Reproduction and Genetics

BEEF

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Breeding and Reproduction

It is important that you understand some basic facts about the reproductive system and what you need to do to manage the cow and calf. Here are some important points to remember when planning for a heifer to calve by the time she is two years old:

1) A heifer will come into heat (estrus) sometime after eight months of age, depending on her breed and weight. Heat (estrus) is the time when the reproductive system begins functioning.
2) The estrous cycle repeats every 18 to 21 days until she is bred if nutritional requirements are met and diseases are not present.
3) The heifer's size is more important than her age when deciding on a breeding time. A heifer should weigh 2/3 of her mature body weight at the onset of the breeding season.
4) Start and end the breeding season the same dates every year.
5) Depending on the breed, a cow will calve approximately 283 days after conception, the time when the sperm fertilizes the egg. This 283-day period is called "gestation". Cattle that are hard to breed or are "nonbreeders" should be sold from the herd.
6) A bull that is known to sire smaller calves when born should be used on heifers.
7) Heifers should calve when feed and management resources are at the highest levels. This commonly occurs in the spring but can happen at any time. If you have purebred cattle and will be involved in breed shows, planning your calving for a time that would fit show and sale schedules may be an important consideration.
8) You may breed your heifer by natural service with a bull or by artificial insemination (A.I.). Whatever your choice, evaluate the performance records of the bull being considered.
9) Mature cows that are in good body

condition and have had no problems calving need about 45 days to return to heat after they calve.

10) Two-year-old females may need from 60 to 75 days to return to heat after they calve. This means that younger two-year-old females need more time to come back into heat to be bred again. Therefore, these heifers should be bred earlier than the cow herd. This is done by turning out the bull or artificially inseminating the yearling heifers three weeks before the rest of the cow herd. For example, we want the herd to calve in March and April. This means the breeding season for the cows would begin May 20 and end July 20, so the heifers' breeding season would begin May 1.

The Male Reproductive System

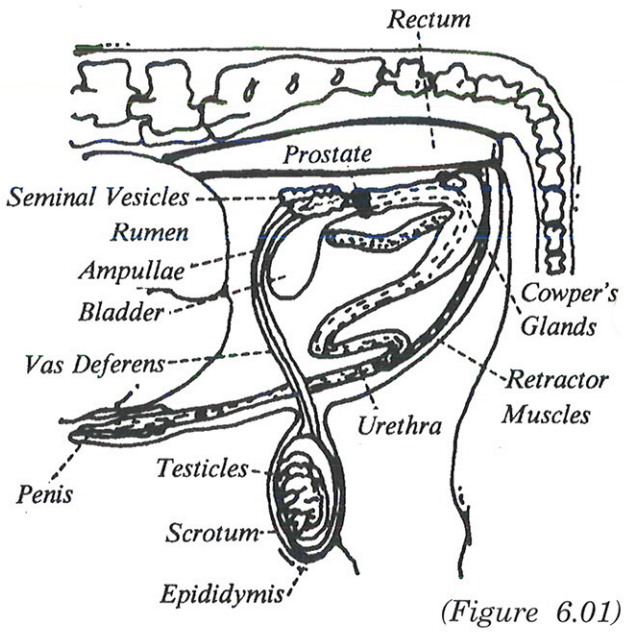
The major male reproductive organs include the testicles, epididymis, scrotum, vas deferens, penis, urethra, and accessory glands. (Figure 6.01)

The bull has two testicles contained inside the scrotum, the pouch that hangs from the body. The testicles produce sperm, the male sex cells, and the epididymis serves as a storage place for the sperm while they mature. The scrotum regulates the temperature of the sperm in the testicles. During hot weather, the scrotum hangs away from the body and during cold weather the scrotum contracts closer to the body.

The vas deferens is a tube that connects the epididymis to the urethra. It serves as a passageway for the sperm. The urethra is the tube that carries both sperm and urine to the penis. The accessory glands include the prostate, seminal vesicles, and Cowper's glands. They produce fluids that nourish and preserve sperm.

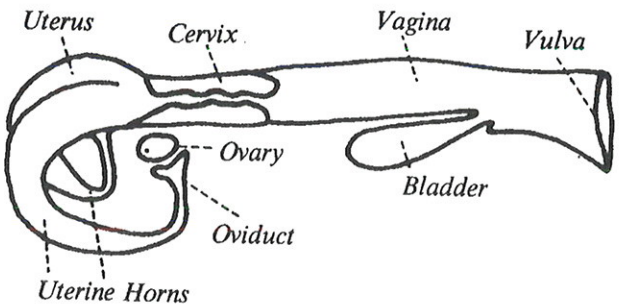
After passing through the urethra, sperm are sent to the penis, the organ used for depositing sperm into the female reproductive tract during mating. During mating, the accessory glands discharge fluids through the urethra that serve as a carrier for the sperm through the penis.

Male Reproductive System



(Figure 6.01)

Female Reproductive System



(Figure 6.02)

The Female Reproductive System

The major female reproductive organs include the ovaries, uterus, cervix, and vagina. (Figure 6.02)

Cows have two ovaries. The ovaries produce the female sex cell called the egg. After fertilization, the egg passes through the oviduct (a small tube) to the uterus (womb). The uterus (womb) is the place where the calf develops. The cervix and vagina are called the birth canal because the calf passes through them during birth.

A cow having a normal estrous cycle shows heat (estrus) every 18 to 21 days. Several days before a cow begins heat, an egg ripens in one of her ovaries. This ripening is controlled by several hormones that also cause the signs of heat and prepare the uterus to receive the egg if it is fertilized.

A cow shows heat for about 14 to 20 hours. About 10 to 16 hours after the last signs of heat, the egg leaves the ovary and enters the oviduct. If sperm are present to fertilize the egg, fertilization can occur. After fertilization, the egg leaves the oviduct and goes to the uterus where it attaches to the uterine lining and remains for the rest of the pregnancy (about 283 days from the date of fertilization). If a cow does not become pregnant, she will return to heat in approximately 18 to 21 days.

Most mature cows in average body condition that have not experienced calving difficulty require approximately 45 days to begin cycling and return to estrus (heat) after calving. Postpartum Interval (PPI) is the period of time from calving to first heat. In contrast to mature cows, young two-year-old cows may require from 60 to 75 days to return to estrus after calving. In other words, they have a 65-day PPI. This is the basis for recommendation to breed yearling heifers a heat cycle (21 days) before mature cows. Earlier breeding gives them more time to recycle and prepare to breed for their second calf during the same breeding season as the mature cows.

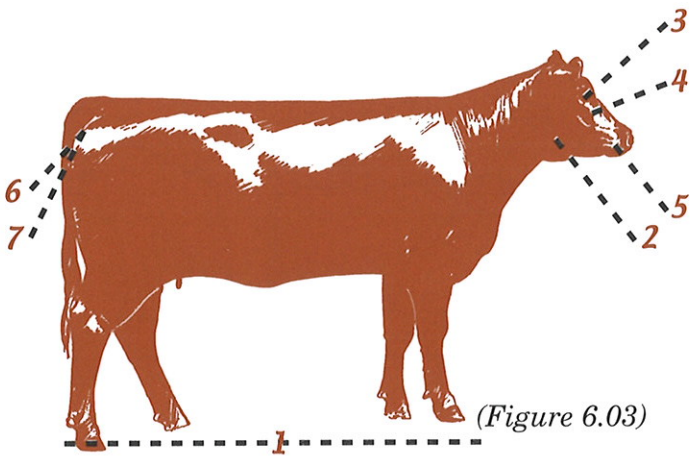
Heat and Fertilization

Heat, also called estrus, is the time when the bull can breed a female. Heat lasts from 14 to 20 hours. If she is not bred, heat will return every three weeks.

If you use artificial insemination, females should be bred 12 hours after standing heat. Breed by the AM/PM rule. If she shows signs of heat at night, breed in the morning; if she shows signs of heat in the morning, breed at night.

Is She in Heat?

The illustration in Figure 6.03 shows where to look for seven signs of heat.



(Figure 6.03)

Signs of Estrus

1. Standing for other cows to ride her. This is the primary sign of estrus.
2. May try to ride other cows.
3. Loss of appetite.
4. Head is up in air. Lots of sniffing and smelling.
5. A great deal of bawling, nervous and excited behavior (walking fences).
6. Increase in mucous discharge from vulva.
7. Vulva is red and swollen.

When to Breed

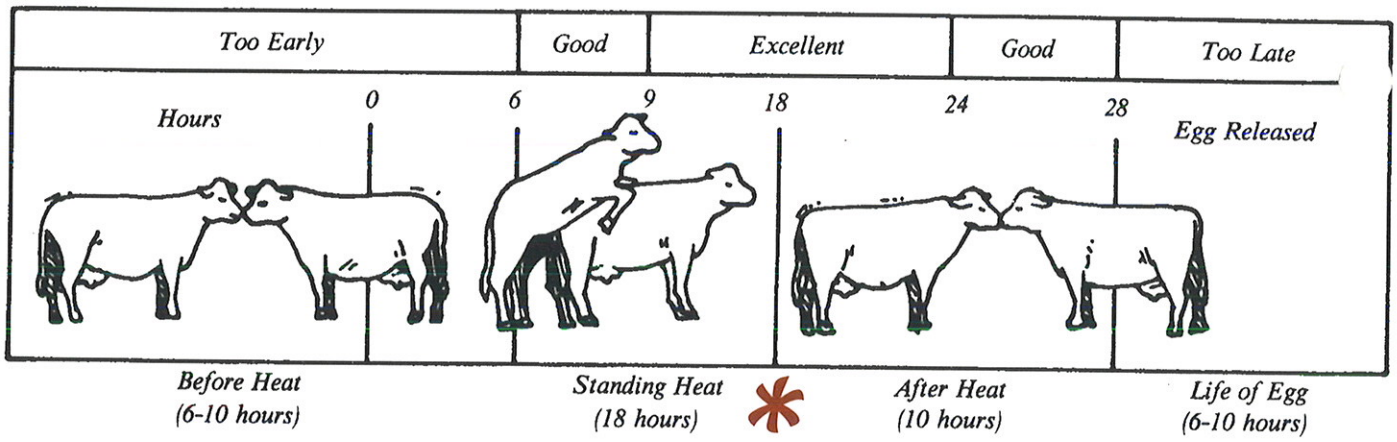
At breeding, a sperm cell from the bull joins the ovary cell (egg) from the female, and a calf begins to develop. The time when these two cells join together is called fertilization. The illustration in Figure 6.04 offers a timetable of the best times to breed cattle.

Detecting Heat

Detecting heat in the cow herd can be done by any of the following:

1) **Observation**
2) **Gomer bulls** – Gomer bulls are bulls that have been altered so they cannot breed but can detect cows in heat. A marker, such as a chin ball marker, is placed on a gomer bull. When the bull rides the cow, she is marked.
3) **Detector pads** – Detector pads are plastic pads that contain a colored dye. They are glued to the cow's rump and when she is mounted by another animal, the dye is released in the pad and the patch changes color.
4) **Androgenized cows** – Androgenized cows are cows destined for slaughter that can have their behavior altered by an injection of male hormones. The hormones cause them to detect heat more aggressively, like a bull. Androgenized cows can also be equipped with chin ball markers.

When to Breed



(Figure 6.04)

Bringing Females into Heat

Estrous synchronization (heat synchronization) is a technique to bring females into heat. It works well with artificial insemination because it uses an injection of prostaglandin, a hormone naturally produced in the female reproductive tract. Prostaglandin is available commercially under the trade names of Lutalyse, Estrumate, Bovilene, and others. Prostaglandin has no affect on non-cycling females and no affect in the first five days of a cycling female. Injecting this compound into a cycling female in the last 75% of her cycle will bring her into heat three to five days later.

These methods allow the beef producer to bring several cows into heat and facilitate breeding in a short period of time. Not

only does this technique help bring several cows into heat at one time and reduce the labor required to breed cattle, it can also shorten the length of the calving season.

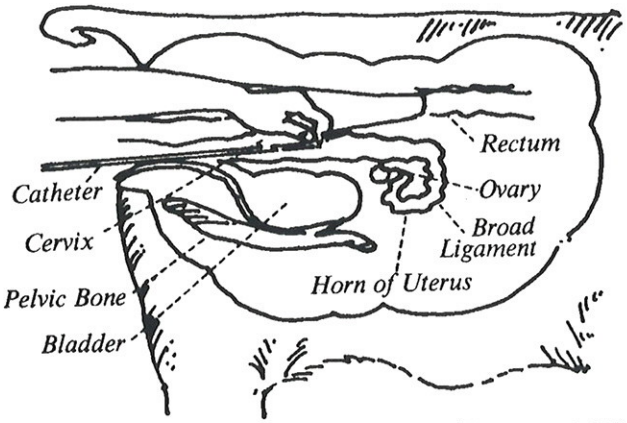
Orally active synthetic progesterone, such as Melengesterol Acetate (MGA), is a feed additive used to keep feedlot heifers out of heat. It can also be used as a synchronizing agent, especially with yearling heifers. MGA will keep cycling heifers out of heat until the desired time. MGA has also been shown to bring about heat in some non-cycling heifers. For more information on the methods of synchronizing estrus, contact your county Extension office. Note: Synchronization is not a substitute for adequate nutrition and management. In fact, if cattle are not fed properly so that they are cycling normally, using synchronizing agents is a wasted effort.

Mating Systems

There are three systems for breeding cows: 1) pasture breeding, 2) handmating, and 3) artificial insemination.

1) **Pasture breeding** – The bull runs with cows for the entire breeding season. A bull that is two years old or older can service (breed) 35 cows. Yearling bulls will adequately service 15 to 20 females.
2) **Handmating** – Used to mate specific females to specific bulls. Purebred breeders sometimes use handmating. In handmating, females are brought into a pen where they are serviced by a bull. Handmating is not practiced on a large scale.
3) **Artificial Insemination (A.I.)** – A great advancement in the beef industry because it genetically improves livestock, A.I. is a process of collecting semen from a superior bull and placing it into the reproductive tract of the female at the proper time. A small amount of semen is frozen in a plastic straw, then thawed and placed into the reproductive tract of a cow at the end of her standing heat. The breeding females must be inseminated at the proper time of their cycle. The general procedure for A.I. breeding is to follow the AM/PM rule. If the cow shows signs of standing heat at night, breed her in the morning. If she shows signs of heat in the morning, breed her at night. (Figure 6.05)

Artificial Insemination



(Figure 6.05)

A.I. is used because it:

- Increases the use of outstanding sires. (The top bulls from each breed are available to every beef producer. The use of sire summary EPDs helps to eliminate the guesswork in sire selection.)
- Increases uniformity of calves, replacement heifers, and the cow herd.
- Helps control reproductive and genetic defects and reproductive diseases. (A.I. helps prevent reproductive disease problems because the bulls are not in physical contact with the cows. Careful selection and testing reduces the risk of undesirable recessive genes, such as dwarfism.)

- Improves marketing. (The use of genetically superior sires in the herd helps to market the resulting calves.)
- Offers the capability to use sires that are no longer alive. (Frozen semen can be stored for several years. Therefore, an exceptionally outstanding sire can still be used even if he is no longer living. Although younger bulls coming onto the scene should be genetically superior, occasionally there have been outstanding bulls that have remained competitive among the other proven sires, even after death.)

Many A.I. companies offer breeders semen for purchase at a reasonable cost. Also, schools are available that teach the A.I. procedure.

Pregnancy Testing

Only 70 – 75 percent of all beef females that are used in the breeding season wean a calf each year in the United States. The major cause of this 25 – 30 percent loss is open cows, cows that do not get bred.

A female that does not breed is an economic loss to the producer. Early pregnancy testing should be a routine part of the management of a cow herd to avoid this loss. Once open cows are identified, they should be culled. Pregnancy checks by palpation (entering the cow by placing a hand and arm in the rectum and feeling the reproductive tract) can be done between 45 – 60 days after the end of the breeding season. A practical time to do a check is at the same time vaccinations are given and calves are weaned. Palpation checks can be done by a veterinarian or by anyone who has had careful training and practice. Pregnancy determination can also be done using ultrasound technology.

Gestation

The first few months after a cow is bred, she can be fed low-cost roughage (such as corn stalks and low-quality hay) and pasture. Give her plenty of fresh water and supplement her feed with minerals and vitamins. Do not overfeed the heifer during gestation. An overweight heifer may have difficulty calving.

About 100 days before calving, increase the amount of feed given. This is the time when the calf grows the most and the heifer has increased nutrient requirements. Heifers need the highest quality and largest amount of feed after calving because they need to produce milk for the calf and prepare their own body to breed again two months later.

Remember, after a heifer or cow calves, she needs approximately 30% more energy, 50% more protein, 50% more calcium and 33% more phosphorus in her diet. In addition, her Vitamin A requirement increases about 50%.

As the heifer gets close to calving, watch her closely. Follow the two rules below:

1) Move the heifer to a clean, dry area before calving begins. (It should be close to your house.)
2) Check the heifer at least four times each day.

Table 6.01 shows a sample Gestation Chart.

Cow Gestation Calendar

Breeding Date	Due to Give Birth	Breeding Date	Due to Give Birth
January 1	October 11	July 2	April 11
January 8	October 18	July 9	April 18
January 15	October 25	July 16	April 25
January 22	November 1	July 23	May 2
January 29	November 8	July 30	May 9
February 5	November 15	August 6	May 16
February 12	November 22	August 13	May 23
February 19	November 29	August 20	May 30
February 26	December 6	August 27	June 6
March 5	December 13	September 3	June 13
March 12	December 20	September 10	June 20
March 19	December 27	September 17	June 27
March 26	January 3	September 24	July 4
April 2	January 10	October 1	July 11
April 9	January 17	October 8	July 18
April 16	January 24	October 15	July 25
April 23	January 31	October 22	August 1
April 30	February 7	October 29	August 8
May 7	February 14	November 5	August 15
May 14	February 21	November 12	August 22
May 21	February 28	November 19	August 29
May 28	March 7	November 26	September 5
June 4	March 14	December 3	September 12
June 11	March 21	December 10	September 19
June 18	March 28	December 17	September 26
June 24	April 4	December 24	October 3
		December 31	October 10

Note: First-calf heifers often have shorter gestation periods than mature cows and may calve slightly earlier than the table suggests.

Table 6.01

The Three Stages of Calving

The calving process is divided into three stages: dilation, calving, and discharge of the placenta (afterbirth).

Stage 1 is dilation. During dilation…

- The calf moves into the birth canal area.
- The uterus contracts every 10 – 15 minutes.
- The cervix begins to open.
- The heifer becomes restless and may try to go off by herself.

Stage 2 is calving, during which the calf is delivered…

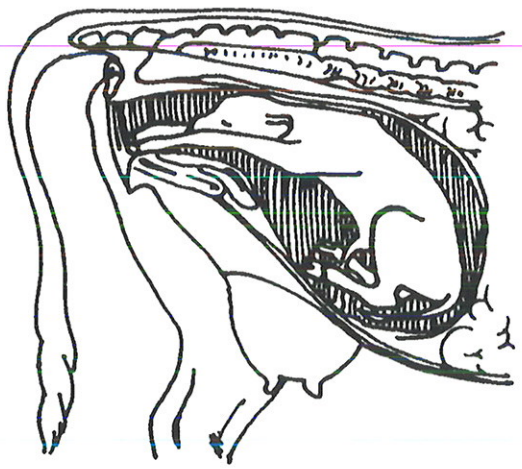
- The water bag will appear and break.
- The front feet should appear first.
- The heifer will have hard contractions.
- The muscles around the tailhead relax.
- The uterus contracts every 2 minutes.
- The calf should be delivered within two hours after the water bag breaks. (If this does not happen, call your veterinarian.)

Stage 3 is the discharge of the afterbirth (placenta)…

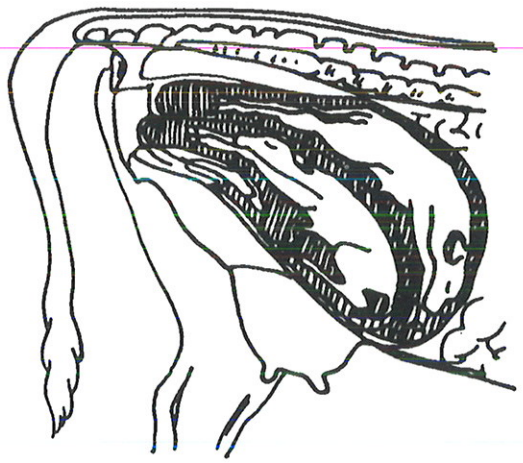
- The placenta is usually released immediately after the calf is born. If it is not expelled after 12 hours, the heifer will need to be treated with antibiotics. Consult your veterinarian.

Figure 6.06 illustrates the normal position of both a calf and a set of twin calves before birth.

Normal Position of a Calf and a Set of Twin Calves Before Birth



Normal Presentation



Normal Twin Presentation

(Figure 6.06)

After Calving

- After the calf is born, help it breathe. To assist breathing, follow these three steps:
  1) Clear the mucous from the mouth and nose.
  2) Rub the calf.
  3) Tickle the inside of the nose with a straw to cause it to sneeze and help it to begin breathing.
  4) If the calf shows signs of excess fluid in the windpipe, hang the calf upside down for 2 – 3 minutes. (Be sure the rear legs are held by a rope passed over a barn beam.)
- The calf should nurse within the first few hours because it must receive the colostrum milk from the mother. Colostrum milk contains important antibodies that the calf needs to fight disease and stay healthy. If the calf is weak and cannot nurse, administer some warm colostrum milk with a stomach tube. Colostrum milk can be frozen and stored in the freezer for this use.
- Dip the navel cord in 7% iodine. This will protect the navel from infection.
- A calf should be ear tagged or tattooed soon after birth. Always record the birth date, birth weight of the calf, the tag number of the mother, and the ear tag or tattoo numbers. You may also vaccinate the calf for scours if this is a problem on your farm. You may also give the calf a vitamin shot.
- This also may be a good time to castrate a bull calf.
- If white muscle disease is a problem in your area, give the calf an injection of selenium. Consult your local veterinarian.

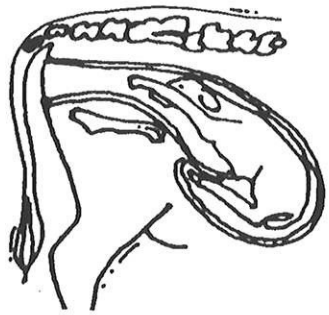
Knowing and Avoiding Calving Difficulties

Unfortunately, dystocia (calving problems) can be a problem, especially in first-calf heifers. Calves that need help during birth are four to five times more likely to die than calves that are born unassisted. First-calf heifers that had dystocia have more trouble getting bred for their second calf.

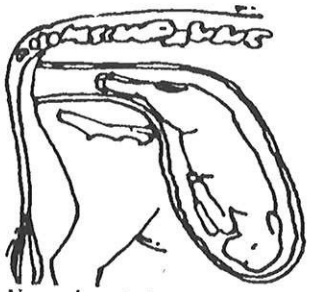
It is obvious that calving difficulties cause some problems in the herd. The goal of every producer should be to do everything possible to prevent calving problems. Figure 6.07 shows difficult calving positions and what to do. Following are some prevention tips:

1) Breed yearling heifers to A.I. sires that have low birth weight EPD's as identified in sire summaries or to natural service bulls that have low birth weight EPD's as identified on performance pedigrees.
2) Feed pregnant females adequately. Do not underfeed or overfeed. Heifers require more nutrients in their diets for growth and development in the last one-third of their pregnancy. Underfeeding heifers may cause calving problems, and it will also take longer for the heifers to breed again after calving. (Refer to the Appendix for nutrient requirements of different reproductive phases of the female.)
3. Breed over a short period (45 to 60 days), and breed heifers to calve 20

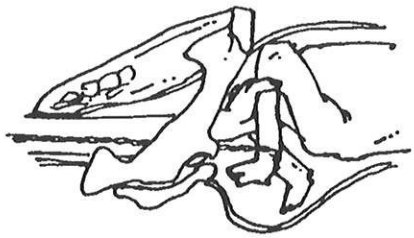
Difficult Calving Positions



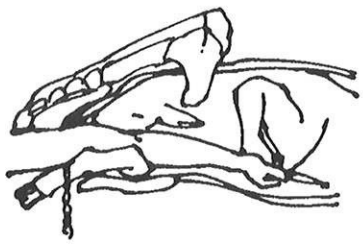
Normal anterior presentation, position and posture.



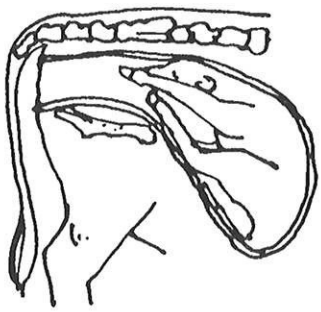
Normal posterior presentation of calf. Assistance necessary if prolonged labor.



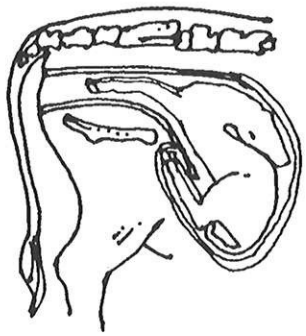
Correction of hind legs in breech presentation. Push calf forward, guide foot over pelvic rim as an assistant pulls OB chain.



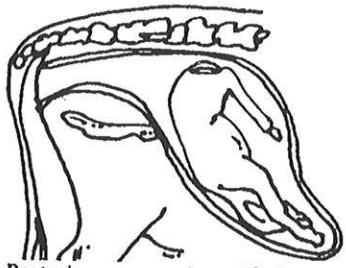
Correction of retained foreleg. Cup hoof with palm of hand to prevent tearing of uterus or vagina.



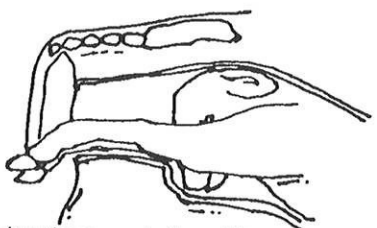
Anterior presentation with rear legs extended. Serious malpresentation. Death of calf results unless early assistance given.



Head and neck turned back over body. Secure legs and push body forward.



Posterior presentation with fetus upside down. Never attempt delivery in this position.



Anterior presentation with vertex posture of the calf. Calves are often dead when in this position.

Correct application of obstetrical chain.

(Figure 6.07)

to 30 days ahead of the cow herd. This program allows the heifers more time to rebreed after calving. Another advantage of breeding heifers before the cow herd is that the producer can spend more time checking and assisting heifers with calving difficulty.

4. Feed heifers separately from mature cows. This allows you to feed a larger amount of high-quality feeds to the heifers.
5. Starting two to four weeks before the first calf is due, feed late in the day. This will encourage more daytime calving. Remember, it is much easier to monitor the herd during daylight hours.
6. Select heifers with adequate growth as replacement heifers. Give preference to older heifer calves as they will be more developed at breeding time.

Genetics: The Basics

Understanding the basics of genetics and the principles of inheritance is important and necessary in order to improve livestock. In the improvement of cattle, the goal is to join together male sperm and female eggs that have a high proportion of desirable genes to produce cattle with traits that are economically important.

Differences between animals are a result of two factors: heredity (genetics) and environment. Both affect the performance of all animals. Identical twin beef cattle are genetically the same. The differences are environmental, such as feed, weather, and management factors.

Each animal begins as a fertilized egg, or zygote. The fertilized egg cell is formed by the union of the egg (from the female) and the sperm (from the male). This cell divides and duplicates until it becomes an adult.

Each fertilized egg has chromosomes and genes. Chromosomes determine a calf's sex. Usually, there is a 50/50 chance of a cow giving birth to a bull or a heifer calf. The sex of the unborn calf is always determined by the bull because sperm can carry either the female X chromosome or the male Y chromosome, whereas the egg only carries the X chromosome. Genes located on the chromosomes are responsible for the characteristics in an individual.

Characteristics are passed from generation to generation, a process known as heredity (genetics). Each animal receives half of its inheritance from the male and half from the female. For example, a beef animal has 30 pairs of chromosomes (a total of 60 individual chromosomes). The sperm gives 30 chromosomes and the egg gives 30 chromosomes. Genes, like chromosomes, are found in pairs and most of the economically important characteristics or traits in cattle are controlled by pairs of genes.

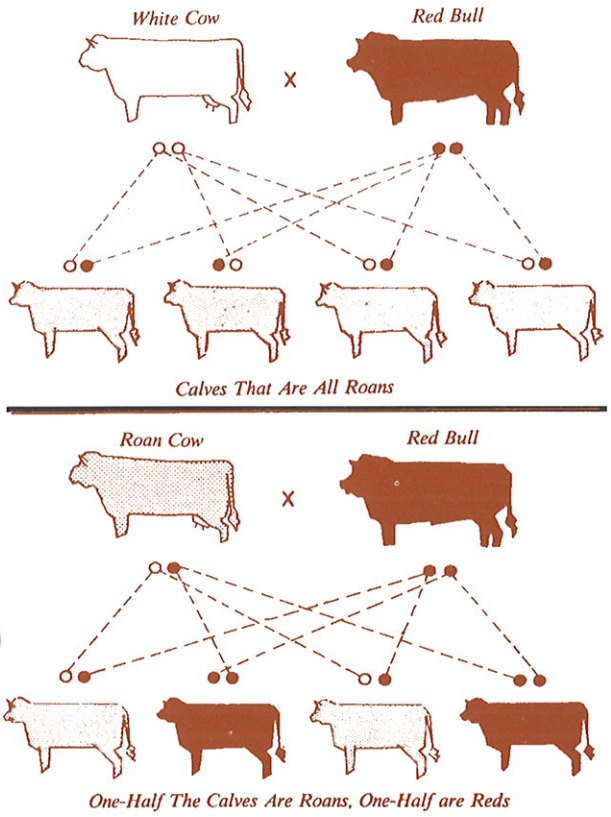
Simple Gene Inheritance

Simple gene inheritance is when a characteristic is controlled by one pair of genes. The color of hair in Shorthorn cattle is an interesting example of a characteristic that is controlled by one pair of genes. Here is how it works:

A red Shorthorn has two genes for red color (RR). A white Shorthorn has two genes for white color (rr). A roan (mix of genes for red and white hair) Shorthorn has two genes, one for red and one for white (Rr). Breeding a red animal (RR) to a white animal (rr), will produce all roan

Shorthorn calves (Rr). If two roans are bred, they will produce calves in the proportion of one red (RR), two roans (Rr) and one white (rr). Breeding a roan (Rr) to a red (RR) will produce one half red (RR) and one half roan (Rr) calves. This principle is illustrated in Figure 6.08.

Color Inheritance in Shorthorn Cattle



(Figure 6.08)

Dominant and Recessive Gene Inheritance

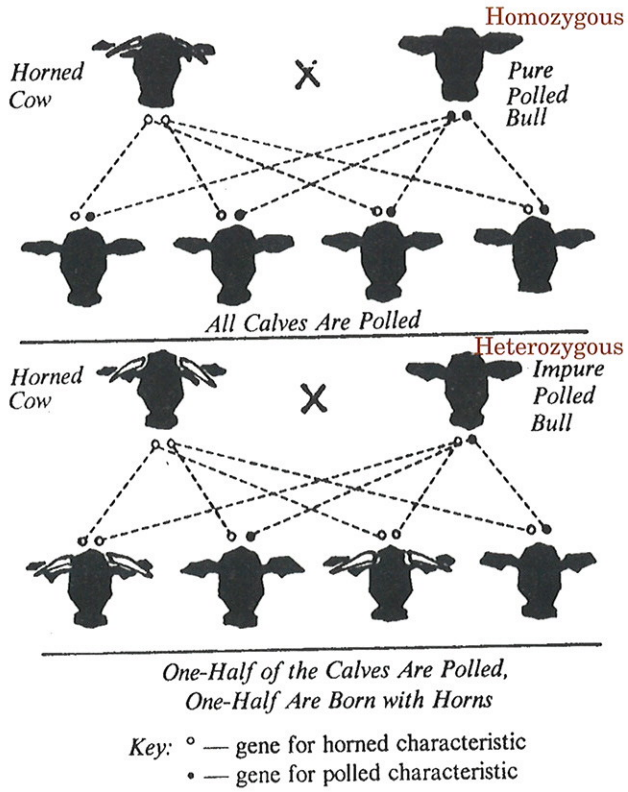
The ability of some genes to mask or cover up the presence of other genes is called dominance. The gene that is masked is called a recessive gene, and the gene that has the ability to mask or cover up the recessive gene is called a dominant gene. One example of dominant and recessive gene inheritance is polled and horned cattle. In cattle, the polled characteristic is dominant to the horned feature. If a polled (PP) bull is used on a horned (pp) cow, the calf will be polled (Pp).

Animals can have one characteristic or both. Animals that are pure for the character (PP or pp) are called homozygous because they only have one of the characteristics. Those that have both – those that have one dominant and one recessive gene (Pp) are heterozygous for that character. If a heterozygous bull for horns (Pp) is bred to homozygous horned cows (pp), one half of the calves will be horned, and one half will be polled. (Figure 6.09)

Often you can find breeders that will use the homozygous characteristic for polled bulls as a marketing tool. They will use the phrase "polled homozygous bull" in their advertisement.

Additional examples of dominant and recessive gene inheritance are: the white face color in Herefords (dominance); black (dominant) versus red (recessive) color in Angus; and dwarfism (recessive) in cattle. Partial or incomplete dominance in genes is found in the roan color in Shorthorns.

Inheritance of Horns



(Figure 6.09)

Genetic Progress

When breeding cattle, a certain proportion of the offspring will be genetically superior to the average of their parents. In these offspring, there is a chance to make genetic progress. By culling animals that are lower than average in important traits, the frequency of those undesirable genes in the herd will be lowered. Three major factors influence how fast we can make genetic improvement in the economically important traits of cattle.

1) Heritability is the degree that genes, not environment, control a trait. The higher the heritability, the greater the rate of genetic improvement that can be made in the trait. See *Table 6.02* to compare the different traits and their amounts of heritability.
2) Selection differential is the difference between the trait of the selected cattle and the average from the herd where they came.

Example:

Selected Individual's Weaning Weight = 550 pounds
Average Weaning Weight of Herd = 520 pounds
Selection Differential = 30 pounds (550-520 = 30)

3. Generation interval is the average age of all the parents in the herd when the offspring are born. The average in most herds is between 4 1/2 and 6 years. The younger the herd, the faster genetic improvement can be made.

All three of these factors are put together in a formula to determine progress:

Rate of Genetic Improvement per Year = Heritability (h^2) x Selection Differential / Generation Interval

Example:

A group of yearling cattle are 50 pounds heavier than the average in the herd (the selection differential).

The heritability for yearling weight is 40 percent, and the generation interval is 5 years. By using these selected individuals, the annual rate of improvement for yearling weight would be 4 pounds.

0.40 x 50 ÷ 5 = 4 pounds

Heritability Estimates of Some Economically Important Traits in Beef Cattle

Trait	Heritability
Female Reproduction	10-20%
Weaning Weight / Mothering Ability	20-25%
Gain After Weaning	35-40%
Yearling Weight	40-50%
Feed Conversion	30-35%
Carcass Cutability	25-30%
Carcass Quality Grade	25-30%
Rib Eye Area	70%
Mature Weight	60-80%

Table 6.02

Traits of Economic Importance

Four traits of economic importance are:

1. Reproductive performance – A trait affected by fertility level, calving ease, and maternal ability.

- **Fertility level** – Determining the fertility level in a young bull can be done by a breeding soundness exam as conducted by a veterinarian. This exam will include checking the internal sex organs, as well as measuring the circumference of the scrotum. Scrotal circumference (measured at the widest part of the scrotum) should be at least 30 to 32 cm for a yearling bull depending on the breed. Research has shown that a larger scrotal circumference indicates increased fertility level of the bull.

The daughters of such bulls reach puberty at a younger age. Both the male and female should be considered in selecting for fertility in the beef herd. Selecting yearling heifers that conceive early during a short 45-day breeding season, beginning 21 days before the mature cows, will result in a more productive cow herd.

- **Calving ease** – Birth weight is the most important factor related to calving ease. Birth weight is a major consideration when evaluating sires and dams. Be sure to select a low birth weight EPD sire for use on heifers.
- **Maternal ability** – Milk production is the most important factor of maternal ability. The most accurate reflection of a cow's maternal or mothering ability is the weight of her calf at weaning. It is important to select sires that excel in this trait because milk production is passed to daughters. Bulls whose mothers have superior weaning weight ratios of their calves should be considered. Match the genetic potential for milk production with the environment (feed resource availability).

2. Growth rate and feed efficiency – Growth rate is measured using adjusted 205-day weaning weights, postweaning gain, and adjusted 365-day (yearling) weights. The single best selection trait for growth is yearling weight EPD. Feed efficiency is the pounds of feed needed for the animal to put on a pound of gain. By selecting for growth (daily gain), you can indirectly select for feed efficiency at the same time.

3. Conformation traits – Include structural soundness and natural muscling. A structurally sound beef animal is one that has a lengthy, productive life in the herd. Cattle producers may use visual appraisal to select for conformation. Many performance-testing programs have a scoring system for conformation. It is an important trait to consider. For example, a top gaining bull may be unsound on his feet and legs. If he will not be able to hold up as a herd sire, his outstanding growth rate will not be very valuable.

4. Carcass traits – Include desirable characteristics such as the proportion of fat to lean as measured by yield grade. Yield grade is determined by carcass weight, external fat cover, rib eye area, and the percentage of pelvic, kidney, and heart fat. In contrast, quality grade, determined by maturity and marbling score, is used as an indicator of eating quality including tenderness, marbling, juiciness and flavor.

Traits to Improve

Beef cattle breeders must select the traits that are most important and concentrate on improving their livestock through those selections. It is impossible to select cattle for all the economically important traits at the same time.

The most improvements that can be made in the least amount of time are for traits that are highly heritable. (*Table 6.02*) Also, the fewer number of traits selected for, the faster the improvement of a single trait. In contrast, the greater the number of traits selected, the slower the progress in any one trait.

Embryo Transfer

A relatively new way to take advantage of superior sires and dams is through a process called embryo transfer. Embryo transfer involves the collection of several embryos from a donor cow and implanting them in other cows called recipients. The biggest advantage of embryo transfer is the chance to produce more calves during the life of a superior cow.

First the donor cow is treated with hormones that cause the ovaries to ovulate several eggs at once (this is called "superovulation"). When the donor cow comes into heat, she is artificially inseminated. About a week later, the embryos are flushed out of the donor's uterus in a nonsurgical procedure. Fresh embryos can be transferred to recipient females or frozen for transfer at a later time.

Crossbreeding

Crossbreeding is the mating of animals from two or more different breeds. It provides the commercial producer the chance to increase the production of beef for each cow in the herd. A well-planned crossbreeding program can increase the overall performance of offspring as much as 20 percent above the average of the parents.

Crossbreeding helps in two ways:

1) It helps by combining the desirable characteristics of two or more breeds because if selected properly, the strong points of one breed can compliment the weak points of another breed.
2) Crossbreeding also helps through heterosis. Heterosis (hybrid vigor) is a phenomenon that causes crossbreeds to out-produce the average of their straightbred parents. Traits that are low in heritability are the ones that best respond to heterosis, and they include those from the reproductive phase through weaning.

Example:

The average weaning weight of a sire and dam was 400 pounds, and the average of their crossbred calf was 420 pounds. The amount of heterosis was 20 pounds or 5 percent.

$$\text{Percentage of Heterosis} = \frac{\text{Crossbred Average - Straightbred Average}}{\text{Straightbred Average}} \times 100$$

$$\frac{420 - 400}{400} \times 100 = 5 \text{ percent}$$

In general, lower heritable traits, such as fertility, are enhanced through systematic crossbreeding. In contrast, highly heritable traits, such as yearling weight and carcass characteristics, are enhanced by individual selection, most notably, individual sire selection. Much of the advantage in heterosis of traits of low heritability is obtained by using the crossbred cow.

Determining a Crossbreeding Program

In a commercial cow/calf operation, determining a crossbreeding program can be done by answering three questions: 1) Which crossbreeding system should be used? 2) Which breeds logically fit the system? and 3) Which individual bulls within a breed should be used?

When determining a breeding program, remember the following points:

- Crossbreeding provides the commercial producer the chance to increase the total production of beef per cow in the breeding herd.
- Crossbreeding is not a substitute for good management.
- The best animals available within breeds should be used. Select breeds that compliment each other.
- Traits that are high in heritability (for example, carcass traits) respond best

to selection and show less response to heterosis.

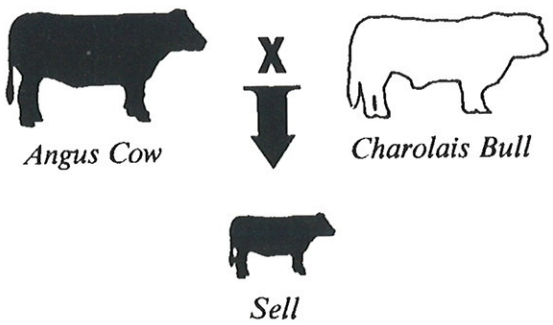
- The level of heterosis achieved depends on the genetic differences between the breeds used in the cross.
- Crossbreeding works extremely well in breeding females where you can increase the less heritable traits such as fertility, survivability of the calves, milk production, conception rate, etc.

Crossbreeding systems

There are several approaches to developing a crossbreeding system. The one a producer chooses depends upon the herd size, available resources (time, money, facilities, etc.), breed preference, management ability of the producer, and the marketing plan for the calves that are produced. Four such crossbreeding systems are:

1. Two-breed terminal cross is a system in which straightbred cows are bred to a bull of another breed. The cross ends with the calves. The replacement females are kept as straightbreds. Therefore, part of the herd must remain straightbred or replacements must be purchased. The producer benefits only from the individual heterosis in the calf (no maternal heterosis). (Figure 6.10)

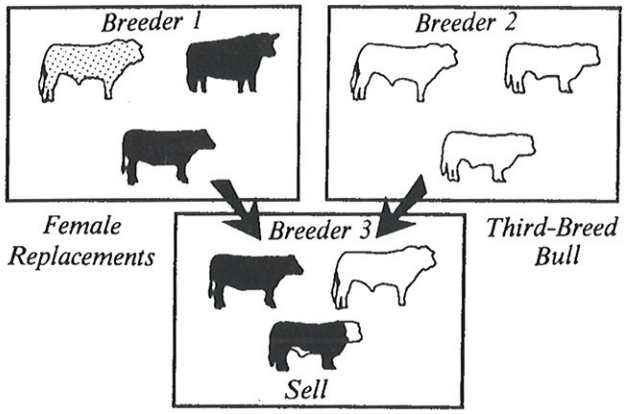
Two-Breed Terminal Cross



(Figure 6.10)

2. Three-breed terminal cross is a system in which a two-breed cross cow, called the "F_1", is bred to a bull of a third breed. This three-way cross gives the maximum amount of heterosis in both the cow (maternal heterosis) and calf (individual heterosis). The producer either raises the F_1 females or purchases them. (Figure 6.11)

Three-Breed Terminal Cross

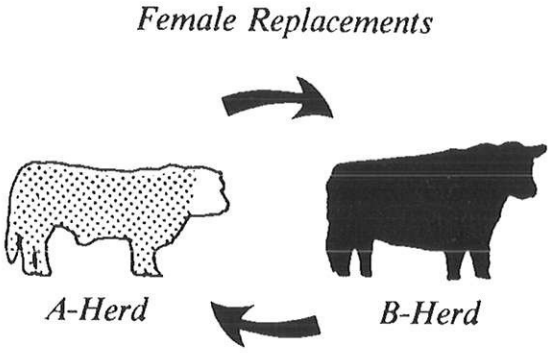


(Figure 6.11)

The breeds used in the cross for the females should be based on maternal characteristics (fertility, easy calving, milking ability, etc.). The breed chosen for the terminal bull should compliment the female breeds by excelling in fertility level, growth rate, and carcass characteristics. All of the calves from this cross are marketed, and no replacements are selected from this three-way cross.

3. Crisscross or backcross is a system in which two breeds are used. Female replacements are saved from the crossbred offspring to breed back to one of the parent breeds. From then on, the replacement females are bred to bulls of the opposite breed of their own sire. Two separate herds must be kept. The only purchases that must be made are bulls. (Figure 6.12)

Criss-Cross or Backcross

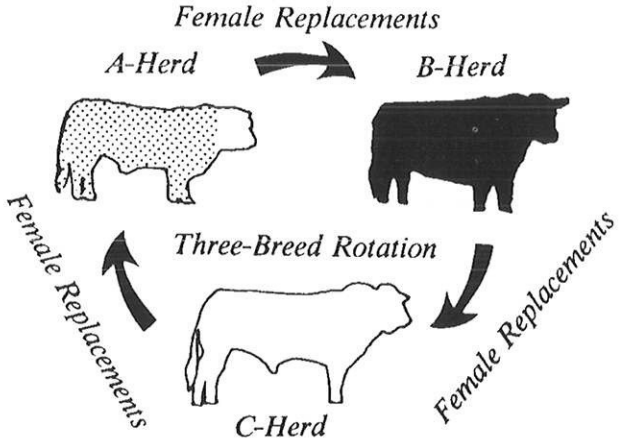


(Figure 6.12)

Even though you do not get the maximum heterosis from this cross, the big advantage is that you can raise all your own replacement females.

4. Three-breed rotational cross is a system that includes the use of three breeds of sires in a rotation with the females kept from these crosses. Three breeds are chosen, and each breed is used for 2 or 3 years in a row. The females are bred to the breed of bulls to which they are least related. In this system, 87 percent of the heterosis possible is obtained. (Figure 6.13)

Three-Breed Rotational Cross



(Figure 6.13)

Performance Records

Performance records are the basis for making genetic improvement in all species of livestock. Programs are designed to help beef producers make better decisions in selecting and breeding quality cattle. Over time, this will improve the genetic base of the herd and will then result in highly productive beef cattle. Records should be used along with visual appraisal when making selection decisions.

Performance records can be used in a variety of ways: 1) to evaluate the producer's management ability of the herd; 2) to evaluate the productivity of the females and the sires used in the herd and thus cull unproductive animals; 3) to select replacement females; and 4) to select herd sires or semen to use artificially.

If involved with a purebred herd, consult your breed association to enroll in their performance program. For commercial cattle, a similar performance testing program is available from most land-grant universities. Contact your county Extension office to enroll.

Performance data is more meaningful if the cattle are compared only within a contemporary group. A contemporary group is a group of cattle of the same sex, within 160 to 250 days of age (for weaning weight), and exposed to the same environment (same pasture conditions). The easiest way to have all of your calves close in age is to begin with a short 45 to 60 day breeding season.

Be sure to set up an identification system in the herd that will be useful to you. One practical method is to use one number for the year the calf was born and follow this by the animal's individual herd number. For example, a calf's number is 911. The 11 suggests it was the eleventh calf born in a particular year. The nine would be the last digit of the year the calf was born, for example, 1999. This will be helpful to remind you at what stage in the calving season a calf was born within a certain year.

Birth Weight

When purchasing a young bull for natural service, check the bull's birth weight. If it is at breed average or lower, he is likely to sire calves that deliver easily and could be considered a candidate for use on heifers. When selecting a bull to use on smaller, British breed heifers it is recommended that they not be mated to large, continental breed bulls, but instead to British breed bulls with low birth weights.

Four-year-old cows and older can likely be mated to bulls of the same breed that are above breed average for birth weight without having serious calving problems. However, extreme birth weights should be avoided.

When checking the birth weight of a bull, consider the age of his dam when he was dropped because younger cows give birth to lighter calves.

205-Day Adjusted Weaning Weight

Weaning weights are a reflection of the mothering ability of the cows in the herd. They are also useful in measuring the differences in growth and growth potential of the calves. Adjust all weaning weights to a standard in order to accurately compare the calves within the herd. They are adjusted to a standardized 205-day weight and also for the age of the dam.

Weaning weights may be taken between 160 to 250 days of age, but they should be taken as close to 205-days as possible. This weight is only relative to the herd in which it is obtained. You cannot compare 205-day weights from different herds because of the differences in environment (feed management, weather conditions, etc.) Likewise, comparisons should only be made within the same sex groups (heifers to heifers, steers to steers, etc.).

The 205-day weaning weight formula is the following:

- Adjusted 205-Day Weaning Weight

$$\text{Adjusted 205-Day Weaning Weight} = \frac{\text{Weaning Weight - Actual Birth Weight}}{\text{Age in Days}} \times 205 + \text{Birth Weight} + \text{AOD}$$

- Adjust individual records for the age of the dam to a mature dam equivalent. Younger cows (2 years) usually wean lighter calves than mature cows (5 to 10 years). Therefore, to adjust for the age of the dam, you should add factors to the calculated 205-day weaning weight based on the age of the dam for each calf.

Add the following factors for the age of dam (AOD) adjustment:

If Dam is:	Male calves	Female calves
2 years	60 lbs.	54 lbs.
3 years	40 lbs.	36 lbs.
4 years	20 lbs.	18 lbs.
5 - 10 years	0 lbs.	0 lbs.
11 years and older	20 lbs.	18 lbs.

365-Day Adjusted Yearling Weight

This figure provides a way to evaluate the combination of milking ability of the cow (weaning weight) and the ability of the calf to gain weight after it is weaned. It provides the best indicator of the growth performance of the animal. Yearling weight is a trait that is highly heritable, therefore, it is easy to make genetic improvement in it through selection.

The formula for the 365-day adjusted yearling weight is as follows:

- Adjusted 365-Day Yearling Weight

$$\text{Adjusted 365-Day Yearling Weight} = \frac{\text{Final Weight - Weaning Weight}}{\text{Days between Weights}} \times 160 + \text{Adjusted 205-Day Weaning Weight}$$

205-Day and 365-Day Weight Ratios

Using ratios, you can determine whether genetics or the environment is responsible for the heavier weights. The 205-day and 365-day weight ratio is useful for identifying the genetically superior calves within a herd.

To calculate the ratio, do the following:

- Adjusted 205-Day Weaning Weight and Adjusted 365-day Yearling Weight Ratio

$$\text{Adjusted 205-Day Weaning Weight and Adjusted 365-Day Yearling Weight Ratio} = \frac{\text{Individual Adjusted Weight}}{\text{Average Adjusted Weight of Contemporary Group}} \times 100$$

205-Day Adjusted Weaning Weight Example

Your three-year-old cow had a heifer calf on January 1st that weighed 85 pounds. The calf's weaning weight on July 18th was 585 pounds. The adjusted weight for this heifer is 633.5 pounds.

$$\frac{\text{(Weaning Weight) } \mathbf{585 \text{ lbs.}} - \text{(Actual Birth Weight) } \mathbf{85 \text{ lbs.}}}{\text{(Age in Days) } \mathbf{200 \text{ days}}} \times \mathbf{205} + \text{(Birth Weight) } \mathbf{85 \text{ lbs.}} + \text{(AOD) } \mathbf{36 \text{ lbs.}}$$

$$= \text{Adjusted 205-Day Weaning Weight} = \mathbf{633.5 \text{ lbs.}}$$

The average ratio for the contemporary group is assigned a value of 100. The ratios of the individual animals in the group are expressed as percentages above or below the average.

For example, a calf with a ratio of 106 is six percent heavier than the group's average. Compare two calves from the same herd which had an average weaning weight of 550 pounds. Calf A had a weaning weight of 575 pounds. This would give Calf A a weaning weight ratio of 105 pounds. Calf B had a weaning weight of 625 pounds. This would give Calf B a weaning weight ratio of 114. Calf B would be genetically superior to Calf A in this environment.

The key is to learn how to determine whether genetics or the environment is responsible for the heavier weights.

Most Probable Producing Ability (MPPA)

Many of the performance testing programs available provide individual cow record summaries. These summaries are based on the adjusted weaning weight of her calves. The **Most Probable Producing Ability** (**MPPA**) is calculated from one or more records on the same cow to predict her future level of performance. It is a ratio of the most probable producing ability of the cow to the average of the other cows in the herd.

In the MPPA formula, the more calves a cow has raised, the more accurate the information will be. Just like the weight ratio, MPPA uses 100 as the average for the herd. For example, a cow with a MPPA of 99 is one percent lower than the average for the herd. A cow with a MPPA of 108 is eight percent better than the average of the cow herd.

Expected Progeny Difference (EPD)

The **Expected Progeny Difference** (**EPD**) is a figure used to describe how the offspring of an animal will perform in relation to the average performance of other animals in the breed. It is calculated by gathering data on the calves from a bull or cow, other information from close relatives of the animal, plus the animal's individual record.

The EPD for growth traits is reported in plus or minus pounds. For example, a bull with a weaning weight EPD of +30.0 lbs. is expected to sire calves that will be 30 pounds heavier at weaning than the calves from a bull of the same breed with a weaning EPD of 0.0 lbs.

Performance Pedigrees and Sire Summaries

EPD's are found in **performance pedigrees** and **sire summaries** and can be used to accurately compare animals from different herds within a breed. Review the sire summary offering about five bulls in *Table 6.03*.

Both performance pedigrees and sire summaries have EPD information available for various traits. Performance pedigrees not only include the normal pedigree information on the grandsire, grandam, sire and dam, but they also provide information on their performance. They are helpful in evaluating what a calf's value may be before it is born.

Sire summaries have enabled the beef industry to make more genetic progress in recent years. They rank bulls and cows in comparison to other animals within a breed based on progeny records. Progeny refers to the offspring, or the calves produced, by the bull or cow. Sire summaries make extensive use of EPD's and sire summaries are provided and regularly updated by breed associations.

Sire summaries include the traits of economic importance. Although some traits vary, they all evaluate the ability of a sire to transmit birth, weaning, and yearling weight characteristics to his offspring.

Most breeds will also evaluate the performance of the bull's daughters (for example, for calving ease and milking ability). These traits are called the maternal weaning weight or pure milk EPD. A milk EPD predicts the amount of weaning weight attributed to the milk production by the sire's daughter.

Sire Summary EPD Data

	Birth Weight		Weaning Weight		Yearling Weight		Milk	
Sire	EPD	Acc.	EPD	Acc.	EPD	Acc.	EPD	Acc.
A	-1.1	0.85	-4.1	0.88	-8.5	0.87	+2.0	0.97
B	+2.3	0.90	+16.1	0.90	+43.6	0.89	+3.0	0.96
C	-1.0	0.88	+18.7	0.91	+44.8	0.90	-5.0	0.97
D	+2.9	0.96	+11.6	0.97	+32.6	0.97	+16.0	0.99
E	+5.6	0.94	+25.2	0.95	+56.0	0.94	+22.0	0.98
Breed Avg.	+1.5		+14.0		+40.0		+10.0	

Table 6.03

Using Sire Summaries

Table 6.03 is an example of a sire summary. In this table, five sires are listed with their respective EPD's along with the breed averages. This information can be utilized in the decision making process when making breeding choices.

The EPD's in Table 6.03 can aid you in making mating decisions. If you are looking for a bull to use on heifers, sires A and C would be recommended as they are below breed average for birth weight. If a sire is needed to add growth, consider sires B, C and E because of their superior weaning and yearling weight EPD figures. When looking for a sire to boost milk production, utilize sires D and E.

The accuracy number (Acc.) is a measure of how much the EPD value might change as more data is accumulated on a bull. For example, a sire with many calves in several different herds will have a higher EPD accuracy figure. The higher the accuracy (closer to 1.0), the more confident you can be in the figures available on a bull.

Individual Performance Record (Within Herd)

Bull	Date of Birth	Birth Weight	Adjusted 205-Day Weight	Wean Ratio	Post ADG	Gain Ratio	Adjusted 365-Day Weight
A	Feb. 23, '99	79 lb	554 lb	94	3.04 lb/d	96	1,004 lb
B	Mar. 03, '99	84 lb	615 lb	105	3.25 lb/d	103	1,149 lb
C	Mar. 20, '99	70 lb	567 lb	96	3.00 lb/d	95	1,051 lb
D	Feb. 26, '99	68 lb	589 lb	100	2.93 lb/d	92	997 lb
E	Feb. 28, '99	82 lb	614 lb	104	3.64 lb/d	115	1,157 lb

Bull	Yearling Ratio	365-Day Hip Height	Frame Score	Back Fat	Scrotal Circumference
A	94	46.0 in	3	0.26 in	35 cm
B	107	49.5 in	5	0.28 in	37 cm
C	98	47.5 in	4	0.38 in	33 cm
D	93	48.0 in	4	0.32 in	35 cm
E	108	48.5 in	4	0.40 in	35 cm

Table 6.04

Individual Performance Records

One of the best ways to make genetic improvement in a beef cattle herd is through sire selection. A herd bull contributes 50 percent to the genetic improvement of the resulting calves. Over a long period of time, a few bulls will greatly increase this percentage. For example, a producer that raises his own replacement heifers will have 87.5 percent of the genetic base of those heifers coming from the last three bulls used in the pedigree of the cattle.

Table 6.04 shows the records of five yearling bulls from the same herd. Review it and compare the bulls.

Notice that bulls B and E are exceptional in growth. Bull B has the highest weaning ratio (105), the second highest yearling ratio (103), the largest frame (5), one of the lowest backfat thicknesses (.28 inches), and the largest scrotal circumference (37cm). Bull C has slightly below average growth and size and low birth weight of 70 pounds. He might be bull to consider using on heifers. The poorest performers are bulls A and D, with lower gain and yearling weight ratios.

Performance Data to Use in Selection

Today, selecting a sire is based on several sources of information that are generated by central bull test stations, breed associations, on-farm performance records, and bull studs. When EPD information is available, use it as your major source for sire selection. For bulls with no available EPD figures, an individual performance record should be used as the basis for selection.

When selecting replacement heifers for a purebred herd, utilize EPD information available from performance pedigrees. Choosing heifers in a commercial herd should be based on the individual's own performance. Heifers should be growthy and well developed. They should be bred to calve early in order to help shorten the calving season of the herd.

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