

UTILISATION OF MAJOR FODDER TREE SPECIES
WITH RESPECT TO THE FOOD HABITS OF DOMESTIC
BUFFALOES IN RAJAJI NATIONAL PARK, INDIA.

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CERTIFICATE

This is to certify that Mr Advait Edgaonkar of the Wildlife Institute of India has carried out an original piece of research work entitled " Utilisation of major fodder tree species with respect to the food habits of domestic buffaloes in Rajaji National Park, India." in partial fulfilment of MSc (Wildlife Science) degree of Saurashtra University. This work was carried out under my supervision at the Wildlife Institute of India from November 1994 to July 1995 and has not been submitted for any other degree of any university.

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CONTENTS

SUMMARY

ACKNOWLEDGEMENTS

1: Introduction	1
2: Study area	6
2.1 General	6
2.2 Climate	7
2.3 Fauna	7
2.4 Vegetation	7
2.5 The Gujjars	9
3: Methods	11
3.1 Selection of Gujjar families	11
3.2 Estimating utilisation of fodder tree species	11
3.3 Estimating availability of fodder tree species	11
3.4 Estimation of intensity of lopping and elephant damage	12
3.5 Feeding trials to estimate preference by buffaloes	12
3.6 Assessing the regeneration of fodder tree species and the presence of weeds	13
3.7 Chemical analysis and secondary data for nutritive values of fodder trees	13
4 Analysis of data	14
4.1 Construction of a Preference index	14
4.2 Lopping ratio	15
4.3 Correlation of nutritive values, Preference index and lopping ratio	16
4.4 Preference significance for feeding trials	16
4.5 Differences in the intensity of lopping and elephant damage	16
4.6 Similarity between buffalo and elephant diets	16
4.7 Differences in regeneration and weed cover	17
5: Results	18
5.1 Utilisation of fodder tree species	18
5.2 Availability of fodder tree species	18
5.3 Preference index for fodder tree species	21
5.4 Correlations between nutritive values and utilisation	21
5.5 Feeding trials	21
5.6 Lopping and elephant damage in the three blocks	21
5.7 Similarity between buffalo and elephant diets	22
5.8 Regeneration of tree species	22
5.9 Presence of weeds in the study area	22
6: Discussion	32
6.1 Utilisation of fodder trees	32
6.2 Availability of fodder resources	32
6.3 Estimation of preference	33
6.4 Correlation with nutritive parameters	34
6.5 Regeneration of seedlings	35
6.6 Presence of weeds	37
6.7 Conclusion	37

List of tables

Table 1: Densities of commonly occurring species in the study area	8
Table 2: Lopping ratio for major tree fodder species	24
Table 3: Availability of major tree fodder species in the two seasons	25
Table 4: Preference index with confidence intervals for winter and spring	26
Table 5: Nutritive values for major lopped species	27
Table 6: Matrix of Correlation coefficients for nutritive values	28
Table 7: Confidence intervals for feeding trials	29
Table 8: Estimating densities of elephant damage	30
Table 9: Species utilised on random transects	31
Table 10: Species lopped in the study area	38

List of Figures

Fig 1: Probable impacts of Gujjars on Rajaji	3
Fig 2: Map of the study area	10
Fig 3: Availability and utilisation in different gbh classes of major fodder species	19 & 20
Fig 4: Regeneration of fodder and nonfodder species in the study area	23
Fig 5: Factors affecting regeneration of fodder trees in the study area	36

SUMMARY

The fodder tree utilisation patterns of the domestic buffaloes of the Gujjars, a transhumant pastoralist community in Rajaji National Park were studied from November 1994 to April 1995. The study was conducted in three forest blocks in Dholkhand range with different levels of lopping. Thirty three tree species were used as fodder, of which 11 were important. *Millettia extensa*, *Miliusa velutina*, *Anogeissus latifolia*, and *Grewia elastica* were some of them. I calculated a preference index for these 11 major fodder trees using utilisation and availability data with a confidence interval. Ten out of 11 species were neither significantly preferred nor avoided in winter, *Shorea robusta* being significantly less preferred. In spring, *Millettia extensa* was less preferred out of the five utilised; the others were neither preferred nor avoided. A feeding trial was conducted for seven species in which *Stereospermum suaveolens* was significantly preferred and *Terminalia belerica* was significantly avoided. Neither utilisation nor preference correlated significantly with percentage N, Ca, Ash and Crude Fibre. Lopping of most trees was done regardless of the phenophase as long as the species had foliage. The Gujjars faced a seasonal scarcity of fodder in spring. It is argued that preferences break down in a situation of scarcity and any species edible to the buffaloes is lopped. Even a clearly less preferred species like sal is used. A comparison between occurrences of seedlings of buffalo fodder and nonfodder species between a lopped and a negligibly lopped block showed significant differences. The lopped block had more seedlings. An index of dietary similarity between domestic buffaloes and elephants gave an overlap of 39 percent.

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1. INTRODUCTION

Over-utilisation of forests by livestock is a problem faced by many protected areas, making them less suitable for wildlife. Kothari *et al.* (1989) found that 56% of the protected areas they studied were used by livestock. The Rajaji National Park is one such protected area whose resources are used by livestock and people. The presence of buffaloes inside the park and cattle grazing on the fringes has been seen as a problem of dependence on the Park's resources (Khatri 1994) and incompatible with its status as a proposed National Park.

Rajaji is a part of the Rajaji-Corbett National Park area which represents a viable conservation unit in northwestern India for the Asian elephant, *Elephas maximus* (Johnsingh *et al.* 1990). A population of about 750 elephants has been reported in this area (Singh 1989). Conservation of the Rajaji-Corbett conservation unit is essential for the long term survival of this flagship species.

The Gujjars are transhumant pastoralists. Gujjar settlements are spread across the Rajaji National Park as well as other forested areas (Khatri 1994). There could be around 2000 families (Johnsingh *et al.* 1990) in the park, though no accurate census is available. Earlier, they used to migrate to the pastures in the Himalayas in summer, where they stayed till October. Some Gujjars have now stopped migrating as they are not allowed access to the pastures by the villagers in the Himalayas. In recent years they have been forced to settle down in the forests of Rajaji, where they live in hamlets known as *deras*. As a result the pressure on the forest has increased. The lopping of trees by the Gujjars in order to feed their buffaloes is said to be harming the fragile ecosystem. Panwar and Mishra (1994) have said that fodder trees have ceased to flower and that there is a total absence of regeneration as a result of lopping to feed the buffaloes. Lopping affects the reproduction of trees and is assumed to reduce their ability to prevent erosion caused by heavy rains, especially in the geologically fragile Shivaliks. Lopping results in sap loss, attracts insect attacks and results in mortality (Khatri 1994).

Lopping of trees has been found to have an adverse impact on their growth and regeneration. The lopping of more than 75% of branches of *Acacia nilotica* trees have been found to have an adverse effect on its growth (Rawat 1993). Another study however suggested that 30% lopping would not have

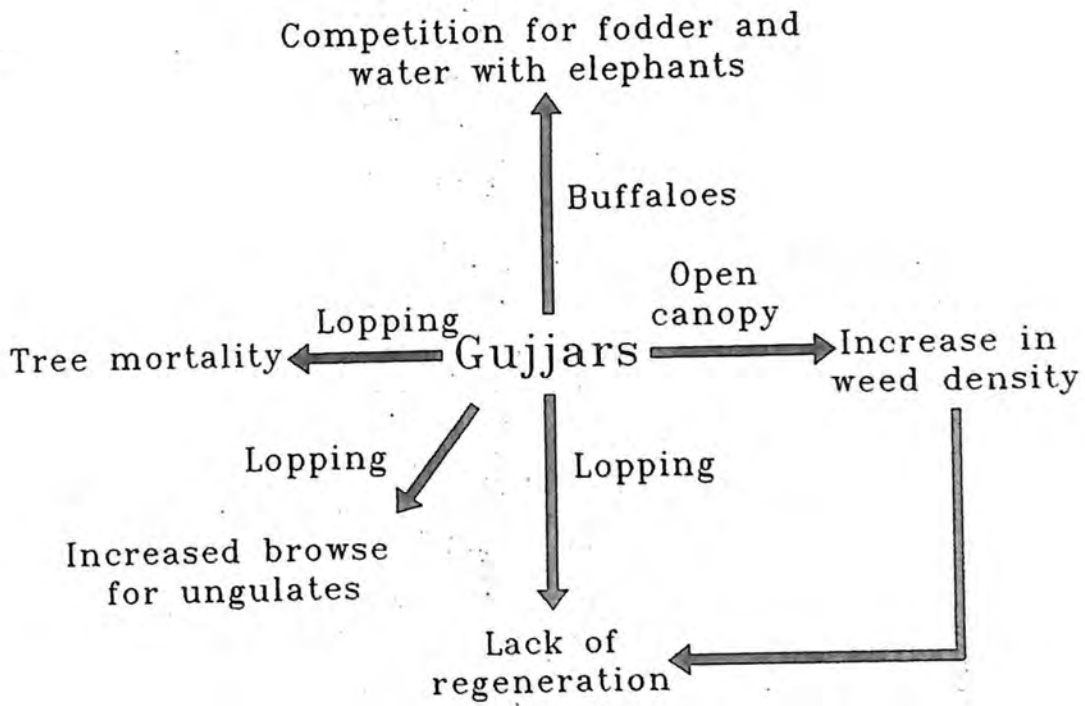
an adverse impact on the yield, canopy spread and shoot regeneration in *Albizia lebbek* (Roy 1988). Ganguli *et al.* (1964) reported that *Prosopis cineraria*, a species found in the semi-arid regions, can withstand recurrent and severe lopping without detrimental effects on its growth. Srivastava (1978) opines that complete lopping is better than two-thirds and one-third lopping in *P. cineraria*, and leaving of a few top shoots is enough. Studies indicate that *Bauhinia* spp. can be lopped twice a year without affecting the growth and subsequent fodder production (Deb Roy *et al.* 1980). They have also observed that trees carefully lopped in the winter usually recover in the next season, but recommend that it is safe to give two seasons' rest in order to recover from the lopping.

Much has been said about the damage that the Gujjars cause to the ecosystem of Rajaji (Fig. 1) and about the need to control lopping. Many Working Plans in the past have made recommendations to this effect. The working plan for the Saharanpur division (Singh 1963), for example, calculates a safe lopping capacity 'in terms of acres that will yield sufficient leaf fodder to feed a buffalo during the whole lopping season without affecting tree growth in general and hill protection in particular' for different areas in what is now part of Rajaji. Some species of trees are not allowed to be lopped at all, some forest blocks have been completely closed to lopping, and restrictions on the quantity of fodder and periodicity of lopping also exist. Most of these restrictions are ignored by the Gujjars (*pers. obs.*).

A major attempt at resettlement has been made but has not succeeded, largely because the needs of the Gujjars and their buffaloes were not considered (Poti 1995).

There is considerable debate about the relevance of the exclusionist model of National Parks to the situation prevalent in India. Increasingly it is being realised that the environment and human rights go hand in hand. Protection of one cannot be achieved while ignoring the other. The latest forest policy says that the legitimate domestic requirements of the tribals and poor people living near forests should be met as far as possible (Jha 1994). Many voices are being raised about the need to reconcile conservation interests in Rajaji with traditional rights of the Gujjars there (e.g. Singh and Kothari 1995). It is necessary to formulate a rational policy of management of lopping in the Park such that the damage

Fig 1: Probable impacts of Gujjars on the Rajaji ecosystem



to wildlife habitat is minimised and the fodder needs of the Gujjars buffaloes are met. Developing an understanding of the food habits of the buffaloes and their dependence on fodder trees over the lopping season would be a useful input to the formulation of such a policy. In the present study I attempt to provide this input.

Studies in wildlife ecology conducted in Rajaji have been on habitat preferences of ungulates, avian community structure, food selection in primates and the habitat loss faced by elephants (Bhatnagar 1991, KarGupta 1991, Rai 1991, Bhat 1993). Bhatnagar (1991), studying habitat preferences of sambar (*Cervus unicolor*), found that sambar abundances did not differ significantly in lopped and unlopped areas. Kar-Gupta (1991), while trying to identify nutritional factors responsible for the selection of food species by common langurs (*Presbytis entellus*) found percent time spent feeding on a species in winter was correlated with the Crude Protein and Acid Detergent Fibre content of that species.

Johnsingh and Joshua (1994) in a paper describing the problems facing the park, cite discrepancies between the administrative and ecological boundaries of the elephant populations, the loss of continuity in elephant habitat due to development activities along the river Ganges and increasing biotic pressures as the major problems facing the park. The Gujjars and elephants compete for fodder resources and water. They recommend strengthening the elephant corridors, rehabilitation of the Gujjars outside the park while ensuring that they get a fair deal, and reducing biotic pressures from outside as measures to alleviate these problems.

Sociological studies on the Gujjars have also been done (e.g. Gooch 1991) which describe their pastoralist way of life, the pressures faced in terms of resource degradation, the increasing population adapting to the fast degrading system. The exploitation that the Gujjars face at the hands of unscrupulous outsiders is also discussed.

A detailed assessment of the type and intensity of the dependency of the nearby communities on the resources of the Park in different areas and the distribution of grazing and firewood collecting pressure was undertaken and it was found that all except 5 of the 37 blocks of the western part of the park were subject to grazing by Gujjar buffaloes (Berkmüller et al. 1987).

The effects of overgrazing in India have been studied by numerous workers over the years (Kumar and Joshi 1972, Ahuja 1975, Tiwari 1983). Loss of diversity of the herb and shrub layer was found to be correlated with intensity of grazing (Saxena and Singh 1980) and human disturbance (Babu *et al.* 1984). It has been seen that grazing in the forests leads to an increase in the number of weeds and unpalatable species (Dabadghao and Shankararayan 1977).

Quantified information on the lifestyle of the Gujjars is not available (Johnsingh and Joshua 1994). The present study was aimed at understanding fodder tree resource use patterns of the domestic buffaloes in Rajaji National Park. Field work for the study was conducted from November 1994 to April 1995, a period of six months.

Objectives

In this study I attempt to address the following objectives:

1. To identify major fodder tree species lopped by the Gujjars to feed their buffaloes.
2. To estimate relative preferences for these fodder tree species lopped over the lopping season.
3. To investigate whether the estimated differences in preference are due to differences in the nutritive values of the species.
4. To compare the extent of regeneration for the major fodder tree species and weed proliferation in two areas of high and low lopping intensities .
5. To estimate the extent of overlap between fodder species lopped for buffaloes and food species of elephants.

2. STUDY AREA

2.1. General

The Rajaji National Park (Fig. 2) covers an area of 824 sq km in the Dehradun, Hardwar, and Pauri Garhwal districts of Uttar Pradesh. The sanctuaries of Rajaji, Motichur, and Chilla along with some reserve forest areas are included in the area of the proposed park. It is a wildlife habitat of conservation significance in the fragile Shivalik ecosystem because of its location at the meeting point of the Himalayan foothills and the beginning of the Indo-Gangetic plain. It contains the flora and fauna of both these biogeographic regions (Rodgers and Panwar 1988). The study was undertaken in Dholkhand range (78°E and 30°N) in the southwestern part of the park. Dholkhand range supports some of the highest densities of ungulates in Rajaji National Park. It is also utilised by some Gujjar families for their fodder requirements. Parts of Dholkhand have been closed to lopping by the park management. Comparisons between lopped and unlopped areas in close proximity and with similar vegetation composition could thus be made. Three forest blocks were selected in Dholkhand range. Selection of these blocks was governed by considerations of logistics. It was necessary to get back to base camp by nightfall because of the presence of elephants. One site each in Ganjarban forest block (1172 ha), Lakkarkot forest block (1507 ha) and the Shikaribada area of Dholkhand forest block (1479 ha), henceforth called Shikaribada block, all of Dholkhand forest range (15466 ha) in the southwestern part of the park were chosen for the present study. The sites in Ganjarban and Lakkarkot were those areas which were lopped by the Gujjars being studied, called *khols*. Ganjarban was lopped heavily and mainly in winter while Lakkarkot was lopped moderately and only in spring. The site in Shikaribada was chosen because lopping was legally not allowed there, and in practice was negligible. The vegetation of the site was similar to that of Lakkarkot, the two sites being separated by a narrow metalled road, and it was used as a control area.

2.2. Climate

The area has a continental monsoon climate. There are three distinct seasons, according to Rodgers (1990): the monsoon or rainy season (July to September), the post monsoon winter (November to February) and the summer (April to June). October and March are transitional months. However, for the purpose of describing changes in patterns of logging I felt that it would be more meaningful to divide the study period into winter (November to February) and spring (March and April).

2.3. Fauna

The Rajaji-Corbett conservation unit is home to the largest population of elephants (*Elephas maximus*) in the north-western part of India. Species found in Rajaji include the tiger (*Panthera tigris*), leopard (*Panthera pardus*), Himalayan yellow throated marten (*Martes flavigula*), goral (*Nemorhaedus goral*), sambar (*Cervus unicolor*), chital (*Cervus axis*), and barking deer (*Muntiacus muntjac*). Three hundred and twelve species of birds have been reported for the park (Pandey *et al.* 1994).

2.4. Vegetation

Champion and Seth (1968) have classified the forests of the area as Moist Deciduous Sal forest of type 3C/C2. The vegetation that characterised my study site (Table 1) was as follows (all species names follow Kanjilal (1979)):

Ganjarban: The area used by the Gujjars in Ganjarban comprises mostly of mixed plantations of *Albizia procera*, *Ailanthus excelsa*, *Acacia catechu*, *Anogeissus latifolia*, *Bridelia retusa*, *Dalbergia sissoo*, *Kydia calycina*, *Stereospermum suaveolens*, *Milium velutina* and *Zizyphus xylopyrus*. The original Sal forests of type 3C/C2b(i) are also found. The understorey in both the Sal and the mixed plantations comprised of naturally regenerated *Mallotus philippensis*, *Ehretia laevis*, *Cassia fistula*, *Holarrhena antidysenterica* and *Zizyphus mauritania*. Some plantations of pure *Tectona grandis* exist. Climbers were represented by *Millettia extensa* and *Zizyphus oenoplia*. *Terminalia tomentosa*, *Adina cordifolia*, *Ficus*

spp, *Bombax ceiba* are met with in rather low densities. *Adhatoda vasica* and *Lantana camera*, two species considered as weeds, are found here. The former is especially abundant.

Table 1. Estimated densities per hectare of commonly occurring species in the study area (from random transects)

Species	Block 1	SE	Block 2	SE	Block 3	SE
<i>Milletia extensa</i>	3.10	0.61	4.40	1.05	1.22	0.47
<i>Shorea robusta</i>	3.30	1.67	44.10	3.09	42.56	3.53
<i>Stereospermum sauveolens</i>	3.20	0.63	0.50	0.21	0.22	0.21
<i>Anogeissus latifolia</i>	0.30	0.20	0.00	0.00	0.56	0.36
<i>Acacia catechu</i>	5.40	2.40	0.00	0.00	0.00	0.00
<i>Miliusa velutina</i>	10.00	1.39	2.70	0.75	1.00	0.54
<i>Grewia elastica</i>	1.00	0.55	0.00	0.00	0.00	0.00
<i>Litsea glutinosa</i>	0.70	0.25	0.00	0.00	0.67	0.52
<i>Kydia calycina</i>	2.30	0.60	0.00	0.00	0.00	0.00
<i>Bauhinia racemosa</i>	0.40	0.38	0.00	0.00	0.00	0.00
<i>Zizyphus xylopyrus</i>	1.20	0.63	0.30	0.20	0.33	0.22
<i>Tectona grandis</i>	37.90	7.42	0.60	0.25	0.00	0.00
<i>Mallotus philipensis</i>	39.10	5.74	11.70	3.58	69.56	12.97
<i>Lagerstroemia parviflora</i>	8.70	2.06	65.90	8.57	1.67	0.35
<i>Cassia fistula</i>	10.70	1.77	33.80	2.51	12.56	1.86
<i>Ehretia laevis</i>	60.70	11.20	8.50	4.89	61.22	11.95
<i>Holarrhena antidysenterica</i>	42.50	5.70	2.70	1.21	10.44	2.98

Block1 : Ganjarban; Block2 : Lakkarkot; Block3 : Shikaribada
SE : Standard error

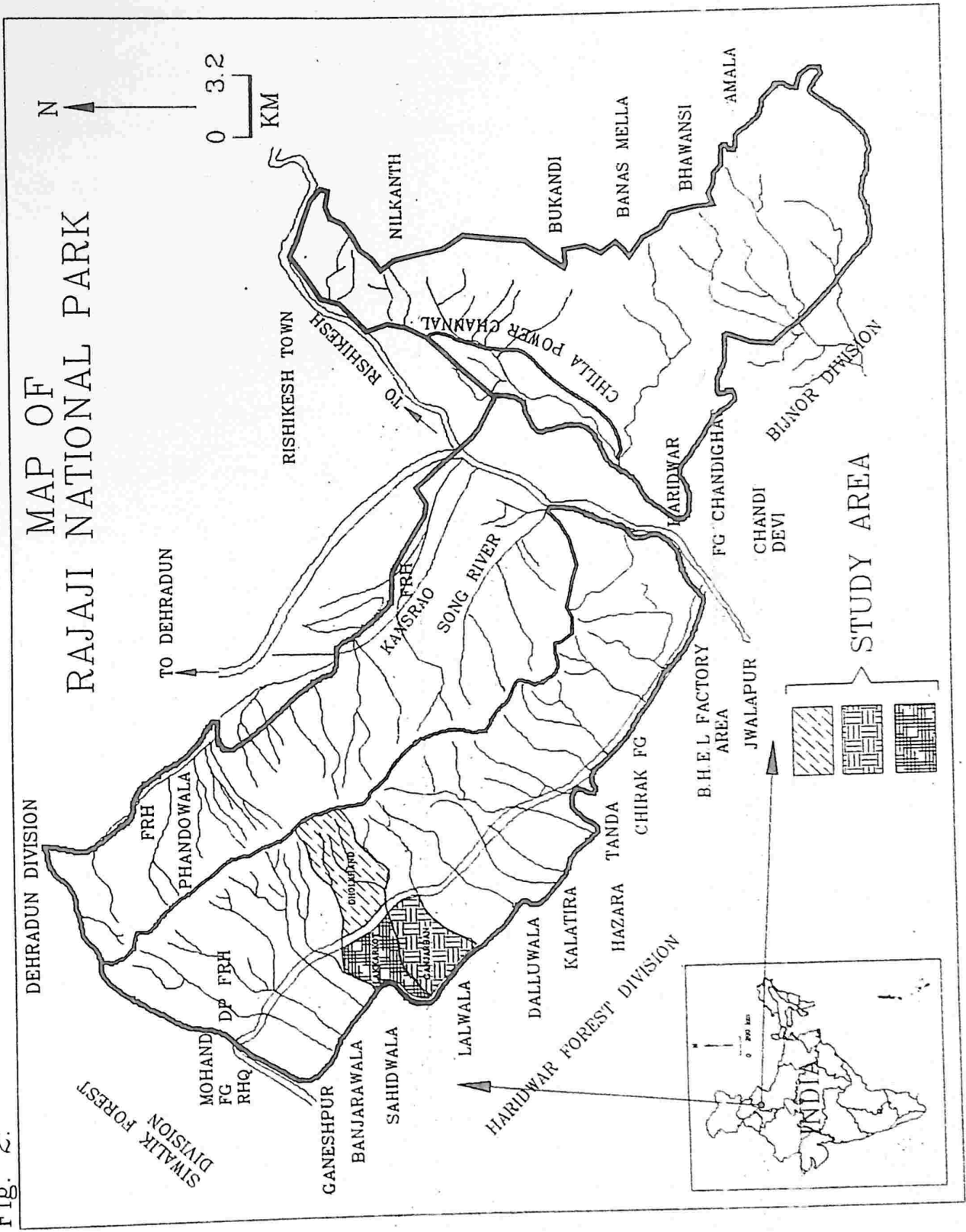
Lakkarkot and Shikaribada: The forest in Lakkarkot and Shikaribada was dominated by *Shorea robusta*. The understorey was of *Mallotus philipensis*, *Ehretia laevis*, *Cassia fistula*, *Holarrhena antidysenterica* and *Lagerstroemia parviflora*. The climber *Milletia extensa* was present. A few

individuals of *Adina cordifolia*, *Stereospermum suaveolens* and *Ougeinia ougeinensis* were scattered in the Sal forest. *Terminalia tomentosa* was seen along the banks of the dry bouldery river beds called *raus*, characteristic of the *bhabar* regions. The hilly regions of Shikaribada had forests of *Buchanania lanzan*, *Anogeissus latifolia*, *Ougeinia ougeinensis*, *Pinus roxburghii*, and scattered individuals of *Bauhinia vaahli*.

2.5. The Gujjars

The Gujjars live in *deras*, small hamlets with houses of mud and grass. The buffaloes are kept in an enclosure near the houses. Each Gujjar family has been allotted an area of forest, a *khol*, by the Forest Department to lop in. Lopping is usually done twice a day by the men. The buffaloes eat the lopped fodder in the forest itself. The women lop a few trees from near the *dera* and bring back loads of leaves to feed to the calves. The main lopping season was supposed to be from October to March, after which the Gujjars traditionally migrated to the hills. With the denial of access to the summer grazing grounds, some families have become permanent residents in the Park.

Fig. 2:



3. METHODS

3.1. Selection of Gujjar families

The lopping patterns of three Gujjar families of the eight resident in Dholkhand at that time were studied in winter and all the five present in spring. Families were selected such that they lopped in similar adjacent areas which had similar vegetation types. Proximity to the base camp also played a major role in the selection of Gujjar families.

3.2. Estimating utilisation of fodder tree species

Sampling was done of randomly selected lopping sessions for each family. Ninety lopping sessions in the study period were sampled. The species of each individual tree lopped in the sampled session, its girth at breast height (gbh), at 1.3 m, and any damage already present was noted. The intensity of lopping as a percentage in 25% interval classes was also noted during the early part of the study but given up later as almost all individual trees were lopped completely. In addition, opportunistic data gathering on the lopping sessions of other families further away from base camp was done. The migration of some Gujjar families in March resulted in an inability to make continuous observations on the same families over the two seasons.

3.3. Estimating availability of fodder tree species

Thirty random transects of approximately 1 km length were laid, 10 each in Ganjarban, Lakkarkot and Shikaribada at the end of the study in April. At every 100 m length concentric circular plots of 10, 5 and 1 m radius were used for gathering data on availability of fodder trees, and on weeds and seedlings respectively. A total of 300 plots were thus laid. Species of lopped trees were counted if they were more than 15 cm in girth. This was borne out by observations of the Gujjars who did lop species even of this small girth during the month of March. Availabilities were estimated for each season using this data. I analysed availability of fodder tree resources after ascertaining exactly what the Gujjars considered to be available for their buffaloes. Species such as *Tectona grandis*, *Mallotus*

phillipensis, *Cassia fistula* and *Holarrhena antidysenterica* are abundantly present but not lopped. They are thus not included in the estimation of availability. Species were also considered unavailable after they had shed their leaves in spring. The phenology data collected from a control unlopped site could not be extrapolated to the area in which the Gujjars lopped. Moreover loppable trees were lopped regardless of phenophase, unless leaves were completely absent. I therefore assumed that a species became unavailable from the month it stopped being lopped. A species could become unavailable because it had shed its leaves. Other species were simply lopped out before the end of winter. Most species were lopped out in Ganjarban at the end of winter (notable exceptions being *Miliusa* and *Milletia*). I removed species from the dataset used to calculate availability from the month in which it stopped being lopped. The method I have used takes care of all these different kinds of 'unavailabilities'.

However, infrequently occurring species like *Bridelia retusa* and *Garuga pinnata* did not turn up in my availability sampling at all and therefore could not be analysed for preferences. This was the main disadvantage in using random transects.

3.4. Estimation of intensity of lopping and elephant damage

The vegetation transects were also used to estimate the intensity of lopping in terms of trees lopped per hectare and the elephant damage to the trees in each block. Pushed trees, either dead or alive, broken stems and branches, and debarking was taken as elephant damage.

3.5. Feeding trials to estimate preference by buffaloes

Feeding trials were conducted in which similar amounts of fodder tree leaves of 7 species viz. *Stereospermum suaveolens*, *Terminalia belerica*, *Zizyphus xylopyrus*, *Miliusa velutina*, *Milletia extensa*, *Litsea glutinosa* and *Bridelia retusa* were fed to an adult female buffalo after weighing them. Selection of species was done such after consultations with the Gujjars. All the lopped species could not be tested because due to logistical reasons. Care was taken to ensure that fodder in excess of the buffalo's requirement (as approximated by the owner) was available of each species. The buffalo was allowed

to feed *ad libitum* for twelve hours at night. This time was similar to that spent by the animal in the forest each night. The trial was replicated six times using different buffaloes each time.

3.6. Assessing the regeneration of fodder tree species and presence of weeds

The random transects laid for estimating the availability of fodder tree species were also used for assessing the extent of regeneration of seedlings in the three forest blocks. All the seedlings found in a circular plot of 1 m radius were enumerated. The extent of weed cover was estimated ocularly as a percentage in a circular plot of 5 m radius.

3.7. Chemical analysis and secondary data for nutritive values of fodder tree leaves

Crude protein content for sal flowers was estimated by the Kjeldahl method. Nutritive values were obtained from secondary data (Puri 1954) for all the other species. Puri analysed 9 to 10 samples of mature leaves collected in October-November from the forests of Asarori, Lacchiwala and Kansrao. The proximity of these areas to my study site means that I could reasonably use this data. Chemical analysis of the leaves could not be done due to paucity of time.

4. ANALYSIS OF DATA

Analysis of data was done using Foxbase, Lotus, and SPSS. χ^2 values and Bonferroni z-statistics were calculated using the program PREFER (Prasad and Nath undated). The significance level was set at 0.05.

4.1. Construction of a Preference index

The Petrides (1975) method was used in calculating a simple index of preference. The formula used in obtaining values for preference of major utilised fodder tree species is as follows:

$$P_i = \frac{\text{prop of species}_i \text{ utilised}}{\text{prop of species}_i \text{ available}}$$

The availability and utilisation of three *deras* was used to calculate mean preference for the major fodder species. All individuals of species lopped in a season were deemed available for that season. I collected phenology data in an unlopped area, but did not incorporate it into availability calculations for two reasons. One was that the Gujjars lopped in a big area and my unlopped control trees (in Dholkhand) did not accurately reflect the phenological status of the individuals that were present in Gujjar lopped areas. The other was that while in spring many species lost their leaves and were thus not available for lopping, some species were not available for what I call cultural reasons. For example *Bombax ceiba* was not lopped in spring as the leaves were considered to be 'hot' while *Butea monosperma* was unavailable because only new leaves were considered palatable for the buffaloes.

A species is said to be preferred if the preference index has a value of more than 1. Values less than one mean that the species is not preferred and a value of 1 indicates neither preference nor avoidance.

Confidence intervals were constructed on this preference using the formula suggested by Hobbs (1982). The formula used in calculation of the confidence limits was as follows:

$$SE(P_i) = \sqrt{\frac{1}{Y^2} \left[\frac{S_x^2}{n_x} + P_i^2 \frac{S_y^2}{n_y} \right]}$$

$$df = \frac{\left(\frac{S_x^2}{n_x} + (P_i)^2 \frac{S_y^2}{n_y} \right)^2}{\frac{\left(\frac{S_x^2}{n_x} \right)^2}{n_x - 1} + \frac{\left(\frac{P_i^2 S_y^2}{n_y} \right)^2}{n_y - 1}}$$

$$CI = P_i \pm t_{(df, \frac{\alpha}{2})} SE(P_i)$$

where:

x = mean percentage of the species_{*i*} across observed diets

y = mean percentage of frequency of the species_{*i*} in replicate study plots

S_x = standard deviation of percentages used to calculate x

S_y = standard deviation of percentages used to calculate y

n_x = number of independent replicates of diet compositions

n_y = number of study plots

If the confidence interval does not overlap 1, then the species can be said to be significantly preferred or avoided.

4.2. Lopping ratio

The Lopping ratio is a proportional measure of the utilisation of a species when compared with that of all the fodder species combined. It was calculated for each month in the duration of the study as also for the two seasons. Values were calculated using pooled data from all the *deras*.

$$\text{Lopping ratio of species}_i = \frac{\text{frequency utilisation of species}_i}{\sum \text{frequency utilisation of all speci}}$$

4.3. Correlation of nutritive values, preference index and lopping ratio

The preference index of major fodder species as well as their lopping ratio, were correlated with their nitrogen content, crude fibre, calcium, and ash content to see whether preferences and utilisation were explained by chemical composition.

4.4. Preference significance for feeding trials

Analysis of the feeding trials was done using by the computer package 'Prefer'. The method suggested by Neu *et al.* (1974) is used in this. A χ^2 test was done on differences in amounts of fodder eaten and confidence intervals using the Bonferroni z- statistic were constructed.

4.5. Differences in the intensity of lopping and elephant damage

Lopping intensity was defined as number of trees lopped per hectare and a Kruskal-Wallis one way ANOVA test was done to see whether the lopping intensities of the three blocks differed. A similar test was done for differences in elephant damage densities.

4.6. Similarity between buffalo and elephant diets

The similarity in diet between the domestic buffaloes and elephants was estimated using a Sørensen's index of similarity, S_s . (Kent and Coker 1992)

The formula used to calculate this was as follows:

$$S_s = \frac{2a}{2a+b+c}$$

where

a = number of species common to both elephant and buffalo diets

b = number of species eaten by buffalo

c = number of species eaten by elephant

This gives a measure of the extent of diet overlap between the two animals. A coefficient of 0 indicates absolute dissimilarity and 1 indicates absolute similarity.

4.7. Differences in regeneration and weed cover

I considered only the occurrence of a seedling species in a circular plot of 1 m radius for analysis. A χ^2 contingency table was constructed to analyse differences in regenerating species between the two blocks, Lakkarkot and Shikaribada. Fodder species were pooled together as were nonfodder species because of low sample size. Differences in weed cover could not be analysed because of low occurrences.

5. RESULTS

5.1. Utilisation of Fodder tree species

Eleven species of trees were designated important fodder tree species on largely subjective criteria. An important fodder tree is that which makes up at least 2 percent of all species lopped in any season. The important species are listed in **Table 2** along with the proportion in which they were used in each season. It can be seen that in winter *M. velutina* was the most lopped species, comprising 29 percent of the sample for that season. *S. robusta* is almost never used in winter, a mere 0.4 percent of the number of total individuals lopped. In spring on the other hand, *S. robusta* is the single largest contributor to the fodder needs of the buffaloes. Seventy two percent of all individuals lopped in spring were sal. Only four other species were used, *M. velutina* being the important one among these. The percentage of utilisation from all major fodder trees enumerated at the end of the study period (not to be confused with availability) is given in **Table 9**. At the end of the season 47 % of the individuals of all the major species combined were found lopped.

5.2. Availability of fodder tree species

Table 3 shows the proportional availability of each species of fodder tree in each season. In winter *M. velutina* was abundantly available as was the climber *M. extensa*. Sal was proportionally most available in both the seasons, 52% in winter and 82% in spring. Availability of other species was very low compared to this, with *Milletia* at 7%. The availability and utilisation of 8 species in different gbh classes is given in **Fig.3**. For *Zizyphus*, *Acacia* and *Miliusa*, utilisation was proportionally less than availability in the lowest gbh class.

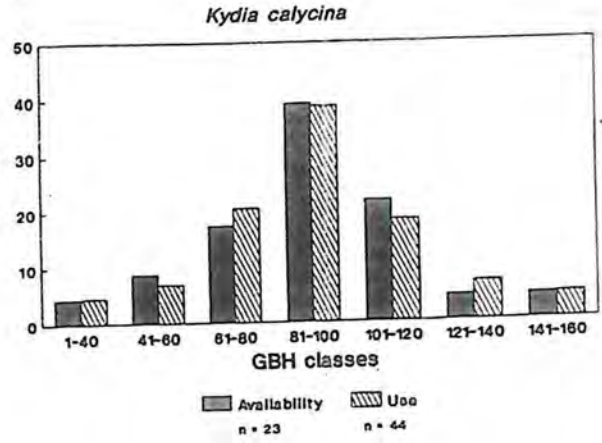
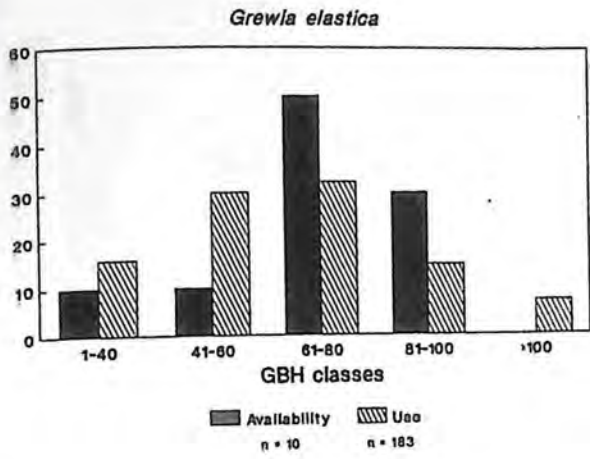
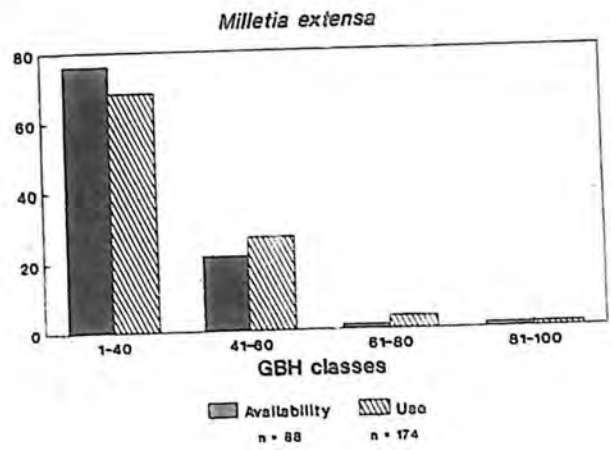
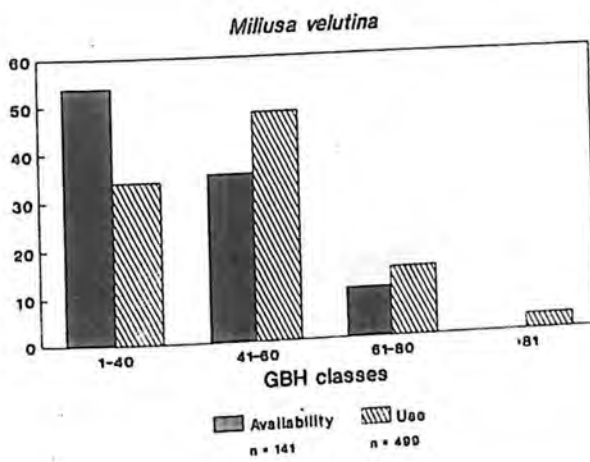
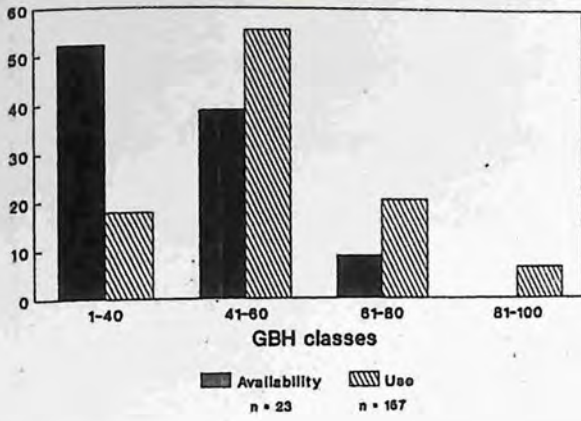


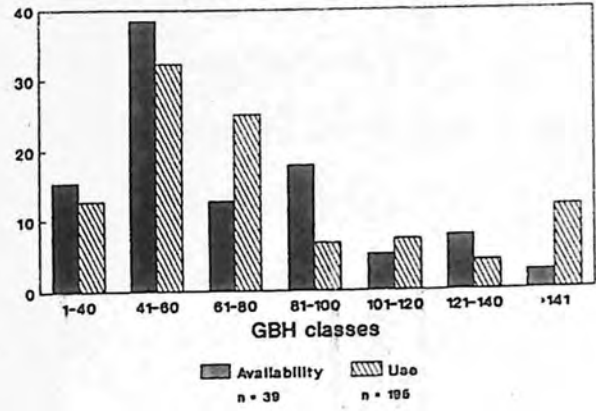
Fig. 3



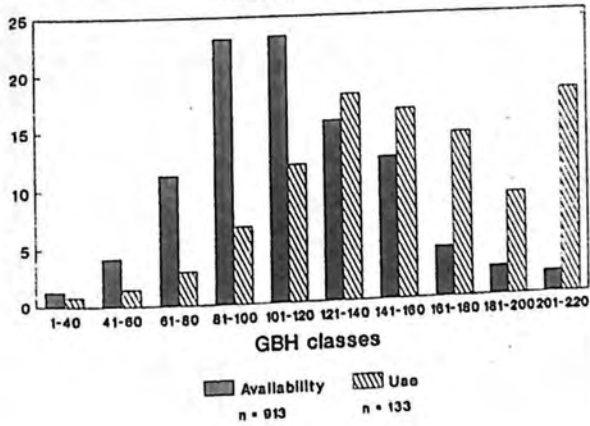
Zizyphus xylopyrus



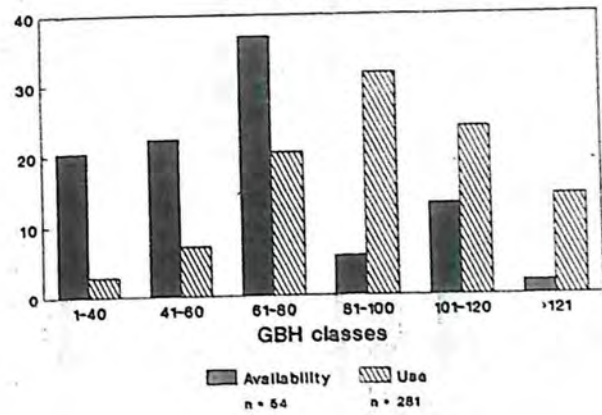
Stereospermum suaveolens



Shorea robusta



Acacia catechu



5.3. Preference Index for fodder tree species

The preference index values for the fodder tree species in the two seasons are given in Table 4. The calculation of confidence intervals, at 95% confidence on these results shows that most species are not significantly preferred or less preferred. That is, the confidence index overlaps 1. *M. extensa* is an exception in spring and *S. robusta*, sal, in winter.

5.4. Correlations between nutritive values and utilisation

The percentage nitrogen, calcium, ash and crude fibre for the important lopped species are presented in Table 5. I attempted to correlate both preference index values and the lopping ratio with the nutritive parameters of N, Ca, Ash and Crude Fibre. Significant correlations could not be obtained for any of these. Neither lopping ratio nor preference is correlated with any of these parameters, as can be seen in Table 6.

5.5. Feeding Trials

Seven species were given to buffaloes in a feeding trial. The feeding trial results were analysed using a χ^2 goodness of fit to see whether the buffaloes were choosing any species proportionally more or less than expected from its availability. Buffaloes consumed from 34 to 78 kg of green leafy fodder (mean 52.5 kg, \pm 5.8 kg) in 12 hours. It was found that *Terminalia belerica* was consumed less than expected and *Stereospermum suaveolens* consumed more than expected ($\chi^2 = 39.13$). The confidence intervals, as calculated by the Bonferroni z- statistic are given in Table 7.

5.7. Differences between intensities of lopping and between densities of elephant damage in the three blocks.

The intensity in lopping in Ganjarban was found to be 57.9, in Lakkarkot 11.8 and in Shikaribada 3.1 trees per hectare. A Kruskal-Wallis analysis of variance showed that these lopping intensities were different ($\chi^2 = 21.37$, $p < 0.001$). The intensities of elephant damage were also different in the three blocks ($\chi^2 = 20.91$, $p < 0.001$). Elephant damage intensity was found to be highest in

Ganjarban (Table 8). *Mallotus philippensis* and *Dalbergia sissoo* were the most affected with 25 and 21 damaged trees per hectare.

5.8. Similarity between buffalo and elephant diets

In the study area 22 species were seen to be used by elephants, and 34 to be used by the domestic buffaloes. 18 species were used by both. The Sørensen index calculated for the overlap between buffalo and elephant diets indicated a 39% similarity.

5.9. Regeneration of tree species

As can be seen graphically (Fig 4), 16 % of the 90 plots had occurrence of buffalo utilised fodder species and 50 % of nonfodder species in Ganjarban, the most heavily used of the three blocks (lopping intensity 57.9, SE 6.1 trees per ha). There are significant differences between regeneration of buffalo utilised trees and those not lopped in Lakkarkot and Shikaribada as shown by a 2 by 2 χ^2 contingency table ($\chi^2 = 5.18$, $df=1$). The abundance of fodder tree species seedlings (expressed as presence of seedlings per circular plot of 1 m radius) was more in Lakkarkot, a lopped area (lopping intensity 11.8, SE 2.6 trees per ha) than in Shikaribada, a negligibly lopped area (lopping intensity 3.1, SE 1.4 trees per ha).

5.10. Presence of weeds in the study area

Weeds species found in the study area were *Lantana camera*, *Adhatoda vasica*, *Cassia tora* and *Colebrookia oppositifolia*. In Ganjarban, *Adhatoda vasica*, an indigenous weed, was the most abundant with an occurrence in 27% of the plots. *Cassia tora* and *Colebrookia oppositifolia* were present in 6% of the plots. Weeds occurred in 4.4% of the plots in Lakkarkot, being mainly *Cassia tora*. Thirty one percent of the plots in Shikaribada had weedy species, mainly *Adhatoda vasica*.

Fig 4

Regeneration of Fodder and Nonfodder Species

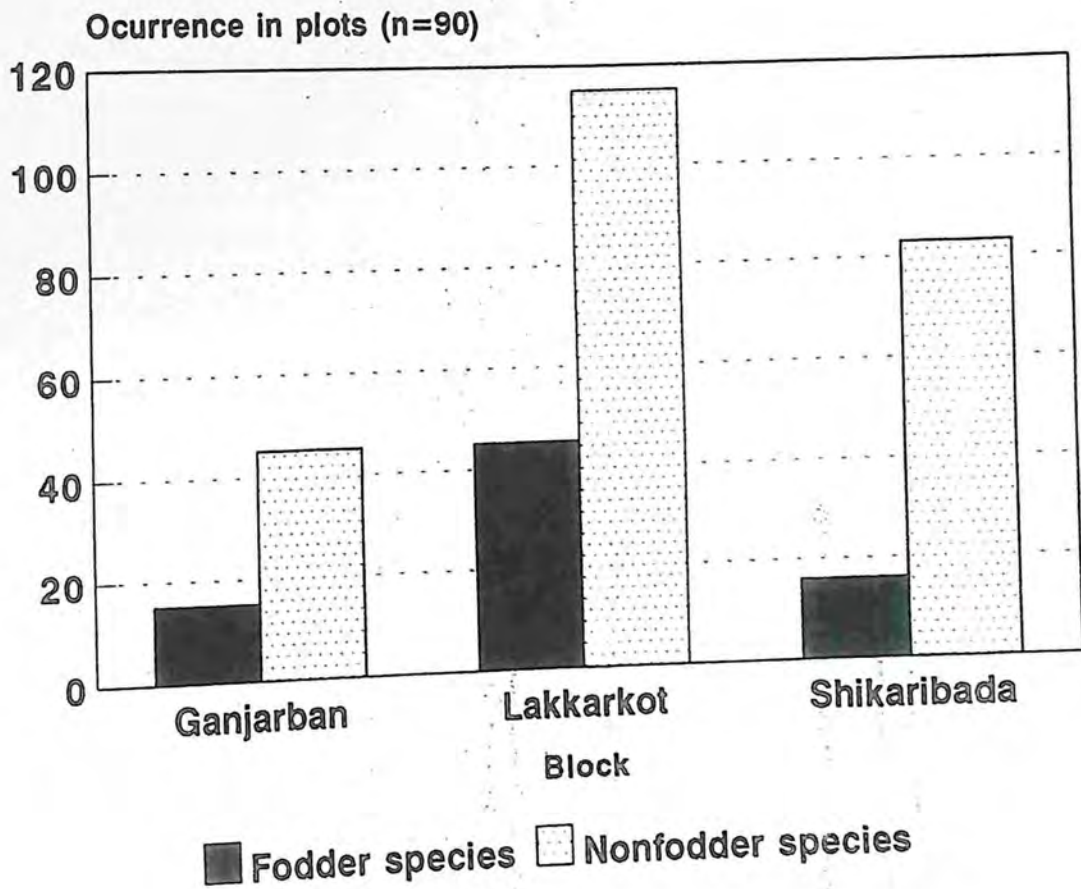


Table 2 : Lopping ratio for major fodder species in the two seasons.

Species	Winter	Spring
<i>Miliusa velutina</i>	0.29	0.11
<i>Milletia extensa</i>	0.08	0.02
<i>Stereospermum sauveolens</i>	0.18	0.10
<i>Shorea robusta</i>	0.004	0.72
<i>Zizyphus xylopyrus</i>	0.10	0.05
<i>Grewia elastica</i>	0.09	0
<i>Anogeissus latifolia</i>	0.03	0
<i>Acacia catechu</i>	0.09	0
<i>Bauhinia racemosa</i>	0.02	0
<i>Litsea glutinosa</i>	0.03	0
<i>Kydia calycina</i>	0.04	0

Table 3 Availability of fodder tree species in the study area expressed as a proportion for each season (from random transects).

Species	Winter	Spring
<i>Miliusa velutina</i>	0.15	0.05
<i>Milletia extensa</i>	0.09	0.07
<i>Anogeissus latifolia</i>	0.00	0.01
<i>Stereospermum sauveolens</i>	0.04	0.02
<i>Bauhinia racemosa</i>	0.00	0.01
<i>Litsea glutinosa</i>	0.01	0.00
<i>Shorea robusta</i>	0.59	0.82
<i>Acacia catechu</i>	0.06	0.00
<i>Kydia calycina</i>	0.03	0.00
<i>Zizyphus xylopyrus</i>	0.02	0.01
<i>Grewia elastica</i>	0.01	0.02

Table 4 Preference index with confidence intervals for winter.

Winter Species	preference	upper confidence	lower confidence
27	1.81	5.21	0
49	3.37	8.96	0
6	3.46	12.86	0
1	0.63	1.68	0
41	1.68	3.74	0
34	0.85	1.44	0
32	1.20	2.30	0
35	0.70	1.44	0
30	0.51	1.58	0
40*	0.05	0.10	0
9	2.19	7.01	0

Preference index with confidence intervals for spring

Spring species	Preference	Upper confidence	Lower confidence
34	2.18	5.32	0.0
35*	0.28	0.92	0.0
41	8.73	49.21	0.0
40	0.85	1.07	0.63
49	3.21	9.44	0.0

* significantly avoided

Table 5 Nutritive Parameters for the major lopped species, as percent of dry matter (Puri 1954).

Species	Ash%	Ca%	N%	Crude fibre%
<i>Miliusa</i>	9.62	2.81	3.88	29.7
<i>Milletia</i>	5.83	1.46	1.47	24.3
<i>Anogeissus</i>	13.48	1.67	1.81	28.8
<i>Stereospermum</i>	7.88	3.22	2.26	24.1
<i>Bauhinia</i>	5.95	2.03	4.18	22.5
<i>Litsea</i>	6.97	1.61	2.10	na
<i>Shorea</i>	10.03	3.28	1.47	12
<i>Shorea</i> flowers	na	na	1.15*	na
<i>Acacia</i>	5.60	1.15	2.42	na
<i>Kydia</i>	16.29	6.00	1.96	23.7
<i>Zizyphus</i>	6.76	2.21	2.48	18.5
<i>Grewia</i>	6.78	1.82	1.98	na

* estimated by Kjeldahl method

Table 6: Matrix of correlation coefficients for lopping ratio, preference, and nutritive values (p values are in italics).

Spring						
	Lops	P _i s	Ash	Ca	N	Cfibre
Lops		-0.29	0.7	0.59	0.07	-0.76
		<i>0.63</i>	<i>0.18</i>	<i>0.29</i>	<i>0.91</i>	<i>0.14</i>
P _i s			-0.03	0.47	0.03	0.22
			<i>0.96</i>	<i>0.42</i>	<i>0.96</i>	<i>0.72</i>
Winter						
	Lopw	P _i w	Ash	Ca	N	Cfibre
Lopw		-0.03	-0.11	0.01	0.33	0.33
		<i>0.91</i>	<i>0.74</i>	<i>0.97</i>	<i>0.32</i>	<i>0.32</i>
P _i w			-0.036	-0.32	-0.02	0.24
			<i>0.92</i>	<i>0.32</i>	<i>0.94</i>	<i>0.48</i>

Table 7 Chi-Square value and proportional utilisation of different species in the feeding trial.

Species	exp prop use	lower conf	upper conf
<i>Zizyphus xylopyrus</i>	0.132	0.046	0.229
<i>Milletia extensa</i>	0.151	0.025	0.19
<i>Miliusa velutina</i>	0.123	0.025	0.19
<i>Bridelia retusa</i>	0.151	0.053	0.241
<i>Stereospermum suaveolens</i>	0.16	0.244	0.501*
<i>Litsea glutinosa</i>	0.142	0.007	0.15
<i>Terminalia belerica</i>	0.142	0	0.107+

* preferred
+ avoided

$\chi^2 = 39.13$ $z = 2.68$

Table 8 Estimations of densities of elephant damage (nos per hectare) in the study area.

Species	Block 1	SE	Block 2	SE	Block 3	SE
<i>Dalbergia sissoo</i>	33.07	7.54	0.00	0.00	0.00	0.00
<i>Kydia calycina</i>	1.91	0.70	0.00	0.00	0.00	0.00
<i>Grewia elastica</i>	1.91	1.27	0.00	0.00	0.00	0.00
<i>Acacia catechu</i>	5.09	2.81	0.00	0.00	0.00	0.00
<i>Mallotus phillipensis</i>	33.71	9.59	3.82	3.48	25.44	6.02
<i>Ehretia laevis</i>	18.76	5.09	0.95	0.95	13.78	1.84
<i>Shorea robusta</i>	0.95	0.68	4.13	1.50	6.71	1.63

Block1- Ganjarban; Block2- Lakkarkot; Block3- Shikaribada
 SE - Standard error

Table 9: Percentage of species found to be utilised out of all present in random transects at the end of the study period

Species	Utilised	Recorded	Percent
<i>Milium</i>	49	132	37
<i>Milletia</i>	26	77	34
<i>Stereospermum</i>	28	37	76
<i>Shorea</i>	1	530	19
<i>Zizyphus</i>	4	19	21
<i>Grewia</i>	4	10	40
<i>Anogeissus</i>	3	3	100
<i>Acacia</i>	18	54	33
<i>Bauhinia</i>	4	5	80
<i>Litsea</i>	3	7	43
<i>Kydia</i>	13	23	57

6. DISCUSSION

6.1. Utilisation of fodder trees

The relative importance of fodder tree species in the diets of the buffaloes is reflected in their proportional utilisation, the lopping ratio. It was seen that *Miliusa velutina*, second in rank of availability, was the single most utilised species in winter. Its late shedding nature meant that it was used in spring as well, along with *Millettia extensa*, a late shedding climber. *Millettia* provided sustenance for the Gujjar buffaloes when very little leafy fodder was available in late February and early March. In spring most species had shed their leaves; therefore availability of fodder was low and sal was used to a very high degree. I ocularly estimated that sometimes upto 50 percent of the lopped leaf biomass from sal was discarded in March and April, the buffaloes seemed to choose to eat the flowers more than the leaves. The buffaloes did not like this species as fodder, according to the Gujjars. The buffaloes were being forced to eat less preferred food. A shift in the diet was also seen during this period. In winter the diet of the buffaloes comprises almost entirely of tree leaves. I observed tree lopping ranging from 5 trees to 98 trees in a lopping session. Free range grazing was almost absent (*pers. obs.*). In the past all the Gujjars used to start migrating to the hills in March and April, when the fodder resources were scarce. In spring the Gujjars who stay in the park adopt a strategy of a combination of lopping, stall feeding at the dera, and letting the buffaloes graze in the forest on their own (*pers. obs.*).

6.2. Availability of fodder resources

Johnson (1980) draws attention to the fact that conclusions about whether a food component is used above, in proportion to or below availability depends a lot on what the investigator thinks is available to the animal. A decision on availability is thus quite subjective when dealing with animals. If components that are used sparingly are included in the food rating, preferences for other components would be exaggerated. It was thus important to know which species were actually available to the buffaloes. Some species were traditionally not lopped in a particular season even if they were phenologically available. For instance, *Ficus benghalensis* and *Butea monosperma* were not used in

winter and *Bombax ceiba* not used in summer. Based on conversations with the Gujjars, I could find out the utilised species accurately.

A wide range of species was available in winter but by spring this had narrowed down to 8 species given in **Table 3**. These species are the ones that shed their leaves late. Most of the major utilised species in Ganjarban are lopped out (*pers. obs.*) and the Lakkarkot block, not available earlier because of richer fodder resources in Ganjarban in winter, is shifted to. Since most of the fodder species present in Lakkarkot are present in low densities (**Table 1**) the Gujjars are forced to utilise the most abundant, sal.

6.3. Estimation of Preference

Many studies estimating preference have suffered from the problem of accurate sampling for availability (Mitchell 1975). Sal was clearly less preferred in winter and *Milletia* in spring. Could I have shown a preference between other species as well with a bigger sample size than the present 3 and 5 *deras*? I speculate that since almost all fodder tree individuals in a *khol* are lopped, the existence of a preference, as shown by the index should be viewed with caution. Clear trends are visible from the preference index only when comparing across seasons. Based on the index, it can be said that *Stereospermum*, *Miliusa* and sal are more preferred in spring than in winter. *Stereospermum* (0.5 per ha) and *Miliusa* (2.7 per ha) are two species found in low densities in Lakkarkot block while *Milletia* is more commonly found. After the *khol* in Ganjarban had been lopped out by the end of winter, lopping was done in Lakkarkot. The utilisation of *Miliusa*, *Stereospermum* and *Milletia* thus increased for a while in March along with the preference of the former two. Preference for *Milletia* went down because it was proportionally more abundantly available in Lakkarkot than utilised. Sal increases in preference simply because other species are unavailable in April, when all the lopping was that of sal. The results of the feeding trial however showed that of the seven species used, *Terminalia* was used less than expected and *Stereospermum* more than expected. Conversations with the Gujjars also revealed that *Stereospermum* was relished by the buffaloes because of its taste. This indicates that preferences might operate in a situation of surplus of fodder. The preference of a species in the forest would be

relevant in cases where the animal has the opportunity and the surplus from which to choose. In the case of the Gujjars buffaloes even a clearly less preferred species like sal with a preference index value of 0.047 in winter has to be consumed because of a shortage of fodder. Preferences exhibited in the trial are probably not reflected in the forest where the Gujjars know that they will experience a scarcity by the end of the season.

6.4. Correlation with nutritive parameters

Why could a significant correlation not be observed between nutritive parameters and either lopping or preference?

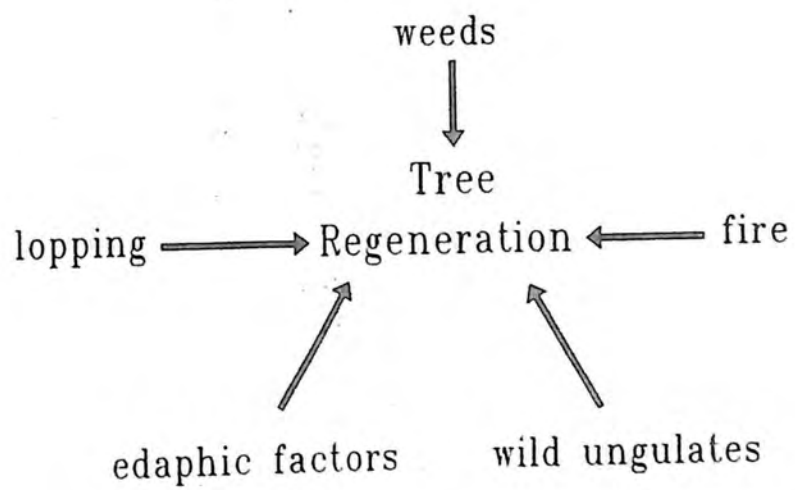
The buffalo is an animal of the humid tropics and swamps, eating grasses, sedges, aquatic plants as well as some bushes and trees (Sinclair 1977). Free ranging animals might evolve an optimal foraging strategy if they had an opportunity to do so over evolutionary time, in a system where tree browse was freely available. They may then choose their fodder taking into consideration criteria of nutritive value and availability. The buffaloes are not free ranging but get their food through the Gujjars, they have not evolved to eat tree browse and they face a shortage of fodder by the end of the lopping season. The lowest content of nitrogen among the species lopped was found in least preferred sal. Preference and utilisation was complicated by the fact that species like *Shorea robusta*, *Acacia catechu*, *Albizia procera*, *Bombax ceiba*, *Hymenodictyon excelsum* and *Adina cordifolia* found in the area are legally protected from lopping. These species are therefore less utilised than would be otherwise expected. Cultural factors may also play a role in the nonselection of a species. *Cordia dichotoma*, *Dalbergia sissoo* and *Ehretia laevis* are species which are commonly utilised by villagers in Uttar Pradesh (Singh 1982), but are not lopped by the Gujjars for feeding their buffaloes at all, even in times of scarcity. *Lagerstroemia parviflora*, considered a good fodder, was negligibly lopped by the Gujjars (0.002% lopped in winter and 0.02% in spring) inspite of being very abundantly available. The presence of digestive inhibitors and other chemical defenses above a certain threshold may also completely exclude a species from the tree lopping repertoire of the Gujjars, but this will have to be investigated.

6.5. Regeneration of seedlings

The regeneration of buffalo utilised fodder tree seedlings in the three blocks is very low. Non fodder species such as *Mallotus*, *Lagerstroemia*, *Cassia*, *Ehretia* and *Holarrhena* seedlings comprised 66.5 percent of the total regeneration. The two fodder species regenerating are *Miliusa* and *Milletia*. The former comprised 29% of all individuals lopped in winter and 11% in spring. The latter was utilised 8% and 2% respectively. The χ^2 contingency table test shows that there are significant difference between regeneration of fodder and nonfodder seedlings in the blocks of Lakkarkot and Shikaribada. There seem to be more fodder species seedlings in the moderately lopped block of Lakkarkot than the negligibly lopped block of Shikaribada. I attribute this primarily due to the presence of much higher densities of wild ungulates in Shikaribada resulting in a higher browsing pressure on seedlings. Ganjarban was not compared with the other blocks because the extensive mixed plantations in this block altered the type of the vegetation found here.

The regeneration of trees can be affected by various factors (Fig 5). Soil conditions may not be ideal, competition from weeds may exist, grazing pressure may be high and forest fires may destroy the undergrowth in summer. Ungulate densities are quite high in Dholkhand range and fires swept the study area in summer. Fires are a regular feature in Lakkarkot and Shikaribada blocks (Yasin *pers. comm.*). Gujjar lopping has also been blamed for the lack of regeneration. Considering the above factors, coupled with the fact that more seedlings were seen in the moderately lopped block, there is insufficient evidence to blame lopping for the lack of regeneration.

Fig 5: Probable causes for lack of fodder tree regeneration in the study area



6.6. Presence of weeds

Ganjarban and Shikaribada are more severely affected than Lakkarkot by weeds. Weeds have been correlated with the presence of overgrazing (Dabadghao and Shankararayan 1977). Forestry practices like clear felling were practised in Ganjarban in the past, according to the park staff. Lopping also opens the canopy and can let the more vigorous weeds outcompete plants edible to wild ungulates. More weeds are found in Shikaribada than in Lakkarkot. The high presence of weeds in Shikaribada is not accounted for unless lopping and/or forestry practises in the past are responsible.

6.7. Conclusion

I found that at least 34 species of fodder trees were used by the Gujjars to feed their buffaloes in the study area (Table 10). Most of these species were used only in winter. Sal was heavily utilised in spring when the Gujjars faced a fodder shortage. They then supplemented lopping with free range grazing and stall feeding of grass. They exhibited a lack of preference between most lopped species. Nutritional factors were not found to play an important role in species selection. Cultural factors governed the non-utilisation of at least some species. The regeneration of presently lopped fodder species was poor, and unless other species start being utilised, or fodder needs are met by grasses, fodder shortages could become more severe in the future.

Meeting the fodder requirements of the Gujjars has to be done in such a way that the wildlife values of the Park are safe guarded. The Gujjars utilise grass species, which they stall feed during the months of March and April. They have to compete with the villagers from outside the Park for this. A management system whereby they can obtain grass to meet a greater percentage of their fodder requirements would help alleviate pressure on the trees. *Bauhinia* is utilised by the Gujjars for fodder. Plantations of *Bauhinia* spp should be attempted in buffer areas on soils with good drainage, since this species is able to withstand heavy lopping (Deb Roy *et al.* 1980). The Gujjars should also be encouraged to use understorey species like *Lagerstroemia* and *Ehretia* so that the lopping pressure is distributed over a larger number of abundant species. There is also a need for studies to identify the long term

effects of lopping of varied intensities on different species of trees so that a maximum sustained fodder yield can be obtained.

Table 10: Species seen to be lopped for feeding domestic buffaloes in the study area.

Acacia catechu
Adina cordifolia
Ailanthus excelsa
Albizzia procera
Albizzia lebbek
Aegle marmelos
Anogeissus latifolia
Bauhinia malabarica
Bauhinia purpurea
Bauhinia racemosa
Bauhinia variegata
Bauhinia vahlii
Bombax ceiba
Bridelia retusa
Butea monosperma
Buchanania lanzan
Emblica officinalis

Ficus religiosa
Gardenia turgida
Garuga pinnata
Grewia elastica
Grewia oppositifolia
Kydia calycina
Litsea glutinosa
Miliusa velutina
Milletia extensa
Ougeinia ougeinensis
Randia dumetorum
Shorea robusta
Stereospermum suaveolens
Terminalia arjuna
Terminalia belerica
Terminalia tomentosa
Zizyphus xylopyrus

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* not seen in the original.