PASSAGE OF Cr-EDTA THROUGH THE DIGESTIVE TRACT OF CATTLE AND SHEEP

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SUMMARY

After a single injection of Cr-EDTA into the rumen of cattle and sheep, the faecal excretion curve of Cr was analysed to determine the passage rate constant, k_1, of Cr in the rumen and k_2 in the caecum and proximal colon, the transit time and total mean retention time in the digestive tract. Cattle tended to have a slower passage rate constant, k_1, in the rumen, and this was associated with a higher efficiency of cattle for digesting forage. Cattle had a higher value of k_2 in the caecum and proximal colon than did sheep. There was little difference in the total mean retention time of Cr between cattle and sheep.

INTRODUCTION

Cattle digest forage more efficiently than do sheep when the forage is offered *ad libitum* (Blaxter *et al.*, 1966; Playne, 1970, 1978). This difference between the digestive efficiency of cattle and sheep applies to both the leaf and stem fractions of a tropical grass when offered *ad libitum* (Poppi, Minson and Ternouth, unpublished data, Table 1). To determine the possible cause of this difference in digestive efficiency a study was made of the passage of water from the rumen and through the small and large intestines of cattle and sheep fed these leaf and stem fractions. Previous studies have shown a positive correlation between the rate of passage of water and solid phase markers (Grovum and Williams, 1977).

METHODS

Rhodes grass was harvested as 6- and 12-week regrowths and separated into its leaf and stem fractions by a gravity feed separator (Laredo and Minson, 1973). The four fractions were offered *ad libitum* to four steers (452 to 514 kg liveweight) and four

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TABLE 1: VOLUNTARY INTAKE AND DIGESTIBILITY OF LEAF AND STEM FRACTIONS BY CATTLE AND SHEEP (10-DAY MEASUREMENT PERIOD)

	6-week Regrowth		*12-week Regrowth*		*Mean*
	Leaf	*Stem*	*Leaf*	*Stem*	
	Dry matter intake ($g/kg\ W^{0.9}$)				
Cattle	30.8	24.6	28.5	20.4	26.1a
Sheep	26.8	23.0	28.2	19.0	24.2b
	Dry matter digestibility coefficient				
Cattle	0.596	0.591	0.500	0.494	0.545a
Sheep	0.564	0.545	0.460	0.430	0.500b

(Poppi, Minson and Ternouth, unpublished data).
Different letters between means indicate a significant difference ($P < 0.05$).

wethers (39 to 50 kg liveweight) in two separate 4 × 4 Latin square design experiments. All animals were fistulated at the rumen and kept in a constant-environment room. Fresh feed was offered every hour using automatic 24-hour feeders (Minson and Cowper, 1966, 1977).

After 14 days on the experimental diets, Cr-EDTA was injected into the rumen contents using a large number of sites to facilitate even dispersion. Excreted faeces were collected every hour for the next 33 h, between 46 and 56 h and at 72 h, and the concentration of Cr in the faeces dry matter determined by atomic absorption spectrophotometry. The Cr concentration curves were analysed by the procedure of Grovum and Williams (1973) and Grovum and Phillips (1973) to determine the passage rate constant of the marker in the reticulo-rumen (k_1) and in the caecum and proximal colon (k_2), the transit time of the marker through the digestive tract and the total mean retention time of the marker in the digestive tract. The passage rate constant, k, is related to retention time as follows:

$$k = 1/\text{Retention time} = 0.693/T^{\frac{1}{2}}$$

where $T^{\frac{1}{2}}$ is the time taken for half the marker to disappear.

RESULTS

Cattle tended to have lower k_1 values in the rumen and higher k_2 values in the large intestine, with small differences between cattle and sheep in the transit time of Cr-EDTA. There was no difference between cattle and sheep in the total mean retention time of Cr-EDTA (Table 2). Animals fed leaf always had a

TABLE 2: PASSAGE RATE CONSTANTS FOR Cr-EDTA, TRANSIT TIME THROUGH THE DIGESTIVE TRACT AND TOTAL MEAN RETENTION TIME OF MARKER

	6-week Regrowth		*12-week Regrowth*		*Mean*
	Leaf	*Stem*	*Leaf*	*Stem*	
			k_1 *rumen (per hour)*		
Cattle	0.065	0.058	0.059a	0.042b	0.056a
Sheep	0.068	0.068	0.068	0.061	0.066b
			k_2 *large intestine (per hour)*		
Cattle	0.402	0.292	0.280	0.240	0.303†
Sheep	0.199	0.179	0.199	0.187	0.181†
			Transit time (h)		
Cattle	9.7	10.2	10.0a	11.4b	10.3
Sheep	11.2	12.0	11.0	12.6	11.7
			Total mean retention time (h)		
Cattle	27.6	30.8	30.6	39.4	32.1
Sheep	30.9	32.3	30.7	34.4	32.1

Different letters between leaf and stem means of same regrowth and between cattle and sheep means indicate a significant difference ($P<0.05$). †Indicates difference, $P < 0.1$, between cattle and sheep means.

higher passage rate constant for Cr-EDTA in the rumen (k_1) and large intestine (k_2) and a lower transit time and total mean retention time of Cr-EDTA in the digestive tract, but most of these differences were not significant ($P > 0.05$, Table 2).

DISCUSSION

The marker Cr-EDTA is water-soluble and can be used to measure the passage of water from the rumen and the passage of water in digesta through the intestine. The rates of passage of a water-soluble marker and a marker of the dry matter are positively correlated (Grovum and Williams, 1977), so the lower passage rate constant for water leaving the rumen of cattle indictates that more time is probably available for digestion of dry matter in the rumen. This is supported by the higher digestive efficiency of the cattle when fed both the leaf and stem fractions in this (Table 1) and previous studies (Blaxter *et al.*, 1966; Playne, 1977, 1978). Exposure to low temperature increases the passage rate constant of Cr-EDTA from the rumen of sheep, changes the VFA proportions and increases the efficiency of microbial synthesis (Kennedy and Milligan, 1978). The observed

difference in passage rate constant (k_1) between cattle and sheep may also affect VFA proportion and microbial efficiency.

The cattle tended to have higher k_2 values for the large intestine than sheep. This difference was not as large as that recorded by Hecker and Grovum (1975), but this is possibly due to their use of a restricted level of feeding and animals of different ages. In our studies the diets were offered *ad libitum* and the animals were of similar age and physiological status. The mean difference of 59% is quite large and suggests that sheep may have a greater potential for digesting feed in the large intestine than do cattle. However, the values of k_2 are high and equivalent to retention times of 3.3 and 5.2 h in cattle and sheep, respectively, so that any advantage gained by the sheep would be relatively small. The k_2 values found with the sheep are similar to those reported by Grovum and Williams (1977) in sheep offered lucerne at or near *ad libitum* levels, and indicate the short time digesta is retained in the caecum and proximal colon of animals offered feed at the *ad libitum* level. Grovum and Williams (1973) have suggested that, in sheep, k values determined by the above technique are approximately 66% of the actual value. Despite this, the k values recorded here under *ad libitum* feeding conditions are still higher (lower retention time) than most of the values reported by Ulyatt *et al.* (1975).

The transit time of Cr-EDTA through the digestive tract was similar to values reported by Grovum and Williams (1977) in sheep. There was little difference between cattle and sheep in transit time, and since cattle have a longer length of small intestine and colon (Dukes, 1955), digesta must pass more rapidly through these organs in cattle. Similarly, the total mean retention time of Cr-EDTA in the digestive tract was similar for cattle and sheep. Therefore total retention time does not indicate differences that may occur between cattle and sheep in the time digesta is retained in the rumen and large intestine.

It was concluded that when feed is offered *ad libitum*, Cr-EDTA tends to stay for a longer time in the rumen of cattle compared with sheep, and this partly accounts for the higher digestive efficiency of cattle fed *ad libitum*.

ACKNOWLEDGEMENTS

We are grateful for the skilled technical assistance of L. B. Currell, R. C. Flint, T. Magner, P. Tuckett and K. L. R. Willson, and to R. Hansen for the analysis of Cr.

REFERENCES

Blaxter, K. L.; Wainman, F. W.; Davidson, J. L., 1966. *Anim. Prod., 8*: 75.

Dukes, H. H., 1955. *The Physiology of Domestic Animals* (7th edit.). Comstock, Ithaca, p. 300.

Grovum, W. L.; Phillips, G. D., 1973. *Br. J. Nutr., 30*: 377.

Grovum, W. L.; Williams, V. J., 1973. *Br. J. Nutr., 30*: 313.

——— 1977. *Br. J. Nutr., 38*: 425.

Hecker, J. F.; Grovum, W. L., 1975. *Aust. J. Biol. Sci., 28*: 161.

Kennedy, P. M.; Milligan, L. P., 1978. *Br. J. Nutr., 39*: 105.

Laredo, M. A.; Minson, D. J., 1973. *Aust. J. agric. Res., 24*: 875.

Minson, D. J.; Cowper, J. L., 1966. *Br. J. Nutr., 20*: 757.

——— 1977. *J. Anim. Sci., 44*: 814.

Playne, M. J., 1970. *Proc. Aust. Soc. Anim. Prod., 8*: 511.

——— 1978. *Anim. Feed Sci. and Technol., 3*: 41.

Ulyatt, M. J.; Dellow, D. W.; Reid, C. S. W.; Bauchop, T., 1975. In *Digestion and Metabolism in the Ruminant* (Eds. I. W. McDonald and A. C. I. Walker). Univ. of New England Press. p. 119.