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A validation of technologies monitoring dairy cow feeding, ruminating, and lying behaviors

M. R. Borchers,* Y. M. Chang,† I. C. Tsai,* B. A. Wadsworth,* and J. M. Bewley*[1]
*Department of Animal and Food Sciences, University of Kentucky, Lexington 40546
†Research Support Office, Royal Veterinary College, University of London, London, United Kingdom NW1 0TU

ABSTRACT

The objective of this study was to evaluate commercially available precision dairy technologies against direct visual observations of feeding, rumination, and lying behaviors. Primiparous (n = 24) and multiparous (n = 24) lactating Holstein dairy cattle (mean ± standard deviation; 223.4 ± 117.8 d in milk, producing 29.2 ± 8.2 kg of milk/d) were fitted with 6 different triaxial accelerometer technologies evaluating cow behaviors at or before freshening. The AfiAct Pedometer Plus (Afimilk, Kibbutz Afikim, Israel) was used to monitor lying time. The CowManager SensOor (Agis, Harmelen, Netherlands) monitored rumination and feeding time. The HOBO Data Logger (HOBO Pendant G Acceleration Data Logger, Onset Computer Corp., Pocasset, MA) monitored lying time. The CowAlert IceQube (IceRobotics Ltd., Edinburgh, Scotland) monitored lying time. The Smartbow (Smartbow GmbH, Jutogasse, Austria) monitored rumination time. The Track A Cow (ENGS, Rosh Pina, Israel) monitored lying time and time spent around feeding areas for the calculation of feeding time. Over 8 d, 6 cows per day were visually observed for feeding, rumination, and lying behaviors for 2 h after morning and evening milking. The time of day was recorded when each behavior began and ended. These times were used to generate the length of time behaviors were visually observed. Pearson correlations (r; calculated using the CORR procedure of SAS Version 9.3, SAS Institute Inc., Cary, NC), and concordance correlations (CCC; calculated using the epiR package of R version 3.1.0, R Foundation for Statistical Computing, Vienna, Austria) evaluated association between visual observations and technology-recorded behaviors. Visually recorded feeding behaviors were moderately correlated with the CowManager SensOor (r = 0.88, CCC = 0.82) and Track A Cow (r = 0.93, CCC = 0.79) monitors. Visually recorded rumination behaviors were strongly correlated with the Smartbow (r = 0.97, CCC = 0.96), and weakly correlated with the CowManager SensOor (r = 0.69, CCC = 0.59). Visually recorded lying behaviors were strongly correlated with the AfiAct Pedometer Plus (r >0.99, CCC >0.99), CowAlert IceQube (r >0.99, CCC >0.99), and Track A Cow (r >0.99, CCC >0.99). The HOBO Data Loggers were moderately correlated (r >0.83, CCC >0.81) with visual observations. Based on these results, the evaluated precision dairy monitoring technologies accurately monitored dairy cattle behavior.

Key words: precision dairy monitoring, feeding behavior, ruminating behavior, lying behavior

INTRODUCTION

Many precision dairy-monitoring technologies claim to monitor udder health, estrus events, feet and leg health, and metabolic health (Rutten et al., 2013). These technologies provide benefit to producers and researchers by frequently monitoring dairy cattle without disturbing natural behavioral expression (Müller and Schrader, 2003). Dairy producers purchase precision dairy-monitoring technologies to improve individual animal, pen, and whole-farm management, increasing overall farm production efficiency (Wathes et al., 2008). However, for precision dairy-monitoring technologies to increase labor and production efficiency, they must easily and accurately quantify meaningful physiological or behavioral parameters (Senger, 1994).

The automatic measurement of chewing and ruminating activity can enable the early detection of feeding deficiencies and assist in ration adjustments (Zehner et al., 2012). Feeding and ruminating behaviors have traditionally been monitored through visual observation or video recording methods (Schirmann et al., 2009), but these methods are time consuming and only practically used in research settings. Additionally, monitoring animal behaviors using visual observation is subjective and open to observer interpretation (Weary et al., 2009). Monitoring rumination and feeding behaviors with precision dairy-monitoring technologies could replace

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[1]Corresponding author: jbewley@uky.edu

subjective visual observations while providing useful and continuous measures of these behaviors. Technologies recording feeding and rumination behaviors have traditionally quantified these behaviors using chewing activity monitors (pressure and strain recorders; Beauchemin et al., 1989; Kononoff et al., 2002; Zehner et al., 2012). Chewing activity (pressure and strain) and feeding behavior monitors are primarily used in research settings, but commercially available rumination and feeding behavior quantification methods have recently been developed and evaluated. Bikker et al. (2014) evaluated a technology (CowManager Sensoor, Agis, Harmelen, the Netherlands) monitoring rumination and feeding behavior through head movement and found these behaviors to be closely related to visual observations. Similarly, Schirmann et al. (2009) evaluated a technology (HR Tag, SCR Engineers Ltd., Netanya, Israel) quantifying rumination sounds through a microphone and microprocessor and found a strong correlation between visual observations and technology. Another method to quantify feeding behaviors is through technologies describing when cows approach feeding areas. Many of these types of technologies have been evaluated and found to be highly correlated with visual methods (DeVries et al., 2003; Chapinal et al., 2007). These findings indicate the potential for technology performance to vary among technologies monitoring the same parameters through different methods.

Lying behavior is a parameter frequently quantified by precision dairy monitoring technologies (McGowan et al., 2007; O'Driscoll et al., 2008; Ledgerwood et al., 2010). Time spent lying can indicate cow comfort, welfare, and health changes (Haley et al., 2000). Proudfoot et al. (2014) found sick or ill cattle spent more time lying apart from the herd. Compared with other parameters measured by precision dairy-monitoring technologies (e.g., feeding behavior, rumination, and activity), standing and lying events are easily visually monitored but the process remains time-consuming.

Previous studies evaluating lying behavior have reported strong correlations between technologies and visual or video monitoring. Lying behaviors measured by the HOBO Data Logger (HOBO Pendant G Acceleration Data Logger, Onset Computer Corporation, Pocasset, MA) have strongly matched video monitoring observations (Ledgerwood et al., 2010). Similarly, the AfiAct Pedometer Plus (Afimilk, S.A.E. Afikim, Kibbutz Afikim, Israel) and IceTag (a version of the IceQube intended for research; IceRobotics Ltd., Edinburgh, Scotland) monitored dairy cow lying behavior and observations were closely related to video monitoring observations (Mattachini et al., 2013a,b).

Behavioral recording methods have rarely been compared on the same animals over the same periods. The objective of the current study was to evaluate commercially available precision dairy monitoring technologies against direct visual observations for feeding, rumination, and lying behaviors. To our knowledge, this study will also serve as the first to validate the Track A Cow (ENGS, Rosh Pina, Israel) system for feeding and lying behaviors, and the Smartbow (Smartbow GmbH, Jutogasse, Austria) system for rumination behavior. The hypothesis of our study is that lying behaviors will most closely match visual observations. Ruminating and feeding behaviors will be more variable when compared with visual observations.

MATERIALS AND METHODS

This study was conducted at the University of Kentucky Coldstream Dairy Research Farm in Lexington under Institutional Animal Care and Use Committee protocol number 2014–1309. The lactating herd (80 cows) was housed in 2 equal groups separated by a shared, raised feedbunk with a conveyer feed delivery system. A TMR ration containing corn silage, alfalfa silage, whole cottonseed, and grain mix was delivered twice daily, at 0530 and 1330 h. Cows were provided with unrestricted access to freestalls. One group of cows was provided sawdust-covered rubber-filled mattresses (PastureMat, Promat, Ontario, Canada). The other group of cows was provided sawdust-covered Dual Chamber Cow Waterbeds (Advanced Comfort Technology Inc., Reedburg, WI). Grass-seeded exercise lot access was permitted for 1 h per day at 1000 h, weather permitting. All other surfaces (freestall area, feedbunk alley, holding pen, and alleys) contained grooved concrete. Milking occurred twice daily at 0430 and 1530 h. All cattle within the herd were fitted with the following technologies before or at calving, as per standard herd protocol (further information presented in Table 1): AfiAct Pedometer Plus, CowManager SensOor, CowAlert IceQube, Smartbow, and Track A Cow.

The number of cattle needed for our study was determined using the methods of Friedman (1982). All power tests were calculated to obtain a power ($1 - \beta$) of 0.90 and a type I error probability (α) of 0.05 (2-tailed). Effect size was determined by previous studies (equal to correlation coefficients; Bikker et al., 2014) and was 0.93 for rumination time (Bikker et al., 2014), 0.88 for feeding time (Bikker et al., 2014) and 0.90 for lying time (Ledgerwood et al., 2010). A minimum of 24 cows was needed to meet statistical power requirements and this number was doubled to account for potential instances of missing data (n = 48). Eligible cattle were randomly selected and balanced for herd group and parity. No cattle within 21 DIM were included in our study to remove potential effects from the transition period. The