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Protein Status of Indigenous Nguni and Crossbred Cattle in the Semi-arid Communal Rangelands in South Africa

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ABSTRACT : The objective of the current study was to determine factors influencing concentrations of protein-related blood metabolites in indigenous Nguni and crossbred cattle in the semi-arid communal rangelands in South Africa. The body condition scores (BCS), packed cell volume (PCV) and serum concentrations of protein-related metabolites were determined seasonally in 100 cattle raised on communal rangelands from August 2007 to May 2008. Nguni cattle had lower ($p<0.05$) albumin-globulin ratio, albumin, urea and creatinine, and higher ($p<0.05$) globulin concentrations than the local crossbreds. Local crossbreds had higher ($p<0.05$) alanine aminotransferase and alkaline phosphatase concentrations and lower ($p<0.05$) aspartate aminotransferase concentrations in the post-rainy season than Nguni cattle. The creatinine concentrations of Nguni and crossbred cattle were lowest in the sour rangeland during the hot-wet season. The albumin concentrations of Nguni and crossbred cattle were higher ($p<0.05$) whilst PCV, albumin-globulin ratio and creatine kinase concentration were lower ($p<0.05$) in the sour rangeland than in the sweet rangeland. Total protein, albumin, globulin, aspartate aminotransferase and creatine kinase concentrations of Nguni and crossbred cattle were lower ($p<0.05$) in the hot-wet and late cool-dry seasons than in other seasons across rangeland types. Urea concentrations in both breeds were highest in the sweet rangeland in the hot-dry season compared to other seasons. It was concluded that Nguni cattle had lower concentrations of protein metabolites than local crossbreds and protein deficiencies were most prominent in the sweet rangeland during the cool-dry seasons. (**Key Words :** Albumin, Alanine Aminotransferase, Aspartate Aminotransferase, Globulin, Creatinine, Urea)

INTRODUCTION

Nutrition has been identified as the most important factor limiting cattle production in the semiarid communal areas (Singh et al., 2008; Nqeno et al., 2009). Under the communal production system, the availability of nutrients depends on the fodder consumed, which is influenced by the season, cropping patterns, agro-ecological conditions, type and size of land holdings and socio-economic status of the farmers (Devendra and Sivella, 2002). Although both energy and minerals hamper cattle production on communal rangelands, protein which is as little as 10-30 g/kg CP is the most critical nutrient, especially during the dry season (Tainton, 1999). As a result, cattle usually fail to meet their protein requirements for both maintenance and production (Collins-Luswet, 2000). The seasonal shortage in protein supply leads to changes in cattle condition and populations (Boone and Wang, 2007), and subsequently fluctuations in cattle production efficiency (Mapiye et al., 2009a). The impact of seasonal variations in protein supply for cattle on communal rangelands has, however, not been determined.

Crossbreeding between indigenous and imported breeds generated non-descript crossbreeds of cattle, which are now dominant in the communal areas of South Africa (Mapiye et al., 2009a). The performance and sustainability of these crossbreeds in the communal areas, where feed is scarce is, however, not well known. Protein deficiencies in the communal areas could be worsened by predominance of these large-framed crossbred cattle, which require high amounts of feed (Nqeno et al., 2009). On the other hand, small-framed indigenous cattle such as the Nguni breed with low-maintenance feed requirements (Collins-Luswet, 2000), are found in small populations in the communal areas (Mapiye et al., 2009b). In South Africa, at present, there are on-going efforts to repopulate the communal areas with Nguni cattle (Mapiye et al., 2009b). No evidence, however, is available on whether the protein status of Nguni and the local crossbreds differ. A comparative study of protein status of Nguni and crossbred cattle on communal

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rangelands could be influential in deciding which breed to adopt under low-input production systems.

Concentrations of serum total proteins, albumin, globulin, urea, creatinine and metabolic enzymes are useful indicators of protein and health status of cattle (Agenas et al., 2006; Ndlovu et al., 2009). Despite their importance, reference values for these protein metabolites in cattle breeds raised on communal rangelands in the semi-arid areas are not available, making it difficult to draft suitable supplementary feeding and disease prevention and control strategies. It is also crucial to identify serum proteins that are reliable and sensitive enough to detect changes in protein and health status of Nguni and crossbred cattle on communal rangelands. Although it is well known that variables such as rangeland type, season, parity, sex and physiological status influence the protein status of animals (Doornenbal et al., 1988; Grunwaldt et al., 2005; Yokus and Cakir, 2006), their effect on Nguni and crossbred cattle reared on communal rangelands has not been adequately quantified. Quantifying the effect of these factors is crucial for the understanding of the production constraints and management of the communal herds. The objective of the current study was, therefore, to determine the effect of season and rangeland type on concentrations of protein-related blood metabolites in Nguni and crossbred cattle in the semi-arid communal rangelands in South Africa. The hypothesis tested was that the seasonal concentrations of protein-related blood metabolites in Nguni and crossbred cattle in the sweet and sour rangelands in the Eastern Cape Province, South Africa are not different.

MATERIALS AND METHODS

Study sites

The study was conducted in two communities; one from a sour rangeland (Cala) and another from a sweet rangeland (Sterkspruit) in the Eastern Cape Province of South Africa. In the sour rangelands, forages have low nutritive value (20-50 g/kg CP) and are largely unpalatable during the dry season compared to the sweet rangelands, where forages remain palatable and nutritious throughout the year (Tainton, 1999). The selection of study areas was based on rangeland types and the willingness of the communities to participate in the study.

Cala is located 31° 33′ S and 27° 36′ E at an altitude of 1,440 m above the sea level. It receives 600 to 800 mm of rainfall of between November and April. Mean monthly minimum and maximum day temperatures are recorded in July (11°C) and January (20°C), respectively. The most common grass species are *Themeda triandra*, *Heteropogon contortus*, *Sporobolus africanus* and *Microchloa ciliate*. *Acacia karroo*, *Acacia mearnsii*, *Euryops pyroides*, *Chrysocoma ciliate* and *Dyspyros scrabrida* are the common bush species. In the sour rangelands, cattle are grazed on communal rangelands during the hot-wet and post-rainy seasons and on croplands during the cool-dry and hot-dry seasons.

Sterkspruit is situated 30° 37′ S and 27° 22′ E at an altitude of 1,507 m above sea level. It has a semi-arid climate with most of the rain falling between November and April (500 mm) and about 200 mm fall between May and October. Ambient temperatures fluctuate between 10°C and 20°C, with minimum and maximum temperatures being recorded in July (9°C) and January (22°C), respectively. The most common grass species are *Elionurus muticus*, *H. contortus*, *Microchloa caffra*, *Setaria sphacelata* and *T. triandra*. The rangelands are dominated by *E. pyroides* and *A. karroo* invader woody species. In the sweet rangelands, cattle are grazed on communal rangelands throughout the year.

Experimental animals

The selection of cattle was based on the health status of the animals and willingness of the owners to participate in the study. For easy identification, all the cattle were ear-tagged at the beginning of the study. Fifty clinically healthy cattle from each community were targeted for sampling throughout the study period. The animals were body condition scored using a 5-point scale (1-very thin and 5-obese). Most of the selected cattle had a body condition score between 2 and 3. A total of 490 samples (196 and 294 from sweet and sour rangelands, respectively) were obtained from cattle for the study period. The number of samples in each season depended on the farmer's willingness to bring their tagged animals to the holding facilities. Table 1 shows the number of Nguni and local crossbred cattle sampled in each season in the sweet and

Table 1. Number of Nguni and local crossbred cattle sampled in each season in the sweet and sour rangelands

Season (month)	Sweet rangeland		Sour rangeland	
	Nguni	Crossbreds	Nguni	Crossbreds
Late cool-dry (August)	20	35	19	45
Hot-dry (October)	19	26	27	48
Hot-wet (January)	18	22	17	39
Post-rainy (March)	17	31	13	33
Early cool-dry (May)	14	21	19	37

sour rangelands. The animals were further categorised into different classes based on sex, age (1-2, >2-3, 3-4, >4-5 and >5 years), physiological status of the cow (pregnant lactating (PL), pregnant non-lactating (PNL), non-pregnant lactating (NPL) and non-pregnant non-lactating (NPNL)) and parity (0, 1, 2, 3, 4, 5 and 6). Pregnancy status was assessed through trans-rectal palpation by a veterinarian.

Body weight and body condition scores

Body weights and (BCS) were recorded immediately before blood sampling in the late cool-dry (August, 2007), hot-dry (October, 2007), hot-wet (January, 2008), post-rainy (March, 2008) and early cool-dry (May, 2008) seasons. Cattle body weights were estimated using a weigh-tape (Cattleway, Johannesburg, South Africa). Cattle were palpated and scored using a 5-point scale (1-very thin and 5-obese) to determine the BCS (Nicholson and Butterworth, 1986).

Blood collection and analyses

Blood was collected from the coccygeal vein using an 18-gauge needle between 0700 and 0900 h once a season from August 2007 to May 2008. For the determination of packed cell volume (PCV), blood was collected into Vacutainer® blood tubes containing EDTA anti-coagulant. The blood was transferred into micro-haematocrit tubes and centrifuged in a micro-haematocrit centrifuge (Gemmy Industrial Corp.) for three minutes. Reading of the PCV was performed on the Micro-haematocrit Reader Scale. For biochemical analyses, anti-coagulant free vacutainer tubes were used for blood collection. The blood was allowed to coagulate at room temperature and centrifuged for 10 min at 1,000×g within 2 h of collection. The serum was then stored in propylene tubes at -20°C, pending analyses.

Serum samples were analyzed using a Chexcks machine (Next/Vetex Alfa Wasseman Analyser, Woerden, Netherlands) and commercially purchased kits (Siemens, South Africa). The serum was analysed spectrophotometrically for total proteins, (Wechselbaum, 1946) (Doumas and Biggs, 1972), creatinine (Tietz, 1995), and alkaline phosphatase (ALP) (Tietz et al., 1993) using colorimetric methods. Globulin concentrations were calculated as the difference between TP and albumin whilst albumin-globulin (A/G) ratio was obtained by dividing the albumin concentration by globulin concentration. Enzymatic methods were used for urea (Tietz, 1995) analysis, whilst ultraviolet methods were used for aspartate aminotransferase (AST), (Bergmeyer et al., 1986) alanine aminotransferase (ALT), gamma glutamyltransferase (GGT) and creatinine kinase (CK) determinations (Horder et al., 1991).

Statistical analyses

The data were analysed using the generalised linear models procedure of SAS (2003). The model fitted the effect of rangeland type, season, sex, breed, age and some interactions on PCV and concentrations of protein-related blood metabolites and the liver enzymes.

The linear model was:

$$Y_{ijklmn} = \mu+A_i+B_j+C_k+D_l+E_m+AB_{ij} +AC_{ik}+BC_{jk}+ABC_{ijk} +\varepsilon_{ijklmn}$$

Where Y_{ijklmn} = PCV, concentrations of protein metabolites and liver enzymes);

μ = overall mean;

A_i = effect of rangeland type (i = sweet, sour);

B_j = effect of season (j = late cool-dry, hot-dry, hot-wet, post-rainy, early cool-dry);

C_k = effect of breed (k = Nguni, crossbred);

D_l = effect of sex (l = male, female);

E_m = effect of age (m = 1-2, >2-3, 3-4, >4-5 and >5 years);

AB_{ij} = interaction of the i^{th} level of rangeland type and j^{th} level of season;

AC_{ik} = interaction of the i^{th} level of rangeland type and k^{th} level of breed;

BC_{jk} = interaction of the j^{th} level of season and k^{th} level of breed;

ABC_{ijk} = interaction of the i^{th} level of rangeland type, j^{th} level of season and k^{th} level of breed;

ε_{ijklmn} = residual error

Similar models were used to analyse the effects of parity and physiological status of the cow. Pair-wise comparisons of the least square means were performed using the PDIFF procedure (SAS, 2003). Chi-square test was computed to determine the association between proportions of cattle that had metabolite values within and outside the normal range with season, rangeland type and breed (SAS, 2003). Normal range values were obtained from literature (Doornenball et al., 1988; Farver, 1997; Otto et al., 2000; Ndlovu et al., 2009).

RESULTS

Body weight and body condition scores

Nguni cattle (420.7±15.35 kg) had lower ($p<0.05$) body weight than local crossbreds (455.8±14.54 kg). Nguni and crossbred cattle in the sour rangeland (458.4±35.05 kg) were heavier than those in the sweet rangeland (420.1±35.09 kg) ($p<0.05$). Highest Nguni and crossbred cattle body weights were recorded in the hot-wet and post-rainy seasons ($p<0.05$; Figure 1A). Nguni and crossbred cattle had higher ($p<0.05$) BCS in the hot-wet and post-rainy seasons than the other seasons (Figure 1B). Rangeland type, breed, age, sex and parity had no effect on the BCS ($p>0.05$).

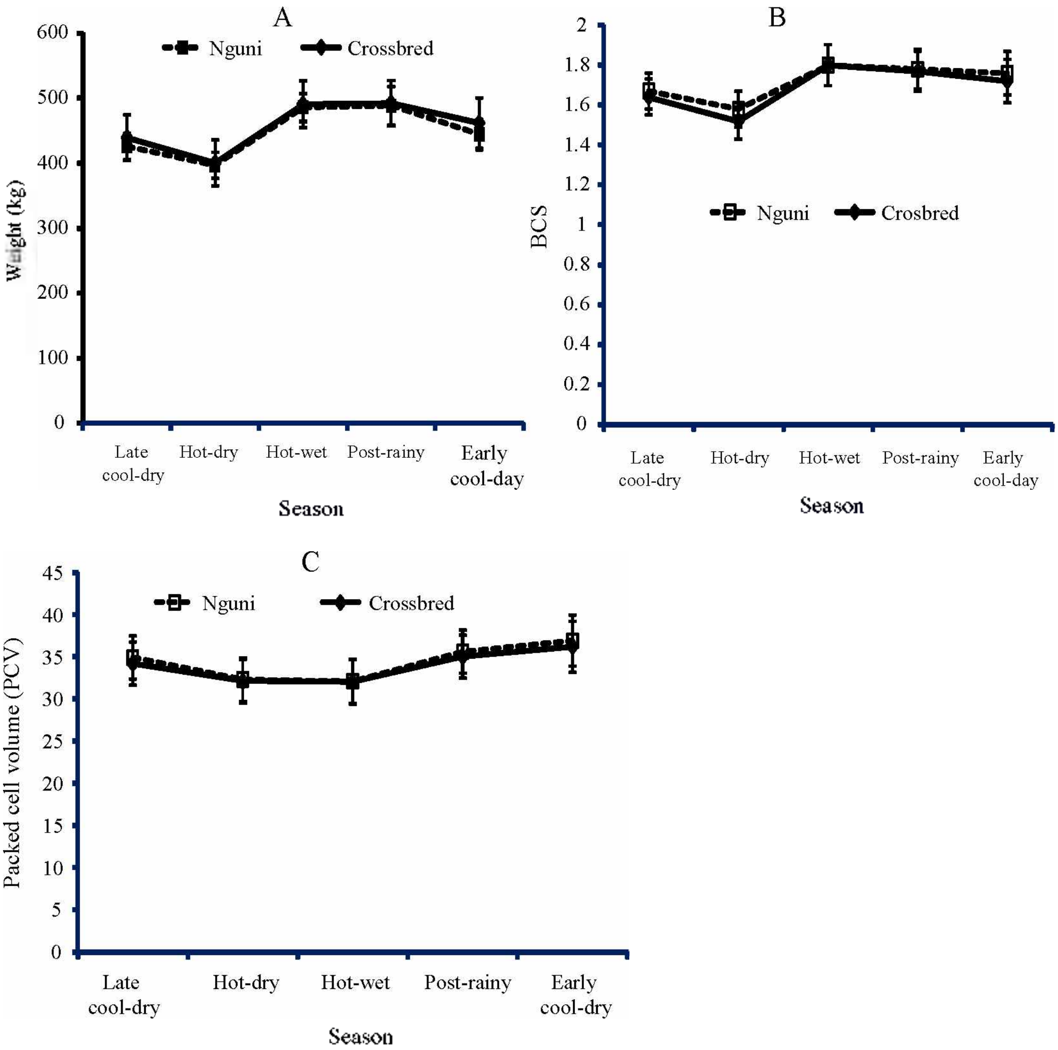

Figure 1. Least square means (±standard error of means) of body weight (A), body condition scores (B) and packed cell volume (C) of Nguni and crossbred cattle based on season.

Packed cell volume

Crossbred cattle had higher PCV values (35.2±1.01) compared to Nguni cattle (33.9±1.08). Nguni and crossbred cattle on the sweet rangelands had significantly higher PCV values (36.6±2.76) compared to those on the sour rangeland (32.5±1.75). Packed cell volume was lowest in the hot-wet season and highest in the cool-dry season (Figure 1C). Age, sex, parity and physiological status of the cow had no effect on PCV values.

Total protein, albumin and globulin concentration

Overall, rangeland type and breed were not significantly associated with proportions of cattle that had protein-related metabolites values within the reference range. About 50% of cattle in the hot-wet season had total protein (TP) concentrations below the normal range whilst 77% in the post-rainy season had concentrations above the normal range ($p<0.01$; Table 2). Total protein concentrations were lowest in the hot-wet season and highest in the post-rainy season in the sweet rangeland (Figure 2A). Pregnant non-lactating cows had highest TP concentrations compared to other cows (Table 3). Breed, sex, age and parity had no effect ($p>0.05$) on total protein concentration.

Nearly 70 and 85% of cattle in the hot-dry and hot-wet seasons, respectively had albumin concentrations below the normal range ($p<0.01$; Table 2). Nguni cattle had lower ($p<0.05$) albumin concentrations than local crossbreds (25.4±0.34 versus 27.7±0.24). Nguni and crossbred cattle in the sweet rangeland had higher ($p<0.05$) albumin concentrations (29.9±0.97 g/L) than those in the sour rangeland (27.4±0.96 g/L). Albumin concentrations of both breeds were lowest in the hot-wet season (Figure 2B). Heifers had the highest albumin concentrations compared to cows in other parities (Table 4). Albumin concentrations was highest in pregnant non-lactating cows compared to other cows ($p<0.05$; Table 3). Age and sex had no effect on

Table 2. Proportions (%) of Nguni and local crossbred cattle that had normal, below and above reference range values for the different blood metabolites based on season

Season	Level	Protein-related metabolites					Liver enzymes				GGT[9]
		TP[1]	ALB[2]	Glob[3]	Urea	Creat[4]	ALT[5]	AST[6]	ALP[7]	CK[8]	
Late cool-dry	Below	13	26	4	90	0	3	8	0	0	0
(n = 119)	Normal	73	73	48	10	39	97	92	99	92	98
	Above	14	1	48	0	61	0	0	1	8	2
Hot- dry	Below	6	69	1	69	0	0	0	0	0	0
(n = 110)	Normal	75	30	35	31	83	100	100	100	95	99
	Above	19	1	64	0	17	0	0	0	5	1
Hot- wet	Below	50	85	10	68	0	0	5	0	1	0
(n = 89)	Normal	41	15	47	32	92	100	95	100	98	97
	Above	9	0	43	0	8	0	0	0	1	3
Post- rainy	Below	0	23	0	77	0	0	1	0	0	0
(n = 91)	Normal	23	73	7	23	68	100	99	100	90	94
	Above	77	4	93	0	32	0	0	0	10	6
Early cool-dry	Below	3	15	0	86	0	0	0	0	0	0
(n = 81)	Normal	55	85	24	14	67	100	100	100	91	91
	Above	42	0	76	0	33	0	0	0	9	9
Significance		**	**	**	**	**	**	**	**	**	**
Minimum[a]		65	28	28	3.6	10	36	21	33	12	0
Maximum[b]		78	37	42	10.7	133	91	167	328	146	45

** p<0.01. [a] Minimum and [b] Maximum reference values for cattle. Sources: Doornenbal et al. (1988) and Farver (1997).
[1] TP- total protein. [2] ALB: albumin. [3] Glob globulin. [4] Creat: Creatinine. [5] ALT: alanine aminotransferase.
[6] AST: aspartate aminotransferase. [7] ALP: alkaline phosphatise. [8] CK: creatinine kinase. [9] GGT: gamma glutamyltransferase.

albumin concentration.

Most of the cattle in the hot-dry (64%), post-rainy (93%) and early cool-dry season (76%) had globulin concentrations above the reference range (p<0.01; Table 2). Crossbred cattle on sour rangelands had the highest globulin concentrations (42.5±5.43 g/L) followed by Nguni cattle on sour rangeland (38.6±5.24 g/L), local crossbreds on sweet rangeland (36.5±3.31 g/L) and Nguni cattle on sweet rangeland (34.4±2.44 g/L). Globulin concentrations were lowest in the hot-wet season and highest in the post-rainy season (Figure 2C). Serum globulin concentrations increased (p<0.05) from parity 0 to 6 (Table 4). Sex, age and physiological status of cow had no effect (p>0.05) on globulin concentrations.

Nguni cattle had lower (p<0.05) AG ratio than local crossbreds (0.60±0.01 vs. 0.71±0.01). Nguni and crossbred cattle in the sweet rangeland (0.72±0.087) had significantly higher (p<0.05) AG ratio than those in the sour rangeland (0.84±0.087). Albumin-globulin ratio was highest in early and late cool-dry seasons (p<0.05; Figure 2D). Males had higher (p<0.05) AG ratio than females (1.0±0.18 vs. 0.56±0.038). Generally, AG ratio increased (p<0.05) with age of the animal (Table 5). The AG ratio decreased (p<0.05) as the parity increased from 0 to 6 (Table 4). Physiological status of the cow had no effect on AG ratio.

Serum urea and creatinine concentrations

Over 65% of the cattle had urea concentrations below the reference range across all the seasons (p<0.01; Table 2). Nguni cattle had lower (p<0.05) urea concentrations than local crossbred cattle (2.3±0.13 versus 2.8±0.09). Urea concentrations were highest in the hot-dry season in the sweet rangeland (Figure 3A). Pregnant cows had higher (p<0.05) urea concentration than non-pregnant cows (Table 3). Sex, age and parity had no effect on urea concentrations.

About 61% of the cattle in the late cool-dry season had creatinine concentrations above the normal range whilst more than 65% of the cattle in the other seasons had creatinine concentration within the normal range (p<0.01; Table 2). Nguni cattle had lower (p<0.05) creatinine concentrations than crossbred cattle (115.8±2.70 vs. 123.3±1.82). Creatinine concentration of Nguni and crossbred cattle was lowest in the sour rangeland during the hot-wet season (Figure 3B). The concentration of creatinine was highest in pregnant non-lactating cows and lowest in pregnant lactating cows (Table 3).

Liver enzymes concentrations

More than 90% of the cattle had liver enzymes (ALT, ALP, AST, CK and GGT) concentrations within the normal range across all the seasons (Table 2). There was no association between rangeland type and breed with the proportions of cattle that had liver enzymes values within the reference range. The concentrations of ALT were highest in local crossbreds during the hot-wet season (Figure 4A). ALT concentrations were highest in 1-2 year-old animals compared to other age groups and decreased (p<0.05 with age (Table 5).

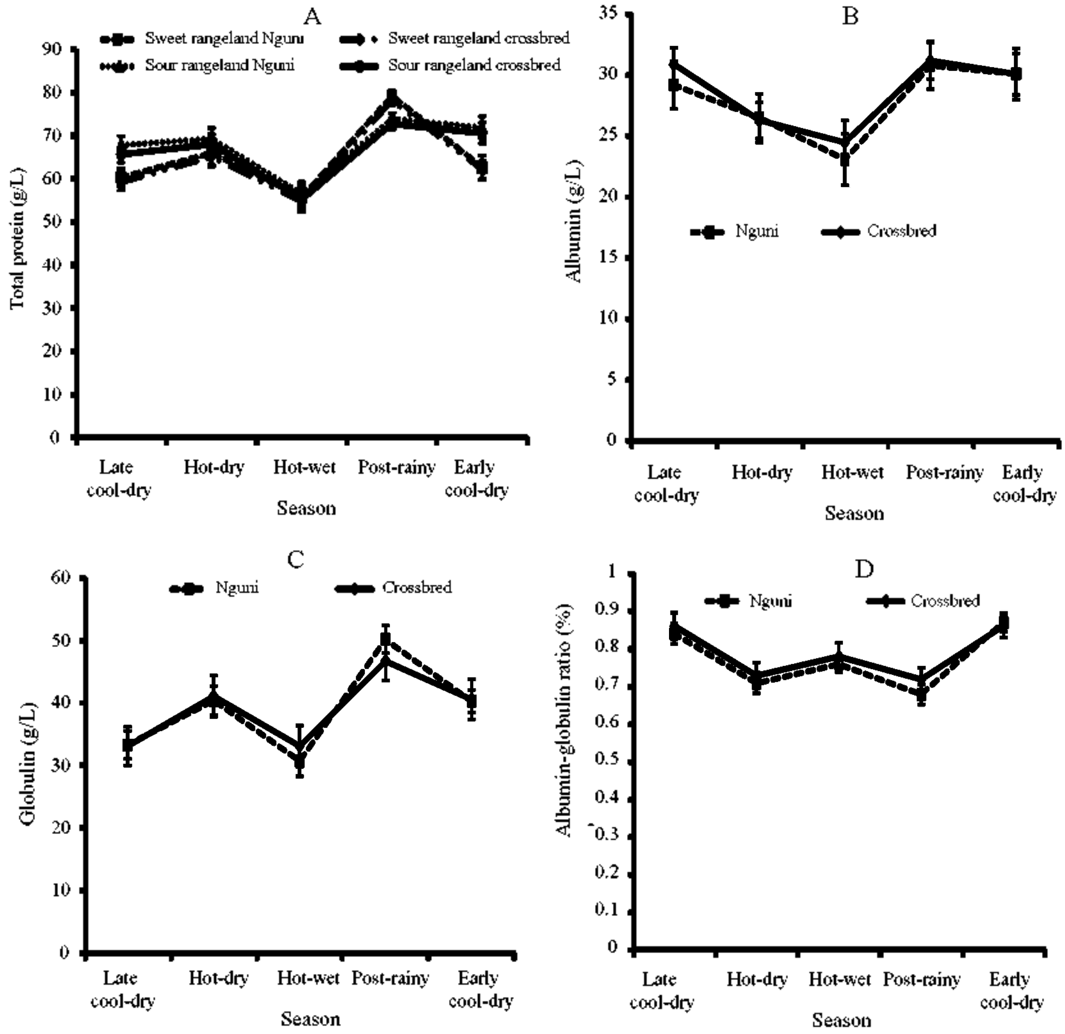

Figure 2. Least square means (±standard error of means) of total protein concentration of Nguni and crossbred cattle (A) based on rangeland type and season, and least square means (±standard error) of albumin (B), globulin (C) and albumin globulin ratio (D) of Nguni and crossbred cattle based on season.

Table 3. Least square means (±standard error of means) of total protein (g/L), albumin (g/L), urea (mmol/L), creatinine (μmol/L) and creatine kinase (μ/L) concentrations of Nguni and crossbred cattle based on cow physiological status

Metabolite	Breed	Physiological status of the cow			
		NPL	NPNL	PL	PNL
Total protein	Nguni	66.7±4.36^{ab}	63.7±4.28^{a}	64.4±4.37^{a}	73.1±4.29^{b}
	Crossbred	66.2±4.56^{ab}	63.6±4.27^{a}	65.5±4.48^{a}	70.1±4.45^{b}
Albumin	Nguni	27.9±2.33^{a}	28.5±1.33^{a}	28.5±1.95^{a}	32.1±1.34^{b}
	Crossbred	26.5±2.21^{a}	27.4±1.35^{a}	27.6±1.75^{a}	32.0±1.37^{b}
Urea	Nguni	3.09±1.06^{ab}	2.78±1.04^{a}	4.39±1.35^{b}	3.54±1.03^{b}
	Crossbred	3.29±1.16^{ab}	2.88±1.17^{a}	4.51±1.39^{b}	3.80±1.14^{b}
Creatinine	Nguni	114.3±20.00^{b}	118.3±20.09^{b}	85.2± 20.42^{a}	138.4±20.21^{c}
	Crossbred	115.3±21.00^{b}	120.3±21.18^{b}	89.3±20.54^{a}	140.4±21.19^{c}
Creatine kinase	Nguni	20.8±35.67^{a}	38.9±36.32^{a}	66.6±35.95^{b}	61.8±36.09^{b}
	Crossbred	21.8±35.61^{a}	40.1±36.21^{a}	67.5±35.79^{b}	64.4±36.16^{b}

a, b, c Values across rows and columns with different superscripts for a particular metabolite are different ($p<0.05$).
NPL = Non-pregnant lactating; NPNL = Non-pregnant non-lactating; PL = Pregnant lactating; PNL = Pregnant non-lactating.

Table 4. Least squares mean (±standard error of means) of albumin-globulin (AG) ratio and albumin (g/L), globulin (g/L), alanine aminotransferase (ALT (µ/L)) and aspartate aminotransferase (AST (µ/L)) concentrations of Nguni and crossbred cattle based on parity

Parity	Breed	Metabolite				
		Albumin	Globulin	AG ratio	ALT	AST
0	Nguni	30.6±2.02^{b}	31.2±2.43^{a}	0.90±0.09^{d}	11.6±9.06^{a}	40.5±17.72^{a}
	Crossbred	31.6±2.12^{b}	32.2±0.43^{a}	0.91±0.09^{d}	11.9±9.16^{a}	42.3±17.72^{a}
1	Nguni	29.0±2.97^{ab}	36.1±2.30^{b}	0.82±0.09^{c}	21.6±8.86^{b}	42.8±17.29^{a}
	Crossbred	29.0±2.97^{ab}	36.3±2.31^{b}	0.82±0.09^{c}	22.6±8.86^{b}	42.7±17.28^{a}
2	Nguni	29.6±2.02^{ab}	36.4±2.44^{b}	0.81±0.08^{c}	31.4±9.11^{c}	51.0±17.78^{a}
	Crossbred	29.4±2.04^{ab}	36.9±2.46^{b}	0.81±0.09^{c}	32.3±9.18^{c}	52.1±17.79^{a}
3	Nguni	29.2±1.91^{ab}	38.3±5.15^{bc}	0.80±0.08^{c}	21.7±8.67^{b}	44.5±16.83^{a}
	Crossbred	29.3±1.71^{ab}	38.5±5.31^{bc}	0.80±0.09^{c}	21.8±8.62^{b}	44.4±16.85^{a}
4	Nguni	28.3±2.08^{ab}	38.9±2.60^{bc}	0.75±0.092^{b}	27.4±9.36^{bc}	69.8±18.20^{b}
	Crossbred	27.3±2.15^{ab}	38.9±3.49^{bc}	0.75±0.09^{b}	27.3±9.37^{bc}	69.7±18.29^{b}
5	Nguni	27.2±1.17^{a}	41.8±3.84^{bc}	0.74±0.09^{b}	21.3±9.73^{ab}	41.2±19.08^{a}
	Crossbred	27.3±1.17^{a}	40.8±2.73^{bc}	0.75±0.09^{b}	21.1±9.77^{ab}	41.9±19.03^{a}
6	Nguni	26.6± 0.65^{a}	46.3±7.13^{c}	0.64±0.17^{a}	18.2±11.92^{abc}	45.9±22.27^{ab}
	Crossbred	27.1±0.64^{a}	47.3±6.23^{c}	0.65±0.11^{a}	18.5±11.91^{abc}	45.2±23.29^{ab}

[a, b, c, d] Values with different superscripts within a column and within a particular parity are different ($p<0.05$).

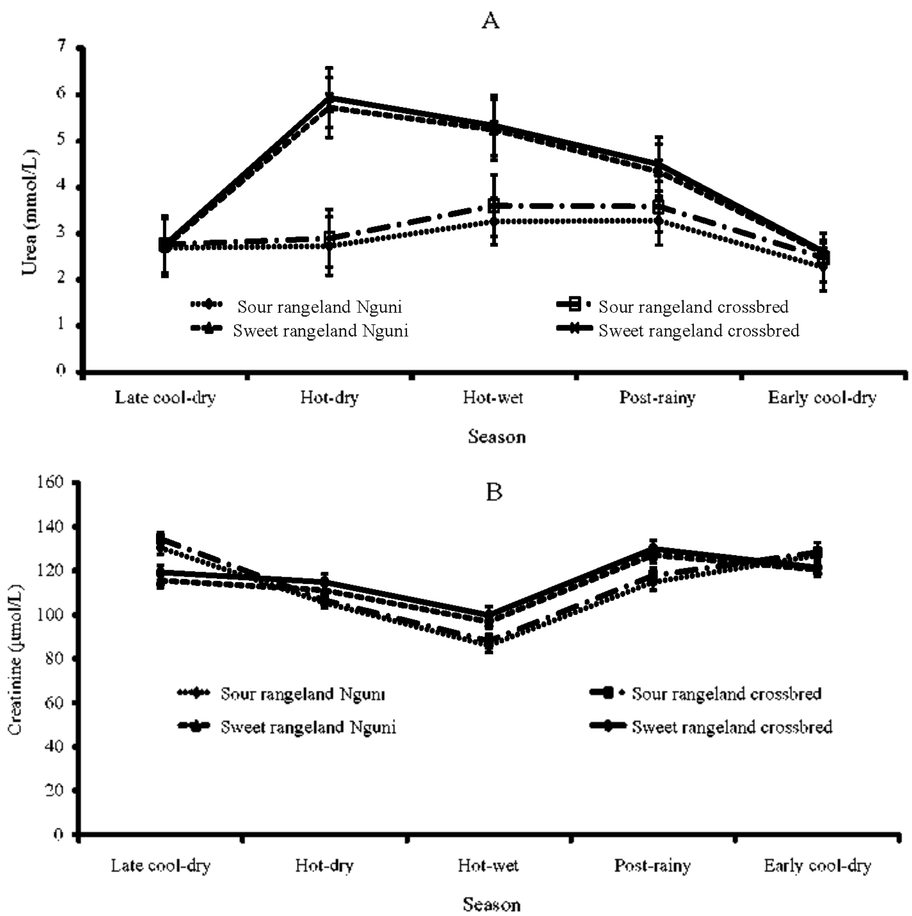

Figure 3. Least square means (±standard error of means) of urea (A) and creatinine (B) concentrations of Nguni and crossbred cattle based on rangeland type and season.

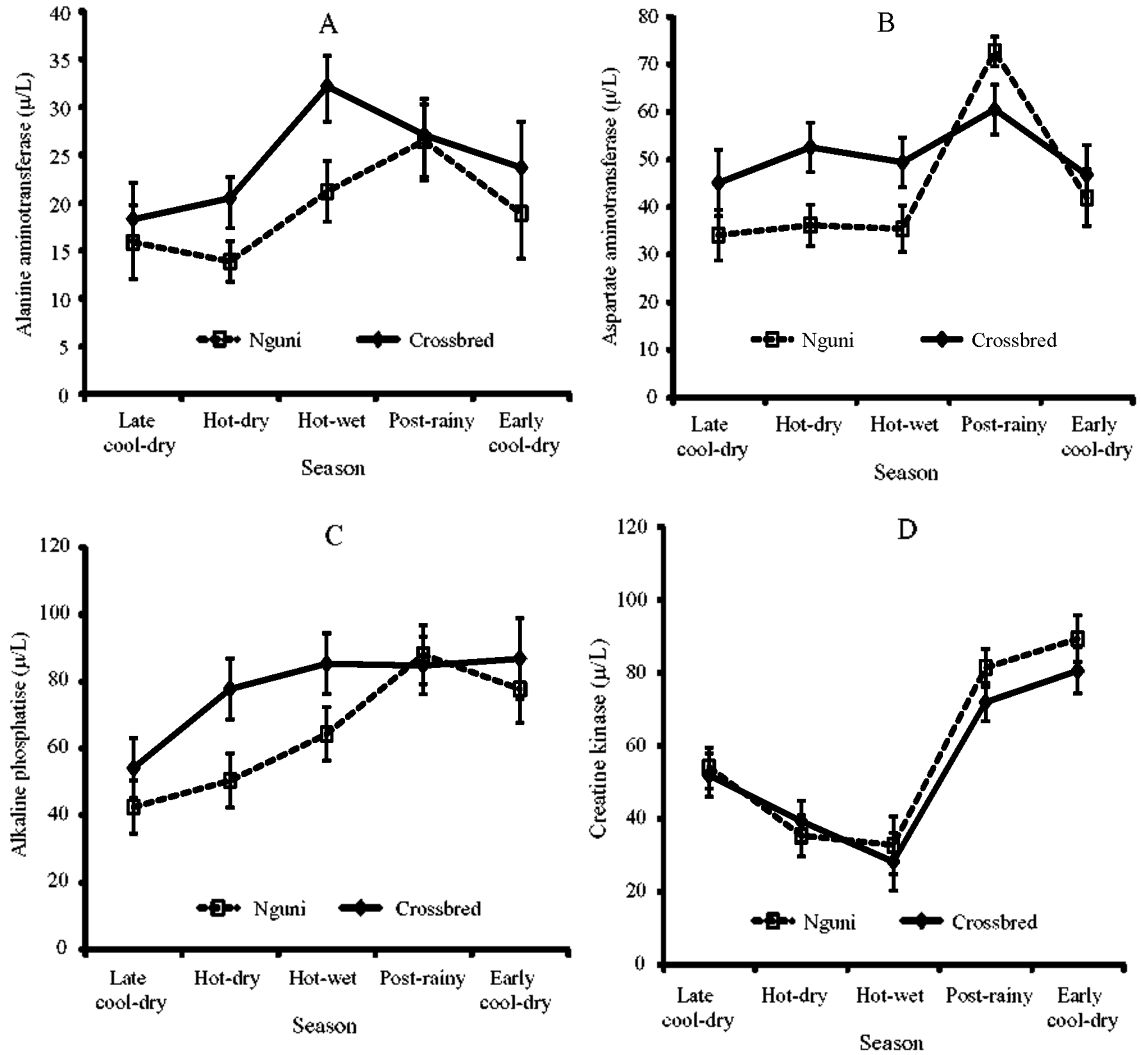

Figure 4. Least square means (±standard error of means) of alanine aminotransferase, (A) aspartate aminotransferase, (B), alkaline phosphatise (C) and creatine kinase (D) concentrations of Nguni and crossbred cattle based on season.

The concentrations of ALT were lowest in heifers, and generally increased ($p<0.05$) with parity (Table 4). The ALT concentrations were not influenced by rangeland type, sex and physiological status of the cow.

Nguni cattle had the highest concentrations of AST in the post-rainy season (Figure 4B) compared to other seasons. Generally, AST concentrations increased ($p<0.05$) up to the fourth parity (Table 4). Rangeland type, sex, age and physiological status of the cow had no significant influence on AST concentrations. Nguni cattle had lower ($p<0.05$) ALP concentrations in the hot-dry and hot-wet seasons than local crossbreds (Figure 4C). Rangeland type,

Table 5. Least square means (±standard error of means) albumin-globulin ratio and alanine aminotransferase concentration of Nguni and crossbred cattle based on age

Age (years)	Metabolite			
	Albumin-globulin ratio		Alanine aminotransferase (μ/L)	
	Nguni	Crossbred	Nguni	Crossbred
1-2	0.72±0.089^{a}	0.73±0.078^{a}	33.20±9.124^{c}	35.21±8.144^{c}
>2-3	0.76±0.089^{ab}	0.77±0.088^{ab}	24.48±8.824^{b}	26.45±8.134^{b}
>3-4	0.81±0.088^{b}	0.82±0.088^{b}	22.36±9.054^{b}	25.23±8.252^{b}
>4-5	0.81±0.089^{b}	0.81±0.089^{b}	15.72±9.104^{a}	19.12±9.314^{a}
>5	0.80±0.089^{b}	0.80±0.089^{b}	13.88±9.054^{a}	14.83±9.224^{a}

$^{a, b, c}$ Values with different superscripts across rows and columns for a particular metabolite are different ($p<0.05$).

sex, age, parity and cow physiology had no effect on ALP concentrations ($p>0.05$).

The concentration of CK in Nguni and crossbred cattle was higher ($p<0.05$) in the sweet rangeland (43.3±30.35 μ/L) than in the sour rangeland (69.7±30.39 μ/L). The post-rainy and early cool-dry seasons had higher ($p<0.05$) CK concentrations than other seasons (Figure 4D). Pregnant lactating and pregnant non-lactating cows had highest concentrations of CK (Table 3). Breed, sex, age and parity had no effect on CK concentrations. No tested factors influenced GGT concentrations.

Correlations among body weight, BCS, PCV, protein metabolites and liver enzymes

There was a strong positive correlation between body weight and BCS, and total protein and globulin concentrations ($p<0.01$; Table 6). Body weight and BCS were positively correlated with total protein and albumin concentrations ($p<0.05$; Table 6). Packed cell volume and albumin concentrations were positively correlated ($p<0.05$; Table 6). Albumin concentration was positively correlated with total protein and creatinine ($p<0.05$; Table 6).

DISCUSSION

The high albumin concentration recorded in the sour rangeland can be ascribed to provision of supplementary feeds. Sour rangelands receive 600-800 mm per annum that supports excess plant growth during the hot-wet season (Tainton, 1999), which is subsequently conserved as standing hay or crop residues for dry season supplementary feeding (Mapiye et al., 2009a, b; Nqeno et al., 2009). Feed supplies decrease from post-rainy season onwards as temperatures and rainfall decrease, reaching a low-point during the dry season when plant materials are dormant (Tainton, 1999). It subsequently increases as new shoots start appearing on trees and shrubs during the late dry season, and grass shoots emerge following rains in the hot-wet season. In general, the patterns of body weight, BCS and serum concentrations of total protein, albumin, and creatinine were consistent with this seasonal trend in rainfall and feed availability, indicating that these blood metabolites are sensitive to seasonal variations in feed availability and protein intake.

The observation that body weight, BCS, total protein, albumin, urea and creatinine were highest in pregnant non-lactating cows could be a result of the greater efficiency of converting nitrogenous substances to amino acids and proteins for foetus growth and development (Doornenbal et al., 1988; King, 2000). The low albumin and creatinine concentrations in pregnant lactating cows could be a consequence of the dam's increased basal metabolic rate, the maximal nutrient requirements of the placenta and the growing foetus, together with the transfer of serum albumin, and amino acids from the bloodstream to the mammary gland for milk synthesis (Jainudeen and Hafez, 2000; Otto et al., 2000).

The decline in PCV concentrations in the hot-wet season could be an indicator of protein deficiency, and high levels of parasites. In the Eastern Cape, highest ticks (Marufu, 2008; Muchenje et al., 2008) and nematode (Ndlovu et al., 2008) infections occur in the hot-wet months. The reduction in PCV in the hot-wet season might also be related to the reduction in cellular oxygen requirement in order to reduce metabolic heat load (Carlson, 1990; Johnston and Morris, 1990). The low PCV concentrations

Table 6. Correlations between body weight, BCS, PCV and protein-related blood metabolites of Nguni and crossbred cattle on communal rangelands

	Weight	BCS	PCV	Total protein	Albumin	Globulin	Urea	Creatinine	ALT	ALP	AST	CK	GGT
BCS	0.61**	-											
PCV	0.17	0.22	-										
TP	0.35*	0.48*	0.10	-									
Albumin	0.37*	0.45*	0.46*	0.51*	-								
Globulin	0.25	0.12	-0.10	0.69**	0.13	-							
Urea	-0.09	-0.03	0.14	0.05	0.06	0.04	-						
Creatinine	0.25	0.23	0.27	0.34	0.53*	0.14	-0.03	-					
ALT	0.04	0.18	0.06	0.20	0.18	0.14	0.04	0.02	-				
ALP	0.07	0.20	0.11	0.03	0.08	0.02	0.01	-0.01	0.17	-			
AST	-0.02	0.08	0.11	0.31	0.25	0.25	0.12	0.10	0.28	0.05	-		
CK	-0.06	0.04	0.14	0.07	0.18	-0.03	0.02	0.15	0.13	0.06	0.15	-	
GGT	0.06	0.04	-0.01	0.29	0.11	0.30	0.01	0.07	0.10	0.06	0.25	0.08	-

Significantly correlated at * $p<0.05$; ** $p<0.01$.

BCS = Body condition score, TP = Total protein, ALT = Alanine aminotransferase, ALP = Alkaline phosphatise,

AST = Aspartate aminotransferase, CK = Creatine kinase and GGT = Gamma glutamyltransferase.

observed in sweet rangeland could be due to low plane of nutrition, especially iron (Farver, 1997). The lower PCV values observed in the Nguni breed could suggest a higher innate and/or acquired resistance to parasites than local crossbreds (Ndlovu et al., 2008; Marufu et al., 2009).

The mean concentration of serum TP was within normal physiological range for cattle (Farver, 1997; Otto et al., 2000). Albumin values were, however lower than the reference values and this could be ascribed to protein under-nutrition and parasitism (Slobodianik et al., 1999; Ndlovu et al., 2009). The decrease in albumin, and increase globulin, ALT and AST concentrations with parity can be attributed to increased calf birth weight and milk production (Doornbos et al., 1984; Browning, 1994).

The high percentage of the cattle that had TP and albumin concentrations below the normal range and the marked decline in mean TP, albumin, globulin, creatinine, AST and CK concentrations in the hot-wet season, especially in the sour rangeland could also be partly attributed to parasitism and heamodilution. In contrast, Akerejola (1980) reported higher values of protein metabolites in the Fulani cattle during the hot-wet season. Ticks and nematodes reduce feed intake and metabolic activity of cattle (Kaufman et al., 2006; Marufu et al., 2009). In addition, gastrointestinal parasitism induces loss of proteins from the blood into the gastrointestinal tract, reducing protein and energy retention in infected animals (Kaufman et al., 2006). Increased blood water concentration and viscosity through consumption of wet forages or as a response to high temperatures during the hot-wet season, particularly in the sour rangeland where rainfall is high, lead to haemodilution, which in turn reduces concentration of blood protein metabolites (Akerejola et al., 1980; Shaffer et al., 1981). The observed low serum proteins concentration during the hot-wet season can be partially attributed to decline in feed consumption and marked increase in respiratory activity with rising temperature (Fox et al., 1988).

The observation that crossbred cattle on sour rangelands had highest globulin concentrations can be linked to high parasite infections, which are more prevalent in the sour rangeland (Marufu et al., 2009). Parasites infections lead to a chronic stimulation of the immune system and the production of gamma globulin (Otto et al., 2000). The lower globulin concentrations observed for Nguni for each rangeland type, could imply that Nguni cattle are resistant or resilient to parasite infections (Marufu et al., 2009; Ndlovu et al., 2009). Following reports by Marufu (2008) and Marufu et al. (2009) on prevalence of ticks and tick-borne diseases in the same study areas, it is crucial to ascertain the effect of tick infections on blood protein metabolites and cattle performance, especially in the sour rangeland.

The low AG ratio observed could be due to lower albumin and higher globulin concentrations than normal range values (9-1.4%) (Doornenbal et al., 1988). Farver (1997) and Ndlovu et al. (2009) attributed the low AG ratio to a marked decrease in albumin concentration and an increase in globulin concentration in the infected animals. The small AG ratio recorded for young animals could mean that they are more susceptible to infections than older ones. Older animals usually develop age-immunity and, therefore, have low infestation rates, but remain a source of infestation for younger animals (Sikka et al., 1994; Matjila and Penzhorn, 2003).

The observation that most of the cattle had urea concentration below the reference range was possibly due to lower intakes of CP (Farver, 1997; Ndlovu et al., 2009). The high stocking rates in the communal areas (Mapiye et al., 2009a; Nqeno et al., 2009) may affect rangelands quantity and quality, especially protein status and subsequently lead low protein intake. When protein intake is low as indicated by low albumin concentrations in this study, resorption of urea nitrogen from blood to the rumen is increased to compensate for the decrease in ruminal ammonia nitrogen (Nonaka et al., 2008). Blood urea is, therefore a good indicator of concentration of rumen ammonia, and this is related closely to intake and solubility of the nitrogen-containing compounds fed (Hayashi et al., 2005).

Blood urea concentration can be inversely related to the efficiency of nitrogen utilization (Nonaka et al., 2008) and its reduction is generally associated with an increase in the efficiency of nitrogen utilisation (Butler et al., 1996). The low albumin and urea concentration observed for Nguni cattle compared to local crossbreds might, therefore imply that Nguni cattle utilised amino acids more efficiently for growth and development, despite the consumption of low protein diets. This could mean that Nguni cattle are more adaptable to low protein diets than local crossbreds. The higher urea concentrations observed in the sweet rangeland during the hot-dry season compared to other seasons can be attributed to low dietary CP intake (Hayashi et al., 2005).

The observed live enzymes concentrations (AST, ALT, ALP, CK and GGT) were within the reference range (Farver, 1997; Otto et al., 2000; Ndlovu et al., 2009). The observation that local crossbreds had higher creatinine levels might suggest that they have more skeletal muscle compared to Nguni cattle. Creatinine is a breakdown product of creatine phosphate in muscle, and its rate of production usually depends on body muscle mass (Gross et al., 2005). This observation was further supported by higher levels of ALT in local crossbreds compared to Nguni cattle. The ALT enzymes are a valuable indicator of skeletal muscle mass and tissue damage in response to strenuous physical exercise (Otto et al., 2000). In addition, the small-framed Nguni cattle are, therefore, likely to travel shorter distances in search of feed to meet their low maintenance requirements, thus could be less prone to skeletal tissue damage than large-framed local crossbreeds (Collins-Luswit, 2000).

High concentrations of ALT observed in cattle aged less than two years may be a result of the faster growth rate in young animals (Doornenbal et al., 1988). The higher ALT concentrations in young animals are indicative of rapid skeletal growth (Ndlovu et al., 2009), which tend to decline with age (Gross et al., 2005). High metabolic rates of the young result not only from high rates of cellular reactions but also partly from rapid synthesis of cellular materials and growth of the body, which require moderate quantities of energy, and hence ALT (National Research Council, 2001).

The elevated concentrations of AST in Nguni cattle during the post-rainy season could be associated with increased feed availability and, consequently, increased growth rates as indicated by improved body weight and BCS in the same season. Previous research on rangeland showed Nguni cattle have higher growth rates than exotic breeds (Muchenje et al., 2008). Similar to this finding, Otto et al. (2000) found higher AST activity in Angoni cattle raised on rangelands. The AST enzyme is an indicator of skeletal muscle growth and liver damage (Otto et al., 2000).

The observed breed differences in ALP values in the hot-dry and hot-wet seasons reflect differences in growth, body size and weight for the cattle in this study. Small-framed animals, have low feed intake and, consequently, lower skeletal growth (Adachi et al., 1997) than local crossbreds. Besides possible involvement in membrane phospholipids synthesis, ALP activity is associated with the process of calcification (Farver, 1997) and, therefore, could be correlated with growth (Pattanaik et al., 1999). The high CK concentrations in pregnant cows probably reflect the increase in foetal musculature and muscle damage in the dam (Castillo et al., 2005). It may be partly due to either partitioning of protein towards foetal growth and development or low CP intake over a long period of time (Castillo et al., 2005).

The observed correlations between body weight and BCS with total protein and albumin concentrations confirm earlier reports that protein supply influence cattle condition (National Research Council, 2001; Boone and Wang, 2007). It might also suggest that body weight and BCS are useful indicators of protein intake and protein status of cattle on communal rangelands.

CONCLUSIONS

It was concluded that Nguni cattle had lower concentrations of protein metabolites than local crossbreds and protein deficiencies were most prominent in the sweet rangeland during the cool-dry seasons. These findings could suggest that Nguni cattle are able to utilise protein more efficiently for growth and development under low protein conditions than local crossbreds. Communal farmers could be encouraged to adopt Nguni cattle as they are resistant to parasite infections and could be able to utilise amino acids more efficiently for growth and development under low protein conditions than local crossbreds. Provision of protein supplements to Nguni cattle could, however, be crucial especially, in the cool-dry seasons where body weights, BCS and blood protein levels are low.

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