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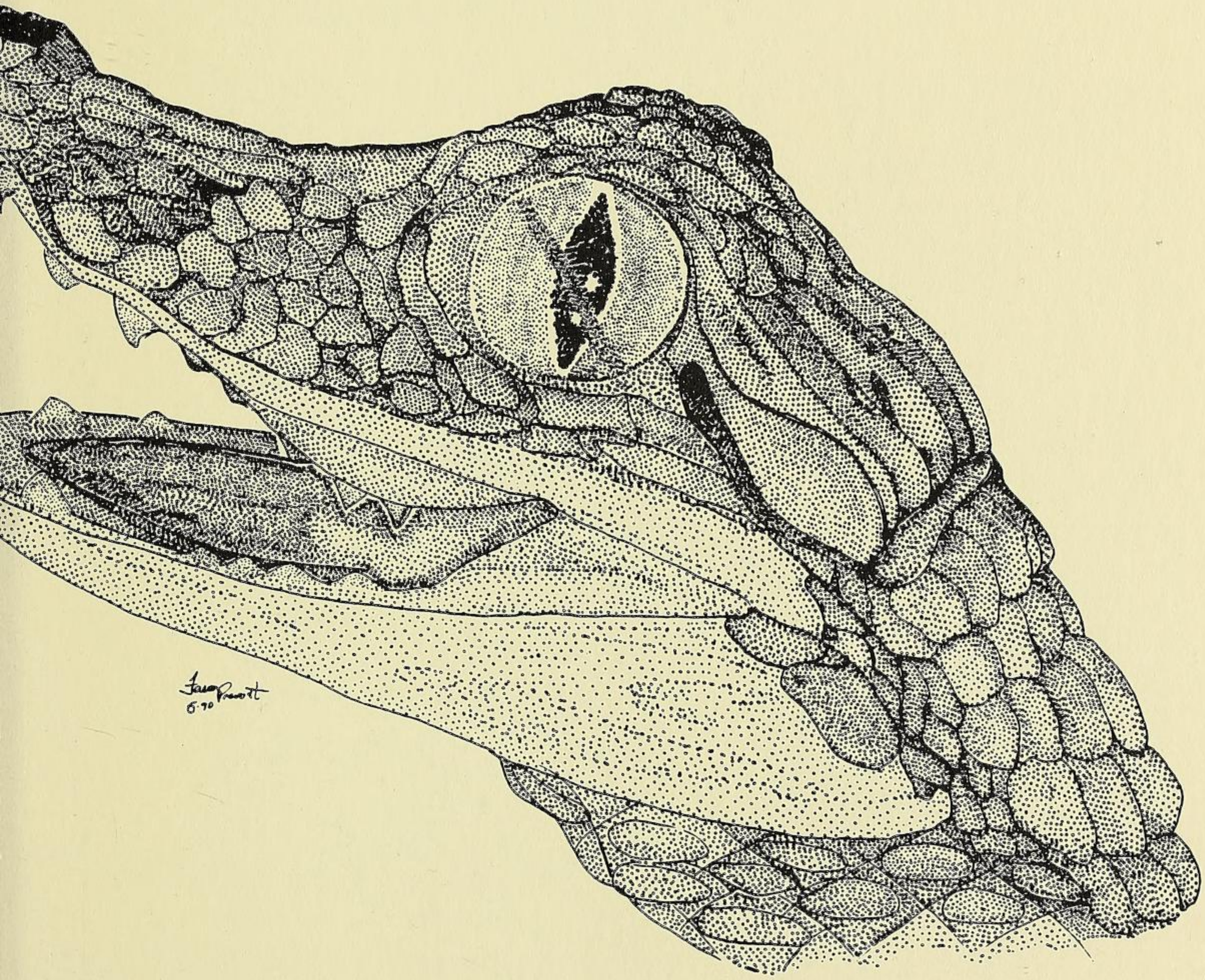

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Black Rhinoceros
(Diceros bicornis)
Nutrition

By
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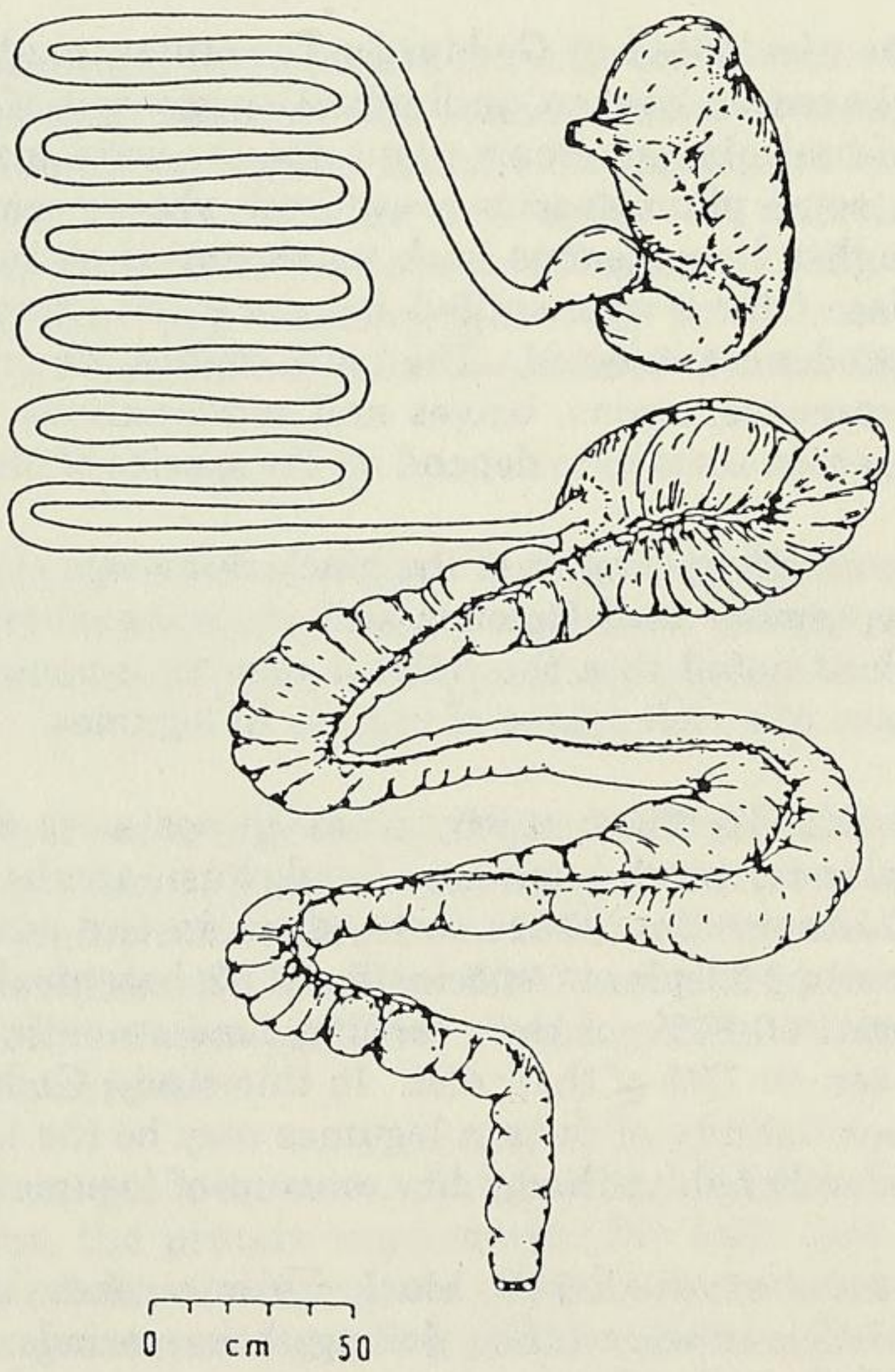
The black rhinoceros (*Diceros bicornis*) has adapted to a very selective diet consisting of browse. In captivity, replicating this diet would be costly. In addition, North American species of browse may have a different nutrient make-up, thus resulting in an unbalanced diet. By reviewing the literature on the rhino's digestive anatomy and physiology, wild diets, and present captive diets, guidelines can be established for captive diets.

Digestive Anatomy and Physiology

The black rhinoceros' upper lip is a prehensile appendage which wraps around feedstuff and draws it into the mouth (Ritchie, 1963). The mouth contains twenty-eight, low crowned, browsing cheek teeth (premolar 4/4, molar 3/3) which are efficient at grinding fibrous feedstuff (Nelson and Fowler, 1986).

The gastrointestinal tract, described by Clemens and Maloiy, 1982, consists of the cranial and caudal halves of the stomach, three equal segments of the small intestine, the caecum, and five segments of the colon (Figure 1). The stomach is generally non-compartmentalized with the cranial one-half to two-thirds comprised of stratified squamous tissue and the caudal portion is glandular epithelium (Cave and Aumonier, 1963). Although the stomach appears structurally non-compartmentalized, differences in pH, sodium, potassium, and osmolality suggest less mixing of ingesta. The data on volatile fatty acid and lactic acid indicate it as a site of bacterial activity with rapid fermentation (Clemens and Maloiy, 1982).

Figure 1. Gastrointestinal tract of a rhinoceros.
Clemens and Maloiy (1982)



Although the stomach is a site of bacterial activity, the caecum is the principal site of fermentation. Caecal fermentation is indicated by high levels of volatile fatty acids. A high acetate to propionate ratio shows that the rate of fermentation is slow (Clemens and Maloiy, 1982).

The colon is also a fermentation site. This is indicated by the presence of 53 to 80 mmoles/1 volatile fatty acid concentrations. The bacterial activity is less than in the caecum and greater than in the stomach (Clemens and Maloiy, 1982).

To summarize, the prehensile feeding style of the black rhinoceros enables it to be selective. The black rhino relies on enteric microbes for fermentation and degradation of fiberous materials. The major sites of fermentation are the caecum and, to a lesser extent, the colon. The structural characteristics and physiological properties of the gastrointestinal tract are similar to that of the pony and donkey (Argenzio and Stevens, 1975; Maloiy and Clemens, 1980).

Wild Diet

Three food preference studies were done on black rhinos in their native habitat. Two studies were authored by John Goddard. The first study was in northern Tanzania from 1964 to 1966 (Goddard, 1968). The second study was in Tsavo National Park, Kenya from 1967 to 1969 (Goddard, 1970). John Mukinya (1977) undertook the third study in the Masai Mara Game Reserve, Kenya from May 1971 to August 1972.

In Goddard's Tanzanian study, two different black rhino populations were studied in six habitat types (plains-Ngorongoro, shrub, marsh, forest, plains-Olduval, and gorge). A total of 307 observation hours were taken in two seasons (wet: Nov.-Apr.; and dry: May-Oct.). Black rhinos were observed eating 191 plant species from 48 botanical families. Of the wide variety of ingested plants, legumes made up between 25-70% of the total diet in all six habitats. Green and succulent herbs were preferred throughout the year, but several herb dominants appeared to be unpalatable in large quantities. On the other hand, green succulent legumes appeared to be highly palatable. Grass was rejected except in the wet season.

It was also noted in Goddard's Tanzanian study that the selectiveness of the black rhino was based on season, individual specimens of certain plant species, and select parts of individual plants. Some plant species were more available in one season than in others. Also, some plant species grew fresh shoots seasonally. Goddard observed rhinos feeding through a homogenous herb patch and they selected only certain specimens of the same species. Others were sniffed, but not eaten. Some specimens that appeared identical to ones accepted were rejected. The black rhinos ate only certain parts of many of the plants (e.g. inflorescence, stems, leaves and combinations of all three, or tips of shoots). The exact parts eaten seemed to depend on the species of plant.

The coprophagus habit of the black rhino was observed on eight different occasions, but only in September and October and in areas where legumes were extremely sparse or dry. Goddard noted that the habitat may be a means of obtaining nitrogenous material in the absence of a rich source of protein in legumes.

In Goddard's Tsavo study, black rhinos were observed in six habitats (grasslands, bush-grasslands, scrub-bush-grassland, bush-scrub, bush-grassland, bush-woodland). A total of 70 observation hours were taken in two seasons (wet: Dec.-May and dry: June-Nov.). They ate 102 plants species from 32 botanical families. The black rhinos concentrated between 60-80% of their feeding time on eating herbs and scrubs. Legumes consisted of between 40-75% of their diet. In this study, Goddard postulated that the relative abundance and availability of certain legumes may be the key to an optimum black rhino habitat. The grasslands habitat had a low amount of legumes and thus it had lower carrying capacity.

Mukinya studied 108 black rhinoceroses in Masai Mara Game Reserve, Kenya. Observations were taken during three periods: May-Sep. 1971 (wet - semi-dry), Oct.-Feb.

1971-72 (dry), and Feb.-May 1972 (wet - semi-dry). During 240 observation hours in thirteen distribution areas, black rhinos ate seventy plant species from thirty botanical families. In all areas, they were selective for herbs (up to 41% in wet - semi-dry season) and young trees (up to 69% in dry season).

Mukinya observed that the black rhinos fed during two peak periods, between 7:30 - 12:00 hours and between 14:00 and 19:00 hours. They drank water primarily at night. They visited salt holes on six occasions during the day and twice at night. Analytical tests done on these salt holes found them to contain magnesium, sodium, potassium, and calcium.

In conclusion, due to its selective feeding habits, the protein content of the wild black rhino's diet is probably high. Jones (1979) suggests levels near 10-25% of the dry weight, thus allowing for seasonal variations. The black rhino forages during two day periods and drinks water primarily at night. At least during the dry period, when the food quality of plants is low, it will supplement its diet with salts. Also, in areas where legumes are sparse, dry and/or sterile, it may recycle nitrogens by consuming dung.

Captive Diets

Captive dietary information was found in the published Black Rhinoceros Survey (Maruska, 1986), which involved 47 facilities from the U.S.A. and other countries. Although the diets were varied in the types of feedstuff and the amounts fed, there are many similarities in overall dietary make-up. Eighty-eight percent of 45 facilities that specified crude protein content used a complete feed or grain mixture of 14% or higher. Of the 32 facilities that specified type of hay, 31% used alfalfa hay, 47% used alfalfa mixed with other types, and 9% used grass hay. In addition to concentrates and hay, produce was added by 77% of 44 facilities. Twenty-nine facilities offered trace mineral salt either free choice or supplemented in the diet (up to 1.5 pounds per week). Eighteen supplemented their diets with vitamins and nine (not in Africa) indicated that they fed browse regularly. Browse made up to 20% of the total "as fed" weight at two institutions. The types of browse used were Hutsache brush, Acacia, Phicus, Witstinkwood, Willow, Oak and various deciduous trees.

Discussion

In setting up dietary guidelines from the literature, three factors must be considered. First, although there are differences in gastrointestinal anatomy and feeding habits in a natural ecological setting, most wild species, like domestics, require specific nutrients, not specific feedstuff (Ullrey, 1980). Secondly, one must consider the order of nutritional requirements: water > energy > protein > mineral and vitamins (Clemens, 1985). The third factor is that the status of the animal (e.g working, growing, third trimester pregnancy, lactating, or non-productive adult) determines nutritional need (Hintz, 1977).

Guidelines

1. Water - In the wild, black rhinos primarily drink at night. In captivity, fresh water should be provided at all times. The wild diet contains mostly succulent plants with a moisture content of up to 90% as compared to a captive diet with a moisture content as low as 20%.

2. Energy - The estimated daily requirement of net energy for a 5,000 to 7,000 pound rhino is twenty-four to thirty-two mega calories (Rohweder, 1980) or about twelve to thirteen calories per kilogram of body weight per day for maintenance (Wallach, 1983). Black rhinos in late pregnancy, in lactation, or weaning should receive less than 50% more energy over the maintenance requirement. Due to their fermentation abilities, a good quality alfalfa hay should meet the energy requirement for maintenance.

3. Protein - Although the browsing black rhinoceros consumes forage with a higher protein content than the grazing white rhinoceros, the protein requirement for both species is probably the same when the total nitrogen intake over a 24-hour period is considered. The black rhinos daily food capacity is not as great as its grazing relative (Jones, 1979). If given excessive protein, black rhinos may be subjected to excessive hoof growth, laminitis, and/or abnormal hoof growth.

Table 1. General Mammal Vitamin and Mineral Requirements (Ullrey and Allen, 1986)

Type	Requirement			
vitamin A	2,000	to	10,000 IU/kg diet	
vitamin D	200	to	1,000 IU/kg diet	
vitamin E	15	to	100 IU/kg diet	
vitamin K	(if vitamin K antagonist is present, 2 to 5 mg Menadione/kg diet)			
thiamine	1/2	to	3mg/kg diet	
riboflavin	2	to	4mg/kg diet	
pantothenic acid	10	to	20mg/kg diet	
niacin	10	to	30mg/kg diet	
vitamin B_6	1	to	2mg/kg diet	
biotin	100	to	300µg/kg diet	
vitamin B_{12}	5	to	25µg/kg diet	
choline	200	to	1000mg/kg diet	
vitamin C	(if not synthesized 50 to 100mg/kg diet)			
calcium	0.20	to	2.75 % of diet	
phosphorus	0.10	to	0.80 % of diet	
magnesium	0.04	to	0.20 % of diet	
sodium	0.08	to	0.30 % of diet	
chlorine	0.10	to	0.30 % of diet	
potassium	0.20	to	0.80 % of diet	
sulfur	(wool producer dietary nitrogen-sulfur ratio no greater than 10:1 and non-wool producers no greater than 12 to 15:1)			
iron	40	to	100	ppm
copper	5	to	10	ppm non-ruminant
iodine	1	to	10	ppm ruminant
	0.05	to	0.15	ppm growth
	0.2	to	1.0	ppm reproduction
cobalt			0.1	ppm ruminant
zinc	40	to	80	ppm
magnesium	less than 10			ppm
selenoium	0.05	to	0.03	ppm

Table 2. Required protein content of concentrate when feeding legume hay or grass hay (percent). (Hintz, 1977).

Status	Legume Hay	Grass Hay
weanlings	14 - 16	18 - 20
growing	12 - 14	15 - 18
maintenance	8 - 10	8 - 10
gestation	10 - 12	12 - 14
lactation	12 - 14	15 - 18

The dietary protein requirements for a mature animal for maintenance ranges from 8 to 10%. Levels of 11 to 12% are required for the last third of a pregnancy and levels of 13 to 15% for growth and lactation (Hintz, 1977).

4. Vitamins and Minerals - The dietary requirements for mammals are generalized in Table I. In addition, Jones (1979) reported that the plasma of captive rhinos often contains moderate levels of carotene but almost no vitamin A. Injection of vitamin A and oral doses of vitamin C appear to improve a number of cases of dermal lesions, indicating either the rhinos do not receive sufficient amounts of vitamin A or they cannot utilize commercial forms of the vitamin. Also, rhinos may not be able to make vitamin C (Jones, 1979).

It should also be noted that the nutrient requirement for older animals is reversed, which places a greater importance on vitamins and minerals.

5. The selection of feedstuff - The selection of hay should be made on price versus efficiency. Rhinos fed diets containing either legume hay or grass hay have produced offspring. Legume hays are generally higher in protein, vitamins, and minerals, which requires less supplementation. Grass hays are lower in protein and minerals, and higher in fiber. In periods when legume hay prices are high, grass hay could supplement or replace alfalfa if additional supplements are cost effective. The selection of a concentrated feed should be based on two factors: animal condition and type of hay (see Table 2).

A good quality hay and concentrated feed should contain sufficient amounts of vitamins and most minerals. If there is concern about usable vitamin A levels, carrots, kale and/or sweet potatoes can be added. Special attention should be given to calcium and phosphorus levels when a cow is lactating. Trace mineral salt should be free-choice or added to a diet to insure mineral levels.

Browse can be very therapeutic and should be added to the diet. Caution should be taken to avoid creating an imbalance by feeding large amounts or by the side effects of secondary plant products.

Conclusion

By reviewing the literature about other species' digestive anatomy and physiology, wild diets and present captive diets, similar guidelines could be set up to examine and improve their captive diets.

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Dedication and Acknowledgement

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