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EFFECT OF MINERAL SUPPLEMENTATION ON MILK YIELD AND CALF GROWTH OF CAMELS IN MARSABIT DISTRICT OF KENYA

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ABSTRACT

A study was conducted in Ngurunit and Kargi locations of Marsabit district in Kenya to determine the effect of mineral supplementation on milk yield and calf growth of settlement based camels. Two mineral supplements were formulated; one comprised of locally collected, ground bones mixed with locally available natural salt and the other of commercial ingredients. Fifty nine (59) and 56 camels in early lactation and their calves were selected at Kargi and Ngurunit, respectively. Of these, 22 and 21 camels were randomly assigned the commercial supplement while 12 and 11 were assigned the local supplement at Kargi and Ngurunit, respectively. There were 25 and 23 control camels in Kargi and Ngurunit, respectively. Each dam was individually fed 200 g of mineral supplement daily for 190 days. During the data collection period, milk yield measurements were taken at weekly intervals and calves weighed monthly. The results showed that supplemented camels produced higher ($P = 0.000$) amount of milk than controls in Ngurunit (3.2 ld^{-1} versus 2.3 ld^{-1}). In Kargi, the mean milk yield for supplemented and control camels were similar ($P > 0.05$) at 2.6 ld^{-1}. Calves from the supplemented dams grew faster ($P = 0.000$) than the controls, gaining 441.3 gd^{-1} and 424.8 gd^{-1} compared with 275.7 gd^{-1} and 307.7 gd^{-1} for controls in Kargi and Ngurunit, respectively. The results suggested that mineral deficiency existed among the Rendille camels. The problem could however be reduced by judicial use of locally available raw material.

Key words : Calf growth, camel, milk yield, mineral supplementation

In tropical countries, mineral deficiencies, imbalances and toxicities severely limit productivity of grazing livestock and are often of more significance than infectious diseases (McDowell, 1985). This is in the backdrop of serious difficulties to provide camels with supplemental feeds due to scarcity of raw materials locally and prohibitive transportation costs (Vittorio *et al*, 1999). Camels, therefore, almost exclusively rely on the scarce natural forages for all their nutritional needs including minerals (McDowell and Conrad, 1990).

The Rendille are semi-nomadic pastoralists inhabiting the western part of Marsabit district in Kenya. Their camel grazing system is extensive, with both settlement based and mobile herds. The settlement based herd comprise of 2-10 lactating camels that graze within 15 km from homesteads while mobile herd comprise of heifers, bulls, dry, pregnant and some lactating dams grazing far from homesteads. The settlement-based herd size is relatively small compared to the mobile herd but is the source of milk to the vulnerable household members i.e. young children and the aged (Garmagar, 2001).

The settlement-based camel herd grazes within a radius of 10-15 km from the settlements, an area whose vegetation tends to be degraded and of low nutritive value (Simpkin and Guturo, 1995). The herd is therefore more vulnerable to mineral deficiency due to its restricted grazing area, which limits access to natural salty water or plants located outside this radius (Kaufmann, 1998).

McDowell and Conrad (1990) reported that mineral requirements in livestock were influenced by the level of productivity. In the low producing indigenous animals like the Rendille camels, mineral deficiencies tend to remain sub-clinical in contrast to the high producing animals, which easily express deficiency signs. Underwood (1981) reported that mild and transient mineral disorders were difficult

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to diagnose since they were easily confused with effects of energy and protein deficiencies and various types of parasitism. As the production level of camels improve, mineral deficiencies that are often marginal are likely to become more important, with the symptoms becoming more evident. It is important therefore to devise strategies to deal with mineral deficiencies alongside other camel productivity improvement efforts.

This was an intervention study based on the results of Kuria (2002). This study established inadequacy of sodium (Na), calcium (Ca), potassium (K), phosphorus (P), zinc (Zn) and copper (Cu), during both dry and wet seasons on the basis of mineral content of consumed forages and plasma levels of minerals in camels. The objective of this study was to determine the effect of mineral supplementation on milk yield and calf growth of camels kept by the Rendille in settlement areas.

Materials and Methods

Two study sites were identified within the wider Rendille area that is, Ngurunit (802 m.a.s.l; 500mm annual rainfall; 22.5°C to 27°C temperature range) and Kargi (460 m.a.s.l; 250 mm annual rainfall; 27°C to 38°C temperature range). Both sites are administrative locations in Marsabit district with Ngurunit being located on the mountain slopes and Kargi in the plains. Soils in Kargi area are of volcanic origin while those in Ngurunit are metamorphic in nature (Bake and Kekem, 1984). Vegetation is denser in Ngurunit area and becomes sparse towards Kargi.

Kuria (2002) reported mineral levels in forages preferred by camels in the study area. This report indicated deficits in some mineral elements based on the recommended minimum level in forages (McDowell, 1997). To estimate the deficit of specific mineral elements, the camels' daily requirements of the elements (g) was first estimated from the estimated dry matter intake (DMI kgd^{-1}) and the recommended minimum level in forages (%). The DMI was estimated as 2.1% of live weight assumed to be 450 kg (Simpkin, 1995) in line with Richard (1989), Gerald and Richard (1989) and Kamoun *et al* (1989). The daily intake of each element (g) by the camels was then estimated from the forages' dry season mean content of the element, corrected for preference (%) and the estimated DMI (kg). Preference was estimated from the bite counts recorded for various forage species during field observation of grazing camels. Dry season mean values were used since they were lower than those for the wet season. The difference between the camels' daily requirement and the estimated intake was assumed to be the deficit for the various elements, to be supplied in the supplement. The deficits are presented in table 1. The following example demonstrates how the deficits were estimated. Take the case of calcium in Kargi during dry season.

Calcium requirement = recommended minimum level in forages (%) X DMI

Assuming a 2.1% live weight DMI and an average camel live weight of 450kg

DMI ≈ 10kg

Recommended minimum level in forages = 0.29% (McDowell, 1997)

Calcium requirement = 0.29/100 X 10kg = 29 g

Calcium intake = forages' dry season mean (corrected for preference)/100 X 10kg

Forages' dry season mean (corrected for preference) = 0.09%

Calcium intake ≈ 0.09/100 X 10kg = 9 g

Shortfall = Requirement - intake i.e. 29 - 9 = 20 g

Kargi dry season deficit values were used as they were higher except for copper where the value for Ngurunit, dry season was used (Table 1). Deficits for the eight minerals totaled 91.65 grams. Chemical compounds to supply various elements were identified (Table 2). Amount of each chemical (g) required to supply the required amounts of mineral element was computed based on their molecular weights (Table 2).Sodium chloride (14.5 g) was added to the mixture to improve palatability. Packaging was in single dose sachets weighing 200g as recommended by Vittorio *et al* (1999). Table 2 summarises composition of the supplement. As the deficits of various elements in both sites were similar (Table 2) the same formulation was used. This supplement was formulated using livestock bones and salt collected from Chalbi desert. The bones were roasted in drums using firewood for 4 -5 hours and crushed while still hot using timber pestles. The crushed bones were sieved through a 1.5 mm wire mesh. Chalbi salt was similarly sieved to remove large particles. Based on the mineral content of the raw materials and the estimated deficits, they were thoroughly mixed in the ratio of 2 (ground bones): 3 (Chalbi salt), weighed and packaged into 200 g sachets.

Unlike the commercial supplement, the packaged amount of the local supplement did not

cover the estimated deficit for all the minerals due to low levels of some of the target elements in the raw materials. However, the cost of this supplement was low due to the local availability of raw materials. The composition of a 200 g sachet of local supplement is shown in table 3.

In both sites, 115 camels in early lactation and their calves were recruited, 56 from Ngurunit and 59 Kargi. The average stage of lactation of the supplemented camels at recruitment was 1.2 months and 19 days in Kargi and Ngurunit, respectively while that of the control camels in both sites averaged 1.1 months. The recruitment process favoured no particular breed since camels in early lactation were few in both study sites. In Kargi, 58 of the 59 recruited camels were of Rendille breed with only one Rendille X Somali cross. However in Ngurunit, experimental camels comprised 24 Rendille, 30 Somali, 1 Rendille X Somali cross and 1 Turkana breeds. Recruited camels were randomly assigned the two mineral supplements and the control as shown in Table 4. Individual camels represented the experimental units while group of camels under each treatment represented replications. By the end of the experiment, 11 and 4 camels had dropped off the experiment in Kargi and Ngurunit, respectively mainly through owner withdrawal or camel death.

The supplements, packaged in 200 g sachets were offered to each camel daily. The contents were emptied in a plastic container, mixed with water to a semi-solid paste and orally administered to a restrained camel. This was fed every morning for 190 days with the assistance of trained field assistants.

During the study period, data on milk yield of dams and calf growth was collected on weekly and monthly basis, respectively. Milking was done between 6.00 am and 8.00 am following an overnight separation of the calves from their dams. Full, half or three quarters udder was milked depending on individual camel owners milking management (Simpkin, 1994; Kaufmann, 1998). The milk was measured using an ordinary household cup of pre-determined volume. The yield estimates for the morning milking were standardised to a full udder and then to a day. Calves of the experimental camels were weighed using a clock balance attached on a tree branch with the help of straps and a gunny bag.

The milk and calf weight data was entered and analysed using the Windows based Statistical Package for Social Scientists (Norman *et al*, 1975). Multiple regression analyses were performed on both data sets to test whether the independent variables of site, type of supplement and time affected the dependent variables of growth and milk yield of camels. The model used was as follows:

$$MY/CG = \mu_1 + \beta_2 site + \beta_3 supplement + \beta_4 time + \varepsilon$$

where;

MY/CG = milk yield/calf growth

μ_1 = population mean

β_2 site = effect of site

β_3 supplement = effect of supplement type

β_4 time = effect of time

ε = random error

Further analysis was done using Analysis of Variance (ANOVA). Mean separation was done using Least Significant Difference (Snedecor and Cochran, 1980) followed by cross tabulation of the means. Charts were drawn using Windows based Excel (Maria, 1999).

Results and Discussion

The milk yield of experimental camels is summarised in Table 5. The average milk yield of control camels (n = 49) in the study area was estimated at 2.4 ± 0.03 ld^{-1}. The range was 0.6–6.4 ld^{-1} with a 160 days lactation total yield of 387 litres. These estimates compared favourably with 2 ld^{-1}– 4 ld^{-1} reported by Schwartz and Dioli (1992) and Field (1993) in Kenya. The mean was however lower than the 4.5 ld^{-1} and 10 ld^{-1} for pastoralists' and ranch camels in Kenya, respectively (Wangoh *et al*, 1998), 9 ld^{-1} for Neggas (Kamoun, 1997), and 13.3 ld^{-1} for India and Pakistani camels (Knoess *et al*, 1986). These variations in milk yield of camels could have resulted from differences in the milking management such as frequency of milking, milking speed, number of teats milked and period of dam and calf separation. Other factors may include stage of lactation, feeding and watering management and breed (Farah, 1996). The mean for supplemented camels was 3.0 ± 0.05 with a range of 0.5 to 8.9 ld^{-1}.

The average milk yield for Ngurunit camels was higher (P = 0.000) than for those in Kargi (2.9 ld^{-1} and 2.6 ld^{-1}, respectively). These differences could be attributed to vegetation, watering management and the wide distribution of Somali camel breed in Ngurunit. Ngurunit's higher altitude, rainfall and lower temperature promoted vegetation growth resulting in higher forage availability than in Kargi. Ngurunit camels were also watered more regularly (4 – 7 days compared to 7 – 14 days for Kargi camels).

Table 1. Deficits for the mineral elements estimated at Kargi and Ngurunit.

	Kargi	Ngurunit		
	Dry season	Wet season	Dry season	Wet season
Element	*D (g)	*D (g)	*D (g)	*D (g)
Calcium	20	(-)	9.0	13
Phosphorus	13	12	13.0	12
Magnesium	3	(-)	1	(-)
Potassium	55	47	52	38
Cobalt	(-)	(-)	(-)	(-)
Copper	0.04	0.04	0.04	0.04
Iron	0.30	0.30	0.30	0.30
Zinc	0.30	0.28	0.29	0.28
Total	91.65			

*D – deficit (per animal/day/450 kg live weight); (-) in the table means no deficit that season e.g. for cobalt during dry season.

Table 2. Composition of the commercial supplement.

Element	Source	Estimated amount supplement in feed (g)	Deficit to be supplied in supplied (g)	Amount of ingredients (g)
Ca	Calcium carbonate	9.00	20.00	30.70
P	Di-Calcium phosphate	1.00	13.00	16.90
Mg	Magnesium sulfate	4.00	3.00	15.00
Cu	Copper sulfate	0.01	0.05	0.13
Fe	Ferrous oxide	0.00	0.30	0.43
Zn	Zinc oxide	0.00	0.30	0.37
K	Potassium Sulfate	5.00	55.00	122.00
Sub-total				185.5
Na	Sodium chloride			14.5
Total per camel per day				200.0

Water intake has been reported to positively affect milk yield of camels (Yagil, 1982). Additionally, while a 100% of the supplemented and control

Table 3. Composition of the local supplement.

Element	Chalbi salt	Charred bone meal (%)	[a]Deficit (g) to be supplied in supplement (g)[a]	Amount supplied by 200g of supplement (g)
Ca	0.33%	30.10	20.00	24.50
P	0.08%	14.00	13.00	11.30
Mg	0.54%	0.59	3.00	1.13
Na	28.50%	trace	6.00	34.30
K	0.43%	0.16	55.00	0.64
Fe	0.17%	trace	0.30	0.21
Cu	28.20ppm	trace	0.05	0.003
Co	21.30ppm	trace	-	0.003
Zn	28.90ppm	trace	0.30	0.003

[a]Calculated from mineral content of preferred forages and the estimated minimum requirement of the various minerals

camels at Kargi, were of Rendille breed, 70% of the supplemented and 35% of control camels at Ngurunit were of Somali breed. In similar environmental and management situations, Somali produce more milk than Rendille camels (Simpkin *et al,* 1998). Variation in milk yield of camels with location in Kenya has been reported by Onjoro *et al* (2003) and attributed to differences in mineral content of forages and water among locations.

Camels receiving the mineral supplements (Table 5) produced more (P = 0.000) milk than controls in Ngurunit (3.4 ld^{-1} and 3.1 ld^{-1} for local and commercial supplements compared to 2.3 ld^{-1} for control). The interaction between site and supplement type was significant (P = 0.000). This is attributed to the site factors discussed above. At Kargi, the mean milk yield for supplemented and control camels were similar (P > 0.05) i.e. 2.7 ld^{-1} and 2.5 ld^{-1} for local and commercial supplements, respectively compared to 2.6 ld^{-1} for control. While Mg is involved in metabolism of carbohydrates, lipids and protein synthesis, Na and Co are essential for nutrient uptake at cellular level and Vitamin B_{12} synthesis by rumen microbes, respectively (McDowell, 1997). Copper and Fe are important in body metabolic functions through enzyme activity

Table 4. Distribution of experimental camels between treatments.

Sites	Ngurunit			Kargi		
Treatments	Control	Commercial supplement	Local supplement	Control	Commercial supplement	Local supplement
Number of camels	23	22	11	25	22	12
Site totals	56			59		

Table 5. Summary of milk yields of experimental camels.

Site	Treatments	Mean (litres)	Standard error
Kargi	Controls	2.56[a]	0.02
	Commercial	2.52[a]	0.03
	Local	2.74[a]	0.04
Ngurunit	Controls	2.31[a]	0.03
	Commercial	3.13[b]	0.05
	Local	3.42[b]	0.07

In every site, column means followed by the same letter superscript are similar (P > 0.05).

Table 6. Summary of the average daily weight gain of experimental camel calves.

Site	Treatments	Mean (gd^{-1})	Standard error
Kargi	Controls	275.7[a]	16.4
	Commercial	446.3[b]	22.7
	Local	436.4[b]	37.2
Ngurunit	Controls	307.7[a]	22.8
	Commercial	427.7[b]	15.8
	Local	421.8[b]	26.4

In every site, column means followed by the same letter superscript are similar (P > 0.05).

and oxygen supply to the body cells, respectively. Thus, by having the required mineral supply to camels, functions such as feed digestion, absorption and the ultimate metabolism at cell level improves and subsequently, milk yield increases.

The increase in milk yield as a result of mineral supplementation in the present study (2.7 to 49.3%) was in accordance with Miles and McDowell (1983) and Vittorio *et al* (1999). Miles and McDowell (1983) observed that mineral supple-mentation increased milk and all the other production parameters in livestock. Vittorio *et al* (1999) reported increased milk yield in camels following mineral supplementation. They observed that supplementation with trace elements alone did not affect milk yield of dairy camels and recommended a combination of micro and macro elements. The increased milk yield of the camels in this study confirms that camels in the area were suffering from mineral deficiency. Ghosal and Shekhawat (1992) observed that production response to mineral supplementation is the best way of determining the level of micronutrient deficiency in camels. McDowell (1997) observed that the higher the level of deficiency, the higher the response to specific mineral supplementation. While the mean milk yield for supplemented camels at Ngurunit was within the 3.0 ld^{-1} to 6.0 ld^{-1} range reported by Bachmann and Schultess (1987) and Farah (1996) for unsupplemented camels under similar environmental conditions, the mean for supplemented camels at Kargi was below this range. This could be explained by differences in forage quantity and quality, breed of the camels and variations in milking management of the pastoralists including inconsistency in time of calf and dam separation, level of udder stripping and milking skills of the pastoralists in harmony with Kaufmann (1998). Graphs 1 and 2 (fitted) illustrates how the milk yield of experimental camels changed with time.

The initial milk yield of supplemented and control camels (Graph 1 and 2) was low, increased and then declined. Low forage and water availability due to a dry spell during early lactation depressed the milk yield of both supplemented and control camels. This implied that the positive effects of mineral supple-mentation might have been masked by the protein-energy deficiency during this period (Lamand, 1985). The authors observed that quality basal diet is crucial for effects of a mineral supplementation to

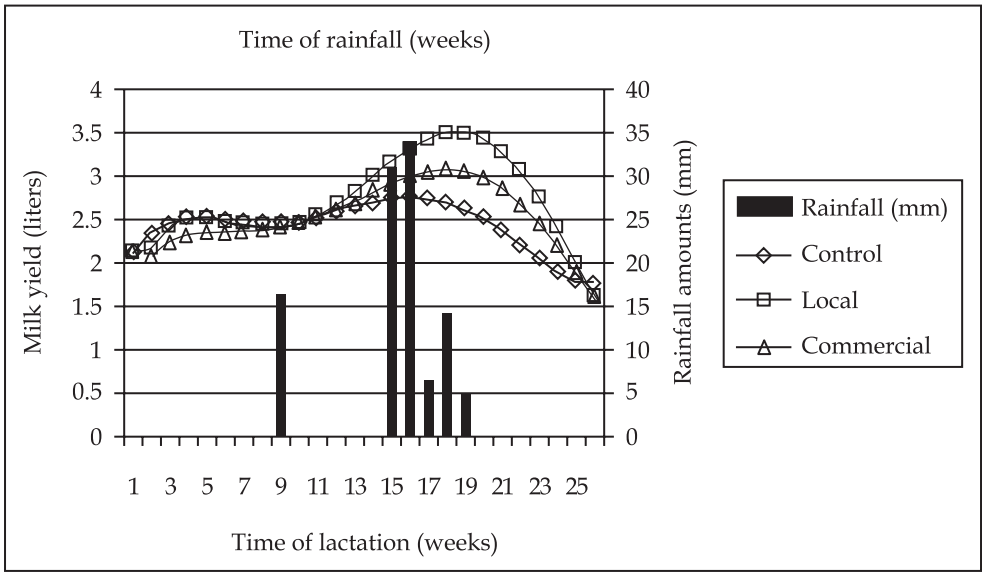

Fig 1. Effect of mineral supplementation on milk yield of camels with an overlay of rainfall trend at Kargi.

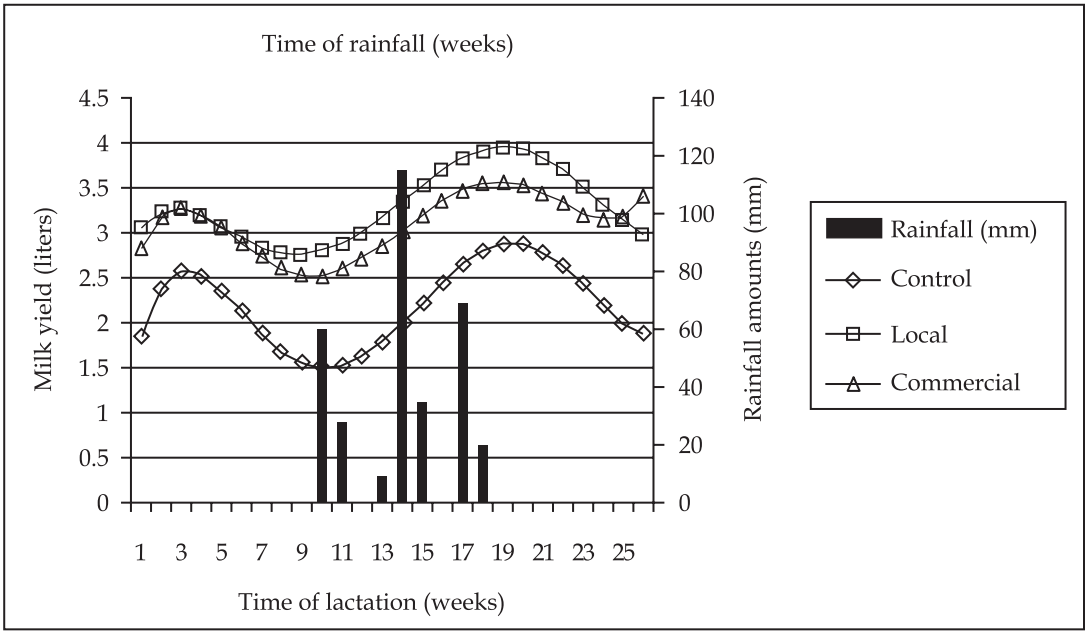

Fig 2. Effect of mineral supplementation on milk yield of camels with an overlay of rainfall trend at Ngurunit.

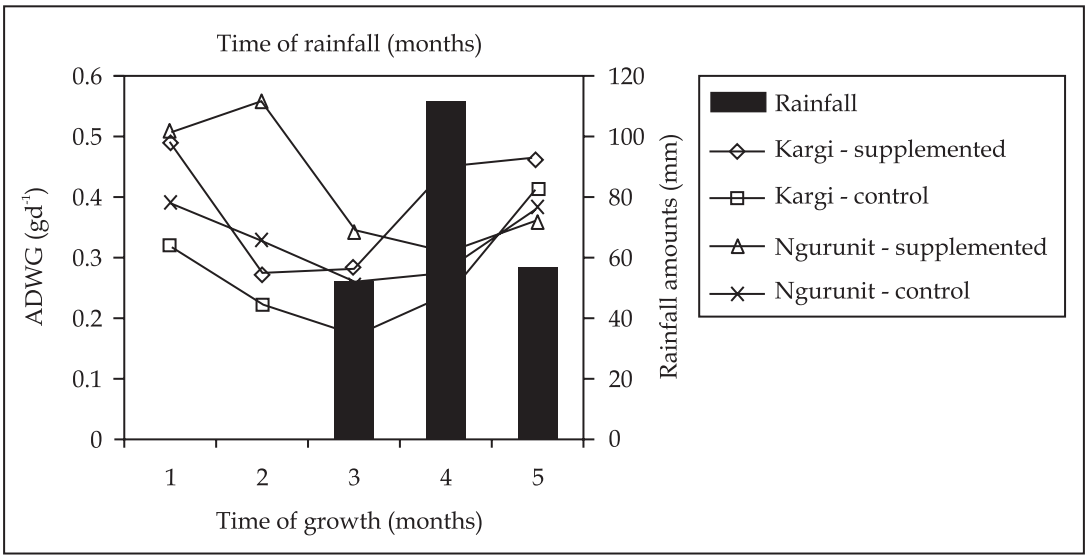

Fig 3. Effect of mineral supplementation on ADWG (gd^{-1}) of calves in Kargi and Ngurunit.

be realised. The impact of the dry spell on milk yield of camels was higher in Ngurunit than in Kargi. This observation may have been due to the fact that the experimental camels in Ngurunit were predominantly of Somali breed, which have been described as less adapted to dry conditions compared to the Rendille breed in Kargi (Kaufmann *et al*, 2002). Kargi herders were also observed to shift their camels more regularly in search of pastures.

During the first 11 weeks of the experiment, no differences in milk yield were noted between the control and supplemented camels in Kargi (Graph 1). There was low or no rainfall during this period. Forage and water availability were also low. Thereafter, the supplemented camels yielded more milk than the control. During this period, precipitation had improved. In Ngurunit, milk yield of the supplemented (Graph 2) was higher than that of the control camels throughout the experiment. Peak milk yield for supplemented and control camels at Ngurunit (Graph 2) occurred in the 20th week of study (after 5 months of lactation). At Kargi however, the milk yield peaked earlier i.e. in the 19th and 16th week of study for supplemented and

control camels, respectively. This suggested that supplementation increased persistence in milk yield at Kargi, a trend that agreed with Vittorio *et al* (1999) who reported peak yields at 13th and 13th to 20th week for control and supplemented camels, respectively. Early milk yield peak in Kargi could be attributed to temperature stress unlike in Ngurunit which is cooler and has better water availability. The peak milk yields were 3.0 ld^{-1}, 3.5 ld^{-1}, and 2.7 ld^{-1} for commercial, local supplements and control camels, respectively in Kargi. At Ngurunit, peak milk yields for supplemented camels were 3.6 ld^{-1} and 4.0 ld^{-1} for commercial and local supplements while that of control camels was 2.9 ld^{-1}.

In Kargi, commercial and local mineral supplements increased the daily milk yield of experimental camels by 2.7% and 10.6%, respectively over the controls. In Ngurunit, commercial and local supplements increased the daily milk yield of camels by 39.7% and 49.3%, respectively over the controls. The level of mineral deficiency and thus response to supplementation is a factor of body requirement. Thus, the predominant Somali breed in Ngurunit being higher yielding experiences higher degree of deficiency.

The local supplement supplied adequate Ca and Na, 87% of required P, 69% of Fe and 37% of Mg to the camels. Levels of Cu, Co and Zn in the mixture were too low and attempting to meet their requirements would mean feeding impossibly large amounts of the mineral mixture daily. It was expected that due to the presence of balanced minerals in the commercial supplement, the camels in this group would perform better. However, improvements in milk yield resulting from use of both supplements were similar ($P > 0.05$) in both Ngurunit and Kargi. This may suggest that the mineral intake from available forages was underestimated or the recommended minimum mineral levels in camel diets were too high. This agrees with Faye and Bengoumi (1994) who observed that camel mineral requirements were not well established. As in many grazing studies, it was difficult to estimate the dry matter intake of camels, the mineral content of consumed forages (sample representation) and therefore the daily intake of mineral elements.

Apart from improvement in milk yield, the local pastoralists opined that mineral supplementation also improved body condition score, increased body water retention capacity and the subsequent watering interval of the camels. Additionally, it improved the milk quality as evidenced by froth on the milk. However, no data was collected to support these pastoral observations.

The average daily weight gain of experimental camel calves is summarised in table 6. The initial live weight of the control calves in the study (n = 49) was 35.1± 1.0 kg while the weight at end of the study was 78.8±1.8 kg. The calves gained an average of 43.7 kg during the study period. The average weight gain was 291.7 ± 19.6 gd^{-1} with a range of 215.1 gd^{-1} to 367.6 gd^{-1}. This was lower than 580 gd^{-1} recorded by Field (1984) under commercial ranch conditions. This author however reported 140 gd^{-1} for similar calves on pastoral management systems and further observed that variations in calf growth results from nutrition, particularly milk allowance to the calf, among other factors. The mean daily weight gain for supplemented camels was 333.0 ± 25.5 g.

Regression analysis indicated that the growth rates of camel calves in Kargi and in Ngurunit were similar ($P > 0.05$), (275.7 gd^{-1}, 446.3 gd^{-1} and 436.4 gd^{-1} in Kargi versus 307.7 gd^{-1}, 427.7 gd^{-1} and 421.8 gd^{-1} in Ngurunit for control, commercial and local supplements, respectively). The model was significant ($P = 0.000$).

Calves from the supplemented dams (Table 6) grew faster ($P = 0.000$) than the controls (446.3 gd^{-1}, 436.4 gd^{-1}, 275.7 gd^{-1} in Kargi and 427.7 gd^{-1}, 421.8 gd^{-1}, 307.7 gd^{-1} in Ngurunit for commercial, local supplements and control, respectively. The interaction between site and supplement type was insignificant ($P = 0.434$). Mineral supplementation of dams increased the growth rate of their calves by 60.1% and 38.1% in Kargi and Ngurunit, respectively. The higher daily weight gain of calves from supplemented dams was due to higher amount of milk available to the calves, also reported by Field (1984) and improved quality of the milk in terms of mineral content (Wangoh *et al*, 1998 and Vittorio *et al*, 1999). Hammadi *et al* (1998) reported differences in calf weight gain between supplemented and unsupple-mented female camels. These authors attributed this trend to difference in milk production between the two groups of camels. Calves from the supplemented dams in Kargi gained more weight compared to those in Ngurunit suggesting that they had access to higher amounts of milk.

The average daily weight gain (ADWG) of experimental calves at Kargi and Ngurunit are shown

in Graph 3. Camel calves responded to mineral supplementation of their dams quite fast in both sites (Graph 3), attaining an average daily weight gain of over 500 gd^{-1} in the first month of the experiment, in comparison with the calves from control dams whose average weight gain was 370 gd^{-1} during the same period. Daily weight gain of calves from the supplemented camels at Kargi peaked in the first month while in Ngurunit, peak gain occurred in the second month of study. The weight gain of all calves followed seasonal changes in forage quantity and quality, reaching a minimum of 300 gd^{-1} and 230 gd^{-1} for calves from supplemented and control dams, respectively at the peak of the dry season. Following commencement of the long rains, there was evidence of compensatory growth for both groups and the daily weight gain increased to 385 gd^{-1} and 420 gd^{-1} for control and calves from supplemented dams, respectively.

During this wet season, the calves were over four months old and were grazing (Mares, 1954; Yagil and Etzion, 1980). The calf compensatory growth observed during this period was attributed to higher milk supply by the dams, availability of quality forage and the mineral supplements. The observed trend in calf growth agreed with Nagpal and Sahani (1998). These authors reported that phosphorus supplemen-tation increased the average daily weight gain of *Bikaneri* camel calves, attributing the increase to improved nutrient absorption and utilisation (P is essential for proper functioning of rumen microorganisms especially those which digest plant cellulose, utilisation of energy from feeds - McDowell, 1997). The ADWG of calves in the present study declined during the peak of dry spell due to limited forage supply to the dams which lowered the milk production of dams and supply to the calves. Faye *et al* (1991) while experimenting with camels in Djibouti recorded weight losses of up to 75 gd^{-1} in camels fed nutritionally poor mangrove leaves and supple-mented with trace elements. Thus, the effect of supplementation may not be felt if quality of basal diet is low.

Camel keepers would expect to realise extra income from supplementation resulting from higher growth rate (meat) and milk. A cost benefit analysis was done for camels in the Ngurunit area. The average weight gain of the calves from supplemented dams was 430 gd^{-1} compared to 308 gd^{-1} for control calves, an additional 122 gd^{-1} (3.66 kg/month). Assuming a dressing percent of 55 (Shalash, 1979; Staatz, 1979), this would translate to an extra 2.01kg meat/month. The supplemented camels consumed 120g of Chalbi salt and 80 g of bone meal. The cost of chalbi salt at the local markets was US$[1] 0.38/kg. Bones were collected free of charge, but the cost of charring was estimated at US$ 0.15/kg (cost of firewood) and a labour cost of US$ 0.26/kg. Thus to feed a camel on the supplement would cost US$ 0.08/d (US$ 2.34/month).

The cost of camel meat in local butcheries was US$ 1.38/kg, thus an extra income of US$ 2.76 is realised at a supplement cost of US$ 2.34/month. Extra income to the camel keeper resulting from supple-mentation would be US$ 0.42 per month. The other benefit to the camel keeper is in additional milk. The average milk yield increase in Ngurunit was 44.5% compared to the control. At the yield of 72 litres/month for control camels, the extra milk realised from supplemented camels was 32.0 litres. At the price of milk of US$ 0.18/litre, the extra income realised would be US$ 5.6/month.

Conclusions

Whether one used local or commercial supplement, in whichever site, mineral supple-mentation increased the lactation yield by increasing the daily milk yield of camels. Supplementation also increased the average daily live weight of calves. These positive responses confirmed existence of mineral deficiency in the Rendille camels. Use of locally available raw material could help Rendille pastoralists to economically ameliorate mineral deficiency related problems in their camel herds.

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Haenlatobiochemical studies on the haemoparasitised camels

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A total of 100 camels of either-sex, different ages, functional classes and maintained at different localities in and around Faisalabad district (Pakistan) were investigated for serum biochemical and haematological changes owing to haemoparasitism caused by *Trypanosoma evansi* and *Dipetaloneina evansi* over a course of one year. The mean total serum proteins in the normal camels were found to be 7.381 ± 0.048 g/dl; whereas, the corresponding values in haemoparasitised group was 6.831 ± 0.270 g/dl. The haemoparasitc infection had a significant ($p \leq 0.05$) effect on the total serum proteins. The mean ± SE values of serum aspartate aminotransferase (SCOT) in normal and haemoparasitised camels were 51.975 ± 3.717 µ/litres and 58.179 ± 6.598 µ/litre, respectively. The mean ± SE values of SCPT in normal and haemoparasitised camels respectively were 14.597 ± 1.867 and 18.262 ± 2.748 µ/litre. The change in both enzymes was non-significant. The mean values of different haematological parameters viz. Erythrocyte sedimentation rate, haematocrit, haemoglobin, total erythrocytic and total leukocytic counts did not differ significantly between the infected and non-infected camels. A mild eosinophilia (0.53%) was observed in the haemoparasitised camels.

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