ОРИГИНАЛЬНАЯ СТАТЬЯ

SERUM MINERAL LEVELS IN GOATS OF VARIOUS PHYSIOLOGICAL STAGES IN THE DRY AND WET SEASONS IN CENTRAL TRINIDAD

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ABSTRACT. A study was conducted to evaluate blood serum macro and micro-mineral concentrations of 158 goats, regarding season, farm and physiological stage. Samples were collected in the late dry (April – May) and late wet (November – December) seasons of Central Trinidad. Blood samples were collected from the state owned Sugar Cane Feeds Centre and three private farms of the Cunupia, Chaguanas and Couva locations of Central Trinidad. Samples were collected from growing (6– 12 mths), dry pregnant (mainly late), early lactating (up to 8 wk) and dry non-pregnant goats (1–3 yrs). In goats, lower serum P ($p<0.001$) was found in the dry than the wet season, whereas Mg ($p<0.001$) and Zn ($p<0.01$) were lower in the wet season. Lower Ca ($p<0.001$) was observed in goats in the wet season than in the dry season. Significant variations also occurred among farms for serum P, Mg, Na and Cu in goats ($P<0.001$), and also for Ca, K and Zn in goats ($p<0.01$). Percent of serum Mg Below Critical Level (BCL) was 64% for Mg (<18 mg/l) in goats of the Sugar Cane Feeds Centre. Also 79 and 60% of Cu (<0.5mg/l) and Zn (<0.6 mg/l) were BCL in goats at the Couva farm. Significant variations among physiological stages occurred for serum P and K in goats ($p<0.01$), and also Zn in goats ($p<0.001$) respectively. Forage Mg and Mn were lower ($p<0.001$) in the wet than the dry season, whereas P was lower ($p<0.001$) in the dry season. Significant variations also occurred among locations for forage Ca ($p<0.001$), Mg ($p<0.001$), Cu ($p<0.05$) and Zn ($p<0.001$). In the dry season, the order of serum minerals likely to limit production was P, Cu, Mg and Zn in goats. In the wet season, the order of serum minerals was Cu, Zn, Mg, Ca and P in goats. In both the dry and wet seasons, the order of forage minerals probably limiting production was Na, Cu, Mg and Zn, respectively. Regarding farm location, the serum minerals of major importance probably limiting production was Mg at the Sugar Cane Feeds Centre, and Cu and Zn at the Couva, respectively. The low serum mineral concentrations probably of physiological importance were Ca in non-pregnant and lactating goats; P, Cu and Mg in pregnant and lactating goats, and Zn in lactating goats. Although the levels of mineral deficiencies found were mainly marginal, findings implied that growth, feed intakes and milk yields were probably being affected while some animals may have been prone to metabolic disorders.

KEYWORDS: goats; mineral concentrations; season; farm; physiological stage.

INTRODUCTION

Serum biochemical analysis is an important diagnostic tool used to determine and monitor the health status of animals, as well as for the diagnosis, treatment and prognosis of diseases. In addition, the major and minor trace minerals should also be routinely assessed in ruminants to determine if deficiencies, imbalances and toxicities are present, as these elements are important for maintenance of normal metabolic state and productivity, and can also be indicators of nutritional status (Mcdowell and Arthington, 2005). Marginal mineral deficiencies are more commonly encountered in livestock, and are often not readily detected compared to clinical deficiencies. As marginal deficiencies can affect growth and production and often go undiagnosed, they are considered to be equally important as mineral deficiencies in which the animals show clinical signs that can be detected and treated (Suttle, 2010).

Factors such as season, age, sex, production level, activity level, physiologic status, species and genetic strain can influence requirement levels for minerals, as well as thresholds of deficiency and toxicity (Suttle, 2010). For example, animals most sus-

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ceptible to trace mineral deficiencies are young growing animals and animals during their first pregnancy or lactation (El Deen et al., 1985)). It has also been found that mineral deficiencies in livestock are often seasonal, resulting from increased demands of pregnancy, lactation or rapid growth coinciding with reduced mineral content or availability in the pasture (Tashi et al., 2005). It is therefore important to perform serum chemistry and mineral profiles in livestock in order to detect and prevent imbalances that can lead to reduced production and reproductive disturbances and as a result, economic losses (Yokus and Cakir, 2006).

Trinidad and Tobago is a twin island tropical country located close to northern part of South America, and is part of the chain of islands surrounding the Caribbean Sea. There are two seasons annually – the dry season for the first six months of the year, and the rainy season in the second half of the year. As there are no reports on the impact of environmental and physiologic factors on blood mineral levels in sheep in the Caribbean, this study was undertaken to investigate the possible influences of physiological and seasonal variations on serum levels of calcium, phosphorus, magnesium, sodium, potassium, copper and zinc. The effect of season on the mineral levels in forage in Trinidad was also evaluated, as it has been shown that the mineral content in forages can be influenced by factors such as soil, plant species, stage of maturity, pasture management and climate (Youssef, 2000).

MATERIALS AND METHODS

Ethics Approval. The research protocols for this study were approved by the Veterinary Ethics committee of the Faculty of Medical Sciences, The University of the West Indies.

Farms and management. This study was carried out in the late dry (April–May) and late wet (November- December) of 1995 on four local farms of Central Trinidad. These included the state owned Sugar Cane Feeds Centre of Longdenville and three private farms from the Cunupia, Chaguanas and Couva locations of the Central region. The first farm was situated on a fine sandy loamy soil, while the latter were situated on fine sandy clay, a sandy clay loam and fine sandy soil types. Maximum montly rainfall in the late dry and late wet seasons from the five locations ranged 25–53 mm and 42–191 mm, respectively. Correspondingly, minimum and maximum temperatures ranged from 22–34 °C and 20–32 °C, respectively.

Goats were reared intensively at the Sugar Cane Feeds Centre and semi-intensively at the Cunupia, Chaguanas and Couva farms. Goats were of Saanen and Anglo Nubian origins. Goats were either zero grazed or allowed grazing mainly on forages bamboo grass (*Paspalum. fasiculatum*), elephant grass (*Pewnnesetum purpureum*) and tapia grass (*Sporobolus indicus*). Goats at the Cunupia and Chaguanas farms were allowed grazing on these grasses and also were reared intensively on a feed mixture containing bagasse, molasses, poultry by-product meal, wheat middlings, urea, dicalcium phosphate and NaCl.

Except for the Couva farm, goats at other farm locations were occasionally dewormed at weaning or during pregnancy. Animals were dewormed orally using fenbendazole, at a dose rate of 5 mg/kg (Anglian nutrition Products Co., Ipswich, UK), or by sub-cutaneous injection with ivermectin (1% m/v) at a rate of 200 μg/kg (ECO Animal Health Southern Africa Ltd., Northmead, Gouteng).

Sample collections. Blood samples were collected from 158 goats in the late dry and late wet seasons of Central Trinidad (Table 1). Thirty-eight grasses and in the late dry and late wet seasons. Goat blood samples were collected from the Cunupia, Chaguanas, Sugarcane Feeds Centre and Couva farms (Figure 1).

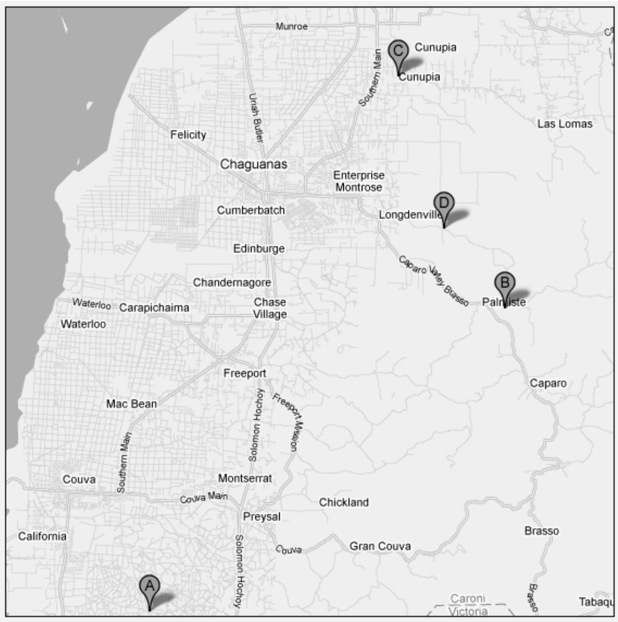

*Figure 1. Blood Sampling at farm locations of Central Central Trinidad:
A – Couva Farm; B – Palmiste farm;
C – Cunupia Farm;
D – Sugar Cane Feeds Center, Longdenville*

Table 1. ***Number of goats sampled at various physiological stages and farms sampled in the late dry and late wet seasons of Central Trinidad***

Farm	Season	Physiologic State				Total
		Growing	Dry Pregnant	Lactating	Dry Non-pregnant	
Cunupia	Dry Wet	4 4	4 4	5 4	3 5	16 17
Chaguanas	Dry Wet	11 8	1 3	1 4	3 3	16 18
Sugar Cane Feeds Centre(SFC)	Dry Wet	5 5	4 4	3 3	4 5	16 17
Couva	Dry Wet	6 8	11 8	7 8	6 4	30 28
Total	Dry Wet	26 25	20 19	16 19	16 17	78 80
Grand Total		51	39	35	33	158

Blood samples were collected from growing (6–12 mth), dry pregnant (mainly late), early lactating (up to 8 wk) and dry non-pregnant goats (1–3 yrs). Blood samples were taken from different animals at the same farm in the dry and wet seasons, according to availability of animals by physiological stage. Approximately 50–60% of goats at all farms were blood sampled. Blood samples were drawn by venipuncture (16–18 mm needle gauge) and collected in acid-washed demineralized tubes. Clotted blood was centrifuged within 4 hours of collection to remove serum, which was stored at –20 °C. Sub-samples of various grasses were collected from zero-grazed or outdoor grazing material from various locations. Goats were watched grazing before portions of grasses were cut with a stainless steel knife, according to the choice of the animal or parts consumed.

Chemical analysis. Grasses and feed samples were oven-dried at 60 °C in a forced draught oven to constant weight and hammer milled in a stainless steel mill to pass through a 1 mm sieve. Serum, grass and feed samples were prepared for Ca, P, Mg, Na, K, Cu, Zn, Fe and Mn analyses according to Fick *et al*. (1979). Calcium, P, Mg, Na, K, Cu, Zn concentrations were determined in serum, whereas the same minerals including Fe and Mn were analysed in grasses and feeds. Except for P, mineral analyses were carried out using a Pye Unicam 2900 Atomic Absorption Spectrophotometer equipped with a PU9090 data graphics system. Phosphorus was determined colorimetrically according to Cavell (1955), using a Pye Unicam PU8600 uv/vis spectrophotometer. Crude protein levels in grasses and feeds were determined by the Kjeldhal method.

Statistical analysis. Serum minerals means were tested between seasons and among locations and physiological stages with interactions by analysis of variance using the GenStat Release 13.3, Copyright 2010 VSN International Ltd. Significantly different means were compared using the protected Fishers LSD (p<0.05) test.

RESULTS

Serum minerals in the dry and wet seasons. In this study, serum mineral concentrations Below Critical Level (BCL) (Table 2) could represent a dietary insufficiency, ultimately resulting in poor health and performance in goats (McDowell and Youssef, 2000; Suttle, 2010).

However, goats had lower (p<0.001) serum Ca in the wet than in the dry season. Consequently, a higher percentage of serum Ca BCL (<80 mg/l) was recorded in goats in the wet (34%) than in the dry season (12%). Serum P was lower (p<0.001) in the dry than in the wet season in goats. Concomitantly, a higher percentage of goats had serum P levels BCL (<40 mg/l) in the dry (67%) than in the wet season (26%). Serum Mg in goats was lower (p<0.001) in the wet than in the dry season. Consequently, a higher percentage of serum Mg was BCL (<18 mg/l) in the wet than in the dry season in goats (41% cf. 33%).

However, goats had high percentages of Cu BCL in both the dry (63%) and wet (54%) seasons. Serum Zn was lower (p<0.01) in the wet than in the dry season in goats. Higher percentages of serum Zn BCL (<0.6 mg/l) was recorded in the wet than in the dry season in goats (41 cf. 28%).

Table 2. ***Serum mineral levels in goats pertaining to location physiological stage and season***

Chemical element	Location						Physiological Stage						Season				^{x}Significance		
	Cunupia	Chaguanas	SFC	Couva	Avg ±SE	Avg LSD	Growing	Late preg-nant	Early Lac-tating	Dry non-pregnant	Avg ±SE	Avg LSD	Dry	Wet	Avg ±SE	Avg LSD	Location	Phys. State	Season
	Mean	Mean	Mean	Mean			Mean	Mean	Mean	Mean			Mean	Mean					
Calcium	86.65^{a}	88.39^{a}	84.88	92.47^{b}	2.477	4.903	90.34	89.4	85.51	89.28	2.414	4.777	95.33	82.83^{b}	1.698	3.360	***	NS	***
Magnesium	17.66^{a}	20.17^{b}	16.74	20.13^{b}	0.661	1.308	19.1	18.65	18.61	19.3	0.6441	1.275	19.19	18.67^{b}	0.453	0.896	***	NS	*
Phosphorous	50.59^{a}	54.87^{b}	44.56	37.25^{c}	3.504	6.935	50.66^{a}	46.87^{ad}	39.77^{b}	41.28^{bd}	3.414	6.757	35.34	54.45^{b}	2.402	4.753	***	**	***
Sodium	3111a	3130^{a}	3073^{b}	3003^{b}	37.48	74.18	3063	3114	3046	3041	36.52	72.28	3053	3080	25.69	50.84	**	NS	NS
Potassium	180.2^{a}	168.2^{a}	158^{b}	173.4^{a}	6.538	12.94	180.3^{a}	164^{b}	158.4^{b}	175.9^{a}	6.370	12.61	168.4	172.3	4.481	8.869	**	**	NS
Copper	0.53^{a}	0.58^{a}	0.46^{b}	0.35^{c}	15.40	3.049	0.47	0.44	0.44	0.48	1.501	2.971	0.48	0.44	1.056	2.09	***	NS	NS
Zinc	0.69^{a}	0.8^{b}	0.73^{ab}	0.61^{c}	0.039	0.078	0.71^{a}	0.75^{a}	0.59^{a}	0.73^{a}	0.038	0.076	0.76^{a}	0.64^{b}	0.027	0.054	***	***	***

Means with different superscripts significantly different at $p<0.05$, protected Fishers LSD test $p<0.054$; ^{x}Significance *$p<0.05$;** $p<0.01$; ***$p<0.001$.

Table 3. ***Serum physiological stage goats mineral levels in goats in the dry and wet seasons***

Chemical element	**Physiological Stage**								SE	LSD	Significance^{x}		
	Growing		Late Pregnant		Early Lactation		Dry non- pregnant				Phys. State	Season	Phys. stage X Seas
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet					
Calcium	95.24	85.85	96.48	82.92	94.25	77.51	95.26	83.81	7.0	13.85	NS	***	NS
Magnesium	19	19.18	18.55	18.75	18.67	18.56	20.79	17.93	1.868	3.697	NS	*	NS
Phosphorous	**37.87^{a}**	**62.36^{b}**	**33.69^{a}**	**58.92^{b}**	**32.35^{a}**	**46.56^{b}**	**36.61^{a}**	**45.56^{b}**	9.90	19.60	**	***	*
Sodium	3078	3048	3108	3119	3029	3062	2974	3103	105.9	209.6	NS	NS	NS
Potassium	182.7	178	159.6	167.9	148.7	167.3	177.8	174.1	18.48	36.57	**	NS	NS
Copper	0.43	0.51	0.48	0.42	0.48	0.40	0.54	0.42	4.353	8.62	NS	NS	$p<0.07$
Zinc	**0.77^{a}**	**0.66^{b}**	**0.79^{a}**	**0.7^{ab}**	**0.56^{b}**	**0.61b^{a}**	**0.91^{c}**	**0.57^{b}**	0.055	0.108	***	***	*

Means with different superscripts significantly different at $p<0.05$, protected Fishers LSD test $p<0.05$; ^{x}Significance *$p<0.05$;** $p<0.01$; ***$p<0.001$.

Table 4. ***Mineral levels in goats at various locations in the dry and wet seasons***

Chemical element	Location										Significance[x]		
	Cunupia		Chaguanas		SFC		Couva		SE	LSD	Location	Season	Location X Season
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet					
Calcium	**98.23[a]**	**76.05[b]**	**89.20[c]**	**87.65[c]**	**89.03[c]**	**81.09[bd]**	**100.91[a]**	**84.74[cd]**	7.0	13.85	***	***	***
Magnesium	**18.67[a]**	**16.73[b]**	**22.52[c]**	**18.03[ab]**	**16.20[b]**	**17.22[ab]**	**19.22[a]**	**20.95[c]**	1.868	3.697	***	*	***
Phosphorous	**35.89[a]**	**64.03[bc]**	**40.96[a]**	**67.60[b]**	**31.19[a]**	**56.79[c]**	**34.09[a]**	**40.13[a]**	9.90	19.60	***	***	***
Sodium	3119	3104	3170	3094	3034	3109	2958	3043	105.9	209.6	**	NS	NS
Potassium	**176.30[a]**	**183.70[a]**	**152.60[b]**	**182.5[a]**	**160.60[b]**	**155.6[b]**	**177.60[a]**	**169.50[ab]**	18.48	36.57	**	NS	*
Copper	0.58[a]	0.49[b]	0.54[a]	0.62[c]	0.35[d]	0.56[a]	0.45[e]	0.26[f]	4.353	8.62	***	NS	***
Zinc	**0.80[a]**	**0.60[b]**	**0.89[a]**	**0.71[b]**	**0.76[a]**	**0.69[b]**	**0.65[a]**	**0.59[b]**	0.055	0.108	***	***	***

Means with different superscripts significantly different at $p<0.05$, protected Fishers LSD test $p<0.05$; [x]Significance *$p<0.05$;** $p<0.01$; ***$p<0.001$.

Table 5. ***Forage mineral concentrations at goat farm locations and in the dry and wet seasons***

Chemical element	Location						Season				Significance[x]		
	Cunupia	Chaguanas	SFC	Couva	AVG. SE	LSD	Dry	Wet	AVG± SE	LSD	Farm Location	Season	Farm X Season
	9	10	11	10			18	22					
	Mean	Mean	Mean	Mean			Mean	Mean					
Calcium	3.78[a]	5.4[b]	3.38[a]	3.43[a]	0.55	**1.12**	3.56	4.34	0.39	**0.794**	**	NS	NS
Magnesium	1.79[a]	3.73[b]	0.87[c]	2.43[d]	0.35	**0.711**	2.75[a]	1.72[b]	0.25	**0.504**	***	***	***
Phosphorous	3.22	2.99	2.95	2.68	0.45	**0.921**	2.55[a]	3.29[b]	0.32	**0.653**	NS	*	NS
Sodium	0.61	0.46	2.15	0.99	0.68	**1.38**	1.29	0.92	0.48	**0.978**	NS	NS	NS
Potassium	17.28	18.21	15.83	18.95	2.28	**4.644**	17.24	17.77	1.62	**3.293**	NS	NS	*
Copper	4.67[a]	8.29[b]	6.31[b]	4.56[a]	1.33	**2.715**	5.73	6.22	0.95	**1.925**	*	NS	NS
Iron	72.6	72	86.3	96.3	21.19	**43.16**	68.7	93.1	15.02	**30.6**	NS	NS	NS
Manganese	515[a]	911[b]	99[c]	601[a]	120.2	**244.8**	791[a]	300[b]	85.2	**173.5**	***	***	***
Zinc	76.3[a]	81.7[a]	33.7[b]	39.9[b]	13.13	**26.75**	59.3	54.9	9.31	**18.97**	***	NS	NS

Means with different superscripts significantly different at $p<0.05$, protected Fishers LSD test $p<0.05$; [x]Significance *$p<0.05$;** $p<0.01$; ***$p<0.0001$.

Serum minerals at various farm locations. Serum Ca varied among farms in goats ($p<0.01$) with a farm **x** season interaction ($p<0.001$) (Table 2 and 3). Contrastingly, in goats, lowest serum Ca was recorded at the Sugarcane Feeds Center. Percentage BCL (<80 mg/l) in serum Ca in goats at the Sugarcane Feeds Center and at Cunupia was 27 and 39%, respectively. Serum P also varied among farms ($p<0.001$) in goats with a farm **x** season interaction ($p<001$). In goats the lowest P value was found at the Couva farm location. Percent P BCL in goats at Couva was 64%.

Serum Mg varied among farms ($p<0.001$) in goats. In goats, lower serum Mg was recorded at the Sugarcane Feeds Center and at Cunupia than at other farms. Serum Na varied among farms ($p<0.001$) in goats. Serum K varied with farms in goats ($p<0.01$) with a farm **x** season interaction ($p<0.01$).

Serum Cu varied among farms in goats ($p<0.001$) with a significant farm **x** season interaction ($p<0.001$) (Table 2 and 3). The lowest serum Cu in goats (0.34 mg/l) with the highest percentage BCL (79%) was found at the Couva farm. Serum Zn varied with farm in goats ($p<0.01$). Highest and lowest serum Zn in goats was recorded at the Chaguanas and Couva farms, respectively. Consequently, the lowest and highest percentages of Zn BCL in goats were recorded at the Chaguanas (6%) and Couva (57%) farms, respectively.

Serum minerals at different physiological stages. Although serum Ca did not vary with physiological stage ($p>0.05$) (Table 2) in goats, 29% lactating and 24% dry non-pregnant goats had serum Ca BCL. Serum P also varied among physiological stages in goats ($p<0.01$) with a physiological stage **x** season interaction ($p<0.05$) in goats. In goats lowest serum P was observed in lactating animals (Table 4). Sixty-two and 60% of goats had serum P BCL (<40 mg/l) in late pregnancy and early lactation.

Serum Mg did not vary ($p>0.05$) among physiological stages in goats. High percentages of serum Mg BCL was found in pregnant and lactating goats (26–49%). Serum K varied among physiological stages in goats ($p<0.01$). Lower serum K levels were found in dry pregnant and lactating goats than in other physiological stages (Table 2).

Moreover, high percentages (40–60%) of serum Cu BCL (<0.5 mg/l) was found at all physiological stages in goats. Serum Zn levels also varied among physiological stages ($p<0.001$) in goats with a physiological stage **x** season interaction ($p<0.001$). Lactating goats had the lowest serum Zn compared with other physiological stages. Consequently, the highest percentage of serum Zn BCL (<0.6 mg/l) was found in lactating goats (60%) compared with other physiological stages (23–33%) compared with other physiological stages (Table 2).

Forage minerals pertaining to seasons and farms. Forage Ca did not vary with season ($p>0.05$) but among farms ($p<0.001$) with a farm **x** season interaction ($p<0.05$) (Tables 5). Highest forage Ca was found at Chaguanas compared to other farms of Central Trinidad. Although most grasses had Ca levels above minimum requirements (2.0 g/kg DM), 29% had levels below 3.0 g/kg DM (AFRC, 1998; Meschy, 2000). At the Cunupia farm however, the Ca concentration in the daily feed mixture given to goats was 1.7 g/kg DM (not shown). Forage P varied with season ($p<0.05$) but not farm location ($p>0.05$). Forage P was lower in the dry than in the wet season. Twenty one percent of all grasses had P levels below 2.0 g/kg DM while 54% had levels below requirement for pregnancy and lactation (<3.0 g/kg DM). Forage Mg varied significantly with season ($p<0.001$) and farm ($p<0.001$) with a farm **x** season interaction ($p<0.05$) (Table 5). Forage Mg was lower in the wet than in the dry season. Also, forage Mg was lower at the Sugarcane Feeds Center and at Cunupia than at other farms. Thirty seven percent of all grasses had low Mg levels (<1.6 g/kg DM) while 55% had levels below 2.0 g/kg DM (AFRC, 1998; Meschy, 2000).

Forage Na did not vary with season or farm ($p>0.05$). However highest and lowest Na was recorded at the Sugarcane Feeds Center and at the Chaguanas farms, respectively. Sixty eight percent of all grasses were below the minimum requirement (<0.9 g/kg DM) for sheep while 42% had levels below 0.5 g/kg DM. Forage K did not vary with farm or season ($p>0.05$). However, 21% of grasses had K levels above 20 g/kg DM. Forage Crude Protein (CP) did not vary ($p>0.05$) with season or location. However, 21% of grasses had CP levels below the minimum requirement (<70 g/kg DM) in the dry season. Additionally 58 and 26% of grasses had levels below 100 g/kg DM in the dry and wet seasons, respectively

Forage Cu varied with farm ($p<0.05$) but not season ($p>0.05$) (Table 5). Highest and lowest forage Cu was observed at the Chaguanas and Cunupia farms, respectively. Fifty nine percent of all grasses in this study had Cu levels below minimum requirements for sheep (<7 mg/kg DM) while 54% had levels below 5.0 mg/kg DM. (AFRC, 1998; Meschy, 2000). Forage Zn varied with farm ($p<0.001$) but not season ($p>0.05$). Lower forage Zn was recorded at the Sugarcane Feeds Center and at

Couva than at other farms. Twenty four percent of grasses had Zn levels below requirements for pregnancy and lactation in goats (<30 mg/kg DM) while 44% had levels below requirements for lactating goats (<50 mg/kg DM) (AFRC, 1998; Meschy, 2000).

Forage Fe did not vary with farm or season (p>0.05). Except for two grasses, the remaining samples had Fe levels above general recommendations for sheep and goats (>30 mg/kg DM). Forage Mn varied with season (p<0.001) and farm location (p<0.001) (Table 5). Forage Mn was higher in the dry than in the wet season. Higher forage Mn was recorded at the Chaguanas, Couva and Cunupia farms than at the Sugarcane Feeds Center. All grasses collected at the Chaguanas farm in the dry season had Mn levels (1815–2693 mg/kg DM) above the toxicity level (>1000 mg/kg DM) for sheep.

DISCUSSION

Serum and forage mineral levels in relation to seasons. Lower serum Ca levels found in goats in the wet than in the dry season compared with the findings for beef cattle from Malawi (Mtimuni et al., 1990) and Ethiopia (Khalili et al., 1993a). In agreement with forage P, serum P in goats was lower in the dry than in the wet season. Lower serum P recorded in the dry than in the wet season have also been found in Nigerian sheep breeds (Cook and Fadlalla, 1987) and in beef and dairy cattle from Malawi and Western Sudan (Mtimuni et al., 1990; Abdelrahman et al., 1998). The high percentage of serum P observed Below Critical Level in goats in the dry season resembled findings in Nigerian sheep breeds.

In agreement with forage Mg, serum Mg in goats was lower in the wet than in the dry season. However, serum Mg levels found in goats especially in the wet season were lower than that reported for Indian Assam goats (Bhattacharyya et al., 1995). From studies in cattle, similarly high percentages of serum Mg Below Critical Level are observed in the wet than in the dry season in beef cattle from Colombia (Lebdosoekojo et al., 1980) and St. Croix (Wildeus et al., 1992).

Forage Cu levels were in agreement with the high percentages of serum Cu found Below Critical Level in goats at both seasons. The high percentage of low Cu levels found in goats in the late dry and wet seasons is similar to the findings in dairy cattle from Western Sudan (Abdelrahman et al., 1998). Seasonal variations of serum Cu pertainiing to systems of management have been reported for Cahmere goats (Shamsaddini, 2016). The higher percentages of serum Zn Below Critical Level found in goats in the wet than in the dry season are similar to reports for beef cattle in Ethiopia (Khalili et al., 1993b) and St. Croix (Wildeus et al., 1992). In the dry season, the order of serum minerals probably limiting production was P, Cu, Mg and Zn in goats. In the wet season, the order of minerals likely to limit production was Cu, Mg, Zn and Ca in goats.

Serum and forage mineral levels in relation to farm locations. Low dietary Ca probably accounted for the high percentage of serum Ca found Below Critical Level in goats at the Cunupia farm. The lack of regular deworming practices in goats at Cunupia and the Couva farms could have resulted in a build up of intestinal parasites inhibiting P absorption thereby accounting for the high percentages of serum P recorded Below Critical Level.

Low forage Mg was probably accounted for the high percentages of serum Mg observed Below Critical Level in goats at the Sugar Cane Feeds Center and at the Cunupia farm. Generally, the low Na and high K concentrations found in certain grasses could have affected ruminal concentrations of Na and K to such an extent that reduced intestinal Mg absorption could have occurred, resulting in lowered serum Mg levels at respective locations (Dua and Care, 1995).

Differences due to farm location, in forage and serum Cu, as were observed at Couva and Chaguanas, have similarly been reported for penned and grazing sheep of Saudi Arabia (Ali and Al-Noaim, 1992). However, the highest forage Cu at the Chaguanas farm was in agreement with the mostly normal serum Cu levels recorded there. The high percentage of serum Zn observed Below Critical Level in goats at the Couva farm was probably related to the low forage Zn at the latter. Variations in serum Zn among the Couva and other farm locations are similar to findings for beef cattle with low Zn levels from certain regions of Guatemala (Tejada et al., 1987).

The minerals of major importance probably limiting production were Ca and P at the Cunupia farm, Mg at the Sugar Cane Feeds Center, and Cu and Zn at the Couva farm. Most serum mineral levels at the Chaguanas farm were within normal ranges for goats, which probably indicated a better system of feeding and mineral supplementation. Note that a high percentage (54%) of anemia in goats was previously recorded at the Couva farm and was apparently related to the observed serum Cu deficiency (Mohammed et al; 2016).

Serum mineral levels in relation to physiological stages. Low serum Ca found in some dry non-pregnant goats were probably associated with an inadequate dietary Ca supply, because intestinal Ca absorption should increase from mid-lactation onwards (Brathwaite, 1986). Low serum Ca found in some lactating goats is likely to be associated with the increased demand for milk Ca output (El-Deen et al., 1985a; Ahmed et al., 2000), without an adequate dietary supply. The low serum P found in pregnant and lactating animals agreed with the findings by El-Deen et al., (1985a) for goats. The lowering of serum P in late pregnancy and early lactation is attributed to reduced intestinal P absorption at the former and increased milk P output demand at the latter. However, a build up of gastro-intestinal parasites, attributed to decreased host resistance before and after parturition, may have further limited P absorption in pregnant and lactating animals (Wilson and Field, 1983).

Serum Mg levels in pregnant and lactating goats were lower than that observed by other workers (Sansom et al., 1982; Ahmed et al., 2000). Variations in goats due to physiological stage in plasma and forage Mg have also been reported but for temperate seasons in Southern Pakistan (Zafar et al; 2009).Note that, Mg levels found in pregnant and lactating goats was probably age related since higher levels are reported in older goats of similar physiological stages (Mbassa and Poulsen, 1991; Ahmed et al., 2000)

Serum K found in lactating goats is similar to that observed in cows, where it is associated with the stress of lactation or a lack of appetite (Rowlands et al., 1975). Serum K levels found in pregnant goats were similar to those found in Indian Baladi goats (Azab and Abdel-Maksoud 1999). Serum K found in pregnant goats could be associated with low dietary K intakes (Telle et al., 1964).

High percentages of low serum Cu levels in pregnant and lactating animals were reflecting the observed high incidence of deficient forage Copper. Note that, the low serum Cu found in pregnant goats may have resulted from inadequate dietary Cu intakes coupled with the increased foetal Cu demand from mid-pregnancy onwards (Williams and Bremner, 1976; Suttle, 2010). High percentages of Cu deficiencies due to location have been reported among several districts of the Kashmere valley (Yatoo et al., 2013) The low serum Zn recorded in lactating goats was similar to findings for goats lactating beef cattle from Colombia (Lebdosoekojo et al., 1980). Variations due to plasma Zn levels due to location have been reported among several districts of the Kashmere valley (Yatoo et al., 2013). Plasma Zn levels have been found to rise to normal concentrations after parturition in Hereford cattle (Dufty et al., 1977) and in sheep (McSporran et al., 1977). The high percentage of serum Zn Below Critical Level observed in lactating goats was probably related to inadequate Zn intakes because of the stress of lactation; increased demand for milk Zn output or inadequate dietary Zn levels.

The low mineral concentrations of physiological importance was probably Ca in non-pregnant and lactating goats, P, Mg and Cu in pregnant and lactating goats, and Zn in lactating goats. Although the levels of mineral deficiencies found were mainly marginal, findings implied that growth, feed intakes and milk yields were probably being affected while some animals may have been prone to metabolic disorders. It is interesting to note that to a persistent skin scab condition observed on two growing kids at the Couva farm and untreatable by routine antibiotics could have been Zn-related.

Forage mineral concentrations. Forage Ca levels agreed with the findings of Devendra (1977) for grasses from Trinidad and of McDowell et al. (1977) for Latin American forages. Forage Mg and P were similar to the findings of Youssef (1988, 2000) for grasses from Trinidad and of McDowell et al. (1977) for Latin American forages. Sodium in forages compared with recent findings for grasses from Trinidad (Youssef, 2000). However, K in grasses was higher than that reported by Youssef (2000). The low dry season P levels in grasses were similar to the findings in grasses in the dry season of the Sudan (Cook and Fadlalla, 1987) and Malawi (Mtimuni et al., 1990). The higher percentage of wet than dry season low Mg levels found in grasses is similar to the findings by Mtimuni et al. (1990) for upland grasses from Malawi.

Forage Cu agreed with the findings by Youssef et al., 1999) for grasses from Trinidad. Variations in Cu concentrations in forages due to farm location have also been reported in studies involving sheep and goats from Western Sudan (Tartour, 1975) and Saudi Arabia (Ali and Al-Noaim, 1992). Forage Zn at the Sugarcane Feeds Center and Couva farms were similar to levels reported by Youssef et al. (1999) for grasses from Trinidad. Differences in forage Zn due to location, possibly attributed to soil type, have also been reported by Poland and Schnabel (1980) for grasses in Jamaica. The order of forage minerals probably limiting production was Na, Cu, Mg and Zn in both the dry and wet seasons.

Iron was similar than, while Mn was higher than the levels of these minerals found in grasses as reported by Youssef (2000). The high Fe found in feeds at the Mon Jaloux Livestock Farm could have inhibited dietary Cu absorption in sheep (Bremner et al., 1987). High forage Mn intakes at the Chaguanas farm in the dry season, could have resulted in elevated Cu but lowered Fe tissue levels in sheep and goats (Watson et al., 1973).

CONCLUSIONS

In this study, variations in forage P and Mg levels were in agreement with serum P and Mg levels in goats in the dry and wet seasons. In the dry season, the order of serum minerals likely to limit production was P, Cu, Mg and Zn in goats. In the wet season, the order of minerals was Cu, Zn, Mg, Ca and P in goats. The order of forage minerals likely to affect animal production was Na, Cu, Mg and Zn in both the dry and wet seasons. For specific farms, the serum minerals of major importance probably limiting production were Mg in goats at the Sugar Cane Feeds Center and Cu and Zn in goats at Couva. Low Ca was found in feeds at Cunupia, low Mg in grasses at the Sugar Cane Feeds Center, and low Cu and Zn in grasses at Couva. Low serum mineral concentrations of physiological importance likely to limit production were Ca in lactating goats; P, Cu, and Mg in pregnant and lactating goats and Zn in lactating goats. More than half of grasses deficient in P, Mg and Cu production requirements were in agreement with the high percentages of low serum P, Mg and Cu levels found in pregnant and lactating animals. Mineral deficiency findings implied that growth, feed intakes and milk yields were being compromised in several animals while some animals may have been prone to metabolic diseases.

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REFERENCES

Abdelrahman M.M., Kincaid R.L., Elzubeir E.A. Mineral deficiencies in grazing dairy cattle in Kordofan and Darfur regions in Western Sudan. Trop. Anim. Hlth. Prod. 1998, 30:123–135.

AFRC Report 10 Commonwealth Agricultural Bureau (CAB) international Vitamins and minerals. 1998. P. 68–85.

Ahmed Muna M.M., Siham Khalid K., Barri M.E. Macromineral profile in the plasma of Nubian goats as affected by the physiological state. Small Rumin. Res. 2000, 38:249–254.

Ali K.E., Al-Noaim A.A. Copper status of Najdi sheep in Eastern Saudi Arabia under penned and grazing conditions. Trop. Anim. Hlth. Prod. 1992, 24:115–120.

Azab M.A., Abdel-Maksoud H.A. Changes in some hematological and biochemical parameters during prepartum and postpartum periods in female Baladi goats. Small Rum. Res. 1999, 34:7–85.

Bhattacharyya B.N., Talukdar S.C., Baruah R.N., Baruah (Sr) K.K., Baruah (Jr) K.K., Baruah A. Concentration of certain macromineral in the serum of goats under different seasons. Ind. Vet. J. 1995, 72:1222–1223.

Braithwaite G.D. Phosphorus requirements of ewes in pregnancy and lactation. J. Agric. Sci. Camb. 1986, 106:271–278.

Cavell A.J. The colorimetric determination of phosphorus in plant materials. J. Sci. Fd. Agric. 1955, 6:253–256.

Cook R.H. and Fadlalla B. Seasonal variation in plasma phosphorus levels of transhument sheep in Kordofan, Sudan. Trop. Anim. Hlth. Prod. 1987, 19:57–62.

Devendra C. The mineral content of Caribbean feeding stuffs. Trop. Agric. (Trinidad). 1977, 54:29–38.

Dua K., Care A.D. Impaired absorption of magnesium in the aetiology of grass tetany. Br. Vet. J. 1995, 151:413–424.

Dufty J.H., Bingley J.B., Cove L.Y. The plasma zinc concentration of non-pregnant, pregnant and parturient Hereford cattle. Aust. Vet. J. 1977, 53:519–522.

El-Deen A.M., Hassan G.A., Samak M.A, Abo-Elezz Z.R. Changes in milk yield and certain blood biochemical components of of cross-bred (Baladi X Angora) goats and their correlation associated with lactation, pregnancy and dry seasons. Wld. Rev. Anim. Prod. 1985, 21(3):35–40.

Fick K.R., McDowell L.R., Miles P.H., Wilkinson N.S. Funk J.P., Conrad J.H. Methods of mineral analysis for plant and animal tissues. University of Florida, Gainesville. 1975

Khalili M., Lindgren E., Varvikko T. A survey of mineral status of soils, feeds and cattle in the Selale Ethiopian Highlands. I. Macroelements. Trop. Anim. Hlth. Prod. 1993, 25:162–172.

Khalili M., Lindgren E., Varvikko T. A survey of mineral status of soil, feeds and cattle in the Selale Ethiopian Highlands. II. Trace elements. Trop. Anim. Hlth Prod. 1993, 25:193–201.

Lebdosoekojo S., Ammerman C.B., Raun N.S., Gomez J., Littell R.C. Mineral nutrition of beef cattle grazing native pastures on the Eastern Plains of Columbia. J. Anim. Sci. 1980, 51(6):1249–1260.

Mbassa G.K., Poulsen J.S.D. Influence of pregnancy, lactation and environment on some clinical reference values in Danish Landrace dairy goats (*Capra hircus*) of different parity – I electrolytes and enzymes. Comp. Biochem. Physiol. 1991, 100B(2):413–422.

McDowell L.R., Arthington J.D. Minerals for grazing ruminants in tropical regions. University of Florida IFAS, 2005.

McDowell L.R., Conrad J.H., Thomas J.E., Harris L.E., Fick K.R. Nutritional composition of Latin American forages. Trop. Anim. Prod. 1977, 2:273–279.

McSporran K.D., Lorentz P.P., Pryor W.J. Plasma zinc levels in sheep in the peri-parturient period. Br. Vet. Sci. 1977, 22:393–394.

Meschy F. Recent progress in the assessment of mineral requirements of goats. Liv. Prod. Sci. 2000, 65(1):9–14.

Meschy F. Recent progress in the assessment of mineral requirements of goats. Liv. Prod. Sci. 2000, 64:9–14.

Mohammed A., Campbell M., Pargass I., Sieuchand S., Bridgemohan P., Khan A., Youssef F. The Association of Serum and Forage Copper Levels and Blood Values of Grazing Goats of Different Physiological Stages Pertaining to Location in the Dry and Wet Seasons from Central Trinidad. ARC J. Anim. Vet. Sci. 2016, 2(2):1–10.

Mtimuni J.P., Conrad J.H., McDowell L.R., Martin F.G. Effect of season on mineral concentration of soil, plant and animal tissues. Int. J. Anim.Sci. 1990, 5:181–189.

Poland J.S., Schnabel J.A. Mineral composition of *Digitaria decumbens* and *Brachiaria decumbens* in Jamaica. Trop. Agric. (Trinidad). 1980, 57(3):259–264.

Sansom B.F., Bunch K.J., Dew S.M. Changes in plasma calcium, magnesium, phosphorus and hydroxyproline concentration in ewes from twelve weeks before until three weeks after lambing. Br. Vet. J. 1982, 138:393–401.

Shamsaddini Bafti M. Seasonal variations of serum copper concentration in Raeini cashmere goats. http://lst.uk.ac.ir J. of Livest.Sci. and Tech. 2016, 4(1):33–38.

Suttle N.F. Mineral nutrition of livestock 4th Edition CABI head office Okfordshire UK, 2010.

Tartour G. Copper status in livestock, pasture and soil in Western Sudan. Trop. Anim. Hlth. Prod. 1975, 7:87–94.

Tashi N., Xugang L., Shungxiang Y., Judson G. A survey of the mineral status of livestock in the Tibet Autonomous Region of China, No 118371, Working Papers, Australian Centre for International Agricultural Research, 2005. P. 3–31

Tejada R., McDowell L.R., Martin F.G., Conrad J.H. Evaluation of cattle trace mineral status in specific regions of Guatemala. Trop. Agric. (Trinidad). 1987, 64:55–60.

Telle P.P., Preston R.L., Kirtner L.D., Pfander W.H. Definition of the ovine potassium requirement. J. Anim. Sci. 1964, 23:59–66.

Watson L.T., Ammerman C.B., Feaster J.P., Roessler C.E. Influence of manganese intake of metabolism of manganese and other minerals in sheep. J. Anim. Sci. 1973, 36(1):131–136.

Wildeus S., McDowell L.R., Fugle J.R. Season and lactation effects on serum and liver mineral concentration of Senepol cattle on St. Croix, Virgin Islands. Trop. Anim. Hlth Prod. 1992, 24:223–230.

Williams R.B., Bremner I. Copper and zinc deposition in the foetal lamb. Proc. Nutr. Soc. 1976, 35(86A):968–971.

Wilson W.D., Field A.C. Absorption and secretion of calcium and phosphorus in the alimentary tract of lambs infected with daily doses of *Trichostrongylus colubriformis* of *Ostertagia circumcinta* larva. J. Comp. Path. 1983, 93:61–71.

Yatoo M.I., Saxena A., Jhambh R. Nabi S.U., Melepad D.P., Kumar P., Dimri U., Sharma M.C. Status of trace mineral deficiency in sheep and goat in Kashmir Valley. Res. J. Vet. Pract. 2013, 1(4):43–45

Yokus B., Cakir D.U., Kanay Z., Gulten T., Uysal E. Effects of seasonal and physiological variations on the serum chemistry, vitamins and thyroid hormone concentrations in sheep. J. Vet. Med. Physiol. Pathol. Clin. Med. 2006, 53(6):271–276.

Youssef F.G. Within-season variations in the mineral content of tropical grasses. Trop. Agric. (Trinidad). 2000, 77:213–219.

Zafar I.K, Muhammad A., Kafeel A., Ehsan E.V., McDowell L.R. Mineral status of forage and its relationship with that of plasma of farm animals in Southern Punjab, Pakistan. Pak. J. Bot. 2009, 41(1):67–72.

УРОВНИ МАКРО- И МИКРОЭЛЕМЕНТОВ В СЫВОРОТКЕ КРОВИ КОЗ НА РАЗЛИЧНЫХ ФИЗИОЛОГИЧЕСКИХ СТАДИЯХ В СУХОЙ И ВЛАЖНЫЙ СЕЗОНЫ В ЦЕНТРАЛЬНОМ ТРИНИДАДЕ

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РЕЗЮМЕ. Проведено исследование с целью оценки концентрации макро- и микроэлементов в сыворотке крови 158 коз в зависимости от сезона, местонахождения фермы и физиологической стадии. Сбор образцов проводили в конце сухого сезона (апрель – май) и в конце сезона дождей (ноябрь – декабрь) в Центральном Тринидаде. Образцы крови были собраны в хозяйстве государственного Центра кормовых сахаров и на трех частных фермах в районах Канупия, Чагуанас и Кува. Образцы брали у подрастающих (возраст 6–12 мес.), нелактирующих беременных (в основном на поздних сроках), лактирующих (на ранних сроках, до 8 недель) и нелактирующих небеременных коз (возраст 1–3 года). У коз в сыворотке более низкий уровень P (*p* <0,001) был обнаружен во время сухого сезона, тогда как Mg (*p* <0,001) и Zn (*p* <0,01) были ниже в сезон дождей. Ca у коз был ниже в сезон дождей по сравнению с сухим сезоном (*p* <0,001). Значительные различия наблюдались между фермами по содержанию в сыворотке крови у коз P, Mg, Na и Cu (*p* <0,001), а также Ca, K и Zn (*p* <0,01). Встречаемость сывороточного Mg ниже критического уровня (<18 мг/л) у коз из Центра кормовых сахаров составила 64%. Также ниже критического были уровни Cu (<0,5 мг/л) и Zn (<0,6 мг/л) у 79 и 60% коз на ферме Кува. Значительные различия между физиологическими стадиями наблюдались в сыворотке крови коз для P, K (*p* <0,01), а также Zn (*p* <0,001). Содержание Mg и Mn в корме было ниже (*p* <0,001) в сезон дождей, чем в сухой сезон, тогда как P был ниже (*p* <0,001) в сухой сезон. Значительные вариации в зависимости от места (фермы) были в содержания в кормах Ca (*p* <0,001), Mg (*p* <0,001), Cu (*p* <0,05) и Zn (*p* <0,001). В сухой сезон в сыворотке крови у коз элементами, способными ограничить продуктивность, были P, Cu, Mg и Zn, в сезон дождей – Cu, Zn, Mg, Ca и P. В кормах элементами, вероятно ограничивающими продуктивность, как в сухой, так и во влажный сезон, были Na, Cu, Mg и Zn. Что касается местоположения фермы, то сывороточным элементом, значимым и, вероятно, ограничивающим продуктивность, в Центре кормовых сахаров был Mg, а в Куве, соответственно, Cu и Zn. Низкие концентрации макро- и микроэлементов в сыворотке, вероятно, имеющие физиологическое значение, были отмечены для Ca у небеременных и кормящих коз; P, Cu и Mg – у беременных и кормящих коз, и Zn – у кормящих коз. Хотя обнаруженные дефициты макро- и микроэлементов были в основном незначительными, результаты предполагают, что они, вероятно, влияли на рост, потребление кормов и выход молока, а также на склонность некоторых животных к нарушениям обмена веществ.

КЛЮЧЕВЫЕ СЛОВА: козы, концентрация макро- и микроэлементов, сезон, ферма, физиологическая стадия.