

Factors To Improve Reproductive Management and Getting Cows Pregnant

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Introduction

The dairy industry of the 21st century continues to change as numbers of dairy herds continue to decrease in the U.S. while numbers of cows increase per farm (Lucy, 2001). Management of more cows per person is common place and greater pressure is placed on cows as they are moved into confinement onto concrete alleys from the natural pasture environment of days gone by. Detecting estrus in lactating cows is a greater challenge because of limited space for cow-to-cow interactions and less-sure footing surfaces. Increased milking frequency increases time away from free stalls and the feed bunk. This time away limits rest and feeding time. All of these factors have impacted conception rates because they have declined during the last 20 years (Lucy, 2001), not only in the U.S., but elsewhere. Even in the U.K., where cows produce much less milk, conception rates have declined about 1% per year since 1983 (Royal et al., 2000).

A number of factors influence overall pregnancy rates of dairy cows. These factors can be divided into two groups: 1) heat-detection or AI submission rates; and 2) conception rates. The mathematical product of these two rates define pregnancy rate. The objective of this report is to identify and describe some of those factors that interact to determine herd pregnancy rates.

Definitions

What is pregnancy rate as it is defined today? This subject is quite confusing until you understand the basis for these definitions. Traditionally, we define conception rates and pregnancy rates as the number of pregnancies achieved per unit of time. The unit of time could be a week, a month, or between pregnancy diagnosis periods. Conception rate is defined as the number of cows that became pregnant after insemination divided by the number of cows inseminated during some defined period of time.

Let's use a simple example of one breeding week in which we give a PGF₂ injection on Monday morning, checked for estrus, and inseminated those detected in heat. Let A = the number of cows given PGF₂ and attempted to AI (10 cows); B = number of cows detected in heat and inseminated (8 cows); and C = number of cows diagnosed pregnant (4 cows). Heat detection rate or AI submission rate is $8 \div 10$ or 80%. Conception rate = $C \div B = 4 \div 8$ or 50%. Pregnancy rate for that period is the number of cows diagnosed pregnant divided by the number *attempted* to AI. Pregnancy rate = $C \div A = 4 \div 10$ or 40%. The difference between the two measures is the 2 cows that were not detected in heat and not AI-bred. Pregnancy rate counts those 2 cows as open or zero conception rate. Pregnancy rate is the product of conception rate $\times$ heat detection rate (or AI submission rate) or $0.8 \times 0.5 = 0.4$ or 40%.

Let's expand our example to include a second group of cows to which we applied the Ovsynch protocol. In other words, we will inseminate all cows whether or not they show heat. So the AI submission rate is 100%. Let's say we get 4 cows to conceive. Conception rate = $C \div B = 4 \div 10$ or 40% and pregnancy rate = $C \div A = 4 \div 10$ or 40%. The reason these rates are similar is because we inseminated all cows, and therefore, conception rate is exactly equal to pregnancy rate. So when timed AI is used and we AI-breed all cows, conception rate is identical to pregnancy rate. This is often what researchers measure when doing studies in which fertility is assessed after a single AI.

When people refer to pregnancy rates of 13 to 14%, they are referring to a continuous pregnancy rate that is similar to a rolling average. After the end of the voluntary waiting period (VWP), each open cow always has a pregnancy rate of 0 until she becomes pregnant. So if she is not detected in heat at the expected time 21 days after her last insemination, she continues to have a pregnancy rate of 0. Therefore, poor rates of heat detection reduce pregnancy rate, because you have missed an opportunity to inseminate each cow when not detected in heat every 21 days. So if you are only detecting 50% of all expected heats every 21 days and conception rates of those you AI-breed is 30%, pregnancy rate = $0.5 \times 0.3 = 15\%$.

Therefore, you can see why pregnancy rates when measured on a rolling, continuous basis can be less than 20%. What influences pregnancy rate is the percentage of cows re-inseminated at each eligible heat every 21 days (heat detection or AI submission rate) and the actual fertility or conception of each AI-breeding. If heat detection and conception rate are quite low, pregnancy rate is low because it is the product of these two measures. Two pregnancy rates can be identical (16%) in two different herds, but caused by two different conditions. In one herd, heat detection rate (AI submission rate) may quite high (80%), but actual conception of those inseminations is very low (20%); pregnancy rate = $0.8 \times 0.2 = 16\%$. In a second herd, AI submission rate may be low (40%), but actual conception is greater (40%); pregnancy rate = $0.4 \times 0.4 = 16\%$. Most dairy record processing centers now report this running pregnancy rate as do other management software programs such as Dairy Comp.

Factors Affecting AI Submission Rates

Table 1 lists several factors that can be considered to affect AI submission and conception rates. This is not an exhaustive list, but identifies the major bottlenecks to improving pregnancy rates. The goal is to increase the number of breeding females that are identified correctly at each eligible heat period.

Heat Detection

The relationships between estrogen secretion, onset of estrus and the LH surge, and ovulation is illustrated in Figure 1. As a follicle matures, more estrogen is secreted by the follicle cells that eventually cause a peak in circulation. This triggers the onset of the pre-ovulatory surge of LH secretion, which initiates final follicle maturation and eventual ovulation. This process requires about 27 h from initial increase in blood LH to the rupture of the follicle wall and exclusion of the oocyte into the waiting oviduct. The purpose for the increased titers of estrogen is to trigger the hormonal cascade of events including the LH surge and various follicular changes that facilitate ovulation in addition to initiating sexual behaviors that are associated with mating.

The cardinal sign of estrus is the standing immobile posture assumed by the cow when approached from the rear and mounted. The amount of standing behavior or standing heat is a function of the number of other “receptive” females with which the estrual female may interact. Figure 2 illustrates that the number of standing events increases as the number of females in heat increases (up to 3 or 4 interacting cows in the same pen; Hurnik et al., 1975). More than 90% of the cows that show standing behavior are truly in heat. Further, a large variation exists in the number of standing events per cow (1 to 179 per estrus). As many as 179 observed standing events have been detected. If estrus is 18 hours in duration, then that cow would stand nearly 10 times per hour or once every 6 minutes! No one should miss seeing that cow. The cow that stands only a few times is the one usually missed. The average individual standing event is about 2.5 seconds in duration (Stevenson, 2001a). Even if the cow stands 10

times during a 10- to 12-hour heat period, that represents only 25 seconds! It is a wonder that we see as many cows as we do.

The inclination to mount is stage-of-cycle dependent (Helmer and Britt, 1985). In other words, breeding females that are either pregnant or in the luteal phase of the cycle (under progesterone dominance), are less inclined to mount other females that are in heat. Nearly 86% of the mounting females are in proestrus or estrus (under estrogen dominance). Therefore, it is essential that open females be penned with other open females for maximum sexual behavioral interactions. Housing and footing play key roles in their “desire” to mount and stand (Vailes and Britt., 1992). When given a choice of footing environments, cows in estrus will spend 73% of their time on a dirt rather than on a concrete surface. Mounting activity of cows increases by 3 to 15 times on dirt compared with concrete. Duration of estrus and individual standing events of cows also are greater on dirt than on concrete.

Various heat-detection aids have been compared with visual observation (Stevenson, 2001a). Table 2 illustrates the accuracy and efficiency of various aids in addition to the amount labor necessary to maintain them (Heersche and Nebel, 1990). Accuracy represents the correct diagnosis of heat by the heat-detection aid. Efficiency measures the proportion of all heat activity that is detected by the aid. Tail paint or tail chalk is less expensive compared with heat mount patches, but each requires daily monitoring. Interpretation of chalk marks or heat mount patches is the real key to making them a useful part of a heat-detection program. When the chalk marks are rubbed off since the last heat check, you can be reasonably certain that the female was mounted excessively. Most experienced AI technicians examine the cow for other signs of estrus and palpate the uterus for evidence of tone and presence of mucus to confirm the possibility of estrus.

More expensive and more permanent technologies include pedometry and the electronic HeatWatch pressure-sensitive heat mount detectors (Stevenson, 2001a). The latter two technologies are more efficient in detecting activity that often goes unseen than the less costly aids described above. Pedometers have been utilized to measure activity or motion of the cow by a miniaturized microprocessor memory chip embedded in the device that is mounted on an ankle or neck band. Research has demonstrated that a cow in heat walks (moves) more than four times that of a cow not in heat. Some of these devices are on the market and can be read manually or automatically when the cow moves through the milking parlor or read by antenna receivers placed near cow pens. The information is integrated into a computer and compared with the individual baseline activity of the same cow during a similar interval in the previous 2 or 3 days. If the cow's activity has increased significantly then the cow is identified by blinking lights on the ankle device or is flagged in a computer-generated report to alert the manager to examine further this cow for possible signs of heat. Research with this type of device indicates that fertility based on pedometer readings is comparable with that of cows observed in standing heat.

When mounted, the electronic HeatWatch pressure-sensitive heat mount detector sends a radiotelemetric signal to an antenna located outside the pen and is integrated into a computer software system. The signal includes the cow identification, time, date, and duration of the standing event. Using such devices in heifers, we have found them to be very accurate for identifying those with short heat periods and few standing events. In fact, when comparing the accuracy of identifying heat in 49 estrus-synchronized heifers, the accuracy of the herdsman was equal to that of the device (100%), but the herdsman missed seeing estrus in 13 out of 49 heifers (26%), whereas the electronic heat mount device identified all heats (Stevenson et al.,

1996). This type of device has the potential of increasing the efficiency of heat detection (catching all possible heats) compared with simple observation of cows by more conventional methods.

Remember that all heat-detection aids require judicious management and interpretation by knowledgeable cow people. People are the MOST important component in any heat detection and AI program. Let's not forget the tried and tested "eyeball" technique, which requires cow-watching time, and exercising good judgment. No matter what technique is employed, success of heat detection programs requires dedicated, observing people. Good heat detection increases the number of eligible cows to be inseminated or re-inseminated each week (i.e., increases AI submission rates).

Timed AI Programs before First Services

The Ovsynch protocol consists of a 100- μ g injection of GnRH given 7 days before a PGF₂ injection, and then a second 100- μ g injection of GnRH administered 48 hours after PGF₂, with one TAI given 0 to 24 hr later (Pursley et al., 1998; Figure 3). The first GnRH injection alters follicular growth by inducing ovulation of the largest follicle (dominant follicle) in the ovaries after the GnRH injection to form a new or secondary corpus luteum (CL; Pursley et al., 1995). Thus, estrus usually does not occur until after a PGF₂ injection regresses the natural CL and the secondary CL (formed from the follicle induced to ovulate by the first GnRH injection). Therefore, a new group of follicles appears in the ovaries (based on transrectal ultrasonographic evidence) within 1 to 2 days after the first injection of GnRH. From that new group of follicles, a newly developed dominant follicle emerges, matures, and can ovulate after estrus is induced by PGF₂ or it can be induced to ovulate after a second injection of GnRH. The GnRH injections release pituitary luteinizing hormone (LH), the natural ovulation-inducing hormone of the estrous cycle. Few cows will show heat in this program. About 8 to 16% may show heat around the time of the PGF₂ injection (Stevenson et al., 1999). If so, those cows should be AI-bred according to the a.m.-p.m. rule and the second GnRH injection eliminated.

Using Ovsynch during any season allows all cows to be inseminated that are set up properly using the correct hormonal sequence. But particularly helpful is its application during summer when greater difficulty exists in detecting estrus. Results in Figure 4 illustrate that when estrous cycles of control lactating cows were synchronized by injecting GnRH 7 days before a PGF₂ injection and then observed for estrus, only 59% of the cows were detected in heat and inseminated during the week following PGF₂ injection (Cartmill et al., 2001). In contrast, by design, all cows were inseminated to which the Ovsynch protocol was applied. Although conception rates were similar (32 vs. 33%), more cows conceived in the Ovsynch group (greater pregnancy rates) because 41% more cows were inseminated. The bottom line is that more cows become pregnant because AI submission rate was increased.

Frequency of Pregnancy Checks

Pregnancy checks ought to be done weekly rather than every 2 weeks or monthly. How else are you going to promptly find the open cows? That is our objective! If you are doing a good job with heat detection, you should be able to detect cows in heat at their first eligible heat after AI. For example, if heat detection rate is 50%, you should identify 50% of the cows in estrus 19 to 23 days after AI. The pregnancy status of the remaining cows will not be known until pregnancy diagnosis. At that time, start those open cows on the Ovsynch protocol. This technique will allow these open cows to be re-inseminated within 9 to 10 days after they are found not pregnant or 45 to 50 days after their last AI (depends on how early pregnancy

diagnosis begins). If they are detected in heat at any time after the Ovsynch protocol is initiated, simply AI those cows and discontinue the protocol.

Figure 5 illustrates the results of two such treatment protocols for cows found not pregnant at pregnancy diagnosis. Either the Ovsynch or Heatsynch protocols were applied to these cows. In either case, the subsequent conception rates of cows were similar. Unfortunately, estradiol cypionate is no longer for sale in the U.S. market.

The important point is that the cows were re-inseminated as soon as possible. When nothing is done with those open cows very few get rebred or pregnant. If you are depending on your DHI or other software like Dairy Comp to print out a list of open cows for rebreeding, make certain you have activated those cows or engaged the re-enroll command. If not, that is a costly mistake. On a recent visit to a large herd, one consultant found nearly 300 open cows on the “sidelines” because of this very problem: the command for re-enrolling open cows was not setup properly. As a result, those cows, unless seen in heat, were not in the rebreeding system.

Resynchrony of Repeat Services

One option is to give all inseminated cows an injection of GnRH one week (7 days) before pregnancy diagnosis (all cows regardless of pregnancy status are treated with GnRH). This can be done regardless of when pregnancy diagnosis is conducted. In one study, GnRH was injected on day 21 after TAI and pregnancy diagnosis was conducted on day 28 by transrectal ultrasonography. Cows found open were given PGF₂, then injected with GnRH 48 hours later, and inseminated 16 hours after GnRH. Control cows found open at pregnancy diagnosis were treated with the first GnRH injection of the Ovsynch protocol (i.e., one week later than the treated cows). Conception rates of cows that were found pregnant did not differ (33.1 vs. 33.6%), so GnRH given to pregnant cows did no harm. Although conception rates of those cows inseminated within 3 days after open diagnosis were not different from those of controls inseminated 10 days after open diagnosis (28 vs. 27%), the treated cows were inseminated 1 week earlier.

Another study (Fricke et al., 2003) followed the same logic, but all cows of unknown pregnancy status were injected with GnRH on either day 19, 26, or 33 after TAI and pregnancy was then diagnosed 7 days later, on days 26, 33, and 40, respectively (Figure 6). Pregnancy rates of the cows found pregnant on days 26 and 33 were greater than those identified on day 40. This decrease was not treatment related, but is a consequence of embryo loss that naturally occurs between day 26 and 40. The resulting conception rates of cows re-inseminated by TAI on day 29 were less than those re-inseminated on days 36 and 43. This difference is likely related to the poorer follicle synchrony that occurs in cows in which GnRH was given on day 19 (proestrus) than for those on days 26 (metestrus) and 33 (mid-diestrus).

Remember the best and least costly approach to getting these repeat cows pregnant is to practice intense heat detection about 19 to 24 days after the most recent AI-breeding. This practice allows inter-insemination intervals to approximate the duration of one estrous cycle. All of the protocols described above have advantages and disadvantages. Don't miss the mark by missing those first eligible heats and increase AI submission rates!

Factors Affecting Conception Rates

Proper Handling and Placement of Semen

Thawing semen at the proper temperature according to each AI company's recommendation is critical to maximizing post-thaw survivability and motility of sperm. Preventing "cold shock" of the thawed sperm is done by preventing a decrease in temperature of the semen. It only takes about 30 seconds for semen in a plastic straw to drop from 35°C to room temperature (23°C). Warm the AI gun and maintain thawed temperature of semen until the gun is inserted into the vagina. Don't thaw and load more AI breeding guns than you can inseminate in 10 minutes. Take precautions to maintain cleanliness of all AI equipment (thaw box, AI guns, scissors or straw cutter, etc.). Don't attempt to AI-breed too many cows on one day to prevent arm fatigue.

Improper placement of the semen in the reproductive tract can be a limiting factor when the technician is unsure where the tip of the breeding gun is placed upon deposition of semen. Research demonstrated that fewer numbers of motile sperm gain access to the oviduct when semen is placed in the cervix. The target for insemination is the uterine body. When in doubt, deposition of the semen slightly into one or both uterine horns is less likely to compromise fertility than when placed only in the cervix. Because approximately 85 to 90% of the inseminate is expelled from the female by retrograde flow, it is critical that all of the semen be placed in the uterus (Hawk, 1987). Errors in semen placement are common among professional technicians (Graham, 1988). Below-average technicians only placed the semen in the target site (body of uterus) about one-third of the time compared with 85.7% accuracy by above-average technicians. Nearly 25% of the time, semen was not even placed in the uterus by below-average technicians. Few cows will conceive when the semen is placed in the vagina!

Dry Matter Intake and Energy Balance

A study conducted at the University of Florida emphasized the importance of dry matter intake on early cyclicity and milk yield of cows (Staples et al., 1990; Figure 7). Cows with the greatest dry matter intakes produced more milk, cycled back earlier, and lost less body weight. Cows with extra body condition generally lose more weight and consume less feed. Healthy, thinner cows have better appetites and lose less body condition.

Attention to dry matter intakes and body condition is critical. That attention and care begins long before the cow calves, usually in the last 100 DIM. At that stage of lactation, you have time to adjust body condition and prepare all cows for their dry period, next lactation, and breeding period. Attention to dry cows and early transition cows can pay big dividends in monitoring subsequent body condition, dry matter intakes, and cyclicity.

Increasing milking frequency results in more milk yield and a greater nutrient demand for the cow. When dry matter intake is insufficient, dietary nutrients do not meet the necessary energy expenditures of the dairy cow. As a result, adipose (fat) tissue (NEFA's or non-esterified fatty acids) serves as a source of metabolic fuel to meet those demands (expenditures of energy). Listed in priority order, each of those expenditures of energy have greater priority over reproduction: 1) body maintenance (cell maintenance, thermo-regulation, and locomotion), 2) growth, 3) milk production, and 4) reproduction (i.e., initiation of estrus and ovulation after calving; Stevenson et al., 1997).

Timing of the first ovulation after calving seems to be highly related to when energy balance is most negative (Zurek et al., 1995). In other words, ovulation occurs at a fairly consistent interval after the day when the nadir of energy balance occurs. This relationship was studied in 17 dairy cows (Figure 8). These cows lost 123 lb (56 kg) of body weight between calving and

when ovulation first occurred. As a result, their daily energy deficit was 17.5 Mcal of energy that was made up by metabolizing NEFA's released from fat stores. That amount of energy is sufficient to produce 56 lb (26 kg) of milk (3.5% fat)! Clearly, time of ovulation depends on when energy balance reaches its most negative point. Therefore, cows that are poor eaters after calving will have greater energy deficits and prolonged intervals to ovulation compared with those cows that are better eaters. Consumption of dry matter also is related to body condition.

This tie of energy balance and ovulation is related to the secretory pattern of luteinizing hormone (LH)--the key gonadotropin that controls follicle maturation and eventual ovulation. Early after calving, limited amounts of LH are secreted. As the time of first ovulation approaches, basal concentration of LH increases and its secretory pattern becomes more pulsatile. Pulses of LH must occur at about an hourly frequency to support follicle maturation and eventual ovulation. Studies have shown that frequency of LH pulses did not increase until after the nadir of negative energy balance. First ovulation occurred within 2 weeks of the increased LH pulse frequency and negative energy balance nadir (Canfield and Butler, 1990).

The implications of this research are clear. We must do everything to provide a well-balanced, palatable diet for our cows to meet her metabolic needs as soon as possible after calving. We must encourage intake by every means (more than one daily feed offering) so she will produce milk and ovulate early. Attention to ration details is critical. Is the diet formulated for your cows on paper, the same diet that is mixed and then consumed by them? Make every effort to maximize dry matter intake in your cows.

Cycling Status

During last several years, we have studied 1,919 dairy cows on three dairy farms. As part of those studies we have estimated the cycling status of these cows based on blood samples that were collected before synchronization of estrus, ovulation, or both (between 40 and 83 DIM). Upon measuring the hormone progesterone in these samples, we determined which cows were cycling before the end of the VWP. Body condition scores (1 = very thin and 5 = very fat) were measured during that same period of time. In Figure 9, you will find the results of those studies. Two were conducted in non summer months and the third during a hot summer in Kansas. One of these herds was milking 3× daily and all herd rolling averages for milk exceeded 20,000 lb (9,000 kg). On average, 25.8% of the first-lactation cows and 18.5% of the older cows were not cycling by the end of the VWP. Some important findings were:

- Cows in better body condition were more likely to be cycling than thinner cows.
- Cows with more DIM were more likely to be cycling.
- Younger and thinner cows were less likely to be cycling.
- For every 0.5-unit increase in body condition, the percentage of cows cycling increased by 7 to 24%.
- Milk yield (150-day energy-corrected milk) had little to no influence on cycling percentages.

An important point learned from these studies: cows that were not cycling by the end of the VWP conceived at lesser rates and took longer to eventually get back in calf! In each case, body condition was a very important predictor of when cows began estrous cycles after calving.

Use of Presynch before Ovsynch

The Ovsynch protocol (Figure 3) was designed to work in all lactating cows, regardless of the stage of the estrous cycle at which the first GnRH injection is given. However, fertility is better when the first GnRH injection is administered when cows are in the early to mid-diestrus (days 5 to 12) of the cycle. As a result, several studies were initiated to determine if one could

presynchronize the estrous cycles of cows to a more favorable “fertile” stage of the cycle before initiating the Ovsynch protocol. This was accomplished by administering two injections of PGF₂ 14 days apart with the second injection given 12 to 14 days before initiating the Ovsynch protocol. On average, if cows are cycling, about 60% of them given one injection of PGF₂ will have CL regression, whereas nearly 100% of those given two injections 14 days apart should be grouped together, regardless of whether estrus is observed after either injection of PGF₂. Therefore, after two injections of PGF₂, most cows should be grouped between days 5 and 12 of the estrous cycle when the Ovsynch protocol is initiated 12 days after the second of two PGF₂ injections.

The results of such experiments are illustrated in Figure 10 (Moreira et al., 2001; El-Zarkouny et al., 2004). The findings from both Florida and Kansas demonstrated that presynchronizing the estrous cycles in cows before Ovsynch significantly improved pregnancy rates compared with initiating the Ovsynch protocol in cows at random stages of their estrous cycles. The bottom line is better conception rates after Presynch + Ovsynch!

Recently, we completed a study (Portaluppi and Stevenson, 2004) in which we evaluated the proper timing of the second GnRH injection and the TAI of Ovsynch-treated cows in which their estrous cycles were presynchronized with Presynch. Estrous cycles of lactating cows on 2 commercial dairy farms were synchronized by using two injections of PGF₂ 14 days apart, with 12 days intervening before initiating the Ovsynch protocol. The protocol and results are illustrated in Figure 11. Although pregnancy rates assessed at day 40 or 41 after TAI were greater in herd 2 than herd 1, the G72 + TAI72 combination of GnRH injection and TAI produced the best results. In herd 2, pregnancy rates exceeded 40% for these cows at first service.

Use of Recombinant-Derived Bovine Somatotropin (bST)

With the advent of programmed AI-breeding protocols that reduce the need for detecting estrus (at least at first services), the negative effects of bST may be less detrimental to getting cows pregnant. A Florida study found that using bST in conjunction with the Ovsynch protocol improved conception rates in dairy cows (Moreira et al, 2000). All cows were treated with Ovsynch and inseminated at 73 ± 3 DIM. One group received their first GnRH injection at the same time they received their first bST injection, whereas the second group did not receive any bST until 4 to 5 weeks (105 ± 3 days) after their first AI-breeding. Conception was improved by combining bST injections with the Ovsynch protocol.

The next question asked was whether or not the timing of bST injections was important relative to when the timed AI occurred at the end of the Ovsynch protocol (Moreira et al., 2001). So they designed another experiment to answer that question. The first study was repeated with one additional treatment. Again, all cows were treated with Ovsynch and inseminated at 73 ± 3 DIM. One group received the first GnRH injection of the Ovsynch protocol at the same time they received their first bST injection at 63 ± 3 days, whereas the second group received their first bST at the time of AI-breeding at 73 ± 3 days. The control in this experiment did not receive bST until 6 to 7 weeks after first AI after Ovsynch.

Figure 12 summarizes the results for *cycling* lactating dairy cows in which bST treatment was initiated on day 63 ± 3 (onset of the Ovsynch protocol) or on day 73 ± 3 near the TAI associated with the Ovsynch protocol (bottom line of Figure 12). Conception rates were not different regardless of when biweekly bST injections were initiated. But in both cases

conception rates were 34% and were greater than those in controls (25%) in which bST injections were not given until well after first AI-breeding (day 147 ± 3).

Again, as before, when all cows were inseminated at the timed AI of the Ovsynch protocol after the Presynch protocol, those that received bST at the beginning (63 ± 3 days) or end (73 ± 3 days) of the protocol had greater pregnancy rates (56-58%) than the control cows (43%) that were inseminated at the same time (73 ± 3 days), but did not receive bST until 147 ± 3 DIM.

Another recent study (Santos et al., 2004) tested whether or not conception rates at first services were improved in cycling dairy cows treated with bST or no bST. In that study of *cycling* lactating dairy cows, cows were inseminated based on detected estrus after a GnRH +PGF₂ (7 days after GnRH) protocol. Those treated with bST had greater conception rates at 45 days after first AI (53%; n = 163) than similarly inseminated non-bST treated cows (40%; n = 171). Treatment with bST also reduced pregnancy losses after first AI.

An experiment was conducted to determine the effect of bST on the development of embryos from superovulated donors and on pregnancy rates of recipient cows also treated with bST (Thatcher et al., 2001). Donor cows were superovulated by using estrogen, progesterone, norgestomet, and FSH during a 7-day protocol and then were inseminated at estrus and every 12 hours until the end of heat. At the time of first insemination, cows were assigned to receive a single dose of bST or no bST. Flushed eggs and embryos were collected 7 days after AI. Results of the embryo collections are in the Table 3. Collectively, this study indicated that treatment of donor cows with bST increased fertilization rates (fewer unfertilized eggs), percentages of transferable or freezable embryos, and accelerated embryo maturation (more embryos in the early blastocyst and expanded blastocyst stages).

The second phase of the experiment determined whether transfer of embryos from bST-treated or control cows to bST-treated or control recipients would affect pregnancy rates. Lactating Holstein cows served as recipients and either received bST treatment 1 day after estrus was observed or served as untreated controls. After the initial bST treatment, bST treatments continued every 14 days throughout lactation. Either a bST or a control embryo was thawed and transferred directly to a bST-treated or control recipients on day 7 after detection of estrus. Pregnancy was diagnosed at 40 to 45 days after ET.

Among control recipients, transfer of embryos from bST donors increased pregnancy rates compared with transfer of control embryos (56 vs. 26%), but no differences were detected among bST recipients. Regardless of embryo source, pregnancy rates of bST recipients (43%) were greater than those of control recipients receiving control embryos (26%). Collectively, these results indicated that bST may be increasing pregnancy rates in lactating dairy cows via enhancing egg maturation, increasing fertilization rates, accelerating early embryonic development, and affecting factors within the pregnant cows that enhance embryo development.

Conclusions about use of bST in *cycling* lactating dairy cows: 1) administering bST at the beginning or end of the Ovsynch protocol produced better fertility than Ovsynch-treated cows without concurrent bST treatment; 2) Presynch clearly improved conception beyond that achieved with Ovsynch alone; and 3) combining Presynch and bST with the Ovsynch protocol improved fertility.

Duration of Voluntary Waiting Period

Before the availability of prostaglandin F_2 ($PGF_{2\alpha}$) and gonadotropin-releasing hormone (GnRH) to control the estrous cycle by inducing estrus and ovulation, much concern was expressed about waiting too long to begin the AI-breeding period after calving. The goal was to achieve calving intervals of 12 to 13 months. To maintain calving intervals in that range, it was common to have VWP of 40 to 50 days. A review of early-breeding studies (Britt, 1975) indicated that beginning AI-breeding by 40 days postpartum resulted in more calves and greater milk yield per day of herd life. Although early-bred cows required more services per conception, calving intervals could be shortened by attempting to maintain average intervals to first AI of 50 to 60 days. Part of the reason for increased number of services per conception was the poorer conception rates achieved in those early bred cows (inseminations before 50 days postpartum). Based on a summary of 8 different studies (Britt, 1975), conception rates of cows inseminated at first AI at various postpartum intervals increased at a decreasing rate until they reached a peak in conception at about 80 to 90 days (Figure 13).

The optimal calving interval may be elusive for today's dairy cow, but slightly longer calving intervals have been tolerated because of more milk production and greater persistency of lactation in response to use of bovine somatotropin (bST). Nonetheless, duration of calving interval is highly correlated to when the cow is first inseminated. Because of programmed-breeding options (Ovsynch or Presynch + Ovsynch), dairy producers are more likely to wait at least 50 to 60 days before initiating first inseminations.

Why would one consider delaying breeding and purposely extending calving intervals? Generally, greater profitability is highly correlated with calving intervals of 12 to 13 months (Galton, 1997). Rate of decline or persistency of milk yield after peak is correlated with the rate of accumulated profit (Ferguson, 1989a). Thus, persistency of the lactation curve is very important when determining the appropriate calving interval. Clearly, increased milk yield affects the optimal profitable calving intervals in first-lactation cows because of their greater persistency of lactation than that of older cows. Supplementation with bST increases lactation yields by altering the lactation curve with an immediate increase in milk yield (Bauman, 1992). Further, milk yield is maintained at greater persistency with bST supplementation compared with lactation curves without bST (Peel and Bauman, 1987).

Because of programmed-breeding options (Ovsynch or Presynch + Ovsynch), we are more likely to wait at least 60 days before first AI. If you examine the conception rate history of your herd by breaking out conception rates for the intervals of <50, 50 to 59, 60 to 69, and >70 DIM at first AI, you will likely find that conception rates increase by delaying first AI to at least 70 or more days.

Computer model simulations of extending calving intervals to 14 or more months indicated that improvements might occur in energy balance, uterine health, number of estrous cycles before AI, and conception rates as a result of delaying first AI-breeding until 150 to 200 DIM (DIM; Ferguson, 1989b). Herd life and cow health are important considerations when considering the benefits of extended calving intervals. Extended calving intervals and delayed AI-breeding may:

- improve fertility of cows and reduce culling rates of cows that are sold because of reproductive failure (#1 or #2 reason for culling).
- reduce total veterinary costs because nearly 60% of all veterinary costs are incurred during the first 45 DIM.

- reduce losses in milk that occur as direct or indirect effects of such metabolic disorders as milk fever, ketosis, displaced abomasum, and metritis, in addition to mastitis, which occur during this early period of lactation.
- reduce death loss because the greatest risk for death is associated with parturition (Mather and Malancon, 1981).

All of these reasons are arguments for extending lactation and calving intervals, resulting in potentially reduced health problems associated with more frequent calvings. But most importantly, because persistency of lactation curves is increased when cows are treated biweekly with bST, extended lactations may be more profitable.

Computer Simulations of Extended VWP. Simulated values of days open for cows of differing milk yields and varying calving intervals are illustrated in Table 4. It is clear from this study (Holmann et al., 1984) that calving intervals produced increased net returns for cows having calving intervals of 12 to 13 months, regardless of milk-producing ability of cows. When calving intervals were increased from 12 to 15 months, net returns varied depending on milk yields (some were positive and some were negative or break even). Clearly, increasing calving intervals from 13 to 15 months resulted in slight negative net returns at all production levels. The authors concluded that the 13-month calving interval seems to be close to optimum. Costs associated with changes in either direction from 13 months were small enough not to be a major management issue when cows were grouped and fed according to milk yield and when dry periods were at 65 days.

Another simulation compared VWP of 50 vs. 150 days (Allore and Erb, 2000). Delaying breeding by 100 days resulted in a predicted 89 days to conception for the 150-day VWP group suggesting that fertility might be increased as a result of delayed breeding. Milk yields were greater for the 150-day VWP (24,016 lb [10,893 kg] in 409 days) than for the 50-day VWP (18,826 lb [8,539 kg] in 325 days), but milk per day of lactation was similar (59 lb [26.3 kg] vs. 59 lb [26.6 kg], respectively). Culling was predicted to be less for cows in which delayed breeding was practiced, but intramammary infections were predicted to be greater. No increase in the risk, however, was predicted for any of the other disorders studied (e.g., left-displaced abomasum, ketosis, milk fever, cystic ovarian disease, dystocia, retained placenta, twinning, and uterine infection).

Analyses of 611,680 records from 348,243 cows in 5,694 Wisconsin herds revealed that for each 220 lb (100 kg) increase in 305-day milk produced, days open increased by 1.1 to 1.3 days (Marti and Funk, 1994). Within herd, days open were always greater for cows producing the most milk. This antagonistic relationship between days open and milk production was consistent at all production levels, but was always more severe in lower than higher producing herds. These data indicate that in high-producing herds, effective reproductive management of cows overcame some of this negative relationship.

Actual Cow Studies of Extended Calving Intervals. Studies in Israel were carried out in actual herds in which VWP of first-lactation cows was delayed by 60 days from 90 to 150 days and that in older cows were delayed from 60 to 120 days (Arbel et al., 2001). Illustrated in Figures 14 and 15 are the days to first AI, days open, DIM, and calving intervals of first-lactation and multiple-lactation cows. Actual conception rates were not increased for younger or older cows, despite a delay of 61 and 53 days to first AI, respectively. Days open were increased by 61 and 50 days, respectively, resulting in more prolonged calving intervals. Milk yields, measured as energy-value or energy-corrected milk per day of calving interval, were increased

by 1.8 lb (0.8 kg) in first-lactation cows, but not in older cows (Figure 16). Based on the first year in which delayed breeding was practiced, net returns per day of calving interval were improved by \$0.19 in younger cows and \$0.12 in older cows compared with cows in which VWP were 90 and 60 days, respectively. When milk yields for the second year (first 150 DIM only) were analyzed, again, milk yield per day were increased in 2-year-old cows by 3.7 lb (1.7 kg) per day in which delayed breeding occurred during the previous lactation (Figure 16). Net returns were again increased by \$0.21 and \$0.16 for younger and older cows. The authors concluded that an economic advantage for extending lactations by 60 days in high-yielding cows was demonstrated. This advantage was greater for first-lactation than for multiple-lactation cows, because of their high persistency in milk yield (including yields of fat and protein in milk) as lactation progressed. In markets in which a quota system is used for payment, the advantage of extended lactations for high-yielding cows may increase even more, because a greater proportion of cows are lactating throughout the year, and fewer replacements are required, than in herds with shorter VWP.

A Cornell study in which two VWP (60 vs. 150 days) were compared during a 2.5-year study produced some interesting results. Average milk per day of lactation did not differ (70 v. 69 lb), nor did percentages of fat or protein in milk differ among cows inseminated after 60 vs. 150 DIM. Comparisons of reproductive traits are illustrated in Figure 17. Days to first AI were 93 days greater for the delayed breeding group, but rates of heat detection, conception, and pregnancy were not different. Clearly, delayed breeding of lactating cows failed to increase conception rates or reproductive performance. The author concluded that extended calving intervals of 16 to 16.5 months may be warranted, especially in high-producing herds. An extra benefit of the extended calving intervals may be realized with the first-lactation cows because of their greater persistency. In addition, longer calving intervals for younger cows may allow them more time to reach mature body size and condition before initiating their second lactation. With extended calving intervals, herds need to be managed to maximize the milk response to bST throughout the year in order to realize the profitability associated with longer calving intervals. Practicing extended calving intervals may be necessary for some groups of cows, such as problem-breeding cows, in order for them to have sufficient time to eventually conceive.

In response to the findings of the previous study, a large multi-region study was initiated in the U.S. by the Monsanto Dairy Company in which two VWP (60 vs. 165 days) were compared in addition to supplementing cows with bST (McGrath et al., 2003). The study included 2,335 first-lactation cows and 1,386 older cows located on 26 dairy farms. The first-lactation cows on 22 farms also were studied during their second lactation. Cows were assigned to three treatments: 1) 60-day VWP + no bST (control); 2) 60-day VWP + biweekly bST injections begun in the ninth week of lactation; and 3) 165-day VWP + bST. Only healthy cows were enrolled during all seasons of the year and produced no less than 50 lb (22.7 kg) of milk at enrollment in the study. Milk production at conception and dry off was greater in first-lactation cows when breeding occurred after 60 days and bST was administered. Older cows, bred early and regardless of bST treatment, produced more milk at conception than cows in which delayed breeding occurred. Days to first AI were greater for all cows bred early after 60 days. It is not known whether this difference had a biological basis (cows showing better heats, more cycling cows, etc.) or whether dairy producers became anxious and applied more effort to inseminate these cows as soon as they were eligible for breeding. Delayed breeding resulted in more days dry, longer calving intervals, and similar percentages of cows pregnant. One of the biggest concerns of authors at the outset of the study was the effect of an extended VWP on eventual days dry. When they examined the results, they found that the delayed-breeding cows generally had more days dry indicating that persistency of production and bST treatment did not

compensate for the increased duration of lactation. The authors concluded that delayed breeding was not recommended despite the additional use of bST and the Monsanto Dairy Company is not recommending that dairy producers adopt this management strategy because benefits were not observed universally in all participating herds.

Timed Breeding Programs and VWP. If you examine the conception rate history of your herd by breaking out conception rates for the intervals of <50, 50 to 59, 60 to 69, and ≥70 DIM at first AI, you will likely find that conception rates increase by delaying first AI to at least 70 or more days. When we examined these data in our own herd, we found that conception rates after first AI were much improved by delaying first services to after 70 DIM. Conception rates of cows inseminated between 60 and 69 days was 38/138 (28%) compared with 39% (64/165) for cows inseminated between 70 and 79 DIM.

A recent German study (Tenhagen et al., 2003) attempted to determine the ideal VWP in a herd. They studied 1,288 Holstein cows. The authors used the Ovsynch protocol to ask three questions: Is conception: 1) influenced by individual production level (e.g., low, average, or high) relative to herd ranking; 2) greater when first AI was initiated later in lactation; and 3) affected by stage of lactation or actual amount of milk produced? Low, average and high levels of milk yield (assessed at 35 DIM) for first-lactation cows were 55, 56-66, and >66 lb, and for high-producing cows were 71, 72-88, and >88 lb.

When the Ovsynch protocol was applied to all three production groups between 73 and 81 DIM, resulting pregnancy rates tended to decrease as milk production increased (Figure 18; Tenhagen et al., 2003). When the Ovsynch protocol was applied to only low-producing cows between 53 and 59 days compared with their low milk-producing contemporaries between 73 and 81 days, pregnancy rates were greater in the latter group (34.5 vs. 14.4%). When the Ovsynch protocol was applied to only high-producing cows between 73 and 81 days compared with their high milk-producing contemporaries between 94 and 104 days, pregnancy rates again were greater in the latter group (41.4 vs. 28.2%). Figure 19 illustrates pregnancy rates of the three production groups when inseminated after different VWP. Clearly, pregnancy rates are not impaired by high milk production when high-producing cows are inseminated after a longer, more appropriate VWP. Other multiple-herd studies also indicated improved pregnancy rates after an Ovsynch protocol for cows first inseminated after 75 DIM (Pursley et al., 1997).

Conclusions for VWP. Days open are consistently greater for cows of higher milk production in every herd, but more severe in lower producing herds.

- Improved reproductive management seems to overcome the negative relationship that may exist between some reproductive traits and high levels of milk production.
- Computer simulations of the mid 1980's indicated that the optimal calving interval is 13 months. Net returns were quite small, however, when calving intervals were shorter or longer than 13 months.
- Delaying breeding from 90 to 150 days for first-lactation cows improved milk yields (no bST used) and net returns during the current lactation and up to 150 days into the subsequent lactation. Net returns also were increased for older cows when breeding was delayed from 60 to 120 days, but milk yields were not consistently improved.
- Extended calving intervals (>15-16 months) proved beneficial in early studies, but not consistently in all herds tested in a multiple-regional study in the U.S., despite concomitant use of bST. Days dry were too long for cows with extended VWP indicating that persistency of milk production and bST did not compensate for the increased duration of lactation.

- Delayed breeding associated with extended VWP (>100 days) did not improve conception rates or other reproductive traits of lactating dairy cows.
- Delayed breeding to between 75 and 100 DIM improved pregnancy rates after Ovsynch protocol regardless of production level.

Improved conception rates by delaying breeding for up to 3 weeks probably occur because cows are in more positive energy balance, better body condition, and consuming more dry matter intake; all of which are likely to improve chances for conception at first AI. These benefits are likely to be herd-dependent and not all herds may achieve improved fertility by delayed first inseminations. Examination of herd conception rates after first services may reveal the potential for improving first-AI conception rates by delaying first AI to greater than 70 DIM.

Sire Fertility

One of the newest evaluations available for determining differences in sire fertility is provided by AgriTech Analytics. Their summary of Holstein and Jersey sire fertility is based on actual veterinary confirmed pregnancies from 567 AgriTech herds located in Arizona, California, Colorado, Hawaii, Idaho, Kansas, Oregon, Nebraska, Nevada, New Mexico, and Washington.

Their most recent summary includes 1,656,077 AI records from 660,041 Holstein cows that occurred between January 1, 2002 and February 29, 2004. Each insemination record was required to have one of three outcomes reported within 75 days: 1) a subsequent AI-breeding in 8 or more days; 2) an “open” vet check; or 3) a “pregnant” vet check. Records from cows that were culled less than 75 days after AI-breeding or those bred less than 75 days before the most recent herd test were excluded. The average confirmed pregnancy rate in these Holstein herds was 30.2%. Because vet check data were used, resulting sire rankings should be more accurate and stable than those based on non-return rates. A non-return rate assumes that the cow is pregnant if no further AI-breeding is reported. Many reasons explain why no further services are reported besides a confirmed pregnancy. These reasons include culling, decision to no longer breed the cow, death, etc.

The results are available for 1,078 Holstein sires that had a minimum of 10 AI-breeding in each of 10 herds. The sire list reads similar to a sire proof. The sires are ranked from the highest (+5.7%) to lowest fertility (8.7%). Sires were grouped into quintiles (top 20%, next 20%, etc.). Sires ranked in the top 20% received 5 stars, the next 20% received 4 stars, etc. Similar information is available for Jersey sires.

One should exercise caution in how much and where you choose sires with the largest negative percentage deviations (< .3). Because bull studs have such good quality control programs, few poor-fertility sires are available for sale. I believe your objective in selecting for sire fertility is best served when you focus on the actual fertility deviation (most positive deviations) and use the number of services for that sire as a measure of accuracy.

All of the results for Holstein and Jersey sires are available to AgriTech herds as part of their member services. For non-AgriTech herds, the information can be obtained for a nominal charge (AgriTech Analytics, 5545 Avenida de los Robles, Visalia, CA 93291; tel: 800-532-0900 or 559-738-5300; fax: 559-738-5321).

The ERCR (Estimated Relative Conception Rate) is another source of sire fertility. It is, however, based on a 70-day non-return rate rather than confirmed pregnancies and represents data from herds east of the Rockies compared with the AgriTech system whose member herds

are in the western U.S. The relative differences in sire fertility are fairly accurate using the ERCR, but not as accurate as if it were based on confirmed pregnancies.

It is important to understand these between-herd measures of bull fertility (both AgriTech and ERCR) will generally be much more accurate than within-herd calculations based on your own herd records in which you compare sires. Estimates for sires used on your farm are less accurate because you probably don't have sufficient numbers of services to make comparisons of all sires used in your AI-breeding program.

Because both the ERCR and AgriTech systems are determined from many breeding records in many different herds, they are more accurate in identifying high, average, and low fertility bulls than a single herd estimate. The proportion of conception rate that can be attributed to the AI sire is small. But, when an additional fertility advantage is needed, these systems should identify less-than-average fertility bulls to avoid or better-than-average fertility bulls to select. Sire fertility should be a secondary trait of selection, after considering Net Merit\$, PTA milk, and other traits that may have more impact on the economic return from the dairy herd. But, when a choice is to be made between two bulls of equal merit on the primary traits, the one with a superior fertility should be chosen.

Remember that sire fertility, as any other of the factors discussed above, is only one of many puzzle pieces to make-up the fertility picture. Don't over-emphasize the importance of sire fertility when so many other factors also are important contributors to the success of your AI-breeding program.

Conclusions

Maintaining acceptable pregnancy rates is a difficult job. Attention must be paid to every detail of the AI program. Every person on the dairy team in your herd must do his job well including milking, feeding, and breeding cows. Proper health care and cleanliness are essential. Make every effort to increase AI submission rates and conception rates so pregnancy rates take care of themselves.

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Table 1. Various Factors that Determine Pregnancy Rates on the Basis of Whether They Influence AI Submission Rates or Conception Rates

AI Submission Rates		Conception Rates
Heat detection	Proper handling and	Use of Presynch before
TAI programs at first services	placement of semen	Ovsynch
Frequency of pregnancy checks	Dry matter intake	Duration of voluntary waiting
Resynchrony of repeat services	Cycling status	period
	Energy balance	Herd health programs
	Use of bST	Sire fertility

Table 2. Characteristics of Various Heat Detection Aids

Device	Accuracy (%)	Efficiency (%)	Amount of labor	Cost
Visual observation	66 - 98	20 - 95	High	Moderate
Tail chalk or tail paint	66 - 98	44 - 96	Moderate	Low
Heat mount patches	36 - 80	56 - 94	Slight	Low
HeatWatch	70 - 85	> 95	Moderate	High
Pedometers	22 - 100	60 - 100	Moderate	High

Source: Heersche and Nebel, 1994.

Table 3. Characteristics of Embryos from bST-Treated Donor Cows

Item	bST	No bST
Total number of egg/embryos per flush	9.3 ± 1.5	9.4 ± 1.5
Number of unfertilized eggs	1.0 ± 0.9*	3.7 ± 0.9
Percentage of transferable embryos	77%	56%
Number of embryos at blastocyst stage	2.4 ± 0.7*	0.4 ± 0.7
Percentage distribution of embryos:		
Morula	18.4	28.0
Early blastocyst	41.3	53.4
Blastocyst	32.5	9.3
Expanded blastocyst	7.8	9.3

*Different ($P < 0.05$) from no bST.

Source: Thatcher et al., 2001.

Table 4. Simulated Value of Days Open for Cows of Different Milk Yield and Varying Calving Intervals

Milk-producing ability, lb (kg) per 300 days				
Calving interval	13,007 (5,900)	14,991 (6,800)	16,976 (7,700)	18,960 (8,600)
(months)	(\$/day open)			
12 to 13	+0.36	+0.21	+0.40	+0.36
12 to 15	+0.12	-0.07	+0.07	0.00
13 to 15	-0.04	-0.23	-0.12	-0.20

Source: Holmann et al., 1984.

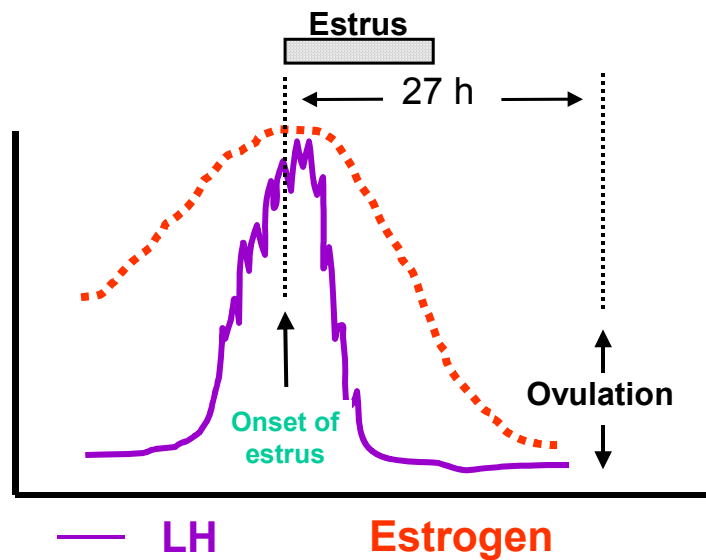


Figure 1. Timing of estrogen and LH secretion, estrus, and ovulation.

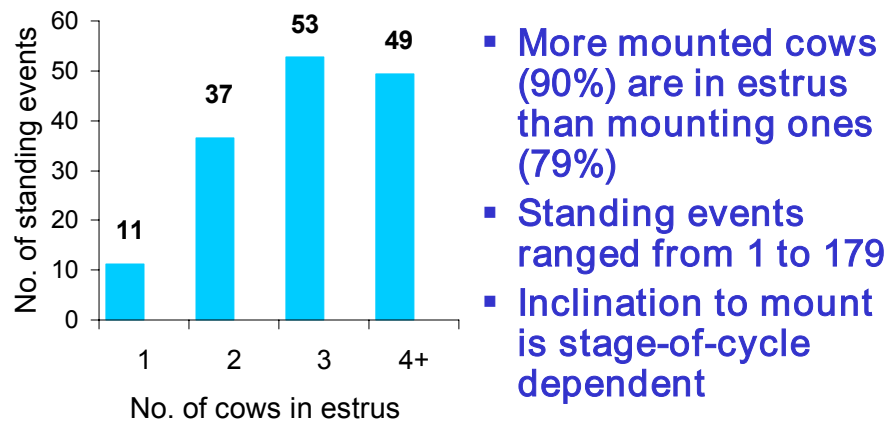


Figure 2. Standing activity is a function of the number of cows in estrus (Hurnik et al., 1975).

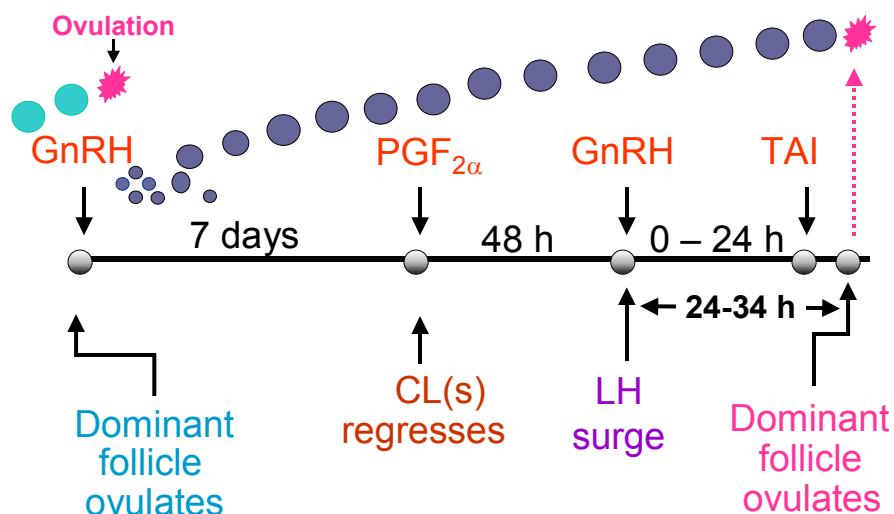
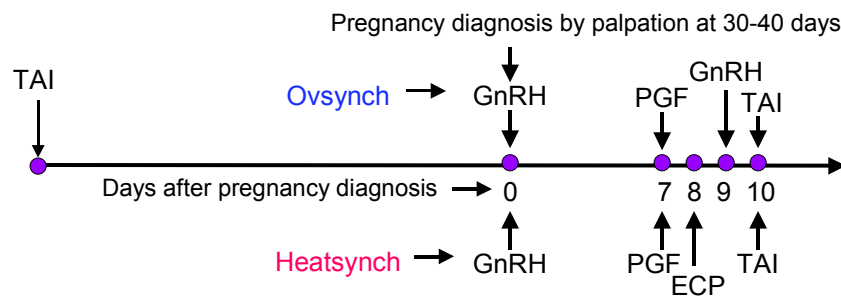


Figure 3. The Ovsynch protocol used to synchronize follicular development with luteal regression before induced ovulation.

<u>Item</u>	<u>Control</u>	<u>Ovsynch</u>
Cows attempted to A.I.	218	207
A.I. submission rate, %	58.7	100
Conception rate, %	32.0	33.3
Pregnancy rate*, %	17.9	33.3

GnRH = Fertagyl™

Figure 4. Administration of GnRH + PGF_{2α} and subsequent heat detection (Control) vs. application of the Ovsynch protocol during summer (Cartmill et al., 2001).



Study	<u>Ovsynch</u>	<u>Heatsynch</u>	
Florida	18.0% (155)	18.7% (160)	Bartolome et al., 2002
Kansas	29.4% (221)	28.6% (220)	Stevenson et al., 2004

Figure 5. Resynchronizing estrus in cows and heifers found open at pregnancy diagnosis.

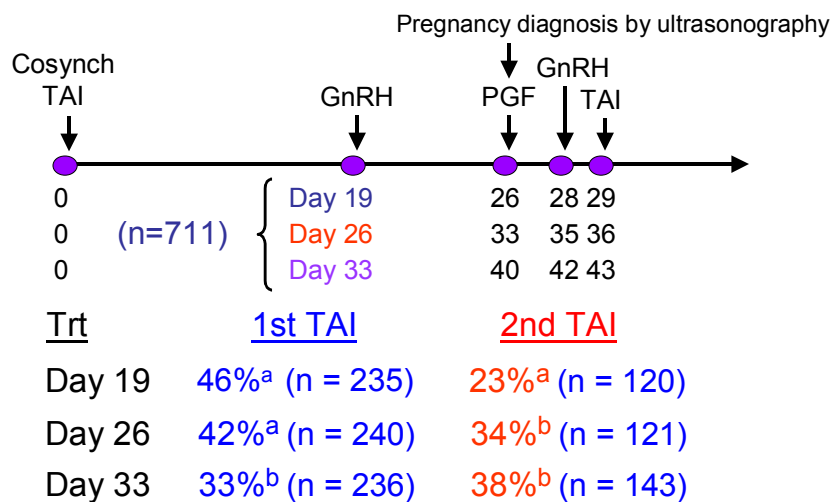


Figure 6. Resynchronization of ovulation in lactating dairy cows of unknown pregnancy status with the Ovsynch protocol (Fricke et al., 2003).

Item	Early	Late	Very late
No. of cows	25	14	15
Days to first ovulation	22	43	–
Days to first estrus	47	73	110
4% milk, kg/day	34	32	29
DM intake, kg/day	19	18	15
BW change, kg/day	–0.8	–0.8	–1.2

Figure 7. Prebreeding anestrus in lactating dairy cows according to when they initiated estrous cycles after calving (Staples et al., 1990).

Item	Mean of 17 dairy cows	SE
Body weight, kg		
Calving	729	13
Change during anovulation	–56	8
Energy balance, Mcal/day		
Anovulation	–17.5*	4.2
Interval, days		
Calving to EB nadir	8.7	1.1
EB nadir to ovulation	15.4	1.2
Calving to ovulation	24.1	1.5

*Sufficient energy to produce
56.5 lb (26 kg) of 3.5% milk/day

Figure 8. The relationship of energy balance in lactating dairy cows and onset of first ovulation (Zurek et al., 1995).

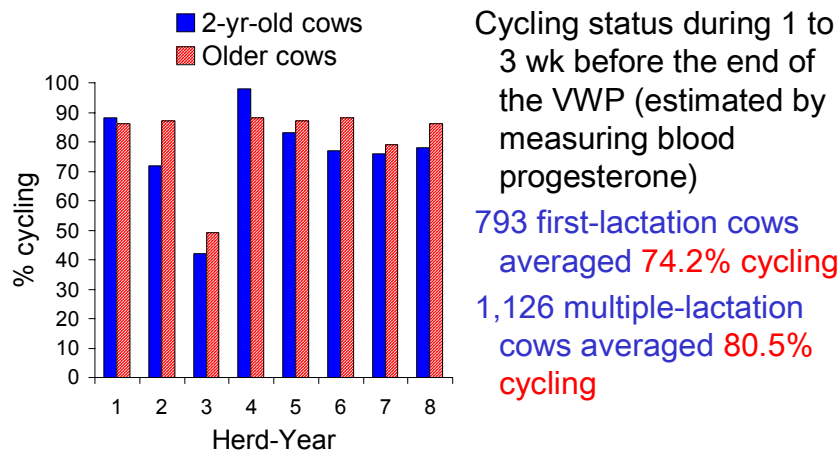


Figure 9. Estimates of cycling status in lactating dairy cows before the end of the voluntary waiting period (VWP; Stevenson, 2001).

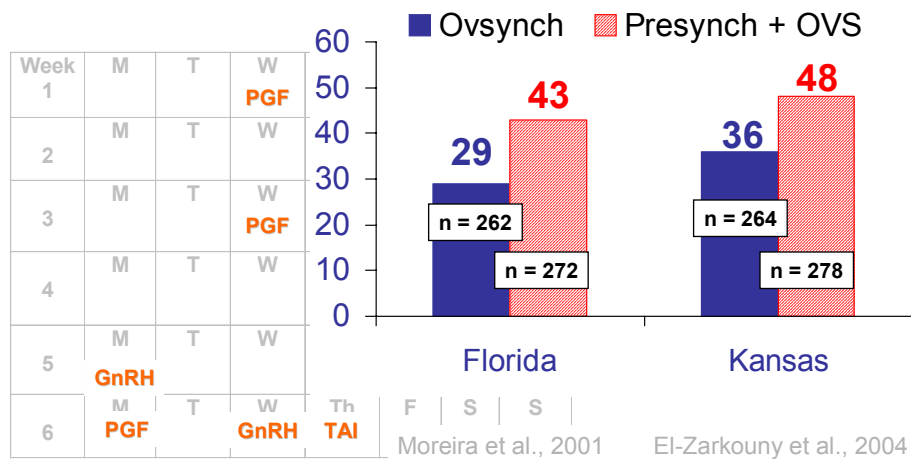


Figure 10. Pregnancy rates (%) of lactating dairy cows after applying the Presynch + Ovsynch or Ovsynch protocols before first AI after calving.

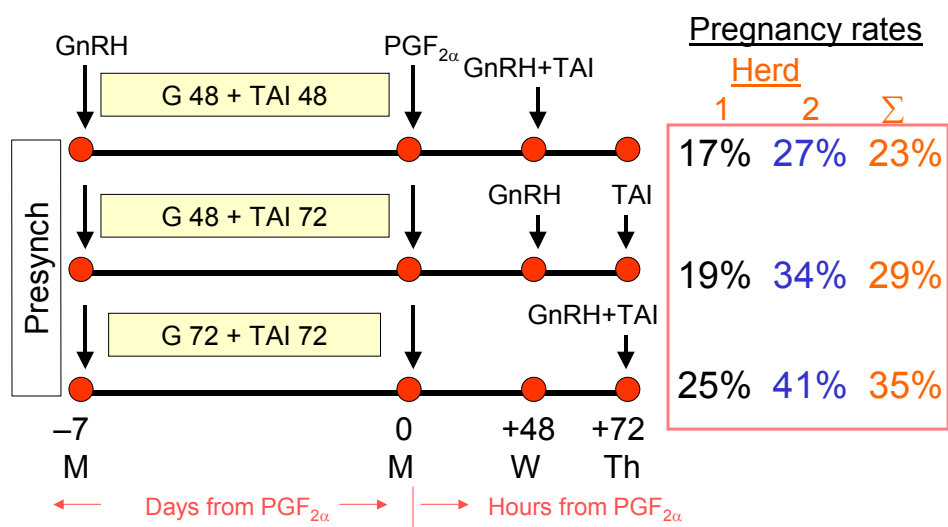


Figure 11. Variations in applying Ovsynch protocol after presynchronizing estrous cycles with the Presynch protocol (Portaluppi and Stevenson, 2004).

	Days in milk when bST was initiated		
	63 7 3	73 7 3	147 7 3
Presynch	----- % pregnant at 74 days -----		
+ Ovsynch	58% ^{a,x} (58)	56% ^{a,x} (60)	43% ^{b,x} (62)
Ovsynch	34% ^{b,y} (63)	34% ^{b,y} (66)	25% ^{b,y} (66)

^{a,b}bST effect ($P < 0.01$).
^{x,y}Presynch effect ($P < 0.01$).

Figure 12. Pregnancy rates in cycling lactating dairy cows plus the administration of bST (Posilac) at the beginning or end of the Ovsynch protocol (Moreira et al., 2001).

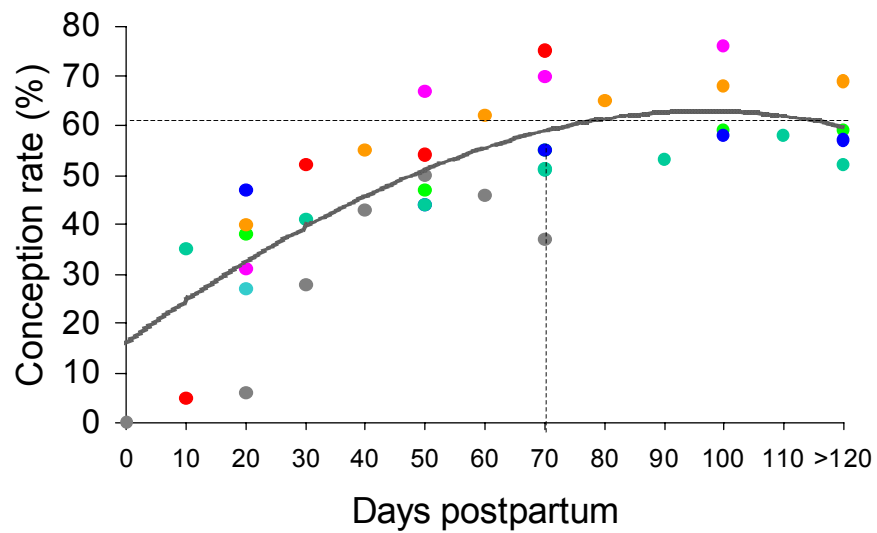


Figure 13. Conception rates after first AI (eight studies summarized) when conducted at various postpartum intervals after calving (Britt, 1975).

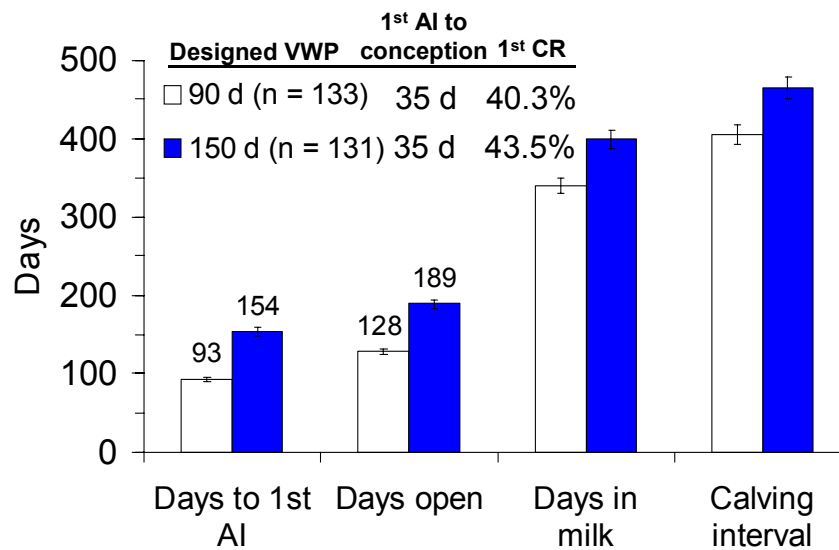


Figure 14. Traits of first-lactation dairy cows first inseminated after a 90- or 150-day voluntary waiting period (VWP; Arbel et al., 2001).

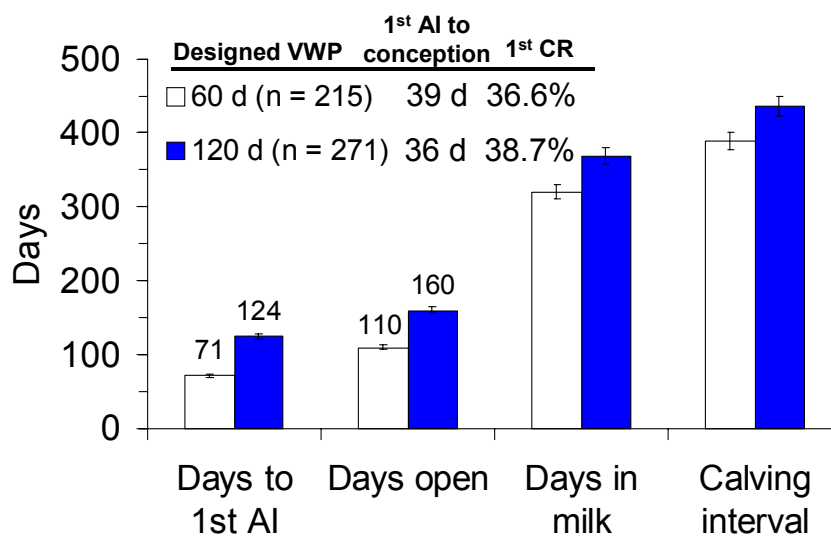


Figure 15. Traits of multiple-lactation dairy cows first inseminated after a 60- or 120-day voluntary waiting period (VWP; Arbel et al., 2001).

	First-lactation cows		Older-lactation cows	
	90-d VWP	150-d VWP	60-d VWP	120-d VWP
Yield/period				
First year	(kg)	(kg)	(kg)	(kg)
ECM/lactation	11,232	13,207	12,767	14,376
ECM/d of CI	27.7	28.5*	32.8	33.0
Net return/d of CI	\$3.42	\$3.61	\$4.34	\$4.46
Second year				
ECM/150 d	5,965	6,210*	6,430	6,487
ECM/DIM	39.7	41.4*	42.6	43.2
Net return/period	\$4.04	\$4.25	\$4.69	\$4.85

*Different ($P < 0.05$) from 90-day VWP for first-lactation cows.

Figure 16. Economic analysis of milk production traits for cows with extended calving intervals (Arbel et al., 2001).

Item	VWP, days	
	60	150
Days to 1 st AI	68	161
Heat detection rate, %	49	57
Conception rate, %	71	62
Pregnancy rate, %	35	35
Calving interval, mo	13.2	16.5
Culling (repro and milk), %	16.6	9.2

Figure 17. Reproductive traits of lactating dairy cows with different voluntary waiting periods (VWP; Galton, 1997).

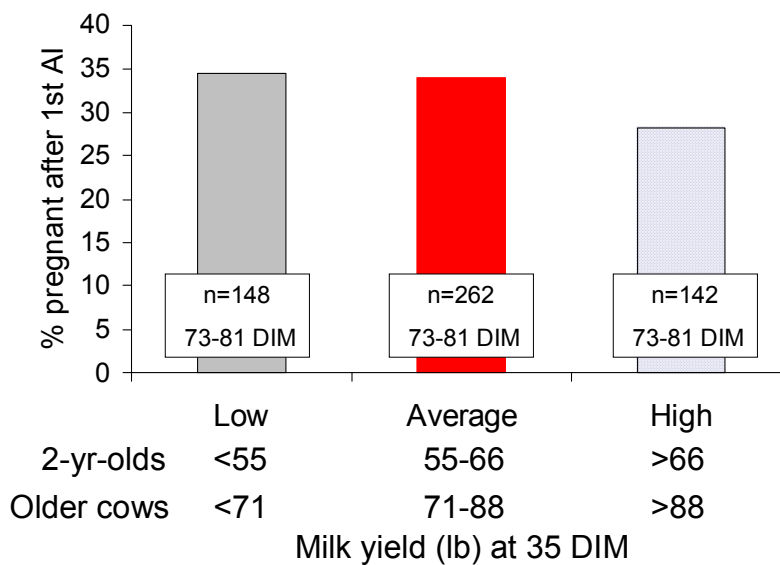


Figure 18. Pregnancy rates of lactating dairy cows with various milk production levels inseminated during the Ovsynch protocol between 73 and 81 days in milk (Tenhagen et al., 2003).

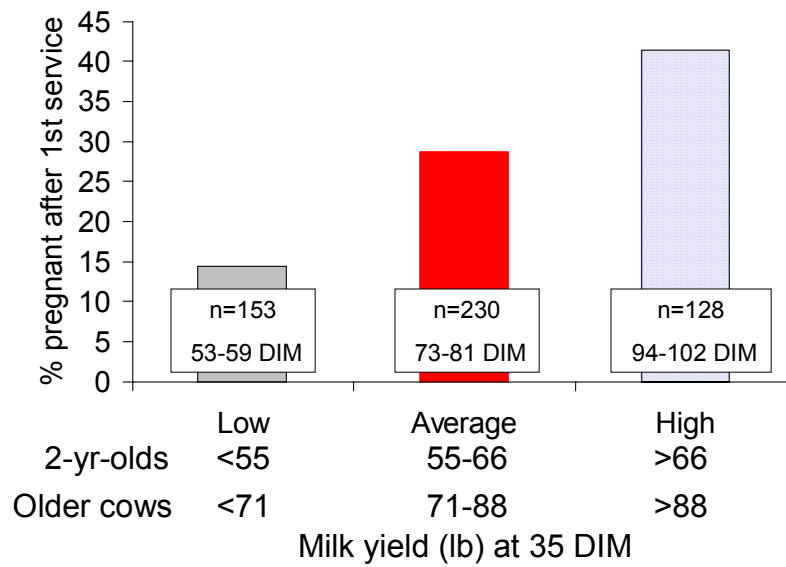


Figure 19. Pregnancy rates of lactating dairy cows with various milk production levels inseminated during the Ovsynch protocol at different days in milk (Tenhagen et al., 2003).