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SEASONAL VARIATION IN SOME PHYSIOLOGICAL PARAMETERS OF CALVES ON COMMUNAL RANGELAND OF NORTH WEST PROVINCE, SOUTH AFRICA

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ABSTRACT

Mineral deficiency of roughages has been widely proven in research to affect productivity in ruminants. Accurate determination of grass minerals and biochemical profile of blood will provide valuable information to assist in diagnosis, prognosis and treatment of nutritional diseases of veterinary importance. This study, therefore, aimed to document the variations in levels of some selected micro and macro mineral concentrations of both grass and blood and blood chemistry as influenced by season of the year (winter, spring, summer and autumn) in selected communal farming locations of the North West Province of South Africa. Blood and Grass samples were collected from herds and areas distributed throughout the North West Province. Areas selected were the Southern region (5 herds, n=48), Bophirima region (8 herds, n=62), Central region (9 herds, n=70) and Bojanala region (6 herds, n=45). The phosphorus (P) and calcium (Ca) concentrations of grass (3.65 and 15.22 mg/g) were increased ($P<0.05$) during the spring and summer, respectively, compared to other seasons while lower P, Ca and magnesium (Mg) concentrations (0.89, 6.45 and 0.97 mg/g) were obtained during the winter. Serum P, Ca, Mg, Iron (Fe), potassium (K) and copper (Cu) concentration were significantly ($P <0.05$) influenced by change in season. Higher ($P <0.05$) serum P, Mg, potassium (K) and copper (Cu) concentration were obtained during the summer compared to other seasons. However, Ca and Iron (Fe) were significantly ($P <0.05$) increased during the summer, autumn and spring than winter period. Albumin, alanine transaminase (ALT), total bilirubin (TBIL), cholesterol (CHOL), creatinine kinase (CK), glucose (GLU) and lactate dehydrogenase (LDH) concentrations were significantly ($P<0.05$) reduced in summer compared to other season. Seasonal variations across the year have a great influence on mineral concentration of the grass and subsequently on blood serum concentrations. Therefore, proper documentation and timely evaluation of nutritional quality of available forages is required.

Key words: blood chemistry, calves, seasonal variation, rangeland, mineral concentrations, nutrition

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INTRODUCTION

In beef cattle production, seasonal fluctuation in quantity and quality of available grasses has been the major factor causing suboptimal performance. This fluctuation is occasioned by change in season across the year. The looming climate change also has its effect on the fluctuation of the seasons due to increase in the environmental temperature, change in humidity, protracted rainfall and others [1]. Some authors were of the opinion that the nutritive value of available forages tends to change as season progresses [2].

Notably, blood biochemical profile is important in accurate diagnosis, prognosis and treatment of diseases of veterinary importance as it reflects the nutritional status of the animals. It has been reported that serum chemistry and mineral levels in animals can be affected by various factors such as seasonal and physiological variations [3].

Minerals are essential for maintenance of normal metabolic state, biological processes and also productivity in farm animals. Over the years, studies conducted proved that prolonged deficiency of both micro and macro minerals resulted in serious biological problems including nutritional diseases impaired physiologic and metabolic functions [4, 5, 6, 7].

North West province of South Africa has been one of the regions of concern as marked deficiencies in forage minerals were noticed over the seasons especially Phosphorus (P), Calcium (Ca), Magnesium (Mg), Selenium (Se), Cupper (Cu) and Zinc (Zn) [8,9].

There is a need for proper documentation of mineral contents of the available grasses as well as the resultant blood serum and mineral composition in calves that feed on these grasses throughout the year. This will serve as a guide for farmers as climatic conditions vary throughout the year. It can also serve as a means for decision making for herd management. This research, therefore, aimed to report the seasonal variability in the levels of some micro and macro minerals and blood biochemical constituents that are of considerable importance in different activities of the animal body. Also, it sought to assess the seasonal variations in mineral composition of grazed grasses in the selected communal farming locations of North West province in South Africa.

MATERIALS AND METHODS

Environmental condition

North West province consists mainly of flat areas covering a total area of 116 320 km² of scattered trees and grassland. Species of grasses that are commonly found are *Eragrostis lehmannia, E. globosa, E. curvula, E. trichophora, E. curvula, Heteropogon contortus, Panicum coloratum, Digitaria eriantha, Stiptagrostis uniplumis, Aristida congesta, Themeda triandra* and *Anthephora pubescens.* Temperatures range from 16° to 38 °C in the summer and from 2° to 21 °C in the winter. Annual rainfall totals about 360 mm, with almost all of it falling during the summer months, between October and April [10]. Soils and plants from all areas of the NWP were known to be deficient in P, Ca, Mg and Se [9].

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Experimental animals

Different cattle breeds from communal, free ranging animals between 9 and 18 months of age were used in this study. The selection criteria excluded animals that were showing signs of peri-paturient or nutritional diseases and animals considered unhealthy by veterinary clinical examination. The clinical examination was carried out a day before sampling following a series of assessments considering body temperature measurements (Normal range: 38-39.0^{o}C): urine analysis by test strips (Roche Diagnostics, Milan, Italy) measurements with the acceptable pH range between 8.2 – 8.4 with the absence of ketones and proteins; rumination activity (<60 chews/cud) and fecal score by Hutjens [11] with the acceptable score range of 2 to 3. Samples were collected from a total of 225 animals that were clinically proven healthy and free from internal and external parasites. Samples were collected from herds at areas distributed throughout the North West Province in the Southern region (5 herds, n=48), Bophirima region (8 herds, n=62), Central region (9 herds, n=70) and Bojanala region (6 herds, n=45) (Fig1.). During winter, animals were fed hay or silage to NRC standards. The experiment commenced after the approval from North West University Ethical Committee (UNW-B-00018-17-S9)

Figure 1: Regional distribution of animal herds collected for blood analysis

Collection and analysis of samples

Blood sampling

Triplicate blood samples were collected in the morning from all animals available for research. The animals were calmly driven into a crush pen to minimize stress where they were bled from the jugular vein into a 10 ml EDTA vacutainer tubes (K_2 EDTA, 10.8 mg) to harvest plasma and also into the red stoppered tubes (Vacuette with Z serum Clot Activator) to harvest serum, placed on ice and transported to the laboratory for analysis. Samples were collected during winter, spring, summer and autumn in all experimental locations.

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Blood serum preparation and Analysis

Blood for serum harvesting was collected and stored at –4 °C and transported to the laboratory. Blood samples were centrifuged at 1500 x g for 15 min. Fifteen (15) samples from 15 animals sampled were discarded due to haemolysis before analysis, and the animals were also removed from the experiment as they were showing signs of weakness throughout the survey. Samples were analysed for minerals (Magnesium (Mg), Calcium (Ca), Phosphorus (P), Iron (Fe), Potassium (K), Zinc (Zn), Manganese (Mn), Copper (Cu) and Selenium (Se)] using Nexion ICP-MS machine (Perkin-Elmer Inc., Pretoria, South Africa). Protein and energy metabolites [albumin (ALB), total protein (TP), blood urea nitrogen (BUN), and glucose (GLU)] hepatic and enzyme markers Cholesterol (CHOL), alanine aminotransferase (ALT), aspartate aminotransferase (AST), lactate dehydrogenase (LDH), and creatinine kinase (CK) were determined using the Idexx vet test® chemistry Analyzer (IDEXX Laboratories, Inc., Pretoria, South Africa).

Grass sampling

Grass samples were taken from the sampling area where the animals were grazing per single period of collection to prevent time and mineral variation between sample periods. At each communal area site 5m x 5m homogenous vegetation units (HVU) were marked in different directions and used as the replicates. In each HVU, three 1m^2 quadrats were randomly put to sample grass species. All the species found were harvested, dried, ground and bulked together and placed in a tight container pending analysis.

The experiment started in winter 2015 (June, July and August) through spring 2015 (September, October, and November), summer 2015/16 (December, January, and February) and autumn 2016 (March, April and May).

Grass preparation and analysis

Grass samples were analysed using the dry ashing macro and trace minerals method for feed and plants [12], and digested using a microwave digestion system conditions stated in the methods for the Anton- Paar Multiwave 3000 reaction system and subjected to the Nexion ICP-MS machine (Perkin-Elmer Inc., Pretoria, South Africa) for analysis.

Statistical analysis

The grass minerals concentrations and blood analytes were analysed using one-way analysis of variance as contained in the general linear models procedures of SAS [13]. When the analysis of variance revealed the existence of the significant difference among treatment means, probability of difference (pdiff) option in least square means statement of the GLM procedure of SAS (2010) were used to separate treatment means. Statistical significance was declared at $P \leq 0.05$.

RESULTS AND DISCUSSION

Seasonal variation in mean grass minerals collected in communal grazing land

Seasons significantly ($P<0.05$) influenced all grass mineral concentration considered except Selenium (Table 1). Highest grass phosphorus and calcium concentrations (3.65 and 15.22 mg/g) were observed during the spring and summer, respectively, while the least phosphorus, calcium and magnesium concentrations (0.89, 6.45 and 0.97 mg/g) were obtained during the winter. The lowest manganese concentration recorded in the

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grass was observed in grass harvested during the summer. The concentrations of copper, iron and zinc in grass were higher in both autumn and spring compared to summer and winter. The least concentration of Calcuim (Ca), Zinc (Zn) and Magnesium (Mg) observed in this present study is similar to those reported elsewhere [14]. The reported higher concentrations of Ca in summer is also in consonance with the report of the same authors, but the value recorded for Ca is higher compared to that obtained in this study. Some researchers also reported a seasonal fluctuation in mineral concentration of some selected forages [15]. In addition, some variations were also reported in tropical grasses in Mexico [16]. The range (6.45-15.22 mg/g) of Ca obtained in this study across the season is higher than that (2.1-10.8 g/kg) reported by AFRC for different class of cattle [17]. It is also higher than the required mean 4.5 mg/kg reported for growing cattle [18]. These variations might be attributed to seasonal fluctuations in soil minerals composition, stage of maturity and botanical classification of the grasses. The phosphorus (P) content obtained in this study during the winter, autumn and summer were lower than that reported for grass hay [19]. However, higher P was reported in the spring compared to the reported range. The Mg contents in summer and winter in this study is lower compared to the reported value of grass hay [19].

Mean blood Chemistry of healthy young cattle grazing in communal land

Albumin, Alanine aminotransferase (ALT), total bilirubin (TBIL), cholesterol (CHOL), creatinine kinase (CK), glucose (GLU), and lactate dehydrogenase (LDH) activities were significantly ($P < 0.05$) reduced in summer compared to other seasons (Table 2). During summer and winter, calves had significantly ($p<0.05$) higher Alkaline Phosphatase (ALKP) activities than in autumn and spring. Creatinine (CREA) levels were lower ($P < 0.05$) during winter than in autumn, spring and summer. The lowest TP value was recorded in winter. Blood Urea nitrogen concentration was least ($p<0.05$) in winter when compares compared to summer, autumn and spring. A significant variation in blood mineral profile of Nguni cattle, similar to the report of this present study where significant changes occurred for most of the blood minerals were observed by others [20, 21]. Despite the variation across the season, serum Ca range obtained in this study was within the normal range reported by several authors [22, 23]. The reported range for serum Mg was higher than those in other reports [22, 23]. During the autumn and spring, serum Iron (Fe) concentration was within the reported normal physiological range for clinically healthy cattle. Serum Zn and Selenium (Se) observed in this study were higher than the range reported earlier [22, 23]. In this present study, the selected serum biochemistry considered varied across seasons. However, it is similar to the report obtained for indigenous sheep breed [24]. In a recent research on Indian goats, seasonal variation in blood biochemical parameters was also observed [25]. Most of the serum chemistry observed in this present study are within is normal range reported for clinically healthy cattle [22, 23].

Serum minerals concentration of the sampled calves as influenced by the season

Table 3 shows the serum minerals concentration of the sampled calves as influenced by the season. Serum Phosphorus, Calcium, Magnesium, Iron, Potassium and Copper concentration were significantly ($P < 0.05$) influenced by change in season. However, Zinc and Selenium were similar ($P > 0.05$) across the season. Lowest mean values (1.09, 1.86, 1.30 and 0.95 mmol/L) of phosphorus and calcium, magnesium and iron were

recorded during winter while potassium and copper concentration were highest during the summer season. Iron concentration was highest during the spring season. The higher Ca obtained in this study can be due to the fact that this study combined the analysis of different types of forages on communal range land. The highest mean concentration of blood potassium (K) observed in summer may be due to high temperatures leading to high dehydration rate by the animals. However, the dehydration rate is dependable on water intake which is not taken into consideration in this present study. Minerals deficiency or imbalance in tropical and sub-tropical forages as occasioned by seasonal fluctuation in grass mineral often leads to production loss as most disorders observed in livestock production are mainly due naturally occurring mineral deficiency in forages [26]. Thus, adequate blood mineral elements are essential in various metabolic processes in cattle. They are involved in structural, physiological, catalytic and regulatory functions within an animal [27]. Their essentiality in bone formation, cell differentiation, acid-base balance and as part of amino acid profile cannot be overruled. It is highly essential to monitor constantly monitor seasonal variation in blood minerals in case of deficiency. In mammals, hormonal and metabolic changes that occur during metabolic stress subdue the immune systems' ability to protect the body, this is further depressed when nutritional stress sets in, due to nutrient imbalance [28]. The nutritional stress is occasioned by seasonal climatic variations, which will subsequently affect the animals' immune functions through variation in their blood metabolites. Blood biochemical evaluations are very important in monitoring the physiological and health status of farm animals [29]. It has been reported that serum chemistry and mineral levels in animals can be affected by various factors such as seasonal and physiological variations [24]. These noted variations in grass and serum mineral concentrations and serum biochemical constituents highlight the need to strictly monitor minerals deficiency in cattle all throughout production year to avoid deficiency and incidence of diseases. This can be achieved through adequate record keeping and timely supplementation of the required minerals.

CONCLUSION

Seasonal variation in forages from communal rangeland especially in the recent period of climatic changes subsequently influenced the blood mineral concentration of calves reared on the forages. This research revealed the need for proper record keeping in livestock production most especially in grazing herd. This is essential in order to monitor the herd's production and health performance throughout the year.

CONFLICT OF INTEREST

No conflict of interest in the course of the research

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Table 1: Seasonal variation in mean grass minerals collected in communal grazing land

Parameters	Summer (n=10)	Winter (n=10)	Autumn (n=10)	Spring (n=10)
Phosphorus (mg/g)	1.76±0.04^{c}	0.89±0.01^{a}	1.08±0.07^{b}	3.65±0.06^{d}
Calcium (mg/g)	15.22±1.54^{c}	6.45±0.81^{a}	10.24±1.20^{b}	11.54±1.04^{b}
Magnesium (mg/g)	1.20±0.04^{b}	0.97±0.02^{a}	1.74±0.09^{c}	2.84±0.82^{d}
Copper (ppm)	10.5±0.93^{a}	11.8±1.30^{a}	15.5±0.35^{b}	16.3±0.73^{b}
Iron (ppm)	93.5±6.35^{a}	100.1±7.03^{a}	129.9±7.14^{b}	120.5±8.44^{b}
Potassium (ppm)	ND	ND	ND	ND
Zinc (ppm)	69.3±5.62^{a}	70.6±4.53^{a}	103.8±6.32^{b}	110.4±7.98^{b}
Manganese (ppm)	138.7±10.2^{a}	160.4±12.32^{b}	175.5±15.32^{b}	165.9±14.01^{b}
Selenium (ppm)	0.09±0.001^{a}	0.028±0.0002^{a}	0.03±0.0001^{a}	0.05±0.0002^{a}

$^{a, b, c, d}$: Means along the same row with different superscript are differed significantly

ND: Not determined

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Table 2: Mean blood chemistry of healthy young cattle grazing in communal land

Parameters	N	Summer	Winter	Autumn	Spring	Normal range
ALB = Albumin (g/L)	210	19±3[a]	43±7[d]	32±5[c]	28±6[b]	25-38 g/L
ALKP = Alkaline Phosphatase (U/l)	210	149±9[c]	109±8.2[b]	97±7.6[a]	95±8.6[a]	90-170U/L
ALT = Alanine aminotranferase(U/l)	210	21±3[a]	31±5[b]	35±4[c]	38±3[c]	14-38 U/L
Amylase (U/l)	210	243±15[b]	145±8[a]	144±9[a]	146±7[a]	126-250 U/L
AST = aspartate aminotransferase (U/l)	210	125±6.2[b]	79±6[a]	129±5[b]	130±9[b]	78-132 U/L
BUN = Blood Urea Nitrogen (µmol/L)	210	5.2±1.5[c]	2.4±0.97[a]	4.3±1.9[b]	4.0±0.90[b]	2.50-6.14 mmol/L
TBIL = Bilirubin, Total (µmol/L)	210	2.33±0.26[a]	5.15±1.33[b]	4.98±1.4[b]	4.96±1.25[b]	1.71-8.55 µmol/L
CHOL = Cholesterol (mmol/L)	210	2.18±0.87[a]	3.39±0.54[b]	3.62±0.93[b]	3.88±0.98[b]	2.10-4.70 mmol/L
CK = Creatinine kinase (U/l)	210	74.2±6.2[a]	114.3±6.3[b]	114.1±7.3[b]	118.6±8.3[b]	66 - 120 U/L
CREA = Creatinine (fLmol/L)	210	140.1±8.5[b]	95.7±5.5[a]	175.5±9.5[c]	142.9±7.2[b]	88-177 fL/mol/L
Glucose (mmol/L)	210	3.14±0.23[a]	4.22±0.42[b]	3.99±0.35[b]	4.00±0.75[b]	2.50-4.10 mmol/L
LDH = Lactate dehydrokinase (U/l)	210	74±8[a]	124±6[c]	110±8[b]	110±6[b]	8-302 U/l
TP = Protein, Total (g/l)	210	68.9±7.4[b]	62.00±4.1[a]	69.6±5.7[b]	72.3±5.6[b]	67-75 g/L

[a, b, c, d]: Means along the same row with different superscript are differed significantly

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Table 3: Mean blood minerals of healthy young cattle grazing in communal land

Parameters	n	Summer	Winter	Autumn	Spring	Normal range*
Phosphorus (P)	210	1.72±0.21^{c}	1.09±0.04^{a}	1.33±0.16^{b}	1.38±0.25^{b}	1.38-2.55 mmol/L
Calcium (Ca)	210	3.31±0.89^{b}	1.86±0.08^{a}	2.86±0.67^{b}	3.01±0.74^{b}	1.95-5.62 mmol/L
Magnesium (Mg)	210	2.57±0.75^{d}	1.30±0.2^{a}	1.87±0.14^{c}	1.67±0.19^{b}	0.52-1.00 mmol/L
Iron (Fe)	210	1.02±0.01^{b}	0.95±0.04^{a}	1.32±0.60^{c}	1.36±0.32^{c}	1.30-1.40 ppm
Potassium (K)	210	4.24±1.02^{c}	3.12±0.75^{a}	3.41±0.75^{b}	3.41±0.87^{b}	3.9-5.8 mmol/L
Copper (Cu)	210	1.62±0.12^{c}	1.45±0.26^{b}	0.78±0.06^{a}	0.60±0.05^{a}	0.65-1.50 ppm
Zinc (Zn)	210	2.01±0.65^{a}	1.98±0.42^{a}	2.35±0.49^{a}	2.40±0.81^{a}	0.80-1.40 ppm
Selenium (Se)	210	1.97±0.05^{a}	1.89±0.09^{a}	1.92±0.43^{a}	1.94±0.38^{a}	0.12-0.25 ppm

$^{a, b, c, d}$: Means along the same row with different superscript are significantly differed

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