Comparative changes in monthly blood urea nitrogen, total protein concentrations, and body condition scores of Nguni cows and heifers raised on sweetveld

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(Received 25 April 2014; Accepted 18 March 2015; First published online 29 March 2015)

Abstract

The objective of this study was to determine the comparative changes in the monthly blood urea nitrogen (BUN) concentration, total protein (TP) concentration in blood serum and the body condition score of Nguni cows and heifers raised on sweetveld. Twenty-four clinically healthy animals in different parities, namely Parity 1 (n = 5), Parity 2 (n = 5), Parity 3-6 (n = 9) and heifers (n = 5), were randomly selected for the study. BUN concentration, TP concentration and body condition scores of the animals were measured over 12 months. Blood samples were collected from the coccygeal vein, while body condition score was assessed once a month during weighing. Cows in Parity 1 maintained a significantly higher body condition score (2.6 ± 0.01) than all the other animals in the trial. All the cows and heifers maintained higher levels of BUN concentration (7.5 ± 0.03 mmol/L) in November, while a lower value (1.9 ± 0.03 mmol/L) was recorded in January. The TP concentration was lowest in August at 70.8 ± 2.65 g/L, before it improved to reach a peak value of 92.3 ± 2.66 g/L in March. The Nguni cows and heifers had variations in the levels of BUN and TP concentrations in the various months while maintaining a steady body condition score throughout the trial.

Keywords: Coccygeal vein, parity, Sanga cattle, weighing
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Introduction

Environmental conditions play an integral part in influencing the form and structure of any rangeland (Scholes & Archer, 1997). In the process, they regulate the quantity and quality of forage biomass production (Scholtz *et al*., 2011; 2013), while simultaneously providing an enabling environment for cattle to express their normal behaviour. Cattle must adopt strategies to deal with cyclical changes in forage quality and quantity (Hatch, 1999), temperature, relative humidity and solar radiation changes in different seasons and environments (Scholtz *et al*., 2013). Such environments include biomes in the tropical and subtropical areas of South Africa; for example sweetveld, which is composed mainly of preferred perennial grass species such as *Themeda triandra* (Acocks, 1988; Mucina & Rutherford, 2011). Grasses from the sweetveld type are more prone to heavy grazing during active growth (Acocks, 1988; Hatch, 1999), thereby limiting animal production during the dry periods, as there will be little residual carryover biomass. Breeding cows reared in such systems have to partition nutrients harvested from such environments to meet protein and energy requirements for maintenance, as well as for pregnancy, lactation and breeding (McManus *et al*., 2009).

Continuous exposure of cattle to stressful environmental conditions provides a platform for natural selection of potential future parents in a breeding population. In the tropical and sub-tropical environments of Africa, these conditions have formed the basis for and shaped the characteristics of indigenous breeds of cattle that are reared extensively. Therefore, the natural environment plays a central role in defining the adaptation potential of breeds. One such breed is Nguni, which is found in South Africa. This breed is being restocked in the communal areas of South Africa in order to promote *in situ* conservation of indigenous resources (Raats *et al*., 2004). Farmers who benefited from this programme are resource limited and hence rear these animals extensively with little or no dietary supplements.

Different climatic regions in South Africa are inhabited by different sub-breeds of Nguni cattle, which are called ecotypes (Hunlun, 2008). It is not yet known how these ecotypes adapt to and perform in adverse environmental conditions in their own climatic regions. Information on environmental adaptation is pertinent, given that global warming and climate change impacts are affecting the natural veld at large (Scholtz *et al*.,

URL: http://www.sasas.co.za
ISSN 0375-1589 (print), ISSN 2221-4062 (online)
Publisher: South African Society for Animal Science http://dx.doi.org/10.4314/sajas.v45i1.12

2010). Therefore, the use of performance and health proxy indicators, such as monthly changes in blood urea nitrogen (BUN) concentration, total protein (TP) concentration in blood serum, will provide useful information for close monitoring of protein management of animals raised extensively on the veld. The farmers can accomplish this by checking whether the protein concentration is below the normal threshold levels, while simultaneously monitoring the condition of the animals. If the concentrations and corresponding body condition scores should be below the threshold, the farmer could provide protein supplements or cull the animals, depending on the associated scales of economy at play. BUN concentration, on the other hand, gives a clue to rumen ammonia reabsorption and ultimately its utilization by the host animal (Hayashi *et al*., 2005); subsequently influencing the changes in protein metabolism in its body (Ndlovu *et al*., 2009). Nguni cattle reportedly recycle urea (Scholtz & Linington, 2006), which, when channelled back, becomes available to the rumen for microbial protein production. Therefore, the objective of this study was to determine monthly changes in BUN concentration, TP concentration and body condition scores of Nguni cows and heifers reared on a sweetveld system in different seasons. It was also hypothesized that cows and heifers have similar BUN concentration, TP concentration and body condition scores in different months of the year.

Materials and Methods

This study was conducted at Honeydale Farm, University of Fort Hare, Alice, which is situated 120 km inland from the Eastern Cape coastline of South Africa. The farm lies between 450 and 600 m above sea level and is located at latitude 32.8º S and longitude 26.9º E. Average annual rainfall ranges between 500 and 550 mm per annum, most of which occurs from November to March (Acocks, 1988). The average maximum temperature is 24.6 ºC and the minimum is 11.1 ºC, with a mean annual temperature of 17.8 ºC. The farm is located in the Bisho Thornveld of the Eastern Cape of South Africa (Mucina & Rutherford, 2011). The vegetation on the rangelands includes *Acacia karroo* as an invasive species, and other woody species include *Scutia indica*, *Maytens heterophyla*, *Rhus longispina*, *Ehretia rigida*, *Olea africana*, *Grewia accidentials* and *Crussonia spicata*. Grass species are dominated by *Themeda triandra,* while *Panicum maximum*, *Eragrostis curvula*, *Digitaria eriantha*, *Cymbopogon excavates*, *Eragrostis capensis*, *Sporobolus fimbriatus* and *Aristida congesta* occupy the other part on the rangeland. The veld is classified as sweet-veld type, which is regarded as fairly good (Acocks, 1988; Van Oudtshoorn, 2012).

Table 1 Environmental weather conditions from the study area

	Rainfall (mm)	Solar radiation[#] (MJ/M^2/day)	Temperature (ºC)	Evaporation (mm/day)	Wind speed (m/s)
June	28.70	9.07	11.64	1.69	1.40
July	21.70	10.69	11.02	1.86	1.23
August	1.95	12.06	13.15	2.35	1.54
September	1.45	17.22	14.59	3.15	1.24
October	20.83	16.09	15.61	2.84	0.96
November	123.70	25.02	18.20	4.61	0.91
December	107.19	24.74	21.48	4.83	0.79
January	56.70	20.32	22.28	3.68	0.82
February	45.72	33.92	22.62	2.67	0.79
March	46.48	25.39	21.09	4.33	0.80
April	28.96	22.42	18.28	3.26	0.76
May	21.08	17.42	15.68	2.16	0.78

[#] Solar radiation is measured per unit surface area using megajoules per square metre per day or a measure of the amount of sunlight energy that is falling per unit area per day.

The soils are deep alluvial-derived types in arid areas, while non-cultivated areas have high proportions of silt and fine sand, which are mostly shallow (less than 450 mm depth). The topography of the area is generally flat with gentle slopes (Acocks, 1988).

For this study, 24 Nguni females in various parities were randomly selected from 64 animals; namely Parity 1 (n = 5), Parity 2 (n = 5), heifers (n = 5) and Parities 3–6 (n = 9). There were few cows from Parities 3–6 (old cows in the group); hence, the available animals were assigned to a single group. There were two cows in Parities 3, 4 and 5, and three cows in Parity 6. At the beginning of the trial, all the animals were weighed with a digital Waikato scale (Waikato, New Zealand) to establish an average weight in each group. Heifers weighed on average 326 ± 11 kg. Cows in Parity 1 weighed 338 ± 11 kg; those in Parity 2 weighed 370 ± 10 kg; and cows in Parity 3–6 had an initial average weight of 430 ± 8 kg. The animals were monitored for 12 months. Animals were identified by ear tags. Water was available ad libitum inside each paddock. The animals were raised on the natural rangeland. The grasses had low growth potential from June to October, while it improved from November to May. Likewise, most of the rain fell from late November to early April, and the dry season set in from late May to October (Table 1). Rotational grazing was practised, and cows were moved into a new paddock after 21 days. The animals used in this trial were all in the same trimester (month of pregnancy) at the beginning of the trial. They all calved within 10 days from first to last animal. The only variation between the cows was noticeable in the time taken to reconceive (heifers and those in Parity 2 were 2½ months pregnant, Parity 1 were 3 months, and those from Parities 3–6 were 4 months pregnant) as shown in Table 2.

Table 2 Timeline sequence of changes in physiological status for Nguni females during the trial

Parity	Season			
	Cool-dry*	Hot-dry#	Hot-wet	Cool-wet**
Heifers	Pregnant/birth	Lactation/breeding	Lactation/breeding	2½ months pregnant
1	Pregnant/birth	Lactation/breeding	Lactation/breeding	3 months pregnant
2	Pregnant/birth	Lactation/breeding	Lactation/breeding	2½ months pregnant
3–6	Pregnant/birth	Lactation/breeding	Lactation/breeding	4 months pregnant

NB: * All the Nguni females calved down in September.
#Breeding started in late November **Pregnancy diagnosis done in March.
Cool-dry season: June - August; hot-dry season: September - November; hot-wet season: December - February; and cool-wet season: March - April.
All animal classes refer to the parities from the previous breeding season for clarity.

Blood samples were collected once a month before the cows and heifers were weighed. Blood was collected from the coccygeal vein of the cows and heifers into a 10 mL disposable vacutainer tube. Corresponding ear-tag numbers of the animals were marked on the vacutainer tubes immediately after collection. The vacutainer tubes were placed in cooler boxes containing ice packs prior to centrifugation. The blood serum was then separated by centrifuging (Eppendorf, Germany) at 3500 rpm with a temperature of 21 ºC for 10 minutes. The resulting blood serum was transferred to clean vacutainer tubes and labelled as previously described. Blood serum was then analysed spectrophotometrically for TP concentration (Weichselbaum, 1946), while BUN concentration was determined by a procedure by Tietz (1995). Body condition scores were assessed on a scale of 1 - 9 following the procedure described by Lawrence & Fowler (2000) through visual appraisal and palpation once a month immediately before blood sample collection. This procedure was done by the same researcher, who was blindfolded for parity throughout the trial.

All the quantitative data collected from this study was analysed with the Statistical Analysis System (SAS, 2003). Before analysis, data for body condition scores were square root transformed to adjust them into normal distribution. The main effects (month and parity) were incorporated into the linear model using PROC GLM of SAS (2003), while weight was considered a covariate. Initially interactions between the main effects were considered in the model before they were removed because of non-significance. Fisher's least significant difference (LSD) method was used to separate means for BUN concentration, TP concentration and body condition score at P <0.05.

Results

The effect of parity on BUN concentration, TP concentration and body condition scores from the Nguni cows and heifers used in this study is shown in Table 3 below. There were no significant differences (P >0.05) in TP and BUN concentrations from all the animals used in this trial. However, cows in Parity 1 maintained significantly (P <0.05) higher body condition scores (2.6 ± 0.01) than all the other animals in the trial.

Table 3 Effect of parity on blood urea nitrogen concentration (mmol/L), total protein concentration (g/L) in serum and body condition scores (mean ± standard error) of the Nguni heifers and cows

	Parity				
	Heifers	1	2	3	*P* value
BUN concentration	5.0 ± 0.21^{a}	4.89 ± 0.21^{a}	5.03 ± 0.17^{a}	4.98 ± 0.19^{a}	0.94
TP concentration	77.3 ± 1.94^{a}	78.9 ± 1.86^{a}	81.4 ± 1.52^{a}	81.3 ± 1.65^{a}	0.43
Body condition score	2.5 ± 0.02^{a}	2.6 ± 0.01^{b}	2.5 ± 0.01^{a}	2.5 ± 0.01^{a}	0.03

BUN: blood urea nitrogen; TP: total protein.
Means with the same superscript in the same row are not significantly different at P <0.05.

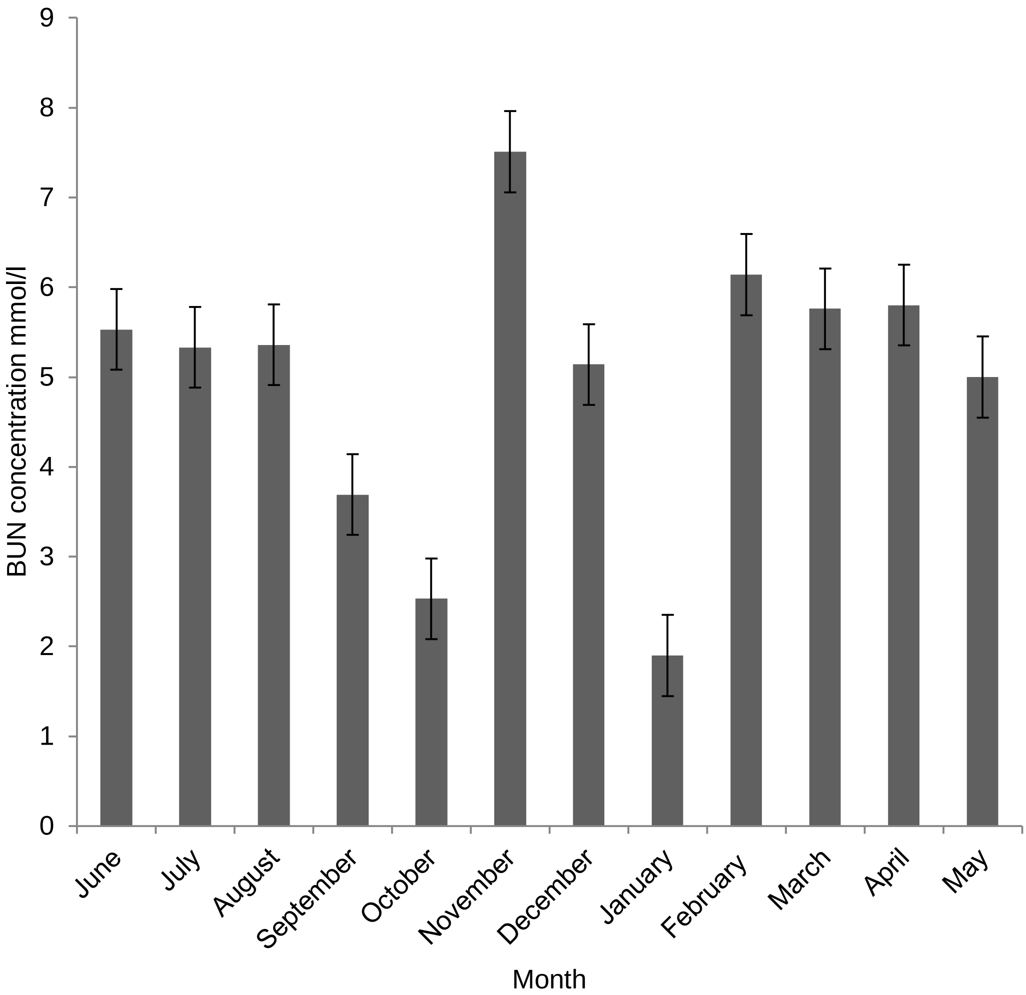

Figure 1 Monthly changes in blood urea nitrogen (BUN) concentration of the Nguni cows and heifers.

Results for monthly changes in BUN concentration, TP concentration and body condition scores from all the animals used in the trial are shown in Figures 1, 2 and 3, respectively. All the animals had significantly lower BUN concentration in January (1.9 ± 0.03 mmol/L), while a peak level was recorded in November (7.5 ± 0.03 mmol/L) (Figure 1). The TP concentration was lowest in August, namely 70.8 ± 2.65 g/L, and then it improved to reach a peak value of 92.3 ± 2.66 g/L in March (Figure 2). All the animals maintained similar (*P* >0.05) body condition scores from June to November before they then improved, reaching a significantly higher value of 2.6 ± 0.02 in December (Figure 3).

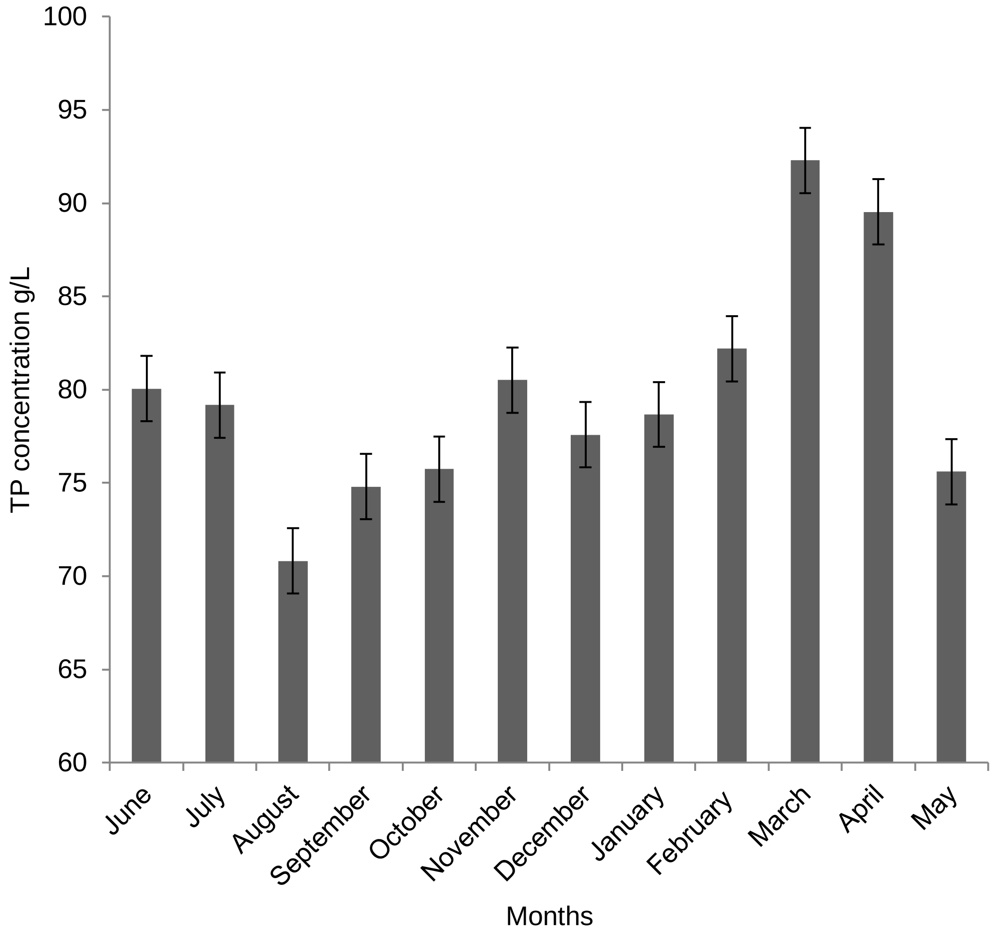

Figure 2 Monthly changes in total protein (TP) concentration in the blood serum of the Nguni cows and heifers.

Discussion

The animals used in this trial were not given supplements, but grazed entirely on natural grassland. These conditions mimic those of small-scale communal grazing lands. Therefore, the results from this study can formulate the basis of and provide background knowledge for recommendations to the small-scale farmers who benefited from the Nguni cattle project.

The average BUN concentration recorded in this study is comparable with that reported by Otto *et al*. (2000) for Angoni cattle in Mozambique, while it is higher than values reported by Osler *et al*. (1995), Schoeman (1989) and Ndlovu *et al*. (2009) for Nguni cattle. Otto *et al*. (2000) found an average of 4.5 ± 1.1 mmol/L, while Schoeman (1989) and Ndlovu *et al*. (2009) reported values of 3.38 ± 0.87 and 3.27 ± 0.099 mmol/L, respectively. However, low BUN concentrations were recorded in the dry months. Low concentrations of BUN recorded in September and October (during the dry seasons) could have been related to low protein quality and quantity during this period (Ndlovu *et al*., 2009, Mapiye *et al*., 2010).

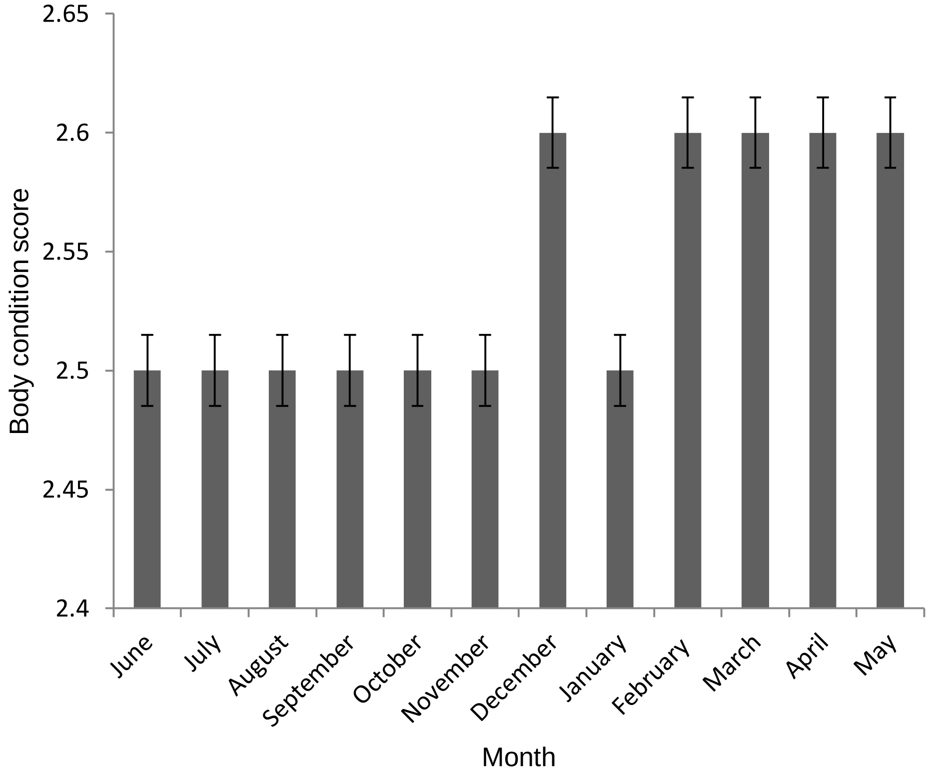

Figure 3 Monthly changes in body condition scores of the Nguni cows and heifers.

In the dry spell there is low protein intake because of high fibrous diets from dry forage materials (MacDonald *et al*., 2006; Ndlovu *et al*., 2009). This is related to low nitrogen concentration in the forage material from the veld, which then limits microbial growth and utilization of organic matter (Scholtz *et al*., 2010). Blood urea nitrogen concentration improved from September to November and then dropped from December to reach its lowest value in January. This drop could have been as a result of loss of nitrogen in urine through low kidney reabsorption rates (MacDonald *et al*., 2006), since the veld condition had improved after the first rains.

The TP concentration found in this study was comparable with those reported by Otto *et al*. (2000) and Mapekula *et al*. (2011). Otto *et al*. (2000) reported a value of 77.0 ± 3.6 g/L, while Mapekula and co-workers (2011) reported TP concentration that ranged from 67 to 98.1 g/L. The high concentration of TP above the optimum range of 65 - 78 g/L (Faver, 1997) in this study could be related to the high BUN concentration highlighted earlier. The lower variations in the TP concentration could have emanated from optimal urea reabsorption in the kidneys for ammonia production in the rumen (Nonaka *et al*., 2008; Mapiye *et al*., 2010). Early studies on BUN concentration analysis highlighted that there is a relationship between kidney function and absorption of solutes such as urea (Eggum, 1970). Therefore, this process will ensure sustainable quantities of protein production to meet the animals' physiological demands.

Cows and heifers lost body condition during the dry months (from June until November). The dry period is characterized by low forage quantity and quantity; therefore animals lose condition (Scholtz, 2008; Ndlovu *et al*., 2009; Mapiye *et al*., 2010; Mapekula *et al*., 2011) as the feed resource base cannot sustain their nutritional demands during this period (Mapekula *et al*., 2009; Nqeno *et al*., 2010). The sweetveld is considered to have good-quality forage material. However, low rainfall or moisture during the dry season limits the quantity of dry matter material available for grazing by cattle (Ellery *et al*., 1995). In addition, during the dry spell, forage material is fibrous and ultimately high in structural carbohydrates, which are subsequently not easily degraded by rumen microbes (MacDonald *et al*., 2006).

Conclusion

The Nguni cows and heifers had variations in the levels of BUN and TP concentrations in different months, while maintaining relatively stable body condition scores in the trial. Nguni animals used in this study maintained higher BUN and TP concentrations than previous studies on the breed under different veld and production systems. These are indications that the animals can withstand seasonal environmental changes with minimal changes in nutritional status and body condition scores. Therefore, based on these results, it is recommended that they could be reared in areas with low feed resource bases.

Acknowledgements

The authors wish to thank the management and staff at Honeydale Farm for the upkeep of the animals during the trial. This study was sponsored by Adam Fleming through the Nguni Cattle Project (P329) and the National Research Foundation (NRF). Our sincere gratitude is also extended to all the technical staff from the Department of Livestock and Pasture Science at the University of Fort Hare for their helping hands.

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