Reproductive Management of Dairy Heifers

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Take Home Messages:

- The most effective method to accelerate genetic progress and maximize profitability on a dairy operation is to breed dairy heifers using artificial insemination (AI).
- Estrus detection aids can dramatically improve estrus detection efficiency for use of AI in dairy heifers.
- Use of the AM-PM rule for timing of AI may not be the most effective strategy for managing AI in dairy heifers.
- Controlled breeding programs for dairy heifers improve estrus detection efficiency and labor associated with estrus detection and AI.

Artificial Insemination in Dairy Cattle

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, the August 1999 USDA Holstein Sire Summary estimates a Net Merit Dollars advantage of $72 per lactation for a cow sired by an average first-evaluation AI sire compared with a cow sired by an average first-evaluation natural service bull. This estimate is conservative because dairy managers can use semen from above-average bulls for AI 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, 1999). 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; Table 1). Based on these statistics, heifers continue to be the most underutilized genetic resource on dairy farms (Everett, 1989).

TABLE 1. Percent of dairy farmers reporting use of natural service bulls for breeding dairy cows and dairy heifers.

	1990	1992	1994	1996
Use a Bull for Breeding Dairy Cows	34.9%	36.2%	38.8%	41.7%
Use a Bull for Breeding Dairy Heifers	44.0%	46.9%	47.0%	49.9%

Source: Hoard's Dairyman Continuing Market Study, 1997

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). Enhancing dairy farm profitability through development of effective and practical management systems to increase use of AI in dairy heifers is an essential step toward maintaining the competitiveness of Wisconsin's dairy industry.

Behavioral Estrus and Estrus Detection Aids

Dairy producers have the most control over service rate in their herds. Improving management techniques can increase service rate by increasing estrus detection efficiency. First, it is essential that farm personnel accurately assess signs of estrus behavior. Standing to be mounted by a herdmate is the primary sign of estrus and is the best indicator of the fertile period.

Estrus Expression in Dairy Cattle

Research from Virginia Tech using a computerized system to continuously monitor mounting activity indicates that lactating dairy cows stand to be mounted, on average, only 7.2 times during an estrus period, and that the average duration of each estrus period, from first to last mount, is only 7.3 hours (Table 2). In contrast, dairy heifers stand to be mounted, on average, 16.8 times during an estrus period, and that the average duration of each estrus period, from first to last mount, is 11.3 hours (Table 2). Thus, estrus detection efficiency is greater for dairy heifers because heifers express estrus more frequently and longer than lactating dairy cows.

In addition, the number of times per day heifers are observed, as well as the timing and location of these observations, profoundly influences estrus detection rate. Because dairy heifers express estrus for nearly 12 hours (Nebel et al., 1997), estrus detection can be conducted at two to three evenly spaced 20-minute intervals per day to achieve adequate results. Certain physiologic factors also can reduce estrus behavior including illness, feet and leg problems, and acyclicity due to nutritional deficiencies or health problems. Environmental factors such as heat stress, poor footing, or other environmental stresses may also decrease estrus behavior.

TABLE 2. Estrus expression in lactating dairy cows and virgin dairy heifers.

Item	Lactating Cows	Virgin Heifers
n	307	114
Standing Events	7.2 ± 7.2	16.8 ± 12.8
Duration of Estrus (hours)	7.3 ± 7.2	11.3 ± 6.9

Source: Nebel et al., 1997

The effect of inadequate estrus detection programs for dairy heifers makes estrus detection a major problem limiting reproductive performance and use of AI. Today, dairy managers have many options when choosing to incorporate estrus detection aids to improve their reproductive management program. When used correctly, each of these methods can improve service rate by increasing estrus detection efficiency. The decision to incorporate one or more of these estrus detection aids in a reproductive management program should include, cost of the estrus detection aid, and integration of the aid into the overall operation.

Tail Chalk, Tail Paint, and Pressure Activated Devices

Use of tail chalk, tail paint, or pressure-activated heat mount detectors can increase estrus detection efficiency (Senger, 1994) at a marginal cost. Because standing to be mounted by a herdmate is the most reliable indicator of the estrus period, these estrus detection aids should never fully replace visual estrus detection. When used correctly, these aids not only improve visual detection of estrus, but also identify those heifers that are not cycling or do not express estrus behavior.

HeatWatchÒ

Surface applied or implantable pressure sensors have shown promise for providing accurate daily estrus detection (Senger, 1994). For example, the HeatWatch® system (DDx Technology) provides continuous information on mounting activity by using a pressure-activated transducer that sends information to a computer where it can be recorded and analyzed. When HeatWatch® was compared with visual estrus detection (Walker et al., 1995), efficiency of estrus detection was greater with HeatWatch® (91% vs. 51%) with similar accuracy (96% vs. 94%).

Timing of AI

Timing of AI in relation to behavioral estrus is critical for maximizing conception rates. Many dairy producers have used the AM-PM rule for timing AI in dairy heifers. The AM-PM rule states that heifers detected in estrus in the AM should receive AI later that PM, whereas, heifers detected in estrus in the PM should receive AI the following AM. This rule was formulated based on research conducted during the 1940's that indicated that breeding heifers approximately 12 hours after the onset of estrus yielded maximum conception rates (Trimberger, 1943). The AM-PM rule works well if estrus detection is conducted frequently and the onset of estrus can be identified. Unfortunately, estrus detection is conducted infrequently, and a heifer detected in estrus may be at the onset, middle, or the end of the estrus period.

Research with dairy heifers has shown that once-daily AI yielded similar conception rates as using the AM-PM rule (Table 3). Furthermore, heifers receiving a single AI service at the onset of estrus had similar conception rates to heifers receiving two AI services, one at the onset of estrus and one 12 hours later (Table 4).

TABLE 3. Effect of once-daily AI (0800 to 0900 hours) versus AI using the AM-PM rule on conception rates in dairy heifers.

Treatment	No. of Heifers	Conception Rate (%)
AM-PM Rule	132	62.9
Once Daily AI	129	62.0

Source: Gonzalez et al., 1985

TABLE 4. Conception rate of dairy heifers receiving one AI at the onset of estrus (One AI) or one AI service at the onset of estrus and one 12 hours later (Two AI).

Treatment	No. of Heifers	Conception Rate (%)
One AI	84	70.2
Two AI	86	68.6

Source: Wahome et al., 1985

Collectively, these data indicate that dairy heifers can be inseminated immediately upon detection of standing estrus or using once-daily AI. By using these methods, labor associated with estrus detection and AI can be minimized.

Controlled Breeding Programs for Dairy Heifers

Many estrus synchronization protocols have been developed for cattle using exogenous hormones including progestogens, prostaglandin (PG) $F_{2\alpha}$ (or $PGF_{2\alpha}$ analogs), and estrogens alone or in various combinations to control the physiology of the reproductive cycle and synchronize estrus behavior (Odde, 1990). 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). As stated by Heersche and Nebel (1994), "Until a better predictor of time of ovulation is available, dairy managers must rely on visual determination of standing estrus and other secondary signs of estrus to determine when to breed cows and heifers".

Ovsynch

Ovsynch is 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). Use of fixed-time AI is beneficial to dairy producers who struggle to adequately manage estrus detection and can dramatically improve reproductive efficiency of lactating cows in herds with inadequate AI service rates (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). *Therefore, use of Ovsynch and fixed-time AI in dairy heifers is not recommended*.

Prostaglandin F_{2a}

Synchronization of estrus behavior using $PGF_{2\alpha}$ can improve reproductive efficiency. Two prostaglandin products currently are approved by the FDA for use in dairy heifers: Lutalyse® and Estrumate®. Because label approved dosages differ with each of these products, carefully read and follow directions for proper administration prior to their use. Many studies have shown that use of $PGF_{2\alpha}$ can reduce the interval between detected estrous cycles and improve estrus detection efficiency. However, $PGF_{2\alpha}$ does not effectively regress corpora lutea from Days 1 to 6 after estrus; therefore, two injections of $PGF_{2\alpha}$, administered 11 days apart, are required to effectively synchronize estrus in dairy heifers. In addition, $PGF_{2\alpha}$ will not induce prepubertal heifers to cycle because they lack a corpus luteum. Synchronization of estrus with $PGF_{2\alpha}$ has been successful if heifers are bred at a detected estrus (Lucy et al., 1986; Stevenson et al., 1987; Larson and Ball, 1992), because estrus detection rates increase and management of AI is more efficient compared with daily estrus detection. However, estrus is not precisely synchronized with $PGF_{2\alpha}$ in dairy heifers that respond to $PGF_{2\alpha}$ because this treatment only regulates the life span of the corpus luteum and does not synchronize growth of follicles. Thus, heifers with functional corpora lutea will exhibit heat from one to six days after treatment with $PGF_{2\alpha}$.

Synchronization of estrus using $PGF_{2\alpha}$ can improve reproductive efficiency, but is limited by estrus detection efficiency in an operation. Administration of $PGF_{2\alpha}$ to a heifer that displays estrus poorly at a spontaneous estrus will not improve her ability to express estrus behavior. Furthermore, administration of $PGF_{2\alpha}$ in the absence of an effective visual estrus detection program will yield poor results. Use of estrus detection aids and a sound estrus detection protocol in conjunction with estrus synchronization using $PGF_{2\alpha}$ is recommended to fully realize the benefit of an estrus synchronization program.

Melengestrol Acetate (MGA) and PGF_{2a}

Melengestrol acetate (MGA) is an orally active progestogen that suppress estrus in dairy cattle when fed with a grain or protein carrier and either top-dressed onto other feed or batch-mixed with larger quantities of feed (Roussel and Beatty, 1969; DeBois and Bierschwal, 1970; Randel et al., 1972). Advantages of using MGA include its oral activity, thereby eliminating the need for excessive handling of animals and its cost effectiveness ($0.02/head/d). A disadvantage of MGA is that estrus suppressing ability is directly related to ingestion. Thus, inadequate mixing of MGA in feedstuffs or poor feed intake can dramatically alter its effectiveness.

One method for controlling the estrus cycle is to use MGA in combination with $PGF_{2\alpha}$. In this system, MGA is fed to heifers for 14 days and then withdrawn. Heifers will display estrus from between 2 to 6 days after MGA withdrawal, however, this is a subfertile estrus and none of the heifers should be bred at this time. Instead, a $PGF_{2\alpha}$ injection is administered to all heifers 17 to 19 days after MGA withdrawal. This treatment places all animals in the late luteal stage of the estrous cycle at the time of the $PGF_{2\alpha}$ injection, which should shorten the synchronization period and maximize conception rate. Heifers should be detected in estrus and bred from between 2 to 5 days after the $PGF_{2\alpha}$ injection.

Synchro-Mate B

The Synchro-Mate B system (Merial Inc., Iselin, NJ) uses a combination of an estrogen (estradiol valerate) and a synthetic progestogen (norgestomet) ear implant to synchronize estrus.

A 9-day implant containing 6 mg norgestomet plus an injection of 5 mg of estradiol valerate and 3 mg of norgestomet given at the time of implant insertion successfully synchronizes estrus in noncycling beef heifers (Wiltbank and Gonzalez-Padilla, 1975). This treatment now is approved by the FDA for synchronization of estrus in dairy and beef heifers and postpartum beef cows. Synchro-Mate B treatment results in a high percentage of cattle showing estrus soon after treatment. The range of females showing estrus after Synchro-Mate B treatment is 77 to 100%, with values being greater than 90% in most trials (Odde, 1990). The fertility of this estrus, however, is variable, with first service conception rates ranging from 33 to 68% (Odde, 1990). An advantage of the Synchro-Mate B system is that timed AI after implant removal results in acceptable conception rates in most studies. A practical disadvantage is that many farms lack facilities to restrain individual heifers for insertion and removal of ear implants.

Intravaginal Progesterone Inserts (IPI)

Intravaginal progesterone-releasing insert (IPI) devices are scheduled for FDA approval in 2001 (Dr. Harold Hafs, personal communication). Each IPI device is produced by coating a nylon spine with silicon-based elastomer containing 1.9 g of progesterone. When inserted into the vagina, IPI devices deliver a defined amount of progesterone that inhibits estrus behavior in cattle (Macmillan and Peterson, 1993). Advantages of using IPI 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 IPI devices.

Conclusion

The most effective method to accelerate genetic progress and maximize profitability on a dairy operation is to breed dairy heifers using AI. Although the AM-PM rule can be used for timing of AI, research indicates that heifers can be immediately bred after a detected estrus or once-daily AI breeding programs can be used. Use of estrus detection aids and controlled breeding programs can improve the success of a heifer AI breeding program by improving estrus detection efficiency and labor associated with estrus detection and AI. Although Ovsynch is an effective program for fixed-time AI in lactating dairy cows, heifers respond poorly to Ovsynch and fixed-time AI. Research is ongoing to develop methods for successful fixed-time AI in dairy heifers.

References

AgSource/CRI. 1999. AgSource Cooperative Services, Verona, WI.

DeBois CHW, Bierschwal CJ Jr. 1970. Estrous cycle synchronization in dairy cattle given a 14-day treatment of melengestrol acetate. Am J Vet Res 31:1545-1548.

Erven BL, Arbaugh D. 1987. Artificial Insemination on U.S. dairy farms. Report of a study conducted in cooperation with the National Association of Animal Breeders. NAAB, Columbia, MO.

Everett RW. 1989. Are heifers your untapped genetic resource? Hoard's Dairyman, April 25, p. 348.

Fricke PM. 1997. Bulls are no bargain. Hoard's Dairyman, December, 1997 p. 841.

Gonzalez . 1985.

Head HH. 1992. Heifer performance standards: rearing systems, growth rates and lactation. In: Large Herd Dairy Management. Van Horn HH, Wilcox CJ (Eds). American Dairy Science Association, Champaign, IL, p. 422.

Heersche G, Nebel RL. 1994. Measuring efficiency and accuracy of detecting estrus. J Dairy Sci 77:2754-2761.

Hoard's Dairyman, 1997. Hoard's Dairyman Continuing Market Study, 1997. Hoard's Dairyman Research Department, Fort Atkinson, WI.

Hogeland JA, Wadsworth JJ, 1995. The role of artificial insemination on U.S. dairy farms survey report. Study conducted in cooperation with the National Association of Animal Breeders. NAAB, Columbia, MO.

Larson, L. L., and P. J. H. Ball. 1992. Regulation of estrous cycles in dairy cattle: a review. Theriogenology 38:255.

Lucy, M. C., J. S. Stevenson, and E. P. Call. 1986. Controlling first service and calving interval by prostaglandin $F_{2\alpha}$, gonadotropin-releasing hormone, and timed insemination. J. Dairy Sci. 69:2186.

Macmillan KL, Peterson AJ. 1993. A new intravaginal progesterone releasing device for cattle (CIDR-B) for oestrous synchronization, increasing pregnancy rates and the treatment of post-partum anoestrus. Anim Reprod Sci 33:1-25.

Macmillan KL, Taufa VK, Barnes DR, Day AM. 1991. Plasma progesterone concentrations in heifers and cows treated with a new intravaginal device. Anim Reprod Sci 26:25-40.

Macmillan KL, Taufa VK, Barnes DR, Day AM, Henry R. 1988. Detecting oestrus in synchronized heifers using tail paint and an aerosol raddle. Theriogenology 30:1099-1114.

Nebel, R. L., S. M. Jobst, M. B. G. Dransfield, S. M. Pansolfi, and T. L. Bailey. 1997. Use of a radio frequency data communication system, HeatWatch®, to describe behavioral estrus in dairy cattle. J. Dairy Sci. 80(Suppl. 1):179.

Odde KG. 1990. A review of synchronization of estrus in postpartum cattle. J Anim Sci 68:817-830.

Pursley JR, Kosorok MR, Wiltbank MC. 1997a. Reproductive management of lactating dairy cows using synchronization of ovulation. J Dairy Sci 80:301-306.

Pursley JR, Mee MO, Wiltbank MC. 1995. Synchronization of ovulation in dairy cows using $PGF_{2\alpha}$ and GnRH. Theriogenology 44:915-923.

Pursley JR, Wiltbank MC, Stevenson JS, Ottobre JS, Garverick HA, Anderson LL, 1997b. Pregnancy rates per artificial insemination for cows and heifers inseminated at a synchronized ovulation or synchronized estrus. J Dairy Sci 80:295-300.

Randel RD, Callahan CJ, Erb RE, Garverick HA, Brown BL. 1972. Effect of melengestrol acetate on plasma progesterone, luteinizing hormone and total corticoids in dairy heifers. J Anim Sci 35:389-397.

Roussel JD, Beatty JF. 1969. Effect of melengestrol acetate on synchronization of estrus, subsequent fertility, and milk constituents of lactating dairy cows. J Dairy Sci 52:2020-2023.

Schmitt EJ-P, Diaz T, Drost M, Thatcher WW. 1996. Use of a gonadotropin-releasing hormone agonist or human chorionic gonadotropin for timed insemination in cattle. J Anim Sci 74:1084-1091.

Senger, P. L. 1994. The estrus detection problem: new concepts, technologies, and possibilities. J. Dairy Sci. 77:2745.

Stevenson, J. S., M. C. Lucy, and E. P. Call. 1987. Failure of timed inseminations and associated luteal function in dairy cattle after two injections of prostaglandin $F_{2\alpha.}$ Theriogenology 28:937.

Trimberger GW, 1943. Conception rate in dairy cattle by artificial insemination at various stages of estrus by artificial insemination. J Dairy Sci 27:659.

Wahome JN, Stuart MJ, Smith AE, Hearne WR, Fuquay JW, 1985. Insemination management for a one-injection prostaglandin $F_{2\alpha}$ synchronization system. II. One versus two inseminations following detection of estrus. Theriogenology 24:501.

Walker, W.L., R. L. Nebel, and M. L. McGilliard. 1995. Characterization of estrus activity as monitored by an electronic pressure sensing system for the detection of estrus. J. Dairy Sci. 78(Suppl. 1):468.

Wiltbank JN, Gonzalez-Padilla E. 1975. Synchronization and induction of estrus in heifers with a progestagen and estrogen. Ann Biol Anim Biochem Biophys 15:255.

Xu ZZ, Burton LJ. 1999. Reproductive performance of dairy heifers and estrus synchronization and fixed-time artificial insemination. J Dairy Sci 82:910-917.