

NEW TOOLS FOR REPRODUCTIVE MANAGEMENT OF DAIRY HEIFERS

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Artificial Insemination

Artificial Insemination (AI) breeding programs have long been recommended for dairy producers that raise heifers for herd replacements because of the proven genetic and economic advantages of using AI compared with using natural service bulls for breeding dairy cattle. For example, research estimates a lifetime Net Merit Dollars advantage of \$211 for a Holstein cow sired by an average (first-proof) AI bull when compared with a cow sired by an average, proven natural-service bull. This estimate is conservative because dairy managers often select semen from above-average AI bulls and because the genetic merit of an average, proven natural-service bull is greater than that of an average, unproven natural-service bull (Fricke, 1997).

Advantages of Artificial Insemination for Dairy Heifers

Under most circumstances, the economic advantages of using AI to breed dairy heifers exceeds that realized when using AI exclusively to breed lactating cows. On farms using AI, heifers represent the most advanced genetic population of females on the farm. Thus, the genetic merit of AI-sired calves from heifers is superior to that of AI-sired calves from older cows. Based on age, first lactation cows constitute the largest group of cows on a dairy (34%; AgSource/CRI, 2002). Heifer AI programs accelerate genetic progress because calves from heifers contribute proportionately greater numbers of offspring available for herd replacements compared with cows in older age groups. Semen costs per pregnancy and per replacement heifer produced also are lower for heifers because heifers exhibit higher conception rates than lactating cows (74% vs. 39%; Pursley et al., 1997b) and, therefore, require fewer AI services per pregnancy. Lifetime milk yield, 305-day lactation yields, and lifetime profit of replacement heifers are maximized when heifers calve for the first time between 23 and 25 months of age (Head, 1992). Synchronized breeding protocols used in conjunction with AI allow dairy producers to more precisely manage age at first AI service and age at first calving in heifers. Finally, heifer AI programs allow for use of Holstein AI sires with proven calving-ease rather than using bulls of other breeds to avoid dystocia. Thus, the most effective method to accelerate genetic progress and maximize profitability on a dairy operation is to incorporate use of heifer AI breeding programs.

Industry Trends for Use of Artificial Insemination in Dairy Heifers

Despite the overwhelming economic advantages of using AI for breeding heifers, a paradoxical trend exists in the dairy industry. A national survey sponsored by the National Association of Animal Breeders (NAAB) revealed that, depending on herd size, only 55% to 63% of dairy heifers were serviced using AI (Erven and Arbaugh, 1987). A more recent NAAB survey showed that only 62 to 68% of dairy heifers receive at least one AI service (Hogeland and Wadsworth, 1995). Finally, a biannual market survey conducted by Hoard's Dairyman indicates that the reported use of natural service bulls for breeding dairy heifers increased by nearly 6% between 1990 and 1996 and was nearly

10% greater for dairy heifers than for lactating dairy cows (Hoards Dairyman, 1997). Based on these statistics, heifers continue to be the most underutilized genetic resource on dairy farms (Everett, 1989).

Several reasons for the lack of widespread use of AI to breed dairy heifers and for the trend toward increased use of natural service bulls for breeding dairy heifers have been cited. When asked to rank reasons for using natural service bulls to breed heifers, farmers listed "Heifers Not at a Convenient Location", "Inadequate Heat Detection for AI", and "Lack of Time to Supervise AI" among the most important factors contributing to this management practice (Erven and Arbaugh, 1987).

Development of New Controlled Breeding Programs for Dairy Heifers

The primary reason for synchronizing estrus in dairy heifers is to facilitate use of AI (Xu and Burton, 1999). Effectiveness of current estrus synchronization strategies is limited because dairy producers must rely on visual estrus detection, which is inefficient on most farms, to accurately time AI. In support of this notion, "Inadequate Heat Detection for AI", and "Lack of Time to Supervise AI" were two important factors identified by dairy producers in a national survey as reasons for not using AI to breed dairy heifers (Erven and Arbaugh, 1987). We recently have conducted a series of experiments to develop timed AI protocols for dairy heifers. These research results are summarized in the three studies below.

Study 1

Rivera, H. and P. M. Fricke. 2002. Synchronization of estrus in dairy heifers using GnRH, PGF_{2α} and ECP. *J. Dairy Sci.* 85(Suppl. 1):267.

Recently, several studies on the effectiveness of using an estrogen rather than GnRH to induce ovulation to facilitate TAI have been reported (Lopes et al., 2000; Jordan et al., 2001; Pancarci et al., 2001). Estradiol cypionate (ECP; Pharmacia Animal Health, Kalamazoo, MI) is the oil-soluble 17β-cyclopentylpropionate ester of alpha estradiol. It provides estradiol-17β, in the form of the cyclopentyl-propionate ester, a highly fat-soluble derivative with a prolonged estrogenic effect. Administration of an estrogen in the absence of progesterone and the presence of a follicle with ovulatory capacity causes ovulation by stimulating GnRH release from the hypothalamus, which in turn causes a surge in pituitary LH secretion, the ovulatory stimulus. To determine the usefulness of using ECP in heifers, the following trial was conducted.

In a preliminary trial, cycling Holstein heifers (n=12) received GnRH (100 μg) at a random stage of the estrous cycle followed by PGF_{2α} (25 mg) 6 d later. The proportion of heifers in estrus by 24, 48, 72, and 96 h after PGF_{2α} was 2/12, 2/12, 6/12, and 1/12, respectively, with one heifer not displaying estrus. To assess the effect of ECP on timing of estrus and ovulation, cycling Holstein heifers (n=24) were randomly assigned to receive either GnRH (100 μg) at a random stage of the estrous cycle followed by PGF_{2α} (25 mg) 6 d later (GP) or GnRH and PGF_{2α} as per GP heifers with the addition of estradiol cypionate (ECP; 0.5 mg) 24 h after PGF_{2α} (GPE). Timing of estrus was assessed

using Kamar devices, and timing of ovulation was assessed by ultrasound examinations conducted every 6 h after Kamar activation.

Overall, 50.0% (12/24) of heifers ovulated within 48 h after GnRH. Follicle diameter at GnRH was greater ($p < 0.01$) for ovulatory vs. nonovulatory follicles (11.9 ± 0.5 vs. 7.6 ± 0.8 mm), and 4 nonovulatory heifers displayed estrus after GnRH but before PGF_{2 α} . Based on serum progesterone, 83.3% (20/24) of heifers had a functional CL at PGF_{2 α} ; 90.0% (18/20) of functional CL regressed and 16.7% (2/12) of GnRH-induced CL failed to regress. Overall, 70.8% (17/24) of heifers displayed estrus within 3 d after PGF_{2 α} , and the interval from PGF_{2 α} to estrus (47.3 ± 2.6 vs. 48.7 ± 3.4 h) and ovulation (76.5 ± 2.7 vs. 84.0 ± 4.4 h) did not differ between GP and GPE heifers, respectively. Although the diameter of ovulatory follicles at PGF_{2 α} did not differ between treatments (10.7 ± 0.6 vs. 9.9 ± 0.9 mm for GP vs. GPE, respectively), the diameter of ovulatory follicles 6 h before ovulation tended to be greater ($p = 0.06$) for GP (13.7 ± 0.5 mm) than for GPE (12.1 ± 0.7 mm) heifers. Diameter of ovulatory follicles at PGF_{2 α} was negatively correlated ($p < 0.01$) with time from PGF_{2 α} to ovulation ($r = -0.72$).

Based on these results, it appeared that ECP administration suppressed follicular growth and delayed ovulation. Although several studies have reported successful use of ECP for timed insemination protocols in lactating dairy cows, we chose to discontinue use of ECP in favor of use of GnRH as an ovulatory stimulus in studies 2 and 3.

Study 2

Rivera, H., H. Lopez, and P. M. Fricke. 2003. Fixed-time artificial insemination in Holstein dairy heifers after synchronization of ovulation or removed tail chalk. *J. Dairy Sci.* Submitted.

Ovsynch was the first protocol developed to successfully synchronize ovulation in lactating dairy cows (Pursley et al., 1995). By using Ovsynch, dairy producers need not rely on estrus detection for timing of AI. Rather, cows receive a fixed-time AI in relation to a synchronized ovulation which results in conception rates similar to that of cows receiving AI to a detected estrus (Pursley et al., 1997a). Unfortunately, dairy heifers respond poorly to Ovsynch and fixed-time AI, exhibiting conception rates 20% to 40% lower than heifers receiving AI to a standing estrus (Pursley et al., 1997b; Schmitt et al., 1996). Although we have recommended against using Ovsynch for use in dairy heifers, certain modifications in management during the protocol and of the protocol itself may improve response of heifers to the protocol.

Holstein dairy heifers ($n = 352$) on a custom heifer operation in Wisconsin that were between 13 and 14 mo of age were subjected to a 42 d AI breeding period in which heifers received AI after removed tail chalk evaluated once daily (09:00 h). At AI breeding period onset (Day 0), heifers were randomly assigned to receive synchronization of ovulation and TAI (100 μ g GnRH, Day 0; 25 mg PGF_{2 α} , Day 6; 100 μ g GnRH+TAI, Day 8) followed by AI after removed tail chalk for the remainder of the AI breeding period (GPG; $n = 175$), or AI after removed tail chalk for the duration of the AI breeding period (TC; $n = 177$).

The interval from AI breeding period onset to first AI service was greater ($p < 0.01$) for TC than for GPG heifers (9.9 ± 0.6 vs. 7.5 ± 0.1 d), whereas conception rate at 30 d post AI was similar between treatments (46.5%, 80/172 vs. 38.3%, 67/175 for TC vs. GPG heifers, respectively). No treatment x AI technician interaction was detected ($p = 0.70$); however, AI technician affected ($p < 0.01$) conception rate (Tech 1=24.8%, 28/113; Tech 2=30.0%, 18/60; Tech 3=58.0%, 101/174). Thus, the overall poor conception rates in this study can be attributed to differences due to AI technician rather than failure of the protocol itself. Pregnancy loss from 30 to 75 d post AI was 10.2% (15/147) and was similar between treatments.

Many heifers that failed to synchronize displayed estrus before the second GnRH injection of the protocol. For GPG heifers, 17.7% (31/175) received AI before the day 8 (Day 5.2 ± 0.2) and did not receive TAI. We have shown a similar response in low-producing lactating dairy cows managed in a grazing-based dairy in Wisconsin (Cordoba and Fricke, 2002). For GPG heifers receiving TAI, 90.9% (131/144) ovulated within 48 h after the second GnRH injection (double ovulation rate=4.9%, 7/144). Thus, heifers that did not display estrus during the protocol synchronized ovulations at a high rate to the second GnRH injection. Blood samples collected from GPG heifers at each injection were classified based on serum progesterone (P) concentrations as High (≥ 1.0 ng/ml) or Low (< 1.0 ng/ml). The proportion of GPG heifers with a functional CL (High P) at PGF_{2 α} was 91.6% (132/144), and 96.2% (127/132) of functional CL had regressed (Low P) by 48 h after PGF_{2 α} . Thus, luteal regression in response to PGF_{2 α} was also high in this experiment.

In summary, this protocol for fixed-time AI of dairy heifers can yield acceptable conception rates if estrus detection and AI is conducted between the first GnRH and PGF_{2 α} injections and the effect of AI technician is optimized.

Study 3

Rivera, H., H. Lopez, and P. M. Fricke. 2003. Fixed-time artificial insemination in Holstein dairy heifers after synchronization of ovulation using GnRH and PGF_{2 α} with or without a CIDR device. *J. Dairy Sci.* Submitted.

Controlled Internal Drug Releasing (CIDR) Devices were recently approved by the FDA for use in dairy heifers. Each CIDR device is produced by coating a nylon spine with silicon-based elastomer containing 1.38 g of progesterone. When inserted into the vagina, CIDR devices deliver a defined amount of progesterone that inhibits estrus behavior in cattle (Macmillan and Peterson, 1993). Advantages of using CIDR devices include ease of insertion and withdrawal (compared with ear implants) and high retention rates (Macmillan et al., 1988, 1991). A practical disadvantage is that many farms lack facilities to restrain individual heifers for insertion and removal of CIDR devices.

Holstein dairy heifers ($n = 190$) on a custom heifer operation in Wisconsin that were between 13 and 14 mo of age were subjected to a 42 d AI breeding period in which heifers received AI after removed tail chalk evaluated once daily (09:00 h). At AI

breeding period onset (Day 0), heifers were randomly assigned to receive synchronization of ovulation and TAI (100 µg GnRH, Day 0; 25 mg PGF_{2α}, Day 6; 100 µg GnRH+TAI, Day 8) followed by AI after removed tail chalk for the remainder of the AI breeding period (GPG; n=96), or synchronization of ovulation and TAI as for GPG heifers, but with addition of a CIDR device inserted at the first GnRH injection and removed at the PGF_{2α} injection (GPG+CIDR; n=94).

We are currently analyzing this data set; however, we do have some preliminary results. Similar to Study 2 above, 23.9% (23/96) of GPG heifers received AI before the day 8 (Day 5.2 ± 0.2) and did not receive TAI. By contrast, none of the GPG+CIDR heifers displayed estrus before day 8. Conception rate at 30 d post AI was similar between treatments (29.1%, 28/96 vs. 31.9%, 30/94 for GPG vs. GPG+CIDR heifers, respectively). As in Study 2, no treatment x AI technician interaction was detected (p=0.70); however, AI technician affected (p<0.01) conception rate. Pregnancy loss from 30 to 75 d post AI was 6.9% (4/58) and was similar between treatments.

Conclusion

The most effective method to accelerate genetic progress and maximize profitability on a dairy operation is to breed dairy heifers using AI. We have made some progress in developing protocols that allow for fixed-time AI in heifers by modifying the Ovsynch protocol and using CIDR devices. Research is ongoing to develop methods for successful fixed-time AI in dairy heifers.

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