Proceedings Applied Reproductive Strategies in Beef Cattle
August 30-31, 2022, San Antonio, TX

MANAGEMENT DECISIONS TO IMPROVE THE REPRODUCTIVE PERFORMANCE OF YOUR HERD: FROM CALVING TO REBREEDING

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Introduction

Reproductive performance is of critical importance to the profitability of a cow-calf producer, and numerous factors (e.g. heifer development, nutrition, cow body condition at calving, bull fertility, environment, etc.) affect reproductive efficiency. Research has indicated it takes the net revenue from approximately 6 calves to cover the development and production costs of each replacement heifer (E. M. Mousel Unpublished data). In addition, any cow that misses a single calving is not likely to recover the lost revenue of that missed calf (Mathews and Short, 2001). Considering the importance of longevity, non-pregnant cows or heifers are often culled from the herd. These females increase the developmental or maintenance costs of herd mates and negatively impact the overall profitability of the farm. Therefore, longevity and consistent productivity of a beef female is very important to the sustainability of any beef operation. The purpose of this paper is to discuss the primary factors affecting reproductive performance in the beef herd and to provide some management suggestions for increasing reproductive performance in postpartum cows and first calf heifers.

A first step to improving production is to understand critical benchmarks required for success. To evaluate the reproductive performance of your herd you should ask the following questions:

Question 1 - Over the past few years, what has been the pregnancy rate for my heifers and cows during the first 60 to 70 days of the breeding season? Pregnancy rate is defined as the total number pregnant during the breeding season divided by the number of females exposed to breeding (expressed as a percent). If the pregnancy rate in your heifers and cows is 85% or greater during the first 60 to 70 days of the breeding season, then your herd is doing well reproductively.

Question 2 - What proportion of my herd has calved by day 21, 42, and 63 of the calving season? In high production herds it is common for 61% of the calves to be born by day 21, 85% by day 42, and 94% by day 63.

Question 3 - What does the calving pattern of my two- and three-year old cows look like? If the majority of your first calf heifers and three-year old cows are calving late or in the middle of your calving season, then you should pay closer attention to heifer development and the management of your first calf heifers.

Factors affecting pregnancy rate

When it comes to reproductive management the things you do well do not compensate for the mistakes you make. Instead, the mistakes you make cancel out all the things you do well. This is best illustrated by examining the primary factors that affect pregnancy rate when using natural service or artificial insemination (AI). Pregnancy rate = estrous detection rate x conception rate (see definitions below). Of course with natural service the bull takes on the role of both detecting estrus and inseminating. The following definitions can be applied to an entire breeding season or to a synchronized period (period of time during which estrus is expressed after treatment with a protocol to synchronize estrus [normally 5 to 7 days]).

Pregnancy rate – total number pregnant during the breeding season divided by the number of females exposed to breeding (expressed as a percent).

Estrous detection rate – total number of females detected in estrus (or mated in the case of natural service) divided by the number of females exposed to breeding (expressed as a percent).

Conception rate – percentage of females that become pregnant to a designated insemination.

The effect of a decrease in estrous detection rate and/or conception rate on pregnancy rate can be seen in **Table 1**. In an optimal scenario, assume that 100% of the cows are cycling and that you or the bulls are able to detect 95% of the cows in estrus during a synchronized period (AI program) or during the first 21 days of the breeding season (natural service). With a conception rate of 70% per service the pregnancy rate after a single breeding would be: 95% estrous detection rate x 70% conception rate = 67% pregnancy rate! If we hold conception rate at 70% and decrease estrous detection rate to 75%, due to fewer animals cycling, reduced libido of a bull, or less time spent detecting estrus, pregnancy rate will be reduced to 53%. Alternatively, if estrous detection rate remains at 95% but conception rate is decreased to 50% due to compromised semen quality or poor insemination technique, pregnancy rate would decrease to 48%. Finally, a decrease in both estrous detection rate and conception rate will decrease pregnancy rate from 67% to 38%. Therefore, understanding the effect of estrous detection rate and conception rate on pregnancy rate and the importance of attention to detail to the management of your bulls or your synchronization/AI program is essential!

Table 1: **Effect of estrous detection rate and conception rate on pregnancy rate in cattle.**

Estrous detection rate	Conception rate	Pregnancy rate
95%	70%	67%
75%	70%	53%
95%	50%	48%
75%	50%	38%

Importance of early calving cows:

The primary reason a beef cow does not wean a calf is that she fails to become pregnant during the breeding season, which is likely due to not showing estrus or a failure to conceive following estrus. Cows that conceive late in the breeding season will calve late and wean a calf that is much younger at weaning compared to a cow that weans a calf that is born early in the breeding season. Age a weaning is generally considered to be the most important factor affecting weaning weights in beef cattle. The importance of maximizing the proportion of cows that conceive early in the breeding season cannot be overemphasized in a beef herd. Research has indicated that animals that conceive earlier in the breeding season are more likely to conceive in the subsequent breeding season compared to cows that conceive late in the breeding season (Burris and Priode, 1958). More recent data from the University of Nebraska also reported that heifers born during the first 20 days compared to the second or third 20 days of the calving season had greater weaning weights, prebreeding weights, and precalving weights; more heifers cycling by the start of the breeding season; and higher pregnancy rates. Heifers that conceive early in the breeding season have greater longevity in the herd which increases profitability. Furthermore, steer progeny born during the first 20 days compared to the second or third 20 days of the calving season had greater weaning weights, increased hot carcass weights, higher marbling score, and greater carcass value (Larson and Funston, 2009; Funston et. al., 2011). Consequently, the advantages of calves born early include improved end product quality as well as increased reproductive performance of heifers.

Since open cows result in reduced profitability, some producers will extend the length of the breeding season as a strategy for increasing pregnancy rate during the breeding season. However, do long breeding seasons necessarily result in higher pregnancy rates? To examine this question, records of 230 beef herds in Missouri which included over 22,000 cows from purebred and commercial herds of various herd sizes were analyzed. In this study longer breeding seasons did not increase pregnancy rate (**Figure 1**).

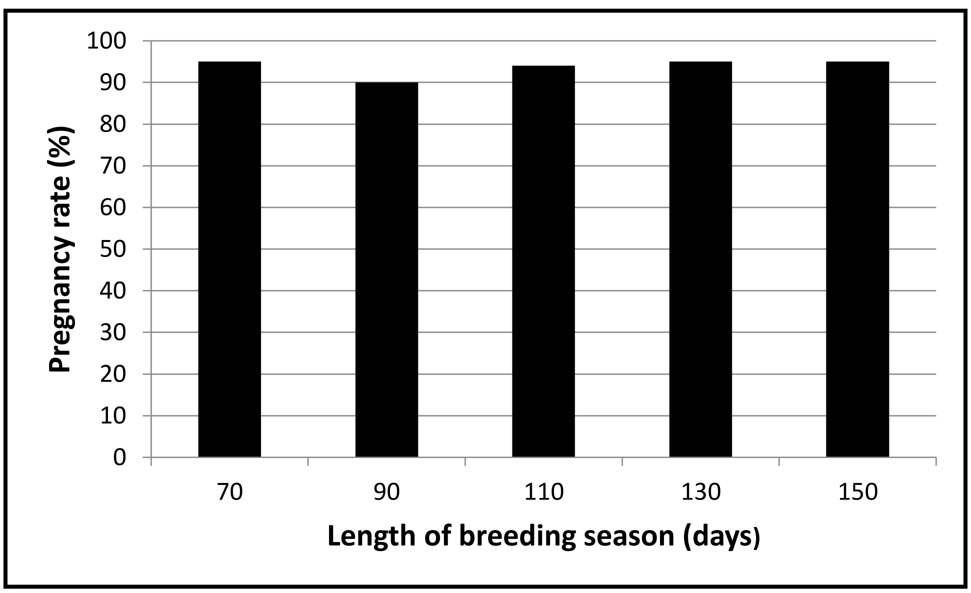

Figure 1: This figure illustrates the relationship between length of the breeding season and pregnancy rates in beef herds. Extending the length of the breeding season did not increase the pregnancy rate.

One of the reasons that lengthening the breeding season does not increase pregnancy rate is that longer breeding seasons result in longer calving seasons. Cows that calve late frequently don't have adequate time to return to estrus and conceive before the end of the breeding season, which can lead to further extension of the breeding season and a perpetuation of the problem. Decreasing the length of the breeding season can actually increase reproductive performance and weaning weights. This is because decreasing the length of the breeding season will shorten the calving season and provide cows with more time to return to estrus by the start of the breeding season and increase weaning weights due to increased calf age at weaning. Furthermore, a shorter calving season allows a producer to provide more supervision at calving which can reduce calf loss, particularly in heifers.

Postpartum anestrus is major limiting factor to reproductive efficiency

To maintain an annual calving interval (≤ 365 days), conception must occur within 80 days of calving; however, the period of anestrus (absence of estrous cycles) following calving is frequently greater than 60 days. Based on data from Missouri beef herds only 60% of postpartum beef cows were cycling at the start of the breeding season. The importance of a female calving early and maintaining a short breeding season were discussed previously, and the effect of calving date on the proportion of beef cows calving the subsequent year is shown in **Figure 2**. The reason that cows which calve late have difficulty conceiving is due to the prolonged interval from calving to the establishment of normal estrous cycles (i.e. postpartum interval).

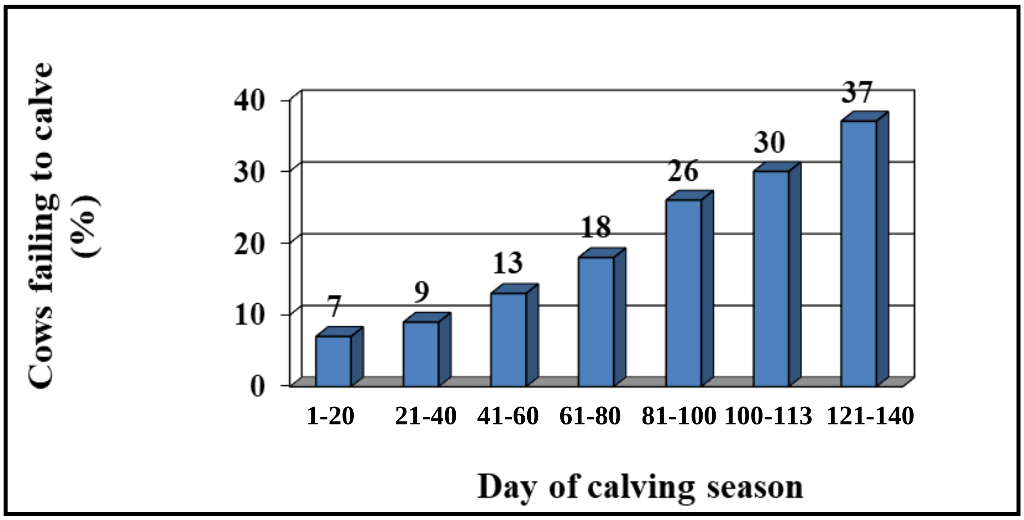

Figure 2: Effect of calving date on the proportion (%) of cows failing to calve the subsequent year Burris and Priode, 1958). Fewer of the cows that calved the first 20 days of the calving season failed to calve the next year (7%) compared to cows that calved 121 to 140 days after the start of the calving season (37%). This is because cows that calve late frequently don't have time to show estrus and conceive during the breeding season.

In beef cattle, prolonged postpartum intervals decrease the proportion of cows that are cycling at the start of the breeding season and thereby decrease pregnancy rates and pounds of calf weaned per cow exposed during a breeding season. Postpartum interval length is influenced by a variety of factors including suckling, nutrition, age, dystocia, genetic variation, stress, and disease (Short et al., 1990; Yavas and Walton, 2000). These factors can be classified into primary factors that have a significant influence on postpartum interval, and secondary factors that influence postpartum interval but may be mediated through primary factors.

Primary factors affecting postpartum interval length

Suckling: Postpartum beef cows that are suckled ad libitum have a longer postpartum anestrous period than cows that are suckled once daily, or not suckled at all (Williams, 1990). This extended anestrous period is a direct function of suckling and the bond that develops between a cow and her own calf. The ability of a cow to recognize her calf prolongs postpartum interval length in addition to the neural stimulation of the suckling stimulus. Luteinizing hormone (LH) is an important reproductive hormone that is secreted from the anterior pituitary gland into the blood and is required for the establishment and maintenance of estrous cycles in numerous mammals, including cattle. An increase in LH pulse frequency is required for growth and maturation of an ovulatory follicle. As time from calving increases so does the frequency of LH pulses in the circulation and this culminates in a short luteal phase followed by the first normal estrous cycle postpartum. Interestingly, the biological changes from calving to the first ovulatory estrus in a postpartum cow are similar to the physiological changes in a heifer as she approaches puberty. For example, initiation of normal estrous cycles in prepubertal heifers and cows is frequently preceded by an ovulation, without estrus, that results in a short luteal phase (Perry et al., 1991; Werth et al., 1996). This short exposure to progesterone is believed to be necessary for reprogramming the reproductive axis to resume normal estrous cycles. Therefore, in herds that have a large proportion of prepuberal heifers or anestrous cows, progestin pretreatment (Melengestrol acetate or CIDR treatment) before induction of ovulation can initiate estrous cycles by simulating a short luteal phase. Management strategies that reduce suckling frequency have also been employed to reduce postpartum interval length and facilitate rebreeding (Williams 1990). Methods of reducing suckling frequency commonly include early weaning, once-daily sucking, and temporary calf removal. Normally as the degree of suckling frequency decreases the benefit to postpartum reproduction increases.

Early weaning: Early weaning requires additional management and is normally only used under adverse environmental conditions such as drought, over grazing, or inadequate feed quality. Calves have been weaned between 45 and 80 days of age and conception rate was reported to increase in two year olds, three year olds, and four year olds by 26%, 16%, and 8%, respectively (Bellows et. al., 1974, Ray et. al., 1973; Smith and Vincent 1972). However, costs associated with the increased labor and management associated with early weaned calves must be carefully considered.

Once-daily suckling: As the name implies calves are allowed to suckle once a day beginning at 30 to 40 days of age. Cows are introduced to their calves once a day and the duration of suckling is approximately 30 minutes. Although this management strategy requires daily sorting of cows and calves, once a cow shows estrus and has been inseminated her calf can be returned to her. Normally once-daily sucking does not last more than 40 days. The calves need to be provided proper shelter and nutrition and although calf weights may decrease during the period of once-daily suckling not reduction in weaning weights have been reported (Randel 1981).

Short-term calf removal: This is the least aggressive method of reducing suckling frequency and requires less labor than the two previous methods. Short-term calf removal normally occurs for 48 hours since removing calves for 72 hours has not proved to be advantageous compared to 48 hour calf removal. Calves should be at least 40 to 45 days of age at the time of calf removal and provided water, high quality hay, and a creep feed that is approximately 14% crude protein. At calf return, calves should be allowed adequate time to “mother-up” before cows are moved to pasture. If the weather is inclement (rainy and cold) calf removal should be delayed until the weather improves. Depending upon calf age and body condition score of the cow, approximately 30 to 80% of postpartum cows will return to estrus within 20 days following short-term calf removal and pregnancy rates have been increased by 4 to 8%. In some cases, short-term calf removal has been combined with progestin-based synchronization systems and increased pregnancy rates have been reported. Calf removal will work on anestrous cows that are in moderate body condition (≥ 5 body condition score); however, cows in thin body condition (< 5 score) will require a more aggressive means of reducing suckling frequency such as once-daily suckling or early weaning.

Nutrition: Short et al. (1990) proposed the following biological priorities for nutrient utilization (nutrient partitioning) by cattle: 1) basal metabolism, 2) motor activity, 3) growth, 4) basic energy reserves, 5) maintenance of pregnancy, 6) lactation, 7) additional energy reserves, 8) estrous cycles and initiation of pregnancy, and 9) excess reserves. The preceding priorities for nutrient partitioning demonstrate that reproduction (resumption of estrous cycling and pregnancy) is a low priority, particularly for heifers calving at two years of age. Consequently, underfeeding energy and/or protein precalving and post calving reduced both pregnancy rates and first service conception rates, and increased the postpartum interval (see review by Randel, 1990). Both suckling and nutrition interact to have a powerful effect on return to estrus in beef cows.

A simple method of assessing bovine energy reserves is through a subjective body condition scoring (BCS) system, which ranges from 1 (emaciated) to 9 (obese). The scoring system evaluates the amount of fat cover at specific locations on the female. Cow body condition at calving has a critical role in determining postpartum interval length compared to body condition score at the start of the breeding season (Dziuk and Bellows, 1983). Consequently, prepartum nutrition level and maintenance of nutrition level postpartum has an important effect on subsequent reproductive performance (Randel, 1990). Cows having a body condition score ≥ 5 at calving returned to estrus sooner than cows having a lower body condition score (Spitzer et al., 1995), and cows with a body condition score of six or seven had higher pregnancy rates compared to cows with a body condition score of four or five (DeRouen et al., 1994). A strategic time to assess cow body condition is at weaning since a cow’s nutrient demands are significantly reduced after weaning and this is the most economical time to improve cow body condition. In general, a cow needs to gain approximately 80 lbs (not including the weight of a gestating calf and the associated fluids) to increase one condition score. Consequently, if a cow has a BCS of 3 at weaning and you want her to have a BCS of 5 at calving she will need to gain 160 lbs. By knowing how much weight she needs to gain and the number of days from weaning to calving you can calculate an expected average daily gain to achieve the targeted BCS goal by calving.

Precalving nutrition has an important effect on cow body condition at calving and subsequent postpartum interval length. The effects of poor body condition in cattle can be overcome by feeding cows prepartum to obtain a good body condition score at parturition (Morrison et al., 1999). Cows fed a high energy diet for 135 to 142 days prior to calving had higher pregnancy rates, conceived earlier in the breeding season, had a shorter interval from calving to conception, and exhibited estrus earlier postpartum than cows fed half the energy of the high energy ration (Dunn et al., 1969). Increased energy content of feed as late as two months before calving increased BCS, percent cycling and pregnancy rates during the first half of the breeding season (Espinoza et al., 1995).

Whereas precalving nutrition is an important determinant of postpartum interval length, postcalving nutrition has an important effect on conception rate. Increasing energy content in a ration after calving resulted in higher pregnancy rates and cows conceived earlier in the breeding season, but cows did not exhibit estrus earlier postpartum compared to control animals (Dunn et al., 1969). Waiting until 4 weeks after calving and 11 days before breeding to increase energy supplementation had no effect on concentrations of LH or estradiol. This practice did increase the size of the largest follicle 7, 9, and 12 days after feeding was initiated, and it also increased pregnancy rates and maintenance of the embryo (Khireddine et al., 1998). Therefore, supplementation of cattle following calving resulted in a shorter duration of negative energy balance and increased reproductive performance.

Secondary factors affecting postpartum interval length

Cow age: As previously discussed, growth is a higher priority for nutrient partitioning than reproduction, and heifers consistently had longer postpartum intervals than multiparous cows (Doornbos et al., 1984; Fajersson et al., 1999). In addition, the first ovulation postpartum in primiparous cows was delayed relative to multiparous cows (Sharpe et al., 1986; Guedon et al., 1999). Consequently, as animals reach mature body size nutrients that were previously partitioned for growth can be utilized for lower priority functions including reproduction. Consequently, feeding first calf heifers separate from older cows and providing supplemental nutrition to first calf heifers can be effective strategies for negating the effect of cow age on rebreeding.

Dystocia: Heifers calving at two years of age have increased incidence of dystocia compared to older cows. Furthermore, heifers that experienced calving difficulty at two years of age weaned fewer calves that were younger and lighter (Brinks et al., 1973). Cows experiencing dystocia resulted in a lower percentage of cows exhibiting standing estrus within 45 days of calving, decreased AI pregnancy rates, and decreased total pregnancy rates (Laster et al., 1973). Therefore, minimizing the incidence of dystocia through proper heifer development and use of "calving ease" bulls as well as being proactive in providing obstetrical assistance will help reduce postpartum interval length and increase reproductive performance.

Additional methods of decreasing postpartum interval length

Fixed-time Artificial Insemination (FTAI)**:** At the start of a breeding season, most herds consist of a mixture of cycling and anestrous females. In order to maximize the proportion of females that conceive early in the breeding season protocols to synchronize estrus have been developed that permit cycling and anestrous cows to be inseminated at a predetermined time and achieve pregnancy rates similar to synchronization protocols that depend upon estrous detection. To achieve pregnancy rates to FTAI in anestrous cows that are similar to cycling cows it is necessary to utilize a progestin-based protocol. As mentioned earlier, a short luteal phase usually occurs in postpartum beef cows following the first ovulation. This short exposure to progesterone is believed to be necessary for reprogramming the reproductive axis to resume normal estrous cycling. Therefore, in herds with a large proportion of prepuberal heifers or anestrous cows, progestin pretreatment before induction of ovulation will simulate a short cycle and initiate normal estrous cycles. Two progestin products that are commercially available for synchronization protocols include Melengestrol Acetate (MGA) and the CIDR (Controlled Internal Drug Release). In

Missouri, approximately 2300 postpartum cows were administered a progestin-based FTAI protocol and 43% of the cows were anestrus when the protocol was administered. However, the pregnancy rate for the cycling and anestrous cows following FTAI was essentially the same (64.8% and 63.8%, respectively). Consequently, progestin-based FTAI protocols can be effective in inducing a fertile ovulation and increasing the proportion of anestrous cows that become pregnant at the start of the breeding season.

Biostimulation (Bull Exposure)**:** The interval from calving to estrus and ovulation is reported to be decreased by 14 to 18 days following exposure of first calf heifers and older cows to bulls (Berardinelli, 2007). Furthermore, the effect of bull exposure has been reported in both Bos taurus and Bos indicus breeds. The best results have been achieved when the cows are at least 40 days postpartum at the time of bull exposure. The stimulatory effect of yearling bulls seem to be as effective as older bulls and fenceline contact can be as effective as having the bulls mixed with the cows provided the cows have close contact with the bulls for a period of time that has not yet been determined. The cow to bull ratio for effective biostimulation is dependent upon pasture size and bull number. Since the biostimulatory effect is believed to be mediated by pheromones (chemical messages that communicate from animal to animal), cows in a small pasture or pens will not require as many bulls as cows on a large pasture that does not have a local center where the cattle gather. This is an ongoing area of research.

Additional strategies from calving to breeding that improve reproductive efficiency

Attention to detail if using FTAI: Postpartum cows that are good candidates for synchronization programs normally meet each of the following criteria: 1) body condition score at calving of ≥ 5 (1= emaciated; 9 = obese), 2) mean postpartum interval of the cows to be synchronized should be ≥ 40 days at the beginning of the protocol. This does not mean that each cow should be ≥ 40 days postpartum but that the mean of the entire group to be synchronized should be ≥ 40 days. If the synchronization protocol you plan to use includes CIDR administration, each cow should be a minimum of 21 days postpartum at the time of CIDR insertion, and 3) low incidence of calving difficulty since dystocia will lengthen the postpartum interval.

Synchronization protocols must be followed precisely. Each product must be administered at the correct dose on the correct day (refer to protocol sheet) and in some cases at the right time of day. For example, the interval from prostaglandin $F_{2\alpha}$ (PGF) to gonadotropin releasing hormone (GnRH) and insemination must be in accordance with what is recommended in the protocol sheet (e.g. 66 ± 2 hr for the CO-Synch + CIDR protocol). The recommended time of insemination relative to PGF injection is based on research trials and should be strictly adhered to. In addition, synchronization products must be stored, handled, and administered correctly. For specific tips on handling synchronization products see **Tables 2 and 3.** Should a mistake occur in product administration or the treatment timeline seek advice immediately from a veterinarian, an extension agent specializing in reproduction, or a representative from an AI company. To minimize the probability of making a mistake, a good practice is to write each of the days of treatment, the product name, dose to be administered, and the day of insemination on a calendar and ask a trusted veterinarian, extension specialist, or AI company representative to review it before beginning the protocol. Understanding the basic principles of the bovine estrous cycle and how the products synchronize estrus and ovulation can be helpful in reducing the probability of administering the wrong product on a certain day. For more information on how protocols synchronize estrus and ovulation refer to the web based course entitled “Fundamentals of Beef Reproduction and Management: Focus on Estrus Synchronization” (http://animalsciences.missouri.edu/extension/beef/estrous_synch/).

Table 2. Proper handling and administration of GnRH and PGF products.

• All injections of GnRH and PGF products should be given intramuscularly (IM)
• Wear latex gloves when administering GnRH and PGF products
• An 18 gauge 1 ½ inch needle is recommended for these injections
• Change needles frequently
  ○ Make sure that injection sites are free of manure and dirt, which may cause infection
  ○ Injecting cattle during wet weather increases the potential for infection
• **Always** follow manufacturer’s recommended storage, dosage, and administration procedures

Table 3. Proper handling and administration of progestins.
Controlled Internal Drug Release (CIDR)
1) Wear protective (e.g. latex) gloves when handling CIDR inserts.
2) The CIDR applicator should be rinsed in a disinfectant solution (Nolvasan or Chlorohexidine). There should be two buckets each containing a disinfectant solution. The applicator should be washed free of debris in the first bucket and then rinsed clean in the second. This sequence of events will improve sanitation from animal to animal and reduce the likelihood of infection.
3) Fold the wings of the CIDR and insert it into a clean applicator. The CIDR will protrude approximately one inch from the applicator.
4) Apply lube to the end of the applicator.
5) Wipe the vulva clean before inserting the applicator.
6) When inserting the CIDR make sure that the nylon tail is curved downward. If the tail is pointed upward it will be easier for other animals to pull out the CIDR thus reducing retention rate. To prevent other animals from removing the CIDR, the nylon tail can be clipped such that only 2 ½ inches protrude from the vulva.
7) Gently insert the applicator containing the CIDR in an upward manner similar to the insertion of an AI catheter.
8) Push the applicator as far forward as possible, deposit the CIDR by pressing the plunger, and slowly remove the applicator.
9) At CIDR removal, gently but firmly pull on the nylon tail until it is removed. Be sure to dispose of the CIDR properly.
Melengestrol Acetate (MGA)

1)	MGA is an orally active feed additive that should be fed once a day at the recommended dose - 0.5 mg in a 3 to 5 lb carrier. Do not top dress MGA on other feeds. Provide adequate bunk space - 18-24 inches per animal. Allow heifers to adjust to carrier prior to MGA administration.
2)	MGA is approved by the FDA for heifers intended for breeding (suppression of estrus) and for heifers fed in confinement for slaughter for increased rate of weight gain, improved feed efficiency, and suppression of estrus.
3)	Use of MGA as part of any protocol to synchronize estrus in beef cows constitutes and extra label use of medicated feed that is prohibited by the Animal Medicinal Drug Use and Clarification Act and regulation 21 CFR 530.11(b).

In cattle, the estrous cycle normally varies from 17 to 24 days and the duration of standing estrus is generally 12 to 15 hours; however, considerable variation exists among individual animals (range < 8 to > 30 hours; (O'Connor and Senger, 1997). The primary sign of estrus in cattle is standing to be mounted and secondary signs of estrus include frequent mounting, watery mucus from the vulva, and restlessness. Maximizing the estrous detection rate is dependent upon accurate detection of animals in standing estrus, which can be a difficult and time-consuming activity. When estrus was detected in 500 Angus cows with the HeatWatch® detection system, the length of estrus averaged 10 hours (range: 0.5 hours to 24 hours); however, 26% of cows exhibited estrus for less than 7 hours and had fewer than 1.5 mounts per hour (Rorie et al., 2002). To maximize detection of standing estrus, it is 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 that 55.9% of cows initiated standing estrus from 6 p.m. to 6 a.m. (**Table 4**). 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.

Table 4. Time of day when cows exhibit 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 %

Data adapted from (Hurnik and King, 1987; Xu et al., 1998), G.A. Perry unpublished data).

There are commercially available products to help detect estrus. These products can be used in conjunction with visual observation to increase estrous detection efficiency in beef herds. Some of the more common products to assist with detection of estrus include tail chalk/paint, pressure mount detectors, gomer (spotter) bulls (teaser bulls; rendered sterile by vasectomy, epididectomy, and (or) penile deviation), and androgenized cows. **Table 5** provides a list of common products used to detect estrus, a description of how they work, some potential concerns, and relative cost. A comparison between visual detection of estrus 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). Increased visual observation, in addition to the use of products to detect estrus, can improve pregnancy rates by determining the most appropriate time for insemination.

Table 5. A list of products to assist with detecting estrus in beef cattle, a description of how they work, potential concerns, and relative cost.			
	How it Works	**Potential Concerns**	**Relative Cost**
Tail Chalk	Chalk is applied to tailhead. When animal is mounted the color will be rubbed off and hair will be ruffled.	Removal by trees, water, fences, or licking by other animals	$
Heat Mount Detectors	Detectors are applied to tailhead and turn a different color when mounted.	Partial activation or loss of detector requires interpretation, false activation (e.g. trees, fences, other animals)	$$
Gomer Bulls	Vasectomized, epididyectomized, and (or) penile-deviated animals are used as teaser animals and will mount females in estrus.	Feeding and maintenance expense, potential loss of desire to mate, and disease transmission by non penile-deviated animals	$$$
Chin Ball Marking Harness	Detector animal is fitted with harness leaving an inkmark on the back and neck of females that have been mounted.	Maintenance of equipment, feeding and maintenance of animal, ill-defined markings	$$
Androgenized cows	Testosterone injections before and during the breeding season or androgen implant causes cow to mount other females in heat.	Cost and labor of administering drug, variable response to hormone	$$

The number of mounts per estrus increases as the number of females in estrus increases (Helmer and Britt, 1985; Landaeta-Hernandez et al., 2002). This is likely due to the formation of sexually active groups of cattle which is known to increase the number of mounts per female (Hurnik et al., 1975; Galina et al., 1994). In nonsynchronized cattle there will be fewer sexually active groups (or fewer animals per group) and less mounting activity. Therefore, improved efficiency of detecting estrus is an advantage of a synchronization program. However, it is also true that frequent animal handling and restraint are stressors (Dobson and Kamonpatana, 1986) and that increased handling and restraint of heifers during a synchronized estrus decreased the number of mounts per estrus (Lemaster et al., 1999). Depending upon the synchronization protocol, a fixed-time insemination protocol should reduce the amount of animal handling associated with sorting estrual heifers at the time of insemination.

When utilizing a synchronization protocol that requires detection of estrus, insemination occurs approximately 8 to 12 hours following first observation of standing estrus (AM/PM rule) when using conventional semen. In other words, if a cow is detected in estrus in the AM then AI should occur the following PM; whereas, if a cow is detected in estrus in the PM then AI should occur the following AM). It is essential that the presence of fertile sperm in the oviduct coincide with the time when the oocyte is viable (8 to 10 hour period following ovulation). Insemination (AI) too soon, following detection of estrus, can decrease the probability that viable sperm are present at ovulation. However, insemination too late, relative to detection of estrus, may result in the oocyte dying before the sperm complete capacitation (process, within the female tract, by which sperm gain the capacity to fertilize the egg) and are capable of fertilizing the oocyte. The time of insemination is based on an understanding of the relationship among the following biological parameters: duration of estrus, interval from the gonadotropin (LH) surge to ovulation, lifespan of the oocyte (egg), lifespan of frozen-thawed sperm in the female tract, and duration of capacitation. For pregnancy to occur it is essential that fertile sperm be present in the vicinity of the oocyte when it is still alive. The duration of the preceding factors are shown in **Table 6** below and relationship among these factors when insemination twelve hours after first detection of estrus (AM/PM rule) is depicted in **Figure 3**. However, with FTAI protocols, time of insemination becomes a compromise between maximizing the proportion of females that show estrus before insemination and not waiting too long such that heifers or cows that were the first to show estrus end up being inseminated too late. There can be variation in the fertility of sires used in a FTAI protocol. Sires that achieve high fertility when insemination occurs approximately 12 hours after detection of estrus (AM/PM rule) do not always achieve high pregnancy success following fixed-time AI. Although the exact reasons for the difference are not known, it is likely that sperm longevity in the female tract is a primary reason.

Table 6. Duration of biological factors that affect the time of artificial insemination with frozen-thawed semen in cattle.

Biological factor	Duration
Duration of standing estrus	Highly variable but normally 12 to 15 hr
Time of the gonadotropin (LH) surge which initiates the ovulatory process	Begins around the onset of standing estrus and lasts a few hours
Time from the LH surge to ovulation	25 to 30 hr
Lifespan of the oocyte (egg)	8 to 10 hr
Lifespan of frozen-thawed semen in the female reproductive tract	Approximately 24 hr but can be variable among bulls
Duration of capacitation within the female tract	4 to 6 hr following insemination but may vary among bulls.
Lifespan of fertile (capacitated) sperm in the female tract	18 to 20 hr

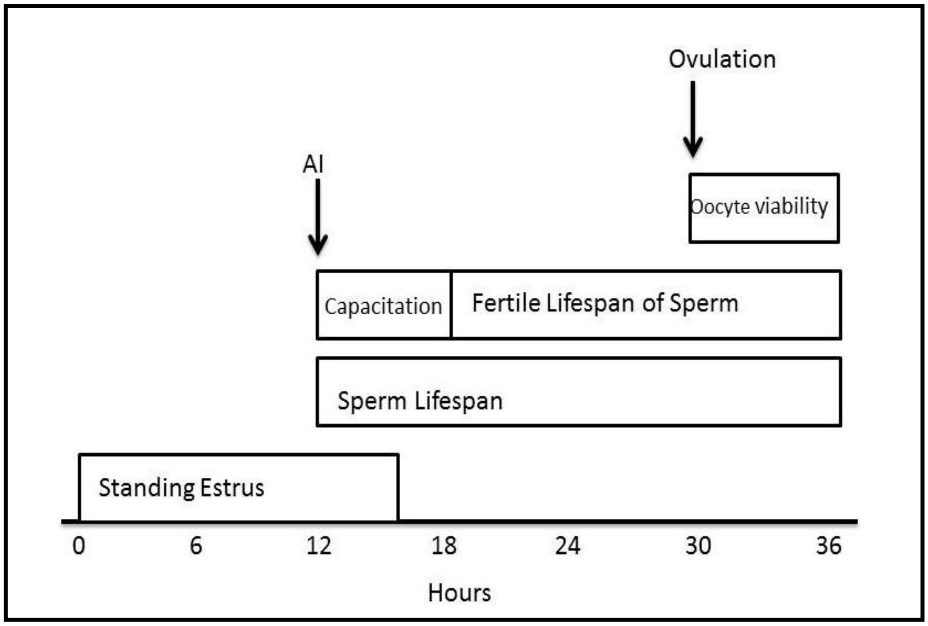

Figure 3: Illustration of the relationship among duration of estrus, duration of the sperm lifespan, length of capacitation, duration of fertile lifespan of sperm, time of ovulation, and duration of oocyte lifespan. Time periods are based on data from Table 6.

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. Sperm injury (as judged by sperm motility) occurs at temperatures as warm as -79 ^{o}C/-110 ^{o}F (Etgen et al., 1957; Bean et al., 1963; deJarnette, 1999), and injury to sperm cannot be corrected by returning semen to the liquid nitrogen (Berndtson et al., 1976; Saacke et al., 1978). Proper semen handling has been discussed in another chapter of this proceedings.

When numerous cows must be inseminated on a given day, multiple straws of semen are routinely thawed simultaneously to facilitate AI. Dalton et al. (2004) conducted a trial to determine: a) the effect of simultaneous thawing of multiple 0.5-mL straws of semen and sequence of insemination (1st, 2nd, 3rd or 4th) on conception rates, b) whether conception rates achieved following AI by professional AI technicians (PAI) and herdsman-inseminators (HI) differed, and c) the effect of elapsed time from initiation of thawing straws of semen to seminal deposition on conception rates. Average conception rate differed between PAI and HI (45% vs. 27%, respectively), but simultaneous thawing and sequence of insemination (1st, 2nd, 3rd or 4th), and elapsed time from initial thaw to completion of fourth AI had no effect on conception rate within inseminator group (Dalton et al., 2004). Conception rates are most likely maximized when personnel: a) accurately identify and administer the appropriate treatments to all cows to synchronize estrus or ovulation, b) accurately identify cows in estrus, c) follow the AI stud's recommendations for thawing semen, d) prevent direct straw-to-straw contact during thawing of multiple straws simultaneously to avoid decreased post-thaw sperm viability as a result of straws sticking together (Brown et al., 1991), e) use appropriate hygienic procedures, f) maintain thermal protection of straws during AI gun assembly and transport to the cow, and g) deposit semen in the uterus of the cow within approximately 15 minutes after thawing.

Using conventional semen, many studies have compared semen deposition near the greater curvature of the uterine horns with traditional deposition into the uterine body. Although Senger et al. (1988), López-Gatius (1980), and Pursley (2004) reported increased conception rates when semen was deposited in the uterine horns rather than the uterine body, Hawk and Tanabe (1986), Williams et al. (1988), and McKenna et al. (1990) found no difference in fertility when comparing uterine body and uterine horn inseminations. Furthermore, Diskin et al. (2004) reported an inseminator and site of semen deposition interaction, with evidence of either an increase, decrease, or no effect of uterine horn deposition on conception rate for individual inseminators. Unfortunately, it is not clear why some studies have shown an advantage following uterine horn insemination while others have not. A possible explanation for the positive effect of uterine horn inseminations may be related to the minimization or elimination of cervical semen deposition. Cervical insemination errors account for approximately 20% of attempted uterine body depositions (Peter et al., 1984). Macpherson (1968) reported that cervical insemination resulted in a 10% decrease in fertility when compared with deposition of semen in the uterine body. Clearly, all AI technicians must develop sufficient skill to recognize when the tip of the AI gun remains in the cervix. To maximize conception rates, AI technicians must continue to manipulate the reproductive tract until the tip of the AI gun is past the cervix and deposition into the uterus can be accomplished.

Vaccinations: The effects of vaccination on pregnancy rates are variable. A study in which the vaccination history was not reported, and titer concentrations were not determined, indicated that vaccination with a modified live vaccine (MLV) at time of the start of a synchronization protocol (day -9, with AI on day 1 to 5) did not impact estrous response or pregnancy success (Stormshak et al., 1997). In another study, animals were vaccinated with a MLV vaccine at least two times prior to synchronization protocol (the second dose being administered at day -90 prior to peak breeding day). Those heifers were then revaccinated either at -40 d or -3 d prior to peak breeding (three doses total) and no differences in conception rates were observed (Bolton et al., 2007). However, several studies have reported negative impacts on pregnancy success by vaccinating naïve heifers with a MLV around time of breeding (Miller et al., 1989; Chiang et al., 1990; Miller, 1991; Perry et al., 2013; Perry et al., 2018).

Naïve Animals: Decreases in fertility by vaccination of naïve animals around the onset of standing estrus are likely mediated through negative effects on corpus luteum (CL) function (Van der Maaten and Miller, 1985; Smith et al., 1990), with the hypothesis that the virus can get inside large dominant follicles and disrupt the formation and development of the corpus luteum. However, protocols developed to synchronize estrus or for fixed-time AI in heifers and cows try to control follicular development by inducing ovulation at the start of the synchronization protocol; therefore, insemination should occur on the second ovulation after the start of the protocol (Lamb et al., 2010; Grant et al., 2011). Therefore, a recent study investigated the effect that vaccinating naïve heifers with either a MLV or inactivated virus vaccine (IVV) at the time of the first induced ovulation of a fixed-time AI synchronization protocol has on changes in hormone production, estrous cycle length, and pregnancy success (Perry et al., 2013). Results are discussed below and depicted in **Table 7**.

In this study, no control heifers (nonvaccinated) experienced an abnormal estrous cycle following AI. An abnormal estrous cycle was defined as an estrous cycle less than 15 d (concentrations of P4 decreased to < 1 ng/mL prior to day 15 after AI) or concentrations of P4 never increased above 1 ng/mL. Heifers vaccinated 36 and 8 days before AI with an IVV (ViraShield® 6VL5HB) experienced 10% (2/21) abnormal cycles and heifers vaccinated 8 days before AI with an IVV (ViraShield® 6VL5HB) experienced 14% (1/7) abnormal cycles. There was no difference between these groups (P = 0.72), and both were similar to the control group (P = 0.31 and 0.22, respectively). A greater percentage of heifers vaccinated with a MLV (BoviShield Gold® FP 5 VL5) 8 days before AI had abnormal estrous cycles [38% (8/21)] compared to control heifers (P = 0.02). In addition, bulls were with the heifers for only14 d following AI, thus heifers only had one chance to conceive unless they experienced an abnormal estrous cycle. Of the heifers that experienced an abnormal estrous cycle, 100% of heifers vaccinated 36 and 8 days before AI with an IVV (2/2) and heifers vaccinated 8 days before AI with an IVV (1/1) conceived during the breeding season. However, only 38% of heifers vaccinated with a MLV 8 days before AI (3/8) conceived during the return cycle.

When heifers that conceived following an abnormal estrous cycle were considered open to allow comparison of conception rates following the synchronization protocol, pregnancy rates were similar (P = 0.52) between control heifers [90% (9/10)] and heifers vaccinated 36 and 8 days before AI with an IVV [81% (17/21)]. Both control and heifers vaccinated 36 and 8 days before AI with an IVV had greater pregnancy rates compared to heifers vaccinated with a MLV 8 days before AI [33% (7/21); P < 0.01 and < 0.01, respectively]. Pregnancy rates for heifers vaccinated only 8 days before AI with an IVV [71% (5/7)] were intermediate. They were similar to control (P = 0.32) and heifers vaccinated 36 and 8 days before AI with an IVV (P = 0.59), but tended (P = 0.08) to be greater than heifers vaccinated with a MLV 8 days before AI.

Table 7. Impact of vaccine on luteal function and pregnancy success in naïve animals.

Vaccine	Abnormal luteal function	AI Pregnancy Success (%)	Pregnancy Success (%) to second service
1 dose Modified Live	8/21 (38%)^{b}	7/21 (33%)^{b}	3/8 (38%)
1 dose Inactivated	1/7 (14%)^{a}	5/7 (71)^{ab}	1/1(100%)
2 doses Inactivated	2/21 (10%)^{a}	17/21 (81%)^{a}	2/2 (100%)
Saline	0/10 (0%)^{a}	9/10 (90%)^{a}	-----

Means within a column having different superscripts are different $^{ab}P < 0.05$
Adapted from Perry et al., 2013

Thus, it has been well established that vaccination of naïve heifers with a MLV around time of breeding has negative impacts on corpus luteum development and on pregnancy success (Miller et al., 1989; Chiang et al., 1990; Miller, 1991) even when utilizing a synchronization protocol that induces ovulation of the dominant follicle at the start of the protocol (Perry et al., 2013). This negative impact on pregnancy success has been reported on not only first service conception rates, but also on a low percentage of animals conceiving during the second service following vaccination (Chiang et al., 1990; Perry et al., 2013), and in some heifers infected with BHV-1 at or near estrus, normal estrous cycles were delayed for up two months (Van der Maaten and Miller, 1985). Furthermore, BVDV antigen has been detected in the ovary up to 30 d post-vaccination (Grooms et al., 1998) although the impact of this finding is not clear.

Previously Vaccinated Animals: The same effect of abnormal luteal function that occurs following vaccination of naïve animals has not been reported when previously vaccinated heifers were vaccinated with a MLV (Spire et al., 1995). Few studies have attempted to measure the effect of vaccinating well vaccinated (non-naïve) beef animals (Stormshak et al., 1997; Bolton et al., 2007), and one deficiency in these studies is the lack of true control (non-vaccinated animals) against which to measure conception rates. In this regard, it is difficult to draw a conclusion regarding vaccination timing and its effect on ovarian function and conception rates in well vaccinated animals. A recent study in dairy cattle reported no difference in conception rates between vaccinating previously vaccinated primiparous dairy cows (3 MLV as calves and 1 prebreeding as a heifer) with either a MLV or inactivated vaccine 45 days prior to FTAI (Walz et al., 2015b). In another recent study (Walz et al., 2015a), heifers were vaccinated with either a MLV or inactivated vaccine 40 and 10 d prior to a 45 day breeding season (n = 30) or 61 and 31 d prior to a 45 day breeding season (n = 30). Among heifers vaccinated 40 and 10 days prior to breeding, heifers vaccinated with the inactivated vaccine had a 20% greater pregnancy success compared to MLV vaccine, and heifers vaccinated at 61 and 31 days prior to breeding with an inactivated vaccine had a 15% greater pregnancy success compared to heifers vaccinated at 61 and 31 days prior to breeding with a MLV vaccine. However, in this study animal numbers were small, limiting their ability to detect small differences in pregnancy success. Another recent study (Walz et al., 2017), reported a 20% decrease in pregnancy success between heifers vaccinated with 2 doses of MLV compared to heifers vaccinated with 2 doses of saline, but again the animal numbers were small (n = 60 and 15; respectively). However, with the large numerical differences noted between those vaccinated with a MLV vaccine and non-vaccinated controls in these two studies, the question arises, does vaccination 30 days prior to the start of an AI breeding season negatively influence breeding season pregnancy success? Therefore, a study was conducted to examine the differences in pregnancy success between beef females vaccinated with either a MLV (BoviShield Gold® FP 5 L5 HB) vaccine or an inactivated (ViraShield® 6 L5 HB) vaccine 30 days before the breeding season, with sufficient power to detect a difference of less than 10 % in pregnancy success between groups (9 herds with 1436 animals) (Perry et al., 2016; **Table 8**).

Conception rates to the fixed-time AI tended to differ between MLV treated animals and IVV treated animals (P = 0.055), but control animals were intermediate with no difference in conception rates between MLV and Control (P = 0.21) or between IVV and Control (P = 0.49). When pregnancy was determined on day 56 of the breeding season (AI conceptions plus 1 return estrus) conception rates in the IVV group were greater (P = 0.01) compared to the MLV group. Animals treated with MLV also had decreased pregnancy success compared to the Control (P ≤ 0.01), but there was no difference between IVV and Control. Following the breeding season, pregnancy success was similar between MLV and Control (P = 0.34) as well as between the Inactivated and Control (P = 0.14), but there was still a difference between MLV and IVV (P = 0.01).

Table 8. Impact of vaccine on pregnancy success among previously vaccinated animals.

Vaccine	AI Conception (%)	Day 56 Pregnancy Success (%)	Breeding Season Pregnancy Success (%)	Early Embryo Loss (%)
Modified Live	40.0 ± 4^{a}	88.9 ± 2^{c}	95.2 ± 2^{c}	2 ± 1
Inactivated	46.5 ± 4^{b}	93.2 ± 2^{d}	98.0 ± 1^{d}	2 ± 1
Saline	43.3 ± 4^{ab}	92.5 ± 2^{d}	96.4 ± 1^{cd}	2 ± 1

Means within a column having different superscripts are different ^{ab}P = 0.055, ^{cd}P ≤ 0.01
Adapted from Perry et al., 2016

It is commonly thought that IVV provide some protection against these viruses, but the same level of protection as a MLV is not achieved (Zimmerman et al., 2007; Rodning et al., 2010).

However, a recent publication reported that heifers vaccinated with a MLV prior to their first breeding season and then vaccinated with a Chemically Altered/Inactivated vaccine CA/IV (CattleMaster Gold FP5) before their second breeding season had similar levels of abortions following both a BVD and IBR challenge as animals vaccinated with a MLV (Bovi-Shield Gold 5 FP) before their second breeding season (Walz et al., 2017; **Table 9**).

Table 9. Impact of BVD and IBR challenge following vaccination with either a MLV or IVV.

Vaccine	Abortions following BVD and IBR challenge (%)	Detection of BVDV in fetuses and/or calves	Detection of IBR in fetuses and/or calves	Detection of BVD and/or IBR in fetuses and/or calves
Modified Live	3/23 (13%)[a]	2/23 (9%) [a]	2/23 (9%) [a]	4/24 (17%) [c]
Inactivated	1/22 (5%)[a]	0/22 (0%) [a]	0/22 (0%) [a]	0/22 (0%) [d]
Saline	11/15 (73%)[b]	14/15 (93%) [b]	8/15 (53%) [b]	15/15 (100%) [b]

Means within a column having different superscripts are different [a,c,d vs b]$P < 0.01$, [cd]$P = 0.045$
Adapted from Walz et al., 2017

Therefore, with CattleMaster Gold FP5's ability to protect the fetus from abortion and virus, a field study was conducted to examine the differences in pregnancy success between beef females vaccinated with either a MLV (BoviShield Gold® FP 5 L5 HB) vaccine or a CA/IV (CattleMaster Gold FP5) vaccine between 27 and 89 days before the breeding season, with sufficient power to detect a difference of less than 10 % in pregnancy success between groups (10 herds with 1565 animals; Perry et al., 2018). Conception rates to AI were greater in the CA/IV vaccine group compared to the MLV vaccine group ($P = 0.05$; 60% vs 52%). Furthermore, interval from vaccination with either vaccine until AI also influenced conception rates ($P = 0.02$). Animals vaccinated 27 to 30 days prebreeding and animals vaccinated 30 to 37 days prebreeding had similar ($P = 0.98$; 52% and 52%) conception rates; however, both were decreased compared to animals vaccinated 38 to 89 days prebreeding ($P < 0.03$; 64%). There was no treatment by interval interaction ($P = 0.79$), indicating at all three intervals conception rates to the CA/IV vaccine were increased compared to the MLV. Furthermore, there was no effect of treatment ($P = 0.18$) or treatment by interval interaction ($P = 0.17$) on breeding season pregnancy rates. In summary, vaccination of well-vaccinated beef cows and heifers with a MLV vaccine pre-breeding (28 to 89 d) decreased AI conception rates compared to a CA/IV vaccine (**Table 10**).

Table 10. Impact of vaccine and timing of vaccine on pregnancy success among previously vaccinated animals.

Vaccine	AI Conception (%)	Breeding Season Pregnancy Success (%)	Breeding Season Pregnancy Success (%)
Modified Live	52.0%[a]	95.2 ± 2	95.2 ± 2
Chemically Altered/Inactivated	60.0%[b]	96.4 ±1	96.4 ±1
27 to 30 days	52%[a]		
30 to 37 days	52%[a]		
38 to 89 days	64%[b]		

Means within a column having different superscripts are different [ab]$P < 0.05$; Adapted from Perry et al., 2018

So where do these studies leave us on the impact of virus vaccines on reproductive success? Vaccines against infectious reproductive diseases are valuable tools in the prevention of these diseases, as outbreaks of these diseases can be potentially devastating to a beef herd. This emphasizes the importance of proper vaccination of females before they enter the breeding herd. However, evidence is growing that MLV versions of these vaccines can have negative effects on reproductive management in well managed herds. Studies utilizing different prebreeding vaccination protocols and intervals indicate that MLV vaccines, even when given at labeled prebreeding intervals, may negatively affect reproductive parameters compared to cattle vaccinated with inactivated vaccines. In light of this research, it appears the choice of prebreeding vaccine product type and timing is one to carefully consider. Important to this consideration is the level of exposure that a given herd may have, as none of these large prebreeding studies were carried out in the face of disease challenge and do not address the question of protection in the face of an infectious reproductive disease exposure. Future research will help determine how to strike the best balance between appropriate disease protection and minimizing harmful effects from the vaccines themselves. It is reasonable to expect that striking this balance will be different for each individual cattle operation, making it imperative that cattle producers consult their veterinarian and weigh all available information when making decisions about prebreeding vaccinations in their herds.

Shipping and stress of cows: In order to understand how stress may increase embryonic mortality, one must first understand the development of the embryo (**Table 11**). Just like the estrous cycle, embryo development begins on day 0, or the day of standing estrus. This is the day the female is receptive to the male and insemination occurs. Ovulation occurs on day 1 or about 30 hours after the first standing mount (day 0 Wiltbank et al., 2000). If viable sperm is present, fertilization occurs inside the oviduct shortly after ovulation. The first cell division occurs on day 2, and by day 3 the embryo has reached the 8-cell stage (Shea, 1981). Between days 5 and 6 the embryo migrates into the uterine horn and by day 7 to 8 it forms into a blastocyst (Flechon and Renard, 1978; Shea, 1981; Peters, 1996). At this stage two distinct parts of the embryo can be seen: 1) the inner cell mass, which will form into the fetus and 2) the trophoblast, which will form into the placenta. Between days 9 and 11 the embryo hatches from the zona pellucida, a protective shell that has surrounded the embryo to this point (Shea, 1981; Peters, 1996). Then, on days 15 to 17, the embryo produces a chemical signal to prevent corpora lutea destruction and allow the cow to remain pregnant (Peters, 1996). The embryo attaches to the uterus beginning on day 19, and around day 25, placentation, an intricate cellular interface between the cow and the calf, begins. By day 42 the embryo has fully attached to the uterus of the cow (Peters, 1996).

With the knowledge of the critical time points in embryonic development, it is possible to completely understand how stress from shipping can result in increased embryonic mortality in cows. When animals are loaded on a trailer and hauled to a new location, they become stressed and release hormones related to stress. These hormones lead to a release of different hormones that change the uterine environment in which the embryo is developing. During blastocyst formation, hatching, maternal recognition of pregnancy, and attachment to the uterus, the embryo is vulnerable to these changes. The most critical time points are between days 5 and 42 after insemination. Before day 5, the embryo is in the oviduct and is not subject to changes in the uterine environment. Therefore, stress does not influence embryo survivability at this time. The greater the length of time after day 42, the less severe the influence of shipping stress on embryonic loss appears to be. At the time of complete attachment of the embryo to the uterus the embryo is supported by the dam and appears to be not as easily affected by changes in its environment. On the other hand, in between these time points (5 – 42 days), the embryo is at greatest risk. Shipping during this time can cause detrimental changes to the uterine environment and may result in embryonic mortality. Administration of the prostaglandin inhibitor flunixin meglumine to cows and heifers 10 to 13 days after AI (when they were transported) reduced pregnancy losses about 9% (Merrill et al., 2007). However, administration of flunixin meglumine 10 to 15 d after breeding did not increase pregnancy establishment in cows. In another study, handling heifers to administer flunixin meglumine (compared to leaving them in the pasture) reduced pregnancy rates by 6% (Geary et al., 2010). Taken together, these studies provide evidence that some heifers are more susceptible to the stress of handling.

Table 11. Time course of early bovine embryo development

Event	**Day**
Estrus	0
Ovulation and 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

Data adapted from: (Flechon and Renard, 1978; Shea, 1981; Telford et al., 1990; Peters, 1996)

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 12**). 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.

Table 12. Effect of time of transport after insemination on pregnancy rates

	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)

Data adapted from Harrington et al., 1995, and T. W. Geary unpublished data

Conclusions

In summary, the profitability and sustainability of any cattle operation is dependent on the longevity of each animal and the production of a live calf every year. Management tips from calving to breeding that are important for improving reproductive performance in a beef herd are summarized in **Table 13**. Increasing the proportion of females cycling at the start of the breeding season is essential for maximizing lifetime reproduction. The length of the postpartum interval is primarily affected by suckling frequency/cow-calf bond and cow body condition score/nutrition and to a lesser extent by cow age and dystocia. There are several strategies available to shorten the anestrous postpartum interval and improve reproductive performance. Methods to eliminate or reduce the negative effect of the previously discussed factors on postpartum interval include: 1) maintain a positive energy balance 2) reduce suckling frequency, and 3) reduce the incidence of dystocia or provide early obstetrical assistance. Other methods to reduce postpartum interval length include hormonal induction of estrus/ovulation and exposing anestrous postpartum cows to novel bulls. Additional strategies such as attention to detail during FTAI / AI, ensuring optimal male fertility, vaccination strategies, and timing of hauling or stress also promote optimal reproductive performance.

Table 13. Management tips for increasing reproductive performance in a beef herd.

Evaluate reproductive performance of your herd

- If the pregnancy rate in your herd after 60 days is < 85% there are management issues that need to be addressed.
- In high production herds it is common for 61% of the calves to be born by day 21 and 85% by day 42. Set a goal to have 70% of cows calved by day 30 of the calving season.
- Examine the calving pattern of your two- and three- ear old cows. If the majority of your first calf heifers and three-year old cows are calving late, then focus on heifer development and the management of your first calf heifers.

General recommendations

- Keep accurate calving, breeding, and pregnancy records.
- Animal identification should be clear and easily readable.
- Maintain breeding females on an adequate nutrition and mineral program.
- Ensure herd health and disease prevention with a well-designed prebreeding vaccination program. Vaccinate females a minimum of 30 days before the breeding season begins.
- Ship cows before day 4 post breeding if at all possible

Postpartum cow management

- Pay attention to precalving and postcalving nutrition.
- At calving, cows should have a body condition score of ≥ 5 (1 = emaciated; 9.0 = obese).
- Systematically decrease the length of the breeding season to 60 to 70 days.
- Consider implementing fixed-time AI to increase the proportion of early calving cows.

Male fertility

- Have your veterinarian perform a breeding soundness exam on all natural service sires.
- Maintain an appropriate bull to cow ratio
- Handle semen correctly and utilize semen collected from a certified semen services (CSS) facility

Things to do when implementing a synchronization and/or artificial insemination program

- Make sure females meet the criteria for being good candidates.
- Utilize one of the synchronization protocols published in the sire catalogs.
- Meticulously follow the synchronization protocol!
- If detecting estrus, spend as much time observing the animals as possible.
- Use a minimum of one person to detect estrus per 100 head of cattle.
- Use heat detection aids to facilitate visual observation of estrus.
- Use a properly trained technician for AI.
- To distinguish between AI and bull bred pregnancies at pregnancy diagnosis, you should wait approximately 10 days to turn in clean up bulls after AI

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