THE EFFECT OF A GRADUAL INCREASE OR DECREASE OF DAILY HAY INTAKE ON EATING AND RUMINATING BEHAVIOUR IN SHEEP

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Summary

In the present experiment, the relationship between rumination and the amount of roughage eaten by sheep was investigated in detail. Daily time spent eating was obviously changed along with an increase or decrease in daily hay intake. Daily time spent ruminating and daily number of boli regurgitated was also linearly increased or decreased with an increase or decrease of daily hay intake, and there were regression lines between daily amount of hay eaten and daily ruminating time or daily number of boli with statistical significant coefficients. Cyclic rate (total rumination time(s)/number of boli regurgitated) and daily number of rumination periods did not change in an outline along with the changes in daily hay intake. From these results, it can be suggested that daily dry matter intake by sheep could be presumed by measuring daily time spent ruminating when they were fed only roughage feed.

(Key Words: Sheep, Daily Hay Intake, Eating Behaviour, Rumination)

Introduction

It is obvious that the roughage utilization in ruminants would be influenced by an extent of ruminal fermentation, and the act of chewing during eating and ruminating has an important role to reduce the particle size of ingested roughage feed, which could facilitate microbial fermentation in the rumen (Gordon, 1958). The eating and ruminating behaviour appears to be influenced clearly by physical property and chemical composition of feed eaten (Campling et al., 1962; Morgan and Campling, 1978; Ørskov et al., 1974; Fujihara, 1980). There is also another factor affecting the rumination behaviour in roughage feeding, which is the amount of feed eaten (Hancock, 1954; Gordon, 1965; Welch and Smith, 1969; Harumoto and Kato, 1978). Hancock (1954) has reported formerly that daily time spent ruminating was greatly changed with the changes of quality and quantity of ingested forage ration, and there were also quite big variation among individuals. Welch and Smith (1969) have reported with rams that progressing from 250 g/d offerings of hay to 1,800 g/d in continuous feeding experiment produced a curvilinear increase in rumination time with a maximum in the range between 500 to 600 minutes per day. Gordon (1965) has also reported with sheep that daily ruminating time might be periodically increased with an increase of hay intake, *i.e.*, the typical curve of increasing rumination appears to be in three or possibly four parts, and then, something approaching a plateau occurring at certain daily hay intake, when each sheep was additionally fed a total of 300 g of grain mixture per day. There are also some observations on the changes of eating and ruminating behaviour with an increase of forage intake by sheep (Okamoto, 1979) and cattle (Harumoto and Kato, 1978). These observations would show that daily rumination time appears to be increased curvilinearly with an increase of roughage intake. Relatively little work has been done on the relationship between rumination and the amount of roughage intake, in which the range of daily change in roughage intake was relatively small (Gordon, 1965).

On the other hand, there is no correct and simple method for measuring the forage intake by grazing animals in the existing circumstances. If there is a relatively positive relationship between rumination and the amount of forage eaten, it could be useful method for estimating the amount

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of forages ingested by grazing ruminants.

In the present study, the eating and ruminating behaviour in sheep fed only forage ration were investigated in detail, when the amount of daily intake was increased or decreased gradually at a level of small amount.

Materials and Methods

Animals and diets

Two Japanese Corriedale male sheep (nos. 531 and K790) and one wether (no. 503), and three cross bred wethers (Corriedale X Suffolk) (nos. F533, F535 and F537), each weighing 24-35 kg, were used repeatedly. These sheep were allocated for the two experiments as follows: experiment I, 503, F535 and F537; experiment II, 531, F533 and K790, respectively.

The sun-cured hay was made from the herbage harvested at heading stage from a predominantly Italian ryegrass or cocksfoot pasture (1st cut), and the chemical composition (% of D.M.) of each hay, determined by the methods of AOAC (Hoitz, 1960) and Van Soest and Wine (1971), is shown in table 1.

Experimental procedure

Experiment I

The experimental animals were kept in the metabolism crates throughout the experimental period of 21 days. During the initial 7 days of experimental period, each animal was offered 600 g (about 2.0% D.M. of body weight) of hay per day to roughly equalize the ruminal contents, and then the daily amount of hay offered was gradually increased (50 to 700 g/head) during 14 days (8th-21st day). One-half of the daily ration was given at 09:00 h and another half at 17:00 h. Fresh water and salt licks containing trace minerals were freely available at all time.

Experiment II

After the experiment (A) as same as experiment I except animals and hay used, during 7 days each animals was daily offered 600 g of hay, and daily amount of hay offered was gradually decreased (700 to 50 g) during 14 days (8th-21st day) (B). The other experimental procedures were similar to that of experiment I mentioned above.

In both experiments, during 14-day sampling period the time spent chewing during eating and ruminating was measured daily from records of jaw movement using a wire strain gauge held against the under-jaw of each animal according to the procedure described by Harumoto and Kato (1979). The statistical analysis of the data was made by t-test (Yoshida, 1975).

Results

Experiment I

The hay used in expt. I was somewhat low quality as shown in table 1, as compared with that used in expt. II, i.e., the protein content was relatively lower and the crude fibre content was contrariwise relatively higher in the former than in the latter.

Figure 1(a) shows the changes in daily time spent eating, daily rumination time and daily number of boli regurgitated in sheep, when daily amount of hay was gradually increased from 50 g to 700 g/head. The time spent eating hay was almost linearly increased with an increase of daily hay intake, and there was a regression line between the eating time (Y) and daily amount of hay eaten (X) as follows; Y = 49.86 + 0.27X,

TABLE 1. CHEMICAL COMPOSITION OF HAY (PERCENT OF DRY MATTER)

Experiment		Organic matter	Crude protein	Crude fat	Crude fibre*	NFE**
I	(Hay I)***	92.7	11.2	1.7	35.9	43.9
II	(Hay II)#	93.5	12.9	2.4	28.9	49.3

*NDF: 68.1 & 71.3 (Hay I & II), ADF: 36.2 & 40.2 (Hay I & II).
**Nitrogen free extract.
***Italian ryegrass hay (Late heading stage)
#Cocksfoot hay (heading stage).

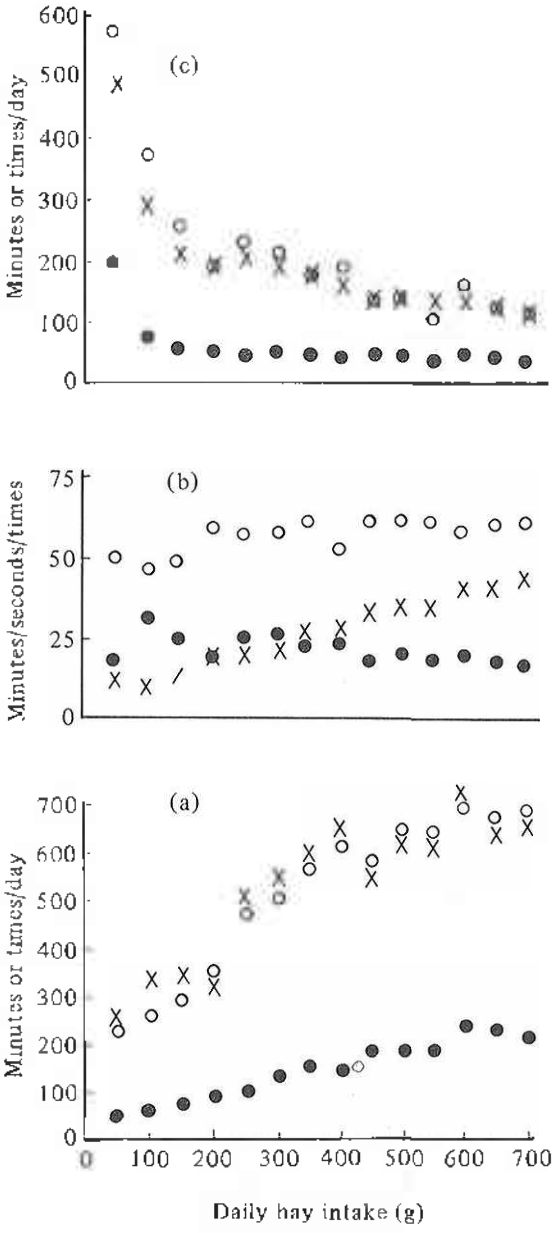

Figure 1. The eating and rumination behaviour in sheep with the increase of daily hay intake (Experiment I). (a) Time spent eating (●), rumination time (○) and the number of boli regurgitated (X); (b) Rumination period (●), rumination time/rumination period (X) and cyclic rate (○); (c) Time spent eating (●), rumination time (○) and the number of boli regurgitated (X) per 100g dry matter eaten.

and the coefficient of correlation ($r = 0.865$) was significant statistically ($p < 0.01$). Daily time spent ruminating and daily number of boli regurgitated were also increased linearly with an increase of daily hay intake, and there were also regression lines between the rumination time (Ya) or daily number of boli (Yb) and daily hay intake (X) as follows; $Ya = 229.96 + 0.75X$ ($r = 0.898$) and $Yb = 286.28 + 0.63X$ ($r = 0.806$), respectively. The both coefficients of correlations were also significant statistically ($p < 0.01$). As shown in figure 1(b), rumination periods and cyclic rate (total rumination time(s)/number of boli regurgitated) were not changed largely with an increase of daily hay intake, although rumination periods was a little bit more in feeding of small amount hay (50-150 g/d). Therefore, time spent ruminating per rumination period was gradually, but slightly, increased with an increase of daily hay intake as same as daily time spent ruminating.

Figure 1(c) shows the time spent eating, rumination time and the number of boli regurgitated per 100 g dry matter eaten, when daily hay intake by sheep was gradually increased from 50 g to 700 g. The time spent eating was almost similar when daily hay intake was in a range between 100 g to 700 g, and the time spent ruminating and the number of boli were also similar in a range of daily hay intake between 200 g to 700 g per head.

Experiment II

The hay used in expt. II was slightly high quality as compared with that used in expt. I, as mentioned above. As shown in figure 2(a), daily time spent eating hay was linearly increased with an increase of daily hay intake, and there was a regression line between daily time spent eating (Y) and daily hay intake (X) as follows; $Y = 9.45 + 0.18X$, and a coefficient of correlation ($r = 0.987$) was significant statistically ($p < 0.01$). Daily time spent ruminating and the number of boli regurgitated were also linearly increased with an increase of daily hay intake, and there was also regression line between daily time spent ruminating (Y) and daily hay intake (X) as follows; $Y = 146.59 + 0.53X$, and a coefficient of correlation ($r = 0.985$) was statistically significant ($p < 0.01$). As shown in figure 2(b), the number of rumination periods and cyclic rate did not change markedly with an increase of daily hay intake, and therefore, the rumination time during a rumination period

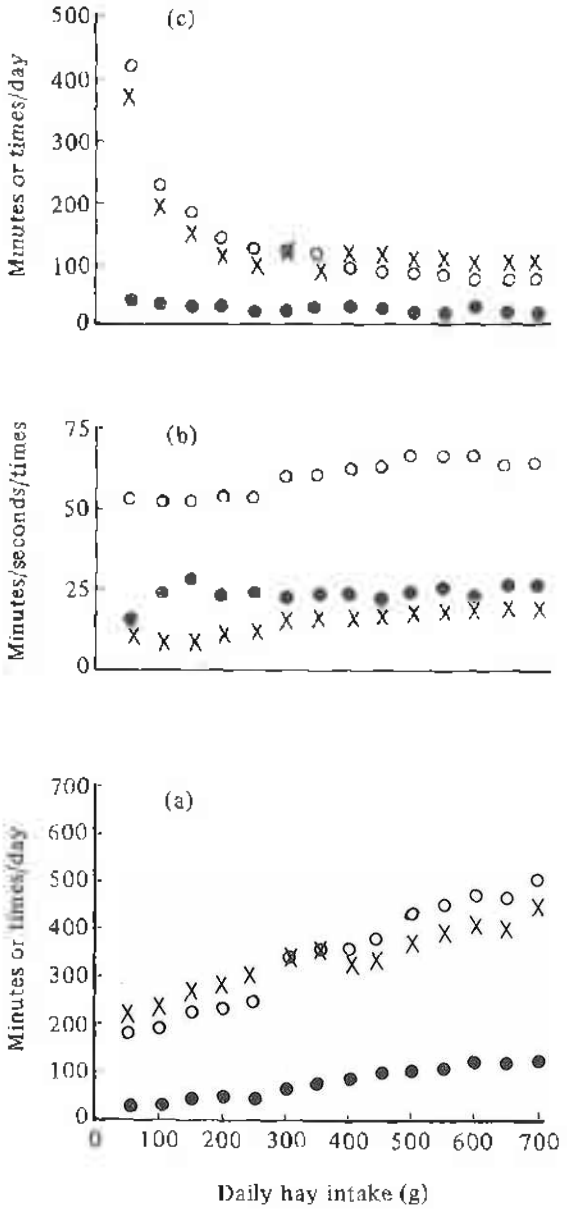

Figure 2. The eating and rumination behaviour in sheep with the increase of daily hay intake (Experiment II). (a) Time spent eating (●), rumination time (○) and the number of boli regurgitated (X); (b) Rumination period (●), rumination time/rumination period (X) and cyclic rate (○); (c) Time spent eating (●), rumination time (○) and the number of boli regurgitated (X) per 100 g dry matter eaten.

resulted in increase slightly.

Figure 2(c) shows the time spent eating, time spent ruminating and the number of boli regurgitated per 100 g dry matter eaten by sheep when they were fed a hay diet at daily level of 50 g to 700 g. The time spent eating 100g dry matter did not change with an increase of daily hay intake. The time spent ruminating and the number of boli regurgitated also did not change with an increase of daily hay intake, when sheep were fed daily in a range between 200 g to 700 g hay.

Figure 3(a) shows the changes in daily time spent eating, daily time spent ruminating and daily number of boli regurgitated in sheep when daily amount of hay offered was gradually decreased from 700 g to 50 g during 14 days. Daily time spent eating diet was decreased with a decrease of daily hay intake, and there was a regression line between the eating time (Y) and daily amount of hay eaten (X) as follows; $Y = 10.28 + 0.18X$, and the correlation coefficient ($r = 0.978$) was significant statistically ($p < 0.01$). Daily time spent ruminating and daily number of boli regurgitated were also linearly decreased with a decrease of daily hay intake. There was also regression line between daily time spent ruminating (Y) and daily hay intake (X) as follows; $Y = 166.01 + 0.47X$, and the coefficient of correlation ($r = 0.974$) was significant statistically ($p < 0.01$).

As shown in figure 3(b), daily number of rumination periods and cyclic rate were not changed with a decrease of daily hay intake, and as a result, the rumination time per rumination period resulted in a slight decrease with a decrease of daily hay intake.

Figure 3(c) shows the eating time, rumination time and the number of boli regurgitated per 100 g dry matter eaten by sheep. The eating time did slightly increase when the amount of hay offered daily was quite small (150-50 g), and the rumination time and number of boli did rapidly increase with small amount of hay offered daily in a range between 100 g to 50 g.

Discussion

Daily time spent eating hay diet in average was slightly longer in experiment I than that in experiment II, and this would be due to the differences of kind and quality of hay used in both experi-

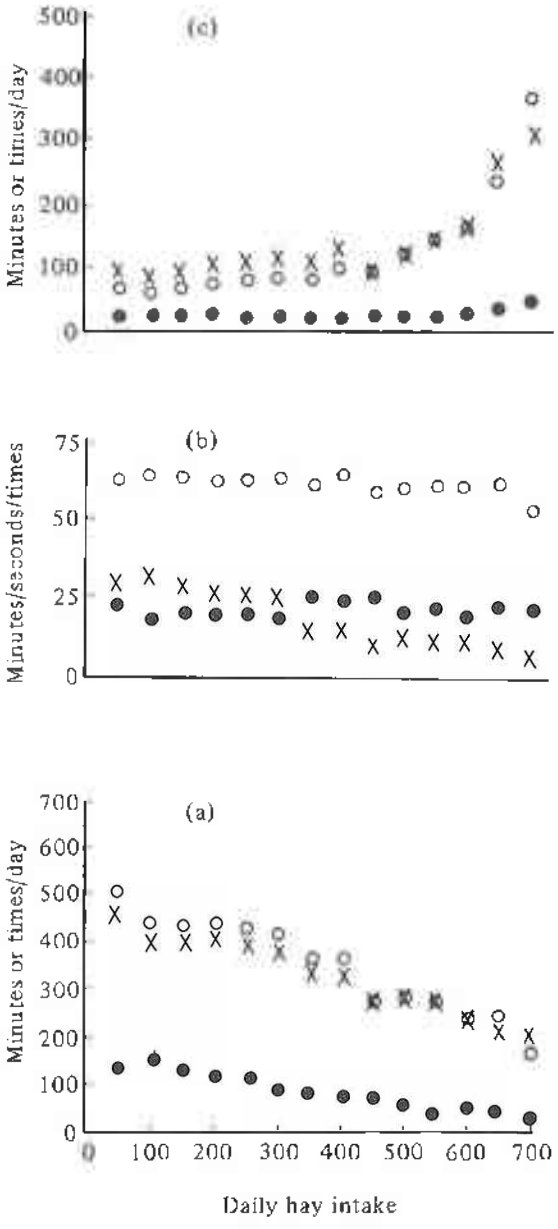

Figure 3. The eating and rumination behaviour in sheep with the decrease of daily hay intake (Experiment II). (a) Time spent eating (●), rumination time (○) and the number of boli regurgitated (X); (b) Rumination period (●), rumination time/rumination period (X) and cyclic rate (○); (c) Time spent eating (●), rumination time (○) and the number of boli regurgitated (X) per 100 g dry matter eaten.

ments. In our previous results (Fujihara, 1981; Fujihara and Nakao, 1982), it was also shown that some differences in eating time in sheep fed various roughages were obviously due to the differences in physical form and/or quantity of dietary fibre drived from some differences in the original plants.

Daily time spent eating hay diet almost linearly increased with an increase of daily hay intake (figures 1(a) and 2(a)), and also decreased linearly with a decrease of daily hay intake (figure 3(a)). Daily time spent eating per 100 g dry matter of hay was relatively longer when daily hay intake was quite small (50-150 g) than when daily hay intake was in a range between 200 g to 700 g. This finding did not always agree with that reported by other workers (Freer and Campling, 1965), in which the rate of eating diet was faster with small amount than that with large amount of ration. Freer and Campling (1965) have described that the complementary relationship between the time spent eating and the time spent ruminating was observed with diets of hay and dried grass, that is, the rate of eating roughage was fast with small amounts of food, and the rumination per unit (pound) food high; with large amounts of food opposite trends occurred so that the total amount of chewing per unit (pound) food was about the same. In the present study, however, any complementary relationship between the eating time and ruminating time was not found when daily amount of hay eaten was increased or decreased gradually.

In the present study, there was a regression line between daily time spent ruminating and daily amount of hay eaten, and this do not agree with the results obtained by other workers (Hancock, 1954; Welch and Smith, 1969; Harumoto and Kato, 1979; Okamoto, 1979), in which there were quadratic regression between the daily rumination time and daily hay intake in sheep or cattle. The differences in both experiments would be due to the differences in the rate of daily change of hay eaten. Then, in the present study, if the data was summarized according to the rate of 200 g hay intake per day, the regression between the rumination time and daily hay intake also obviously showed a quadratic.

According to Gordon (1965), the typical curve of increasing rumination with an increase of hay intake appeared to be in three or four parts, i.e., the first of all there was rapid rise from minimum

hay intake, then something approaching a plateau occurring at a daily hay intake range 200-300 g. In the present experiment, however, we could not find any 'plateau' phenomenon in all sheep when either the daily hay intake was gradually increased or it was decreased gradually. It may be a reason that the feeding level before experiment should obviously affect the rumination behaviour i.e., in the present study, daily feeding level of hay during the preliminary period (7-day) was about 2.0 % D.M. of body weight to equalize the rumen volume at the opening of experiment, and in Gordon's experiment, the sheep had been eaten daily 300 g of hay during the preliminary period.

On the receptor of a reflex to ruminate, it is generally accepted that there is a organ obviously which may be an end of the exciter (Hill, 1957, 1958). It has been also recognized that the rumination can be originally induced by some elongative stimuli to the cardia, the reticulo-rumen wall and/or the reticular wall, and mainly a rumination seems to be clearly induced with stimulation of a tactile receptor in the reticular wall induced by tactile stimuli of some coarse particles of food eaten (Schalk and Amadon, 1928; Ash and Kay, 1957, 1959). It may be also assumed that some other tactile stimuli to another digestive organs except the reticulo-rumen is another important factors stimulating the rumination activity (Harding and Leek, 1973). Therefore, the results obtained in the present study, in which the rumination activity was markedly stimulated or suppressed with an increase or a decrease of daily hay intake by sheep, would have been occurred with an increase or a decrease of tactile stimuli to the reticulo-rumen wall as a receptor related to rumination in changing the amount of roughage eaten day to day.

In the present study, the body weight of experimental animal was slightly different in each experiment, and that was not always similar in both experiments I and II. Therefore, to standardize the result with the relationship between the daily hay intake and daily time spent ruminating, the rumination time was shown in relation to the changes of dry matter intake per metabolic body size ($B.W.^{0.75}$) of each animal (see figure 4). There was also a regression line between daily time spent ruminating (Y) and daily intake of dry matter per kg $B.W.^{0.75}$ (X) as follows; Y = 207.48 + 113.5X (figure 4(a)), Y = 140.13 + 90.00X

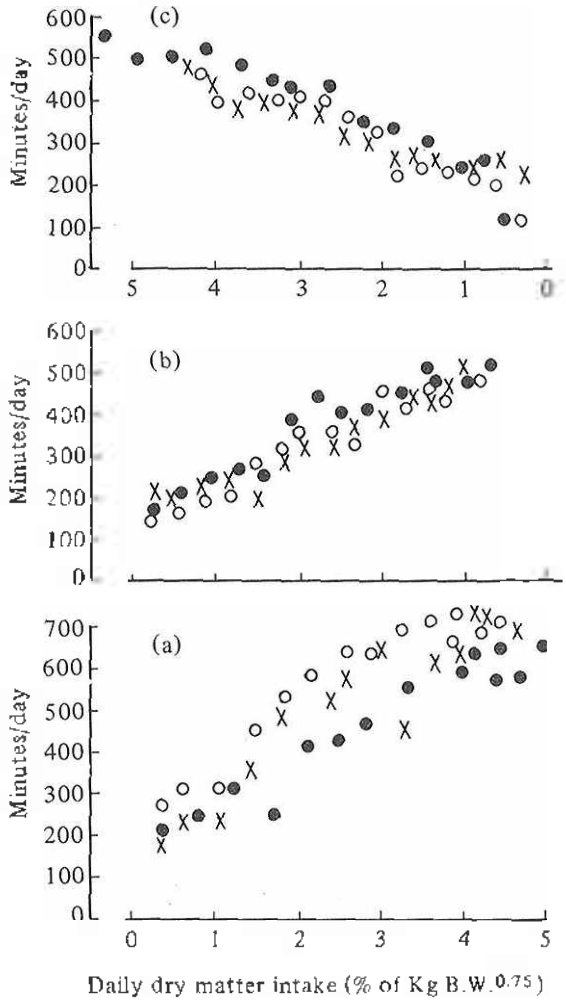

Figure 4. The changes in daily time spent ruminating per dry matter intake (% of Kg $B.W.^{0.75}$) of each sheep (No.1: X, No. 2: ○, No.3: ●). (a), Experiment I; (b), Experiment II; (c), Experiment II.

(figure 4(b)) and Y = 153.61 + 75.89X (figure 4(c)) in experiment I and II, respectively, and the coefficients of correlation in each regression line, r = 0.901, 0.950 and 0.942 were significant statistically ($p < 0.01$). As a result, the regression line calculated was obtained using all the data (n = 46) as follows; Y = 158.85 + 96.9X, and coefficient of correlation ($r = 0.830$) was also significant statistically ($p < 0.01$). This final regression line would be useful to presume the daily dry matter intake in sheep fed only hay containing crude fibre in a range between 29-36% D.M. by measuring the

daily time spent ruminating.

It is considered in ruminants that the boli regurgitation during ruminating will be occurred in concert with a contraction of the reticulum, and that a contraction of the reticulum do not change with the change of quantity or quality of food eaten (Balch, 1952). According to Campling (1966), the daily number of rumination periods did not change with the change in dietary characteristics and/or the daily time spent ruminating, though there were obvious differences among individuals. The results obtained in this study confirm the facts mentioned above in an outline, though there were slower cyclic rate and slight increase of the daily number of rumination periods during the period which the daily amount of hay intake was relatively small (50-150 g). From these facts, it can be concluded that cyclic rate and daily number of rumination periods as mechanical factors induced in the rumination activity can not be influenced by the change in amounts of food eaten.

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