FIELD ESTIMATES OF THE PHOSPHORUS KINETICS OF GRAZING CATTLE

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SUMMARY

Dry matter and phosphorus intakes and phosphorus kinetics *were* measured in 12 cattle grazing buffel grass paddocks fertilized annually with 0, 2.5, 5.0 and 15.0 kg P/ha. Ruminal chromium capsules and intravenous ^{32}P were administered to the 12 resident cattle and subcutaneous ^{32}P to four additional non-resident cattle with oesophageal fistulae. The growth rate and pasture intake of the cattle were reduced during the experimental period. At the measured levels of P intake, the P kinetics of the cattle were similar to those obtained in *pen* studies, absorption coefficients were 0.7-0.8 and faecal endogenous losses l0-17 mg/kg LW.

INTRODUCTION

The kinetics of phosphorus have been studied extensively in housed animals (Braithwaite 1984; Challa *et al.* 1989) but not in grazing cattle. This paper reports on the use and results of concurrent studies using chromium capsules and ^{32}P in resident steers and non-resident oesophageal fistulated cattle.

MATERIALS AND METHODS

The field work was completed at the CSIRO Narayen Research Station (25 41'S, 150 52'E) which has an inland subtropical climate and 714 mm mean annual rainfall. Further details of the site, the vegetation and pastures are given elsewhere (Kerridge and McLean 1988).

Twelve Belmont Red Steers (15-17 mo of age) were maintained in separate 1.2 ha paddocks originally sown with buffel grass *(Cenchrus ciliaris cv. Biloela)* and siratro (*Macroptilium atropurpureum)* in 1981. The paddocks were fertilized with 0, 2.5, 5.0 or 15 kg P/ha annually. Chemical analyses of pasture samples plucked from the same paddocks in January 1984 indicated concentrations of 1.3–2.5 g P, 1.3–1.8 g Ca, 1.2–1.3 g S and 12.9–13.6 g N/kg DM. All animals had access to salt blocks and had been resident in the paddocks for 8 months at the time of the experiment (January 1989). When initially assigned to their paddocks they weighed 189.2 $\pm$ 3.3 (s.e.) kg. Four non-resident steers (500-600 kg) with oesophageal fistulae were transferred to the experimental site and grazed in neighbouring paddocks when not being used for extrusa sampling.

To measure faecal excretion of DM and P the resident steers were dosed with chromium capsules (Captec) 1 week before the start of the experiment. To measure endogenous faecal P, catheters (1.00 mm I.D., 2.00 mm O.D.; Dural Plastics) were inserted in a jugular vein of each animal, flushed with heparinised saline and stoppered. The exposed portion of each catheter was covered in plaster and attached to the halter. The following day, a blood and faecal sample was collected from each animal and then ca. 80 MBq ^{32}P was injected through the catheter. The saline used to dilute the ^{32}P and to flush the catheter before and after the injection contained 6.8 g $Na_2H PO_4$/l. Blood samples were collected *ca.* 22, 32, 46, 73, 96, 120, 142, 152 and 168 h after injection, into lithium heparin tubes and the plasma separated by centrifugation for later analysis. When the jugular catheters became blocked, blood was collected by jugular venipuncture. Rectal faecal samples were collected at the same time as the blood and in addition 27 and 54 hours after

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injection. A composite sample and the individual samples of the faeces were frozen for later analysis.

Extrusa samples were collected from oesophageal fistulated steers for measurement of pasture digestibility and P content during four days of the same experimental week. The steers were injected with *ca.* 9 MBq ^{32}P subcutaneously 24 hours before the collection of the first extrusa samples. The steers were held without food overnight and on the following morning extrusa samples were collected from each animal after grazing in three paddocks. Saliva samples were collected before and after each paddock was grazed (McLean and Little 1979).

Plasma and saliva were prepared for *Cerenkov* ^{32}P counting by precipitation with 100 g/l trichloroacetic acid and the centrifuged supernatant decanted into scintillation vials (Ternouth 1990). Faecal and extrusa samples were prepared for Cerenkov ^{32}P counting by dry ashing and then dissolving the ash in 0.1 N HCl. The dry matter of all samples was estimated by drying to constant weight at 95°C and the P content by the technique of Fiske and Subarrow (1928). The bulked faecal samples and the extrusa samples *were* dried and analysed for acid insoluble ash (AIA) as a measure of digestibility (Van Keulen and Young 1977). Digestibility was also estimated by *in vitro* analysis (McLeod and Minson 1978). The buffel grass hay digestibility standards had *been* fed to sheep so that a constant of 0.03 was used to adjust the data for cattle (Poppi *et al.* 1980). Faecal Cr in the bulked samples was measured by the method of Costigan and Ellis (1987).

Endogenous and dietary faecal P were partitioned using the ratio of areas under the faecal and plasma specific activity curves after adjustment for gastro- intestinal transit time (Ternouth 1990). The specific activity curves were determined by linear regression analysis and visual display of the specific activity curves was employed to estimate transit time to the nearest 6 hours. All results were analysed using a one way analysis of variance program.

Table 1 The effect of rate of fertilization upon live weight, growth rate faecal chromium, dietary phosphorus and dry matter digestibility of steers

	Rate of fertilization (kg/ha)				s.e.
	0	2.5	5.0	15.0	
Live weight (kg)	268^{ab}	252^{a}	289^{bc}	308^{c}	8.8
January growth rate (kg/d)	0.52	0.83	0.41	0.55	0.18
Faecal Cr (g/kg DM)	0.73	0.55	0.54	0.62	0.06
P conc. in diet (g/kg DM)	1.28^{a}	1.60^{ab}	1.87^{bc}	2.27^{c}	0.15
Dry matter digestibility (g/g)					
AIA estimate	0.66	0.67	0.74	0.78	0.05
In vitro estimate	0.63	0.59	0.63	0.63	0.02

For each row, means with different superscripts are significantly different ($P<0.05$).

RESULTS

There was a significant effect of fertilization upon the live weight over the eight month period of residence of the steers. During the one month period which encompassed the kinetic measurements, the live weight changes *were* not related to previous growth rate (Table 1). Estimates of the concentration of faecal chromium and the proportion of endogenous P in the faeces were not significantly different between fertilizer treatments. Rate of fertilization

did influence P concentration in the ingesta. The AIA and *in vitro* digestibility results were markedly different, particularly at the higher rates of fertilization.

Using the *in vitro* digestibility results, the dry matter intakes were 3.8, 4.5, 4.9 and 4.4 (± 0.45) kg/d for the four fertilizer treatments (Table 2). Differences in the P contents of the extrusa samples resulted in significant differences in P intake and absorption and total and endogenous faecal losses of P but not the coefficients of P absorption.

Table 2 The effect of fertilisation upon dry matter intake (g/kg LWd), plasma- inorganic phosphorus (mg/l) and phosphorus kinetics (mg/kg LW.d) estimated using the *in vitro* digestibility data

	Rate of fertilization (kg/ha)				s.e.
	0	2.5	5.0	15.0	
DM intake (g/kg LW)	14.2	17.9	17.0	14.2	1.5
Plasma inorganic P (g/l)	54.3^{a}	69.6^{ab}	77.5^{b}	80.4^{b}	6.4
Phosphorus intake (g/kg LW)	18.4^{a}	28.2^{ab}	31.5^{b}	32.2^{b}	3.2
Total faecal P (g/kg LW)	15.2^{a}	22.9^{b}	21.5^{b}	25.2^{b}	1.9
Endogenous faecal P (g/kg LW)	10.7^{a}	15.1^{b}	13.6^{ab}	16.6^{b}	1.2
Absorption of dietary P (g/kg LW)	13.9^{a}	20.4^{ab}	23.7^{b}	23.6^{b}	2.7
Absorption coefficient (g/g)	0.76	0.72	0.75	0.74	0.03

For each row, means with different superscripts are significantly different (P<0.05)

DISCUSSION

The results are dependent upon the validity and compatibility of the techniques used in this experiment, The estimates of faecal losses of dry matter and phosphorus are dependent upon a constant rate of release of Cr in animals grazing pastures of varying quality when sampled at particular times of the day. To test this we measured the faecal losses of Cr of four steers fed chopped lucerne and pangola hay in metabolism crates (DM digestibility 0.59 and 0.48 respectively). The amount of Cr released each day was 0.99 ± s.e. 0.06 g/d with no significant differences between diets, The value is similar to that promulgated by the manufacturer (1.05 g/d). In addition there was no diurnal pattern of Cr concentration over a 48 hour period in which every defaecation from these cattle was analysed (MacDonald 1989). Thus the bulking of single samples taken over a period of days is satisfactory as a measure of faecal DM and P output.

Separate digestibility measurements were made by AIA and *in vitro* techniques. The *in vitro* results are similar to those recorded elsewhere for buffel grass at similar stages of maturity (Minson and Bray 1985). Both values rely on extrusa samples taken from mature hungry steers which may be different from the forage eaten by the young resident steers (Coates *et al.* 1987). This is of particular relevence when the AIA values from the oesophageal fistulated animals are used in conjunction with the AIA faecal values from the resident animals. The AIA digestibility values were considered unrealistic so that the *in vitro* results were used in all subsequent analyses,

Derived feeding standards (Minson and McDonald 1987) suggest that the cattle should have intakes of 5.5-6.2 kg DM/d to achieve the recorded growth rates. The low food intakes may be due to the catheterisation, injection and collection of blood and faecal samples as well as the frequent mustering and handling of the cattle. When the cattle were weighed at the end of the

experimental week, their growth rates for the month were less than other cattle not used in the experiment (18 v 27 kg) but this difference was reversed the following month (35 v 27 kg).

The time of faecal sampling for specific activity analysis was restricted by daylight and the need to minimise the disturbance of the normal grazing of the animals. Transit time as estimated from the specific activity peak ranged from 36 to 54 h. An error of 12 hours in the estimate of transit time was calculated to change the endogenous faecal losses and dietary faecal losses by *ca.* 1.0 mg P/kg LW. This error is small and similar to that estimated by Boxebeld *et al.* (1983).

The pastures used in this experiment were initially sown with buffel grass and siratro but in January 1989, siratro represented 1–4% of the available pasture. Analysis of plucked buffel grass 'on offer' in previous January periods indicated that the concentrations of all other minerals were adequate. The P concentration of the extrusa samples was lower than the earlier plucked samples although the increase of P concentration with fertilizer was similar.

The lower dry matter intakes during the kinetic study lowered the P intake of the cattle. At these lower intakes, the use of these techniques provided data which was similar to that obtained in experiments with housed Friesian calves (Challa *et al.* 1989) and in housed *Bos indicus* cross steers fed forage diets (Ternouth 1989). In our field experiments, the absorption coefficients were 0.72–0.76 with daily faecal endogenous losses of 10–17 mg/kg LW. At comparable levels of P intake, the Friesian calves had coefficients of absorption of 0-68-0.81 and daily endogenous losses of 12-15 mg/kg LW. Comparable values for the housed *Bos indicus* cattle were 0.76–0.80 and 12-17 mg/kg LW. All these studies show that P absorption and endogenous faecal P losses are closely related to intake so that reduced food intake, created by the imposition of the experimental regimen, would not adversely affect the import of these results.

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