Effects of cold exposure on chewing behaviour and rumen particle size in sheep given 4 diets

P. M. KENNEDY

Department of Animal Science
University of Alberta, Edmonton, Canada T6G 2P5

ABSTRACT

The physical breakdown of 4 forage diets in the chopped or pelleted form was studied in 16 closely-shorn wether sheep at room temperatures of approximately 24 °C or 3 °C. Cold exposure increased the motility of the reticulum ($P < 0.01$) and increased the rate of eating by 21% for the chopped rations and by 7% for pelleted rations. Cold exposure had no consistent effect on rumination behaviour or on the proportion of rumen digesta retained on a 1 mm screen but changed the efficiency of breakdown of large digesta particles of chopped reed canary grass.

Keywords Eating behaviour; rumination; particle size; cold stress; sheep

INTRODUCTION

Voluntary feed intake has been related to the retention of ingested plant material in the rumen of sheep (Thornton and Minson, 1973). Both breakdown of large particulate matter by chewing during eating and rumination, and removal of small particles by passage during contractions of the reticulum are presumably important factors affecting digesta retention time and therefore feed intake. Recent studies in Alberta on the effects of cold exposure of sheep on reticulum motility, digesta particle size, rumination behaviour and feed intake (Westra and Christopherson, 1976; Gonyou *et al.*, 1979; Kennedy *et al.*, 1982; P. M. Kennedy and R. J. Christopherson, unpublished) indicated that the increased feed intake of chopped diets observed in cold-exposed sheep may have been caused by both increased passage of small particulate material from the rumen, and increased breakdown of large digesta particles during rumination. Accordingly an attempt was made to compare eating and ruminating behaviour and digesta particle size in sheep given 4 diets in warm and cold environments.

EXPERIMENTAL

Diets used were lucerne (2.3% N, 43% cell walls), red clover (1.9% N, 54% cell walls), reed canary grass (1.5% N, 69% cell walls) and brome grass (1.4% N, 68% cell walls) either chopped through a 3-inch screen or ground (⅛ inch screen) and pelleted.

Suffolk wethers (32 to 42 kg) were randomised into 4 groups and given either the pelleted or chopped form of the diet at fixed intakes (1.0 to 1.3 kg/d) within diets in approximately equal amounts at intervals of 2 h. The experimental design was four, 4 × 4 Latin squares run concurrently, with treatments comprising the chopped or pelleted diet given at 22 to 25 °C (warm) or 1 to 4 °C (cold). Each animal was maintained in a metabolism cage for a period of 6 weeks, and was closely shorn at the beginning and after 18 days of each period. Measurements of feeding and rumination behaviour were made over 24 h using a microswitch mounted on a head halter, connected to a digital counter and chart recorder. Samples of rumen digesta were taken and sieved through screens of 4, 2, 1, 0.5, 0.25 mm as described previously (Mudgal *et al.*, 1982). Measurements of frequency of biphasic contractions of the reticulum (motility) over 4 h were taken using a pressure transducer and open-tipped catheter located in the reticulum. All measurements were made between 24 and 28 days of temperature exposure.

RESULTS AND DISCUSSION

For all diets, cold exposure increased ($P < 0.01$) reticular motility by 5 to 17% (Table 1). This result was in agreement with that of Westra and Christopherson (1976), who observed that exposure of sheep given pelleted grass once daily to a cold (1.3 °C) ambient temperature increased reticular motility by 21%.

Eating time at fixed intake was less ($P < 0.01$) in cold-exposed sheep, with a decrease of 20.5% for the chopped diet and 6.5% for the pelleted diets (interaction, $P < 0.05$ (Table 1)). The functional significance of the increased rate of eating in the cold was not clear, although eating rate appeared to be correlated with voluntary feed consumption when comparisons were made between breeds of cattle (Frisch and Vercoe, 1969). Estimates of voluntary feed consumption of sheep in the present experiment made during the final 8 days of the experiment period showed that cold-

TABLE 1 Effects of warm (22 to 25 °C) or cold (1 to 4 °C) room temperatures on closely shorn sheep given 4 forage diets in the chopped or pelleted form.

	Chopped		Pelleted	
	Warm	Cold	Warm	Cold
Reticulum motility (contractions/h)	63	68	60	66
Eating:				
bites × 10^{-3}/kg DM intake	21	17	7.4	8.2
min/kg DM intake	197	155	100	95
Rumination:				
min/24 h	534	612	165	154
bites × 10^{-3}/24 h	52	55	13	15
bites/min	97	104	72	77
Eating and rumination bites × 10^{-3}/kg DM	64.2	61.4	18.2	20.7
Particle size in rumen:				
> 1 mm (%)	57	56	47	41
> 4 mm (%)	13	16	—	—

exposure increased intake of chopped hay by 13%, compared to no increase for the pelleted diets (P. M. Kennedy and R. J. Christopherson, unpublished).

Duration of rumination attained maximum values of 8 to 10 h/d in sheep given chopped clover, canary and brome-grass diets. Literature values of up to 9 to 10 h (Church, 1969) indicated that increased rumination bites would be achieved only by higher rates of chewing. It was noteworthy there was a non-significant increase from 95 bites/min to 118 bites/min in cold-exposed sheep given chopped canary grass when duration of rumination was at the maximum value of 10 h/d. This result is in agreement with that of Appleman and Delouche (1958) who found that rumination chewing increased in goats from 90 bites/min at 20 to 30 °C to 110 bites/min at 0 °C.

For sheep given pellets there was a close ($r = -0.95$) relationship within diets between the proportional change due to cold exposure in the percentage of particles retained on a 1 mm screen and the proportional change in total (feeding plus rumination) bites. This indicated that chewing effort was inversely related to reduction in particle size. This relationship did not hold for the chopped diets, especially for canary grass, for which the proportion of particles retained on both 1.0 and 4.0 mm screens increased despite an increase (by 22%) in total bites/kg feed. These contrasting patterns defy ready explanation but imply that efficiency of particle breakdown may change in sheep given chopped diets. Such changes in efficiency could conceivably to due to more efficient mastication of large particles during rumination. Studies with cattle given the same diets as in the present experiment have indicated that the size of the bolus retained in the mouth for chewing and the enhancement of the proportion of the large particles in the bolus during regurgitation may affect rates of large particle breakdown (P. M. Kennedy and L. P. Milligan, unpublished). The results of Bae *et al.* (1979), who found that rumination time per g cell walls declined markedly as intake of sheep increased, also indicate that efficiency of large particle breakdown may be variable. In addition, if microbial activity in the rumen becomes depressed by nutrient deficiency, it would be expected that the large particles in rumen digesta would retain more structural strength, requiring more rumination effort for their breakdown to small particles. This appears to be the reason for the substantial (10 to 25%) decreases in total bites/kg feed found by Freer *et al.* (1962) and Pearce (1965) when they supplied urea or casein into the rumen of sheep given oaten chaff. The increase (by 22%) in total bites/kg chopped canary grass for cold-exposed sheep in the present experiment was also probably associated with microbial nutrient deficiency, since concurrent measurements of flow of digesta through the duodenum indicated that apparent OM digestion in the rumen was depressed by 20%. In addition, the resultant decrease in VFA production may have resulted in a stimulation of rumination (Ruckebusch and Candau, 1968).

Acclimation of sheep to cold exposure consistently appears to be associated with increases in contraction rates of the reticulum and increases in eating rate. Dietary characteristics of nutrient supply, fibrousness and rate of cell wall comminution in the rumen determine the effects of cold exposure on digestion and rumination behaviour.

ACKNOWLEDGEMENTS

Dr R. J. Christopherson and Mr J. Kelly provided assistance. The Agricultural Research Council of Alberta and the Natural Sciences and Engineering Research Council of Canada provided funding.

REFERENCES

Appleman R. D.; Delouche J. C. 1958. Behavioural, physiological and biochemical responses of goats to temperature, 0 °C to 40 °C. *Journal of animal science* **17**: 326-335.

Bae Dong Ho; Welch J. G.; Smith A. M. 1979. Forage intake and rumination by sheep. *Journal of animal science* **49**: 1292-1299.

Church D. C. 1969. Digestive physiology and nutrition of ruminants. O and B Books Inc. Corvallis USA.

Freer M.; Campling R. C.; Balch C. C. 1962. Factors affecting voluntary intake of food by cows. 4. The behaviour and reticular motility of cows receiving diets of hay, oat straw, and oat straw with urea. *British journal of nutrition* **16**: 279-295.

Frisch J. E.; Vercoe J. E. 1969. Liveweight gain, food intake, and eating rate in Brahman, Africander and Shorthorn and Hereford cattle. *Australian journal of agricultural research* **20**: 1189-1195.

Gonyou H. W.; Christopherson R. J.; Young B. A. 1979. Effects of cold temperature and winter conditions on some aspects of behaviour of feedlot cattle. *Applied animal ethology* **5**: 113-124.

Kennedy P. M.; Christopherson R. J.; Milligan L. P. 1982. Effects of cold exposure on feed protein degradation, microbial protein synthesis and transfer of plasma urea to the rumen of sheep. *British journal of nutrition* **47**: 521-535.

Mudgal V. D.; Dixon R. M.; Kennedy P. M.; Milligan L. P. 1982. The effects of two intake levels on retention times of liquid, particle and microbial markers in the rumen of sheep. *Journal of animal science* **54**: 1051-1056.

Pearce G. R. 1965. Rumination in sheep. II. The circadian pattern in sheep. *Australian journal of agricultural research* **16**: 635-648.

Ruckebusch Y.; Candau M. 1968. Sur la rumination chez le veau. *Compte rendu des séances de la Société de biologie* **162**: 897-902.

Thornton R. F.; Minson D. J. 1973. The relationship between apparent retention time in the rumen, voluntary intake, and apparent digestibility of legume and grass diets in sheep. *Australian journal of agricultural research* **24**: 889-898.

Westra R.; Christopherson R. J. 1976. Effects of cold on digestibility, retention time of digesta, reticulum motility and thyroid hormones in sheep. *Canadian journal of animal science* **56**: 699-708.