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The relationship between activity clusters detected by an automatic activity monitor and endocrine changes during the periestrous period in lactating dairy cows

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ABSTRACT

The aim of this study was to determine the relationship between observed estrous-related behavior, activity clusters (AC; detected by automatic activity monitor), endocrine profiles, and ovulation time. Twenty-one cows in estrus (after 2 cloprostenol treatments, 11 d apart) and 12 nonsynchronized cows, to establish Heatime (SCR Engineers Ltd., Netanya, Israel) herd baseline activity, were enrolled. Cows had Heatime monitors applied 3 wk before the trial to establish their own baseline activity level. Cows in standing estrus had ultrasonography and phlebotomy carried out every 4 h to determine dominant follicle size, endocrine profiles, and ovulation time. After ovulation, these procedures were repeated once on d 3 to 6. Heatime alerted estrus in 90% of cows, and incorrectly alerted 17% of AC. The mean ± SEM duration for standing estrus was 9 ± 1 and 13 ± 1 h for estrous-related behavior. Estrous-related behavior began after the start of the proestrous estradiol-17β (E_2) increase (59 ± 6.5 h). Cows with longer durations of raised proestrous E_2 had longer intervals from its onset to the start of standing estrus and AC. The AC duration increased with longer durations of estrous-related behavior. Higher peak E_2 occurred with longer standing estrus and estrous-related behavior. As E_2 concentration decreased after the peak, 90% of cows still had estrous-related behavior. Duration of estrous-related behavior increased with higher average E_2 concentration during the last 8 h before the start of the LH surge. During this surge 90% of cows had all of their standing estrus. As yields increased, so did the magnitude of the preovulatory FSH surges. Higher surges occurred with shorter standing estrus and estrous-related behavior. Cows with shorter LH surges had longer standing estrus. Peak LH preceded the AC peak (6.6 ± 0.8 h). Duration of overlap between the AC start and the LH surge end ranged between 0 and 14 h; 1 cow had none. No association was found between the AC characteristics with the E_2, LH, or FSH profiles. In conclusion, the relationship between the timing of the E_2 increase and estrous activity may be mediated by other factors (GnRH surge). Estrous-related behavior, but not endocrine profiles, was related to AC duration. Timing of standing estrus during the LH surge ensures that mating allows sperm maturation before ovulation. Based on the interval from the start of an AC to ovulation (27 ± 1 h), the optimum time to artificial insemination is, on average, between 9 and 15 h after the AC start.
Key words: dairy cow, automatic activity monitor, endocrine profile, estrous behavior

INTRODUCTION

Artificial insemination using semen from high-genetic merit sires results in increased genetic merit of the offspring. The main problems associated with its use are the accurate identification of cows in estrus and deciding the optimum time to inseminate cows detected in estrus. Monitoring of estrous behavior in cows is very labor intensive, and accuracy is affected by the fact that modern, high-yielding Holstein dairy cows (~10,000 L; quoted by Dobson et al., 2007) are only in estrus for a short period of time. One trial, monitoring 17 farms using HeatWatch (DDx Inc., Denver, CO) to detect estrous activity, found that the number of standing events during estrus averaged (±SD) 8.5 ± 6.6 per cow, and the average duration of estrus was 7.1 ± 5.4 h (Dransfield et al., 1998). Lopez et al. (2004) identified that, in the 10 d preceding estrus, high-producing cows (≥39.5 kg/d) had larger follicles but lower circulating estradiol-17β (**E_2**) compared with lower-producing cows (<39.5 kg/d). Higher-yielding dairy cows (≥39.5 kg/d) had shorter durations of standing to be mounted (6.2 ± 0.5 compared with 10.9 ± 0.7 h; $P < 0.0001$), decreased number of standing events (6.3 ± 0.4 compared with 8.8 ± 0.6; $P = 0.001$), and reduced duration of stand-

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ing time (21.7 ± 1.3 compared with 28.2 ± 1.9 s; P = 0.007) when compared with lower-yielding cows (<39.5 kg/d).

It has been suggested that the reduced intensity of expression of estrous behavior by high-yielding dairy cows (Lopez et al., 2004) compared with nulliparous heifers (Nebel et al., 1997) may be related to increased metabolism of E_2 by the liver due to a higher metabolic rate in Holstein cows (Sangsritavong et al., 2002). Yet other studies have found no correlation between milk yield and estrous expression (Lyimo et al., 2000; Van Eerdenburg et al., 2002). This apparent disagreement in findings may be due to differences in levels of milk production at the time of the different studies and the less frequent periods of visual observation carried out (Lopez et al., 2004).

Other factors have also been identified as affecting the intensity of estrous expression. Negative energy balance during the early postpartum period was shown to affect negatively the development of the preovulatory follicle and estradiol production. Some studies found that the maximum estradiol produced was related to total estrous expression (Lyimo et al., 2000; Roelofs et al., 2004), whereas others disagreed with this finding (Walker et al., 2010). No correlation has been found between follicle size and the intensity of estrous expression (Van Eerdenburg et al., 2002). The genetic background of cows has also been found to influence estrous detection, with the daughters of different sires displaying significantly different estrous behavior intensities (Heres et al., 2000). In nonlame cows, as the size of sexually active groups increase, the intensity of estrous behavior has been found to increase (Hurnik et al., 1975; Roelofs et al., 2005a; Gilmore et al., 2011). Cows that are clinically lame have been shown to express estrus of lower intensity (Walker et al., 2010). In these cows, it was found that although estradiol concentrations were normal, the progesterone (**P_4**) concentrations before estrus were not. In ruminants, prior exposure to P_4 was previously shown to affect the intensity of estrous behavior (Fabre-Nys and Martin, 1991). Other stressors, such as clinical disease, poor management, and production diseases, also influence the intensity of estrous behavior (Dobson et al., 2008).

Furthermore, in high-yielding dairy cows, the percentage of cows that display standing to be mounted by other cows has decreased, leaving it more difficult to detect estrus. Roelofs et al. (2005a) found that only 58% of cows were observed in standing estrus. This, in turn, decreases submission rate to AI and thereby contributes significantly to reduced reproductive efficiency (Diskin, 2008). Several aids exist to improve the efficiency of detection of estrus. One such labor-saving technology available to the farmer to help increase submission rate and decrease labor requirements for estrous detection is the use of automated systems.

Attempts have been made to monitor changes in physical activity to predict estrus using these automated systems. The pedometer, attached to a leg, detects an increase in the number of steps taken per hour during estrus (e.g., S.A.E. Afikim, Kibbutz Afikim, Israel; Holman et al., 2011), whereas the use of a neck collar (e.g., Alpro; DeLaval International AB, Tumba, Sweden; Peralta et al., 2005) identifies increased physical activity (walking, mounting, getting up and lying down) expressed as an activity cluster (**AC**). The characteristic estrous behavior of standing to be mounted can be monitored through the use of systems such as the electronic device HeatWatch, scratch cards (e.g., Estrotect; Rockway Inc., Spring Valley, WI), color ampoules (Kamar Products Inc., Zionsville, IN), vasectomized bulls fitted with a chin-ball marker, or the use of tail-painting methods (Diskin and Sreenan, 2000). A recent study, using the neck collar activity monitor Heatime (SCR Engineers Ltd., Netanya, Israel), identified that the odds of an AC being in a preovulatory follicular phase rather than a luteal phase improved by 29% for every 1-unit increase in peak activity and by 91% for every 2-h increase in duration of an AC (Aungier et al., 2012).

To date, the emphasis has been mainly on the study of the efficacy of these aids as physical activity monitors for estrus detection and prediction of the time of ovulation (Roelofs et al., 2005b). However, a lack of data exists on how accurate automatic activity monitors are at identifying the association between the intensity of physical activity associated with estrous behavior and the pattern of endocrine changes during the periovulatory period. There is also a need to revisit the relationship between the pattern of endocrine profiles, observed estrous behavior, and timing of ovulation in modern dairy cows (Roelofs et al., 2005a).

The generally accepted optimum time for insemination of dairy cows is 12 to 18 h before ovulation (Hunter, 1994). In practical terms, the timing of insemination is usually based on the a.m.-p.m. rule, where a cow observed in standing estrus in the morning is inseminated that afternoon or if identified in the afternoon it is carried out the following morning (Trimberger and Davis, 1943; Trimberger, 1948). The inaccurate timing of insemination in relation to ovulation decreases the conception rate partially due to a decrease in the percentage of viable embryos produced (Roelofs et al., 2006; Dalton, 2011). The relationship between the characteristics of accelerometer AC and time of ovulation require further research. The aims of the current paper were to determine the relationships between (1) observed estrous behavior and the characteristics