J. Dairy Sci. 98:1–9
http://dx.doi.org/10.3168/jds.2014-9223

Prediction of parturition in Holstein dairy cattle using electronic data loggers

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ABSTRACT

The objective of the present study was to assess the effect of parturition on behavioral activity [steps, standing time, lying time, lying bouts (LB), and duration of LB] 4 d before calving using electronic data loggers. Animals (n = 132) from 3 herds were housed in similar freestall barns using a prepartum pen 21 d before the expected calving date and were moved into a contiguous individual maternity pen for parturition. Electronic data loggers were placed on a hind leg of prepartum heifers (heifers, n = 33) and cows (cows, n = 99) at 7 ± 3 d before the expected calving date and removed at 14 ± 3 d in milk. Calving ease (scale 1–4), parity, calving date and time, and stillbirth (born dead or died within 24 h) were recorded. The number of steps (no./d), standing time (min/d), lying time (min/d), number of LB (no./d), and duration of LB (min/b) were recorded. Data were analyzed using MIXED procedures of SAS, adjusting for the herd effect. Only cows experiencing unassisted births (calving ease = 1) were included in the study. An activity index was developed to predict calving time. Heifers and cows with unassisted births had significantly higher number of steps and longer standing time, decreased lying time, and more LB of shorter duration 24 h before calving compared with d −4, −3, and −2. Additionally, the number of LB increased as both heifers and cows approached labor starting on d −2 and peaked at the day of calving. The time since the activity index increased over 50% to parturition did not differ between heifers and cows, and the activity index revealed the shift in activity on average 6 h 14 min (range from 2 h to 14 h 15 min) before calf birth. This study provided evidence that heifers and cows approaching parturition showed a similar, but distinct, behavioral pattern that can be observed on average 6 h before calf birth. The potential benefits of electronic data loggers as predictors of parturition along with proactive management practices should improve the overall survival and welfare of both the dam and calf.

Key words: calving, prediction, precision management, dairy cattle

INTRODUCTION

For any dairy operation, calving is an essential requirement of the dairy production system in which cows initiate lactation and provide the future replacements of the herds. Parturition is divided into 3 stages (Noakes et al., 2001; USDA, 2010) that are characterized by hormonal, behavioral, and physical changes (e.g., dilation of soft tissues). Under normal conditions (eutocic births), parturition progresses gradually from one stage to the next (Wehrend et al., 2006; Miedema et al., 2011a,b; Schuenemann et al., 2011), ending with the delivery of the calf (Noakes et al., 2001; Schuenemann et al., 2011). Under field conditions, observations of the amniotic sac (**AS**) or feet of the calf outside the vulva are clear landmarks that calving personnel can easily identify to monitor calving progress (Schuenemann et al., 2011, 2013). In an ideal situation, calving personnel would monitor prepartum cows around the clock (24 h, 7 d per week) at regular intervals. In practice, however, the frequency of observation (calving personnel walking the pen and actually observing cows every 1 h) is critical to determine the onset of the AS or feet of the calf outside the vulva and to identify cows in need of assistance (dystocia; Schuenemann et al., 2013) that likely results in stillbirth (Hunter et al., 2013). Therefore, development of monitoring systems that can predict calving time before the appearance of imminent signs of birth (AS or feet of the calf) would enable dairy producers and their personnel to implement a precision calving management program to help reduce undesirable calving-related events such as stillbirth due to late or no interventions.

Received December 10, 2014.
Accepted April 21, 2015.
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The technology to monitor activity such as detecting cows in estrus using activity meters (Kamphuis et al., 2012), pedometers (Chebel et al., 2013), or rumination devices (Reith and Hoy, 2012; Elischer et al., 2013) as well as health events (e.g., locomotion; Chapinal et al., 2011) are management tools available for dairy herds. The assessment of cow activity before parturition using electronic data loggers may provide an effective alert system for calving time as opposed to waiting for the imminent signs of labor (appearance of AS or feet of the calf). For instance, the frequency of transitions from lying to standing (Schuenemann et al., 2011) and restless behavior (e.g., pawing, walking) increased in the first stage of labor (Wehrend et al., 2006; Miedema et al., 2011a). This shift in calving-related activity may be identified by using a data-based activity index or algorithm and serve as a predictive tool that aids the typical visual observation by calving personnel. Therefore, the objective of the present study was to assess the effect of parturition on behavioral activity [steps, standing time, lying time, lying bouts (**LB**), and duration of LB] 4 d before and 1 d after calving using electronic data loggers (IceQube, IceRobotics, Edinburgh, UK). The hypothesis was that Holstein dairy cattle approaching parturition will exhibit a distinct behavioral activity that can be used to predict calving time.

MATERIALS AND METHODS

Animals, Feeding, and Facilities

In total, 132 pregnant Holstein animals (33 heifers and 99 cows) from 3 dairy herds were used in the present study. Briefly, cows were housed in freestall barns and milked thrice daily at approximately 8-h intervals until dried off. Cows were fed twice daily, in the morning and afternoon, with a TMR formulated to meet or exceed dietary nutritional requirements for lactating and dry dairy heifers and cows (NRC, 2001). This study was conducted from July 2011 through August 2012. The procedures described below were reviewed and approved by The Ohio State University Institutional Animal Care Use Committee.

Management of Animals and Calving

Every week, a list of heifers and cows were obtained based on expected calving dates using on-farm computer records (Dairy Comp 305, Valley Agricultural Software, Tulare, CA). Pregnant cows (lactation $\geq$1; cows) were dried off 60 $\pm$ 3 d before the expected calving date and moved into the dry pen immediately after last milking. Similarly, pregnant heifers (lactation = 0; heifers) were moved into the dry pens (separated from dry cows) 60 d before the expected calving date. Then, heifers and cows were moved into prepartum pens 21 d before the expected calving date. All heifers and cows were housed in similar prepartum pens and moved into a contiguous individual maternity pen for parturition. Pregnant animals were closely monitored by on-farm personnel for imminent signs of parturition (appearance of AS or feet of the calf outside the vulva) every 1 h (Schuenemann et al., 2011). All calving personnel received the same training at the beginning of the study (Schuenemann et al., 2013). The calving ease of cows (assistance provided at birth) were recorded using a 4-point scale (1 = no assistance provided; 2 = light assistance by one person without the use of mechanical traction; 3 = mechanical extraction of the calf with an obstetric calf-puller; and 4 = severe dystocia: surgery or fetotomy needed; Schuenemann et al., 2011). Only cows with calving ease of 1 were included in the present study. Body condition scores of all animals were assessed 7 $\pm$ 3 d before calving using a 5-point scale with 0.25-unit increments (Ferguson et al., 1994). Additionally, calving date and time, and stillbirth were recorded. Calving time (0 h) was recorded as the calf (single or twins) was expelled from the birth canal to the ground. Stillbirth was defined as a calf born dead or died (normal gestation length) within 24 h after birth (Schuenemann et al., 2011). After calving, cows were processed (e.g., harvesting of colostrum) and moved to the postpartum pens and calves were moved to a straw-bedded pen. All calves were fed colostrum (3.8 L) within 3 h after birth, their navel disinfected with a 7% iodine solution, and fitted with ear tags for identification. Subsequently, calves were moved to individual hutches until weaning.

Calcium Status

To assess the potential effect of hypocalcemia around the time of calving, blood samples (8 mL) for determination of serum calcium status were collected 7 $\pm$ 3 d before the expected calving by coccygeal venipuncture (BD Vacutainer, Franklin Lakes, NJ). Briefly, blood samples were centrifuged at 2,785 $\times$ *g* for 20 min at 4°C immediately after collection, and serum samples were stored at $-$ 20°C until assayed for total calcium. Total serum concentration of calcium were determined in duplicates using a commercially available kit (Calcium Liquicolor No. 0150, Stanbio Laboratory, Boerne, TX) according to manufacturer's instructions. Cows were classified as hypocalcemic when the concentration of calcium from the blood sample was $\leq$8.0 mg/dL (Reinhardt et al., 2011).