WILDLIFE NUTRITION AND FEEDING

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In their natural environment wild species have little need for supplementary feeding as their free ranging habits enable them to pursue more nutritious grazing and therefore satisfy their requirements. With the advent of game forming wild animals have been confined to limited areas and this has necessitated some form of supplementary feeding. In the case of zoo animals their total feed requirements have to be met.

With the exception of zebra, elephants, rhinoceroses, hippopotamuses, bushpigs and warthogs, the larger herbivorous game are classified as ruminants. Game species would (in the habitat to which they are adapted) select a diet with a digestibility in accordance with their feeding habits and are thus classified accordingly (Hofmann (1973):

- bulk and roughage eaters (grazers) characterized by capacious stomachs normally filled to capacity with relatively low-quality feed composed mostly of grass;

- selectors of juicy, concentrated herbage (browsers) characterized by small stomachs normally filled to only 50-60% of their capacity, but with concentrated food composed mostly of leaves, flowers and fruits of forbs, shrubs and trees;

- intermediate feeders (herbivores that eat both grass and leaves) which are not strictly intermediate between the previous two groups but have the ability to adapt in different seasons and places towards one or the other of the above two feeding types, i.e. they have greater ability to tolerate variations in the quality of their diet.

These three groups will probably select diets with an approximate digestibility percentage of 55, 75 and 65 respectively. Ostriches would select a diet of 55 percent digestibility. Poor natural pasture such as winter grazing has a digestibility of about 45-50%, i.e. a digestible energy content (DE) of 45-50%. Good pasture as in the rainy season has a bE% of 60-65 and even higher, while artificial (grass-legume) pasture could have a bE% of 70.

The above classification is based on feeding strategy of common South African ruminants. Mentis (1981) proposed a more refined classification which include non-ruminants and indicate relative potential for defoliation and selective defoliation (Table 1). Bulk grazers are defined as large, essentially grazing animals which normally do not excercise a high degree of selection. Concentrate grazers are generally small animals (less than 200 kg mean individual liveweight) which are predominantly grazers. However, they may include any grazing animal which excercises some or other form of extreme selective defoliation (white rhino - area selection). Browsers are animals which feed mostly on the leaves, flowers and fruits of woody plants and forbs.

Nutrient Requirements

Studies of wildlife energy transactions have been popular since the early 1950's because of the recognition that the animal is often intimately coupled to its environment via energy flow and must ultimately balance its energy ledger. The nutritionist is often required to estimate energy and protein requirements of wildlife as a prelude to estimating necessary food intake. For the captive animal in which the ingested food can be easily measured, changes in tissue balance relative to feed intake can be used to estimate requirements for many whole body processes. Intake per animal is often expressed as a function of body weight and provides a means for extrapolating or comparing the results to other animals of the same or differing species.

Additional productive requirements can be determined by feeding at differing levels and measuring the rate (milk production) or success (reproduction) of the specific process being examined. Therefore the requirements can be estimated by a direct feeding trial approach, although such estimates may be applicable only to the conditions in which the measurement occurred. The use of captive animal feeding trials to estimate the requirements of the free-ranging animal poses many philosophical questions. For example, the maintenance energy requirements of captive animals are often below what might be expected under free-ranging conditions since activity and thermoregulatory requirements may be minimized. Free-ranging wild and domestic ungulates may expend 25-100% more energy than confined animals (Holleman et al., 1979). The expenditure by wild herbivores may be even higher in heavily grazed areas requiring extensive food searching activities, in areas where disturbance by human beings or predators is extensive, or in severe continental climates requiring an increased thermoregulatory expenditure. Due to the number of different biotic and abiotic variables affecting the animal's daily existence, the complexity of predicting requirements can be formidable.

A useful approach when formulating diets for wild animals is to consider dietary habits in the wild, oral and gastrointestinal morphology and physiology, needs of similar species whose requirements are known, and environmental features that affect energy and nutrient need. Collection of information on natural food preference provides an indication as to nutrient intakes and whether the diets are high or low in protein, fibre or secondry plant metabolites which may influence acceptability, digestibility or metabolism. Oral anatomy and gastrointestinal tract morphology have a high correlation with natural diet. The presence of a ruminoreticulum suggests that qualitive nutrient requirements are similar to those of cattle and sheep, with significant syntheses of amino acids and B-vitamins. If the gut has a cecum and sacculated colon, capacious enough to support microbial fermentation, nutrient needs are likly to be similar to those of the horse. A simple stomach with limited lower gut space for microbial activity is similar to that of the pig (Ullrey, 1988). Thus, one can extrapolate nutrient requirements from domestic species with known needs to wild species with known needs to wild species that are similar in dietary habits and gastrointestinal structure and function. The gastrointestinal tract (61T) contents of herbivores maintain some degree of consistancy over a wide range of bodyweights, they are approximately 10% of the bodyweight. Parra (1978) found that the logY (kg wet GIT contents) = 1.0763 logX (bodyweight kg) - 1.0289 (r2=0.99, n=33) and for fermentation contents logY = 1.0959 logX - 1.1188 (r2=99, n=28) for a range of ruminant and non-ruminant herbivores between 0.7 and 1400 kg. Van Soest (1982) confirmed this relationship with a slightly wider range of animals, including foregut-fermenters, which do not ruminate. It is clear that the smallest animals must select highly concentrated and digestible foods, their digestive capacity is comparable to that of larger species, but their nutritional demands per unit weight are much greater.

i) Energy

Brody (1945) derived the value for basal metabolism kcal per day = 70.5 kg BW°734. Kleiber (1961) states that the mean standard metabolic rate of mammals is 70 BW°35 kcal per day. The increment in energy consumption of an active animal over that of an individual at rest varies according to the physiological and reproductive status and level of activity of the animal and is influenced by external factors. Using the above relationship, one assumes that differences are only proportional to 0.75 of body mass and that once correlations are made, no dfferences remain. The implication is that food intake per unit metabolic mass would be the same for all animals within the same productive function, which is in conflict with other reported literature which indicate that food intake of wild ungulates of subtropical regions is less than that of domestic species of comparable size (Meissner, 1982).

Due to the lack basic nutritional research pertaining to the requirements of wild species, determinations have been based on observed growth data and knowledge of the composition of that growth, basal heat production, the efficiency of feed utilization for maintenance and growth and the actual nutritional niche of the animal (Meissner, 1982). With the aid of this data energy requirements for wild ungulates can be calculated (Table 2). The species shown include only those of which growth data were available. For other species it is recommended that the method of scaling for size by means of metabolic moss should be used.

Meissner (1982) does caution that this theoretical approach may not be biologically sound as certain assumptions had to be made, however, sound scientific judgement was applied and is therefore a step closer to meeting the energy requirements of wild species. Knowledge of the ability of the natural pasture to satisfy these determined requirements gives us a measuring stick whereby we can determine nutritional excess/shortfall in the pasture and thus apply supplemental feeding as is necessary, or as is the case with zoo animals the total energy requirement.

ii) Protein

The requirements for essential amino acids relative to necessary dietary intake are reduced or eliminated in ruminants, animals with active caecal fermentation and animals practising coprophagy. Amino acids are essential for body function, however, very few wildlife studies have examined amino acid composition or requirements. The lack of amino acid studies may became increasingly troublesome as wildlife management intensifies and as zoological gardens increase their use of processed diets. Nutritionists who work with domestic animals often express protein requirements as a percentage of the diet. However, free-ranging wildlife are often on varied diets because of range conditions, and the usable ratios of energy to protein may vary widely. Similarly, the animal may not be able to consume an unlimited food source. Dietary protein requirements for early growth in weanling mammals range from 33% for cats (Scott, 1968), 25% for mink, foxes and guinea pigs (NRC, 1968, 1978a), 19% for the rhesus monkey (NRC, 1978b) and 13-20% for white-tailed deer (Smith et al., 1975). Such estimates are not applicable to nursing animals dependent on their mother's milk since the protein content of milk dry matter often far exceeds these levels. The dietary protein requirements for maintenance of adult mammals range from 19-25% for adult carnivores to as low as 5.5-9% for wild ruminants (Halter et al., 1979).

Other protein requirements, such as for gestation and hair growth, would be intermediate to the requirements for rapid neonatal growth and adult maintenance. While such estimates are suitable for developing diets for captive wildlife, the nutritionist has a more complex and difficult problem in estimating protein requirements for free- ranging populations. Similarly, one must question whether a maximum growth rate imparts greater fitness than does a slightly reduced rate, because many authors have observed identical weights at maturity for captive animals on protein intakes below those suggested as the requirement. Very high growth rates of captive animals fed concentrate diets are increasingly associated with bone and tendon abnormalities (Seraf in, 1981). The ad libitum feed availability of most requirement studies using captive animals may exceed that available to the free-ranging animals and require an interplay between food quality and quantity.

Protein requirements for South African ungulates are based on extrapolations from domestic species and research obtained in the field.

Elephants - Research conducted in Zimbabwe by Wiliamson (1975) found that browse species eaten by elephants had crude protein concentrations ranging from 12 - 18%. Box and Sheldrick (1963) found that during the dry season in Kenya grasses contained 5 - 7% crude protein, but legumes and herbs eaten contained 10 - 12% crude protein. These observations, and extrapolation of information from studies of herbivores with postgastric fermentation, suggest that diets for elephants should contain nutrients similar to those used for the horse (Ulley, 1989). Elephants consume large quantities of fibrous feed and therefore the combination of hind-gut fermentation and rapid transit time results in poor digestive effiency. The most suitable hays would be mixes of grasses and legumes and during certain critical periods pellets designed to complement these hays should be fed at between 20 - 50% of dry matter intake.

Rhinoceros - Little information has been published on the white rhino, although the square lip indicates that it is primarily a grazer. It feeds largely on grasses such as Pennisetum, Panicum, Urochloa and bigiteria (Owen-Smith, 1975). The black rhino has a central upper lip projection that is prehensile and and serves the browsing habit of this species. Herbs and shrubs are highly favoured with a decided preference for So/anuin incanu,n, bichrostachys c/nero and Acacia species (Mukinya, 1977). Grasses were not consumed seperately but were occasionally in the same mouthful with herbs and shrubs. Hall-Martin et al., (1982) noted that 111 plant species were utilized in the Addo National Park. While browsing habit was predominant, herbs were less important than shrubs and succlents at ground level were higly used during the dry season. Loutit et al., (1987) observed in Namibia that crude protein concentrations of plant species eaten by black rhinos averaged betweeen 2-18% dry basis.

Hippopotamus - It is a nocturnal grazer that is rather non-selective in its dietary habits. It prefers short grass which it grips with its wide lips and tears off with a sideways or upward swing of the head. It has an enlarged, compartmentalized stomach that resembles the complex stomach of the ruminant, despite the fact that the hippo does not ruminate. Food consumption of the free ranging hippo is reported to be quite low 0.9 - 1.3% of body weight as dry material. Arman and Field, (1973) proposed that this indicated a longer retention time and a means of compensating for a slower fermentation rate than that found in ruminants. Scotcher et al., (1978) concluded that hippos are area selective grazers, preferring plant communities that offer a continous dispersion of grasses. There is little selection for species, although they may select a leafy grass in preference to one with a high stem:leaf ratio.

Giraffe - Natural dietary habits have been studied in Kenya, Uganda, Tanzania and South Africa (Ullrey, 1989). Giraffe feed mainly on taller shrubs, observations in Kenya revealed that 50% of giraffe browsing occured below 2m above the ground. This varied with season, 67% below 2m in the green season. In both seasons, trees and shrubs constituted over 90% of the plant types that were browsed. Mean crude protein concentrations ranged from 12 - 22% dry basis, while crude fibre levels ranged from 32 - 49%. In Tanzania plant part selection was shown for flushing shoots with high protein. Crude protein concentrations in diet dry matter ranged from 12 - 15% in the dry season to 14 -19% in the wet season. In South Africa Acacia karoo, Rhus undulata, Ziziphus mucronata and Asparagus laricinus were the plant species preferred. Leaves of decidous trees and shrubs were preferred in the wet season while those of evergreens (Rhus) dominated the dry season.

Concentrate selectors - This group of antelope generally choose tender, easily digestible plant parts. Suni and dikdik are amoungst the smallest of African ruminants. Suni digestion is charaterized by high rumen fermentation rate and rapid passage of digesta from the rumen. In captivity suni only consumed the leaves when offered lucern hay, and mean dry matter intake was 3.5% body weight (Hoppe, 1977). Apparent digestibility of diet dry matter, crude protein and crude fibre were 69, 77 and 52% respectively. Dikdik also only consumed the leaves when offered lucern hay, mean dry matter intake was 3.8% of body weight (Hoppe, 1977). During lactation, the dry matter intake increased by 50%. Apparent digestibility of the diet dry matter, crude protein and crude fibre were 68, 66 and 54% respectively. The grey duiker feeds on leaves, twigs, bark, young shoots, pods and fruits of many different plants (Baer, 1987). It rearly eats grass but may occasionally consume animal matter such as eggs, insects and small rodents or birds. Food selection in the wild is such that high fermentation rates in the rumen are supported, while relatively rapid digesta passage rate may explain the rather high fermentation rate in the caecum (Boomker, 1984). Conybeare (1975) found that kudu in Zimbabwe ate 32 shrub and tree species, 27 herb species and 10 grass species. Where shrubs, trees and herbs were predominant, browse predominated the diet, however, when scarce, grass was consumed in considerable amounts. Condensed tannins in browse appear to protect plant cell walls against microbial attack and to inhibit fermentation by symbiotic microorganisms in the herbivore digestive tract. Browse condensed tannin concentrations that were higher than 5% of dry matter in the wet season generally resulted in rejection by kudu (Owen-Smith, 1985). When other seasons were considered, certain unpalatable species became temporarily highly acceptable when new leaves emerged even though condensed tannin levels were just as high as in mature leaves (Cooper et al., 1988). Studies on bushbuck in South Africa emphasize the importance of browse, 83% of the diet, while grass and fungi were about 5% each (Ondendaal, 1983). The grey rhebok have been called grazers (Smithers, 1983), however, careful studies have revealed that they are mainly browsers (Beukes, 1988). Dicotyledonous shrubs and forbs comprised 96.9% of rumen contents while grasses and sedges comprised 2.7 and 0.4% respectively.

Bulk and Roughage eaters - The buffalo is primarily a grazer, but because their feeding behaviour is rather indiscriminate they may consume prostrate forbs and roots. The blue wildebeest are almost pure grazers, taking about 1 to 2% forbs during wet periods and almost none otherwise. They are very selective for grass leaves as opposed to sheath and stem (Lowaga, 1975). Gemsbok are predominantly

grass-eating ruminants that are adapted to extreme arid conditions without surface water. Rumino-reticulum contents of five gemsbok revealed that three had grass as 100% of dry matter, one had 99% grass and 1% dicotyledenous leaves, and one had 83% grass and 17% twigs (Giesecke and Van Galswyk, 1975). Waterbuck generally only eat perennial grasses although small quantities of dicotledenous foliage may also be consumed during periods of grass shortage (Child and Von Richter, 1969). Jungius (1971) studied the reedbuck and concluded that its main diet was grass, including a total of 15 species. Only during the dry season did this species browse shrubs and trees as well. Much of the grass consumed was unpalatable to other species such as tsessebe and impala.

Intermediate feeders - Impala both graze and browse, with species selection being a function of availability and palatibility. McAllister and Bornman (1972) conclude that in Natal, grasses and dicotyledons were consumed in the ratio of 1.67:1. Monro (1982) found that during the wet season, although distributed throughout varoius vegetation types, the diet MICIS mainly grass. In the dry season impala congregated in Acacia savanna changing to a predominantly browse diet. Crude protein of the diets ranged from 11 - 21% dry matter. The eland is the largest antelope and was reported by Littlejohn (1968) to be primarily browsers that ate grass only in the wet season. At least 29 gross species and 57 dicotyledon species have been found in their diet.

A basic requirement guideline per day can be given as 10 grams of protein per MJ of ME intake (Meissner, personal communication). The daily requirement can thus be calculated from the values given in Table 2.

<u>iii) Minerals</u>

Mineral requirements of wildlife have traditionally been evaluated in relation to deficiency symptoms and the establishment of maximum growth or reproductive rates. Most of the information currently available on minerals in nutrition is on domestic and laboratory animals. The values given in Table 3 were found to be adequate for normal growth under South African conditions. More importantly the ratios between the various minerals are optimal for growth and are universally accepted.

<u>iv) Vitamins</u>

Vitamins are usually found in minute amounts and are crucially important to animal health. Most of the deficiencies have been detected in captive animals, while free-ranging wildlife continually adapt their food habits to avoid diets deficient in one or more of the vitamins or precursors. Many of the vitamin requirements are made available through ruminal synthesis. It is paradoxical that the microbes increase the vitamin requirements of the host animal, while at the same time they synthesize considerable quantities of the vitamin B complex and vitamin K. Some vitamins may be absorbed from the lower gut in some species, but most rely on some method of recycling, such as caprophagy, to derive benefit from the vitamins and microbial. Recommended supplementary vitamin requirements are 10,000 IU Vitamin A, 1,500 IU Vitamin D3 if limited amount of sunlight is available and 50mg Vitamin E.

<u>Feeding recommendations:</u>

Ensure that the wildlife maintain normal body weight and that young animals attain normal growth rates. Information on general conditions such as hair coat, horn development, and disease give an indication as to the nutritional status of the animal. Indications of reproductive success, assays of animal excreta and body fluids, post-mortem examinations, observation of pica behaviour all have value to obtain the information required. Animals should first be adapted by giving them access to natural feed or by providing good quality hay. The adaptation period should take two to three weeks after which time the animals should be used to being artificially fed. At this time a more balanced ration can be fed using an energy value of 10 MJ ME/kg and protein concentrate of 10% for maintenance., 11-12% for lactation and 14-15% for growing animals. Browsers would require higher levels of protein (14-16%) for maintenance and 18% for lactation and growth. Balanced concentrates or antelope cubes can initially be mixed with chopped hay and finally, when eaten readily, fed separately at 1-1.5% of body weight together with roughage fed ad lib. Concentrates should not exceed 40% of the daily feed intake. Acidosis can be a serious problem with game and care should be taken to ensure the gradual introduction of concentrates over a 2-3 week period. Non-protein nitrogen should not be used as a protein source for non-ruminants. Provide feed in a shallow trough at ground level. Water should be provided ad lib also in shallow troughs. Wildlife species are sensitive to any changes in the water quality. Game species that are under social, environmental or nutritional stress succumb to parasite infestation. Faecal egg counts should be conducted to establish the degree of parasite infestation. Medication of the feed with commercially available anthelmintics has been successful.

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Table 2. Energy requirements of South African wild ungulates after Meissner (1981).

CLASS	WEIGHT (kg)	I ME (MJ/d)
ELEPHANT		
CALF, 5 YEARS	850	84.8
COW, DRY, 15 YEARS	1850	285
COW, DRY, 50 YEARS	3300	291

COW, WITH CALF, 15 YEARS	1850	362
COW, WITH CALF, 50 YEARS	3300	375
BULL, 15 YEARS	2200	303
BULL, 50 YEARS	3700	310
GIRAFFE		
CALF, 9 MONTHS	390	57.8
COW, DRY, 5 YEARS	770	111
COW, DRY, 10 YEARS	850	101
COW, WITH CALF, 5 YEARS	no	139
COW, WITH CALF, 10 YEARS	850	130
BULL, 5 YEARS	960	126
BULL, 10 YEARS	1190	127
ELAND		
CALF, 8 MONTHS	200	38.9
COW, DRY, 3 YEARS	460	75.5
COW, DRY, 6 YEARS	500	72.1
COW, WITH CALF, 3 YEARS	460	96.6
COW, WITH CALF, 6 YEARS	500	87.1
BULL, 3 YEARS	760	99.5
BULL, 6 YEARS	815	96.0
ZEBRA		
FOAL, 5 MONTHS	95	24.6
MARE, DRY, 4 YEARS	270	48.9
MARE, DRY, 7 YEARS	290	45.0
MARE, WITH FOAL, 4 YEARS	270	61.0
MARE, WITH FOAL, 7 YEARS	290	58.9
STALLION, 4 YEARS 310	54.0	
STALLION, 7 YEARS I335	T52-1 –	

KUDU		
CALF, 6 MONTHS	55	15.8
COW, DRY, 3 YEARS	125	27.9
COW, DRY, 5 YEARS	160	29.8
COW, WITH CALF, 3 YEARS	125	34.9
COW, WITH CALF, 5 YEARS	160	38.7
BULL, 3 YEARS	220	42.1
BULL, 5 YEARS	240	
T-39.9 BLUE WILDEBEEST		
CALF, 4 MONTHS	51	15.6
COW, DRY, 3 YEARS	145	29.8
COW, DRY, 5 YEARS	160	29.4
COW, WITH CALF, 3 YEARS	145	37.3
COW, WITH CALF, 5 YEARS	160	38.3
BULL, 3 YEARS	195	37.2
BULL, 5 YEARS	215	36.3
BLE5BOK		
LAMB, 4 MONTHS	23.5	7.63
EWE, DRY, 3 YEARS	60	12.3
EWE, DRY, 5 YEARS	67	14.7
EWE, WITH LAMB, 3 YEARS	60	15.4
EWE, WITH LAMB, 5 YEARS	67	19.1
RAM, 3 YEARS	73	14.3
RAM, 5 YEARS	81	14.8
WARTHOG		
PIGLET, 3 MONTHS	13.5	6.23
SOW, DRY, 2 YEARS	59	15.0
SOW, DRY, 3 YEARS	65	13.9

SOW, WITH PIGLETS, 2 YEARS	59	21.1
SOW, WITH PIGLETS, 3 YEARS	65	20.1
BOAR, 2 YEARS	74	18.4
BOAR, 3 YEARS	80	16.2
IMPALA		
LAMB, 4 MONTHS	119	I

EWE, DRY, 2 YEARS 37

EWE, DRY, 4 YEARS 45

EWE, WITH LAMB, 2 YEARS	37
EWE, WITH LAMB, 4 YEARS	45
RAM, 2 YEARS	51
RAM, 4 YEARS	60
SPRINGBOK	
LAMB, 2.5 MONTHS	12.5
EWE, DRY, 18 MONTHS	27
EWE, DRY, 3 YEARS	31
EWE, WITH LAMB, 18 MONTHS	27
EWE, WITH LAMB, 3 YEARS	31
RAM, 18 MONTHS	30
RAM, 3 YEARS	36

10.8

10.2

14.0

13.9

11.9

12.2

3.19

6.28

7.02

7.85

9.10

7.08

7.36

Table 3. Mineral requirements of South African ungulates

IMINERAL	I g/kg	mg/kg
PHOSPHORUS (min)	6	
CALCIUM (max)	12	
SULPHUR (min)	2.5	
FLUORINE (max)	0.04	
SODIUM (min)	1.2	
COBALT (min)		0.15
MANGANESE		60
ZINC (min)		60
IODINE (min)		0.75
COPPER (min)		5
SELENIUM (min)		0.15
IRON (min)		50