Evaluation of forages as mineral sources for camels in western Marsabit, Kenya

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Abstract

A survey to identify forage mineral sources for settlement-based camels was carried out in the semi-arid rangelands of the southwestern Marsabit district of Kenya during dry and wet periods. The respondents included men and boys who were responsible for the herding and watering of camels in the area. Identification of the sources was followed by field verification, sampling and analyses for minerals. A table of mineral composition of the sources was compiled. Over 80% of preferred forage species had calcium, phosphorus, magnesium, potassium, sodium, iron and cobalt concentrations above the recommended levels during both dry and wet seasons at all the study sites. Eight to 50% of the forage samples were adequate in terms of copper (Cu) and zinc (Zn). Although some forages perceived as important mineral sources by pastoralists, had high mineral levels, they were not consumed by camels, mainly due to limited availability or palatability. Some of the preferred forage species also had limited temporal availability. It was concluded that forages are important sources of minerals for grazing camels in the study area. Apart from Cu and Zn, the forages can potentially satisfy the daily requirements of camels for the studied minerals. A need to create awareness among the camel herders about mineral contents of forage species as a guide in grazing management was noted.

Keywords: Camel, plant mineral sources, foliage, Kenya
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Introduction

The semi-nomadic Rendille pastoralists who keep camels and small stock among other livestock species inhabit the western part of the Marsabit district. They use locally available plants and salty water as sources of mineral supplements for their camels (Simpkin, 1998) with minimal use of commercial supplements (Kaufmann, 1998). Under natural conditions camels have the capacity to choose their forages efficiently, grazing more on forage trees than grasses (Field, 1993). Leaves from trees are generally richer in minerals than grasses (Basmaeil, 1989; Faye & Tisserand, 1989; Rutagwenda *et al*., 1990; Wardeh, 1991; Field, 1995). However, wide variations in mineral concentrations of natural pastures have been reported, depending on season and state of the pastures (Long *et al*., 1972). Studies on assessment of nutritional requirements of camels remain scanty, so that requirements are often inferred from cattle studies (Wilson, 1989). Mineral deficiencies and toxicities in camels have not received due consideration (Farid, 1989) except for sodium chloride and the calcium/phosphorus ratio despite the fact that these are known to limit productivity (McDowell, 1985). In the Rendille area of the Marsabit district information on the mineral content of major sources of minerals is lacking (Bake, 1991). Subsequently, the extent and distribution of mineral deficiencies for camels are poorly understood (Faye & Bengoumi, 1997), thus limiting attempts to improve productivity of camels through mineral supplementation. This study was designed to identify forage sources of minerals for *manyatta* (a settlement comprising several households) based camels and to determine their mineral content.

Materials and Methods

The study was conducted in Ngurunit (01°44.125N 037°17.454E; 802 m.a.s.l), Korr (02°00.192N 037°30.295; 566 m.a.s.l and Kargi (02°30.567N 037°34.481; 460 m.a.s.l) administrative locations of the Marsabit district. The area covered by the study was within a 30 km-grazing radius from each settlement. The mean annual precipitation in the study area ranged from less than 250 mm on the plains (Korr and Kargi area) to 800 mm on the foot slopes of the mountain e.g. Ngurunit area (Schwartz *et al*., 1991). Soils in Kargi are of volcanic origin while those in Ngurunit are metamorphic in nature (Bake & Kekem, 1984). Vegetation

in the area was mainly shrubs interspersed with annual grasses and trees, with the bush being thicker in the Ngurunit area.

Thirty respondents were selected in each of the three study locations and individually interviewed using a semi-structured questionnaire during the dry and wet seasons. The respondents were mainly boys and men who were directly involved in the herding of camels. Forage mineral sources were identified and also ranked in order of the perceived importance by the respondents. The information was confirmed through direct field observation of grazing camels. Thirty camels were observed per season per site (5 – 6 camels per day) in a period of 5 – 7 consecutive days. Camels and the grazing areas were randomly selected such that each camel was exposed to a similar array of forages from which they selected their diets. None of the camels was alien to the area, thus, all had equal chances of selecting the best combination of forages using their past experience. The observations were carried out by two people with each person observing 2 - 3 camels daily, between 10:00 and 12:00. Each camel was observed for 15 minutes, recording the number of bites made by the camel on various forage species. Bites made on particular forage species by different camels were tallied to get the site totals. Field observations also facilitated assessment of plant parts eaten by the camels for purposes of sampling.

Forage parts commonly eaten by the camels were sampled, weighed, sun-dried for five days, packed in paper bags and stored for laboratory analyses. Forages that registered at least a bite by a grazing camel were all sampled (a bite was counted every time a camel raised up the head for purposes of chewing). In addition, forage species perceived as important by the respondents were sampled for mineral analyses.

Preparation of the forage samples was done in accordance with AOAC (1995). The Atomic Absorption Spectrophotometric (AAS) method (Bellanger, 1971; Bellanger & Lamand, 1975) was used to determine the mineral concentration of forage material. The samples were assayed for sodium (Na), calcium (Ca), potassium (K), phosphorus (P), magnesium (Mg), iron (Fe), copper (Cu), zinc (Zn) and cobalt (Co). The data was entered in the Statistical Package for Social Sciences (SPSS) for Windows (Norman *et al*., 1975). Frequencies and percentages for bite counts were then computed.

Results and Discussion

The camels spent over 85% of their grazing time on five main forage species per site per season (Table 1) except in Ngurunit during the dry season. Their mineral concentrations are shown in Table 2. Other forage species (eaten) registered a low number of bite counts and were assumed to be unimportant in the overall camel mineral nutrition. However, across sites and seasons, there were forage species that were perceived as important by the herders though not eaten by camels during field observation. Their mineral composition is shown in Tables 3 and 4 for dry and wet seasons, respectively.

A zero value in Table 1 implies that the forage species was not eaten by the camels either because it was absent in the grazing field or was present but in an unpalatable state. During the dry season, shrubs and dwarf shrubs in all sites were present but were either too dry or had dropped the leaves, and thus not eaten. Grasses and herbs had died off during this period, hence unavailable for the grazing camels. In the wet season, zero % bite count implied that the forage species irrespective of the growth form, was not present in the specific area where grazing observations were carried out but was present in other areas within the study sites.

The plant parts preferred by grazing camels varied with the growth form. While grass species were eaten whole, in the case of herbs, the leaves, stems or whole plant were selected. Pods, flowers, tender spines and stems/twigs and pods were preferred from shrubs (dwarf or otherwise) whereas leaves and tender stolons were selected from climbers.

On the basis of bite counts *Indigofera spinosa* and *Duosperma eremophilum* were the most important sources of minerals for camels across the three study sites in both seasons. These results are in agreement with earlier reports by Field (1979), Wangoi (1984) and Kuria (1996). After a two year diet preference study, Wangoi (1984) concluded that camels in the Rendille area had special preference for dwarf shrubs, mainly *Indigofera spinosa* and *Duosperma eremophilum*. The author further noted that camels also fed on a few trees, shrubs and grass species. During a camel feeding observation study at Kargi, Field (1979) recorded *Indigofera spinosa* as the most important plant species in the diet of camels while Kuria (1996), using a micro histological analysis of faeces, reported a 32.8% relative density for *Duosperma eremophilum* in Ngurunit. This implied that these two dwarf shrubs were the major contributors to the daily mineral supply

of camels in the study area by virtue of their intake. These two forage species were also the most readily available. Other relatively less important forages were *Commiphora* species, *Sericocomopsis hilderbrantii*, *Grewia tenax* and *Heliotropium* species. There was considerable variation in preference for the other forage species between sites and seasons, e.g. *Heliotropium* species (*Thubarar* and *Okomi*) were selected during both dry and wet seasons at Korr. *Ficus* species and *Dactylotinium bogdanii* were preferred at Kargi during dry seasons whereas *Lawsonia inermis* and *Portulacea oleracea* were valuable dry season forages at Ngurunit and Korr, respectively.

Table 1 Growth form, name (botanical and local) and camel bite counts (%) of the most preferred forage species in Rendille area, northern Kenya during dry and wet seasons

Site	Growth form	Forage species	Local name	[1]Bite counts percent	
				Dry season	Wet season
Kargi	Shrubs	*Acacia reficiens*	Khasah	0	2.6
		Acacia mellifera	Bilhil	0	2.8
	Dwarf shrubs	*Ficus* species	Arabhalis	28.0	0
		Indigofera spinosa	Khoro	15.5	79.9
		Indigofera cliffordiana	Hanhanis	0	6.5
		Duosperma eremophilum	Yabah	0	8.1
	Grasses	*Dactylotenium bogdanii*	Maho	22.9	0
		Digitaria velutina	Kulusum	12.6	0
		Aristida adscensiosis	Maad	8.9	0
Sub-total				**87.9**	**99.9**
	[2]Others			**12.1**	**0.1**
Korr	Dwarf shrubs	*Indigofera spinosa*	Khoro	23.3	42.3
		Duosperma eremophilum	Yabah	22.0	13.0
		Sericocomopsis hilderbrantii	Giib	0	9.5
		Indigofera cliffordiana	Hanhanis	0	5.2
	Herbs	*Heliotropium studineri*	Thubarar	34.2	0
		Portulacea oleracea	Yamheso	12.5	0
		Heliotropium species	Okomi	0	16.0
	Climbers	*Maerua oblongifolia*	Geigiri	2.4	0
Sub-total				**94.4**	**86.0**
	Others			**5.6**	**14.0**
Ngurunit	Shrubs	*Lawsonia inermis*	Lgiria	13.8	0
		Cordia sinensis	Lgoita	10.0	0
		Balanites aegyptica	Khulum	7.7	0
		Justicia exigua	Lamanera	0	46.9
		Opilia campestris	Lpukenyi	0	5.2
		Commiphora boiviniana	Layamai	0	4.9
		Grewia tenax	Lkogomi	0	4.3
	Dwarf shrubs	*Indigofera spinosa*	Khoro	16.8	0
		Duosperma eremophilum	Yabah	11.5	27.4
Sub-total				**59.8**	**88.9**
	Others			**40.2**	**11.1**

[1]Total bite counts for all the forage species were: Kargi dry = 515, Kargi wet = 617; Korr dry = 657, Korr wet = 831; Ngurunit dry = 651; Ngurunit wet = 718

[2]Others –include forages whose combined bite counts account for 14% and below of the total except in Ngurunit, dry season (40.2%) where the list of consumed forages was long

Compared to the recommended mineral levels in forages for grazing ruminants (McDowell, 1985; NRC, 1989) at least 97% of the forage samples had adequate Ca, P, Mg, Na, Fe and Co during dry and wet seasons across the sites. About 80% of the samples had adequate K. Across the sites, 50% of the samples had

below the recommended level of Cu, mainly during the wet season. Zinc was insufficient in 90% of the samples across sites. Thus, depending on the grazing management, diet selection and intake, there was potential for the grazing camels to get enough of the mineral elements from these forage species with the exception of Zn and Cu. The ratio of Ca : P was, however, quite high (1:1 to 39:1), compared to the recommended 1:1 to 2:1). Excess Ca or P render each other unavailable and may also decrease the availability of trace elements (McDowell, 1997; Lukhele & Van Ryssen, 2003). However, in this study no obvious signs of P deficiency (osteophagia) and other mineral deficiencies were observed on the camels, perhaps due to their variety in intake (Faye & Bengoumi, 1997) that makes them less affected by mineral deficiencies compared to bovines and small stock.

Table 2 Major and trace mineral concentration of forage species preferred by camels in the Rendille area, northern Kenya during dry and wet seasons

Plant species	Major elements (g/kg DM)						Trace elements (mg/kg DM)		
	Ca	P	Mg	K	Na	[1]Fe	Co	Cu	Zn
Kargi – dry season									
Ficus species[a]	9	1	10	8	27	1	8.0	14.0	5.0
Indigofera spinosa[b]	30	2	5	4	1	1	7.0	8.0	7.0
Dactylotenium bogdanii[c]	4	1	3	4	17	1	5.0	13.0	1.0
Digitaria velutina[c]	1	1	1	4	11	0	4.0	11.0	5.0
Aristida adscensiosis[c]	8	1	3	4	1	1	6.0	6.0	6.0
Kargi – Wet season									
Acacia mellifera[a]	7	1	5	11	1	1	37.0	10.0	27.0
Acacia reficiens[a]	7	2	3	14	1	2	17.0	12.0	21.0
Indigofera spinosa[b]	25	1	8	6	1	3	78.0	7.0	12.0
Duosperma eremophilum[b]	35	2	16	20	4	1	66.0	10.0	19.0
Indigofera cliffordiana[b]	21	2	6	15	1	2	44.0	7.0	13.0
Korr – dry season									
Indigofera spinosa[b]	31	2	5	4	2	12	44	10.0	15
Duosperma eremophilum[b]	118	3	34	32	2	15	1.4	18	27
Heliotropium studineri[d]	41	2	9	28	7	14	127	17.0	45
Portulacea oleracea[d]	26	2	10	43	3	14	47	11.0	45
Maerua oblongifolia[e]	14	2	10	22	3	7	40	11.0	12
Korr – wet season									
Sericocomopsis hilderbrantii[b]	12	3	12	46	1	1	61	6.0	38.0
Duosperma eremophilum[b]	34	3	21	23	10	1	52	9.0	18.0
Indigofera cliffordiana[b]	26	2	9	18	4	1	11.0	5.0	21.0
Indigofera spinosa[b]	4	24	10	12	1	2	92	4.0	21
Heliotropium species[d]	28	3	7	17	1	2	15	7.0	17.0
Ngurunit – dry season									
Lawsonia inermis[a]	10	2	6	13	3	19	25.0	11.0	10
Cordia sinensis[a]	40	3	6	20	6	17	9.0	0.0	20
Balanites aegyptica[a]	17	2	6	6	5	17	6.0	16.0	7.0
Indigofera spinosa[b]	24	2	4	6	2	17	7.0	16.0	29
Duosperma eremophilum[b]	69	2	18	12	1	16	1.2	15.0	12
Ngurunit – wet season									
Justicia exigua[a]	8	3	3	21	1	1	39.0	4.0	8.0
Opilia campestris[a]	32	3	25	39	1	1	23.0	7.0	28.0
Commiphora boiviniana[a]	10	3	7	14	0	1	27.0	5.0	15.0
Grewia tenax[a]	15	3	10	31	3	1	38.0	4.0	15.0
Duosperma eremophilum[b]	32	2	19	31	3	1	22.0	9.0	23.0
Recommended requirements in diet	**3***	**1-3****	**2***	**6–8***	**0.6***	**0.03***	**0.1***	**10***	**30***

Source: *McDowell (1985); ** NRC (1989)
a – shrub; b – dwarf shrub; c – grass; d – forb; e - climber
[1]Fe is a trace element although the units used are g/kg DM

Table 3 Major and trace mineral concentrations of forage species perceived as important by Rendille herders of northern Kenya in the dry season

Plant species	Major elements (g/kg DM)						Trace elements (mg/kg DM)		
	Ca	P	Mg	K	Na	[3]Fe	Co	Cu	Zn
Kargi – dry season									
Barlaria proxima[a]	31	1	8	9	4	1	9	14	9
Cordia sinensis[a]	17	1	3	5	6	1	7	14	7
Crotolaria deserticola[a]	7	0	5	6	7	1	7	10	7
Sericocomopsis hilderbrantii[a]	24	1	7	13	7	1	6	10	6
[1]*Cadaba glandulosa*[b]	31	1	18	35	1	2	9	6	9
Salvadora persica[b]	46	1	17	5	22	0	8	8	8
Boscia coreacea[b]	22	1	13	7	1	0	9	9	9
Cadaba mirabilis[b]	18	1	14	78	2	0	8	9	6
Maerua classifolia[b]	11	1	16	13	6	0	5	6	4
Salsola dendroides[b]	9	1	7	14	56	17	7	28	7
Blepharis linariifolia[c]	17	1	3	2	1	3	9	7	8
Neuracanthus species[c]	57	0	11	9	1	2	12	11	14
Sporoborus spicatus[d]	2	2	3	4	9	32	4	12	3
Maerua oblongifolia[e]	13	2	7	11	4	0	8	5	3
Cadaba farinosa[e]	11	2	6	9	8	1	4	15	9
Korr – dry season									
Indigofera cliffordiana[a]	28	1	10	5	1	11	76	9	15
Salvadora persica[b]	126	1	12	7	4	7	1	10	15
Cadaba glandulosa[b]	28	1	18	23	4	8	8	14	16
Ficus sp.[b]	12	1	7	11	27	11	53	17	28
Maerua classifolia[b]	33	1	26	28	1	12	7	11	13
Cadaba ruspoli[b]	22	0	14	18	2	20	51	9	13
Cadaba mirabilis[b]	33	1	30	53	6	7	80	12	13
Boscia coreacea[b]	19	2	13	8	1	9	127	7	20
Balanites orbicularis[b]	8	3	4	27	2	10	1	13	7
Cadaba farinosa[d]	7	1	3	16	3	6	60	9	9
Ngurunit – dry season									
Craibia inurentii[a]	33	1	7	11	0	8	68	13	11
Tarenna graveolena[a]	21	1	6	8	1	7	14	9	15
Ormacarpum trichocarpum[b]	26	1	14	9	6	23	50	14	7
Boscia coreacea[b]	19	0	10	5	0	22	0	5	1
Dobera glabra[b]	36	1	11	9	2	23	8	10	3
Cadaba glandulosa[b]	27	1	18	16	3	22	6	10	12
Maerua oblongifolia[e]	21	1	17	18	8	15	2	10	10
Cadaba farinosa[e]	9	2	5	12	4	19	28	12	7
Heliotropium studineri[f]	22	2	4	9	3	18	2	13	21
Barlaria proxima[f]	41	1	6	8	2	11	40	15	27
[2]*Acacia tortilis*[h]	26	2	6	14	4	12	38	16	16
Recommended requirements in diets	**3***	**1-3****	**2***	**6-8***	**0.6***	**0.03***	**0.1***	**10***	**30***

Source: *McDowell (1985); ** NRC (1989)

a–shrub; b–salty shrub; c–grass; d-salty grass; e-salty climber; f–forb; h-tree

[1]Pastoralists presumed that salty plants during the dry season were also salty in the wet season

[2] Tree species are only important as forages for camels when young or in terms of pods

[3] Fe is a trace element although the units used are g/kg DM

Table 4 Major and trace mineral concentration of forage species perceived as important by Rendille herders of northern Kenya in the wet season

Plant species	Major elements (g/kg DM)						Trace elements (mg/kg DM)		
	Ca	P	Mg	K	Na	[1]Fe	Co	Cu	Zn
Kargi – wet season									
Barlaria proxima[a]	23	2	7	21	2	2	18	9	20
Cordia sinensis[a]	15	20	4	16	12	1	87	11	19
Salvadora persica[b]	43	1	13	7	15	1	20	7	50
Lycium europaem[b]	3	2	3	8	24	1	33	8	60
Cadaba mirabilis[b]	11	2	24	53	3	1	0	5	10
Salsola dendroides[b]	5	1	6	16	54	1	98	8	126
Cadaba glandulosa[b]	15	1	17	31	1	3	40	7	11
Ficus sp.[b]	6	1	14	11	46	1	41	7	17
Maerua classifolia[b]	19	1	37	24	2	1	42	5	5
Boscia coreacea[b]	5	2	5	18	0	1	43	6	12
Sporoborus spicatus[c]	1	2	2	7	12	1	74	5	5
Dactylotenium bogdanii[c]	6	1	5	10	28	2	39	4	12
Maerua oblongifolia[d]	10	1	13	27	4	1	46	7	9
Korr – wet season									
Cadaba glandulosa[b]	11	1	19	24	1	2	35	4	12
Ficus sp.[b]	4	2	6	12	39	2	3	9	52
Cassia sp.[b]	6	3	3	17	2	2	6	11	27
Maerua classifolia[b]	15	1	22	31	1	1	32	3	11
Lycium europaem[b]	7	2	6	16	35	1	5	9	45
Salvadora persica[b]	49	2	6	15	10	1	57	6	16
Dactylotenium bogdanii[d]	2	2	3	8	17	2	28	3	17
Cadaba farinosa[e]	5	1	5	24	1	2	20	5	18
Maerua oblongifolia[e]	5	1	6	26	1	1	56	5	11
Indigofera hochstetteri[f]	25	3	8	19	1	2	65	5	16
Heliotropium studineri[f]	33	3	16	31	0	1	50	8	31
Blepharis linariifolia[f]	18	3	8	23	1	2	35	8	22
Portulacea oleracea[f]	19	3	21	55	3	2	51	7	19
Ngurunit – wet season									
Indigofera spinosa[a]	21	2	6	6	1	1	54	5	17
Commiphora paolii[a]	15	2	8	8	0	1	37	3	16
Maerua classifolia[b]	12	1	24	33	0	1	26	3	8
Sclerocarpus africanus[b]	14	4	6	30	3	1	25	13	14
Balanites aegyptiaca[b]	11	3	5	17	0	1	40	10	18
Ficus sp.[b]	5	1	8	14	55	0	49	2	20
Kedrostis gijef[b]	63	3	8	15	1	2	96	9	18
Salvadora persica[b]	9	2	3	28	1	2	37	7	28
Combretum molle[e]	15	2	5	14	0	1	23	7	24
Recommended requirements in diets	**3***	**1-3****	**2***	**6-8***	**0.6***	**0.03***	**0.1***	**10***	**30***

Source: *McDowell (1985); ** NRC (1989)
a–shrub; b–salty shrub; c–grass; d-salty grass; e-salty climber; f–forb
[1] Fe is a trace element although the units used are g/kg DM

Iron concentration in Korr and Ngurunit forages during the dry season was notably high. It was, however, lower than the 250 mg/kg suggested to interfere with Cu absorption (Humpries *et al*., 1983; Suttle & Field, 1983) which would in turn induce a secondary imbalance of Fe (Cu facilitates Fe absorption). These

results partly agree with the 1974 Latin American Tables of Feed Composition which reported the mineral elements Co, Cu, Mg, P, Na and Zn to be inadequate in tropical forages with a P deficiency being the most widespread and economically important. Contrary to the reports of McDowell & Conrad (1990) and Judson (1996) that Co is among the most widespread trace elements deficient in tropical forages, Co levels in the present study were above the recommended level. Thus, with moderate bioavailability, camels in the study area were unlikely to suffer from a Co deficiency.

Across the study sites a few forage species had high levels of some mineral elements, e.g. during the wet season *Indigofera spinosa* in Korr had eight times the recommended level of P. *Salsola dendroides* from the Kargi area in the dry season had 40 times the recommended value for Cu and 4.5 times the recommended level of Zn during the wet season. *Heliotropium* species from the Korr area during the wet season and *Justicia exigua* from Ngurunit during the wet season also had high levels of P whereas *Ficus* species and *Duosperma eremophilum* from Korr had high levels of Cu during the dry season.

Between 92 and 100% of the samples for forages perceived as important by the respondents were adequate in terms of Ca, P, Mg, K, Na, Fe and Co. However, only 38% and 8% of the samples contained the recommended level of Cu and Zn, respectively. Regarding the mineral concentration, these forages were therefore similar to those selected by the camels. Forage species perceived as important by the herders were not necessarily consumed by camels during field observations due to unavailabity resulting from poor spatial distribution within a site and/or low palatability. While some forage species lacked leaves/tender twigs or were too dry to be eaten by camels, the distribution of forage species in space was such that certain species were only found in specific grazing areas within a site.

There was no clear trend in the specific mineral element concentration in forages between seasons. There were variations from site to site and from one mineral element to the other, in agreement with McDowell & Conrad (1990) and Judson (1996). Variations between forage species were also eminent. However, P levels increased and Cu levels decreased from dry to wet season in all the three sites. At Kargi and Ngurunit, Zn, Co, K and Mg increased from the dry to wet season. The reverse was, however, true for Korr, possibly because more than 50% of forage species eaten and thus sampled during the dry season were the evergreen type. Differences between sites could be attributed to differences in soil types, as indicated. Within a site, differences between forage species could be explained by the internal mineral dynamics of individual plants (Long *et al*., 1972) and/or growth form. Close to ground type of forages are likely to be contaminated by soil (McDowell, 1997) and thus have a higher than expected concentration of minerals. For forages that were eaten during the wet and dry seasons, age factor may explain the variations. Mature plants are usually low in minerals due to translocation of nutrients to the root system (Tergas & Blue, 1971; Underwood, 1981). The evergreen forage species are able to continue growing early into the dry season due to their capacity to draw water from the deeper soil layers which may also contribute to the observed variations in mineral content.

Conclusions

Forages are a major source of minerals for grazing camels in the study area with *Indigofera spinosa* and *Duosperma eremophilum* being the most important across the three study sites in both seasons. At all the sites between 80 and 100% of the forage samples were adequate in terms of Ca, P, Mg, K, Na, Fe and Co concentrations during both dry and wet seasons. While 38 to 50% of the forage samples were adequate in terms of Cu concentration, only 8 to 10% of the samples contained the recommended level of Zn. Thus, there is potential for grazing camels to get sufficient mineral elements from these forage species except for Zn and Cu.

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