other activities differed only marginally between seasons.

3.3 Feeding

A total of 3373 feeding records were collected, of which 2031 were in winter, and 1342 in spring. The study group used nine plant parts from 51 plant species during 5 months (Table 3.3, see Appendix II for details).

3.3.1 Composition of diet

Leaves accounted for more than half of the time spent feeding (53.00%) over the 5 months (Table 3.3). There was no substantial difference between mature leaves (25.58%) and young leaves (27.42%). Almost equal percentage of time (12-16%) was spent on seeds, unripe fruits and flowers (flowers and floral buds).

Time spent feeding on young leaves and mature leaves, and other food items differed substantially between the two seasons. In winter they fed mostly on mature leaves (34.61%). Seeds contributed 19.25% followed by unripe fruits (15.75%). Flower buds contributed 9.20%. *Cuscuta radiata*, a parasite, was also eaten in winter (2.41%). In spring the scenario was quite different. Young leaves accounted for 65.50% of the feeding time while mature leaves contributed only 11.92%. There was also a major reduction in time spent feeding on seeds and unripe fruits in spring (1.11% and 6.71% respectively). I did not observe any feeding on ripe fruits in winter while in spring (April), they fed on the non-fleshy ripe fruits of *Mallotus phillipinensis* (1.71%).

In winter, eight species contributed 80% of the leaf diet. Of that *A.catechu* mature leaves were eaten most (22.04%) followed by *Z.mauritiana*, *P.latifolia* and *W.tomentosa* (16.07%, 12.51% and 8.81% respectively). There was a shift of species from winter to spring. Of the eight species that contributed more than 80% of the leaf diet in spring, young leaves of *D.sissoo* contributed 37.62%, and mature leaves of *A.catechu* 6.97% (Table 3.4).

Table 3.3: Percent time spent feeding on various plant parts in 5 months and 2 seasons

PLANT PART	DEC.	JAN.	FEB.	MAR.	APR.	WINTER	SPRING	TOTAL
ML	26.20	39.15	39.38	19.65	0.37	34.61	11.92	53.00
YL			6.22	62.93	69.33	2.26	65.50	
FB	1.51	13.58	13.39	3.48	0.37	9.20	2.23	6.43
FL	2.48	1.58	14.07	7.33	13.56	6.30	9.83	11.50
UF	15.58	22.92	10.41	3.85	10.96	15.75	6.71	12.15
RF					4.46		1.71	0.71
SE	45.24	4.58	5.00	1.86		19.25	1.11	12.03
BARK		0.35	3.51	0.49	0.55	1.37	0.52	1.03
PITH	3.72	7.23	5.54	0.30	0.36	5.36	0.37	3.38
LP	1.51	6.52	2.43			3.24		1.95
CUSCUTA	4.00	3.52				2.41		1.45

Table 3.4: Percent time spent feeding on leaves in (a) winter and (b) spring.

(a) Winter

No.	Species	Dec.	Jan.	Feb.	Total	%Feeding
Mature leaves						
1	A.catechu	23	6	126	155	22.04
2	Z.mauritiana	40	64	9	113	16.07
3	P.latifolia	25	63		88	12.51
4	W.tomentosa	6	30	26	62	8.81
5	G.arborea	43			43	6.11
6	F.indica	14	18	6	38	5.40
7	L.acidissima		12	20	32	4.55
8	C.opaca			30	30	4.26
9	E.laevis	14	6	5	25	3.55
10	A.latifolia			10	10	1.42
11	Z.xylopyra			20	20	2.84
12	Z.oenoplia			15	15	2.13
13	D.falcata	4	10	1	15	2.13
14	A.marmelos	9		5	14	1.99
15	O.oojeinensis			12	12	1.70
16	C.myxa	5			5	0.007
17	B.ceiba	4	1		5	0.007
18	D.sissoo	3	1		4	0.005
19	A.odoratissima		3		3	0.004
20	M.auriculata		3		3	0.004
21	G.pinnata		3		3	0.004
22	G.targita			2	2	0.002
23	T.belerica			1	1	0.001
24	F.bengalensis			1	1	0.001
25	N.arbortristis			1	1	0.001
26	Bauhinia sp.			1	1	0.001
27	P.emblica			1	1	0.001
28	V.heynei			1	1	0.001

TOTAL RECORDS = 703

(continued....)

(b) Spring

No.	Species	Mar.	Apr.	Total	%Feeding
Young leaves					
1	D.sissoo	162	221	383	37.62
2	C.opaca	165	21	186	18.27
3	E.laevis	100	11	111	10.90
4	F.indica	54	10	64	6.28
5	A.lebbek		43	43	4.22
6	S.cumini	23	3	26	2.55
7	Ficus sp.		32	32	3.14
8	F.semicaudata		11	11	1.08
9	B.monosperma		3	3	0.002
10	A.marmelos		2	2	0.001
11	P.emblica		2	2	0.001
12	A.odoratissima		2	2	0.001
13	O.oojeinensis		2	2	0.001
14	C.myxa		1	1	0.0009
15	M.auriculata		1	1	0.0009
16	Bauhinia sp.		1	1	0.0009
Mature leaves					
1	A.catechu	71		71	6.97
2	A.latifolia	38		38	3.73
3	A.odoratissima	7		7	0.006
4	D.falcata	7		7	0.006
5	W.fruticosa	6		6	0.005
6	Z.xylopyra	5		5	0.004
7	Z.mauritiana	3		3	0.002
8	Z.oenoplia	3		3	0.002
9	L.acidissima	2		2	0.001
10	V.heynei	2		2	0.001
11	Ficus sp.	2		2	0.001
12	S.sovellens	1		1	0.0009
13	B.retusa	1		1	0.0009

TOTAL RECORDS = 870 + 148 = 1018

3.4 Food availability

Young leaves were absent in winters and mature leaves were present, and vice-versa in spring, in most of the species. Mature leaves were present in 50 and 34 species in winter and spring respectively. In contrast, young leaves were available only in three species in winter, compared to 31 species in spring. The relative availability of young and mature leaves out of the total foliage biomass (as indicated by the Availability Index) varied between seasons - with mature leaves 96.17% in winter and 18.51% in spring.

In winter, among the food species, availability of mature leaves varied between the species from 18.53% in *E.laevis* to 0.23% in *G.arborea*. Availability of young leaves in winter was only 3.82%. In spring, the availability of mature leaves went down drastically. They were available in the range between 0.006% and 6.66% in case of *A.catechu* and *Z.mauritiana* respectively. Young leaves of *E.laevis* formed 30.60% while *D.sissoo* formed 30.09%.

Thus, these results show that deciduous trees have substantial changes between the seasons, in composition of foliage biomass among the food species (Table 3.5).

3.5 Selection ratio

As seen in the previous sections, both time spent on mature and young leaves of various species and their relative availability varied between the two seasons. Selection ratio represents an

Table 3.5: Percent food availability and selection ratio in 2 seasons.

Species	Plant part	Food Availability		Selection Ratio	
		Winter	Spring	Winter	Spring
A.catechu	ML	15.54	6.66	1.42	1.04
	YL	0.00	0.00	0.00	0.00
D.sissoo	ML	16.80	0.00	0.002	0.00
	YL	2.38	30.09	0.002	1.25
E.laevis	ML	18.53	0.00	0.19	0.00
	YL	1.05	30.60	1.39	0.35
Z.mauritiana	ML	13.35	6.96	1.20	0.0002
	YL	0.00	0.007	0.00	0.00
P.latifolia	ML	3.42	0.00	3.65	0.00
	YL	0.00	6.63	0.00	0.00
W.tomentosa	ML	13.14	0.94	0.67	0.00
	YL	0.00	0.00	0.00	0.00
L.acedatum	ML	5.40	3.18	0.84	0.00
	YL	0.00	0.64	0.00	0.00
G.arborea	ML	0.23	0.006	26.56	0.00
	YL	0.00	0.76	0.00	0.00
C.opeka	ML	1.03	0.00	4.13	0.00
	YL	0.07	1.95	51.42	9.37
A.lebbek	ML	6.38	0.00	0.00	0.00
	YL	0.00	1.02	0.00	0.00
S.cumini	ML	5.39	0.77	0.00	0.00
	YL	0.11	6.64	0.00	0.38
F.indica	ML	1.63	0.00	3.31	0.00
	YL	0.21	3.36	0.02	1.86

attempt to compare relative availability of foliage biomass at a given time with intensity of feeding. Selection ratio has been used as an index of relative preference of food parts (Clutton-Brock 1977). When selection ratio is 1.0, consumption is equal to availability and, therefore, shows neither preference nor avoidance; larger ratio suggests preference, and less than 1.0 suggests avoidance. Selection ratio of 24 plant parts belonging to mature and young leaves of 12 species are in Table 3.5.

3.6 Leaf chemistry

A total of 16 samples of mature and young leaves belonging to 12 species were analysed for *CP*, *ADF* and tannins (Table 3.6). These included mature leaves from eight species and young leaves from six species. Both mature and young leaves were analysed only from 2 species (*E.laevis* and *F.indica*). For each item, *CP* and *ADF* were taken as the mean of three assays each. As mentioned Chapter II, *CP* and *ADF* were estimated as % content in dry matter, and tannin was qualitatively ranked from 0 (absent) to 9 (heavy content).

3.6.1 Crude protein

CP for the same plant part varied from species to species (Table 3.6). Among mature leaves *A.catechu* had the highest amount of crude protein (20.73%) and *F.indica* had the lowest (9.36%). Among young leaves, crude protein level was highest in *D.sissoo* (23.4) and lowest in *S.cumini* (8.66%). Although young leaves contained more *CP*

Table 3.6: Percentage feeding, selection ratio, crude protein, acid detergent fibre and tannins of leaves in winter and spring.

SPECIES	LF	% FD	SR	% CP	% ADF	T1	T2
Winter							
A.catechu	ML	22.04	1.41	20.73	15.69	6	9
Z.mauritiana	ML	16.07	1.20	13.38	25.9	8	8
P.latifolia	ML	12.51	3.65	14.7	22.64	2	6
W.tomentosa	ML	8.81	0.67	13.59	23.02	1	1
G.arborea	ML	6.11	26.56	11.84	19.42	1	4
F.indica	ML	5.4	3.31	9.36	33.28	5	5
L.acidissima	ML	4.55	0.84	14.98	23.54	0	0
E.laevis	ML	3.55	0.19	11.39	33.82	4	4
Spring							
D.sissoo	YL	37.62	1.25	23.71	13.14	2	2
C.opaca	YL	18.27	9.37	10.67	18.42	6	8
E.laevis	YL	10.90	0.35	20.3	22.74	7	5
F.indica	YL	6.28	1.86	12.07	25.54	7	5
A.lebbek	YL	4.22	6.75	19.51	24.8	9	9
S.cumini	YL	2.55	0.38	8.66	33.12	8	2
A.catechu	ML	6.97	1.04	19.51	15.58	6	9
Z.mauritiana	ML	0.00	0.02	13.12	27.80	8	8

LF - Leaves; FD - Feeding; SR - Selection Ratio; CP - Crude Protein; ADF - Acid Detergent Fibre; T1 - Tannin1; T2 - Tannin2; ML - Mature leaves YL - Young Leaves

(mean=15.82, for 6 species) than mature leaves (mean=13.74, for 8 species), the difference was not statistically significant.

3.6.2 Acid Detergent Fibre

ADF ranged from 13.14% to 33.27% and was higher in mature leaf (mean=24.67, 8 species) than in young leaf (mean=22.96, 6 species), eventhough the difference was not significant. Among mature leaves, *E.laevis* had the highest amount of *ADF* (33.82%), it was lowest in *A.catechu* (15.69%). Among young leaves *D.sissoo* had the lowest 13.14% while *S.cumini* had a high fibre content (33.12%). *CP* and *ADF* are negatively correlated (r_s=-0.43, N=16, $p<0.05$).

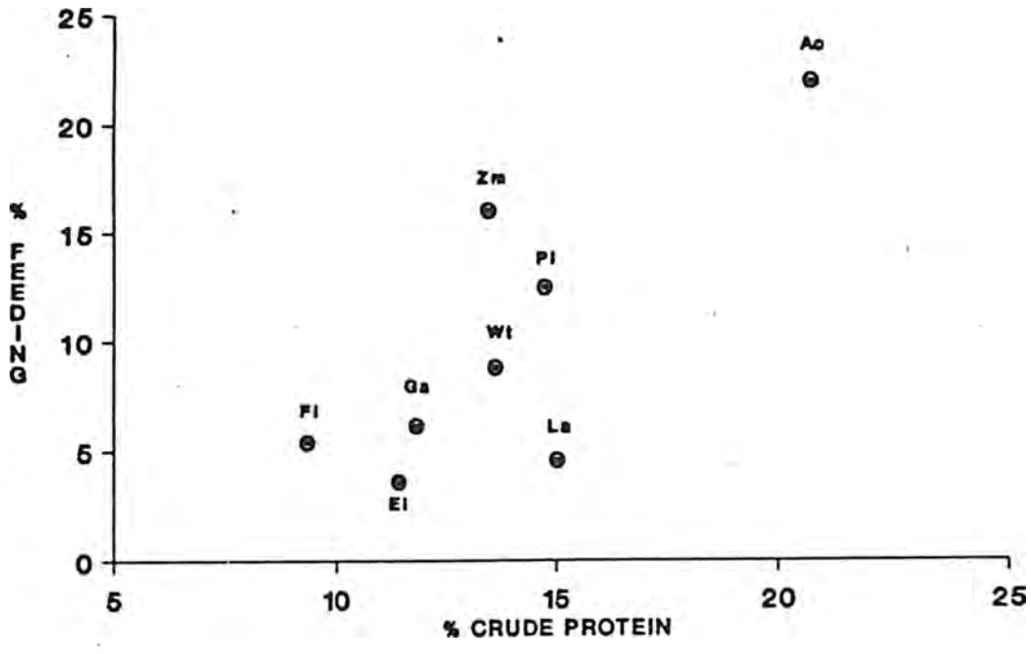
3.6.3 Tannin

The qualitative assay of tannin revealed that young leaves had higher concentration than mature leaves (Table 3.6). *A.catechu* and *Z.mauritiana* had higher levels of tannin among mature leaves, while among young leaves *A.lebbek* and *C.opaca* had high levels of tannins.

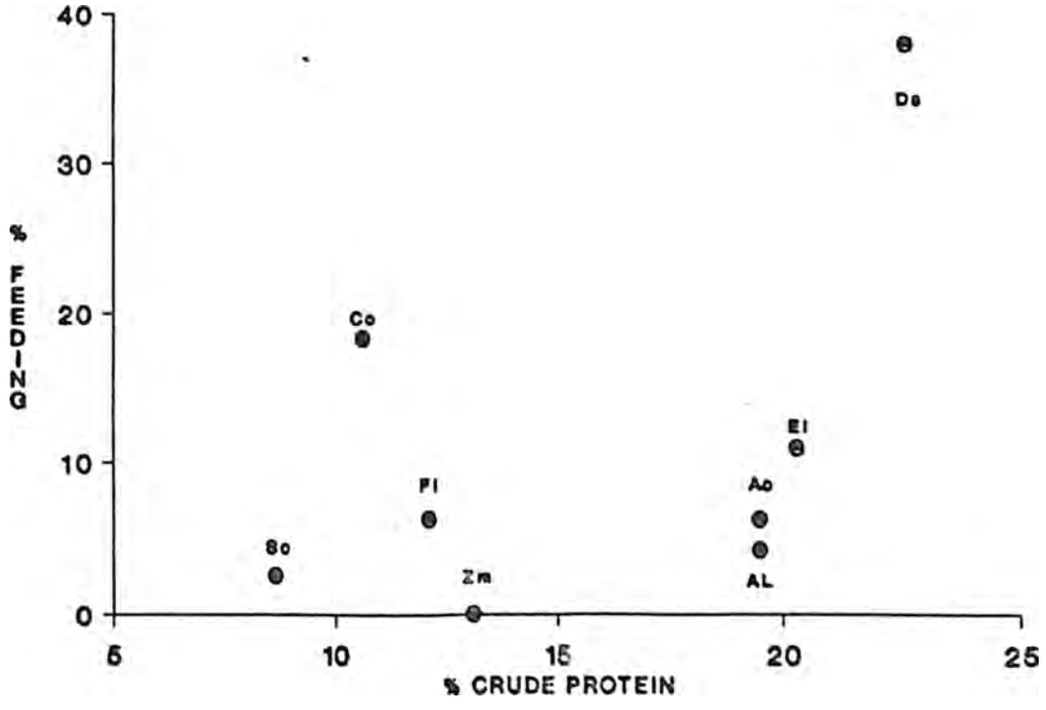
3.7 Leaf chemistry and food selection

I hypothesized that food selection is related to leaf chemistry (Section 1.2). Time spent feeding in winter was strongly correlated with *CP* amount if we remove *Limonia* from the sample (r_s=0.86, N=7, $p<0.01$, Table 3.7; Fig.3.1A). In winter, a negative correlation between % time spent feeding and *ADF* was seen (r_s=0.64, N=8, $p<0.05$; Fig. 3.2A). In spring, *ADF* was strongly correlated

Fig. 3·1:Plot of % FD with CP in
(A) winter & (B) spring

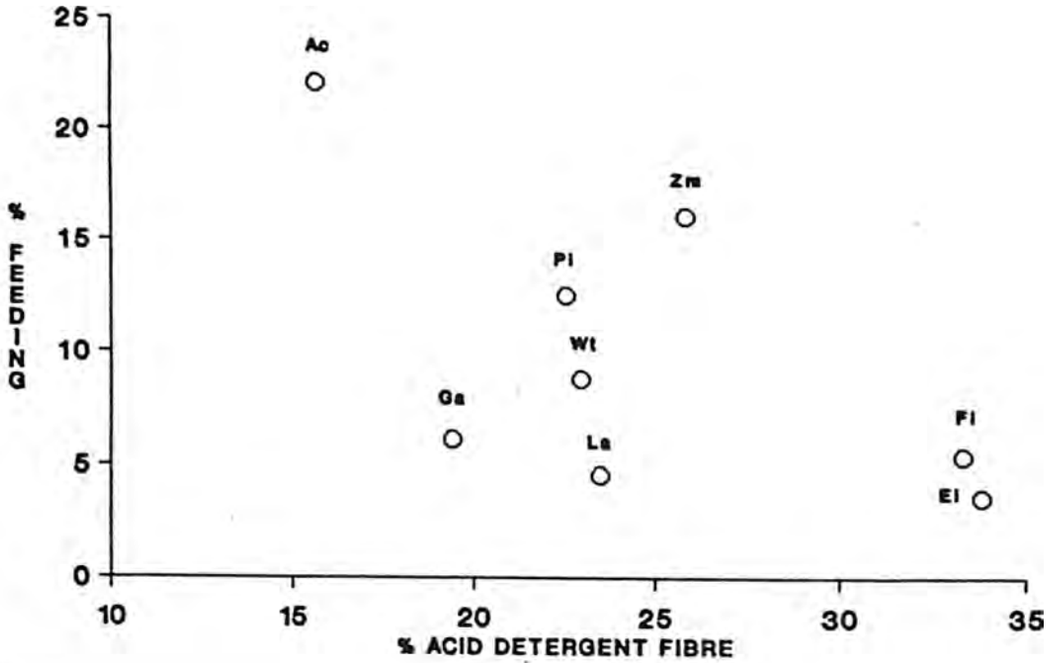


(A)

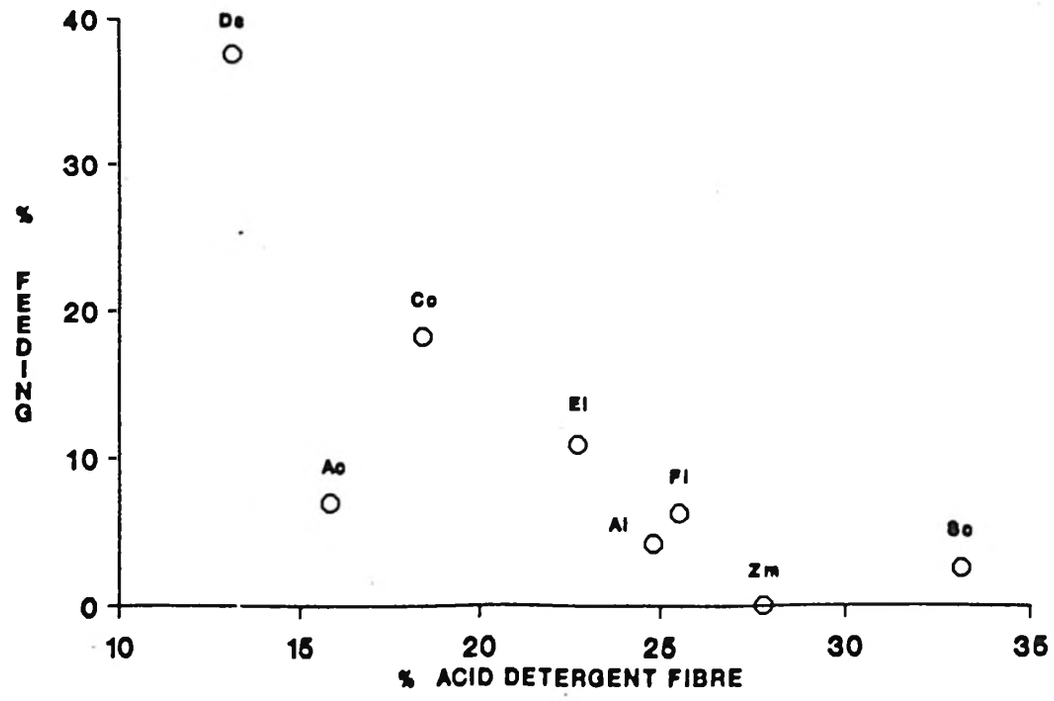


(B)

Fig.3·2:Plot of % FD with ADF in
(A) winter & (B) spring



(A)



(B)

with time spent feeding (r_s=-0.95, N=8, p<0.01; Fig. 3.1B). There was no significant correlation with *CP*, however (r_s=0.49, N=8, p>0.05; Fig. 3.2B).

CP/ADF ratios in winter and spring showed significant correlations with time spent feeding (r_s=0.53, N=8, p<0.05, and r_s=0.74, N=8, p<0.05, respectively), but the r_s values in both the seasons were lower than the best predictor in that season.

No correlation tests were done between overall % time spent feeding and values of *CP* and *ADF* because the availability of mature and young leaves varied highly between seasons. Young leaves were not available in winter and mature leaves of most of the species were not available during spring.

Table 3.7: Spearman rank correlation of percent time spent feeding and selection ratio with *CP*, *ADF* and *CP/ADF*. (In winter two estimates were made for *CP*; including *Limonia* (N=8) and excluding it (N=7).

Season	Chem.	N	r_s with feeding	p	r_s with S.R	p
Winter	*CP*	8	0.54	>0.05	-0.01	>0.05
	CP	7	0.86	<0.01		
	ADF	8	-0.64	<0.05	-0.54	>0.05
	CP/ADF	8	0.53	>0.05	0.31	>0.05
Spring	*CP*	8	0.49	>0.05	-0.14	>0.05
	ADF	8	-0.95	<0.01	-0.23	>0.05
	CP/ADF	8	0.74	<0.05	0.14	>0.05

Selection ratio is an attempt to represent the preference among leaves of different species controlling for availability. There was no correlation between selection ratio and *CP* (r_s=-0.01,

N=8, p>0.05 in winter, and r_s=-0.14, N=8, p>0.05 in spring), and *ADF* (r_s=-0.54, N=8, p>0.05 in winter, and r_s=-0.23, N=8, P > 0.05 in spring), and selection ratio and *CP/ADF* (r_s = 0.31, N=8, p>0.05 in winter, and r_s=0.14, N=8, p>0.05).

CHAPTER IV: DISCUSSION

The objective of this study was to examine the hypothesis that selection of foliage for feeding by *P.entellus* is determined by leaf chemistry, more specifically that: % time spent feeding is positively correlated with *CP* and *CP/ADF*, and negatively with *ADF* and tannins. One accessory question was asked - Is selection ratio related to food selection?

In this study selection ratio (SR) did not show any correlation with *CP* and *ADF*. Estimation of availability of young and mature leaves might not have been accurate in terms of actual variation in availability. Moreover, basal area might not have given a good estimate of crown size because of human disturbances like lopping in some species. SR of foliage was taken to be a linear relationship with preference. This is based on the assumption that feeding on one species should increase linearly with its availability. It is often the case, however that young and mature leaves of a species, when present, are available in sufficient quantities for the animals not to be restricted by it. In other words, availability of a food item beyond certain level would not cause an increase in feeding on it. The relationship of feeding with availability is, therefore, very likely to be an asymptotic one. If so SR would not reflect true preference. Under this circumstance %time spent feeding would be a better predictor of preference. The results presented in the last chapter are,

therefore, mostly based on the correlation between time spent feeding and leaf chemistry.

The results reveal that *CP* and *ADF* provide good predictors of food selection, but also that the best predictor might vary with season. In winter, if *Limonia acidissima* was excluded, time spent feeding was significantly correlated with *CP*, and negatively correlated with *ADF* level (Table 3.7). In spring, food selectivity did not bear any strong correlation with *CP*, but was strongly negatively correlated with *ADF*.

In many folivorous monkeys, nitrogen does not appear to be a major factor in food selection, e.g., *Presbytis johnii* (Oates et al. 1980). *Colobus badius* (Waterman and Choo 1981); *P.melalophos* and *P.rubicunda* (Davies *et al.* 1988). In some others both *CP* and *ADF* affect selection of food; *C.satanus* (McKey *et al.* 1981); in *Alouatta palliata* (Milton 1979, Glander 1981). Food selection has been shown to be influenced by *ADF* alone in P.johnii (Oates et al. 1980).

Time spent feeding showed a significant positive correlation with *CP/ADF* in spring but not in winter. In both the seasons the r_s values with *CP/ADF* were lower than the best predictors (*CP* in winter and *ADF* in spring). None of the above studies have, however, looked at seasonal variation in correlates of food selection.

A 3-dimensional plot of time spent feeding against *CP* and *ADF* shows that in both the seasons time spent feeding tended to increase with *CP* and decrease with *ADF* (Fig.4.1). Species which

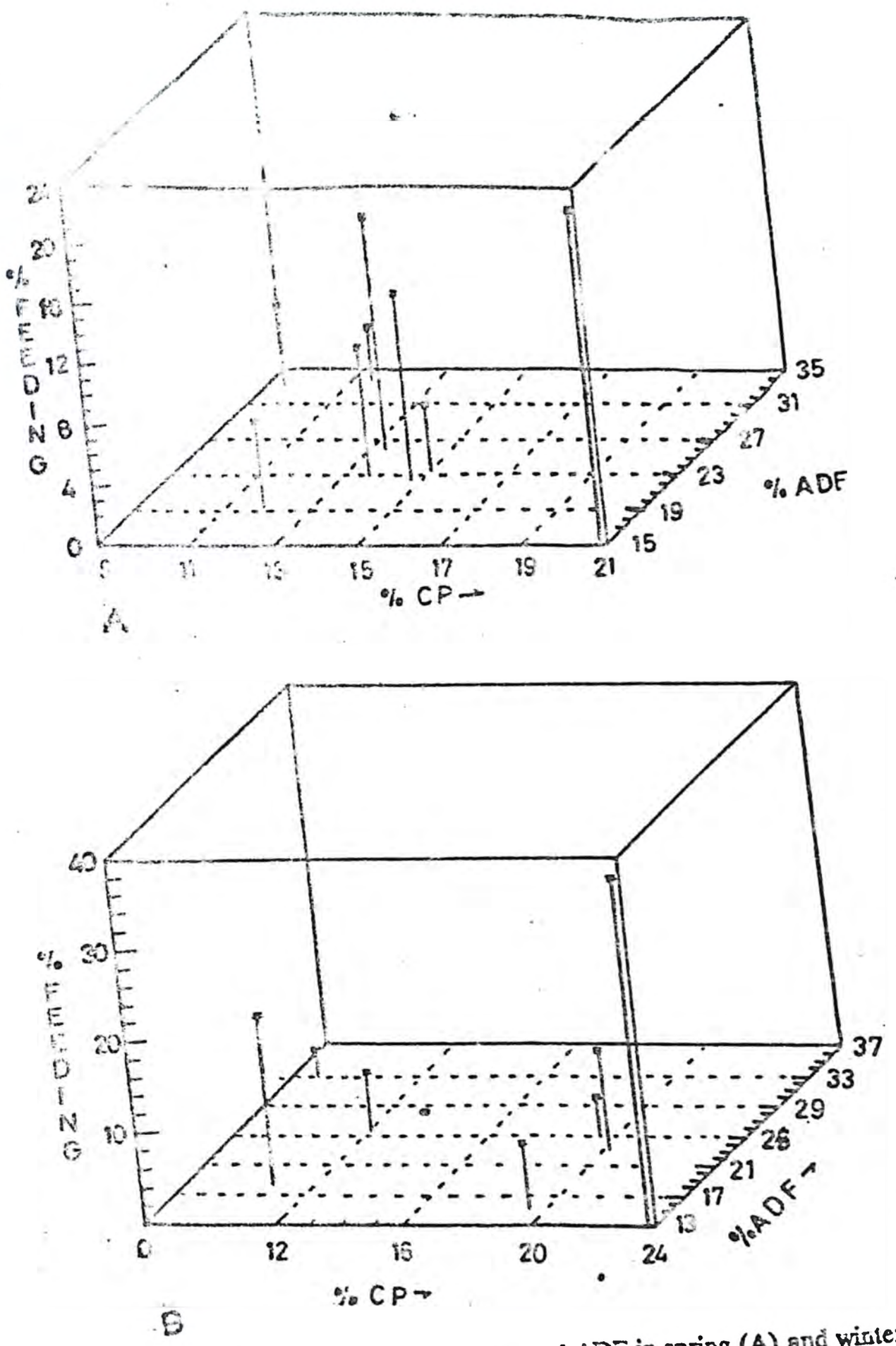


Fig.4-1 Plot of % time spent feeding with CP and ADF in spring (A) and winter (B).

contain maximum *CP* and minimum *ADF* had highest % time spent feeding (*A.catechu* in winter and *D.sissoo* in spring). Species which had the lowest *CP* and highest *ADF* were also eaten the least *E.laevis* in winter and *S.cumini* in spring). Those species that contained medium amount of *ADF* and *CP* also had medium amount of time spent feeding. However, there are exceptions in this area; *L.acidissima* in winter and *Z.mauritiana* in spring. It is very likely that in the medium range of *CP* and *ADF* other factors might influence the food selection. For instance, the ratio of *N/(ADF+CT)* show a better correlation than *CP* or *ADF* alone in case of *Colobus satanus* (McKey *et al.* 1981) and *P.johnii* and *C.badius* (Waterman and Choo 1981). However McKey et al. (1981) found the best correlation with the composite equation of *(N+10P+Ash) RDIG / (ADF+CT)* (where *N*= Nitrogen %, *P*=Phosphorus %, *RDIG*=rumen liquor digestibility %).

Another important factor might be tannin, which influences food selection. As mentioned in Chapter II, only qualitative tests of tannins could be carried out, which did not allow any statistical analysis of data. Tannin levels were higher in young leaves than in mature leaves. Some highly-fed species like *A.catechu, Z.mauritiana, C.opaca* and *A.lebbek* contained higher levels of tannin.

In *Presbytis rubicunda* and *P.melalophos* (Davies *et al.* 1988) and *P.johnii* (Oates *et al.* 1980), both condensed tannin and total phenolics do not play a significant role in food selection. There was strong negative correlation between condensed tannin and feeding in *Colobus guereza* (Oates *et al.* 1977) and *C. satanus*

(McKey *et al.* 1981). However, preference for food with relatively high tannin levels might also occur because it can improve nitrogen metabolism (Jones and Mangan 1977) or denature protein which enhances proteolysis by mammalian digestive enzymes (Mole and Waterman 1987). As suggested by Waterman (1984) and Mole and Waterman (1987), it is difficult to predict the effect of tannins, and therefore the role of tannin is perhaps over-emphasised in the food selection of primates (Waterman 1983).

Due to time and resource constraints, non-food species and those eaten in small quantities were not analysed for *CP, ADF* and tannins. It is possible that the presence of toxic compounds like alkaloids, volatile oils and resins might have prevented animals from feeding on many species which are common in the area. For example, leaves of Dipterocarps (to which *Shorea robusta* one of the major uneaten species belongs to) contain oleoresins which have an antifeedant effect on the fore-stomach microflora (Trease and Evans, 1977). Leaves of Rutaceae family contain essential oils, alkaloids, glucosides and saponins (Chopra *et al.* 1984). This may explain why *Limonia acidissima* was eaten less than expected. Tender shoots of bamboo contain high amount of toxic cyanides ander *et al.* 1989). Consumption of many species in very small ıtities might be accounted for by the requirements for onutrients like calcium, phosphorous, sodium or specific amınoacids. Oates (1978) reported that sodium deficiency in *Colobus guereza*'s staple diet leads them to feed on sodium-rich foliage of some swamp plants. Giant squirrels have been reported to

select species for calcium (Borges 1990). Lar gibbons have been reported to feed on flowers of *Xanthophyllum* species which has very high level of phenylalanine (Vellayan 1982). The lion-tailed monkey (*Macaca silenus*) also feed on flowers of *Xanthophyllum* sp. for some unknown reasons (Ajith Kumar pers. comm.).

Thus in summary major factors like *CP, ADF* and *CT* either alone or in combination have been found to account for a significant proportion of the variance in the selection of the major food species, especially of foliage, among most of the folivores including *Presbytis entellus* as reported above. Inclusion of other factors like digestibility, micronutrients and toxic secondary compounds would certainly increase the predictability of food selection, not only of the major species but also the minor ones (Milton 1979, Glander 1981). Such a detailed study was beyond the scope of this project.

CONCLUSION

The results from the present study reveal that the factors influencing food selection of *Presbytis entellus* are similar to those reported from other colobine monkeys in rain forests of southeast Asia, Africa and Central America. ADF plays a central role in food selection of major species and more so in spring than winter.

Protein level is a more important determinant of food selection in winter than in spring. Qualitative assay of tannin did not explain food selection.

Other chemical compounds such as micronutrients and toxic compounds undoubtedly influence food selection.

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APPENDIX I: Number of records in each day over 5 months.

Mon	Date	No.hrs.	Scans	Total records	Ind./ Scan
Dec	16 12 90	9.50	38	219	5.76
	17 12 90	9.75	39	241	6.18
	18 12 90	9.75	39	287	7.36
	19 12 90	10.00	40	299	7.47
	20 12 90	10.00	40	229	5.72
	21 12 90	9.25	37	310	8.38
Jan	16 01 91	9.75	39	251	6.43
	17 01 91	9.75	39	302	7.74
	18 01 91	10.00	40	206	5.15
	19 01 91	9.50	38	315	8.29
	20 01 91	8.50	34	216	6.35
	23 01 91	8.75	35	200	5.71
Feb	16 02 91	10.75	43	297	6.90
	17 02 91	11.00	44	296	6.72
	18 02 91	10.00	40	295	7.37
	19 02 91	10.50	42	298	7.09
	20 02 91	10.50	42	257	6.12
	21 02 91	10.25	41	279	6.80
Mar	16 03 91	10.50	42	398	9.48
	17 03 91	10.50	42	385	9.16
	18 03 91	10.75	43	392	9.12
	19 03 91	10.50	42	352	8.38
	20 03 91	10.00	40	324	8.10
	21 03 91	10.50	42	341	8.20
Apr	16 04 91	11.25	45	299	6.64
	17 04 91	9.75	39	218	5.59
	19 04 91	10.50	42	226	5.38
	20 04 91	10.25	41	227	5.54
	21 04 91	9.50	38	199	5.24
	22 04 91	8.50	34	199	5.85

PENDIX II. Number of food items and time spent feeding in five months and two seasons.

	Species	Prt.	MONTH Dec.	Jan.	Feb.	Mar.	Apr.	SEASON WIN.	SPR.
1.	*A.catechu*	ML	3.17	1.05	17.05	8.83		7.63	5.29
		SE	45.24	4.40	4.73	0.37		19.10	0.22
2	*Z.mauritiana*	ML	5.51	11.28	1.21	0.37		5.56	0.22
		UF	2.48	0.17				0.93	
3	*T.belerica*	LP	0.55	5.29	1.89			2.36	
		UF	8.82	10.40	0.13			6.10	
		PI	3.72	7.23	4.46	0.37		4.97	0.22
4	*B.ceiba*	ML	0.55	0.17				0.25	
		LP	0.82					0.29	
		FB	1.51	11.28	3.11			4.82	
		FL			10.06			3.40	
5	*W.tomentosa*	ML	0.82	5.29	3.52			3.05	
		UF	0.96	6.70	0.13			2.26	
6	*P.latifolia*	ML	3.44	11.11				4.33	
7	*A.marmelos*	ML	1.24		0.67			0.69	
8	*H.antidysentrica*	UF	0.55	0.52	5.95	3.48		2.51	2.09
		BA	0.13					0.05	
		YL					1.11		0.45
9	*G.arborea*	ML	5.93					2.12	
0	*D.fulcata*	ML	0.55	1.76	0.13	0.87		0.74	0.52
		FL	2.48	1.58	0.54			1.52	
1.	*E.laevis*	ML	1.93	1.05	0.67			1.23	
		YL			1.48	12.43	2.04	0.54	8.27
		FB			1.89		0.74	0.25	
2	*N.arbotristis*	ML			0.13			0.05	
		UF	0.41		1.89			0.83	
3	*F.indica*	ML	1.93	3.17				1.57	
		YL				6.71	1.85		4.76
		FB			2.30			0.84	
		BA			0.87			0.29	
		UF					3.90		1.56
		FL				1.11			
4	*S.robusta*	LP	0.13	1.05	0.54			0.54	
		FB			1.89			0.69	
		FL				1.61	11.71		5.66

15	*D.sissoo*	ML	0.13	0.17					
		YL			0.67	20.14	41.07	0.25	28.53
		FB				0.12			0.07
		SE		0.17				0.05	
16	*C.myxa*	ML	0.68					0.25	
		YL					0.18		0.07
17	*Z.oenoplia*	ML		0.88	2.02	0.37		0.99	0.23
		UF	0.27		0.27			0.19	
18	*Cuscuta*		4.00	3.52				2.41	
19	*L.acedatum*	ML		2.11	2.70	0.24		1.57	0.15
20	*P.emblica*	ML			0.13			0.05	
		YL					0.37		0.15
		UF		2.64	0.81	0.37		1.03	0.22
21	*Ficus* sp.	ML				0.24			0.15
		YL							
		UF		1.58				0.44	
22	*A.odoratissima*	ML		0.52		0.87		0.14	0.52
		YL					0.37		0.15
		RF					1.11		0.45
23	*B.monosperma*	YL					0.55		0.22
		FB		2.29	2.84	2.36		1.67	1.41
24	*G.pinnata*	ML		0.52				0.14	
		YL							
		LP		0.35				0.10	
		FL					1.30		0.52
25	*V.heynei*	ML		0.17		0.24		0.05	0.15
26	*A.cordifolia*	ML		0.17				0.05	
27	*Mellitia* sp.	L		0.52		0.12	0.18	0.14	0.15
		PI					0.18		0.07
28	Unknown	ML		0.17		0.74		0.05	0.45
		YL				0.24			0.15
		UF					0.74		0.30
29	*S.villosa*	FB			0.94			0.34	
		FL			1.48		0.18	0.54	0.07
		UF					3.90		1.56
30	*O.ougenensis*	ML			1.62	0.12		0.59	0.07
		FL			0.40	0.37		0.14	0.22
31	*C.opaca*	ML			4.05			1.47	
		YL			3.6[illegible]	20.52	3.90	1.32	13.85
		FL							

Z.xylopyra	ML	2.70	0.62		0.98	0.37
	UF	0.27			0.10	
B.vahlii	FB	0.40	0.49	0.18	0.14	0.37
	UF	0.13			0.05	
	BA			0.18		0.07
	PITH			0.18		0.07
G.targita	ML	0.27			0.10	
	FL	0.54			0.19	
	SE	1.35			0.49	
	BA	0.54			0.19	
A.latifolia	ML	1.35	4.72	0.18	0.49	2.90
	UF	0.27			0.10	0.30
	BA		0.37	0.18		
K.calycina	SE	0.27			0.10	
Bauhinia sp.1	ML	0.13			0.05	
	UF					
	BA			0.18		0.07
Bauhinia sp.2	RF					0.60
	SE		0.99			
B.malabarica	YL			0.37		0.15
F.bengalensis	ML	0.13			0.05	
E.suberosa	FB		0.24			0.15
S.sovellens	ML		0.12			0.07
B.retusa	ML		0.12			0.07
L.chinensis	ML		0.12			0.07
M.phillipinensis	ML		0.12			0.07
	RF			3.34		1.34
W.fruticosa	ML		0.74			0.45
	FL		3.60	0.37		2.30
S.cumini	YL		2.86	0.55		1.93
A.lebbek	YL			7.99		3.20
T.cilliata	UF			0.18		0.07
G.elastica	ML			0.18		0.07
Ficus sp.	YL			5.94		2.38
F.semic udata	YL			1.11		0.45