

Behavioural responses by yaks in different physiological states (lactating, dry or replacement heifers), when grazing natural pasture in the spring (dry and germinating) season on the Qinghai-Tibetan plateau

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Accepted 3 December 2006

Available online 1 February 2007

Abstract

Using heterogeneous vegetation in alpine grassland through grazing is a necessary component of de-intensification of livestock systems and conservation of natural environments. However, better understanding of the dynamics of animal feeding behaviour would improve pasture and livestock grazing managements, particularly in the early part of the spring season when forage is scarce. The changes in behaviour may improve the use of poor pastures. Then, enhancing management practices may conserve pasture and improve animal productivity. Grazing behaviour over 24 h periods by yaks in different physiological states (lactating, dry and replacement heifers) was recorded in the early, dry and later, germinating period of the spring season. Under conditions of inadequate forage, the physiological state of yaks was not the primary factor affecting their grazing and ruminating behaviour. Forage and sward state affected yaks' grazing and ruminating behaviour to a greater extent. Generally, yaks had higher intake and spent more time grazing and ruminating during the later part of the spring season, following germination of forage, than during the earlier dry part of the season. However, the live weight of yaks was less during

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pasture germination than during the early dry part of the season because the herbage mass is low, and the yaks have to expend much energy to seek feed at this particular time.

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Keywords: Yak; Grazing; Ruminating; Behaviour; Physiological state; Qinghai-Tibetan plateau

1. Introduction

The yak (*Bos grunniens*) plays an important role on the Qinghai-Tibetan plateau, where it has been acclimated to the harsh environmental conditions (e.g. cold, low oxygen and high ultraviolet radiation) in Alpine grassland. Yak husbandry depends throughout the year on the natural forage produced by alpine rangeland. Appropriate grazing management of such alpine areas must ensure, not only availability of forage, but also an environment for sustainable development. However, achieving good grazing management of alpine rangelands presupposes knowledge of how yaks interact with the vegetation.

The spring season is a key period for yak production in the grazing ecosystem of the alpine area because the most calving are occurred at this time. The interval of calving in yaks is proximate 20–24 months. Therefore, the calving rate of yaks is between 50 and 60%. The yaks live through an approximately 5-month winter period with scarce forage. At beginning of the spring season, the pastures provide very little forage available for the yaks to graze. If the herdsmen are unable to manage adequately the scarce resources, the yaks would become very emaciated, and may even die from starvation. The spring season is also a transitional period when the sparse dry forage is superseded by fresh germinating forage. As above, we believe that it is important to indicate why it is important to investigate their behaviour.

Previous work conducted with dairy cows on temperate, intensively managed grass swards (Gibb et al., 1999) has shown that lactating cows eat more at pasture than dry cows by increasing the time spent grazing at the expense of reducing ruminating time, rather than by an ability to overcome significantly the constrains on bite mass, bite rate and intake rate imposed by sward state. Penning et al. (1995) have also shown that sheep are able to alter their grazing time in relation to their physiological state. In the current experiment, we investigated the effects of different physiological states (lactating, dry and replacement heifer) on the behaviour of yaks grazing under different pasture conditions (dry and germinating).

2. Materials and methods

2.1. Study site

The experiment was conducted from April to May 2006 in Wushaoling (N37°12.479' and E102°51.695', altitude 3154 m) of Tianzhu, Tibetan Autonomous County, Gansu Province, Northwest China. The climate of the research area is dominated by the southeast monsoon and high atmospheric pressure from Siberia, with severe, long winters and short, cool summers. The mean annual temperature is -0.1 °C, and mean annual precipitation is 416 mm. The pasture is alpine meadow with the sedges as the main species. Seasonal grazing is a major grazing management in this area. Therefore, the livestock graze on the natural pasture all year round without irrigation, fertilizer or other practices to the pasture.

2.2. Animals

The individuals used for the behavioural observations were selected from a herd of 58 yaks normally resident on the experimental area. Six individual females were selected as representatives of each of the following physiological states: yaks with 1-year-old calves (LY-1) yaks with 2-year-old calves (LY-2), dry (non-lactating) yaks (DY) and replacement heifer yaks (RH). Within each physiological category, the six animals constituting the experimental group were chosen for their similar age and live weight. The age of DY, LY-1 and LY-2 was about 9 years old. And the RH's age was 3 years old. As the April (dry period) is calving period, the LY-1 were not selected as experimental object. Because temperatures are very low in the dry period, all the yaks were enclosed in a corral at night. During the later period (May), all adult yaks were remained at pasture overnight, whilst the 1-year-old and 2-year-old calves were kept in the corral overnight. There are two corrals in the family. One is covered with plastic on the top in order to keep warm during the winter and the early spring periods. The other is a semi-open corral covered with dry shrub branches. In April and May, the calves were confined in the warm corral at night. The other yaks were only confined in the semi-open corral at night in April. The lactating yaks were milked once a day from 8:00 to 9:30 a.m. throughout the experimental period, whilst the DY and RH were also kept in the corral in order that no difference other than physiological state would exist between the three classes of animal. The live weight of the yaks was measured using Cattle Weighting Tape (Dalton Supplies Ltd., Oxon, England) every day in the morning (about 8:00 h).

The yaks, except for the 1-year-old and 2-year-old calves, received a supplement containing crushed maize cob (85%) and barley flour (15%) during the dry period. The LY-2 received 1 kg of supplement twice daily, in the morning (8:00 h) and evening (19:00 h), respectively. The LY-1 and RH received 1 kg of supplement daily in the evening (19:00 h). During the germinating period, only the lactating yaks (LY-1, LY-2) could receive a supplement of crushed rape stalk (90%) and barley flour (10%) in amount of 1.2 kg daily in the morning.

2.3. Climate and sward measurement

During the experimental period, air and ground surface temperatures and humidity were recorded three times (9:00, 14:00 and 18:00 h) a day, except the bad weather days. The air temperatures and the humidity were measured at 2 m high above ground surface by using a temperature–humidity meter (WHM5-type, Weather and Ocean Instrument Company, Tianjin). The above measurements were carried out at three sites of the grazing area. The water content at two soil layers (0–10 and 10–20 cm) was measured by using a portable Soil Water Content Measurement System (HydroSense, Campbell Scientific Inc.) at six sites.

Herbage mass (g DM m^{-2}) was also measured by cutting all herbage to ground level from 20 randomly selected quadrats ($50 \text{ cm} \times 50 \text{ cm}$) in the grazing area. In dry period, all the aboveground herbage was bulked from each quadrat for further measurements. However, in germinating period, the newly emerged plants (young shoots) were separated into two categories, i.e. grasses-sedges and forbs. The individual fresh sample was weighed before oven dried at 60°C for 24 h. Then the samples were crushed through 1 mm sieve and dried at 100°C for a further 5 h to obtain the DM content. The contents of crude protein, acid-detergent fiber (ADF) and neutral-detergent fiber (NDF) were also determined by the improved methods of Kjeldahl (Silva, 1990) and the methods described by Van Soest et al. (1991). The samples were also combusted in a muffle furnace to at 550°C for calculating the content of ash.

The undisturbed, vertical heights of 100 randomly selected individual plants were measured with a ruler to assess mean sward height. The horizontal cover (total ground cover in dry period, grasses-sedges and forbs cover in germinating period) was assessed using a $1 \text{ m} \times 1 \text{ m}$ quadrat, subdivided into a grid of 100 ($10 \text{ cm} \times 10 \text{ cm}$) squares. Twelve sites were selected in order to measure the cover.

2.4. Behaviour measurements

Recordings of grazing behaviour were made using solid-state behaviour recorders (IGER-Recorder) (Rutter et al., 1993, 1997). Before the trial, all the experimental yaks were fitted with recorders for 3 days so that the animals could become accustomed to wearing recorders. The yak herds were driven to a corral for milking in the morning about 8:00 h. Then the experimental yaks were fitted with recorders to record their

temporal patterns of grazing, ruminating and idling behaviour over 24 h. Three animals in the same physiological category were recorded each time. A total of six animals in the same physiological state were recorded twice in one experimental period. Those grazing yaks were also followed to observe their behaviour for calibration of the recorders.

Behaviour recordings were analysed using the software 'graze' (Rutter, 2000). The IGER-Recorder can record the following data over 24 h (through analysis and calculation): total grazing time, total eating time, grazing jaw movement, total grazing bites, number of meals, total ruminating time, number of ruminative boluses, ruminative mastications and total jaw movements. The parameters were set according to manual observation. The time of grazing, ruminating and idling in different time of 1 day was recorded by the following person. The parameters were adjusted to fit the manual behaviour recordings when the software was used to analyse auto-behaviour recording. The jaw movement parameters were set as: minimum jaw movement size (adc units), 25; minimum prehension subpeak (adc units), 4; minimum inter-jaw movement interval ($1/20 \text{ s}^{-1}$), 14. The 'graze' software uses three criteria to decide whether or not a particular waveform peak is a jaw movement. The jaw movement size is specified in 'adc' units that mean the amplitude of a waveform from the top of the peak down to the lowest trough associated with the peak. Interpretation of the recorded data was conducted following the protocol described by Gibb et al. (1999, 2002), viz. 'the total eating time (TET) was calculated as the sum of the periods of grazing jaw movement (GJM), excluding intervals of jaw inactivity >3 s. Total grazing time (TGT) was the sum of the periods of grazing jaw movement, including any periods of jaw inactivity <5 min. Total idling time was calculated as the time within each 24 h when yaks were not grazing and ruminating and will have included drinking and social interactions. The number of biting and non-biting GJM during eating, and the number of mastications during ruminating were counted automatically. The term 'non-biting GJM' refers to those jaw movements made during grazing that are not identified as bites, and therefore includes movements which may have a masticative or manipulative function. The bite rate (BR) was calculated in the time base of TET.

Following close visual observation of the grazing animals, simulated 'bites' of grazed material were collected by hand. After drying at 100°C for 10 h, the bulked samples were weighed to estimate individual bite DM mass. Daily intake was estimated as the product of bite mass and total number of bites per day. The number of grazing bites was automatically counted by the IGER-Recorder. Fresh faeces were collected by following different yaks. Visible non-faeces objects were avoided when taking a faecal sample from the ground. Faecal samples were also dried in the oven and muffle furnace for calculating DM and ash.

2.5. Statistical analysis

One-way ANOVA was used to determine the effects of yaks in different physiological states and ages on grazing behaviour. Each group of experimental animals (six animals) was recorded twice in each period. The mean of behaviour data from the two recordings of the same yak in each period was used as the unit of replication, because individual animals within a group cannot be regarded as statistically independent (Rook and Penning, 1991). In all statistical analysis of the data, between-pair variance was used as the error term. Because the behaviour data of LY-1 was not recorded in dry period, the data for this period were excluded from a number of relationships in the analysis. Multicomparison was made in relation to the different physiological state and ages of yaks in the same period using Duncan's Multiple Range Test. Because the yaks were kept in the corral at night in dry period, and remained at pasture overnight in germinating period, a comparison of the behavioural data between these two periods was not undertaken.

3. Results

3.1. Climate and sward measurements

The data on sward characteristics are shown in Table 1. The soil water content at soil depth of 10 and 20 cm is shown in Fig. 1. The soil water content at soil depth of 20 cm was higher than that at 10 cm, but no significant difference in statistical analysis ($P > 0.05$).

Table 1

Swards' herbage mass, height, cover and the content of crude protein, ADF and NDF in dry and germinating periods of spring season (mean \pm S.E.)

	In dry period	In germinating period	
		Grasses-sedges	Forbs
Herbage mass (g DM m ⁻²)	14.6 \pm 1.62 ^a	19.9 \pm 3.07 ^a	13.4 \pm 2.59 ^a
Sward height (cm)	1.7 \pm 0.04 ^b	2.1 \pm 0.10 ^a	2.1 \pm 0.10 ^a
Cover (%)	54 \pm 4.77 ^b	58 \pm 6.01 ^a	45 \pm 3.22 ^b
Crude protein (g kg ⁻¹ DM)	58.3 \pm 0.31 ^c	128.5 \pm 0.22 ^b	189.3 \pm 0.14 ^a
ADF (g kg ⁻¹ DM)	298.1 \pm 0.28 ^a	229.9 \pm 0.30 ^b	212.9 \pm 0.16 ^b
NDF (g kg ⁻¹ DM)	502.1 \pm 0.10 ^a	424.4 \pm 0.15 ^b	350.5 \pm 0.26 ^c

Numbers within rows followed by different letters (a–c) are significantly different at the 5% level (by Duncan test).

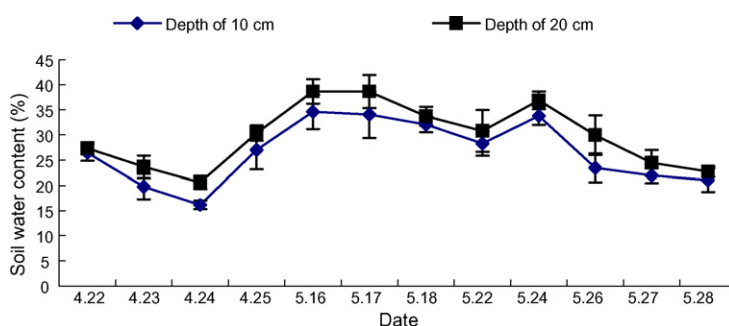


Fig. 1. Mean daytime soil water content (at a soil depth of 10 and 20 cm) during the experimental period. Vertical bars represent the standard error of the mean ($n = 18$).

The ground surface and air temperature showed a significant linear increase during the experimental period (Fig. 2). The surface and air temperature in May was significantly higher than in April ($P < 0.05$). Humidity measured at and above (2 m) the ground surface was between 30 and 65%. However, no significant trend with time over the course of the experiment was identified (Fig. 3).

The ash content of the herbage samples which represented the diet of yaks in dry period were significantly higher than in germinating period ($P < 0.05$) (Table 2). However, the ash content of

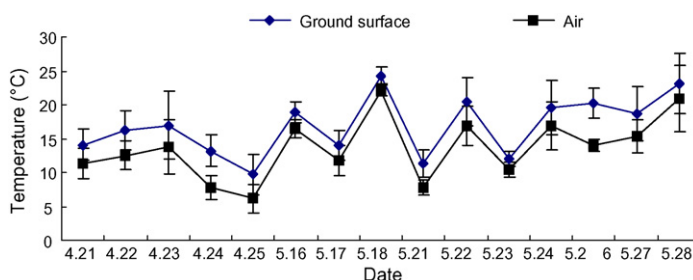


Fig. 2. Mean daytime ground surface and air temperature during experimental period. Vertical bars represent the standard error of the mean ($n = 9$).

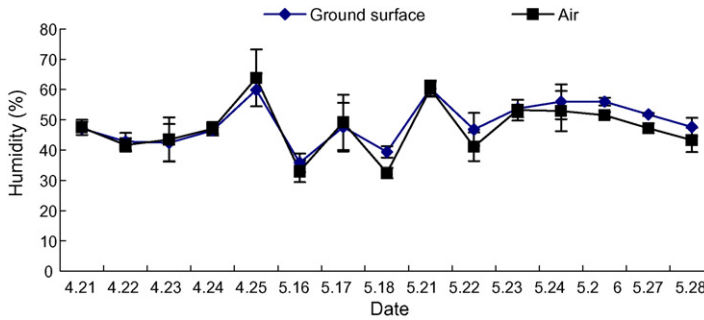


Fig. 3. Mean daytime ground surface and air humidity during experimental period. Vertical bars represent the standard error of the mean ($n = 9$).

Table 2

The ash content (% DM as the basis) of herbage and faeces of the yaks in dry and germinating periods of spring season (mean \pm S.E.)

	In dry period	In germinating period	Significance
Herbage	16.57 \pm 0.27	9.19 \pm 0.20	*
Faeces	23.16 \pm 1.82	24.09 \pm 0.84	NS
Significance	NS	*	

NS, not significant.

* $P < 0.05$.

the faeces in the two periods did not differ significantly. The ash content of the faeces in the germinating period was significantly greater than that in the herbage ($P < 0.05$).

3.2. Behaviour measurement

3.2.1. Temporal patterns of grazing and ruminating

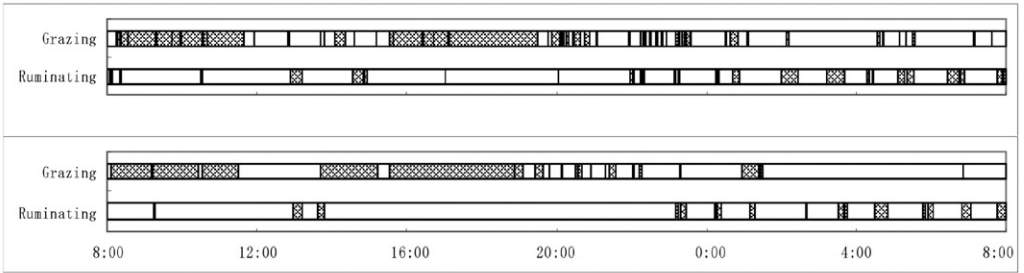
The grazing and ruminating activities of DY, LY-1, LY-2 and RH over 24 h are shown in Fig. 4. Generally, all the yaks grazed in the early morning and late evening. The ruminating activity mostly happened in the late night (approximately from 0:00 to 5:00 h). All the yaks grazed more continuous in the germinating period than in the dry period. No distinctive variations in rumination were found between the two periods.

3.2.2. Effects of physiological state on grazing behaviour over 24 h

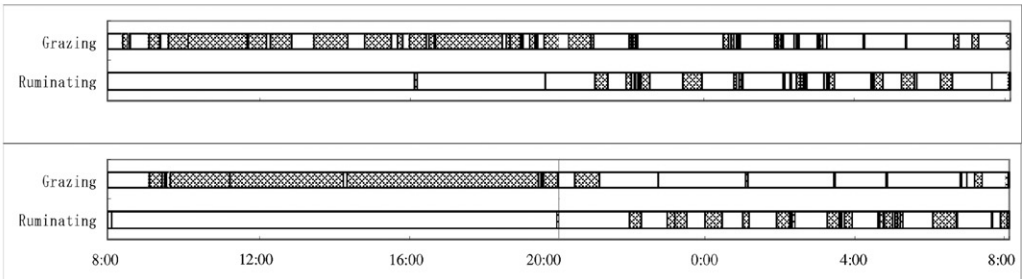
The time that yaks spent in grazing and eating is shown in Table 3. The grazing and eating time of all yaks in different physiological states did not differ significantly in dry period ($P > 0.05$). The grazing time of LY-1 was significantly higher than that of LY-2 in germinating period ($P < 0.05$). However, the eating time of yaks in different physiological states did not differ significantly in germinating period ($P > 0.05$).

No significant difference ($P > 0.05$) was found in total bites and non-biting GJM of yaks in different physiological states in dry period (Table 3). The total bites of LY-1 were significantly higher than that of LY-2 in germinating period ($P < 0.05$). The daily number of non-biting GJM by yaks in different physiological states in germinating period did not differ significantly ($P > 0.05$).

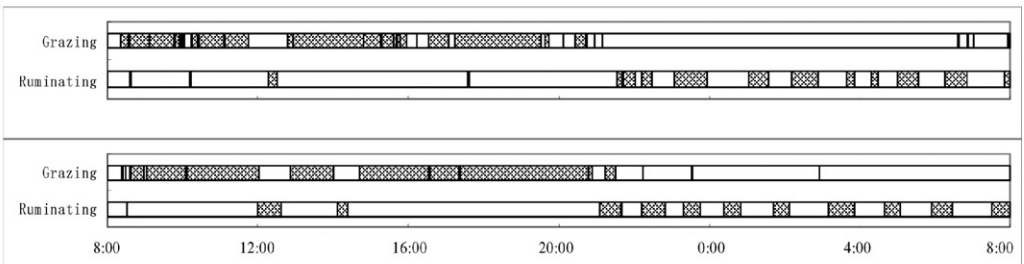
DY (a)



LY-2 (a)



RH (a)



DY (b)

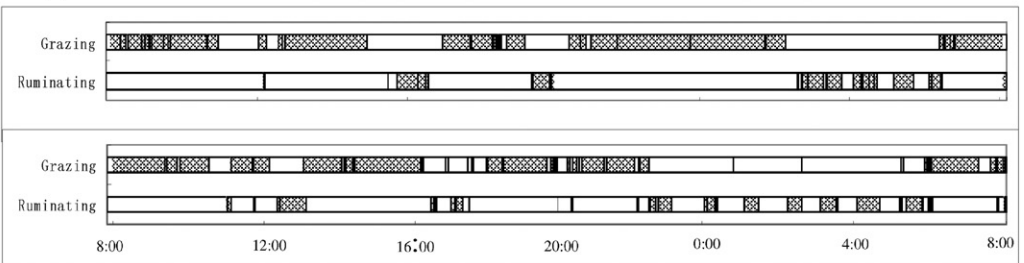
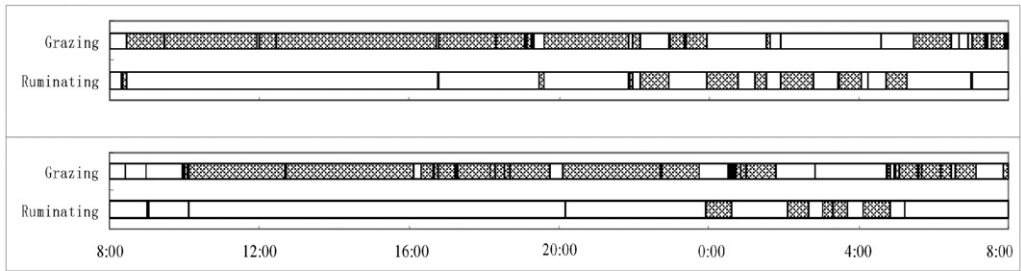
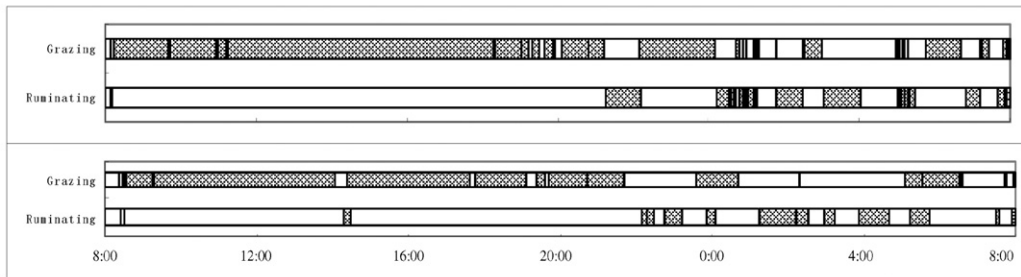


Fig. 4. Temporal patterns of grazing activity and ruminating activity by yaks in different physiological state (DY, LY-1, LY-2, RH) measured over 24 h in dry period (April, a) and in germinating period (May, b). The behaviour patterns of two yaks are shown in this figure. The grey bars mean grazing and ruminating activities. The white bars mean the other activities except for grazing or ruminating activities.

LY-1 (b)



LY-2 (b)



RH (b)

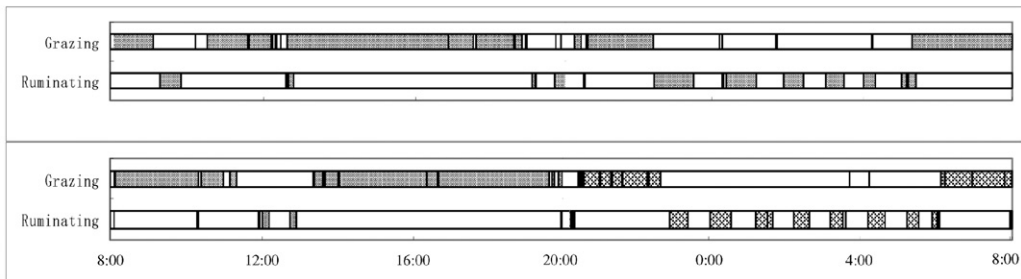


Fig. 4. (Continued).

There was no significant difference between BR by yaks in different physiological states in either the dry or germinating period ($P > 0.05$) (Table 3). The intake of yaks in different physiological states in two periods is shown in Table 3. The intake of yaks in dry period was not affected by their physiological state ($P > 0.05$) and was approximate 2 kg DM day⁻¹. In the germinating period, the LY-1 had the highest intake (5 kg DM day⁻¹), and was significantly higher than LY-2 (4 kg DM day⁻¹) ($P < 0.05$). The intake of DY and RH was about 4.5 kg DM day⁻¹ in the germinating period.

3.2.3. Effects of physiological state on ruminating behaviour over 24 h

Total ruminating time of RH was significantly higher than that of DY in the dry period ($P < 0.05$), and significantly higher than that of LY-1 in the germinating period ($P < 0.05$) (Table 3). The more ruminating time the yaks took, the more ruminative boluses and mastications the yaks made in dry or germinating period. The mastications per bolus by yaks in different physiological states and in the two periods did not differ significantly ($P > 0.05$) (Table 3).

Table 3

Yak grazing behaviour measured 24 h in dry and germinating periods of spring season (mean \pm S.E.)

	In dry period			In germinating period			
	Dry yak (DY)	Lactating yak with 2-year-old calves (LY-2)	Replacement heifer (RH)	Dry yak (DY)	Lactating yak with 1-year-old calves (LY-1)	Lactating yak with 2-year-old calves (LY-2)	Replacement heifer (RH)
Grazing behaviour							
Total grazing time (min)	521 \pm 24.50 ^a	609 \pm 80.97 ^a	605 \pm 27.50 ^a	864 \pm 63.03 ^{AB}	1009 \pm 56.91 ^A	795 \pm 65.14 ^B	871 \pm 51.01 ^{AB}
Total eating time (min)	475 \pm 45.01 ^a	563 \pm 58.07 ^a	557 \pm 30.00 ^a	793 \pm 70.44 ^A	944 \pm 55.70 ^A	742 \pm 67.06 ^A	826 \pm 51.41 ^A
Total GJM	22556 \pm 1602.24 ^a	26452 \pm 3356.27 ^a	25318 \pm 1602.24 ^a	62603 \pm 7097.61 ^{AB}	85589 \pm 9486.34 ^A	55767 \pm 7797.99 ^B	68788 \pm 5338.07 ^{AB}
Total bites	20907 \pm 2537.38 ^a	22804 \pm 3308.36 ^a	22533 \pm 1388.21 ^a	52725 \pm 6944.57 ^{AB}	67401 \pm 6180.00 ^A	45079 \pm 6239.95 ^B	49054 \pm 4866.66 ^{AB}
Non-biting GJM	1649 \pm 935.14 ^a	3648 \pm 336.40 ^a	2785 \pm 214.03 ^a	9878 \pm 1504.11 ^A	18188 \pm 5840.02 ^A	10688 \pm 1928.84 ^A	19734 \pm 4692.94 ^A
Number of meals	23 \pm 7.00 ^a	13 \pm 2.19 ^a	11 \pm 3.00 ^a	8 \pm 1.68 ^A	12 \pm 0.65 ^A	14 \pm 2.69 ^A	12 \pm 1.47 ^A
Bite rate (BR, bites min ⁻¹)	43.90 \pm 1.18 ^a	40.13 \pm 1.97 ^a	40.44 \pm 0.31 ^a	65 \pm 3.72 ^A	71 \pm 2.94 ^A	59 \pm 3.78 ^A	59 \pm 4.03 ^A
Intake rate (g DM min ⁻¹)	4.05 \pm 0.03 ^a	3.73 \pm 0.05 ^a	3.72 \pm 0.01 ^a	5.12 \pm 0.03 ^{AB}	5.41 \pm 0.03 ^A	4.68 \pm 0.03 ^B	4.57 \pm 0.04 ^B
Intake (g DM 24h ⁻¹)	1923 \pm 233.40 ^a	2098 \pm 304.36 ^a	2073 \pm 127.70 ^a	4060 \pm 534.73 ^{AB}	5190 \pm 475.86 ^A	3471 \pm 480.48 ^B	3777 \pm 374.73 ^{AB}
Ruminating behaviour							
Total ruminating time (min)	149 \pm 31.00 ^b	230 \pm 28.57 ^{ab}	314 \pm 26.00 ^a	253 \pm 16.03 ^{AB}	176 \pm 26.64 ^B	239 \pm 21.54 ^{AB}	289 \pm 40.73 ^A
Total boluses	120 \pm 35.51 ^b	172 \pm 28.31 ^{ab}	261 \pm 14.00 ^a	223 \pm 15.10 ^{AB}	167 \pm 22.49 ^B	221 \pm 13.11 ^{AB}	290 \pm 54.37 ^A
Total mastications	6112 \pm 1036.66 ^b	9609 \pm 1507.55 ^{ab}	15813 \pm 2598.39 ^a	12245 \pm 906.41 ^{AB}	9783 \pm 1872.06 ^B	10912 \pm 1114.59 ^B	16739 \pm 2981.21 ^A
Mastications per bolus	53.27 \pm 7.15 ^a	55.99 \pm 2.03 ^a	60.23 \pm 6.72 ^a	55 \pm 3.12 ^A	58 \pm 3.98 ^A	49 \pm 2.95 ^A	58 \pm 2.44 ^A
Idling behaviour							
Total idling time (min)	816 \pm 14.00 ^a	647 \pm 43.98 ^{ab}	569 \pm 56.01 ^b	394 \pm 66.97 ^A	320 \pm 45.9 ^A	459 \pm 68.02 ^A	325 \pm 80.51 ^A
Total jaw movements	33095 \pm 321.05 ^b	41075 \pm 1047.00 ^{ab}	42708 \pm 4158.13 ^a	78387 \pm 6165.59 ^{AB}	97892 \pm 10157.68 ^A	70484 \pm 6448.09 ^B	87322 \pm 7706.81 ^{AB}

Numbers within rows followed by different letters (a, b, A, B) are significantly different at the 5% level (by Duncan test).

3.2.4. *Effects of physiological state on idling behaviour over 24 h*

Total idling time includes standing, wandering, lying and social activities. DY had a significantly higher idling time than RH in the dry period ($P < 0.05$) (Table 3). In the germinating period, total idling time of yaks in different physiological states did not differ significantly ($P > 0.05$). The total jaw movements over 24 h by RH were significantly higher than that of DY in dry period ($P < 0.05$). And in germinating period, LY-1 had higher total jaw movements than LY-2 ($P < 0.05$).

3.3. *Animal production*

Although this experiment was not specifically designed to measure animal production, live weight of the yaks in different physiological states were measured. DY had a significant live weight gain between the two periods ($P = 0.0198$) (Table 3). The live weight of LY-2 and RH was also a little decrease in the germinating period, but not significant ($P > 0.05$).

4. Discussion

4.1. *Effects of physiological state on grazing behaviour*

The experimental design and analysis were constrained by the numbers of suitable yaks available and a degree of independence between replicates, and was also constrained by the effect of social facilitation on the behaviour of yaks during measurements.

The ash content of the herbage in the germinating period was lower than in the dry period ($P < 0.05$), but the ash content of the faeces in the germinating period was higher than that in the herbage ($P < 0.05$), and did not differ from the ash content of the faeces in the dry period (Table 2). The ash content of the herbage and faeces in the dry period had no significant difference ($P > 0.05$). Because the soil became soft and humid and the herbage mass or sward height was low in the germinating period, the yaks consumed some soil when grazing (Table 1), which resulted in significant higher content of ash in the faeces compared with herbage in the germinating period. Much more soil that was eaten by yaks might affect the physiological metabolize and nutritional balance, which need further study.

In the dry period, all the yaks grazed for only 35–40% of the day, and did not differ significantly in relation to physiological state. This was because the sward was sere with low height, low herbage mass as well as poor quality, and might hardly meet the appetite of all the yaks, which was also reflected from the low intake rates in this period. In addition, the yaks were supplemented more and were constrained in the corral at night in this period, which also led to decrease the eating time over 24 h. In part, it also explained the non-significant increase in grazing time by the LY-2. As we analysed, the forage had a better quality in germinating period than in dry period (Table 1). However, the yaks had to increase their grazing time in order to obtain enough forage and compensate for the low intake rates constrained by low herbage mass and low sward height in the germinating period. The studies of Gibb et al. (1999) and Penning et al. (1995) showed that the lactating cows or lactating sheep would spend more time in grazing than dry ones. In present experiment, the eating time by LY-2 yaks during the dry period was slightly more than that of DY and RH yaks, but did not reach a significant level ($P > 0.05$) (Table 3). The similar results were found in the germinating period (Table 3). Unquestionably, the lactating yaks will output more than dry yaks because of milking. As is normal husbandry practice under these harsh conditions, the herdsmen gave the lactating yaks more supplement feeds than other animals. To some certain degree, this will have offset the depletion body reserves in the lactating yaks. Because of the low herbage mass and short sward height

Table 4
Live weight (kg) of yaks in different physiological states in dry and germinating period

Physiological state	Dry season	Germinating season	<i>P</i> -value
DY	311	290	0.0198
LY-2	294	281	0.4248
RH	210	204	0.6017
LY-1	–	252	–

in the two periods (dry and germinating), all the yaks showed almost the same BR in either period. Therefore, the BR of yaks in different physiological states did not differ significantly in the dry or germinating period. The grazing time and intake rates of LY-1 were significantly higher than that of LY-2 in the germinating period (Table 3). Despite supplementation, the higher nutritional demand during early lactation (LY-1) compared with late lactation (LY-2) resulted in the recently calved yaks significantly increasing the time spent grazing compared with those which had calved the previous year, and achieving significantly greater daily herbage intake.

The quality of forage was better in the germinating period than in the dry period (Table 1), which may have contributed to the differences in grazing time observed (Table 3). Under better sward conditions, the normal expectation is that yaks should gain live weight in the germinating period. However, our results showed the yaks in the germinating period still lost live weight, especially for DY (Table 4). The yaks had to expend considerable energy to walk very long distances covered and increase their bites to obtain more forage as the height of the forage was short even in the germinating period. Consequently the negative nutrition balance results in lost weight in yaks. The DY animals, were supplemented in the dry season, but supplemented nothing in the germinating period. As a result, they lost significantly more live weight in the germinating period compared with the dry season ($P = 0.0198$).

4.2. Effects of physiological state on ruminating behaviour

Usually, yaks began ruminating after they had eaten some time in the morning. Although it is exceptional sometimes, such as in the milking time, the yaks ruminated because of confinement. The finding that the act of rumination started only after the yaks had been at the pasture for some time is because a certain level of reticulo-rumen fill must be reached for an animal to start the process of rumination. This agrees with the result obtained by Fredrick (2002) on camel. Therefore, the speed with which this level is attained depends, among other things, on the rate of herbage consumption that is in turn influenced by herbage quality, quantity and degree of selectivity of the animals. Compared with DY and LY, the body size of RH is relative small which might lead to a smaller rumen dimension in RH than those in DY and LY. So the RH had to spend more time ruminating than DY in dry period and LY-1 in germinating period. Because the low herbage quality and short swards constrained bite mass and, therefore, short-term intake rate, the yaks could not achieve a critical level of gut fill quickly and spent less time in ruminating in the daytime (Table 3). Low quality or quantity forage is usually accompanied by a low level of DM intake per unit time which consequently delays the onset of rumination (Mugerwa et al., 1973). There were no differences in the ruminating time between DY and LY in either period. And the largest ruminating time of 4.2 h per day was observed in DY in the germinating period, which is less than the findings (5–9 h) by Arnold and Dudzinski (1978). It would appear that in order to increase intake, the DY and LY reduce comminution in order to spend more time grazing. As expected, these results also demonstrated a very high correlation (in dry period, $r = 0.97$,

$P < 0.01$; in germinating period, $r = 0.94$, $P < 0.01$) between ruminating time and the total number of ruminative mastications per day in either period (Table 3).

5. Conclusion

The results show that the quality of forage and sward condition can affect yaks grazing and ruminating behaviour greatly. The eating time of the yaks in different physiological states over 24 h did not differ significantly in the dry or germinating period. Under the condition of less forage supplied, the physiological states are not the main factor affecting the behaviour of yaks. In the dry period with inadequate forage and poor quality of forage, the yaks were estimated to eat less than in the germinating period. All the yaks extended their grazing and ruminating time in the germinating period at the expense of reducing idling time. Supplementary feeding in the spring season may compensate for lack of forage, if economically viable, irrigation or fertilizer application to pastures, may improve the capacity of grassland by providing more food for yaks. As the germinating time is a key period for sward growth, if stocking density is not properly controlled it would lead to aggravation of grassland degradation. It is feasible to sell out more yaks before the dry season to mitigate the stocking density. On the other hand, an alternative feed resource should be paid much attention in spring season.

Acknowledgements

We thank P.Y. Zhao for assistance with the fieldwork and X.L. Liu for supplying animals and caring for my daily life in field. We would like to thank Prof. Malcolm Gibb at North Wyke for his assistance in revising this manuscript. This work was financially supported by the Hundreds-Talent Program, Chinese Academy of Sciences.

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