Managing Reproduction

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Reproductive efficiency is the single most important factor affecting gross returns in a cow-calf operation. Even though reproductive efficiency determines gross income, few producers actually have a plan to regulate or control reproduction in their cow herd. Ideally, one should strive to wean a calf from every cow exposed to breeding and have every cow calve within 20 to 30 days from the start of the calving season. More realistically, an excellent overall goal would be to wean a calf from greater than 90 percent of cows exposed to breeding and have 80 percent of the calves born in the first month of the calving season. This goal can be achieved through application of sound reproductive management practices. These practices include:

- Proper nutrition of the brood cow
- Estrous synchronization for either natural service or artificial insemination (AI)
- Proper development of heifers and young cows
- Disease prevention
- Minimizing calf death loss
- Using fertile bulls
- Culling infertile/inefficient cows

The term "reproductive efficiency" is confusing to many cattle producers. The industry is full of terms and calculations used to determine reproductive efficiency. Some of these are listed below.

Conception Rate: Percentage females that conceive at one estrus. This calculation is best understood using an example. If a producer synchronizes 20 cows for AI and 15 of them conceive to the AI then the conception rate to AI was 75 percent.

Pregnancy Rate: Percentage of cows pregnant at the end of a breeding season. Calculated by dividing the number of cows pregnant at the end of the season by the total number of cows exposed to the bull.

Calving Rate: Percentage of cows that calve. Calculated by dividing number of cows that calve by the number of cows that were exposed to the bull.

Equation 5-1.

$$\frac{\text{Number of calves weaned}}{\text{Number of cows exposed for breeding}} = \text{Percent calf crop}$$

Equation 5-2.

$$\frac{\text{Total pounds of calf weaned}}{\text{Number of cows exposed for breeding per cow exposed}} = \text{Pounds of calf weaned}$$

Equation 5-3.

$$\frac{\text{Annual cow costs}}{\text{(average weaning weight) x (\% calf crop)}} = \text{Breakeven price}$$

Weaning Rate: Percentage of cows that wean a calf.

Reproductive efficiency is best evaluated by three calculations; percent calf crop weaned, and pounds of calf weaned per cow exposed, and break even.

Percent calf crop is directly influenced by the number of cows that become pregnant and the number of pregnant cows that wean calves (Equation 5-1).

The calculation of pounds of calf weaned per cow exposed combines weaning performance and pregnancy rate. Weaning performance is most directly influenced by the age of the calf. Thus, pounds of calf weaned per cow exposed indicates not only the fertility of a herd but also the calving performance (Equation 5-2).

A breakeven in a cow-calf operation is derived by the formula in Equation 5-3.

The denominator that drives this equation is directly influenced by reproductive success or failure in any given herd. Average weaning weight is affected by calving distribution (i.e., early born calves weigh more at weaning than late-born calves). Economic analyses of herds in other parts of the United States show that high-profit cattle producers average 70 percent of their calves born during the first 21 days of the calving period. Calves grouped this close to one another in terms of birth date logically are more uniform at weaning than calves born during the second or even third 21-day period in the same calving year. Larger groups of uniform calves are more valuable and are easier to manage in terms of health and feeding programs.

Reproductive Anatomy of the Cow Tract

The cow's reproductive tract is located in the pelvic and abdominal cavities and consists of a pair of ovaries, oviducts (also called fallopian tubes), a uterus, a cervix, a vagina, and a vulva (see Figure 5-1).

Ovaries

Ovaries produce the female sex cells (eggs, or ova) plus estrogen and progesterone. Each egg is produced in a blister-like structure on the ovary called a follicle. There are cells in the follicles that produce estrogen. High levels of estrogen make the cow "come into heat" (estrus) and stand to be ridden by other cows or bulls. After the egg is released from the follicle, the follicle changes to a corpus luteum, or "yellow body." The corpus luteum produces progesterone ("pregnancy" hormone), which is vital if conception occurs and pregnancy is to be maintained.

Figure 5-1. A cow's reproductive system.

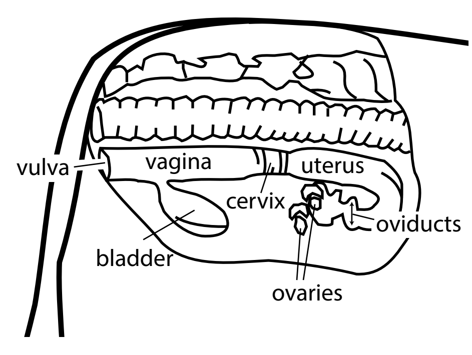


Table 5-1. The heat cycle of the cow.

	Average	Range
Duration of heat (hour)	14-18	12-30
Ovulation (hours after beginning of heat)	30	18-48
Length of heat cycle (days)	21	17-24

Table 5-2. Origin and action of female reproductive hormones.

Structure	Hormone	Action
Ovarian follicle	Estrogen	Stimulates heat and release of egg
Ovarian corpus luteum	Progesterone	Maintains pregnancy, inhibits estrus
Uterus	Prostaglandin	Regresses corpus luteum

Oviducts

Oviducts are a pair of tubes that extend from the ovaries to the uterine horns. Immediately after ovulation, the egg is caught by the funnel-like portion of the oviduct and transported through the oviduct to meet the sperm of the male. Fertilization occurs in the oviduct and the newly fertilized embryos resides in the oviduct for about five days.

Uterus

In a cow, the uterus has a body and two horns. The body of the uterus is located near the cervix. Semen is deposited here during artificial insemination. The sperm cells from the male move from the body of the uterus to the oviducts by way of the uterine horns. The uterine horns house the developing fetus during pregnancy.

Cervix

The cervix connects the vagina to the uterus. It forms a gateway between the uterus and the vagina. The canal through the cervix is tortuous and is tightly closed or sealed during pregnancy. During estrus, estrogen stimulates cervix secretions (mucous) and relaxes the cervix. Thus, the canal opens and the cervical mucous moistens the canal.

Vagina

The vagina is the birth canal during calving and the site where semen is deposited if the cow is serviced by a bull. There is a "blind pouch" in the vagina that has little significance except but it frequently presents a problem for inexperienced artificial insemination technicians because the tip of the insemination rod may be placed in it during insemination.

Vulva

This is the external opening or entrance to the cow's reproductive tract. It becomes swollen and moist during estrus. The vulva also becomes very swollen and relaxed as calving (parturition) approaches.

The Estrous Cycle

Estrus (heat), ovulation, and pregnancy are controlled by hormones. Estrus and ovulation occur as a cycle. Estrus, the time when the cow will accept a bull, generally lasts about 14 to 18 hours. Ovulation generally occurs about 30 hours after the beginning of heat. If pregnancy does not occur, the cycle repeats itself in about 21 days (see Table 5-1).

The fertilized embryo begins a series of cell divisions as it migrates down the oviducts. It attaches to the wall of one of the uterine horns where it is nourished during pregnancy. The gestation period (pregnancy) lasts about 283 days. Gestation length varies both within and between breeds. Typically, European breeds (i.e., Simmental, Charolais, etc.) have longer gestation periods than British breeds (i.e., Angus, Hereford, Shorthorn). Management at calving time is discussed later in this chapter.

Reproduction in the female revolves around changes in ovarian structures and the hormones (Table 5-2) produced by each structure. The cyclic changes in ovarian structures are called the ovarian cycle. Estrus or heat in cows is stimulated by the production of estrogen by a large follicle (Figure 5-2). Follicles are the fluid-filled, balloon-like structures on the ovaries that contain the oocyte (egg). The large amount of estrogen produced by the follicle also stimulates a massive release of luteinizing hormone (LH). This phenomenon is known as the LH surge. The LH surge occurs generally at the same time as the onset of standing estrus and stimulates the rupture of the large follicle (termed ovulation) and release of the oocyte (egg). Ovulation of the large follicle occurs approximately 24 to 36 hours after the onset of standing estrus. During ovulation, the oocyte is released, and the follicle wall collapses and begins to form a corpus luteum (CL). After ovulation, the CL increases in size and increases its production of progesterone. Progesterone inhibits final maturation of ovarian follicles and estrus. Approximately 16 to 17 days after estrus, the uterus releases prostaglandin $F_{2\alpha}$ (PG) that stimulates regression of the CL and a reduction in

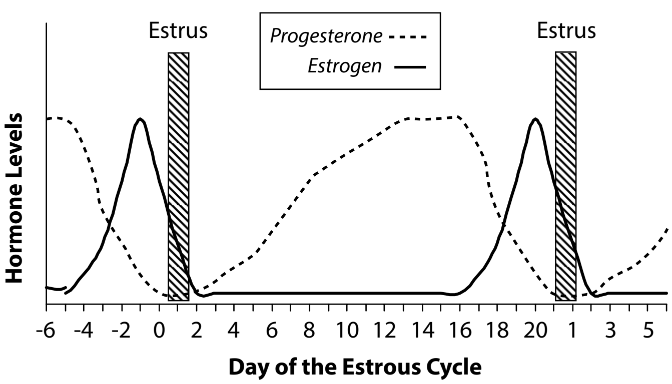


Figure 5-2. Cyclic changes in reproductive hormones.

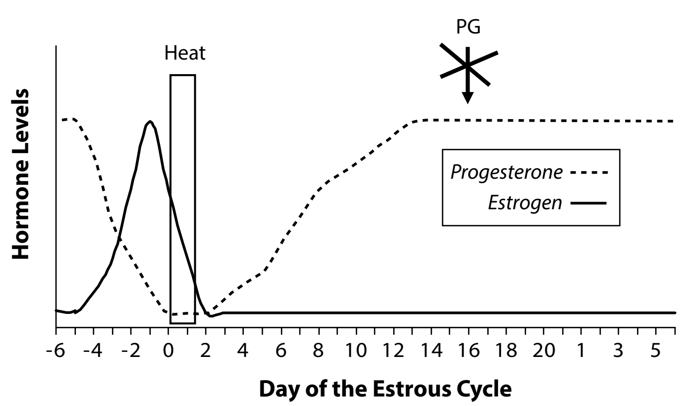


Figure 5-3. Changes in reproductive hormones during pregnancy.

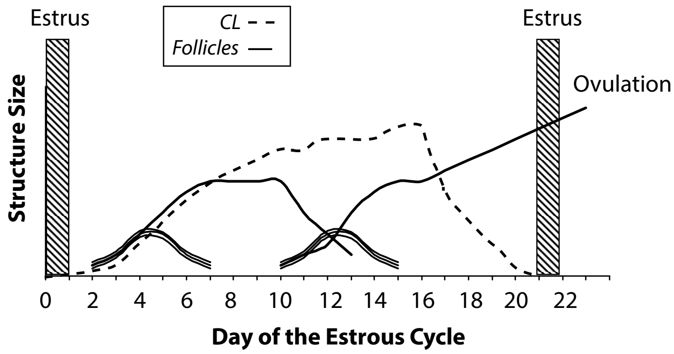


Figure 5-4. Changes in follicle growth—2 waves.

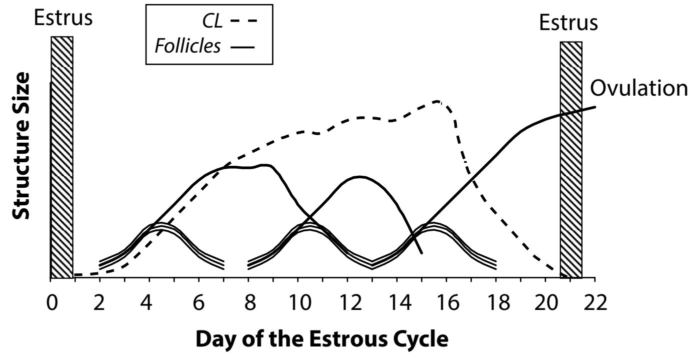


Figure 5-5. Changes in ovarian structures—3 waves.

progesterone production. Declining progesterone production allows final maturation of a large follicle that stimulates the subsequent estrus.

Alternatively, if a cow is pregnant (Figure 5-3), the developing embryo produces hormones that prevent the uterus from releasing PG. If PG is not released, the CL is preserved, and pregnancy is maintained until calving.

Follicles grow and regress throughout the estrous cycle. Follicle growth in cattle occurs in a wave-like pattern, and females generally have either two or three waves of follicular development during an estrous cycle (figures 5-4 and 5-5). A wave of follicular growth is characterized by the initial growth of several small follicles (< 5 mm in diameter). Within a couple of days of emergence, one follicle grows larger than the remaining follicles and is regarded as the dominant follicle. The dominant follicle then suppresses the continued growth of the subordinate follicles, resulting in their regression. The dominant follicle grows until it reaches its maximal size (12 mm to 15 mm). If progesterone concentrations are high, the dominant follicle regresses, and a new wave of follicles begins to grow. Alternatively, if progesterone concentrations are low, the dominant follicle continues to grow until ovulation. Emergence, growth, and regression of a follicular wave generally take eight to 10 days.

Reproductive States

Cows that exhibit regular estrous cycles as described above are usually little problem to breed. Most reproductive management programs are centered on the population of cows that most dramatically affect reproductive efficiency: anestrous cows. Anestrous females are those that have not yet begun to exhibit regular estrous cycles. Anestrus occurs every year of a female's productive life. The first period of anestrus occurs prior to puberty. After females have reached maturity, they exhibit periods of anestrous after every calving. The reproductive activity of cows after calving is shown in Figure 5-6. After calving, cows are anestrous for a variable period of time. The time period from calving to the resumption of estrous cycles, called the postpartum interval, can range from 17 days to 180 days. The average length of the anestrous period in mature (> 4 years of age) cows in adequate body condition (5 or greater) is 60-70 days. The length of the postpartum interval is regulated by age, nutritional status, calving difficulty, calving season, and genetic makeup. To maximize the opportunity for profit, cows need to be reproductively efficient and most research indicates that reproductively efficient cows maintain a 365-day calving interval. To maintain a 365-day interval, a cow needs to rebreed within 80 days of calving. Cows with long periods of anestrus struggle to maintain a profitable 365-day calving interval.

The transition from anestrus to estrous cycles is preceded by the occurrence of an abnormally short estrous cycle—seven to 14 days (Figure 5-6). The "short cycle" occurs in most (80 percent) anestrous females that are transitioning to estrous cycles. Estrus does not normally occur prior to the short cycle and is nonfertile (Figure 5-7). Fertility increases until the second estrus after the short cycle.

The proportion of cows that are anestrous on the first day of the breeding season regulates reproductive success. Current research has demonstrated that approximately one-half of all cows are

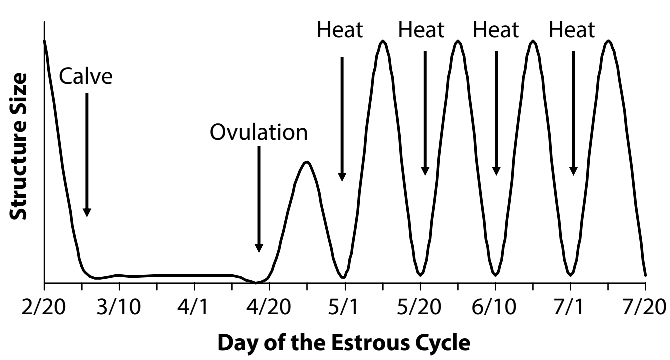


Figure 5-6. Postpartum (after calving) reproductive activity.

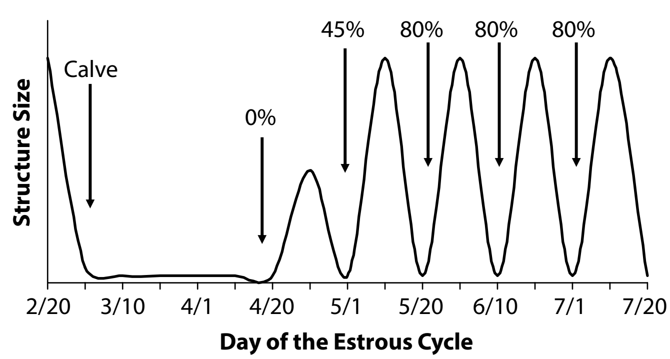


Figure 5-7. Changes in fertility after calving.

anestrous on the first day of the breeding season. However, the percentage of cows that were anestrous on the first day of the breeding season ranged from only 20 percent to as high as 83 percent. Logically, methods to reduce the incidence of anestrus in the cowherd will increase the opportunities of conception.

Estrous cycles can be induced in anestrous cows. The most successful method of inducing anestrous cows to initiate estrous cycles is to administer progesterone. Two sources of progesterone are available for use by producers. The first is an orally active, synthetic form of progesterone called melengestrol acetate (MGA). The best source of progesterone for inducing anestrous cows is the CIDR® (Controlled Internal Drug Release) device (discussed later). Cows exhibit estrus once the CIDR® device is removed or the MGA feeding is stopped. Typically, anestrous cows are treated with a CIDR® or MGA for seven days to induce estrous cycles. Treatment of anestrous cows with either a CIDR® device or MGA can induce estrus in approximately 80 percent of all anestrous cows.

Reproductive Management of the Beef Cow Herd

The first step in reproductive management of the herd is to determine when to calve. Choose the time of year for calving that is best for your operation. Most Kentucky producers choose spring calving because it fits with their pasture programs. However, fall calving is most favorable in terms of weather.

Spring Calving (March-May)

Most cows calve in the spring. Many cattle producers prefer spring calving because input costs are lower; cows can be wintered with less harvested and poorer quality feed because they are "dry" during the winter. Calving in the spring has several disadvantages. Spring calves generally are born during the wettest season, when it is frequently cold. Poor weather at calving can lead to increased calf sickness and death. Rebreeding is more difficult when cows calve in the spring. Heat stress caused by consumption of endophyte-infected fescue can be a problem during the latter part of the breeding season (July-August) of spring-calving cows. The conception rate of cows experiencing heat stress is only 30-35 percent (normal conception rate for Kentucky is 60-70 percent). Overall, the reproductive rate of cows that calve in the spring is lower than fall or winter calving. Maximizing the marketing value of spring-born calves is also more difficult due to the number of calves flooding the market each fall and winter (for more information on seasonal prices for calves, see Chapter 10: Marketing).

Fall Calving (September-October)

Calving in the fall has many advantages over spring calving. Cows are usually in better condition, and the weather at calving and breeding is more favorable. Cows that calve in the fall have smaller calves, a lower incidence of dystocia, and better colostrum. Calf sickness and death rates are lower for fall calving cows. Stockpiled/accumulated fescue can be used effectively during the breeding season. Endophyte-infected fescue is less of a problem in the breeding season of fall-calving cows than that of spring-calving cows. Cows resume estrous cycles earlier after calving in the fall, have a higher conception rate, and more cows become pregnant over a short time period. Fall calves offer some flexibility in marketing: they can be sold at weaning or grazed for a period of time. The market for fall-born calves is usually better than for spring-born calves. However, more stored feed of higher quality is required to meet the nutritional requirements for the fall-calving herd because cows are in lactation and must rebreed during the winter.

Winter Calving (January-February)

Winter calving occurs during the coldest part of the year, which means you must pay more attention during the calving period. The calves have heavier weaning weights for fall marketing than spring-born calves. The cows require ample amounts of feed in February and March if they are to rebreed on time. Calf disorders such as scours and pneumonia may be a problem.

Rationale for Controlled Calving Season

The second step in reproductive management is controlling the calving season. Whichever calving season (spring, winter, or fall) is chosen, the following reasons illustrate why a controlled, seasonal calving schedule is desirable:

- The culling of cows and selection of replacements are based on production records; however, accurate comparisons of the production of cows within a herd cannot be made unless a certain degree of uniformity exists among their calves. Decisions to keep or cull cows should reflect relative performance of calves within the herd. Acceptable performance implies not only weaning weight but also that a cow produces a calf every 12 months.
- Shortened calving seasons provide a better opportunity to offer improved management and observation of the cow herd likely resulting in fewer death losses at calving (a major source of reproductive failure among any herd of cows). This is vital because percent calf crop weaned is one of the major profit-determining factors in a cow-calf operation.
- Shortened calving periods facilitate improvements in herd health and management. Uniformity in timing of vaccinations and routine management practices result in decreased labor requirements and enhanced efficiency. Calving in controlled seasons aids in accurate pregnancy testing and culling of open cows which can reduce feed expense and improve herd efficiency.
- Brood cow nutrition can be improved by grouping cows according to stage of gestation and feeding each group accordingly. When cows are strung out in their expected calving dates, some cows may be over/under fed making it difficult to provide adequate nutrition to cows in a cost-effective manner.
- Calf crops that are uniform in age and size can be marketed in groups. Marketing groups of calves generates premiums compared to marketing single calves, (see Chapter 10: Marketing) which increases revenue and profit potential. Calves born in the first 21 days of the calving season can weigh 30-50 pounds more at weaning than those born during the second 21-day period. Calves born 42 days into the calving season have been found to weigh as much as 70 pounds less than those born in the first 21 days and 42 pounds less than calves born in the second 21 days.

- A research analysis of 394 ranch observations from the Texas, Oklahoma, and New Mexico SPA (standardized performance analysis) data set provided insight into the age-old argument about "leaving the bull out" or having a defined breeding season. Oklahoma State University and Texas A&M agricultural economists (Parker, et al) presented a paper at the 2004 Southern Association of Agricultural Scientists. They found a positive relationship between number of days of the breeding season and the production cost per hundredweight of calf weaned. Also they reported a negative relationship between number of days of the breeding season and pounds of calf weaned per cow per year.

The data suggested that for each day the breeding season was lengthened, the annual cost of producing a hundred pounds of weaned calf increased by 4.7 cents and pounds of calf weaned per cow per year decreased by 0.158 pounds. The range of breeding seasons in the data set was from extremely short (less than one month) to 365 days or continuous presence of the bull. The trend lines that resulted from the analysis of the data give us an opportunity to evaluate the economic importance of a defined breeding season. The producer that leaves the bull out year-round (365 days) would sell 45.82 fewer pounds of calf per cow per year on the average than producers with a 75-day breeding season. That same producer would have $13.63 greater costs per *hundredweight* of weaned calf than the producer that used a 75-day breeding season. In this era of cost/price squeezes, a well-defined breeding and calving season provides a better opportunity to survive the volatility of cattle prices and input costs.

Hence, shortening the calving season results in:

- Heavier, more uniform calves at weaning
- Better use of available labor
- Better opportunity to select for fertility in the cow herd
- Greater income potential

The best tool to shorten and manage the breeding and calving season is estrous synchronization.

Converting from Year-round to Controlled Calving

Converting from a year-long breeding season to a shortened 2-3 month breeding season should not be done haphazardly.

A system for converting from year-round to a 75-day controlled calving season over a period of two years would present less loss and fewer problems than to try to convert in one year. The following steps are suggested for getting on a controlled breeding system:

- Determine the ideal time of year and the length of your new calving season. For example, cows will calve from March 1 to May 10 (71 days).
- Pull the bull. You cannot gain control of the calving season with the bull in the pasture with the cows. Either sell him or build a strong bull pen or well-fenced bull pasture. An electric fence in addition to the regular fence may be needed.
- Determine the reproductive status of each cow in the herd. First, go to your record book to determine the last date each cow calved. If you don't keep records, try to match the cows and calves up and estimate their age. For example, let's assume we have 30 cows and today's date is January 18, 2019. Calving dates for 2018 are as follows: Jan = 0 calved, Feb = 3 calved, Mar = 9 calved, Apr = 5 calved, May = 5 calved, June = 2 calved, July = 1 calved, Aug = 0 calved, Sept = 2 calved, Oct = 2 calved, Nov = 1 calved, Dec = 0 calved. The bull has been in the entire time so the cows that calved last spring are most likely getting ready to calve in Spring 2019 and the five cows that calved in the fall could be pregnant. Next, work with your veterinarian to determine the pregnancy status of the herd. When will the spring cows calve? Are the fall-calvers open or pregnant? The cows that calved in October and November may not have conceived yet so they can roll easily into your spring-calving system.
- Based upon the reproductive status of your herd, determine if you would like one controlled calving season or two. In our example, we only have six cows calving in the fall window (July-Nov) so having two seasons doesn't really make much sense. If, however, half of your herd calved July-December, it is a better economic decision to make these your fall-calving cows and the ones that calve from January-June your spring-calving cows.
- Identify cows are going to be "problem" breeders. Problem breeders are those cows that are anticipated to be anestrus at the start of the breeding season. These cows include all two-year-old cows (first-calf heifers) and any cow that calves within 45 days of the starting of the breeding season. Thin cows are also a problem regardless of when they calve. If cows calved thin (body condition score < 5), they need to be separated and fed to gain weight at least through the first 30 days of the breeding season.
- Identify cows are going to be "extreme problem" breeders. Extreme problem cows are those that are anticipated to be anestrus for more than half of the upcoming breeding season. These are mainly cows that either calve right before or during the breeding season. These cows need to be managed separately from the breeding herd if at all possible.
- Create a plan to improve the reproductive performance of your cows.
  - » All cows need to be fed to maintain or increase body condition score (slightly) and need to be vaccinated (respiratory viruses, lepto, vibrio, etc.) and dewormed. Vaccination against abortifacients needs to occur at least 28 days before the breeding season.
  - » Early-calving mature cows need no additional management. Just turn them out with the bull at the start of planned breeding season.
  - » "Problem cows" need to receive a CIDR® device or be fed MGA for 7 days immediately prior to bull turn out (see section *Estrous Synchronization Protocols for Natural Service* below. Results from UK field trial work in over 300 late-calving cows suggests exposure of cows as early as 14 days after calving can improve the rebreeding performance in 80 percent of females treated. The average shift in calving interval was 36 days earlier.
  - » "Extreme problem" cows need to receive a CIDR® device for 7 days immediately prior to turning them with

a bull. Group the cows so that they receive a CIDR® device at least 14 days after calving. Thus, cows calving during the planned breeding season would receive a CIDR® device for 7 days immediately before transporting them to the breeding pasture.

- Plan your breeding season. For example, a cow that calved in November was open when the bull was removed. She will be rolled to the spring with the cows that will calve from January-July. A decision will need to be made for the August-October calving cows. Do we cull and replace them or do we hold them after they calve this year? Remember, they were pregnant when reproductive status was determined in Step 3 so we have to either cull and replace or wait on them to calve and hold them over until the spring of 2020. Typically, it is a little cheaper to simply hold the cow over because the "cost" of this decision is the loss of 4-6 months of potential revenue ($200-$400). If the cow is older (8+ years) then consider culling her and replacing with a bred heifer that will calve in February. The cost difference between a bred replacement heifer and a cull cow is about $500 but that is highly variable. Recently, cull cows have been really cheap so the cost to replace is a bit higher.
- Expose your herd to the bull on May 20 and remove the bull September 1st in this example. This is later than ideal but the process to move from year-round calving to controlled-calving is normally a two-year process. Sixty days after removing the bulls from the herd (or at a convenient time near this date), pregnancy check all cows and cull open cows. Your fall-calving cows have likely either calved or are very close to calving.
- If you are developing your own replacements, consider starting the breeding season of replacement heifers 20 to 30 days ahead of the final breeding date for the herd. Most extended calving seasons are the result of failure of young cows to rebreed in a timely fashion. The additional 20-30 days enhances the opportunity for these young cows to rebreed next season. So, the replacement heifer breeding season would start around April 20 and these females would begin calving around February 1. Weather in February is not always ideal calf death loss might increase 1-2 percent. Financially, 1-2 percent death loss is easier to swallow than a 25 percent decrease in pregnancy rate the following year.
- The second year, follow the same system as outlined above except remove the bull on August 1. If you have fall and spring calvers, then put the bull in for the fall cows around November 20 and remove him around February 1.

Data currently being collected by the University of Kentucky Beef IRM group demonstrates that following this step-wise plan for reproduction can improve pregnancy rate by 6 percent and increase the pounds of calf weaned per cow exposed to the bull by about 150 pounds (more calves born, wean more at marketing). Revenue on these farms increased by 34 percent even in today's market. Controlling reproduction pays regardless of the market.

Example of Implementing a Plan to Control Calving

The IRM Farm Program was designed by the UK Beef IRM team to increase the use of production practices favoring high reproductive rates in the cowherd. This program is delivered through on-farm instruction to demonstrate the benefits of implementing these production practices.

Below is an example of controlling the calving season from one of the farms enrolled in the IRM Farm Program This producer managed a small herd of Limousin-influenced cattle and, before joining the program, the cowherd did not calved in a defined calving season. Because of his other farm obligations, this producer targeted a fall calving season beginning in September.

The results from this operation over the last four years are depicted in Table 5-3. The first step was to sell the bull. In order to control the calving season, we need to control the breeding season therefore our first step was to remove the bull from the cowherd. The second step was to assess the reproductive status and fitness of individual cows in the herd and develop a management plan. During the fitness assessment, six cows were determined to be inadequate for various reasons that included: age, feet/leg problems, and failure to have a calf and were sold in 2015. Two open replacement heifers were purchased.

In the first year of the program, the cows that calved in the spring of 2015 were held open until the fall breeding season. In 2015, only 56 percent of the cows calved in the desired window. The producer was interested in the benefits of using estrous synchronization and AI. In the first breeding season in the program, 12 cows were bred using a timed-AI protocol. To help her advance in the calving season, one late-calving cow that received a CIDR® device for seven days beginning 14 days after calving. She was exposed to the bull after the CIDR® device was removed. Half of the females conceived to the AI, 12 of the 13 cows weaned a calf, and 100 percent of the herd calved in the desired window. The 2016 calving season took place in a 60-day window, beginning September 10 and ending on November 9.

Table 5-3. Results on transitioning to a controlled calving season.

	2015	2016	2017	2018
Total Cows	17	13	17	24
# Cows Calved	15	12	15	21
Calving %	88%	92%	88%	88%
# Cows Weaned a Calf	13	12	15	20
% Weaned / Cow Exposed	71%	92%	82%	83%
Total WW (lbs)	5281	5184	6270	9414
WW / Cow Exposed (lbs)	311	399	369	392
Date of First Calf	1/14/15	9/10/16	8/26/17	8/15/18
Date of Last Calf	12/22/15	11/9/16	10/11/17	10/2/18
Calving Season Length (d)	342	60	46	48
% Calved in Desired Window	56%	100%	100%	100%
AI %	0%	50%	75%	59%

In 2016, the producer added a few replacement heifers, increasing his herd size to 17 total breeding age females. Pleased with the first-year results, he wanted to implement estrous synchronization and AI again. In the fall of 2017, 75 percent conceived AI and 15 of the 17 females calved from August 26 to October 11; a 46-day calving season. The two cows that failed to conceive were sold and seven replacement heifers were retained. In 2018, 59 percent conceived AI and 21 of the 24 cows calved during a 48-day window. These cows weaned 20 calves that weighed 9,414 pounds total, equaling 392 pounds of calf weaned per cow exposed to breeding.

Cows are evaluated before each breeding season for soundness. In 2018, seven cows were culled because of infertility, poor feet/legs, udder quality, size, age, and were replaced with seven purchased bred heifers. All breeding-age females were subjected to a timed-AI protocol in the fall of 2018. Results from the pregnancy diagnosis this spring indicate that all but one cow conceived, almost 60 percent conceived to the AI, and all conceived in a short time period. Weaning weight per cow exposed to the bull increased 82 pounds (310 lb. to 392 lb.) from 2015 to 2018. Weaning weight was not adjusted for cow age. Using an average market value (average of steer and heifer) for a 300 lb. calf ($188/cwt) and 400 lb. calf ($176/cwt), this 82-pound increase equates to an additional revenue of $104 per cow.

These numbers are just a snapshot at the progress that has been made. The calving season length decreased, productivity increased, and production efficiency increased. The changes were the result of the producers desire to improve and his willingness to make changes, and adopt production practices favoring high reproductive rates. The cowherd is not recognizable compared to the start of the program. This producer now has a herd with improved disposition, feet/leg structure, and udders quality. Cow size has decreased, weaning weights have increased, a stringent health program and estrous synchronization and AI have been implemented, and a condensed calving seasons has been maintained. Additionally, the behavior of the producer has completely changed. He has a herd to be proud of and enjoys his cattle enterprise.

In summary, the results are truly incredible. The calving season length has been shortened from 342 days to less than 60 days. The pounds weaned per cow exposed increased over 80 pounds. This reduction in calving season length was possible through controlling exposure to the bull and implementing an estrous synchronization program and AI.

Reproductive Techniques

Artificial Insemination

Successful artificial insemination (AI) breeding programs depend on adequate facilities, good herd health programs, sound nutritional management, and experienced, well-trained technicians responsible for detecting estrus and insemination. Most problems and failures in AI programs are associated with poor nutritional development in replacement heifers, inadequate body condition of cows after calving, failure to identify cows in heat, and/or failure to breed cows at the proper time. Rarely is infertility the result of poor quality semen or technician error.

Heat Detection

Accurate heat detection and record keeping are perhaps the most time-consuming and least-interesting jobs associated with an AI program. However, in many respects, they are the most important to the overall success rate. Heat detection requires skilled observation, patience, and a general familiarity with the reproductive processes of cattle. Data from Colorado State University demonstrate the importance of accurate heat detection. In this trial, cows were observed for estrus either twice daily, four times daily, or continuously. As heat detection intensity increased, conception rates to AI were 67 percent, 75 percent, and 90 percent. Inadequate heat detection can affect herd profitability in the following ways:

- Undetected heats result in longer calving intervals and decreased weaning weights of calves.
- Breeding cows that are not ready to be inseminated results in decreased conception rates and wasted time and semen. (See Figure 5-9 for the best times for breeding to occur.)
- Inseminating already pregnant cows that were mistakenly identified as being in heat can result in abortion.

Figure 5-8. Cow in standing estrus.

Standing to be mounted is the sign of heat that is most accurate in selecting cows for insemination. Because pregnant cows will on occasion exhibit heat, it is important to keep thorough records and use a skilled technician.

The efficiency of heat detection may depend on the proportion of animals in heat at the same time. This is usually not a problem in larger herds but may present problems in smaller herds. Synchronization of estrus becomes a valuable alternative in these situations.

Other physical and behavioral signs that may signal that a cow is either coming into heat or actually is in estrus include mounting of other cows (Figure 5-8), swelling of the vulva, strands of mucus discharged from the vulva, chin resting, and sniffing and licking of the vulva of other cows.

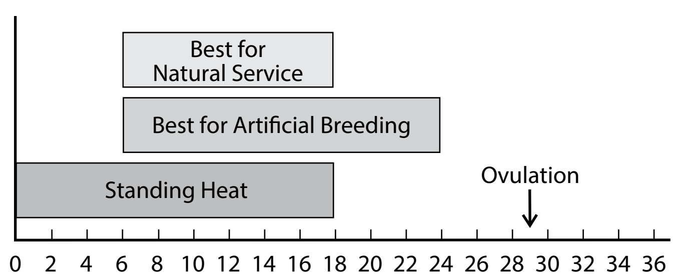


Figure 5-9. Best times for breeding relative to the start of estrus.

Figure 5-10. Proper placing of estrus detection patch. Courtesy of Estrotect, Inc.

Observation	Vigorous Visual Observation	Bull	ESTROTECT™ Heat Detectors
% identified correctly	**92% (83/90)**	**92% (34/37)**	**91% (82/90)**
% identified incorrectly	8% (7/90)	8% (3/37)	9% (8/90)
% suspect	2% (2/90)	3% (1/37)	2% (2/90)
% identified in standing estrus	97% (67/69)	100% (34/34)	97% (66/68)
% identified in standing estrus that ovulated (including ovulated animals)	97% (69/71)	100% (35/35)	97% (68/70)

South Dakota State University, 2005.

Figure 5-12. Accuracy of estrus detection patches. Source: Estrotect, Inc.

Figure 5-11. Example of an estrus detection patch. Courtesy of Estrotect, Inc.

Cows that are isolated or with cows that are not sexually active may exhibit signs of estrus that include hyperactivity and movement, bellowing, tail raising and switching, and frequent urination. Extremes in weather, including periods of extreme cold or heat, can disrupt or diminish estrual behavior and make accurate heat detection difficult.

Heat detection can be assisted through the use of estrous detection patches or electronic devices. Estrotect was one of the first estrous detection patches available for use. The estrous detection patches are placed perpendicular to the spine on the highest part of the tail head (see figures 5-10, 5-11, 5-12). The patches adhere more tightly when the skin is dry and the temperature is above 50°.

Electronic devices can also give a real-time assessment of a cow estrual activity.

Semen

Semen storage. Frozen semen is stored in plastic straws maintained in liquid nitrogen (320°F). Semen should be transferred from one container to another carefully and swiftly (the transfer should be completed within 10 seconds). Semen tanks should be routinely checked to determine if the level of liquid nitrogen is sufficient to ensure proper storage of semen.

Semen thawing. Frozen semen should be thawed in a warm water bath at 95°F for a minimum of 30 seconds. Extreme water temperature can kill the sperm. It is important to routinely check the accuracy of the thermometer used to determine water temperature.

Insemination procedure. Use semen within 20 minutes of being thawed. Once the semen is thawed, the straw should be removed from the thaw bath and thoroughly dried with a paper towel. In loading the gun, the straw should be cut straight across on the crimped end of the straw. The model of French gun determines the type of sheath used. Thawed semen should be protected against temperature shock, preferably by wrapping the front end of the gun with a paper towel.

Semen deposition. Once the external genitalia have been wiped clean, the inseminating rod may be inserted into the reproductive tract. It is important that the cervix be worked over the rod and not vice versa. To ensure proper placement of semen in the body of the uterus, the tip of the technician's index finger should run over the front edge of the cervix to enable the technician to feel the tip of the gun as it protrudes into the uterus (Figure 5-13). Placement too far into the uterus may result in damage to the uterine lining. Research has clearly shown that the body of the uterus is the preferred site of semen deposition. However, semen may be deposited in the cervix on second and later services. This is to prevent disrupting pregnancy if a pregnant cow is accidentally reinseminated.

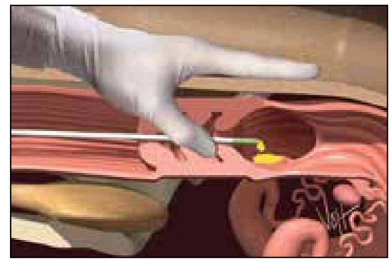


Figure 5-13. Deposit semen into the uterine body. Courtesy of Select Sires, Inc.

Estrous Synchronization

Requirements for the Control of Estrus

One of the major limitations in effectively synchronizing estrus in beef cows is that most postpartum beef cow herds consist of both anestrous and cyclic cows. Thus, for a system to effectively control estrus in all cows, it must: (1) induce death of the CL, (2) control follicular growth, and (3) induce estrus and ovulation in both "problem" and "extreme problem" cows. Problem cows are those that are nearing the spontaneous resumption of estrous cycles, while extreme problem cows are several weeks from initiating estrous cycles. A good example of an extreme problem cow is a first-calf heifer, in moderate to thin body condition and only 30 days after calving. The goal, then, is to develop a system that can be delivered to all cows and result in a synchronous, fertile estrus in most cows (>70%) in the first one to four days of the breeding season.

Products Available for Use for Estrous Synchronization

Several pharmaceutical products are available for use to synchronize estrus in beef cattle. These products can be categorized as prostaglandins, progestins, or gonadotropin-releasing hormones. These products are described in Table 5-4. All hormones used to control estrus must be administered intramuscularly. It is best to administer the drugs with an 18-gauge, 1½-inch needle.

The products used to control estrus are differentially effective according to the two reproductive states; cyclic and acyclic (anestrous). Prostaglandins and GnRH are used predominately to synchronize cyclic cows. Prostaglandins stimulate regression of the corpus luteum (CL) and anestrus cows do not have a CL so prostaglandins have no or a very limited role. GnRH stimulates follicle rupture, formation of a CL, and recruitment of a new follicle wave. Both reproductive classes of cows have growing follicles but GnRH is only effective when a cow has a follicle that is about 10 mm in diameter. GnRH is typically injected at the beginning and end of most estrous synchronization protocols. Studies have shown that GnRH is effective 10-80 percent of the time when used at the beginning of the protocol so its usefulness if injected alone to anestrous cows is also limited. Progestins (MGA and CIDR® devices) are most effective for synchronization of estrus in anestrous cows. A seven-day progestin protocol alone has limited ability to synchronize estrus in cyclic cows.

In June 2002, the Federal Drug Administration approved the use of the Controlled Internal Drug Releasing (CIDR®) device for use in estrus synchronization of beef females. The CIDR® device is the best source of progesterone available for use. Several systems have been developed that utilize the CIDR® device to synchronize estrus.

A CIDR® is a T-shaped device made of soft pliable plastic that is coated in progesterone. The CIDR® is inserted into the vagina of the cow, and the progesterone is absorbed into the bloodstream. To insert the CIDR® device, restrain the female, and prepare a container of clean water with a disinfectant solution. Wash the applicator with water between uses. Insert the CIDR® device into the CIDR® applicator by pushing the wings together; keep the tail pointed outward. Apply a lubricant to the end of the CIDR® device, wipe the vagina clean, and insert the CIDR® into the vagina until the device meets significant resistance. Depress the plunger and rotate the applicator approximately one-quarter turn. Best results are obtained when the tail of the device is pointed downward. If significant loss of the CIDR® device is observed (> 5 percent), clip the tail of the CIDR® so that approximately 2½ inches protrude from the vagina (for more information, view this YouTube video: https://www.youtube.com/watch?v=j8ZHjzzuZNg&list=PLC5aJFY_Be8XJZ_03_Ql73TK0826T8Fjq&index=4&t=7s).

Table 5-4. Products used to control estrus in beef cattle.

	Product	Administration	Action
Prostaglandins	Lutalyse	5 ml, i.m.	Regress the corpus luteum
	Prostamate	5 ml, i.m.	
	Estrumate	2 ml, i.m.	
	In-Synch	5 ml, i.m.	
Progestins	MGA	0.5 mg/head/day	Imitate the corpus luteum
	CIDR	7 days intravaginally	
Gonadotropin-releasing hormone (GnRH)[a]	Cystorelin	2 ml, i.m.	Causes formation of a corpus luteum
	Fertagyl	2 ml, i.m.	
	Factrel	2 ml, i.m.	
	Ova-Cyst	5 ml, i.m.	
Estrogens	Estradiol Cypionate	0.5 ml, i.m.	Stimulate heat and release of egg

[a] Keep refrigerated.

Estrous Synchronization for Artificial Insemination

General

Following is a brief discussion of the preferred protocols to synchronize estrus in heifers and cows. The protocol sheet developed by the Beef Reproduction Task Force is included for reference.

Heifer Systems

Synchronizing a fertile estrus in yearling heifers is a challenge. Two factors limit conception rate to AI in heifers; puberty and follicle growth. Most systems discussed will induce puberty but controlling follicle growth to effectively synchronize a fertile estrus and ovulation is difficult.

Long-term Protocols

MGA-PG

The most reliable and proven protocol for synchronizing estrus in beef heifers is the MGA-PG system (see Figure 5-14). This system was developed in 1988 and works very well. The biggest problem with this system is it is not suitable for a fixed-time AI.

The most common progestin used to synchronize estrus in beef females is melengestrol acetate (MGA). MGA is an orally active, synthetic progestin that effectively suppresses estrus when fed at a rate of 0.5 mg/head/day. In this system, MGA is administered for 14 days and prostaglandin is administered 19 days after the last day of MGA feeding. Administration of the MGA-PG system synchronizes estrus in most cyclic females and can induce estrus in most anestrous females. Also, after the long-term MGA feeding, females are between days 10 and 15 of the estrous cycle when PG is administered, thus ensuring that PG is maximally effective in stimulating the regression of the CL. Administration of the MGA-PG system to females usually results in estrus in approximately 80% to 100% of females. Since fertility is normal in this system, pregnancy rates usually range from 45% to 70%.

The biggest disadvantage to the use of the MGA-PG system is that it takes 39 days to complete and requires consistent intake of MGA. The MGA is normally supplied to the females as a supplement to normal prebreeding diets and should be fed at a rate of 0.5 mg/head/day. It is imperative that all females consume adequate levels of MGA. Therefore, at least 2 feet of bunk space is necessary to ensure that even timid females have access to feed. Producers should also observe feeding to ensure that all females are consuming the MGA supplement. The most common failure of the MGA-PG system lies in consistent, adequate consumption of MGA.

14 CIDR® - PG

A CIDR® device can replace MGA in this system. The 14-Day CIDR®-PG protocol involves inserting a CIDR® device for 14 days. Prostaglandin is administered 16 days after the CIDR® device is removed. Heifers can then be observed for estrus and bred accordingly.

The number of days of estrus detection can be reduced by injection of gonadotropin hormone-releasing hormone (GnRH; pharmaceutical trade names Cystorelin®, Factrel®, Fertagyl®, Ovacyst®). In this system, estrus should be detected for 72 hours after PG. All heifers in estrus should be inseminated approximately 12-14 hours after first estrus is observed. Heifers not observed in estrus by 72 hours are injected with GnRH and time inseminated 72 hours after PG.

Timed insemination using MGA-PG or 14-Day CIDR®-PG

Many producers simply do not have the labor or facilities to support multiple days of estrus detection and cattle handling. The MGA-PG and 14-Day CIDR®-PG protocols are both suitable for timed insemination. Timed insemination should occur in heifers 72 hours after PG if you are using the MGA-PG system and at 66 hours after PG if you are using the 14-Day CIDR®-PG system. Females are administered GnRH at the fixed-time AI. GnRH is only necessary for females that are NOT in estrus. Therefore, if cows were observed for estrus or if estrous detection aids are used, then GnRH is only given to females that have not yet been in estrus. If cows were not observed or an estrus detection aid used, then all females need to be injected with GnRH at fixed-time AI. Conception rates to timed insemination are higher when using the 14-Day CIDR®-PG protocol than the MGA-PG protocol (Figure 5-15).

Short-term Protocols for Heifers

7-Day Co-Synch + CIDR® and the 5-Day CO-Synch + CIDR®

One of the major drawbacks to using the MGA-PG and 14-Day CIDR®-PG protocols is the length of time (33-39 days) from the beginning to the end of treatment. Two short-term protocols have been developed for use in heifers that have both proven effective. These two protocols are the 7-Day CO-Synch + CIDR® and the 5-Day CO-Synch + CIDR® (Figure 5-16).

Both of these systems begin with insertion of a CIDR® device and an injection of GnRH (Day 0). The CIDR® is removed and PG given 7 (Monday-Monday) or 5 (Monday-Saturday) days later. A second injection of PG is needed when using the 5-Day CO-Synch + CIDR® system. The second injection is administered 6-10 hours after CIDR® removal and the first PG injection. Timed insemination occurs about 54

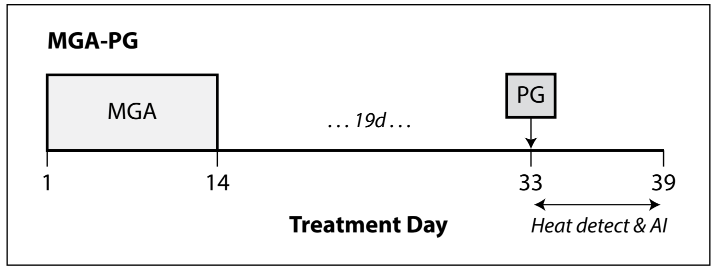


Figure 5-14. MGA-PG protocol.

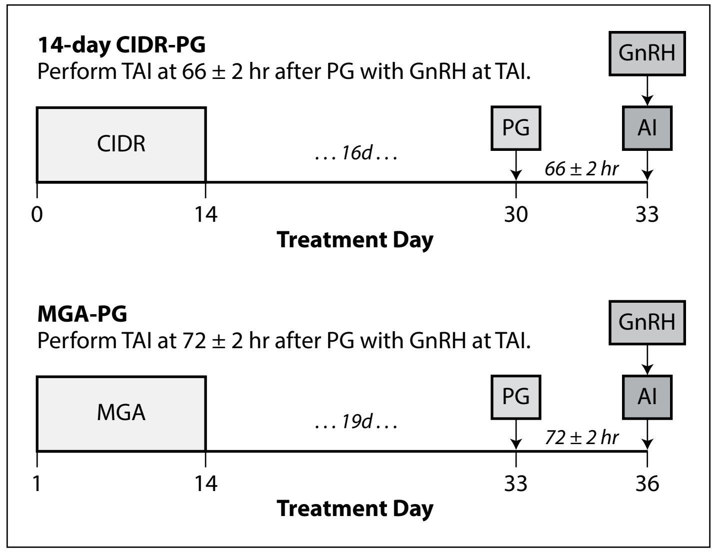


Figure 5-15. 14-day CIDR-PG and MGA-PG protocols.

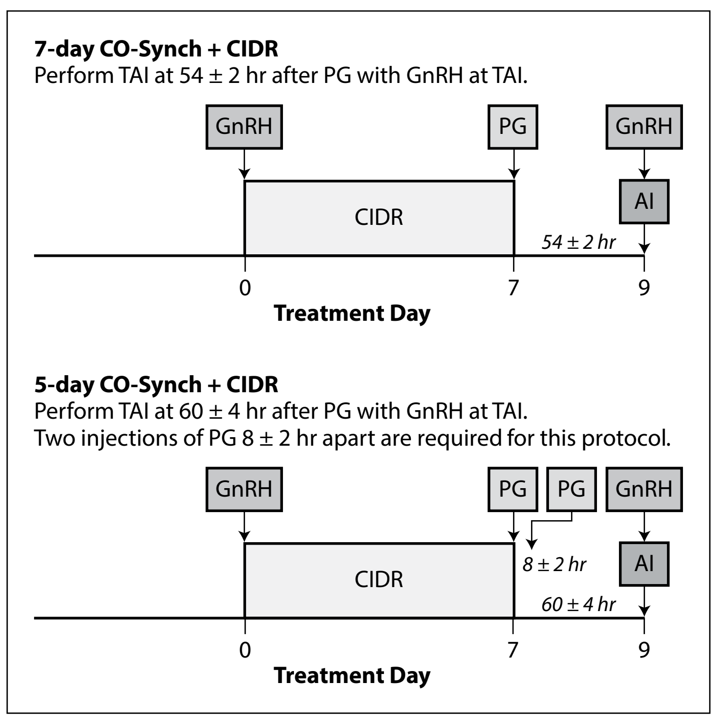


Figure 5-16. 7-day and 5-day CO-Synch + CIDR protocols.

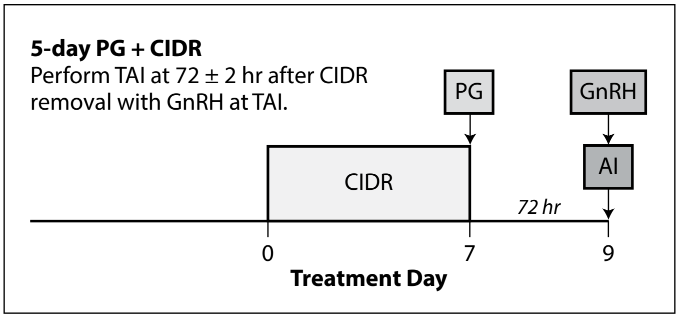


Figure 5-17. 5-day PG + CIDR protocol.

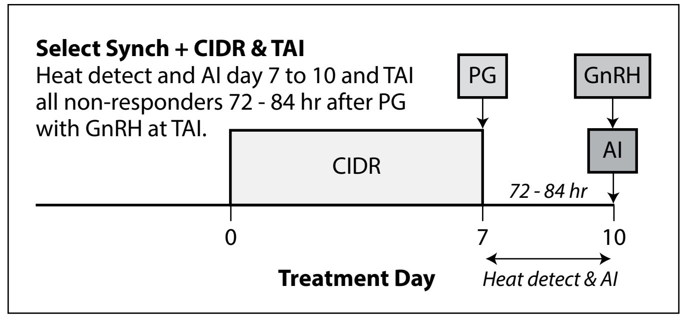


Figure 5-18. Select Synch + CIDR & TAI protocol.

hours after CIDR® removal in the 7-Day CO-Synch + CIDR® protocol and from 60-72 hours after CIDR® removal in the 5-Day CO-Synch + CIDR® protocol; most research actually favors the timed insemination at 72 hours. Recently, the 5-Day CO-Synch + CIDR® protocol has been simplified. Acceptable conception rate to AI can be achieved when a CIDR® is inserted for 5 days and PG administered at CIDR® removal. Females are inseminated 66-72 hours after CIDR® removal. This simplification of the 5-Day CO-Synch + CIDR® protocol needs more research but looks very promising. Approximately 2,000 heifers have been inseminated in Kentucky using the modified 5-day PG + CIDR® protocol (Figure 5-17) since 2015. Conception rates to AI consistently reach 60%. Conception rates to AI are typically higher in heifers using the 5-Day systems compared to the 7-Day protocol.

Cow Systems

Many new systems for controlling the expression of a fertile estrus have been developed in recent years. Beef cow-calf producers have numerous ESAI protocols at their disposal. Many of these protocols can result in acceptable pregnancy rates but vary in cost, effectiveness, and implementation. To determine the appropriate system, producers need to consider several factors: 1) proportion of cows that are anestrus and the calving distribution, 2) available labor, skill, expertise, and facilities for accurate detection of estrus and stress-free handling of cattle, 3) cost of synchronization treatment, 4) value of semen, 5) availability of AI technician, and 6) acceptable level of success. Each of these factors will affect the choice of estrus synchronization protocol. A major consideration affecting the system of choice is labor availability for estrus detection and AI. Systems are available that require complete, limited, or no estrous detection (fixed-time inseminations or TAI).

Select Synch + CIDR® & TAI

Many beef producers have neither the time nor the available labor for adequate estrous detection and the cattle handling necessary for Select Synch. Also, the availability of a quality AI technician is often limited. Thus, many producers desire protocols in which estrous detection is limited (2-3 days) or cows are artificially inseminated at a fixed time (TAI). Select Synch + CIDR® & TAI was developed to reduce the number of days of estrous detection. The Select Synch + CIDR® & TAI begins with an injection of GnRH (100 µg) and insertion of a CIDR® followed 7 days later by treatment with PG and removal of the CIDR® insert.

Producers that want to maximize AI pregnancy rates with limited estrous detection need to use Select Synch + CIDR® & TAI (Figure 5-18). In this system, cows are observed for estrus for 72-84 hours after PG is administered and the CIDR® is removed. Cows observed in estrus are inseminated accordingly. At 72-84 hours, all cows NOT observed in estrus are subjected to TAI and are given a second injection of GnRH. Treatment of postpartum cows with Select Synch + CIDR® & TAI has several advantages: 1) only 3 days of estrous detection, 2) inclusion of the CIDR® prevents early estrus (before PG) and induces estrus in more anestrous cows, 3) results in high AI pregnancy rates. The high AI pregnancy rates are the result of combining the higher conception rates to AI following accurate estrous detection and conception that occurs in some cows that would have been missed using estrous detection alone.

Select Synch + CIDR® & TAI should be used for ESAI if:

- A large proportion of the cows are anestrus before treatment. If cows are a little thinner (BCS 4-5), the herd consists of several young cows, and many of the cows are less than 45 days postpartum, a system that includes a CIDR® is necessary.
- Facilities and labor are available for daily estrous detection and cattle handling for at least 3 days.
- Technician is available twice daily for at least 3 days.

Value of the semen is moderate to high. When the value of the semen is high, conception rate must be maximized. Select Synch + CIDR® & TAI maximizes pregnancy rates to AI but the cost is higher because all cows are inseminated. Conception rate is lower even though the AI pregnancy rate is higher.

- Higher AI pregnancy rates are more important to the producer than the higher costs of the estrus synchronization protocol.

7-Day CO Synch + CIDR®

Producers that desire systems that require NO estrous detection should use 7-Day CO-Synch + CIDR® (Figure 5-19). In this system, all cows are subjected to a second injection of GnRH & TAI anywhere from 60-72 hours after PG is administered. Acceptable AI pregnancy rates can be achieved when GnRH & TAI occurs at any time from 48-72 hours after PG. The highest AI pregnancy rates appear to occur when TAI occurs near 66 hours after PG administration.

Systems that incorporate total TAI are more variable in AI pregnancy rate than systems that use either total or partial estrous detection. The decision to use systems with complete TAI needs to involve an assessment of your or the producers comfortable level of risk. Systems that use total TAI involve higher risk. Several management factors can reduce the risk involved with systems that use complete TAI. First, cows must be in a BCS ≥ 5 (BCS scale 1-9; 1 = emaciated, 9 = extremely obese) both at calving and at the beginning of treatment. Also, mineral status (i.e. copper and selenium) of the cows can affect pregnancy rate to and many cows in the Southeast are deficient in these two minerals. Second, cows must be at least 30 days (preferably 45 days) postpartum at the beginning of treatment. Third, minimize the number of primiparous cows that are subjected to the TAI protocol. Fourth, cows must have been previously vaccinated and dewormed at least 28 days before AI. Success is possible using TAI systems if the risk factors are minimized.

7-Day CO-Synch + CIDR® & TAI should be used for ESAI if:

- Facilities and labor are NOT available for daily estrous detection and cattle handling.
- Technician availability is very limited.
- Value of the semen is low to moderate. When the value of the semen is high, conception rate must be maximized. CO-Synch + CIDR® & TAI reduces conception rates to AI and the cost is per pregnancy is higher because all cows are inseminated. Semen of high value should not be used.
- Pregnancy rates of anestrous cows to this system have been acceptable but low. Reducing the proportion of anestrous cows will reduce the risk associated with TAI protocols.

Resynchronization of Estrus

The CIDR® device can also be used to synchronize the return heats in females previously subjected to estrus synchronization and AI. To resynchronize heats (Figure 5-20), a CIDR® device is inserted 14 days after the previous synchronization period. Seven days later, the CIDR® device is removed. Estrus is observed and females inseminated over the next three days. Preliminary data using Resynch appear excellent. In this trial, females were synchronized using Select Synch plus a CIDR® device and then resynchronized using a CIDR® device. Only 32% of all females treated returned to estrus and were re-inseminated. Most females were observed in heat 24 to 48 hours after CIDR® removal. The conception rate to the AI was excellent and averaged 60%. Thus, after two estrous synchronization periods and six trips down the chute, 80 to 85% (average 84%) of all females treated conceived to AI.

Reuse of a CIDR® device is *not* approved by the FDA and is not recommend by its manufacturer. Reuse of the CIDR® devices can lead to increases in vaginal infection that could reduce fertility. Additionally, the concentration of progesterone released by the previously used CIDR® devices may not be adequate for effective estrus synchronization. Unpublished data have demonstrated that the effectiveness of the CIDR® device is reduced in once- and especially twice-used CIDR® devices.

Many cattle producer reuse CIDR® devices. If a CIDR® device is to be reused, care must be taken to ensure that the device is clean. Immediately after removal, wash the CIDR® devices with a limited amount of water and a soft-bristled brush. *Do not* soak the CIDR® devices. After cleaning, the CIDR® devices should be dipped in a disinfectant, rinsed with clean water, and allowed to dry. The best possible option for reusing CIDR® devices is to get them sterilized using an autoclave. An autoclave uses heat and pressure for sterilization. Many veterinarian offices have autoclaves and may be willing to sterilize CIDR® devices.

Economics of Estrus Synchronization

The genetic reliability with AI is generally greater than with most natural sires. However, less than 10% of the beef cows in the United States are artificially inseminated each year. Many reasons exist for the low rate of implementation of estrus synchronization and AI (ESAI) into beef cow-calf operations. One reason is the extensive nature of beef production. Most cows are pastured in large acreages, and the labor necessary for handling the cows is too great. Additionally, many producers lack adequate facilities to enable safe and easy cattle handling.

Beef production is a minor enterprise on many farms. The income from the beef enterprise in most small and medium-sized operations is secondary to other enterprises or to off-farm income. However, the primary reason for the limited inclusion of ESAI is likely facilities and labor. Little information is available to aid producers in making decisions regarding return on investment and profitability

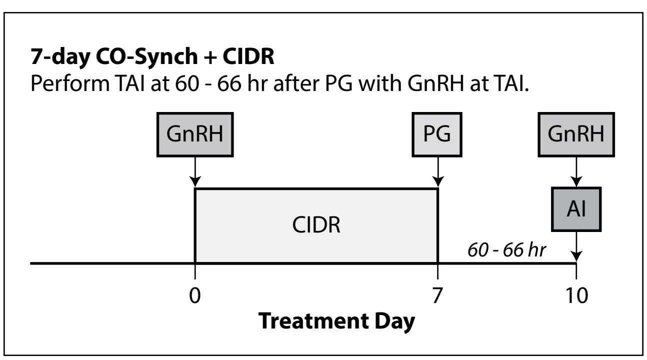


Figure 5-19. 7-day CO-Synch + CIDR protocol.

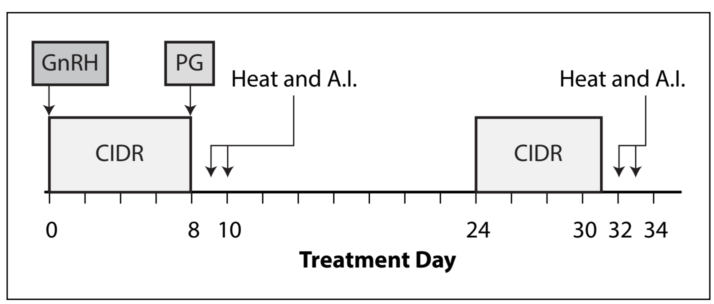


Figure 5-20. CIDR with Resynch.

when considering using ESAI. Many producers may incorporate ESAI if it would improve their profitability both short- and long-term.

Costs per Pregnancy

Few producers understand the costs associated with producing a pregnant female. Sandy Johnson and co-workers from Kansas State University published an excellent article discussing the costs associated with pregnancy using either natural service or a variety of estrus synchronization protocols. Table 5-5 illustrates the costs per pregnancy for bulls that range in price from $1,500 to $5,000 and bull-to-cow ratios from 1:15 to 1:50. Assumptions of the model included use of the bull for four seasons; 10% death loss; 9% interest rate; and an 85% pregnancy rate. Annual bull maintenance costs are variable, and increasing the feed costs by $100 increased cost per pregnancy from $2.22 to $7.41 for high and low bull-to-cow ratios, respectively. Costs per pregnancy ranged from $15.98 to $90.51, depending predominantly on the purchase price and bull-to-cow ratio. Certainly, the ability to identify bulls with a high serving capacity could reduce costs associated with impregnating females.

Use of ESAI will alter cost per pregnancy. Producers can use a partial budget (Table 5-6) for enterprise analysis of ESAI. Implementation of ESAI can increase returns by increasing the weaning weight of the calves (both age and genetic effects), altering market price by increasing the uniformity of the calf crop, and improving cow productivity by enhancing the number of high-quality replacement heifers. Alternatively, ESAI can reduce potential income because fewer bulls are available to sell as cull bulls. Estrus synchronization and AI increases costs because of costs for synchronization products and supplies, labor, technician, and perhaps facilities. However, ESAI can reduce costs by lowering the number of bulls needed for natural service and reducing the labor hours at calving due to a more concentrated and predictable calving season.

Several factors affect the cost per pregnancy of an estrus synchronization and AI program. Conception rate to the AI influences the cost per pregnancy (Table 5-7). As conception rate to AI increases, the cost of pregnancy of the system decreases. Cost per pregnancy is also influenced by total labor hours associated with the ESAI system, the cost of labor, and the cost of semen. If pregnancy rate is held constant, the cost per pregnancy of ESAI exceeds that of natural service especially for smaller herds. However, if the costs are adjusted for the expected increase in weaning weight of the calves resulting from the ESAI, the cost of pregnancy for Select Synch and MGA-PG is lower to produce a 500-pound equivalent weaned

Table 5-5. Effect of changing pregnancy rate on breeding cost per pregnant female in a Select Synch protocol.

Calving Herd Size	AI Pregnancy Rate (%)	No. of Bulls for Natural Service	Breeding Cost ($) per Pregnancy	Proportion % of Total Cost Attributed To:			
				Bulls	Semen	Labor	Treatments
100	75	1	42.06	20	37	19	15
100	55	2	46.08	37	24	18	14
100	48	3	53.01	48	19	15	12
300	65	5	40.90	35	33	11	16
300	55	6	41.49	41	27	11	15

Source: Adapted with permission from Johnson et al., 2003. Kansas State University Cattleman's Field Day 2003. Pub. No. SRP908.

Table 5-6. Cost per pregnancy using natural service.

Purchase price	$1,500.00	$1,700.00	$2,000.00	$2,300.00	$2,500.00	$3,000.00
Salvage value	860.00	860.00	860.00	860.00	860.00	860.00
Summer pasture	104.13	104.13	104.13	104.13	104.13	104.13
Crop residue	7.50	7.50	7.50	7.50	7.50	7.50
Hay	90.61	90.61	90.61	90.61	90.61	90.61
Protein, mineral	25.00	25.00	25.00	25.00	25.00	25.00
Labor	50.00	50.00	50.00	50.00	50.00	50.00
Vet	21.00	21.00	21.00	21.00	21.00	21.00
Repairs	31.00	31.00	31.00	31.00	31.00	31.00
Misc.	7.00	7.00	7.00	7.00	7.00	7.00
Interest	15.13	15.13	15.13	15.13	15.13	15.13
Total variable	351.37	351.37	351.37	351.37	351.37	351.37
Depreciation on equipment	12.39	12.39	12.39	12.39	12.39	12.39
Depreciation on bull	160.00	210.00	285.00	360.00	410.00	535.00
Interest on bull	212.40	230.40	257.40	284.40	302.40	347.40
Death loss	15.00	17.00	20.00	23.00	25.00	30.00
Total fixed	399.79	469.79	574.79	679.79	749.79	924.79
Total cost/year	751.16	821.16	926.16	1,013.16	1,101.16	1,276.16
Purchase price	$1,500.00	$1,700.00	$2,000.00	$2,300.00	$2,500.00	$3,000.00
Cows Exposed per Year	**Cost per Pregnancy ($)**					
15	53.27	58.24	65.69	73.13	78.10	90.51
20	39.96	43.68	49.26	54.85	58.57	67.88
25	31.96	34.94	39.41	43.88	46.86	54.30
30	26.64	29.12	32.84	36.57	39.05	45.25
35	22.83	24.96	28.15	31.34	33.47	38.79
40	19.98	21.84	24.63	27.42	29.29	33.94
50	15.98	17.47	19.71	21.94	23.43	27.15

Source: Reprinted with permission from Johnson et al., 2003. Kansas State University Cattleman's Field Day 2003. Pub. No. SRP908.

Table 5-7. Partial budget for synchronization of estrus synchronization plus AI.

Budget Effect	Source	Budget Effect	Source
Increased returns	• Heavier calves (earlier average birth date) • Improved genetics (calves and replacement females) • Uniformity of calf crop (fewer sires could be used, total breeding season could be shorter)	Decreased returns	• Fewer cull bulls to sell
Decreased costs	• Fewer bulls to purchase and maintain • Less labor for more concentrated calving season • More predictable calving ease	Increased costs	• Planning and management for synchronization of estrus and AI • Synchronization products and supplies • Labor • Improved facilities?

Source: Reprinted with permission from Johnson et al., 2003. Kansas State University Cattleman's Field Day 2003. Pub. No. SRP908.

calf (cost per hundredweight of calf). The cost per pregnancy of CO-Synch to produce a 500-pound equivalent calf was only $0.51 per hundredweight higher than that of natural service. If conception rate to AI increases to 60%, the cost per 500-pound equivalent calf is not different between CO-Synch and natural service.

From these data, it seems apparent that the costs of pregnancy are not significantly different between natural service and most ESAI protocols. Of course, if labor is high, if semen costs are excessive, or if conception rate to the AI is low, the cost per pregnancy of ESAI can dramatically increase.

Short-term Return on Investment

Use of ESAI can improve productivity and revenue. Recent research from Dr. Cliff Lamb examined the short-term economic impact of a breeding system that included FTAI + natural service or just natural service in about 1,200 females on 8 different farms (Table 5-8). The breeding seasons began and ended on the same day in both groups on all farms. A partial budget was used to compare the positive economic impact (added revenue, reduced costs) with the negative economic impact (added costs, reduced revenue). Use of ESAI improved short-term returns by about $50. One of the more interesting aspects of this work is that a positive economic impact was observed in 7 of the 8 farms and ranged from +$123 to -$10 per cow. The lone farm that saw reduced revenue did not observe an increase in overall pregnancy rate or a shift in days to calving indicating that the short-term impact (profit/loss) is dictated by the improved reproductive performance normally observed when ESAI is used.

Similar data have collected at UK evaluating the return on investment of incorporating estrus synchronization and AI. Crossbred postpartum cows (n = 351) on one farm were assigned to one of two breeding systems. Approximately two-thirds of the cows (n = 251) were subjected to an estrous synchronization protocol suitable for a fixed-time insemination (SYNC). The remaining cows (n = 100) were exposed to natural service for 60 days (NAT). The bull-to-cow ratio in the NAT treatment was 1:25. The bull-to-cow ratio was different between the SYNC and NAT groups because we anticipated that approximately one-half of the cows in the SYNC group would conceive to AI. To verify date of conception, pregnancy was diagnosed on day 90 using transrectal ultrasonography.

To determine return on investment, all costs associated with the estrus synchronization and AI were recorded and are summarized in Table 5-9. Labor was determined by recording amount of time required to bring the cattle to the corral, work the cows, and then return them to the breeding pastures. Four laborers were used, three trips through the chute, and an hourly wage of $7.00 per hour. To determine differences in revenue, calves were weighed at weaning, and the differences in weight available to market were determined. Calves from both treatments were given a value of $80 per hundredweight.

Table 5-8. Impact of Estrus Synchronization and AI

Treatment	n	Weaning %	Days to Calving	WW (lb) per Cow Exposed	$/Cow
ESAI	582	84	26.8 ± .8	425.5 ± 9.5	+ $49.14
NS	615	78	31.3 ± .8	386.9 ± 9.5	

Source: Rodgers et al., 2012. Journal of Animal Science 90(11): 4055-4062.

Table 5-9. Cost of AI.

Item	Cost per Cow
GnRH	$4.00
Prostaglandin	$4.00
Technician	$5.00
Semen	$10.00
Labor[a]	$2.88
Total	$29.88

[a] 8.6 hours x 3 working days x 4 workers x $7.00 per hour for 251 cows.

Table 5-10. Results of short-term ESAI trial.

	SYNC	NAT	Diff
Cows	251	100	
Calving rate	90%	81%	9%
% calving 1st 30 days	85%	62%	23%
Mean Julian date of calving	74 ± 0.4	84 ± 0.7	10 d
% calf crop weaned	88%	79%	9%
Weaning age	210 ± 9	200 ± 12	10 d
Weaning weight	576.9 ± 18.1	504.8 ± 21.2	72.6 lb
Lb. calf weaned/cow exposed	507.9	398.4	109.5 lb

The results of this trial are shown in Table 5-10. More cows calved in the SYNC group than in the NAT group, and more cows calved in the first 30 days of the calving season in the SYNC versus the NAT treatment. The average date of calving was earlier in the cows in SYNC than in the NAT group. The average weaning weight of calves was heavier from cows in the SYNC than from those in the NAT group. The increase in percent calf crop weaned and weaning weight increased the pounds of calf weaned per cow exposed by nearly 110 pounds.

Return on investment is shown in Table 5-11. Gross revenue increased by $99.62 in the SYNC group. This increased revenue was achieved by investing $29.88 per cow. However, this increase in gross revenue was not achieved without some cost. If the cost of raising the additional calves is included, the net revenue decreases to $73.48. The gross and net gains achieved from this enterprise were $69.74 and $43.60, respectively. The return on investment for the estrus synchronization and AI was 92%, or the producer nearly doubled the money invested. This return does not include savings associated with reduced bull costs. One-half the number of bulls was used per cow in SYNC group than in the NAT group. If savings on bull purchases are included, the gross return increases to $129 per cow, and the return on investment was 432%. These short-term increases in revenue are quite attractive, but the long-term effects of increasing cow productivity by retaining the heifers sired by proven sires are not as easy to determine.

Table 5-11. Increased revenues from ESAI.

	Revenue		
Weaning weight	72.6 lb. x $80 cwt.	=	$58.08
% calf crop	9% more calves x $80 cwt.	=	$41.54
Total revenue		=	$99.62
Return on investment	$99.62 – 29.88	=	$69.74

Table 5-12. Effects of ESAI on production efficiency and profitability in a medium-sized herd.

	Avg. from 1991 to 2000	2001	2002
No. of females exposed	45	45	44
Calving rate percentage[a]	82%	95%	93%
% calf crop weaned	74.5%	91%	86%
WW Average (lb.)			
Steers	525	542	556
Heifers	484	514	482
Sale Weight[b]			
Steers	554	588	600
Steer sale price (per cwt.)	$77.00	$88.00	$83.00
Lbs of calf weaned per cow exposed	381.2	481.4	448.2
Number of cows sold	5	9	6
Cash cow costs	$235.38	$285.82	$292.26
Net profit per cow exposed[c]	$57.75	$116.62	$76.83

[a] Number of cows calving divided by the number of cows exposed.
[b] Calves were backgrounded for approximately 25 days prior to marketing.
[c] Cash sales per cow minus cow cost.

Long-Term Effects of Estrus Synchronization and AI

Little data are available that address the long-term impact of estrus synchronization and AI in commercial beef cow-calf operations. Two trials were designed to examine the long-term effects of incorporating estrus synchronization and AI into a beef cow-calf operation. The data from the first trial were collected on a single cow-calf operation from 1991 to 2003. Data collected from 1991 to 2000 serve as the baseline or control. During this time period, approximately 45 females (35 to 40 cows and five to eight heifers) were exposed to a 60-day natural service season. Two bulls were used each year. The breeding system used was a two-breed rotational system using Angus and Charolais bulls. The average performance of this herd is illustrated in Table 5-12.

The breeding system was changed to determine the effects of estrus synchronization and AI. All females were subjected to an estrus synchronization protocol suitable for fixed-time insemination (CO-Synch). Females were inseminated to bulls from maternally oriented breeds (Angus and Hereford). Charolais-cross cows were inseminated to the Angus sire, and Angus-cross cows were inseminated to Hereford bulls. Ten days after AI, cows were exposed to a 50-day natural service season. The natural service sire was from a terminally oriented breed (Charolais). Replacement heifers with AI sires were retained. All calves sired by the terminally oriented sire were marketed.

The results from the first two years of the trial are shown in Table 5-12. Incorporation of estrus synchronization and AI increased the percentage of cows that calved, percent calf crop weaned, and the average weaning weight of the steer calves. These increases lead to a marked improvement in pounds of calf weaned per cow exposed. The increases in production efficiency led to increased profitability. Net profit per cow exposed to the bull doubled in the first year and was $20 per cow higher in 2002. Do to unforeseen circumstances, this trial ended in 2002.

Recently, data have been compiled from two farms enrolled in a long-term field study designed to examine the impact of a breeding system on production efficiency. The components of the breeding system included ESAI with natural service (70-day season), organized crossbreeding (Angus, Hereford), and organized selection for the environment (limit purchase feed) and market (post-weaning and bred heifers). One farm was large for the Southeast (150-200 head) while the other was average (23-25 head). At the beginning of the project, average cow size was 1,570 lb. and 1,750 lb. for the large and small farm, respectively. Herd productivity at the start of the project is shown in Table 5-13. An efficient cow weans about 50% of her body weight and these were big cows that were not weaning big calves. We adjusted this by dividing by the number of cows exposed for breeding to get a new cow efficiency indicator we called percent body weight weaned per cow exposed.

Over the next 7-9 years, cows from these farms were subjected to ESAI followed by a 70-day natural service breeding season. Sires were selected to maximize heterosis in a two-breed rotation and to decrease mature cow size while minimizing possible decrease in weaning performance. Cows were rapidly replaced (15-25% replacement) on both farms with females that were sired by our chosen AI sires.

On both farms, average cow size decreased considerably over time (Figure 5-2). What impact could this have on production efficiency? Smaller cows (1,200 vs. 1,600) simply eat less feed (nearly a ton less; Table 5-13) resulting in lower feed costs per year (Table 5-14).

Reducing cow size normally is associated with a reduction in productivity. In this project, averaging both farms together, the length of the calving season decreased (35 days), pregnancy rate increased (8%), the average age of calf increased (17 days), weaning rate increased (10%), adjusted weaning weight increased (118 lb.), and the pound of calf weaned per cow exposed increased (106 lb.; Figure 5-22).

One of our main goals was to increase cow efficiency. An "efficient operation," as defined above, compares production with costs. If we use cow size as a rough estimate of cost, we can estimate cow efficiency by dividing the percent body weight weaned by the total by the number of cows exposed to breeding. Why are we dividing %BW Weaned by the number of cows exposed? Why not just look at average %BW Weaned? Because the successful cows, those that wean a calf, have to be efficient enough to pay for the cows that fail. Cow efficiency appeared to increase over time. In this project, when we started, the 1,660 lb. cows were weaning about 488 pounds. So, these cows were weaning about 29% of their body weight and about 24% of their body weight per cow exposed to the bull. To date, using this estimate, cow efficiency has increased approximately 10% (Figure 5-23).

Table 5-13. Impact of estrus synchronization and AI.

Farm	No. of Cows	Weaning %	Calving Season	Adj. WW	Per Cow Exposed WW (lb)	Per Cow Exposed % BW
Average	23	93	64 days	521	203	28.9
Large	153	74	123 days	455	337	21.5

Table 5-14. Daily dry matter intake (lb) of beef cows of varying mature weights.[1]

Cow Weight (lb)	Lactation Early	Lactation Late / Pregnancy Early	Pregnancy Mid	Pregnancy Late	Yearly Total	Compared to 1200-lb cow (lb)
1000	24.8	23.5	21.0	21.0	8249	-1095
1200	27.6	26.5	24.1	24.2	9344	0
1400	30.4	29.4	27.0	27.1	10403	1059
1600	33.1	32.2	29.9	30.0	11425	2081

[1] Adapted from NRC (2000).

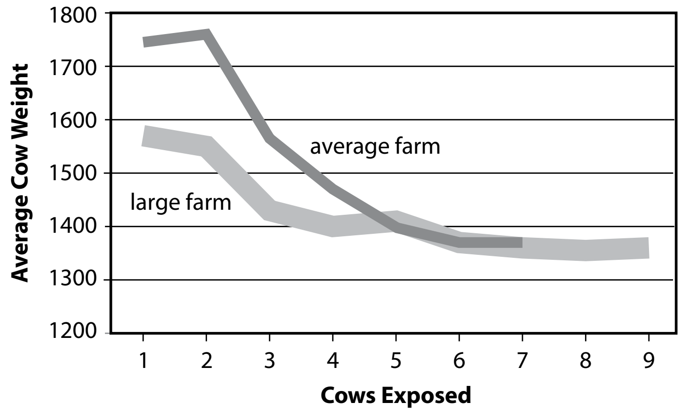


Figure 5-21. Average cow weight (lb).

Conclusions

Estrus synchronization and AI is a profitable enterprise for commercial beef cow-calf operations. The short-term returns on investment were approximately $70 per cow simply by increasing reproductive efficiency and thus the pounds of marketable calf. Additional short-term increases in revenue exist if the producer retains ownership. Data from the Angus Association demonstrated that the carcass value was $206 per head greater

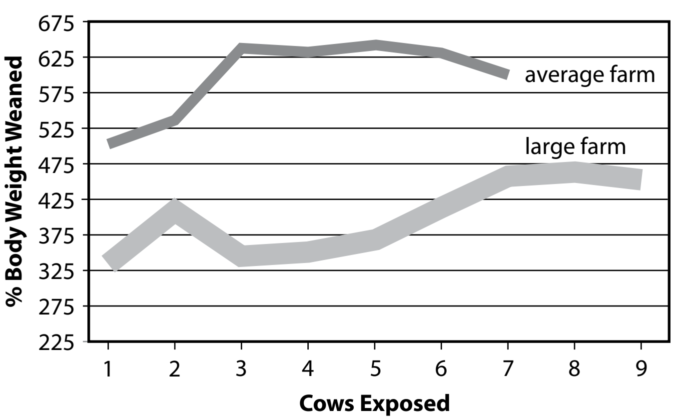


Figure 5-22. Pounds of calf weaned per cow exposed.

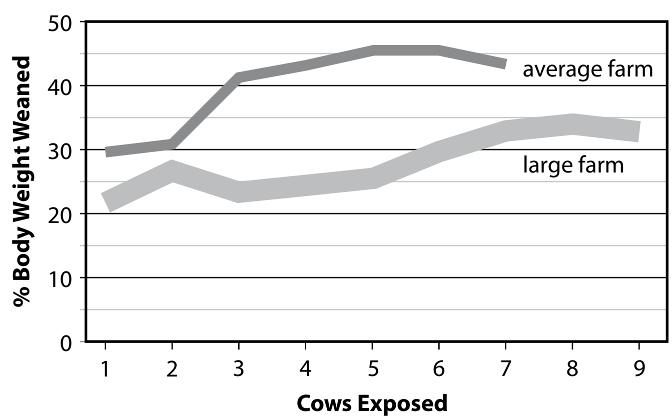


Figure 5-23. Percent body weight weaned per cow exposed.

for sires from the top 10% than the bottom 10% for carcass value. Therefore, if the calves produced from the herds used in the above trials were from sires that were only average and the bulls used for AI were in the top 10% and the cattle were marketed on the grid, an additional $100 to $125 per calf is profited. The key to capturing the greatest potential profit is to utilize alternative marketing systems. However, even in a commodity market, inclusion of ESAI is a profitable rather than costly venture.

Estrus Synchronization Systems for Natural Service

The easiest road to maximum breeding efficiency in the beef cow-calf industry is through estrous synchronization. Estrus synchronization helps shorten the calving season, increases herd pregnancy rates, and helps increase calf uniformity and weight (calves are typically older). Many beef producers also recognize the potential advantage of ESAI. However, many have neither the time nor facilities to utilize estrous synchronization and AI. Systems for use with natural service could markedly improve reproductive efficiency for those producers unable to incorporate AI.

The key to understanding why estrus synchronization improves reproductive rate arises from the fact that all cows do not have the same opportunity to breed. The ability of a cow to conceive during a breeding season is dictated by two main factors; the number of opportunities she has to conceive during a breeding season and her ability to conceive (conception rate).

One method to improve reproductive performance of your cow herd is to synchronize estrus prior to bull turn out. Studies conducted at UK have demonstrated that treatment of cows with a CIDR® device for seven days before natural service can have increase pregnancy rate 5%-10% and can increase the proportion of cows that calve in the first 30 days of the breeding season. Our most recent data indicates that the CIDR® devices only need to be inserted in cows that are likely to have trouble conceiving early in a breeding season; late-calvers and two-year old cows. By "targeting" our reproductive management to these cows, we can improve the whole herd performance and limit our input costs.

Below is just one example of the successful application of this technique. A producer in our IRM Farm Program calves about 150 cows and prefers his herd to calve starting the second week of February. Like many cowherds, the calving season had gotten a bit longer than preferred as several of his cows were calving in late April and May. CIDR® device were inserted into April and May calving cows and all two year olds (25 total cows). The reproductive performance of this group of cows was super. Most (17) conceived in the first 30 days of the breeding season, five conceived in the next 40 days, and three were open. All three of the open cows were two-year olds. One was pretty thin, one calved at the end of April, and the third didn't have an excuse; she just didn't breed back. All the late-calving mature cows conceived. The simple application of the CIDR® device greatly enhanced reproductive performance as nearly 70% of the "problem" cows in this herd conceived early and nearly 95% conceived during the breeding season. This outcome is similar to data from controlled experiments that indicate the tremendous economic impact of synchronizing estrus in cows before natural service.

The length of anestrus impacts the opportunity for a cow to rebreed in a timely fashion. Most cattlemen agree that they would like their cows to calve about every 365 days; if they calve September 1 this year, we would like them to calve about September 1 next year. The length of gestation in beef cattle is about 283 days so cows have on average a cow needs to breed back within 82 days from calving. So, if a cow is anestrus for 65 days

Lastly, ranchers need to develop a plan to enhance the rebreeding potential of their first-calf heifers and late-calving cows. Young cows and late-calving cows have one characteristic in common that will greatly impact their reproductive success; anestrus. After each calving, cows undergo a period of time when they do not come into estrus. This anestrus period can be as short as 14 days but can also last as long as 180 days depending upon a number of factors. Typically, mature cows in good BCS will be anestrus for 45-90 days (avg. about 60-70 days) while first-calf heifers will be anestrous for 75-120 days. Research has shown that only 64% of mature cows have initiated estrous cycles about 70 days after calving while only 50% of first calf heifers have initiated estrous cycles at nearly 90 days after calving. Let's consider the impact of anestrus and calving date for a herd that calves from March 1 until May 10. Bull turnout is May 20th and the length of anestrus for mature cows is 60 days and for young cows is 90 days. A mature cow that calves on March 1 will begin to cycle on May 1 and is highly likely to conceive early. However, the mature cow that calves on April 20 won't cycle until June 20 and her opportunity to conceive early is very limited. A first-calf heifer that calves on April 20 won't begin to cycle until July 20 and will have limited opportunities to conceive. Cattlemen can reduce the anestrous period by fence-line exposure to a mature bull or by treating the cows with progesterone for 7 days prior to bull exposure. Sources of progesterone include the feed additive melengestrol acetate (MGA) or an EAZI-Breed CIDR® insert (Zoetis Animal Health). Both sources have been shown to induce estrus in anestrous cows and exposure of anestrous cows to progesterone for 7 days before bull exposure will not reduce fertility. Pregnancy rates will actually be increased in these females because inducing estrus will increase the number of opportunities these cows have to conceive in the breeding season.

System

A short-term protocol for estrous synchronization and natural service has been developed. This system involves either feeding MGA or inserting a CIDR® device for seven days immediately prior to exposing the females to a bull (Figure 5-24). Data from controlled experiments demonstrate that exposure of females to either MGA or a CIDR® device for seven days before bull exposure can increase pregnancy rate and shift calving distribution dramatically (Table 5-15). These systems to synchronize estrus before natural service improve pregnancy rates by about 9% and increase the percentage of cows that calve in the first 30 days. The normal shift in calving date is about 20 days and results in a 50+-pound increase in calf weaning weights. A CIDR® insert can also be used to induce estrus in cows that have recently calved. Our research

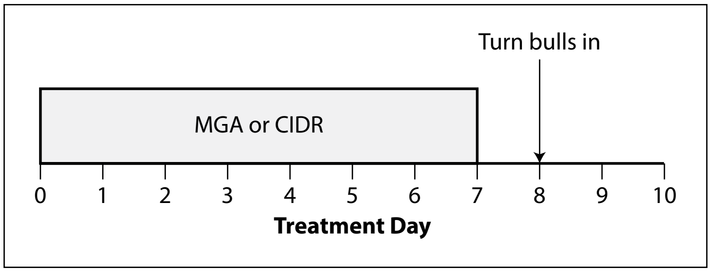


Figure 5-24. Estrus synchronization for natural service.

Table 5-15. Results of synchronizing estrus prior to natural service.

Treatment	Numbers	Preg. Rate	1st 30 d
Control	621	83	47
MGA	614	93	78
Control	419	83	45
CIDR	421	91	80

Bull:cow range from 1:23 to 1:42 (91% PR)

has shown that a CIDR® device can be used to enhance breeding performance in cows as early as 14 days after calving. Here is an example of how to use the CIDR® to improve the reproductive performance of cows that calve late in the calving season. Let's assume that the target calving season is March and April. The plan was to turn bulls out on May 20 but some cows are calving in May. For these May-calving cows, wait 14-21 days after they calve and then insert a CIDR® device for 7 days. Turn the cows into the breeding pasture once the CIDR® is removed. Data on approximately 300 late-calving cows have been collected. Seventy-five percent of mature cows in good body condition treated as described will conceive in the first 30 days of the breeding season and normally cows will calve 30-35 days earlier than the previous year.

Using Sex-Sorted Semen

Progressive cattlemen are constantly working to improving the herd's efficiency and productivity. For those operations that implement artificial insemination already, another potential step to improve production efficiency would be to control the gender ratio of their calf crop. Controlling the gender ratio of a calf crop can be accomplished by incorporating sex-sorted semen into a breeding program. Several scenarios have been outlined below to describe situations where controlling the gender of a calf-crop is desirable.

Semen Sorting Technology

Sorting semen into X- and Y- bearing sperm is possible due to the size differences that exist between chromosomes. Studies indicate that the X-chromosome is about 4% larger than the Y-chromosome. Currently, no other sorting technique is as effective as flow cytometry. Flow cytometry involves 21 steps prior to cryopreservation, compared to three or four steps for conventional semen.

Significant advancements have been made in sperm sorting technology, allowing sex-sorted semen to become commercially available. In the early 1990s, sorting speeds were 200-400 cells/second, sorting accuracy of 83%, and 70% fertility of conventional semen. However, in the last few years, sorting speeds are now 7,000-10,000 cells/second with greater than 90% sorting accuracy, and conception rates near 90% of conventional semen. Typical concentrations of sex-sorted semen have been 2.0×10^6, however SexingTechnologies (Navasota, TX) is currently marketing sex-sorted semen at a concentration of 4.0×10^6, under the tradename SexedULTRA 4M.

Previous Research

Several studies have indicated reduced conception rates using sex-sorted semen compared to conventional semen of the same sires. Conception rates of sex-sorted semen have ranged from 70-80%, with recent work reporting conception rates near 90% of conventional semen (Figure 5-25). Interestingly, some research has reported favorable conception rates with sex-sorted semen when females expressed estrus prior to insemination. Near normal conception rates had been reported when females expressed estrus prior to insemination. However, when females were non-estrus prior to breeding, conception rates were significantly reduced (Figure 5-26). It is imperative for females to have expressed estrus prior to breeding when using sex-sorted semen to maximize pregnancy potential.

Strategies to Incorporate Sex-Sorted Semen

As mentioned, it is crucial to ensure females have exhibited estrus prior to insemination when breeding with sex-sorted semen. A method to increase conception rates using sex-sorted semen has been to delay insemination in the non-

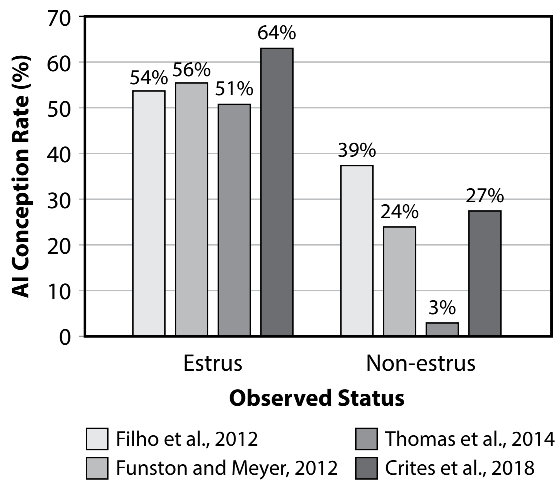


Figure 5-25. Effect of observed estrus status.

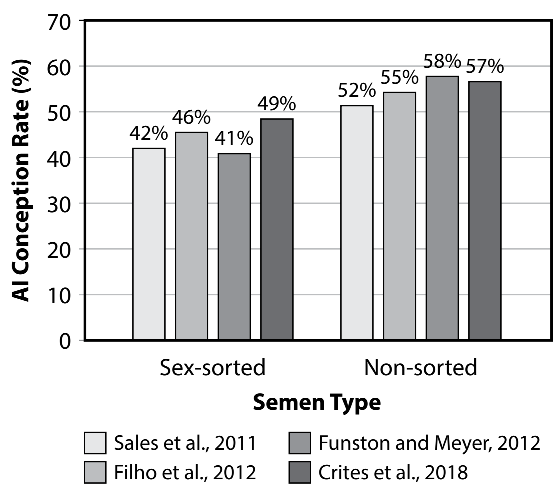


Figure 5-26. Comparison of AI conception rates.

estrus females. In this process known as split-time AI (**STAI**), females that exhibit estrus are inseminated as scheduled and the non-estrus females receive GnRH and breeding is delayed 20 h (Figure 5-27). Several studies conducted in 2014 observed increased conception rates in non-estrus females when using sex-sorted semen in STAI protocols. A concern with STAI is that it requires an additional handling and a second insemination time. This may not be conducive to operations that hire breeding technicians as they would have to schedule two consecutive breeding dates. A 2009 survey of United States beef producers reported labor and time as the two most common reasons that AI was not utilized. Therefore, a protocol that increases both time and labor for producers and professional AI technicians, may limit the adoption of the STAI protocol in commercial beef operations.

Another option when using FTAI protocols, such as the 7-d CO-Synch + CIDR® protocol discussed earlier, would be to inseminate all the females that exhibit estrus prior to the scheduled breeding time using sex-sorted semen and the remaining non-estrual females would be inseminated with conventional semen. This allows for the greatest chance of a successful pregnancy using sex-sorted semen in a single breeding period, as well as increases the pregnancy potential for the non-estrus females.

Can we be more efficient? The goal of most commercial cattlemen is to sell more calves, sell heavier calves, and sell calves that are more valuable. But, can we make our product (calves) more valuable? What would happen to efficiency if we control gender, weaning heifers from our top performing cows and steers from everything else?

For commercial cattlemen, steers simply return more value. Kentucky market data from 2010-2016 (Figure 5-28) demonstrates the value difference in gender. At the same age, steers typically weigh more and are worth $146.71/hd more in revenue. Sex-sorted semen has been available for use for several years and is used most often in the dairy and beef seedstock industries. Conception rate of sex-sorted semen was initially too low for most cattlemen to consider but the sorting/freezing process has improved considerably and conception rates now are basically similar to conventionally-frozen semen. Sex-sorted semen costs slightly more. Male-sorted beef semen normally costs about the same as conventional but female-sorted beef semen is about 50% more ($50 conventional = $75 female sorted). Does the additional value of gender control pay for the added costs? In a typical 30-cow herd, 13 steers and 13 heifers might be weaned (88% weaning rate). Using the values from the above dataset, the steers would be worth $12,035 while the heifers would be worth $10,128. Let's assume that we implement an ESAI system suitable for fixed-time AI using sex-sorted semen and conception rate to AI is 50%. We breed 6 cows to female-sorted semen and 24 to male-sorted semen. We can either use natural service to clean up or shift to a total AI system. Both systems are shown in Table 5-17.

Table 5-16. Results of synchronizing estrus prior to natural service.

Treatment	Numbers	Pregnancy Rate (%)	Percentage Calved in 1st 30 days (%)
Control	621	83	47
MGA	614	93	78
Control	419	83	45
CIDR	421	91	80

Bull:Cow range from 1:23 to 1:42 (91% pregnancy rate).

At first glance, the data in Table 5-16 is not impressive. Remember, this is just the added revenue resulting from the shift in gender ratio. Shifting from natural service to an ESAI system has been shown to increase short-term revenue by about $50 per head. Shifting gender ADDS $24-37 more revenue per head making the shift to ESAI even more attractive. This value is underestimated slightly because market value will be about $2 higher per hundred in both of the groups subjected to ESAI due to marketing 14 versus 19-22 "like" steers in a group. Revenue can be even higher if the producer selects carcass-oriented genetics, ownership is retained, and the steers are fed to hit a high-value grid. Using sex-sorted semen will increase costs slightly; in the above example, six females will be inseminated using female-sorted semen that will only increase the total cost about 10%. Long-term, using maternally-oriented genetics on your top cows should increase maternal performance.

The road to efficiency travels through ESAI. Compared to typical natural service, use of ESAI increases revenue, optimizes heterosis, and matching geno-

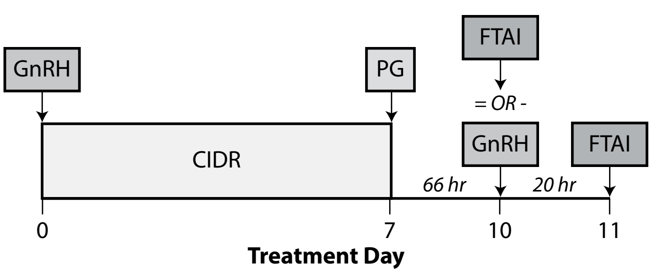
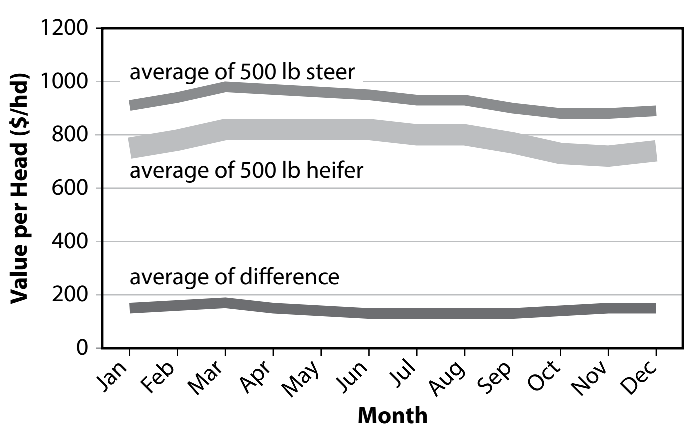


Figure 5-27. Split-time AI.



USDA-AMS Kentucky Weekly Livestock Summary, 2010-2016

Figure 5-28. Average steer and heifer value, 2010-2016 status.

type with market and environment. Long-term, producers can make real strides in cow efficiency and improve their opportunities for profit. Controlling gender offers exciting opportunities for all cattlemen to take their operations to the highest possible level.

Table 5-17. Characteristics of the bovine fetus during pregnancy.

Day of Gestation	Approx. Size	Inches	Characteristics
30 (1 mo.)	1/100 oz.	½	Some fluid in embryonic vesicle (marble size)
45 days	1/8 oz.	1	Gravid horn enlarged
60 (2 mo.)	1/4 oz.	2	Fetus size of a mouse, uterine horn banana size (2 in. diameter)
90 (3 mo.)	8 oz.	6	Fetus size of a small rat, uterine horns 3 in. in diameter and dropping into abdominal cavity
120 (4 mo.)	2 lb.	12	Fetus size of a small cat, uterine horns 5 in. in diameter, placentomas are palpable
150 (5 mo.)	5 lb.	18	Fetus size of a cat, might be too deep in abdominal cavity to palpate, uterine horns 7 in. in diameter, placentomas 2 to 2.5 in.
180 (6 mo.)	11 lb.	24	Fetus size of a small dog
210 (7 mo.)	23 lb.	30	Fetus is easily palpated from this point till term
240 (8 mo.)	47 lb.	36	Fetus is easily palpated from this point till term

283 (term): Size depends on genetic and environmental factors.

Potential Reasons to Utilize Female-Sorted Semen

Producers looking to expand the size of their operations could do so rapidly by increasing the number of female calves born. This eliminates the need to purchase any replacement females and reduces the risk of bringing in any outside diseases. Both seedstock and commercial cattleman could have a potential market for selling yearling heifers and bred females to other producers. One thought is to breed all yearling heifers with female-sorted semen. Research has demonstrated that heifer calves usually come smaller at birth and it has also been found that breeding a heifer to have a smaller calf reduces the incidence of dystocia.

It may be the case that certain sires produce females that make extremely good cows (i.e. phenotypically, high fertility, performance) that perform well in a particular environment. Additionally, it might also be that a heifer calf is more desirable from a certain cow family. Perhaps these females are genetically superior, good structured, sound on their feet and legs, display high udder quality, wean heavier calves, exhibit increased fertility, better fit the environment, and ultimately make superior dams as a mature cow. Using female-sorted semen allows producers to select the matings that they would like to generate daughters from.

Potential Reasons to Utilize Male-Sorted Semen

A seedstock producer's main goal is to generate and sell bulls for commercial cow-calf operations and to other seedstock breeders as well. Selecting and using sons from proven, high-accuracy sires can make rapid improvements in the genetic progress of herds. Additionally, by using male-sorted semen, bulls can be produced from the best dams for different marketing scenarios.

In commercial beef production, not only is a feeder steer typically worth more money per pound, but male calves also gain more from calving to weaning then female calves on average. Data from feeder calf sales from 2010 to 2016 in Kentucky indicated that the average value of a 550 lb. steer was $925.76/hd and a 500 lb. heifer was $779.05/hd. Using these values, a steer is worth $146.71 per head more than their heifer contemporaries. This price difference highlights why it would be desirable for commercial producers to maximize the number of steer calves marketed.

Incorporating Both Genders

A proposed method to utilize sex sorted semen of both genders in a crossbreeding system known as Two-Breed Rotational and Terminal-Sire, that was previously described by Gregory and Cundiff (1980). This breeding system involves breeding all replacement females and 25% of the mature cows to female-selected semen of maternal sires. The remaining cows in the herd would then be inseminated with male-selected semen using a terminal sire. This breeding scenario would capture the maximum advantage of breed differences for maternal and terminal roles and the maximum advantage of individual and maternal heterosis.

Scenario Summaries

These scenarios describe several potential avenues for incorporating sex-sorted semen into breeding programs for both commercial and seedstock cattlemen. Before incorporating sex-sorted semen into a breeding program an economic analysis should be conducted; as each farm and ranch operation experiences different input costs and marketing opportunities. While sex-sorted semen may not be appropriate for every operation, it has the potential to increase the production efficiency in the cattle industry.

Pregnancy Testing

Pregnancy diagnosis is a management tool used to identify nonpregnant females and to aid in grouping pregnant females according to anticipated calving dates.

Pregnancy testing offers the following advantages:

- Pregnancy diagnosis provides early warning of breeding problems, such as infertility in males and problem breeders in females.
- Management decisions can be made regarding rebreeding or sale of nonpregnant females.
- Separation and grouping of females based on pregnancy status improves feed utilization and enhances management efficiency.
- Improved utilization of facilities is possible.
- It is possible to guarantee pregnancy in females available for sale.
- Most importantly, producers can avoid the additional expenditures associated with feeding cows that fail to produce a calf.

Pregnancy diagnosis in cattle is generally performed by rectal palpation. A thorough understanding of the female reproductive system is essential in order to accurately perform a pregnancy examination. Realtime ultrasonography is used routinely to diagnose pregnancy and determine fetal sex. Table 5-22 provides a summary of fetal development and identifying characteristics based on fetal age.

Practice and experience are the keys to accurate palpation. In most instances, the producer should not be the one to palpate but should supervise the operation and critically observe cows as they are processed through the chute. This provides an ideal time to begin making decisions regarding which cows to keep and which to cull.

Pregnancy diagnosis should be performed at the stage of gestation that the technician feels most comfortable with. Some technicians are more comfortable and more accurate at earlier stages of gestation (i.e., less than 120 days), while others are more comfortable at later stages (i.e., greater than 120 days). In general, cows should be diagnosed for pregnancy at some point in the fall so that culling decisions can be made before winter feeding.

The easiest and most accurate method of pregnancy diagnosis is blood sampling. Several laboratories in Kentucky can analyze blood samples for the presence of Bovine Pregnancy Specific Protein, a protein that is only produced by the placenta. Pregnancy can be diagnosed in females as early as 26 days of pregnancy and the total costs per cows is approximately $5. The accuracy of the test is greater than 95 percent. Here is a link to a YouTube video demonstrating how to take a blood sample for determining pregnancy. https://www.youtube.com/watch?v=IuNbsTMrIuI&t=9s

Reproductive Biotechnologies

Reproductive biotechnologies include estrous synchronization, artificial insemination, superovulation, embryo recovery and transfer, cryopreservation of sperm and embryos, sexing semen, *in vitro* fertilization, bisection and cloning of embryos, biopsy of embryos for sex determination and other genetic analyses, and transgenic technology.

This list can be expanded to include even more procedures; however, it is generally assumed that, at least at this point, selective breeding programs are perhaps more profitable for the majority of beef cattle operations than the biotechnologies listed. Estrus synchronization and artificial insemination are the most important and widely applicable technologies currently available and, at present, offer the best opportunity to affordably impact a beef production system.

Heifer Development Strategies to Improve Reproductive Efficiency

Improvements in reproductive efficiency certainly impact profitability in beef cow herds. The first step in improving reproductive efficiency is to properly manage reproduction in yearling heifers. Research has clearly demonstrated that heifers that conceive earliest in their first breeding season become more productive and more profitable cows. The goal of a heifer reproductive management program should be to give heifers the opportunity to conceive early and to reduce calving difficulties. So the goal is to identify management practices that increase the opportunity for yearling heifers to conceive early and calve without trouble. The key to proper heifer development lies in understanding the factors that influence successful heifer development. The key factor regulating heifer development is age at puberty. Most producers do not consider age at puberty of their heifers to be a major problem, yet few know how many heifers are actually cyclic at the beginning of the breeding season. A Nebraska study demonstrated that the proportion of heifers that were pubertal on the first day of the breeding season varied greatly over five consecutive years in a single a herd. The percentage of heifers that were pubertal on the first day of the breeding season ranged from 21% to only 64% over the five-year period. For maximum fertility and reproductive performance, heifers must have had at least one estrus *before* the beginning of the breeding season. The goal then is to incorporate reproductive management tools to reduce the age of puberty, increase fertility, and shorten the interval to conception.

The three main factors that regulate the onset of puberty are age, weight, and genetic makeup of the heifer. Age most limits the onset of puberty. Heifers must reach a minimum biological age before the pubertal process can be initiated. The second factor that regulates puberty in the heifer is weight. For puberty to occur, heifers must weigh at least 65 to 70% of their mature weight. This weight is referred to as their target weight. More information on heifer development rations can be found in Chapter 8, Feeding the Beef Herd. Most heifer development programs require that heifers reach their target weight, approximately 67% of their expected mature weight, by the onset of their first breeding season. Because fertility increases until the third estrus after puberty, heifers should reach their target weight at least 30 days before the start of the breeding season. The final factor regulating puberty is genetic makeup of the heifer. Age at puberty has a highly negative correlation with milk production. In other words, breeds that excel in milk production reach puberty at a younger age than lower milking breeds. Within the British breeds, the heavier milking breeds, Angus and Shorthorn, reach puberty at a younger age than the lighter milking breed, Hereford. Within the Continental breeds, Simmental and Gelb.vieh reach puberty at a younger age than Charolais, Limousin, and Chianina. Age at puberty is an even greater problem in breeds with Brahman influence. Females from Brahman-influenced breeds can reach puberty as late as 24 months of age.

The only breeding management tool available for reducing the age at puberty is crossbreeding. Lowly heritable traits, such as reproduction, are greatly enhanced by heterosis (see Chapter 6: Planning the Genetics Program).

Successfully Managing Heifers

How are heifers successfully managed to reach puberty at an optimal time? Proper heifer development begins at weaning. At weaning, select the oldest heifers that are heaviest with respect to their target weight. Remember, age and weight are two key factors that determine age at puberty. Also, select at least 20% more heifers for development than are needed for replacements. Developing additional heifers allows the producer to cull heifers that do not perform during the development.

The next step is to set the breeding date. It is widely recommended that heifers be bred 20 to 30 days before the mature cowherd. For example, if the mature cows start calving on March 1, the heifers should start calving approximately February 1. Use a gestation table to determine the start of the breeding season. In this example, the breeding season starts on April 25. To ensure that only the most fertile heifers are selected for replacements, limit the breeding season to only 30 days and cull those heifers that do not conceive. After the start of the breeding season is determined, determine the number of days from weaning to breeding, then subtract 30 days. Research has clearly demonstrated that fertility increases approximately 20% from the first to the third estrus. Therefore, it is logical to manage heifers to reach puberty before the breeding season begins. If the heifers were weaned on October 1, there are 207 days from weaning until the breeding season starts on April 25. Subtracting 30 days leaves 177 days for the heifers to reach their target weight.

Next examine the cowherd and determine the approximate weight of the cows. Use this weight to set the target weight of the heifers. The target weight is 67% of their expected mature weight. Then determine the amount of weight gain needed to reach the target weight. If the average mature weight of the cowherd is 1,200 pounds, the target weight of the heifers is 800 pounds. If the heifers weighed on average 500 pounds at weaning, the heifers need to gain 300 pounds to reach their target weight. Dividing the weight by the number of days indicates that the heifers need to gain approximately 1.7 pounds per day to reach their target weight 30 days before the start of the breeding season. Once the weight gain is determined, a ration should be developed so those heifers can reach their target weight. It is a good practice to weigh the heifers periodically to ensure that they are gaining the appropriate amount of weight. If they are not, the ration can be adjusted to compensate for any discrepancies.

The next important phase in heifer development occurs one month prior to the start of the breeding season. At this time, pelvic area measurements and reproductive tract scores should be determined for each heifer. Pelvic area is a measurement of the size of the birth canal in heifers. Heifers with small pelvic areas and especially large heifers with small pelvic areas tend to have greater difficulty calving. The key question then becomes what size pelvic area is too small? Gene Deutscher and co-workers at the University of Nebraska developed tables to help producers to relate size of heifer, size of pelvic area, and the potential size of an easily deliverable calf (tables 5-18 and 5-19). To determine the size of a deliverable calf (Table 5-18), divide the pelvic area by the appropriate ratio as determined by age and weight. For example, an 800-pound yearling heifer with a pelvic area of 180 square centimeters should be able to deliver a 78-pound calf (180/2.3) with little difficulty. Most heifer development professionals cull those heifers with a pelvic area that is inadequate to allow delivery of a 70- to 75-pound calf. In other words, an 800-pound heifer with a pelvic area less than 160 square centimeters should be culled. It is important to recognize two facts. One, the ratios used to determine size of a deliverable calf are only about 80% accurate, so some variability does exist in this model. Second, producers should set their own pelvic area minimum that fits within their individual production situation. In other words, if you want your 800-pound yearling heifers to be able to deliver an 80-pound calf, set your pelvic area limit at 184 square centimeters.

Heifers should also be subjected to a reproductive tract score. Reproductive tract score is used to determine the maturity of a heifer. Reproductive tract scores (RTS) range from 1 to 5, and heifers with higher reproductive tract scores are more mature. If estrus synchronization is *not* going to be used, cull those heifers with a RTS less than 3. If estrus is to be synchronized using melengestrol acetate (MGA), an RTS of 2 is acceptable.

At this time heifers should also be vaccinated against Vibrio fetus, Leptospirosis, and the respiratory disease complex, which includes PI_3, BRSV, BVD, and IBR. A modified-live vaccine is preferred because this vaccine generally stimulates a better immune response. Heifers also need to be dewormed at this working.

The final step in heifer development is breeding. Producers should consider estrus synchronization and/or AI. There are many advantages to estrus synchronization and AI. The advantages of estrus synchronization include higher pregnancy rates; heavier, more uniform calves at weaning; and increased production and labor efficiency. The greatest advantage of AI is the ability to use superior, more predictable sires. Since a majority of calving problems in a herd occur when calving first-calf heifers, it seems only logical to use estrus synchronization and AI to proven calving-ease bulls.

Proper heifer development is one of the key components to profitability in a beef cattle operation. Understanding the principles of heifer development can enable producers to incorporate management techniques to improve the efficiency of the operation.

Table 5-18. Using pelvic measurements to estimate deliverable calf size (birth weight).

Time of Measurement	Heifer Age (mo.)	Heifer Wt. (lb.)	Pelvic Area (cm.2)	Pelvic Area/Birth Wt. Ratio	Estimated Calf Birth Wt. (lb.)
Before breeding	12-13	600	140	2.1	67
			160	2.1	76
			180	2.1	86
Pregnancy exam	18-19	800	180	2.7	67
			200	2.7	74
			220	2.7	82

Source: Deutscher, 1988. Journal of Animal Science 66(5):1081-1088.

Table 5-19. Pelvic area/calf birth weight ratios for various heifer weights and ages to estimate deliverable calf birth weight.

Heifer Wt. (lb)	Age at Time of Measurement (mo.)			
	8-9	12-13	18-19	22-23
500	1.7	2.0	--	--
600	1.8	2.1	--	--
700	1.9	2.2	2.6	--
800	--	2.3	2.7	3.1
900	--	2.4	2.8	3.2
1000	--	2.5	2.9	3.3
1100	--	--	--	3.4

Source: Deutscher, 1988. Journal of Animal Science 66(5):1081-1088.

Diversity among Breeds

Table 5-20 groups breed crosses by their biological types and four other criteria. The table summarizes data from the Meat Animal Research Center for 19 F1 crosses grouped into seven biological types based on relative differences (X lowest, XXXXXX highest) in growth rate and mature size, lean-to-fat ratio, age at puberty, and milk production. These data show that faster-gaining breed groups of larger mature size reach puberty at later ages than do slower-gaining breed groups of smaller mature size. Breeds that have a history of selection for milk production (e.g., Gelb. Vieh, Brown Swiss, and Simmental) tend to weigh less at puberty than do those with the same genetic potential for growth and mature size that are not selected for milk production (e.g., Charolais, Limousin, and Chianina).

Heifers sired by breeds with a large mature size tend to be older and heavier at puberty than heifers sired by breeds with a smaller mature size. The relationship between mature size and age at puberty can be offset by associations with milk production (i.e., heavier milking breeds or lines within a breed reach puberty at younger ages and lighter weights). When these interpretations are expanded to mature cows, it is evident that the additional nutrient requirements of cows of large size and higher milk production potential must be met, or the intervals from calving to first estrus increase and conception rates decline.

Table 5-20. Breed crosses grouped in biological type on the basis of four major criteria.[1]

Breed Group	Growth Rate & Mature Size	Lean:Fat Ratio	Age at Puberty	Milk Production
Jersey	X	X	X	XXXXX
Hereford-Angus	XX	XX	XXX	XX
Red Poll	XX	XX	XX	XXX
Devon	XX	XX	XXX	XX
South Devon	XXX	XXX	XX	XXX
Tarentaise	XXX	XXX	XX	XXX
Pinzgauer	XXX	XXX	XX	XXX
Brangus	XXX	XX	XXXX	XX
Santa Gertrudis	XXX	XX	XXXX	XX
Sahiwal	XX	XXX	XXXXX	XXX
Brahman	XXXX	XXX	XXXXX	XXX
Brown Swiss	XXXX	XXXX	XX	XXXX
Gelbvieh	XXXX	XXXX	XX	XXXX
Holstein	XXXX	XXX	XX	XXXXXX
Simmental	XXXXX	XXXX	XXX	XXXX
Maine-Anjou	XXXXX	XXXX	XXX	XXX
Limousin	XXX	XXXXX	XXXX	X
Charolais	XXXXX	XXXXX	XXXX	X
Chianina	XXXXX	XXXXX	XXXX	X

[1] X lowest, XXXXXX highest.
Source: Cundiff, 1986. Crosssbreeding Beef for Western Range Environments. University of Nevada-Reno and USDA TB-88-1.

Matching the Development Program with Genotype

Most components of fertility that influence first calving and subsequent reproductive performance are not highly heritable. This suggests that management practices are most likely to influence the majority of factors related to reproductive performance. How replacement heifer calves are managed from the time they are weaned from their dams to the beginning of the first breeding period is critical for their subsequent performance.

Studies indicate that puberty can be expected to occur at a genetically predetermined size among individual animals, and only when heifers reach target weights can high pregnancy rates be obtained. In other words, heifers with the genetic potential to reach a heavier mature weight must attain a heavier prebreeding weight before their first breeding season. Using the standard set by the Beef Improvement Federation for nine frame-size classifications for U.S. breeding cattle (Table 5-21), producers can estimate body composition and energy requirements per pound of gain at various weights during the feeding period.

Optimal growth rates for replacement females of various body types are also available. These growth rates (Table 5-22) represent optimums for heifers that vary in mature size; they were established to maximize female lifetime productivity. The target weight principle calls for feeding heifers to a prebreeding target weight that represents 67% of the heifer's projected mature weight.

Table 5-21. Body weight and height of breeding females of different frame sizes.[1]

Frame Score	205 Day		426 Day		Maturity	
	Height	Weight	Height	Weight	Height	Weight
1	35	356	41	580	44	880
2	37	375	43	618	46	953
3	39	396	45	653	48	1,027
4	41	418	47	693	50	1,100
5	43	438	49	728	52	1,172
6	45	458	51	766	54	1,247
7	47	480	53	803	56	1,320
8	49	499	55	838	58	1,393
9	51	521	57	880	60	1,467

[1] Hip height (in.) based on Beef Improvement Federation standards. Weights (lb.) are expected averages for flesh condition (body condition score 5; Fox et al., 1988).

Table 5-22. Optimum growth rate for breeding herd replacement females.[1]

	Frame Size				
	1	3	5	7	9
Optimum weight at first estrus, lb.	580	653	728	803	880
Mature weight, lb.	880	1,027	1,172	1,320	1,467

[1] Optimum weight or target weights at which reproductive cycles are initiated are reinitiated as soon as possible without excess fat deposition that will inhibit milk production and reproduction (Fox et al., 1988).

Management of Heifers at Calving

At least two weeks prior to calving, move heifers to an accessible area. An ideal situation would be a small pasture near a corral, complete with a place to deliver calves and a small pen for getting heifers to "pair up" with their calves after they are born. Check heifers at least three times a day during the calving season.

Keep heifers separated from the older cows, and supplement them to meet their nutrient needs after calving. Heifers nursing their first calves often have low conception rates or are slow to rebreed. Inadequate nutrition is often at fault. Rations should contain ample energy. Many producers turn heifers on to spring grass after they calve. Most immature grasses are of high quality. However, cattle must consume large quantities of grass, due to its high moisture content, to meet their nutritional needs. Supplementation with high-energy feeds, such as grain or soyhulls, is justified when grass is short or sparse.

Producers should emphasize high fertility, early pregnancy, and ease of calving when managing heifers. These are more important than trying to get calves with heavy weaning weights from first-calf heifers.

Management during Calving

Death of calves at or near calving time represents a major economic loss for beef producers. A newborn calf represents the chance to recover the annual cost of maintaining the beef cow and obtain a profit. Death rates in excess of 5% unfortunately are not uncommon at calving time. You generally can prevent these losses by providing keen management to the beef herd during the calving season. It is important to have a short calving period so you can provide frequent observation and assistance if needed.

Here are some specific things you can do:

- Separate first-calf heifers from mature cows. Calving difficulty can run as high as 30 to 40% for two-year-old heifers, whereas 3% might be normal for mature cows. It is especially important to closely observe first-calf heifers. Place them in a small, accessible pasture near a corral where assistance can be given if needed.
- Provide a clean area for calving. The calving area should be a well-sodded pasture or clean, dry maternity pen instead of a wet, muddy lot. Calving pastures should be large enough to permit adequate exercise and offer protection against prevailing winds.
- Be familiar with the signs of calving. The earliest sign that may be noticed is enlargement of the udder; however, this can occur several weeks before calving. Several days before calving, the ligaments around the tailhead and in the pelvic area relax. The vulva becomes swollen and may begin to sag with strings of mucus appearing. Within a few hours of calving, most cows become nervous and uneasy. Cows generally wander away from the rest of the herd as contractions increase.
- Check cows frequently. Close observation is needed so that assistance can be given to cows with calving difficulty. Observing cows three or four times daily and providing assistance as needed results in more live calves. However, cows should be disturbed as little as possible during labor.
- Know when cows need assistance. Intervention is justified when two or three hours have passed without progress or if delivery has not occurred within 90 minutes after the water sac appears. In a normal delivery, the calf's forelegs and head, surrounded by membranes, are forced through the birth canal and appear from the vulva. Train yourself to recognize an abnormal delivery, and know when professional help is needed. Using a disposable glove, determine the position of the calf by feeling the parts of the calf.
- If a cow/heifer needs assistance, wash around the vulva with soap and water, and dry with paper towels.

When the calf is in a normal position, the bottoms of the feet are face downward and the head can be felt between the front legs. Some abnormalities—such as one or both forelegs back or head turned back—can be corrected by pushing the calf back and putting the extremities into the correct position. Figure 5-29 illustrates some normal and abnormal presentations of the calf at parturition.

The cow needs help when these conditions occur:

- Presentation is backward (dew claws are facing upward).
- Only the calf's head or tail is visible.
- The front feet protrude past the knees, but the calf's nose cannot be located.
- The head and one foot are visible.
- More than two feet are visible.

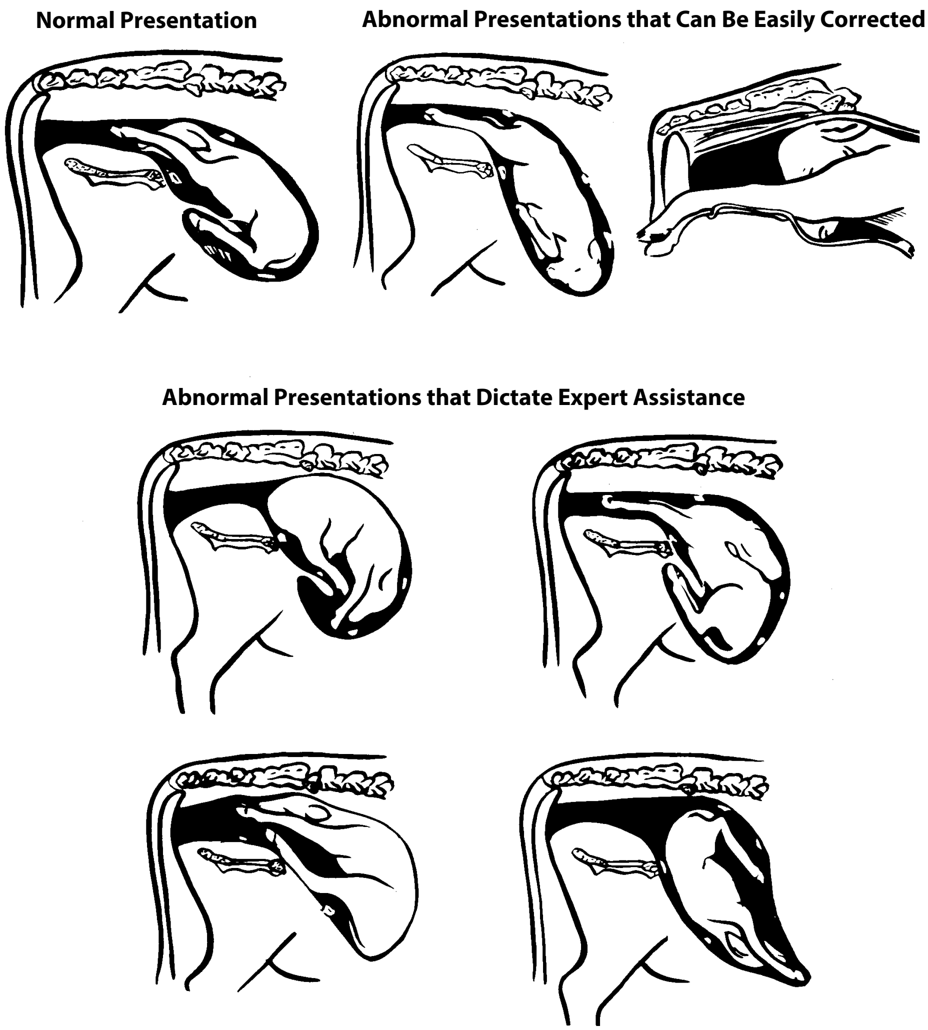
What to Watch

- Be sure the calf is breathing normally. After the calf is delivered, some stimulation may be required to start its breathing. You can rub it briskly, slap it on the ribs, or tickle its nostrils with a piece of straw. Remove mucus from the mouth and throat. Lifting the calf up by the hind legs helps drain fluids from the respiratory system.
- Be sure the calf consumes colostrum. Every calf should ideally consume colostrum (first milk) within 15 to 30 minutes after birth. A newborn calf depends on colostrum as a source of antibodies to protect it from diseases. The sooner a calf receives colostrum, the better its protection will be. Saving and freezing colostrum or using a commercial colostrum supplement helps save calves that do not nurse within one to two hours after birth. Give colostrum through an esophageal feeder to calves that were assisted during calving. Use a lubricant (petroleum jelly, etc.) on the ball of an esophageal feeder.
- Increase feed after calving. Increase the cow's energy intake to about 16 pounds of total digestible nutrients (TDN) per day as soon as the calf appears to be taking all of the milk (10 to 14 days after calving). The extra energy helps the cow produce enough milk for her calf and rebreed on schedule.

For more detailed information regarding calving cows, please refer to Chapter 7: Health and Management Techniques.

Proper Management of Young Cows

The single greatest source of reproductive inefficiency is the rebreeding of young cows (those two to three years old). The reduced fertility of young cows is the result of a greatly extended postpartum interval. The postpartum interval (i.e., the time period from calving to the initiation



Source: *Hardin, R. 1986. Factors Affecting Calving Difficulty. Athens, GA: University of Georgia Cooperative Extension Service. Bulletin 943.*

Figure 5-29. Normal and some abnormal presentations of the calf at parturition.

of estrous cycles) is primarily regulated by the following four factors:

- Suckling and the maternal bond
- Time
- Nutrition
- Calving difficulty

Suckling and the Maternal Bond

The single greatest factor controlling anestrous in beef cows is suckling of the calf and the presence of the maternal bond. The influence of suckling is illustrated in Table 5-23. If a calf is weaned at birth, the female initiates estrous cycles 14 days later. The postpartum interval increases as the number of times a calf is nursed daily. A considerable amount of research has demonstrated that estrus can be induced in most (about 80%) anestrous females by removing the calves from the cows for 48 hours. This short-term removal was not found to influence either the incidence of illness or the weaning weight of the calves. Producers could utilize short-term weaning by removing the calves from all young cows, thin cows, and late-calving cows the first two days of the breeding season. Calves should have access to hay and water. Short-term weaning can also be used in estrus synchronization and AI protocols. If using CO-Synch, remove the calves from the cows the day the PG is given and return after breeding. Research from Colorado State University has demonstrated that combining short-term calf removal with CO-Synch will improve pregnancy rates 12% compared to CO-Synch alone.

Time

Because of the nutrient requirements for growth, young cows simply need more time after calving to attain adequate available energy to initiate estrous cycles. Research has clearly demonstrated that most cows do not stop growing until they are four years of age. Interestingly, this is when cows enter their most productive years. The postpartum interval is 20 to 30 days longer for young cows. One method to overcome this problem is to breed yearling heifers to calve 20 to 30 days before the mature cowherd.

Breeding heifers to calve early has two distinct advantages. First, calving heifers earlier greatly increases the proportion of young cows that are cyclic on the first day of the breeding season and increases the pregnancy rate of these cows. Second, calving heifers before the cowherd enables closer examination of heifers at calving and could decrease calf death loss due to calving problems. On the other hand, calving heifers early also has two disadvantages. First, early calving lengthens the overall calving season. Second, choosing an appropriate time for early calving can be difficult. For example, if a producer calves the mature cowherd in February and March, does this producer want to calve the heifers in January? Perhaps the best solution is to calve heifers two weeks before the mature cowherd. Calving two weeks early will increase cyclicity and pregnancy rates without extending the calving season significantly.

Nutrition

The influence of nutrition and body condition score (BCS) on reproductive efficiency is discussed in Chapter 8: Feeding the Beef Herd. Generally, maintaining cows at a BCS of 5 from calving to rebreeding is recommended. However, some recent data from Oklahoma State University (Table 5-24) suggest that perhaps more condition is necessary to maximize reproduction when calving two-year-old cows. In this experiment,

Table 5-23. Influence of suckling intensity.

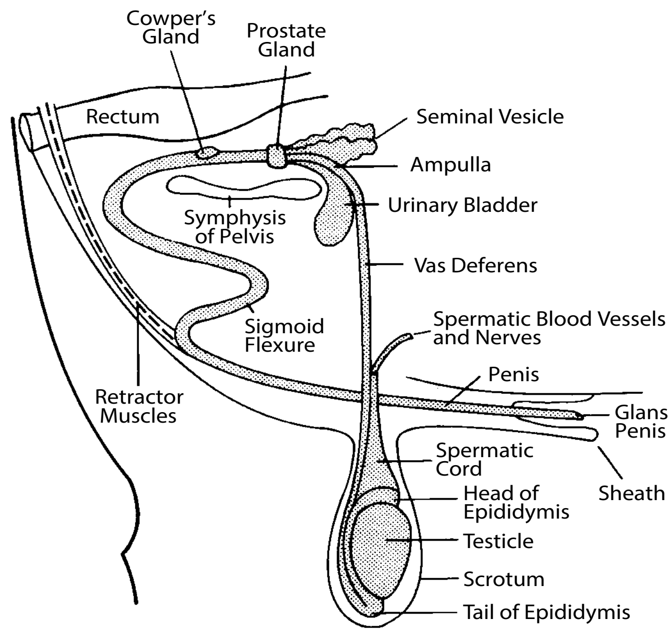
	Continuous Nursing	Milked 4x/day	Nursed 1x/day	Weaned at Birth
Interval to first heat (days)	62	44	35	14

pregnancy rate was examined in 450 two-year-old cows that calved with a BCS from 4 to 7 (Table 5-25). Data from this experiment clearly demonstrate that reproductive efficiency is higher in two-year-old cows that calved with a BCS of 6 compared to a BCS of either 4 or 5. No difference in either calf birth weight or calving difficulties was reported. Increasing the BCS of two-year-olds seems warranted.

Type of supplement fed may also influence reproductive efficiency. An experiment from the USDA Research Center in Miles City, Montana, examined the effects of feeding high-fat supplements on rebreeding performance in two-year-old cows. In this experiment, 149 two-year-old cows were supplemented with either a corn-soybean meal (CSM) mixture or with a whole oilseed. Supplementation occurred over the last 60 days of pregnancy. The three oilseeds tested were soybeans, safflower seeds, and sunflower seeds. Each supplement contained equal levels of energy and protein. No difference was observed between treatments in dam BCS, dam weight, calving ease, birth weight, or the proportion of cows that were cyclic on the first day of the breeding season. However, more cows became pregnant and calf weaning weight was higher in cows fed whole oilseeds compared to those fed CSM. Similar results have been observed in experiments at the University of Kentucky and at the University of Missouri. Combining the results, feeding young cows 3.5 to 5 pounds each of whole soybeans either during late pregnancy or from calving to the middle of breeding season has the potential to increase pregnancy rate and reproductive performance.

Calving Difficulty

Calving difficulty extends the period of anestrous. Females that experience calving difficulty are 16% less likely to conceive than those that do not. Cows that have a prolonged labor (i.e., more than four hours), even though they calve unassisted, have longer periods of anestrus. Cows that receive assistance early return to estrus more quickly and have a high pregnancy rate. The best method of reducing calving difficulties is by using proven, calving-ease sires and by using pelvic area measurements as a culling tool, which was discussed earlier.



Source: *Turman and Rich. 1977. Reproductive Tract Anatomy and Physiology of the Bull. Great Plains Beef Cattle Handbook GPE-8450. Cooperative Extension Service, Great Plains States.*

Figure 5-30. Diagram of the reproductive system of the bull.

Table 5-24. Effect of calving difficulty on reproductive performance of 2-yr.-old heifers calving first calves.

	Postpartum Anestrus (days)	Cyclic at Beginning of Breeding	Services per Conception	Preg. Rate
Short labor	61	87	1.16	88
Long labor	64	70	1.30	69

Table 5-25. BCS and reproductive performance of young cows.

BCS	Preg. n	Rate %	Days to n	Preg. Days
4	73	65	47	92
5	157	71	100	82
6	120	87	96	74
7	73	91	61	76

Reproduction in the Bull

Figure 5-30 shows the reproductive tract of the bull. The bull's organs of reproduction include two testicles, which are held in the scrotum. Male sex cells (called sperm) are formed in the testicles. Upon ejaculation, sperm are transported from the testicle through a tube called the vas deferens. The vas deferens empties into the urethra, which serves to excrete both semen and urine. The penis serves as a passageway for semen and urine, and it is the organ of copulation. Semen, the fluid ejaculated from the male, contains sperm cells in fluid from the accessory sex glands (seminal vesicles and prostate). The sperm cells carry genetic information from the male and fertilize the female egg.

Breeding Soundness and Bull Fertility

Fertility of the herd bull is essential to a successful cow-calf operation. In many respects, it is more of a concern than that of the cow since the bull contributes half of the genetic potential of the entire calf crop in comparison to a cow that is expected to wean only one calf per year. Subfertile bulls create low calf crop percentages and can be responsible for poor herd weaning weights. This is evidenced by the fact that for every heat cycle a female fails to conceive, there is a corresponding decrease in calf weaning weight from 25 to 45 pounds. It does not take long to realize that poor fertility or infertility of a bull can be extremely expensive to the cow-calf producer.

Two factors influence bull breeding performance: libido (sexual drive) and fertility (high quality and volume of semen). Currently, no test exists for determining libido in bulls. Examination of the bull during the breeding season is the only option. Libido is highly heritable and highly correlated with serving capacity. Therefore, bulls with high libido can service more cows. Our only tool to assess bull fertility is the breeding soundness exam (BSE).

Beef bulls should be evaluated for breeding soundness 30 to 60 days before the breeding season is scheduled to begin. A breeding soundness exam helps eliminate losses due to infertility and provides time to replace questionable or unsatisfactory bulls. A breeding soundness evaluation should include:

- A physical examination
- An examination of the reproductive tract
- A semen evaluation.

Physical examination. A thorough physical examination should be conducted to ensure that bulls are capable of locating cows in heat and physically capable of mating. The physical should include an appraisal of body condition. Thin bulls lack stamina necessary to breed and settle cows during a short or restricted breeding season, whereas overly fat bulls lack vigor and fail to realize their breeding potential. Feet and legs should be carefully inspected to identify faults that can impair the bull's ability to travel and mount. Structural problems, including sickle hocks, post legs, and sore feet, can impair breeding performance. Eyes should be clear and free of disease or injury. Bulls should also be evaluated for disease or sickness that might impair breeding performance.

Examination of the reproductive tract. A complete examination of the reproductive tract for disease and abnormalities should be made. This includes rectal palpation of the bull's internal reproductive organs. The external examination includes palpation of the spermatic cord, testes, scrotum, and epididymis. The penis and sheath should also be examined. Hair rings, warts, and other structural damage to the penis will reduce the ability of a bull to breed cows. Scrotal circumference may be obtained at this time. Recommended scrotal circumferences are shown in Table 5-26. Young bulls with an above-average scrotal circumference should produce more sperm cells. University research shows that 63 million more sperm cells are produced for each additional centimeter of scrotal circumference. Scrotal circumference is highly correlated with semen output and semen quality (Figure 5-31). Therefore, bulls with a large scrotal circumference can serve more females than bulls with a smaller scrotal circumference.

Scrotal circumference can be measured by slipping a flexible centimeter tape over the bottom of the scrotum. The tape should be pulled snugly over the widest point of the scrotum with the testicles fully descended. Commercial measuring devices are available. However, a sewing tape can be used in an emergency. Measurements are generally given in centimeters (1 inch = 2.54 centimeters).

Semen evaluation. After collection, the semen is evaluated under a microscope to determine motility (the percentage of sperm that are moving) and whether morphological aberrations are present. Motility is very important for sperm transport and fertilization of the egg. Sperm that is classified as 70% or better for motility is very acceptable. Two types of morphological abnormalities exist in sperm. The first type is malformed sperm heads, while the second type is malformations of the sperm tail. Tail abnormalities are usually the result of poor maturation of the sperm. Often these abnormalities disappear with age and additional collections of the bull. Bulls classified as "Deferred" usually have sperm tail abnormalities, and often these bulls will pass a subsequent BSE.

Table 5-26. Scrotal circumference by age.[1]

Age	Very Good	Good	Fair
12-14 mo.	> 34 cm	30-34	< 30
15-20 mo.	> 36 cm	31-36	< 31
21-30 mo.	> 38 cm	32-38	< 32
over 31 mo.	> 39 cm	34-39	< 34

[1] > = greater than; < = less than.
Source: Spitzer, et al. Breeding Soundness Evaluation on Beef Bulls. Southern Region Beef Management Handbook. ASC-121. Lexington, KY: University of Kentucky Cooperative Extension Service.

Factors That Affect Bull Fertility

Several factors affect bull fertility. Injury can greatly reduce the breeding performance of a bull. Injuries to be aware of are penis abnormalities, which include a broken penis, hair rings around the penis, and structural damage to either the penis or the sheath that prevents extension of the penis. Additionally, the retractor penis muscle may be injured, which would prevent penis extension and contraction.

Genital warts are another common problem. Penile warts are painful and prevent the bull from properly servic-

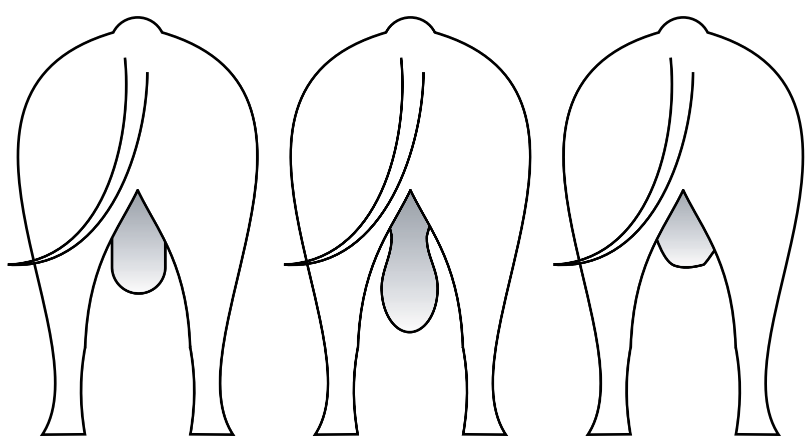


Figure 5-31. Three scrotal shapes seen in beef bulls are the straight-sided scrotum (A), the normal scrotum (B), and the wedge-shaped scrotum (C). Scrotal shapes A and C are the least desirable. Adapted from Cates (1975).

ing the female. Each BSE should include extension of the penis to ensure proper function. Injuries to either the scrotum or the neck of the scrotum can also reduce fertility by preventing the bull from maintaining the proper temperature of the testis.

Health can dramatically influence bull fertility. Any illness that elevates body temperature for 2 degrees for 48 continuous hours renders a bull totally infertile for about 60 days. If the illness is treated early, fertility in the bull is reduced for about 14 days. To limit the impact of illness on fertility, producers need to treat illness in bulls quickly and aggressively.

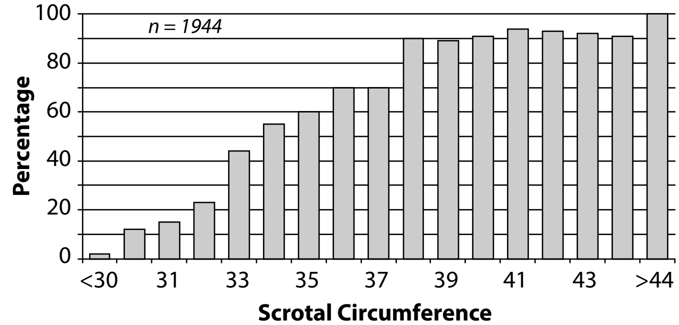


Figure 5-32. Scrotal circumference and seminal output.

Nutrition

Nutritional management of bulls from weaning to maturity can dramatically affect bull fertility. Research has demonstrated that bulls fed moderate-energy diets (forage-based) from weaning to yearling had a 52% higher semen output at the same scrotal circumference than bulls fed high-energy diets (starch-based). If fed these diets from weaning to two years of age, the bulls fed the moderate-energy diets had a 300% increase in semen output. The reduced fertility of the bulls fed the high-energy diets was suggested to arise from a higher fat deposition in the scrotum and spermatic cord. The function of the scrotum and spermatic cord is to reduce the temperature of the testis. Sperm production occurs best when the temperature of the testis is about 2 degrees below body temperature. Insulation of the scrotum and spermatic cord via fat deposition could reduce the bull's ability to regulate the temperature of the testis and, therefore, reduce fertility. Researchers observed that bulls fed high-energy diets had surface scrotal temperatures 2.3 degrees higher than bulls fed moderate-energy diets. Additionally, back-fat thickness was negatively associated with pregnancy rates in range bulls. To maintain high fertility, bulls should not be fed such that BCS exceeds 6.

Scrotal shape can be used as an indicator of fertility. Scrotal shape is known to influence testicular development and function. As scrotal shape is a conformational trait, it would be expected to have a high heritability. Three basic shapes have been recognized in the beef bull: normal, straight-sided, and wedge-shaped (Figure 5-31). The normal shape of the scrotum is bottle-shaped. Bulls having a normal scrotal shape with a distinct neck (Figure 5-31, Bull B) generally have the best testicular development and function. This scrotal shape allows for optimal regulation of testicular temperature. Often bulls with a straight-sided scrotal shape (Figure 5-31, Bull A) have only a moderate testicular size. The straight-sided appearance of the scrotum is generally the result of fat deposition and will likely reduce sperm production by ineffective thermoregulation of the testis. Wedge-shaped scrotums (Figure 5-31, Bull C) are pointed toward the apex of the scrotum and tend to hold the testis close to the body. Bulls with this scrotal shape generally have small testes and rarely produce semen of satisfactory quality. For optimal fertility, select bulls with a normal, bottle-shaped scrotum that is well defined and free of fat.

Development of Young Bulls

Try to develop young bulls so that they have a good rate of growth, and try to ensure early development of their reproductive capacity without excessive condition. Most bulls are sold at about one year of age and still have a lot of growth and development ahead of them. This is particularly true of today's bulls, which are frequently selected for extra growth.

Most bull sales are held in March and April to allow some time before the start of the breeding season for spring calving. Most of the bulls have been on a fairly high-concentrate diet for more than 100 days as a result of being on a performance-testing program or just because bull buyers prefer bulls in fleshy condition. Whether the yearling bull is fed on the farm or at a test station, most are fed to gain 2.5 to 4.0 pounds per day. After coming off test, they should continue to gain about 2 pounds per day.

Very fleshy young bulls require some conditioning prior to the breeding season. They will have to maintain a high level of physical activity when they are breeding several cows. You can give them plenty of exercise by locating feed and water away from each other in a small pasture. Bulls should be "let down" gradually by decreasing the amount of grain and increasing the amount of roughage in the diet. To keep gain at about 2 pounds per day, feed about 8 to 12 pounds of grain per day in addition to spring pasture, or provide free-choice high-quality roughage with 1 to 1.5 pounds of grain supplementation per 100 pounds of body weight daily.

At the start of the breeding season, bulls should be in good physical condition, fertile, and able to cover considerable distance to keep up with the cows. Over-conditioned bulls lose weight rapidly and may not be as fertile as well-conditioned bulls.

Yearling bulls should *not* be purchased unless they have passed a BSE. If yearling bulls are purchased without a BSE, they should be given one before the start of the breeding season. All bulls should be subjected to a BSE before *each* breeding season. They should be observed closely during the breeding season to see if they are detecting heat and getting the cows bred. If they become too thin, it may be necessary to rest and/or hand feed them.

It is not uncommon for yearling bulls to lose as much as 100 to 300 pounds during their first breeding season. They should gain this weight back and continue to grow so that they weigh about 75% of their mature weight by the time they are two years old. This requires more than summer grass pasture; however, too much grain too fast can cause founder.

Serving Capacity

Serving capacity of bulls is highly variable and is influenced predominantly by scrotal circumference and libido (Figure 5-32). Serving capacity increases with age because older, more experienced bulls are more efficient. Research has demonstrated that older bulls spend less time with each estrual female and can service more estrual females in a day. Serving capacity is also influenced by social effects. In multiple-sire mating systems, the dominant bull sires a majority of the calves. If the dominant bull is less fertile, breeding performance can be greatly reduced. Multiple-sire systems are most efficient when bulls of similar age, weight, and breed are used. Also, rearing bulls together helps reduce potential problems associated with social dominance.

Traditionally, bull-to-cow ratios of 1:25-30 have been recommended for mature bulls and 1:10-20 for yearling bulls. Some current research indicates that bull-to-cow ratio can be increased if bulls have a large scrotal circumference (> 35 cm at a year of age) and experience. Bull-to-cow ratios of 1:44 and even 1:60 have not reduced pregnancy rates in a 70-day breeding season. However, the bulls used were experienced, *highly fertile,* bulls with *a large scrotal circumference.* Likewise, bull-to-cow ratios had no effect on pregnancy rate when estrus synchronization is used prior to natural service. Bull-to-cow ratios ranged from 1:20 up to 1:42 with no effect. In these trials, *experienced* bulls with *a large scrotal circumference* were used. The traditional bull-to-cow ratios have less risk and should be followed when fertility, libido, and yearling scrotal circumference are unknown.

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