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Changes in Metabolites Concentration in Nguni and Crossbred Calves on Natural Pasture

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ABSTRACT: Accurate assessment of the nutritional status of Nguni cattle is becoming increasingly important in determining their mechanism for adaptation to challenging environments. Changes in body weights and concentrations of total protein (TP), albumin, globulin, glucose, cholesterol, non-esterified fatty acids (NEFA), phosphorus (SIP), calcium and magnesium were determined in Nguni and crossbred calves raised on natural pasture from birth until weaning. At an early age, TP concentration in crossbreds was higher ($p<0.05$) than that of Nguni calves. However, TP levels increased with age in Nguni calves so that Nguni's had higher ($p<0.05$) TP levels than crossbreds at weaning. Nguni calves had higher ($p<0.05$) glucose concentrations than crossbreds in all the ages except in the third month. Serum NEFA levels in Nguni calves were higher ($p<0.05$) than in crossbreds at all ages except for the second month. Calcium levels decreased ($p<0.05$) with age in both genotypes. The blood TP concentrations tended to decrease ($p<0.05$) as body weight increased up to 80 kg, thereafter blood TP concentration increased ($p<0.05$) as body weight increased. Calcium concentrations in crossbred calves decreased ($p<0.05$) quadratically as the body weight increased. There was, however, a linear increase ($p<0.05$) in calcium concentrations in Nguni calves. The higher NEFA and TP concentrations at weaning and the TP increase in Nguni calves beyond 80 kg suggest that Nguni's utilise fibrous feeds better than crossbreds. (**Key Words :** Age, Calcium, Glucose, Non-esterified Fatty Acids, Total Protein, Calf)

INTRODUCTION

For survival, animals need to be adapted to their environmental conditions by being able to utilise available feed resources efficiently and to develop immune systems that protect against infections. In the rural areas of South Africa, the cattle genotypes kept are crossbreds, where imported bulls (*e.g.*, Angus, Bonsmara, Brahman, Friesian and Jersey) are mated with local Nguni cows (Mapiye et al., 2009a). There are renewed efforts to re-populate rural areas with pure-bred indigenous Nguni cattle due to their adaptability to local environment (Mapiye et al., 2009b). Nguni cattle are part of the Sanga group in Southern Africa, descendants of *Bos taurus* animals that were domesticated in north-eastern Africa 7,000-8,000 years ago and later crossed with *Bos indicus* cattle from the Arabian Peninsula that arrived in South Africa around 300-700 AD (Scherf, 2000). Owing to their ability to produce organic meat, Nguni cattle are becoming popular for the production of organic beef in Southern Africa (Muchenje et al., 2008a; Mapiye et al., 2009a).

In the view of the high capacity of the Nguni cattle to produce organic meat, the bulk of the farmers in Southern Africa are becoming interested in purchasing weaners from renowned Nguni cattle breeders (Mapekula, 2009). Currently, farmers are estimating the price of the weaners using body condition scores (BCS) and body weights, as is practiced for mature cattle (Ndlovu et al., 2009a). This is grossly imprecise, difficult (Ndlovu et al., 2007) and does not provide adequate evidence to justify the high prices that are charged for the Nguni weaners. Given that blood metabolites are good pointers of animals' health status and adaptability to the environment (Ndlovu et al., 2007), they can be used to complement BCS and body weights in selecting and pricing high performing weaners. For example, the globulin concentration in animals, which are usually highly susceptible to infections, is a good indicator of the degree of infections in animals (Marufu et al., 2010). Differences in the globulin levels in animals kept on the

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same farm, therefore, suggests possible differences among breeds or individuals on resistance, resilience or tolerance to endemic diseases and parasites. Overall, protein and energy related metabolites reflect animal's adaptation to locally available feed resources (Mapiye et al., 2010a, b). Establishing the levels of such metabolites in Nguni and crossbred calves could, therefore, be of paramount importance.

Monitoring the changes in the levels of nutritionally-related metabolites between the Nguni and crossbred calves until weaning could assist in understanding the adaptation of Nguni cattle from an early age. Little effort, so far, has been put on assessing the adaptability of Nguni cattle from a young age. However, if the adaptability to utilising fibrous feeds observed in mature Nguni animals is genetic, it is likely to be observable in calves (Mapekula, 2009). Such information is crucial for improving genetic progress of high-value animals. It could also be useful in generating benchmarks for assessing the nutritional and health status of Nguni cattle. The objective of the current study was to determine the concentrations of nutritionally-related blood metabolites and their relationship to body weight in Nguni and crossbred calves on natural pasture.

MATERIALS AND METHODS

Study site

The study was conducted in Seymour, a sub-municipality of Nkonkobe municipality in the Amathole district of the Eastern Cape Province of South Africa. Seymour is located in the Valley Bushveld of the Eastern Cape (Beckerling et al., 1995). The dominant grass species include *Panicum maximum*, *Themeda triandra*, *Digitaria eriantha*, *Aristida congesta* and *Cynodon dactylon* (Lesoli, 2008). In the valleys, the main bush species is the *Acacia karroo*, whilst the mountainous areas are dominated by *Olea africana*, *Ptaeroxylon obliquum* and *Portulacaria afra* (Beckerling et al., 1995). The area receives an average rainfall of 480 mm per annum, and is mostly received in summer. The average minimum and maximum temperatures during the study period were 14.3 and 29.4°C, respectively (Lesoli, 2008).

Experimental animals

A total of 20 calves (10 Nguni and 10 crossbred) were randomly selected from the calves kept by the community and ear-tagged for easy identification. The calves used were crosses between Brahamn bulls and Brahman×Nguni cows. Brahman bulls were donated by the government to upgrade the Nguni cattle in the rural areas and Nguni bulls were eliminated. In each genotype, there were five male and five female calves. All the calves were born in December 2008 and relied on the dam's milk and rangeland forages for feeding until weaning. They were always with their dams throughout the study period. All the calves were dipped once a month using a commercial acaricide, Decatix 3® (Cooper Veterinary Products (Pty) Ltd, Registration Number. 2002/021376/07, Pretoria, South Africa). No other medication was provided. They were all clinically healthy throughout the six months of the study.

All the cows were in the second parity and had produced their first calves in the previous year. All the cows were clinically healthy and had body condition scores ranging from 2.5 to 3 on a 5-point scale (1-very thin and 5-obese; Nicholson and Butterworth, 1986) throughout the trial. The average milk yield from once a day milking of the Nguni and crossbred cows was 1.5 and 3.1 kg/d, respectively. Milk samples were collected at each milking stage and analysed at the Agricultural Research Council Analytical Laboratory, Elsenburg, for fat, protein, lactose and total solids using CombiFoss™ (Copenhagen, Denmark) and MilkoScan™ (Copenhagen, Denmark) according to Association of Official Analytical Chemists (AOAC, 2003; Table 1). Cows entirely relied on the natural pasture for feed. All animals obtained water from the river and windmill in the wet and dry seasons, respectively.

Table 1. Least square means and standard error of mean (SE) for milk protein, fat, lactose and total solids in Nguni and crossbred cows across stages of lactation

Milk component	Genotype	Stage of lactation			SE
		Early	Mid	Late	
Protein (g/kg of milk)	Nguni	32.2[a]	35.1[b]	37.8[c]	2.96
	Crossbred	32.9[a]	32.8[a]	33.8[a]	2.56
Fat (g/kg of milk)	Nguni	29.8[a]	31.1[a]	32.5[b]	0.63
	Crossbred	33.5[c]	34.3[c]	37.3[c]	0.55
Lactose (g/kg of milk)	Nguni	47.7[c]	48.8[c]	35.1[a]	2.05
	Crossbred	44.8[b]	48.7[c]	48.7[c]	1.76
Total solids (g/kg of milk)	Nguni	94.7[a]	103.9[a]	108.5[a]	8.19
	Crossbred	123.1[b]	124.1[b]	131.3[b]	7.01

[ab] Values with different superscripts for each parameter are different ($p<0.05$).

Nutritional composition of the natural pasture

Five 100 m long transects were randomly positioned in each paddock and five 0.25 m^2 quadrats were placed 20 m apart along each transect. Grasses were cut at 5 cm above the ground and the biomass collected from each transect was mixed and a composite sample taken for the nutritional evaluation of the natural pasture. Dry matter (DM), crude protein (CP), calcium, magnesium, potassium, zinc, copper, iron, manganese, phosphorus and sodium (Table 2) were evaluated using the AOAC (2003) procedures. Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined according to Van Soest et al. (1991) (Table 2).

Blood collection and analyses

Blood samples were collected from Nguni and crossbred calves monthly from a month old (January, 2009) until they were six months old (June, 2009). Blood for total protein (TP), albumin, cholesterol, calcium, magnesium and inorganic phosphorus (SIP) determination was collected via jugular veni-puncture into red top vacutainer tubes without anticoagulant. Blood to be analysed for non-esterified fatty acids (NEFA) and glucose was collected using the Vacutainer® blood tubes containing ethylene diaminetetracetic acid (EDTA) and sodium fluoride, respectively. The blood was collected at 0800 h, before calves were released from pens for grazing. The blood was immediately placed and kept in a cooler box at about 4°C for transport to the laboratory. At the laboratory the blood was centrifuged at 1,000×g for 10 minutes within 2 h of collection. The tubes containing serum were stored at -20°C, pending analysis.

Non-esterified fatty acids were analysed using commercially available kits (Siemens, South Africa) and a Chexcks machine (Next/Vetex Alfa Wasseman Analyser, Woerden, Netherlands). Serum samples were analysed spectrophotometrically for TP, albumin, NEFA (De Villiers et al., 1977), SIP, calcium and magnesium (Young, 1990). Globulin concentrations were computed as a difference between TP and albumin, whilst albumin/globulin (A/G ratio) was obtained by dividing the albumin value by the globulin concentration. Enzymatic methods were used for glucose and cholesterol analyses (Tietz, 1993).

Statistical analyses

Data were analysed using the PROC MIXED procedure of SAS (2006) for repeated measures. For each metabolite, the model used accounted for the genotype, age (month), sex and the two- and three-way interactions for each calf. First-order autoregressive correlation (AR (1)) was fitted to the model on each metabolite. Comparisons of least square means were done using the PDIFF option of SAS (2006). The effect of varying body weight on blood metabolites in each genotype was examined using the quadratic response surface model (SAS, 2006).

RESULTS

Protein-related metabolites concentration

Although Nguni calves had lower (p<0.05) birth weight than crossbred calves, they had higher (p<0.05) ADG and weaning weight (Table 3). There were interactions between genotype and calf age on TP levels (p<0.05) (Table 4). One, two and five-month old crossbred calves had higher (p< 0.05) TP than Nguni calves but at six months, Nguni calves had higher (p<0.05) TP levels than crossbreds. Genotype and age had no effect on albumin levels. One, two and six months old crossbred calves had higher (p<0.05) globulin levels than Nguni calves (Table 4). Crossbred calves had

Table 2. Nutritive value of natural pasture in Seymour between January and June 2009

Parameter (g/kg DM unless stated)	Month						SD[1]
	January	February	March	April	May	June	
Dry matter (DM)	927.0	926.0	925.0	925.0	921.0	927.0	7.00
Crude protein	40.6	39.6	36.3	31.9	33.5	32.7	11.30
Neutral detergent fibre	650.6	648.6	656.1	636.9	625.7	648.3	15.20
Acid detergent fibre	380.9	383.9	404.1	407.7	395.9	417.2	20.40
Calcium	1.0	1.0	1.0	0.9	0.8	0.8	0.50
Magnesium	0.2	0.2	0.2	0.1	0.2	0.1	1.02
Potassium	2.0	2.0	2.0	1.6	1.6	1.3	1.09
Sodium	0.1	0.1	0.1	0.1	0.1	0.1	0.00
Phosphorus	0.1	0.1	0.1	0.1	0.1	0.1	0.00
Zinc (mcg/g DM)	29.2	24.1	21.7	23.1	20.6	19.5	5.23
Copper (mcg/g DM)	10.1	9.8	9.0	8.3	9.7	7.3	2.12
Iron (mcg/g DM)	432.6	423.2	421.6	370.1	310.7	326.8	45.52
Manganese (mcg/g DM)	53.7	50.2	49.7	43.0	41.7	47.7	3.12

[1] SD = Standard deviation.

Table 3. Least square means (±standard error of mean) of birth weight, average daily gain and weaning weight of Nguni and crossbred calves on natural pasture

Measurement	Nguni	Crossbred
Birth weight (kg)	25.2±0.50[a]	27.3±0.77[b]
Average daily gain (kg/d)	0.61±0.018[b]	0.52±0.012[a]
Weaning weight (kg)	138.0±2.45[b]	123.4±2.15[a]

[a,b] Values with different superscripts for each parameter are different (p<0.05).

lower (p<0.05) A/G ratios at weaning than Nguni calves. Sex of calf had no effect on the concentration of protein-related blood metabolites.

Energy-related metabolites concentration

Nguni calves had higher (p<0.05) glucose levels compared to crossbred calves at all ages except in the third month (Table 5). Sex of calf had no effect on glucose concentrations. Age, genotype and sex did not influence cholesterol concentrations in Nguni and crossbred calves. Nguni calves had higher (p<0.05) NEFA levels than crossbred calves at all ages, except in second month (Table 5). Female Nguni calves had higher (p<0.05) NEFA levels (0.6±0.15 g/L) than Nguni males (0.3±0.09 g/L), crossbred females (0.3±0.25 g/L) and crossbred males (0.3±0.27 g/L).

Mineral metabolites concentration

Genotype and sex had no effect on calcium levels. The age of calf had significant effects on calcium levels. All calves had higher (p<0.05) calcium concentrations up to the fourth month (Table 6). Genotype, age and sex had no effects on magnesium and SIP concentrations in both calf genotypes (Table 6).

Relationships between body weight and blood metabolites

No significant relationship was observed between body weight and TP in crossbred calves (Table 7). On the contrary, a quadratic relationship existed between the body weight and TP in Nguni calves (p<0.05; Table 7). The TP concentrations tended to decrease as the body weight increased up to 80 kg then increased with body weight thereafter (p<0.05; Figure 1). There was a linear relationship (p<0.05) between body weight and globulin concentration in Nguni calves, but no relationship existed in the crossbred calves' body weight and globulin concentration. Unlike crossbred calves, there was a quadratic increase (p<0.05) in A/G as body weight increased in Nguni calves. There were no significant relationships between body weight and energy-related blood parameters in both genotypes. A positive linear relationship (p<0.05) was found between body weight and calcium

Table 4. Least square means for concentration (g/L) of protein-related blood metabolites in Nguni and crossbred calves on natural pasture

Calf age (months)	Total protein		Albumin		Globulin		A/G[1]	
	Nguni	Cross[2]	Nguni	Cross	Nguni	Cross	Nguni	Cross
1	67.1[a]	73.8[b]	32.0	33.9	35.1[a]	48.1[c]	0.9[b]	0.7[ab]
2	72.9[b]	77.9[c]	32.4	35.6	40.5[b]	49.9[c]	0.8[b]	0.7[ab]
3	73.1[b]	73.7[b]	25.6	30.7	43.1[b]	43.0[b]	0.6[a]	0.7[ab]
4	73.6[b]	72.2[b]	32.4	33.9	44.2[b]	47.7[c]	0.7[ab]	0.7[ab]
5	73.6[b]	86.5[d]	32.4	31.6	44.3[b]	54.8[d]	0.7[ab]	0.6[a]
6	98.1[e]	71.3[b]	34.9	32.2	38.0[a]	63.3[e]	0.9[b]	0.5[a]
SE[3]	5.68	4.55	4.53	4.05	2.35	2.26	0.33	0.16

[a,b,c,d,e] Values with different superscript for a given parameter are different (p<0.05).
[1] A/G = Albumin:globulin ratio. [2] Cross = Crossbred (non-descript) calves. [3] SE = Standard error of mean.

Table 5. Least square means for energy related metabolite levels (g/L) in Nguni and crossbred calves on natural pasture

Calf's age (months)	Glucose		Cholesterol		Non-esterified fatty acids	
	Nguni	Crossbred	Nguni	Crossbred	Nguni	Crossbred
1	4.7[c]	2.1[a]	3.2	3.4	0.4[b]	0.2[a]
2	3.8[b]	2.1[a]	3.6	3.7	0.3[a]	0.2[a]
3	3.0[a]	4.0[b]	3.2	4.0	0.6[b]	0.3[a]
4	3.9[b]	1.9[a]	3.4	3.4	0.6[b]	0.4[a]
5	3.9[b]	1.1[a]	3.2	3.6	0.5[b]	0.3[a]
6	3.8[b]	2.3[a]	3.7	3.6	0.6[b]	0.3[a]
SE[1]	0.53	0.53	2.44	1.81	0.07	0.06

[a,b,c] Values with different superscript for a given parameter are different (p<0.05). [1] SE = Standard error of mean.

Table 6. Least square means for calcium, magnesium and phosphorous concentrations (mmol/L) in Nguni and crossbred calves on natural pasture

Calf's age (months)	Calcium		Magnesium		Phosphorus	
	Nguni	Crossbred	Nguni	Crossbred	Nguni	Crossbred
1	2.4[b]	2.5[b]	0.9	0.9	3.1	3.2
2	2.4[b]	2.5[b]	1.0	1.1	3.2	3.3
3	2.4[b]	2.5[b]	1.7	1.0	3.6	3.6
4	2.4[b]	2.4[b]	1.7	1.0	3.5	3.6
5	2.2[a]	2.1[a]	1.7	1.0	3.5	3.6
6	2.2[a]	2.1[a]	1.0	0.9	3.8	3.7
SE[1]	0.07	0.07	0.52	0.52	0.45	0.34

[a,b,c] Values with different superscript for a given parameter are different ($p<0.05$). [1] SE = Standard error of mean.

Table 7. Relationship between body weight and blood metabolite concentrations in Nguni and crossbred calves on natural pasture

Variable	Genotype	Relationship	Equation
Total protein	Crossbred	NS	
	Nguni	Quadratic	$Y = 87.17-0.47x+0.003x^2$
Albumin	Crossbred	NS	
	Nguni	NS	
Globulin	Crossbred	NS	
	Nguni	Linear	$Y = 41.78-0.065x$
A/G ratios	Crossbred	NS	
	Nguni	Quadratic	$Y = 0.09+0.12x+0.217x^2$
Calcium	Crossbred	Quadratic	$Y = 2.07+0.01x-0.0001x^2$
	Nguni	Linear	$Y = 2.37+0.003x$
Magnesium	Nguni	NS	
	Crossbred	NS	
Phosphorus	Crossbred	NS	
	Nguni	NS	
Cholesterol	Crossbred	NS	
	Nguni	NS	

NS = Non significant ($p>0.05$).

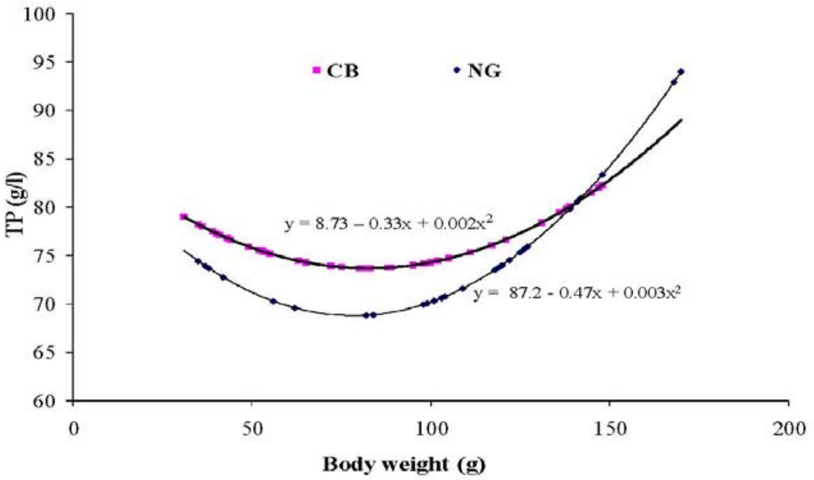

Figure 1. Relationship between total protein and body weight in Nguni (NG) and crossbreds (CB) calves on natural pasture.

concentrations in Nguni calves (Table 7). Although calcium concentrations between genotypes tended to be similar below a body weight of 100 kg, at higher body weights, Nguni calves had higher ($p<0.05$) calcium levels (Figure 2).

DISCUSSION

Determining breed differences in nutritionally-related blood metabolite profiles across seasons could be useful in understanding nutrient demands and utilisation efficiency of a particular breed in a given environment (Mapiye et al., 2010a, b). Such information is crucial in making recommendations on the adoption of appropriate cattle genotypes under specified production conditions. Overall, the information on blood metabolite profiles of Nguni calves is scarce. The current study is the first of its kind to establish values of blood metabolic profiles in Nguni calves. The mean concentration of serum TP was within normal physiological range for calves (Doornenbal et al., 1988; Otto et al., 2000). The causes of lower serum TP levels observed in Nguni calves compared to crossbreds in the first month are not clear. Serum total protein of calves has been reported to be lower in the early weeks of life due to the expansion of plasmatic fluids following ingestion of colostrum (Paré et al., 1993). Low serum TP levels may also be a consequence of malnutrition, malabsorption of nutrients, subclinical infections (Kapela et al., 2008) and inadequate iron intake (Bisalla et al., 2007). In the current study, no calf showed subclinical signs of any disease or experienced nutritional problems.

The differences in TP concentrations observed in Nguni and crossbred calves at weaning could be of genetic origin. Mapekula et al. (2011) reported that although Nguni cows had lower milk yield than crossbred cows, they produced milk with higher protein content in the late lactation than crossbreds. Thus, Nguni calves might have derived high serum proteins from their dams through milk consumption. Alternatively, the observed disparities in the TP concentrations could have possibly emanated from breed differences in diet selection and/or feed digestive efficiency (Cárdenas-Medina et al., 2010). Given the low amount of milk produced by Nguni cows to meet protein requirements at weaning their calves might have selected high quality feed resources from the rangelands and/or digested poor quality rangeland forages more efficiently than crossbreds. It is important to investigate the diet selection, rate of rumen development and colonisation by microbes, and digestion efficiency of rangeland feed resources in these genotypes.

Overall, the variation in the serum globulin observed in Nguni and crossbred calves throughout the trial period could be due to genetic and physiological factors. Similarly, Mapiye et al. (2010a) reported lower globulin levels in Nguni cattle compared to crossbreds. Since globulins protect animals against infectious diseases (Bisalla et al., 2007) elevated concentrations are associated with the presence of infections and inflammatory diseases (Whitaker et al., 1999). Hence, serum globulin concentrations indicate an animal's humoral immune status or response, and consequently, disease and parasite resistance or resiliance (Kapela et al., 2008; Shrikhande et al., 2008). The high globulin levels in the crossbred calves could, therefore, suggest that they were more prone to infections than their Nguni counterparts. The Eastern Cape Province, where the

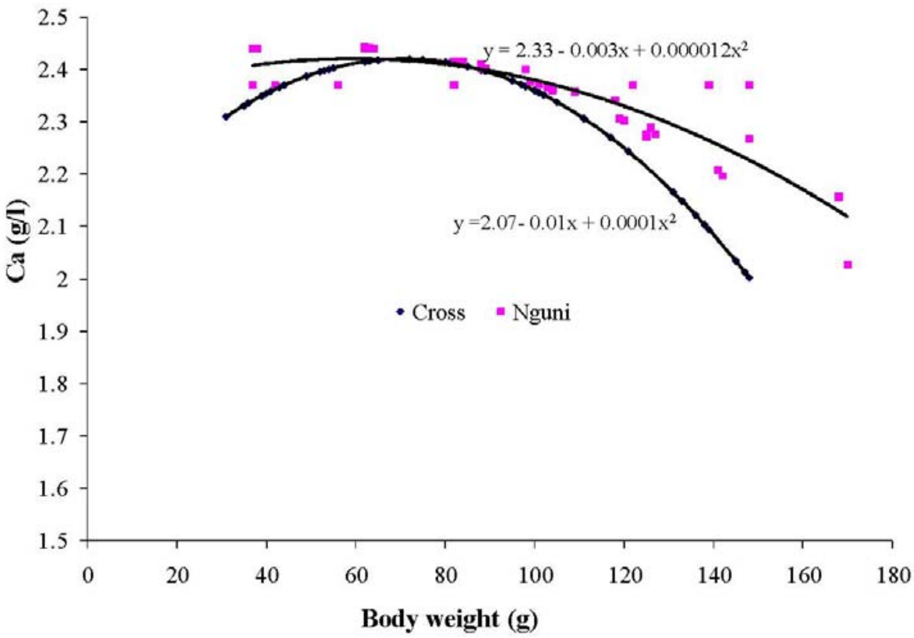

Figure 2. Relationship between body weight and calcium levels in Nguni and crossbred calves on natural pasture.

study was conducted, is fraught with many parasites and pathogens (Ndlovu et al., 2009a; Marufu et al., 2011), which may lead to a chronic stimulation of the immune system and the production of gamma globulins (Otto et al., 2000). The current findings, therefore, support the notion that Nguni cattle are naturally selected for resistance to existing parasites and pathogens in their local environment (Muchenje et al., 2008b; Marufu et al., 2010). At weaning, the low A/G ratio recorded in crossbred calves compared to the Ngunis' could be due to higher globulin concentrations observed in the former breed.

Concentrations of glucose recorded for crossbred calves were lower than literature values for calves (Otto et al., 2000). The differences in serum glucose concentrations between the Nguni and crossbred calves could be related to their digestive efficiency of low quality forages and energy requirements for maintenance. Generally, small framed indigenous cattle breeds such as Nguni are more efficient digesters of fibrous feeds and have lower energy requirements for maintenance than large framed breeds and their crosses (Cárdenas-Medina et al., 2010; Mapiye et al., 2010b). The small size for these indigenous breeds has been considered as adaptive attributes to fibrous feed resources. The small size of the Nguni breed could, therefore, be a result of natural synchronization of the genotype with locally available feed resources.

The cholesterol concentrations were similar between the Nguni and crossbred genotypes across all ages. Contrary to these findings, Moody et al. (1992) reported increasing cholesterol concentrations with age of calves. As calves approach weaning, milk consumption decrease, thereby lowering blood cholesterol levels in the calves (Kamimura et al., 2006).

The higher NEFA concentrations in Nguni calves than crossbreds might mean that they had more energy reserves than crossbreds, implying the adaptability of the Nguni under rangeland conditions (Mapiye et al., 2010b). The NEFA are considered a biomarker of negative energy balance, where the supply of glucose is insufficient to meet energy needs (Stokol and Nydam, 2005). When energy is insufficient, stored fatty acids in the body are rapidly mobilized to meet energy demands (Kamimura et al., 2006).

The observed higher calcium levels during the early months of age could be related to milk consumption and forage quality. Mapekula et al. (2011) reported that milk from Nguni and crossbred cows had higher calcium levels in the early and mid lactation stages compared to other seasons. The first four months coincided with the hot-wet and post-rainy season when grasses are richer in calcium than those found in the cold-dry season (Ndlovu et al., 2009b). Secondly, the high calcium levels in the forages during late pregnancy could have led to calves being born with sufficiently high amounts of calcium in their bones. More research is required to evaluate the ability of these genotypes to utilise calcium from milk or mobilise stored calcium from the bones.

The lack of relationships between body weight and all the measured energy-related blood metabolites in all the genotypes was unexpected. The adaptability of Nguni cattle was largely thought to be linked to their ability to utilise fibrous feeds for energy production (Mapiye et al., 2010b). There is little, if any, literature on the relationships between body weight changes and nutritionally-related blood metabolites in calves. Such relationships are crucial when making predictions about animal performance. Understanding these relationships sheds light on the nutritional status and adaptability of different genotypes to the environmental conditions they survive under.

The sharp increase in TP concentrations in Nguni calves beyond 100 kg live weight, might suggest their increased ability to utilise feeds early in life, unlike the crossbred calves. It would be interesting to monitor these profiles even after weaning, although the results are likely to change as the farm conditions change (Mohri et al., 2007). Interestingly, there was a quadratic increase in A/G as body weight increased, suggesting that the albumin concentration were increasing, although it was not statistically significant. Such relationships warrant further investigation. The relationship observed between serum Ca and body weight is difficult to explain but could be related to the ability of these genotypes to utilise Ca from diet or mobilise stored calcium from the bones.

CONCLUSIONS

Nguni calves had higher NEFA and TP concentrations at weaning than crossbred calves. There was a sharp increase in TP concentrations in Nguni calves that weighed more than 80 kg. A quadratic increase in A/G as body weight increased was observed in Nguni calves. The higher NEFA and TP concentrations at weaning and the TP increase in Nguni calves beyond 80 kg might mean that they are better able to utilise fibrous feed resources than crossbreds.

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