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The Eating and Rumination Behaviour in Sheep Fed only Herbage Diet in the Fresh Form†

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生草給与時におけるメンヨウの採食・反芻行動について

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It is well known in ruminants that rumination behaviour is considerably influenced by difference in chemical property of the diet.[1,2,3] Especially, the crude fibre content of roughage diet should effect on the time spent ruminating.[4] It has been suggested that when sheep were given a similar amount of hay the daily time spent eating and ruminating was fairly changed by differences in hay species and fibre content.[5,6,7]

The food value of herbage should be decreased by the progress of growing stage in plant, and this would be due to the increase of crude fibre (cellulose) in plants and the decrease of dry matter digestibility as plants mature.[8] Ishiguri[9] reported that in seasonal variation of feeding value of hay prepared from a same pasture, the quality of the 1st cutting hay was lower grade than that of the 2nd cutting hay.

Relatively little work has been reported on rumination behaviour in relation to the quality of herbage diet in the fresh form, although it has been discussed in relation to the fibre content of herbage in sheep by Harumoto and Kato.[4] In the present experiment, the eating and rumination behaviour of sheep was investigated when they were given the fresh herbage harvested at different times from a same pasture.

EXPERIMENTAL PROCEDURE

The herbage was harvested at three times (May, July and October ; 1st, 2nd and 3rd cutting, i. e. forage A, B and C) from the same pasture (Italian ryegrass/red clover). The daily ration of fresh herbage was harvested each morning from the pasture, and was cut to about 5 cm long before feeding. The chemical composition (as % D. M.) of herbage, determined by the method of A. O. A. C.,[10] is shown in Table 1.

Three Japanese Corriedale male sheep (no. k433, k468 and k790) and four wethers (no. 441, 501, 503 and 523), weighing 22-32 kg, were used repeatedly. These sheep were

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† Studies on the roughage utilization in sheep. No. 2.

Table 1. Chemical composition of diet

Diet	Organic matter	Crude protein	Crude fat	Crude fibre	NFE*
Forage A (1st cut)	90.4#	10.6	3.5	30.3	46.0
Forage B (2nd cut)	90.1	17.5	3.6	23.8	45.3
Forage C (3rd cut)	90.5	21.4	3.6	21.0	45.3

* Nitrogen free extract.
\# % of dry matter.

allocated for the three feeding treatments as follows ; forage A, 503 and 523 ; forage B, 501, 523, k433, k468 and k790 ; forage C, 441, 501 and 523, respectively. The sheep were kept in the metabolism cages throughout the experimental period. Five-day sampling periods were preceded by 7-day preliminary periods. Each sheep was given a diet in which the dry matter was 1.8-2.4% of body weight per day. Water and salt licks containing trace minerals were accessible at all times. One-half of the daily ration was given at 09:00 h and the another half at 17:00 h. During the 5-day sampling period the time spent chewing during eating and rumination was measured daily by the method of Fujihara[5] using a wire strain guage on the lower jaw.[11] The terms used for indicating rumination behaviour is the same as in a previous report of Fujihara[6] based on the work of Gordon.[12]

RESULTS and DISCUSSION

As shown in Table 1, the contents of organic matter, crude fat and NFE were similar on all these forages. Crude protein content tended to increase with an increase of cutting times of herbage, and the crude fibre content tended to decrease with the progress of cutting times from 1st to 3rd. The high content of crude protein and the low content of crude fibre with forage C (3rd cutting) would be due to predominant in number of clover in the pasture. In general, crude protein content is higher in clover than in Italian ryegrass, and the fibre content of clover is lower than that of Italian ryegrass.[13] The chemical composition of forage A was in agreement with that generally accepted for a predominantly Italian ryegrass pasture (1st cutting). In forage B (2nd cutting), the nutrient contents was similar to those reported previously.[14]

Table 2 shows the eating and rumination behaviour of sheep given only herbage diet in the fresh form. The time spent eating forage C was markedly shorter than for forages A and B, and the value was similar to that of Fujihara.[5] This result suggested that the forage C was easily formed into a bolus for swallowing. According to Osuji et al.,[15] the energy cost was high per unit of dry matter ingested when the rate of eating of sheep was slow. Therefore, it can be assumed that the energy cost of eating forage C was low and was markedly lower than those for forages A and B in the present experiment. The time spent eating forage A and B was fairly longer than that of fresh grass reported by Fujihara.[5] The rate of eating forage A was slower than that of forage C and that of earlier report.[5] Fujihara and Nakao[7] suggested that the difference in time spent eating hay could be due to a difference in hay species and quality. In the present study, it would seem that forage

Table 2. Eating and rumination behaviour in sheep fed only grass diet in fresh form

	Forage A (2)†	Forage B (5)	Forage C (3)
Time spent eating (min)	195.0± 8.0*	188.5±18.1	119.7±15.5
Rate of eating (g D.M./min)	2.5± 0.3	3.7± 0.4	4.8± 0.7
Daily time spent ruminating (min)	528.3± 55.1	512.2±30.5	567.1±12.7
Daily no. of boli regurgitated	683.5±138.5	562.2±30.7	543.4±17.2
Daily no. of rumination periods	15.9± 2.9	24.8± 2.2	18.2± 0.5
Cyclic rate (sec)**	48.6± 4.2	54.4± 1.9	63.0± 2.8
Time spent per rumination period (min)	33.7± 2.7	21.6± 2.4	29.9± 0.9
No. of boli per rumination period	42.8± 0.9	25.0± 2.9	28.7± 1.5
Rumination index***	116.1± 31.2	81.1±10.5	104.3±12.4
No. of chews per bolus	62.7± 0.1	59.3± 3.6	—
Bolus time (sec)	37.7± 0.3	43.5± 4.0	—
Rumination chewing rate/min	100.8± 0.0	74.4± 7.8	—

* Mean±S.E. of 2–5 sheep.
** Total rumination time/no. of boli regurgitated.
*** Time spent ruminating per 100 g D.M. eaten.
† Number of sheep used.

C contained more clover than Italian ryegrass. The fact that the time spent eating forage A was much more than forage C would be caused by a difference in forage quality as indicated in Table 1. Thus, the difference in quality, especially crude fibre content, of fresh herbage might cause a difference in a ease of making boli for swallowing, and this could result in a difference of eating time in feedings of forages A and C.

As shown in Table 2, the daily time spent ruminating was greater with forage C than with forages A and B. The daily number of boli regurgitated, however, was fairly small with forage C compared with those of forages A and B, though there were considerable variations of values among the experimental animals. The value on the forage C was closely agreement with that reported previously[5], in which sheep were given the fresh grass only. Harumoto and Kato[4] reported that when sheep were given fresh grass or legume, the time spent ruminating and the number of chews were more with grass diet than legume. They also described that the time spent ruminating per unit of ingested crude fibre was more with legume than with grass diet. The fact that the time spent ruminating with forage C was slightly higher than that with forage A in the present study, might be due to the increase of amount of clover in the forage eaten. It has been noted that the ratio of lignin to crude fibre varies with forage species, particularly between grasses and legumes, the latter having a much higher proportion of lignin and lower fibre digestiaility than the former.[16] In the present experiment, the digestibility of crude fibre was fairly lower in feeding of forage C than in feedings of forages A and B.[17] From these results described above, it is assumed that the time spent ruminating of sheep fed only fresh herbage should be influenced by the herbage species as same as the amount of crude fibre contained in the forage.

Balch[2] proposed that the total time spent by ruminants in chewing their food, during eating and during ruminating, should be reasonable as an expression of the response of the animal to the physical fibrousness of roughage feed. Thus, he also proposed "roughage

index'' which was indicated as the time spent chewing (eating plus ruminating) per kg dry matter eaten. This index might show the work done by ruminant in comminuting the food. In the present experiment, the total time spent during eating and ruminating was 723, 700 and 686 minutes per day in the feedings of forages A, B and C, respectively. This result shows that the total time spent during eating and ruminating would be prolonged with an increase of crude fibre content in the forage eaten.

The daily number of rumination periods in feeding of forage A or C was comparable to that observed in sheep fed the ground timothy hay[19], and was smaller than in feeding of forages B. The value in feeding of forage B was very in agreement with that reported previously.[5] The number of rumination periods per day in feeding of forage C was close agreement with that of Fujihara,[6] in which sheep were fed the diet of fibrous-residue silage of broad bean plus timothy hay (equal amount of dry matter). According to Campling,[19] the number of rumination periods per day was not affected by the changes of amounts and types of roughage feed in cows. Recently, Okamoto[18] reported with sheep that the daily number of rumination periods tended to decrease with an increase of the ratio of small particle in ground or chopped hay diet.

Cyclic rate defined by Gordon,[20] i. e. total rumination time (in seconds)/number of boli regurgitated, with forage C was longer than with forages A and B. The figure with forage B was slightly longer than with forage A, and was comparable with that previous result[5] using sheep fed only fresh grass. These results show that reticulo-ruminal contractions became slower[20] when feeding forage C than when forages A and B. It is also suggested that cyclic rate closely related to the crude fibre content of forage eaten (see Table 1).

Time spent ruminating per rumination period was longer with forage A or C than with forage B. The number of regurgitation boli per rumination period in the feeding of forage A was larger than that in the feedings of forages B and C, and the value was larger than that reported previously[5] using sheep fed the fresh grass diet. Okamoto[19] reported with sheep that the time spent ruminating and the number of boli regurgitated within each rumination period were increased with an increase in moduli of fineness of timothy hay. Recently, Fujihara and Nakao[7] reported that some variations in the time spent chewing and the number of regurgitation boli within each rumination period would be caused by a difference of hay species when sheep were fed various hays. Rumination index on the forages A and C was larger than that reported previously with fresh grass,[5] and the values were rather similar to that with timothy hay[7] or cocksfoot hay.[6]

On the feedings of forages A and B, the efficiency of rumination for comminuting the food eaten was estimated by measuring the number of chews per bolus, bolus time (average time in seconds spent chewing per bolus) and the rumination chewing rate. The number of chews per bolus with forage A was slightly more than that with forage B, and the value was similar to the result with sheep fed only fresh grass diet.[5] Harumoto and Kato[4] also reported that the number of chews per bolus was decreased with a decrease of crude fibre content of roughage eaten. Bolus time was slightly shorter with forage A than with forage B. Accordingly, the rumination chewing rate was higher in forage A feeding than in forage B feeding. From these results it is concluded that rumination by these sheep was more intensive and efficient in forage A feeding than in forage B feeding.

From the results obtained in the present experiment, it is concluded that some variations

in eating and rumination behaviour of sheep fed a fresh herbage only would be caused by a difference n crude fibre content of herbage eaten as same as herbage species.

SUMMARY

In the present experiment, the eating and rumination behaviour of sheep was investigated after feeding of the herbages harvested at three times (1st, 2nd and 3rd cutting ; forage A, B and C) from the same pasture (Italian ryegrass/red clover).

Crude protein content of herbage tended to increase with an increase of cutting times (1st to 3rd), and contrarily, the content of crude fibre tended to decrease with an increase of cutting times. This would be caused by an increase of the clover ratio in the pasture plants.

The time spent eating forage C was markedly shorter than for forages A and B, and thus, the rate of eating was fairy fast in the feeding of forage C. This might indicate that forage C was more easy to make into a bolus for swallowing than forages A and B.

The time spent ruminating per day was greater with forage C than with forages A and B. The total time spent chewing (eating plus ruminating) was 723, 700 and 686 minutes per day in forages A, B and C, respectively, and these figures are in proportion to the content of dietary crude fibre. This result suggests that the time spent chewing for comminuting the food eaten, during eating and during ruminating, would be greately influenced by a difference in the contents of dietary crude fibre.

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摘　　要

生草給与時のメンヨウにおける採食・反芻行動について検討するため，イタリアンライグラスと赤クローバの混播草地から刈取った，1，2および3番刈の生草を各々乾物で1日1頭当り体重の1.8〜2.4%の量をメンヨウに給与して，7日間の予備期の後連続5日間の採食・反芻行動について調査した．

生草中の粗蛋白含量は刈取り時期がすすむにつれて増加し，一方粗繊維含量は低下したが，3番草では1・2番草に比べて赤クローバの混入割合が高くなったためと思われる．

1日当りの採食時間は1・2番草給与時に比べて3番草給与時では著しく短かくなり，そのため採食速度は3番草給与時で速くなった．このことは3番草では1・2番草に比べて柔らかく，口腔内で呑み込むために適当な食塊になり易いことを示している．

1日当りの反芻時間は3番草給与の場合に，1・2番草給与の場合より若干長くなった．しかし1日当りの採食＋反芻に要した時間では，1，2および3番草給与時でそれぞれ723，700および686分と，給与生草の粗繊維含量の多い順に長くなった．この事から，1日当りの総咀しゃく時間（採食＋反芻）は給与草中の粗繊維含量の違いによって著しく影響をうけることが明らかになった．

（メンヨウにおける粗飼料の利用性に関する研究　2）