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BOTANICAL AND CHEMICAL COMPOSITION OF COMMON GRASS SPECIES AROUND DIP–TANK AREAS IN SEMI–ARID COMMUNAL RANGELANDS OF SWAZILAND

[COMPOSICIÓN BOTANICA Y QUIMICA DE ESPECIES COMUNES DE PASTOS EN LOS ALREDORES DE BAÑOS GARRAPATICIDAS EN LAS SEMI ARIDAS COMUNALES DE LOS AGOSTADEROS DE SWAZILANDIA]

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SUMMARY

Communal rangelands in arid and semi–arid areas of southern Africa are the source of virtually all feeds for wild and domestic ruminants. However, the quality and quantity of feed fluctuates in response to rainfall patterns. Little is known about the capacity of these rangelands to support ruminant productivity during the 4-month dry season. This study assessed the botanical composition of grasses and nutritive values of selected grass species growing in the communal rangelands of Swaziland at the start of the dry season. Vegetation survey and sampling were carried out in two semi–arid ecological zones (Lower Middleveld (LMV) and Lowveld (LV) savannas). Dry matter (DM), organic matter (OM), crude protein (CP), minerals, neutral detergent fibre (NDF) and acid detergent fibre (ADF) contents were determined. Of the 20 grass species identified in the two zones, 9 were perennials and 11 were annuals. Only 3 the grass species were classified as highly palatable. Grass species showed significant ($P<0.05$) (LMV) and non–significant (LV) variations in the DM yield. In both zones the highest NDF level was measured in *Panicum maximum* and *Urochloa mosambicensis* and lowest in *Digitaria longiflora* and *Eleusine coracana*. In the LV region, *P. maximum* ranked first in CP content, while *E. coracana* ranked last. In the LMV region, the level of CP was highest in *P. maximum*, and lowest in *D. argyrograpta*. In most instances, macro and trace elements showed variations ($P<0.05$) between grass species. Grass species collected from the two ecological zones showed great variations in NDF, ADF, CP, macro and microminerals. $P<0.05$– It was concluded that most grasses were deficient in protein, phosphorus and potassium. It is recommended that protein and mineral supplements should be offered to animals to optimize the utilization of grasses and improve animal productivity during the dry season.

Key words: botanical composition; nutrient content; semi-arid savannas; biomass yield; nutrient supplementation.

RESUMEN

Los agostaderos comunales en las regiones áridas y semiáridas del sureste africano son la fuente de virtualmente todos los alimentos para los rumiantes domésticos y silvestres. Sin embargo, la calidad y cantidad de los alimentos fluctúa en respuesta a los patrones de precipitación pluvial. Este estudio evaluó la composición botánica de pasturas creciendo en los agostaderos comunales de Swazilandia al inicio de estación de sequía. Se realizó un muestreo de vegetación en dos zonas agroecológicas semiáridas (Bajo Middleveld (LMV) y la savana Lowveld (LV)). Se determinó materia seca (DM), orgánica (OM), proteína cruda (CP), minerales y fibra (NDF, ADF). De las 20 especies de pastos identificadas en las dos zonas, 9 fueron perenes y 11 anuales. Solamente 3 especies fueron clasificadas como altamente palatables. Se encontró variación significativa ($P<0.05$, LMV) y no significativa (LV) en la producción de MS. En ambas zonas el mayor nivel de NDF fue obtenido en *Panicum maximum* y *Urochloa mosambicensis* y el menor en *Digitaria longiflora* y *Eleusine coracana*. En la region LV, *P. maximum* presentó el mayor en contenido de CP mientras que *E. coracana* tuvo el menor. En la región LMV, los niveles de CP fueron mayors en *P. máximum* y menores en *D. argyrograpta*. En la mayoría de los casos se encontró variación ($P<0.05$) de macro y micro minerales entre las especies de pastos. Se concluyó que la mayoría de los pastos son deficientes en proteína, fósforo y potasio. Se recomienda suplementar con proteína y minerales para hacer un uso óptimo de los pastos y mejorar la productividad animal durante la estación seca.

Palabras clave: composición botánica; contenido de nutrientes; sabana semi árida; producción de biomasa.

INTRODUCTION

Livestock production plays a significant role in the livelihood of farmers in the arid and semi arid communal rangelands of Swaziland. The livestock production system is predominantly extensive, with virtually all cattle and small ruminants relying on the natural rangelands and crop residues for feed. In the savannas of southern Africa, grasses make up a significant proportion of the diet of domestic ruminants in both the wet and dry seasons. Grasses in the savannas of Swaziland are generally dominated by perennials although a significant proportion of annuals occur in few areas (Solomon *et al*., 2007). Holecheck *et al.* (2001) reported that annual grasses are seldom considered as having good forage value as perennial grasses. Yet, some annuals grow in the dry periods when perennials are dormant and contribute significantly to the nutrition of livestock, while others provide good quality nutrition in the growing season.

The productivity of ruminants on communal grazing lands largely depends on the quality and the quantity of the available forage. Pasture quality is related to the amount of nutrient in the pasture that can be available for grazing (Walton, 1983). Optimum nutrition is dependent upon a delicate balance of four basic factors i.e. the animal's nutrient requirements, nutrient content of the feedstuffs consumed, digestibility of the feed stuffs consumed, and the amount consumed (Vallentine, 1990). These factors are in turn affected by botanical and chemical composition of the range forage, both of which vary with season. Annual and perennial grass species grow rapidly during the growing rainy season and decline in growth rate, production, and nutritive value as they mature towards the end of the growing season (Tefera *et al*., 2009).

Information on the distribution and botanical composition of the vegetation in the key communal grazing lands such as those surrounding the dip–tank areas are vital to identify the key grass species that contribute to the diets of grazing animals. In the communal areas of Swaziland, ticks are controlled chemically through a compulsory programme of dipping cattle and livestock movement controls (Musisi and Lawrence, 1995) . The country has approximately 800 registered dip–tanks (plunge dips and spray races) at which all cattle are mandatorily dipped at weekly intervals in summer and bi–weekly in winter. These dip–tanks are located in the middle of the grazing areas where ruminant livestock derive their nutrition for long periods during the year. Understanding the nutritional dynamics of foragesaround the dip–tank areas is vital for proper management and sustainable use of the grazing resources. In the savannas of Swaziland, however, there is little data that describes the botanical composition and nutritional dynamics of grasses in general and the status of nutrients at the beginning of the dry season. Knowledge of the distribution of grass species and their nutritive value will assist in their timely utilization, help predict nutrient deficiencies, and suggest supplementation needs. The objective of this study was to determine the botanical and chemical composition of grasses around dip–tank areas in the Lowveld and Lower Middleveld savanna ecosystems of Swaziland. Veld (or veldt) is an Afrikaans word used to describe open, flat fields covered with grass and/or shrubs in southern Africa.

MATERIAL AND METHODS

Study area

The study was conducted on Swazi Nation Land (SNL) located in the northern part of Swaziland. The study areas fall in the semi—arid Lower Middleveld (LMV) and Lowveld (LV) savanna ecological zones. Altitude in the LMV ranges between 400–600 m above sea level, and annual rainfall ranges between 625 – 725 mm. The LV lies in the altitude range from 250 – 400 m and has relatively low mean annual rainfall (400–600 mm). In both study areas, mean annual temperature varies from an average of 18 — 26 ^{o}C in summer and can drop to as low as 10 ^{o}C in winter (Environmental Centre for Swaziland, 1993). About 12% of the study area in the LV has good or fair soils that are mainly dominated by sandstone or claystone, while the LMV is dominated by gneiss (Environmental Centre for Swaziland, 1993). The vegetation of the study areas is mainly characterized by broad–leafed and mixed savanna vegetation (Kunene, 2005).

Site selection and determination grass species composition

Vegetation survey was conducted around three and two dip–tank areas in the LV and LMV ecological zones, respectively.. The sites were identified with the aid of a geographical information system of Swaziland. Five sites were selected around each dip–tank area, and a 20 x 50 m (1 000 m^2) plot was marked in each site, making a total of 25 plots . Grass species composition was estimated using a step point method (Hardy and Walker, 1991). The nearest plant and basal strikes were recorded from 200 point observations per plot. Point observations were spaced by 2 m interval and records were made over the length of each plot in straight parallel lines about 1 m distance apart. The palatability of grasses was classified based on the succession theory described by Dyksterhuis (1949) and on ecological information for the arid to semi–arid regions of Southern Africa (Tainton *et al*.,1980; Vorster,1982). Accordingly, the species were grouped into (i) highly palatable species - those which occur in rangeland in good condition and decrease with overgrazing (decreasers), (ii) moderately palatable species - those which occur in rangeland in good condition and increase with moderate overgrazing (increaser IIa), and (iii) less and poorly palatable species - those which occur in rangeland in good condition and increase with severe/extreme overgrazing (increasers IIb and IIc, respectively).Vegetation survey was carried out during the late growing season (February–March, 2008) when most grasses were in bloom to aid in their identification. Based on the survey result, the following grass species dominated the study areas: *Bothriochloa radicans, Cynodon dactylon, Digitaria argyrograpta, Digitaria longiflora, Eleusine coracana, Panicum maximum,* and *Urochloa mosambicensis* (Table 1). These species were targeted for chemical composition analysis.

Grass sampling for dry matter and chemical analysis

Grass samples for each species were collected once from four 0.25m^2 quadrates distributed randomly within each plot. Samples were cut to a stubble height of 20 mm. The samples from each plot were bulked and oven dried at 72^{o}C for 48 hours. Grass samples were then ground to pass through a 1 mm sieve and kept in paper bags for one week at room temperature pending analysis. Grasses were harvested towards the end of the growing season (April, 2008), thus the grasses had been growing for 3 months, the length of the growing (rainfall) season.

Chemical analysis

Grass samples were analyzed for dry matter (DM), organic matter (OM), crude protein (CP), neutral detergent fibre (NDF), acid detergent fibre (ADF), macro–minerals (phosphorus (P), magnesium (Mg), calcium (Ca), potassium (K)), and micro–minerals (iron (Fe), copper (Cu), manganese (Mn) and zinc (Zn)). The DM content was measured by placing 1 g of sample in a pre–weighed porcelain crucible in an oven set at 100°C overnight. The loss in weight was used as a measure of moisture content. The OM content was determined by igniting the sample in a muffle furnace set at 500°C overnight. The loss in weight was used as a measure of OM content. Neutral detergent fibre (NDF) and ADF were determined by refluxing 2 g grass samples with neutral detergent and acid detergent solutions, respectively, for 1 hour according to Van Soest *et al*. (1991). Neutral detergent fibre was assayed without sodium sulfite and α–amylase since mature grasses contain very little neutral detergent insoluble protein and starch that can interfere with fibre determination. Both NDF and ADF were expressed exclusive of residual ash. Nitrogen content was determined by a Kjeldahl method (AOAC 1999, method no. 976.06) and converted to CP content by multiplying % N content by 6.25. Phosphorous was analyzed by using the Ultra—violet spectrophotometer (Chemicallab instruments, method no–075–01, Bavaria, Germany), K by flame photometer and Ca, Mg, Fe, Zn and Cu by atomic absorption spectrophotometer (Perkin Emer 1982).

Statistical Analysis

Statistical analysis of all data was done using the general linear models (GLM) procedure of SAS (1996) in a randomised complete block design to test differences between species within an ecological zone, and same species between ecological zones. The main effects were ecological zones and grass species. Plots are nested within ecological zones and served as replicates. Means were separated using the PDIFF option of the least squares means statement of the GLM procedure of SAS.

RESULTS

Botanical composition and dry matter production

In both study areas, 20 grass species were identified, 9 of which were perennials. In terms of palatability grouping, 3 species were classified as highly or less palatable, 7 species as moderately or poorly palatable. (Table 1). In the LV area, the mean frequency of *B. radicans, C. dactylon, D. argyrograpta, D. longiflora, E. coracana, P. maximum,* and *U. mosambicensis* ranged between 5 – 15% and were regarded as commonly occurring species. In the LMV area, *C. dactylon* and *D. longiflora* were recorded as dominant with a mean frequency value of >15% and the remaining species were regarded as common (mean frequency ≥ 5 – 15%) (Table 1). All the above grass species together contributed to about 68% and 78% of the total grass frequency in the LV and LMV areas, respectively (Table 1). The DM yield of the grass species is presented in Table 2. $P<0.05$In the LV area, *E. coracana* produced the highest ($P<0.05$) DM followed by *U. mosambicensis*.

Dry matter production did not differ ($P>0.05$) between all the other grass species (Table 2). In the LMV area, *E. coracana*, *P. maximum* and *U. mosambicensis* yielded higher ($P<0.05$) DM than the other species. *Bothriochloa radicans, E. Coracana* and *U. mosambicensis* growing in the LV area produced higher ($P<0.05$) DM than the LMV area (Table 2).

Table 1. Palatability, life forms and distribution of grass species around dip–tank areas in the northern communal rangelands of Swaziland

Grass species	Life form[a]	Palatability[b]	Species composition (%)	
			Lowveld	Low middleveld
Bothriochloa radicans	P	PP	9.4	5.0
Brachiaria deflexa	A	MP	10.8	1.3
Cynodon dactylon	P	MP	12.7	17.2
Dactyloctenium aegyptium	A	MP	0.5	1.3
Digitaria argyrograpta	P	HP	9.3	8.9
Digitaria longiflora	A	MP	8.3	17.9
Digitaria velutina	A	LP	0.01	2.3
Eleusine coracana	A	PP	5.0	5.0
Eragrostis ciliaris	A	LP	0.2	1.4
Eragrostis cylindriflora	A	PP	1.5	–
Eragrostis racemosa	A	LP	1.7	3.6
Eragrostis superba	P	MP	3.2	4.5
Fingerhuthia africana	A A (MP)	MP	0.3	0.6
Panicum maximum	P	HP	10.8	10.3
Perotis patens	A	PP	0.9	1.9
Sporobolus africanus	P	PP	3.6	2.7
Sporobolus nitens	P	PP	2.9	–
Themeda triandra	P	HP	3.5	1.4
Tragus berteronianus	A	PP	3.4	1.5
Urochloa mosambicensis	P	MP	12.3	13.5

[a] Life forms: A = annual; P = perennial

[b] Palatability: HP = highly palatable; MP = moderately palatable; LP = less palatable; PP =poorly palatable.

Table 2. Mean dry matter production (kg/ha) of the selected grass species in the two study areas.

Grass species	Lowveld	Low Middleveld
B. radicans	676.8 ± 89.9^{Ca}	383.8 ± 84.9^{Bb}
C. dactylon	575.4 ± 89.9^{Ca}	609 ± 69.4^{ABa}
D. argyrograpta	607.2 ± 80.0^{Ca}	518.7 ± 69.4^{Ba}
D. longiflora	556.5 ± 89.9^{Ca}	510.1 ± 60.1^{Ba}
E. coracana	1006.8 ± 87.2^{Aa}	739.8 ± 84.9^{Ab}
P. maximum	651.4 ± 89.0^{Ca}	725.1 ± 69.4^{Aa}
U. mosambicensis	809.1 ± 51.9^{Ba}	677.7 ± 42.5^{Ab}

Lowercase superscripts are used to compare site (ecological zone) means within each grass species while uppercase superscripts are used to compare grass species within each site.
Means with different superscripts differ significantly ($P<0.05$).

Chemical composition

Table 3 presents the NDF, ADF and CP contents of grasses harvested from the LV and LMV ecological zones. In both ecological zones, the highest NDF level was measured in *P. maximum* and *U. mosambicensis* and the lowest in *D. longiflora* and *E. coracana*. *Urochloa mozambicensis* had the greatest ($P<0.05$) ADF in both studied areas, while *D. longiflora* and *E. coracana* had the lowest. In the LV region, *P. maximum* ranked first in CP content (81.9 ± 6.7 g/kg DM), while *E. coracana* ranked last (50.5 ± 1.0 g/kg DM). In the LMV region, the level of CP was highest (95.4 ± 6.1 g/kg DM) in *P. maximum*, and lowest in *D. argyrograpta* (47.9 ± 0.9 g/kg DM). When comparing between the ecological sites,the NDF content of *B. radicans* harvested from the LV was significantly ($P<0.05$) higher than the LMV area, while the reverse was true for *C. dactylon* and *E. coracana*. *Cynodon dactylon, D. argyrograpta, D. longiflora*, and *E. coracana* had significantly ($P<0.05$) higher ADF content in the LMV than the LV area. *Digitaria argyrograpta, D. longiflora, E. coracana* and *P. maximum* harvested from the LV had higher ($P<0.05$) CP content than the same grasses harvested from the LMV area.

The macromineral contents of grasses collected from the two ecological zones are presented in Tables 4 and 5. *Eleusine coracana* (2.4 g/kg DM) and *C. dactylon* (3.3 g/kg DM) had the highest ($P<0.05$) Ca level in the LV and LMV, respectively, while *B. radicans* had the lowest (1.3 g/kg DM) in both areas. In the LV, except for *D. argyrograpta* which had no detectable P, and *E. coracana*, grass species did not show significant differences ($P>0.05$) in the level of P. In the LMV area, grass species except *D. argyrograpta* had similar P values (range: 0.001 – 0.49 g/kg DM). Comparing the results of the ecological zones, Ca content in *C. dactylon* differed ($P<0.05$) between the LV and LMV areas (Table 4). All the grass species had similar P levels across the two ecological zones. *Urochloa mosambicensis* and *E. coracana* had significantly ($P<0.05$) the highest K content in both study areas. *Eleusine coracana* and *P. maximum* displayed the highest Mg content in both ecological zones. The lowest Mg level was measured in *D. longiflora* (LV) and *C. dactylon* (LMV). With regard to ecological zones, *B. radicans* and *C. dactylon* had significantly ($P<0.05$) the highest concentration of K and Mg in the LV area.–. $P<0.05$.

Table 3. Fibre and crude protein content (g/kg DM) of grasses harvested from the Lowveld and Low Middleveld ecological zones.

	NDF		ADF		CP	
Grass species	LV^1	LMV^2	LV	LMV	LV	LMV
B. radicans	743.4 ± 27.5^{Aa}	435.6 ± 0.5^{Eb}	430.0 ± 61.6^{Aa}	383.0 ± 0.2^{Da}	64.4 ± 2.3^{BCa}	66.3 ± 0.5^{Ca}
C. dactylon	421.9 ± 26.7^{Cb}	509.9 ± 21.9^{CDa}	364.5 ± 24.7^{BCb}	446.1 ± 12.2^{BCa}	65.0 ± 4.3^{BCa}	72.6 ± 3.9^{Ba}
D. argyrograpta	616.2 ± 90.0^{Ba}	586.7 ± 84.0^{BCa}	375.7 ± 10.3^{Bb}	513 ± 14.1^{Aa}	68.9 ± 6.8^{Ba}	47.9 ± 0.9^{Eb}
D. longiflora	333.2 ± 87.0^{Ca}	491.2 ± 77.6^{DEa}	269.1 ± 82.8^{Cb}	413.4 ± 68.7^{CDa}	57.3 ± 5.3^{CDa}	76.9 ± 5.1^{Bb}
E. coracana	383.8 ± 14.2^{Cb}	455.7 ± 24.8^{Ea}	334.4 ± 19.2^{Cb}	415.6 ± 28.9^{CDa}	50.5 ± 10.0^{Da}	86.1 ± 25.1^{ABCb}
P. maximum	731.5 ± 37.6^{ABa}	694.4 ± 16.7^{Aa}	388.1 ± 10.7^{Ba}	433.4 ± 22.2^{BCa}	81.9 ± 6.7^{Aa}	95.4 ± 6.1^{Ab}
U. mosambicensis	752.9 ± 38.1^{Aa}	668.3 ± 65.9$^{Aa\ B}$	462.9 ± 39.7^{Aa}	500.0 ± 64.6^{ABa}	67.7 ± 4.4^{Ba}	59.6 ± 4.3^{Da}

$^{1–}$LV–Lowveld, $^{2–}$LMV–Lower Middleveld

Lowercase superscripts are used to compare site (ecological zone) means within each grass species while uppercase superscripts are used to compare grass species means within each site.

Means with different superscripts differ significantly ($P<0.05$).

Table 4. Calcium and phosphorus contents (g/kg DM) of grasses harvested from the Lowveld and Low Middleveld ecological zones.

	Calcium		Phosphorus	
Grass species	LV	LMV	LV	LMV
B. radicans	0.94 ± 0.4^{Ca}	1.63 ± 0.4^{Ca}	0.50 ± 0.4^{Aa}	0.26 ± 0.3^{Aa}
C. dactylon	1.53 ± 0.1^{Bb}	3.25 ± 0.1^{Aa}	0.50 ± 0.1^{Aa}	0.27 ± 0.3^{Aa}
D. argyrograpta	1.80 ± 0.6^{ABa}	2.27 ± 0.4^{BCa}	0.0001	0.001
D. longiflora	1.58 ± 0.13^{Ba}	1.72 ± 0.15^{Ca}	0.30 ± 0.2^{ABa}	0.34 ± 0.2^{Aa}
E. coracana	2.41 ± 0.6^{Aa}	2.5 ± 0.1^{Ba}	0.09 ± 0.09^{Ba}	0.30 ± 0.3^{Aa}
P. maximum	1.90 ± 0.3^{ABa}	1.96 ± 0.2^{Ca}	0.39 ± 0.3^{ABa}	0.49 ± 0.4^{Aa}
U. mosambicensis	1.90 ± 0.2^{ABa}	2.22 ± 0.2^{Ba}	0.47 ± 0.2^{Aa}	0.30 ± 0.2^{Aa}

Lowercase superscripts are used to compare sites (ecological zone) within each grass species while uppercase superscripts are used to compare grass species within each site.

Means with different superscripts differ significantly ($P<0.05$).

Table 6 shows the micromineral content of grass species harvested from the two study areas. The levels of Zn and Fe displayed species variation within the LV region. *Cynodon dactylon* had the highest level of Zn followed by *B. radicans* and *P. maximum*. The lowest level of Fe was measured in *C. dactylon* and *B. radicans*. In the LMV area, Zn and Fe did not show significant differences (P>0.05) between the grass species. The amount of Cu did not differ (P>0.05) between species in both ecological regions. *Bothriochloa radicans* and *C. dactylon* showed the highest Mn content in both ecological zones followed by *D. longiflora*, *E. coracana*, *P. maximum* and *U. mosambicensis*. Grass species, except *B. radicans*, *C. dactylon* (Zn), and *D. argyrograpta* (Cu), had no significant differences in the level of microminerals between the two ecological zones.

Table 7 presents the number of grass species in the two ecological zones whose mineral content fell below, within or above the normal mineral requirement of ruminants. Four grasses in the LV area had Ca levels within the normal animal requirements while this was 6 in the LMV. In both ecological zones, the P level of all grass species was below the normal animal requirement, while the Fe and Zn levels were above the normal requirements.

DISCUSSION

Data on the species composition indicated that although many grass species have been identified in the study areas, only a few species made up the bulk of the dry matter yield. The findings of this study generally does not concur with the concept of Abule et al. (2007) who suggested that the natural community of a rangeland is dominated by one of a few species, which are best adapted to the specific combination of environmental factors of that site. This is not always true because in the current study, all the dominant grass species, except *P. maximum* could have low frequency under natural community, but increase in abundance mainly in response to disturbance such as moderate to heavy grazing.

Table 5. Potassium and magnesium contents (g/kg DM) of grasses harvested from the Lowveld and Low Middleveld ecological zones.

Grass species	Potassium		Magnesium	
	LV	LMV	LV	LMV
B. radicans	3.11 ± 0.6^{ABa}	1.1 ± 0.1^{Db}	3.51 ± 0.8^{Aa}	1.31 ± 0.6^{DEb}
C. dactylon	3.11 ± 0.9^{ABa}	1.06 ± 0.8^{CDb}	2.57 ± 1.5^{ABCa}	0.70 ± 0.2^{Eb}
D. argyrograpta	2.96 ± 0.58^{Bb}	5.37 ± 0.8^{Aa}	2.57 ± 0.37^{Ba}	1.59 ± 0.6^{CDb}
D. longiflora	1.17 ± 0.56^{Ca}	2.13 ± 0.6^{Ca}	1.87 ± 0.1^{Ca}	2.14 ± 0.3^{CDa}
E. coracana	4.1 ± 1.91^{ABa}	4.2 ± 0.8^{ABa}	3.3 ± 0.2^{Aa}	3.3 ± 0.3^{Aa}
P. maximum	3.79 ± 1.5^{ABa}	3.92 ± 0.6^{Ba}	3.67 ± 0.6^{Aa}	2.31 ± 1.3^{ABCDa}
U. mosambicensis	3.84 ± 0.3^{Aa}	4.39 ± 0.4^{ABa}	2.64 ± 0.3^{Ba}	2.39 ± 0.4^{Ba}

Lowercase superscripts are used to compare sites (ecological zone) within each grass species while uppercase superscripts are used to compare grass species within each site.
Means with different superscripts differ significantly (P<0.05).

Table 6. Micromineralconcentrations (g/kg DM) of grasses harvested from the Lowveld and Low Middleveld ecological zones.

	Zn		Cu		Fe		Mn	
Grass species	LV	LMV	LV	LMV	LV	LMV	LV	LMV
B. radicans	0.12^{Ba}	0.04^{Ab}	0.02^{Aa}	0.02^{Aa}	0.47^{Ba}	0.44^{Aa}	0.27^{Aa}	0.23^{Aa}
C. dactylon	0.34^{Aa}	0.05^{Ab}	0.03^{Aa}	0.02^{Aa}	0.47^{Ba}	0.44^{Aa}	0.84^{ABa}	0.23^{Aa}
D. argyrograpta	0.09^{Ca}	0.09^{Aa}	0.01^{Aa}	0.04^{Ab}	0.83^{ABa}	0.46^{Aa}	0.14^{Aa}	0.16^{Da}
D. longiflora	0.06^{Da}	0.06^{Aa}	0.003^{Aa}	0.02^{Aa}	0.54^{Aa}	0.47^{Aa}	0.17^{Ba}	0.21^{ABa}
E. coracana	0.1^{Ba}	0.1^{Aa}	0.01^{Aa}	0.01^{Aa}	0.81^{Aa}	0.67^{Aa}	0.1^{Ba}	0.2^{Ba}
P. maximum	0.12^{Ba}	0.12^{Aa}	0.01^{Aa}	0.02^{Aa}	0.85^{ABa}	0.75^{Aa}	0.18^{Ba}	0.18^{Ba}
U. mosambicensis	0.07^{Da}	0.07^{Aa}	0.01^{Aa}	0.01^{Aa}	0.80^{Aa}	0.67^{Aa}	0.19^{Ba}	0.2^{Ba}

Lowercase superscripts are used to compare site (ecological zone) within each grass species while uppercase superscripts are used to compare grass species within each site.
Means with different superscripts differ significantly (P<0.05).

Table 7. Number of grass species below, above and within the normal mineral requirements of ruminants

Mineral	Normal requirement[a] (g/kg DM)	Lowveld			Lower middleveld		
		Below	Within	Above	Below	Within	Above
Ca	1.9 – 8.2	3	4	0	1	6	0
K	5 – 10	7	0	0	5	2	0
Mg	1 – 2.5	0	1	6	1	5	1
P	1.2 – 4.8	7	0	0	7	0	0
Cu	0.007 – 0.011	1	4	2	0	2	5
Fe	0.03 – 0.05	0	0	7	0	0	7
Zn	0.02 – 0.04	0	0	7	0	0	7

[a]Recommended mineral requirements for all classes of ruminants suggested by National Research Council (1996) and summarized by McDowell (1997).

The findings that grasses in this study had high fibre (NDF and ADF) and low protein content is in agreement with Gonzalez Ronquillo *et al*. (1998) and Mlay *et al*. (2006). These results are typical for mature tropical grasses found in the rangelands of Swaziland which are available for about 7 months grazing starting from the end of summer to the beginning of spring . –It is obvious that the utilization of mature grasses without supplementation will cause protein deficiency in ruminants. Protein deficiency reduces the cellulolytic activity of rumen microbes resulting in the slow breakdown of fibre and low passage rate (Nogueira Filho *et al*., 2000). Ultimately, the intake of these grasses will be inadequate to support the maintenance functions of ruminants leading to loss in weight. When protein deficiency is combined with mineral imbalances the result is low productivity of ruminant animals. It is therefore, essential that communal farmers explore the use of non–conventional protein supplements such as forage from trees that tend to retain green leaves throughout the long dry season. Some significant variations in terms of fibre contents were observed between grass species. Although *D. longiflora* and *E. coracana* had the least concentration of NDF and ADF, which would have made these species easier to digest, they also had low protein content especially in the LV area.

The presence of great variations in the level of macro–elements among the grass species within each ecological zone reflected the studies of Nsinamwa *et al*. (2005), Javed *et al*. (2008) and Tefera *et al*. (2009) in similar ecological zones. Except for P, significant variations were also noticed for the same grass species harvested from the LV and LMV areas. Indeed, the inter–species (within ecological zone) and intra–species (between ecological zones) variations were not consistent.

Table 8. Calcium: Phosphorus ratio of grass species harvested from the Lowveld and Lower middleveld areas.

Species	Lowveld	Lower middleveld
B. radicans	1.9 : 1	3.3 : 1
C. dactylon	3.1 : 1	12.0 : 1
D. argyrograpta	1800 : 1	2270 : 1
D. longiflora	5.3 : 1	5.1 : 1
E. coracana	26.8 : 1	8.3 : 1
P. maximum	4.9 : 1	4.0 : 1
U. mosambicensis	4.0 : 1	7.4 : 1

Optimal Ca: P ratio for ruminant animals ranges between 1 : 2 – 2 : 1.

In the LV area, *E. coracana, P. maximum* and *U. mosambicensis* had Ca level (range: 1.9–2.4 g/kg DM) that fall within the normal requirement for ruminants (Table 7), while the remaining species had Ca level below the normal requirement (range: 0.94 –1.8 g/kg DM). In the LMV area, all grass species, except *B. radicans* and *D. longiflora* had Ca level within the range of ruminant requirement. The Ca content reported in this study falls within the range reported by Moleele (1998) and Nsinamwa *et al*. (2005) in Botswana, Javed *et al*. (2008) in Pakistan, and Tefera *et al*. (2009) in Swaziland rangelands. Except for *D. longiflora,* Mg levels of grasses from the LV area were above the animal diet requirements as suggested by National Research Council (1996) and McDowell (1997). Most grasses harvested from the LMV area had Mg level within the dietary requirement of ruminants. Mean Mg concentrations (range: 0.7–3.7 g/kg DM) found in this study overlap with those reported in Botswana (Nsinamwa *et al*., 2005) (range 0.4–2.4 g/kg DM), and in Swaziland savannas (Tefera *et al*., 2009) (range: 0.4–20.0 g/kg DM).

All grass species harvested from the two ecological zones were deficient inK and P. The K levels recorded in this study are within the range reported by Nsinamwa *et al*. (2005) (range: 0.4–2.4 g/kg DM), but far lower than those reported by Tefera *et al*. (2009) (range: 35.8–123 g/kg DM). The consistent low P content across all grasses might be due to the low P content in the soil. According to Murdoch (1970), Sutcliffe (1975), and Tefera (2010), most savanna rangelands in Swaziland are deficient in P. The low P concentrations can also be linked to the advanced stage of maturity of the plants (Minson, 1990). Grass samples were collected towards the end of the rainy, growing season. Lower dietary P has been associated with reduced feed intake by ruminants (Little, 1982). According to Moleele (1998), however, it is the Ca: P ratio which is considered a better index for grass utilization than the absolute concentrations of the two minerals. Calcium is closely related to P metabolism in the formation of bones. In this study, Ca: P ratio was variable between ecological zones, with higher ratios being observed in the LMV than the LV area. The highest ratio was obtained (Table 8) in *D. argyrograpta* at 1 800: 1 in the LV area and 2270: 1 in the LMV area. In general, most grasses had high Ca: P ratio which is outside the range required for optimal absorption of both minerals. It is therefore expected that animals grazing on these communal lands may encounter problems associated with mineral imbalances. In these regions, supplementary feeds during the dry season originate from cereal by–products and crop residues that have low Ca and high P levels, and these feed stuffs are likely to correct the imbalances. It has been suggested that high Ca: P ratio is associated with poor conception and infertility in cattle (Khanal and Subba, 2001), bone diseases or hormonal imbalances reflecting a chronic disturbance.

The significant variations in the concentrations of micro elements among grass species found in this study were also reported in Botswana (Nsinamwa *et al*. 2005), Pakistan (Zafar *et al*. 2007; Javed *et al*. 2008), and Swaziland (Tefera *et al*., 2009). These variations among and within forage species reflect differences in soil nutrient uptake (Zafar *et al*., 2007). –In general, for most grass species, micro–nutrient concentrations are either within or above the dietary requirements for ruminants as suggested by National Research Council (1996) and McDowell (1997). In particular, as regards for Zn and Fe, all grass species harvested from both study areas had above critical levels sufficient to meet the requirement of the ruminants. The observed ranges of microelement concentrations found in this study correspond to findings by Tefera *et al*. (2009). In contrast, Nsinamwa *et al*. (2005), reported a far greater values for Zn (range: 1.67–36.3 g/kg DM), Fe (Range: 4.9–58.9 g/kg DM) and Cu (1.2–12.6 g/kg DM).

CONCLUSION

Our study indicates that most forage species in the study areas would meet the macro and micro–nutrient requirements for grazing ruminants managed in the communal grazing lands. Phosphorus and K, however, were deficient in all forage species. Correcting P deficiencies by cost–effective supplementing could result in acceptable Ca: P ratio. Provision of mineral licks could ensure that P and K requirements of animals are met. In order to enhance utilization of the high–fibre, low–protein grasses; it is desirable that farmers feed animals conventional and non–conventional protein supplements. This study also highlights the need for further research into the *in vitro* ruminal fermentation of grass species that occur in the study areas in order to provide information on the ability of the grasses to support microbial activity and assess the potential availability of nutrients. In addition, future studies should also define the correlation between mineral content of the forages (grasses and browses), the soil and the body tissues of grazing animals.

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