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Eating and rumination behaviour of Scottish Highland cattle on pasture and in loose housing during the winter

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Summary

This study examined eating and rumination behaviour in 13 Scottish Highland cattle for 13 days on a winter pasture and then for 13 days in a loose housing barn during winter. The cows were fed hay ad libitum and each was fitted with a pressure-sensitive transducer integrated into the noseband of the halter. The endpoints for each cow at both locations were calculated per day and included eating and rumination times, number of chewing cycles related to eating and rumination, number of regurgitated cuds and number of chewing cycles per cud. Air temperature, wind speed, relative humidity, barometric pressure and precipitation were recorded. Pastured cows had significantly longer eating and rumination times, more chewing cycles related to eating and rumination, more regurgitated cuds and more chewing cycles per cud than housed cows. Meteorological conditions were very similar at both locations.

Keywords: Scottish Highland cattle, free range, loose housing, eating, rumination, pressure transducer recordings

Fressen und Wiederkauen von Schottischen Hochlandkühen bei Freiland- und Offenstallhaltung

In der vorliegenden Arbeit wurden Wiederkauen und Fressen von Schottischen Hochlandrindern unter winterlichen Verhältnissen untersucht. Die Kühe wurden zuerst 13 Tage im Freiland, danach 13 Tage in einem Offenstall gehalten und in beiden Fällen mit Heu ad libitum gefüttert. Die Aufzeichnungen von Fressen und Wiederkauen erfolgten mit einem druckempfindlichen Sensor, der im Nasenband eines Halfters integriert war. Beurteilt wurden pro Tier und Ort die pro Tag ermittelte Fress- und Wiederkaudauer, die Anzahl Kauschläge beim Fressen und Wiederkauen, die Anzahl Wiederkauboli und die Anzahl Kauschläge pro Wiederkaubolus. Ebenso festgehalten wurden Lufttemperatur, Windgeschwindigkeit, relative Luftfeuchtigkeit, Luftdruck und Niederschlag. Bei der Freilandhaltung waren die Fress- und Wiederkaudauer, die Anzahl Kauschläge beim Fressen und Wiederkauen, die Anzahl Wiederkauboli und die Anzahl Kauschläge pro Wiederkaubolus signifikant länger bzw. grösser als bei Offenstallhaltung. Die Witterungsbedingungen waren an beiden Orten annähernd gleich.

Schlüsselwörter: Schottisches Hochlandrind, Freilandhaltung, Offenstallhaltung, Fressen, Wiederkauen, Kausensor

Introduction

Southern Switzerland has been home to several hundred Scottish Highland cattle for a number of years. They are kept primarily on extensively grazed grasslands to prevent overgrowth of the pastures. Because the cattle are kept outside year round, concerns were raised regarding their well being during the winter months, and a recommendation was made that the cattle have access to a stable. Assessment of animal well-being is complex (Roffeis et al., 2006) and not uniform among jurisdictions. An "animal-friendliness" index is used to assess animal well-being in Austria (Bartussek, 1998), and similar assessment tools have been proposed for pastured suckler cows (Matthes et al., 1998) and young stock (Schmutz and Schürger, 1999). Under Swiss law, criteria for well-being include that the animal be clinically healthy and the husbandry system not interfere with body function and normal behaviour (Schweizerische Eidgenossenschaft, 2005). Rumination constitutes an important parameter for the assessment of general health and well-being in ruminants because this behaviour requires a minimum comfort level (Kaske, 2005). Excitement and stress (Herskin et al., 2004), anxiety (Bristow and Holmes, 2007) and various diseases (Welch, 1982; Hansen et al., 2003; Yeiser et al., 2012) inhibit rumination and eating. The purpose of this study was to examine the eating and rumination behaviour of Scottish Highland cattle kept on a winter pasture for 13 days and then in loose housing for another 13 days. A novel device consisting of a halter with a data logger incorporated in the noseband for recording jaw movements through a pressure sensor was recently developed for detailed assessment of eating and rumination behaviour in cows (Nydegger et al., 2011a,b). This measuring technique was validated in Brown Swiss cows (Trösch, 2013; Braun et al., 2013).

Animals, Material and Methods

Animals

The study was conducted in the winter of 2012 using 13 healthy Scottish Highland cows. They ranged in age from 4 to 6 years old (4.6 ± 0.9 years) and were not more than 6 months pregnant.

Geographic location and feeding

For the first 13 days of the study, the cows were on a 1.6-ha winter pasture at location A in southern Switzerland, 220 m above sea level. The pasture did not allow grazing (Fig. 1A), hay was fed ad libitum from two hay feeders and water was available from one trough. There were three areas bedded with hay and straw (Fig. 1B); two tents erected for shelter (Fig. 1A) were not used by the cows.

The loose housing facility was at location B in eastern Switzerland, 460 m above sea level. This was a prototype of a barn that exceeded Swiss welfare criteria (Eidgenössisches Volkswirtschaftsdepartement, 2008) and consisted of an open yard measuring 276 m^2 and a resting area measuring 125 m^2 that was bedded daily with straw (Fig. 1C). The same hay used at location A was fed ad libitum from a manger with 28 head gates (Fig. 1D). Water was available ad libitum from two troughs. Buckets with a mineral supplement were available at both locations.

Pressure transducer recordings of eating and rumination activities

The recordings were made as described recently (Nydegger et al., 2011a,b) after an 18-day habituation period at the respective location using a pressure-sensitive sensor integrated into the noseband of a halter (MSR Elec-

Figure 1: Scottish Highland cattle on a 1.6-ha winter pasture at location A (A), cow at a resting area bedded with hay and straw (B), resting area of the loose housing barn at location B (C), cows at the hay manger in a loose housing barn (D).

tronics, Seuzach, Switzerland, Patent CH 700 494 B1). The method was recently evaluated (Braun et al., 2013) and allows the recording of jaw movements in cattle. The sensor is located in the noseband and registers pressure changes in an oil-filled tube. Opening of the mouth causes bending of the tube, which results in an increase in pressure within the tube. The change in mechanical pressure alters the electrical resistance, which is recorded as a signal. Data were stored on a secure digital (SD) card in a data logger, which was water-proof and attached to the side of the halter in a leather pouch. The logger was connected to the external pressure transducer and recorded the physical measurements. The SD card had a 4 GB capacity, which allowed a measuring period of three weeks. At the end of a measuring period, the data were uploaded from the logger to a personal computer using the SD card. Programming and charging of the battery were achieved via USB interface, and the MSR-PC-Software (MSR Electronics) was used for data analysis.

Analysis of pressure transducer recordings

A computer program (MSR Electronics) was used to identify and quantify the different and rumination phases of the recordings. For each day, the following variables were determined from the uploaded data: Eating and rumination times, number of chewing cycles related to eating and rumination, number of regurgitated cuds and number of chewing cycles per cud.
Meteorological data (air temperature, wind speed, humidity, barometric pressure)
A portable weather station (Skywatch-GEOS 11, JDC Electronic SA, Yverdon-les-Bains, Switzerland) was used to record air temperature, wind speed, relative humidity and barometric pressure every 15 minutes at each location, and two-hour means for each variable were calculated. Precipitation was measured using a rain gauge (Rain gauge according to Prof. Hellman, Möller-Therm GmbH, Kreuzwertheim, Germany).

Statistical analysis

The Stata software (StataCorp., 2011; Stata Statistical Software: Release 12; College Station, Texas, USA) was used for analysis. Data were tested for normality using the Wilk-Shapiro test and non-normal data were transformed accordingly [ladder variable]. Normal data are given as mean ± standard deviation and non-normal data as median, minimum and maximum. Differences between continuous data were analysed using t-test, analysis of variance, linear regression and, when required, Bonferroni test. A general linear model was used to examine the effect of time on the variables eating and rumination times, number of chewing cycles during eating and rumination, number of cuds and mean number of chewing cycles per cud. A P value ≤ 0.05 was considered significant.

Results

Meteorological data

The mean daily air temperatures, the mean relative humidity, wind speed and precipitation were similar at both locations (Tab. 1). Precipitation was limited to 5 mm of rain on day 11 at location A and to 4 cm of snow on days 1 and 2 at location B. The mean barometric pressure was significantly higher at location A than at location B ($P < 0.01$).

Eating and rumination

Recordings made during eating and rumination were readily differentiated based on their characteristic pressure profiles (Braun et al., 2013). Each chewing cycle was represented by a peak on the pressure profile. Rumination was associated with regular chewing movements producing sequences of uniform pressure profiles. This regular profile pattern was briefly interrupted by periods without deflections when there were no jaw movements during swallowing and subsequent regurgitation of another food bolus. The pressure pattern recorded during eating was much more irregular and created a profile with uneven waveforms, and the intervals between swallowing were less regular during eating than during rumination. During eating, there were interruptions of the pressure profiles without jaw movements because of other activities such as pushing feed around in the manger. Similar but more regular interruptions also occurred during rumination when a new cud was regurgitated.

Table 1: Weather variables at locations A (winter pasture) and B (loose housing barn) (medians, range in brackets).

Variable	Location A (winter pasture)	Location B (loose housing barn)
Temperature (°C)	1.8 (–6 to +20)	2.3 (–5 to +12)
Relative humidity (%)	76 (24 to 93)	83 (53 to 90)
Barometric pressure (hPa)	994 (983 to 1006)	969 (956 to 975)
Wind speed (km/h)	0 (0 to 6)	0
Precipitation	5 mm rain	4 cm snow, 2 days

In pastured cows, eating times decreased significantly ($P < 0.05$) on days 5 and 6 (Fig. 2A). The reason for the precipitous drop was lack of water attributable to a clogged pipe. This was remedied immediately upon detection, after which the daily eating times returned to the previous level until the end of the study period. Similarly, chewing cycles related to eating (Fig. 2B) were greatly reduced on days 5 and 6 and returned to previous level after rectification of the problem. The same observations were made for the rumination time (Fig. 2C), the chewing cycles related to rumination (2D), the number of regurgitated cuds (Fig. 2E) and the number of chewing cycles per cud (Fig. 2F).
For the entire study period, pastured cows had significantly longer mean daily eating and ruminating times than housed cows (Tab. 2). Pastured cows also had on average significantly more chewing cycles per day related to eating and rumination and significantly more cuds per day and more chewing cycles per cud than housed cows (Tab. 2).

Correlations between eating and rumination and meteorological variables

There were a few significant correlations between eating and rumination and meteorological variables (Tab. 3). The coefficients of correlation ranged from –0.42 (number of regurgitated cuds per day and air temperature in housed cows) to +0.35 (chewing cycles related to eating per day and wind speed in pastured cows) and were relatively small.

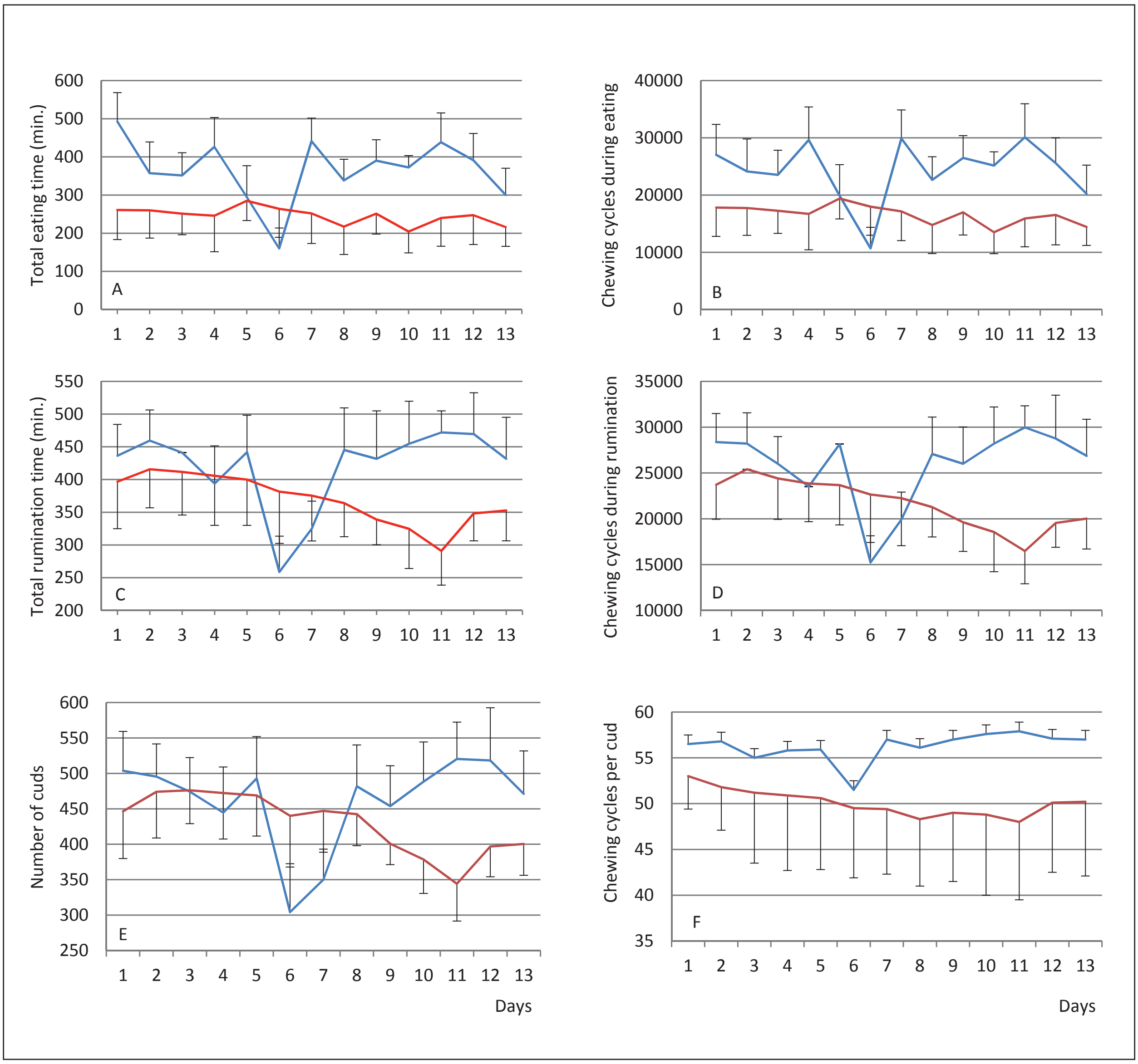

Figure 2: Daily eating time (A), number of chewing cycles related to eating (B), rumination time (C), number of chewing cycles related to rumination (D), number of regurgitated cuds (E) and number of chewing cycles per regurgitated cud (E) of 13 Scottish Highland cows during a 13-day period on a winter pasture and in a loose housing barn (means ± standard deviations). Blue lines housed in a dry lot, red lines stabled in loose housing.

Table 2: Eating and rumination variables in 13 Scottish Highland cows during 13-day periods on a winter pasture and in a loose housing barn (means ± standard deviations), medians, range).

Variable	Per day	
	Pasture	Barn
Eating time (min)	359 (91)	243* (93, 451)
Chewing cycles related to eating	24,227 (6,844)	16,721** (6035, 30,288)
Rumination (min)	421 (81)	373** (198, 532)
Chewing cycles related to rumination	25'721 (5,595)	21'828** (10,224, 31,424)
Regurgitated cuds	461 (83)	428* (264, 570)
Chewing cycles per cud	57 (47, 69)	50** (7.3)

* P < 0.05
** P < 0.01
NA Not applicable

Discussion

The results confirmed that the pressure sensor technique is an excellent method to measure eating and rumination variables in Scottish Highland cattle. In a previous study of Brown Swiss cows, there was a strong correlation between results of the automated recording technique and direct observation (Trösch, 2013; Braun et al., 2013). It appears safe to assume that the recordings obtained in the present study are as precise as those of the study using Brown Swiss cows. This study has shown that cows fed hay on a winter pasture spend significantly more time eating than when they are kept in a loose housing barn and fed hay (359 vs. 243 minutes) and, by extension, have more chewing cycles related to eating per day (24'227 vs. 16'721). The area of the winter pasture was 40 times the area of the loose housing barn. This allowed more generous spacing of the feeding places and ensured that more cows could eat at a given time at the feeders without lower-ranking cows being bullied by higher-ranking herd mates. In addition, cows could also eat at the resting places that were bedded with straw and hay. There were never more than five cows eating in the barn although there were 28 head gates at the hay manger. It was necessary for the cows to stand side by side to eat in the barn and this was often associated with hierarchical differences between cows. The limitation in eating space in the barn was therefore a possible stress factor because it affected the social structure of the herd and made it more difficult for cows to avoid higher-ranking cows, and thus affected eating behaviour. Only on day 6 was the eating time shorter in pastured cattle than in housed cattle, but this was only temporary because of a problem with the drinking water, which was quickly fixed. Eating behaviour is strongly correlated with water intake (Utley et al., 1970) and the clogged water pipe explains the drop in eating. Pastured cows ruminated significantly longer per day than housed cows (421 vs. 373 minutes) and had more chewing cycles related to rumination (25'721 vs. 21'828). Likewise, the daily number of regurgitated cuds (461 vs. 428) as well as the number of chewing cycles per cud (57 vs. 50) were higher in pastured cows.

Eating and rumination behaviours of the pastured Highland cows were similar to those recorded in lactating Braunvieh cows housed in tie stalls (Braun et al., 2013). The Highland and Braunvieh cows ate for 359 and 445 minutes per day, respectively, and ruminated for 421 and 388 minutes per day, respectively. Highland cows in loose housing spent considerably less time eating per day than Braunvieh cows (243 vs. 445 minutes) but daily rumination times were similar (373 vs. 388 minutes) The mean daily eating time of Highland cows in loose housing was 116 minutes (32 %) shorter and the mean daily rumination time was 48 minutes (11 %) shorter than in cows on pasture. Comparison of eating and rumination behaviour of pastured and housed Highland cows of the pres-

Table 3: Correlation coefficients between eating and rumination variables and weather variables at locations A (winter pasture) and B (loose housing barn).

Variable	Temperature		Humidity		Barometric pressure		Wind speed	
	A	B	A	B	A	B	A	B
Eating time	0.21**	–0.14	0.02	0.07	0.12	–0.04	0.32**	NA
Chewing cycles related to eating	0.22**	–0.16*	–0.01	0.07	0.11	–0.04	0.35**	NA
Rumination Time	0.26**	–0.34**	0.16*	0.12	0.02	–0.18*	0.05	NA
Chewing cycles related to rumination	0.21**	–0.36**	0.21**	0.12	–0.01	–0.17*	–0.01	NA
Regurgitated cuds	0.30**	–0.42**	0.11	0.09	–0.05	–0.16*	0.10	NA
Chewing cycles per cud	0.10	–0.05	0.09	0.11	–0.01	–0.12	0.06	NA

* P < 0.05
** P < 0.01
NA Not applicable

ent study and of Highland cows and Braunvieh cows of a previous study (Braun et al. 2013) indicate that loose housing affects eating behaviour more than rumination behaviour. There were other interesting comparisons. The number of regurgitated cuds per day was higher in pastured (461) and housed Highland cows (428) than in lactating Braunvieh cows (410). Numbers of chewing cycles per cud were similar in pastured Highland cows (57) and Braunvieh cows (60) but considerably lower in housed Highland cows (50). Because of the larger daily number of regurgitated cuds, the number of daily chewing cycles was similar in pastured Highland cows and Braunvieh cows (25'721 and 24'751, respectively) but the number of chewing cycles related to rumination was reduced considerably (21'828) in housed Highland cows.
Weather variables were very similar at both locations. The correlations between eating and rumination variables and weather phenomena were relatively weak and inconclusive, and we concluded that under the prevailing conditions, weather had no or only minimal effects on eating and rumination. However, it can be expected that extreme temperatures, high humidity, heavy rain and snowfall or high winds affect eating and rumination in cattle.

Conclusion

Eating and rumination activity is higher in Scottish Highland cattle kept on pasture compared to the same cattle maintained in a loose housing. The climatic conditions were very similar and the feed was the same at the two locations, and it is therefore likely that the greater activities were related to the larger space on pasture.

Alimentation et rumination des vaches Highland à l'extérieur et dans une stabulation ouverte

Dans le présent travail, on étudie l'alimentation et la rumination de vaches Highland dans des conditions hivernales. Les vaches ont tout d'abord été détenues à l'extérieur durant 13 jours puis durant 13 jours également dans une stabulation ouverte; du foin était dans les deux cas affouragé ad libitum. L'enregistrement de l'alimentation et de la rumination était effectué au moyen d'un détecteur de pression intégré à la muserole du licol. On a analysé pour chaque animal et dans les deux endroits la durée journalière d'alimentation et de rumination, le nombre de mouvement de mastication lors de l'alimentation et de la rumination, le nombre de boli ruminatoires et le nombre de mouvement de mastication par bolus. On a également enregistré la température de l'air, la vitesse du vent, l'humidité relative, la pression atmosphérique et les précipitations. Dans la garde à l'extérieur, les durées d'alimentation et de rumination, le nombre de mouvements masticatoires, le nombre de boli ruminatoires et le nombre de mouvement masticatoire par bolus étaient tous significativement plus longs respectivement plus grands que lors de la garde en écurie ouverte. Les conditions climatiques étaient très similaires aux deux endroits.

Alimentazione e ruminazione dei bovini di razza Highlander scozzesi tenuti all'aperto o in stalla aperta

Nel presente studio, sono state esaminate l'alimentazione e la ruminazione dei bovini di razza Highlander scozzesi in condizioni invernali. Le mucche sono state tenute dapprima 13 giorni all'aperto dopo altri 13 in una stalla aperta e in entrambi i casi alimentati con fieno ad libitum. I rilevamenti dell'alimentazione e della ruminazione sono stati eseguiti con un sensore sensibile alla pressione che è stato integrato nello stringibocca della cavezza. Per ogni animali e luogo sono stati valutati la durata dell'alimentazione e della ruminazione, il numero di masticazioni durante l'alimentazione e la ruminazione, il numero di boli nella ruminazione e il numero di masticazioni per bolo nella ruminazione quotidianamente. Allo stesso modo si sono controllate la temperatura dell'aria, la velocità del vento, l'umidità relativa, la pressione atmosferica e le precipitazioni. Durante la tenuta all'aperto la durata di alimentazione e ruminazione, il numero di masticazioni durante l'alimentazione e la ruminazione, il numero di boli nella ruminazione e il numero di masticazioni per bolo nella ruminazione erano più lunghi risp. grandi che durante la tenuta in stalla aperta. Le condizioni metereologiche erano approssimativamente le stesse in entrambi i luoghi.

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