SDSU Extension

BEEF

Chapter 25

Management Factors That Influence Fertility

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Introduction

Reproductive failure is a major source of economic loss in the beef industry. The majority of this loss occurs because cows do not become pregnant during a defined breeding season. Therefore, the goal of any breeding program (AI or natural service; Synchronized or not) is to optimize the number of females that become pregnant. This means that fertility plays a major role in the success of any breeding program. This chapter will focus on the factors that affect pregnancy rates in both natural service and AI and synchronized and non-synchronized breeding programs. Fertility is influenced by many factors, but one of the best methods to look at factors that influence fertility is with the “Equation of Reproduction.” The equation looks at 4 main topic areas: 1) Percentage of animals detected in standing estrus and inseminated, 2) Inseminator efficiency, 3) Fertility level of the herd, and 4) Fertility level of the semen.

Percentage of Animals Detected in Standing Estrus and Inseminated

For successful insemination of cattle to occur, animals must be detected in standing estrus. Detecting standing estrus (also referred to as heat detection or detecting standing heat) is simply looking for the changes in animal behavior associated with a cow/heifer standing to be mounted by a bull or another cow/heifer.

With natural service estrous detect is considered to be easy, it is the bulls job. However, differences do exist among bulls. Libido refers to a bull’s desire to mate. Libido is thought to be a highly inherited trait with heritability ranging as high as 0.59 (Chenoweth, 1997). This is because there is more variation in libido between sons of different sires than between sons of the same sire. It is important to remember that scrotal circumference, semen quality, and physical confirmation (evaluated in a Breeding Soundness Evaluation) are not related to libido. Libido has a direct affect on pregnancy rate and, as such, it can influence the success of an entire breeding

Key Points

- One of the best methods to look at factors that influence fertility is with the “Equation of Reproduction.”
- For successful insemination of cattle to occur, animals must be detected in standing estrus.
- With natural service inseminator efficiency is influenced by the ability of a bull to service a cow.
- With AI, inseminator efficiency is influenced by semen handling and the ability of the technician to deposit semen in the correct location.
- Fertility level of the herd includes cycling status, compliance with protocols, embryonic mortality, body condition (nutrition level), and disease, and may be the hardest factor to evaluate.
- Fertility level of the semen refers to differences among bulls in the ability to achieve pregnancy success.

season. Libido can be practically evaluated by closely watching a bull after introducing him to a cow herd and determining his desire to detect cows in estrus.

For successful artificial insemination of cattle to occur, the producer (herd manager, etc.) must take the place of the herd bull in detecting the cows/heifers that are ready to be inseminated. Accurate detection of animals in standing estrus is the goal of good estrous detection and plays a vital role in the success of any artificial insemination program. To maximize detection of standing estrus, it is extremely important to visually monitor cattle as much as possible. Observations should occur as early and as late as possible as well as during the middle of the day. Continuous observation of over 500 animals exhibiting natural estrus in 3 separate studies indicated 55.9% of cows initiated standing estrus from 6 p.m. to 6 a.m. (Table 1). Furthermore, when cows were observed for standing estrus every 6 hours (6 a.m., noon, 6 p.m., and midnight), estrous detection increased by 10% with the addition of a mid-day observation and by 19% when observed four times daily (every 6 hours) compared to detecting standing estrus at 6 a.m. and 6 p.m. alone (Hall et al., 1959). Therefore, detection of standing estrus can be one of the most time-consuming chores related to artificial insemination. Several estrous detection aids have been developed to assist with this time-consuming chore. These estrus-detection aids can effectively help determine which cows are or have been in standing estrus, therefore relieving some of the time required to visually observe cattle for standing estrus. A comparison between visual estrous detection every 3 hours (8 times daily), a marker animal (a bull with a deviated penis), and Estrotect® patches resulted in a similar (P > 0.79) percentage of animals correctly identified in standing estrus (92%, 92%, and 91%, respectively; Perry, 2005). However, increased visual observation, in addition to the use of estrus-detection aids, could improve fertility by determining the most appropriate time for insemination.

Table 1: Time of day when cows exhibit standing estrus. *Data adapted from Hurnik and King, 1987; Xu et al., 1998, G.A. Perry unpublished data.*

Time of Day	Cows exhibiting standing estrus
6 a.m. to 12 noon	26.0%
12 noon to 6 p.m.	18.1%
6 p.m. to midnight	26.9%
Midnight to 6 a.m.	29.0%

Inseminator Efficiency

With natural service inseminator efficiency is influenced by the ability of a bull to service a cow. The purpose of the physical examination portion of a breeding soundness evaluation is to determine a bull's mating ability. Mating ability can be described as the physical capabilities needed to successfully breed a cow. In addition to structural unsoundness, diseases or injuries to the penis or prepuce can result in an inability to breed via natural service. These abnormalities will only be detected by careful examination or observing an attempted mating of a cow. A bull that has high quality semen but is unable to physically breed cows is unsatisfactory for natural service.

With AI, inseminator efficiency is influenced by semen handling and the ability of the technician to deposit semen in the correct location. A detailed inventory of semen should be easily accessible, so that straws may be located and removed from the tank quickly to avoid exposure of semen to ambient temperature. When removing a straw from a liquid nitrogen refrigerator, it is imperative that the technician keep the canister, cane and unused semen straws as low as possible in the neck of the tank. It is best to keep all unused straws below the frost-line in the neck of the tank. The temperature of liquid nitrogen in a semen tank is -196 degrees Celsius (°C; -326 degrees Fahrenheit, °F). Sperm injury (as judged by sperm motility) occurs at temperatures as warm as -79°C (-110°F; Etgen et al., 1957; Bean et al., 1963; DeJarnette, 1999). Effects of liquid nitrogen level in a tank that is being used during breeding can dramatically affect the temperature of straws that are repeatedly raised and lowered in the tank for semen retrieval. When the tank was full of liquid nitrogen, elevation of the semen into the neck of the tank for periods of approximately 1 minute resulted in a temperature increase of just 15°C (from -196 to -180°C). However, when the liquid nitrogen level in the tank was low (approximately 14 cm), the temperature of straws increased 72°C (from -196 to -124°C) and the temperature did not return to -196°C when replaced. Furthermore, injury to sperm cannot be corrected by returning semen to the liquid nitrogen (Berndtson et al., 1976; Saacke et al., 1978).

Sexed semen for commercial use is currently packaged in 0.25-mL straws with each straw containing 2.1 million sperm. Although 0.25-mL straws containing sexed semen may be handled similarly to 0.5-mL straws (as outlined above), the smaller diameter makes them more sensitive to semen handling errors. Recent research from ABS Global demonstrated the decline in sperm motility over time when sexed semen is not handled properly (Figure 1). To maximize the potential fertility in each straw of sexed semen, extreme caution must be exercised during semen handling. Conception rates will most likely be maximized when AI personnel follow the previously mentioned guidelines with special attention to a) the maintenance of thermal protection of straws during AI gun assembly and transport to the animal, and b) deposition of semen in the uterus as soon as possible.

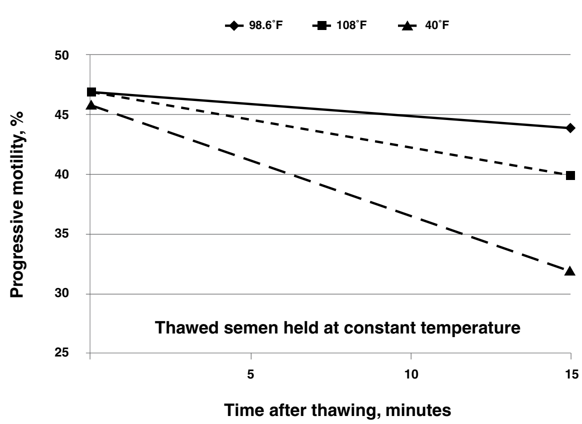

Figure 1: Progressive motility of sexed semen after thawing in a water bath at 95 to 98°F. Thawed semen was held at constant temperatures of either 98.6°F (recommended; denoted by a solid line with diamond endpoints), 108°F (heat shock; denoted by small dashed line with square endpoints), or 40°F (cold shock; denoted by large dashed line with triangle endpoints). Adapted from ABS Global, 2009.

Fertility Level of the Herd

Fertility level of the herd may be the hardest factor to evaluate. Herd fertility includes cycling status, compliance with protocols, embryonic mortality, body condition (nutrition level), and disease.

Cycling status is a direct reflection of the nutritional status of the cowherd. Cows calving in body condition scores of less than 5 and heifers less than 6, and not on an increasing plain of nutrition from calving to breeding, will not return to estrus as quickly as their counterparts that have been offered a diet that meets their nutritional needs.

Cattlemen utilizing synchronization technologies in their breeding programs must adapt a regimented mindset when following protocol recommendations in order to achieve desirable reproductive performance. These researched protocols are based on years of study and applied trials with hundreds/thousands of cattle. Non-compliance with them could be extremely costly to the cattleman in terms of open/late cows and heifers.

Fertilization rates are usually between 89% and 100% when an animal exhibits estrus and semen is present at the time ovulation occurs (Bearden et al., 1956; Diskin and Sreenan, 1980; Gayerie de Abreu et al., 1984; Kidder et al., 1954; Maurer and Chenault, 1983). While fertilization usually takes place, conception rates (number of animals that conceive divided by number of animals inseminated) are usually around 60% to 70% for natural service or artificial insemination. Although nature (poor oocyte quality, disease, chromosomal abnormalities, etc.) contributes much of this loss, management practices can also increase embryonic mortality. Stress, particularly heat and shipping stress, can be detrimental to embryos and decrease pregnancy rates.

Stress and Embryonic Mortality

With the knowledge of the critical time points in embryonic development, it is possible to completely understand how stress can result in increased embryonic mortality in cows (Table 2). A cow does not even know an embryo is present until day 15 to 17. Thus stress or changes can impact the growth of that embryo and result in the embryo dying before the cows even knows she is pregnant. When animals are stressed they can release hormones related to stress that can change the uterine environment in which the embryo is developing. In addition during early embryo growth the embryo is totally dependent on secretions from the uterus for its growth and survival, and changes in these secretions can impact an embryo's survival.

Table 2: Time course of early bovine embryo development. *Data adapted from: Shea, 1981, Flechon and Renard, 1978, Peters, 1996, Telford et al., 1990*

Event	Day
Estrus	0
Ovulation	1
Fertilization	1
First cell division	2
8-cell stage	3
Migration to uterus	5-6
Blastocyst	7-8
Hatching	9-11
Maternal recognition of pregnancy	15-17
Attachment to the uterus	19
Adhesion to uterus	21-22
Placentation	25
Definitive attachment of the embryo to the uterus	42
Birth	285

When should I not ship cows?: Shipping cows between days 5 and 42 can be detrimental to embryo survival and cause around a 10% decrease in pregnancy rates (Table 3). Critical time points such as blastocyst formation, hatching, maternal recognition of pregnancy, and adhesion to the uterus take place during this early time of pregnancy. If any of these time points are disturbed, then the result would lead to increased embryonic mortality and decreased pregnancy rates. Research has also demonstrated that shipping cattle 45 to 60 days after insemination can result in 6% of embryos being lost. Therefore, it is important to plan on transporting cattle before the breeding season or immediately after insemination.

When can I ship cows?: Shipping between days 1 - 4 is best. The embryo is still in the oviduct during this time; therefore, it is likely not subjected to uterine changes. Also after day 45, the embryo is well established and fully attached with the placenta; therefore it is less susceptible to the changes resulting from stress. Shipping at this point is less risky. However, embryonic loss from shipping has been reported up to 60 days after insemination. Care should always be taken to try to reduce the stress involved when animals are shipped. Do not overcrowd trailers and handle cattle as gently and calmly as possible.

Heat Stress and Embryonic Mortality: The best time to ship cattle is during early stages of development. However, this is also the time point when the embryo is most susceptible to increased temperatures. Temperature, humidity, radiant heat, and wind all affect heat stress in cows. The rectal temperature of cattle is normally 102.2°F, and an increase in rectal temperature by as little as 2°F can result in decreased embryonic development (Ulberg and Burfening, 1967). When rectal temperatures reach 105.8°F for as little as 9 hours on the day of insemination, embryonic development can be compromised (Rivera and Hansen, 2001). Heat stress has also been reported to change follicular waves, resulting in reduced oocyte quality (Wolfenson et al., 1995). Researchers have reported that heat stress 42 days prior to (Al-Katanani et al., 2001) and up to 40 days after breeding can affect pregnancy rates (Cartmill et al., 2001). This illustrates how important it is to plan ahead for the breeding season.

Table 3: Effect of time of transport after insemination on pregnancy rates. *Data adapted from Harrington et al., 1995, and T. W. Geary unpublished data.*

	Days after insemination that transportation occurred			
	1 to 4	**8 to 12**	**29 to 33**	**45 to 60***
Synchronized pregnancy rate	74%	62%	65%	---
% pregnancy loss compared to transportation on days 1 to 4	---	12%	9%	6%*
Breeding season pregnancy rate	95%	94%	94%	---
*Loss in heifers compared to percentage pregnant prior to transportation (pregnancy determined by transrectal ultrasonography)				

Stress from Change in Diet: Changes in nutritional status can also have a tremendous influence on embryonic survival through many mechanisms. Heifers fed 85% maintenance requirements of energy and protein had reduced embryo development on day 3 and day 8 compared to heifers fed 100% maintenance (Hill et al., 1970) indicating decreased embryonic growth. In addition, changes in diet immediately after insemination resulted in decreased AI pregnancy success (Perry et al., 2013). Therefore, changes in nutrition can have a tremendous impact on embryo survival and the ability of heifers to conceive during a defined breeding season.

Impact of Timing of Vaccination on Pregnancy Success

Several studies have reported negative impacts on pregnancy success by vaccinating naïve heifers with a modified live vaccine (MLV) around time of breeding (Miller et al., 1989; Chiang et al., 1990; Miller, 1991), but among pre-vaccinated heifers, conception rates did not differ between heifers vaccinated 3 days before peak AI or 40 days before peak AI (Bolton et al, 2007). Therefore, general recommendations for vaccination of replacement heifers include: before and at weaning, with both heifers and cows receiving a booster vaccine at least 30 to 60 days before breeding. If it is absolutely necessary to give a vaccine less than 30 days prior to breeding, the vaccine should be administered as soon as possible and it is a better option to utilize a killed vaccine at this point in time. Animals that have not previously been vaccinated (naïve animals) should not be vaccinated with a modified live vaccine near the time of breeding.

Fertility Level of the Semen

Clearly there are differences among bulls in the ability to achieve pregnancy success. For several decades seminal traits have been studied to try to predict reproductive success. Nevertheless, the determination of fertility differences between bulls requires the insemination of several thousand animals under the same management practices. All natural service bulls should have a comprehensive breeding soundness evaluation approximately 60 days prior to each breeding season. Whether natural service or AI is used, two of the most important indicators of bull fertility currently available are sperm motility and morphology. The influence of these different traits on the likelihood of pregnancy is discussed in great detail in another chapter of these proceedings.

Summary

This chapter has focused on some of the many factors that affect pregnancy rates in both natural service and AI and synchronized and non-synchronized breeding programs. One of the most comprehensive methods to look at factors that influence fertility is the "Equation of Reproduction." The equation looks at 4 main topic areas: 1) Percentage of animals detected in standing estrus and inseminated; 2) Inseminator efficiency; 3) Fertility level of the herd; and 4) Fertility level of the semen.

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