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RESEARCH OPINIONS IN ANIMAL & VETERINARY SCIENCES

Assessment of status of minerals in forages preferred by camels (*Camelus dromedarius)* in the Arid North Eastern Kenya

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Abstract

The study was carried out in three locations of north eastern Kenya i.e. Saka in Garissa, Kutulo in Wajir east and Bute in Wajir north to evaluate the level of mineral elements in forage species preferred by camels at the wet and dry seasons and also to establish whether an existing mineral supplement in upper eastern Kenya could as well be effective in north eastern Kenya. The study was implemented using a Completely Randomized Design (CRD) with a factorial arrangement of treatments. The total concentration of minerals in the preferred forage species were measured after focus group discussions, field observation of grazing camels, sampling and laboratory analysis of forage species. The concentration of calcium (Ca) in the forages species was lower than standard recommended value in wet season while the rest of the mineral elements were within the recommended levels. While the concentration of copper (Cu) was marginal compared to the recommended level in the dry season, that of zinc (Zn) and cobalt (Co) was lower than the recommended level. Selenium (Se) and molybdenum (Mo) could not be detected in the forages during the dry season. Furthermore, the results showed that the upper eastern Kenya had higher ($P<0.05$) levels of potassium (K), sodium (Na), Ca, magnesium (Mg), iron (Fe), Cu and Co than north eastern in the dry season while in the wet season, the concentration of phosphorus (P), K, Ca, Mg and Fe was higher ($P<0.05$) in upper eastern than in the north eastern Kenya forages. Regarding Cu, Zn and Co during the wet season, the north eastern Kenya forages had higher levels ($P<0.05$) than those in the upper eastern Kenya. The study concluded that depending on the management there was potential for the grazing camels in north eastern Kenya to meet their daily mineral requirements from the natural forages in respect of P, K, Mg, Na, Fe and chromium (Cr) during the wet season. Such camels may be suffering deficiencies with regard to the elements Ca in the wet season and Cu, Zn, Co, Se and Mo in the dry season. The study also concluded that the existing mineral formulation needs to be revised in order to make it effective in north eastern Kenya.

Key words: Mineral deficiency, camels' preferred forages, recommended mineral levels.

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Introduction

Pastoralists in the northern part of Kenya where camels are reared mainly depend on the locally available plants and the salty water as sources of minerals for camels (Simpkin, 1998; Kuria et al., 2004) with minimal use of commercial supplements (Kaufman, 1998). Under natural conditions, camels have the capacity to choose their diets efficiently, selecting more of browse than grasses (Field, 1993). The browse species are richer in minerals than grasses (Basmaeil, 1989; Faye and Tisserand, 1989; Rutagwenda et al., 1990; Wardeh, 1991; Field, 1995). Studies on the mineral status of camels in north eastern Kenya which host over 50% of all camels in Kenya (GoK, 2009) remain scanty despite the fact that mineral

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deficiency is suspected to limit productivity of camels in the area (Wilson 1998, Onjoro et al., 2004). Information on the mineral content of the major sources of minerals in the area is also lacking. Subsequently, the nature, extent and distribution of mineral deficiencies in north eastern Kenya are poorly understood thus limiting attempts to improve productivity of camels in the area through mineral supplementation. This study was designed with the objective of establishing the levels of minerals in the camels' preferred forage species at the wet and dry seasons in three sites in north eastern of Kenya and to determine whether an existing mineral supplement in upper eastern Kenya could as well be effective in north eastern Kenya.

Materials and Methods

The study was carried out in three locations of Saka in Garissa, Kutulo in Wajir East and Bute in Wajir North administrative districts. The community involved in the study was Somali and the study area lie approximately between longitude 37°35’ to 40°30’E and latitude 01°00’ to 03°00'N. These locations were selected due to their relative importance with respect to mineral sources for camels and the fact that they most of the time tend to have a high density of camels. The three districts are classified as arid, falling in the ecological zones V and VI but with a few pockets of high crop production potential especially along permanent rivers. The area is generally low lying with annual rainfall ranging from 120 to 500 mm. The rainfall pattern is bimodal with peaks in April and November. The temperatures vary from 23 to 34^{o}C with the period between January and April being very hot (MLFD, 2003). Evaporation is high, exceeding 2,600 mm annually over most of the area. Soils in the study area vary greatly ranging from whitish sand, heavy clay, dark red calcareous clay and dusky red soils.

Different methods were used to gather information depending on the kind of data needed. These included focus group discussions (FGDs), field observation of grazing camels, sampling of the highest ranking forage species and laboratory analysis.

The FGDs comprised of 12-15 purposively selected experienced camel keepers per site. For the purposes of sampling, these camel keepers helped the research team to identify the forage species preferred by camels in wet and dry seasons, forage species perceived as salty by pastoralists in wet and dry seasons, other natural salt sources perceived as important for camels by pastoralists like water and natural licks in wet and dry seasons, commercial mineral salts usually fed to camels. Ranking of the identified species was done based on perceived importance by the respondents.

Field observation of grazing camels was to confirm or verify the forage species identified during the FGD before taking the samples. The feeding observations were done for five randomly selected camel herds per site with five randomly selected camels being observed per herd, thus a total of 75 camels for the three sites. The selection ensured that the camel herds were grazing in different sub-sites within the main sites. These observations were conducted between the clocks 7:00 and 10:00 in the morning when the camels were actively grazing and the selected camels did not include any newly acquired camel that would not be familiar with the grazing area. Each camel was observed for 15 minutes, recording the number of complete bites made by the camel on various forage species and also the plant parts eaten by the camels. The end of a bite was marked by the time the camel raised its head for purposes of chewing. The researchers doing the observations were accompanied by two experienced local camel herders who knew all the plants in vernacular for quick identification and recording. It is important to note that these observations were done for the same camels in dry and wet seasons.

Ranking was based on the sum of bites made on a particular forage species by the different camels in the different sub-sites. This ranking suggested the order of forage species preference by the grazing camels. One composite sample of each of the top ranked 12, 15 and 13 forage species in Saka, Kutulo and Bute, respectively, were taken during the wet season (May) targeting the forage parts that were being eaten by the grazing camels during the field observations. Fresh weight of the samples was taken and the samples were then sun dried for five (5) days and packed for laboratory analysis. In the dry season (September), the plant species diversity was low as expected and thus, only 8 plant samples were taken each in Saka, Kutulo and Bute.

For the laboratory analysis, preparation of the forage samples was done in accordance to the AOAC (1995). The atomic absorption spectrophotometric method (Bellanger, 1971; Bellanger and Lamand, 1975) and graphite furnace AAS (US EPA, 2004) were used to determine the mineral concentration in the forage material. Graphite furnace AAS was specifically used to analyze for Se, Mo and Cr. The samples were assayed for P, Na, Ca, K, Mg, Fe, Cu Zn, Co, Se, Mo and Cr. Duplicate samples were analyzed for each forage species after which an average was computed.

The concentration of the various minerals was computed by working out the mean for the top ranked forage species in each site. The experimental design was a Completely Randomized Design (CRD) within a factorial arrangement. The two factors were site and season where the site had three levels: Saka, Kutulo and Bute while the season had two levels: dry and wet. The total number of observations was 150 (5 animals × 5 herds × 3 sites × 2 seasons).

Statistical analysis

The comparison of the data of the two seasons (dry and wet) and the three sites was done using the GLM procedure of SAS (2003). Mean separation was done using the Least Significant Difference (LSD). Within sites between seasons and, within seasons between sites comparisons were carried out to establish which minerals were deficient in which seasons, sites and the severity of the deficiencies. Reference was made to the standard recommended values. Seasonal comparison between north eastern and upper eastern Kenya was also done for the purpose of addressing the second part of the objective of this study.

Results and Discussion

Details of the specific plant species sampled in the three study sites in dry and wet seasons are presented in Tables 1 and 2.

The differences between seasons and the standard were significant with the concentration for the macro elements being higher in dry than wet season with exception of K and Na (Table 3). It was not clear why this trend although it may has to do with the fact that about 40% of forage species sampled during the dry season were the evergreen type in line with an earlier observation by Kuria et al. (2004). While mature plants are usually low in minerals due to translocation of nutrients to the root system (Tergas and Blue, 1971; Underwood, 1981), the evergreen forage species are

Table 1: Mineral composition of the forages sampled during the dry season in Saka, Kutulo and Bute

Vernacular name	Botanical name	Macro elements concentration (g/kg)						Micro elements concentration (mg/kg)					
		Ca	Na	K	Mg	P	Fe	Co	Cu	Zn	Se	Mo	Cr
Saka													
Kalankal	*Boscia coriacea*	0.4	1.0	12.9	2.9	1.5	0.1	0	0	.3	0	0	1.2
Mareer/haab	*Cordia sinensis*	0.3	2.8	8.5	3.4	0.7	0.6	0	0	17.2	0	0	2
Adi	*Salvadora persica*	0.6	1.0	7.1	2.3	2.2	0.5	0	17	11.6	0	0	1.5
Kholof*	-	1.5	1.0	9.2	1.6	3.1	0.2	0	4	27	0	0	1
Dugh Dugh	*Cadaba glandulosa*	11.9	1.4	3.3	1.4	3.6	0.6	0	12	25	0	0	1
Kulan	*Balanites sp.*	20.7	1.1	19.2	12.5	9.7	0.8	0	7	22	0	0	1.8
Maratel	*Indigofera spinosa*	9.0	2.7	19.4	2.6	1.4	0.1	0	8	54	0	0	2
Darqa	*Comiphora sp.*	15.6	1.4	10.5	26.8	6.4	0.3	0	0	8.2	0	0	1
Kutulo													
Mareer/haab	*Cordia sinensis*	0.3	1.7	11.9	0.5	1.1	0.9	0	11	22	0	0	1
Megaag/rigow	*Boscia minimifolia*	0.05	1.2	5.0	1.8	3.3	0.3	0	8	12	0	0	2.2
Dugh Dugh	*Cadaba glandulosa*	0.1	1.3	16.9	3.3	0.8	0.3	0	12	16	0	0	2
Herin	*Hildebrandtia Africana*	0.09	1.0	4.0	1.0	1.9	0.4	0	9	21	0	0	1.8
Ohob	*Grewia penicillata*	12.2	1.1	5.0	0.7	1.4	0.1	0	10	16	0	0	1.6
Khura	*Acacia tortilis*	9.3	1.1	7.0	1.6	1.4	0.2	0	13	17	0	0	1
Banis haath*	-	36.5	1.0	8.9	3.0	1.2	0.01	0	10	18	0	0	2.2
Qot*	-	22.0	1.0	8.9	0.7	2.1	0.2	0	12	18	0	0	1.6
Bute													
Ano	*Eurphobia tirucalli*	0.8	12.6	163.1	27.7	20.8	2.1	0	10	13	0	0	1
Kulan	*Balanites sp.*	0.3	1.1	6.9	2.4	0	1.6	0	15	12	0	0	2
Kobakor	*Aristida sp.*	0.1	1.2	29.9	11.4	6.3	0.1	0	8	8	0	0	1
Salelma	*Sesamnothamnus busseanus*	0.04	1.0	12.4	2.5	1.8	0.1	0	5	15	0	0	0.01
Wahanri	*Lannea triphylla*	4.1	1.0	7.7	1.1	1.0	6.3	0	10	79	0	0	1
Galogalol	*Acacia bussei*	0.1	1.0	6.5	1.6	6.7	0.2	0	12	21	0	0	2
Kuka	*Commiphora sp.*	4.9	0.97	10.3	1.5	1.6	0.2	0	8	15	0	0	1
Dei dei	*Dalbergia sp.*	12.5	0.9	4.1	1.9	1.3	0.2	0	13	21	0	0	1.6

*Botanical names of the plants were not established

Table 2: Mineral composition of the forages sampled during the wet season in Saka, Kutulo and Bute.

Vernacular name	Botanical name	Macro elements concentration (g/kg)						Micro elements concentration (mg/kg)		
		Ca	Na	K	Mg	P	Fe	Co	Cu	Zn
Saka										
Surur	*Lycium europium*	0.2	53.1	4.4	1.1	1.9	0.2	67	48	28
Darqa athe	*Comiphora sp.*	0.2	0.8	15.0	0.5	3.1	0.4	62	37	32
Murufur	*Boswellia hildebrandtii*	0.2	0.8	7.0	1.7	2.9	0.2	70	40	40
Darqa mathow	*Indigofera sp.*	0.3	0.8	8.6	1.6	2.8	0.3	67	47	57
Balanbal	*Sericocomopsis pallida*	0.3	1.9	7.3	1.2	1.9	0.2	67	43	35
Mareer	*Cordia sinensis*	0.3	10.6	13.3	1.2	1.7	0.3	72	43	33
Maratel	*Indigofera spinosa*	0.2	0.8	9.0	0.3	2.7	0.4	68	50	22
Musmuso	*Comiphora sp.*	0.2	0.8	7.3	3.6	2.9	0.6	67	52	35
Kamuthey	*Commiphora species*	0.2	0.9	9.9	1.8	2.3	0.2	67	45	30
Ilkabat	*Boscia sp.*	0.2	1.0	23.5	3.1	2.2	0.3	72	43	37
Washaqar*	-	0.3	1.0	6.3	3.2	2.9	0.3	82	50	48
Kowle	*Kleinia sp.*	1.5	4.6	29.5	9.9	2.3	0.09	127	17	32
Kutulo										
Hagar	*Commiphora erythraea*	0.2	0.6	5.7	1.0	2.9	0.5	83	80	30
Mareer	*Cordia sinensis*	0.3	2.1	16.2	2.0	1.6	0.3	70	75	78
Duyaa	*Dalbergia commiphoroides*	0.3	0.9	5.7	1.3	3.0	0.3	82	63	37
Mugle	*Boswellia microphylla*	0.6	0.7	11.1	1.6	2.2	0.03	107	48	35
Matatha*	-	0.6	2.0	11.1	1.8	2.0	0.02	103	28	130
Ohob	*Grewia penicillata*	0.8	1.3	11.4	1.5	2.4	0.02	103	32	27
Banya	*Blepharispermum pubescens*	1.0	0.7	23.8	2.0	2.5	0.03	115	33	30
Mured	*Grewia species*	1.0	0.8	14.6	1.8	2.2	0.04	115	30	35
Gosai	*Commiphora species*	0.6	0.7	12.7	1.0	3.0	0.04	120	25	30
Madalmadal	*Gardenia volkensii*	0.8	0.7	17.8	3.0	1.8	0.04	118	38	37
Gontat*	-	0.8	0.9	14.0	2.4	2.0	0.06	117	7	37
Ilkabat	*Boscia sp.*	0.6	1.0	27.0	3.6	2.0	0.06	122	40	35
Saren	*Duosperma eremophilum*	1.0	12.8	19.7	4.3	2.1	0.1	122	22	38
Kamuthey	*Commiphora species*	0.2	1.1	3.2	1.1	3.5	0.6	73	57	390
Seir	*Sporobolus helvolus*	0.1	8.4	14.0	1.8	1.7	0.09	110	118	98
Bute										
Idigod*	-	0.3	0.8	4.1	1.6	2.6	0.3	57	30	35
Baar	*Hyphaena coriacea*	0.3	1.2	28.9	2.3	3.5	0.5	58	32	48
Tugar/Tuk ha	*Cadaba glandulosa*	3.7	0.7	6.3	0.9	2.3	0.2	50	30	20
Kulan	*Balanites sp.*	4.1	0.7	15.2	1.6	3.4	0.2	68	35	28
Uldig	*Caucanthus albidus*	0.2	0.8	8.9	1.6	2.2	0.2	62	35	27
Dabi	*Grewia microcarpa*	0.3	0.8	24.5	0.1	2.2	0.3	52	42	48
Dei Dei	*Dalbergia sp.*	0.2	2.1	4.8	1.2	2.4	0.2	58	28	32
Gogon	*Combretum sp.*	0.2	0.9	3.2	1.0	2.2	0.3	58	37	25
Kore ad	*Ruellia patula*	0.3	0.8	19.4	5.0	2.4	0.3	52	35	52
Hagar	*Commiphora erythraea*	0.3	0.8	25.1	3.2	2.3	0.3	55	40	60
Mareer	*Cordia sinensis*	0.9	4.3	13.7	2.2	1.6	0.06	120	7	37
Duyaa/Tonya	*Dalbergia commiphoroides*	0.3	4.0	7.6	1.2	1.6	0.07	118	15	45
Balanbal	*Sericocomopsis pallida*	0.9	0.8	12.4	2.3	2.4	0.1	117	15	37

*Botanical names of the plants were not established

able to continue growing early into the dry season due to their capacity to draw water from the deeper soil which may explain the observed trend. However, for the micro elements Cu, Zn and Co, the trend was opposite i.e. concentrations for the wet were significantly higher than those for the dry season (Table 3) in agreement with Kuria et al. (2004). This finding also partly agreed with Khan et al. (2004) who reported higher level of Cu and Zn in winter than summer. An important observation is that in the dry season, the ratio of Ca: P was within the recommended level of 1:1 to 2:1 while in the wet season, P was about four times the

Table 3: Comparison between mineral concentrations (ppm) in the forage species preferred by camels with the standard recommended levels (ppm)

	Mineral concentration (ppm)		P values	Recommended values
Mineral elements	Dry season	Wet season		
Number of observations				
Phosphorus (g/kg)	2.6±0.5[a]	2.4±0.1[b]	P<0.0001	2[***]
Potassium (g/kg)	10.5±1.3[a]	13.1±1.2[b]	P<0.0001	7[**]
Sodium (g/kg)	1.3±0.1[a]	3.3±1.4[b]	P<0.0001	0.6[**]
Calcium (g/kg)	6.8±1.9[a]	0.6±0.1[b]	P<0.0001	3[**]
Magnesium (g/kg)	5.2±1.7[a]	2.1±0.3[b]	P<0.0001	2[**]
Iron (g/kg)	0.6±0.3[a]	0.2±0.02[b]	P<0.0001	0.03[**]
Copper (mg/kg)	8.9±0.9[a]	39.8±3.2[b]	P<0.0001	10[**]
Zinc (mg/kg)	20.4±3.2 [a]	49.8±9.4 [b]	P<0.0001	30[**]
Cobalt (mg/kg)	0.0 [a]	84.3±4.2 [b]	P<0.0001	0.1[**]
Selenium (mg/kg)	0	-	-	0.2[***]
Molybdenum (mg/kg)	0	-	-	1.2[***]
Chromium (mg/kg)	1.5±0.1	-	-	0.6[***]

**the source is McDowell (1985); ***the source is NRC (1983, 1989)

level of Ca. Excess Ca or P renders each other unavailable and may also decrease the bioavailability of trace elements (McDowell, 1997; Lukhele and Van Ryssen, 2003). Long et al. (1972) reported wide variations in mineral concentrations of natural pastures depending on season and state of pastures.

Comparing the mineral concentrations in the forages with the recommended values, calcium was lower in the wet season while the rest of the mineral elements were within the recommended levels. This largely agreed with the report of Kuria et al**.** (2004) that the preferred forage species in the upper eastern Kenya had minerals concentration within the recommended levels of Ca, P, Mg, Na, Fe and Co during dry and wet seasons. The concentration of Cu was marginal when compared with the recommended level in the dry season, whereas that of Zn was lower than the recommended level. Kuria et al. (2004) also indicated that 50% of the studied forages had mineral concentrations below the recommended level of Cu while 90% of the forage species had concentrations below the recommended levels of Zn in both dry and wet seasons, agreeing with the findings of the current study. Furthermore, these findings partly agreed with the LATFC (1974) which reported the elements Co, Cu, Mg, P, Na and Zn to be inadequate in tropical forages. Interestingly, it was reported that P being the most widespread and economically important was within the recommended level in both dry and wet seasons. McDowell and Conrad (1990) and Judson (1996) noted that Co was among the most widespread trace elements deficient in tropical forages, Co level in the current study in dry season was below the recommended level. The concentration of Fe was above the recommended level suggesting some degree of contamination of the sample by soil or dust and this is in line with Maryland and Shewmaker (2001). Mayland and Sneva (1983) observed that the contamination of herbage material is usually reflected by fact that the sample Fe concentrations was greater than 250 ppm.

Selenium and Mo were not detected in the forages during the dry season i.e. they were completely lacking while analyses for these two elements were not done in the wet season. Regarding Mo, this finding agreed with that of McDowell (1997) who observed that many pastures grazed by ruminants contained less than 0.35 ppm Mo with no evidence of a deficiency. It is worth noting that under the influence of sulfur, excess molybdenum interacts with copper depressing absorption of the latter through formation of thiomolybdates complexes which bind copper in the rumen (Gooneratne et al., 1989). A Cu: Mo ratio of not less than 4:1 was proposed by Alloway (1973). However, Mo deficiencies are rare and ruminants are able to perform normally under extremely low levels of molybdenum (McDowell, 1997). McDowell (1997) however noted that such low levels of Mo in pastures favor accumulation of Cu in the ruminant tissues which can lead to chronic Cu poisoning. This may suggest that even in the current study where Mo was not detected in the camel forages, characteristic deficiency syndrome may not be observed in grazing camels. Selenium was not detected in the forages during the dry season. There is usually a complex nutritional interrelationship between Se and vitamin E such that each can spare or alter the requirements of the other but not completely replacing each other (McDowell, 1997). Although no data was collected on incidences of retained placenta (poor reproductive performance) in the current study, this is one profound effect of Se deficiency in the grazing ruminants. Selenium deficiency is widespread and many researchers (Rojas et al., 1993; McDowell, 1997; Velasquez-Pereira et al., 1997) had reported Se levels of less than 0.1 ppm in forages of grazing ruminants in different parts of the world and this is in line with the findings of the current study.

Table 4: Preferred forages mineral concentrations (ppm) comparisons with the standard recommended levels (ppm)

	Mineral concentration (ppm)				
Mineral elements	Kutulo	Bute	Saka	P values	Critical values
Number of observations					
Phosphorus (g/kg)	2.1±0.1[a]	2.5±0.3[b]	2.9±0.4[c]	P<0.0001	2***
Potassium (g/kg)	12.0±1.3[a]	12.8±1.8[b]	11.6±1.5[c]	P<0.05	7**
Sodium (g/kg)	1.9±0.6[a]	1.3±0.2[a]	4.5±2.6[b]	P<0.0001	0.6**
Calcium (g/kg)	3.9±1.8[a]	1.6±0.6[b]	3.2±0.1[c]	P<0.05	3**
Magnesium (g/kg)	3.1±1.4[a]	2.3±0.5[b]	4.1±1.4[c]	P<0.0001	2**
Iron (g/kg)	0.2±0.05[a]	0.6±0.3[b]	0.4±0.04[c]	P<0.0001	0.03**
Copper (mg/kg)	34.0±6.0[a]	22±2.8[b]	28.2±4.5[a]	P<0.0001	10**
Zinc (mg/kg)	52.5±16.4[a]	32.3±3.9[b]	29.7±3.2[b]	P<0.0001	30**
Cobalt (mg/kg)	67.8±11.0[a]	44.0±9.0[b]	44.4±8.8[b]	P<0.0001	0.1**
Selenium (mg/kg)	0	0	0	-	0.52****
Molybdenum (mg/kg)	0	0	0	-	1.5****
Chromium (mg/kg)	1.7±0.2[a]	1.2±0.2[b]	1.4±0.2[b]	P<0.0001	0.6****

Table 5: Mineral levels (ppm) in forages preferred by camels in the examined sites of north eastern compared with the upper eastern Kenya at dry and wet seasons

	Dry				Wet			
Mineral elements	Upper Eastern	North eastern	LSD	s/ns (P<0.05)	Upper eastern	North eastern	LSD	s/ns (P<0.05)
Number of observations								
Phosphorus	1.9	2.6	0.02	s	3.8	2.4	1.4	s
Sodium	6.1	1.3	1.6	s	2.2	3.3	1.2	ns
Potassium	14.0	10.5	3.9	ns	21.2	13.1	2.9	s
Calcium	24.5	6.8	3.1	s	19.7	0.6	2.3	s
Magnesium	8.7	5.0	1.0	s	10.7	2.1	0.8	s
Iron	10.1	0.6	0.1	s	1.4	0.2	0.1	s
Copper	11.8	8.9	10.7	ns	7.1	39.8	7.8	s
Zinc	16.4	20.4	27.1	ns	19.7	49.8	19.8	s
Cobalt	22.5	0	11	s	41	84.3	7.9	s

Overall, these findings suggested that depending on the grazing management, diet selection and intake, there was potential for the grazing camels in north eastern Kenya to meet their daily mineral requirements from the natural forages in respect of P, K, Mg, Na, Fe and Cr during the wet season. However, the findings also suggested that such camels may be suffering deficiencies with regard to the elements Ca in the wet season and Cu, Zn, Co, Se and Mo in the dry season.

There were variations in the concentrations of minerals among sites (Table 4) and this was in agreement with McDowell and Conrad (1990), Judson (1996), Khan et al. (2004) and Onjoro et al. (2004). The forage mineral concentrations of Ca, P, Mg, Co and Cu in this study were much higher than those reported by Onjoro et al. (2004) in Isiolo and Laikipia districts of Kenya. Furthermore, the observed mean values for the elements Zn, Cu and Fe were much higher than those reported by Khan et al. (2004) in Pakistan. In Bute, Ca was below the recommended level. In Saka Zn, Se and Mo were below the recommended level. These differences between sites could be attributed to differences in soil types.

In the dry season, forage mineral levels in the upper eastern were higher than those in the north eastern forages (7 of 9 mineral elements) with the exception of phosphorus and zinc. In the wet season, the concentrations of 5 out of 9 mineral elements those are P, K, Ca, Mg and Fe were higher in upper eastern forages than in the north eastern forages. Regarding Na, Cu, Zn and Co during the wet season, the north eastern forages had higher levels than those in the upper eastern Kenya. Overall, the upper eastern Kenya appears better in terms of the mineral status in key forages for camels particularly with respect to the macro minerals while the north eastern Kenya seems to have an edge over the upper eastern with respect to the micro mineral elements. These differences were attributed to disparities in soil types between the two regions (Onjoro et al., 2004). The regional differences in forage mineral concentration were largely significant suggesting that the mineral formulation prepared using the data from upper eastern Kenya cannot work effectively in the north eastern Kenya and it needs to be modified.

Conclusion

The study concluded that depending on the grazing management, diet selection and intake, there was potential for the grazing camels in north eastern Kenya to meet their daily mineral requirements from the natural forages in respect of P, K, Mg, Na, Fe and Cr during the wet season. Such camels may be suffering deficiencies with regard to Ca in the wet season and Cu, Zn, Co, Se and Mo in the dry season. Furthermore, the study concluded that the existing mineral formulation would need to be revised in order to make it effective in addressing mineral deficiency related challenges in the north eastern Kenya camels.

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References

Alloway, B.J. 1973. Copper and molybdenum in swayback pastures. amels under controlled management, in: Galal, E.S.E., Aboul Ela, M.B. and Shafie, M.M (editors), Ruminant production in the dry subtropics, constraints and potentials. Proceedings of international symposium on constraints and possibilities of ruminant production in the dry subtropics (MOA of Egypt, ESAP, EAAP, FAO, ICAMAS, WAAP) Cairo Egypt, 5-7 November 1988, EAAP Publication No. 38, 1989, Wagenigen, Netherlands.

Bellanger, J. 1971. Le dosage des oligo elements dans les fourrages. *Alimentos NutriÇão*, 25: 59-96.

Bellanger, J. and Lamand, M. 1975. Methode de dosage du cuivre et du zinc plasmatique. Bulletin technical INRA Theix, 20: 53-54.

Faye, B. and Tisserland, J.L. 1989. Les problemes de la determination de la valuer alimentaire des fourrages preleves par les dromadaires. Options mediterranneennes. CIHEAM, Series Seminaries No 2: 61-65.

Field, C.R. 1993. Biological characteristics and physiology of camels. A series of lectures given by Farm Africa at University of Nairobi, Farm Africa, London.

Field, C.R. 1995. Camel Nutrition, in: Evans, J.O., Simpkin, S.P., Atkins, D.J (editors), Range Management Handbook of Kenya, Vol. III 8. Ministry of Agriculture, Livestock Development and Marketing, 1995 Nairobi, Kenya P: 3.

Gooneratne, S.R., Buckley, W.T. and Christensen, D.A. 1989. Review of copper deficiency and metabolism in ruminants. *Canadian Journal of Animal Science*, 69 (4): 819-845.

GoK, Government of Kenya 2009. Kenya Population and Housing Census. Ministry of National Planning, Nairobi Kenya.

Judson, G.J. 1996. Survey of the mineral, trace elements and vitamin status of Alpacas, in: Proc. 78, Camelid Medicine and Surgery. Central Veterinary laboratories, Dubai, UAE.

Kaufmann, B. 1998. Analysis of camel husbandry in northern Kenya. Hohenheim Tropical Agricultural Series 5. Centre for Agriculture in the Tropics and Subtropics, University of Hohenheim. Wekersheim Margraf. P: 194.

Khan, Z.I., Hussein. A., Ashraf, M.Y., Valeem, E.E. and Ahmad, M.S. 2004. Soil and forage mineral (trace elements) status of a grazing pasture in the semi-arid region of Pakistan. *Pakistan Journal of Botany*, 36(4): 851-856.

Kuria, S.G., Wahome, R.G., Gachuiri, C.K. and Wanyoike, M.M. 2004. Evaluation of forages as mineral sources for camels in western Marsabit, Kenya. *South African Journal of Animal Science*, 34 (3): 180-188.

Long, M.I.E., Marshall, B., Ndyanabo, W.K. and Thomton, D.D. 1972. Mineral status of dairy farms in eastern Uganda. II. Nitrogen and mineral content of grasses and some mineral content of bovine plasma. *Trinidad Tropical Agriculture*, 49:227-234.

Lukhele, M.S. and Van Ryssen, J.B.J. 2003. The chemical composition and potential nutritive value of the foliage of four subtropical tree species in southern Africa for ruminants. *South African Journal of Animal Science*, 33:132-141.

Mayland, H.F. and Sneva, F.A. 1983. Effect of soil contamination on the mineral composition of forage fertilized with nitrogen. *Journal of Range Management*, 36:286–288.

Mayland, H.F. and Shewmaker, G.E. 2001. Animal health problems caused by silicon and other mineral imbalances. *Journal of Range Management*, 54: 441–446.

McDowell, L.R. 1985. Nutrition of grazing ruminants in warm climates. Academic Press, New York

McDowell, L.R. 1997. Minerals for grazing ruminants in tropical regions. 3rd (ed.) Animal Science Department, Centre for Tropical Agriculture, University of Florida, USA.

McDowell, L.R. and Conrad, J.H. 1990. Mineral imbalances of grazing livestock in tropical countries. *International Journal of Animal Science*, 5: 21-32.

MLFD, Ministry of Livestock and Fisheries Development 2003. Department of Animal Production Annual Report, Nairobi Kenya.

NRC, National Research Council. 1983. “Selenium in Nutrition”. Revised edition, National Academy of

Sciences-National Research Council, Washington DC.

NRC, National Research Council. 1989. Nutrient requirements of dairy cattle. (6th ed.). National Research Council, National Academy Press, Washington DC, USA.

Onjoro, P.A., Njoka-Njiru, E.N. and Ottaro. J. M. 2004. Status of minerals in the soils, water, forage, blood, milk, urine and faeces of free ranging camels (*Camelus dromedarius*) in northern Kenya during the dry season. *International Journal of Agriculture and Rural Development*, 5: 121-128.

Rojas, L.X., McDowell, L.R., Martin, F.G. and Wilkinson, N.S. 1993. Mineral status of soils, forages and beef cattle in south eastern Venezuela. II. Micro-minerals. *International journal of Animal Science,* 8: 183 – 188.

Rutagwenda, T., Lechner-Doll, M., Drochner, W., Lindhauer, M.G., Beringer, H. and Engelhardt, W.V. 1990. The soluble fraction of a number of Kenyan range plants grazed by indigenous ruminants, camels and donkeys. *Journal of Animal Physiology and Nutrition*, 64: 94-102.

SAS, 2003. Statistical Analysis System Users Guide, Statistics Version 6 Edition, SAS Inst, Inc, Cary, NC, USA.

Simpkin, S.P. 1998. The effect of breed and management on milk yield of camels in Kenya. PhD thesis University of Newcastle-Upon-Tyne, UK

Tergas, L.E. and Blue, W.G. 1971. Nitrogen and phosphorus in Jaragua grass {*Hyparrhenia rufa* (Nees) Stapf} during the dry season in a tropical savanna as affected by nitrogen fertilization. *Agronomy Journal*, 63: 6-9.

Underwood, E.J. 1981. The mineral nutrition of livestock. Common wealth Agricultural Bureaux. England.

US EPA, United States Environmental Protection Agency 2004. Graphite furnace Atomic Absorption Spectrometry. Technology Innovation and Field Services Division, USA.

Velásquez-Pereira, J., McDowell, L., Conrad, J., Wilkinson, N. and Martin, F. 1997. Mineral status of soils, forages and beef cattle in Nicaragua. I. Micro-minerals. *Revista de la Faculatd de Agronomia de La Universidad del Zulia*, 14: 73-89.

Wardeh, M.F. 1991. Camel nutrition and grazing behavior, in: Wardeh, M.F., Wilson, R.T. and Zaied, A.A (editors), Proceedings of International Camel Production and Improvement, December 10-13, 1990 Eds. ACSAD, Tobruk, Libya pp: 113-123.

Wilson, R.T. 1998. Camel. Ed. CTA/McMillan Press, London, Britain.