Estimating phosphorus intake by grazing sheep

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Estimating phosphorus intake in grazing sheep is difficult since hand-picked samples of forage do not represent actual intake. Results showed that faecal P did reflect dietary P levels. A minimum of 30 sheep should be sampled to obtain an error of 6% for pooled analysis of faecal P. The relationship between the level of P in feed and that in faeces was remarkably constant. Bone P levels tended to follow bone Ca levels rather than dietary P levels.

Dit is moeilik om die fosfor inname van weiende skape te skat, aangesien die handgeplukte monsters van die voergewas nie die werklike inname verteenwoordig nie. Resultate het getoon dat fekale P nie die P vlakke in die rantsoen weerspieël nie. Die verwantskap tussen die vlak van P in die voer en dié in die ontlasting was verbasend konstant. Been P vlakke neig na die been Ca vlakke eerder as om die P vlakke in die rantsoen te volg.

Keywords: Phosphorus intake, grazing sheep

Introduction

As sheep are highly selective grazers, hand-picked samples of forage do not represent actual intake (Engels, 1972). Thus to establish the intake of phosphorus, a method other than forage analysis must be used. In the following experiments various possibilities were examined.

Experimental

Experiment 1

An experiment was conducted to establish whether the phosphorus levels in various organs, tissues, bones, body fluids or excretory products of sheep reflected dietary intake (Belonje, 1978).

Method

For 29 weeks, three groups of six, 6-month-old South African Mutton Merino × Merino wethers were fed three diets containing different percentages of phosphorus (P) and calcium (Ca). (1 = P 0,05:Ca 0,22; 2 = P 0,27:Ca 0,62; 3 = P 0,63:Ca 0,20)

Blood samples were taken during weeks 5, 10, 14, 18 and 24 for plasma inorganic phosphate (Pi) and Ca determinations. Composite 4-day faecal and urine specimens as well as single grab samples were taken from each sheep during week 24 for P and Ca analyses. At the end of week 29 the animals were slaughtered and the following specimens removed for P and Ca analyses: tongue, wall of left ventricle, *gluteus medius*, brain, liver, kidney, cervical vertebra, rib, femur and rumen fluid.

Results

Plasma Pi levels were lowest in the 0,05% P group but did not usually differ between the 0,27 and 0,63% P groups (Table 1). Mean faecal P levels reflected dietary intake and the grab sample P content was closely correlated with that of the 4-day composite sample ($P < 0,01$; $r = 0,96$). The P content of bone did not reflect intake but rather followed the bone Ca content which in turn appeared to reflect dietary Ca intake. However, low availability of P did decrease bone mineral deposition slightly. Rumen fluid P and total daily urinary P levels did reflect P intake. Organ and soft tissue P levels were unaffected by P intake.

Conclusions

Plasma Pi levels are useful to indicate low dietary P intake but are unsatisfactory to differentiate between higher levels of intake. Faecal P levels did reflect dietary P levels and it is suggested that this method be chosen to assess the P intake of free-ranging animals. Furthermore, to diminish the effect of abnormal animals and to decrease the number of analyses, it is proposed that small samples of rectal faeces be collected from a large number of animals and pooled for analysis. Organ, soft tissue and bone P levels did not reflect P intake.

Table 1 The levels (mean ±SD) of phosphorus (P) in the three diets and the corresponding levels of P in the faeces, bone and plasma (inorganic P = Pi) of the three groups of sheep

Group	Feed P (%)	Faeces P (%)	Bone P (%)	Plasma Pi[a] (mmol/l)
1	0,05	0,15 ± 0,02	6,69 ± 0,58	0,64
2	0,27	0,57 ± 0,13	8,99 ± 0,60	2,56
3	0,63	1,21 ± 0,40	7,75 ± 0,77	2,74

[a] Mean values for weeks 18 and 24 calculated from original mean mg/100 ml units.

Experiment 2

To determine whether the level of P in a pool sample was the same as the arithmetic mean of the P content of individual samples used to make the pool sample the following experiment was done (Belonje & Van den Berg, 1980a).

Method

Rectal faeces were taken from various groups of sheep. Within each group a pool specimen was made by combining three faecal pellets from each of the animals. The individual and pooled samples were analysed for P. The groups consisted of 20 non-pregnant, non-lactating ewes from five different flocks; 20 pregnant ewes sampled five times during the 16th–20th weeks of gestation; 20 lactating ewes sampled at about 24, 31 and 38 days of lactation.

An analysis of variance was used to establish the optimum number of sheep and the number of faecal pellets per sheep to be used for the pool sample.

Results and Conclusions

There were no statistical differences between the pool and the mean of the individual samples (Table 2). It was established that for a 5–6% error a minimum of 30 animals should be sampled for the pool, taking three faecal pellets from each.

Experiment 3

The level of faecal P was determined when sheep were fed a reasonably constant intake of P (Belonje & Van den Berg, 1980b).

Method

50 non-pregnant, non-lactating ewes were fed a diet containing 0,3% P at a level of 1 kg/sheep/day. Pooled samples of the diet were taken on days 1–5; 8–12 and 15–19 inclusive. Rectal faeces were taken randomly from 30 of the 50 sheep and three pellets from each were pooled for analysis. This was done on days 5–9; 12–16 and 19–23 inclusive.

Table 2 A comparison between the levels of phosphorus (P) in pool samples and the mean of the individual samples used to make the pool in various groups of ewes

	Faecal P/%	
Groups of 20 sheep	Pool analyses	Mean of individual analyses
Non-pregnant, non-lactating		
	0,75	0,73
	1,19	1,14
	0,82	0,85
	1,06	1,04
	0,86	0,85
Pregnant		
113 d	0,69	0,60
120 d	0,69	0,68
127 d	0,62	0,61
134 d	0,54	0,53
141 d	0,77	0,77
Lactating		
24 d	0,68	0,71
31 d	0,54	0,53
38 d	0,73	0,72

Results and conclusion

The level of P in the feed was found to be 0,35% (±0,04 SD) and that in the faeces was 0,94% (±0,06 SD) which is remarkably constant.

Experiment 4

The effect of changing intake of dietary P on the levels of faecal P was examined (Belonje & Van den Berg, 1980b).

Method

The same sheep were used as in Experiment 3. They also continued to receive the same 0,3% P diet from days 1–20 at 1 kg/sheep/day. On days 2, 3 and 4 each sheep was dosed *per os* with 40 ml of a solution containing 3 g of phosphorus (754,8 g $NaH_2PO_4.2H_20$ made up in 2l water). On the mornings of days 12, 13 and 14 the animals received only 0,5 kg of ration/sheep/day and from the morning of day 15 they returned to 1 kg/sheep/day.

On day 21 the 0,3% P diet was replaced by a high P diet (0,5% P) at 1 kg/sheep/day. On day 25 the 0,5% P diet was replaced by a low P diet (0,2% P) at 1 kg/sheep/day until the trial terminated on day 33. Faecal pool samples were taken daily, pooling three faecal pellets from 30 of the 50 sheep selected at random.

Results

Within 24 h of dosing soluble P, the faecal P was above the upper 2 SD limit set in Experiment 3 and remained there until 24 h after the final administration after which the level dropped back, staying within the limits set previously (Figure 1).

In the second phase when the intake was halved the faecal P rose within 24 h but within three days of being on the full ration again the faecal P returned to within the established range. In the third phase when the diet was changed from 0,3% to 0,5% P, there was again a rise in faecal P to above the upper limits and this level fell below the lower limits when a low P diet of 0,23% was fed in the final phase.

Conclusion

An increase in the level of P intake, whether by means of soluble P or dietary P, is reflected by a rise in faecal P, whereas a drop in dietary P is reflected by a drop in faecal P. The rise in faecal P when intake was halved indicates that food must not be withheld before sampling.

Experiment 5

To confirm the suggestion in Experiment 1 that bone P levels do not reflect P intake, the following experiment was performed (Belonje & Van den Berg, 1983).

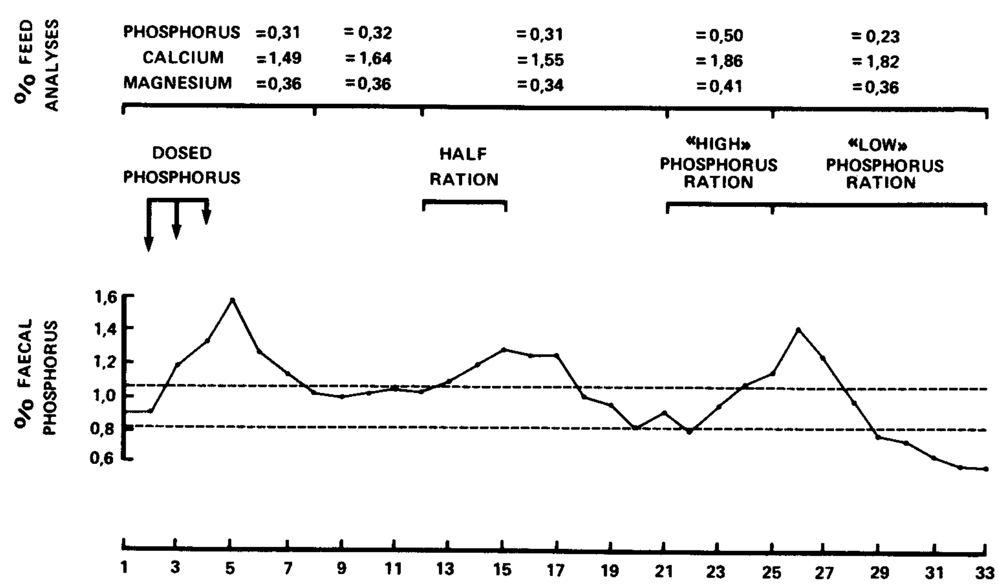

Figure 1 The phosphorus levels in the pooled faecal samples from 30 out of 50 sheep whose intake of phosphorus was periodically changed. (Parallel lines indicate 2 SD limits of faecal phosphorus when sheep consumed a 0,3% phosphorus diet — Experiment 3).

Table 3 A comparison between the mean (±SD) levels of phosphorus and calcium and their ratio in the ribs of the sheep and the feed they consumed

Determination	Specimen[a]	Group 1 (0,05% P)	Group 2 (0,27% P)	Group 3 (0,63% P)
Phosphorus (%)	Feed	0,36 ± 0,01	0,47 ± 0,01	0,64 ± 0,03
	Bone	10,49 ± 0,73	9,42 ± 0,26	9,24 ± 0,56
Calcium (%)	Feed	1,47 ± 0,32	0,85 ± 0,08	0,37 ± 0,05
	Bone	21,20 ± 2,64	19,54 ± 1,80	19,10 ± 2,16
Calcium:phosphorus ratio				
	Feed	4,09 ± 0,81	1,81 ± 0,15	0,61 ± 0,10
	Bone	2,01 ± 0,15	2,07 ± 0,16	2,07 ± 0,16

[a] In each group there were four composite feed specimens and bone specimens from five animals.

Method

Fifteen 6-month-old Merino lambs were blocked by body mass into three equal groups. They were fed three diets which were alike in composition except for their levels of P and Ca. After 98 days rib biopsy specimens were removed and analysed for P and Ca.

Results and conclusion (Table 3)

Bone P levels tend to follow bone Ca levels rather than dietary P levels. Therefore, if an animal's Ca intake decreases then bone P levels will also show a decrease even in the face of supplementary dietary P. Secondly, should growing animals receive sufficient Ca their bone P levels will follow bone Ca levels and may give a false impression that dietary P levels are adequate. Finally, the availability of P does modify bone deposition slightly. Therefore, if animals are kept on a constant Ca intake then P supplementation will be reflected in a rise in bone P and *vice versa*.

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