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Evaluation of an ear-tag-based accelerometer for monitoring rumination in dairy cows

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ABSTRACT

The objective of this study was to evaluate the ear-tag-based accelerometer system Smartbow (Smartbow GmbH, Weibern, Austria) for detecting rumination time, chewing cycles, and rumination bouts in indoor-housed dairy cows. For this, the parameters were determined by analyses of video recordings as reference and compared with the results of the accelerometer system. Additionally, we have tested the intra- and inter-observer reliability as well as the agreement of direct cow observations and video recordings. Ten Simmental dairy cows in early lactation were equipped with 10-Hz accelerometer ear tags and kept in a pen separated from the other herd mates. A total mixed ration was fed twice a day via a roughage intake control system. During the study, cows' rumination and other activities were directly observed for 20 h by 2 trained observers. Additionally, cows were video recorded for 19 d, 24 h a day. After exclusion of unsuitable videos, 2,490 h of cow individual 1-h video sequences were eligible for further analyses. Out of this, one hundred 1-h video sequences were randomly selected, and visually and manually classified by a trained observer using a professional video analyses software. Based on these analyses, half of the data was used for development (based on data of 50-h video analyses) and testing (based on data of additional 50-h video analyses) of the Smartbow algorithms, respectively. Inter-and intra-observer reliability as well as the comparison of direct against video observations revealed in high agreements for rumination time and chewing cycles with Pearson correlation coefficients of $r > 0.99$. The rumination time, chewing cycles, as well as rumination bouts detected by Smartbow were highly associated ($r > 0.99$) with the analyses of video recordings. Algorithm testing revealed in an underestimation of the average ± standard deviation rumination time per 1-h period by the Smartbow system of 17.0 ± 35.3 s (i.e., −1.2%), compared with visual observations. The average number ± standard deviation of chewing cycles and rumination bouts was overestimated by Smartbow by 59.8 ± 79.6 (i.e., 3.7%) and by 0.5 ± 0.9 (i.e., 1.6%), respectively, compared with the video analyses. In summary, the agreement between the Smartbow system with video analyses was excellent. From a practical and clinical point of view, the detected differences were negligible. However, further research is necessary on testing the system under various field conditions and on evaluating the benefit of implementing rumination data into herd management decisions.

Key words: cow, accelerometer, rumination, monitoring

INTRODUCTION

Rumination is essential in the digestive physiology of ruminants. It can be defined as a process characterized by regurgitation, mastication, and re-swallowing of ingesta (Beauchemin, 1991). The number of chews per bolus is associated with the fiber content of the feed, but in general rumination activity can be influenced by several environmental factors, such as the nature and amount of feed (Metz, 1975; Suzuki et al., 2014) or milking schedules and patterns of lighting (Beauchemin, 1991). Adult cows ruminate approximately 8 h per day in 4 to 24 periods, each of them lasting 10 to 60 min (Gáspárdy et al., 2014). Nevertheless, rumination time seems to have a physiological limit of approximately 10 h per day, but rumination times of 12 h per day have also been reported (Welch, 1982; Beauchemin, 1991; Liboreiro et al., 2015).

An inhibition of rumination activity can be caused by low pH or high osmotic pressure in the rumen (Welch, 1982). Focant et al. (1979) detected a reduced rumination activity in association with VFA concentrations in the ruminal fluid in goats.

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A decrease of rumination activity is also reported as an indicator for stress (Herskin et al., 2004). Considering these physiological factors, a sensor-based continuously monitoring of the rumination activity has the potential to be used as an instrument for herd health management decisions. For instance, the association between rumination activity and ruminal pH (Welch, 1982) provides the opportunity for an early detection of cows suffering from rumen acidosis. Recently, Stangaferro et al. (2016a,b,c) evaluated the monitoring of rumination and activity for identification of cows with health disorders. For nondiseased animals, the authors reported an average rumination time of approximately 500 min per d. For cows that developed metabolic disorders, digestive disorders, or both, the rumination time was lower ($P \leq 0.05$) from −5 to 5 d relative to the clinical diagnosis (d 0) with a nadir of approximately 262 min per d on d 0.

Liboreiro et al. (2015) reported the days relative to calving, stillbirth, subclinical hypocalcemia, and retained fetal membranes as the most important factors associated with the daily rumination time during the prepartum period. Postpartum, the most important factors associated with the daily rumination time were the days relative to calving, twinning, subclinical hypocalcemia, subclinical ketosis, and retained fetal membranes.

A health index score (**HIS**) based on rumination and activity data determined by the Hi-Tag rumination monitoring system (SCR Engineers Ltd., Netanya, Israel) was recently evaluated by Stangaferro et al. (2016a,b,c). The HIS showed high sensitivities of 98, 91, and 89% in detecting animals suffering from displaced abomasum, ketosis, and indigestion, respectively, that were detected 0.5 to 3 d before the clinical diagnosis by farm personnel. The reported sensitivities of HIS in detecting clinical mastitis and metritis were 58% (81% for mastitis caused by *Escherichia coli*) and 55%, respectively. Hence, the authors concluded that monitoring rumination time and physical activity could be useful for identifying cows with metabolic and digestive disorders in the early postpartum period. Additionally, the automated rumination and monitoring system was reported to be effective for identifying cows suffering from mastitis caused by *E. coli* as well as for cows suffering from severe metritis.

As rumination activity is reported to decrease during estrus (Reith and Hoy, 2012) and parturition (Pahl et al., 2014; Clark et al., 2015), this parameter might be useful for detecting cows in estrus or in predicting parturition.

Visual observation of rumination activity is regarded as a reliable method and considered as the gold standard, but is labor intensive (Schirmann et al., 2009; Burfeind et al., 2011). Some devices for monitoring rumination, for instance the Hi-Tag rumination monitoring system (SCR Engineers Ltd.) and Qwes-HR (Lely Ltd., St. Neots, UK), record mastication sounds (Beauchemin et al., 1989; Schirmann et al., 2009; Burfeind et al., 2011; Goldhawk et al., 2013; Ambriz-Vilchis et al., 2015), whereas others, for instance the IGER Behavior Recorder systems (Ultra Sound Advice, London, UK), measure jaw movements (Kononoff et al., 2002; Umemura et al., 2009). Another system, the CowManager SensOor (Agis Automatisering BV, Harmelen, the Netherlands) consists of an ear-tagged device (Bikker et al., 2014; Borchers et al., 2016). Similar to this system, the Smartbow ear tag (Smartbow GmbH, Weibern, Austria) used in this study comprises of an acceleration sensor to recognize rumination activity, among others. Furthermore, the location as well as the locomotion activity of a cow can be detected (Wolfger et al., 2017).

The primary objective of this study was to evaluate the suitability of the Smartbow system for monitoring rumination activity by comparison of the recorded rumination time, jaw movements, and rumination bouts with video observations, performed by a trained observer. Additional objectives were to test the intra- and inter-observer reliability as well as the agreement of direct animal observations and video recordings.

MATERIALS AND METHODS

All study procedures were discussed and approved by the institutional ethics and welfare committee in accordance with Good Scientific Practice guidelines and national legislation (ETK-05/07/15). The study was conducted from June to August 2015 at the Teaching and Research Farm of the University of Veterinary Medicine, Vienna (Austria), keeping approximately 75 Simmental dairy cows in a freestall barn. The cows were milked twice daily in a tandem milking parlor. The average ECM yield (based on 4.0% butterfat and 3.4% protein) of the herd in 2016 was 8,755 kg per cow.

Animals and Housing

Ten clinically healthy cows were selected from the herd. These cows were housed together in a pen (Figure 1) separated from the other herd mates for the duration of the study (i.e., during visual and video observations and data recording by accelerometers). Cows were enrolled in the study at the same time independent of lactation number (median lactation number: 2; minimum: 1; maximum: 8) and in peak lactation (mean DIM ± SD: 73 ± 27 d). Each of the 10 cows was equipped with one Smartbow ear tag device. Every cow