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Evaluation of calving indicators measured by automated monitoring devices to predict the onset of calving in Holstein dairy cows

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ABSTRACT

Dystocias are common in dairy cows and often adversely affect production, reproduction, animal welfare, labor, and economics within the dairy industry. An automated device that accurately predicts the onset of calving could potentially minimize the effect of dystocias by enabling producers to intervene early. Although many well-documented indicators can detect the imminence of calving, research is limited on their effectiveness to predict calving when measured by automated devices. The objective of this experiment was to determine if a decrease in vaginal temperature (VT), rumination (RT), and lying time (LT), or an increase in lying bouts (LB), as measured by 3 automated devices, could accurately predict the onset of calving within 24, 12, and 6 h. The combination of these 4 calving indicators was also evaluated. Forty-two multiparous Holstein cows housed in tie-stalls were fitted with a temperature logger inserted in the vaginal cavity 7 ± 2 d before their expected calving date; VT was recorded at 1-min intervals. An ear-attached sensor recorded rumination time every hour based on ear movement while an accelerometer fitted to the right hind leg recorded cow position at 1-min intervals. On average, VT were 0.3 ± 0.03°C lower, and RT and LT were 41 ± 17 and 52 ± 28 min lower, respectively, on the calving day compared with the previous 4 d. Cows had 2 ± 1 more LB on the calving day. Of the 4 indicators, a decrease in VT ≥ 0.1°C was best able to predict calving within the next 24 h with a sensitivity of 74%, specificity of 74%, positive and negative predictive values of 51 and 89%, and area under the curve of 0.80. Combining the indicators enhanced the performance to predict calving within the next 24, 12, and 6 h with best overall results obtained by combining the 3 devices for prediction within the next 24 h (sensitivity: 77%, specificity: 77%, positive and negative predictive values: 56 and 90%, area under the curve: 0.82). These results indicate that a device that could simultaneously measure these 4 calving indicators could not precisely determine the onset of calving, but the information collected would assist dairy farmers in monitoring the onset of calving.
Key words: dairy cow, calving indicator, onset of calving, test performance

INTRODUCTION

Calving is a critical time for both the dam and the calf (Schuenemann, 2012). Difficult births, known as dystocias, are common in dairy cows (Lombard et al., 2007). Studies show that dystocia rates in the United States range from 28.6 to 51.2% in primiparous cows and from 10.7 to 29.4% in multiparous cows (Meyer et al., 2001; Lombard et al., 2007). Dystocias are associated with increased risk of stillbirth, calf mortality before 30 d of age, and morbidity (Lombard et al., 2007). They also increase the likelihood of trauma on the dam (Schuenemann et al., 2011), retained placenta (Oltenacu et al., 1988), uterine disorders (Sheldon et al., 2009), and decreased milk yield (Dematawewa and Berger, 1997; Rajala and Gröhn, 1998). Furthermore, dystocia is negatively associated with fertility and dam survival (Tenhagen et al., 2007). Prevention of dystocia in dairy cows should, therefore, be a high priority in farm management.

Predicting the onset of parturition can help preserve the integrity of the newborn calf and protect the dam during difficult birth situations by facilitating timely human intervention (Shah et al., 2006; Palombi et al., 2013). Moreover, predicting calving time allows careful management around the time of parturition, thus minimizing unnecessary pain and distress especially in situations requiring humane intervention (Miedema et al., 2011b). External signs such as pelvic ligament relaxation, udder distension, teat filling, vaginal discharge, vulva edema, and behavior changes are often used to predict the onset of calving in dairy cows either

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manually, visually, or by video observation (Berglund et al., 1987; Streyl et al., 2011). Such assessments are subjective and time consuming, and the signs themselves vary widely among dairy cows. Furthermore, whereas the number of farms is decreasing in North America and Europe, the number of cows per farm is increasing. Hence, less time is accorded to individual cow supervision around parturition time, especially in small operation farms. Therefore, an automated device that could accurately predict the onset of calving would be valuable to minimize the effects of dystocia on dairy cows.

Changes in cow behavior and physiology observed on the day of calving have been well documented. Schirmann et al. (2013) report that cows spent, on average, 63 ± 30 min less time ruminating on the day of calving. Miedema et al. (2011a) and Jensen (2012) report an increase of lying bouts (**LB**) on the day of calving compared with a control period during gestation, whereas a decrease of 1 h in daily duration of lying time (**LT**) was observed. A decrease in body temperature before the onset of parturition has also been reported for dairy cows (Burfeind et al., 2011; Streyl et al., 2011). Burfeind et al. (2011) report that a decrease in vaginal temperature (**VT**) of ≥0.3°C over 24 h as measured by a temperature logger can predict calving within 24 h with a sensitivity (**Se**) ranging from 62 to 71% and with a specificity (**Sp**) ranging from 81 to 87%. Rumination time (**RT**), VT, LB, and LT show measurable changes that are consistent between individuals. Therefore, RT, VT, LB, and LT are considered to be useful calving indicators that can help predict the onset of parturition.

Various automated devices that record RT and the number of LB and LT are available commercially for producers. To our knowledge, the test performance of those calving indicators measured by automated monitoring devices has not been determined. Therefore, the objective of this study was to determine the performance of 3 automated devices to predict the onset of calving based on measuring 4 calving indicators (decrease of VT, RT, and LT; increase of LB). Specifically, we set out (1) to investigate the test performance of the calving indicators during 3 time periods (within the next 24, 12, and 6 h) before calving, and (2) to evaluate the test performance using combined calving indicators. We hypothesized that, of the 4 calving indicators, a decrease in VT, recorded by a temperature logger, would obtain the highest test performance to predict calving, with the best predictive value for a calving prediction within the next 24 h, and that combining the indicators would improve the predictive performance of the individual indicators.

MATERIALS AND METHODS

The study was conducted on a commercial dairy farm (Saint-Anselme, QC, Canada), which had a milking herd of 108 Holstein cows producing, on average, 10,390 kg/cow per yr. All experimental procedures were approved by the Animal Care Committee from Université Laval, Quebec, Canada.

Animals, Housing, and Feeding

A total of 42 multiparous Holstein cows (average ± SD; parity: 1.9 ± 1.2; gestation length: 281 ± 3 d; calving interval: 408 ± 52 d) housed in freestalls were enrolled from November 2013 to June 2014. About 21 d before their expected calving date, the cows were moved to 1 of the 12 tie-stalls reserved for calving (mean dimension 2.4 m long × 1.3 m wide; chain length 0.60 to 0.63 m). All 12 tie-stalls were fitted with a water bed mattress (DCC waterbeds HQ, Reedsburg, WI) covered with a thin layer of sawdust. A TMR was provided once daily (at 0800 h) consisting of 54% corn silage, 21% alfalfa hay, and 26% concentrate and minerals on a DM basis. Feed was pushed up 4 times per day. Water was freely available from water bowls (1 per 2 neighboring cows).

Experimental Measurements

Cows were fitted with 3 automated devices to measure 4 calving indicators (i.e., VT, RT, LB, and LT). Vaginal temperature was recorded continuously every minute using a microprocessor-controlled temperature data logger (Minilog II-t, Vemco Ltd., Halifax, Canada) as validated by Vickers et al. (2010). The temperature data loggers were attached to a modified, controlled, internal drug-release device without progesterone (CIDR, InterAg, Hamilton, New Zealand) and inserted into the vaginal cavity 6 ± 2 d before the predicted calving date, as described by Burfeind et al. (2011). During the process of calving, the temperature logger was expelled from the vaginal cavity and collected by the farm staff, resulting in a sudden decrease in measured temperature, as described by Burfeind et al. (2011). The time of complete expulsion of the logger was established as the calving time for each cow. The temperature data were downloaded after calving.

Rumination time was measured continuously every hour using a 3-dimensional accelerometer (SensOor; Agis Automatisering BV, Harmelen, the Netherlands) designed to be attached to the ear identification tag of the cows as validated by Bikker et al. (2014). Rumination data were sent through a wireless connection, via routers and coordinators, to an on-farm computer