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EFFECT OF INCREASING PHOSPHORUS INTAKE ON THE P FAECAL ENDOGENOUS LOSS IN THE SHEEP

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SUMMARY

Three groups of four New Zealand Romney wethers, aged 20 to 24 months and weighing 38 to 42 kg, were used to investigate the effect of increasing phosphorus (P) intake (1.52 to 5.6 g/d) on the P faecal endogenous loss. Increasing the P intake ($\bar{X}$) (g/d) increased the P faecal endogenous loss ($\bar{Y}$) (g/d), and the relationship between the two parameters was described by the regression equation $\bar{Y} = 0.36 + (0.38 \pm 0.03)\ \bar{X}$. The minimal P faecal endogenous loss was estimated to be 9 mg P/kg body weight. The urinary P excretion was variable and the mean urinary P output was 5.5 mg P/kg body weight. From the above data it was calculated that the P requirement for maintenance of a 40 kg sheep was 1.0 g/day.

INTRODUCTION

The British Agricultural Research Council (ARC, 1965), on the basis of the data then available, used values of 40 mg P/kg body weight for the P faecal endogenous loss and 1.5 mg P/kg body weight for the urinary excretion of P to calculate the P requirements for sheep.

Recent studies have suggested that these values for the P faecal endogenous loss are too high. Field *et al.* (1974) observed in hill sheep that the total daily amounts of P excreted in the faeces were less than 23 mg/kg body weight, while Sykes and Dingwall (1976) calculated from a slaughter experiment that the P faecal endogenous loss could be no more than 12 to 15 mg/kg body weight. Also, investigations on the P kinetics of sheep fed different levels of P have suggested that the magnitude of the P faecal endogenous loss was related to the P intake (Grace, 1979). This paper presents data showing the relationship between the P intake and the P faecal endogenous loss.

EXPERIMENTAL

Twelve New Zealand Romney wethers, aged 20 to 24 months and weighing 38 to 42 kg, were fitted with rumen fistulae and fed a basal diet of lucerne pellets so as to give a daily DM and P intake of 650 g and 1.52 g, respectively. Group P_1 had 1 600 ml distilled water infused via the rumen while groups P_2 and P_3 had their daily P intakes increased to 3.0 and 5.6 g, respectively, by infusing 1 600 ml of $NaH_2PO_4.2H_2O$ solution.

After a pre-experimental period of 21 days each animal was given a single dose of 100 μCi ^{32}P in 20 ml of 0.9% sterile saline via an indwelling cannula in the jugular vein. Blood was then taken using vacutainers at 6, 12 and 18 h after the ^{32}P administration, and then daily at 0900 hours for 15 days.

The blood was centrifuged, the plasma removed, TCA added to give a final concentration of 5% and then recentrifuged to give a clear TCA supernatant containing the plasma inorganic P. The daily faecal and urinary ^{32}P and P outputs were measured. The radioactivity in the plasma TCA supernatant and the acid digesta of the urinary and faecal samples was measured by Cerenkov radiation, with standards prepared from the ^{32}P solution which was administered to the sheep. The P faecal endogenous loss was determined by an isotope dilution technique (Kleiber *et al.*,

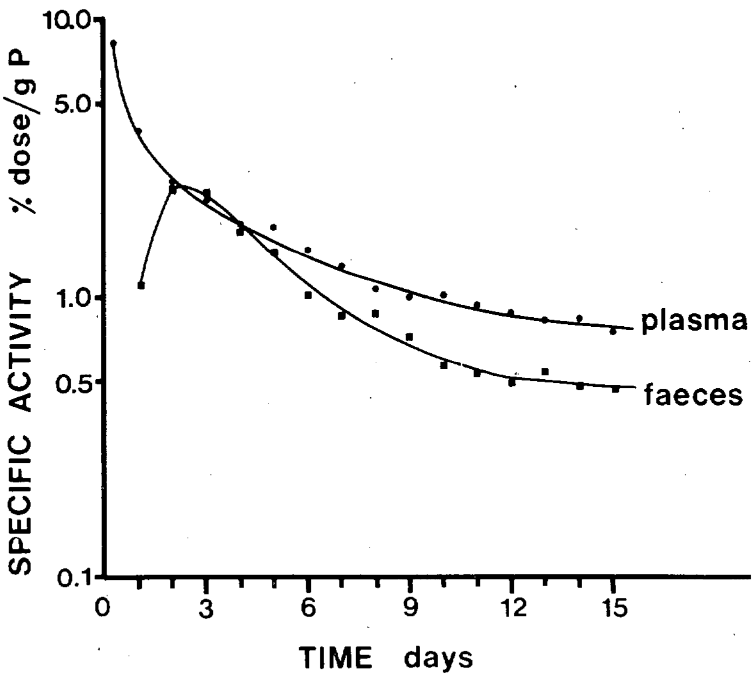

FIG. 1: *Changes in specific activity of plasma inorganic P and faecal P with time after a single intravenous injection of* ^{32}P.

1951) and was calculated using the faecal and plasma P specific activity (SA) data collected from day 8 to day 15 in the following formula:

$$\text{P faecal endogenous loss (g/d)} = \frac{\text{mean faecal } ^{32}\text{P (\% dose/d)}}{\text{mean plasma inorganic P (\% dose/g P)}}$$

RESULTS

An example of the changes in plasma inorganic P and faecal P SA with time after a single dose of ^{32}P is shown in Fig. 1.

Increasing the P intake increased the faecal P excretion and the apparent retention of P as well as the plasma inorganic P levels (Table 1). The excretion of urinary P was variable and did not significantly increase with the increase in P intake. The mean urinary P excretion was 5.5 mg/kg body weight.

TABLE 1: EFFECT OF P INTAKE ON THE PLASMA INORGANIC P, THE EXCRETION OF P IN THE FAECES AND URINE AND THE APPARENT RETENTION OF P

Group	P_1	P_2	P_3
P intake (g/day)	1.52 ± 0.02	3.04 ± 0.01	5.60 ± 0.05
Faecal excretion (g/day)	1.29 ± 0.07	2.45 ± 0.03	4.31 ± 0.21
Urinary excretion (g/day)	0.20 ± 0.04	0.30 ± 0.11	0.56 ± 0.33
Apparent retention (g/day)	0.03 ± 0.02	0.29 ± 0.03	0.73 ± 0.11
Plasma inorganic P (mg/l)	66 ± 4.0	79 ± 3.0	116 ± 9.5

Increasing the P intake (X) increased the P faecal endogenous loss (Y), and the highly significant relationship between the P intake and the P faecal endogenous loss was described by the regression equation (Fig. 2): $Y = 0.36 + (0.38 \pm 0.03)X^{**}$.

DISCUSSION

The faecal endogenous loss of P (*i.e.*, the net secretion of P into the digestive tract) increased as the intake of P was increased. At P intakes of 1.5, 3.0 and 5.6 g/d, the respective mean P faecal endogenous losses were 0.92, 1.45 and 2.45 g/d (or 23, 36 and 61 mg P/kg body weight). These figures compare with those of Tillman and Brethour (1958) and Young *et al.* (1966), who have reported values ranging from 16 to 28.3 mg P/kg body weight for sheep weighing 43 kg on P intakes ranging from 1.6 to 1.86 g/day. The ARC (1965), on the data then available, which included many studies where the P intake was greater than 2.5 g/day, accepted a value of 40 mg P/kg body weight.

The minimal P faecal endogenous loss (*i.e.*, the obligatory faecal loss when the P intake is zero) can be found by extrapolating to zero the P intake regression line relating the P intake and the faecal endogenous loss (Fig. 2). Minimal faecal endogenous loss determined this way was 0.36 g P/day or 9 mg P/kg body weight. This agrees with the findings of Sykes and Dingwall (1976), who calculated that minimal P faecal endogenous loss should be less than 12 to 15 mg P/kg body weight.

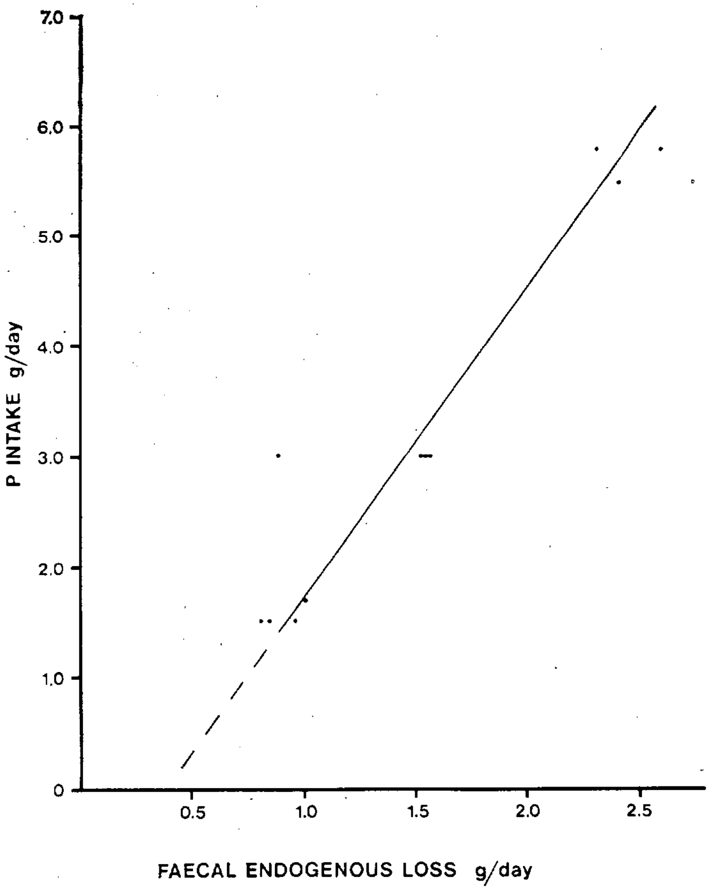

FIG. 2: *Effect of P intake on the P faecal endogenous loss.*

The P requirement for maintenance can be defined as that amount of P required to replace the P lost from the body; that is, the minimal P faecal endogenous loss and the urinary P. Any P losses via the wool and suint are regarded as negligible. As the faecal endogenous loss is the major route of P loss from the body, the value taken will greatly influence the estimate of the P requirement. In calculating the P requirement, the minimal P faecal endogenous loss should be taken because it reflects the minimal loss of P from the body during the normal P metabolism of the sheep. The higher values observed for the P faecal endogenous loss when the P intake increases represent the excess of the absorbed P not required by the body which is returned to the digestive tract, principally via the saliva, as part of the mechanism of P homeostasis.

The ARC (1965) estimate of 2.2 g P/day for the P maintenance requirement of a 40 kg sheep was calculated using the value of 40 mg P/kg body weight for the P faecal endogenous loss. Using data from this study — that is, taking P losses in the urine as 5.5 mg P/kg body weight and the minimal P faecal endogenous loss (9 mg P/kg body weight) as the estimate of P losses from the body into the digestive tract and the availability of dietary P as 0.6 — the maintenance requirement for P for a 40 kg non-lactating sheep with little or no change in body weight was calculated to be 1.0 g/day. This compares favourably with the value of 1.2 g P/day published by Sykes and Dingwall (1976) for a 50 kg ewe 2 months pregnant.

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