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Nutritive value of selected forages on the coastal region rangelands of Tanzania

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Abstract

Although the nutritive value of forage species is of paramount importance to livestock production, it is largely unknown for most rangelands of East Africa. A study was carried out on a rangeland area west of the Ruvu floodplains, Bagamoyo district, coastal Tanzania to determine the nutritive value of palatable herbaceous species. The commonly occurring palatable grasses (at their flowering stage) and browse species were analysed for crude protein (CP), crude fibre (CF) and major mineral elements (calcium, magnesium and phosphorus). The forage species analysed were *Urochloa mosambicensis*, *Panicum maximum*, *Panicum parvifolium*, *Eragrostis superba*, *Sporobolus pyramidalis* (grasses), *Commiphora africana* and *Pteleopsis myrtifolia* (browse). The species had adequate levels of crude protein (grass: 8.65±2.15%; browse: 13.61±2.26%), crude fibre (grass: 35.98±5.15%; browse: 19.17±3.64%), phosphorous (grass: 0.23±0.13%; browse: 0.18±0.01%), calcium (grass: 0.25±0.10%; browse: 0.49±0.11%), Ca:P ratio (grass; 1.0:1.0 - 5.6:1.0; browse: 1.79:1.0 - 3.68:1.0), and magnesium (grass: 0.36±0.11%; browse: 0.33±0.01%) to support the growth and maintenance of livestock. Their CP, CF and mineral contents were significantly different, with browse having highest nutritive value. *P. maximum*, *P. parvifolium*, *Urochloa mosambicensis*, *Sporobolus pyramidalis*, and *E. superba* were significantly different in their %CP ($P<0.001$), %CF ($P<0.0001$), Ca ($P<0.05$), and P ($P<0.05$) contents. There was a significant negative correlation between %CF and phosphorus, calcium, and %CP; and between magnesium and %CP. Significant positive correlations occurred between %CP and phosphorus; and %CP and calcium. Implications of these results for rangeland utilisation for animal production and management are discussed.

Key words: Animal production, crude fiber, crude protein, mineral nutrients

Introduction

Among the factors which determine the livestock production potential of an area are the quantity and quality of the forage species present. The value of any feed usually depends on the quantity eaten and the extent to which the food consumed supplies the animal with energy, protein, minerals and vitamins (Skerman, 1977). The nutritional quality of grasses depends on their protein, fibre, minerals and vitamins. Protein and fibre contents have been stressed as important determinants of forage quality (Robbins, 1983; McNaughton and Georgiadis, 1986). Crude protein content has been used as an indicator of the nutritive value of forage. The level of crude fibre provides a rough indication of the dry matter digestibility of a feed (Skerman, 1977), which also indicates its available energy. The proportion of minerals in the diet is important for all forms of livestock in meeting requirements for body growth and maintenance, and milk production. Minerals required by livestock in large amounts include Na, K, Mg, Ca, P, S, and Cl (Mwakatundu, 1977; NRC, 1996). Since vegetation remains the main source of feed for animals on the coastal rangelands, it is important to understand the quality to ensure improved and sustainable utilisation.

Materials and methods

The study area

The study was carried out in an area West of the River Ruvu floodplains extending from Vigwaza to Chemakweza village along the Dar es Salaam - Morogoro road, in the Coast Region, Eastern Tanzania. It lies approximately between longitude 38°30'- 38°40' E and latitude 6°37' - 6° 47' S. It has an altitude of between 45 - 122 m above sea level. The area is flat with occasional undulating plains, small ridges and depressions (Mashalla, 1978).

The annual rainfall varies across the Coastal region from 1000 mm in the east to 600 mm in the midlands and up to 700 mm in the west. The rainfall is bi-modal, with the long rains stretching from March to May, and the short rains from November to December, while the dry season stretches from June to October. Generally the rainfall is unreliable particularly at the beginning of the wet season. This variability in the timing and quantity of rainfall negatively affects agriculture.

The soils are on Neogene sediments, are poorly drained and seasonally water logged. In many places the soil is characterised by shallow (less than 40 cm deep) sandy surface horizon underlain by compact and impervious sandy clays. With hard impervious sub-soils and widespread ponding, the best option for economic utilization of the area is livestock husbandry. The natural vegetation of the area includes; woodland, extensive wooded grasslands, and thickets (IRA, 1984).

Fresh samples of plant materials were collected in polyethylene bags in accordance with the technique described by Allen *et al.* (1989). The grasses were cut at about 6 cm above the ground when they were flowering. The collected material was washed with clean water to get rid of the soil particles and other debris and air-dried under glasshouse conditions below 40°C for 24 days. The dried material was ground to pass through a 2 mm screen on a sample mill.

Nutrient/chemical analysis

Samples of ground material were analysed for CP by the Kjeldahl nitrogen method using a micro-Kjeldahl procedure on a Kjeltec System 1 machine (Tecator, 1979; AOAC, 1990). Percentage CP was calculated by multiplying the Kjeldahl nitrogen by 6.25 (Campbell and Lasley, 1975; AOAC, 1990). Thus %CP = % N x 6.25.

The crude fibre content was determined by the Weende method using the Fibertec System (Tecator, 1978). This involved boiling samples successively in 0.128 M H_2SO_4 and 0.223 M KOH in crucibles on a hot extraction unit, and subsequent washing of the extracted samples with distilled water and finally with acetone.

Air-dried samples were dry-ashed at 540 °C for 4 hours, and the resultant ash dissolved in a 1:1 HCl solution. The dissolved solutions were used for the determination of phosphorus, calcium and magnesium. Phosphorus was determined colorimetrically as phosphovanadomolybdate, while calcium and magnesium were determined by Atomic Absorption Spectrophotometry (AAS) (Allen *et al.*, 1989; AOAC, 1990).

Data analysis

Crude protein (%CP), and crude fibre (%CF) content data, among the grass and browse samples were subjected to single factor Analysis of Variance (ANOVA). Additionally correlation analysis was performed to determine the relationship between %CP, %CF and the major elements in the forage.

Results and discussion

Crude protein (CP) and crude fibre (CF)

A range of crude protein (%CP) and crude fibre (%CF) values were obtained for all the samples analysed (Table 1). The crude fibre content values ranged from 14.57 to 23.29% and 26.89-44.08% for browse and grass samples, respectively. Of the 62 grass samples only 2.3% had a fibre content below, and 23.8% were above, while all the browse samples were on the lower end of the crude fibre range (29-41% CF) as reported for tropical forages by Minson (1980).

Among the grass samples 75.81% were above, while 24.19% were below the %CP critical value of 7%, and all the browse samples were well above it (Table 1). With a %CP range of 9.88-16.75%, and %CF range of 14.57-23.29% the browse generally had a higher nutritive value than grass species. Thus, browse and many of the grass samples analysed are capable of meeting the minimum crude protein requirement for the grazing animals. Browse is also capable of meeting the crude protein requirements of lactating cows (Table 2).

Crude protein and crude fibre content varied between species and within species of grasses and browse. Among the grass species, *Urochloa mosambicensis* was of higher nutritive value in terms of crude protein, with a range of 6.56-14.78% (mean= 10.28±2.02%), while *Eragrostis superba* was of the lowest nutritive value with a range of 6.64-7.23 (mean= 7.05±0.29%) (Table 1). Crude protein and crude fibre are important chemical constituents, indicating the nutritive value of forage. The CP content of forage has been used as an indicator of the nutritive value of forage (Robbins, 1983;

Table 1. Mean percentage crude protein (%CP), crude fibre (%CF) and major elements of some of the palatable grass and browse species (on a dry matter basis) commonly occurring on the rangeland area west of the Ruvu floodplains.

Species	Parameters				
	Crude protein (%)	Crude fibre (%)	Phosphorus (%)	Calcium (%)	Magnesium (%)
Urochloa mosambicensis	10.28 ±2.02	30.36 ±2.54	0.34 ±0.12	0.22±0.04	0.33 ±0.01
Panicum maximum	8.06 ±1.94	38.04 ±3.73	0.19 ±0.09	0.25 ±0.09	0.63 ±0.14
Panicum parvifolium	7.61 ± 0.92	37.49 ±1.94	0.19 ±0.02	0.18±0.02	0.44 ±0.22
Eragrostis superba	7.05 ±0.29	41.17 ±3.14	0.11 ±0.03	0.45 ±0.03	0.33 ±0.02
Sporobolus pyramidalis	7.26 ±1.17	41.49 ±2.04	0.17±0.14	0.29 ±0.15	0.35 ±0.02
Commiphora africana	15.25±2.12	15.54 ±1.37	0.17 ±0.01	0.57 ±0.01	0.35 ±0.02
Pteleopsis myrtifolia	13.89 ±0.49	21.94±0.28	0.19 ±0.01	0.41 ±0.07	0.32 ±0.01

±: Standard deviation.

Table 2. Mean percentage of crude protein (%CP), crude fibre (%CF) and major elements (on a dry matter basis) of the forage of the rangeland area west of the Ruvu floodplains.

Parameters	Grasses			Browse		
	Mean	SD	Critical value[1]	Mean	SD	Critical value[1]
Crude protein (%)	8.65	2.15	7.00	13.61	2.26	7.00
Crude fibre (%)	35.98	5.15	–	19.17	3.64	–
Phosphorus (%)	0.23	0.13	0.24	0.18	0.01	0.24
Calcium (%)	0.25	0.10	0.30	0.49	0.11	0.30
Magnesium (%)	0.36	0.11	0.20	0.33	0.01	0.20

SD: Standard deviation.

[1]Adapted from Sendalo *et al.* (1988).

McNaughton and Georgiadis, 1986). Usually the higher the protein content, the higher the nutritive value.

The CP content of the studied grasses was above the minimum requirement for a ruminant's body maintenance. Ruminants need a minimum of 5% crude protein (0.8% nitrogen) in their food to maintain body weight (ARC, 1965). Whereas in diary cattle, potential milk yield is limited when the crude protein (CP) content in the feed falls below 12% (Stobbs, 1971). McDonald *et al.* (1973) noted that if the protein level in forage falls below 7%, food intake in ruminants decreases and rumen microbe activity is inhibited so that nitrogen excretion exceeds nitrogen intake. Boxter and Wilson (1963) suggested that the activity of the cellulolytic microorganisms in the rumen might be limited by the availability of nitrogen at levels lower than 8.5% crude protein. French (1957) has noted that cattle in East Africa may tolerate a minimum crude protein level of 3% before they exhibit negative digestibility. Milford and Minson (1966) reported a marked decline in intake when crude protein falls below 7%. According to Kinyamario and Macharia (1992), the minimum CP in the whole plant, which may be tolerated, depends on the ability of the animal to select the protein rich parts. The intake therefore depends on the relative availability of species in the sward and, within a species or parts of plants. With a more diverse vegetation, cattle are likely to obtain higher CP than what the analysis can reveal. With a relatively high species diversity, the Ruvu rangeland may be said to be in a good condition, and is likely to support a variety of animals for sustained productivity.

Compared to results from other savanna systems (e.g., Gihad, 1976; Sreeramulu and Chande, 1983) the grasses analysed in this study were low in CP and high in CF. This is probably because the grass samples were collected at the end of the rainy season and after they had started flowering. As grasses mature, they tend to accumulate more fibers than proteins, thus, declining in feeding value (Minson and McLeod, 1970). In addition, grasses were from a disturbed environment with frequent fires, charcoal burning and grazing. A study by Georgiadis and McNaughton (1990) reported higher fibre content values at all times in areas of high herbivore-use intensity. Furthermore, several studies have reported the stage of growth of plants, botanical composition, nutrient status of the soil, climate, and management of the sward as the factors which influence the composition and nutritive value of herbage (Mwakatundu, 1977). Thus, management and grazing practices influence the overall value of grasses in semi-arid areas (Karue, 1974).

As some of the grasses were found to contain %CP below the critical value of 7%, then use of browse with more than 12% CP, is of great importance for livestock feeding on this rangeland. These results suggest that dicot browse are very important in the diet of grazing cattle especially during the dry season when the protein content of the grasses is likely to fall below the critical level required for body maintenance. Browse can maintain its nutrients for long periods (Skerman, 1977).

Although digestibility was not measured directly in the present study, the analysis of crude fibre gives a relative index of the concentrations of less digestible structural carbohydrates such as cellulose, hemicellulose, and lignin. The %CF of 16.79 and 23.29 for browse and 32.71 for *Urochloa mosambicensis* were on the low end, and of 39.76-41.83 for *Panicum spp.* were on the upper end, whereas 44% for *Sporobolus spp.* was above the upper end of the range (29-41% CF), reported for tropical forages (Minson, 1980). On this basis *P. maximum, P. parvifolium, Urochloa mosambicensis,* except *Sporobolus pyramidalis, Sporobolus consimilis,* and *Echinochloa haploclada,* are palatable and digestible throughout the year.

Mineral nutrients (Ca, P and Mg) content

Calcium (Ca)

The concentration of calcium in browse and grass samples ranged from 0.34 - 0.57% (mean = 0.49%), and 0.09 - 0.58% (mean = 0.25%), respectively (Table 2). All the browse samples contained more than 0.3% calcium. About 82% of the grass samples contained less than 0.3% calcium, and 17.08%

contained more than 0.30% calcium. Among the grass species only *Urochloa mosambicensis* samples were all below the 0.30 % calcium level.

If 0.30% Ca is taken as the critical value for forages (McDowell *et al.*, 1983), then 82.92% of the grass samples collected in the present study may be considered to have Ca deficiency, whereas all the browse samples may not. This then suggests that palatable browse species on this rangeland have to be conserved and managed to supply the livestock with sufficient levels of calcium for sustained productivity. However, according to Singh and Mishra (1987) levels of Ca associated with minimum dietary requirements for animals are generally lower than the levels associated with calcium deficiency (0.35%) in grasses. It is therefore, assumed that the Ca levels in the forage of the studied rangeland were probably adequate for the grazers. The availability of Ca in the diet of ruminants may also be influenced by its solubility. Although, some forages may be high in Ca its availability to cattle may be low as some of it might be held in the form of insoluble calcium oxalate (Blaney *et al.*, 1982). It should however, be remembered that a proper ratio between Ca and P is a better index for their utilisation by animals than their absolute concentrations (Singh and Mishra, 1987).

Phosphorus (P)

Phosphorus content in the grass and browse samples ranged from 0.06 - 0.49 (mean = 0.23±0.13%), and 0.16 - 0.19% (mean = 0.18±0.01%), respectively (Table 1). Of the grass samples about 72.43% contained phosphorus levels less than 0.24% suggested by McDowell *et al.* (1983) to be the critical level for maintenance of the grazing animals. Using the 0.18% P critical level proposed by Butterworth (1985), 57.14% of the grass samples contained phosphorus levels above the critical value. About 0.12% of the samples, all of *Urochloa mosambicensis*, contained more than 0.4% P, a value considered to be high range in plants (Chapman, 1966 cited in Singh and Mishra, 1987). On the other hand all the browse samples contained P less than the 0.24% P critical value (McDowell *et al.*, 1983), while only one sample was above the critical level of 0.18% P suggested by Butterworth (1985). Phosphorous deficiency is probably the most common nutritional mineral problem in tropical areas, due to low P in the soils and herbage (Gartner *et al.*, 1980). Phosphorus concentrations of about 0.18% or above in dry matter (DM) are required for the maintenance of grazing animals (Butterworth, 1985). However, earlier work has shown that a level of 0.12% P in the feed is adequate for the maintenance of the growth of young cattle at 0.5 kg/day (Little, 1980 cited in Gartner *et al.*, 1980).

Studies carried out in other parts of Tanzania gave a high mean value of 0.319±0.1679% for phosphorus content in the grasses of the Mbulu district, but many of the samples had a phosphorus content of less than 0.05% (Butterworth, 1985). The P levels recorded in the present study were more or less comparable with those obtained in other parts of Tanzania by Sreeramulu and Chande (1983).

Phosphorus levels of less than 0.18% in forage indicate a probable deficiency for most classes of livestock (Butterworth, 1985). Taking 0.18% P as the baseline value, then grasses with *Urochloa mosambicensis* as the leading species can be argued to be a better source of phosphorus for the grazing animals than browse species. The phosphorus levels in the grass species of the area west of the Ruvu floodplains are adequate to support animal productivity when the grass is at the peak of its growth.

However, the consideration of P in ruminant nutrition as a single isolated nutrient and panacea for ill-thrift and infertility is no longer acceptable (Cohen, 1980). This calls for the consideration of the Ca:P ratio in the diet as it is important for the proper utilisation of these two nutrients (Singh and Mishra, 1987). The mean ratios of Ca:P for the grass and browse samples were 1.09:1 and 2.75:1, respectively. These values although fairly low are nonetheless well within the recommended range of 1:1 to 7:1 in forages (Sendalo *et al.*, 1988). A ratio of these elements in the range of 1:1 to 2:1 is generally accepted as a safe range for adequate animal productivity (Singh and Mishra, 1987), and it is preferred for milk production (Jacobson *et al.*, 1972). Therefore livestock on this rangeland have an adequate Ca:P ratio for maintenance and milk production.

Magnesium (Mg)

The concentration of Mg in browse and grass samples ranged from 0.32-0.36% (mean = 0.33±0.01%), and 0.22-0.83% (mean = 0.36±0.11%), respectively (Table 2). All browse and 87.80% of the grass samples were above 0.30% Mg concentration, while 12.20% of the grasses contained Mg concentration less than 0.30% but above 0.20%. Grass species were, however, not significantly different in Mg content ($P>0.05$). The 0.2 % Mg level in grasses is commonly regarded as the minimum safe dietary concentration for adequate animal health (Kemp, 1960 cited in Singh and Mishra, 1987; McDowell *et al.,* 1983). If this is taken as the critical level for both plants and ruminants then Mg deficiency is likely not to occur on the Ruvu rangeland.

However, it has been reported that forages high in nitrogen, potassium, and organic acids are conducive for the incidence of grass tetany, a clinical deficiency of magnesium (Mayland *et al.*, 1990). A number of studies (e.g., Greene *et al.*, 1983; Wylie *et al.*, 1985) have shown that high dietary potassium reduces magnesium absorption. This suggests that probably not all the magnesium recorded in the present study may be available to the animal. But since no cases of grass tetany amongst the livestock grazing in the study area have been reported, it is assumed that whatever levels of magnesium were available to the grazers were adequate for the sustenance of animal productivity.

Relationship between nutrients (i.e. %CP, %CF, Ca, Mg, and P) in the analyzed forage samples

There was a significant negative correlation between %CF and phosphorus, calcium, and %CP; and between magnesium and %CP. There were significant positive correlations between %CP and phosphorus; and %CP and calcium (Table 3). The negative correlation between %CP and %CF for grasses is shown in Figure 1. A single factor analysis of variance (ANOVA) revealed that the grass species (i.e., *P. maximum*, *P. parvifolium*, *Urochloa mosambicensis*, *Sporobolus pyramidalis*, and *Eragrostis superba*) were significantly different in their %CP ($P<0.001$), %CF ($P<0.0001$), Ca ($P<0.05$), and P ($P<0.05$) contents.

Conclusion and recommendations

The frequently occurring palatable grass and browse species on the rangeland of the Coastal region of Tanzania have adequate levels of CP, CF, P, Ca and Mg to support the growth and maintenance of livestock. There is however, a need to evaluate all possible sources of mineral elements for livestock on the rangeland (i.e., soil licks and water), and mineral content of animal tissues (serum) to be able to exactly determine any deficient mineral nutrients in the animals' diet. Since critical levels stated elsewhere may not exactly apply to all animals under different environmental conditions, evaluation of critical levels of individual mineral elements required for growth and maintenance of livestock grazing on this rangeland is necessary before any supplementation measures can be taken.

Table 3. Correlation matrix for crude fibre, crude protein and some major nutrients in forages of the area west of the Ruvu flood-plains.

	P	Ca	Mg	%CP
Ca	-0.05053			
Mg	-0.18499	-0.21045		
%CP	0.2634*	0.3859*	-0.27773*	
%CF	-0.41781*	-0.40429*	0.20294	-0.73615*

*. Significant correlations at $P< 0.05$.

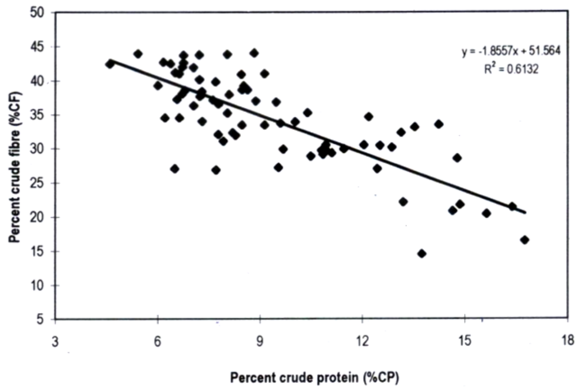

Figure 1. The relationship between forage (grasses) percent crude protein (%CP) and crude fibre (%CF). The calculated regression line is shown with 95% confidence.

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