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Dry Season Browse Preference for the Black Rhinoceros (Diceros bicornis): The Case of the Midlands Black Rhino Conservancy (MBRC), Zimbabwe

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Research Article

Dry Season Browse Preference for the Black Rhinoceros *(Diceros bicornis):* The Case of the Midlands Black Rhino Conservancy (MBRC), Zimbabwe

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ABSTRACT

Dry season browse preference for the black rhinoceros (*Diceros bicornis*) was studied at the Midlands Black Rhino Conservancy (MBRC), Zimbabwe, in 2010. Free ranging black rhinos were tracked and 8 687 individual bites were recorded at 131 feeding stations and 616 feeding points. Only 34 plant species accounted for the black rhino diet. Trees contributed much of the diet (52.9%) followed by shrubs (44.0%) and lastly herbs (7.3%), with most of the browse (68.7%) coming from the 1.0-1.5m height category. Early dry season diet was richer and more evenly distributed (34 species, H'=3.812.) than late dry diet (27 species, H' =3.413). *Acacia nilotica, Acacia karoo, Dichrostachys cineria, Ziziphus mucronata, Lantana camara, Gardenia volkensii* and *Rhus tenuinervis* constituted the principal diet of the rhino, contributing 69.4% and 81.6% of the browse in the early dry and late dry season respectively. In the early dry season *L. camara* was the most important principal species contributing 32.9% of the browse, scoring the highest proportional usage. (0.33) and was also the most available (0.26), a position that switched onto *A nilotica* in the late dry season. The restricted diet obtained in the study may encourage wandering of rhinos into unprotected neighbourhoods making them prone to poaching.

Key words: browse, *Diceros bicornis,* feeding station, principal species.

INTRODUCTION

The rhinoceros family belongs to the order Perissodactyla. In Africa the family has two (2) genera *Ceratotherium* and *Diceros* (Ritchie, 1963). The black rhinoceros *(Diceros bicornis)* is a charismatic yet critically endangered megaherbivore of Sub Saharan Africa. Until the late 1960s, the black rhinoceros was relatively plentiful in Africa but between 1970 and 1994, black rhinos suffered a 95 % decline (WWF, 2007). Cumming *et al.* (1990) reported that an estimated population of 65 000 black rhinos in 1970 decimated to 3 800 rhinos by 1986. This decline in rhino population in Africa has been a major concern to conservationists and wildlife managers.

Various internal problems within African countries have exacerbated this situation, including their economic situation, corruption, the increased availability of sophisticated weapons and the resentment of conservation areas by some local people (Williams, 1992). The ever expanding human population has also placed higher demand on farmers in developing countries (which comprise 100-% of the rhino's natural range), to increase crop production hence causing the destruction of rainforests for building roads and the reclamation of ideal rhino habitat for hunting, agriculture and human settlements (Olson *et al.,* 2008).

Added to these factors are issues of human and wildlife conflicts which can occur when wild animals encounter human settlements and destroy crops and plantations simply because they are in their path (Hutchins and Kreger, 2006). This is an increasing problem now with parks dropping fences to allow animals' larger ranging areas, as well as villagers refusing to move when their homes and farms fall directly on game paths around borders of national parks (Hofstatter, 2005).

After decades of being hunted and poached for their valuable horn and falling victim to drastic habitat encroachment across the globe, the rhino numbers have reached critical stages (Balfour and Balfour, 1991). Although all trade in rhino products is banned under CITES, illegal trade in rhino horn continues today supporting aggressive poaching syndicates and a lucrative black market (Nowell *et al,* 1992). The horn of the rhino has been used in Traditional Chinese Medicine (TCM) for centuries as a fever remedy (Rabinowitz, 1996). This, together with its use in making ceremonial artefacts and a belief in its aphrodisiac properties (Foose and van Strien, 1997; Ellis, 2005), continue to spur poaching activities.

The main aim of the current conservation strategy for the endangered black rhinoceros is to ensure a population growth above 5-% per annum in Southern Africa, to minimise the loss of genetic diversity and outpace outbreaks of poaching. However, population growth has been impeded by diet related performance and overstocking of some reserves.

Black rhino conservation strategies in Zimbabwe have taken many dimensions over the years. In the late eighties to early nineties the then Department of Parks and Wildlife Management (DPWLM) mooted rhino translocation programmes as part of management responses to the decimating rhino populations (Tatham and Taylor, 1989). Under this scheme, translocations of the black rhino to other relatively safe areas within parks and wildlife land where these animals were known to have existed previously were conducted. Translocation into privately owned farms and ranches was also carried out. Once landowners satisfied a number of minimum requirements such as adequate areas of suitable habitat and appropriate security, they were granted authority to hold in custody on behalf of the state an allocated number of rhinoceros. In some cases, farmers had to consolidate their pieces of land to meet this requirement. In this way additional breeding herds could be established (Tatham and Taylor, 1989). The Midlands Black Rhino Conservancy (MBRC) was borne out of these translocation programmes in 1996. The aim of the translocation programme was to find suitable habitat that was large and secure enough to protect the rhinos and where private funds could be used to maintain security. The ultimate goal of translocation programmes was to establish viable black rhino populations (Caughley and Gunn, 1996). This is a very long term goal so it is essential to have measurable goals for short term evaluations as the project progresses. The post release needs and behaviour of translocated rhinos needs to be monitored as there is still little that is known in this regard with particular attention being paid to their movements around the landscapes and establishment of ranges. There are gaps in literature (Morrell, 2008), on the dynamics, particularly spatial of translocated indigenous large mammals as well as general *in situ* data on black rhinos.

No initial range assessment of MBRC is documented but the dense acacia thickets dotted throughout the conservancy seemed to provide ideal habitat for the megaherbivores (Zimuto pers. Comm.). The conservancy initially supported up to 60 black rhinos after its inception in 1996 but by 2007 the rhino population had plummeted to 22 animals (Gripper, 2010).

The land reform programme in the first decade of 2000, coupled with the discovery of chrome ore deposits saw a decline in the size and quality of the rhino habitat due to habitat fragmentation, increased deforestation and poaching (Zimuto pers. Comm.). Currently only 5 black rhinos remain in the conservancy and the range size has been reduced from the initial nine consolidated properties to only three.

Olson *et al.* (2002) proposed that extra conservation research efforts need to be assigned to conserving species with “minimum area requirements” as they are frequently used as umbrellas to plan the ideal size limits of areas protecting various additional biodiversity features. Even though the Zimbabwean government and conservation organisations have devoted considerable but scarce resources to *in situ* protection, few attempts have been made to analyse objectively the results achieved for particular management actions. Relatively little research has been carried out on small populations of rhinoceros confined to limited areas. The Midlands Black Rhino Conservancy is one such area where the precipitous decline in rhino population from over 60 animals in 1996 to the current 5, is largely attributed to poaching. No in-depth independent research has been conducted in the conservancy to assess the adaptability of the translocated rhinos to the new habitat, with regards dietary requirements.

Efforts to rehabilitate the rhino population in Zimbabwe have therefore focused on increasing security and the creation of conservancies. Although little is known about the minimum habitat that can be managed effectively to sustain a viable rhino population, food availability and quality are major factors that determine habitat suitability. For large browsers such as black rhinoceros that ingest much of their diet by biting twigs (Kotze *et al.*, 1993), variations in physical and chemical characteristics among twigs of different diameter are likely to be important in determining foraging efficiency, and therefore reproductive success (Shipley *et al.,* 1999).

Given the foregone, an assessment was made in the MBRC on the relative availability, dry season preferences and utilisation of plants by the black rhino. A detailed knowledge of black rhino diet has several uses that include; estimating appropriate stocking rates for this critically endangered species (Adcock, 2010); determining key plant species as early warning indicators of food limitation and threats to highly preferred plant species (Luske *et al.,* 2009); facilitating research on nutritional requirements of black rhinos in the wild and in captivity (Atkinson, 1995); and improving our understanding of diet selection by the species (Muya and Oguge, 2000).

The black rhinoceros is predominantly a browser concentrating on forbs and low growing shrubs (Owen-Smith, 1988). This research aimed at establishing browse preferences of the black rhinoceros in order to improve their management and to assess the suitability of the habitat for further reintroduction purposes. To achieve this. The research centred on determining the principal and preferred species in the diet of the black rhino as well as the temporal changes in diets in the conservancy for the dry season period.

MATERIALS AND METHODS

Study area

The study was conducted in Benthree and East Range ranches in the MBRC, Midlands, Zimbabwe (Figure 1). The conservancy covers a total area of 85 000 hectares with Sebakwe river and the Kwekwe-Mvuma road forming boundaries to the north and south respectively. The area consists of privately owned bush and farmland and is 35 km from the city of Kwekwe along Mvuma road and lies between 18 °58, 31 °S and 030 °06, 62 °E.

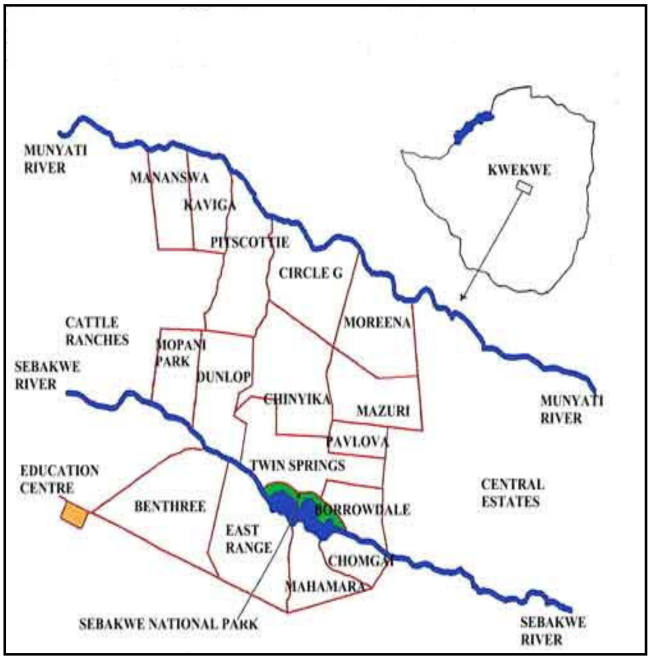

Figure 1: The location of Benthree and East Range properties in the MBRC.

Fifteen farmers in the area practising cattle ranching and semi intensive farming of cereals and citrus plants joined their properties to form the MBRC. The area is under the control of the Kwekwe Rural District Council (KRDC) and supports a total of five (5) IUCN red listed black rhinoceros *(Diceros bicornis)*.

Climate and geography

The conservancy lies in Zimbabwe's agro-ecological region 3 which is a semi intensive farming region that receives a total annual rainfall of between 650- 800 mm characterised by mid- season dry spells and high temperatures with annual average minimum and maximum of 11.9 and 27.5^{o}C respectively, and an annual average of 21.1^{o}C. The region is generally suitable for drought resistant crops, livestock and semi intensive farming.

Herbivore and carnivore species in study area

Apart from a population of critically endangered black rhinoceros, the MBRC is also home to a rich diversity of herbivore and carnivore communities. Elephant *(Loxodonta africana)*, Kudu *(Tragelaphus scriptus)*, Impala *(Aepyceros melampus)*, Eland *(Taurotragus oryx)*, Giraffe *(Giraffa camelopardalis),* Duiker *(Cephalophus natalensis)*, Zebra *(Equus burchelli)* and Warthog *(Phacochoerus aethiopicus)* form the greater proportion of herbivores while lion *(Panthera leo)*, Leopard *(Panthera pardus)* and Hyena *(Crocuta crocuta)* form a small carnivore community. The MBRC also boasts of a rich avian community and was accorded the Important Bird Area (IBA) status.

Data collection.

Data was collected between May and November 2010. This period comprised a predominantly early dry season (May–September) and a late dry season (October – November). Rhinoceros and rhinoceros signs (footprints/spoor, dung middens and bedding sites) were located with the help of rangers. Feeding preference data and details of the surrounding vegetation were then recorded.

Field assessment methods

Feeding data was collected using the backtracking method to avoid the inadvertent charging or fleeing characteristic of the rhino. Backtracking was done in the early hours of the day. This involved locating fresh spoors or track (<5hours) and associated feeding or a feeding rhino, and following it at a distance ranging from 100 to 1000 metres from the downwind direction, examining the vegetation browsed at each feeding station along the feeding path (trail). Each feeding station was taken to be a 5m radius circle around a central browsed plant. At each feeding station, freshly browsed plants (feeding points) were identified (the characteristic scissor like oblique clip on the cut surface of a shoot or twig made it much easier to distinguish the black rhino browse from those of other herbivores).

A total of 131 feeding stations and 616 feeding points were assessed. All plants (feeding points) that were browsed within the circle were considered as part of the same feeding station. At each feeding station the following data was collected; plant species browsed; height of browsed plant (each assigned to one of the four height classes 0-0.5 m, 0.51-1 m, 1.01-1.5 m, 1.51-2.0m and > 2m); number of bites taken per each browsed plant; part of plant species browsed; twig diameters of browsed plant parts (each allocated to one of the four diameter classes 0-3.5 mm, 3.51-6.5 mm, 6.51-10 mm, and >10 mm); the major vegetation and time and date of the observation.

A bite was defined as any number of twigs < 5 mm in diameter browsed within a radius of 50 mm of one another or more or less on the same plane. Twigs with a diameter ≥ 5 mm were regarded as single bites. Identification and nomenclature of plant species followed those of Van Wyk and Van Wyk (1997) and Kwembeya and Takawira (2002). Browsed plants were identified on the spot where possible. Other browsed species that were difficult to identify in the field were collected in plastic sample bags and later pressed for expert identification in the laboratory at the Midlands State University, Zimbabwe.

From the obtained data, the principal browsed species, proportional usage (Pu), proportional availability (Pa), food preference indices (FPIs) and percentage availability were determined. Principal browsed species were considered to be those species that contributed ≥ 5-% to the diet in that vegetation type in terms of the number of bites. Proportional usage (Pu) was calculated by using the number of bites taken from a plant species divided by the total number of bites from all species in a given feeding station. Proportional availability (Pa) was calculated from every fifth quadrat along the feeding path and it was calculated by dividing the number of times that a species occurred in all the availability plots by the total number of occurrences for all species in that habitat type. Food Preference Indices (FPIs) of all browsed species were calculated by using the following formula: FPI =Pu/Pa, where Pu–proportional usage and Pa–proportional availability (FPI values greater or lesser than 1 indicated species that are preferred or avoided respectively) (Petrides, 1975).

Data analysis

Statistical analysis was done using the MINITAB statistical software package (MINITAB Release 13.31). All plant species that were represented by four or more stations in both seasons were included in a t-test, comparing the number of cuts per station between early dry and late dry periods. T-test were also performed to compare the percentage contributions, proportional usages and food preference indices of the principle browsed species between the early dry and late dry seasons. Proportion analysis was done to find out if there were marked differences in the proportions contributed by the different vegetation types (herbs shrubs, and trees) to the diet of the rhino. Correlation and regression analyses were used to measure associations and relationships between browse utilisation and quantity. Shanon diversity index was used to calculate the food plant diversity while the Simpsons Diversity Index was used to calculate the dominant species in the diet of MBRC rhinos.

RESULTS

Rainfall regime

The early dry season of the study period was characterised by no rainfall from June to August, while the late dry season (September to October) experienced flush showers that signalled the onset of the wet season (Figure 2).

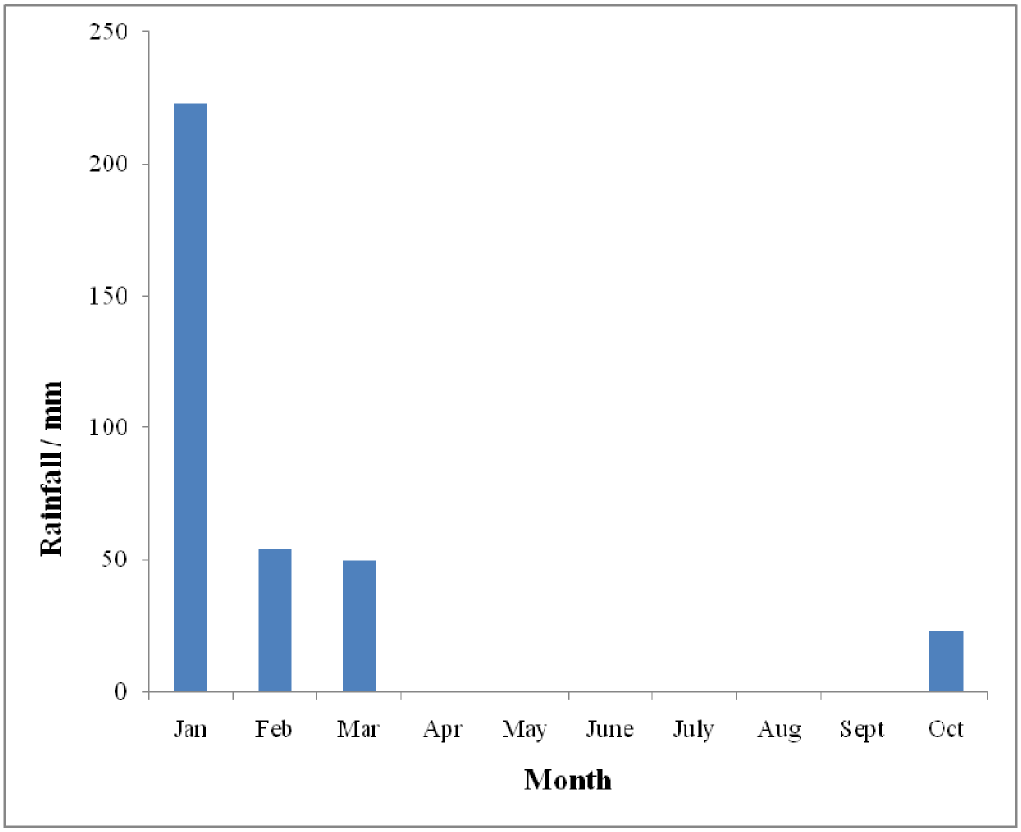

Figure 2: Mean monthly rainfall totals for MBRC for January – October 2010 (ZINWA).

Vegetation

The main vegetation in the two ranches comprised Miombo and Acacia woodlands interspersed with patches of Mopani and Combretum woodlands. This is typically the case in Benthree ranch where eastern and western sides are dominated by Mopani woodland. In the East Range. Open grassland and Terminalia woodland intercept the dominant acacia thickets comprising mainly of *Acacia nilotica* and *Dichrostachys cinerea* dotted in both ranches that form the ideal browsing sites for the black rhinos in the conservancy.

Species browse contributions

A total of 34 plant species from at least 16 families were eaten by the black rhinoceros in the MBRC during the specific data collection periods (Table 1). Families having at least three representatives were Anacardiaceae (3), Mimosaceae (5), Caesalpiniaceae (4) and Combretaceae (5), (Table 1). In total 8 677 individual cuts were recorded at 131 feeding stations and 616 feeding points. A wider variety of plant species constituted the rhino diet in the early dry season (34) than the late dry season (27).

Staple plant species eaten during both early dry and late dry periods were *Acacia nilotica*, *Acacia karoo*, *Dichrostachys cineria, Euclea divinorum, Ziziphus mucronata* and *Rhus tenuinervis. Lantana camara* was the most browsed plant during the early dry season (1320 bites) but was not eaten at all (0 bites) during the late dry season (Table 1) when this species was completely leafless. The species composition of black rhino diet was not significantly different between the two time periods (p=0.868).

Table 1: Dry season variation in the feeding ecology of black rhinoceros in the MBRC based on backtracking observations

Plant Family and Species	Growth Form	Number of Stations	Number of Cuts		Part Eaten
			Early Dry	Late Dry	
ANACARDIACEAE					
Linnea discolor	tree	01	08	00	L,S
Ozoroa insignis	tree	02	15	04	L,S
Rhus tenuinervis	shrub	28	293	642	L,S
APOCYNACEAE					
Carissa edulis	shrub	09	70	43	L,S
Rauvolfia caffra	tree	07	198	22	L,S
BALANITACEAE					
Balanites maughamii	shrub	08	90	96	S
CAESALPINIACEAE					
Brachystegia spiciformis	tree	05	34	12	T
Brachystegia boehmii	tree	05	41	29	T
Colophospermum mopane	tree	05	43	13	T
CAESALPINIACEAE					
Julbernadia globiflora	tree	03	28	07	T
CELASTRACEAE					
Gymnosporium senegalensis	shrub	07	127	79	S
COMBRETACEAE					
Combretum apiculatum	tree	02	09	09	B,L,S
Combretum imberbe	tree	02	05	05	B,L,S
Combretum collinum	tree	03	29	00	L,S
Combretum molle	tree	02	03	09	S
Terminalia sericea	tree	04	07	08	S

EBENACEAE					
Euclea divinorum	shrub	11	73	129	L,S
EUPHORBIACEAE					
Fluegga virosa	shrub	08	38	36	S
FLACOURTIACEAE					
Flacourtia indica	shrub	02	08	00	S

LOGANICEAE					
Strychnos spinosa	tree	03	31	04	F,S,L
Strychnos madagascarensis	tree	01	17	00	F,S,L
MIMOSACEAE					
Albizia amara	tree	01	21	00	S
Acacia karoo	tree	31	118	656	S
Acacia nilotica	tree	27	407	1140	S
Dichrostachys cinerea	shrub	49	301	399	S
Faidherbia albida	shrub	18	69	77	S
OLACEAE					
Ximenia americana	shrub	02	03	04	S
Ximenia caffra	shrub	02	04	03	S
RHAMNACEAE					
Ziziphus mucronata	tree	17	110	383	S
RUBIACEAE					
Gardenia volkensii	shrub	27	230	596	S
Canthium huillense	shrub	04	23	00	S

Table 1

Plant Family and Species	Growth Form	Number of Stations	Number of Cuts		Part Eaten
			Early Dry	Late Dry	
TILIACEAE					
Grewia flavescens	climber	17	156	110	S
Grewia monticola	shrub	18	72	161	S
VERBENACEAE					
Lantana camara	shrub	21	1320	00	L,S

Key: L = Leaves, B = Bark, S = Stem, F = Fruit, T = Shoot Tips.

In the early dry season 34 plant species were browsed by the black rhinoceros and of these, only 10 species (*R. tenuinervis, R. caffra, G. senegalensis, A karoo, A. nilotica, D. cinerea, Z. mucronata, G. volkensii, G. flavascens* and *L. camara*) contributed more than 100 bites per species, accounting for a total of 3 260 (81.4-%) bites of the early dry season browse. The remaining 24 species contributed a total of 741 bites accounting for 18.6-% of the diet during this early dry season.

A more skewed pattern was observed during the late dry season with fewer (9) species (*R. tenuinervis, E. divinorum, A. karoo, A. nilotica, D cinerea, Z. mucronata, G. volkensii, G. flavascens and G. monticola)* contributing the greater percentage of the black rhino diet. During this late dry season the 9 species from a total of 27 browsed contributed bites greater than 100, accounting for 4 216 bites and contributing a total of 90.1% of the black rhino diet. The remaining 18 species contributed 460 bites, accounting for 10.9% of the browse during the late dry season.

The relative importance of food plants differed between the early dry and late dry seasons (Table 1). The early dry season diet was richer (more plants were utilized) than the late dry season by seven species (*Linnear discolor*, *Cambretum collinum*, *Flacoutia indica*, *Strychnos madagascarensis*, *Albizia amara*, *Canthium huillense* and *Lantana camara). These were only utilized in the early dry season and not at all in the late dry season.*
Different plant growth forms were not represented equally well. Of the 34 browsed species in the conservancy, 18 species were trees contributing 52.9-% of the total species while a total of 15 (44.1-%) species were shrubs and only 1 species was herbaceous, contributing 9-% of the total number of browsed species in the conservancy. A comparison between the early dry and late season also shows marked differences in the bites contributed by the different plant forms (Table 2).

Table 2: Contribution made by the different plant forms to the diet of the rhino during the two time period of the dry season

Plant form	***Early dry season***			***Late dry season***		
	No.	***Number of bites***	***% bites***	***No***	***Number of bites***	***% bites***
Herbs	1	156	3.9	1	110	2.4
Shrubs	15	2721	68	12	2263	48.4
Trees	18	1124	28.1	14	2300	49.2

Whilst there were no marked differences in the contributions made by herbs to the rhino diet between the early dry (3.9%) and late dry season (2.4%) (χ^2= 2.02, p = 0.05), there were marked differences in the contributions made by the shrubs (χ^2 = 7.40, p < 0.006) and trees (χ^2=10.12, p < 0.006) between the two time periods of the dry season.

The browsed plant parts included stems, leaves, shoot tips and bark of the different browsed species. Because of the deciduous nature of the bulk of the vegetation in the conservancy, there were few plants with leaves during the dry season and browsing preference was made for stems and branch tips. Only in the case of small herbs were all plant parts eaten. In general rhinos ate the same parts of particular plant species during both early dry and late dry periods.

Diet diversity and richness

The Shannon species diversity index H' (In) for the diet of black rhinos was higher during the early dry season (3.812) as compared to the late dry season (3.413), giving an approximate 6-% diversity difference between the two seasons (Table 3). The number of cuts per station can be considered an approximate measure of the amount eaten on particular plants.

Table 3: An analysis of food plant data for black rhinoceros in the MBRC during the early and late dry seasons.

Parameter.	*Early Dry Season*	*Late Dry Season*
Species richness	34	27
Simpsons diversity index	0.86	0.87
Shannon's (H') diversity index (based on cuts)	3.81	3.41
Number of stations	78	53
Number of equally common species (n=34, n =27)	14.05	10.66

The number of cuts/bites counted on single species was apparently equal to the number of stems eaten. However, for other species like *Lantana camara*, *Grewia flavescens*, *Acacia nilotica*, *Rhus tenuinervis* and the bulk of the herbs a different pattern was noticed. These species were extensively browsed by the black rhinoceros such that the number of cuts remaining was less than the number of stems eaten.

Principal species

Principal species were considered to be those that contributed ≥ 5-% to the black rhino diet in all vegetation types in terms of the number of bites. Seven principal species were identified in the MBRC (Table 4). These contributed 69.4 and 81.6% of the browse in the early and late dry season respectively.

Table 4: Early and late season variation in principal species contribution to the black rhinoceros diet in the MBRC.

Species	*Percentage contribution (%)*	
	Early Dry Season	*Late Dry Season*
Acacia nilotica	10.17	24.4
Acacia karoo	2.9	14
Dichrostachys cinerea	7.5	8.5
Ziziphus mucronata	2.7	8.2
Lantana camara	32.9	0
Gardenia volkensii	5.7	12.7
Rhus tenuinervis	7.3	13.7

Acacia nilotica, *Gardenia volkensii*, *Dichrostachys cinerea*, and *Rhus tenuinervis* showed seasonal fluctuations above 5 % while other species like *Acacia karoo*, *Lantana camara* and *Ziziphus mucronata* were principal species in only one season (Table 4). *L. camara* was the most favoured species in the early dry season whilst *A. nilotica* was the favorite in the late dry season. Statistical analysis however showed that there were significant differences in percentage contributions by the seven principle species between the early and late dry season (t= 0.363, p = 0.001)

Proportional usage (Pu)

The proportional usage of the 10 commonly eaten plant species was different during the early dry and late dry seasons (Figure 3 and 4). *L. camara* had the highest (Pu) value during the early dry season (Figure 3), while *Gymnosporium senegalensis, Grewia monticola*, *Ziziphus mucronata* and *A nilotica* had (Pu) values less than 0.05.

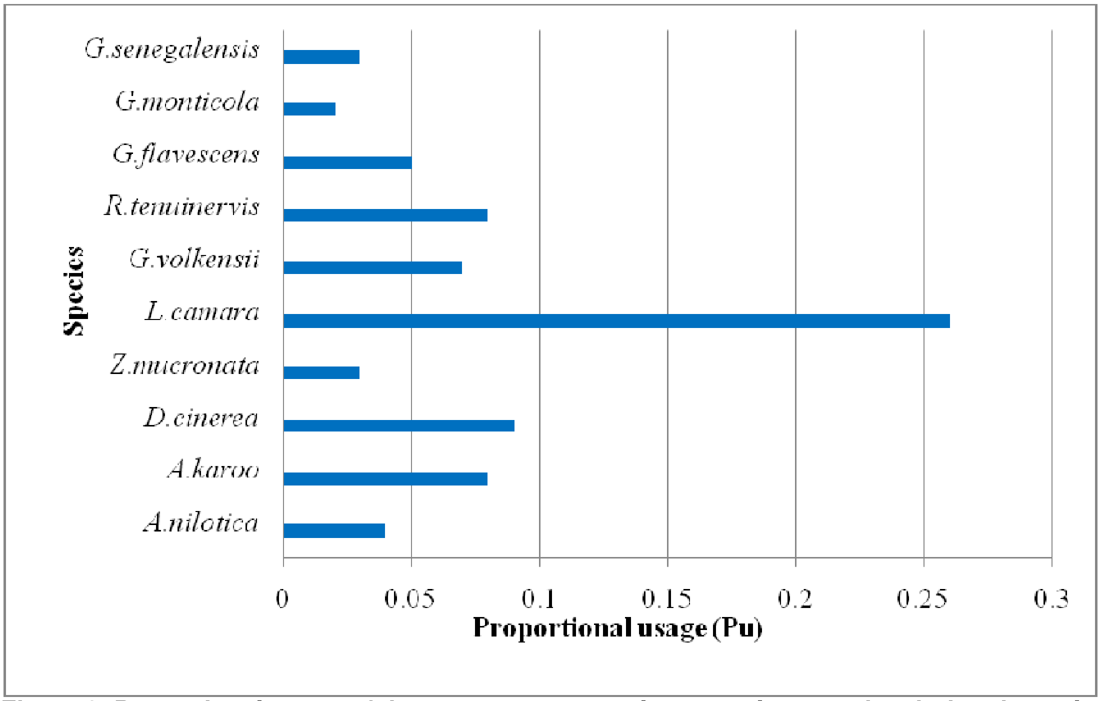

Figure 3: Proportional usage of the ten most commonly eaten plant species during the early dry season.

During the late dry season *Acacia nilotica* had the highest (Pu) value (0.24), while *Lantana camara* had the least Pu value of (0.00) (Figure 4). *G. senegalensis*, *G. monticola* and *G. flavescens* had Pu values less than 0.05. On the overall, there were no significant changes in the Pus between the two time periods of the dry season ($t = 0.0508$, $p > 0.05$).

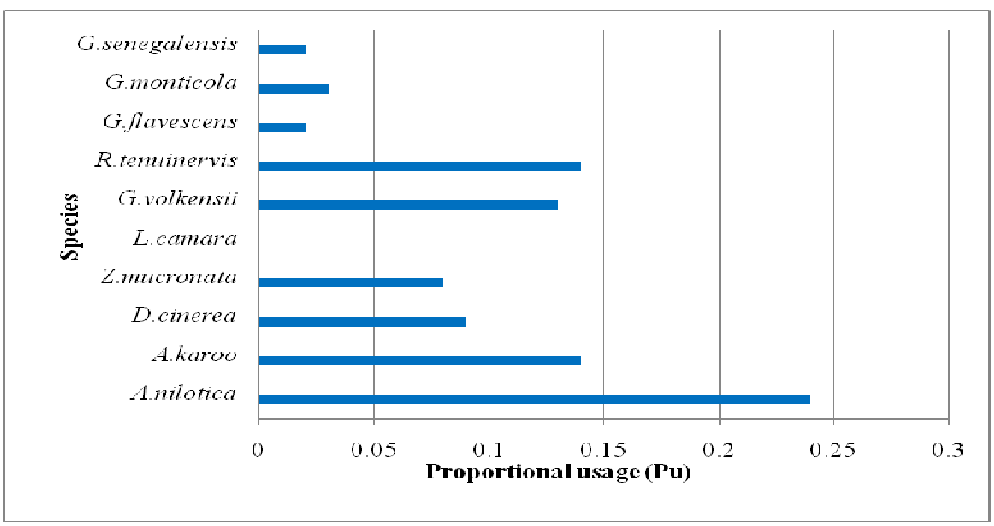

Figure 4: Proportional usage of the ten most commonly eaten plant species during the late dry Season

Proportional availability (Pa)

The most available species were those that recorded proportional availability indices greater than or equal to 0.1. The ten species showed seasonal variation in availability with fluctuating availability indices across the two time periods. *L. camara* recorded the highest availability index (0.26) during the early dry season, but the least index (0.0) during the late dry season (Figure 5). On the other hand, during the late dry season, *A nilotica* had the highest availability index (0.24). A. *karoo*, *D. cinerea*, *G. volkensii* and *R. tenuinervis* were relatively consistent in their availability status during both the early dry and late dry seasons with availability indices ranging from 0.8 to 0.14. *G. flavescens, G. monticola*, and *G. senegalensis* were hardly available for the browsing rhinos across all seasons recording availability indices fluctuating between 0.02 and 0.05 (Figure 5).

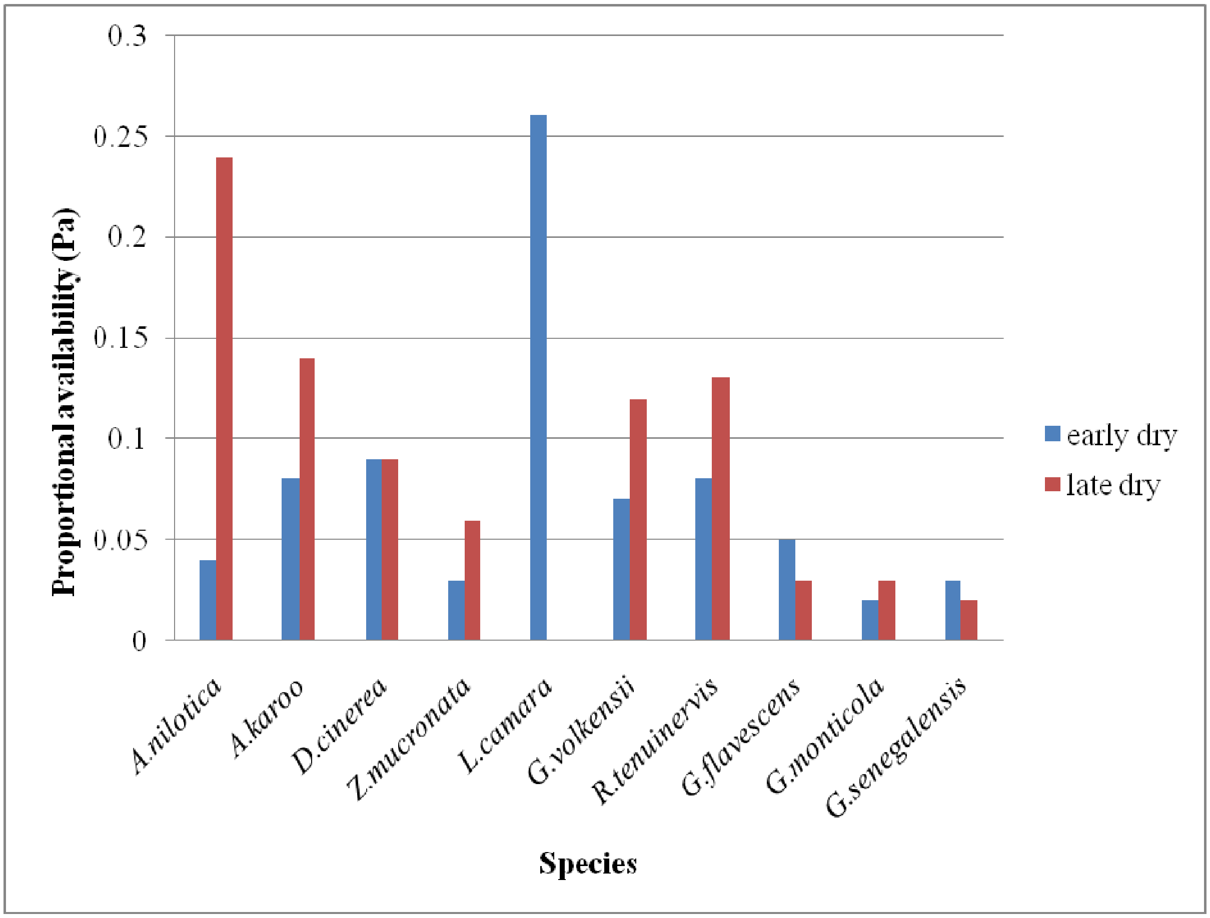

Figure 5: Seasonal variation in proportional availability of the ten most commonly browsed plant species in the MBRC.

Food preference indices (FPI)

The food preference index (FPI) for each of the ten most commonly browsed plant species in the MBRC are shown in Table 5 below.

Table 5: Food Preference Indices (FPI) for the ten commonly browsed plant species in the MBRC

Plant species	*Food Preference Index (FPI)* Early dry season	Late dry season
A. nilotica	2.5	1
A. karoo	0.37	1
D. cinerea	0.89	1
Z. mucronata	1	1.33
L. camara	1.27	0
G. volkensii	0.86	1.08
R. tenuinervis	0.88	1.08
G. flavescens	0.8	0.67
G. senegalensis	1	1
G. monticola	1	1

Whilst the early dry season was marked by a few more favoured species like *Acacia nilotica, Lantana camara and Ziziphus mucronata, Gymnosporium senegalensis and Grewia monticola,* the late dry season preference shifted so that there was a general equal preference for all the ten most browsed species with the exception of *L camara* which was over-ally rejected (no evidence of it being eaten) as food item. However, a general comparison of the two time periods showed that there were no marked differences in food preferences between the two time periods of the dry season (t= 0.674, p > 0.05).

Browsing stratification

There were no differences in the height preference for browsing between the early and the late dry season. Across all vegetation types, more than 68.7-% of the bites were taken from vegetation that was less than 1.5 m in height, and only 31.3-% of the bites were taken from vegetation that was > 1.5m in height in the early dry and late dry season respectively (Table 6).

Table 6: **Number of bites by the black rhinoceros in five different height (metres) categories in the five major vegetation types in the MBRC. n = number of bites.**

Vegetation	*0-0.5*		*0.51-1.0*		*1.01-1.5*		*1.51-2.0*		*>2*	
type	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Acacia	343	7.4	852	18.4	2366	51	588	12.7	488	10.5
Miombo	80	12.6	153	24.3	244	38.7	127	20.1	28	4.4
Terminalia	49	11.6	91	21.5	219	51.8	39	9.2	25	5.9
Mopani	0	0	75	12.7	241	40.8	107	18.1	167	28.3
Riverine acaia	252	9.6	194	7.4	968	36.7	673	25.6	544	20.7

No discreet (2.0 – 2.5m) category was used in this study but the number of bites above 2m was quantified. The acacia woodland recorded the highest number of bites with total of 4636 bites in all height categories, contributing 52-% of all bites recorded in both seasons. Riverine acacia recorded 2631 bites, contributing 29.5-% of all the bites. The black rhinos in the MBRC did not adjust habitat usage according to season. The study revealed that *Mopani*, *Terminalia* and *Miombo* woodlands are not favourite browsing areas for the black rhino as the bites of these vegetation types contributed 6.6-%, 4.7-% and 7.1-% respectively.

The black rhinos also showed similar patterns of browse height preference between the early dry and late dry seasons. The browse category (1.01 – 1.5m) recorded the peak number of bites in both seasons (Figure 6). The number of bites in this height category was however greater during the late dry season as compared to the early dry season.

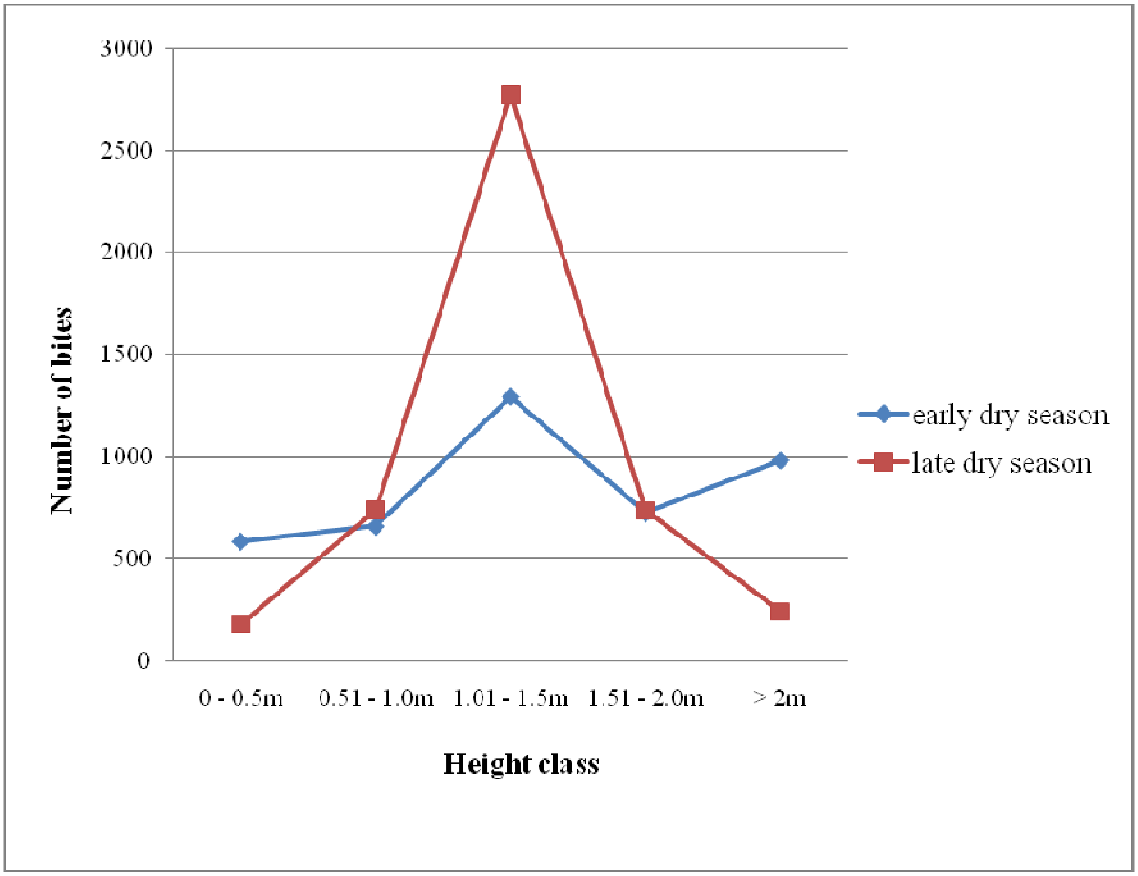

Figure 6: Seasonal trends in browsing height preference by the black rhinoceros in MBRC.

Relationship between browse height and number of bites

A weak positive linear relationship was observed between browsed height and number of bites (browse volume) (21.8%) R^2 = 0.2182 during the early dry season, whilst there was no relationship at all between the two variables in the late dry season (R^2 of 0.0003 (0%)).

DISCUSSION

Diet composition and diversity

Black rhinoceros are browsers with broad diets wherever they have been studied in Southern Africa (Buk and Knight, 2010). The 34 plant species from 16 families identified for the MBRC falls slightly below the ranges of studies in other Southern African National Parks such as Augrabies Falls National Park (51 species), Karoo National Park (53 species) and Valbos National Park (41 species) (Buk and Knight, 2010). Other investigators like Oloo *et al.*, (1994) have reported even broader diets. In their studies of the rhinos of Ol Ari Nyiro Range, Laikipia in Kenya, they noted at least 103 plant species from at least 37 families. All of these lists are probably incomplete because black rhinos apparently have the ability to eat a wide variety of plants at least in small quantities (Goddard, 1968). The relatively down side of the species list obtained in this study can be attributed to two reasons; first, it is possible that the habitat itself is not rich in the plants and thus not all the species normally fed upon by the rhino are found in this conservancy or that the time period for the study in itself excluded some of the plants eaten by the rhino as they were not in leaf. The availability of particular food plants can affect the movement of black rhinos for example, the scattered *Strychnos spinosa* trees, although making up a small proportion of the black rhino diet (0.4-%) were occasionally sought after for their fruit. Frequently rhino tracks led straight to individual *Strychnos spinosa* trees over considerable distances. Oloo *et al.,* (1994) observed a similar pattern in Ol Ari Nyiro Ranch in Kenya where black rhinos travelled long distances to *Euphorbia candelabrum* trees.

The choice of food plant genera in MBRC showed similarities with other study sites. Acacia species were principal and preferred food plants in Karoo and Valbos National Parks, South Africa (Buk and Knight, 2010). Acacia species were also important black rhino food plants in Itala-South Africa, Masai Mara-Kenya, and Nairobi-Kenya (Kotze and Zacharias, 1993; Mukinya, 1977; Muya and Oguge, 2000). There were slight differences although not significant in the species composition of the black rhino diet in the MBRC between the early dry and late dry seasons. There are several possible explanations for the slight seasonal differences. Firstly, some food plants were only available during the early dry season but absent in the late dry season. These include *Lantana camara*, *Linnea discolor*, *Flacourtia indica* and *Indigofera setiflora.* Secondly, as more favoured plant species become less available during the late dry season, rhinos may shift to less palatable species. Thirdly, some species may provide key resources during critical times such as succulents during drought. Plants also differed in their relative availability between the early dry and late dry seasons. The black rhinos ate different parts of the same plants during the different dry season periods. During the relatively wet early dry season, nutrients are translocated to the roots and bark. This may explain the tendency for rhinos to eat the bark of *Combretum apiculatum* and *Combretum imberbe* during the early dry season.

The contribution of deciduous trees might also have contributed to the slight variation observed across the two extremes of the dry season. It appears that the black rhinoceros favoured browsing on deciduous plants during the late dry season when they had started to make new leaves. This was particularly noticed on *Acacia nilotica* that became the dominant principal species during the late dry season. The low occurrence of herbs in the black rhino diet during the late dry season is also another factor that might have introduced the slight variation observed in browse species composition between the early dry and late dry seasons.

Contrary to the diet diversification hypothesis (Muya and Oguge, 2000) in MBRC. the black rhinoceros diet was less diverse than both available and eaten browse. Instead of diversifying their diet to deal with dietary and possible chemical defence constraints, the black rhinos concentrated their feeding on a few species. *Lantana camara*, *Acacia nilotica* and *Dichrostachys cinerea* contributed a cumulative 50.5-% of bite volumes during the early dry season, while *Acacia nilotica*, *Rhus tenuinervis* and *Acacia karoo* contributed a cumulative 52.1-% of the bite volumes during the late dry season. The complete absence of grass in the recorded diet could have resulted from the shortcoming of the backtracking method applied in this study, which ideally should be performed in conjunction with faecal analysis (van Liverloo *et al.,* 2009).

Browsing intensity

Black rhinos in the MBRC have a significantly restricted diet with a preference for a few principal species. The most common potential competitors of the black rhinoceros in the Midlands Black Rhino Conservancy are the kudu *(Tragelaphus scriptus)*, and the giraffe *(Giraffa camelopardalis*). Diet overlap with these other browsers could further reduce the capacity of the vegetation to sustain the browser population through the dry season (De Boer and Ijdema, 2007). In the MBRC browsing intensity of the black rhinos on the vegetation as a whole was relatively low but reached much higher levels on the eaten browse species.

Browse availability

The importance of food availability to animal populations depends on, among other factors the extent to which the animals can exploit it for their growth. Since availability is an important factor in utilisation, the rhino is expected to select widely available browse of high quality. The study showed that browsing intensity on particular species increased with a corresponding increase in availability. *Lantana camara, Rhus tenuinervis*, *Dichrostachys cinerea*, *Acacia karoo* and *Gardenia volkensii* recorded (Pa) values greater than 0.05 during the early dry season and also contributed a significant amount of browse volumes during the same period. Similarly, the upsurge in *Acacia nilotica* availability during the late dry season attracted a consequent increase in browse volume contribution of the species.

Browse preference

The study showed that *Lantana camara*, *Acacia nilotica*, *Ziziphus mucronata*, *Gymnosporium senegalensis* and *Grewia monticola* had the highest preference indices during the early dry season. The preference index of *Lantana camara* fell from 1.27 during the early dry season to 0.0 during the late dry season, due to its unavailability during the late dry season. The species had completely desiccated during the late dry season and was avoided by the foraging black rhinos.

Several of the food plant species were so highly preferred that they could be labelled "ice cream species" a few species especially *Grewia flavescens* even appeared to be under "snack attack"- being subjected to unsustainable browsing and being driven towards local extinction. Buk *et al.,* (2010) also revealed that several of the food plant species were so highly preferred in Augrabies Falls National Park, these included *Tetragona arbuscula* and *Plexipus garipensis* which were subjected to unsustainable browsing. Other plant species may have been over utilised by black rhinos locally within the MBRC or in combination with other browsers. This could apply to species like *Rhus tenuinervis*.

The preference index based on bite volumes divided by plant numbers along feeding paths applied in this study suffers from a number of limitations. Firstly the plant composition along the feeding path already reflects habitat and micro habitat selection by the foraging rhino rendering this frequently used method inherently flawed. Secondly, measures are essentially mismatched in this method as browse availability is measured in plant numbers and feeding is measured in plant volume. However, only recording the number of plants eaten gives an inaccurate measure of both feeding and availability. Nevertheless, it is a widely employed method due to its speed and ease of use.

Browsing stratification

No discreet 2.0 – 2.5m category was used in this study but the number of bites above 2m was quantified. The data presented in table 6 shows browse stratification in the black rhino diet in the MBRC. The information can be used for future comparisons of the number of bites in each height category. As the number of black rhinoceros increase in the area, it may be that the intensity of browsing on the vegetation will also increase. Increasing browsing intensity may translate to lower availability of browse in the lower height categories and such changes may be valuable in revealing possible stress in the population.

The highest impact on all the ten most commonly eaten species occurred in the 1.01 – 1.5m height class. This applied to both the early dry and late dry seasons with the height category contributing browse peaks at 59.8% in the early dry season and 79% in the late dry season. This finding conforms to studies by Buk (2004), who assessed the contribution of browse to the diet of black rhino in 20cm height intervals on *Acacia mellifera* plants that were > 2m in height and found that the preferred feeding height range was 1.01-1.5m and that 97% of all browse was below 2m.

Species with smaller growth forms were more frequent among the highly preferred plant species and a larger percentage of each individual was consumed in a feeding incident. The implication is that smaller plant species especially nutritious and/or evergreen ones are more vulnerable and prone to overutilization by the black rhinoceros despite being below the preferred feeding height. This was observed in species like *Rhus tenuinervis* and *Balanites maughamii* which exhibited shrub like growth forms. Du Toit (1990) further notes that the situation is further exacerbated by smaller plants being browsed by all sizes of browsers.

CONCLUSION

In conclusion, it can be said that the study has shown that diet selection is correlated with plant availability and that there is no significant difference in diet selection of the MBRC black rhinos between the early dry and late dry seasons. The study also identified key dry season plant species for the black rhino in the MBRC and a few species severely affected by unsustainable black rhino browsing; this finding has further shown that there is significant dependence of the rhino diet on specific plant species during the dry season. The abundance of key plant species should be monitored to act as early warning signals of food limitation and to protect preferred plant species against localised extinction.

Although none of the food plant species recorded in the diet of the MBRC black rhinos has a threatened conservation status, there is need to monitor principal plants in the black rhino diet across all seasons. For sustainable rhino conservation, canopy volumes of the seven principal species which are all preferred by the black rhinoceros in the conservancy should be monitored annually. Although there appears to be no shortage of staple rhino food plants in the conservancy, the distribution and seasonal use of particular food plants should be considered in future management of these rhinos. The movement of rhinos off the conservancy boundaries into vulnerable areas in times of drought and influence that food shortage may have on these movements are of critical importance to the future of black rhinos in the MBRC. During the (2005-2008) period many rhinos were poached as they wandered off the confines of the conservancy in search for food (Zimuto pers comm). Due to the reductions in rhino numbers in the conservancy, this wandering in search for food may not be a problem at present, with rhinos occupying only three South Western properties of the conservancy which constitute a small portion of the conservancy. But if continued successful protection of the population and breeding success leads to a larger population, these animals might be under increased pressure to wander in search of sufficient food particularly during drought seasons. The management may wish to consider providing dry season food around waterholes such as lucerne and salt licks. This could act as lures to reduce the tendency for rhinos to leave the conservancy during drought and could also serve to concentrate the rhino population within the safer areas of the conservancy.

The ability of the various browse species to respond to browsing has important implications for the condition of vegetation in the MBRC in the long term. Preferred species that have a high productivity will be more valuable than preferred species of low productivity because productive species provide more forage and should be more resilient to browsing pressure. It will also be especially important to determine the productivity of those species contributing the most acceptable browse units to a vegetation type. To further the understanding and management of plant browser interactions there is need to periodically collect data on browse availability, browse growth rates and browser competition in different settings. The information of the black rhino diet in the MBRC will be of greater value if corresponding information is obtained on the diet and feeding behaviour of the kudu *(Tragelaphus scriptus)*, and the giraffe *(Giraffa camelopardalis*) which are some of the most abundant browsers in the conservancy. This will reveal areas of dietary overlaps and therefore competition that would influence the management of the rhino population.

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