Attaining reproductive solutions through activity monitoring

R. L. Nebel
Select Sires Inc., Plain City, OH

Abstract

Today's activity monitoring systems do much more than just identify cow/heifer for insemination. The addition of rumination monitoring allows the identification of health events along with reproductive events. Performance of automated activity monitoring (AAM) systems in combination with timed artificial insemination (TAI) compared to TAI exclusively has been widely researched and adopted.

Detecting a high percentage of cows in estrus is essential to maintain reproductive performance in dairy herds using AI. The Dairy Records Management Systems reported a mean yearly estrus detection rate on 8,749 US Holstein herds (including all reproductive management strategies) as 46.5% in January of 2018.[1] Automated activity monitoring technologies are an available alternative to supplement or replace visual estrus detection. Parameters with potential for AAM include mounting events, activity level, lying time, rumination and eating times, feeding events, progesterone levels, body temperature, and more. The automatic measurement of chewing and ruminating activity can enable the early detection of feeding deficiencies and assist in ration adjustments. Feeding and ruminating behaviors have traditionally been monitored through visual observation or video recording methods, but these methods are time consuming and only practically used in research settings. Commercially marketed technologies recording feeding behavior, rumination, and lying behavior performed well when compared with visual observation. Rumination behavior was most variable from visual observation. Similar performance to visual observations and other validated technologies indicates dairy cattle behavioral monitors to provide accurate information for use in dairy cow management.

Introduction

Activity monitoring systems are now the backbone of many herd reproductive management systems. This technology is helping herds achieve reproductive results that seemed impossible only a decade ago. The growth in usage and performance of AAM technology is one of the reasons we are now seeing many herds achieving a pregnancy rate of thirty percent or higher.

Activity Monitoring systems do much more than just identify cow/heifer for insemination they provide new insight into individual animal characteristics. The addition of rumination monitoring allows the identification of health events along with reproductive events. The milk a cow produces today is dependent on what she consumed yesterday thus it allows for an advanced signal prior to any clinical signs. It must be remembered that an increase in activity is a secondary sign of estrus and systems that minimize false positive alerts (cow with an estrus alert that are not in estrus), and maximize true or positive alerts will give optimum results. Every AAM system has three basic components: sensor, receiver of data from the sensor to the software, and software. Neck activity, ear activity, leg activity, step count, lying bouts, lying time, rumination, feeding time, and reticulorumen temperature are useful as predictors of estrus. Rumination time is positively associated with milk yield in early-lactation across all parities. Algorithms combining decreases in rumination and increasing lying or resting minutes are used to declared health alerts. Performance of AAM monitoring systems in combination with TAI compared to TAI have been reported.

Monitoring of activity for detection of estrus

Detection of estrus was the initial function of an AMM systems.[2,3] Despite the widespread adoption of hormonal synchronization protocols that allow for TAI plays an important role in the reproductive management of most dairies. Increase physical activity is a secondary expression of estrus in cattle, and a new generation of AAM systems that continuously monitor physical activity to predict timing of insemination are now available. Seventy to eighty percent of eligible lactating cows and seventy to ninety percent of eligible dairy heifers monitored using an AMM system are usually detected in estrus. There are many issues that influence the percentage of animals detected by a monitoring system. These issues always relate back to the nutrition, cow comfort and general health. Extended the length and higher the peak in activity, the more likely a cow will be detected accurately by the system. Recent work done at the University of British Columbia[4] reported factors related to peak activity levels and duration when monitoring cows with commercially available activity systems. Each cow was fitted with an activity collar and a leg-mounted pedometer. The neck collar and leg-mounted pedometer had an estrus detection rate of 89.6 percent and 85.5 percent, respectively, during the trial.

This research showed that a low body condition score was associated with reduced peak and duration. They also reported more pregnancies per insemination from cows that had a higher peak activity level. Lactation and secondary signs of heat were also related to estrus. This recent Canadian study,[4] reproductive performance between two approaches to management of first insemination on commercial farms, one based on the use of an AMM system combined with TAI if cows were not identified in estrus by 25 days after the voluntary waiting period and the other based exclusively on TAI. Heavy reliance on an AAM system was compared with a Double Ovsynch protocol, which has been reported to result in high pregnancies per insemination, particularly in primiparous cows, in intensively managed confined dairy herds [5,6] The study design provided for all cows in each treatment to be inseminated by 88 days in milk. The design also allowed a proportion of cows in the AAM + Ovsynch treatment to be inseminated twice by the time cows in the Double Ovsynch treatment received their first insemination, which explains the difference between the proportions of cows pregnant in the AAM + Ovsynch treatment at first AI and at 88 days in milk. The proportion of cows pregnant at 88 days in milk was not a biological or specific economic endpoint but, given the design, was used to describe reproductive performance with the two reproductive management practices. One of the potential advantages of using an AAM system is to have the opportunity to re-inseminate cows at approximately three-week intervals. Overall, the treatments offered similar performance, as shown in previous studies [7,8] yet, as in other trials with multiple herds, relative performance of AMM systems compared with TAI differed between herds.[7,9,10]

One important result from these studies is the effect of treatments differed between the two herds. Cows in the Double Ovsynch treatment in one herd were more likely to become pregnant at first AI than cows in the AAM + Ovsynch treatment. On the contrary, in the other herd, cows in the AAM + Ovsynch treatment were more likely to be pregnant by 88 days in milk than cows in the Double Ovsynch treatment. The interaction of treatment with herd remained for the time to pregnancy up to 200 days in milk. These interactions point to differences among herds in the relative performance of TAI and incorporation of an AAM system. This variability among herds has been shown previously for AMM systems,[7,9] but has not been reported for Double Ovsynch (i.e., no farm by treatment interactions; [5,6] These studies were not designed to explain the variability in response to treatment between herds, but it can be hypothesized that differences in farm-specific characteristics and management, as well as the use of different AMM systems, might have played a role, as may be expected, AAM systems performed better in the herd in which the insemination rate was greater. Although the authors could not formally explain the reasons behind the differences between herds, they noted that the success of estrus detection was likely an important determinant of the results that were obtained. In the AAM + Ovsynch treatment, the insemination rate was 57% greater in herd 1 than in herd 2 from 50 to 88 days in milk (1.52 vs. 0.97 inseminations per 21 cow-days). The probability of pregnancy at first AI and by 88 days in milk was also greater in herd 1 than in herd 2 for AAM + Ovsynch treatment. This difference is also reflected in the proportion of cows not identified in estrus by the AAM before 75 days in milk. The proportion of cows (7% in herd 1 and 36% in herd 2) not detected in estrus between 50 and 75 days in milk is in the expected range, but this represents the ends of the distribution.[8,9] Their results with AAM + Ovsynch are consistent with controlled trials[11] and observational studies[12,13] that show that a greater insemination rate is a key determinant of good performance when employing estrus detection as part of a reproductive management program. Barring a substantial reduction in pregnancies per insemination, more inseminations will result in more pregnancies per unit of time, in this case contributing to the difference between treatments in the proportion of cows pregnant by 88 days in milk in herd 1. Factors such as the prevalence of lameness, stocking density in the breeding pens, and the sensitivity of the AAM system are likely involved in the probability of identifying cows in estrus by an AAM system, but were not assessed in these studies.

Timing of insemination

Several research studies over the last five years in lactating dairy cows and heifers have indicated that insemination closer to the time of ovulation with gender sorted semen may improve conception rates.[14,15] A previous study indicated that insemination between 8 to 16 hours after activity thresholds[16] was ideal for use with conventional semen in lactating Holstein cows. Bombardelli, and co-workers[14] reported the optimal timing of insemination using Heatime AAM system (SCR Engineers Ltd., Netanya, Israel) occurred somewhere between 23 to 41 h after the reaching the activity threshold activity level in lactating Jersey cows. Inseminating 16 plus hours after the onset of activity defined by CowManager AAM technology (Agis, Harmelen, the Netherlands) resulted in in a greater conception rate compared to breeding early (0 to 8 hours) in lactating Jersey cows and heifers. Although there were no significant differences in conception rate between 8 and 16 and 16 plus hours, the heifer and cow data along with data from other studies suggests breeding 16 to 24 h after the onset of activity should maximize conception rates when using gender sorted semen.

Rumination monitoring

The automatic measurement of chewing and ruminating activity can enable the early detection of feeding deficiencies and assist in ration adjustments.[17] Feeding and ruminating behaviors have traditionally been monitored through visual observation or video recording methods,[18] but these methods are time consuming and only practically used in research settings. Additionally, monitoring animal behaviors using visual observation is subjective and open to observer interpretation.[19] Monitoring rumination and feeding behaviors with precision AAM technologies could replace subjective visual observations while providing useful and continuous measures of these behaviors. Technologies recording feeding and rumination behaviors have traditionally quantified these behaviors using chewing activity monitors (pressure and strain recorders;[17,20,21] Chewing activity (pressure and strain) and feeding behavior monitors are primarily used in research settings, but commercially available rumination and feeding behavior quantification methods have recently been developed and evaluated. Bikker et al.[22] evaluated a technology (CowManager SensOor, Agis, Harmelen, the Netherlands) monitoring rumination and feeding behavior through head movement and found these behaviors to be closely related to visual observations. The rumination time, chewing cycles, as well as rumination bouts detected by a different AAM system (Smartbow GmbH, Jutogasse 3, 4675 Weibern, Austria) were highly associated ($r > 0.99$) with the analyses of video recordings.[23] Algorithm testing revealed in an underestimation of the average ± standard deviation rumination time per 1-h period by this AAM system of 17.0 ± 35.3 s (i.e., −1.2%), compared with visual observations. The average number ± standard deviation of chewing cycles and rumination bouts was overestimated by 59.8 ± 79.6 (i.e., 3.7%) and by 0.5 ± 0.9 (i.e., 1.6%), respectively, compared with the video analyses. In summary, the agreement between the Smartbow system with video analyses was excellent. From a practical and clinical point of view, the detected differences were negligible. However, further research is necessary on testing the system under various field conditions and on evaluating the benefit of implementing rumination data into herd management decisions. Similarly, Schirmann et al.[18] evaluated a technology (HR Tag, SCR Engineers Ltd., Netanya, Israel) quantifying rumination sounds through a microphone and microprocessor and found a strong correlation between visual observations and this technology. Another method to quantify feeding behaviors is through technologies describing when cows approach feeding areas. Many of these types of technologies have been evaluated and found to be highly correlated with visual methods.[24,25] These findings indicate the potential for technology performance to vary among AAM systems for the same parameters through different methods.

Health alerts

Lying behavior is a parameter frequently quantified by AAM.[26-28] Time spent lying can indicate cow comfort, welfare, and health changes.[29] Proudfoot et al.[30] found sick or ill cattle spent more time lying apart from the herd. Compared with other parameters measured by precision dairy-monitoring technologies (e.g., feeding behavior, rumination, and activity), standing and lying events are easily visually monitored but the process remains time-consuming. Previous studies evaluating lying behavior have reported strong correlations between technologies and visual or video monitoring. Lying behaviors measured by the HOBO Data Logger (HOBO Pendant G Acceleration Data Logger, Onset Computer Corporation, Pocasset, MA) have strongly matched video monitoring observations.[28] Similarly, the AfiAct Pedometer Plus (Afimilk, S.A.E. Afikim, Kibbutz Afikim, Israel) and IceTag (a version of the IceQube intended for research; IceRobotics Ltd., Edinburgh, Scotland) monitored dairy cow lying behavior and observations were closely related to video monitoring observations.[31,32]

Conclusion

Activity monitoring provides adequate opportunity to monitor cow health, comfort, and welfare but human factors related to successful adoption cannot be overlooked nevertheless activity information must be interpret and appropriate action taken. These systems change the way producers manage their animals. The primary successful application has been detection of estrus; however, rumination monitoring potential return on investment is greater by early detection of health events, decreasing death lost, and days in the hospital pen as well as early treatment to minimize antibiotic treatment is now being realized.

References

1. DRMS: DairyMetrics. Dairy Records Management Systems, Raleigh, NC. 2018.
2. Kiddy CA: Variation in physical activity as an indication of estrus in dairy cows. J Dairy Sci 1977;60:235-243.
3 Dransfield MBG, Nebel RL, Pearson RE, et al: Timing of insemination for dairy cows identified in estrus by a radiotelemetric estrus detection system. J Dairy Sci 1998;81:1874-1882.
4. Denis-Robichaud J, Cerri RLA, Jones-Bitton A, et al: Performance of automated activity monitoring systems used in combination with timed artificial insemination compared to timed artificial insemination only in early lactation in dairy cows. J Dairy Sci 2018;101:624-636.
5. Souza AH, Ayres H, Ferreira RM, et al: A new presynchronization system (Double-Ovsynch) increases fertility at first postpartum timed AI in lactating dairy cows. Theriogenology 2008;70:208-215.
6. Herlihy MM, Crowe MA, Diskin MG, et al: Effects of synchronization treatments on ovarian follicular dynamics, corpus luteum growth, and circulating steroid hormone concentrations in lactating dairy cows. J Dairy Sci 2012;95:743-754.
7. Neves RC, Leslie KE, Walton JS, et al: Reproductive performance with an automated activity monitoring system versus a synchronized breeding program. J Dairy Sci 2013;95:5683-5693
8. Fricke PM, Giordano JO, Valenza A, et al: Reproductive performance of lactating dairy cows managed for first service using timed artificial insemination with or without detection of estrus using an activity monitoring system. J Dairy Sci 2014;97:2771-2781.
9. Dolecheck KA, Heersche Jr G, Bewley JM: Retention payoff–based cost per day open regression equations: application in a user-friendly decision support tool for investment analysis of automated estrus detection technologies. J Dairy Sci 2016;99:10182-10364.
10. Burnett TA, Madureira AML, Silper BF, et al: Integrating an automated activity monitor into an artificial insemination program and the associated risk factors affecting reproductive performance of dairy cows. J Dairy Sci 2017;100:5005-5018.
11. Tenhagen B-A, Drillich M, Surholt R, et al: Comparison of timed ai after synchronized ovulation to ai at estrus: reproductive and economic considerations. J Dairy Sci 2004;87:85-94.
12. Ferguson JD, Skidmore A: Reproductive performance in a select sample of dairy herds. J Dairy Sci 2013;96:1269-1289.
13. Denis-Robichaud J, Cerri RLA, Jones-Bitton A, et al: Performance of automated activity monitoring systems used in combination with timed artificial insemination compared to timed artificial insemination only in early lactation in dairy cows. J Dairy Sci 2017;101:624-636.
14. Bombardelli GD, Soares HF, ChebelRC: Time of insemination relative to reaching activity threshold is associated with pregnancy risk when using sex-sorted semen for lactating Jersey cows. Theriogenology 2015;85:533-539.
15. Nebel RL: Time of insemination relative to onset of activity threshold of CowManager® is associated with pregnancy risk when using Gender Selected™ semen for Jersey cattle. Dairy Vet Sci J 2018;5:1-3.
16. Stevenson JS, Hill SL, Nebel RL, et al: Ovulation timing and conception risk after automated activity monitoring in lactating dairy cows. J Dairy Sci 2014;97:1-13.
17. Zehner N, Niederhauser JJ, Nydegger F, et al: Validation of a new health monitoring system (RumiWatch) for combined automatic measurement of rumination, feed intake, water intake and locomotion in dairy cows. Proc Int Conf Agric Eng CIGR-AgEng, 2012:C-438.

18. Schirmann K, von Keyserlingk MAG, Weary DM, et al: Technical note: validation of a system for monitoring rumination in dairy cows. J Dairy Sci 2009;92:6052-6055.
19. Weary DM, Huzzey J, von Keyserlingk M: Board-invited review: using behavior to predict and identify ill health in animals. J Anim Sci 2009;87:770-777.
20. Beauchemin KA, Zelin S, Genner D, et al: An automatic system for quantification of eating and ruminating activities of dairy cattle housed in stalls. J Dairy Sci 1989;72:2746-2758.
21. Kononoff PJ, Lehman HA, Heinrichs AJ: Technical note: a comparison of methods used to measure eating and ruminating activity in confined dairy cattle. J Dairy Sci 2002;85:1801-1803.
22. Bikker JP, van Laar H, Rump P, et al: Technical note: evaluation of an ear-attached movement sensor to record cow feeding behavior and activity. J Dairy Sci 2014;97:2974-2979.
23. DeVries TJ, von Keyserlingk MAG, Weary DM, et al: Technical note: validation of a system for monitoring feeding behavior of dairy cows. J Dairy Sci 2003;86:3571-3574.
24. Chapinal N, Veira DM, Weary DM, et al: Technical note*:* validation of a system for monitoring individual feeding and drinking behavior and intake in group-housed cattle. J Dairy Sci 2007;90:5732-5736.
25. McGowan J, Burke C, Jago J: Validation of a technology for objectively measuring behavior in dairy cows and its application for estrous detection. Proc N Z Soc Anim Prod 2007; p. 136.
26. O'Driscoll K, Boyle L, French P, et al: The effect of out-wintering pad design on hoof health and locomotion score of dairy cows. J Dairy Sci 2008; 91:544-553.
27. Ledgerwood DN, Winckler C, Tucker CB. Evaluation of data loggers, sampling intervals, and editing techniques for measuring the lying behavior of dairy cattle. J Dairy Sci 2010;93:5129-5139.
28. Haley DB, Rushen J, de Passille AM: Behavioral indicators of cow comfort: activity and resting behavior of dairy cows in two types of housing. Can J Anim Sci 2000;80:257-263.
29. Proudfoot KL, Jensen MB, Weary DM, et al: Dairy cows seek isolation at calving and when ill. J Dairy Sci 2014;97:2731-2739.
30. Mattachini G, Antler A, Riva E, et al: Automated measurement of lying behavior for monitoring the comfort and welfare of lactating dairy cows. Livest Sci 2013;158:145-150.
31. Mattachini G, Riva E, Bisaglia C, et al: Methodology for quantifying the behavioral activity of dairy cows in freestall barns. J Anim. Sci 2013;91:4899-4907.