Kansas Agricultural Experiment Station Research Reports

Volume 0
Issue 2 *Dairy Research (1984-2014)*

Article 34

1993

Components of a progressive reproductive management program (1993)

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COMPONENTS OF A PROGRESSIVE REPRODUCTIVE MANAGEMENT PROGRAM

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Summary

These are somewhat exciting times for dairy producers because of the new arsenal of hormones available for controlling estrous cycles and improving fertility. Using Bovilene® seems to assist cows in releasing a retained placenta. Most studies have demonstrated that using GnRH as a follow-up treatment (day 10 to 18 postpartum) for dairy cows with periparturient problems such as retained placenta improves their subsequent reproductive performance. Prophylactic treatment of early postpartum cows with GnRH (days 10 to 18) or prostaglandin $F_{2\alpha}$ (days 20 to 40) improved their reproductive performance in most studies as well. Injections of GnRH at the time of insemination during late estrus in repeat-service cows effectively improves pregnancy rates. As with all new technologies and hormonal therapies, it is critical that attention be paid to consistent heat detection and good A.I. technique. Use of hormones will not replace, only supplement, good management procedures and common sense.

(Key Words: GnRH, Prostaglandins, Fertility, A. I.)

Introduction

Postpartum Reproductive Events. Initiating early reestablishment of normal estrous cycles after calving is essential to allow adequate time for cows to be inseminated and maintain a 12- to 13-month calving interval. Normally, intervals from parturition to first ovulation average 3 to 4 wk in milking cows. Because most first ovulations are not preceded by estrus, interval to first heat averages about 5 to 6 wk. Involution of the previously gravid uterus is another critical event that must occur during the early postpartum period. The rate of involution is somewhat remarkable because by 20 days after calving, tissue sloughing and hemorrhaging have ceased, and the size of the uterus has been reduced by more than 80%. By 40 days, the uterus has completely involuted except for isolated pockets of leukocytes. All of these events (involution, first estrus, and first ovulation) are delayed in cows with periparturient problems such as dystocia; twinning; uterine infections; ovarian cysts; injury; or metabolic diseases such as ketosis, displaced abomasum, and milk fever. Furthermore, all measures of reproductive efficiency are reduced in cows with periparturient problems compared to normal cows. Infertility or reproductive failure is often difficult to resolve because of its multiple causes. However, many new tools are available to dairy producers to enable them to prevent, properly treat, and improve the overall reproductive health of the dairy herd.

Calving Intervals. Numerous studies have concluded that 12- to 13-month calving intervals are optimal for achieving maximal annual milk yield and economic value for dairy producers. Conceptions occurring before 60 days in milk resulted in shorter calving intervals and reduced cumulative milk yields of current and following annualized lactations. Calving intervals longer than optimum resulted in cows spending a greater proportion of their productive herd life in later and less profitable stages of the lactation curve. Moreover, economic losses associated with more or less than optimal calving intervals often go undetected, because they represent lost potential income in lieu of actual "out-of-the-pocket" expenses.

Replacement Heifers. Proper scheduling and introduction of replacement heifers into the milking string are of equal importance. Heifers should enter the milking herd no later than 2 years of age to maximize their lifetime performance and reduce maintenance costs. Inseminating growthy and well-developed heifers at younger ages offers the advantage of earlier recovery of their rearing costs. As long as special attention is paid to the nutrition and growth of heifers, and proven sires with known calving ease (less than 9% DBH [difficult first births]) are used as breeding sires, research has shown that heifers can calve earlier than 2 years of age. It is not difficult to find excellent sires with acceptable levels of calving ease because 36 of the top 100 Holstein sires in the USDA Sire Summary (January, 1993) had DBH scores of 8 or less (9.1% is breed average for Holstein sires).

Controlled Breeding programs. In managing the breeding of both heifers and cows, use of prostaglandin-$F_{2\alpha}$ (PG) or one of its analogs offers many options to the dairy producer. Beyond the broad concept of estrous synchronization, these products allow manipulation of the estrous cycle according to the goals and convenience of the herd manager, including managing insemination schedules of lactating cows to optimize calving intervals and age at first breeding in heifers.

The purpose of this report is to present some realistic applications of current techniques available to allow dairy producers to manage a progressive reproductive program.

Periparturient Health

Treatment for Retained Placenta. Retention of the fetal membranes or retained placenta (RP) probably is one of the most common postpartum reproductive abnormalities in dairy cattle. The incidence of RP averages about 10% in Holsteins and is affected by dystocia, milk fever, abortion, twinning, nutritional deficiencies, sex of calf, and induced calving. If the placenta has not been released by 24 hr after calving, it is unlikely to do so for 4 to 8 days. Although RP might cause reproductive problems itself, it is a predisposing factor for clinical metritis, which is strongly associated with decreased reproductive performance. A successful treatment for dairy cows with RP is one of the PG's. When injections of Bovilene® (2 cc; 1 mg s.c.) were given to cows with RP 6 hr after calving, 67% had expelled their placenta by 4 days after calving compared to only 45% of the control cows given saline. Neither Lutalyse® nor Estrumate® has produced positive results comparable to Bovilene® in this application.

Variously administered treatments of GnRH have met with success when given to dairy cows, which earlier had an RP, in attempt to preclude the negative effects of resulting uterine infections on the reproductive performance of those cows. In two studies, administration of GnRH during the second week postpartum (days 10 to 18) resulted in earlier first ovulation, more estrous cycles before day 60 postpartum, reduced interval from calving to first service and conception, and tendency for fewer services per conception. In one study, 378 cows with RP were treated with GnRH or saline on day 15 postpartum. However, the GnRH treatment was successful in improving overall reproductive performance of only 39 cows when first breeding began before an average of 80 days postpartum in several herds.

Husbandry of Cows with Retained Placenta. Good husbandry of cows with RP is very critical. A recent study utilized Holstein heifers that were induced to calve with a prostaglandin injection (500 **μg** Estrumate®) on day 274 of pregnancy. Sixteen heifers retained their placentas and were assigned randomly to either allow their placentas to be expelled without intervention (RP left) or to attempt manual removal of the placenta for 15 min on day 3 after calving (RP removed). These two treatment groups were compared to 17 heifers without RP's (seven of whom were induced to calve but did not retain their placentas). Manual removal of the RP prolonged the interval from calving to first appearance of a functional corpus luteum (CL) by 20 days, increased interval to first service, increased the severity of uterine infection, and prolonged the presence of pathogenic bacteria in the uterus compared to allowing the placenta to expel spontaneously. In those heifers in which the placentas were untreated the characteristics described were not different than in the control group.

Treatments with GnRH and/or Prostaglandin. Since the mid 1970's, a number of studies have validated the benefit of utilizing GnRH as a prophylactic treatment for postpartum dairy cows. Injections of GnRH were first demonstrated to induce ovulation and normal cycling activity in dairy cows as early as day 14 postpartum. Use of GnRH is effective in inducing ovulation in 80 to 90% of the dairy cows treated around days 10 to 14 postpartum. Those CL formed in response to GnRH are responsive to an injection of prostaglandin in approximately 5 to 6 days. Various studies have examined the reproductive performance of cows treated with both hormones in the early postpartum period. The rationale for giving GnRH 10 to 18 days postpartum, followed by a prostaglandin in about 10 days, is based on the observation that fertility of dairy cows during the normal breeding period is directly proportional to the number of estrous cycles occurring before breeding and the idea that GnRH should enhance the chances of earlier cycling activity followed by a prostaglandin to reduce the length of the first induced estrous cycle. One theory for the beneficial effects of these hormones and the increase in the number of estrous cycles in treated cows is the conditioning effect that several heats have on the uterus. Normal uterine contractions during estrus probably aid in preparing the uterus for subsequent pregnancy. Injections of GnRH also hasten the process of uterine involution.

Several studies have shown that cows with periparturient disorders (reproductive or metabolic) are likely to benefit from GnRH given 10 to 18 days postpartum. In an earlier study, cows were classified before day 18 postpartum as abnormal based on enlargement of one or both uterine horns; poor uterine tone; an enlarged; inflamed or dilated cervix; little ovarian activity; or a significant purulent, mucopurulent, or bloody vulvar discharge. When treated with 100 **μg** GnRH at 12 to 18 days postpartum, abnormal cows responded with earlier first estrus, and fewer days open and services per conception, whereas similarly treated, normal cows had no improvement after GnRH treatment.

In another study (Table 1), marked improvement in the reproductive performance of cows occurred as evidenced by reduced days open and fewer services per conception in normal and abnormal cows when treated with either GnRH or PG, but not both, except for fewer services per conception in normal cows treated with GnRH and PG.

Various treatments of dairy cows with PG have demonstrated profertility effects when cycling cows (i.e., most cows assumed to be cycling with a functional CL at the time of treatment with PG) were treated during the early postpartum period before the onset of the breeding period (i.e., before 40 to 60 days postpartum). When PG was given on day 26 and/or day 40 after calving, interval to first estrus was delayed, but treatments reduced intervals to conception compared with placebo-treated controls.

Table 1. Fertility Traits Associated with Postpartum Treatments with GnRH and/or Prostaglandin $F_2\alpha$ (PG)

Trait	Saline-Saline	GnRH-Saline	Saline-PG	GnRH-PG
No. cows	59	59	59	57
Days open	115	88[a]	86[a]	96
Normal	97	92	83	82
Abnormal	133	85[a]	90[a]	109
Services/conception	2.3	1.7[a]	1.8[a]	2.1
Normal	2.2	1.7[a]	1.6[a]	1.7[a]
Abnormal	2.4	1.7[a]	1.9[a]	2.4

Source: Adapted from Benmrad and Stevenson (1986) J. Dairy Sci. 69:800.
[a]Different ($P < .05$) from saline-saline group within health status.

Prebreeding Anestrus

Attempts to induce cycling activity in dairy cows with prolonged anestrus (smooth ovary cows with no ovulation [anovulation] and no observed estrus [anestrus]) have been few. The incidence of anovulation, which includes those cases in which dairy cows have prolonged or delayed intervals to first postpartum ovulation, ranges from 2 to 22% (average = 5%). Recent observations in one California dairy herd with a rolling herd average exceeding 20,000 lb, based on evaluation of milk progesterone, indicated that about 15 to 20% of cows in their first lactation and 5 to 10% of older cows were not cycling before 60 days postpartum. Problems associated with negative energy balance and periparturient problems are probably contributing to this greater incidence of anovulation. High milk-producing cows that lose more weight and fail to maintain adequate dry matter intakes are slower to cycle than cows of similar milk-producing ability that consume more dry matter.

A paucity of information exists assessing treatments for resolving the problem of anovulation in dairy cows. One French study found that regular monitoring of anovulatory cows with milk progesterone tests to determine when cows began to cycle after an injection of GnRH was successful in reducing the interval to first breeding compared to no treatment or treatments with GnRH but without progesterone monitoring. Some field observations by veterinary practitioners and dairy producers have suggested that treating such anovulatory cows with progestin for several days appeared to induce ovarian cycles. In some preliminary work, we found that implanting two anovulatory dairy cows (> 100 days postpartum) with Syncro-Mate-B" implants (one implant per ear containing 6 mg norgestomet per implant) induced ovulation in both cows, one of which was preceded by estrus. In a more recent study utilizing GnRH in dairy cows in an aggressive herd monitoring and ovarian palpation protocol, reproductive performance was improved compared to controls without GnRH treatments. Cows not responding to an initial treatment with GnRH were followed up with a second treatment 14 days later. If cows cycled spontaneously early postpartum or responded to the first or second injection of GnRH, they had higher pregnancy rates at 180 days in milk; overall reduced calving intervals; and, in some cases, required fewer services per conception.

Available Products for Controlling Estrus

Currently, three prostaglandin products are labelled for use in cattle. However, only Lutalyse® and Estrumate® are labelled for use in lactating dairy cows. Lutalyse® or PG, the first prostaglandin product cleared by the FDA in the U. S., is identical to the substance naturally produced by the uterine endometrium. It is capable of inducing luteolysis or the demise of the corpus luteum (CL). The two remaining PG's are chemical analogs of Lutalyse® produced by various substitutions on the terminal carbons of the fatty acid-like structure, which increase their plasma half-life but not their efficacy. Although inferences have been made about the relative efficacy of these products based on their longer plasma half-lives, all three PG's are equally effective in their ability to lyse and destroy the CL in the nonpregnant cow or heifer. Furthermore, the label claims of all three PG's provide evidence for their efficacy as abortifacients in heifers through 150 days of pregnancy. At the present time, only one progestin product (Syncro-Mate-B®) is approved by the FDA for the use in only dairy heifers.

Heat Detection

Voluntary signs of heat such as mounting and standing in dairy cattle are influenced by many factors. Those factors that are most important on dairy farms are: 1) number of sexually active animals in a group, 2) freedom for sexually active animals to interact, 3) freedom from interfering activities, 4) ambient temperature, and 5) footing conditions. Behavioral signs of heat require that at least two animals interact. Secondary signs such as butting, licking, and head-resting are influenced less by environmental conditions than are the primary signs of heat, such as mounting and standing. Most experienced observers utilize these secondary signs to pick out cows that are most likely to be in heat even when the immediate environmental conditions limit mounting and standing activity.

A cow will not be detected to stand if no other animal is available to mount. Mounting activity is stimulated strongly by estrogen and inhibited by progesterone. Thus, mounting frequency is considerably greater for cows in proestrus or estrus than for cows that are out of heat or in midcycle with a functional CL. Once there are four or more sexually active animals (proestrus or estrus) in a group, mounting activity will normally be sufficient for maximal efficiency of heat detection.

Table 2 indicates relative mounting activity that one might expect to observe in various locations and conditions on dairy farms. These empirical values are based on data from several published and unpublished studies and on casual observations made on many farms. A value of 1.0 is assigned to mounting activity expected to occur on a relatively dry, grooved, concrete alley. A high index means more mounting activity.

Activities or conditions that restrict interactions among cows influence whether cows show heat. Cows that are eating or are crowded in holding pens or alleys do less mounting. Cows that are on slippery alleys, frozen ground, or any surface that makes footing tenuous show less mounting activity. Cows in heat are more likely to mount one another if the other cows are loose rather than tied. Perhaps this indicates that freedom to interact before mounting is important for maximum expression of mounting activity. Cows that have foot problems, regardless of whether the problem is structural, subclinical, or clinical, apparently show less mounting activity. Many of the foot problems that affect mounting activity can be alleviated by proper foot care (foot baths, dry cows on dirt, etc.) and regular hoof trimming.

Table 2. Relative Indexes of Mounting Activity

Location of cows during heat detection	Mounting Index
Milking parlor	0.1
Feedbunk while eating	0.2
Holding pen	0.3
Dry concrete alley	1.0
Dry concrete alley + movement	1.1
Dry dirt lot	1.6
Dry dirt lot + movement	1.8

Source: J.H. Britt, personal communication

No firm experimental evidence shows that high levels of milk yield influence mounting or standing activity. Evidence does show that energy balance during the early postpartum period can influence whether a cow is detected in heat at the beginning of the first postpartum cycle. Apparently, cows experiencing a severe negative energy balance can produce enough estrogen to elicit an LH surge without causing them to show heat. Once cycles have begun, energy balance does not seem to affect intensity or duration of heat, but might affect fertility.

Extremes in temperature affect intensity of heat. Mounting activity is lower on very "hot" or "cold" days than on days when the temperature is near the thermoneutral zone of the cow (30 to 50°F). Heats may appear to be shorter when the temperatures are extreme, but it is unclear whether this is because of less mounting activity or because of less willingness to stand.

Insemination Protocols after Prostaglandin

Various calculations and research trials have shown that most cycling cattle injected once with PG and then reinjected 10 to 14 days later, regardless of their response to the first injection, should be at a stage of the cycle (days 5 to 17) at which luteolysis would occur after the second of two injections. This theoretical projection generally has proved correct (although not as well in lactating dairy cows unless injections are given 14 days apart) and served as a basis of one of four protocols promoted by the suppliers of the various PG's in their marketing information containing the labelled usages.

Four scheduled breeding programs are illustrated in Table 3. Program A consists of injecting all cattle twice with PG 10 to 14 days apart. Inseminations follow only the second of two injections. According to the labelled directions of each supplier, inseminations can be made according to observed heats or by appointment at 72, 80, or 72 + 96 hr after the second injection. Program B is a variation of Program A, in which all animals detected in heat after the first injection are inseminated based **only** on heat detection and **only** the remaining noninseminated cattle are reinjected 10 to 14 days later and then inseminated according to the choices given above for Program A. Program C consists of breeding for 6 days to: 1) detect estrus in those cattle that are on days 17 through 21 of their cycles that would come into heat spontaneously but would not respond to the injected PG, and 2) allow those cattle recently in heat to develop a CL (to at least day 6 of the cycle) that can respond to an injection of PG before **only** undetected and noninseminated cattle receive a first and only injection of PG on the seventh day. Inseminations in this program should follow heat detection or timed inseminations at 72, 80, or 72 + 96 hr after PG. Program D is designed to be used after cattle are palpated for the presence of a functional CL. Success of this program requires great expertise by the veterinary practitioner because of the difficulty of assessing functionality of the CL based on palpation per rectum or on the use of a commercial milk progesterone test to validate high concentrations of progesterone in milk. Those cattle with a functional CL are injected and then inseminated like any of those after a second injection of PG in the previous protocols.

Factors Altering Success of Various Prostaglandins Protocols

Stage of the Estrous Cycle. Some earlier reports had suggested a potential seasonal influence on the timing of estrus after PG. However, it is clear in reports of the last 15 years that the interval to heat after PG in both cows and heifers varies according to the stage of the cycle in which the injection occurs. Injections given on days 5 through 8 resulted in the shortest intervals to estrus (average = 49 hr), compared to days 8 to 11 (average = 70 hr) or days 12 to 15 (average = 62 hr). When heifers were inseminated according to signs of estrus, pregnancy rates were similar regardless of the stage of cycle. However, when heifers were inseminated at 80 hr after the second of two PG injections, pregnancy rates were lower than when they were bred according to detected estrus. This reduction in pregnancy rate undoubtedly occurs because approximately 60% of the heifers inseminated at 80 hr are bred too late relative to the onset of estrus after the second injection of PG. When using one or two injections of PG (i.e., Programs A or B in Table 3), it is recommended to inseminate heifers according to signs of heat after the second injection (Program A) or after both injections (Table 4). Furthermore, we have found that heifers not observed in estrus by 80 hr after the second injection will conceive to a fixed-time insemination at 72 to 80 hr after the second injection about as well as heifers inseminated according to detected heat. This timed service is successful because about 10 to 20 % of the heifers that are in heat after the second injection are not detected in estrus.

Fixed-Time Inseminations in Lactating Dairy Cows

Similar variations in the intervals to estrus have been observed in dairy cows given PG at various stages of the estrous cycle. We have observed that various fixed-time inseminations after the second of two injections of PG (11 days apart) in dairy cows resulted in less than acceptable pregnancy rates. When cows were inseminated either at 80 hr, with or without an injection of GnRH at 72 hr, or at 72 + 96 hr (double insemination) after the second of two injections, pregnancy rates ranged from 23 to 31%, compared to 51% in control cows inseminated according to signs of heat but without prior injections of PG.

Several factors account for the poor results achieved after fixed-timed inseminations of lactating dairy cows. Injections of PG were only 85% effective in regressing the functional CL (defined as high [> 1 ng/mL] serum concentrations of progesterone at the time of the injection and low [<1 ng/mL] concentrations 24 to 48 hr later) regardless of whether it was after the first (40 to 46 days postpartum) or at second (51 to 57 days postpartum) injection of PG. This efficacy of induced luteolysis was similar to that in other studies with cows (91 to 92%) but less than that observed with heifers (95 to 100%). Another limitation to success was that 15% of all cows had low concentrations of progesterone (no CL) at the time of the second injection. One third of these cows was anestrus and the remaining two-thirds were cycling but had low progesterone at the time of the second injection and had high progesterone at the time of the first injection. This latter category suggested that cows were anovulatory, had ovulatory disturbances, or were at an unresponsive stage of the estrous cycle (days 17 to 21 or days 0 to 4) prior to the second injection because they failed to respond to the first injection 11 days earlier. More recent work in Israel with lactating dairy cows has shown some promising results with fixed-time inseminations. When two injections of PG were given to primiparous cows at 11 versus 14 days apart, 84% of those receiving injections 14 days apart conceived within 30 days of their first service compared to 62% of those given injections 11 days apart.

Table 3. Scheduled Breeding Programs Utilizing Prostaglandins (PG)

Program A	Program B	Program C	Program D
Inject **all** females with PG - **first** injection	Inject **all** females with PG - **first** injection ↓		Palpation or positive milk P_4 test: ↓
↓	Detect heat and A.I. for 14 d ↓	Detect heat and breed for 6 d ↓	Must have a functional CL ↓
Inject **all** females with PG 14 d later-**second** injection ↓	Inject **only** females **not yet bred** with PG 14 d after the first injection ↓	Inject **only** females **not yet bred** with PG on d 7 ↓	Inject **all** eligible females with PG ↓
Inseminate	Inseminate	Inseminate	Inseminate

Table 4. Fertility of Dairy Heifers in 45 Michigan Herds with Different A.I. Schedules after Prostaglandins (PG)

		Pregnancy rate, %			
Schedule for insemination	N	Mean	Minimum	Maximum	Range
Insemination at estrus					
After first PG	766	65.4^{a}	47.6^{a}	95.9^{a}	48.3^{a}
After second PG	1025	60.9^{b}	33.3^{b}	92.3^{a}	$59.0^{a,b}$
Insemination at 80 hr after second PG					
No observations made for estrus	561	40.6^{c}	6.7^{c}	$85.7^{a,b}$	79.9^{b}
Observations made for estrus	384	36.9^{c}	0^{c}	73.3^{c}	73.3^{b}

Source: Adapted from Fogwell et al. (1986) J. Dairy Sci. 69:1665.
^{a,b,c}Values lacking a common superscript letter differ ($P < .05$).

Use of Prostaglandins in Reproductive Management Schemes

Weekly Insemination Groups. Although estrous synchronization of many cows or heifers is not feasible in most dairy situations (except in large herds or where seasonal calving is practiced), use of PG for handling small groups of cows and heifers that enter the breeding group based on calving or birth date, respectively, is desirable. This type of system works well when coupled with a weekly or biweekly herd-health visit by the veterinary practitioner. A summary in Table 5 highlights one method in which eligible cows or heifers entered their respective breeding groups when found to have a functional CL. Milking cows given PG were inseminated 11 days earlier and conceived 19 days sooner than controls after assignment to the study. Furthermore, heifers treated in a similar fashion with PG were inseminated 13 days sooner and conceived 18 days earlier than their untreated herd mates. This type of reproductive management, coupled with inseminations based on good heat detection, is an example of utilizing Program D.

Table 5. Use of Prostaglandins (PG) in Reproductive Management of Cows and Heifers

Item	Control cows	PG cows	Control heifers	PG heifers
No. animals	228	219	51	48
Assigned to study[a]	58	58	14.1	14.1
Days to first service	81 ± 1	70 ± 1[b]	21 ± 2	8 ± 1[b]
Days to conception	111 ± 3	93 ± 3[b]	38 ± 4	20 ± 3[b]

Source: Adapted from Seguin et al. (1983) J. Amer. Vet. Med Assoc. 183:533.
[a]Days postpartum for cows or months of age for heifers when entering the breeding group.
[b]Different ($P < .01$) from controls within cow or heifer columns.

Monday Injections of Prostaglandin. Based on the distribution of estrus after PG in the previous study (Table 5), about 88% of all first inseminations in cows could be given on 4 days of the week. This translated subsequently into 82% of all repeat inseminations of cows that returned to estrus occurring on 4 days of the 40-h work week. From these responses, it was suggested that Monday use of PG could allow most of the inseminations to occur on Wednesday through Saturday. Similar programs have been proposed in which eligible cows (at least 40 to 50 days postpartum), formed into small breeding groups or clusters, are given PG (generally without knowledge of stage of the estrous cycle) on Monday mornings and observed for heat during that week. Cows not showing estrus are re-injected on the following Monday. This procedure is repeated on a third Monday if needed. Any cow not detected in heat after a third Monday injection of PG should then be presented for a reproductive examination by the herd veterinary practitioner. A recent study compared the weekly administration of PG to open cows to a system in which all open cows with a CL identified weekly by ovarian palpation were administered PG. Cows receiving weekly doses of PG had a 30% higher pregnancy rate per unit of time. We recently completed a similar study in which cows were given PG based on a high milk progesterone test and compared that system to using no PG's but only inseminating based on natural heats. The results are shown in Table 6. Use of PG improved nearly all measures of reproductive performance.

Table 6. Reproductive Performance of Dairy Cows Given Weekly Injections of Prostaglandin $F_{2\alpha}$ (PG) versus Using No PG (Control) in a Scheduled Breeding Program

	Treatment			
Trait	Control	Milk P4 + PG	SE	P value
No. cows	72	127		
Days to first service	83.6	71.4	3.1	.006
First-service pregnancy rate, %	34.7	41.7	-	.257
Percentage bred once in first 21 d	38.9[2]	52.8	-	.053
Calving interval	406.4	383.1	8.9	.068
Pregnant by 120 d, %	62.3	72.0	-	.174
Overall pregnancy rate, %	73.6	73.2	-	.993

[1]Control cows were inseminated when estrus was detected by visual observation without the use of PG. Cows in the milk progesterone (P_4) + PG group were inseminated when estrus was detected by visual observation after an injection of PG following a high milk P_4 test. Cows in the latter group were tested for high or low milk P_4 status and given injections of PG accordingly, for up to 3 wk.

[2]Days from beginning of breeding period (42 days postpartum) for controls and days from first estimate of milk P_4 in the milk P_4 + PG group.

We attempted to examine the cost effectiveness of our two treatments (milk progesterone + PG vs control) relative to the cost of each pregnancy achieved. Cost comparisons for our two treatments are summarized in Table 7, in addition to those of two other PG systems described above. Costs were estimated to approach realistic values for milk P_4 tests, PG, and individual palpations of cows. An additional cost was added to our control group because of its longer calving interval. Studies assessing the cost of days open beyond 365 days (12-mo calving interval) range from $.25 to $4.68 per day open beyond 85 days. We conservatively used the estimate of $1 per day open for controls beyond that which was achieved in the milk P_4 + PG group, for a total of $23.30 per pregnancy in the controls. The cost per pregnancy in controls was $30.32 compared to a lower cost of $20.59 for the treated cows. To make the cost per pregnancy equal in our two treatment groups, the cost of 1 day open beyond 85 days would have to equal only $.35. In comparison to similar estimates of cost in the previous study, weekly injections of PG cost $17.69 per pregnancy and palpation + PG cost $14.14.

Table 7. Cost Comparison for Breeding Programs Involving Only Visual Detection of Estrus (Control), Milk Progesterone (P_4) + Prostaglandin $F_{2\alpha}$ (PG), Weekly Blind Injections of PG, and Palpation + PG

	Treatment[1]			
Item	Control	Milk P4 + PG	weekly PG	Palpation + PG
No. cows assigned	72	127	184	188
No. pregnancies	53	93	156	154
Cost of milk P_4 ($3 each)	0	864	0	0
Cost of PG ($3 each)	0	399	1665	507
No. of injections/pregnancy	0	1.4	3.6	1.1
Cost of palpations ($2 each)	372	652	1094	1670
Cost of longer days open ($1/day)[2]	1235	0	0	0
Total costs, $	1607	1915	2759	2177
Cost/pregnancy, $	30.32	20.59	17.69	14.14

[1]Control cows were inseminated when estrus was detected by visual observation without the use of PG. Cows in the milk progesterone (P_4) + PG group were inseminated when estrus was detected by visual observation after an injection of PG following a high milk P_4 test. Cows in the latter group were tested for high or low milk P_4 status and given injections of PG accordingly for up to 3 wk. Information for the last two treatments was adapted from a recent report in which weekly injections of PG were given blindly without knowledge of corpus luteum (CL) or P_4 status (weekly PG) or injections of PG were given to cows with a palpable CL (palpation + PG). In both of the latter cases, treatments continued until inseminations occurred or the cow was culled from the herd.

[2]Included was an assessment of $23.30 per control cow ($1 per day open) that did not conceive until 23.3 days later than the milk P_4 + PG group. Median days open were 97 and 110 days for the latter two groups in another, which were similar to that in our milk P_4 + PG group (average = 101 days).

Unobserved Estrus

Despite problems discussed above, there is a place for fixed-time inseminations in dairy cows. Cows that fail to exhibit estrus (or whose heats are missed) at various stages after calving will have delayed intervals to first service and generally longer than average calving intervals. In addition, cows that have unobserved heats after insemination and are found open at pregnancy examination (40 to 50 days after the most recent service) generally have longer than acceptable calving intervals. Both types of cows mentioned are candidates for PG. These cows with observed estrus, which might be difficult to detect in estrus because of subtle or weak signs of heat, are best handled according to Program D in Table 3. Earlier work suggested that about 90% of these cows are cycling but not detected in heat. In our study, every cow with a palpable CL (based on assignment of cows by the various veterinary practitioners in 16 commercial dairy farms) was assigned on an alternate basis to serve as a control (no treatment) or to receive PG. All control cows were inseminated according to heat observations made by the dairy producers and all

PG-treated cows were likewise observed for heat and bred accordingly. However, those cows not detected in heat by 72 hr after the injection of PG were double inseminated at 72 and 96 hr after PG. Cows treated with PG conceived 20 days sooner than controls, even though pregnancy rates were similar to those of controls and only 53% of the treated cows were detected in heat (Table 8). Therefore, 47% of the cows inseminated after PG were not observed in heat and their pregnancy rate was 44% following a double insemination at 72 and 96 hr. Without timed inseminations, 49 pregnancies would not have occurred after treatment with PG. Another study reported nearly equal success with only one fixed-time insemination at 80 hr.

Table 8. Response of Dairy Cows with Unobserved Estrus to Prostaglandins (PG)

Item	Control	PG
No. cows	100	176
Pregnancy rates, %	43	43
Inseminated at estrus, %	43	42
Inseminated at 72 + 96 hr		44
Observed in standing estrus, %	100	53
Interval from treatment to conception, d	55 ± 6	35 ± 4[a]

Source: Adapted from Plunkett et al. (1984) J. Dairy Sci. 67:380.
[a]Different ($P < .05$) from control cows.

The success of the results described in Table 8 depended upon a high degree of accuracy in diagnosing a functional CL (91 % accuracy). The hazards of ovarian palpation per rectum for identifying accurately a functional CL were reported recently in a summary of four studies. The accuracy of diagnosis was verified by concentrations of serum progesterone at the time of palpation. The accuracy of diagnosing a functional CL palpated per rectum was 82% (ranged from 79 to 85%), and the accuracy of diagnosing no functional CL was 70% (ranged from 61 to 75%). In other words, 18% of the cows diagnosed to have a CL did not have high concentrations of progesterone and 30% of the cows with high concentrations of progesterone in their serum were diagnosed as not having a functional CL.

Uses of GnRH to Improve Fertility at Insemination

Repeat Breeders. Administration of GnRH or one of its agonists to repeat breeders (cows that generally failed to conceive after at least two previous services) at the time of insemination has improved fertility in almost all studies. We recently published a six-herd study in which we tested a single versus a double insemination with or without the GnRH treatment, hypothesizing that the repeat breeder is ovulating later after estrus than more fertile cows. A single injection of GnRH given at the time of a single insemination (according to the AM-PM rule) consistently produced the highest pregnancy rates in all six herds (Table 9).

Conclusions

Heifers. Programs A and B (Table 3) seem to be best suited for breeding replacement heifers (Table 3). Program B will require less PG per pregnancy than Program A, but it necessitates two periods of heat detection for each breeding group or cluster formed. Many recommend injecting heifers to be inseminated and then

Table 9. Pregnancy Rates in Repeat Breeders after GnRH Administration and Single or Double Insemination

	Single Insemination		Double Insemination	
Trait	No Injection	GnRH	No injection	GnRH
No. of cows	391	381	383	390
Pregnancy rate, %	33[a]	41[b]	33[a]	37[a,b]

Source: Adapted from Stevenson et al. (1990) J. Dairy Sci. 73:1766.
[ab]percentages without common superscript letters differ (P < .05).

observe for estrus and breed for at least 5 days after the first injection, then reinject the remaining noninseminated heifers 14 days after the first injection of PG and inseminate according to heat detection for 5 more days. We have found that any heifer not observed in heat by 72 hr after the second of two injections should be timed inseminated at 72 hr, not 80 hr, which works well for cows. The reason for the earlier fixed-timed insemination at 72 hr is because heifers come into estrus about 10 to 12 hr earlier than cows. Inseminating heifers at 72 hr after the second injection in the absence of detected heat will produce pregnancy rates nearly equal to those of heifers bred according to heat observations. Program D is a viable alternative, if the veterinary practitioner visits the herd on a weekly or biweekly basis and can work closely with the dairy producer in managing the breeding groups in conjunction with routine ovarian palpation as demonstrated in Table 5. Use of Syncro-Mate-B® has merits for inseminating groups of heifers based on heat detection or fixed-time inseminations. Pregnancy rates seem to be similar when heifers are inseminated based on detection of estrus or a fixed-time insemination is used at 48 to 54 hr after removal of the SMB implant.

Cows. Two approaches for cows are appropriate. Injecting cows once with PG is effective for inducing estrus, if cows are between days 5 and 17 of their estrous cycle. About 60% of cows should respond to PG by coming into heat at any given time, if estrous cycles are nearly randomly distributed across the herd. REMEMBER that these results are based on identifying ALL cows in heat and doing so with nearly 100 % ACCURACY. Inseminations should be based solely on heat detection in the case where only one injection of PG is given without evaluating the CL status by palpation or performing a milk progesterone test. A second approach, which fits the weekly (Monday morning) breeding group or cluster concept, is ideal for handling cows blindly without knowledge of ovarian status or recent heat periods. For those cows that fail to be inseminated by 80 to 100 days postpartum (whatever tolerable limit is set by management), as well as those cows found open at pregnancy diagnosis, Program D is a recommended method of treatment (Table 3). Cows with a positive milk progesterone test or diagnosed to have a functional CL by palpation should be given PG and then watched for estrus. Those not caught in heat by 72 hr should be inseminated at 72 hr and reinseminated at 96 hr after PG. The objective is to get these problem cows inseminated and possibly pregnant before giving up and designating them as reproductive culls. One must remember that cows with unobserved heats might have subtle, weak, short periods of estrus and might benefit from a fixed-time insemination(s). If two injections of PG are used to synchronize estrus, an interval of 14 days is recommended. Regardless of the program (Table 3) selected, the best results occur following good heat detection. Timed inseminations have a role, but we must continue to concentrate on achieving better heat detection.