J. Dairy Sci. 101:1–4
https://doi.org/10.3168/jds.2016-12534

Technical note: Validation of an ear-tag accelerometer sensor to determine rumination, eating, and activity behaviors of grazing dairy cattle

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ABSTRACT

The objective of this study was to validate an ear-tag accelerometer sensor (CowManager SensOor, Agis Automatisering BV, Harmelen, the Netherlands) using direct visual observations in a grazing dairy herd. Lactating crossbred cows (n = 24) were used for this experiment at the University of Minnesota West Central Research and Outreach Center grazing dairy (Morris, MN) during the summer of 2016. A single trained observer recorded behavior every minute for 6 h for each cow (24 cows × 6 h = 144 h of observation total). Direct visual observation was compared with sensor data during August and September 2016. The sensor detected and identified ear and head movements, and through algorithms the sensor classified each minute as one of the following behaviors: rumination, eating, not active, active, and high active. A 2-sided *t*-test was conducted with PROC TTEST of SAS (SAS Institute Inc., Cary, NC) to compare the percentage of time each cow's behavior was recorded by direct visual observation and sensor data. For total recorded time, the percentage of time of direct visual observation compared with sensor data was 17.9 and 19.1% for rumination, 52.8 and 51.9% for eating, 17.4 and 11.9% for not active, and 7.9 and 21.1% for active. Pearson correlations (PROC CORR of SAS) were used to evaluate associations between direct visual observations and sensor data. Furthermore, concordance correlation coefficient (CCC), bias correction factors, location shift, and scale shift (epiR package of R version 3.3.1; R Foundation for Statistical Computing, Vienna, Austria) were calculated to provide a measure of accuracy and precision. Correlations between visual observations for all 4 behaviors were highly to weakly correlated (rumination: r = 0.72, CCC = 0.71; eating: r = 0.88, CCC = 0.88; not active: r = 0.65, CCC = 0.52; and active: r = 0.20, CCC = 0.19) compared with sensor data. The results suggest that the sensor accurately monitors rumination and eating behavior of grazing dairy cattle. However, active behaviors may be more difficult for the sensor to record than others.
Key words: precision technology, pasture, behavior monitoring, rumination

Technical Note

Individual cow technologies may be used to measure rumination and feeding time, health status of cows (Bikker et al., 2014), and activity for estrus detection of dairy cattle. Pasture-based systems are becoming more common in the US dairy industry (USDA, 2016), and grazing dairy producers may benefit from utilizing precision dairy technologies. However, the majority of work conducted with precision technologies has been in confinement systems. In this regard, environmental and management conditions such as walking activity and fly pressure may affect how accurately these technologies work in grazing systems (Elischer et al., 2013; Ambriz-Vilchis et al., 2015; Sjostrom et al., 2016).

The objective of this study was to validate the CowManager ear-tag sensor (CowManager SensOor, Agis Automatisering BV, Harmelen, the Netherlands) in a grazing dairy herd by comparing direct visual observations and sensor data for rumination, eating, not active, and active cow behaviors. The hypothesis of this study was that ruminating behavior would have greater correlation between direct visual observations and sensor data than eating, not active, or active behaviors.

During the summer of 2016 (August to September), 24 crossbred cows (4 Holstein-sired, 4 Jersey-sired, 3 Montbéliarde-sired, 5 Normande-sired, and 8 Viking Red-sired crossbred cows) at the University of Minnesota West Central Research and Outreach Center (Morris, MN) dairy herd were used for the study. The total number of cows needed for the experiment was determined using power analyses with a power of 0.80 and 95% confidence level (Friedman, 1982). The current study evaluated more cows than the original CowManager validation study conducted by Bikker et al. (2014) and had more cows than recent validations of

Received December 29, 2016.
Accepted November 17, 2017.
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precision dairy technologies for pasture-based systems (Elischer et al., 2013; Ambriz-Vilchis et al., 2015).

Cows were offered pasture for 22 h/d. Cows were milked twice per day at 0600 and 1700 h in a swing-9 parabone milking parlor. The pastures comprised diverse grasses and legumes that included smooth bromegrass, orchardgrass, meadow fescue, alfalfa, red clover, and kura clover. Cows were stocked at a rate of 3 cows/ha, with 4,019 kg of DM/ha available at the initiation of grazing, and were rotated to new paddocks every 2 d based on forage availability. Grazing was initiated at 20 to 30 ± 2 to 3 cm (mean ± SD) and leaving 7 to 9 cm ± 2 to 3 cm refusals. In addition to pasture, each cow was supplemented with 2.72 kg of organic corn daily and had free-choice access to minerals from a feeder placed at ground level in each paddock. Cows had ad libitum access to water from a water trough also placed at ground level in each paddock.

All cows were equipped with the CowManager eartag sensor for 6 mo to 1 yr before the study began. The sensor was mounted into a blank radio frequency identification tag (eliminating any interference with the system) first and then placed on the right ear of each cow. Data from the sensor were sent wirelessly through a plug and play router or solar router to a coordinator in the milking parlor and made available through a web-based application (Bikker et al., 2014). Agis Automatisering BV provided raw hourly data for the ruminating, eating, not active, and active behaviors for all cows. The sensor detected and identified ear and head movements and through algorithms classified data as ruminating, eating, not active, active, and high active behaviors. We did not include high active behavior because it may be associated with estrus behavior, which we did not record in the current study.

All direct visual observations were recorded by a single trained observer throughout the study. Prior to the initiation of the study, behavior definitions were agreed upon on site by 4 observers (an experienced ethologist, 2 trained observers, and the observer that was conducting the visual observations for the study). These definitions were based on previous research studies and the ethologist's training.

Rumination was defined as when a cow was lying, standing, or walking and the cow regurgitated a bolus and chewed the cud while moving her head and jaw in a circular motion and then swallowing the masticated cud. If the cow was observed not regurgitating or chewing for more than 10 s, this behavior was considered finished (Elischer et al., 2013). Eating was when a cow had eating jaw movements and the muzzle was in close contact with the ground (Nielsen, 2013); the cow may have been walking at the same time. Eating minerals or corn and drinking water was considered eating behavior. Not active was when a cow was standing or lying on the ground and did not consume feed, ruminate, or perform any activity (Elischer et al., 2013; Bikker et al., 2014). Active was when a cow stood on all 4 legs and the cow walked or moved her body (Mullens et al., 2006; Bikker et al., 2014). During the observation period, each minute was considered to consist of only 1 of 4 behaviors (ruminating, eating, not active, or active). Behaviors were mutually exclusive, and if a cow was eating and walking, she was considered to be eating. If the cow performed 2 behaviors during the minute of observation, the behavior she performed the longest during that minute was the predominant behavior (Rutten et al., 2017). If the cow performed 2 behaviors for exactly 30 s each during the minute of observation, those minutes would be identified as transitional and would not have been included in the analysis.

All 24 cows were observed for a total of 6 h/cow (24 cows × 6 h = 144 h of observation total). The observer had a 1-h break between observation times to control for fatigue. Each cow's predominant behavior during every minute was recorded by the observer on a Microsoft Excel 2016 (Microsoft Corp., Redmond, WA) spreadsheet. Time was recorded on observation sheets, and a digital watch (Timex Group USA Inc., Middlebury, CT) was used to track time. The average temperature, humidity, and dew point during the study were 21.4°C, 76.8%, and 16.5°C, respectively.

The UNIVARIATE procedure of SAS (SAS Institute, 2014) was used to establish normality. A 2-sided *t*-test (PROC TTEST) was conducted to compare the percentage of time each cow's behavior was recorded by direct visual observation and sensor data. Pearson correlations between direct visual observations and sensor data were analyzed with the CORR procedure of SAS. The concordance correlation coefficient (**CCC**; Lin, 1989), bias correction factors, location shift, and scale shift were calculated with the epiR package of R software (R version 3.3.1, R Foundation for Statistical Computing, Vienna, Austria). The CCC was calculated to determine the accuracy of correlations between direct visual observations and sensor data. Overprediction of the location shift results in negative values, and underprediction of location shift may be expected with a positive value (Bikker et al., 2014). Pearson correlations and CCC were considered negligible (0.00–0.30), slight (0.31–0.50), minor (0.51–0.70), moderate (0.71–0.90), and strong (0.91–1.00) as described by Bikker et al. (2014).

The percentage of total time for direct visual observation and sensor-derived behaviors, the median, and 95% confidence intervals are presented in Table 1. The time a cow was ruminating ($P = 0.57$) and eating ($P = 0.77$) was similar for direct visual observation com-