

**HORMONAL AND BEHAVIORAL CHARACTERISTICS  
ASSOCIATED WITH THE ONSET OF  
RADIOTELEMETRIC-DETECTED ESTRUS**

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**Summary**

The objective of this study was to examine changes in ovarian steroids in relation to the onset of first standing estrus detected by pressure-sensitive rump-mounted devices (ABS HeatWatch® [HW]). Twenty Holstein heifers were treated with PGF<sub>2α</sub> on days 5 to 8 (early) or 12 to 15 (late) of the estrous cycle to induce estrus. The following traits were different ( $P < .05$ ) in early vs late heifers: serum progesterone before PGF<sub>2α</sub> (2.3 vs  $5 \pm .3$  ng/ml); interval from PGF<sub>2α</sub> to estrus (HW devices: 42 vs  $52.4 \pm 2.8$  hr or visual: 45 vs  $57 \pm 2.5$  hr); interval (40.6 vs  $57.8 \pm 2.2$  hr) from PGF<sub>2α</sub> to estradiol-17β (E2) peak concentrations in blood serum ( $17.7$  vs  $12.3 \pm 1$  pg/ml) at estrus; duration of estrous cycle after treatment injection of PGF<sub>2α</sub> (20 vs  $21.4 \pm .2$  days); interval from onset of estrus to the peak in E2 ( $1.4$  vs  $-5.4 \pm 1.8$  hr); and E2 peak associated with the first dominant ovarian follicle of the estrous cycle following the treatment injection of PGF<sub>2α</sub> (2.2 vs  $5.2 \pm .6$  pg/ml), respectively. Durations of estrus and standing events were similar regardless of when the corpus luteum was regressed during either the early or late luteal phase. When all sexual behavior was evaluated after 41 injections of PGF<sub>2α</sub>, the number of standing events (28.1 vs  $16.1 \pm 3.1$ ) was greater ( $P < .05$ ) in heifers after early-cycle regression of the corpus luteum. Results indicated that the number of standing events per estrus and concentrations of E2 during estrus were related to the duration of progesterone exposure before a PGF<sub>2α</sub>-induced luteolysis. The first standing event of estrus detected by the HW device corresponded closely to the peak in E2 and LH at the onset of estrus.

(Key Words: Standing Estrus, Hormones, Heifers.)

**Introduction**

The relationship between the timing of the first standing event associated with estrus and pituitary-ovarian hormonal secretions in cattle is based on some empirical evidence; textbook generalizations; and limited experimental evidence (i.e., frequent blood sampling and less frequent observation for estrus). The importance of identifying the beginning of estrus is critical to the proper timing of artificial insemination (AI) to achieve optimal conception in cattle. The timing of AI-breeding to achieve maximal conception is based on research conducted in the 1940's using freshly collected, liquid semen. From that research, the AM-PM, PM-AM rule of breeding was derived. Cattle should be inseminated in mid to late estrus, which means that those heifers and cows identified in heat during the early AM heat detection period should be inseminated approximately 12 hr later in the PM, and those first detected during the PM should be AI-bred the next AM. Using this procedure, the application of AI has served the cattle industry well. With the advent of radiotelemetry and other computer technology on the farm, we are better able to identify the onset of standing estrus and, therefore, correlate the internal hormonal secretions that are associated with the beginning of heat (increased estrogen or estradiol-17β; E2) and subsequent ovulation that occurs 25 to 30 hr after the preovulatory surge of luteinizing hormone (LH).

Using a model in which the interval between luteal regression and the onset of estrus is temporally different, based on administering

PGF<sub>2α</sub> at two stages of the estrous cycle, we attempted to examine the relationships between the onset of standing estrus (and associated measures of sexual behavior) and changes in the secretion of luteal progesterone and surge increases in follicular E2 and pituitary LH.

### Procedures

Pubertal Holstein replacement heifers were fitted with HeatWatch® (HW) rump-mounted radiotelemetric devices (American Breeders Service, DeForest, WI and DDX, Inc., Boulder, CO) that detect standing events associated with estrus. Heifers were given two injections of PGF<sub>2α</sub> 14 days apart. A treatment of PGF<sub>2α</sub> (third injection) was administered either 10 or 17 days after the second injection, corresponding to days 5 to 8 (early; n = 10) or days 12 to 15 (late; n = 10) of the estrous cycle. Blood samples were collected every 12 hr, beginning at the second injection until 7 days after the treatment PGF<sub>2α</sub> to quantify serum concentrations of progesterone and E2. Blood also was collected via jugular catheters at 2-hr intervals for 48 hr, beginning either 12 or 24 hr after treatment with PGF<sub>2α</sub>, to assess changes in E2 and LH during estrus. Hormones were measured by radioimmunoassays. Heifers were observed visually for estrus 3× daily in addition to constant surveillance of standing activity by HW devices. The number and duration of standing events detected by the HW system were summarized, and relationships among timing of hormonal secretions and these behavioral traits were examined after the treatment injection of PGF<sub>2α</sub>.

### Results and Discussion

Ten heifers per treatment averaged 11 mo of age and 778 lb of body weight at the beginning of the experiment. The average periods of the estrous cycle in which the PGF<sub>2α</sub> treatment injection was administered were 7.7 and 14.1 days for the early and late groups, respectively. By design, the earlier-injected heifers (2.5 ± .3 ng/ml) had less (*P*<.01) blood serum progesterone than the later injected heifers (5 ± .3 ng/ml).

The duration of estrus and number and duration of standing events were similar in the

20 heifers (Table 1), regardless of the estrus-cycle day in which PGF<sub>2α</sub> was injected. In contrast, when all 41 estrous cycles were examined in the 20 heifers, those injected early in the luteal phase of the cycle were more active and received more (*P*<.05) mounts when in estrus than heifers in which heat was induced later in the luteal phase (Table 1).

**Table 1. Events Associated with Standing Estrus in Heifers Receiving PGF<sub>2α</sub> Early or Late in the Estrous Cycle**

Item	Early	Late	SEM
No. of heifers	10	10	–
Duration of estrus, hr	10.1	12.4	2.0
No. of standing events (all 41 cycles)	19.4 (28.1)	14.5 (16.8) <sup>a</sup>	3.5 (3.1)
Duration of stands, sec	3.5	3.6	0.3

<sup>a</sup>Different (*P*<.05) from early heifers.

Intervals to estrus and to peak concentrations of E2 and LH are summarized in Table 2. Early treated heifers received their first mount or stood for the first time in estrus 10 or 12 hr earlier than late-treated heifers, when detected by the HW system or by visual observation, respectively. Therefore, correlation of first-detected standing activities by HW and visual observation (3× daily or every 8 hr) was very good. Comparing hormonal events to the onset of estrus as detected by HW showed that concentrations of E2 reached a peak within 1.4 to 5.4 hr of the first standing event. Peak concentrations of LH followed the first standing event by 4.4 to 6.4 hr. The first standing event of estrus was highly correlated (*r* = +.79 and +.89) with the interval from PGF<sub>2α</sub> to the onset of the E2 and LH surges, respectively. Increasing blood concentrations of E2 are produced by the ovarian follicle that will ovulate about 25 to 30 hr after the peak in blood serum concentrations of LH. The peak in E2 induces the sexual behavior associated with heat and triggers the preovulatory release of LH that causes the follicle to ovulate.

The excellent agreement of peak hormonal concentrations with the onset of first standing activity of heifers during estrus confirms earlier reports and assumptions. Insemination of cows and heifers during mid to late estrus seems to be appropriate to achieve maximal conception based on these findings. Recent research to determine the optimal timing of the HW system by researchers at Virginia Tech confirmed that AI-breeding should be done about 10 to 12 hr after the first standing event is detected by the HW system. Because the duration of heat averages 10 to 12 hr, insemination of cattle near the end of estrus should produce the best conception rates.

## Conclusions

Duration of progesterone exposure (stage of the estrous cycle and maturity of a dominant follicle) before PGF<sub>2α</sub>-induced regression of the corpus luteum was related to: 1) interval to estrus (estrus occurred earlier when injections were given earlier in the estrous cycle); 2) interval to estrual surges of E2 and LH (well correlated with the onset of heat); 3) concentration of estrual E2 surge (greatest in heifers with the most standing activity); and 4) number of standing events during estrus (greatest in heifers when injections were given earlier in the estrous cycle).

**Table 2. Intervals to Onset of Estrus and Peaks in Estradiol (E2) and LH in Heifers Receiving PGF<sub>2α</sub> Early or Late in the Estrous Cycle**

Item	Early	Late	SEM
PGF <sub>2α</sub> to estrus, hr			
Heat Watch (continuous)	42.0	52.4 <sup>a</sup>	2.8
Visual detection (3× daily)	45.0	57.0 <sup>b</sup>	2.5
PGF <sub>2α</sub> to E2 surge, hr	40.6	57.8 <sup>b</sup>	2.2
PGF <sub>2α</sub> to LH surge, hr	46.4	58.8 <sup>b</sup>	2.7
Serum E2 surge, pg/ml	17.7	12.3 <sup>b</sup>	1.0
Serum LH surge, ng/ml	10.3	11.6	0.7
Duration of LH surge, hr	13.6	15.2	1.6

<sup>a</sup>Different ( $P < .05$ ) from early heifers.

<sup>b</sup>Different ( $P < .01$ ) from early heifers.