HABITAT AND FOOD OF GREATER ONE-HORNED RHINOCEROS (*RHINOCEROS UNICORNIS*): COMPARING FLORISTIC COMPOSITION OF HABITATS AND DIET SELECTION BETWEEN A DONOR AND A TRANSLOCATED POPULATION IN LOWLAND NEPAL

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KEY WORDS: Greater one-horned rhinoceros, *Rhinoceros unicornis*, habitat, diet, Nepal.

ABSTRACT

Habitat and diet of a translocated (in Royal Bardia National Park) and a donor (in Royal Chitwan National Park) population of greater one-horned rhinoceros (*Rhinoceros unicornis*) are compared. Quadrat sampling (N = 471) along transect lines was employed to describe floristic composition and availability of food plants. Seasonal diets were determined from microhistological analyses of fecal samples (N = 834). Species richness was higher in Chitwan than in Bardia (283 and 179 plant species, respectively), especially in the Tall Grassland community (131 and 79 species, respectively). Among important food plants, *Saccharum spontaneum*, *Erianthus ravennae*, and *Arundo donax* (grasses) and *Mallotus*

phillippinensis, *Calamus tenuis*, and *Dalbergia sissoo* (browse) were more abundant in Bardia, whereas *Cyanodon dactylon*, *Saccharum bengalensis*, *Narenga porphyrocoma* (grasses) and *Trewia nudiflora*, *Litsea monopetala*, *Coffea bengalensis* and *Murraya paniculata* (browse) were more abundant in Chitwan, and the latter two not being present in the Bardia habitats. In spite of lower species diversity in Bardia, the annual diet was more diverse there (57 versus 44 food plants, respectively). In both areas, the annual diet was dominated by grasses (> 60 %), particularly *Saccharum spontaneum*. In Bardia, browse was more important than grasses than in Chitwan during winter and hot seasons, probably because the staple food plant - *Saccharum spontaneum* - was less available and nutritious in Bardia due to a drier floodplain during the dry season. Conversely, during the monsoon, Chitwan animals exploited a larger proportion of browse than in Bardia because of better access to preferred *Trewia nudiflora* fruits. Among available food plants, highest selection was recorded for *Arundo donax* and *Phragmites karka* (grasses) and *Mallotus phillippinensis*, *Cqlamus tenuis* and *Dalbergia sissoo* (browse) in Bardia; in Chitwan *Saccharum spontaneum* and *S. bengalensis* were the most selectively consumed grasses and *Coffea bengalensis* and *Murraya paniculata* the most preferred browse species. Although certain species were selectively eaten in each season, animals in both areas exploited food plants in proportion to their availability, confirming that the greater one-horned rhinoceros is a generalist feeder like other species in this family of megaherbivores.

INTRODUCTION

The family Rhinocerotidae contains five monogastric, herbivorous species. The large body enables them to consume large quantities of food, hence they are commonly referred to as bulk feeders (Owen-Smith 1988). Due to slower metabolic rate, large animals require less energy and protein per unit weight and survive better on lower quality food compared to smaller ungulates (Janis 1976, Jarman 1974). Because of lower energy requirement, rhinoceros fulfill the needs of essential elements like amino acids, vitamins and minerals by favoring a high floristic diversity in the diet (Laurie 1978). However, selection of food plants and foraging pattern vary markedly among the species. The greater one-horned rhinoceros, *Rhinoceros unicornis*, is reported to be a mixed feeder, switching from a graminoid dominated diet during the wet season to increased proportion of woody browse in the dry season (Laurie 1982). Three others, *Diceros bicornis* (Goddard 1968 and 1970), *Dicerorhinus sumatransis* and *Rhinoceros sondaicus* (Owen-Smith 1988) are mainly browsers and forage upon leaves and small branches of diverse woody vegetation. The northern *(Ceratotheruim simum cottoni)* (Gyseghem 1984) and the southern (*Ceratotheruim simum simum*) (Owen-Smith 1988) species of square-lipped white rhinos, on the other hand, are strictly grazers and exploit grasses throughout the year.

The greater one-horned rhinoceros (hereafter termed rhinoceros) is adapted to floodplain and riverine vegetation where water and some green growth remain available all year round. A mosaic of various forest and tall grassland communities on the alluvial floodplain are the critical habitats for this species (Dinerstein and Price 1991). The species is now restricted to small, isolated populations on the Gangetic plains of the Indian sub-continent. At present, Kaziranga national Park, India, holds the largest population of

> 1100 individuals (Bhattacharya 1993, Vigne and Martin 1994). In Nepal, until recently, rhinoceros was confined only to the Royal Chitwan National Park in the mid-southern lowland. During mid 1960s, the population declined drastically to about 100 individuals mainly due to illegal hunting and habitat alteration (Caughley 1969). After the declaration of a national park in 1973 the population has now increased to about 375-400 individuals (Khan and Foose 1994). To safeguard this species against natural calamities and to establish a new viable breeding population, a small sub-population based on individuals translocated from Chitwan was established in the Royal Bardia National Park, about 500 km west from Chitwan (Jnawali and Wegge 1993). The purpose of this paper is to (i) compare the seasonal diets of the translocated Bardia sub-population with the donor population (ii) assess the diversity and availability of food plants in the two rhinoceros habitats, and (iii) assess the habitat quality in Bardia in terms of food by comparing with Chitwan where the population is performing well and where, presumably, food quality is adequate.

STUDY AREA

This study was conducted in two national parks, Royal Bardia (RBNP) in the western and Royal Chitwan (RCNP) in the middle part of Nepal's southern lowland (Fig. 1). In Bardia, the study area consists of a narrow strip of about 70 km^2 in the south-western corner of the park (81°20'E, 28°35'N). About 6 km^2 extends southward from the park boundary to the Indian border along the Geruwa river. In Chitwan, a study area of about 20 km^2 was selected on the northern floodplain of RCNP (84° 20' E 27° 30' N) along the Rapti river, near Sauraha. Both areas lie at about 100 m a.s.l.

The climate in both areas is subtropical, monsoonal type. More than 80% of the precipitation occurs during the monsoon. In Bardia, the monsoon starts somewhat later and the area remains drier than in Chitwan. Average maximum temperatures in both areas may reach up to 40°C during May and early June and gradually drop to about 5° C during December and January.

The vegetation in both study sites exhibits subtropical types ranging from early successional stages on the silty river beds with colonizing *Saccharum spontaneum* to a mature climax type of Sal *Shorea robusta* dominated forest on the upper, drier lands. In Bardia, the vegetation includes four main forest types: (i) Sal (ii) Riverine (iii) Khair-Sissoo and (iv) Mixed Hardwood forests, and three types of grasslands: (i) Tall Grassland (ii) Phanta (revegetated previously cultivated dry fields) and (iii) Wooded Grassland with scattered tree species, also assumed to have an anthropogenic origin. Dinerstein (1979a) has provided a detailed description of these types.

A description of the vegetation types in Chitwan where this study was conducted is available elsewhere (Laurie 1982, Lehmkuhl 1989). Lehmkuhl (1989) classified the vegetation into three forest types: (i) Sal (ii) Mixed Riverine, and (iii) Trewia-Bombax Riverine forest, and several sub-types of Tall Grasslands. For comparative purposes only three distinct vegetation types: (i) Sal forest, (ii) Riverine forest, and (iii) Tall Grassland, were classified in the present study. In Chitwan, formerly cultivated paddy fields now dominated by tall grass species (Lehmkuhl 1989) are combined with Tall Grassland community along river beds. Bushy Pastures outside the National Park boundary were mapped and added as an additional vegetation type to encompass peripheral areas frequently used by rhinoceros in both areas. Bushy Pastures in both areas are similar to the scrub vegetation type described by Laurie (1978).

The fauna in both parks is similar except some species are confined only to either of the areas. Important fauna common to both Parks include *Rhinoceros unicornis*, *Elephas maximus*, *Melursus ursinus*, *Panthera tigris*, *P. pardus*, four species of deer - *Axis axis*, *A. porcinus*, *Muntiacus muntjack*, and *Cervus unicolor*. Uncommon mammalian species include *Bos gaurus* in RCNP, and *Boselaphus tragocamelus* and *Cervus duvauceli* in RBNP. Bolton (1976) and Gurung (1983) have provided a detailed description of fauna of Bardia and Chitwan, respectively.

Of the two study sites, Chitwan harbors a centuries-old population of rhinoceros. More than 60% of the total present population occupies the area where the present study was conducted, estimated at a density of about 8-10/km^2 (Dinerstein and Price 1991). The Bardia population originates from 13 animals that were translocated from Chitwan and released during the dry season of 1986. A description of this population is given by Jnawali and Wegge (1993). From a biological point of view both populations were performing well with a mean annual rate of increment of 6.4 % in Bardia and 2.7% in Chitwan (Dinerstein and Jnawali 1993). Animal density in Bardia during the time of this study was approximately 0.3/km^2, or roughly 2% of that of Chitwan.

METHODS

Vegetation analysis

Vegetation analyses in both areas were carried out between late July and August when all plant species had already emerged. In both areas, quadrat sampling along transect lines was employed to determine the floristic composition in various habitat types. In Bardia, a

total of 20 transect lines spaced 1 km apart were laid out in an east-west direction to pass through the different vegetation types. 10m X 10m quadrats were laid out along the transect lines at a intervals of 150 meters. Altogether 280 quadrats were sampled of which 59 fell in Riverine, 51 in Sal and 60 in Khair-Sissoo forests, 51 in Tall Grassland, 17 in Wooded Grassland, 26 in Bushy Pastures, 7 in Phanta and 9 in Mixed Hardwood forest.

A similar procedure was employed in Chitwan with some modification due to the location of vegetation types. The transects were laid in a north-south direction starting from the bank of the Rapti river. The interval between transects was reduced to 500 m to obtain enough samples in Riverine forest because this vegetation type extends in a narrow strip along the Rapti and Dhungre rivers. Out of 191 quadrats sampled in Chitwan, 63 were in Riverine forest, 41 in Sal forest, 69 in Tall Grassland and 18 in Bushy Pastures.

The minimum number of quadrats needed to describe the floristic features was determined by constructing species area curves for all vegetation types. The number of quadrats needed to include 90% of the total number of species (the asymptote) was used when comparing floristic diversity in the two study areas. In each quadrat, the percent cover of each species assumed to be available for rhinoceros (< 3 m height) was estimated and recorded in classes as follows: high = > 50%, medium = 26 - 50%, low = 11 - 25%, rare = 1 - 10% and trace < 1%. These data were later used to calculate prominence values (PV) for each species (Dinerstein 1979a):

$$PV_x = M_x (\sqrt{f_x})$$

PV_x = Prominence value for species x

M_x = Mean percent cover of x species

f_x = Frequency of occurrence of x species

Simpson's Index of Diversity (Simpson 1949, as described by Krebs 1989) was applied for measuring floral diversity:

$$1 - D = 1 - \Sigma(p_i)^2$$

D = Simpson's index of diversity

pi = Proportion of individuals of species *i* in the community

Sørensen's index of similarity (IS_s) (Sørensen 1948) was employed to compare similarity of plant species in the two study areas:

$$IS_s = \frac{c}{1/2\ (A + B)} \times 100$$

c = Number of species common to both areas

A = Total number of species in habitat *A*

B = Total number of species in habitat *B*

Diet analysis

A microhistological analysis of fecal samples (Jnawali, in press) was conducted to determine the food habits of rhinoceros in each area. In Bardia, fresh fecal samples (N = 354) were collected during 18 months, from January 1990 to June 1991. Individual samples collected in each month were dried, ground and pooled. Monthly sample sizes in Bardia ranged from a minimum of 20-25 during the monsoon, to > 50 during the dry season. Food habit data from Chitwan collected during 1985 - 1986 and analyzed by the same procedure (Gyawali 1986, same as present author) were used to compare with Bardia animals. In addition, results from 30 samples collected from the same area during the monsoon 1993 were combined with the previous ones.

Analysis followed the method described by Jnawali (in ms). Five microscopic slides were prepared from each pooled fecal sample of every month. Identification of plant fragments was based on the morphological features observed by microscopic examination. Volumetric estimation of each food plant species was calculated for every month and later combined for seasons. Seasons referred to here are the same as described by Jnawali and Wegge (1993) -Winter: November - February, Hot: March - June and Monsoon: July - October.

Reference slides from various above ground parts (leaves, twigs, fruits, flowers etc.) of more than 200 plant species collected from both study sites were prepared prior to examining the fecal samples. The histological features of each plant part were also sketched to match with the fecal plant fragments.

Relative Importance Values (RIV) of each plant species observed in the fecal sample were calculated as follows:

$$RIV_x = D_x \ (\sqrt{f_x})$$

RIV_x = Relative importance value for species x

D_x = Mean percent of species x in fecal sample

f_x = Frequency of species x in fecal sample

Two indices were computed to detect selection of plants eaten:

(i) Diet selection value (DSV)

$$DSV_x = RIV_x/PV_x \times 100$$

DSV_x = Diet selection value for species x

RIV_x = Relative importance value of species x in the diet

PV_x = Prominence value of species x in the habitat

(ii) Ivlev's electivity index (IEI) (Ivlev 1961)

$$IEI_i = \frac{r_i - n_i}{r_i + n_i}$$

IEI_i = Ivlev's electivity index for species *i*

r_i = Percentage of species *i* in the diet

n_i = Percentage of species *i* in the habitat

RESULTS AND DISCUSSION

Habitat

Species richness and diversity

Among the four vegetation types common to both areas, species richness was higher in Sal forest, Riverine forest and Tall Grassland community in Chitwan (Table 1 and Fig. 2). Only in Bushy Pasture was species richness higher in Bardia.

The Tall Grassland community in Chitwan was the most (SDI > 0.986) diverse habitat type. In contrast, this community was the least diverse habitat in Bardia. Here, Riverine forest was the most diverse (SID = 0.925) type. When combining all vegetation types, Chitwan was more diverse than Bardia with indices of 0.968 and 0.918, respectively. The diversity indices of other habitat types available only in Bardia were all < 0.8.

Various factors may have contributed to higher diversity, especially in the Tall Grassland community, in Chitwan. Mild grazing is reported to have a positive effect by maintaining the grass proportion and keeping the herbaceous layer more diverse (Singh 1976). Grazing may also reduce competitive exclusion of less abundant species (Whittaker 1977). In Chitwan, the grasslands are seasonally grazed by domestic stock from the surrounding

villages (Sharma 1991). A number of non-floodplain species were also recorded where grazing was more pronounced, particularly in the grasslands around Icharni forest. Besides, rhinoceros' role in seed dispersal may also have increased the diversity in the Tall Grassland in Chitwan. Rhino latrines on Tall Grassland yielded a large number of non-floodplain species, including a most common riverine forest tree, *Trewia nudiflora* (Dinerstein and Wemmer 1988) and *Cassia tora* (Joshi 1986), a common forb species in Bushy Pastures. In Bardia, domestic stock grazing was terminated when the area was made a wildlife reserve in 1976. Only a small population of rhinos and hog deer share the floodplain, and their role in Tall Grassland dynamics is expected to have been minimal. Probably equally or more important: in Chitwan the water table is higher than in Bardia. In Chitwan, in Tall Grassland soil moisture remains 20%-30% throughout the year (Lehmkuhl, 1989). Furthermore, some water logged areas create suitable substrate for other species adopted to such marshy environments. The high moisture content also allow some of the palatable riverine flora to become interspersed in the Tall Grassland. Lastly, inclusion of old tall grass floodplain terraces may also have increased the diversity of Tall Grassland in Chitwan. In Bardia, the floodplain consists of young alluvial sandy soils established on a thick layer of boulders underneath. During the dry season the soil moisture in such sandy soil drops below 5% (Lehmkuhl 1989). As a result, apart from the monsoon season, the floodplain in Bardia remains dry, creating unsuitable substrate for herbaceous plants and seedlings of woody plant species.

Altogether 179 species in Bardia and 283 species in Chitwan were recorded in the present study (Table 1). The highest number (131 species) were recorded in Tall Grassland in Chitwan. In Bardia, highest number of species was observed in Riverine forest with 93 species, compared to 117 species in this type in Chitwan. Among the common habitat types,

Bushy Pastures contained the lowest number of species in both areas.

Among the four common vegetation types, Sal forest had highest (IS_s = 67.1%) similarity in species composition (Table 1). Lowest similarity (IS_s < 50%) was observed in Riverine forest, probably because two kinds of Riverine sub-types were combined in Chitwan. When combining all vegetation types, about 70% of the species were similar.

In Bardia, the total number of species was higher than recorded by Dinerstein (1979a). In his study, Dinerstein (1979a) sampled a smaller section of the present study area. The present study was conducted in a much larger area of the floodplain, including areas outside the park boundary to the south. In addition, exclusion of Bushy Pastures and Phanta also reduced the total range of plant species in his study. In Chitwan, the total number of species recorded by Laurie (1978) was higher than in the present study. His list of plant species was derived from samples collected in a much more larger area both inside and around the park, and also included agricultural crops, vegetation growing in cultivated fields and aquatics. Besides, inclusion of species > 3 m also contributed to a higher species number in his study.

Availability of food plants

Availability of plant species recorded to be eaten by rhinoceros in the two study areas is shown in Tables 2 and 3. *Saccharum spontaneum* was the most abundant species in Tall Grassland of both study areas (PV = 630.3 and 243.0 in Bardia and Chitwan, respectively). *Saccharum bengalensis* was more abundant (PV = 87.5) in Bardia's Tall Grass land than in Chitwan (PV = 78.8). *Narenga porphyrocoma* was abundant (PV = 141.1) in Tall Grassland in Chitwan but occurred only in a small proportion (PV = 1.6) in Bardia. *Themeda sp.* was common in Sal forest (PV = 125.7), Riverine forest (PV = 20.3) and Tall Grassland (PV = 62.0) in Chitwan. In Bardia, this species was only sparsely distributed in Wooded Grassland

(PV = 1.5) and Mixed Hardwood forest (PV = 0.6). *Cynodon dactylon* was abundant in Bushy Pastures of both study areas with prominence values of 77.3 and 217.0 in Bardia and Chitwan, respectively.

Of important browse species, *Coffea bengalensis* and *Murraya paniculata* with PV of 27.2 and 22.8, respectively, occurred only in Riverine forest in Chitwan (Table 2). *Callicarpa macrophylla* was abundant in Wooded Grassland in Bardia (PV = 264.1), and in Bushy pasture (PV = 152.4) in Chitwan. *Litsea monopetala* was more abundant (PV = 61.9) in Riverine forests in Chitwan than in any other vegetation types of both study areas. *Mallotus phillippinensis* was most abundant in Riverine and Mixed Hardwood forests in Bardia with PVs of 30.4 and 12.2, respectively, and less common in Chitwan. In contrast, *Trewia nudiflora* was abundant in Riverine forest (PV = 40.7) in Chitwan, but quite scarce in Bardia.

Among the species listed above, rhinoceros eat only the mature fruits of *Trewia nudiflora* fallen on the ground during the monsoon. Similarly, only seed bearing pods of *Cassia tora* and *Cassia occidentalis* and flowers of *Bombax ceiba* were recorded to be eaten. Hence, their PVs do not reflect their availability as food for the animals; instead they indicate the relative abundances of these species in the two study areas.

Highest proportion of wild food plants occurred in Tall Grassland and Riverine forest (Fig. 3). Animals in Chitwan foraged on a larger proportion of these species in both habitats compared to Bardia (Tall Grassland: 91.5% and 71.9% and Riverine forest: 77.2% and 71.9%, respectively). Also in Sal forest did Chitwan animals exploit a larger proportion of food plants than in Bardia (45.6% vs 33.3%, respectively).

Food habits

Annual and seasonal diet

The diet of rhinoceros consisted of a diverse species of food plants, but > 70% of the volume in the diet was contributed by less than ten species in both areas (Table 4). In Bardia, eight species (five grasses: *Saccharum spontaneum*, *Arundo donax*, *Cyanodon dactylon*, *Saccharum bengalensis* and *Erianthus ravennae*, and four browse species: *Mallotus phillippinensis*, *Dalbergia sissoo*, *Callicarpa macrophylla*, *Calamus tenuis*) composed about 75% of the diet. Similarly, in Chitwan seven species (four grasses: *Saccharum spontaneum*, *Saccharum bengalensis*, *Cyanodon dactylon* and *Narenga porphyrocoma*, and three browse species: *Coffea bengalensis*, *Murraya paniculata* and *Litsea monopetala*) contributed > 85% of the toal volume in the annual diet.

Grass species dominated in both study areas. Their proportion was higher in Chitwan (73.4%) than in Bardia (63.3%). Browse species made up about 20%, and agricultural crops > 6% of the diet in both areas. Other food plants, mainly forbs and herbs, ferns, horsetails, sedges, and equisetum constituted up to 8%, with a higher proportion in Bardia than in Chitwan.

The proportion of plant groups varied remarkably between seasons, but the pattern was not identical in the two areas (Fig. 4). Grass species constituted ca 92% of the total diet during the monsoon in Bardia and ca 86% during the hot season in Chitwan. It constituted the lowest proportion during the winter in both areas, ca 42% in Bardia and ca 57% in Chitwan, respectively. Highest proportion of browse species was recorded during winter (31%) and hot (30%) season in Bardia, and during winter (25%) and monsoon (23%) in Chitwan. Agricultural crops were most important during winter (> 13%) and lowest during the monsoon (< 5%) in both areas. 'Others' were eaten mainly during winter and constituted

a larger proportion in all three seasons in Bardia.

Compared to the present study Laurie (1978) and Jnawali (1989) reported higher proportion of agricultural crops during the monsoon. This discrepancy was probably due to large interspecific variation and small samples. Also, during this period rhinoceros prefer to remain in the floodplain feeding upon sprouting nutritional grasses rather than struggling with the farm guards. Leafy stage of rice and to lesser extent maize are the main crops available during monsoon. Rice raiding becomes prevalent when it has matured in early winter. Other crops such as wheat, mustard and lentils also become available and are eaten during winter and early part of the hot season (Jnawali 1989).

The proportion of browse was higher in Bardia (Fig. 5). Highest ratio of browse to grass was recorded during the winter season in both areas. In Bardia, the ratio declined from winter through the hot season to the monsoon, whereas in Chitwan the ratio declined from winter to hot and then increased slightly during the monsoon. The ratios differed significantly between areas in all three seasons (winter and monsoon: paired $t = 2.02$ and 1.99, respectively, $0.1 > p > 0.05$, hot: paired $t = 3.27$, $p < 0.025$).

The higher proportion of grasses in Chitwan during the winter and hot seasons was probably related to the nature of the grasslands. In Chitwan, the water table is high and substrate moisture is available for plant growth all year round. The most dominant grass species in the floodplain, *Saccharum spontaneum*, keeps sprouting soon after grass cutting and grazing (Dinerstein and Price 1991), and burning (Laurie 1978) in winter, and a new flush becomes available already early in the hot season. Hence, in Chitwan this species is exploited, although to a lesser extent, also during the dry seasons. In Bardia, the low substrate moisture retards grass species from sprouting until the first rain in the latter part of the hot season. In Bardia, scarcity of nutritious grasses is compensated for by exploiting young leaves of browse

species.

Laurie (1978) also recorded highest (22%) proportion of browse species in the diet during the winter. In his study in Chitwan, lowest (2%) proportion of browse was recorded during the monsoon. This contradicts with the present study from Chitwan, but follows the same pattern as observed in Bardia. The increased proportion of browse forage during the monsoon in Chitwan is probably due to *Trewia nudiflora* fruits becoming accessible during this season, as rhinos consume about 5 kg of *Trewia* fruits in a 24 hour cycle during this season (Dinerstein and Wemmer 1988). Due to its scarcity, *Trewia* only contributed < 1% to the diet in Bardia.

Diet selection

Rhinos foraged upon 29.6% of the total number of different wild plant species available in Bardia and about 13.1 % in Chitwan (Fig. 6). The proportion of plant species eaten in each season varied slightly, with animals in Bardia consistently eating a larger proportion of available plants than in Chitwan. In Bardia, the highest proportion (24.0%) of the plant species were exploited during the winter season, whereas in Chitwan the highest proportion occurred during the monsoon (11.0%). The higher proportion of food plants extracted in Bardia was a result of higher diet diversity combined with lower species diversity in the habitats (Table 1 and 4)

Number of different food plants recorded in Bardia was higher in all three seasons (Table 5). Rhinoceros utilized the highest number of species during winter with 47 and 33 species in Bardia and Chitwan, respectively. In both areas, more than 70% of the diet consisted of the same species, but with notable seasonal variation. The highest proportion (66.7%) of similar species was observed during the monsoon and the lowest (49.2%) during

the hot season.

Total number of different food plants in the diet of both populations (n = 64) was less than recorded by Laurie (1978) from direct field observations in Chitwan. However, his study area was much larger area, including the entire floodplains of Rapti, Reu and Narayani rivers, and was conducted over a longer time period of about four years. The high number of species in his study was also due to a variety of soft-tissue plants, including aquatics, which were not recorded in the fecal material from either of the two study areas. Similarly, a number of kitchen garden plants known to be eaten by Chitwan animals (Laurie 1978, Jnawali 1989) did not occur in the present diet analysis. Such species are either digested thoroughly or by chance did not occur in our sample. However, Laurie (1978) also recorded other species of monocots and dicots eaten by rhinoceros that did not occur in the present study. Owen-Smith (1988) estimated about 1% of forb species in the annual diet of white rhinos and reported that most of them were ingested accidentally along with the other preferred species. Laurie probably also incorporated some plant species that were ingested accidently. Furthermore, the microfecal analysis does not incorporate all species, as represented by ca 6% of unidentified material (Jnawali, in press).

A more diverse diet in winter may be attributed to scarcity of good quality food. Laurie (1978) concluded that rhinos exploit higher variety of food plants to fulfill their nutritional requirement during the dry season when most of their preferred food plants in the Tall Grassland have reached maturity and are less nutritional. The high similarity of food plants during the monsoon recorded in this study supports this: during this season rhinos mainly exploit high quality grass species common to both areas.

Seasonal variation of species in diet

Saccharum spontaneum was by far the most important food plant during all seasons in both study areas (Table 4). In Bardia this species was most important during the monsoon (RIV = 45.4), whereas in Chitwan highest RIV (43.1) was recorded during the hot season. *S. spontaneum* was least important during winter in both areas. RIV of *Saccharum bengalensis* was higher during the hot (RIV = 13.8) and winter (RIV = 14.9) seasons in Chitwan and during monsoon in Bardia (RIV = 8.7). *Narenga porphyrocoma* contributed little to the Bardia diet but was consistently recorded in Chitwan with highest RIVs (8.4) during the hot and monsoon seasons. *Arundo donax* was recorded consistently in all three seasons in Bardia diet but did not occur in the diet in Chitwan. Similarly, *Erianthus ravennae* was recorded only in Bardia with a highest RIV (ca 5) during the monsoon.

Among important browse species, *Mallotus phillippinensis* had highest RIVs during winter in both study areas, 7.9 and 2.6 in Bardia and Chitwan, respectively (Table 4). *Dalbergia sissoo* and *Calamus tenuis* were eaten only in Bardia with highest RIVs during the hot season. *Trewia nudiflora* was important during the monsoon in Chitwan (RIV = 11.2). In Bardia, this species was recorded sparsely only during the monsoon. *Coffea bengalensis, Murrya paniculata* and *Litsea monopetala* were recorded only in Chitwan with highest RIVs of 6.5, 5.8 and 5.0, respectively, during the winter season. Among common browse species in Chitwan, *Coffea bengalensis* and *Murraya paniculata* were most important. Their RIVs were significantly higher than that of *Callicarpa macrophylla* in all three seasons ($p = < 0.05$, all one tailed paired t-test). *Calamus tenuis,* a climbing palm, was recorded only in the diet in Bardia with relatively high RIVs during the hot and winter seasons.

Arundo donax, Erianthus ravennae, Calamus tenuis, and *Dalbergia sissoo* were reported to be eaten by animals in Chitwan (Laurie 1978), but were not recorded in the diet

of Chitwan rhino in the present study. *Ceffea bengalensis* and *Murraya paniculata*, two important browse species in Chitwan, were not available in Bardia. *Litsea monopetala*, another important browse species in Chitwan was only sparsely distributed in Bardia and did not occur in the diet. The high consistency of *Arundo donax* in the Bardia diet in all three seasons was probably related to its availability. This species grows on edges of riverlets where substrate moisture is adequate throughout the year, which enables it to sprout even during dry periods. The lower relative proportion of *Saccharum spontaneum* in Chitwan during the monsoon may have been due to availability of *Trewia nudiflora* fruits, but the overall decrease of browse species during the monsoon in both areas was due to availability of high quality grasses.

Oloo et al. (1994) also reported a seasonal variation in preference for various food plants among black rhinoceros *Diceros bicornis*: animals tended to feed less on each plant in the dry season than in the wet season, most likely due to decreased palatibility during the dry season. However, among black rhinoceros the diversity of food plants in the diet was higher (15%) during the wet season (Oloo 1994), contrary to what was found in the present study.

Species Selection

The diet selection values (DSV) varied between different food plants (Fig. 7). In general, highest species selection occurred in Bardia. Among grasses particularly high selection values were found for *Arundo donax* (DSV = 115.9) and *Phragmites karka* (DSV = 70.4) in Bardia. Selection for *Saccharum spontaneum* and *S. bengalensis* was slightly lower in Bardia than in Chitwan. Among browse species, highest DSV was estimated for *Mallotus phillippinensis* (DSV = 88.5), *Calamus tenuis* (DSV = 87.2) and *Dalbergia sissoo* (DSV = 83.8), also all in Bardia. In Chitwan, the highest selection for browse species was calculated

for *Murraya paniculata* (DSV = 61.0) and *Coffea bengalensis* (DSV = 58.5). DSV for *Callicarpa macrophylla* was low in both areas (DSV < 6.6).

Ivlev's electivity index (IEI) gave similar results (Fig. 8): highest preference values were calculated for *Arundo donax* (IEI = 0.8) and *Phragmites karka* (IEI = 0.6) in Bardia and *Saccharum spontaneum* (IEI = 0.5) and *Saccharum bengalensis* (IEI = 0.4) in Chitwan. Among browse species, highest preference was estimated for *Dalbergia sissoo* (IEI = 0.7) and *Mallotus phillippinensis* (IEI = 0.6) in Bardia and *Murraya paniculata* (0.57) and *Coffea bengalensis* (IEI = 0.5) in Chitwan. *Callicarpa macrophylla* was avoided by both populations with IEI values of -0.3 and -0.4 in Bardia and Chitwan diet, respectively.

An important grass *Saccharum spontaneum* and one browse *Mallotus phillippinensis* (in Bardia) and *Coffea bengalensis* (in Chitwan) species were selected from each study area to compare seasonal variation in species diet selection (Fig. 9). The DSV of *Saccharum spontaneum* increased from winter to the monsoon in both areas with consistantly higher values in Chitwan. Seasonal variation in DSV of browse species was opposite with a slight increase in Chitwan during the monsoon.

Higher selection for grasses during the hot and monsoon seasons confirms the pattern reported earlier: grasses are most important during these seasons, and grasses are exploited more vigorously in Chitwan. A higher DSV of browse species in Chitwan during the monsoon was probable due to the species (*Coffea bengalensis*) used in the analysis.

Saccharum spontaneum is the most important single food plant for rhinos in both areas. Higher selection for browse species during the dry season in Bardia indicates that grass quality is poorer there than in Chitwan. The fact that Bardia animals eat proportionally less of *Saccharum spontaneum* and do not select it to the same extent as in Chitwan support this. In Bardia, animals switch to browse species, mainly *Mallotus phillippinensis, Dalbergia*

sissoo, *Callicarpa macrophylla* and *Calamus tenuis*, which appear to be adequate substitutes for poor quality *Saccharum spontaneum*. However, for the increasing Bardia population *Mallotus phillippinensis* may become limiting for rhinos due to competetion with other ungulates. *Mallotus* is highly preferred by nilgai *Boselaphus tragocamelus* (Khatri 1993) and a very dense population of axis deer *Axis axis* (Dinerstein 1979b, Moe and Wegge 1995). This may ultimately force rhinos to become more dependant on agricultural crops, thus accelerating conflicts with the villagers. In Bardia, a switch from grass to browse during dry seasons is not probably due to higher quality of browse species. If this was the case, Chitwan animals would have been expected to eat proportionally more of those browse species (eg. *Mallotus phillippinensis* and *Callicarpa macrophylla)* common in both areas.

The general pattern of food plant selection was related to species abundance in the natural habitats. Mean RIVs and PVs (adjusted according to relative size of habitats) were positively correlated in both areas ($r^2 = 0.861$, $p < .001$, and $r^2 = 0.732$, $p < .001$, in Bardia and Chitwan, respectively). Because the significant correlations may be the result of exceptionally high RIV and PV of *Saccharum spontaneum*, this species was removed from the analysis. Excluding *S. spontaneum* did not change the significance of the correlations in either area.

To detect if species selection occurred in any of the three seasons, seasonal correlations were correlated on the basis of combined data sets from Bardia and Chitwan, with and without *Saccharum spontaneum*. All correlations were significant ($p < 0.05$) with lowest value for the winter season without *S. spontaneum* ($r^2 = 0.313$, $p < 0.5$, $df = 60$) (Fig. 10). The results confirm that, in general, rhinos are generalist feeders. Like reported by Mukinya (1977) and Gyseghem (1984) for black *Diceros bicornis* and northern white *Ceratotherium cimum cottoni* rhinoceros, respectively, the greater one-horned rhinoceros also exploited proportionally more those food plants which were most abundant in their natural habitats.

ACKNOWLEDGEMENTS

The Department of National Parks and Wildlife Conservation provided permission to conduct this study and the King Mahendra Trust for Nature Conservation provided logistic support. Funds for field research in Bardia and Chitwan were made available from the Norwagian Agency for Development Cooperation (NORAD), Norway, and the Smithsonian Institute, USA, respectively. E. Dinerstein provided scientific guidance for the food habit study in Chitwan, and P. Wegge provided valuable suggestions while designing this study and various stages during data analyses and writing. S. Moe provided comments on the manuscript. Man B. Lama, Narayan Tharu, and Man Singh Lama helped in the field.

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Table 1. Floristic composition, diversity and similarity in different habitat types of the two study areas.

Vegetation type	Study areas	Total number of species	Simpson's index of diversity	Total number of common species	Sorensen's Index (%)
Sal forest	Bardia	73	0.781		
	Chitwan	97	0.883	57	67.1
Riverine forest	Bardia	93	0.925		
	Chitwan	117	0.941	52	49.5
Tall Grassland	Bardia	79	0.671		
	Chitwan	131	0.986	58	55.2
Bushy Pastures	Bardia	63	0.863		
	Chitwan	55	0.823	34	57.6
Khair-Sissoo	Bardia	76	-	-	
Wooded Grassland	Bardia	49	-	-	
Phanta	Bardia	35	-	-	
Mixed Hardwood forest	Bardia	53	-	-	
All	Bardia	179	0.918		
	Chitwan	283	0.968	159	68.8

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Sorensen's Index (%)
67.1
49.5
55.2
57.6
68.8

Table 2. Prominence values of plant species recorded to be eaten by rhinos in Royal Bardia (RB) and Royal Chitwan (RC) National Parks

Species	SF		RF		TG		BP		All habitats	
	RB	RC	RB	RC	RB	RC	RB	RC	RB	RC
Grasses										
Cynodon dactylon	0.4	0.5	15.1	35.4	3.1	71.9	77.3	217.0	95.9	324.8
Saccharum spontaneum	0.0	0.1	6.3	21.2	630.3	243.0	1.7	6.3	638.3	270.6
Apluda mutica	0.0	0.0	0.0	0.0	10.0	4.0	32.3	3.0	42.3	7.0
Arundo donax	0.0	0.0	0.0	0.7	23.2	2.2	0.0	0.0	23.2	2.9
Desmostachya bipinnata	168.0	7.2	23.7	3.3	0.2	0.0	47.1	0.0	239.0	10.5
Imperata cylindrica	122.0	28.9	48.1	28.6	37.5	71.9	3.0	128.5	210.6	257.9
Cymbopogon sp.	0.0	0.0	0.2	0.0	8.1	2.7	0.0	0.0	8.3	2.7
Saccharum bengalensis	0.0	0.2	0.1	21.9	87.5	78.8	0.6	0.01	88.2	100.9
Narenga porphyrocoma	15.1	43.6	0.1	22.9	1.6	141.1	0.0	0.01	16.8	207.6
Themeda sp.	0.0	125.7	0.0	20.3	0.0	62.0	0.0	0.0	0.0	208.0
Chrysopogon aciculatus	0.0	0.0	0.2	0.0	0.0	13.6	29.8	204.2	30.0	217.8
Erianthus ravennae	0.8	7.2	0.1	0.0	19.0	11.9	1.2	0.0	21.1	19.1
Vetiveria zizanoides	14.7	0.6	15.1	11.3	6.5	0.1	1.3	0.0	37.6	12.0
Setaria pallide-fusca	0.0	0.0	0.0	0.0	1.2	6.6	0.0	0.0	1.2	6.6
Oplismanus compositus	0.0	0.3	0.2	0.6	0.0	1.0	0.0	0.0	0.2	1.9
Panicum sp	0.0	5.4	0.0	5.2	30.0	40.2	0.0	0.0	30.0	50.8
Brachiaria sp.	0.1	0.0	0.0	0.0	30.6	13.0	0.0	0.0	30.7	13.0
Phragmites karka	0.0	0.5	1.1	2.7	9.7	6.5	0.0	0.0	10.8	9.7
Typha elephantina	0.0	0.0	0.0	0.0	0.3	3.9	0.0	0.1	0.3	4.0
Saccharum arundinaceum	0.0	0.0	0.0	1.1	2.6	15.7	0.0	0.0	2.6	16.8
Browse										
Mallotus phillippinensis	4.2	0.5	30.4	9.4	0.1	1.3	0.1	0.0	34.8	11.2
Ehretia laevis	0.0	0.5	14.5	33.9	0.2	4.4	0.1	4.4	14.8	43.2
Bridelia stipularia	0.0	3.4	2.3	2.4	0.0	0.0	0.0	0.0	2.3	5.8
Ficus glomarata	0.0	0.0	0.5	2.7	0.0	0.1	0.1	0.3	0.6	3.1
Bombax ceiba	0.0	1.4	1.1	3.0	0.1	11.2	1.4	17.2	2.6	32.8
Syzigium cumini	2.8	1.5	11.5	5.2	0.6	0.01	0.0	0.0	14.9	6.7
Bauhinia sp.	0.0	0.1	0.1	7.3	0.0	1.0	0.1	0.0	0.2	8.4
Dalbergia sissoo	0.0	0.0	0.3	0.8	9.5	0.5	0.1	0.0	9.9	1.3
Terminalia nudiflora	0.0	0.0	1.5	40.7	0.1	7.4	0.7	2.5	2.3	50.6
Grewia sp	2.6	14.9	0.1	3.8	0.0	4.0	0.0	0.0	2.7	22.7
Callicarpa macrophylla	2.4	0.0	85.5	63.4	13.0	34.2	3.6	152.4	104.5	250.0
Colebrookia oppositufolia	0.1	0.0	27.4	150.2	0.2	4.0	9.4	131.5	37.1	285.7
Zizyphus mauritiana	0.0	0.0	4.3	2.2	0.1	0.6	169.4	13.0	173.8	15.8
Coffea bengalensis	0.0	0.0	0.0	27.2	0.0	0.0	0.0	0.0	0.0	27.2
Murraya paniculata	0.0	0.0	0.0	22.8	0.0	0.0	0.0	0.0	0.0	22.8
Litsea monopetala	2.1	12.8	0.3	61.9	0.0	1.9	0.0	16.2	2.4	92.8
Calamus tenuis	0.1	0.0	26.2	0.0	0.0	0.0	0.0	0.0	26.3	0.0
Acacia concinna	0.0	0.5	10.3	66.7	0.6	0.9	4.2	0.0	15.1	68.1
Others										
Pogostemon bengalensis	0.0	1.3	14.3	50.8	7.0	16.0	6.1	47.7	27.4	115.8
Cirsium wallichii	0.0	0.0	0.2	9.0	3.7	8.9	0.0	0.0	3.9	17.9
Solanum sp.	0.0	0.0	0.0	0.6	0.5	2.1	0.7	10.2	1.2	12.9
Cassia tora	0.0	0.0	1.1	14.8	0.1	9.4	28.0	262.8	29.2	287.0
Cassia occidentalis	0.0	0.0	0.0	0.0	0.0	0.4	0.4	5.7	0.4	6.1
Desmodium sp.	1.1	0.1	15.9	1.3	2.3	1.7	1.1	3.7	20.4	6.8
Urena lobata	1.7	0.0	1.3	6.6	0.2	3.8	0.0	0.0	3.2	10.4
Cyperus sp.	0.1	0.3	2.2	0.9	2.0	0.4	5.7	16.3	10.0	17.9
Artemisia vulgaris	1.0	0.0	0.9	3.8	0.6	23.6	0.1	62.8	2.6	90.2
Trichodesma sp.	0.0	0.0	1.7	2.7	0.0	1.2	0.6	0.4	2.3	4.3
Sida acuta	0.0	0.0	0.2	0.1	0.0	0.4	0.0	9.8	0.2	10.3
Sida rhombifolia	0.1	0.0	0.0	0.0	0.6	0.8	1.6	17.7	2.3	18.5
Piper nepalense	0.0	0.1	0.1	7.3	1.2	0.4	0.0	0.0	1.3	7.8
Achyranthus spinosus	0.0	0.0	0.0	0.0	0.7	0.2	0.0	0.0	0.7	0.2
Equisetum sp	0.0	0.0	0.3	0.0	1.4	11.3	0.3	0.0	2.0	11.3
Ageratum conyzoides	0.0	0.1	0.1	12.7	0.1	8.2	0.4	43.3	0.6	64.2
Lantana nodiflora	0.0	0.0	0.0	0.0	0.8	3.5	0.1	3.7	0.8	7.2
Ageratum conyzoides	0.0	0.0	0.2	0.7	0.0	1.4	0.0	0.0	0.2	2.1
Asteraceae sp	0.0	0.0	0.0	0.9	0.0	3.2	0.0	0.0	0.0	4.1

SF = Sal forest, RF = Riverine forest, TG = Tall Grassland, BP = Bushy Pasture

Table 3 Prominence values of plant species recorded to be eaten by rhinos in four vegetation types available only in Bardia.

Species	KS	WG	PH	MHF	All 4 types
Grasses					
Cynodon dactylon	42.9	13.3	12.4	0.0	68.6
Saccharum spontaneum	42.9	125.0	241.1	137.2	546.2
Desmostachia bipinnata	42.4	72.6	6.4	45.7	167.1
Imperata cylindrica	62.7	316.5	388.9	124.1	892.2
Cymbopogon sp.	10.4	28.0	8.6	0.0	47.0
Saccharum bengalensis	0.9	0.0	0.0	0.0	0.9
Narenga porphyrocoma	0.0	5.0	37.3	8.2	95.5
Themeda sp.	0.0	1.5	0.0	0.6	2.1
Chrysopogon aciculatus	0.8	0.0	0.0	0.0	0.8
Erianthus ravennae	11.0	1.5	0.0	30.6	43.1
Vetiveria zizanoides	5.6	36.7	17.6	45.9	105.8
Phagmites karka	2.1	0.0	3.1	0.0	5.2
Oplismenus compositus	0.0	0.1	0.0	0.0	0.1
Brachiaria sp.	1.9	6.0	0.0	1.2	9.1
Browse					
Mailotus phillippinensis	0.2	6.3	0.0	12.2	18.7
Ehretia laevis	6.7	20.0	0.0	16.4	43.1
Bombax ceiba	0.3	0.3	0.3	0.9	1.8
Syzigium cumini	1.4	10.1	2.7	13.4	27.6
Bauhinia sp.	0.0	1.6	0.0	0.0	1.6
Dalbergia sissoo	5.2	0.4	2.8	0.0	8.4
Trewia nudiflora	1.5	0.0	0.0	0.0	1.5
Grewia sp.	0.0	0.3	0.0	0.0	0.3
Callicarpa macropylla	96.7	264.1	2.7	4.6	368.1
Colebrookia oppositifolia	45.9	25.9	0.0	95.4	167.2
Ziziphus mauritiana	37.3	0.0	0.0	0.0	37.3
Calamus tenuis	0.1	0.0	0.0	0.0	0.1
Acacia concinna	5.8	0.0	0.0	0.0	5.8
Others					
Pogostemon bengalensis	127.3	0.4	0.4	30.5	158.6
Cirsium wallichii	0.1	0.0	0.2	0.0	0.3
Solanum sp.	0.1	0.0	0.0	0.0	0.1
Cassia tora	25.0	2.1	0.1	0.0	27.2
Cassia occidentalis	1.9	0.0	0.0	0.0	1.9
Pteris sp.	3.6	0.3	0.0	6.4	10.3
Urena lobata	0.1	0.0	0.0	0.0	0.1
Cyperus sp.	3.3	0.9	9.8	1.9	15.9
Artemisia vulgaris	1.0	0.0	0.7	0.0	1.7
Truimfetta spp.	0.2	0.3	0.0	0.0	0.5
Sidda acuta	0.1	0.0	0.0	0.0	0.1
Sidda rhombifolia	0.1	0.0	0.0	0.0	0.1
Piper nepalens	0.0	0.0	0.1	0.0	0.1
Equisetum sp.	0.0	0.0	0.0	1.3	1.3

KS = Khair-Sisso forest WG = Wooded Grassland, PH = Phanta, MHF = Mixed Hardwood forest

available only in

All 4 types
68.6
546.2
167.1
892.2
47.0
0.9
95.5
2.1
0.8
43.1
105.8
5.2
0.1
9.1
18.7
43.1
1.8
27.6
1.6
8.4
1.5
0.3
368.1
167.2
37.3
0.1
5.8
158.6
0.3
0.1
27.2
1.9
10.3
0.1
15.9
1.7
0.5
0.1
0.1
0.1
1.3

Table 4. Relative importance values of main wild food plants in the diet of rhinoceros in Royal Bardia (RB) and Royal Chitwan (RC) National Parks.

Species	Relative Importance Value							
	Winter		Hot		Monsoon		All year	
	RB	RC	RB	RC	RB	RC	RB	RC
Grasses								
Saccharum spontaneum	18.9	25.7	21.2	43.1	45.4	41.9	28.5	36.9
Saccharum bengalensis	0.8	14.9	3.2	13.8	8.7	8.2	4.2	12.3
Narenga porphyrocoma	-	1.6	0.7	8.4	2.3	8.4	1.0	6.1
Erianthus ravennae	2.1	-	3.8	-	4.7	-	3.5	-
Cyanodon dactylon	4.4	4.3	4.7	7.6	3.1	8.2	4.1	6.7
Imperata cylindrica	-	0.4	4.4	2.3	1.2	2.6	1.9	1.8
Themeda sp.	-	3.1	-	2.2	-	2.8	-	2.7
Cymbopogon sp.	0.7	2.3	2.0	3.2	3.8	0.5	2.2	2.0
Phragmites karka	1.9	0.7	1.5	1.2	2.2	0.8	1.9	0.9
Arundo donax	5.6	-	5.4	-	4.5	-	5.2	-
Browse								
Callicarpa macrophylla	3.9	3.7	4.5	1.0	3.2	2.0	3.9	2.2
Litsea monopetala	-	5.0	-	0.4	-	0.6	-	2.0
Coffea bengalensis	-	6.5	-	2.8	-	3.0	-	4.1
Murraya paniculata	-	5.8	-	2.1	-	4.0	-	3.9
Mallotus phillippinensis	7.9	2.6	5.9	0.3	0.6	0.4	4.8	1.1
Dalbergia sissoo	-	-	7.9	-	0.7	-	2.9	-
Trewia nudiflora	-	0.2	-	-	0.1	11.2	0.03	3.8
Calamus tenuis	4.4	-	5.0	-	0.9	-	3.4	-
Bombax ceiba	1.2	0.2	0.6	0.1	-	-	0.6	0.1
Colebrookia oppositifolia	1.6	0.1	0.8	-	0.1	0.2	0.8	0.1
Ehretia laevis	1.1	-	0.3	-	0.1	0.2	0.5	0.1
Ficus glomarata	1.7	-	0.1	-	0.3	-	0.7	-
Ziziphus mauritiana	1.0	-	0.1	-	-	-	0.4	-
Acacia concinna	1.3	0.1	0.4	-	0.2	-	0.6	0.03
Others								
Truimfetta sp.	0.4	0.4	0.1	-	0.1	0.2	0.2	0.2
Urena lobata	0.9	0.1	1.8	0.1	0.6	0.1	1.1	0.1
Circium wallichii	4.2	0.1	3.1	1.5	1.3	-	2.9	0.5

Table 5. Seasonal similarity of food plants[1] recorded in the diet of two rhinoceros populations.

Seasons	Study area	Number of species	Number of common species	Sørensen's Index (%)
Winter	Bardia	47		
	Chitwan	33	23	57.5
Hot	Bardia	43		
	Chitwan	22	16	49.2
Monsoon	Bardia	43		
	Chitwan	32	25	66.7
All season	Bardia	57		
	Chitwan	44	36	71.3

[1] agricultural crops included.

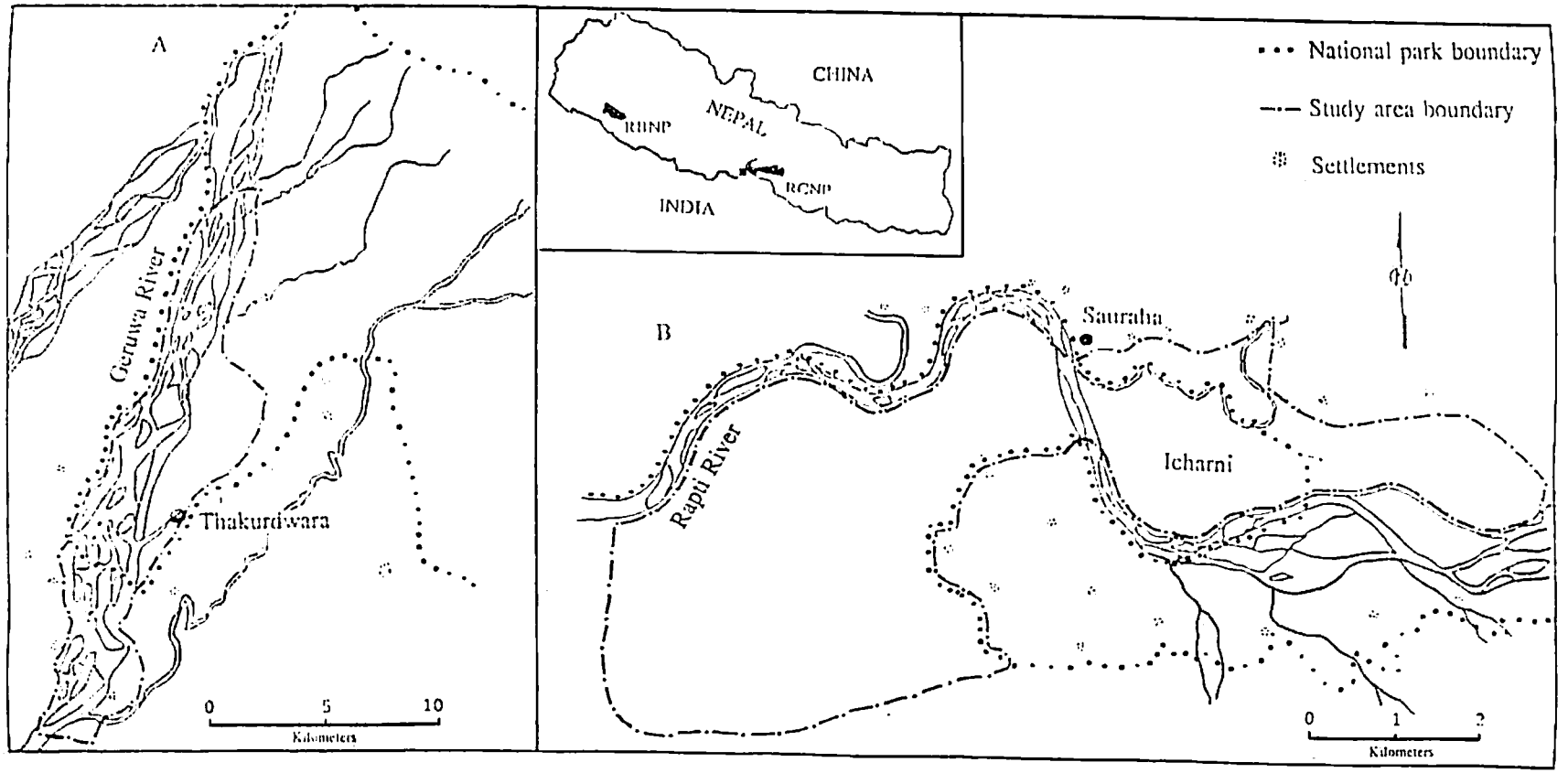

Figure 1. Map of study areas in (a) Royal Bardia and (b) Royal Chitwan national parks.

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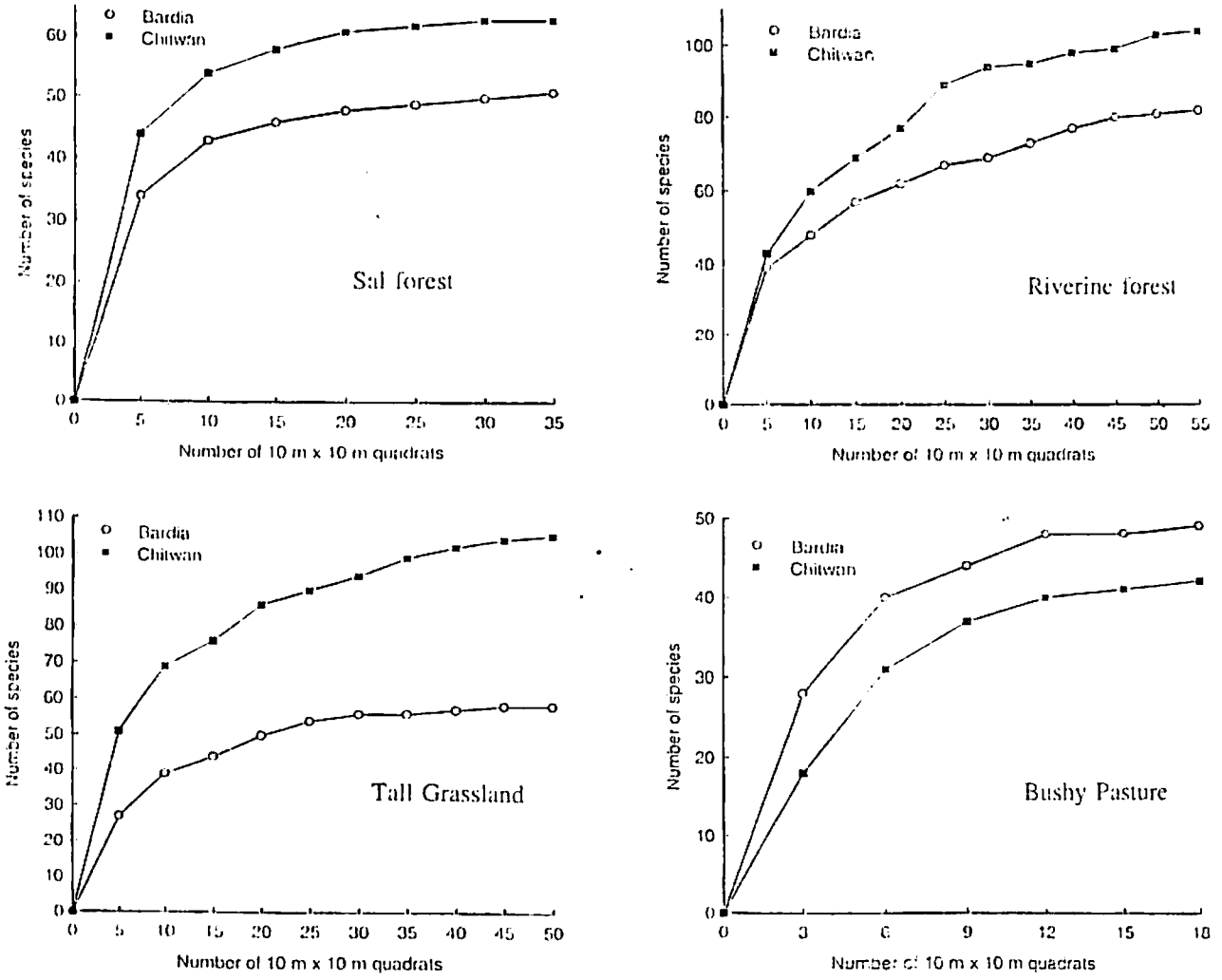
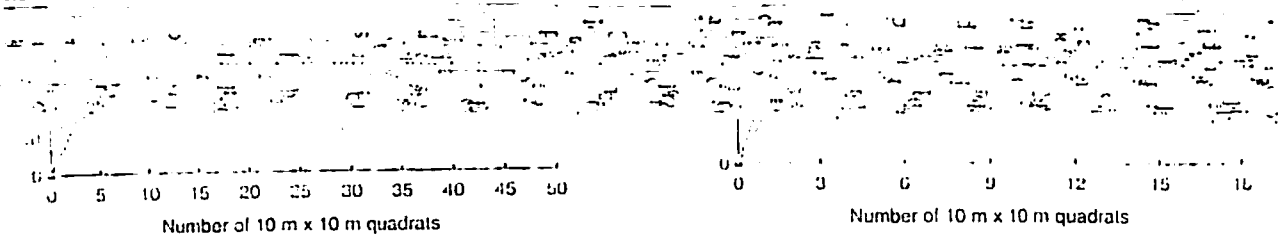


Figure 2. Species area curves for different vegetation types in the two study areas.



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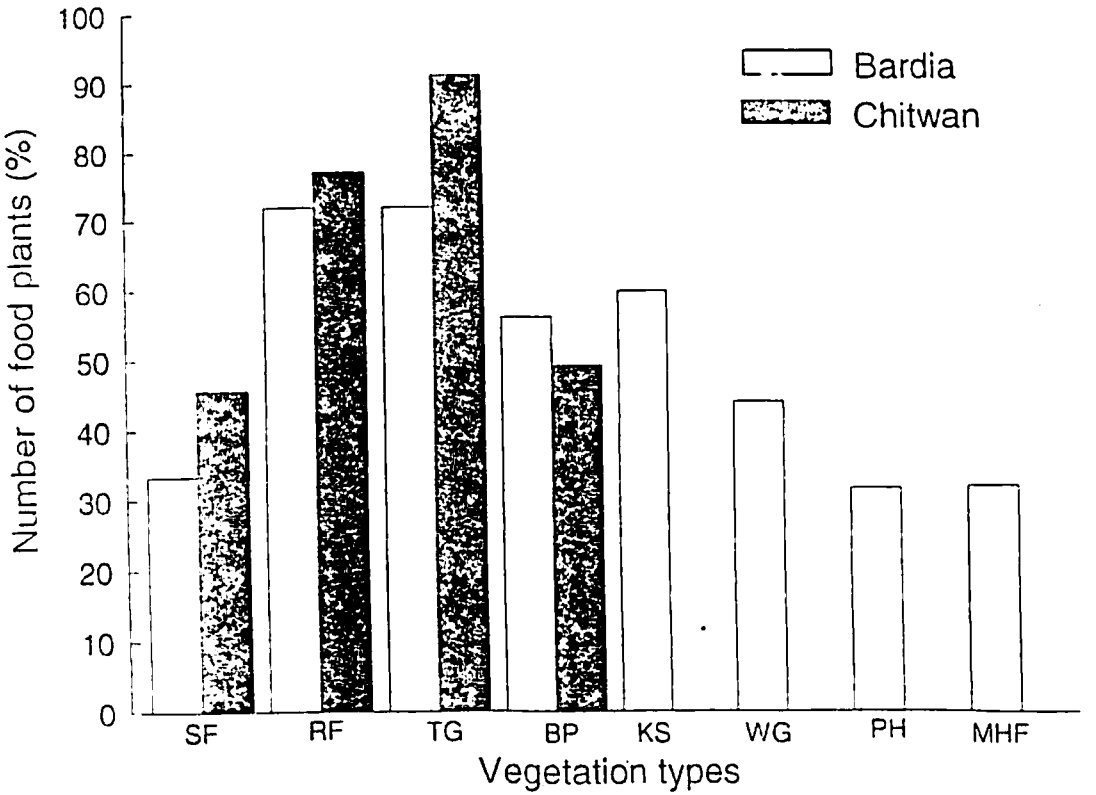

Figure 3. Distribution of food plant species in different habitat types in the study areas.

SL = Sal forest, RF = Riverine forest, TG = Tall Grassland, BP = Bushy Pastures, KS = Khair-Sissoo forest, WG = Wooded Grassland, PH = Phanta, MHF = Mixed Hardwood forest.

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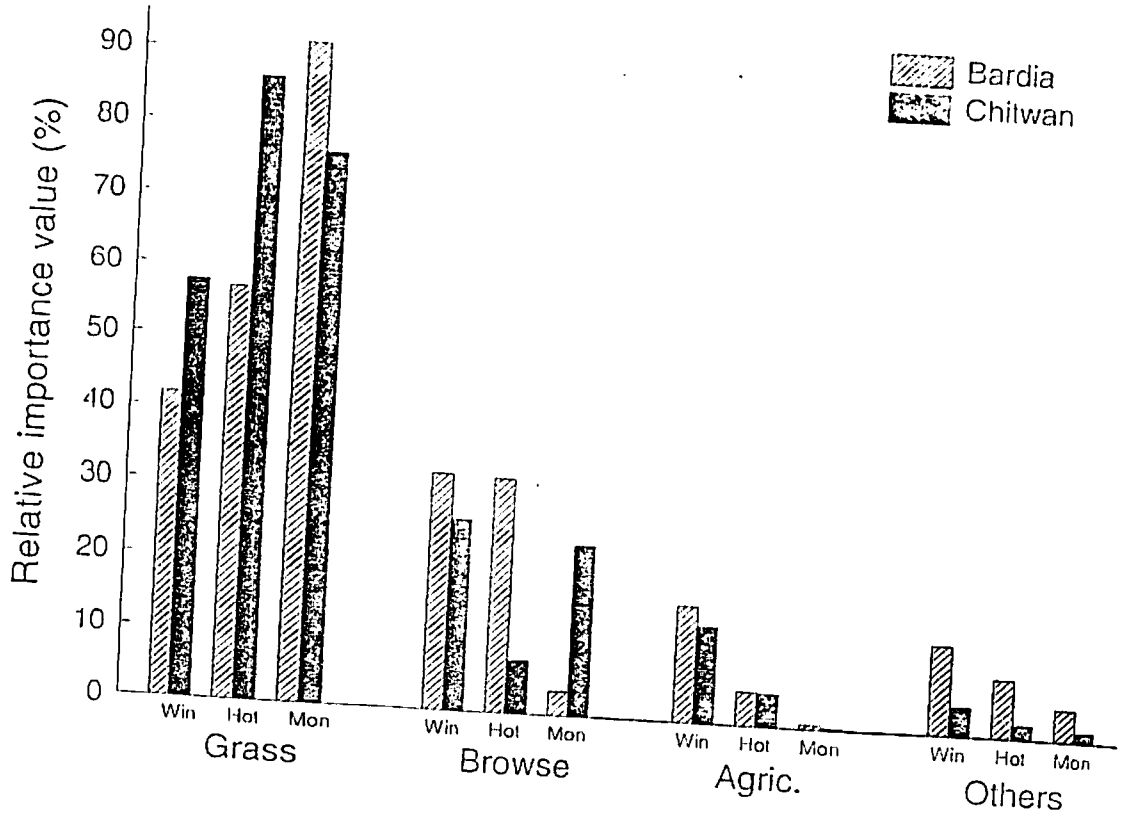

Figure 4. Composition of seasonal diets in the two areas. Win = Winter, Mon = Monsoon, Agric.= Agricultural corps

Grass Browse Agric. Others

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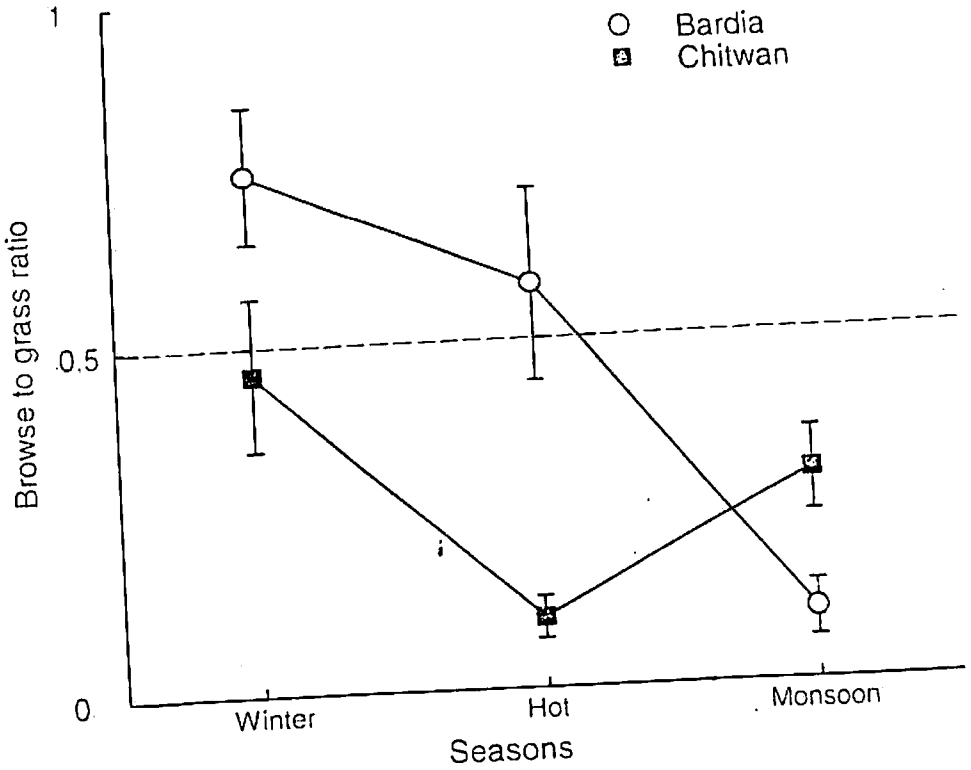

Figure 5. Seasonal variation (mean±s.d.) in browse to grass ratios in the diet of the two rhinoceros populations.

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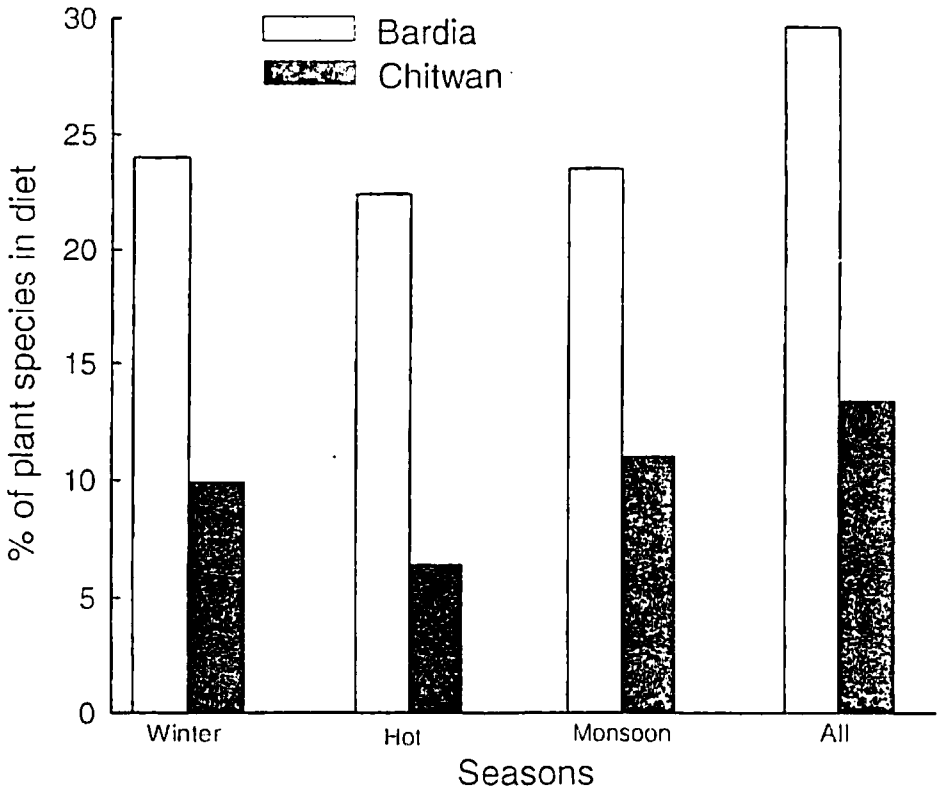

Figure 6. Proportion of plant species in the diet of rhinoceros in the two study areas.

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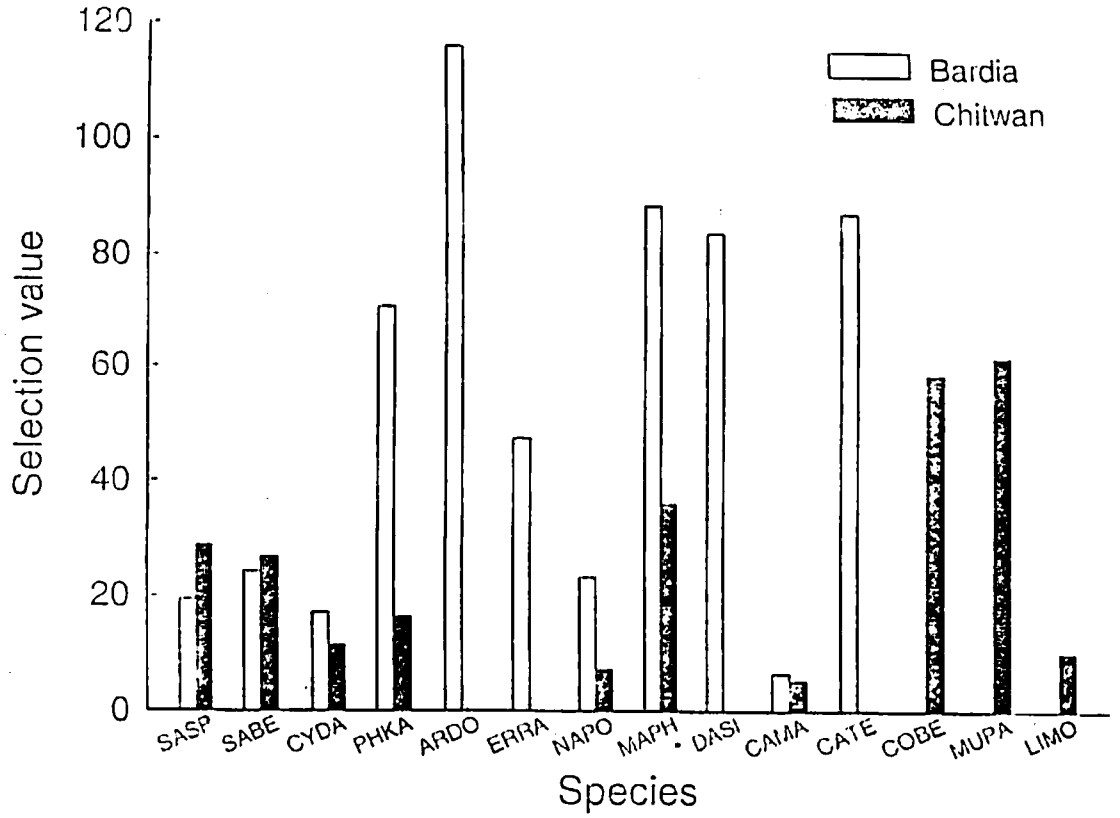

Figure 7. Selection values of important food plants in the two study areas.

SASP = *Saccharum spontaneum*, SABE = *Saccharum bengalensis*, CYDA = *Cyanodon dactylon*, PHKA = *Phragmites karka*, ARDO = *Arundo donax*, ERRA = *Erianthus ravennae*, NAPO = *Narenga porphyrocoma*, MAPH = *Mallotus phillippinensis*, DASI = *Dalbergia sissoo*, CAMA = *Callicarpa macrophylla*, CATE = *Calamus tenuis*, COBE = *Cotton benettensis*, MUPA = *Murraya*

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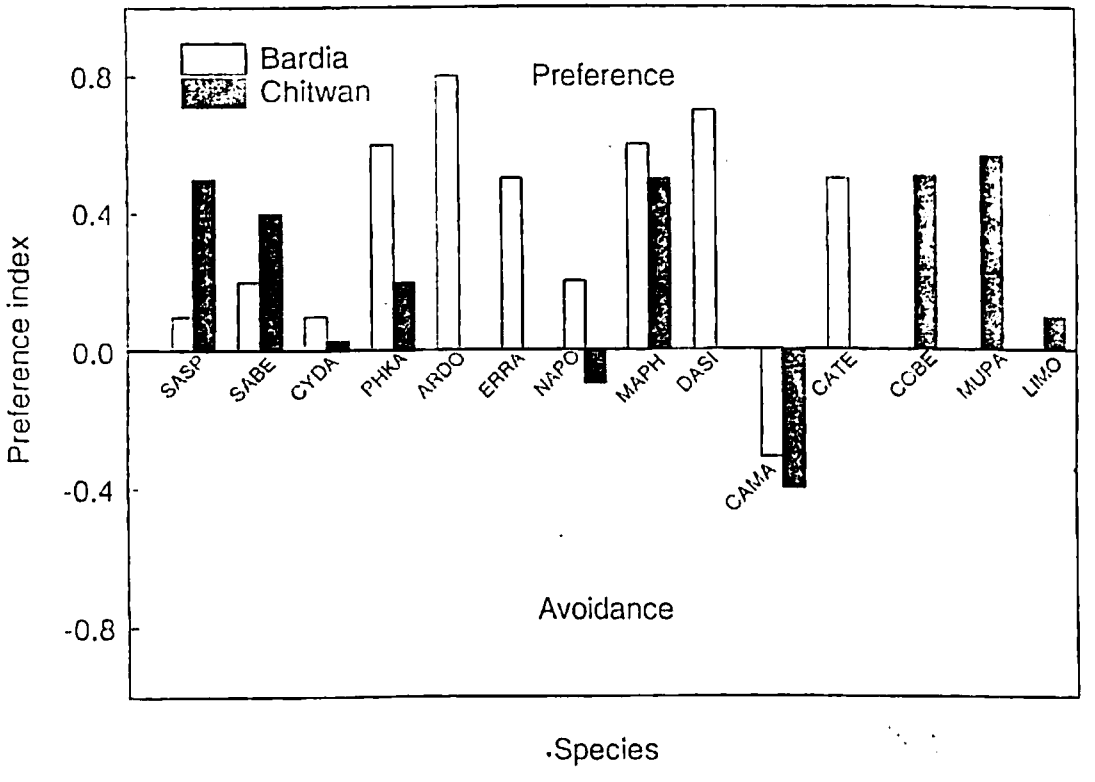

Figure 8. Electivity indices of important food plants in the two study areas.

SASP = *Saccharum spontaneum*, SABE = *Saccharum bengalensis*, CYDA = *Cyanodon dactylon*, PHKA = *Phragmites karka*, ARDO = *Arundo donax*, ERRA = *Erianthus ravennae*, NAPO = *Narenga porphyrocoma*, MAPH = *Mallotus phillippinensis*, DASI = *Dalbergia sissoo*, CAMA = *Callicarpa macrophylla*, CATE = *Calamus tenuis*, COBE = *Coffea bengalensis*, MUPA = *Murraya paniculata*, LIMO = *Litsea monopetala*.

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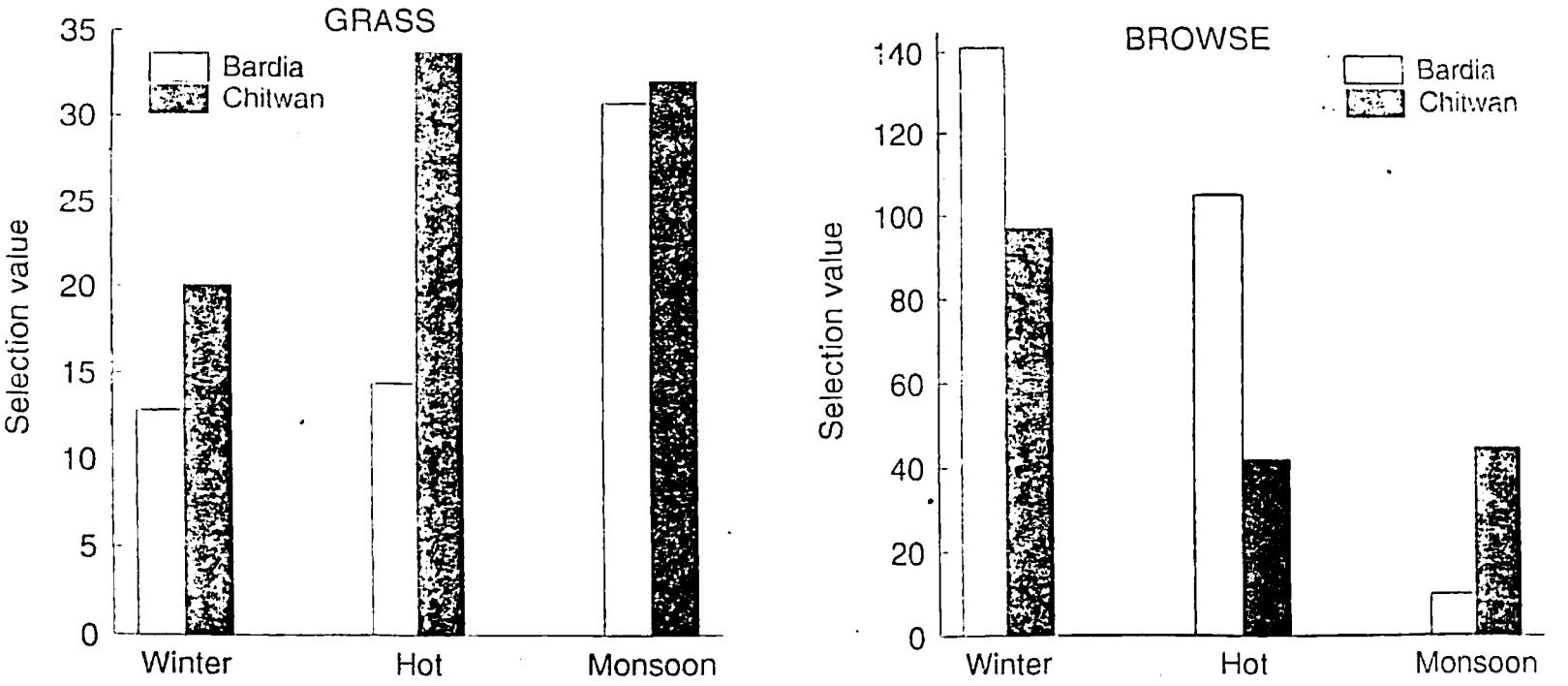

Figure 9. Seasonal variation in selection values of important grass (*Saccharum spontaneum*) and browse species (*Mallotus phillippinensis* in Purbin and *Coffea bengalensis* in Chitwan) in the two study areas.

Figure 9. Seasonal variation in selection values of important grass (*Saccharum spontaneum*) and browse species (*Mallotus phillippinensis* in Bardia and *Coffea bengalensis* in Chitwan) in the two study areas.

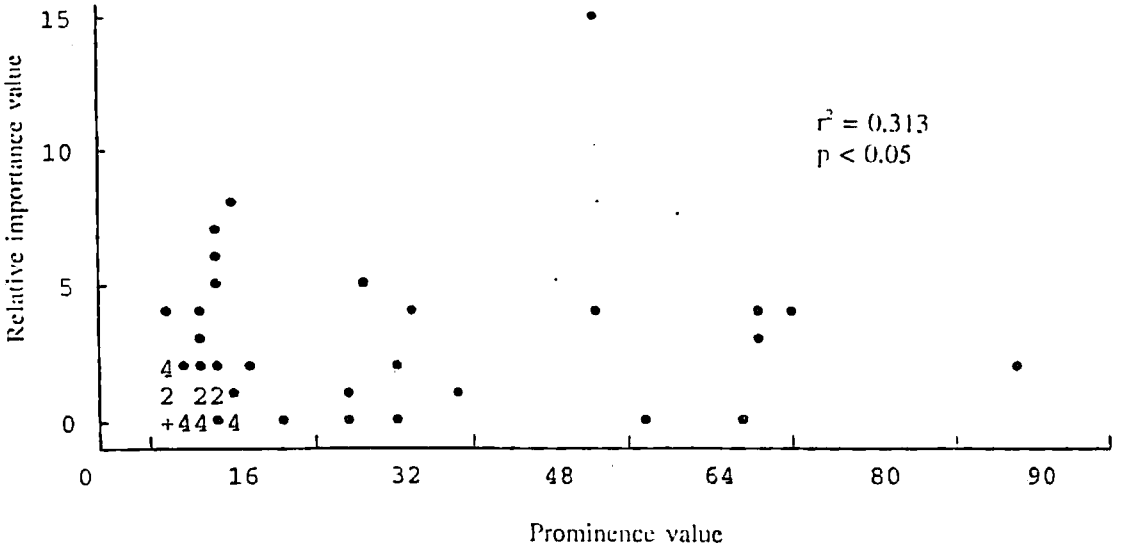

Figure 10. Relationship between relative importance value and prominence value of all food plants known to be eaten by rhinoceros during winter, *Saccharum spontaneum* excluded.