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DairyCheck – a sensor system for monitoring and analysis of the chewing activity of dairy cows

DairyCheck is a developing sensor system for recording chewing activity of dairy cows quantitatively and qualitatively. The measurement is based on the principle of electromyography (EMG). The electromyographic sensor quantifies the electrical potential of masticatory muscle contractions at the cow's skin (*M. masseter*). Analysis and assessment of the recorded EMG-data and signal patterns is realized by a software application, evaluating the duration of chewing and ruminating for each animal quantitatively and qualitatively. This is the basis of early indication of health disorders.

Keywords

Abstract

High milk yields in dairying have to be realized by energetic rations, which are in part contrary to the requirements of the rumen. Health disorders resulting from this can be measured by variations in the ruminating activity. Duration of ruminating depends on fed intake and composition of daily ration, whereby a high level of structure parts promotes ruminating. Chewing and ruminating are important factors for the assessment of the structural impact of feed [1; 2; 3]. Ruminating is an essential behavior for cows, representing physical and psychical animal well-being. Variations in ruminating can be used to identify health disorders (i. e. acidosis) [4]. A sensor system based on electromyographic technique has been developed, which evaluates chewing activity of dairy cows.
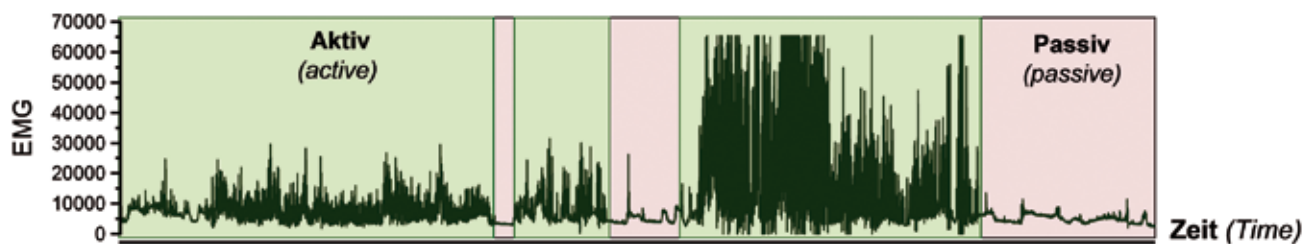
Sensor system

This newly developed system consists of a multi-parametrically monitoring unit and a software module for data sampling and analyzing, focusing on variations of chewing activities animal individually. Wireless radio transmission modules transmit data in real-time via receivers placed in a barn. The sensor system is attached by a halter (**Figure 1**).

Fig. 1
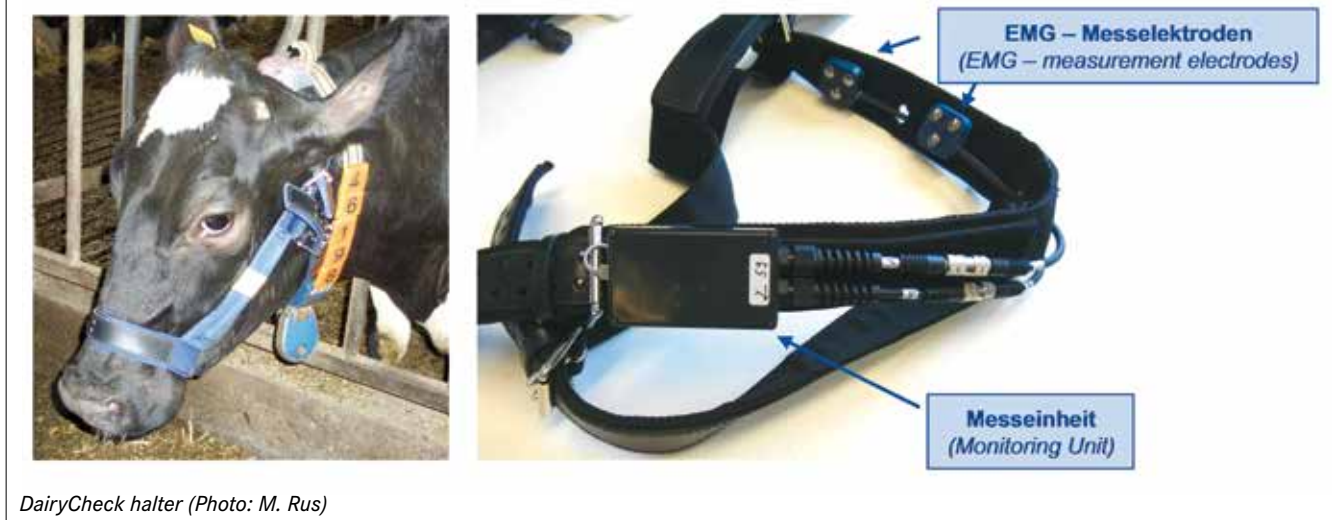
DairyCheck halter (Photo: M. Rus)

EMG signal

The sensor system includes two measurement electrodes; a 3D-accelerometer monitors head position and movement. The system also includes the circuit board for signal processing and power supply. The sensor system allows measuring chewing activity of the cow without disturbing the natural chewing behavior. The system measures electrical signals, which accrue while the contraction of the (*M. masseter*) with a frequency of 10 Hz (**Figure 2**).

The signals for rumination and feeding behavior differ in the muscle activity and the signal pattern. While rumination shows a regularly pattern with defined breaks and chewing activities, feeding behavior is characterized by a very irregular pattern. The DairyCheck software classifies the measured data in phases with and without chewing activity. Afterwards these phases will be segmented in rumination and other activities (i. e. feeding, drinking, etc.). The DairyCheck software package consists of various analysis modules, which evaluate each data record and identify automatically beginning and end time, duration and number of all phases. In the following the function

of the sensor-system will be demonstrated with the analysis of the EMG-signals of 6 healthy cows of second lactation with a mean milk yield of 47.2 ± 2.7 kg/cow/day. The experiments were carried out in the Centre of Research for Cow Husbandry and Technology of the Regional Office for Agriculture and Horticulture (Sachsen-Anhalt, Iden). In addition to the sensor data daily feed intake and feeding duration were recorded. Six consecutive days out of this comprehensive data base were selected (**Table 1**).

Analysis of the chewing activity

During the entire measurement 2714 phases with and without chewing activity were recorded from 6 cows; this corresponds ca. 75.39 phases per cow and day with a mean phase duration of about 19 minutes. **Table 2** shows the results of the determined parameters (number of phases, duration of phases and duration of all phases per day), summed up as a mean for the cow group. The refined observation of the phases recognized shows automatically that only 45 % of all phases were combined

Table 1

*Feed intake and Feeding duration for each cow in the analysed period*

	Tiernummer/*Cow number*					
	7514	**7508**	**7554**	**94997**	**7536**	**7543**
Futteraufnahme [kg/Tag] *Feed intake [kg/day]*	49,9	49,0	47,8	47,7	47,5	52,6
Fressdauer [hh:mm/Tag] *Feeding duration [hh:mm/day]*	07:52	04:54	05:09	04:44	03:12	03:22

Table 2

Average muscle activity (mean ± SD) of each cow in the analysed period

Parameter/*Parameter)*	Anzahl Phasen je Tier und Tag *Number of phases per cow and day*	Phasendauer je Tier *Phase duration per cow*	Gesamtdauer je Tier und Tag *Duration per cow and day*
Wiederkauen *Rumination*	14,94 ± 3,71	0:28:34 ± 0:05:39	7:05:48 ± 2:06:09
Sonstige Maulaktivität *Other activities*	19,28 ± 7,69	0:20:19 ± 0:08:05	5:36:32 ± 1:04:30
Pause (keine Maulaktivität) *Breaks (no activity)*	41,17 ± 9,42	0:16:41 ± 0:04:27	10:59:44 ± 1:43:21

Fig. 3
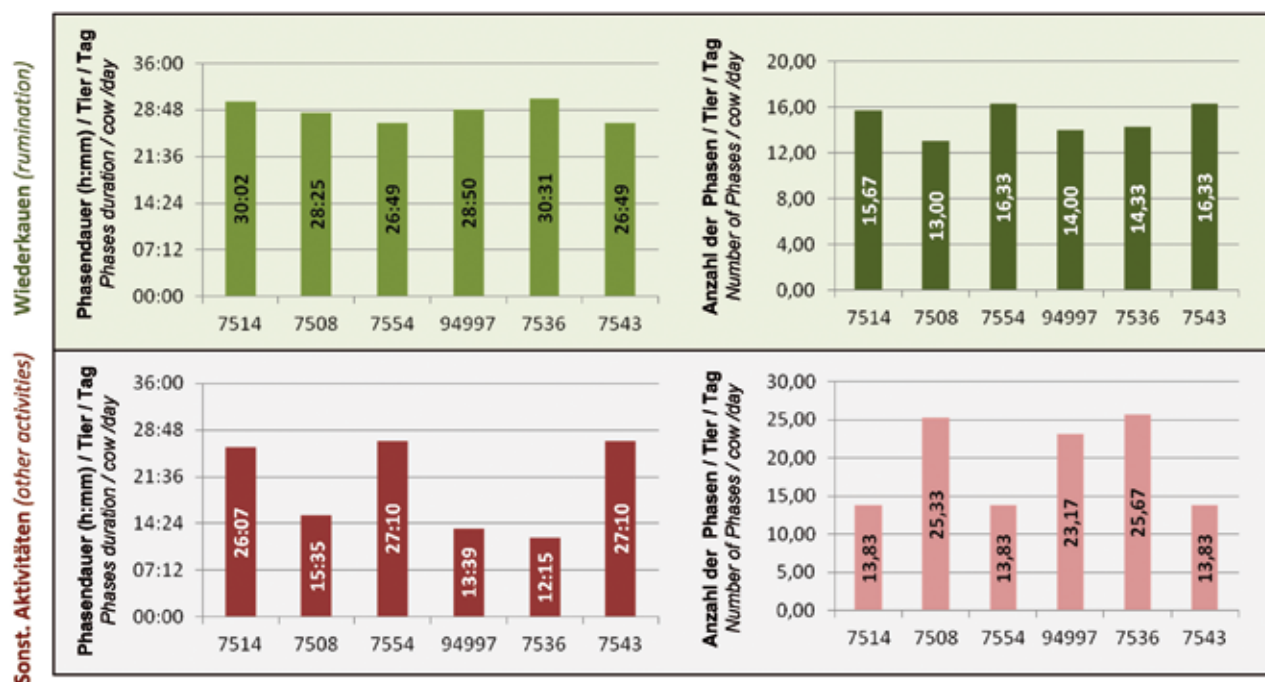
Chewing periods: average duration and number per cow and day

with chewing activity and therefore relevant for analyzing. The mean duration including rumination is about 28 minutes. In contrast the mean duration of a phase with other activities is approx. 20 minutes.

While daily mean ruminating duration is about 7 hours (ca. 30 % of the day), daily mean duration of other activities is about 5.5 hours (24 % of the day). Considering to standard deviation of all phases with chewing activity (SD: 19–40 % of mean) and the results in **Table 1**, the variation between each animal is high. In order to emphasise this, **Figure 3** represents the results of the statistical analysis of phase duration and number of phases with chewing activity for each animal.

It is shown that there are big differences between the cows, depending on phase type and parameter. Mean duration of a rumination phase fluctuates between about 26 min. and 30 min./phase. In contrast the lowest phase duration of other activities was approximately 12 min. /phase while the longest duration

exceeds this one of about 122 %. The number of phases differs also. While the mean number of rumination phases shows only slight variations (± 3 rumination phases/cow/day), the number of phases with other activities shows large variations (± 12 phase other activities/cow/day). These results show that the rumination phases have less individual variations as other activities and can be used for the analysis of chewing activity.

The published literature reports that ruminating activities are subjected to a circadian rhythm [5] and that ruminating phases are influenced by different stress factors [6; 7]. Against this background further analysis concentrate on daily distribution rumination phases (**Table 3**). Classification of daily stages took milking times into account (4:00, 12:00 and 20:00). The comparative analysis of the three parameters points to a slight increased rumination activity during the night. With the results of **Table 3** it is clear, that the variation between the animals is high (SD morning: 25–48 % of mean, SD after-

Table 3

Group analysis of rumination per daily stage (mean ± SD)

	Vormittag (4–12 Uhr) *Morning (4–12 a. m.)*	Nachmittag (12–20 Uhr) *Afternoon (12–8 p. m.)*	Nacht (20–4 Uhr) *Night (8 p. m.–4 a. m.)*
Wiederkaudauer je Tier und Abschnitt [h:mm] *Duration of rumination per cow and day [h:mm]*	2:02 ± 0:59	2:11± 0:48	2:52 ± 0:46
Anzahl der Phasen je Tier und Abschnitt [n] *Number of phases per cow and day [n]*	4,25 ± 1,93	4,58 ± 1,50	6,11 ± 2,16
Wiederkaudauer je Tier und Phase [h:mm] *Duration of rumination per cow and phase [h:mm]*	0:28 ± 0:07	0:30 ± 0:13	0:30 ± 0:09

Fig. 4
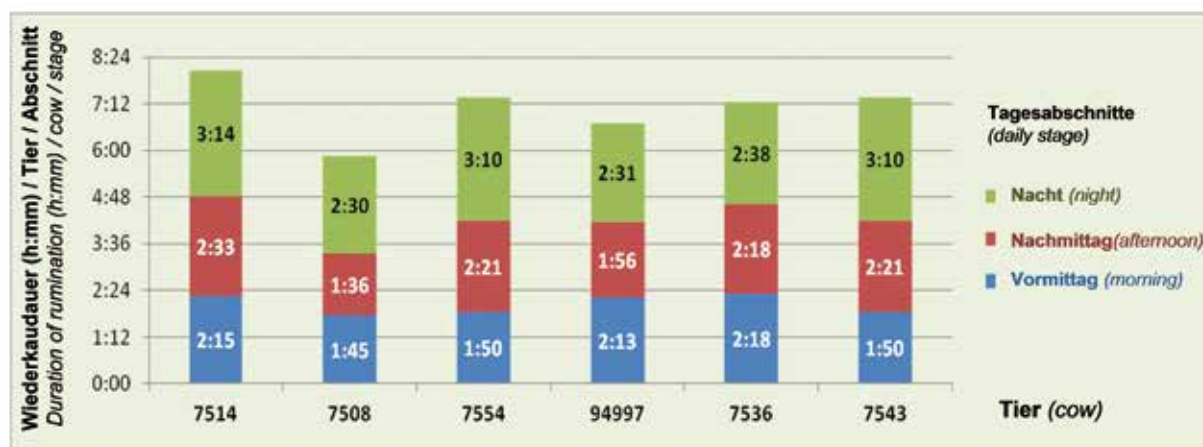
Comparison of rumination of each cow per daily stage

noon: 33–43 %). Furthermore it can be noted that ruminating activity during night show less variations between the animals (SD night: 27–35 %).

The consideration of the individual cow led to similar results as the consideration of the group (**Figure 4**). It is shown that 41 ±3 % of the whole ruminating duration/cow/day occurs equally during night. The rest of the ruminating duration distributes equally in the daily stages (29 ± 4 %; afternoon: 30 ± 2 %).

Conclusions

Electromyographic sensors offer the possibility to quantify and analyze the chewing activity of dairy cows for a long period of time. The results of this study showed that the variation of ruminating activity data is relatively small. The small sample produced the following results: duration per day: 7 hours, number of phases: 15/day; duration per Phase: 28 minutes. Furthermore it is shown that ruminating in the night varies less as at day. Hence, it is expectable that changes in chewing activity could be identified at night-time.

The example presented here about the functionality of the DairyCheck system shows clearly, that ruminating can be distinguished from other chewing activities. Further studies concentrate on characterizing chewing activities while feeding and differentiating other activities, in order to use the muscle activity to identify feeding.

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