Aggressive Management Strategies for Improving Reproductive Efficiency in Lactating Dairy Cows

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❑ Take Home Messages

- ⇒ Reproductive efficiency and dairy farm profitability are maximized when the average calving interval for a herd is around 13 months.
- ⇒ Current indices of reproductive performance based on average service and conception rates for lactating dairy cows result in calving intervals that fail to meet and often greatly exceed the goal of a 13-month calving interval.
- ⇒ New reproductive tools, which include hormonal protocols for conducting timed AI and use of transrectal ultrasound, can improve reproductive efficiency and profitability for a dairy operation.

❑ Introduction

Reproductive inefficiency in lactating dairy cows not only is a source of frustration to dairy producers and their consultants but also substantially reduces dairy farm profitability. Artificial insemination (AI) is one of the most important agricultural technologies developed this century, and most dairy producers use AI to some degree in their herds to remain competitive in the current economic climate of the dairy industry. However, reproductive inefficiency in lactating dairy cows substantially reduces the impact and efficiency of AI in dairy operations. It is important to understand the factors that affect the rate at which cows become pregnant in a dairy herd as well as the management strategies that can be implemented to improve this rate.

❑ The Economics of Calving Intervals

Timely rebreeding of postpartum lactating cows is essential for reducing average days open and the corresponding calving interval. A successful breeding program enhances profitability by maximizing the time cows spend in the most productive portion of lactation. To optimize profitability, dairy consultants have traditionally recommended an average calving interval of around 13 months. The approval by the FDA of recombinant bovine somatotropin (rbST) for use in lactating dairy cows led some dairy scientists to question the validity of short calving intervals and investigate the concept of extended calving intervals. A recent economic analysis, however, indicates that, regardless of rbST use, extending calving interval beyond 13 months results in a decrease in annual revenue per cow in the herd (Table 1). Please note that these calculations are based on modeled rather than empirical data and do not include the economic impact associated with decreased frequency of periparturient periods for extended calving intervals. Further studies are needed to adequately evaluate the feasibility and profitability of extended calving intervals.

Table 1. Predicted annual returns from a dairy cow with varying calving intervals (Jones, unpublished data)*

Calving Interval Weeks (Months)	**Annual Return** ($)	**Difference from 56 Weeks** ($)
56 (13)	959.18	-
60 (14)	936.78	-23.04
64 (15)	909.65	-50.17
68 (16)	879.49	-80.33
72 (17)	847.13	-112.69
76 (18)	813.19	-128.63

*Assumptions of the model: peak milk production at week 8 = 101 lbs; milk production over 305 days = 26,719 lbs; daily decline in production from peak to end of lactation = 0.1844%; initiation of rbST treatment = 63 DIM; initial rbST response = 8 lbs; dry period = 56 days; lactations per cow before culling = 3; replacement cost = $1,400; cull cow value = $450; value of calf = $100; milk price = $13/cwt.

For each cow in the herd, the calving interval can be subdivided into the following four intervals: 1) the voluntary waiting period (VWP), or the interval from calving until a cow is eligible to receive her first AI service; 2) the interval from the end of the VWP to first AI service; 3) the interval from first AI service until conception; and 4) the gestation period. Because each cow in the herd must progress consecutively through these four periods, each interval represents a management opportunity to optimize the average calving interval of the herd. Understanding the factors that regulate the duration of each of these intervals and the management opportunities these intervals present will provide insight into aggressive strategies for managing reproductive efficiency in a dairy herd.

Voluntary Waiting Period (VWP)

The interval that must elapse from calving until a cow is eligible to receive her first AI service is termed the Voluntary Waiting Period (VWP). As the name implies, the duration of this interval is voluntary (i.e., a management decision) and traditionally varies from 40 to 70 days on most dairies. The VWP constitutes part of the transition period immediately after calving and represents a significant risk to the future health and productivity of the cow. Cows often experience physiologic disorders including, retained placenta, metritis, ketosis, displaced abomasum, and cystic ovarian disease during the VWP. Recent advances in transition cow management such as feeding transition rations and monitoring rumen motility and body temperature can minimize many of these complications. Major reproductive events that occur during the VWP include initiation of lactation, uterine involution, and the first postpartum ovulation and resumption of reproductive cyclicity.

Although most dairy producers identify a set duration for the VWP, breeding decisions for individual cows often occur before the VWP elapses. For example, many producers elect to inseminate cows detected in standing estrus at 50 DIM when their VWP is set at 60 DIM. Although this may be an oversimplification of management decisions that occur on farms because the VWP may vary among individual cows within the herd, the decision to AI a cow for the first time postpartum is often determined based on when (or if) a cow is detected in estrus rather than on a predetermined management decision. In such instances, the cow is managing the decision to breed rather than the dairy manager. I believe the decision to inseminate a cow before the VWP elapses is motivated by one factor, and that factor is fear. Most producers fear the decision to not breed a cow detected in estrus because she may not be detected in estrus again until much later in lactation. Unfortunately, this risk is often realized on dairies that rely on visual estrus detection for AI because of poor estrus detection by dairy personnel and poor estrus expression by lactating dairy cows.

Interval from the VWP to First AI Service

Once a cow has passed the VWP, she becomes eligible to receive her first postpartum AI service. The interval from the VWP to first AI service varies dramatically among individual cows within the herd. A few cows may receive their first AI at or near the end of the VWP, whereas other cows often experience extended intervals to first AI service for a variety of reasons. Thus, this interval is calculated as an average for all cows within the herd.

For dairies relying on visual estrus detection to breed cows, the duration of this period is primarily determined by estrus detection efficiency and, to a lesser extent, the physiologic status of individual cows within the herd. Based on the utopian assumptions that 1) all cows within the herd are cycling by the end of the VWP, 2) estrous cycle duration is 21 days, and 3) estrus detection efficiency is 100%, the average duration of this period for all cows in the herd would be 10.5 days. Under field conditions, the duration of this period is much longer for several reasons. First, a recent field trial conducted by the University of Wisconsin in collaboration with several other university research stations in the Midwest showed that 28% of lactating dairy cows were anovulatory at 60 DIM (Pursley et al., 2001). Thus, nearly one third of the cows within these herds would not have expressed estrus at the end of the VWP. Second, estrous cycle duration varies widely among lactating dairy cows and averaged around 24 days in our dairy herd at the University of Wisconsin-Madison (Sartori, unpublished data). Finally, estrous detection efficiency has been estimated to be less than 50% on most dairy farms in the United States (Senger, 1994). This inefficiency in estrus detection not only increases the interval to first AI but can increase the average interval between services to 40 to 50 days (Stevenson and Call, 1983).

Interval from First AI Service to Conception

The interval from first AI service to conception represents the rate at which cows become pregnant in the herd and varies dramatically among individual cows within the herd. The rate at which cows become pregnant in a dairy herd, commonly called the pregnancy rate, is defined as the number of eligible cows in a herd that conceive every 21 days. Two factors that determine pregnancy rate are: 1) services per conception or conception rate, and 2) estrus detection rate or service rate. Thus, a few cows may conceive to first AI, whereas other cows require several services to establish pregnancy. On many dairies, the mathematical inverse of the conception rate or the number of services per conception is calculated. Thus, this interval is calculated as an average for all cows within the herd.

Dairy cow fertility commonly is measured by calculating the percentage of cows that conceive after a single AI service, also known as the pregnancy rate per artificial insemination (PR/AI). Pregnancy rate per AI in lactating dairy cows has decreased from 66% in 1951 (Spalding et al., 1974), to about 50% in 1975 (Spalding et al., 1974; Macmillan and Watson, 1975), to about 40% in 1997 (Butler et al., 1995; Pursley et al., 1997a), whereas PR/AI in heifers has remained at 70% during this same period (Spalding et al., 1974; Foote, 1975; Pursley et al., 1997b). Thus, dairy cow fertility is poor and is a major cause of poor reproductive efficiency in lactating dairy cows. The key to decreasing the interval from first AI service to conception lies not with improving conception rate beyond that which is "normal" for lactating cows, but with improving the AI service rate.

Service rate is defined as the percentage of eligible cows bred during a 21-day period. In herds using AI, the service rate directly reflects estrus detection efficiency because a cow must first be detected in estrus before she can be bred. Unfortunately, less than 50% of all estrus periods are accurately detected on an average dairy farm in the United States (Senger, 1994). Economic cost analysis of improving the estrus detection rate (i.e., service rate) by 20 to 30%, and assuming a 50% AI conception rate, resulted in an estimated annual benefit of $83 per cow (Pecsok et al., 1994). Similarly, increasing the estrus detection rate from 35 to 55% reduced average days open from 136 to 119 days, resulting in a net return per cow of $60 per year (Oltenacu et al., 1981). Thus, management strategies that improve the service rate in an operation result in a net profit to the producer.

Gestation

Although the average duration of gestation for Holstein dairy cows is 282 days, gestation length can vary widely among animals. Of 58 cows that calved, average duration of gestation was 279.4 ± 1.0 days with a range of 269 to 295 days (Fricke, unpublished data). Although many factors affect duration of gestation (Foote, 1981), gestation of cows carrying twins is reduced by 6 to 10 days (Pfau et al., 1948; Foote, 1981; Nielen et al., 1989; Ryan and Boland, 1991; Echternkamp and Gregory, 1999). Despite this variation in gestation length, the gestation period is not considered a useful interval as far as management of calving intervals in a dairy herd.

Based on the four intervals that constitute the calving interval, calving intervals can be predicted based on average or poor indices of reproductive management (Table 2). Thus, average reproductive management results in a longer than desired calving interval based on the argument that a 13-month calving interval results in a higher annual return for cows within the herd. Often farms experiencing difficulties with reproductive management experience calving intervals that exceed 18 months.

Table 2. Predicted average calving interval for a dairy herd based on average or poor reproductive management.

Interval (days)	**Average Reproductive Management**	**Poor Reproductive Management**
Voluntary Waiting Period (VWP)	50	40
End of VWP to first AI service[a]	21	62
First AI service to conception[b]	105	165
Gestation	282	282
Average Herd Calving Interval	458 days (>15 months)	549 days (>18 months)

[a]Based on a service rate of 50% for average reproductive performance; 30% for poor reproductive performance.

[b]Based on a 50% service rate and a 40% conception rate for average reproductive performance; 30% service rate and 40% conception rate for poor reproductive performance.

Aggressive Reproductive Management Strategies

Achieving reproductive efficiency can be difficult, but new tools for managing reproduction can be used to improve reproductive efficiency and attain profitable calving intervals within a dairy herd. Aggressive reproductive management comprises two strategies: 1) improve pregnancy rate by improving AI service rate, and 2) identify open cows early post-AI and implement a management strategy to quickly return nonpregnant cows to AI service. These strategies focus on reducing the duration of the calving interval by eliminating the interval from the VWP to first AI service and reducing the interval from first AI service to conception.

Eliminate the Interval from the VWP to First AI Service

The second of the four periods comprising the calving interval is the interval from the end of the VWP to first AI service. This interval is highly dependent upon the estrus detection rate in the herd and can be a significant cause of extended calving intervals. Timed AI programs such as Ovsynch are powerful tools for improving reproductive efficiency in a dairy operation.

To determine the effectiveness of using Ovsynch for reproductive management of lactating cows, cows (n = 333) from three Wisconsin dairy herds were randomly assigned at parturition to one of two groups (Pursley et al., 1997a). Reproduction for control cows was managed using the typical reproductive management procedure in place on each farm (i.e., estrus detection, AM/PM breeding, and periodic use of $PGF_{2\alpha}$). Reproduction for Ovsynch-treated cows was managed by timed AI after the Ovsynch protocol on the same day each week.

The left panel of Figure 1 shows days to first AI service (VWP = 50 DIM) in a field trial in which cows received AI after a detected estrus (control) or after a timed AI (Ovsynch). Nearly 30% of cows in the control group did not receive their first AI service until after 100 DIM, whereas 100% of cows in the Ovsynch group received their first AI within 7 days of the VWP.

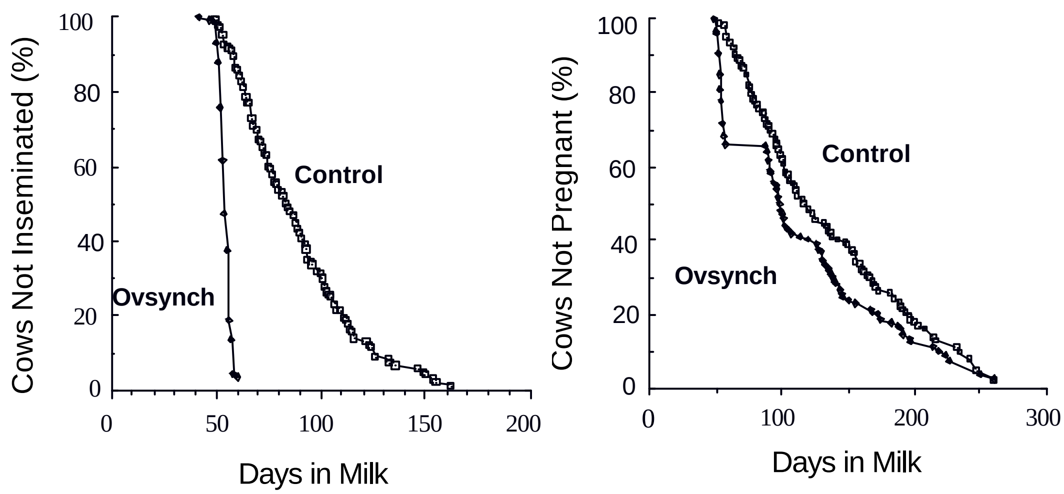

Figure 1. Survival curves for days to first AI (left panel) and days open (right panel) for cows that received AI after a detected estrus (Control) and cows that received appointment AI after synchronization of ovulation (Ovsynch). Median days to first AI and average days open were less for Ovsynch than for Control cows, and pregnancy rate to first AI was similar for both groups. (Adapted from Pursley et al., 1997a).

Results from this study illustrate the benefit of setting up cows for their first AI service using a timed AI program such as Ovsynch. The VWP can be closely managed for individual cows and the period from the end of the VWP to the first AI service can effectively be eliminated, thereby reducing the duration of the overall calving interval.

Improve AI Service Rate and Pregnancy Rate

Use of timed AI programs such as Ovsynch improves pregnancy rate by improving AI service rate. Median days to 1st AI (Figure 2 left panel; 54 vs. 83 days) and average days open (Figure 1 right panel; 99 vs. 118 days) were less for Ovsynch-treated cows than for control cows. Conception rate was similar (37% vs. 39%) for both groups even though Ovsynch cows were bred earlier postpartum. Service rate is dramatically improved using Ovsynch because all eligible cows are routinely serviced on a given day of lactation regardless of estrus detection. Thus, Ovsynch improves reproductive performance of lactating dairy cows by increasing service rate, allows for timed AI, and eliminates reliance on estrus detection for AI compared with standard reproductive management.

Identify Nonpregnant Cows Early and Return them to AI Service

Traditionally, a bovine practitioner detects nonpregnant cows within 32 to 45 days post AI by rectal palpation conducted. New technologies, such as transrectal ultrasound, may provide a further benefit as a practical management tool on a dairy. The use of transrectal ultrasonography to assess pregnancy status early during gestation is among the most practical applications of ultrasound for dairy cattle reproduction. Early identification of open cows post breeding improves reproductive efficiency and pregnancy rate in a dairy by decreasing the interval between AI services and increasing AI service rate.

The use of transrectal ultrasound as a tool for scientific inquiry has revolutionized bovine reproductive biology. Research using ultrasound has contributed to our understanding of ovarian physiology (Ginther et al., 1996), and aided in quantification of conception rates in lactating dairy cows and dairy heifers (Pursley et al., 1997a,b). Practical applications of ultrasound by bovine practitioners for routine reproductive examinations of dairy cattle is the next contribution this technology is positioned to make to the dairy industry. Most veterinary students continue to be taught that ultrasound is a secondary technology for bovine reproductive work; however, the information-gathering capabilities of ultrasonic imaging far exceed those of rectal palpation (Ginther, 1995).

Figure 2 shows a scenario for combining use of Ovsynch and early pregnancy diagnosis using ultrasound. Groups of cows past the voluntary waiting period would receive their first postpartum insemination after synchronization of ovulation using Ovsynch. This would dramatically reduce median days to first AI by eliminating estrus detection for the first postpartum breeding. On Day 25 post AI, ultrasound would be used to identify nonpregnant cows, which would receive the first GnRH injection for resynchronization using Ovsynch. This would result in an average interval between services of 35 days for cows requiring resynchronization.

Figure 2. Reproductive management protocol for combining timed AI (Ovsynch) with early pregnancy diagnosis using ultrasound. Note that hormone injections are scheduled for Monday (M) and Wednesday (W), ultrasound examinations for Monday (M), and timed AI (TAI) for Thursday (T). Average interval between services would be 35 days for cows requiring resynchronization.

Figure 3 shows a more aggressive scenario for combining use of Ovsynch and early pregnancy diagnosis using ultrasound. Groups of cows past the voluntary waiting period would receive their first postpartum insemination after synchronization of ovulation using Ovsynch. On Day 18 post AI, all cows would receive an injection of GnRH regardless of their pregnancy status. Ultrasound would be used on Day 25 to identify nonpregnant cows, which would receive a $PGF_{2\alpha}$ injection for resynchronization using Ovsynch. Although recent data has suggested that administration of GnRH to pregnant cows may increase early embryonic loss (Moreira et al., 2000), these data have not been replicated. Further research into the efficacy of such protocols combining timed AI with ultrasonography for reproductive management of dairy cattle is ongoing.

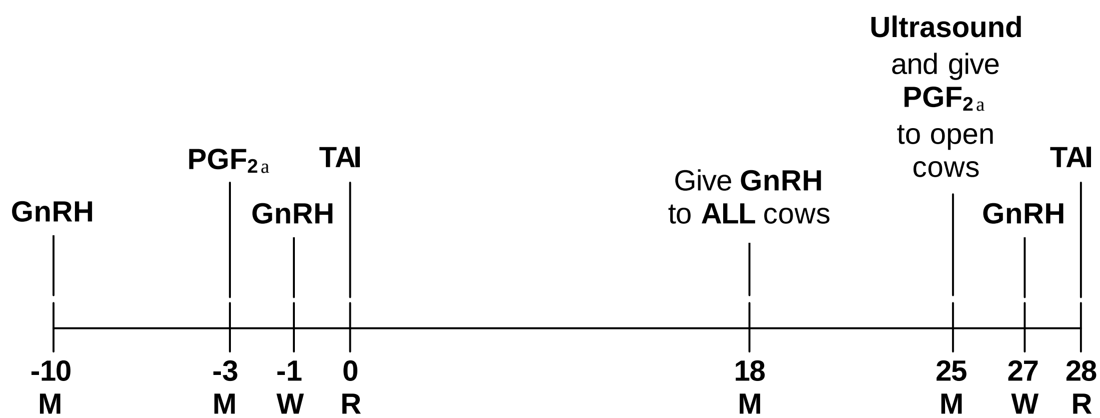

Figure 3. Aggressive reproductive management protocol for combining timed AI (Ovsynch) with early pregnancy diagnosis using ultrasound. Note that hormone injections are scheduled for Monday (M) and Wednesday (W), ultrasound examinations for Monday (M), and timed AI (TAI) for Thursday (T). Average interval between services would be 28 days for cows requiring resynchronization.

Implementation of new reproductive technologies can result in improved reproductive performance and optimized calving intervals. Table 3 shows the predicted average calving interval for a dairy herd based on the aggressive reproductive management strategies outlined herein. Based on this estimation, a calving interval of 392 days (12.9 months) is achievable.

Table 3. Predicted average calving interval for a dairy herd based on aggressive reproductive management.

Interval (days)	**Aggressive Reproductive Management**
Voluntary Waiting Period (VWP)	60
End of VWP to first AI service	0
First AI service to conception[a]	50
Gestation	282
Average Herd Calving Interval	392 days (12.9 months)

[a]Based on a conception rate of 40% and aggressive identification of nonpregnant cows post-AI and resynchronization using timed AI.

Conclusions

Reproductive efficiency and profitability are maximized when the average calving interval is around 13 months in a dairy herd. Unfortunately, current reproductive performance indices result in calving intervals that greatly exceed this 13-month goal. New reproductive management tools such as timed AI protocols and use of transrectal ultrasound can effectively be used to achieve reproductive efficiency and profitability.

References

1. Butler, W.R., D. J. R. Cherney, and C. C. Elrod. 1995. Milk urea nitrogen (MUN) analysis: Field trial results on conception rates and dietary inputs. Proc Cornell Nutr Conf p 89.
2. Echternkamp, S. E., and K. E. Gregory. 1999. Effects of twinning on gestation length, retained placenta, and dystocia. J. Anim. Sci. 77:39.
3. Foote, R. H. 1981. Factors affecting gestation length in dairy cattle. Theriogenology 6:553.
4. Ginther OJ. 1995. Ultrasonic imaging and animal reproduction. Equiservices Publishing, Cross Plains, WI.
5. Ginther OJ, Wiltbank MC, Fricke PM, Gibbons JR, Kot K, 1996. Minireview. Selection of the dominant follicle in cattle. Biol Reprod 55:1187-1194.
6. Macmillan, K.L., and J. D. Watson. 1975. Fertility differences between groups of sires relative to the stage of oestrus at the time of insemination. Anim Prod 21:243.
7. Moreira F, Risco CA, Pires MFA, Ambrose JD, Drost M, Thatcher WW, 2000. Use of bovine somatotropin in lactating dairy cows receiving timed artificial insemination. J Dairy Sci 83:1237-1247.
8. Nielen, M., Y. H. Schukken, D. T. Scholl, H. J. Wilbrink, and A. Brand. 1989. Twinning in dairy cattle: a study of risk factors and effects. Theriogenology 32:845.
9. Oltenacu, P. A., T. R. Rounsaville, R. A. Milligan, and R. H. Foote, 1981. Systems analysis for designing reproductive management programs to increase production and profit in dairy herds. J Dairy Sci. 64:2096.
10. Pecsok, S. R., M. L. McGillard, and R. L. Nebel. 1994. Conception rates. 1. Derivation and estimates for effects of estrus detection on cow profitability. J. Dairy Sci. 77:3008.
11. Pfau, K. O., J. W. Bartlett, C. E. Shuart. 1948. A study of multiple births in a Holstein-Friesian herd. J. Dairy Sci. 31:241.
12. Pursley JR, Fricke PM, Garverick HA, Kesler DJ, Ottobre JS, Stevenson JS, Wiltbank MC. 2001. Improved fertility in anovulatory lactating dairy cows treated with exogenous progesterone during Ovsynch. J Dairy Sci abstract submitted.

13. Pursley, J. R., M. R. Kosorok, and M.C. Wiltbank. 1997a. Reproductive management of lactating dairy cows using synchronization of ovulation. J. Dairy Sci. 80:301.
14. Pursley, J. R., M. C. Wiltbank, J. S. Stevenson, J.S. Ottobre, H. A. Garverick, and L. L. Anderson. 1997b. Pregnancy rates per artificial insemination for cows and heifers inseminated at a synchronized ovulation or synchronized estrus. J. Dairy Sci. 80:295.
15. Ryan, D. P., and M. P. Boland. 1991. Frequency of twin births among Holstein-Friesian cows in a warm dry climate. Theriogenology 36:1.
16. Senger, P. L. 1994. The estrus detection problem: new concepts, technologies, and possibilities. J. Dairy Sci. 77:2745.
17. Spalding, R. W., R. W. Everett, and R. H. Foote. 1974. Fertility in New York artificially inseminated Holstein herds in dairy herd improvement. J Dairy Sci 58:718.
18. Stevenson, J. S., and E. P. Call. 1983. Influence of early estrus, ovulation, and insemination on fertility in postpartum Holstein cows. Theriogenology 19:367.