EFFECT OF FEEDING PATTERN ON DIURNAL VARIATION IN FAECAL CHROMIC OXIDE LEVEL WHEN USING CONTROLLED RELEASE DEVICES IN SHEEP

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Summary

Diurnal variation in faecal chromic oxide levels was estimated from 4 hourly faecal sampling of 56 wethers allotted to one of six different feeding patterns. Sampling occurred on days 6 and 7 (Period 1) after a controlled release device was administered, and was repeated on days 14 and 15 (Period 2) following re-randomisation of the wethers to the feeding patterns.

Increasing the frequency of feeding tended to be associated with higher faecal chromic oxide levels ($p < 0.05$), particularly in wethers fed thrice daily at 8 hour intervals. There was no interaction between feeding pattern and period, sampling day or time within-day.

There were significant period x time within-day ($p < 0.05$) and day x time within-day ($p < 0.001$) interactions, indicating that variation in faecal chromic oxide between sample times was not consistent. This implies that sampling at any time of day is unlikely to result in a biassed estimate of pasture intake, providing sufficient samples are collected.

Significant period ($p < 0.001$) and period x day ($p < 0.01$) effects were associated with slow faecal chromic oxide equilibration in period 1. Equilibration did not occur until after day 7, indicating a need for caution when commencing sampling.

(**Key Words**: Feeding Pattern, Chromic Oxide, Faecal Output, Sheep)

Introduction

In the past, estimating pasture intake by ruminants using the marker chromic oxide was labour intensive and allowed little flexibility in choice of sampling times, while its twice daily administration was associated with diurnal variation in faecal chromic oxide levels (Langlands et al., 1963). The development of intraruminal controlled release devices (CRDs), which deliver chromic oxide at a linear rate over 25 days (Ellis and Rodden, 1987), has increased flexibility in the selection of sampling times for grazing sheep and reduced diurnal variation in ruminal release of chromic oxide. Diurnal variation in faecal chromic oxide levels may lead to bias in pasture intake estimates if faecal samples do not reflect the daily mean. Sampling times should therefore be selected to minimise any bias in estimates of pasture intake. It is important to know the extent of diurnal variation when using CRDs and the factors which can contribute to diurnal variation. Parker et al. (1989) found diurnal variation in faecal chromic oxide level was not significantly affected by feed intake level or by forage type.

Faecal chromic oxide level is a function of digesta flow rate. Digesta flow is subject to seasonal influences, including photoperiodic effects (Corbett and Pickering, 1983). Seasonal effects on pasture quality and quantity (Arnold, 1960), and on photoperiod and climatic effects (Lynch and Alexander, 1973) influence the grazing pattern of sheep which in turn is related to diurnal variation in digesta flow (at least in the abomasum and small intestine - Corbett and Pickering, 1983). Although Ellis et al. (1981) suggested that the use of CRDs will allow faecal chromic oxide levels to be more closely associated with feeding pattern and digesta flow, the effect of feeding pattern on diurnal variation in faecal chromic oxide level, however, has not been examined. This paper reports an experiment which examined the effects of various feeding patterns on diurnal

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variation in faecal levels of chromic oxide, released from CRDs, over consecutive days.

Materials and Methods

Animals and diet

Fifty six mature Merino wethers were housed in individual pens in an animal house. Each animal was fed once daily 600 g (air dry) of a pelleted diet, which consisted of 450 g/kg cracked wheat grain, 500 g/kg lucerne chaff and 50 g/kg cottonseed meal. The pellet contained 887 g DM/kg and 943 g OM/kg DM. Seven days after this diet was introduced (day 0), the wethers were allocated randomly to one of 6 feeding patterns :-

a) 1 meal/day
b) 2 meals/day at 12 hourly intervals
c) 3 meals/day at 8 hourly intervals
d) 6 meals/day at 4 hourly intervals
e) 2 meals/day 8 hours apart
f) 3 meals/day 4 hours apart

All meals within a feeding pattern were of equal size, with all wethers continuing to receive 600 g/d. The daily cycle for all feeding patterns commenced at 10:00 h. The same day (day 0) these feeding patterns were imposed, a CRD (Captec Chrome - Nufarm Ltd, Laverton North, Victoria) was administered to each wether using a custom-made balling gun (Captec, Laverton North, Victoria). The capsules had a 3 cm core consisting of 5 tablets with 65% chromic oxide and a 9 mm orifice (Anon, 1987) with a nominal release rate of 203 mg chromic oxide daily.

On day 6 (after administering the CRD) at 10:00 h, rectal grab sampling of faeces commenced and continued, at 4 hour intervals, over two days (period 1). Each wether was then reallocated randomly to another of the above feeding patterns, with an identical sampling regime recommencing on day 14 (period 2).

Faecal chromium determinations

Faecal samples were dried, prepared and chromic oxide content determined on duplicate 0.2 g samples by atomic absorption spectroscopy using the method of Costigan and Ellis (1987).

Statistical analyses

Faecal chromic oxide level was analysed by least squares analysis of variance using the REG (Gilmour, 1988) statistical program. The effects of feeding pattern, period and their first order interaction were tested against the between-sheep (within period) mean square (fitted as a random effect). Day, time within-day and the other first order interactions between feeding pattern, period, day and time within-day were tested against within-sheep variance.

Repeatability between sampling times was calculated from estimated between - and within--animal variance components according to Becker (1984).

Results and Discussion

Diurnal variation

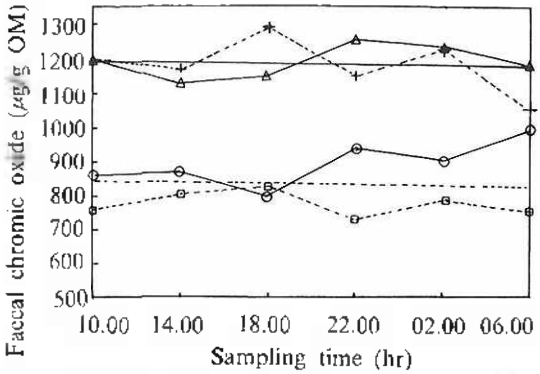
The mean faecal chromic oxide level in period 1 was 346 ± 40.2 μg/g OM lower ($p < 0.001$) than that in period 2. However, within period 1 mean faecal chromic oxide levels on day 7 were higher than those on day 6 (figure 1), the period x day ($p < 0.01$) and period x time within-day ($p < 0.05$) interactions both being significant. The effects of period alone accounted for 29.8% of the total variance (table 1). Although the manufacturers of Captec Chrome have suggested sampling may commence as early as day 5 after administering the CRD (Anon, 1987), the slow equilibration of faecal chromic oxide levels indicates that caution needs to be exercised in choosing the initial sampling time. Our data (obtained using the commercially available CRD) together with those of Parker et al. (1989 - using a prototype CRD) suggest that the initial sampling should not occur until day 9 after administering the CRD.

There was also a significant interaction between day and time within-day ($p < 0.001$), indicating effects of time were not consistent between days (figure 1). Hence, sampling at a given time should not bias the estimate of faecal output (intake) providing sampling is repeated. The number of samples required from an individual (n_I) to obtain the mean within an allowable error (L) for the experimental group can be estimated as follows :-

$$n_I = \frac{(Z_P)^2 \cdot (S_W^2)}{L^2 \cdot n_g}$$

where,

Z_P = normal deviate corresponding to the



------ Period 1 mean, ——— Period 2 mean, ···□··· Day 6, —○ Day 7, ···+··· Day 14, —△— Day 15

Figure 1. Diurnal variation in faecal chromic oxide content of sheep administered with a controlled release device.

two tail significance level P

S_W^2 = within sheep mean square

n_g = number of individuals in the experimental group

Thus to estimate the group mean within 50 μg with 95% confidence will require each animal in the group be sampled $((1.96)^2 \cdot 23{,}587/(50)^2 \cdot n_g) = 36.2/n_g$ times.

Effects of day, time within-day and all the sampling time interactions accounted for less than 5% of the total variation (table 1).

Effects of feeding pattern

The feeding pattern effect on faecal chromic oxide level was significant ($p < 0.05$), although it accounted for only 4.7% of total variation (talbe 1). Faecal chromic oxide levels (table 2) tended to be higher in the groups more frequently and uniformly fed. In particular, sheep fed thrice daily at 8 hourly intervals had significantly higher faecal chromic oxide levels than all other groups except those fed 6 times daily at 4 hourly intervals. This trend indicates either release rate was increased or faecal output was reduced (and since the total daily feed intake was the same, an increase in digestibility). If the latter were the case, the feeding pattern effect represented up to 5.5 digestibility units (table 2), based on faecal chromic oxide levels in period 2 and the chromic oxide release rate of the capsules. Increased digestibility with more frequent feeding of ruminants has been observed previously (Graham, 1967), although the effect is highly variable (Sutton et al., 1985). Jensen and Wolstrup (1977) have suggested that increasing feeding frequency results in a more stable rumen environment and may improve ruminal digestion by increasing the rate of fermentative activity of rumen microorganisms. The feeding pattern effect on faecal chromic oxide level is unlikely to be from an effect on release rate as Parker et al. (1989) found release rate from CRDs was not significantly affected by either a range of feeding levels or herbage types, factors considered more likely to have such an effect.

A low level of feeding (approximately 0.95-

TABLE 1. SOURCES OF SIGNIFICANT VARIATION IN FAECAL CHROMIC OXIDE LEVEL OF SHEEP MAINTAINED ON DIFFERENT FEEDING PATTERNS

Source	df	Mean square	% of total variance
Feeding pattern	5	1,102,448*	4.7
Period	1	35,208,960**	29.8
Between sheep[b]	105	458,530	40.7
Day[b]	1	1,241,520**	1.1
Time[a]	5	77,194**	0.3
Period x day	1	754,336**	0.6
Day x time	5	368,390**	1.6
Period x time	5	217,837**	0.9
Within sheep[b]	1024	23,587	20.4

*$P<0.05$, **$P<0.001$, [a]Within-day, [b]Within-period

TABLE 2. LEAST SQUARE DEVIATIONS (± S.E.) FROM THE MEAN FAECAL CHROMIC OXIDE LEVEL OF SHEEP WITH DIFFERENT FEEDING PATTERNS

No. Meals daily	Interval (hrs)	Faecal chromic oxide (μg/g OM)		Group OM digestibility[d](%)
6	4	26[ab]	(43.7)	66.9
3	8	140[a]	(44.6)	69.7
2	12	−64[b]	(45.6)	64.2
1	24	−53[b]	(45.5)	64.6
3	4	−16[b]	(44.6)	65.7
2	8	−32[b]	(45.6)	65.2

[a,b] Means with like superscript are not different ($p > 0.05$). $LSD_{0.05} = 137.7$

[d] Based on group mean estimates of faecal output in Period 2 only

1.05 times maintenance for housed sheep) was chosen to ensure that each meal was consumed before subsequent meals were offered. As diurnal variation in faecal chromic oxide level is not affected by level of feeding (Parker et al., 1989), the effects of feeding pattern on diurnal variation are unlikely to have been significantly different at other feeding levels.

There were no significant interactions between feeding pattern and period, day or time within-day. Although feeding pattern did influence mean faecal chromic oxide level, providing all groups of animals have a similar pattern no special account needs to be taken in selecting sampling times, However, seasonal effects that influence grazing pattern (Lynch and Alexander, 1973) will have an effect on digestibility and hence on the absolute estimate of pasture intake.

Between and within - sheep variation

The repeatability of faecal chromic oxide levels between samplings (within period) was 64.2%. Between-sheep variation represented 40.7% of total variation, while within-sheep variation accounted for 20.4% of the variance (table 1).

The large between-sheep variance in faecal chromic oxide level would include differences in digestibility between animals and variation between devices in release rate. Dove et al. (1989) found that individual digestibilities of ewes grazing a phalaris pasture had a range of 25% of the mean, which in part may be attributable to herbage selection differences. The manufacturers of the CRD have indicated the coefficient of variation in release rate between - devices may be up to 8% (Anon, 1987). The magnitude of the between - sheep variation under controlled feeding supports the contention that CRD's should only be used to estimate intake of groups and not individuals. Because only one feeding level was used in this experiment, the between sheep variance estimated is not suitable for determining group size (n_g) required to detect a given difference in intake (chromic oxide level) between two groups.

Within-sheep variation, in this experiment, includes analytical errors, variability in the extent of mixing of chromic oxide and digesta in the tract, and any changes over time in digestion within individuals.

Implications for sampling grazing sheep

This study has examined some potential sources of error in estimating faecal chromic oxide level under conditions of controlled feeding. At pasture, the between - sheep variance will be larger because of differences in intake and herbage selection between sheep. In addition, variation between - days in intake will increase variation within - animal. It is not surprising that the repeatability of faecal output estimates between samplings of grazing sheep (Lee et al., 1990) is lower than that reported here.

The lack of a feeding pattern x time within - day interaction and the significant day x time within - day interaction support the contention of Parker et al. (1989) that differences between sampling times within day are not consistent and that no bias is likely by selecting a given time of day for sampling. However, the lower repeatability between samplings for grazing sheep (Lee et al., 1990) make repeated sampling essential.

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