J. Dairy Sci. 100:1–14
https://doi.org/10.3168/jds.2016-11519

Increasing estrus expression in the lactating dairy cow[1]

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ABSTRACT

Using an activity monitoring system (AMS) equipped with an accelerometer, 2 experiments were conducted to test the hypotheses that (1) enhancing progesterone before inducing luteolysis or (2) exposing cows to estradiol cypionate (ECP) or testosterone propionate (TP) after luteolysis would increase occurrence and intensity of estrus. Our goal was to determine if more cows could be detected in estrus by an AMS compared with other estrus-detection aids. In experiment 1, cows (n = 154) were fitted with both an AMS collar and a pressure-sensitive, rump-mounted device (HeatWatch; HW) and assigned to 3 treatments: (1) no CL + progesterone insert (CIDR) for 5 d, (2) CL only, or (3) CL + 2 CIDR inserts for 5 d to achieve a range in concentrations of progesterone. Prostaglandin $F_{2\alpha}$ was administered to all cows upon CIDR insert removal or its equivalent. Progesterone concentration up to 72 h posttreatment was greatest in CL + 2 CIDR, followed by CL only, and no CL + CIDR cows. Estrus occurred 14 to 28 h earlier in no CL + CIDR compared with CL-bearing cows. Estrus intensity was greater for CL + 2 CIDR than for CL-only cows. The AMS and HW detected 70 and 59% of cows defined to be in estrus, respectively. In experiment 2, cows (n = 203) were equipped with both an AMS and a friction-activated, rump-mounted patch (Estrotect patch) and assigned to receive 1 mg of ECP, 2 mg of TP, or control 24 h after $PGF_{2\alpha}$. Concentrations of estradiol 24 and 48 h after treatment were greater in ECP cows compared with controls. Estrus expression detected by AMS or patches in cows defined to be in estrus tended to be greater or was greater for ECP compared with controls, respectively. Compared with controls and in response to TP or ECP, estrus occurred 8 to 18 h earlier and was of greater intensity for ECP cows, respectively. The AMS and patches determined 73 and 76% of cows defined to be in estrus, respectively. Of cows exposed to the AMS, HW, or patches, 70, 61, and 75%, respectively, were detected in estrus and more than 93% of these subsequently ovulated. In contrast, of the residual cows not detected in estrus, 62 to 77% ovulated in the absence of detected estrus. Only ECP was successful in inducing more expression and intensity of estrus, and proportions of cows detected in estrus exceeded 80%. Given the large proportion of cows equipped with AMS collars ovulating in the absence of estrus, further research is warranted to determine if more pregnancies can be achieved by inseminating those cows not detected in estrus at an appropriate time when $PGF_{2\alpha}$ is administered to induce luteolysis.
Key words: estrus, estradiol, progesterone

INTRODUCTION

Reproductive efficiency is of critical importance to the dairy industry (Stevenson, 2014). Average estrus-detection risk (<50%) in most US dairy herds has been identified as a major factor limiting reproductive efficiency (Lopez et al., 2005). Less than optimal days open and pregnancy risk are costly to producers. Detection of behavioral estrus plays an important role in overall reproductive management programs in most US dairies despite the widespread adoption of fixed-time ovulation-synchronization programs (Caraviello et al., 2006; Fricke et al., 2014). Furthermore, other physiological changes are associated with primary and secondary signs of estrus including vaginal cytology, pH, electrical resistance of vaginal mucus, color and swelling of genital tissue, physical activity, changes in body temperature, uterine or ovarian blood flow, pheromones, hormones, milk yield, and DMI (Lewis and Newman, 1984; Roelofs et al., 2010; Saint-Dizier and Chastant-Maillard, 2012). In summary, expression of behavioral estrus is dependent on several factors including hormonal concentrations and physiological and environmental factors (Senger, 1994).

Approximately 76% of large dairy herds (500 or more cows) in the US house dairy cows in confinement freestall barns with concrete flooring, with 32% of those freestall operations also having turnout dry lots, with only 17% of all large operations with cows only in dry

Received May 27, 2016.
Accepted September 28, 2016.
[1]Contribution number 16-331-J from the Kansas Agricultural Experiment Station, Manhattan, KS.
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lots (NAHMS, 2014). One of the most important factors limiting expression of sexual behavior in lactating Holstein cows is the surface on which they are observed for estrus (Britt et al., 1986). Cows are more likely to express estrus when housed on earthen surfaces rather than on dry grooved concrete surfaces. Because milk production affects estrus expression (Lopez et al., 2005), and until recently, genetic selection for only increased milk yield was the standard practice in AI sire selection (Egger-Danner et al., 2015), cows producing greater quantities of milk have shorter and less intense periods of estrus (Lopez et al., 2005). In addition, high-yielding cows have increased metabolic rates, and to meet their nutritional and milk production requirements, dairy diets contain more concentrated energy and less forage than earlier times. As a result of high-energy diets in lactating dairy cows, hepatic blood flow is chronically increased and metabolic clearance rate of estradiol and progesterone also is increased (Sangsritavong et al., 2002), thus reducing systemic concentrations of these 2 essential steroid hormones.

Cows beginning an ovulation-synchronization program with greater progesterone concentrations had more pregnancies per AI (**P/AI**) compared with cows beginning the program with lesser progesterone concentrations (Bisinotto et al., 2010; Stevenson, 2016). Furthermore, cows ovulating a follicle from the second follicular wave of the estrous cycle during elevated concentrations of progesterone had greater P/AI than cows ovulating a first follicular wave follicle (low progesterone; Bisinotto et al., 2010). High-milk-producing dairy cows seem to lack sufficient blood concentrations of estradiol to induce estrus, ovulation, and uterine priming because of increased metabolic clearance of steroid hormones (Wiltbank et al., 2006). A greater proportion of cows expressed estrus after receiving estradiol cypionate (**ECP**; Sellars et al., 2006), in lieu of GnRH (Stevenson et al., 2004), to induce ovulation compared with cows that did not receive ECP. Testosterone propionate or testosterone enanthate administered without any other hormones induced mounting behavior in intact cows (Kiser et al., 1977). Estradiol (200, 400, and 800 μg) and testosterone (up to 1,000 times greater doses) administered to ovariectomized nulliparous cattle increased the frequencies of occurrence of most sexual behaviors typical of cows in estrus (Katz et al., 1980). Furthermore, testosterone did not inhibit the actions of estradiol when both are administered simultaneously (Fabre-Nys and Martin, 1993).

New technologies are available to assist in detecting various physiological correlates of estrus and increased physical activity is a commonly measured correlate of estrus. Cows spend considerably more time walking and less time resting and eating when in estrus (Kiddy, 1977). The average increase in activity assessed by pedometry at the time of estrus was 393% when cows were housed in freestall barns (Kiddy, 1977). With the advancement of technology, pedometers are being replaced with more sophisticated activity monitoring systems (**AMS**) that employ accelerometers (measures movement in 3 dimensions) to assess increased physical activity associated with estrus. Activity monitoring systems have increased reading of activity from twice daily (as with pedometers) to 12 or 24 times per day (Løvendahl and Chagunda, 2010). When an AMS (i.e., Heattime) was compared with a pedometer system (i.e., IceTag), the 2 systems had greater precision of estrus detection when compared with visual observation (Silper et al., 2015). Many newer AMS versions measure changes in activity in real time (Silper et al., 2015).

Our overall goal was to determine if more cows could be detected in estrus by an AMS compared with other estrus-detection aids. Using a market-available automated AMS, we determined if expression of estrus could be enhanced by altering the hormone milieu in which the cow was exposed before or after $PGF_{2\alpha}$-induced luteolysis. In 2 experiments, we tested the hypotheses that (1) enhancing progesterone before inducing luteolysis, or (2) exposing cows to ECP or testosterone propionate (**TP**) after luteolysis would increase occurrence and intensity of estrus.

MATERIALS AND METHODS

Two experiments at the Kansas State University Dairy Research and Teaching Center were conducted under the Kansas State University Institutional Animal Care and Use Committee application #3671 (Manhattan). Lactating Holstein cows were housed at the Kansas State University Dairy Teaching and Research Center in open freestalls with roofs overhead and fed twice or thrice daily a TMR calculated to meet nutritional requirements for lactating dairy cows producing 50 kg of 3.5% milk (NRC, 2001). The diet consisted of alfalfa hay, corn silage, soybean meal, whole cottonseed, corn or milo grain, corn-gluten feed, vitamins, and minerals. Cows were milked thrice daily.

Experiment 1

Treatments. This experiment was conducted to determine if intensity or occurrence of estrus was altered by exposing cows to varying controlled concentrations of progesterone before $PGF_{2\alpha}$-induced luteolysis. Cows were enrolled in a study beginning at 53 ± 3 DIM (Figure 1) with the objective to expose them to low, me-