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Fertility Factors in High Producing Dairy Cows– Which Ones Are Really Important?

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Introduction

The goal of every dairy management team should be to maximize the efficiency of high producing dairy cows so that profitability will increase. The standards which define a high producing dairy cow will move upward as long as genetic progress continues to be made, management priority is placed on cow comfort and improving milk yield, nutrition is improved and new technology is developed and implemented.

Historically, dairy management teams, veterinarians and dairy scientists have promoted the concept that high milk production is related to cow stress, reduced cow health and poor reproduction. In fact, this notion started well before the use of AI, sire proving and rbST. For example, Hansen (31) reported the following quote from a Minnesota dairy bulletin published in 1929.

> *"In recent years the opinion has been held by a large number of dairymen that difficulties with breeding accompany high milk production. Dairymen have had the impression that difficulties with breeding have increased in recent years. As the level of production has also increased during the same interval, the conclusion has been drawn that the two bear the relation of cause and effect." (Eckles, 1929).*

From this historical perspective, it should be clear that modern genetic selection, nutrition and technology cannot be considered unique in receiving all of the blame for sub-optimal reproductive performance. From a physiologic standpoint, it is simply hard to imagine that we are selecting for higher and higher milk yields and susceptibility to higher and higher stress levels at the same time. Stress is generally a cause of poor production **NOT** the result of high production.

The goal of this paper is to present a reasonable case that successful reproductive management in high producing cows can be realized best by focusing on the right factors; the ones that impact fertility the most. This paper will not provide specific programs or recommendations for improvements. These are available from numerous other sources and specific programs must be custom-designed for each herd.

Reproductive management is not easy, regardless of whether cows are producing high or low quantities of milk!! It is complicated by numerous factors (we shall call them *Fertility Factors*), which may or may not be related. A list of *Fertility Factors* is presented below without regard to their relative importance to overall reproductive performance of the cow.

- Age of the Cow (Parity)
- Breed of Cow
- Calving Difficulty (dystocia)
- Environment – heat stress and footing
- Embryonic Death
- Estrous Detection Efficiency
- Estrous Detection Errors
- Fertility of the AI Bull
- Genetic Selection –(possible inbreeding)
- Inseminator Skill
- Milk Yield of the Cow
- Cystic Ovarian Disease
- Transition Cow Nutrition
- Reproductive Diseases (vaccinations)
- Retained Placenta
- Storage and Handling of Frozen Semen
- Uterine Infection
- Twinning

It should be emphasized that no other component of the dairy enterprise has this many variables to manage. Management of the above *Fertility Factors* can be overwhelming for the veterinarian, reproductive manager, workers and the overall dairy herd organization because on a whole herd basis they are "happening-all-at-once", especially in large herds. For example, some cows are calving today, others are beginning to cycle, others are "ready to breed", others are on the "preg check list" and still others need to be treated for something. All the *Fertility Factors* exert themselves in a constant mix of challenges that require a huge variety of management skill. This is further confounded by the fact that other management challenges, such as milk quality and cow comfort, are impacting herd performance at the same time.

Because of obvious economic incentives, management energy is almost always focused on high milk yield. These economic incentives far outweigh the incentives for reproductive management. For example, the results of changing nutrition (or giving bST) to improve milk yield can be observed almost immediately after the management change. However, the results of changing a heat detection program take weeks or months to see. Further, the effect and the financial gains with improved reproduction are often difficult to assess because they represent lost opportunities and are not directly "out-of-pocket."

Given these inherent issues, there needs to be a model that partitions the many *Fertility Factors* into groups that reflect the relative effectiveness of management control points. For example, some *Fertility Factors* are easily controlled and others simply cannot be controlled no matter what the management team does. Often management teams place emphasis on *Fertility Factors* that cannot be controlled rather than focusing on *Fertility Factors* that can be significantly altered to improve reproduction. For example, management energy devoted to solving cystic ovaries may be better spent on improving heat detection efficiency and accuracy. Placing management emphasis on *Fertility Factors* that cannot be easily controlled insures management failure and frustration. This often causes something else to receive the blame, and blame often falls on high production. It would be inappropriate to consider that we might improve reproductive management by lowering milk yield.

In order to determine which *Fertility Factors* should receive the most management attention, we must first answer the following question: **Which *Fertility Factors* have the most influence and which can be managed so that positive change can be realized?** For example, if estrous detection efficiency is only 35%, there is huge opportunity for improvement. In contrast, if only 6% of the herd has cystic ovaries, there is not much room for improvement. Put quite simply, some *Fertility Factors* have a high probability for improvement and others do not. As in this example, management usually has the opportunity to improve estrous detection efficiency and accuracy but can have little effect on the incidence of cystic ovaries.

Organizing the Fertility Factors

One way of organizing the *Fertility Factors* is with regard to who or what controls them. For example, we can subdivide the above list of *Fertility Factors* into three groups that reflect their primary control. These categories include *Fertility Factors*:

I. Controlled by man

II. Controlled by the reproductive system of the cow

III. Natural to any herd or cow

Among these three categories, the most control can be exerted by those under the direct influence of man and the least control is exerted on *Fertility Factors* natural to any herd. *Fertility Factors* controlled by the reproductive system of the cow are intermediate and are moderately difficult to control. Figure 1 illustrates this method of organizing the many *Fertility Factors.*

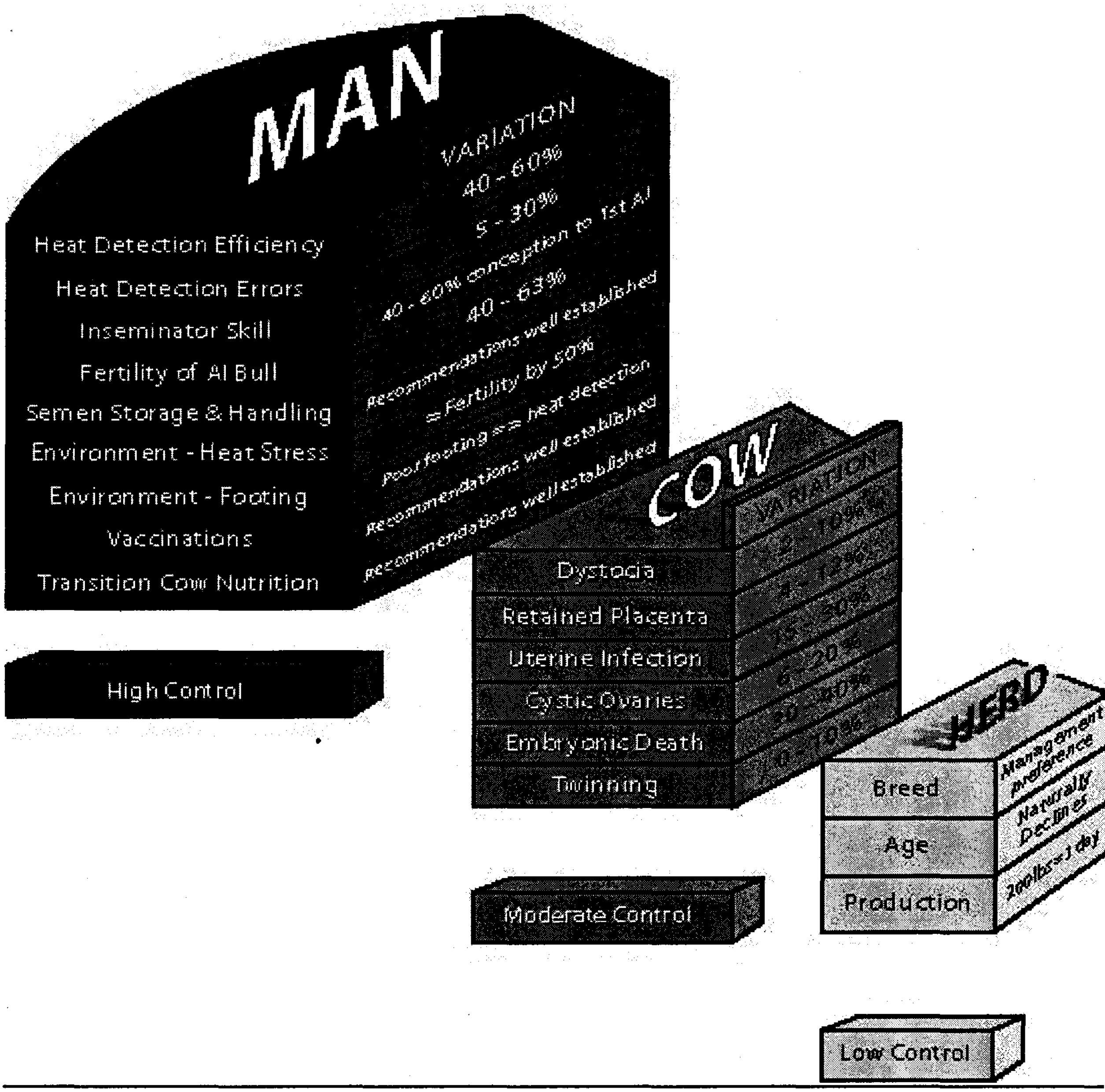

Figure 1. *Fertility Factors* are organized according to who/what controls them. High control can be exerted on factors that the management team can have a major influence on (MAN). Moderate control can be exerted on *Fertility Factors* under the influence of the reproductive tract of the cow (COW). Certain *Fertility Factors* are almost beyond management's control because they are natural (intrinsic) to every herd (HERD).

I. *Fertility Factors* Controlled by Man

The *Fertility Factors* in the box below are almost totally controlled by the individuals performing a task or making a decision (assuming that a cow is healthy and functioning normally). Major improvements in reproduction can be made by managing each of these factors well. Each *Fertility Factor* is followed by an expected range derived from the scientific literature. Each of these *Fertility Factors* will be discussed briefly in the sections subsequent to the boxes.

Fertility Factors Controlled by Man

Fertility Factor	Expected Range
• Heat detection efficiency	40-60%
• Heat detection errors	5-30%
• Inseminator skill	40%- 63% conception to first AI
• Fertility of the AI bull	45% - 60% conception to first AI
• Storage and handling of the frozen semen	adequate if recommendations are followed
• Environment - heat stress and footing	50% reduction in fertility
• Vaccinations	adequate if appropriate vaccination program is consistently maintained
• Transition cow nutrition	adequate if recommendations for lactating cow and dry cow nutrition are followed

Estrous Detection Efficiency

Estrous detection efficiency is defined as the percentage of cows displaying estrus that are identified as being in heat. For example, if 100 cows are cycling normally and only 50% of these cows are detected in heat, the estrous detection efficiency is 50%. It is generally agreed that estrous detection efficiency in most dairy herds is less than 50% (3,7,22,37).

Estrous detection efficiency is almost totally controlled by the estrous detection program designed by the management team. Too often, estrous detection is performed "on-the-fly" (detection of estrous while performing other tasks). This is a problem because generally cows do not display a high degree of standing and mounting behavior when they are eating, resting or being milked. Also, crowded conditions in alleys and the milking parlor entrance cause errors in cow identification if mounting behavior occurs in these areas. Too often, dedicated estrous detection techniques (such as planned focused observation, chalking of tailheads, use of pedometers and electronic pressure sensors) are not used. Kinsel and Etherington (39) reported that estrous detection management accounted for the greatest use of prostaglandin in 45 dairy herds (10,742 lactations) in Ontario, Canada. Use of prostaglandin was not associated with significant improvements in reproductive performance. The researchers further reported that a 1% increase in estrous detection efficiency resulted in a .5-day decrease in days open. Therefore, a 20% improvement in estrous detection efficiency would reduce days open by 10 days. Of the variables they examined, estrous detection rate and conception rate were the dominant factors influencing days open. It should be emphasized that estrous detection efficiency is under the total control of the management team and significant improvements in overall herd reproductive performance can be achieved if estrous detection is improved. Programs designed to focus exclusively on detecting estrus must be implemented or replaced with effective timed insemination programs if this *Fertility Factor* is to be improved.

The Take-Home Message

- Less than 50% of heats are detected in most herds.
- Many estrous detection programs lack structure and focus and can be significantly improved.
- Implementing techniques such as "chalking" tail heads, timed AI programs or focused intense observation periods can significantly improve estrous detection.
- For most herds, improving estrous detection efficiency is the most important impactor of overall reproductive performance.

Estrous Detection Errors

Estrous detection errors are defined as the proportion of cows that are inseminated that are not in estrus. Research using milk and blood progesterone analysis has shown that between 5% - 30% of all inseminations take place in **cows that are not in heat**. (2,57,58). Estrous detection errors are brought about by identifying cows based on secondary signs of estrus rather than standing-to-be-mounted. Also, poor cow identification results in confusion on the part of the person identifying animals in heat and thus the "wrong cow" may be presented for insemination. Financial incentives paid to workers may promote errors, because there is a financial bias on the part of workers to submit cows for insemination that are not in heat.

Costs of heat detection errors may be large because cows are often inseminated during the luteal phase of the cycle when the reproductive tract is susceptible to uterine infection. Errors also result in wasted semen and wasted labor. Furthermore, they create record-keeping errors, via incorrect heat dates that further confuse the management team when trying to predict future heats or breeding dates or the timing pregnancy diagnosis.

Determination of the estrous detection error rate in a herd requires the use of a milk or blood progesterone assay at the time of breeding. Cows that have high progesterone at the time of insemination are not in estrus and represent an error. Every herd should periodically use progesterone tests at the time of insemination to monitor estrous detection error rate.

The Take-Home Message

- 5-30% of cows inseminated are not in heat!!!
- Errors can be monitored by conducting routine milk progesterone assays.
- The goal for estrous detection error rate should be less than 2% in any herd.

Efficiency and accuracy of estrous detection can almost always be improved if the management team implements focused, well-defined programs. A 20% improvement of estrous detection efficiency can result in a 4 to 1 return on investment (47). Estrous detection errors can be corrected by reviewing the primary and secondary signs of estrus with the labor team and insisting that only cows that stand to be mounted be presented for artificial insemination. The error rate goal should always be less than 2%. The principles and techniques for estrous detection programs have been reviewed extensively by O'Connor and Senger (46).

As individual dairy herds continue to increase in size, the problem of poor estrous detection efficiency and accuracy could be amplified because manpower input per cow often decreases.

Environment – Heat Stress and Footing

Heat Stress

The single most important environmental factor impacting reproductive performance is heat stress. A significant portion of the USA is confronted by seasonal heat stress which manifests itself in the following ways: 1) increased embryonic death; 2) decreased length of estrus; 3) decreased number of mounts per estrus period; and 4) decreased conception rate (31). Cooling cows during periods of heat stress improves conception rates (59, 60, 51, 63). Methods of managing heat stress are almost totally under the control of the management team. For example, decisions regarding improved ventilation, misting, shade, etc. are made exclusively by the management team.

Footing

Estrous behavior is dramatically affected by the composition of the footing surface on which cows interact. Cows that interacted on a dirt surface had a more sustained estrus period (13.8 hr) than cows that interacted on a grooved concrete surface (9.4 hr) (9). Further, cows on dirt displayed over twice the number of stands (6.3 vs. 2.9) and mounts (7.0 vs. 3.2) during the observation period when compared to cows on concrete (9). There is little doubt that dirt surfaces provide more secure footing during mounting. While no data exists, there is probably a strong relationship between cow comfort and the composition of the surface on which cows move and interact. It should be emphasized that slippery concrete is a major factor influencing poor estrous behavior (standing and mounting) and cow safety and comfort. Scoring slippery concrete can have profound positive effects on estrous detection.

One problem accompanying a dirt surface for cow interaction is mud. Mud creates a host of problems including difficult mobility, poor mounting, poor foot health, injury and poor udder hygiene. Further, mud on the udder can dramatically increase udder and teat washing time. Mud undoubtedly reduces cow comfort, increases stress and compromises all aspects of production efficiency (including reducing worker comfort and efficiency). Steps should be taken to eliminate exposure to mud.

The Take-Home Message

- A heat abatement system (including adequate water supply, air exchange and evaporative cooling and shade) is a must for improving reproduction under heat stress conditions.
- Dirt footing enhances estrous behavior
- Mud should be eliminated from the dairy management environment

Skill of the Inseminator

Many management teams erroneously assume that any person can artificially inseminate cows with a high degree of success. Thus, good AI technique is often overlooked as a crucial *Fertility Factor*. Research has clearly shown that skill of the artificial inseminator is a significant factor influencing fertility in dairy cattle (27, 48). Successful deposition of semen in the appropriate location of the cow's reproductive tract has been shown to be a major problem associated with insemination technique. (14, 27, 38, 43, 48, 62) In a carefully designed experiment comparing professional AI technicians with herdsman-inseminators, Peters, et al (48) demonstrated, using radiographic evaluation of insemination attempts, that only 39% of insemination pipette placement attempts were located in the desired anatomical location (the uterine body). In contrast, 25% were located in the cervix and 36% were located in the lumen of one uterine horn. Thus, 61% of placement attempts were erroneous when the uterine body was considered the target. Surprisingly, professional inseminators had error rates similar to herdsman-inseminators. In a field study (56) involving a total of 2,820 first services in four commercial Washington dairy herds utilizing a total of 11 herdsman-inseminators, the most skilled inseminator achieved 62.7% conception to first service while the least skilled inseminator in the study achieved only 40.1% first service conception. The within herd variation ranged from 7% to 10% among inseminators. In this study (56), data were statistically corrected for age of cow and level of production. Therefore, all technicians were statistically competing in cows of similar milk production levels. These data clearly demonstrate that there is a significant variation among inseminators.

The management team can keep accurate records and evaluate, on a continual basis, the conception rate of each inseminator within the herd and make changes or retrain inseminators when the data indicate such action is needed. Periodic review/retraining (at least every year) of inseminator technique will keep inseminators aware of the importance of placing the semen in the uterus and **NOT** the cervix. When semen is deposited in the cervix there is twice the retrograde loss of semen as when compared to deposition in the horns or the body of the uterus (25). Pregnancy failures are more likely with cervical deposition than with uterine deposition of semen.

The Take-Home Message

- There is 15-20% difference in 1st service conception rates among inseminators.
- Semen must be placed in the uterus to optimize conception.
- Routine review and retraining of inseminators can improve conception.

Fertility of AI Bull

Since the introduction of herdsman-insemination (herdsman performing the insemination technique) over 30 years ago, the use of non-return techniques for evaluating bull fertility (as well as AI technician performance) has been lost. It has always been known, that there is a significant fertility difference among AI bulls. Senger, et al, (56) have shown that there is about a 10-15-percentage point difference between the highest fertility bulls and the lowest fertility bulls when measured using palpated pregnancy to determine percent conception to first service. Also, Davidson and Farver (15) reported a range in percentage conception among AI bulls of 35% to 70%. Using heterospermic insemination techniques, differences in fertility among bulls were also shown (52). It should be emphasized that this difference is not due to over dilution of semen by the AI organizations. Extension rates used for frozen semen are well above the threshold for optimum fertility. The Dairy Records Management System (DRMS) at N.C. State University has developed the "Estimated Relative Conception Rate" based on large numbers of AI services in dairy cattle throughout the U.S.A. This approach has enabled producers to identify (and eliminate from use) the lowest fertility bulls. By selecting AI bulls, which are in the high fertility group, reproductive managers can maximize their chance of achieving pregnancy in dairy cows. Unfortunately, the pricing structure used by the artificial insemination industry does not penalize or reward a bull for low or high fertility. Therefore, the incentive for bull selection (and semen pricing) is based totally upon the genetic potential for milk yield, milk components, functional type and supply/demand. There is an urgent need to provide producers with accurate data about the relative fertility differences among bulls. If such information were available, then management teams could select high fertility bulls to improve their probability of success.

The Take-Home Message

- All bulls are not created equal. Their fertility differs (by 15% or more).
- AI organizations **DO NOT** over dilute ("water-down") semen.
- Reproductive managers need access to accurate bull fertility data. Fertility estimates should be a mandatory part of the sire summaries in the future.

Storage and Handling of Frozen Semen

Recommendations for thawing and handling of frozen bull semen have been carefully researched and documented during the past 20 years (55). There is NO doubt that the recommendation for warm-water thawing (95° F or 35° C for 30-60 seconds) in French straws is appropriate. Prevention of post-thaw cold shock should be accomplished by wrapping the inseminating syringe with a warm clean paper towel and placing it inside the outer garment. Management of on-the-farm liquid nitrogen refrigerators has been well described. Research evaluating the possible damage to frozen semen stored in on-the-farm liquid nitrogen (LN) refrigerators clearly indicates that there is little risk associated with the potential for damage to semen stored in on-the-farm tanks (54). Regardless, periodic reviews of the principles and methods for handling semen should be done. It should be emphasized that failure of the LN refrigerator usually results in complete loss of sperm fertility and thus cow fertility will be zero unless tank failure is noted and the tank and semen are replaced.

Because herds continue to increase in cow numbers, there is increasing probability that several cows will display estrus on the same day. Furthermore, the use of programmed AI techniques increases the probability that multiple cows will be inseminated on the same day. These sets of conditions have resulted in the desire of inseminators to thaw simultaneously groups of straws as a convenience measure. Data regarding "batch thawing" is controversial. For example, laboratory data (12) indicates that up to 10 straws can be thawed at once without a demonstrable loss in spermatozoal viability. However, field studies (40, 26) indicate that fertility may be compromised when "batch thawing" is employed. A clear recommendation awaits further data from well-controlled fertility experiments.

The Take-Home Message

- Semen handling (thawing) recommendations have been well researched and are easy to follow.
- There is no evidence that LN refrigerators are mismanaged on dairy farms.
- Periodic review (once per year) of LN refrigerator care and semen handling can maximize the chance of good technique
- More data is needed to clarify the efficacy of "batch thawing" of semen

Vaccinations and Transition Cow Nutrition

It is assumed in this paper that well designed immunization programs are in place. Further, transition cow nutrition programs and feedbunk management, if properly designed, should not be a factor limiting fertility. If these factors are limiting, they are totally under the control of management and can be corrected.

Summary – *Fertility Factors* controlled by man

Fertility Factors controlled by man, can be improved significantly with the appropriate management decisions and implementation of the well-focused programs. **The greatest improvement in reproductive performance can be made by improving estrous detection efficiency, estrous detection accuracy and skill of the inseminator. In addition, proper management of the environment, mainly heat stress and footing, can significantly improve reproduction**. The probability of implementing successfully and controlling these factors is much higher than attempting to control other factors, which cannot be totally controlled by the management team. Heavy management emphasis should be placed on these *Fertility Factors* controlled by man.

II. Fertility Factors Controlled by the Cow's Reproductive Tract

These factors are under the direct influence of the reproductive system of the cow. These *Fertility Factors* are somewhat difficult to manage and to control because cow's reproductive system is the primary component influencing the outcome.

Dystocia

Fertility Factors Controlled by the Cow's Reproductive Tract

Fertility Factor	Expected Incidence
• Dystocia	2%-10%
• Retained placenta	4%-12%
• Uterine infection	15%-30%
• Cystic ovarian disease	6%-20%
• Embryonic death	30%-40% of fertilized ova die before 50 days
• Twinning	0 – 10%

Dystocia means "difficult birth." The major cause of dystocia is fetopelvic disproportion (calf too large for the birth canal). Birth weight of the calf and pelvic area of the dam are two of the most important factors that contribute to dystocia (1). Improper positioning of the fetus is also a major contributor. Reduction in incidence of dystocia can almost always occur when bulls are selected for a high degree of calving ease especially in heifers. Further, calvings should be accompanied by attendants with the appropriate obstetrical skills. Such focus can reduce the incidence of dystocia. Growing heifers to achieve 1250 – 1300 lb immediately after calving (24 months) coupled with the use of calving ease bulls can reduce the incidence of dystocia in first-calf heifers. Thus, management can exert a strong preventive influence by selecting calving-ease bulls for use in heifers and employing proper heifer management and maternity pen care. A certain amount of caution should be exercised because continued use of calving ease bulls can predispose a herd to smaller cows over time. Such a practice would amplify the dystocia problem during the same time frame. Regardless, there will always be a certain proportion of cows, which are afflicted by difficult birth. Almost without exception, cows that have difficult births have "downstream" reproductive problems including retained placenta, Metritis, delayed uterine involution and poor cyclicity.

The Take-Home Message

- Most dystocia is related to fetopelvic disproportion (calf too large for birth canal).
- Use of calving ease bulls can reduce dystocia in heifers.
- Some types of dystocia can be neither predicted nor prevented.
- Careful observation during parturition can reduce calving problem

Retained Placenta

The incidence of retained placenta varies from about 4% to about 12%. Retained placenta is defined as the retention of the fetal membranes beyond a 12-hour period. The cause of retained placenta is not understood. However, there is evidence that the lack of cotyledon proteolysis (breakdown of collagen) contributes to retained fetal membranes (19). Like cows afflicted with dystocia, cows with retained fetal membranes are almost always characterized by delayed return to estrus, increased services per conception, lengthened calving interval, higher culling rate, reduced milk production and increased days open (19). Reduction in the incidence of retained placentas has been associated with providing the cow with adequate selenium levels prior to parturition. However, cows with adequate selenium may still be afflicted by retained placenta, suggesting that other causative factors are associated with this abnormality. There is no conclusive evidence to indicate that treatment intervention of retained placenta provides the cow with a reproductive advantage when compared to cows with retained placenta that are not treated.

The Take-Home Message

- Proper nutrition (especially Selenium) can reduce the incidence of RP but cannot totally eliminate it.
- Cows with retained placenta almost always have uterine infection, delayed return to estrus, increased services per conception, lengthened days open and reduced milk production.

Uterine Infection

Most postpartum cows have intrauterine microbial contamination as a normal sequela to parturition. Most of these cows do not develop uterine infection that impairs reproductive performance (41). However, some cows develop more severe infections that compromise reproductive performance. Almost all cows that experience dystocia and retained fetal membranes develop uterine infection. In some herds, 40% of all postpartum cows may be treated for uterine infection (41). Such infections have been reported to cost over $100 per cow per lactation (4).

Uterine infection has two major effects on the cow's ability to become pregnant. First, it may delay the onset of cyclicity by delaying luteolysis. Second, it delays uterine involution and thus delays the time to first breeding. Treatment of uterine infection is controversial. In general infusions, draining uterine fluids and manipulation of the uterus is considered counterproductive both from a therapeutic and economic standpoint (41). Proper sanitation of the fresh cow, the maternity area and cow hygiene are most frequently indicated as good management steps for the prevention of uterine infection. Also, inducing estrus (with $PGF_{2\alpha}$) allows the uterus to be exposed to estrogen when the cow comes into estrus. Estrogen has a powerful therapeutic effect on the involuting uterus. It is important to recognize that poor uterine health can result from a cascade of negative events. The starting point may be dystocia or retained placenta. Either of these events can culminate in severe uterine infection. Any one or combination of these conditions delay pregnancies.

The Take-Home Message

- Up to 75% of all postpartum cows have postpartum uterine microbial contamination.
- Most cows with uterine infection "self-cure".
- Uterine infection cannot be totally eliminated.
- Intrauterine treatment is controversial but appears to be of limited value.

Cystic Ovarian Disease (COD)

The causes of cystic ovarian disease are not understood and therefore controlled prevention is not possible (6). Cows with uterine infections (8, 32, 21) and postpartum diseases (20) appear to have a higher risk of COD.

The effect of milk yield upon COD is controversial. Some studies (21, 13, 29, 35) indicate that high producing cows have a greater risk of COD than their lower producing contemporaries, while others (45, 16) indicate that COD is not related to milk yield.

The incidence of ovarian cysts in dairy herds has been reported to vary between 6 and 20% (49). Between 10 and 14% of all dairy cows will develop ovarian cysts at least once in their productive lifetime (6). Approximately 80% of cows with cystic ovarian disease respond to gonadotropin or GnRH treatment and 20% are non-responsive to hormonal treatment (11). It has been proposed (11) that these animals are characterized as having a genetic abnormality whereby the cystic structure has low receptor density to FSH and LH and therefore is incapable of responding to treatment. Such animals probably should be culled from the herd since they may represent a genetic predisposition for COD. In general, treatment of cows with cystic ovarian disease with gonadotropins or gonadotropin releasing hormones is effective. In this context, cows that are properly diagnosed and treated will have acceptable fertility. It should be emphasized again that in most herds, the incidence of COD is relatively low (<10%). Thus, COD is a *Fertility Factor*, which imposes only moderate impact

The Take-Home Message

- Between 6 and 20% of cows have cystic ovarian disease (COD).
- About 20% of cows with COD will not respond to treatment
- There is evidence that COD is heritable.

Embryonic Death

A major contributor to pregnancy failure (loss) in dairy cattle is early (preattachment) embryonic death (36, 53, 61). Between 30% and 40% of embryos die between fertilization and day 50 of pregnancy. Unfortunately, the precise cause(s) of this loss are not understood and makes this costly *Fertility Factor* among the most difficult to manage. A recent review by Inskeep (34) implicates an imbalance of progesterone, estradiol, and prostaglandins as a cause of early embryonic death. Unfortunately, controlling the timing and balance of these hormones in the cow is beyond the scope of current daily management efforts. An encouraging finding was recently reported by Moriera et al. (44), who showed that lactating cows treated with bST in combination with timed AI (GnRH + 7 days; $PGF_{2\alpha}$ + 48 hr; GnRH + AI; 16-20 hr. later) had improved conception rates. These workers (44) speculated that the combination of bst, GnRH and $PGF_{2\alpha}$ may have improved embryo survival.

Cows exposed to heat stress are quite likely to have elevated body temperature. Elevated body temperature of the cow (above 41° C) especially during the first 1-3 days after insemination causes a marked increase in embryonic death (17, 18, 50). Cooling cows to prevent elevated body temperature prevents embryonic death and thus improves pregnancy rate (59, 57, 60, 63).

The Take-Home Message

- Between 30-40% of potential embryos die between fertilization and day 50 of pregnancy.
- Management control of embryo death is almost impossible except through cow cooling

Twinning

The physiologic factors controlling twinning in cattle are not well understood. However, the incidence of twinning can be genetically influenced (28) and influenced by parity of the dam (24). Recently, high milk yield, especially high peak milk yield, has been implicated as a cause for the increase rate of twinning. The scientific data are far from conclusive and this issue remains controversial. More research is needed to establish a cause and effect relationship. Regardless of the causes of twinning, however, its occurrence has a significant negative impact on reproduction of the dam. The estimated loss associated with each twin birth is $108 (5). These losses are related to elevated risks associated with periparturient problems such as dystocia, retained placenta, uterine infection and an increased incidence of metabolic diseases of the dam.

Early identification of cows with twin fetus should be accomplished by palpation per rectum (day 50-70) or by ultrasonography (day 40-55) (24). Fricke (24) has presented several options for management of cows with twin pregnancies. These are: 1) cull the cow with a twin pregnancy, 2) abort the twin pregnancy, 3) elevate the plane of nutrition during the last trimester of gestation, 4) earlier dry-off and transition diet adjustment, and 5) careful obstetrical observation/management of twin-bearing cows.

Until definitive data is available establishing the factors that control twinning, it will be difficult to manipulate this *Fertility Factor*. Recognition of the "downstream" postpartum problems associated with twinning is important so that appropriate management steps can be taken to minimize the risk associated with multiple births.

The Take-Home Message

- Management can expect little (if any) influence upon the incidence of twinning until definitive cause and effect relationships are established through controlled research.
- Cows with twins should be identified and managed according to the management scenario of Fricke (24).

III. *Fertility Factors* Natural to any Dairy Herd

These factors are an inherent part of any dairy herd. Serious manipulation of these *Fertility Factors* would disrupt the very purpose of producing profitable quantities of milk. While these factors can influence reproduction, little can be done to alter them because of their intrinsic nature to the herd.

Fertility Factors Natural to any Dairy Herd

- Breed of cow
- Age of cow (parity)
- Level of milk production

Breed of Cow

Breed of cow within the herd is a management preference and favors breeds with the highest yields of milk. There appears to be some differences in fertility among the major dairy breeds. A recent study by Brown, et al (10) reported that Jerseys had fewer average days open (147 days) when compared to Holsteins (162 days). Aryshires, Guernseys and Brown Swiss averaged 173 days open. Services per conception were similar among breeds (about 3.1). Once the decision on herd composition (breed) has been made the inherent fertility of the breed constitutes the baseline around which management must operate.

The Take-Home Message

- Once the breed of cow is selected, management must operate within the characteristics of that breed.

Age of Cow (Parity)

Nuliparous heifers have the highest fertility among dairy animals followed by a decline in fertility with advancing parity (33, 23). The composition of any dairy herd includes first-calf heifers, second, third, and fourth (and beyond) lactation cows. This natural herd composition guarantees that there will be a declining fertility with advancing parity. It would be almost impossible to develop a strategy, which would alter this herd composition to improve fertility, while at the same time maintaining high levels of milk production.

Take-Home Message

- Fertility declines with advancing age (parity) but as yet no management scheme has been developed to alter this natural factor.

Level of Production

Genetics

The impact of level of milk production upon fertility continues to be a controversial and much discussed topic. The concept that elevated production results in increased stress on the cow, and negatively impacts reproduction and cow health had been promoted for decades. However, cows producing high levels of milk certainly cannot be under a high level of stress because stress reduces milk and does not promote it.

It is difficult to separate elevated production from genetics and the possible antagonism between production and reproduction. Hansen (30) points out that the heritabilities for reproductive traits are quite low (3% or less). Therefore, most of the variation in fertility is due to nongenetic factors and these have been presented earlier in this paper. Furthermore, if a genetic relationship between increased production and decreased fertility existed, fertility in virgin heifers would be expected to decrease over time. Such a decrease has not been observed. The possibility that the elevated incidence of inbreeding in U.S. Holsteins may contribute to reduced fertility has been presented by Lucy (42).

Management

Because the economic incentives are high and the results of managing for high production occur rapidly (and are often dramatic), every herd has a built-in (intrinsic) drive to improve milk yield per cow. There are fewer incentives for improved reproductive management and the results often lag far behind the steps implemented to improve milk yield. Therefore, the results of good reproductive management are camouflaged, become frustrating and the management emphasis declines. Unfortunately, high production often receives the blame for poor reproduction when, in reality, poor reproductive management should receive the blame. When incentives for both high milk yields and high reproduction are solidly in place it is possible (and even likely) that good reproduction and high milk yields can co-exist.

During the past decade, dairy production has been in a transition from managing cows for the maximum number of peak lactations per lifetime to managing for maximum persistence per lactation. This has created a marked departure from a reproductive management philosophy that has historically indicated that the cow should become pregnant as soon as possible after calving so that she can experience the maximum number of peak lactations in her lifetime. The modern dairy cow, coupled with new technology (more frequent milking, the use of bST, and sophisticated transition cow nutrition) has created higher milk yields through higher peaks and more persistent lactations. This persistence reduces the need for "rapid" pregnancies following parturition because the profit periods within the lactation curve are more sustained. Thus, if "old" measures of reproductive performance continue to be used and producers actually practice postponing pregnancies because of high persistence, it will appear that high milk yields result in poor reproduction. "Old" measures of reproduction were designed to maximize peaks, and may not apply to high persistence. There needs to be a critical evaluation and, if necessary, a "remodeling" of reproductive guidelines that apply to current conditions of management and production. Caution should be exercised when interpreting current data that might imply that high production damages reproduction when in fact, astute management practices will purposely postpone reproduction because of the obvious economic benefit of sustained high milk yield.

The data linking high production to poor reproduction are quite controversial and it would appear that there are many other factors which impact reproduction to a much greater degree than high milk production. These *Fertility Factors* fall into the category of *Fertility Factors* controlled by man. The appropriate economic strategy should be to manage for the highest possible milk yield while focusing reproductive management on *Fertility Factors* that have the greatest variation and a high probability of management impact.

The Take-Home Message

- Management efforts should be toward managing the efficiency of milk yields
- Reproduction should be managed by focusing on the *Fertility Factors* that have a high impact on reproduction and that can be effectively managed

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