

EFFECTS OF ALTERNATING 6-HOUR LIGHT/DARK CYCLES ON THE RUMINATING BEHAVIOR OF FASTED GOATS

S. Oshiro¹, H. Nakamae, K. Furuta, M. Hirakawa and H. Higoshi

College of Agriculture, University of the Ryukyus, Nishihara-cho, Okinawa-ken, 903-01 Japan

Summary

Experiments were conducted to study the effects of a dark (06:00-12:00), light (12:00-18:00), dark (18:00-24:00), and light (00:00-06:00) cycle on the ruminating behavior of five fasting female goats. Ruminating time and number of boli were not different in the dark and light periods of the fed state or in the second and third days of fasting. Ruminating time and number of boli increased in the dark (06:00-12:00) period compared to the light (12:00-18:00) period during the first day of fasting. Ruminating time was higher after the first day of fasting than the fed state, and decreased substantially after the first day of fasting than the fed state, and decreased substantially after the second and third days of fasting compared to the fed state or the first day of fasting. Number of boli/day was not different among the fed state, the second and third days of fasting but was higher after the first day fasting compared to the fed state.

(Key Words : Dark, Light, Ruminating, Feeding, Fasting, Boli)

Introduction

The most common finding from many behavioral observations of ruminating rhythms in cattle, sheep and goats in terms of darkness (Gordon, 1958b; Gordon and McAllister, 1970), night (Bell and Lawn, 1957; Dulphy et al., 1989; Gordon, 1958a; Oshiro, 1985a, 1985b; Oshiro and Kojima, 1987; Welch and Smith, 1971) and normal daylight (Metz, 1975; Sato et al., 1987) was that rumination occurred more during the night or darkness. Gordon and McAllister (1970), Gordon (1958b), Murphy et al. (1983) and Pearce (1965a, 1965b) claimed that rumination was independent of any relationship with eating in sheep. Oshiro et al. (1992) reported that ruminating behavior markedly decreased in two hours after sunset in normal daylight. Oshiro et al. (1992) concluded that the daily light/dark cycle was important in determining the circadian rhythm of ruminating behavior, and the circadian rhythm of ruminating behavior markedly decreased after 2 hours in darkness. Oshiro et al. (1992) reported that number of boli/day of fasting goats maintained for three days after fasting, and ruminating time increased for the first day of fasting compared to fed animals, but decreased acutely during the second and third

days of fasting. The objective of the present experiments were to clarify the ruminating behavior under a daily dark-light-dark-light cycle with fasting goats.

Materials and Methods

Five female Saanen cross-bred goats which weighing 46 ± 5 kg were used for the experiment and housed in individual metabolic cages. The animals were allowed water *ad libitum*, and in the fed state, were given access to alfalfa hay cubes ($2.3 \times 2.3 \times 1.7$ cm) with a continuous feeder (Oshiro and Katayama, 1987). The experimental room had no natural light, and the photoperiod was controlled artificially. Air temperature and relative humidity were $24.6 \pm 0.6^\circ\text{C}$ and $73 \pm 5\%$, respectively. An alternating photoperiod of dark (06:00-12:00), light (12:00-18:00), dark (18:00-24:00), light (00:00-06:00) was used, and the goats were allowed to become accustomed to it for 4 weeks. Then jaw movements were recorded continuously for three days with a computerized auto-counter and analyzer (Oshiro et al., 1987). After observations of the goats in the fed state were completed, jaw movements were observed and recorded for three days of fasting. Jaw movements were analyzed into three components by discriminating between rumination and mastication with a computerized auto-counter after determination of resting time without jaw movement: rumination, resting time, and mastication.

¹Address reprint requests to Dr. S. Oshiro, College of Agriculture, University of the Ryukyus, Nishihara-cho, Okinawa-ken, 903-01 Japan.

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Rumination was further analyzed into its constituent parts: number of boli (boli/day, boli/hour), ruminating time (min/day, min/hour), number of remastications (chews/day), remasticating time (min/day), intermittent time (min/day), bolus time (cycle rate of regurgitation; sec/bolus), remasticating time/bolus (remasticating time spent on each bolus; sec/bolus), intermittent time between boli (sec/bolus), and number of remastications/bolus (chews/bolus) in each rumination, and averages for all of these within each hour of rumination and within each day. Mastication was analyzed into number of mastications (chews/day) and masticating time (min/day, min/hour) averaged for all of

these within each hour of the day and within each day. All data between the time spans (6 hour; dark or light) were statistically ($p < 0.05$) analyzed by SAS-GLM in Tukey methods.

Results and Discussion

Rumination and mastication behavioral data are shown for all feeding and fasting periods in table 1. Only the number of boli increased significantly after one day of fasting compared to the fed state. Ruminating time, number of remastications and remasticating time decreased

TABLE 1. MASTICATION AND RUMINATION DATA FOR 5 GOATS IN FED AND FASTED STATES

Item	Feeding	Fasted		
		1st day	2nd day	3rd day
Number of boli (boli/day)	249 ± 5 ^a	302 ± 5 ^b	274 ± 6 ^{ab}	241 ± 7 ^a
Ruminating time (min/day)	246 ± 5 ^a	280 ± 7 ^a	168 ± 5 ^b	146 ± 5 ^b
Number of remastications (chews/day)	13,536 ± 288 ^a	15,149 ± 416 ^a	4,664 ± 146 ^b	2,860 ± 119 ^c
Remasticating time (min/day)	194 ± 4 ^a	214 ± 6 ^a	70 ± 2 ^b	48 ± 2 ^c
Intermittent time (min/day)	52.6 ± 18.4 ^a	63.3 ± 14.4 ^a	98.3 ± 24.7 ^b	98.0 ± 30.1 ^b
Resting time (min/day)	1,155 ± 75 ^a	1,160 ± 74 ^a	1,272 ± 93 ^{ab}	1,294 ± 44 ^b
Number of mastication (chews/day)	3,755 ± 50			
Masticating time (min/day)	39 ± 1			
Bolus time (sec/bolus)	58.5 ± 2.1 ^a	54.7 ± 2.9 ^a	37.5 ± 4.2 ^b	36.6 ± 3.2 ^b
Remasticating time/bolus (sec/bolus)	45.8 ± 2.6 ^a	42.0 ± 2.1 ^a	14.5 ± 1.6 ^b	11.5 ± 1.6 ^b
Intermittent time between boli (sec/bolus)	12.1 ± 0.7 ^a	12.7 ± 1.0 ^a	22.7 ± 0.7 ^b	24.4 ± 1.4 ^b
Number of remastications/bolus (chews/bolus)	53.7 ± 2.8 ^a	49.9 ± 2.3 ^a	16.8 ± 1.7 ^b	10.7 ± 1.5 ^b

^{a, b, c}: Means ± S. E. with different letters within the same line differ significantly ($p < 0.05$).

significantly during the second and third days of fasting compared to the fed state or first day of fasting ($p < 0.05$). Number of boli in the first and second days of fasting was significantly greater ($p < 0.05$) than in the fed state, but number of boli in the third day of fasting was nearly the same as in the fed state. Intermittent time and resting time after first day of fasting were the same as the fed state, but they increased significantly in the third day of fasting compared to the fed state or first day of fasting.

Bolus time, remasticating time/bolus, intermittent time between boli and number of remastications/bolus did not change significantly after first day of fasting but decreased significantly after second days and third days of fasting compared to the fed state or the first day of fasting.

Figure 1 shows number of boli, ruminating time and masticating time on an hourly basis under light-dark-light-dark cycle in the fed state and one through three days of fasting. Number of boli/hour increased during the 06:00-

12:00 hour period (dark) of the first day of fasting than in the fed state. The number of boli/hour in second and third days of fasting was comparable to the fed state. Number of boli/hour and ruminating time/hour did not differ among the dark, light, dark and light periods during the second and third days of fasting. Number of boli/hour and ruminating time/hour during feeding decreased for 1-2 hours after a change in lighting, and increased for 1-2 hours before a change in lighting. Masticating time/hour was relatively constant for 24 hours, and did not differ between dark and light periods, but increased for one hour immediately after a change in lighting.

Gordon and McAllister (1970), Oshiro (1989), Oshiro and Koja (1987), and Sato et al. (1987) have earlier examined the effects of light and dark cycles or normal daylight on ruminating patterns. The results with adult sheep observed by Gordon and McAllister (1970) indicated that the behavioral pattern of rumination is

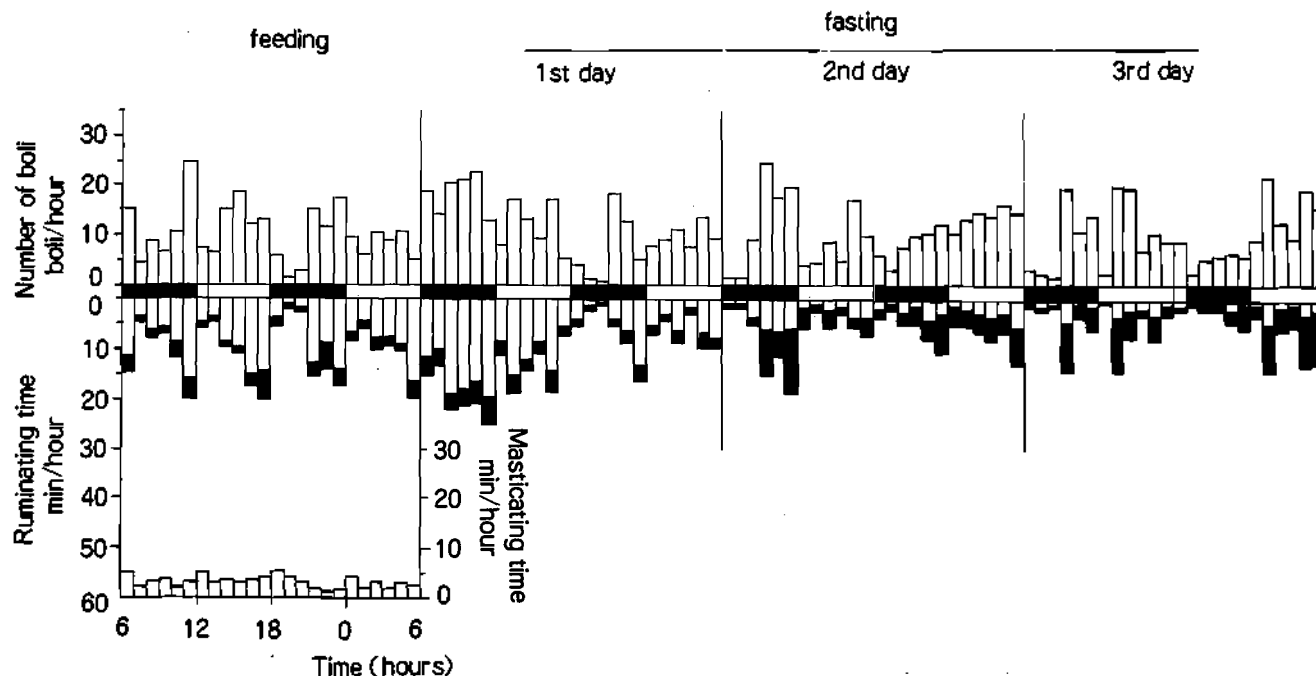


Figure 1. Number of boli (□), ruminating time (▨; ▨ Remasticating time: ▩ Intermittent time) and masticating time (■) in goats fasted under dark (■)-light(□)-dark(■)-light(□) cycle in a day.

oriented to a fixed circadian rhythm, i.e., the pattern is based on 24 hours cycle.

Oshiro (1991) showed that there were decreases of the rumination for two hours immediately after sunset in normal daylight, and daily ruminating pattern was formed by normal daylight. Oshiro et al. (1992) showed that ruminating behavior was affected by artificial dark and light cycles which suggested that ruminating behavior decreased more in response to sunset, and sunrise had no bearing on it. It was considered that ruminating behavior was determined mainly by normal daylight. In the present experiment, ruminating behavior did not increase during the dark period in feeding and fasting, and this result differed from many behavior observations of Bell and Lawn (1957), Gordon and McAllister (1970), Oshiro et al. (1988), Oshiro et al. (1987), Oshiro and Koja (1987), Welch and Smith (1968). The feeding pattern in the present experiment did not vary between dark and light, and was different from the results with sheep described by Forbes (1986). The overall feeding pattern with sheep by Forbes (1986) was related to photoperiod with large, more frequent meals occurring during daylight.

Ruminating time/hour decreased for two hours after changing the lighting, and mostly increased for one hour immediately before a change in light status. In the second and third days of fasting, ruminating time/hour decreased for 1-2 hour after a change in lighting. Ruminating

behavior patterns were similar in fasting and feeding. In fasting, it suggested that ruminating behavior was kept to maintain the circadian pattern as fed state. In the present experiment, ruminating time/day, remasticating time/day and number of remastication/day did not decrease after one day of fasting but decreased after the second and third days of fasting, which was the same results seen with goats by Oshiro (1985a). However, Welch and Smith (1968) claimed that ruminating time/day decreased immediately after the first day of fasting, but in the present experiment, the number of boli/day did not decrease after the first, second, or third days of fasting compared to the fed state.

Ruminating behavior in dark and light environments in the present experiment differ from the ruminating behavior obtained under dark (12 hours) and light (12 hours) cycles with goats (Oshiro et al., 1992). Although ruminating behavior was different between dark and light in goats (Oshiro et al., 1992), the present experiment showed that there were no differences between dark and light. It is likely that the differing durations of light/dark periods account for the differences between the current and earlier experiments. Bolus time and remastication time/bolus in fasting decreased a little after one day of fasting, and markedly decreased after the second and third days of fasting compared to the fed state or the first day of fasting.

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