PARTICLE POOL SIZE AND TURNOVER RATE OF INGESTA IN THE RETICULO-RUMEN OF NORMAL AND ABSESSED SHEEP

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Summary

Sixteen mature sheep were fed chaffed orchardgrass hay once a day for 7 days. In 7th day, four sheep were slaughtered either prior to eating, 2, 8 or 16 hours after the commencement of eating to measure digesta pool size and particle size distribution in the reticulo-rumen. One sheep slaughtered at 8 hours after feeding had absesses at the cardia and in the lungs and could not ruminate normally. Time spent eating and rumination in the sheep on the day before slaughtering were 85 and 29 (pseudo-rumination 227) minutes a day, compared to those were 112 and 277 minutes in the other animals, respectively. Total actual chewing time in the sheep with absesses and the other animals were 98 and 373±132 minutes, respectively. Dry matter(DM) intake in the sheep was 2.9 g/kgBW$^{0.75}$ which was only about 17% of that in the other animals. The pool sizes of reticulo-rumen DM and neutral detergent fiber (NDF) were somewhat smaller in the sheep than the others. The pool sizes of large particle (>1.18mm) DM and NDF in the animal were similar with those in the other animals. Mean DM retention time in the sheep was 207.4 hours which was about 4.2 times longer than that in the other animals.
(Key Words: Particle Pool Size, Ruminal Turnover Rate, Rumination, Absess, Sheep)

Introduction

One of the major factors influencing the voluntary intake of forage is the rate of passage of digesta from the reticulo-rumen(RR) (Balch and Campling, 1965). It has been considered that digesta particles are not passed through the reticulo-omasal orifice until broken down to some threshold degree of fineness (Poppi et al., 1981). The processes involved in particle size reduction are chewing during both eating and rumination, microbial fermentation and ruminal detrition. Our previous study showed that about 80% of variation in large particle (> 1 mm) disappearance in the rumen was explained by the actual chewing activities during rumination (Okamoto et al., 1990). The results indicated that rumination is the major factor responsible for reducing the size of particles in the rumen. One sheep in the previous study had absesses at the cardia and could not ruminate normally. Comparison of the data from sheep with those from normal animals is expect to elucidate the importance of normal rumination on the particle size reduction in the rumen as well as physical inhibition of rumination with muzzle (Pearce and Moir, 1964; Welch et al., 1982; Chai et al., 1988).

The purpose of the present study was to compare the chewing activity, particle pool size in the RR and reticulo-ruminal turnover rate in the sheep with absesses with those in normal sheep, and to find whether differences occurred due to inhibition of normal rumination by absesses at the cardia.

Materials and Methods

Sixteen mature sheep, weighing 50.4 ± 12.3 kg, were fed chaffed orchardgrass hay once a day in individual crates for 7 days as previously described (Okamoto et al., 1990). The hay was available for 2 hours a day and water and trace mineralized salt block were available at all times. Every fous sheep were slaughtered immediately before eating and 2, 8 or 16 hours after commencement of feeding on the 7th day. Jaw movement was recorded for 24 hours immediately before slaughter as described previously (Okamoto et al., 1990). After slaughtering, RR contents were weighed and an aliquot sample was taken for measurement of particle size distribution by wet

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sieving (Okamoto et al., 1990). Large particles (LP) were defined as the particle retained on the 1.18 mm sieve. Mean retention time of dry matter (DM) and neutral detergent fiber (NDF) in the RR was calculated from daily DM and NDF intake and DM and NDF pool size. DM and NDF pool sizes were standardized at 45 minutes after commencement of feeding when about half of intake was occurred. The standardization was made on the assumption that the rates of disappearance of these materials in the RR were constant.

Abnormality of the measurements from the sheep with absesses was tested by Smirnoff's rejection test (Torii et al., 1961).

Results

Autopsy showed that nothing was the matter in sheep used in the present experiment except one sheep slaughtered at 8 hours after commencement of feeding. The sheep had absesses as big as an egg at the cardia and in the lungs. There was no difference in the empty weight of RR (951 g vs. 1067 ± 139 g), other stomachs and guts.

Daily DM and NDF intake, DM and NDF pool size in the RR and mean retention time in the RR are shown in table 1. Daily DM and NDF intakes in the sheep having absesses were only about 17% of those in the other sheep, while the values did not differ significantly from the other sheep ($p > 0.05$). Dry matter and NDF contents in the RR of the sheep with absesses were similar with those of the other sheep slaughtered at various times after the meal, while standardized DM and NDF pool sizes in the RR were somewhat less than those in the other sheep. Mean retention time of DM and NDF based on the DM and NDF contents in the RR and daily DM and NDF intake differed significantly ($p < 0.01$) between the abnormal sheep with absesses and the normals. Similarly, mean retention times of DM and NDF based on standardized DM and NDF pool size in the abnormal sheep were significantly greater than the normals ($p < 0.01$).

Chewing activities for 24 hours before slaughter, including eating time, rumination time, pseudo-rumination time, actual chewing time during rumination and total actual chewing time, are shown in table 2. Eating time of the sheep with absesses was slightly but not significantly shorter than the other sheep. Rumination time of the sheep with absesses was only 10% of the other sheep, while the value was not significantly abnormal. The sheep pseudo-ruminated 227 minutes. Total time spent rumination and pseudo-rumina-

TABLE 1. INTAKE, RETICULO-RUMEN POOL SIZE AND MEAN RETENTION TIME IN THE RETICULO RUMEN OF DRY MATTER (DM) AND NEUTRAL DETERGENT FIBER (NDF)

	Sheep with absesses	Normal sheep[1]	Tn[2]
Daily intake ($g/kg^{0.75}$)			
DM	2.9	16.7 ± 4.9	2.28
NDF	2.0	11.7 ± 3.5	2.28
Reticulo-rumen pool size ($g/kg^{0.75}$)			
DM	25.0	29.9 ± 11.1	0.44
DM standardized	25.8	37.8 ± 11.2	1.10
NDF	16.9	19.9 ± 8.5	0.35
NDF standardized	17.5	26.0 ± 8.3	0.99
Mean retention time (hours)			
DM	207.4	43.9 ± 11.3	3.75**
DM standardized	214.6	56.1 ± 6.4	3.83**
NDF	199.9	41.0 ± 11.5	3.71**
NDF standardized	207.2	53.2 ± 6.3	3.83**

[1] Mean ± Standard deviation (n=15).
[2] $Tn = (Xn - X)^2/S/n$, Xn: Value for sheep with absesses, X: Total mean, S: Sum of square, n = 16 ** $p < 0.01$.

TABLE 2. CHEWING ACTIVITIES (MIN/DAY)

	Sheep with absesses	Normal sheep[1]	Tn[2]
Eating time	85	112 ± 16.8	0.76
Rumination time	29	277 ± 12.4[3]	1.77
Pseudo-rumination time	227	–	–
Proportion of actual chewing during rumination(%)	44.1	82.4 ± 9.8	2.75*
Actual chewing time during rumination	12.8	233 ± 116	1.69
Total actual chewing time	97.8	373 ± 132	1.78

[1,2] See footnotes in table 1.
[3] n = 14.
*$p < 0.05$

tion was not less than rumination time of the other sheep. The proportion of actual chewing time during rumination to rumination time was less in the sheep with absesses than that in the other sheep and was significantly smaller than the normals ($p < 0.05$). Actual chewing time during rumination of the sheep with absesses was only 5.5% of the mean in the other sheep.

Particle size distribution of DM and NDF pools in the RR of sheep with absesses and of sheep slaughtered at 8 hours after feeding are shown in table 3. Proportions of LP (> 1.18 mm) and fine particle (< 0.045 mm) in the sheep with absesses were greater than the mean of those in the other sheep slaughtered at the same time after feeding both in DM and NDF. Therefore, the proportion of particles in middle size(1.18 – 0.045 mm) was less in the sheep than the others. Pool sizes of both DM and NDF in LP in the sheep with absesses were similar with those in the other sheep slaughtered at same time(DM, 10.5 vs. 9.3 ± 6.2 g/kg $BW^{0.75}$; NDF, 9.3 vs. 8.0 ± 5.2 g/kg$BW^{0.75}$).

TABLE 3. PARTICLE SIZE DISTRIBUTION (%) OF DRY MATTER(DM) AND NEUTRAL DETERGENT FIBER(NDF) OF RETICULO-RUMINAL DIGESTA

Sieve opening(mm)	Sheep with absesses	Normal sheep[1]	Tn[2]
DM			
>1.18	42.0	33.5 ± 9.7	0.83
1.18 – 0.30	7.1	21.9 ± 5.8	1.46
0.30 – 0.045	5.9	12.5 ± 3.1	1.37
0.045 >	45.0	32.0 ± 4.9	1.45
NDF			
>1.18	54.8	44.7 ± 10.3	0.90
1.18 – 0.30	8.9	30.1 ± 9.1	1.42
0.30 – 0.045	6.6	15.9 ± 4.6	1.34
0.045 >	29.8	9.4 ± 5.3	1.57

[1]Normal sheep slaughtered at 8 hours after feeding Mean ± Standard deviation (n = 3).
[2]See footnote in table 1.

Discussion

Daily DM intake in sheep with absesses was only about 17% of those in the other sheep. This agreed with Pearce and Moir (1964) and Chai et al. (1988) who reported that preventing rumination by muzzling caused a marked reduction of DM intake.

The sheep with absesses spent less time for eating than the other sheep, whereas time spent eating per DM intake in the sheep was about 4 times greater than the mean of those in the other sheep (29.3 vs. 6.7 min • $BW^{0.75}$/gDM). This may reflect an effort by the sheep to compensate for the lack of normal rumination after feeding. Chai et al. (1988) reported that muzzling decreased DM intake but increased the number of eating chews resulting in smaller particle size in the swallowed boli.

The sheep with absesses was apparently restricted rumination to very short time. In addition, proportion of actual chewing time during rumination was abnormally small. Time spent for pseudo-rumination was similar with rumination time of the other sheep. These results indicate that regurgitation of solid bolus from the rumen was restricted, while rumen fluid containing small particles could be regurgitated to some extent. This may explain the results that proportions of large particle and fine particle in the RR were greater and the proportion of particle in middle size was smaller in the sheep with absesses than those in the other sheep. There is no doubt that the restriction of remastication of large particle resulted in reduced rate of reduction in size to less than 1 mm which is regarded as the critical size to pass the reticulo-omasal orifice (Poppi et al., 1980; McLeod and Minson, 1988) in the sheep with absesses.

Another processes involved in particle size reduction of rumen digesta are microbial digestion and ruminal detrition (Murphy and Nicoletti, 1984; McLeod and Minson, 1988). Pearce and Moir(1964) reported that muzzling resulted in fewer bacteria in the rumen. Activity of rumen microbes and ruminal detrition might be affected in the sheep with absesses. However, no measurements were made in bacterial count, cellulolytic activity of rumen microbes and rumen motility in the present experiment.

The reduced rate of breakdown in size would result in a lowering of passage of particulate matter through the reticulo-omasal orifice, and hence a longer retention time in the RR. The sheep with absesses had abnormally longer retention time (about 4-5 times) in the present experiment. Preventing rumination by muzzling caused a reduced rate of passage of forage material from the rumen

(Pearce and Moir, 1964) and a longer rumen fluid retention time(Chai et al., 1988).

It is concluded that normal rumination was restricted in the sheep with absesses at the cardia and hay intake was markedly decreased. Presumably the limitation of intake resulted from the reduced rate of clearing of particles from the rumen. The process of normal rumination is critical in reducing the size of particles in the RR and the subsequent passage of digesta from the rumen.

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