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Technical Note: Evaluation of an ear-attached movement sensor to record rumination, eating, and activity behaviors in 1-month-old calves

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ABSTRACT

Sixteen male Holstein calves were fitted with ear-attached motion sensors to evaluate the sensor's (3-dimensional accelerometer with algorithms to process the collected data, CowManager SensOor, Agis, Harmelen, the Netherlands) ability to record rumination, eating, and activity behavior compared with scan sampling by trained observers. Before and after weaning, Holstein calves were in individual pens fed milk replacer with free-choice textured starter and water. Three trained observers used live observation to evaluate individual calf behaviors (Table 1). Instantaneous recording was applied at 1-min intervals (5 to 10 s/calf each min) for 12 h/d on 4 different days. Observation periods included after the morning milk replacer feeding; midday; and just before, during, and after the evening milk replacer feeding. Data were analyzed with regression and ANOVA methods, with significance declared if $P \leq 0.05$. Behavior scoring did not differ among the 3 individuals. Relationships of sensor versus observed times were not significant ($R^2 < 0.3$) in 4-wk-old calves; however, changes were made to sensor placement in ear, and face fly irritation of calves for reevaluation. In wk 6 around the time of weaning, simple regression analysis of sensor versus observed rumination ($R^2 = 0.91$), eating ($R^2 = 0.75$), and not active ($R^2 = 0.97$) times had y-intercepts that did not differ from zero and significant slopes. Sensors were a valid measurement tool for rumination, eating, and inactivity times in 6-wk-old calves, but ear placement and environmental conditions discussed are critical for success.

Key words: calf, feeding, welfare

INTRODUCTION

Measuring the behavior of dairy calves can lead to better understandings of the welfare, nutrition, and management of the calves. In one of the first attempts to study rumination in calves, rumination time was positively correlated with dry feed intake and rumination time per kilogram of intake declined with age but varied greatly with day and health of the calf (Swanson and Harris, 1958). Starter intake has been positively related to calf growth and future milk production; thus, rumination and starter intake are physiologically important (Gelsinger et al., 2016).

Behavior measures are typically collected by human observations (Swanson and Harris, 1958). Video is sometimes recorded and observed later to log behaviors (Miller-Cushon et al., 2013). Human observation can be inaccurate and are typically collected for brief periods because they are time consuming (Kononoff et al., 2002).

More recently, a device commercialized to track dairy cow feeding and rumination behaviors using an ear tag–based, 3-dimensional accelerometer with proprietary software algorithms was created (CowManager SensOor, Agis, Harmelen, the Netherlands). It was recently validated to estimate rumination and eating behavior in mature dairy cows (Bikker et al., 2014), evaluated to aid in reproduction and activity in mature dairy cows (Bikker et al., 2014; Dolecheck et al., 2015), and used to estimate rumination and eating behavior in beef steers with 300 kg of BW (Wolfger et al., 2015). Burfeind et al. (2011) evaluated a different type of automated system based on sound to measure rumination in calves, but they speculated that the algorithms had high variability for calves under 9 mo of age. There is a need for automated and long-term measurement of rumination, eating, and activity measurements in young calf research. However, to the author's knowledge, there are no published, validated systems to measure feeding behaviors and rumination in calves. Timms and Breuer (2016) suggested the ear-sensor system has merit in young calves and offers the ability to collect data 24 h per day for consecutive days and months. Thus, our research objective

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was to evaluate it in 4- to 6-wk-old dairy calves fed milk replacer (**MR**), starter, and water and housed under commercial conditions of individual pens.

MATERIALS AND METHODS

Calves were cared for by acceptable practices as described in the *Guide for the Care and Use of Agricultural Animals in Research and Teaching* (FASS, 2010). Male Holstein calves (16 calves, 4 to 6 wk of age, averaging 58 ± 2.3 kg of BW) were used and fed MR (27% CP, 17% fat powder reconstituted to 14% solids) with free-choice textured starter (20% CP, 42% starch) and water. Half the calves were weaned on d 42, and half the calves were weaned on d 49. Calves were housed in 1.2 by 2.4 m individual pens with a coarse rock, tile-drained floor and bedded with straw in a curtain-sided, naturally ventilated barn with no added heat at the Nurture Research Center in southwest Ohio. This barn was described with some detail in Hill et al. (2011). All calves were healthy and not treated for sickness during and between the times of monitoring behaviors in the fall of 2016.

Sensors (CowManager SensOor) were designed to attach to radio-frequency identification tags in calf ears. The sensors were attached over the existing female portion of the radio-frequency identification tags in the left ears of 3-wk-old calves. Sensor readings were checked daily to ensure that data for all measurements were being transmitted and accounted within the system. The sensors include a 3-dimensional accelerometer with proprietary (unpublished) software algorithms providing hourly measurements recorded in minutes for eating, ruminating, highly active, active, and not active, mutually exclusive times.

Comparison in wk 4 Among 3 Observers and to Sensors

Three observers were trained to watch for structural–behavior states of eating, ruminating, standing, lying, and general inactivity (Table 1) in 4-wk-old calves. One 2-h period was during the midday and a second 2-h period was during the following afternoon to encompass the time before, during, and after feeding of MR via a nipple. These behavior states were treated as mutually exclusive to each other. In addition, eating states (nose in nipple pail or nose in water bucket) were noted. Continuous observation via video collection was not possible for this experiment; therefore, live observation and instantaneous time sampling methodologies were applied (Martin et al., 1993). A more conservative time-sampling interval was applied than previously described for calves' nutritive and nonnutritive oral behaviors (Veissier et al., 2002) because to the authors' knowledge, literature did not indicate an estimate of rumination bouts among 4-wk-old calves, unlike adult cattle, where rumination bouts were reported to occur over 30% during resting and 5% while standing (Walker et al., 2008). Three trained observers simultaneously recorded behaviors of 8 calves by time-stamping the 60 consecutive data points using a worksheet with the calf, time periods, and check boxes for the behaviors of interest (Table 1). These 1-min data samples were used to analyze between-observer variation (Table 2).

Observation periods were started and stopped on the hour (00:00) to correspond with the hourly recordings of the sensors. The observational data recorded by minute were summed for the hour in the categories, and data retrieved from the sensor's data output for the corresponding hour were compared in the statistical analyses. However, these data revealed that during wk-4 observations, there were challenges that led to inaccurate measurements by the sensors. Upon further evaluation, issues included sensor placement position in the ear, sensor irritation of the ear, and excessive face flies creating ear and sensor movement. Corrective measures were implemented including the relocation of the radio-frequency identification tags with ear sensors to be more centered within the ear and closer to the head. These challenges were reported to the company, and the CowManager system setup now includes a diagram for correct tag placement. A longer male attachment pin (Agis) to pierce the ear and attach the sensor to the ear was used to reduce squeezing of the ear in an attempt to reduce irritation. Additionally, amelioration measures were implemented to reduce the number of face flies near the calves.

Comparison in wk 6 Between Sensors and Observers

After placement of the sensors was resolved, an new set of human versus sensor data were collected with the same calves at ages 41, 42, 43, and 44 d for 2 consecutive hours for each day. The consecutive 2 h included (1) after the morning MR feeding (d 44); (2) midday (d 43); and (3) before, (4) during, and after the evening MR feedings (d 41 and 42). The 3 trained observers from wk 4 used the live scan sampling methods as described above to compare with the sensor readings.

Measurement data (ruminating, eating, ruminating plus eating, standing, and nonactive) were analyzed using the MIXED procedure with a repeated-measures model (SAS Enterprise Guide, version 5.1, SAS Institute Inc., Cary, NC). Calf was treated as a random variable. The first-order autoregressive structure type was selected as the covariance structure. The least squares means were separated using the option of PDIFF. Regression relationships of behavior measurements determined by sensors with those determined by observers were examined using PROC REG of SAS. Significance was defined as $P \leq 0.05$.

RESULTS AND DISCUSSION

Comparison in wk 4 Among 3 Observers

Observations of calf behavior of the 3 observers did not differ ($P > 0.15$) for eating, rumination, standing, and inactivity (Table 2), thus showing interobserver reliability of