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Estrous detection intensity and accuracy and optimal timing of insemination with automated activity monitors for dairy cows

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ABSTRACT

The objectives of this observational study were to assess the ability of automated activity monitoring (AAM) to detect estrus for first insemination, the accuracy of detection, and the optimum interval from the estrus alert from the AAM system to insemination. Four commercial farms using 1 of 2 commercial AAM systems were studied over 1 yr. Cows were inseminated between 55 and 80 d in milk (DIM) based on AAM only, then by a combination of AAM and timed artificial insemination (AI). Blood progesterone was measured in 1,014 cows at wk 5, 7, and 9 postpartum; purulent vaginal discharge (PVD) was assessed at wk 5; and lameness and BCS at wk 7. Overall, AAM detected 83% of cows in estrus by 80 DIM. Cows that had 3 serum progesterone <1 ng/mL, had PVD, or were both lame and had BCS ≤2.5 has lesser odds of being detected in estrus by 80 DIM (62, 68, and 53%, respectively). Blood samples were collected on the day of 445 AI based on AAM and 323 timed AI. The proportion of cows not in estrus (progesterone >1 ng/mL) on the day of AI was similar between AAM (4 ± 1.8%) and timed AI (3 ± 1.2%). Managers elected, based on subjective criteria, not to inseminate 17% of cows for which an AAM estrus alert was issued, of which 43% were not in estrus. Activity data were extracted from AAM software for 1,399 AI. Onset of estrus was calculated using the same or similar data processing criteria as the AAM system. Producers recorded the time of AI. The interval from onset of estrus to AI was categorized as 0 to 8, 8 to 16, or 16 to 24 h. We found no effect of AAM system on the probability of pregnancy per AI, but noted an interaction of interval with parity. For multiparous cows, the probability of pregnancy per AI was 31%, which did not differ with the interval to AI. For primiparous cows, the odds of pregnancy were greater if AI occurred 0 to 8 h (49%) than 8 to 16 (36%) or 16 to 24 h (31%) after the estrus alert from the AAM. Automated activity monitoring can detect estrus for first AI in just over the length of 1 estrous cycle for over 80% of cows, but the remainder would likely require intervention for timely insemination. For multiparous cows, performing AI based on AAM once per day would not affect pregnancy per AI, but for primiparous cows AI within 8 h of the onset of estrus may be advantageous.
Key words: accelerometer, precision technology, reproduction management

INTRODUCTION

Inseminating cows in a timely manner is important for efficient dairy production management (Walker et al., 1996). Automated activity monitor (**AAM**) systems are useful tools for detection of estrus (Fricke et al., 2014), and producers who have installed AAM systems report satisfaction with their performance (Michaelis et al., 2013). However, many environmental and metabolic variables can have negative effects on the ability of AAM to identify cows in estrus. Optimizing the timing of insemination relative to ovulation is important for pregnancy (Roelofs et al., 2006). The practical obstacle is identifying when ovulation will occur with sufficient precision. The spermatozoa take approximately 8 h to reach the isthmus of the oviduct, and by 12 to 24 h few spermatozoa remain in the reproductive tract (Hawk, 1987); providing sufficient time for sperm capacitation is also important for optimal timing of AI. The time of ovulation relative to signs of estrus is variable among cows, making identifying the optimal time of insemination a challenge (Roelofs et al., 2006).

In a reproductive program that uses activity monitors for heat detection, a cow must have estrus with an associated increase of activity for insemination to occur. Additionally, not specific to estrus detected by AAM, failure of ovulation is reported to occur 7% of the time in lactating dairy cows, more so under heat stress (López-Gatius et al., 2005). To try to capture estrus as accurately as possible, various accelerometers

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and data processing algorithms have been developed to detect relevant changes in activity. A review (Saint-Dizier and Chastant-Maillard, 2012) found that the efficiency of estrus detection (number of cows detected in estrus relative to the number of cows in estrus) of AAM systems is generally greater than 80%. However, the reported positive predictive value of (i.e., the accuracy of the alerts) of these systems varied from 20 to 100% depending on the threshold and algorithm used (Saint-Dizier and Chastant-Maillard, 2012). The extent to which activity monitors might be relied upon to detect cows in estrus for first insemination has not been quantified.

The gold standard for estrus is a cow that is standing to be mounted, has a dominant follicle that subsequently ovulates, and has low a concentration of progesterone (**P4**) in serum or milk. If a cow has high P4 while displaying signs of estrus, including increased activity, it can be considered as a falsely identified estrus (Aungier et al., 2012). However, a cow with a low circulating concentration of P4 cannot be assumed to be in estrus because it is possible that the cow is anovular or may be in proestrus or metestrus. Holman et al. (2011) found that 93.5% of the estrus events detected with activity monitors were associated with milk P4 below 0.2 ng/mL, meaning that there were few false-positives.

Although the time from onset of estrus-based increased activity to ovulation is quite consistent (29 to 30 h; reviewed by Roelofs and van Erp-van der Kooij, 2015), the optimal interval from activity passing a prescribed threshold in the AAM system software to insemination is less clear. Maatje et al. (1997) found that the highest probability of pregnancy per AI (**P/AI**) was achieved 6 to 17 h after an increase of activity using pedometers. In a large field study using 1 commercial AAM system, Stevenson et al. (2014) found a difference in the optimal interval from onset of estrus (signaled the AAM system) to insemination for primiparous cows compared with multiparous cows, such that they should be inseminated 13 to 16 or 0 to 12 h after passing the activity threshold, respectively. A recent review (Roelofs and van Erp-van der Kooij, 2015) supports that the optimal interval from onset of estrus based on AAM to AI is 5 to 17 h.

The first objective of the current study was to determine the proportion of cows detected in estrus by AAM alone by 80 DIM and to evaluate the effects of BCS, milk yield, anovular status, lameness, or having purulent vaginal discharge (**PVD**) on this outcome. The second objective was to evaluate the accuracy of activity monitors (correct identification of cows with low P4 at the time of insemination) and to compare that to timed AI. Our third objective was to assess the association between producer-recorded signs of estrus for cows detected in estrus by AAM and the probability of pregnancy to that AI. The final objective was to determine the time interval from activity monitor estrus alert to insemination associated with the highest P/AI. Our hypothesis was that cows would have the highest probability of pregnancy if bred within 16 h after the activity alert.

MATERIALS AND METHODS

Farms and Monitoring Systems

Four farms within a 1 h drive of the University of Guelph (Ontario, Canada) were enrolled in this observational study, which was conducted from May 2014 to August 2015. The herds were a purposive sample of herds with AAM systems that were enrolled in DHIA and were willing to collect data and participate in the study. Two of the farms had the AfiAct (Afimilk, Kibbutz Afikim, Israel) leg-mounted activity monitor system and were milked 3 times a day. The other 2 farms had neck-mounted Heatime (SCR Engineers, Netanya, Israel) activity monitors, 1 with Heatime HR and 1 with Heatime Dataflow; both of these herds milked 2 times per day. All of the herds used DairyComp305 (DC305; Valley Ag Software, Tulare, CA) as the herd management software. The farms involved in this study are described in Table 1. The data in Table 1 on herd annual reproductive performance were all calculated in DairyComp 305 using a standard voluntary waiting period of 50 DIM. All farms had sand-bedded freestall barns and the herd size ranged from 100 to 400 lactating cows.

During the study, enrolled farms continued with the reproduction management program that they had in place. For all herds, insemination started at 55 DIM and was done exclusively based on estrus detection by AAM until 80 DIM, after which both estrus detection based on activity monitor alerts and timed artificial insemination (**TAI**) protocols were employed. Insemination was generally performed twice daily, but for each insemination producers were asked to record the date, cow identification, the time of insemination, and whether the insemination was based on an activity signal or a TAI protocol. Data were collected from DC305 and from the software of the activity monitors during weekly farm visits. Data on inseminations and pregnancy outcomes were extracted from DC305 and exported to Microsoft Excel (Microsoft Corp., Redmond WA).

Farms were visited once weekly for sample collection and to retrieve data from DC305. Blood samples were collected from all cows via the coccygeal vessels into an evacuated tube without anticoagulant (Vacutainer, Becton, Dickinson and Co., Franklin Lakes, NJ) at wk 5