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Validating the accuracy of activity and rumination monitor data from dairy cows housed in a pasture-based automatic milking system

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ABSTRACT

Behavioral observations are important in detecting illness, injury, and reproductive status as well as performance of normal behaviors. However, conducting live observations in extensive systems, such as pasture-based dairies, can be difficult and time consuming. Activity monitors, such as those created for use with automatic milking systems (AMS), have been developed to automatically and remotely collect individual behavioral data. Each cow wears a collar transponder for identification by the AMS, which can collect data on individual activity and rumination. The first aim of this study was to examine whether cow activity levels as reported by the AMS activity monitor (ACT) are accurate compared with live observations and previously validated pedometers [IceQube (IQ), IceRobotics, Edinburgh, UK]. The second aim of the study was to determine if the AMS rumination monitors (RUM) provide an accurate account of time spent ruminating compared with live observations. Fifteen lactating Holstein cows with pasture access were fitted with ACT, RUM, and IQ. Continuous focal observations (0600–2000 h) generated data on lying and active behaviors (standing and walking), as well as rumination. Activity recorded by live observation and IQ included walking and standing, whereas IQ steps measured cow movement (i.e., acceleration). Active behaviors were analyzed separately and in combination to ascertain exactly what behavioral components contributed to calculation of ACT "activity." Pearson correlations (r_p) were computed between variables related to ACT, RUM, IQ, and live observations of behavior. A linear model was used to assess significance differences in the correlation coefficients of the 4 most relevant groups of variables. Significant but moderate correlations were found between ACT and observations of walking (r_p = 0.61), standing (r_p = 0.46), lying (r_p = −0.57), and activity (r_p = 0.52), and between ACT and IQ steps (r_p = 0.75) and activity (r_p = 0.58) as well as between RUM and observations of rumination (r_p = 0.65). These data indicate that ACT and RUM do reflect cow walking and rumination, respectively, but not with a high degree of accuracy, and lying cannot be distinguished from standing.
Key words: behavior, sensor, data logger

INTRODUCTION

Observing animal behavior is a labor intensive and difficult task whether it is performed with live observations or though video recordings. One possible solution is the use of technology to remotely collect behavioral data on the subjects of interest. When technology is used to collect behavioral data, monitors are typically attached directly to the animal; thus, "losing sight" of the subject and therefore being unable to record data for this reason is nearly impossible. Such devices can collect data 24 h/d over extended periods without the need to rest or download data immediately. Another advantage of such technology is that there is no observer bias related to interpreting behavior or observer effect that alters the animal's actions.

Various types of wireless sensor networks and radio frequency identification tags have been used to identify and monitor the behavior, health, and location of different livestock species such as cattle, horses, and poultry (Ruiz-Garcia et al., 2009). The most commonly used data loggers for cattle are accelerometers that record direction and speed of movement on 2 or 3 axes. When worn on the leg as a pedometer, these devices are able to record active (e.g., standing, walking) and lying behaviors (Müller and Schrader, 2003; McGowan et al., 2007; Martiskainen et al., 2009). For example, information gained from data loggers about dairy cows' activity levels (standing, walking, lying) has been examined to determine how comfortable cows are in their environments (O'Driscoll et al., 2008), where they are in the estrus cycle (McGowan et al., 2007), or what their health status is (LeBlanc, 2010). Several of the commercially available data loggers have been validated (Ledgerwood et al., 2010).

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Other types of monitors, typically utilizing microphones or vibration sensors, can provide information on cows' digestive behavior (i.e., rumination; Watanabe et al., 2008). These rumination monitors could provide insight into the cows' consummatory behaviors, which can be used as an additional method to monitor cow health and comfort (Urton et al., 2005).

However, monitoring technology can be costly in terms of money, with individual units costing up to hundreds of dollars, and in terms of time spent learning the system and generating useful data. These costs could be greatly reduced by using data loggers that are integrated with technology already being used by a farm. For example, most automatic milking systems (**AMS**) have sensors and software integrated into the system capable of recording various cow behaviors.

To date, there has been no research validating the accuracy of the outputs from AMS transponders with regard to either activity or rumination. Further, AMS activity monitors have been developed primarily to detect estrus and signs of illness, with software algorithms that emphasize certain types of motion (i.e., mounting) more than others. Thus, it is not known how accurate the monitors are at recording the activities they report. Therefore, the aim of this study was to validate the accuracy of outputs from AMS activity (**ACT**) and rumination (**RUM**) monitors compared with other methods of recording cow behaviors. We hypothesized that the ACT would collect information on active (e.g., standing and walking) and lying behaviors with similar reliability and accuracy to live observation and previously validated technologies. The RUM would be able to determine the difference between ingestion and rumination and accurately reflect the rumination times and patterns of each individual cow. Live observation and a previously validated data logger technology were used as the gold standards with which to compare the AMS monitor outputs.

MATERIALS AND METHODS

Animals and Husbandry

This study was conducted at the Pasture Dairy and Resource Education Center (PDREC) at the Kellogg Biological Station (KBS) in Hickory Corners, Michigan, between June 2 and July 3, 2011. Before the start of the study, all procedures were approved by the Michigan State University Institutional Animal Care and Use Committee. Housing for the lactating herd consisted of a freestall barn and pastures that were accessed via sand graze-ways. Stalls (58/pen; 1.22 × 2.44 m) contained waterbed mattresses that were top-dressed with wood shavings twice a week. The barn had a north-south center divide that created 2 pens of equal size, and cows remained in their assigned pen during the current lactation cycle. Each pen had 1 Lely A3 Astronaut AMS (Lely, Maassluis, the Netherlands) located at the south end of the pen. Cows only accessed the AMS associated with their pen. The cows had free access to the AMS 24 h/d. Milkings occurred on a voluntary basis, but if an individual cow had not visited the AMS for ≥12 h, she was fetched by farm staff to be milked. Automated alley scrapers cleaned the barn twice a day. Stalls were cleaned and additional shavings added daily as needed.

Access to pasture was controlled via automated sorting gates (Lely) at the north end of the barn, opposite the AMS. Individual cows were identified by their transponders as they entered the sorting gate and were either allowed to exit to the pasture or were routed back into the barn if they were due for milking. Length of time since previous milking and time until next milking were automatically calculated by the AMS management program and were the factors that determined whether the individual cow was directed to pasture or back into the barn. During the study period, all lactating cows had pasture access 24 h/d and pasture was their primary feed source. While being milked in the AMS, the cows were fed a pelleted concentrate based on their level of milk production. Additionally, all lactating cows were fed 0.91 kg/d of coarsely ground corn distributed from a CosMix feeder (Lely).

Fifteen lactating multiparous and primiparous Holstein cows were used for this experiment (Table 1). Sixteen cows were initially enrolled; however, 1 cow was dropped post hoc due to technical problems with the AMS transponder that were discovered after completion of the experiment. All cows were at least 150 DIM, had experience with the AMS, did not require frequent fetching, and were selected across the available range of parities (overall average 2.33 ± 0.30). Two trials, each 15 d in length, were completed: trial 1 = 4 cows/AMS 1 and 3 cows/AMS 2; trial 2 = 4 cows/AMS 1 and 2. For each trial, cows were fitted with IceQube (**IQ**) pedometers (IceRobotics, Edinburgh, UK) on the rear pastern above the fetlock. All cows in each replication had IQ attached before data collection and removed after data collection as a group. Before entering the lactating herd, each cow was fitted with a neck collar containing an identification transponder collar using the pictorial guide provided by the manufacturer (Lely). This transponder also housed the cow activity (ACT) and rumination (RUM) monitors (Qwes-HR, Lely). Each cow was allowed a minimum of 12 h to habituate to wearing the devices before data collection began.