Browse preference of captive black rhinos at Chipangali Wildlife Orphanage, Zimbabwe

Mduduzi Ndlovu[1] and Peter J. Mundy[2]

[1]Percy FitzPatrick Institute of African Ornithology, University of Cape Town, Rondebosch 7701, South Africa; email: mduduzi.ndlovu@uct.ac.za

[2] Department of Forest Resources and Wildlife Management, National University of Science and Technology, Private Bag AC 969, Bulawayo, Zimbabwe; email: pmundy@nust.ac.zw

Abstract

Captive black rhinos (*Diceros bicornis*) were offered five species of woody plant in 'cafeteria' trials, for the animals to show any dietary preferences. Six out of seven rhinos were mother-reared, half of them wild born the others captive born. The seventh rhino was hand-reared and this one consumed significantly less browse than did the mother-reared animals. *Combretum hereroense*, *Acacia nilotica* and *Albizia amara* were significantly more preferred than *Acacia karroo* and *Peltophorum africanum*. The last named had the highest tannin levels, soluble insoluble, and fibre-bound, which probably accounted for its low preference. No correlations were found between browse preference and crude protein, calcium and sodium.

Résumé

On a donné aux rhinocéros noirs captifs (*Diceros bicornis*) cinq espèces de plantes ligneuses dans des essais de 'cafétéria', pour que les animaux manifestent toutes leurs préférences diététiques. Six rhinocéros sur sept avaient été élevés par leurs mères, la moitié d'entre eux étaient nés sauvages et les autres étaient nés en captivité. Le septième rhinocéros avait été élevé par les humains; celui-ci broutait considérablement moins que les animaux élevés par leurs mères. Les rhinos montraient des préférences significatives pour le *Combretum hereroense*, l'*Acacia nilotica* et l'*Albizia amara* par rapport à l'*Acacia karroo* et le *Peltophorum africanum*. Ce dernier avait des niveaux plus élevés de tanin, soluble, insoluble, et lié par des fibres ce qui a probablement expliqué sa faible préférence. On n'a trouvé aucune corrélation entre la préférence du broutage et les protéines brutes, le calcium et le sodium.

Introduction

The improvement on the current knowledge of the feeding ecology of the black rhino (*Diceros bicornis*) has been identified by the IUCN African Rhino Specialist Group (AfRSG) as one of the priorities for successful conservation of the African black rhino both in captivity and in the wild (Emslie and Brooks 1999). Many researchers have conducted studies on black rhinos' feeding ecology (Goddard 1970; Joubert and Eloff 1971; Mukinya 1977; Emslie and Adcock 1994; Ausland et al. 2001; Matipano 2003) but there is no literature on assessing browse preference through actual quantification of browse consumed and from direct observations. The documentation available on browse preference in the wild is all from circumstantial evidence based on knowledge by skilled trackers (Goddard 1970; Loutit et al. 1987; Matipano 2003; Ganqa et al. 2005).

Most of these studies have focused exclusively on the species that comprise the diet and very few studies have analysed the nutritional composition of the species eaten by the black rhinos (Atkinson et al. 1995; Dierenfeld et al. 1995; Graffam et al. 1998; Muya and Oguge 2000). Therefore nutritional factors influencing the browse preference of captive black rhinos are still not well understood.

The objectives of the study were to determine the browse preference of captive black rhinos, the nutritional quality of browse offered, and to investigate any difference in browse preference according to the way the rhinos have been reared.

The hypothesis tested for the study was one based on herbivore nutrition. It predicts that black rhinos like most browsers will prefer plants with low levels of tannins. Soluble tannins lower the nutritive value of browse by toxic effects on the animal or through enzyme inhibition and substrate binding in the digestive tract (Shipley 1999). Condensed tannins, on the other hand, are unpalatable and inhibit fermentation by symbiotic micro-organisms in the herbivore digestive tract (Clauss 2006). The alternative hypothesis predicts that black rhinos optimize energy intake regardless of plant tannin levels since they have a physiological adaptation to minimize the effects of tannins. Therefore tannins will not affect their browse preference significantly but positive nutritional factors like low fibre and crude protein will be important.

Materials and Methods

Study area

Fieldwork was conducted during the dry season (September–October 2005) at Chipangali Wildlife Orphanage (20º 08'S, 28° 36'E), situated 25 km southeast of Bulawayo, Zimbabwe. Comprising 150 hectares of undulating ground with typical granite sand and acacia woodland, it is a semi-arid region on the highveld, 1435 m above sea level, with an average summer rainfall of 600–625 mm. The common woody species found within the Chipangali property include *Acacia karroo*, *Acacia nilotica*, *Albizia amara*, *Combretum hereroense*, *Combretum zeyheri*, *Diplorhynchus condylocarpon* and *Peltophorum africanum*.

Research animals

During the 1980s poaching activities escalated in southern Africa. In 1988 the Zimbabwe Department of National Parks, as part of the effort to preserve the black rhinos in the country, translocated four young rhinos from the wild to Chipangali Wildlife Orphanage for captive breeding purposes (DNPWLM 1997). Two came from the Zambezi Valley and the other two from Hwange National Park. The bull from Hwange has since died. There are in addition four surviving offspring: one bull, two cows, and one female calf.

All seven black rhinos are kept in separate closed *bomas* (large wood fenced cages), and are never let out to browse freely. Cut browse and commercial game cubes are brought into the bomas for feeding. The rhinos are fed three times a day. Cut browse is given in the morning (0900 h) and late in the afternoon (1700 h). At midday each rhino is given approximately 5 kg of concentrated game cubes. During the dry months, June to mid-October when green browse is scarce, ordinary dry grass and Bhana grass (*Pennisetum purpureteum*) is fed to supplement the browse. Fresh borehole water is pumped daily into troughs for drinking.

The rhinos were classified into three categories, which were:

i. Wild born and mother-reared (n = 3). 15–18 years old
ii. Captive born and mother-reared (n = 3). 7–9 years old
iii. Captive born and hand-reared (n = 1). 10 years old.

Since the third category had only one animal it was considered an outlier and therefore data analysis was centred on the first two categories.

'Cafeteria' trials were carried out to determine actual masses of browse consumed. Preference was then reported from mean wet mass values of browse consumed. The trials were done in the mornings (0800–1000 h) on five separate days. Due to limited time and the financial cost, only five browse species were selected for this research. These woody species were the most abundant on the property, frequently fed to the black rhinos, and hence already an important part of their daily diet. The species selected were *Acacia karroo*, *Acacia nilotica*, *Albizia amara*, *Combretum hereroense* and *Peltophorum africanum*. Each browse species weighed 5 kg (± 0.005 kg) wet mass, and had a maximum branch diameter of 10 mm which also was the average maximum diameter that all the rhinos seemed able to chew. At a single trial, individual rhinos were fed a mixture of all five browse species totalling a wet mass of 25 kg (± 0.025 kg). Remnants were collected after two hours, identified and weighed again. The wet mass of the browse consumed was calculated by substitution. Five replications of the mix were conducted for each individual animal.

Plant samples were randomly taken from the same trees from which branches for the trials were obtained, and during the same period that trials were conducted. From each plant species sample, twigs containing leaves, pods and flowers (if present) were collected, rinsed and oven dried at 60º C for 96 hours. They were then ground into a powder that passed through a 2 mm sieve.

Chemical analysis and extraction methods were used, respectively, to appraise the browse nutritional quality and tannin status of the powdered samples. All chemical analyses were carried out according to methods and procedures prescribed by the Association of Official Analytical Chemists (AOAC 1990). Parameters measured were levels of calcium, sodium, crude protein, neutral detergent fibre, soluble tannins, insoluble tannins and fibre-bound tannins. All chemical mean concentrations and levels were determined on a dry matter basis. Chemical analyses of the browse were carried out at Matopos Research Station and at the National University of Science and Technology laboratories.

Parametric tests were used for analysing the raw data obtained from the cafeteria trials. Since the third category comprised only one rhino, it was decided not to include it in the statistical analyses. A two-sample t-test was used to test for significant differences in mean masses of browse consumed by the two rhino categories. A one-way analysis of variance (ANOVA) was used to compare browse preference within the rhino categories. Pearson's correlation test was used to test for associations of browse parameters with preference. *Acacia karroo* was excluded from this test since it was suspected that its thorns influenced rhino preference more than did its browse quality. Hypotheses were tested at the 5% level of significance.

Results

Browse preference

The amounts of browse consumed, and the differences between means, by the rhinos in Category 1 (wild born and mother-reared) and Category 2 (captive born and mother-reared), are presented in Table 1. The wild born rhinos consumed rather more browse on average than did the captive born animals. Preference was determined from the mean masses of browse consumed. *Ac. nilotica*, *Al. amara* and *C. hereroense* were highly preferred (av.. 3.45 kg each), while *Ac. karroo* and *P. africanum* were the least preferred browse species (av.. 0.96 kg each).

Hand-reared rhino

The captive born, hand-reared rhino had a much lower overall browse intake than both categories of mother-reared rhinos (Table 3). It showed a markedly lower preference for *Ac. nilotica* and *P. africanum* as compared to category 1 and category 2 rhinos. Like all other rhinos, it also had a high preference for *C. hereroense* and *Al. amara*.

Table 1. Differences in mean browse consumed between categories of rhinos

Species	Category 1		Category 2		Significant
	Mean (kg)	s.e.	Mean (kg)	s.e.	difference
Acacia karroo	1.270[a]	0.15	0.513[ac]	0.18	*
Acacia nilotica	3.180[b]	0.44	3.557[b]	0.15	ns
Albizia amara	3.493[b]	0.19	3.183[b]	0.12	ns
Combretum hereroense	4.090[b]	0.15	3.223[bd]	0.11	***
Peltophorum africanum	1.190[a]	0.11	0.873[a]	0.05	ns
Total	13.223		11.349		

Levels of significance: *, P<0.05; ***, P<0.001; ns, P>0.05 by two-sample t-test. Means with common superscripts do not differ (P>0.05). s.e.: standard error.

Captive born rhinos consumed less of *Ac. karroo* (P<0.05) and *C. hereroece* (P<0.001) as compared to wild born rhinos. There was no significant difference (P>0.05) in preference for *Ac. nilotica*, *Al. amara* and *P. africanum*. After combining the wild born and captive born categories, the six rhinos had an overall significantly low preference for *Ac. karroo* and *P. africanum*, compared to the other three (P<0.001) (Table 2).

Chemical composition

Table 4 shows the chemical analyses of all the seven measured components. *P. africanum* had the lowest amount of crude protein, at one half of that for *Ac. karroo*. *Ac. nilotica* contained the lowest amount of neutral detergent fibre, at about one third of that for *Al. amara*. *C. hereroense* had the highest levels of calcium and sodium, at 50% higher than the species with the lowest. No single species was consistently the highest in these four constituents. *P. africanum* had very high levels of soluble tannins, insoluble tannins and fibre-bound tannins, nearly four times more than the next highest; it recorded a low preference by the rhinos (Table 2). *Ac. nilotica*, that was highly preferred (Table 2), had the lowest amounts of these tannins.

Table 2. Browse preference for six rhinos (in two categories) combined across all browse species

Species	Category 1 and 2 combined	
	Mean (kg)	s.e.
Acacia karroo	0.925[a]	0.14
Acacia nilotica	3.368[b]	0.23
Albizia amara	3.338[b]	0.11
Combretum hereroense	3.657[b]	0.12
Peltophorum africanum	1.032[a]	0.07

[a] is significantly less than [b], P<0.001, by one-way ANOVA. Column means with common superscripts do not differ (P>0.05). s.e.: standard error.

Table 3. Browse preference of the captive hand-reared rhino across all browse species

Species	Hand-reared rhino	
	Mean (kg)	s.e.
Acacia karroo	0.370a	0.07
Acacia nilotica	1.310b	0.38
Albizia amara	2.780c	0.17
Combretum hereroense	3.100c	0.14
Peltophorum africanum	0.040a	0.04
Total	7.600	

Overall significance is P<0.001, by one-way ANOVA. Column means with common superscripts do not differ (P>0.05). s.e.: standard error.

Correlations of browse preference with chemical compositions

Table 5 shows that soluble and insoluble tannins were significantly inversely correlated (P<0.05) to browse preference. The fibre-bound tannins were strongly positively correlated to soluble tannins and insoluble tannins. Insoluble tannins were also strongly positively correlated to soluble tannins. No nutritional factors (excluding tannins) showed any significant (P<0.05) correlation to browse preference. However, there was a suggestion of a positive correlation with crude protein, calcium and sodium, while fibre-bound tannins and neutral detergent fibre suggested an inverse correlation, although none was significant.

Table 4. Concentrations of calcium, sodium, crude protein (CP), neutral detergent fibre (NDF), soluble tannins, insoluble tannins and fibre-bound tannins

Species	Ca µg/g	Na µg/g	CP %	NDF %	Soluble tannins $Au.A_{550}$/g of sample	Insoluble tannins $Au.A_{550}$/mg of residue	Fibre-bound tannins $Au.A_{550}$/mg of NDF
Acacia karroo	7.945	0.91	18.63	38.22	1.600	0.082	0.043
Acacia nilotica	8.704	0.73	14.07	18.66	1.010	0.019	0.007
Albizia amara	9.800	0.71	15.27	53.63	1.078	0.053	0.102
Combretum hereroense	10.137	1.02	11.35	27.74	2.455	0.066	0.096
Peltophorum africanum	9.031	0.68	9.04	46.32	8.521	0.275	0.366

$au.A_{550}$, absorbance units at wavelength 550 nm.

Table 5. Pearson's pair-wise correlation test for browse preference and chemical compositions

Parameters	Calcium	CP	NDF	Soluble	Insoluble	Fibre-bound	Sodium
CP	Ns (+)						
NDF	Ns (+)	ns (-)					
Soluble tannins	Ns (-)	ns (-)	ns (+)				
Insoluble tannins	Ns (-)	ns (-)	ns (+)	0.992**			
Fibre-bound tannins	Ns (-)	ns (-)	ns (+)	0.969*	0.961**		
Sodium	Ns (+)	ns (-)	ns (-)	ns (-)	ns (-)	ns (-)	
Preference	Ns (+)	ns (+)	ns (-)	-0.954*	-0.965*	ns (-)	ns (+)

Levels of significance: **, P<0.01; ns, P>0.05; (+), positive; (-), negative. *Acacia karroo* was excluded.

Discussion

Captive animals present an opportunity for quantitative research that may prove dangerous and impossible to carry out in the wild. There, is however, the problem of a small sample size in terms of animal numbers, and hence it is difficult to extrapolate results from captivity research to wild populations. The seven rhinos used in this study were the only rhinos in Zimbabwe that were in captivity at the time of the study.

The amount of food consumed is dependent on the mass of the animal (McDonald et al. 1982). In this study it was not possible to measure the rhinos' masses prior to feeding trials. It was therefore assumed that the rhinos' food intake was similar. The effect of age difference was difficult to tease out from the findings.

The findings of this research suggest that there is a difference in browse preference according to a rhino's upbringing, i.e. mother-reared or hand-reared. The captive born, mother-reared rhinos had a browse preference similar to that of their wild born counterparts, probably because the captive born, mother-reared rhinos had copied their mother's browse preference when they were young.

The hand-reared rhino ate less of natural browse as compared to the other rhinos. It differed from the rest because it never got the opportunity to copy browse preference from its wild mother. This rhino was occasionally observed to reject browse and become agitated unless it was presented with some sweet food (molasses, orange, bread, concentrate game cubes, etc). It also had a high preference for Gemsbok bean (*Tylosema esculentum*), a non-woody plant that was rejected by all mother-reared rhinos. Such behaviour may also mean that this rhino is unlikely to survive on natural browse if it was released in the wild. The results of the study suggest that browse preference is a learned behaviour. Therefore where possible, hand-rearing of rhinos below the age of six months should be avoided to ensure that the neonate gets the opportunity to 'copy' browse preferences from its mother.

Browse preference was inversely correlated to soluble and insoluble tannins (Table 5). The captive rhinos select browse with a minimum of tannin content. These results are in agreement with previous observations made by Hall-Martin et al. (1982) and Loutit et al. (1987). The presence of high levels of tannins in *P. africanum* reduced its nutritional value as a browse species (Table 4) and therefore made it less palatable (Tables 2 and 3).

Positive nutritional factors such as crude protein, calcium, sodium and fibre levels were not as important. In fact, the positive association of tannins with NDF means that rhinos are likely to prefer browse with less NDF in an effort to avoid tannins and also to increase digestibility. These findings agree in relative terms with McDonald et al. (1982), who stated that energy and protein requirements per unit weight decline with increasing size, so that larger species can survive on lower quality food, although they have to eat more of it, in that rhinos, compared to smaller herbivores, can eat browse with high NDF compared to smaller herbivores. They disagree, however, in that overall these rhinos are still selecting browse while trying to minimize their NDF intake.

Ac. karroo was less preferred regardless of its high levels of protein and low tannins (Table 4). This could have been due to the presence of long tough thorns on most of its tender browsable branches, which may have made it difficult for the rhinos to consume it. On the other hand, *Ac. nilotica* that had similar chemical compositions to *Ac. karroo* (Table 4) was highly preferred by all the mother-reared rhinos (Table 2), although the hand-reared rhino had a lower preference for *Ac. nilotica* (Table 3).

Another factor that could have favoured the rhinos' preference for *Ac. nilotica* was the presence of ripe pods during the dry season. *Ac. karroo* had no pods at that time. Personal observation revealed that rhinos, like other browsers, enjoy browsing on ripe pods.

The sampled browse contained calcium and protein concentrations that would meet dietary recommendations for domestic equids, and may be nutritionally adequate for the browsing black rhino (Dierenfeld 1996).

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