Evaluation of the mineral status of cattle on communal grazing in the North West Province of South Africa

B G Mokolopi[a*] and D E Beighle[a,b]

ABSTRACT

Twenty five cattle were randomly selected from a herd of animals grazing communally around Mogosane village in the North West Province to evaluate their mineral status based on blood and faecal analysis. Mean faecal phosphorus (P) concentration was curvilinear, increasing from July (0.99 mg/g) to December (3.63 mg/g) and decreasing to 1.29 mg/g in June. Mean P concentration in grass was also curvilinear, increasing from July (0.87 mg/g) to January (1.8 mg/g) and decreasing to 0.9 mg/g in June. There was a high correlation (r^2 = 0.89) between faecal and grass P concentrations. Faecal:grass P ratios suggest that the animals were conserving P by reducing faecal P excretion during times of low dietary P. Animals maintained consistent but very low serum inorganic P (SiP) throughout the year (range 1.33–1.95 mg %) and SiP was not correlated with either faecal or grass P. Mean faecal and grass calcium (Ca) concentrations followed a similar pattern to P. There was also a positive correlation (r^2 = 0.95) between grass and faecal Ca concentrations. Faecal:grass Ca ratios indicated a conservation of Ca by reducing faecal Ca when dietary Ca was low. Animals were better able to conserve dietary Ca by reducing losses in the faeces than they were P, based on a higher faecal:grass P ratio (1.56) compared with Ca (1.18). Magnesium (Mg) was lost through the faeces during times of high dietary Mg concentrations but was conserved when grass Mg was low.

Key words: blood, calcium, faecal, grass, communal grazing, magnesium, phosphorus.

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INTRODUCTION

Since the discoveries around the beginning of the previous century, most mineral research if not all has been associated with commercial farming animals and in controlled feeding trials. Little has been published on the mineral status of animals in farm-based studies especially of communally grazed cattle or of the grass they graze. Long periods of drought and over-grazing often make this a unique deficiency situation that requires extensive investigation before recommendations for mineral supplements can be made. Communal farmers are often reluctant to give mineral licks to their animals for a number of reasons, but especially due to costs. Future development of animal agriculture in communal farming areas will be dependent on the improvement of animal production in such areas and this will require the improvement of the mineral nutrition of the animals. Both production and reproduction are adversely impacted by inadequate phosphorus (P), calcium (Ca) and magnesium (Mg) in the diet[10]. The first step in improving mineral nutrition among communally grazed cattle will be to establish the current mineral status of the animals as well as of the forage.

The objective of this study was to evaluate the status of Ca, P and Mg and their interrelationships in grass and animals grazing communally at Mogosane Village, Molopo District, North West Province, South Africa.

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MATERIALS AND METHODS

Twenty-five animals were randomly selected from a herd of cattle grazing communally at Mogosane Village, north of Mafikeng. Blood, faecal and grass samples were collected at the same time each month from March 2003 to February 2004. The production stage of the animals was not noted. Blood samples were collected from the jugular vein, faecal samples were collected as grab samples from the rectum and grass samples were collected randomly from the veld. A 50 m rope was stretched randomly across the grazing area and grass was collected from an area 30 cm in diameter at 10 m intervals along the rope. Grass species were not recorded at sampling. Rainfall data were obtained from the nearest weather station at the School of Agriculture, north of Mafikeng.

Faecal and grass samples were ground through a 2 mm screen, mixed well and then digested as described by Beighle *et al.*[2] The samples were analysed for P according to the method of Fiske and Subarrow[5] using a Bran and Luebbe Auto-analyzer (Technicon Industry System, Tarytown, NY) and for Ca and Mg by atomic absorption spectrophotometry[6] (SP90 AA Spectrophotometer, Pye Unican Model, Cambridge England).

Blood samples were allowed to clot, serum harvested and protein precipitated using trichloracetic acid. Blood was analysed for P according to the method of Fiske and Subarrow[5] using an Aquamate UV-Visible Spectrophotometer (Thermo Spectronic Mercers Row, Cambridge, UK).

Owners of the animals refused permission to take bone samples, so their P status was based on faecal and blood P.

Experimental design and statistical analysis

Faecal, blood and grass were used as indicators of P, Ca and Mg in the experiment. Analysis of variance and Duncan's multiple range test were used to determine whether the mineral status of the native pasture had a significant effect on the concentration of P, Ca and Mg in the blood and faeces during the 12-month study period. Minitab version 13.13 was used to determine whether there was a positive correlation between faecal, grass and blood P.

RESULTS AND DISCUSSION

Mean faecal P concentration was curvilinear, increasing from July (0.99 mg/g) to December (3.63 mg/g) and decreasing from December to June (1.29 mg/g). Faecal P concentrations were significantly ($P <$ 0.05) lower during the dry season (May to August) compared to the rainy season (October to March). In addition, P concentrations in faeces in December were

Table 1: **Mean faecal and grass P concentrations** (mg/g, dry weight) **and blood P concentrations** (mg %), **standard errors of the means, rainfall and faecal:grass P ratios according to month.**

Month	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June
Faecal P (mg/g)	$0.99^{e} \pm 0.10$	$1.37^{de} \pm 0.1$	$1.84^{cd} \pm 0.2$	$2.18^{bc} \pm 0.13$	$2.53^{b} \pm 0.12$	$3.63^{a} \pm 0.12$	$2.50^{b} \pm 0.12$	$2.18^{bc} \pm 0.12$	$2.06^{bc} \pm 0.09$	$1.70^{cd} \pm 0.09$	$1.42^{de} \pm 0.08$	$1.29^{de} \pm 0.09$
Grass P (mg/g)	$0.87^{h} \pm 0.02$	$1.02^{f} \pm 0.02$	$1.17^{e} \pm 0.03$	$1.28^{cd} \pm 0.02$	$1.59^{b} \pm 0.02$	$1.65^{b} \pm 0.02$	$1.80^{a} \pm 0.02$	$1.36^{c} \pm 0.02$	$1.25^{de} \pm 0.02$	$1.04^{f} \pm 0.02$	$0.99^{fg} \pm 0.01$	$0.90^{gh} \pm 0.02$
Blood P (mg %)	$1.50^{bc} \pm 0.05$	$1.42^{c} \pm 0.05$	$1.95^{a} \pm 0.05$	$1.68^{abc} \pm 0.07$	$1.90^{a} \pm 0.07$	$1.66^{abc} \pm 0.07$	$1.54^{bc} \pm 0.07$	$1.84^{ab} \pm 0.07$	$1.33^{c} \pm 0.05$	$1.56^{bc} \pm 0.05$	$1.50^{bc} \pm 0.06$	$1.54^{bc} \pm 0.05$
Rainfall (mm)	0	0	5	74	117	57	97.2	114.5	15	5	0	0
Faecal:grass P ratio	1.14	1.34	1.57	1.7	1.59	2.2	1.39	1.6	1.65	1.63	1.43	1.43

[abcdefgh]Means with different letters in the same row are significantly (P < 0.05) different.

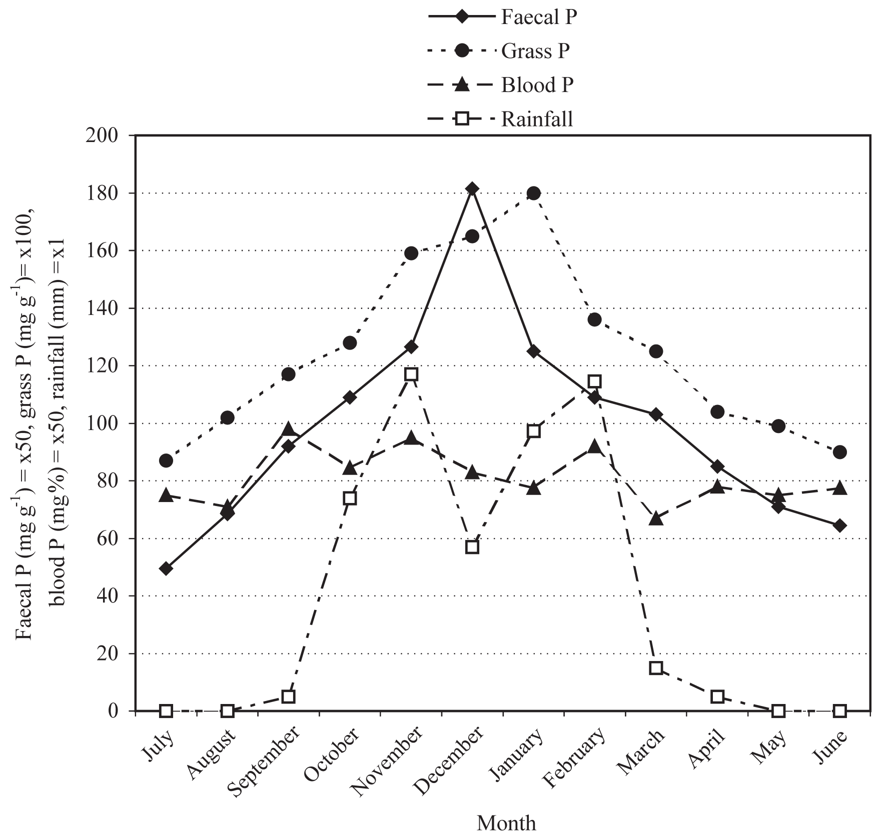

Fig. 1: **Mean faecal and grass P concentrations** (mg/g, dry weight)**, blood P concentrations** (mg %) **and rainfall** (mm) **according to month.**

significantly (P < 0.05) higher compared to all other months (Table 1, Fig. 1). There was a high correlation (r^2 = 0.89) between faecal and grass P, and this is in agreement with previous research[1,3,4,7,8,13] conducted under commercial farming or research trial conditions. Chapuis-Lardy *et al.*[4] found the coefficient of determination (r^2) between dietary and faecal P to be lower in farm-based studies than in P feeding trials, but in the present study, which was farm-based, r^2 between dietary and faecal P was high.

The concentration of P in the grass was also curvilinear, increasing from July (0.87 mg/g) to January (1.8 mg/g) and decreasing to June (0.9 mg/g). Grass P concentrations were significantly (P < 0.05) lower from April to August compared to values from September to March. This is in contrast to faecal P, which was significantly (P < 0.05) lower from May to August. In addition, grass P concentrations were significantly (P < 0.05) higher in January compared to all other months, in contrast to faecal P which was significantly P < 0.05) higher in December compared to all other months (Table 1, Fig. 1). This difference in faecal and grass P values, with the peak of faecal P in December compared with the peak of grass P in January, was unexpected. The young, tender grass early in the rainy season (September to November) must have made abundant P available to the animals so that more P was absorbed from the gut, which in turn increased blood P in September and November (Table 1). This would have made more P available to the salivary glands, thus being returned to the digestive system and raising the faecal P in December. Good rains in October (74 mm) and November (117 mm) would have produced young, tender grass in November and December, but low rainfall in December (57 mm) would have caused the grass to mature so that in January the P concentration in the grass would have peaked due to more seed being included in the samples compared with the December grass samples. At the same time the grass would have become less palatable, leading to less dry matter intake, reducing P intake and faecal P excretion in January even though grass P was higher (Table 1).

The faecal:grass P ratio was lowest in July when the P concentration in the grass was at its lowest and increased to the highest values when grass also had the highest concentrations of P during the rainy season (Table 1, Fig. 1). The overall mean faecal:grass P ratio was 1.56. When there was less P in the diet the animals seemed to be able to conserve P by reducing the amount lost in the faeces and when there were higher concentrations in the grass the animals lost more P in the faeces. This is in agreement with the

Table 2: **Mean faecal and grass Ca concentrations** (mg/g, dry weight), **the standard errors of the means and faecal:grass Ca ratios according to month.**

Month	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June
Faecal Ca (mg/g)	$3.25^{i} \pm 0.46$	$12.20^{fg} \pm 0.6$	$11.78^{g} \pm 0.42$	$19.52^{de} \pm 0.59$	$22.94^{c} \pm 0.54$	$26.50^{b} \pm 0.52$	$34.02^{a} \pm 0.52$	$17.64^{e} \pm 0.56$	$20.42^{d} \pm 0.43$	$14.12^{f} \pm 0.43$	$11.52^{g} \pm 0.40$	$8.26^{h} \pm 0.42$
Grass Ca (mg/g)	$6.36^{g} \pm 0.33$	$11.58^{e} \pm 0.31$	$10.61^{e} \pm 0.30$	$11.34^{e} \pm 0.47$	$16.33^{c} \pm 0.38$	$19.45^{b} \pm 0.38$	$23.89^{a} \pm 0.38$	$16.76^{c} \pm 0.40$	$15.49^{c} \pm 0.31$	$13.48^{d} \pm 0.31$	$10.36^{e} \pm 0.28$	$8.00^{f} \pm 0.31$
Faecal:grass Ca ratio	0.51	1.05	1.11	1.72	1.40	1.36	1.42	1.05	1.32	1.05	1.11	1.03

[abcdefgh]Means with different letters in the same row are significantly ($P < 0.05$) different.

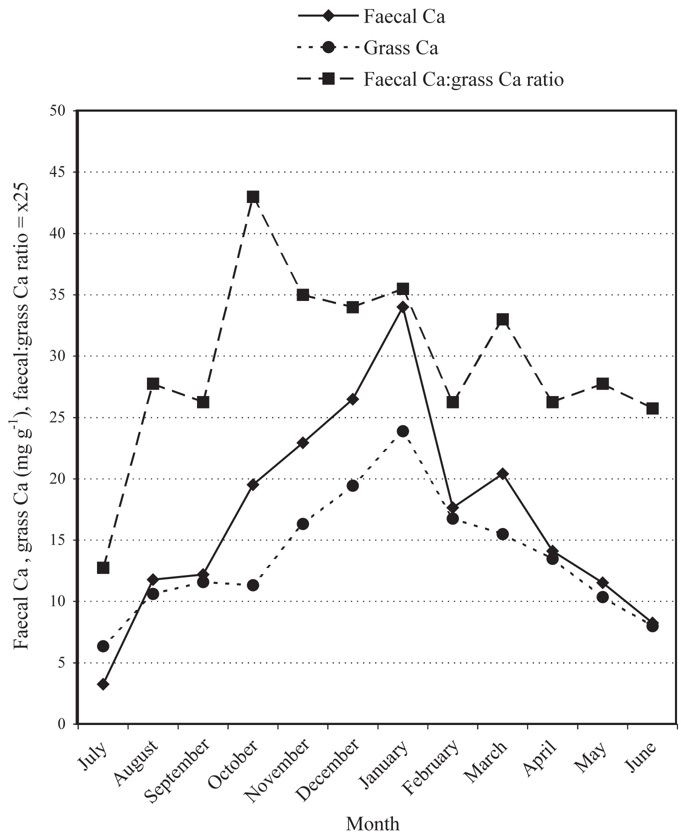

Fig. 2: **Mean faecal and grass Ca concentrations** (mg/g, dry weight) **and faecal:grass Ca ratios according to month.**

findings of Weiss and Wyatt[13], Chapuis-Lardy *et al.*[4] and Knowlton and Herbein[8], who found increased faecal excretion of P with increased intake of dietary P. In our research the only source of P was the grass. No supplements were given. In the dry season when the P concentration in the grass was at its lowest the amount of grass consumed was also at its lowest as there was little grass available because of overgrazing. The grass that was available had very low P concentrations and this small amount of P consumed was reflected by the low faecal P.

In contrast to the high correlation between mean faecal and grass P concentrations, the correlation between both and blood serum inorganic P (SiP) was very low ($r^2 = 0.36$). Mean SiP values were very low throughout the year but similar to some values reported by Read *et al.*[12] in animals on restricted P diets. Despite the low SiP values throughout the year there were no clinical signs of P deficiency. Blood serum inorganic P values failed to follow the pattern of either faecal or grass P. Low values were seen during July and August as expected before the rains and when grass and faecal P were low, but low SiP values were also seen in March after the rains when the grass and faecal P were relatively high. There were no significant ($P > 0.05$) differences in SiP values for July, August, January and March, but grass and faecal P values were significantly ($P < 0.05$) lower in July and August compared to January and March. In addition, SiP concentrations in September and November were significantly ($P < 0.05$) higher than SiP concentrations in January but grass and faecal P concentrations were significantly ($P < 0.05$) lower in September compared to January. In general, SiP values were within a narrow range (1.33–1.95 mg %) throughout the wet and dry seasons compared to a wide range of faecal and grass values (Table 1, Fig. 1). Blood serum inorganic P values recorded in the present study confirm previous research[9] that animals are able to maintain blood P in the face of low dietary P and that SiP is not a good indicator of P status since the animal is able to draw P reserves from the bone to maintain normal SiP even when dietary sources are insufficient to meet P needs[11,12].

Mean faecal and grass Ca concentrations followed a similar pattern to that seen in P except for February when faecal Ca was significantly ($P < 0.05$) lower than in January and March. Faecal Ca values were significantly ($P < 0.05$) higher from October to March compared to values from April to September. By contrast, grass Ca concentrations were significantly ($P < 0.05$) greater from November to April than from May to October. As a result, the highest faecal:grass Ca ratio was seen in October before the significant ($P < 0.05$) increase in grass Ca in Novem-

Table 3: **Mean faecal and grass Mg concentrations** (mg/g, dry weight), **the standard error of the means and faecal:grass Mg ratios according to month.**

Month	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June
Faecal Mg (mg/g)	$0.68^{e} \pm 0.07$	$0.64^{e} \pm 0.06$	$0.85^{e} \pm 0.09$	$1.24^{cd} \pm 0.09$	$1.45^{bc} \pm 0.08$	$1.60^{ab} \pm 0.08$	$1.86^{a} \pm 0.08$	$1.50^{bc} \pm 0.08$	$1.80^{ab} \pm 0.06$	$1.00^{de} \pm 0.06$	$0.92^{de} \pm 0.06$	$0.66^{e} \pm 0.06$
Grass Mg (mg/g)	$0.89^{e} \pm 0.08$	$1.00^{de} \pm 0.07$	$1.11^{cde} \pm 0.11$	$1.43^{c} \pm 0.09$	$2.54^{b} \pm 0.09$	$3.53^{ab} \pm 0.09$	$3.71^{a} \pm 0.09$	$1.34^{cd} \pm 0.09$	$1.17^{cde} \pm 0.07$	$1.06^{cde} \pm 0.07$	$1.01^{de} \pm 0.07$	$0.93^{e} \pm 0.07$
Faecal:grass Mg ratio	0.76	0.64	0.77	0.87	0.57	0.45	0.50	1.12	1.54	0.94	0.91	0.71

[abcde] Means with different letters in the same row are significantly ($P < 0.05$) different.

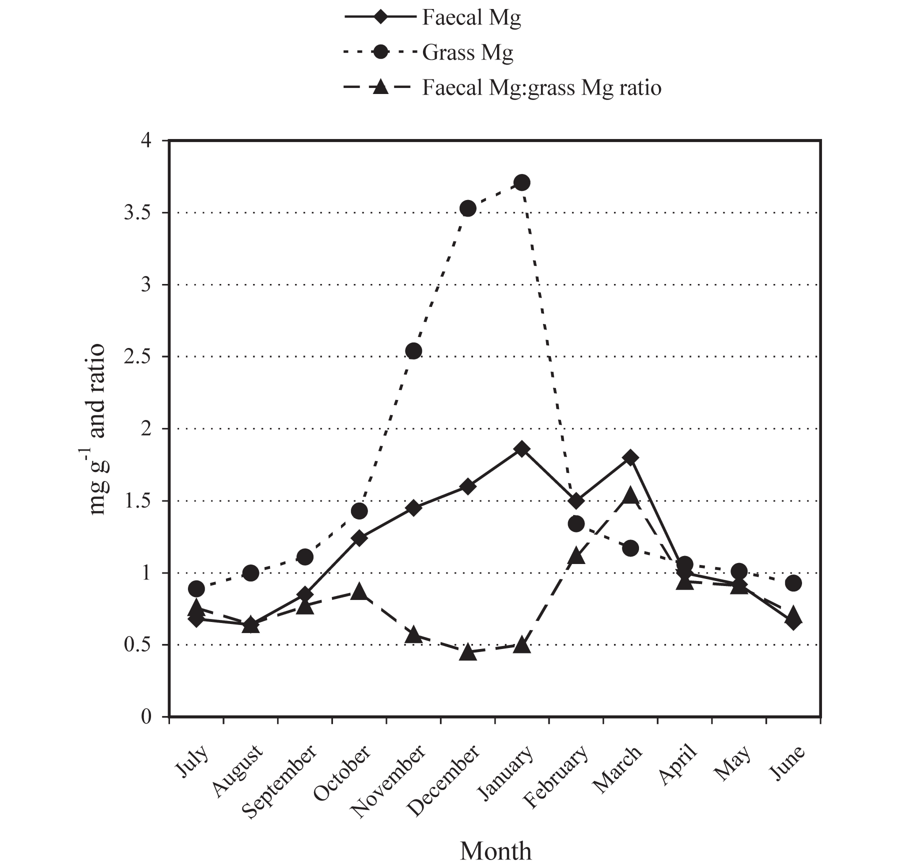

Fig. 3: **Mean faecal and grass Mg concentrations** (mg/g, dry weight) **and faecal:grass Mg ratios according to month.**

ber (Table 2, Fig. 2) but when grass P increased significantly ($P < 0.05$) in October compared to September. Both grass Ca and P values peaked during January but faecal P peaked in December compared to January for faecal Ca. There was a highly positive correlation ($r^2 = 0.95$) between faecal and grass Ca concentrations. A direct relationship between faecal P and dietary P has been reported[1,3,4,7,8,13], but in this study there was also a direct relationship between faecal and dietary Ca.

The faecal:grass Ca ratio was lowest in July (0.51) and highest in October (1.72) corresponding to the lowest but not the highest values for Ca in the grass. There was a significant ($P < 0.05$) increase in grass P concentrations each month from August to October but the grass Ca concentration did not show a significant ($P > 0.05$) increase during these months. Only in November was there a significant ($P < 0.05$) increase in grass Ca concentration compared to the previous 3 months. The overall mean faecal:grass Ca ratio was 1.18 compared to 1.56 for P. As in the case of P, this shows that the animals can conserve Ca when dietary supplies are low by reducing the amount of Ca lost in the faeces. The higher faecal:grass P ratio could have been a function of the generally higher Ca concentration compared to the P concentration in the grass. In addition, from these results the lower faecal:grass Ca ratio could indicate that the animals were better able to conserve Ca than P and this could be an important factor in the inability of cattle to maintain adequate P homeostasis in the face of P deficiencies.

Mean faecal and grass Mg concentrations followed the same trend as P and Ca, with linear increases in faecal Mg from low values in the dry winter months increasing up to the wet summer months, peaking in January and then again decreasing linearly to low values in winter. Magnesium in the grass, however, declined greatly between January and February compared to P and Ca, and there was a less dramatic but noteworthy increase in Mg concentrations in the grass between October and December. As a result, in contrast to Ca and P, grass Mg values were significantly ($P < 0.05$) higher from November to January compared to the rest of the year. Also in contrast to Ca and P, Mg concentrations in faeces were significantly ($P < 0.05$) higher in January compared to the rest of the year apart from December and March, but as seen with Ca and P, were significantly ($P < 0.05$) higher from October to March compared to June to September (Table 3, Fig. 3). This was a deviation from the more gradual slopes seen in Ca and P grass to an abrupt linear increase and decrease in the Mg concentration in the grass during the rainy season (Fig. 3). At the same time there were more gradual changes in the faecal Mg values during the same period and also between July and October and February to June. This suggests an endogenous source of Mg similar to that of P, perhaps from the salivary glands or directly into the gut from the blood or from some other source such as bone. Further research needs to be done on this. The animals were thus able to maintain a more constant faecal Mg and a low faecal:grass Mg ratio in the face of wide variations in dietary Mg. This has implications for grass tetany research and warrants further investigation.

The faecal:grass ratio for Mg was less than 1 throughout the experimental period except for February and March when there was a significant ($P < 0.05$) decrease in grass Mg compared to the previous 3 months. During the wet season (November to January) the faecal:grass Mg ratio was at its lowest, being a third of the value in March as a result of the significantly ($P < 0.05$) higher grass values compared to all other months. During these months the Mg concentration in the grass and faeces was at its highest, and especially in the grass, providing for the low faecal: grass Mg ratio. In the other months the animals were absorbing more Mg from the gut as less became available in the diet so that the greatest amount of Mg that left the gut was at the time when the concentration of Mg was greatest in the diet and as a result the faecal:grass Mg ratio remained low throughout the trial. A direct relation between faecal P and dietary P has been described[1,3,4,7,8,13], but in the present study there was also a direct relationship between faecal Mg and dietary Mg, with faecal Mg decreasing as grass Mg decreased and faecal Mg increasing as grass Mg increased.

CONCLUSIONS

A highly positive correlation ($r^2 = 0.89$) between faecal and grass P concentrations throughout the year and low faecal:grass P ratios during the dry months recorded in the present study provide evidence of the ability of the animal to conserve P in the face of P-deficient grazing in the communal farming situation by reducing the loss of P in the faeces when dietary P is limiting.

The positive correlation between faecal and grass Ca was even higher ($r^2 = 0.95$) compared to P, and the faecal:grass Ca ratio even lower with an overall mean of 1.18 compared to 1.56 for P. This indicates a better ability on the part of the bovine to conserve Ca than P when dietary P is limiting. It is possible that this inability to conserve the loss of P in the faeces as effectively as Ca is a contributing factor to the already stressed P homeostatic mechanisms in P-deficient animals.

Results from this research suggest the presence of a mechanism that allows the animal to conserve P, Ca and Mg so that smaller amounts of minerals are lost via the faeces. Further research is needed to in this regard.

This study confirms, in the communal grazing situation, what has been consistently reported from commercial farming systems, namely that faecal P reflects dietary P. This has implications for estimating dietary P in communal grazing cattle where dietary P is extremely difficult if not impossible to measure owing to grazing practices.

Sub-normal serum inorganic phosphorus values throughout the year in this study indicate a sub-clinical P deficiency, which may adversely affect production. This warrants further investigation into ways in which communally grazed animals can be supplemented to improve production.

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