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J. A. Sauls
Kansas State University, Manhattan, sauls@k-state.edu

B. E. Voelz
Kansas State University, Manhattan, bvoelz@k-state.edu

J. Stevenson
Kansas State University, Manhattan, jss@k-state.edu

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Abstract

This report summarizes the use of various hormones in an attempt to induce greater estrus expression of lactating dairy cows. Average detection of estrus (< 50%) in most U.S. dairy herds has been identified as a problem limiting reproductive efficiency. Detection of estrus plays an important role in reproductive management in U.S. dairy herds despite the adoption of fixed-time artificial insemination programs. When estrus was detected by an activity monitoring system or a rump-mounted device, supplementing cows with progesterone before induction of luteolysis resulted in greater intensity of estrus when compared with controls. In addition, administering estradiol cypionate at 24 h after induced luteolysis resulted in greater frequency of estrus expression compared with cows treated with testosterone propionate or controls when assessed by an activity monitor. Activity monitoring systems achieved heat-detection rates of approximately 70% (80% with estradiol) and are likely cost effective for herds achieving less than that level of heat detection.

Keywords

heat, estradiol, progesterone

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Increasing Estrus Expression in Lactating Dairy Cows

J.A. Sauls, B.E. Voelz, and J.S. Stevenson

Summary

This report summarizes the use of various hormones in an attempt to induce greater estrus expression of lactating dairy cows. Average detection of estrus (< 50%) in most U.S. dairy herds has been identified as a problem limiting reproductive efficiency. Detection of estrus plays an important role in reproductive management in U.S. dairy herds despite the adoption of fixed-time artificial insemination programs. When estrus was detected by an activity monitoring system or a rump-mounted device, supplementing cows with progesterone before induction of luteolysis resulted in greater intensity of estrus when compared with controls. In addition, administering estradiol cypionate at 24 h after induced luteolysis resulted in greater frequency of estrus expression compared with cows treated with testosterone propionate or controls when assessed by an activity monitor. Activity monitoring systems achieved heat-detection rates of approximately 70% (80% with estradiol) and are likely cost effective for herds achieving less than that level of heat detection.

Key words: heat, estradiol, progesterone

Introduction

Expression of estrus is dependent on several factors that include the environment, physiological factors, and hormone concentrations. Approximately 76% of large dairy herds (500 head or more) in the U.S. house dairy cows in confinement free stall barns with concrete flooring. One of the largest factors affecting expression of estrus in lactating dairy cows is the surface upon which they are observed. Cows are more likely to stand to be mounted when on a dirt surface rather than a dry grooved concrete surface.

High milk-producing dairy cows have shorter durations of estrus. A high-energy diet is fed to lactating dairy cows in order to meet their nutritional and lactation demands, and a consequence of high-energy diets is chronically increased liver blood flow, which causes increased catabolism of estradiol and progesterone (two hormones responsible for expression of estrus). Cows that ovulate an oocyte that matured in a high progesterone environment have greater chances of pregnancies per artificial insemination (P/AI). High milk-producing dairy cows often do not have sufficient concentrations of estradiol in blood circulation to cause expression of estrus, and to promote ovulation and uterine preparation for an embryo.

Several technologies on the market measure physiological changes associated with estrus. Physical activity is commonly measured for its association with estrus because of its ease of measurement and accuracy. Cows in estrus spend considerably more time walking and less time eating and resting. The experiments described in this article determined if more cows could be detected in estrus by an activity monitoring system compared with other estrus-detection aids. Two experiments performed at the Kansas State University Dairy Teaching and Research Center assessed if cows exposed to increasing concentrations of progesterone (experiment 1) or estradiol or testosterone (experiment 2) enhanced expression of estrus.

Experimental Procedures

Experiment 1

We conducted this study with 154 cows at the Kansas State University Dairy Research and Teaching Center. Estrus was synchronized and cows were assigned randomly to receive supplemental progesterone before first postpartum insemination. Cows in the low progesterone treatment were administered 1 CIDR (Zoetis Animal Health) and did not have a functional corpus luteum (CL; No CL + CIDR). The control cows had a functional CL (CL only) but received no supplemental progesterone. Cows in the high progesterone treatment had at least one functional CL and received 2 CIDR inserts (CL + 2 CIDR). Progesterone supplementation occurred for 5 days before injecting prostaglandin $F_{2\alpha}$ (PGF) to induce estrus. An activity monitoring system (AMS; Dairymaster Moo Monitor, Kearney, Ireland) containing an accelerometer and a rump mounted pressure device (HW; HeatWatch; Chow Chips LLC, New Jersey) were fitted to cows for detection of estrus.

Experiment 2

Estrus was synchronized in 203 cows with a modified double Ovsynch protocol before first postpartum insemination. Each cow received a used CIDR for 7 days beginning on day 7 of the estrous cycle, and upon its removal, PGF was administered. Cows were assigned randomly to receive either an injection of 1 mg of estradiol cypionate (ECP), 2 mg of testosterone propionate (TP), or no injection (control) at 24 hours after PGF was administered. Estradiol is the hormone responsible for inducing expression of estrus, and testosterone is a precursor substrate to make estradiol. Cows were fitted with an AMS (Dairymaster Moo Monitor) and friction-activated patches (Patches; Estrotect heat detector patches, Rockway, Inc., Spring Valley, WI) for detection of estrus.

In both experiments, estrus was defined to have occurred if cows had at least 1 ovarian follicle ≥ 10 mm and progesterone was < 0.5 ng/mL at 72 hours after administration of PGF to induce estrus (qualifying cows).

Results and Discussion

Experiment 1

Neither occurrence of estrus nor ovulation risk for all enrolled cows differed among treatments (Table 1). As assessed by the AMS, occurrence of estrus ranged from 56 to 67%. Of all cows that expressed estrus, ovulation risk varied from 89 to 100% among treatments. As assessed by HW, occurrence of estrus varied from 45 to 61%. Of cows that expressed estrus, ovulation risk ranged from 93 to 100%. Expression of estrus oc-

curred 1.6 to 1.8 times more ($P < 0.01$) often in primiparous than multiparous cows; however, ovulation risk did not differ between primiparous and multiparous cows.

Occurrence of estrus and ovulation for qualifying cows is also summarized in Table 1. As assessed by the AMS, occurrence of estrus among qualifying cows ranged from 62 to 79%. Of the qualifying cows that expressed estrus, ovulation risk ranged from 88 to 100% and did not differ among treatments. As determined by HW, occurrence of estrus among qualifying cows ranged from 51 to 69%. Of qualifying cows that expressed estrus, ovulation risk ranged from 93 to 100% and did not differ among treatments. Consistent with all enrolled cows, 1.5 to 1.9 times more ($P < 0.01$) qualifying primiparous than multiparous cows expressed estrus, but parity had no effect on ovulation risk.

Although peak factor (measure of the standard deviation of increase in peak activity during 3 hours), a measure of estrus intensity by the AMS, was greater ($P < 0.05$) for cows in the CL + 2 CIDR treatment compared with CL only, no other measures of estrus intensity (mean count, peak count, and mean factor) differed among treatments.

Experiment 2

Estrus expression and ovulation risk for all cows enrolled in experiment 2 are summarized in Table 2. Estrus expression determined by AMS varied from 67 to 79% among treatments, and of the cows that expressed estrus, ovulation risk ranged from 87 to 95%. More ECP cows tended ($P = 0.09$) to have activated patches compared with controls. Of the cows that expressed estrus as assessed by activated patches, ovulation risk ranged from 88 to 98% among treatments. Primiparous cows tended ($P = 0.11$; AOR = 1.93, 95% CI = 0.978 to 3.82) to be more likely to express estrus than multiparous cows.

Estrus expression and ovulation risk for qualifying cows also are summarized in Table 2. As determined by the AMS, occurrence of estrus did not differ among treatments. Of qualifying cows that expressed estrus by the AMS, ovulation risks ranged from 88 to 98%. More ($P = 0.056$) ECP cows with activated patches were detected in estrus compared with control cows. Of qualifying cows identified in estrus, ovulation risk varied from 89 to 98%. Qualifying primiparous cows were more ($P = 0.03$; AOR = 2.28; 95% CI = 1.07 to 4.85) likely to express estrus than qualifying multiparous cows.

Onset of estrus occurred earlier ($P < 0.001$) after treatment with ECP (46 ± 2 hours) and tended ($P = 0.102$) to be earlier after TP (56 ± 2 hours) compared with controls (64 ± 5 hours). Mean duration of estrus ranged from 9.5 ± 0.9 and 10.3 ± 0.6 h among treatments. Compared with controls, average peak counts suggested greater intensity of estrus after ECP ($P = 0.031$) or after TP ($P = 0.070$). Other measures of estrus intensity (mean count, mean factor, and peak factor) did not differ among treatments.

Efficiency and Accuracy of Detected Estrus

Efficiency and accuracy of the three methods employed in both experiments to detect estrus were compared in all qualifying cows. The proportions of enrolled cows meeting these criteria that were detected in estrus (efficiency), ovulated, or both (accuracy) are summarized in Table 3. Efficiency of detected estrus ranged from 61 to 75%. Ovulation risk (accuracy of detected estrus) for the cows detected by the AMS, pressure-sensitive devices, and friction-activated patches were 94, 96, and 94%, respectively. Of particular

interest was the 25 to 39% of cows that did not express estrus in which ovulation occurred, ranging from 62 to 77% in the absence of estrus.

Conclusions

Only the ECP treatment successfully induced more cows in estrus, but proportions of cows detected barely exceeded 80%. Given the large proportion of cows ovulating in the absence of estrus, further research is warranted when AMS are employed to determine if more pregnancies can be achieved by inseminating cows not detected in estrus at an appropriate time after PGF-induced luteolysis. An AMS is likely an appropriate tool for herds achieving less estrus-detection risk than achieved in the current experiments (70% without estradiol). Although efficiency and accuracies of the three estrus-expression methods employed did not differ, the AMS and pressure-sensitive rump-mounted pressure detectors offer continuous monitoring of activity independent of visual assessment of friction-activated patches by herd personnel and potentially offer greater surveillance options in all cows, particularly herds in which cows are housed on concrete with less than ideal footing conditions.

Table 1. Occurrence of estrus and ovulation in all cows and qualifying cows defined to be in estrus fitted with an activity monitoring system (AMS) and a pressure-sensitive rump mounted pressure detector device (experiment 1)

	Treatment[1]			*P* - value[2]	
Item [% (no.)]	No CL + CIDR	CL only	CL + 2 CIDR	No CL vs. CL	CL vs. CL + 2 CIDR
AMS					
Estrus expression[3]					
All cows[4]	66.9 (52)	62.9 (51)	56.3 (51)	0.695	0.541
Qualifying cows[5]	70.3 (42)	79.5 (35)	61.9 (44)	0.480	0.204
Estrus and ovulation[6]					
All cows	94.1 (34)	100 (33)	89.3 (28)	0.406	0.035
Qualifying cows	92.8 (28)	100 (27)	88.5 (26)	0.367	0.047
Pressure-sensitive device					
Estrus expression					
All cows	61.2 (52)	56.2 (51)	45.2 (51)	0.637	0.306
Qualifying cows	59.5 (42)	69.3 (35)	51.3 (44)	0.902	0.216
Estrus and ovulation					
All cows	93.7 (32)	100 (30)	95.6 (23)	0.388	0.304
Qualifying cows	92.8 (28)	100 (24)	95.4 (22)	0.371	0.317

1Corpus luteum (CL) only; no CL + CIDR = CL + CIDR insert (d -5) for 5 d; or CL + 2 CIDR inserts (d -5) for 5 d. On d 0 CIDR inserts were removed and all cows received $PGF_{2\alpha}$.

[2]Orthogonal contrasts.

[3]Percentage of cows expressing activity assessed by AMS or pressure-sensitive patches.

[4]All cows enrolled in the experiment.

[5]Only cows with a follicle ≥ 10 mm in diameter at $PGF_{2\alpha}$ on d 0 and concentrations of progesterone ≤ 0.5 ng/mL at 72 h after $PGF_{2\alpha}$ injection. For cows in either CL treatment, progesterone > 1 ng/mL on d 0 or < 2.35 ng/mL for cows with no CL + CIDR insert.

[6]Percentage of cows that ovulated subsequent to detected estrus.

Table 2. Occurrence of estrus and ovulation in all cows and qualifying cows defined to be in estrus and fitted with an activity monitoring system (AMS) and a friction-activated patch (experiment 2)

	Treatment[1]			*P* - value[2]	
Item [% (no.)]	ECP	TP	Control	ECP vs. control	TP vs. control
AMS					
Estrus expression[3]					
All cows[4]	78.7 (68)	67.4 (68)	70.2 (67)	0.260	0.740
Qualifying cows[5]	81.2 (62)	67.5 (59)	69.4 (59)	0.138	0.827
Estrus and ovulation[6]					
All cows	94.3 (53)	87.0 (46)	95.6 (46)	0.747	0.121
Qualifying cows	96.0 (51)	87.5 (40)	97.5 (40)	0.697	0.060
Friction-activated patch					
Estrus expression					
All cows	84.3 (63)	67.7 (64)	71.4 (60)	0.092	0.667
Qualifying cows	88.0 (58)	66.1 (55)	72.7 (53)	0.056	0.487
Estrus and ovulation					
All cows	98.1 (53)	88.4 (43)	92.9 (42)	0.309	0.501
Qualifying cows	98.0 (51)	88.9 (36)	94.6 (37)	0.490	0.365

[1]Cows received an injection of $PGF_{2\alpha}$ (d 0) and assigned randomly to 3 treatments: ECP = 1 mg estradiol cypionate; TP = 2 mg testosterone propionate; Control = no treatment injection. Treatments were administered on d 1 concurrent with a second injection of $PGF_{2\alpha}$.

[2]Orthogonal contrasts.

[3]Percentage of cows expressing activity assessed by AMS or friction-activated patches.

[4]All cows enrolled in the experiment.

[5]Cows with a follicle ≥ 10 mm in diameter at $PGF_{2\alpha}$, concentrations of progesterone > 1 ng/mL before and ≤ 0.5 ng/mL at 72 h after $PGF_{2\alpha}$ injection.

[6]Percentage of cows that ovulated subsequent to detection of estrus.

Table 3. Percentage of qualifying cows defined to be in estrus (efficiency) during 7 d after $PGF_{2\alpha}$-induced luteolysis, ovulated, or both (accuracy) detected by an activity monitoring system (AMS), pressure-sensitive devices, or friction-activated patches in experiments 1 and 2[2]

Item [% (no./no.)]	AMS	Pressure-sensitive devices	Friction-activated patches
Experiment 1[1]			
Estrus expression	66.9 (81/121)	61.2 (74/121)	...
Ovulation	93.8 (76/81)	96.0 (71/74)	...
No ovulation	6.2 (5/81)	4.0 (3/74)	...
No estrus expression	33.1 (40/121)	38.8 (47/131)	...
Ovulation	70.0 (28/40)	76.6 (36/47)	...
No ovulation	30.0 (12/40)	23.4 (11/47)	...
Experiment 2[2]			
Estrus expression	72.2 (130/180)	...	74.7 (124/166)
Ovulation	93.8 (122/130)	...	94.3 (117/124)
No ovulation	6.2 (8/130)	...	5.7 (7/124)
No estrus expression	27.8 (50/180)	...	25.3 (42/166)
Ovulation	62.0 (31/50)	...	61.9 (26/42)
No ovulation	38.0 (19/50)	...	38.1 (16/42)

[1]Only cows with a follicle ≥ 10 mm in diameter at $PGF_{2\alpha}$ on d 0 and concentrations of progesterone ≤ 0.5 ng/mL at 72 h after $PGF_{2\alpha}$ injection. For cows in either CL treatment, progesterone > 1 ng/mL on d 0 or < 2.35 ng/mL for cows with no CL + CIDR insert.

[2]Cows with a follicle ≥ 10 mm in diameter at $PGF_{2\alpha}$, concentrations of progesterone > 1 ng/mL before, and ≤ 0.5 ng/mL at 72 h after $PGF_{2\alpha}$ injection.