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Short communication

Validation of a noseband sensor system for monitoring ruminating activity in cows under different feeding regimens

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ABSTRACT

Monitoring of ruminating activity in cows can help detecting deficiencies in structural fibre in the diet and also identifying related rumen disorders at an early stage. The aim of this study was to evaluate a noseband sensor system (NSS; "RumiWatch", Itin+Hoch GmbH, Liestal, Switzerland) under variable feeding regimens. Visual and electronic measurements of ruminating activity were compared in eight Holstein cows fed either roughage-only diet, transition diet from roughage to concentrate, or constant feeding of 65% concentrate (dry matter basis). Increasing the concentrate amount in the diet lowered ($P < 0.01$) all ruminating parameters, regardless of the measurement method. The analysis showed that NSS overestimated ($P \leq 0.01$) several chewing variables such as ruminating chews per minute, chews per bolus and ruminating chews per 10 min; however, total duration of rumination did not differ ($P=0.49$) between visual and NSS method. Also, the concordance correlation coefficient (CCC) analysis, representing the reproducibility of the NSS measurements, revealed a substantial agreement between visually observed and with NSS recorded values for ruminating chews per 10 min (CCC=0.92) and a high agreement for the number of boli per 10 min (CCC=0.82). In contrast, the reproducibility of NSS was moderate (CCC=0.67) for chews per bolus and low (CCC=0.36) for chews per min. In conclusion, the NSS is a suitable device to replace time-consuming visual observations for measuring total rumination time in cows under variable feeding conditions. However, specific NSS measurements such as chews per minute, chews per bolus, and the number of boli need further adjustements.

1. Introduction

Rumination is an essential physiological process in ruminants. The length of the rumination periods is affected by structural fiber in the diet (Zebeli et al., 2010), whereby rumination reflects secretion of alkaline saliva and rumen buffering (Allen, 1997). Therefore, measuring of rumination activity can be helpful to evaluate structural fibre adequateness in the cow diets and to prevent rumen metabolic disorders (Tafaj et al., 2005; Zebeli et al., 2010). For this purpose, several electronic devices have been developed (Ambriz-Vilchis et al., 2015; Büchel and Sundrum, 2014). Noseband sensor systems (NSS) detect pressure changes due to jaw movements and have been shown to be suitable monitoring tools for measuring the ruminating activity in cows on real-time basis (Braun et al., 2014; Ruuska et al., 2016; Tafaj et al., 2005; Zehner et al., 2012). Besides these pressure-based halter-systems, audio-based systems such as the rumination collar SCR (Hi-Tag, SCR Engineers Ltd., Netanya, Israel) provide reasonable measures of rumination time in todays' dairy cow farming (Schirmann et al., 2009). However, the use of halters instead of collars might be advantageous to ensure the correct position of the systems on the cow's head (Ambriz-Vilchis et al., 2015).

Although previous studies that validated the NSS ("RumiWatch", Itin+Hoch GmbH, Liestal, Switzerland) showed high agreement between visually observed and automatically recorded ruminating activities (e.g., Ruuska et al., 2016), this was not done under different feeding regimens similar to field conditions. Indeed, previous validations of the NSS in cows investigated neither the effect of different feeding regimens on the accuracy and precision of the NSS nor comprised all of the ruminating parameters provided by the system (Ruuska et al., 2016; Zehner et al., 2012). Cows typically are transitioned from forage to concentrate-rich feeding during their lactation cycle. When fed concentrate-rich diets (e.g., > 50% concentrate), cows

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lower the length and intensity of ruminating chews as compared to diets containing less concentrates (Tafaj et al., 2005). We hypothesized that diet characteristics, especially the amount of concentrate, may affect the accuracy of ruminating reads via electronic devices. Therefore the aim of this study was to compare all ruminating activity estimates recorded by the NSS with visually observed values in dairy cows fed different concentrate levels.

2. Materials and methods

All procedures involving animal handling and treatment were approved by the institutional ethics committee of the University of Veterinary Medicine (Vetmeduni) Vienna and the national authority according to §26 of the Law for Animal Experiments, Tierversuchsgesetz 2012- TVG (GZ: 68.205/0023-WF/V/3b/2015).

2.1. Feeding experiment

The feeding experiment was conducted with eight non-lactating Holstein cows (initial body weight (BW): 834 ± 81 kg). Before the start of the experiment the cows were fed with pasture and hay for three weeks. Then cows were placed in one group in a loose-housing stable at the research dairy farm of Vetmeduni Vienna, Austria. To simulate current feeding practice with low to high concentrate levels cows were fed three different feeding regimens (roughage-only diet, gradual increase from roughage to a concentrate level of 65% and finally a feeding regimen with a constant concentrate level of 65%). In the roughage period, cows were fed a hay/grass silage mix for one week. Cows were then transitioned from the pure roughage to a concentrate diet, increasing the concentrate amount over four days from 0% to 65% (DM basis). During the constant concentrate feeding period, cows received 65% concentrate (DM basis) for one week. The hay/grass silage mix consisted of 50% grass silage and 50% first-cut meadow hay with 49.9% DM, 91.5% organic matter (OM), 12.9% crude protein (CP), 54.0% neutral detergent fibre (NDF), 34.5% acid detergent fibre (ADF), 1.6% ether extract (EE) and 23.1% non-fibre carbohydrates (NFC) (DM basis). The concentrate contained as main ingredients barley grain (33%), wheat (30%), rapeseed meal (16%) and maize (15%). Chemical analysis of the concentrate resulted in 89.5% DM, 95.6% OM, 15.8% CP, 15.9% NDF, 7.4% ADF, 2.9% EE and 61.0% NFC (DM basis). The forage NDF content of the diets varied between 54.0% during roughage feeding and 18.9% (DM basis) during constant concentrate feeding. Cows had access to water and a salt lick stone ad libitum. The diets were fed semi ad-libitum and offered at 1.3–1.9% of BW during the roughage feeding. During the transition to concentrate and constant 65% concentrate feeding the DM allowance was elevated to 1.4–2.0% of BW, meeting the voluntary feed intake potential of the cows. To control the daily allowances of roughage mix and concentrates and to keep the exact concentrate to roughage ratio of 65:35, feeds were offered in separate feeding troughs (Insentec B.V., Marknesse, The Netherlands), which were equipped with electronic weighing scales and computer-regulated access gates. The feeding troughs were used to record the individual feed intake of each cow. Fresh hay/grass silage mix was offered twice daily at 08:00 and 14:00. Fresh concentrate was offered daily and cows had access to concentrate from 10:00 on, to avoid a possible depression effect on forage intake.

2.2. Measurement of ruminating activity

To monitor chewing activity, each cow was equipped with a NSS ("RumiWatch", Itin+Hoch GmbH, Liestal, Switzerland) following the manufacturers' instructions. This NSS consists of a halter containing a vegetable oil-filled silicone tube located in the noseband, a pressure sensor and accelerometer and a data logger. Jaw movements causing pressure changes in the silicone tube are registered at a frequency of 10 Hz. These raw data are saved on a secure digital (SD) memory card situated in the halter. After each feeding regimen, raw data was transferred manually from the SD cards to a computer. The NSS software (RumiWatch Manager, Version V01.13) and the corresponding data converter (Version 0.7.0.0) were used to analyse the raw ruminating data. NSS was used to record ruminating activity on four consecutive days in each of the three feeding regimens. This procedure enabled repeated observations for each cow. During the four days of NSS measurement each cow was visually observed for nine 10 min intervals as a reference method. Observation during roughage feeding started on the first day of the hay/grass silage feeding. On day one, 10 min of observation took place in the evening. On day two and three, cows were observed three times for 10 min after morning feeding, at noon and in the evening and on day four, two observations lasting for 10 min were carried out after morning feeding and at noon.

All observations were conducted by the same trained person, in order to prevent between-person variations. Before each 10 min observation-interval started, the time of the NSS was evaluated against the time on the observers watch. During the observations the observer was sitting in front of the cows at a distance of about two meters and cows were observed one after the other. In total, 216 observations in 10 min intervals were conducted. For validation, the parameters "duration of ruminating (min/10 min)", "number of ruminating chews (n/10 min)", "number of ruminating chews per minute (n/min)", "number of boli (n/10 min)" and "number of chews per bolus (n/10 min)" were determined individually for each cow and each 10 min interval. The start and end of a 10 min interval were time dependent (e.g. 9:00–9:10). For the visual observation the criterion for a new rumination cycle was the regurgitation of a new bolus. If the 10 min interval started or ended in the middle of a rumination cycle the regurgitated bolus was considered as 0.5 bolus. If the bolus was swallowed in the 10 min interval, this was considered as 1 bolus. A pause of about five seconds after swallowing a bolus (before regurgitation of a new bolus) was considered to be a pause in rumination. For the visual observation the chews per bolus were calculated as the chews per 10 min interval divided by the number of boli. The ruminating chews (n/min) were calculated as the number of chews in the 10 min interval divided by the actual ruminating time.

As this validation was based on ruminating parameters, observation was carried out if most cows were ruminating. Periods during which cows were eating or showed other activities were not considered for the validation. During 65% constant concentrate feeding the reduced ruminating time of the cows limited the 10 min intervals during which cows were ruminating. All in all 71 10 min intervals in roughage feeding, 69 10 min intervals in concentrate transition and 42 10 min intervals in the 65% constant concentrate feeding were statistically analyzed.

2.3. Statistical analysis

ANOVA of chewing data was performed using the mixed procedure of SAS (SAS Institute Inc., Cary, NC, version 9.3). For each tested variable the observation method (visually vs. NSS) and the feeding regimen (roughage feeding, concentrate transition and 65% constant concentrate feeding) were considered as fixed effects. Cows were considered as random effects. A possible interaction between method and feeding regimen was tested for all variables, but was not significant and therefore deleted from the final model. The approximation of degrees of freedom was performed according to Kenward-Roger. Multiple comparisons among groups were determined with Tukey's method. The significance level was set at $P \leq 0.05$. Associations among automatically and visually determined measurements were studied by performing Pearson correlations (PROC CORR of SAS 9.3) and Lin's concordance correlations (NLMIXED model of SAS). Further, the relationship between the NSS measurements and the visual observation values was quantified and prediction equations were calculated using linear regression analysis (PROC REG of SAS 9.3).