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Breeding Programs for Dairy Herds Using Prostaglandin $F_{2\alpha}$ Products to Save Labor: Field Trial Evaluation of Reproductive Performance

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Abstract

Three reproductive management systems designed to use prostaglandin $F_{2\alpha}$ (PGF) to save labor needed for estrous detection and artificial insemination (AI) were compared to conventional dairy herd reproductive management to evaluate their potential to maintain herd reproductive performance. The four experimental groups were: (1) CONTROL = daily estrous detection for AI with no PGF intervention, (2) Appointment (APPT) AI = double PGF injection at a 12-day interval followed by single appointment AI at 72 hrs for first AI, with repeat AI based on estrous detection, (3) 7-DAY = weekly (Monday) PGF injection for all cows ready for first or repeat AI with AI based on estrous detection which occurred only four days (Wednesday through Saturday) of each week, and (4) 21-DAY = repeating 21-day blocks of 13 days of AI based on estrous detection with PGF given on day 8 to cows yet to be inseminated and 8 days with no estrous detection or AI. All cows in all groups became eligible for breeding after a voluntary waiting period (VWP) of 54 days.

A total of 234 cows on three farms were randomly assigned at calving to one of the four groups, with 215 actually present at day 55 postpartum to start the breeding trial. All 215 were inseminated at least once according to their respective protocols, with distribution of the 186 that conceived and the 29 culled open not differing significantly between treatment groups. Days to first AI were lowest and the time distribution pattern more condensed for the APPT AI group (as prescribed by the experimental protocol) compared to the other three groups, and days to first AI were lower for the 7-DAY group than for the CONTROL and 21-DAY groups. AI submission rates after 7 days and 21 days were higher for the APPT AI group (both = 100%), and it was higher after 21 days for the 7-DAY group relative to the CONTROL and 21-DAY groups. Days open differed between groups, being lower for the APPT AI group than for the 7-DAY and 21-DAY groups, but not different between the APPT AI and CONTROL groups. The CONTROL group had lower days open than the 21-DAY group, but it was not different than the 7-DAY group, and days open did not differ between the 7-DAY and 21-DAY groups. Pregnancy rate after 7 days of breeding was higher for the APPT AI group than the other three groups, but pregnancy rates after 21 days of breeding did not differ between groups. Conception rate, defined as percent of all services in all cows (including those inseminated but culled open) that produced a pregnancy, did not differ between groups at first service or for all services. More PGF was used in the 7-DAY group than in the APPT AI or the 21-DAY groups. All PGF reproductive management systems tested here produced acceptable reproductive performance and therefore show potential for use on dairy farms. The most impressive reproductive performance occurred with the APPT AI protocol, while the 7-DAY and 21-DAY protocols substantially altered estrous detection and AI labor patterns.

Introduction

The ability of prostaglandin $F_{2\alpha}$ (PGF) products to control estrus in cattle is well established.[3,7,8] In addition to treatment of individual cows for a variety of conditions hindering reproductive performance,[12] PGF products can be used to eliminate estrous detection and breeding during selected time periods and yet improve herd reproductive performance.[14] Three estrous control methods designed with this goal in mind have been shown to be theoretically feasible.[13] This project was a field trial test of these three reproductive management schemes utilizing routine use of PGF products versus conventional (daily estrous detection and AI) dairy herd reproductive management.

Materials and Methods

Four reproductive management systems were compared in three university Holstein dairy herds, with three systems involving the scheduled use of PGF. Cows calving during one calendar year in two herds with continual calving, and during one calving season in one herd calving from September through March were eligible for the trial. Total mixed rations were fed in each herd and balanced separately for early lactation, late lactation and dry cow groups to meet NRC recommendations for maintenance, growth, reproduction and production. Cows were housed and fed in individual tie-stalls and released twice daily into outdoor lots for estrous detection. Cows were eligible for rebreeding after a VWP of 54 days, i.e. on day 55 postpartum. At parturition, cows which herd management planned to rebreed were randomly assigned to one of four treatment groups: 1) CONTROL cows were inseminated based on observed signs of estrus without any PGF intervention. 2) APPT AI cows were given two IM injections of the PGF product cloprostenol[a] (0.5 mg) 12 days apart with AI at 72 hours after the second injection. Injection sequences were potentially started each week so cows were first bred at days 55 to 61 postpartum, with first injections administered on Wednesdays, second injections on Mondays and appointment AI on Thursdays. Cows observed in estrus after the APPT AI were rebred accordingly. If cows known to be nonpregnant after first AI were not observed back in estrus, they could be retreated with the next scheduled group. 3) 7-DAY cows were managed on a 7-day cycle consisting of PGF[a] treatment on Monday followed by four days of estrous detection (Wednesday through Saturday), with cows inseminated when showing signs of estrus and three days (Sunday through Tuesday) without estrous detection. Cows were kept in this cycle until inseminated. After AI, cows that returned to estrus during a four day observation period were immediately rebred. Cows were added to the Monday treatment schedule at day 52 postpartum and when known to be nonpregnant after AI. 4) 21-DAY cows were managed in three week time blocks that were divided into (a) a 13-day period (first Monday through second Saturday) with estrous detection and AI and (b) an 8-day period (second Sunday through third Sunday) with no estrous detection or AI. Eight days into each 13-day AI period (second Monday of each 21-day block), all cows ready for breeding that had not yet been bred were given PGF[a] and estrous detection and AI continued for the remaining 5 days. Repeat AI occurred immediately when a repeat estrus occurred during a 13-day observation period, otherwise cows not pregnant after AI were included in the next 21-day block until rebred.

Cows in all groups were palpated per rectum on a reproductive herd health program that included (1) postpartum and prebreeding examinations and treatments as needed to prepare cows for rebreeding, (2) pregnancy status determination at 35 or more days after AI, and (3) examination of problem cows (anestrus, repeat breeders, irregular heats, etc). On each cooperating farm, cows in all groups were managed identically except for the details of each particular experimental treatment regime. Individual cows were not marked to identify group assignment. Estrous detection was done by regular on-farm personnel. AI eligibility of cows found in estrus was determined by the herd manager by referring to protocol calendars for each treatment group.

Days from calving to first AI and to conception, i.e. days open, were transformed by taking the natural logarithm before statistical analysis to make the data more normally distributed with homogenous variances. The logarithm transformed data were analyzed using a mixed model analysis of variance with the fixed effect of treatment and the random effects of herd and residual. Fisher's protected LSD (least significant difference) test was used for mean comparisons. Number of PGF doses was analyzed using the mean score response function of the Cochran-Mantel-Haenszel test controlling for herd. AI submission rates and pregnancy rates in 7 and 21 days and conception rates at first and all services were analyzed using the general association test of the Cochran-Mantel-Haenszel test controlling for herd. The frequency tables were broken down to compare treatments if the overall test was significant. All analyzes were performed using version 6.12 of SAS.

Results

In total, 234 cows were tentatively assigned at calving to the four experimental groups, with 215 actually made available by herd managers at 55 days postpartum to enter the breeding trial. Thus 19 cows

[a]Estrumate, marketed in USA by Bayer Corp, Shawnee Mission, KS 66201.

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were lost from the trial during their VWP for various reasons: management decisions not to rebreed (9 cows), postpartum uterine problems (3 cows), mastitis (2 cows), chronic cystic ovarian degeneration (2 cows) and use as embryo donors (3 cows). The remaining 215 cows were on trial for at least one AI, with their reproductive performance data presented by treatment group in Table 1. Some cows (29) were culled by herd managers when known to be open after an average of 2.8 inseminations (range = 1 to 7) and at an average of 165.0 days postpartum (range = 58 to 274) on the day of last AI. Days postpartum at last AI and number of culled cows per group did not differ (P=0.25) between the four groups (162.3 days for 11 of 53 CONTROL cows, 161.3 days for 7 of 54 APPT AI cows, 172.0 days for 6 of 53 7-DAY cows, and 168.0 days for 5 of 55 21-DAY cows). Data from these 29 cows were included in all calculations except days open.

Days from calving to first AI were lowest (P<0.05) for the APPT AI group (57.8 days) relative to all other groups. The 7-DAY group (68.2 days) was lower (P<0.05) than the CONTROL (76.2 days) and 21-DAY (76.4 days) groups. Variation for this statistic, as measured by the range in each group, was much less (as dictated by the experimental design) for the APPT AI group (55 to 61 days) than for any of the other three groups (55 to 161, 55 to 124, and 55 to 168 days for CONTROL, 7-DAY, and 21-DAY groups, respectively). Time distribution of first AI in each treatment group is presented graphically as cumulative first AI submission rates in Figure 1. Percent of cows inseminated within 7 days of the start of breeding was much higher (P<0.05) for the APPT AI group (54/54 = 100%) than for the other groups (10/53 = 18.9%, 16/53 = 30.2%, and 12/55 = 21.8% for the CONTROL, 7-DAY, and 21-DAY groups, respectively). After 21 days, AI submission rate was higher (P<0.05) for the APPT AI group (54/54 = 100%) than for the other groups, and it was greater (P<0.05) for the 7-DAY group (42/53 = 79.2%) than for the CONTROL (30/53 = 56.7%) and 21-DAY groups (31/55 = 56.4%). AI submission rate remained higher (P<0.05) for the APPT AI group after 42 days of breeding (54/54 =100% vs 46/53 = 86.8%, 50/53 = 94.3% and 44/55 = 80% for CONTROL, 7-DAY and 21-DAY groups,

Table 1. Reproductive performance of dairy cows managed as controls or via systems routinely using prostaglandin $F_{2\alpha}$

	Management system			
	CONTROL	**APPT AI**	**7-DAY**	**21-DAY**
No. of cows	53	54	53	55
No. culled open (%)	11(21%)	7(13%)	6(11%)	5(9%)
Days to 1st AI				
-geometric mean	76.2±1.0^{x}	57.8±1.0^{y}	68.2±1.0^{z}	76.4±1.0^{x}
-range	55-161	55-61	55-124	55-168
AI submission rate—(% of all cows that were first inseminated)				
--in 7 days	18.9%^{x}	100%^{y}	30.2%^{x}	21.8%^{x}
--in 21 days	56.7%^{x}	100%^{y}	79.2%^{z}	56.4%^{x}
Days open				
-geometric mean	86.4±1 .1^{xy}	79.5±1.1^{x}	95.5±1.1^{yz}	104.8±1.1^{z}
Pregnancy rate—(% pregnant of all cows available for breeding)				
--in 7 days	13.2%^{x}	35.2%^{y}	7.5%^{x}	10.9%^{x}
--in 21 days	37.7%	42.6%	37.7%	23.6%
Conception rate—(% of inseminations that produced a pregnancy in all inseminated cows)				
--for 1st service	52.8%	35.2%	47.2%	43.6%
--for all services	42.4%	39.8%	42.7%	42.8%
Mean PGF doses/cow	----	2.0^{x}	2.7^{y}	1.8^{x}

Values are the back transformed mean ± standard error. ^{xyz}Means with different superscript letters differ at P<0.05. Data in the same row with the same or no superscript do not differ (P>0.05).

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respectively), but there was no difference in AI submission rates after 63 days of breeding.

Days open were lower (P<0.05) for the APPT AI group (79.5 days) than for the 7-DAY (95.5 days) and 21-DAY (104.8 days) groups, but were not significantly different than the CONTROL group (86.4 days). Days open for the CONTROL group were lower (P<0.05) than the 21-DAY group but not different than the 7-DAY group. Days open did not differ between the 7-DAY and 21-DAY groups. These results are graphically presented as cumulative pregnancy rates in Figure 2. More (P<0.05) APPT AI group cows were pregnant after 7 days of breeding (19/54 = 35.2%) than were CONTROL (7/53 = 13.2%), 7-DAY (4/53 = 7.5%) or 21-DAY (6/55 = 10.9%) cows. However pregnancy rates at 21 days (and beyond) did not differ (P>0.1) among groups, although as can be seen in Figure 2, results tended to be lower for the 21-DAY group through 84 days of breeding.

Conception rates (Table 1) (percent of all first or of all total inseminations that produced a pregnancy in all cows that were inseminated) did not differ significantly between groups, although first AI results tended to be lower for the APPT AI group (19/54 = 35.2%) than for the other three groups (28/53 = 52.8% for the CONTROL, 25/53 = 47.2% for the 7-DAY, and 24/55 = 43.6% for the 21-DAY groups). Conception rates for all services did not differ between groups (42/99 = 42.4%, 47/118 = 39.8%, 47/110 = 42.7% and 51/119 = 42.9% for CONTROL, APPT AI, 7-DAY and 21-DAY groups, respectively).

Doses of PGF used per cow differed (P<0.05) between the three PGF groups, with fewer doses needed in the APPT AI (2.0 doses per cow) and the 21-DAY (1.8 doses per cow) groups than in the 7-DAY (2.7 doses per cow) group. Variation for this statistic did not exist for the APPT AI group as all the APPT AI cows had only one treatment (2 PGF doses) for first AI, with all repeat inseminations based on observed signs of estrus. In the 7-DAY group, one cow was not treated with PGF, 14 got one dose, 17 got two doses, 8 got three doses, 7 got four doses, one got 5 doses, three got 6 doses, one got 7 doses and one got 8 doses. In the 21-DAY group, 6 cows were not treated with PGF, 22 got one dose, 17 got two doses, four got three doses, four got four doses, one got 5 doses and one got 6 doses.

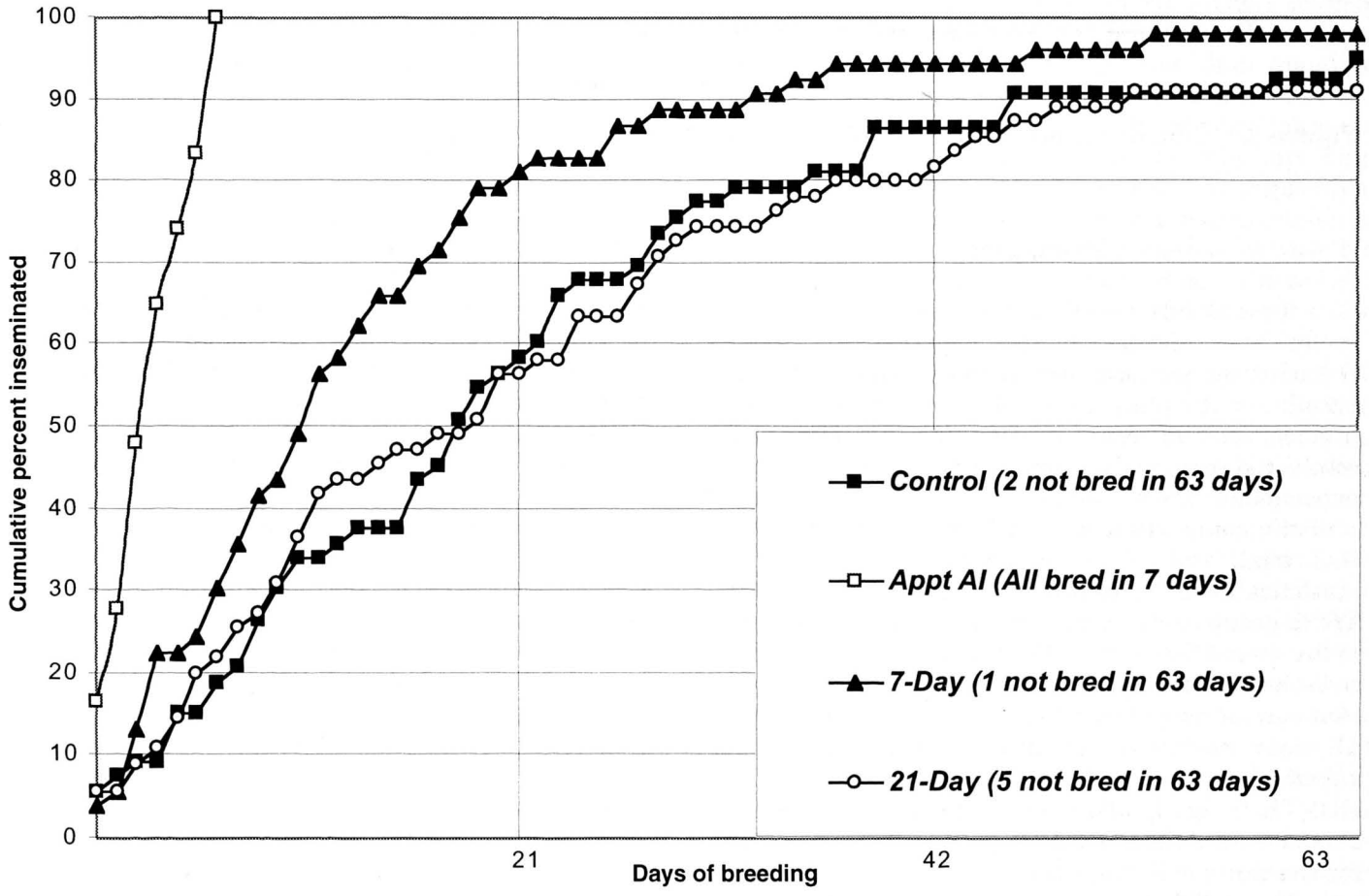

Figure 1. Cumulative insemination rate by days of breeding for each treatment group

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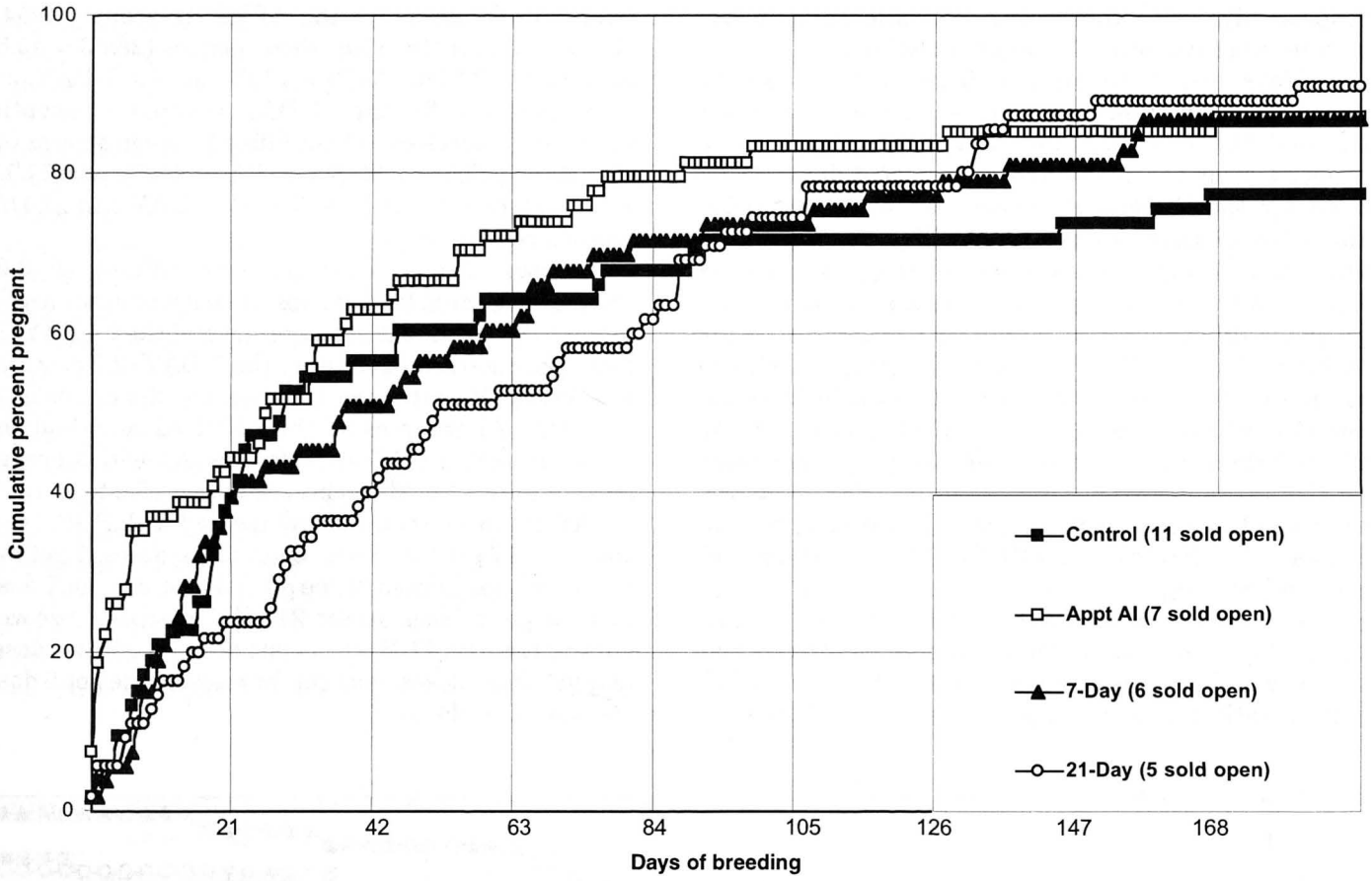

Figure 2. Cumulative pregnancy rate by days of breeding for each treatment group

Discussion

Reproductive performance of the CONTROL group was similar to or superior to average reproductive performance achieved on dairy farms enrolled in the Minnesota DHIA[9] and to reproductive performance of control cows in a similar trial conducted previously at one of the sites[13] used in this experiment. Thus current CONTROL results are a realistic comparison for the PGF systems tested in this trial. Culling of nonpregnant cows did not statistically differ between groups, although CONTROL group culling was numerically higher than that of the three PGF groups. Therefore if more CONTROL cows had been kept longer to more nearly equalize numbers of nonpregnant cull cows across all groups, all data points except days to first AI and AI submission rates would be expected to worsen for the CONTROL group. Thus our data may be favorably biased toward the CONTROL group relative to results for the three PGF treatment groups.

The APPT AI program had a marked effect on timing of first AI in relation to the end of the VWP as compared to the CONTROL, 7-DAY and 21-DAY groups. This was expected, and in fact can be guaranteed when such a program is followed. This early AI submission rate, plus an acceptable conception rate at first AI, produced days open for the APPT AI group that were numerically, but not statistically, lower than CONTROL and statistically lower than 7-DAY and 21-DAY groups. Published trials reporting conception and pregnancy rates with appointment AI after double PGF injection treatments in lactating dairy cows are relatively rare, even though this was one of the first methods recognized to use PGF for estrous synchronization in groups of cattle. In one such trial, results with AI once at 75 to 80 hours (183 cows) or twice at 72 and 96 hours (176 cows) after two PGF injections 11 days apart did not differ (46 vs 47%).[17] Also, first AI conception rate for controls (176 cows) bred based on conventional estrous detection for 21 days did not differ from the two PGF groups (50% vs 46% and 47%). However this trial showed a pregnancy rate advantage for both PGF groups over controls (46% and 47% vs 30%) due to the lower AI submission rate of controls as compared to PGF groups (61% vs 100% and 100%).

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Our results and those previously discussed[17] show that a reproductive management system based on appointment-first-AI for all cows followed by repeat services based on estrous detection is feasible as a routine dairy farm breeding management system. This combination has an advantage of assuring first AI at a narrowly defined interval after the VWP. The VWP can be easily adjusted for the entire herd, or for individual cows or management groups within the herd, to meet specific goals. For example, some may want to use a longer VWP for first calf heifers than for second and later lactation cows. Rebreeding based on estrous detection also allows repeat services at the cow's minimum physiologic interestrous interval, i.e. 18-24 days, whereas the calculated minimum interservice interval would be 50 days if the APPT AI protocol were used to eliminate estrous detection at all services.[13] Some estrous detection, as needed in this protocol for repeat services, may be acceptable when the window of estrous activity is likely to be quite predictable. This protocol may especially appeal to farmers housing their cows in stanchion and tie-stall barns who wish to limit, but not necessarily eliminate, release of cows for exercise and/or estrous detection.

Another possible consideration here, in view of the 18 day advantage in average days to first AI found in the present trial's APPT AI group over CONTROL, is to increase the VWP for APPT AI cows by this 18 day advantage. This change would accomplish two things likely to improve first AI conception rate:[16] 1) it would allow more time for uterine involution and 2) more cows would be cycling by the start of PGF treatments. Thus it may be possible to lengthen the VWP with an APPT AI protocol and yet maintain or improve, i.e. decrease, average days to first AI and days open.

The 7-DAY program, which eliminated estrous detection and AI for three days of each week, produced reproductive performance that was better than CONTROL for days to first AI and for AI submission rate within 21 days of the VWP. More PGF was used in this group relative to the other two PGF programs studied, which was expected because PGF treatments were given weekly without selection of cows for PGF-responsive corpora lutea (CL). The reproductive performance of this group compares favorably to our previous report on a similar weekly program, however, that program used ovarian palpation to select cows for PGF treatment, with estrous detection and AI on all days of each week.[14] A modification of the 7-DAY program has been successfully tested as a way for veterinarians to be more involved in dairy herds where reproductive performance is disappointing.[10] Here all cows between 55 and 62 days postpartum with a PGF-responsive CL, based on palpation, were given PGF on Monday morning. The veterinarian returned each Thursday and Friday to observe injected cows for estrus and to AI those seen in estrus. During the rest of the week herd personnel did all estrous detection and AI. Over a 20 month period, the veterinarian did 842 first service inseminations with a 59% conception rate while herd personnel did 841 services (including all repeats) with a 50% conception rate, which was increased from a pretrial overall conception rate of 42%. Most importantly this protocol dropped average days open from 120 to 98 days, and gave a 4 to 1 return on investment in services.

An advantage of the 7-DAY program is that work schedules are identical each week so it should be an easily adopted routine, which may make this program attractive to dairy farms with hired labor. For example, on farms where one person has special skills for estrous detection and AI, that person's workweek could be the four days of each week when those skills would be needed.

Another consideration is the frequency to repeat the system for cows not yet inseminated and for cows reaching the end of their VWP. In the present trial, this interval was 7 days, but a 14-day interval is also possible. The 7-day interval has an advantage over a 14-day interval because post-AI repeat estrous periods would more frequently occur during scheduled four-day windows of planned estrous detection than would be true for the 14-day interval. This also increases the chance, especially in smaller herds, of more than one cow being in estrus at the same time, thereby improving chances of successful estrous detection.[5] A complication is that interestrous intervals are not as predictable in dairy cows as desired for optimal performance with this program. In one study,[2] only 42% of 76 inseminated and only 55% of 238 non-inseminated Holstein cows had interestrous intervals of 20 to 22 days.

The 21-DAY program was based on a similar PGF program used to start the breeding season in beef herds.[4] This is the first report of this program being used on a continuing basis for dairy herd breeding management. In the present trial, this program produced results statistically similar, except for mean days open, to CONTROL. Principle advantages of this protocol are (1) a 38% reduction in days devoted to estrous detection (8 of every 21 days without detection) compared to CONTROL, (2) relatively long periods (8 days) when estrous detection and AI are not needed, (3) lower number of PGF doses needed per cow compared to the 7-DAY PGF-program tested here, (4) many repeat estrous periods occurring during planned windows of estrous detection, and (5) farms with effective estrous detection programs can continue to use that skill. This method also allows monitoring true anestrus status and/or estrous detection abilities prior to PGF administration, in that 4-5% of any group of cows are

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expected to show estrus each day if all are cycling. In this protocol, about 30% (4-5% X 7 days) of cows are expected to be inseminated by day 8. However, in the present trial, only 6 cows (11%) were inseminated by day 8. The difference between 11% and 30% indicates that the cows in this group had a significant anestrus problem and/or that observation of estrus failed in a significant portion of the cows.

Conclusion

The present trial shows that the three PGF breeding management programs field tested here, and previously successful in theoretical modeling evaluations,[13] are all potentially acceptable for dairy herd use. Reproductive performance results reported here show that each program can provide acceptable dairy herd reproductive performance, and can offer specific advantages regarding timing of first AI (APPT AI protocol) and labor requirements for the estrous detection and AI effort (7-DAY and 21-DAY protocols). While some PGF breeding programs use rectal palpation for PGF-responsive CL to select cows to be treated, the three programs tested here did not require this approach as PGF was given without pretreatment selection of cows for PGF responsiveness. These results demonstrate the possibility for alternatives to today's two most publicized methods for control of estrus in dairy herds (Ovsynch[11] and Target[15]).

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