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Strategies to Improve Reproductive Performance in Dairy Herds: Review

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Abstract: Several attempts have been made to improve the reproductivity of cattle in sub-Saharan Africa (SSA). Understanding the physiology of reproduction is essential to achieve this goal. Most important is finding potential points where intervention in the life cycle of the cow or bull can result in more efficient performance and hence higher productivity. Long dry periods result in reduced milk production and hence economic losses. The number of calves born can be reduced because the periods optimal for conception are missed. In addition, the cost of treatment of reproductive disorders can be high or beyond the reach of smallholder farmers. The ultimate goal of dairy industry is to operate an economical efficient production system and this is depending on high productive efficiency of the cows. Reproductive management can help a cow to conceive and maintain pregnancy when it is served at the appropriate time in relation to ovulation. To improve reproductive management in cows, the first opportunity for intervention is during the period between birth and first conception. We can reduce the period to first conception by adequate nutrition, breeding and proper health management.

Key words: Dairy Herds · Reproductive Performance · Reproductive Management

INTRODUCTION

The artificial insemination of cattle has been important in reducing disease transmission, allowing for genetic selection and ultimately increasing the health, longevity and milk yield of dairy cattle. Increased milk yield, dependence on human labor for the detection of estrus and increased herd size have combined to furnish an environment that challenges management's ability to maintain unacceptable level of fertility. Fertility was defined as conception per insemination that is a broad category that includes semen quality, accuracy of both semen handling and placement in the female reproductive tract, timing of insemination, condition of the female reproductive tract, ambient temperature, breed, season, nutritional status and recent changes in body condition [1].

Conception per insemination is the outcome resulting from a multitude of factors that interact in an intricate fashion. Four general categories will be used to classify the factors that determine the ultimate outcome of conception per insemination or fertility. The four areas that will be discussed are female fertility, male fertility, environmental and techniques used in artificial insemination. Female fertility refers to any factors directly related to the heifer/cow that may alter her probability of becoming pregnant, including condition of the female reproductive tract environment, nutritional status and recent changes in body condition status, age and breed. Male fertility factors associated with artificial insemination will be the primary focus of this section. Techniques involved with AI will include accuracy of the detection of estrus, timing of insemination, semen handling and semen placement in the reproductive tract. The aim of this review was to increase the awareness of professionals and paraprofessionals about reproductive management of cattle [2].

Evaluation of Conception Rates: Analyzing records in a systematic fashion should be the first step in identification of a conception rate problem. Often conception problems occur within sub-populations of animals within a herd, such as the second lactation group or cows bred less than 60 days in milk. Comparing "normal" and problem populations can aid in identifying factors influencing fertility. Adequate sample size is

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Table 1: Conception rate by service number, breed and parity for the Virginia Tech University dairy herd (April 1998 to April 2000)

Service Number	Number of Services	Conception Rate (%)[1]
1	311	45
2	148	44
3	67	40
4+	39	39
Breed	Number of Services	Conception Rate (%)
Holstein	379	41
Jersey	186	49
Lactation Number	Number of Services	Conception Rate (%)
Heifers[2]	277	68
1	211	46
2	158	44
3+	196	40

important for sound interpretation of reproductive performance especially when dealing with data where pregnant and open are the only two outcomes available. It is necessary to determine if changes in conception are real or just due to a small number of observations being evaluated (i.e., if n=10, then each conception changes the outcome by 10%, so is a 10% difference real or just do to one observation?). The bottom line is that abundant numbers of observations are required for reasonably precise estimates of fertility. Such numbers are sometimes available for experiments with non-return rates, but are seldom available for actual conception rates [3].

What is Normal? What should be expected as normal conception rate values in dairy cattle? With no physiologic load and using AI as the method of insemination, conception rates will be 65 to 75%. However, no load is defined as no milk production, no metritis and no stress. Table 1 summarizes the conception rate for various subgroups of cows located at the Virginia Tech University dairy herd from April 1998 through April 2000 [4].

Pregnancy was determined by rectal palpation of the reproductive tract 35 to 60 days after AI. Conception rate is defined as the % diagnosed pregnant for each specific category (service number, breed and lactation number).

The major factor influencing fertility in dairy herds is first calving. Heifers have conception rates close to theoretical optimal values. First calving reduces the conception rate 35 to 50%. The question is why this tremendous reduction after parturition? Milk production, metritis, metabolic diseases, dystocia, etc. contribute to the decline in fertility in the population. Many herds experience at least 50% of cows calving having one or more postpartum diseases. Typically their chance of conception is half that of normal cows. The conception rate in normal cows and the proportion of normal cows in a herd determine the fertility of the overall herd. Cows with problems will have conception rates one half of that of normal cows. Factors such as body condition loss, heat detection errors and less than optimum semen handling and placement, makes it readily apparent why many herds have conception rates less than 30% [4].

Male Fertility: Diagnosis of fertility problems in dairy animals is fairly simple if approached correctly. Clinical problems of dairy herds can be grouped by primary cause, such as environmental effects, infections, neoplasms and trauma. Idiopathic azoospermia or infertility is also common and abnormalities secondary to congenital, metabolic or parasite problems also occur. Decreased semen quality due to high environmental temperature or humidity during the summer is a frequent problem in bulls. Venereal diseases, including brucellosis are common in cattle, epididymitis, orchitis and azoospermia typically result [5].

Failure to produce offspring is the most common manifestation of a fertility problem and can lead to substantial financial loss for the owner. Potential problems can be minimized by use of a breeding soundness examination prior to purchase of a breeding male; diagnosis of a fertility problem can often be relatively simple. Factors such as human-animal bonding and economics, as well as the underlying etiology of the infertility problem, dictate the appropriate course of action [6].

Environment Effects on Fertility: Fertility in dairy cows is depressed during the summer months in warm areas of the world [3]. This depression is caused essentially by heat stress because experimental application of heat stress reduced fertility and increased embryonic mortality while alleviation of heat stress during the summer increased fertility. The magnitude of the seasonal depression in fertility is influenced by environmental factors that define the extent of heat stress and internal factors of the cow that determine her ability to regulate body temperature during heat stress. There is a greater reduction in fertility during the summer for lactating cows than for non-lactating heifers. High milk yield exacerbates the effects of heat stress on fertility. The major reason why high milk yield provokes effects of heat stress on fertility is related to the increased metabolic rates and decreased thermoregulatory ability for cows with high milk yield found that among cows exposed to temperatures within the range of 10 to 24°C, rectal temperature increased 0.02°C for each kg of fat-corrected milk a cow produced above 24 kg/day [4].

Mean daily temperature and humidity have been reported to account for 80% of the variation in conception by month. In a recent study, using the electronic heat detection system Heat Watch to determine cows to inseminate, season significantly affected the conception rate as conception rates were highest when AI was performed during March, April and May. The odds ratio for pregnancy occurring within this period was 45% higher than for insemination during the base comparison period of September and October. The odds of pregnancy for cows inseminated during the summer months (June to October) were 12% lower than the fall and thus 67% lower than cows inseminated during the spring months [5].

When analyzing fertility data, keep in mind how management of dry cows may influence fertility in that group (example: cows dry during the summer) and how calving facility hygiene and maintenance may influence performance post-calving. Summer has a drastic effect on fertility for cows inseminated during the summer and cow inseminated in the fall, which were dry in the summer. Fall inseminations are next lower in fertility after summer inseminations. All cost-effective methods that reduce heat stress and increase cow comfort should be used during the hot and humid seasons of the year. Reductions in heat stress will probably first maintain feed intake and reduce the potential loss in milk production by increasing dry matter intake but also may reduce the magnitude of low fertility usually experienced during this period [3].

Techniques Involved with AI: This section involves the intervention of man into the actual breeding procedure of cattle. First the female must be accurately identified in estrus, then the timing of insemination becomes the next step in the procedure, finally semen handling, thawing and placement finishes the process [1].

Accuracy of Estrus Detection: Accuracy of estrus detection is defined as the percentage of cows identified in estrus that are indeed in true estrus. Inaccuracies occur when cattle are inseminated at times other than true estrus. Examining the frequency distribution of interestrual intervals has been shown to be helpful in documenting errors in the detection of estrus. Two characteristics specific to estrus detection error are; 1) more than 10% of the interestrual intervals are between 3 and 17 days and 2) cows are verified pregnant or to calve to a breeding prior to the one last recorded [2].

In a large field study involving herds in the Northeast U.S., Reimers [6] reported that 5.1% of the cows presented for insemination were not in estrus based on high milk progesterone levels. The error rate varied from 0 to 60% among herds and 10% or more of the cows inseminated were not in estrus from 30% of the herds. Numerous other studies using milk progesterone analysis have shown that 5 to 15% of cows are inseminated when they are not in or near estrus [6].

To make the evaluation of estrus detection accuracy with milk progesterone analysis worthwhile, a milk sample should be collected from 20 cows on the day of AI and 20 consecutive breeding should be sampled. When compared with a standard progesterone sample, the milk obtained on the day of insemination should have low progesterone. Progesterone levels are low for about seven days around the time of estrus. Thus, low progesterone indicates the cow is either in or near estrus, but progesterone levels cannot be used to precisely time insemination. If only one sample of the 20 has a high progesterone level than that group of samples represent a 5% error rate. A 5% error rate is acceptable but should be evaluated to determine the possible cause(s) [2].

Semen Handling Prior to Thawing: The primary objective in handling semen properly is to conserve the fertile life of sperm until deposition in the female. This is accomplished by minimizing exposure of semen to temperature fluctuations and contamination with other compounds especially water and soap. The semen storage tank is a large, metal, vacuum-sealed liquid nitrogen refrigerator encased within an extremely efficient insulation system. With proper attention and handling, most liquid nitrogen semen storage tanks give years of trouble–free service, but all storage tanks will eventually fail. To ensure maximum holding time, the tank should be kept in a cool and dry location away from direct sunlight, in a clean and well-ventilated area away from drafts, elevated above concrete to prevent corrosion and where it can be seen daily. Particular attention must be given to the neck and vacuum fitting. Accumulation of frost on these areas indicates that the vacuum insulation has been lost and liquid nitrogen has been evaporating rapidly and failure of the tank to hold liquid nitrogen is occurring [1].

In addition to the obvious error of permitting liquid nitrogen storage tank to go dry, stored semen may also be exposed to adverse high temperatures when straws are being removed for thawing. An accurate inventory and location of the semen stored in the liquid nitrogen tank is important to prevent exposure of semen during searching for the straw prior to removal for thawing. Thermal injury to sperm causes permanent membrane alterations and cannot be corrected by returning semen to the liquid nitrogen. For optimal maintenance of sperm viability, canisters and canes containing semen should be raised into the neck of the tank only for the time required to retrieve a single straw. This time should not exceed 5 to 8 seconds [3].

Semen Thawing: The recommendation for thawing of semen frozen in straws is not the same for all AI organizations. For optimal results, the recommendations of the semen processor should be followed. However, the situation on most farms is that semen from many AI organizations is being used and only one thawing procedure is being performed. The national association of animal breeders has recommended that, the straw should the thawed for a minimum of 40 seconds in 30 to 35°C water. It has been reported that using a thermostatically controlled water bath allows batch thawing of straws (up to 20 at a time) without compromising semen quality when the ambient temperature is approximately 20°C [7]. A recent study performed at ambient temperatures above 20°C in which four straws of semen were thawed at one time showed decreased conception with time from thawing. They reported the conception rate was highest for the first straw used in sequence and lowest for the last straw ranging for the first straw at 48%, second straw 41%, to 38% for the third and 25% for the fourth [8]. An additional trial reported pregnancy rates from the first to the fourth straw of 48.4%, 41.4%, 17% and 14.3%, respectively. The straw number is an indirect measure of time that the semen is exposed to the environment and emphasizes the fact that preparing more than 2 straws using the recommend methods for AI will result lower pregnancy rates [4].

Semen Handling after Thawing: Regardless of what type of water bath is used, all water should be thoroughly removed from the straw before it is cut. Exposure of the semen in a 0.5 ml and especially the 0.25 ml straw to as little as one drop of water can result in irreversible cell injury. A concern with warm-water thawing is the danger of cold shock caused by mishandling of the semen following thawing. Cold shock occurs when semen is thawed and then subjected to cold ambient temperatures prior to insemination. Because of potential cold shock, many investigators have questioned the wisdom of the warm-water thaw, particularly when breeding cows in cold weather. The effects of thaw rates and cold shock on sperm viability measurements three hours after initial thawing. Both sperm motility and acrosomal integrity were adversely affected by cold shock when compared to a 35°C thaw without cold shock; however, air thaw and 5°C water thaw were still inferior to the 35°C thaw following cold shock [9].

Semen Placement: The highest quality semen placed in the healthiest cow at the right time will not produce a calf if the breeding technique is not performed properly. The mechanics of passing the insemination device through the cervix will not be covered here. For further information an AI organization that provides AI training should be consulted. Practice is required to develop the skill, which should be learned and periodically reviewed with the assistance of professionals. One of the most critical components of the insemination technique is depositing the semen anterior to the cervix approximately 1 cm into the uterine body. The major reason why sperm numbers can be markedly lower for frozen and thawed semen used in AI is that the cervix which is the major barrier to sperm transport is bypassed in correct semen deposition. In contrast, deposition of sperm deep in the uterine horns closer to the site of fertilization has not shown an enhancement in fertility [10].

Factors Influencing Cow Fertility: Female fertility refers to any factors directly related to the heifer/cow that may alter her probability of becoming pregnant, including uterine condition, nutritional status, recent changes in body condition status and health. Many research studies have shown that fertility increases as interval from calving to first service increases up to 70 days postpartum. Repetitive estrous cycles are necessary to confer higher conception rates per insemination. Conception rate and estrus expression improves with each sequential estrous cycle from first ovulation to the third estrous cycle [8].

Following parturition, dry matter intake (DMI) needs to increase 4- to 6-fold in order to meet the high nutrient demands of milk production. However, the high yielding dairy cow is not able to increase DMI post calving as fast as the increased nutrient demands required for lactation; the cow copes with this nutrient shortage by mobilizing body reserves of fat and protein. During this period of declining negative energy balance, LH pulses are suppressed and dominant follicles that develop have a decreased chance of producing sufficient estradiol to induce a pre-ovulatory gonadotrophin surge.

Thus, achieving high DMI in the early postpartum period of high-yielding dairy cows is crucial to normal resumption of ovulation and development of a corpus luteum of normal size and progesterone production capability required for high fertility. The nutritional management of the dairy cow in the transition period approximately 3 weeks before calving to 3 weeks after calving has significant carry-over on reproductive efficiency of high yielding dairy cows [11].

Postpartum Problems: As stated earlier the biggest factor influencing fertility in dairy herds is first calving, but every calving places the cow at risk for metritis, retained placenta, dystocia, milk fever and other metabolic diseases that contribute to the decline in fertility of the population. Typically cows that experience a postpartum problem will have conception rates one half that of normal cows. Ketosis and lameness do not appear to have the magnitude of metritis or abnormal uterine discharge in reducing conception rate; however, many studies have identified these conditions as having a significant impact on fertility. The impact of retained placenta on conception rate may be dependent upon the development of secondary disease, such as metritis or ketosis. Lameness has had varying effects on fertility and may depend on the time postpartum when it occurs and the severity of the problem [9].

Metritis or any abnormal uterine discharge may be perceived as conditions associated with hygiene and stress at calving. Retained placenta, milk fever, uterine prolapse and grass tetany are directly associated with dry cow feeding and mineral content in dry cow rations. Ketosis, laminitis, fatty liver and ovulatory dysfunction, particularly anestrus, may be viewed as metabolic dysfunctions associated with energy balance. In addition, excessive body condition loss should be detected as a problem with energy management that will reduce fertility [6].

Nutrition and Reproduction: Minimizing metabolic problems is contingent upon management of energy and protein, not only in rations fed, but also in body tissue stores. Excessive energy or protein in the dry cow diet can create metabolic problems as readily as low energy or low protein diets. Excessive tissue mobilization associated with low dry matter intake in the late dry period is a risk factor for significant parturient problems. In addition mineral supplementation, particularly Ca, Mg and Se are important in the control of milk fever and retained placenta [5].

Table 2: Effect of body condition change from calving to breeding on first service conception rate

Body Condition Change (X)	Conception Rate (%)	95% Confidence Interval
.75	55.9	49.8 - 61.9
.25	49.5	47.5 - 51.6
0	46.3	38.3 - 54.6
-.25	43.2	41.2 - 45.2
-.75	37.0	31.4 - 42.9
-1.5	28.6	19.5 - 39.6

N = 531 cows, Body condition scale 1 to 5 according to Ferguson *et al.* [13]

Prevention of excessive mobilization of body fat in the first 8 weeks of lactation is of primary importance for subsequent fertility. Cows will tolerate a loss of .5 to .75 units of body condition in the first 8 weeks; more extreme condition loss will predispose her to lower conception rates at first service as seen in Table 2 [11].

The mobilization of body fat observed post-calving actually begins prior to parturition, as seen from profiles of serum lipids. Mobilization of excessive body fat will be correlated with high serum nonesterified fatty acid concentrations (NEFA) and the higher the NEFA the higher fat mobilization and the higher the risk for metritis, ketosis, fatty liver and displaced abomasum [12].

Mobilization of NEFA is normal around parturition and is associated with a decline in dry matter intake prior to calving. The more severe the reduction in intake, the higher the fat mobilization, the higher the risk of fatty liver and other parturient problems. Maintaining feed intake and /or increasing the energy in the close-up dry cow ration will minimize NEFA mobilization and reduce the incidence of parturient problems. Dry cows should not lose weight. A loss of body condition during the dry period will increase the risk of metabolic diseases and calving problems. Loss of more than a. 25 of a body condition score over the dry period will increase the risk of primary problems at calving, particularly dystocia, lameness and ketosis. Cows that are less than 3.0 in body condition at dry off must be given a diet that will stimulate a modest amount of weight gain over the dry period. One unit change in body condition score represents about 55 kg of body weight change and about 400 Mcal of energy [14].

Increasing levels of dietary crude protein have been associated with decreases in fertility [15]. Cows with normal postpartum periods had no decrease in fertility with diets of higher degradable intake protein (DIP);

whereas cows experiencing a postpartum problem were more likely to experience conception failure at first service and to have irregular intervals to second service if they were fed diets with excessive DIP [16]. A decrease in uterine pH was associated with higher DIP and possible cause of conception failure [17].Fertility was sensitive to elevated urea level associated with higher DIP. It was suggested that increasing plasma urea nitrogen (PUN) and milk urea nitrogen (MUN) was associated with reduced fertility in a stepwise fashion [18]. Fertility declined in cows with MUN above 16 mg/dl and a further reduction occurred when values were above 20 mg/dl. PUN and MUN are inversely related to uterine luminal pH and sequential measurements in lactating cows have demonstrated that uterine pH is dynamically attuned to changes in plasma urea with a time lag of several hours [19].

Increasing energy intake will many times decrease urea due to increased efficiency of protein utilization and less protein and nitrogen wastage. Dehydration will result in increased PUN and MUN and increased water intake will cause a reduction. Therefore, MUN and PUN values represent the protein, energy and water status of the cow. Interactions of the three sometimes may make it difficult to interpret test results. Cows consuming the same ration will not have the same MUN or PUN values [20]. Variables such as days in milk, level of milk production, dry matter intake, water intake, etc. will vary from cow to cow and thus affect MUN and PUN values. Results from Iowa State University indicates that at least 75% of cows would need to be sampled in a herd or group to get an accurate determination if individual cows are sampled [21].

CONCLUSIONS

Reproductive performance of a dairy herd is a primary determinant of profitability and the fertility level obtained by a herd is an important component of reproductive performance. Factors which determine the fertility levels of a dairy herd are numerous and often complex in nature. Although it may be difficult to diagnose various causes of fertilization failure are usually related to an AI technique failure or some source of stress experienced by the lactating cow.

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