Black Rhino Nutrition: An Overview

Ellen S. Dierenfeld, PhD
Wildlife Conservation Society, Bronx, NY

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Summary

Several implications for formulating better captive diets for black rhinos, based on data presented here include:

1) the strong possibility that mixed grass:legume hay, rather than alfalfa exclusively, provides a better substitute forage for black rhinos. Insoluble fiber, soluble carbohydrates, and fatty acid composition all seem more suitable in mixed forages.

2) energy sources, including simple sugars and fats, should be considered of primary importance in rhino diets. Attention to the fatty acid content of diets, especially essential fatty acids, is necessary.

3) mineral status, particularly of oxidizing minerals Fe, Cu, and Se, as well as Ca, P, and Na, should be particularly singled out for comparison between captive and free-ranging animals.

4) tissue levels of some of the fat-soluble vitamins are questionable; we need comparative normals from free-ranging animals if possible. Quite likely, â-carotene should replace vitamin A in prepared diets to more duplicate natural physiology of this browsing herbivore.

Introduction

This summary of black rhinoceros nutrition is based on comparative data from field and zoo studies. While many field studies exist describing plants consumed by, and feeding habits of, black rhinos, few have included chemical analyses. Although we can rarely duplicate actual ingredients of an animal's natural diet in managed feeding programs, we can duplicate nutrients in our attempt to properly satisfy physiological requirements of any species. Thus diet description focuses on plant chemistry information gleaned from samples collected in four African countries: Kenya (Mukinya, 1977; Ghebremeskel et al., 1991), Namibia (Joubert & Eloff, 1971; Loutit et al., 1987), South Africa (Hall-Martin et al., 1982), and Zimbabwe (Dierenfeld et al., 1994). Physiological responses to diets have been measured almost exclusively in zoo rhinoceros; combining these two data sets may help us better understand feeding management of the rhinoceros.

Digestive Physiology

With an average body mass of > 1000 kg, rhinos spend > 1/3 of day (and much of night) eating, consuming up to 2.5% of body mass daily. Zoo studies quantified hay intake of black rhinos at 1.1% or 1.6% of body mass (14 and 21 kg for grass and alfalfa hay, respectively; Foose, 1982), whereas animals consuming natural browses ate up to 30 kg (2.5% of body mass; Goddard, 1968). Mean retention of ingesta ranged from 50 to about 60 hr (Foose, 1982).

Both digestion and fermentation processes supply energy needs of the rhionoceros. The rhino stomach, containing high concentrations of lactate and low levels of volatile fatty acids (VFA), is a primary digestion site of soluble dietary carbohydrates (CHO = sugars), and fats (Maloiy & Clemens, 1991). Additionally, dietary energy is available from the fermentation of structural CHO including hemicellulose and unlignified cellulose throughout the cecum and colon, which comprise 73% of gut capacity. VFA ratios in the hindgut of rhinos are similar to those found in the rumen, indicating similar microbial populations and fermentation processes (Maloiy & Clemens, 1991). Due to similarities in digestive tract morphology, horses should probably be considered the best model for nutritional requirements of rhinoceros until more specific data are compiled.

Carbohydrates - Fiber & Soluble Sugars

Unfortunately, differing analytical techniques between studies make direct comparison impossible in some instances, but for the few studies that exist where both cellulose (24-36%, 19-38%) and lignin (8-14%, 6-21%) values are found (South African and Zimbabwean browses, respectively), numbers are quite comparable. Furthermore, the cellulose that is found is highly lignified, thus fairly indigestible. Black rhinos eat diets of variable crude fiber levels (35-48% in South African browses, n=7 spp; 4-41% in Kenyan food plants).

Nonetheless, it is clear from these limited data that while rhino browses contain more lignified tissue in cell wall constituents than either legume (alfalfa) or grass diate hemicellulose level, which may provide a ready source of carbohydrate energy (see Figure 1). Thus a mixed grass:legume forage may, in fact, better represent a forage substitute than either hay fed separately for the black rhino. Zoo studies have shown that while cellulose in alfalfa compared with grass hay is better digested by rhinos (54 vs. 43%; Foose, 1982), little or no difference in hemicellulose digestibility was seen (48% for alfalfa, 47% for timothy; Foose, 1982). Perhaps the 5-carbon sugars of hemicellulose represent a better energy source for this species than other carbohydrates.

Black rhinos in zoos digested 43% of timothy diets, and 65% of alfalfa-based diets (Foose, 1982). Overall, alfalfa hay may be too digestible for black rhinos, compared with a calculated 50% digestibility of natural forages (based on lignin ratio, Hall-Martin et al., 1982).

The soluble sugar content of grass (25% of dry matter) compared to alfalfa (11%) hay differs considerably (Van Soest, 1982), which may also be important for the browsing black rhino, but has not been investigated in detail.

Protein

The crude protein content of rhino browse plants (n=54 spp.) is variable and seasonal (4 to 20% of dry matter), but in general is not as high as seen in many alfalfa hays -- again, mixed grass: legume may better duplicate dietary protein levels found in nature.

Lipids

The crude fat content of rhino browses (2 to 24%) is considerably higher than found in most captive, dry diets -- 2-3%, and may, in fact be the single most important nutrient group for this species. Predominant fatty acids in rhino browses include palm-

continued on Page 11

continued from Page 10

itic (26% by wt) linoleic (16% by wt) and linolenic (21% by wt) (Ghebremeskel et al., 1991), the latter two essential fatty acids not synthesized in the body. These values provide guidelines for substitute diet development. Palmitic acid, a saturated fat, has beenshown to stabilize erythrocyte membranes in primates, and may function similarly in the rhino. Studies of tissue fatty acid content in black rhinos are needed.

Comparing the fatty acid content of grass vs. legume hays vs. rhino browses, once again it appears that a mix of the two might provide the most suitable substitute forage. Stearic and oleic acids, lacking in forages compared to browse, may be provided by grains typically used in manufactured, pelleted diets.

Lipogenesis in rhinos, as in other non-ruminants, probably relies heavily on glucose as a main substrate preferentially through the pentose phosphate shunt. If energy is limiting from imbalanced carbohydrate sources, lipogenesis could be impacted in rhinos. Furthermore, fat appears to be a major dietary constitutent in rhino browses; if not provided or synthesized, fat could most certainly be a main nutrient category to be considered in improvement of black rhino diets.

Minerals

Macromineral and trace element ranges in native rhino browses fall into general ranges for horse requirements (Table 1). Sodium (Na) may be limiting in native browses, but can be readily obtained in natural salt licks. Phosphorus (P) appears to be limiting in natural rhino browses. Se and Zn status in zoo black rhinos have been suggested to be marginal based on blood samples (n=4; Ghebremeskel et al., 1991), and browses may contain low levels of these nutrients.

Vitamins A & E

Plasma vitamin A (retinol) levels in free-ranging black rhinos are 10-fold lower than those seen in most other mammalian species, averaging 0.04±0.01 to 0.06±0.03 ìg/ml (n=100 animals from 4 locations). Values in zoo rhinos are somewhat higher (0.10±0.10 ìg/ml, n=99). If free-ranging values are to be considered normal for black rhinos, zoo animals may be showing possible vitamin A excess. Quite likely, â-carotene should replace vitamin A in prepared diets of black rhinos to more duplicate natural physiology of this browsing herbivore; â-carotene status of rhinoceros remains to be investigated.

Tissue retinol levels measured in zoo black rhinos (ìg/g wet weight) average 83.6±46.4 (liver, n=13), 0.14±0.04 (skeletal muscle, n=11), 0.2±0.05 (heart, n=11) and 0.54±0.24 (adipose, n=8), and do not differ from those of other rhino species. No comparative values from free-ranging animals are currently available.

Plasma vitamin E levels in free-ranging rhinos have been shown to differ among locations, ranging from 0.23±0.07 ìg/ml in Kenya (n=7) to 0.80±0.05 in Namibia (n=3). Most animals (n=129 from South Africa and Zimbabwe) average about 0.6 ìg/ml. Handling protocols for all samples need to be verified for direct comparison, and more Kenyan animal samples have been requested for analysis. By comparison, zoo black rhinos (n=112) average 0.61±0.73 ìg/ml á-tocopherol, and have shown signifivitamin E across species, yet means are still 4- to 10-fold lower compared with other herbivores, probably due to a lack of carrier lipoproteins in rhinoceros.

Vitamin E levels in browses eaten by black rhinos have been measured at about 50-200 mg/kg dry matter, and provide guidelines for captive diet recommendations (Ghebremeskel et al, 1991; Dierenfeld, 1990; Dierenfeld et al., 1994).

Tissue vitamin E levels have been quantified from 9 black rhinos; in general, liver levels are substantially higher (16.3±6.0 ìg/g), and adipose tissue levels lower (4.9 ìg/g), than domestic horse normals (5 and 25 ìg/g, respectively). Normal tissue values of á-tocopherol in domestic horses do not appear to be good comparative indicators for tissue vitamin E status in rhinoceros, perhaps due to difference in fat storage and metabolism between the temperate-evolved horse and tropical rhino. Values in free-ranging rhinos have not been measured, but may be essential to understand optimal captive animal nutrition. It is possible that forms and/or amounts of these nutrients are being supplied in excess of animal requirements, leading to liver and/or other tissue stasis.

Several implications for formulating better captive diets and future research thrusts for investigating nutrition of the black rhino include:

- the use of mixed grass:legume forages in managed feeding programs to balance soluble and insoluble carbohydrates

- supplementation of proper energy sources, including simple sugars and essential fatty acids

- examination of mineral status, particularly of oxidizing minerals Fe, Cu, and Se. As well, Ca, P, and Na should be singled out for comparison between captive and free-ranging animals

- measurement of tissue levels of some of the fat-soluble nutrients including fatty acids and ß-carotene

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continued on Page 12

continued from Page 11

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Table 1. Macromineral (n=42 spp.) and trace element (n=39 spp.) concentrations in browses eaten by black rhinoceros compared wtih nutrient requirements for horses (NRC, 1989).

	Macromineral (%)			Trace Element (mg/kg)	
	Rhino	Horse		Rhino	Horse
Ca	0.7-6.1	0.3-0.6	Cu	3.0-16.1	10
K	0.3-2.0	0.3-.4	Fe	29-215	5
Mg	0.1-0.9	0.1	Mn	4.0-269	40
Na	0.001-0.65	0.1	Se[1]	0.02-0.04	0.1
P	0.05-0.26	0.2-0.3	Zn	2.5-96.3	40

Data sources: Dierenfeld et al., 1994; Ghebremeskel et al, 1991; Joubert & Eloff, 1971; NRC, 1989.
[1](n=10)

FIGURE 1. CELL WALL CONSTITUTENTS IN FORAGES CONSUMED BY RHINOS (VAN SOEST, 1982;DIERENFELD ET AL, 1994).