Reproductive Management of Cows in High-Producing Herds

Jeffrey S. Stevenson

Department of Animal Sciences and Industry, Kansas State University, Manhattan 66506-0201
Email: jstevens@oznet.ksu.edu

■ Take Home Message

- Challenges facing high milk-producing cows limit their reproductive efficiency: interrelationships among body condition, DM intake, transition from the dry period to lactation, onset of normal estrous cycles, detection of estrus, and embryonic survival.
- Attention is required to details associated with diet formulation; feed bunk management; cow comfort in free stalls, holding pen, and milking parlor during extremes of temperature and humidity; proper hoof care; milking management and mastitis prevention; control of ovulation and estrus; and early nonpregnancy diagnosis.
- Body condition should be monitored more closely to reduce dry cow and transition problems and prevent prolonged anestrus by maximizing early postpartum DM intakes.
- Cow comfort should be monitored more closely to minimize standing time for milking, maximize standing time for estrus and feed intake, and maximize resting time for rumination and more efficient milk synthesis.
- Strategies to impregnate high-producing cows will require more ovulation control before first and subsequent services without detection of estrus.
- Many of the reproductive technologies used today, including programmed breeding, will be refined and incorporated into the management of cows on fewer dairy farms with more cows per farm.
- Despite trends for longer lactations associated with bST and lesser pregnancy rates, renewed lactations following parturition will continue to be essential for herd longevity of cows.

Introduction

Reproductive inefficiency of dairy cattle causes great frustration for dairy producers. Even under optimal conditions, the reproductive process is less than perfect because of the multiple factors involved in producing a live calf. To manage the complexities of the estrous cycle and the annual reproductive cycle, understanding of many interrelated physiological functions is critical. Further, reproductive efficiency involves successful management of not only the cows but also the people who milk, feed, house, inseminate, and care for them.

Conception rates of lactating dairy cows in the U.S. have declined since the 1950's (Butler and Smith, 1989), whereas annual milk yield per cow has increased 3.3 times from 2410 to 8061 kg. Based on a sample of dairy cows in the U.K., fertility declined from 1975-1982 to 1995-1998 (Royal et al., 2000). During that period, pregnancy rates after first services decreased from 56 to 40% despite similar intervals to first service, whereas calving intervals increased from 370 to 390 days. Given the inverse relationship between milk yield and fertility, it is no wonder that a genetic antagonism exists between some reproductive traits and milk yield, which is manifested particularly in first-lactation cows (Hansen et al., 1983). However, sound management practices have overcome this inverse relationship to achieve acceptable rates of reproductive efficiency.

Efficient reproduction in a dairy herd is the primary determinant of profitability. Based on a 300-cow Michigan dairy herd, decreasing days to first service from 80 to 60 days, increasing efficiency of detected estrus from 50 to 60%, and increasing conception rates from 35 to 50%, combined to yield an increased net income of $18,485 (Hady et al., 1994). Although the benefits of improving reproduction are apparent, specific causes of poor reproductive performance are difficult to identify and not resolved easily. To improve reproductive efficiency, the limiting factors must be identified. In general, detecting estrus is the major limitation to achieving a pregnancy. But once insemination occurs, two sources of pregnancy failure exist, which include, but are not limited to, fertilization failure and embryonic death. Fertilization failure follows procedures or practices that fail to facilitate union of a viable egg with a viable sperm. Once fertilization occurs, embryonic death results from failure of normal embryonic development, recognition of pregnancy, or normal maintenance of pregnancy.

To maximize the chances of a renewed pregnancy for every heifer or cow that calves into the herd, a number of important time-dependent components of the estrous cycle must be managed. It is critical to understand each component of the estrous cycle as well as the annual reproductive cycle (calving interval) and determine where limited time and resources might be concentrated best to reach AI-breeding goals. Maximal reproductive efficiency requires management of the calving interval. This consists of three major components:

the elective waiting period, the active AI-breeding period, and gestation (including the dry period) plus their various integral parts (Figure 1).

■ Elective Waiting Period

The first component of a calving interval (Figure 1) is the traditional rest period or the elective waiting period (EWP). The duration of this period is partly a management decision. This period varies from 40 to 70 days on most farms. Part of its duration is based on the physiological need for the reproductive tract of the cow to undergo a healing process or involution. Some, but not all studies, indicate that longer elective "rest" periods improve conception rates possibly because of improvements of various uterine traits. Research indicates that when cows calve without complication, this healing process requires no more than 40 days. Involution includes macro- and microscopic changes that prepare the reproductive tract, especially the uterus, for a renewed pregnancy.

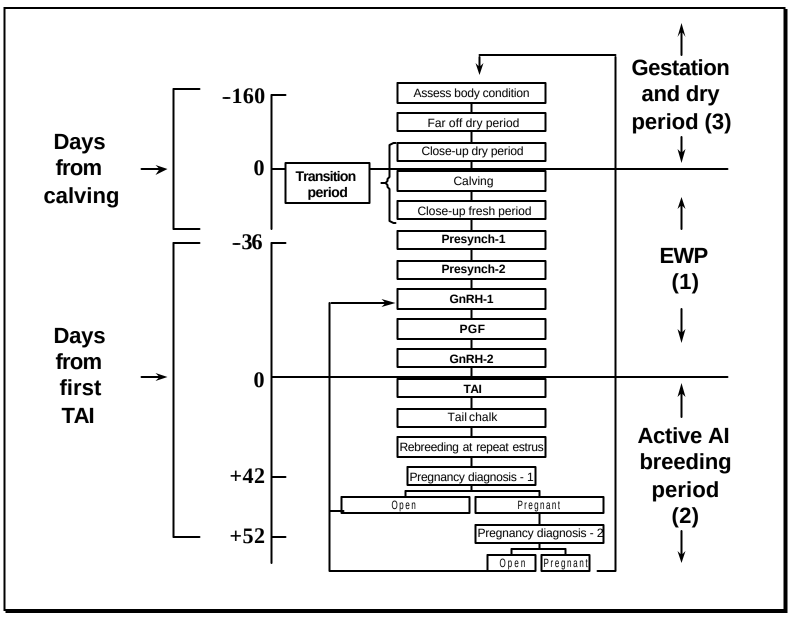

Figure 1. Components of a calving interval consisting of 1) the elective waiting period (EWP); 2) the active AI-breeding period; and 3) gestation and the dry period. Various management elements are illustrated that lead to reproductive management and programming of the annual reproductive cycle or calving interval. Presynch-1 and Presynch-2 are injections of $PGF_{2\alpha}$.

Periparturient Period

Parturition in the cow is a process that requires attention, care, and cleanliness. The risk for death is greater at calving than at any other period of the life cycle. A multitude of calving-related disorders predispose cows to ill health, loss in milk production, and reduced reproductive efficiency (Stevenson and Call, 1989). Whatever can be done to reduce one or more of these disorders will result in the reduced incidences of other disorders because of their strong interrelationships. A number of important physiological adaptations must occur during the EWP. The cow must adapt to the increased demand for nutrients by the mammary gland because of the onset of lactogenesis (Bauman and Currie, 1980). During late gestation, the feto-placental unit is a major nutrient consumer and orchestrates a homeorhetic priority of nutrient utilization (Bell, 1995). Once parturition occurs, the mammary gland becomes the major nutrient user. As a result, an energy prioritization is manifested that places higher priorities on use of nutrients for maintenance and growth (younger cows) of the cow and for milk secretion than for the onset of estrous cycles and the initiation of a new pregnancy. Cows that consume less DM than their contemporaries have delayed first ovulation and first estrus after parturition, produce less milk, and are less fertile (Staples et al., 1990).

Close-up Fresh Period

It is no wonder that newly calved or close-up fresh cows have been the focus of new veterinary intervention and needed research (Drackley, 1999). It is becoming commonplace for well-managed large dairies to isolate newly fresh cows into a transition fresh pen where they are monitored daily for body temperature and visible symptoms of illness during the first 2 weeks after calving. Various hand-held spectrophotometers (e.g., PalmLab, Inc., Madison, WI) are available and can be used to monitor blood concentrations of various metabolites such as BUN, Ca, P, Mg, K, glucose, NEFA's, and -hydroxy butyrate. The pharmaceutical products commonly are used for treatment of close-up fresh cows include fever reducers, uterine contractors, energy providers, calcium sources, and systemic antibiotics (Upham, 1997). Unfortunately, little research is available to validate their efficacy or their economic returns. It is logical to assume, however, that whatever stimulates DM intakes and prevents ill health for close-up fresh cows by providing more available nutrients for reproductive processes will prove beneficial to the cow once maintenance, growth, and milk production requirements are satisfied.

Onset of Estrous Cycles

A recent review (Stevenson et al., 1997) of the factors limiting the onset of estrous cycles in lactating cattle cited a number of events that must occur before cows begin estrous cycles after calving. Ovarian follicular waves are reinitiated within the first week after parturition, and the first dominant follicle usually ovulates. Because follicular waves begin soon after calving, concentrations of blood FSH are sufficient, but a major limiting factor to ovulation is the reinitiation of adequate LH secretion in the form of hourly LH pulses to support final follicular maturation and subsequent ovulation of a dominant follicle.

The stimulation of appetite to ensure adequate DM intake in normal, healthy cows is essential to provide nutrients for maximizing milk secretion, follicular growth, ovulation, uterine involution, and the initiation of pregnancy. However, lactating dairy cows experience a postpartum negative energy balance that reaches its nadir during the first or second week after calving and recovers at a variable rate. The first ovulation occurs approximately 10 to 15 days after the nadir of energy balance and sometime before the peak in daily milk secretion (Zurek et al., 1995). During high milk production in early lactation when metabolic demands are enormous, major amounts of nutrients are required for mammary synthesis of lactose, protein, and triglycerides that cannot be met by dietary intake (Bell, 1995). Normally, peak DM intakes are achieved just after or coincident with zero energy balance (approximately 7 weeks) and after peak daily milk secretion. In the face of these nutrient deficits and negative energy balances, it is no wonder that conception rates are <50% in lactating dairy cows inseminated during the first 100 DIM. Nevertheless, dairy cows with greater DM intake, despite having a negative energy balance, produced more milk, lost less BW, and ovulated earlier postpartum than those with lower intakes (Staples et al., 1990; Zurek et al., 1995). Further, cows with greater intakes also reached the nadir of energy balance earlier and experienced a more severe, but shorter, period of negative energy balance, suggesting that when cows are more efficient in partitioning dietary and stored nutrients toward milk synthesis, they are also better able to recover ovarian cyclicity. Therefore, reestablishment of estrous cycles is correlated highly with the reinitiation of hourly LH pulses, and the onset of these LH secretory patterns is related to the timing of the postpartum nadir of energy balance.

In contrast to the majority of reports of first postpartum ovulations in milked cows occurring by the end of the first month after calving (Stevenson and Call, 1989; Stevenson et al., 1997), our recent findings (Table 1) indicate that a variable proportion of lactating cows have not initiated estrous cycles before the end of the EWP. Our studies indicate that 4 to 58% (average = 24%) of 1,314 cows have low concentrations of progesterone in blood serum and yet are anestrus by 40 to 97 DIM (Table 1).

Table 1. Proportion of lactating dairy cows that had elevated concentrations of progesterone in blood serum prior to timed inseminations after various programmed breeding protocols[1]

Season	No. of cows	Days in milk prior to insemination	Lactation number	
			1	2+
			----- % cycling -----	
Fall-Winter-Spring				
Herd A	284	48-68	88	86
Herd B	394	40-60	72	87
Winter-Spring	251[2]	47-67	42	50
Summer				
Herd A	66	63-83	96	85
Herd B	198[2]	57-97	83	87
Herd C	121	56-76	77	86

[1]Based on samples collected at least twice between 7 and 10 days before prostaglandin F2 was administered (2 to 5 days before AI).

[2]Cows were milked thrice daily.

Programmed Breeding

Programmed breeding is a method to schedule and control the insemination program of lactating cows in the herd. The advantages for programming estrous cycles include: 1) convenience of scheduling labor and tasks; 2) controlling the occurrence of estrus, ovulation, or both; and 3) knowing the stage of the estrous cycle and reproductive status of groups of cows in the herd. These reproductive statuses include: 1) open cows scheduled for first services; 2) open cows scheduled to be reinseminated; 3) open cows designated as culls; and 4) cows confirmed pregnant. Therefore, programmed breeding can be applied to at least two distinct groups of cows: 1) those that are scheduled for their first postpartum inseminations and 2) those that are open at pregnancy diagnosis but are reprogrammed to be inseminated.

Once a system is in place to identify cows and heifers that satisfy those criteria for inclusion in one of those two reproductive statuses, then the specific programmed breeding system can be fit into a management sequence. At least three programs are commonly in use on the U.S. dairy farms: 1) Targeted Breeding™; 2) Ovsynch™; and 3) Presynch + Ovsynch.

■ Active AI-Breeding Period

The second component of the calving interval is the period of time between the end of the EWP and when the first or subsequent estrus is detected followed by AI and eventual conception (Figure 1). The duration of this period is a function of the estrus-detection rate and the level of individual cow fertility. Whether or not hormones are used to induce estrus before first and subsequent services, the percentage of cows detected in estrus depends on the efficiency of detecting estrus in all cows (Stevenson, 2000b). The level of cow fertility depends upon a number of factors, including the fertility of the service sire, correct thawing and handling of semen, AI-breeding technique, and timing of insemination. Level of fertility and estrus-detection rates are rate limiting to the establishment of pregnancy in a timely fashion.

Detection of Estrus

The greatest limiting factor to successful fertilization is detection of estrus. Approximately 50% of the estrous periods go undetected on the average dairy farm in the U.S. (Stevenson, 2000b). Two important challenges exist for detecting estrus: accurately recognizing signs of estrus and identifying all possible periods of estrus in breeding heifers and cows. One might be quite accurate in detecting cows in estrus but still have a major estrus-detection problem because too many estrous periods go unobserved. Problems are caused by a lack of diagnostic accuracy (errors of commission) and a lack of efficient detection of all periods of estrus (errors of omission). Based on elevated progesterone on the day of AI, detection errors of commission range from 2 to 60% in some herds (Stevenson, 2000b). The value of improved estrus detection was estimated to range from $6 to $83/yr when the probability for increasing estrus detection increased from 60 to 70% or from 20 to 30%, respectively (Pecsok et al., 1994). The wide range of values occurred with fixed costs and prices so that fluctuating prices, would introduce further variation in the financial benefits.

Is detection of estrus more difficult in higher milk-producing herds? Surveys of DHI data usually find that herds with greater rolling herd averages for milk also have greater rates of detected estrus (Heersche and Nebel, 1994). Further, in a few studies in which estrus-detection rates and milk production have been reported, the results are equivocal (Fonseca et al., 1983; Harrison et al., 1990). Anecdotal observations indicate that higher producing cows are more difficult to detect in estrus. However, because movement of more cows into confinement has occurred concomitantly with increased milk yield, current estrus-detection rates with less than ideal footing conditions (Britt et al., 1986) and increased milk yield per cow are confounded. Research is warranted to determine whether increased production *per se* has reduced rates of detected estrus.

Clinical Mastitis and Abortions

Evidence is mounting that cows with mammary infections are predisposed to early pregnancy losses because of disruption of normal luteal maintenance (Stevenson, 2000a). Cows that had clinical mastitis during the first 45 days of gestation were at 2.7 times greater risk for abortion during the next 90 days than cows without mastitis. The risk was greatest for cows that conceived early in lactation. Several reproductive traits (days to first service, days open, and services per conception) were impacted negatively in cows with clinical mastitis compared to healthy controls. This phenomenon was manifested when both Gram-negative and Gram-positive pathogens were isolated from milk secretions of cows with clinical mastitis. The mechanism by which mastitis interferes with pregnancy and other reproductive traits is related to the secretion of PGF_2 . This evidence includes: 1) quarters of cows experimentally induced with coliform mastitis have greater concentrations of PGF_2 in their milk than control quarters and 2) i.v. endotoxin infusion increased concentrations of blood plasma prostaglandins, thromboxane B_2, and cortisol, whereas concentrations of progesterone were decreased.

■ Gestation and Dry Period

The third component of a calving interval is gestation, including the dry period (Figure 1). The duration of gestation is fairly constant and cannot be shortened significantly without adversely affecting the health or viability of the newborn. Evidence supports the concept that the dry period is a critical component to subsequent performance of dairy cows rather than an insignificant rest period between lactations. Nutrients required during this period include the maintenance and growth of the cow plus that required by the developing feto-placental unit (pregnancy requirement; Bell, 1995). The diet for the far-off dry period should be balanced for high fiber and less energy density, whereas that for the close-up dry period should contain higher energy density with less fiber (Van Saun, 1991). During the last 10 days before parturition, DM intakes decrease significantly (Bertics et al., 1992) and restrict nutrient intake during a time of increasing demand for protein, energy, and other nutrients by the feto-placental unit and the maternal tissues. Preventing this prepartum decline in DM intake by placing feed refusals into ruminal cannulae of late-gestating cows tended to increase their subsequent milk yield during the first 4 weeks of lactation (Bertics et al., 1992).

■ Summary and Conclusions

Components and parts of the calving interval outlined in Figure 1 illustrate the key management steps in maintaining reproductive efficiency in the dairy herd.

Successful reproduction begins in the previous pregnancy with assessment of body condition about 5 mo before parturition or 3 mo before dry-off. Changes should be made in the nutrition program to allow cows to reach the appropriate BCS ($\cong$3.5) by dry-off. The far-off and close-up dry period nutrition and vaccination programs must be managed well. Balanced nutrition and health of the transition cow are keys to maximal DM intakes after calving. Maximal DM intakes ensure that milk yield, onset of estrous cycles, and initiation of pregnancy can occur in a timely manner, if the programmed breeding protocols and good detection of estrus are in place. Use of the Presynch + Ovsynch program is likely to be the most efficient way to prepare clusters of cows for their best chance to conceive at first AI service. Using tail chalk or other sophisticated electronic detection aids to identify normal returns to estrus at 18 to 24 days after TAI will ensure greater return rates of cows not pregnant to the first TAI. For those open cows not detected in estrus, weekly pregnancy diagnosis by ultrasonography or palpation is critical to resynchronize open cows by applying a TAI program such as the Ovsynch protocol. Once diagnosed pregnant twice, these cows should be safely pregnant with little further fetal losses after 98 days.

Factors governing reduced reproductive performance in dairy cattle are numerous and often difficult to diagnose. In general, those factors resulting from inadequate detection of estrus or fertilization failure (e.g., semen handling, and AI techniques) are resolved more easily than those related to embryonic death. Although detection of estrus and timing of insemination require more labor and common sense, they are more manageable than many causes of embryonic death. Although diagnosing those causes may be difficult, they usually are related to some source of stress experienced by the lactating cows. A continuous effort should be focused on reducing various stressors that lower reproductive efficiency.

■ References

Bauman, D. E., and W. B. Currie. (1980) Partitioning of nutrients during pregnancy and lactation: a review of mechanisms involving homeostasis and homeorhesis. J. Dairy Sci. 63:1514-1529.

Bell, A. W. (1995) Regulation of organic nutrient metabolism during transition from late pregnancy to early lactation. J. Anim. Sci. 73:2804-2819.

Bertics, S. J., R. R. Grummer, C. Cadorniga-Valino, and E. E. Stoddard. 1992. Effect of prepartum dry matter intake on liver triglyceride concentration and early lactation. J. Dairy Sci. 75:1914-1922.

Britt, J. H., R. G. Scott, J. D. Armstrong, and M. D. Whitacre. (1986) Determinants of estrous behavior in lactating Holstein cows. J. Dairy. Sci. 69:2195-2202.

Butler, W.R., and R. D. Smith. (1989) Interrelationships between energy balance and postpartum reproductive function in dairy cattle. J. Dairy Sci. 72:767-783.

Drackley, J. K. (1999) Biology of dairy cows during the transition period: the final frontier? J. Dairy Sci. 82:2259-2273.

Fonseca, F.A., J. H. Britt, B. T. McDaniel, J. C. Wilk, and A. H. Rakes. (1983) Reproductive traits of Holsteins and Jerseys. Effects of age, milk yield, and clinical abnormalities on involution of cervix and uterus, ovulation, estrous cycles, detection of estrus, conception rate and days open. J. Dairy Sci. 66:1128-1147.

Hady, P. J., J. W. Lloyd, J. B. Kaneene, and A. L. Skidmore. (1994) Partial budget model for reproductive programs of dairy farm businesses. J. Dairy Sci. 77:482-491.

Hansen, L. B., A. E. Freeman, and P. J. Berger. (1983) Yield and fertility relationships in dairy cattle. J. Dairy Sci. 66:293-305.

Harrison, R. O., S. P. Ford, J. W. Young, A. J. Conley, and A. E. Freeman. (1990) Increased milk production versus reproductive and energy status of high producing dairy cows. J. Dairy Sci. 73:2749-2758.

Heersche, G. W., and R. L. Nebel. (1994) Measuring efficiency and accuracy of detection of estrus. J. Dairy Sci. 77:2754-2761.

Pecsok, S. R., M. L. McGilliard, and R. L. Nebel. (1994) Conception rates. 1. Derivation and estimates for effects of estrus detection on cow profitability. J. Dairy Sci. 77:3008-3015.

Royal, M. D., A. O. Darwash, A.P.F. Flint, R. Webb, J. A. Woolliams, G. E. Lamming. (2000) Declining fertility in dairy cattle: changes in traditional and endocrine parameters of fertility. Anim. Sci. 70:487-501.

Staples, C. R., W. W. Thatcher, and J. H. Clark. (1990) Relationship between ovarian activity and energy status during the early postpartum period of high producing dairy cows. J. Dairy Sci. 73:938-347.

Stevenson, J. S. (2000a) Mastitis disrupts conception more than you think. Hoard's Dairyman 145:666-667.

Stevenson, J. S. (2000b) A review of oestrous behaviour and detection in dairy cows. Anim. Sci. In press.

Stevenson, J. S., and E. P. Call. (1989) Reproductive disorders in the periparturient dairy cow. J. Dairy. Sci. 71:2572-2583.

Stevenson, J. S., G. C. Lamb, D. P. Hoffman, and J. E. Minton. (1997) Interrelationships of lactation and postpartum anovulation in suckled and milked cows. Livest. Prod. Sci. 50:57-74.

Upham, L. (1997) Managing the post-partum cow: Minimizing the costly effects of post-partum disease complex requires close observation and rapid treatment during the first 10 days fresh. Western Dairyman 78:20, 24, 26.

Van Saun, S. J. (1991) Dry cow nutrition. The key to improving fresh cow performance. Vet. Clin. North Am. Food Anim. Pract. 7:599-620.

Zurek, E., G. R. Foxcroft, and J. J. Kennelly. (1995) Metabolic status and interval to first ovulation in postpartum dairy cows. J. Dairy Sci. 78:1909-1920.