Synchronization of Estrus in Beef Cattle With Prostaglandin

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Story in Brief

A single intramuscular injection of 30 mg of the prostaglandin, $PGF_{2\alpha}$–Tham salt, was administerd to 27 crossbred beef heifers and 19 lactating beef cows whose levels of blood progesterone indicated they were cycling and had a functional corpus luteum. Estrus was observed within 8 days in 96.3 percent of the heifers and 78.9 percent of the cows. The average time from treatment to estrus was 2.35 days in the heifers and 3.40 days in the cows.

Fifteen heifers and 7 cows treated with prostaglandin were artificially inseminated 12 hours after the onset of estrus, with 73.3 percent of the heifers and 71.4 percent of the cows conceiving. This was very similar to the conception rates in the untreated controls of 76.7 percent and 69.0 percent for heifers and cows, respectively. One prostaglandin treated group of 11 cows and 12 heifers were inseminated once 80 hours after $PGF_{2\alpha}$ treatment regardless of when, or whether, estrus occurred, with 50.0 percent of the heifers and 36.4 percent of the cows conceiving.

An additional 40 cows and 41 heifers that were not cycling, and did not have a functional corpus luteum were also injected with $PGF_{2\alpha}$. In this group, only 9 cows (22.5 percent) and 6 heifers (14.6 percent) showed signs of estrus within 8 days, and only two of the cows and none of the heifers conceived at this estrus.

The data obtained in this study suggests that if a cow has a functional corpus luteum on her ovary at the time of treatment, prostaglandin will effectively synchronize estrus. It further suggests that normal fertility will be obtained at this synchronized estrus.

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Introduction

Estrus synchronization is a subject that is of particular interest to cattlemen that are practicing, or desire to practice, artificial insemination. This is to be expected, since any method that would reduce the labor requirements and/or increase the efficiency of heat detection would be of great value in a beef AI program.

A large number of research studies have been devoted to this subject over the past quarter of a century. Methods and materials have varied from study to study, but all have had one thing in common, namely attempting to remove all cows from under the influence of the hormone progesterone at about the same time. Since the primary source of progesterone in the female is a structure on the ovary called the corpus luteum (CL), it is obvious that any effort at estrus synchronization must be concerned with altering it's function.

In a normal estrus cycle of 20-21 days duration, the corpus luteum begins to form on the ovary immediately following ovulation. It becomes functional within the next 5 to 7 days, reaching it's maximum functional level by 10 to 12 days, then slowly regressing to become relatively non-functional by day-16 or 17. During the time the CL is functional the progesterone it produces inhibits the growth and development of another ovarian structure called a follicle. By day 16 or 17 the levels of progesterone have dropped sufficiently to remove this inhibition, permitting a follicle to begin to grow rapidly on the ovary. The maturing follicle produces the female hormone, estradiol, which within 3 or 4 days reaches a level sufficiently high to cause estrus, or heat. The egg, which also develops within the follicle, reaches maturity, is released in the process of ovulation some 10 to 14 hours after the end of estrus, and the cycle repeats.

Basically, synchronizing the onset of estrus, depends on removing all cows from under the influence of their CL at the same time. Until recently the only available procedure was to treat the cows with progesterone at levels high enough to inhibit follicular maturation, regardless of how much progesterone their own CL's are producing, for a period of time long enough to insure that the CL's in all of the cows will regress. At such time, stopping the exogenous hormone would immediately drop the progesterone level of all cows, permit rapid follicle growth and estrus should follow within 3 to 4 days.

Within a herd of cows one would expect to find cows at all stages of the cycle; from those that had just ovulated whose CL is just forming and should remain functional for the next 16 days, to those that are just ready to come into heat and whose CL is non-functional. The cows that had just ovulated would determine how long the entire group must

be treated with progesterone to guarantee that the CL of all cows would be completely regressed. Since their CL's would be expected to be functional for approximately 16 days, it was necessary to provide the exogenous progesterone for 14 to 18 days. In the earliest studies the progesterone was given in daily injections, since it was not effective when taken by mouth. This was not only time consuming, but fertility at the synchronized estrus was very poor.

With the development of compounds with progesterone-like activity, called progestogens, that could be fed, there was a renewal of interest in estrus synchronizing studies. Several such compounds were developed which could be fed daily for 18 days and result in fairly good synchronization. Despite the disadvantages of requiring daily feeding, which could be a problem in cattle running on lush pasture, and a reduced fertility at the synchronized estrus, at least three pharmaceutical companies put progestogens on the market for use in practical livestock production. These compounds have since been withdrawn and are not now available, nor are they likely to again become available.

Within the last three years, research in estrus synchronization has again been stimulated by the discovery that a naturally occurring compound called prostaglandins were very effective in synchronizing estrus in females of a number of species, including cattle, sheep and horses. This is not a new compound since it was first identified many years ago, but it has been only recently that the wide variety of it's physiological effects have been determined. Prostaglandins function in estrus synchronization by causing a very rapid regression of a functional corpus luteum, with most females in estrus within 3 or 4 days after a single intramuscular injection. It has an additional advantage of having little, or no, detrimental effect on fertility. It has the disadvantage that it is effective only when there is a functional CL present to regress. It will not cause an anestrus cow (that is, one that is not cycling) to come to heat. Nor will it cause the regression of a young CL that has not become functional, which means that the cow be at least 7 days into her cycle when she is treated. The most important disadvantage at the present time is probably the fact that the prostaglandins are still experimental, and have not been cleared by the FDA for use in practical cattle production.

The purpose of this experiment was to study the effectiveness of a single intramuscular injection of prostaglandin in synchronizing estrus and ovulation in non-lactating beef heifers and lactating beef cows maintained under range conditions.

Materials and Methods

This study was conducted in April and May, 1974, utilizing 98 lactating mature beef cows and 105 crossbred beef heifers maintained under range conditions at Lake Carl Blackwell range. Both groups were part of the breeding herd of Project 1502, *Comparison of Lifetime Productivity Under Range Conditions Among Certain F_1 Crossbred Cow Groups.*

Three treatments were imposed:

Treatment A – Prostaglandin injected, breeding at time of estrus post-injection–Ovarian activity determined by rectal palpation. Animals with a corpus luteum given an intramuscular injection of 30 mg of $PGF_{2\alpha}$–Tham salt. Cows observed for signs of estrus and inseminated 12 hours after the onset of estrus.

Treatment B – Prostaglandin injected, breeding on schedule – Ovarian activity determined by rectal palpation. Animals with a corpus luteum given an intramuscular injection of 30 mg of $PGF_{2\alpha}$–Tham salt. All animals inseminated 80 hours post-injection regardless of time of occurrence of estrus.

Treatment C – Uninjected controls – Inseminated approximately 12 hours after the onset of a naturally ocurring estrus.

Vasectomized bulls were used to assist in heat detection. Animals were observed twice daily for onset of estrus. The frozen semen used for all inseminations was obtained from a commercial AI organization.

Blood samples were collected at varying times from animals in Treatments A and B. The plasma was frozen until the levels of progesterone could be determined by radioimmunoassay.

Heifers: All heifers were crossbreds, having either an Angus or Hereford dam and a Hereford, Angus, Simmental, Brown Swiss or Jersey sire. A description of the heifer group is presented in Table 1.

Rectal palpations to determine ovarian activity were carried out on April 22 and April 29. On each palpation day heifers that had not been previously assigned to a treatment group were palpated until 34 were found with an active corpus luteum. These were immediately injected with 30 mg $PGF_{2\alpha}$ and randomly assigned to either Treatment A or B. An attempt was made to balance the heifers between the two treatment groups according to the breeding of their sire. In an effort to keep the average date of insemination of the heifers of the three groups as nearly

Table 1. Description of Heifer Group Classified on the Basis of Breeding of Their Sire.

Item	Breeding of Sire				
	Hereford	Angus	Simmental	Brown Swiss	Jersey
Total number of heifers	13	11	25	24	32
Avg. Wt. on 4-8-74 (lb.)	499	471	554	502	477
Avg. Age on 4-22-74 (days)	416	433	420	420	421
Number of heifers assigned to:					
Treatment A	3	4	10	11	6
Treatment B	2	4	10	10	8
Treatment C	9	3	5	3	18

alike as possible, the insemination of control heifers was started on April 14, one week before the day of first $PGF_{2\alpha}$ injection. All heifers observed in estrus prior to April 22 were inseminated and assigned to the Treatment C, as were all heifers in estrus between April 22 and April 29 that had not yet been assigned to a treatment group.

Blood samples were obtained from heifers of Treatment groups A and B on days 3 and 11 following $PGF_{2\alpha}$ treatment. The heifers were artificially inseminated at the first estrus following the start of the study using frozen semen from a Red Poll or Shorthorn bull. All subsequent breedings were by natural service to pickup bulls of these two breeds.

Cows: This group included 49 Hereford and 49 Angus cows. Most had calved in February and March. All of the Angus cows and 41 Hereford cows were suckling a calf at the time the treatments were imposed.

As was the case with the heifers, an attempt was made to keep the average date of insemination as nearly alike as possible for all treatment groups by starting the inseminations of control cows one week before the start of $PGF_{2\alpha}$ treatment. Beginning on April 29, any cow observed to be in estrus was inseminated and assigned to Treatment C. On May 6, all cows that had not been assigned to Treatment C were palpated. A total of 59 cows were determined to have active corpora lutea, were injected with 30 mg $PGF_{2\alpha}$, and 31 assigned to Treatment A and 28 to Treatment B. The remainder of the cows were assigned to Treatment C, to make a total of 39 cows in this group.

Three blood samples were collected from all cows of Treatments A and B: at time of treatment, on day 3 and on day 11 post-treatment. The cows were artificially inseminated either on day of estrus (Treatments A and C) or 80 hours post-treatment (Treatment B) using frozen semen from Simmental bulls.

Results and Discussion

The results are presented in Tables 2 and 3 for heifers and cows, respectively. When based on the total cows and heifers treated, it is apparent that the response to prostaglandin was very disappointing. Data that have been reported from other experiment stations have suggested that 75 percent or more of the treated animals could be expected to be in heat within 8 days of treatment with prostaglandin. In the present study, however, only 41 percent showed estrus at the expected time following treatment.

The progesterone data provides a very logical explanation for the poor overall performance of the cows and heifers in this study. Originally it was planned to bleed the animals only on day 3 and day 11 following treatment. This was based on the expectation that palpation would reveal those animals that had a corpus luteum and were producing progesterone. The day 3 blood sample should contain very little progesterone, evidence that the prostaglandin had caused the corpus luteum to regress. The day 11 sample should be relatively high in progesterone, indicating the cow had been in estrus soon after prostaglandin injection, ovulated and formed a new corpus luteum that was now functional. Thus, based on pro-

Table 2. The Occurrence of Estrus and Conception Rates of Crossbred Beef Heifers Treated With Prostaglandin.

Item	Treatment Group A	B	C
TOTAL HEIFERS:			
Number	34	34	37
No. in estrus in 1st 20 days	16	16	37
No. in estrus within 8 days post-$PGF_{2\alpha}$	16	16	--
Avg. days to estrus post-$PGF_{2\alpha}$	2.31	2.81	--
Range in days to estrus post-$PGF_{2\alpha}$	1 - 4	1 - 5	--
No. conceived at 1st insemination post-trt.	11	6	28
Percent conceived at 1st insemination post-trt.			
of total heifers in study (%)	32.4	17.6	76.7
of heifers in estrus (%)	68.8	37.5	76.7
HEIFERS WITH TYPICAL BLOOD PROGESTERONE LEVELS:[1]			
Number	15	12	--[2]
No. in estrus within 8 days post-$PGF_{2\alpha}$	15	11	--
Avg. days to estrus post-$PGF_{2\alpha}$	2.27	2.45	--
Range in days to estrus post-$PGF_{2\alpha}$	1 - 4	1 - 5	--
Percent in estrus within 8 days post-$PG_{2\alpha}$ (%)	100.0	92.5	--
No. conceived at 1st insemination post-trt.	11	6	--
Percent conceived at 1st insemination post-trt. (%)	73.3	50.0	--

[1] Typical blood progesterone levels defined as less than 1 ng/ml plasma at 3 days post-$PGF_{2\alpha}$ and greater than 2 ng/ml plasma at 11 days post-$PGF_{2\alpha}$.

[2] Progesterone levels not determined for heifers of Treatment C.

Table 3. **The Occurrence of Estrus and Conception Rates of Lactating Hereford and Angus Cows Treated With Prostaglandin.**

Item	Treatment Group A	B	C
TOTAL COWS:			
Number	31	28	39
No. in estrus in 1st 20 days	14	10	29
No. in estrus within 8 days post-$PGF_{2\alpha}$	14	10	--
Avg. days to estrus post-$PGF_{2\alpha}$	3.35	2.70	--
Range in days to estrus post-$PGF_{2\alpha}$	1 - 7	1 - 8	--
No. conceived at 1st insemination post-trt.	7	4	20
Percent conceived at 1st insemination post-trt.			
of total cows in study (%)	22.6	14.3	51.3
of cows in estrus (%)	50.0	40.0	69.0
COWS WITH TYPICAL BLOOD PROGESTERONE LEVELS:[1]			
Number	8	11	--[2]
No. in estrus within 8 days post-$PGF_{2\alpha}$	7	8	--
Avg. days to estrus post-$PGF_{2\alpha}$	3.57	3.00	--
Range in days to estrus post-$PGF_{2\alpha}$	1 - 7	2 - 8	--
Percent in estrus within 8 days post-$PGF_{2\alpha}$ (%)	87.5	72.7	--
No. conceived at 1st insemination post-trt.	5	4	--
Percent conceived at 1st insemination post-trt. (%)	71.4	36.4	--

[1] Typical blood progesterone levels defined as greater than 2 ng/ml plasma at time of treatment, less than 1 ng/ml plasma on day 3 post-$PGF_{2\alpha}$ and greater than 2 ng/ml plasma on day 11 post-$PGF_{2\alpha}$.
[2] Progesterone levels not determined for cows of Treatment C.

gestational changes in normally cycling cows, plasma progesterone levels less than 1 ng/ml on day 3 and greater than 2 ng/ml on day 11 after prostaglandin treatment were considered to be "typical" changes.

The first heifer group was treated 2 weeks earlier than were the cows. Therefore, by the time the cows were treated, it was apparent that a large number of the heifers were not responding as expected. The most logical reason for this appeared to be that the heifers did not have a functional CL and were not cycling, even though there was some structure on the ovary that resembled a CL upon being palpated. It has been well established that for prostaglandins to result in estrus synchronization there must be a functional CL present. Therefore, one additional blood sample was collected from the cows at the time of palpation and treatment. If a functional CL was present, the blood levels of progesterone should be 2 ng/ml or higher. The "typical" progesterone level for cows was set at this value for the day of treatment and the same values as for the heifers on days 3 and 11.

When only the results obtained with cows and heifers showing progesterone levels typical of cycling animals with a functional CL are considered, the results are much more encouraging. There were 27 heifers determined to have typical progesterone levels at time of treatment; 26

(96.3 percent) exhibited an estrus within 8 days. In the case of the cows, 78.9 percent of the 19 cows with typical progesterone levels were in estrus at the expected time. The average time from treatment to occurrence of estrus was approximately 1 day longer in the cows than in heifers (2.35 days vs. 3.40 days).

The fertility data is also encouraging when the conception rates of animals of Treatment A that had typical progesterone levels are considered. This is the logical prostaglandin treated group to compare to the controls. In the heifer group the conception rates for the Treatment A heifers was 73.3 percent, very comparable to the 76.7 percent conception rate for the control heifers. In the case of the cows the conceptions were likewise almost identical, being 71.4 percent for Treatment A cows and 69.0 percent for control cows.

There were 41 heifers and 40 cows treated with $PGF_{2\alpha}$ that did not have typical progesterone levels, thus, were not considered to be cycling. Only six of these heifers showed signs of estrus following treatment and none conceived. In the case of the cows, only eight showed signs of estrus and two conceived.

Thus, data obtained in this study confirms that if the female has a functional corpus luteum at the time of treatment, prostaglandins will effectively synchronize estrus. It further suggests that normal fertility will be obtained from inseminations at the synchronized estrus.

The labor saving potential of Treatment B is readily apparent, since it would permit cows to be bred on a schedule and eliminate the necessity of checking for estrus. The results reported for the animals of Treatment B that had a typical level of blood progesterone revealed that 50.0 percent of the heifers and 36.4 percent of the cows conceived to the insemination made 80 hours after the prostaglandin injection. The cows would be expected to have a lower conception rate since an estrus following $PGF_{2\alpha}$ treatment was observed in only 72.7 percent of the cows compared to 87.5 percent of the heifers. The lower conception rates obtained in both age groups of females on Treatment B, when compared to Treatment A, can be very logically explained by the range in time of occurrence of estrus, 1-5 days for the heifers and 2-8 days for the cows. A range this wide would make it impossible for a single insemination to be given at a time that would guarantee that sperm of high fertilizing capacity would be present in all of the cows at the time ovulation occurred. It would appear that at least two inseminations would be required, most likely timed on either side of the 80 hours used in this study. Additional research is now being conducted to determine the optimum times for such "scheduled" inseminations.

This study points out very clearly one of the major problems invol-

ved in using prostaglandins to synchronize estrus in spring calving cows or yearling heifers being maintained under range conditions. When breeding is begun in late April or early May, a certain percentage of these females will not be cycling. If the producer cannot identify these non-cycling cows and heifers, but rather treats the entire herd he can expect a disappointing response to prostaglandin treatment.

In this study, 51 percent of the cows and 39 percent of the heifers were not cycling (Tables 2 and 3). Most of these were in Treatments A and B, but this should not be considered to be a result of the prostaglandin treatments. The design of the study created this situation by assigning to Treatment C all of the heifers that came in heat during the week prior to the start of prostaglandin treatment. Thus, all of the non-cycling females were in the group from which the animals for Treatments A and B were picked.

It was hoped that rectal palpations would screen out the animals that were not cycling by identifying those with a functional CL. It is now apparent that many of the non-cycling animals had some structure on the ovary that resembled a CL and misled the palpator. The nature of this structure was not determined, but it now appears that rectal palpations are not highly effective in screening cows for prostaglandin treatment if very many of the cows are not cycling.

How can a producer guarantee that all, or at least a high percentage of the females in his herd will be cycling at a given time? With lactating cows the two most important factors in most range herds are level of nutrition and length of the post-partum interval since calving. The closer cows are to 90 days post-partum, the more likely they are to be cycling. As the interval becomes progressively shorter than 90 days, level of nutrition becomes increasingly important. The importance of post-partum interval is shown by the data obtained in this study. The post-partum intervals for cycling Hereford and Angus cows were 75.8 and 75.5 days, respectively, and for non-cycling cows was 63.2 and 67.2 days, respectively.

In the case of yearling heifers, studies at Ft. Reno as well as at other stations, have revealed the importance of a good level of nutrition. Hereford and Angus heifers must be so fed that they will be weighing somewhere between 550 and 600 lb. at the time it is desired to start breeding. Large breeds such as the Brown Swiss or Simmental should have the same, if not higher, requirements. Early maturing, smaller breeds such as the Jersey are known to reach puberty at younger ages and lighter weights. The results obtained in this study supports the above observations. The average body weights, taken 2 weeks before the start of the study, were for cycling and non-cycling heifers, respectively: Hereford sired, 500 and 494 lb.; Angus sired, 492 and 453 lb.; Simmental sired, 571 and 530 lb.;

Brown Swiss sired, 530 and 481 lb.; and Jersey sired, 476 and 481 lb. The same relationship held for average age at the start of the study, but for both measurements the differences were not significant. The Jersey sired heifers had the highest percentage to have reached sexual maturity at the start of the study, 87.5 percent, compared to 69.2 percent of the Hereford sired, 48.0 percent of the Simmental sired, 45.8 percent of the Brown Swiss sired and 45.4 percent of the Angus sired heifers. Thus, as their body weights suggest, the level of nutrition that had been provided to all groups except the Jersey sired group were apparently too low to permit a high percentage of the heifers to reach sexual maturity.

Factors Affecting the Calving Interval in Large Dairy Herds

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Story in Brief

Poor reproduction performance continues to cause major losses for many dariymen. Long calving intervals, loss of profitable cow time in the herd, fewer herd replacement animals and increased cost of the breeding program are among the major factors that take a tremendous cut out of a dairyman's potential profit.

Several factors can add significantly to the length of the period from one calving to the subsequent calving. Some of this time interval is dictated as being necessary for cow recovery postpartum. However, once the cows' reproductive system has recovered from the previous calving, man has his "management opportunity"—to get the cow back in calf as efficiently as his skill allows. This study, based on breeding, calving and production records of cows in the Oklahoma State University dairy herd for the years 1968 through 1974, was conducted to summarize the reproductive performance and determine the relative influence of several factors on the potential length of the calving interval.

The intervals from calving to first service and from first service to conception and the number of services per conception were significant