

# Pregnant! Using activity monitors for reproductive success

Matias L. Stangaferro, DVM, MSc, PhD; Julio O. Giordano,<sup>2</sup> DVM, MSc, PhD

<sup>1</sup>Dairy Health and Management Services, Lowville, NY 13367

<sup>2</sup>Department of Animal Science, Cornell University, Ithaca, NY 14853

Corresponding author: Dr. Matias L. Stangaferro; 6014 Number Four Road, Lowville, NY 13367,

E-mail: mstangaferro@dairyhealth.co

## Abstract

Artificial insemination of cows based on detected estrus is still a regular practice included in most reproductive management programs in the United States and elsewhere. Traditional methods of estrus detection are time-consuming, repetitive, and require qualified labor. In recent years, there has been an explosion in the development and adoption of automated estrus detection systems for dairy farms, especially those monitoring individual changes in physical activity. This article will discuss the potential benefits of using automated estrus detection, limitations of programs relying solely on insemination at detected estrus, and ideas for integrating activity monitors into effective reproductive programs.

**Key words:** dairy cow, automated estrus detection, reproductive strategies

## Résumé

L'insémination artificielle des vaches basée sur la détection de l'œstrus est toujours une pratique courante dans la plupart des programmes de gestion de la reproduction aux États-Unis et ailleurs. Les méthodes traditionnelles de détection de l'œstrus prennent du temps, sont répétitives et demandent une main d'œuvre qualifiée. Il y a eu récemment une explosion dans le développement et l'adoption de systèmes automatisés de détection de l'œstrus pour les fermes laitières surtout pour celles qui font la surveillance de changements individuels de l'activité physique. Cet article va discuter des bénéfices potentiels de l'utilisation de la détection automatisée de l'œstrus, des limites des programmes qui n'utilisent seulement que l'insémination à la détection de l'œstrus et d'idées afin d'intégrer les moniteurs d'activité dans des programmes efficaces de reproduction.

## Introduction

Timing of pregnancy during lactation is paramount to the profitability of dairy herds because it affects the calving interval, milk production efficiency, and herd replacement dynamics of dairy operations.<sup>7,13,17</sup> Thus, dairy farms implement intensive and complex reproductive management programs with the objective of maximizing the insemination rate and

overall fertility. Among programs currently used by farms in the United States and elsewhere, those including artificial insemination (AI) of cows at detected estrus are still common.<sup>4,9,24</sup> For example, surveys conducted in large commercial dairies in the United States reported that most herds used estrus detection as part of their reproductive program, and a combination of insemination of cows at detected estrus and timed artificial insemination (TAI) was by far the most common practice.<sup>4,9,21</sup> Therefore, effective estrus detection programs that correctly identify cows in estrus are essential to maximizing reproductive performance and optimizing timing of pregnancy during lactation.

The proportion of cows inseminated in estrus as well as the methods used to identify cows in estrus differ extensively among farms.<sup>4,9,21</sup> Nevertheless, visual observation or a combination of visual observation and use of estrus-detection aids, such as tail chalk and paint, are still the most commonly used methods to identify cows in estrus.<sup>4,21,24</sup> Studies have reported that on average, farm personnel spent about 30 minutes per session in about 2.8 to 3.5 sessions per day on detection of estrus, and these activities were usually performed by more than 1 person.<sup>4,6</sup> Hence, a substantial amount of time and resources are dedicated by dairy operations to conduct estrus detection. These actions are time-consuming, labor-intensive, repetitive, and inherently subjective, particularly as herd size increases. Moreover, correct identification of primary and secondary signs of heat require qualified and experienced workers, re-trained on a regular basis, and under regular supervision. Thus, implementation of these programs is demanding and may become even more challenging in large dairy herds with decreased availability of qualified personnel.

Automated, sensor-based monitoring of behavioral and physiological parameters can be an alternative to reduce the burden associated with traditional estrus detection programs. Continuous monitoring of 1 or more parameters, objective evaluation of physiological status, and substantial reduction in labor costs are some of the potential benefits. Although the use of sensors to monitor different cow parameters such as physical activity, mounting behavior, or body temperature is not new,<sup>8,10,19,25</sup> substantial advances in technology allowed these systems to improve data collection, integration, and real-time interpretation, becoming more affordable and easier to use. As a result, there has been a recent explosion in the development and adoption of automated

estrus detection (AED) systems for dairy farms, especially those monitoring individual changes in physical activity. Nevertheless, dairy cow physiological conditions that limit estrus expression, along with AED systems technical failures, may limit the success of programs that rely exclusively or almost exclusively on submission of cows for AI based on automated detection of estrus.

Farms considering the implementation of estrus detection programs based primarily or exclusively on AED should consider the potential benefits and drawbacks of such programs. This paper presents an overview of both benefits and drawbacks of AED and some practical recommendations for integrating AED into reproductive management programs of lactating dairy cows.

### Limitations of Programs Relying Solely on AED

Correct identification and differentiation of an estrus vs a non-estrus episode is essential for an AED system to achieve high performance. Ideally, these systems should be sensitive enough to detect cows in estrus (i.e., avoid false negatives) while minimizing the incorrect classification of cows not showing signs of estrus (i.e., avoid false positives).<sup>12</sup> In this regard, the reported accuracy of AED systems differs extensively depending on the parameters monitored, the algorithms used to classify cows, and the method of estrus detection used as gold standard. For example, using intensive monitoring of signs of estrus by visual observation as the gold standard, Roelofs et al reported sensitivity values ranging from 51% up to 95% in cows detected in estrus based on number of steps measured by pedometers.<sup>20</sup> Similarly, Aungier et al reported 90% sensitivity and 17% false positive outcomes when comparing a neck-mounted activity monitoring system versus visual observation of estrous-related behavior.<sup>1</sup> These results confirmed that, far from being perfect, AED systems still have technical difficulties to find all cows that may be detected in estrus by traditional methods (i.e., when implemented in a research setting).

The performance of AED systems is also affected by cow physiological limitations which affect their ability to express estrus behavior, ovulate a preovulatory follicle, or both. For example, using milk progesterone monitoring alone or in combination with ovarian ultrasonography as gold standard, studies have reported sensitivity values for AED systems ranging from 62% to 94%, specificity from 90% to 98%, and positive predictive value from 36% to 97%.<sup>5,16</sup> Interestingly, Valenza et al reported that only 71% of cows treated with prostaglandin F<sub>2</sub> $\alpha$  (PGF<sub>2</sub> $\alpha$ ) were detected in estrus by either neck-mounted activity monitors or pressure-activated Heatmount detectors (Kamar Heatmount Detectors), with no difference between systems.<sup>23</sup> In that study, only cows with a follicle >10 mm in diameter and a functional corpus luteum at the PGF<sub>2</sub> $\alpha$  injection that regressed by 48 h after induction of luteolysis were included in the analysis. Overall, most studies demonstrated that even when using AED systems to monitor cow behavior 24/7, there is always a group of animals not de-

tected in estrus (and consequently, not inseminated) because of technical difficulties of the system (e.g. algorithm, device failures) and physiological limitations of cows to display signs of estrus. Thus, comprehensive reproductive management strategies that include identification and treatment of cows that otherwise will not be inseminated are key to the success of programs that rely on estrus detected AI (EDAI).

### Integration of Activity Monitors for Reproductive Success

Giordano and Fricke recently published a detailed review article describing different strategies to integrate EDAI based on AED into reproductive management programs for lactating dairy cows. Programs vary from those more dependent on EDAI to those more reliant on TAI.<sup>12</sup> The first strategy relies mostly on estrus detection to submit cows for AI, minimizing hormonal treatments and maximizing the proportion of cows bred in estrus. In this strategy, plenty of time is provided for cows to show signs of estrus and receive EDAI, either after the end of the voluntary waiting period (VWP) or after a previous AI service. Subsequently, synchronization of ovulation and TAI are used as a safety net to ensure timely insemination of those cows not bred at detected estrus. Defining the period of time in which cows are expected to receive EDAI is very important for this strategy. Based on previous research, Giordano and Fricke, recommended a period of EDAI of about 15 to 25 days after the end of the VWP for first AI and 32 to 39 days for second and subsequent AI.<sup>11,12,14</sup> In general terms, farms with a high proportion of cows inseminated in estrus may select an extended EDAI period because fewer cows will have delayed breeding.

The second strategy consists of synchronizing estrus using PGF<sub>2</sub> $\alpha$  treatments to take full advantage of EDAI within a few days of the end of the VWP. Thereafter, cows not inseminated at detected estrus because no estrus was detected by the AED system are enrolled in a TAI program. For first service postpartum, 1 or 2 PGF<sub>2</sub> $\alpha$  treatments administered 14-d apart may be used to maximize the proportion of cows EDAI. The synchronization of ovulation protocol may start between 11 and 14 days after the last PGF<sub>2</sub> $\alpha$  for those cows not inseminated in estrus.<sup>15</sup> For second and greater AI services, cows are eligible for EDAI for 32 to 39 d after a previous service (similar to the previous strategy). At the time of non-pregnancy diagnosis coincident with the end of the EDAI period, open cows with a corpus luteum (CL) present on their ovaries might receive a PGF<sub>2</sub> $\alpha$  treatment to induce estrus expression and increase EDAI for another 7 to 11 d period.<sup>14</sup> If not inseminated at detected estrus after induction of estrus with PGF, cows should be immediately enrolled in a TAI program. On the other hand, cows without a CL at non-pregnancy diagnosis are immediately enrolled in a synchronization of ovulation program to receive TAI. Ideally, these cows receive a protocol that includes progesterone supplementation or pre-synchronization of the estrous cycle.

The third strategy aims to maximize the insemination rate after the end of the VWP and pregnancy per AI at first service by using fertility protocols for 100% TAI. These protocols optimize ovarian physiology and uterine environment to achieve high fertility. Double-Ovsynch, Presynch-Ovsynch, G-6-G, and G-7-G, are some examples of protocols that result in pregnancy per AI at first service of ~40 to 55%.<sup>2,3,18,22</sup> For second and greater AI services, a combination of EDAI and then TAI for cows not detected in estrus is used as described previously. Overall, the third strategy does not maximize the use of the AED system for submitting cows to AI or reduce hormonal treatments, but it may achieve excellent reproductive performance.

The 3 strategies described above represent examples of how AED systems can be integrated into reproductive management programs. Nevertheless, a limitless number of combinations based on the proportion of cows receiving EDAI and TAI can be explored. Dairy farms should evaluate their ability to identify and inseminate cows in estrus, compliance with synchronization protocols, and overall preference for the type of method to submit cows for insemination, among other things.

### Conclusion

Effective estrus detection programs that allow correct identification and AI of cows showing signs of estrus are essential to maximize reproductive performance. However, traditional estrus detection programs are time consuming, labor intensive, repetitive, and inherently subjective. Automated, sensor-based monitoring of behavioral and physiological parameters associated with estrus events can be an alternative to reduce the burden associated with these traditional programs. Still, technical difficulties of currently available AED systems (e.g. algorithm, device failures) and physiological limitations of cows demand the use of strategies that include the identification and treatment (TAI) of cows that would otherwise not be inseminated by EDAI. Three strategies, ranging from those more dependent on EDAI to more reliant on TAI, were presented in this paper to integrate AED into reproductive management programs. The appropriate strategy for each specific farm will depend on the intrinsic characteristic of the herd, such as environmental conditions for cows to express estrus, the ability of farm personnel and technologies used to detect cows in estrus, compliance with synchronization protocols, and overall preference for the type of method to submit cows for insemination, among other things.

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