Planning the Genetics Program

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The quality of cattle produced by the beef industry is determined by the cattle's genetic makeup and the management system to which they are subjected. Genetic makeup is under total control of breeders, both seedstock and commercial, and this responsibility should not be taken lightly. Research has shown that different types of cattle perform differently under varied management conditions. This means that beef producers cannot just select for the maximum in traits of economic importance but that they must match their genetics to their resources and environment.

The selection of bulls and heifers, and the breeding system used, dictate the genetic quality of the calf crop. The seedstock producer uses selection for genetic management, while the commercial producer uses both selection and mating systems, especially crossbreeding.

Because most sires are purchased from them, seedstock breeders exert a great influence on the direction of the beef industry. Commercial producers are insisting that the seedstock producer keep records and make these records available. It is important that both seedstock and commercial producers understand and use the principles and tools of genetic improvement.

Goals and Targets

Having goals that you intend to meet is important for many areas of beef production but may be most critical for the genetics program. These goals may include reproduction, calf performance, income, cost containment, or a number of others. Genetic management decisions will impact each of these goals to varying degrees. The breeding management practice that has the greatest impact on reproduction would be crossbreeding, whereas selection is the best management practice for improving carcass quality. Set goals for your beef herd that are important to your family's quality of life and then determine which management and breeding practices will best help you to attain those goals. Remember, most management decisions can be changed in an instant, but changes to your herd's genetics generally take time.

The beef cattle industry is segmented, with many cattle having three or more owners before arriving at the grocer or restaurant. This type of system has its drawbacks for the industry as a whole, but it does allow some opportunities. When considering your breeding program, you must consider when you plan to market your cattle (weaning, preconditioned, yearling, finished) and what kind of product you are trying to produce.

The most common opportunities to market cattle intended for meat production are:

Newly weaned calves sold at auction. Buyer has little to no knowledge of calves other than what is seen in the flesh.

Newly weaned calves sold off the farm. Buyer has direct contact with the producer and is potentially more aware of performance information to varying degrees, breed type, and management information.

Calves sold either at auction or off the farm after preconditioning at least 45 days postweaning. This marketing system is most effective when the buyer is aware of the preconditioning; therefore, if calves are sold at auction, it is generally best to sell in a special preconditioned sale (i.e. Certified Preconditioned for Health–CPH-45) or at a minimum announced at the auction.

Yearlings sold after backgrounding either at auction or off the farm. Buyer generally has little knowledge of the cattle, but older cattle tend to have better health as feeders compared to calves.

Retained ownership through feedyard to finish. Once the cattle have reached their finished condition, there are additional options:

- **Sell live as commodity cattle.** This basically means you take the live-price of finished cattle being offered at that time.
- **Sell on the rail (grid or formula).** This is a precise system that pays premiums for certain types of cattle. Some grids are better suited for high-quality grade cattle, and others are better suited for better yield grading cattle.

Finished and sold locally. This option is becoming more common and allows for the greatest control of the entire process. Selection can be used to target specific needs of customers.

When and how you plan to market your cattle play important roles in your breeding decisions.

There is not a right or wrong answer to when and how to market cattle. Depending on your resources, one option may be better than another, but certain situations may cause you to consider one of the other options. Some examples of situations that may cause you to re-evaluate how you market your cattle would be drought or other restrictions to grazing management, market and/or futures prices, alternative feed availability, or others. Although it is important to set goals and have targets, it is also important to be flexible if opportunities or adversities develop.

Herd Assessment

Once your goals have been established, and you have a target for which you are shooting, it is important to determine the performance level and potential of your current herd. When going through this process, it is very important to be honest with yourself and examine your operation with a critical eye. You may find that your herd is performing at the appropriate level for the management that you have, or you may find that you need to make some drastic genetic changes in order to meet your goals.

The first step in the herd assessment process, for a commercial producer, is to determine the breed makeup of the herd. This will tell you whether you have been doing a good job of crossbreeding. As a general rule, if you have cows in the herd that are greater than 75 percent of one breed, you should make some changes to your breeding program to take advantage of crossbreeding. This will be discussed in greater detail in the crossbreeding section below.

The next step is to determine the production level of your herd. You must keep good records. With good records, you will be able to assess the reproductive performance (including calving distribution), sickness, growth performance, cow condition at weaning, and any other characteristics that you keep records on. Having this information will help you determine if changes are needed and help you determine how best to make those changes. If you do not currently keep good records, see Chapter 12: Record Keeping for Management Decisions and start a record-keeping program. Without records, you can still assess your herd for other factors, but you will be drastically limited.

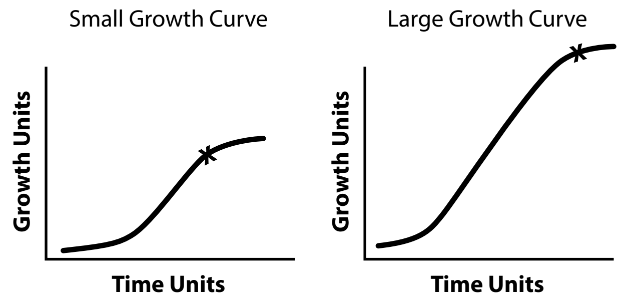
The last step in this process is determining the size of your cows. The mature weight of the cow determines how much nutrition will be required to meet her maintenance needs. The larger the cow is the greater amount of nutrition is needed to sustain her body condition and thus future reproduction. Frame size can give a rough estimate of a female's future size, but there is no substitute to weighing cows to determine their size and nutritional needs.

Frame's Effect on Feedlot Performance and Carcass Weight

The growth and development relationship between large- and small-framed cattle can be observed in Figure 6-1. The growth pattern of the different types of cattle is similar, and the X illustrates the optimal finish point for the cattle. This is the point where most breeds have the opportunity to grade a minimum of low choice on the USDA Quality Grade scale. This is typically achieved when the cattle's fat thickness over the ribeye is approximately .45-.50 inches. At this point, the cattle are starting to accumulate fat at a more rapid rate. Since it requires more feed to put on a pound of fat than a pound of muscle, the cattle become less efficient in feed to gain conversion.

As a general rule, larger-framed cattle tend to grow at a faster rate; however, they reach their optimal finish point later and at heavier weights. The implications are that larger-framed cattle require more feed to finish and have greater expenses due to a longer period in the feedyard; however, they are heavier at finish which will generate more income. As long as cattle do not fall into the light or heavy carcass category, the trade-off is probably similar. The real problem occurs when cattle of varying frames are fed together to a constant endpoint. The average of the group will meet industry needs, but there will likely be a number of over- and under-finished cattle in the group. Grouping cattle according to type going into the feedyard or sorting the cattle out as they finish is essential to producing a uniform, acceptable product.

Figure 6-1. Growth curve comparison of small- vs. large-framed cattle.



> **Example of Calves from a Large-Framed Bull and a Moderate-Framed Bull with the Same EPDs for Growth**
>
> *If two bulls have the same genetics for growth but differ in frame, we would expect the larger-framed bull's calves to be taller at weaning and as yearlings, the finished calves to be heavier and take longer to feed to optimal finish, and the females to be larger as mature cows. However, because the bulls have the same Expected Progeny Differences (EPDs) for growth, we would expect the calves to weigh the same at weaning and as yearlings. If large- and moderate-framed calves weigh the same, the larger-framed calves likely have less muscling and/or less body capacity. To put this into perspective, compare a 6-foot 8-inch person who weighs 250 pounds, with a 5-foot 8-inch person who weighs 250 pounds; the taller person is likely to be leaner with less girth.*

Management Assessment

Management is another component of your operation to assess. To determine the genetic type of cattle that you need, it is important to know what resources are available and how that affects the performance of your herd. When assessing management concerning establishing the proper level of genetics, the primary areas of concern are labor and nutrition availability.

Labor

In the context of genetic impact on the herd, labor is defined as the frequency and duration of time spent with the cowherd during calving season. Using this definition, labor is an important component when determining your breeding program. Determining how closely the cattle will be monitored during the calving season will have a major influence in determining how much calving ease is needed in the bulls or semen being purchased. In other words, are you a full-time farmer who spends a great deal of time with the cattle and can provide assistance when needed, or are you a part-time farmer who gets the opportunity to see the cattle only on occasion and whose cattle are required to be more self-sufficient during calving? Knowing this information can assist in developing a breeding program. As an example, a full-time farmer who observes the cattle multiple times in a day might choose to lessen restrictions on calving ease in favor of more production, whereas the part-time farmer who has limited observation of his cattle must use a calving ease bull to minimize calving difficulty.

Nutrition

The availability and quality of nutrition are extremely important when determining your breeding program. Different types of cattle perform differently depending on the nutrition that they receive. Research has shown that under nutritionally stressful situations, smaller, less-productive cattle are more efficient at turning the resources available into pounds of salable product. Their calves are still smaller on average, but they tend to have higher reproduction rates that offset the deficiency in individual calf weight. Under ideal nutrition, there were very little efficiency differences between high-performing cattle and moderately performing cattle. In an environment that provides abundant nutrition, the larger, high-performing cattle were the most efficient at producing pounds of weaned calves. Based on this information, operations that provide exceptional nutrition should consider more productive types of cattle; however, operations with restricted nutrition, either in availability or quality, should consider less-productive cattle (smaller and/or less milking ability).

Nutrition assessment should include forage base (infected fescue with sparse legumes, high-quality grass/legume mix, cool-/warm-season grass mix, etc.), the nutritional quality of stored feeds (silage, hay harvested and stored correctly, hay harvested after optimum maturity and stored outside on the ground, etc.), and economical availability of purchased feedstuffs. Quantity and quality of feed resources will be a factor in many management decisions, including breeding management.

Genetic Principles

To fully understand breeding management, it is important to know some basic genetic principles. Knowing the role genetics plays in each economically important trait of beef cattle can assist in making wise selection decisions. It is necessary to know which traits can be altered through breeding management (selection and/or crossbreeding) and which traits should be altered by other management techniques.

Most traits of economic importance (calving ease, weaning weight, etc.) in beef cattle are controlled by two factors: the environment in which the animal lives and the animal's genetic makeup (genotype). The environment consists of not only the weather but also how the cattle are managed. Creep feed, forage quality and quantity, and health programs are examples of environmental effects. Environmental effects on economically important traits are impacted by both genetics and other management programs, such as nutrition and health, which are discussed in other chapters of this manual.

The two types of genetic effects on economically important traits of beef cattle are additive and non-additive. When a bull and cow are mated, each contributes 50% of its genetics to their calf. If that calf is then allowed to reproduce, it passes 50% of its genetics to each of its calves; however, each calf gets a different sample of genes from its parents (that is why siblings are genetically similar, but not identical). When the alleles from the parents combine they can behave in one of two ways: the first is that the heterozygous condition is the average of the two homozygous conditions and these effects are called additive. This type of effect will consistently pass from one generation to the next and is therefore the basis for using selection to make genetic improvement. When the combined alleles are non-additive it is difficult to predict how the next generation will perform.

Heritability, the percentage of each trait controlled by the additive genetic effects, is an important factor when making selection decisions. To visualize this better, offspring have more of the same characteristics as their parents for highly heritable traits. In other words, the genetics that caused the parents to perform in a certain manner would be passed on to the calves and they would perform similarly. Highly heritable traits respond more rapidly to selection, while lowly heritable traits respond more rapidly to management practices (environment) and heterosis (crossbreeding). Table 6-1 illustrates the relative heritability and heterosis of several economically important traits.

Another genetic effect that is important when making selection decisions is genetic correlations. A genetic correlation occurs when you select for one trait and another trait is affected. The effect of one trait on the other can be either complementary or disadvantageous. Here is an example of a complementary genetic correlation: As selections are made for increased weaning weight, yearling weight is also increased. An example of a disadvantageous correlation is: As selections are made for increased weaning weight, birth weight increases and calving ease decreases. Genetic correlations work the same regardless of which trait is being selected for. In other words, as selections are made to decrease birth weights, weaning and yearling weights are usually decreased, too. The implications of genetic correlations for many traits for which Expected Progeny Differences (EPD) are calculated are discussed below and in Table 6-2.

Non-additive genetic effects refer to how the genetics from the two parents combine and how they interact with the environment. The best example of non-additive genetic effects are the benefits realized from crossbreeding. These benefits are known as heterosis. Heterosis is

Table 6-1. The relative heritability and heterosis effects of several economically important traits in beef.

Trait	Heritability	Heterosis
Birth weight	moderate-high	moderate
Calving ease	moderate	moderate
Weaning weight	moderate	moderate
Yearling weight	moderate	moderate
Milking ability	moderate	moderate
Carcass traits	high	low
Reproduction	low	high
Longevity	low	high

Table 6-2. Selection based on EPDs.

	Birth weight	Weaning weight	Yearling weight	Milking ability	Calving ease	Mature size
CED EPD	-	-	-	0	+	0
WW EPD	+	+	+	-	-	+
YW EPD	+	+	+	-	-	+
Milk EPD	0	-*	-*	+	0	0

+ = As EPD goes up, this trait also tends to increase.
- = As EPD goes up, this trait tends to decrease.
0 = No relationship.
* Increased milk EPDs result in decreased growth rate for the first generation. Due to added milk production, offspring of first-generation females have increased WW and YW.

defined as the increase in productivity in crossbred offspring over the average of breeds that are crossed. Heterosis is highest for lowly heritable traits (such as reproduction) and lowest for highly heritable traits (such as carcass traits) (see Table 6-1 for the impact of heterosis on several traits). Crossbreeding might result in relatively small amounts of heterosis for each trait, but these effects tend to accumulate to produce large increases in overall productivity. In some instances, a portion of this advantage is passed on to future generations, but to optimize the benefits, a crossbreeding system should be designed and maintained.

Coat Color and Polled/Horned/Scurred

For most traits that we deal with in cattle, the genetic contribution is provided by many gene pairs, and the environment contributes significantly to how the cattle perform. Two exceptions to this are the traits of coat color and polled/horned. To know how color and horns occur, it is important to understand a few concepts.

Color: Black/Red/White/Mixed

For marketing reasons, not production reasons, coat color has become increasing important in selection decisions. It is important to remember that coat color does not impact any economically important traits. In other words, black cattle are not more likely to grade choice, white cattle are not more likely to grow faster and red cattle are not more likely to produce more milk. However, when calves are sold there are differences in value due to coat color, so it is justified to consider coat color when selecting bulls.

In most cases the primary color of cattle is determined by one pair of genes and the result is either red or black. Cattle of most breeds can have either black or red coat color with the exceptions being Charolais and Shorthorn, which will be explained later, and a few grey breeds. The black allele (specific form of a gene) is dominant to red allele which means if a calf has two black alleles, we call it homozygous black (resulting in a black calf); if it has two red alleles, it is called homozygous red (resulting in a red calf); if it has one of each, it is called heterozygous (resulting in a black calf because the black allele is dominant). Another term for heterozygous cattle is carriers, because they are carrying the unobservable recessive allele. In the case of Charolais, in addition to the black/red gene they have what are called diluter genes which cause the animal to repress the coat color genes resulting in white to off-white cattle. When Charolais are crossed with colored cattle the result is generally a smoky or reddish-white color. Shorthorn cattle can have red and white color alleles; two red alleles results in red cattle, two white alleles results in white cattle and cattle with one red and one white allele are red-roan or a blend of red and white hairs. Color patterns, such as white or blazed face, white points, white belts, spots and various others are controlled by genes at other loci (locations in the genome) and are typically breed specific.

From a practical standpoint we can manage coat color through a planned breeding program. Without a planned breeding program the result is usually variation in coat color with some red, black and various other colors showing up. If the desired coat color is red then the breeding program is simple, breed a red bull to red cows and you should always get red calves. Black cows bred to a Charolais bull will always result in smokey colored calves. To get all black calves it typically takes a little more effort. Since black is dominant to red then simply breeding a black bull to black cows does not guarantee black calves. In Figure 6-2, a heterozygous black bull is mated to a herd of heterozygous black cows; in this case 25% of the calves will be homozygous black, 50% will be heterozygous black, but 25% will be homozygous red. The only way to ensure that all calves are black is to breed to a homozygous black bull. Figure 6-3 illustrates that even the extreme case of breeding a herd of red cows, if a homozygous black bull is used, then all of the calves will be black (note: all calves are carriers of the red allele).

Polled/Horned/Scurred

The polled, horned, or scurred condition is less well understood, but can be managed to some degree. Horned feeder calves are not desirable; they are potential hazards for other cattle and the humans working them. For this reason calves with horns are discounted at the sale barn and even though scurs pose no danger to other cattle or humans they are still discounted by many buyers. To minimize these discounts beef producers attempt to use breeding techniques to generate polled cattle or dehorn/de-scur their calves. If you plan to breed for polled cattle it is important to understand the genetic action of the poll/horn gene, however, you will learn that avoiding horns is relatively easy, but avoiding scurs can be much more difficult.

Poll/Horn Gene

In most cattle the horn/poll gene action is simple recessive with the poll allele (P) being dominant to the horn allele (p). Every parent has a pair of genes and they pass one of these genes to their calf; the calf gets one allele from the bull and one allele from the cow to make its pair. What this means is that if a calf gets a polled allele from either parent then it will be polled. If it gets two polled alleles it is considered homozygous polled; if it gets one polled and one horn allele it will be physically polled, but it will be referred to as heterozygous polled or a carrier; if it gets two horned alleles it will be homozygous horned and will grow horns (Figure 6-4).

Since polled is dominant to horned, if you mate a homozygous polled bull to a group of females then all of the offspring will be polled. This is shown in the most extreme case in Figure 6-5 where a homozygous polled bull is mated to a herd of horned cows. In this case 100% of the calves are heterozygous polled, in other words they are physically polled, but carriers of the horn allele. In Figure 6-6, a heterozygous polled bull (Pp) is mated to heterozygous polled cows (Pp). In this mating it is expected that 25% of the calves will be homozygous polled, 50% are expected to be heterozygous polled and 25% to be homozygous horned. This means about 75% of the calves will be polled and 25% horned, even though the bull and cows were all polled.

Reference to poll in this section means the absence of horns, the cattle could be scurred which will be discuss next.

Scur Condition

Unlike the poll/horn trait, scurs is not a simple recessive trait and is not completely understood! It has been hypothesized that the scur condition is controlled on a different gene than the poll/horn gene, but interacts with the poll/horn gene, and it is possibly sex influenced. It has also been theorized that scurs are simply a condition of the poll/horn gene that is sex influenced. It has been shown that, regardless of the cause, the scurs condition can only happen in heterozygous polled cattle, of either sex. The data also support that males develop the scur condition at a higher rate than females. It is postulated that this is due to males expressing scurs when either homozygous or heterozygous for the scur allele and females only have the scur condition when homozygous for the scur allele. However, if there is no actual scur gene, but a sex by poll/horn gene interaction, it is theorized that male hormones could play a role in heterozygous males having an increase in the scur condition compared to heterozygous females.

The condition that is obvious is that horned cattle (pp) cannot have the scur phenotype. If cattle have the genotype for the horned condition (pp) they will always be horned. For cattle to develop scurs, it must be a horn allele carrier (Pp) and have some other unknown genetic influence, realizing that male calves will tend to develop scurs at a higher rate than females. For cattle to be smooth polled it must be either homozygous (PP); or heterozygous polled (Pp) without the unknown genetic influence that allows scurs. Figure 6-4 shows all possible combinations of the poll/horn alleles and where scurs can occur.

Genomics Testing and Planning a Breeding Program to Minimize Horns and Scurs

Genomics tests are available to determine if polled cattle are carriers of the horn allele, but there are no genomics tests for scurs. From a practical standpoint, if you have cattle that develop scurs then it is known that they are carriers of the horn allele and testing is not necessary, however, the lack of scurs does not conversely mean that they are not carriers, they would need to be tested. A common misconception is that a homozygous polled bull should not have scurred calves; it eliminates the possibility of horned calves and reduces the incidence of scurs, but they can occur. If he is bred to cows that have the horn allele then it is possible for him to produce scurred calves. Bottom line, it is easy to breed for polled cattle, buy a homozygous polled bull and you will not have any horned calves (double polled is not the same as homozygous; see glossary). Scurs, as you now know, is a completely different story; buying homozygous polled bulls will assist in reducing the incidence of scurs, since the horn allele is necessary to produce scurs. Until the genetic cause of scurs is determined and a genomics test for the scur allele is developed, if possible, then scurs will be difficult to eliminate.

Crossbreeding for the Commercial Producer

Crossbreeding is the mating of cattle of different breeds or breed composition. It can be an effective method of improving beef production. The two primary reasons to use crossbreeding are (1) heterosis (hybrid vigor) and (2) breed complementarity (breeds have characteristics that complement each other and fit the environment). When crosses are made, one breed's strength can complement the other's weaknesses. Since no one breed is superior in all traits, a planned crossbreeding program can significantly increase herd productivity.

The two greatest economic impacts on profitability from heterosis is the increase in production and longevity of the cows. When production is measured as weaning weight per cow exposed—which takes into account reproductive rate, survival, milking ability, and growth—the increase is between 20 and 25% when compared to straightbred cattle. That means that by maximizing crossbreeding, the effects of heterosis alone can add 20 to 25% more income. The benefit of increased longevity should not be underestimated either. Crossbred cows will stay productive in the herd longer. Cows are the most productive when they are between five and 10 years of age. From an economic standpoint, it is best to have as high of a percentage of the cow herd in the five- to 10-year age group and minimize the number of replacement heifers that are retained each year. This goal is enhanced through crossbreeding. Even if crossbreeding is not maximized, utilizing a system that eliminates cows with greater than 75% of any one breed will make the effort worthwhile.

		Black Bull ♂	
		B	b
Black Cows ♀	B	**BB** *black*	**Bb** *black*
	b	**Bb** *black*	**bb** *red*

Figure 6-2. Mating a heterozygous black bull to heterozygous black females and the possible genotypes and phenotypes of the calves.

		Black Bull ♂	
		B	B
Red Cows ♀	b	**Bb** *black*	**Bb** *black*
	b	**Bb** *black*	**Bb** *black*

Figure 6-3. Mating a homozygous black bull to homozygous red females and the possible genotypes and phenotypes of the calves.

Genotype	Phenotype
PP	Polled
Pp	Polled (scurs possible*)
pp	Horned

Figure 6-4. Possible genotypic combinations and phenotypic appearance of cattle for the poll(P)/horn(p) gene in cattle.
*Expect a higher incidence in males than females.

		Polled Bull ♂	
		P	P
Horned Cows ♀	p	**Pp** *polled**	**Pp** *polled**
	p	**Pp** *polled**	**Pp** *polled**

Figure 6-5. Mating a homozygous polled bull to homozygous horned females and the possible genotypes and phenotypes of the calves.
*Possibly scurred.

		Polled* Bull ♂	
		P	p
Polled* Cows ♀	P	**PP** *polled*	**Pp** *polled**
	p	**Pp** *polled**	**pp** *horned*

Figure 6-6. Mating a heterozygous polled bull to heterozygous polled females and the possible genotypes and phenotypes of the calves.
*Possibly scurred.

Breed complementarity has to do with the breeds that you choose to go into your cross. Finding a combination of breeds that will perform optimally in your environment (management) is critical in developing a successful breeding program. Producers with high management, particularly in nutrition quantity and quality, can utilize high-producing breeds more efficiently than producers that have limited nutrition. Most Kentucky operations would probably be considered moderate in their ability to provide adequate nutrition to their cattle. Under normal conditions, the cattle do very well and maintain an adequate level of condition. However, under adverse conditions, such as drought or harsh winters, the nutrition level is not adequate to maintain condition, and reproductive performance suffers. In general, moderate production levels in the cow herd are what most Kentucky operations can sustain.

To achieve the level of production that is desired, a combination of breed selection and bull selection within the breed can be utilized. Selection can be based on heritable traits, such as growth, while crossbreeding enhances lowly heritable traits such as reproduction. Figure 6-6 shows the relative importance of both selection and crossbreeding in an improvement program. Do not think that if you use crossbreeding you no longer need to buy good bulls. Conversely, do not think that buying good bulls will offset the benefits of crossbreeding. Crossbreeding and selection are complementary and should be used in tandem in commercial herds (see Figure 6-7).

Crossbreeding Systems

Crossbreeding systems must be planned for each operation, depending on herd size, potential market, level of management, and facilities. A long-term plan is necessary to gain maximum benefits from crossbreeding. The advantages and disadvantages of various crossbreeding systems are listed below.

Two-Breed Terminal Cross

This system uses straightbred cows and a bull of another breed. It is considered a terminal cross because all calves are sold and no replacements are retained. An example would be Charolais bulls bred to Angus cows. In this system, replacements must be bought from another source. This is not a desirable system because it does not realize any heterosis in the cow since she is a straightbred (Figure 6-8).

Three-Breed Terminal Cross

This system uses a two-breed cross (F1) cow and a bull of a third breed. It produces maximum hybrid vigor in the cow and calf. This is an excellent system because hybrid vigor is realized for the calf directly and through maternal traits of his crossbred dam. Replacement females for this system must be purchased or raised from another source. This is a good system for any size herd if high-quality replacement females are available.

Two-Breed Rotation or Crisscross

This is a simple crossbreeding system involving two breeds and two breeding pastures. A two-breed rotation is started by breeding cows of breed A to bulls of breed B. In each succeeding generation, replacement heifers are bred to bulls of the breed that is the opposite of their sire (see Figure 6-9). Two breeds of bulls, and a minimum of two breeding pastures, are required after the first two years of mating.

Three-Breed Rotation

This system follows the same pattern as the two-breed rotation, but a third breed and pasture are added (Figure 6-10). The three-breed rotation maintains a higher level of hybrid vigor than the two-breed system. Mating plans can be confusing, but individual cows are not moved from one breeding group to another. Three distinct groups of cows are eventually created, and they are mated to the sire breed to which they are least related. This scheme continues for the life of the cow.

Rotational-Terminal Sire Combination

This system involves the use of rotational mating of maternal breeds (breeds A and B) in a portion of the herd to provide replacement females for the entire herd (Figure 6- 11). The older crossbred

Figure 6-7. Role of selection and crossbreeding in determining level of performance.

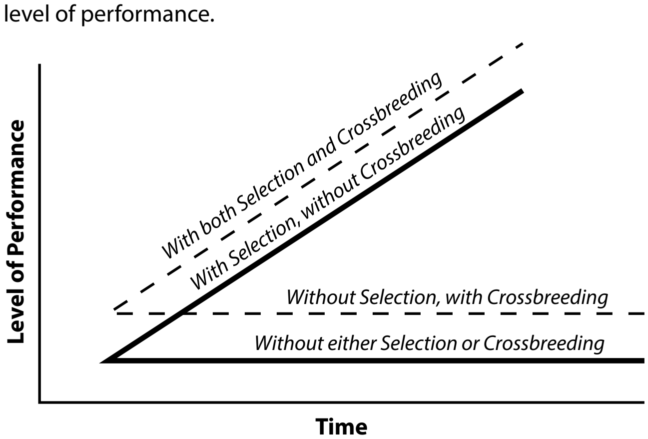


Figure 6-8. Terminal cross.

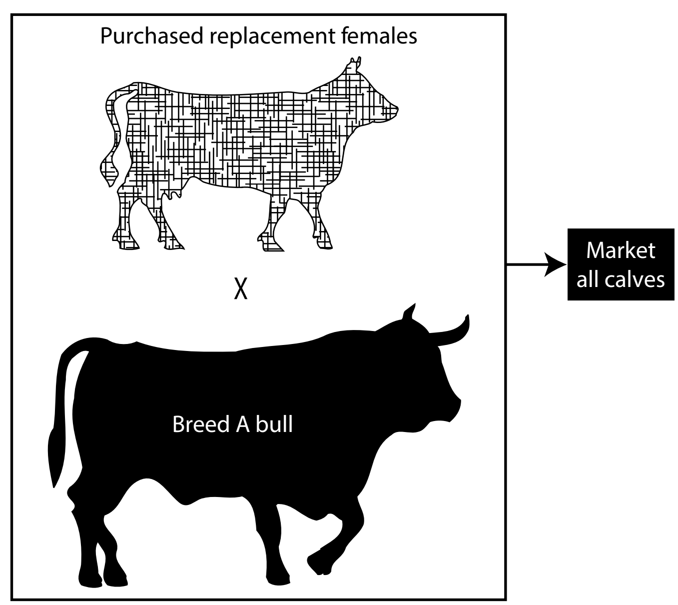


Figure 6-9. Two-breed rotation.

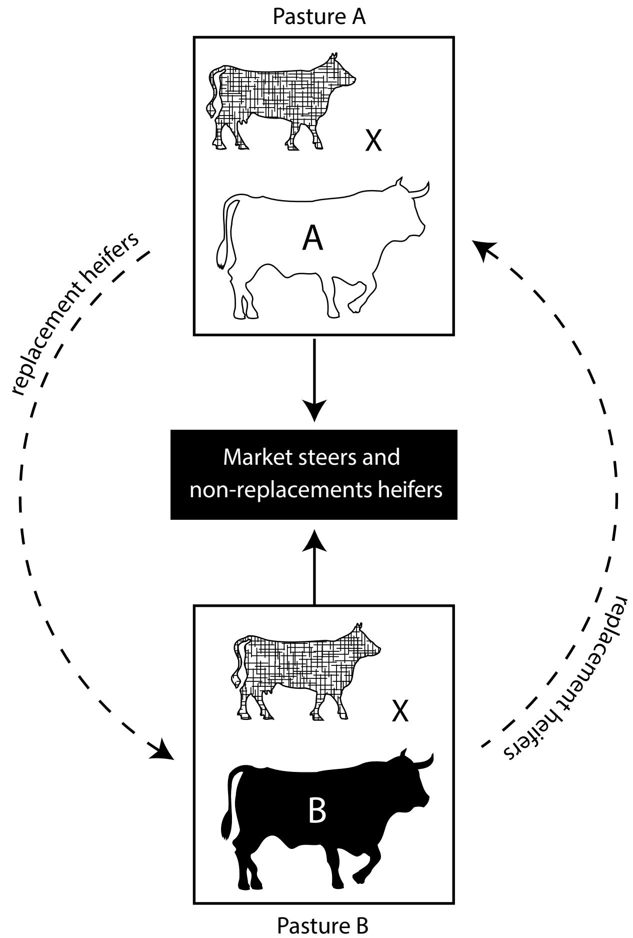
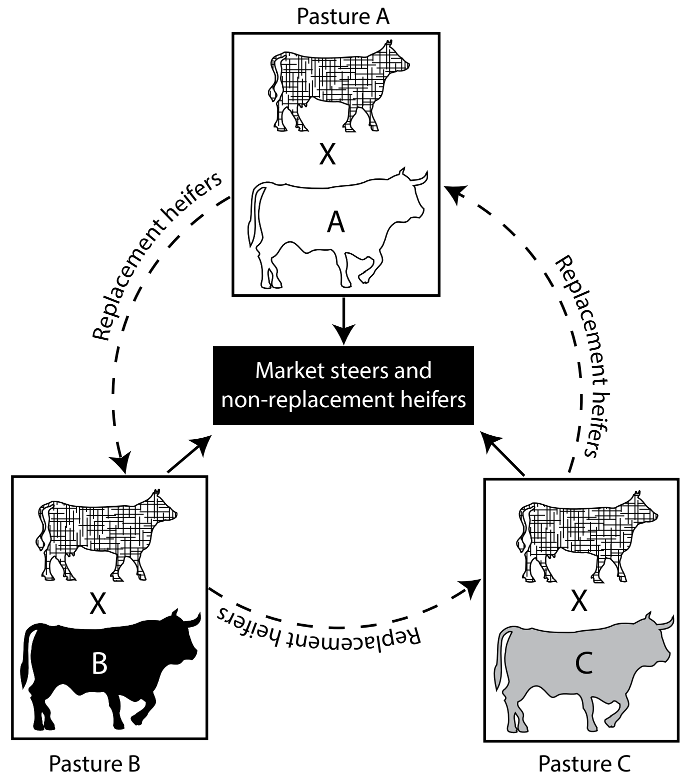


Figure 6-10. Three-breed rotation.



cows are then mated to the terminal sire breed (Breed C). All of the terminal cross offspring are marketed. This system maintains a high level of production but also requires a high level of management.

Heifers out of Heifers

This is a specific example of a rotational-terminal sire combination. There is no foundation to the argument that you should not keep a heifer out of a heifer. In contrast, this system is one of the best available to maximize efficiency. In herds that have more than one bull or where AI is a possibility, this is a productive crossbreeding system. Breed all heifers and enough younger females to total about two-and-a-half times the number of replacement females you plan to keep the next year to an easy-calving, maternal bull. For example, if 10 replacement females are desired the following year, breed 25 heifers and young females to the bull. Select all replacement heifers out of this group of calves. Breed the rest of the herd (older cows) to a high growth, heavy-muscled terminal bull, and market all of the calves (refer to three-breed terminal cross). This system allows the producer to get easy calving in the first-calf heifers and good maternal characteristics in the replacement heifers and to maximize growth and muscling in the majority of the feeder calves. The only drawback is the nonconforming steers out of the heifers and young cows, but the benefits are typically worth it.

AI Roto-Terminal

This system usually uses a very strict synchronization program, and all cows and heifers are mated to a maternal-type/heifer-acceptable bull, using artificial insemination (AI). All cows (excluding virgin heifers, unless the terminal bull is also heifer acceptable) are then exposed to a terminal type bull (Figure 6-12). Virgin heifers that do not conceive by the first mating can be inseminated a second time, or a larger number of replacements will need to be retained through pregnancy testing each year. Heifers are only retained from the AI matings.

Modified Crossbreeding

In many herds, the facilities and level of management required to use intricate crossbreeding systems are not available. However, with some modification, you can use some of the basic crossbreeding principles. Here's how to simplify the traditional systems:

Purchase crossbred females. This is the simplest and fastest method of obtaining maximum hybrid vigor. Purchased two-breed cross females can be bred to a terminal sire of a different breed; this maximizes both individual and maternal hybrid vigor. The producer needs an available supply of high-quality, disease-free females.

Use bull-breed rotation. This involves using a bull of one breed for a set number of years (recommendation of four years), then rotating to a different breed of bull.

If a balance between good feeder calves and good replacement heifers is desired, switching between breed types is also desired. In other words, use a British breed bull for four years, then switch to a Continental breed for four years, then switch back to the original breed. Try to save a larger number of replacement heifers in years that a maternal-type bull is used. Only one breeding pasture is required, and replacement heifers are generated within the herd. This system sacrifices some hybrid vigor when compared to a two-breed rotation, but it is simple and practical for many producers.

Selection

Selection refers to the breeder's decision to use some animals as parents and to cull others. For selection to be most effective, breeders must be able to identify superior animals. This is done by placing emphasis on economically important traits that are heritable (see the "Genetic Principles" segment of this chapter). "National Cattle Evaluations," which compute genetic information (Expected Progeny Differences) on various traits, are available from most breed associations and are useful in making selection decisions. By using AI, the average producer can select a bull of proven breeding value from the "national" herd rather than using one of lesser quality, but this is not required to get good quality bulls.

Bull Selection

Bull selection is one of the most important decisions you will make as a cow-calf producer. The bull is generally thought of as "half the herd" because he contributes half the genetic makeup to each calf crop. However, in herds where replacement heifers are retained, approximately 87.5% of the genetic makeup of each calf comes from the last three generations of bulls used. Therefore, the importance of selecting bulls genetically suited to your operation cannot be overemphasized.

The first decision to make when selecting a bull is which breed or breed type to use. Producers usually have strong feelings about the merits of their favorite breeds of cattle. However, no breed

Figure 6-11. Rotational-terminal combination.

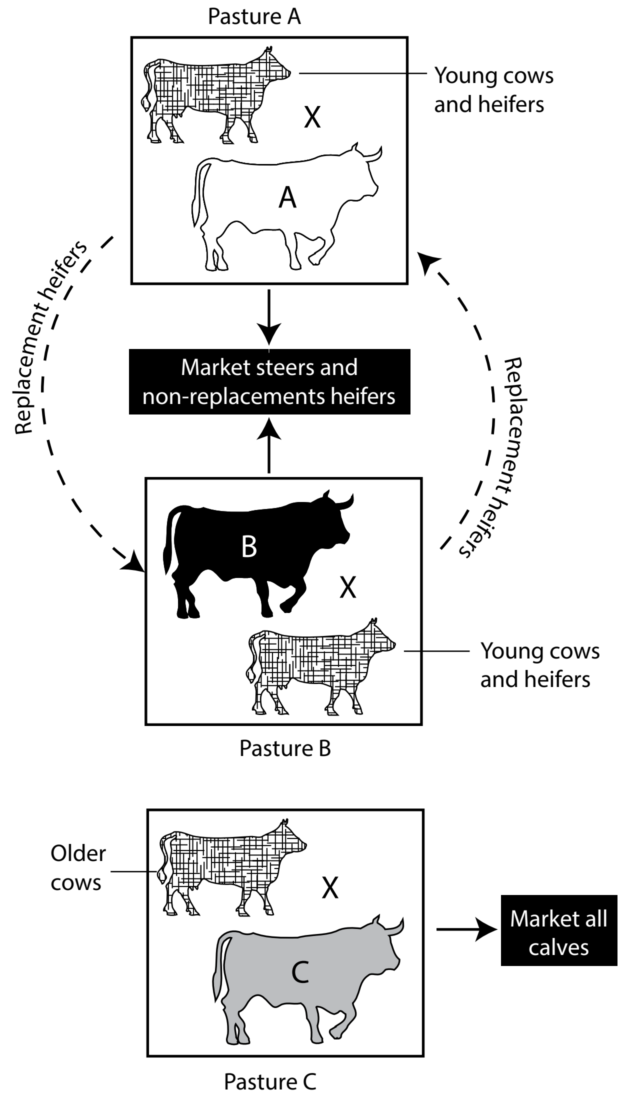
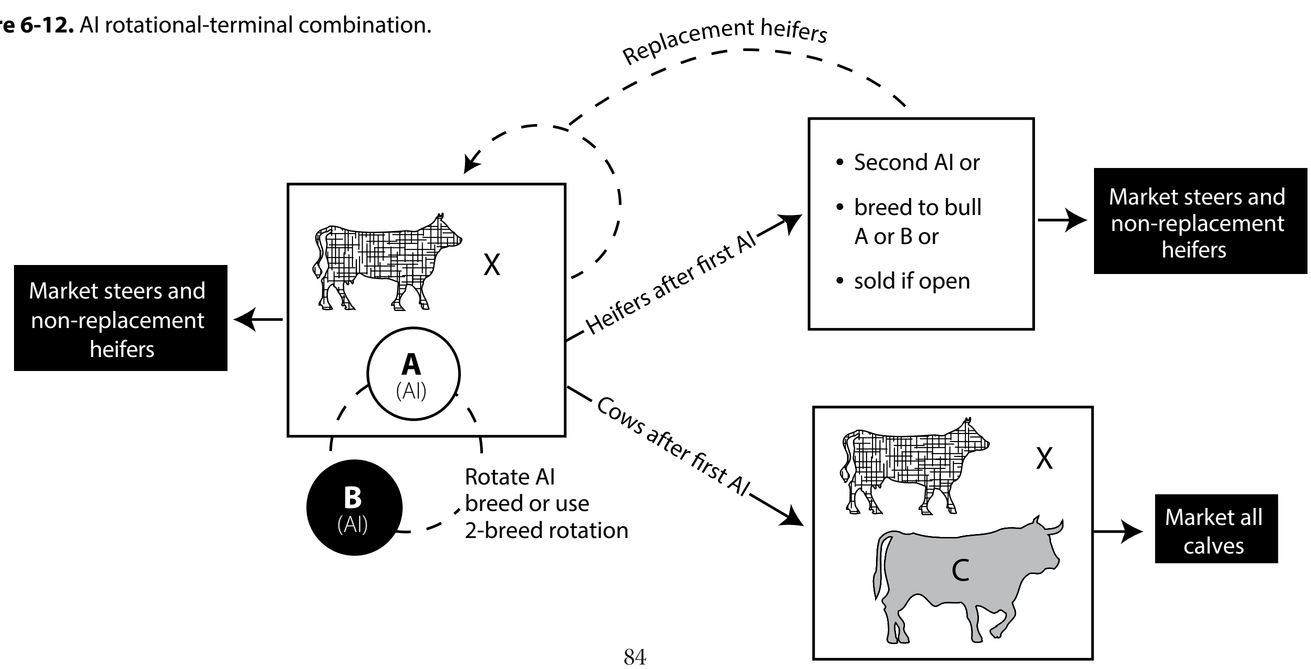


Figure 6-12. AI rotational-terminal combination.



excels in all traits. It is important to know the relative strengths and weaknesses of various breeds so you can plan mating systems in which breeds complement each other and fit your environment.

Knowledge of some general characteristics of breed types is helpful in planning. British breeds (those that originated in the British Isles, such as Angus and Hereford) generally have good fertility, good disposition, moderate birth weights, moderate to high growth and mature size, and grade well at acceptable finish weights. Continental breeds derive from two primary uses; meat and milk (such as Simmental and Gelbvieh) or meat and work (such as Charolais and Limousin). These breeds can have heavier birth weights, are fast growing with large mature size and tend to have leaner carcasses unless fed to heavier weights. The meat-milk breeds tend to have extreme amounts of milk and the meat-work breeds tend to be lighter milkers, are leaner and reach puberty at later ages. American breeds (primarily of Brahman origin) are moderate in growth traits and have better heat tolerance and longevity than other breed types, but can have difficulty reaching puberty at an acceptable age when a high percentage of Brahman breeding is used.

Select a breed or combination of breeds to use in your beef program based on the following:

- Goals of your operation
- Marketability in your area
- Cost and availability of good seedstock
- Climate
- How breeds complement each other
- How breeds fit your environment
- Personal preference

Table 6-3 indicates the level of production of some breed crosses, based on growth rate and mature size, lean-to-fat ratio, age at puberty, and milk production.

A sire breed in a crossbreeding program might have the following characteristics: rapid growth rate, moderate to thick muscling, and adequate calving ease. A dam breed might have these characteristics: high fertility, good milking ability, and small to medium mature size. Since no breed possesses all of these characteristics, some compromises must be made when selecting breeds for a crossbreeding program.

Table 6-3. Some breed crosses grouped into production types.

Breed Group	Growth Rate and Mature Size	Lean-to-Fat Ratio	Age at Puberty	Milk Production
Jersey	+[1]	+	+	+++++
Angus	+++++	++	++	+++
Hereford	++++	++	+++	++
Red Poll	++	++	++	++++
Shorthorn	++++	++	++	+++
Tarentaise	+++	+++	++	+++
Pinzguaer	+++	+++	++	+++
Brahman	++++	+++	+++++	+++
Braunvieh	+++	++++	++	++++
Gelbvieh	++++	++++	++	++++
Simmental	+++++	++++	+++	++++
Maine Anjou	+++++	++++	+++	+++
Limousin	+++	+++++	++++	+
Charolais	+++++	+++++	++++	++
Chianina	+++++	+++++	++++	+

[1] + = low, +++++ = high

Source: Encyclopedia of Animal Science – Beef Cattle: Breeds and Genetics. Cundiff, 2003. Angus Growth Rate and Mature Size modified by Bullock 2019, based on MARC data.

Once you have chosen a breed, it is time to select a bull within that breed. Use four basic criteria when selecting a bull: structural soundness, reproductive soundness, performance information, and visual appraisal.

Structural Soundness

Structural soundness is important if bulls are to travel distances to keep up with cows and be able to mount them (especially if they are expected to breed a large number of cows in a short time). Beware of the following problems: rear legs that are too straight (post legs), rear legs too close at the hocks with too much angle (cow hocked), corns, and abnormal hoof growth (evidence of founder). Structural soundness should be assessed in regard to its impact on function; a minor flaw that will not affect a bull's performance should not be grounds for overlooking the bull. Structure is a heritable trait, so a bull with poor structure can pass this undesirable trait to his daughters and if they are retained as replacements it may decrease there longevity. If the bull is going to be used in a strictly terminal system (no heifers retained), less emphasis can be placed on physical soundness, but it cannot be ignored.

Reproductive Soundness

Reproductive efficiency is best measured at this stage by a breeding soundness evaluation (BSE). (For a complete discussion, see Chapter 5: Managing Reproduction). A bull should have passed his BSE, or the seller should be willing to guarantee that he will before you proceed with the selection process.

Performance Information

When purchasing a herd bull, emphasize the genetics that animal will pass on to its offspring, not on how that animal performed. There are three pieces of information that can be used to evaluate bulls based on performance: actual measurements, contemporary group ratios, and Expected Progeny Differences (EPD).

Actual or Adjusted Measurements

The easiest method of performance evaluation is simply comparing animals' actual or adjusted measurements. Unfortunately, this is a poor method of performance evaluation because the environment contributes largely to the animal's measurement. Raw or even adjusted figures on most economically important traits are not very valuable in bull selection. For example, if you are considering a bull and all you know is that he had a weaning weight of 600 pounds, you do not have much information to base your selectin decision. He could have been raised by a heifer on drought-stricken pasture and have superior pre-weaning growth genetics, or he could have been raised by a mature cow on lush pasture with plenty of creep feed and actually have poor genetics for pre-weaning gain. Environmental conditions play a large part in a calf's actual measurements but have no effect on their future offspring. Selecting cattle based on actual or adjusted measurements should be the last alternative, and information on environmental conditions should not be ignored.

Contemporary Group Ratios

A contemporary group ratio is calculated by dividing a calf's measurement (adjusted for age of dam, age of calf, etc.) by the average adjusted measurement of the group of same-sex calves with which it was raised, and multiplying by 100. This means an average calf in the group would have a contemporary group ratio of 100, calves with larger than average measurements would have values greater than 100, and calves with smaller measurements would have values less than 100. A weaning weight contemporary group ratio of 113 indicates the calf is 13% heavier than the average of the group with which it was raised. However, a contemporary group ratio of 113 on one farm may be entirely different from a contemporary group ratio of 113 on another. Therefore, contemporary group ratios should not be used to compare cattle from different locations or cattle raised under different conditions on the same farm. Contemporary group ratios are the best alternative when EPDs are unavailable but are not a reliable piece of information for making an informed genetic decision.

Expected Progeny Differences

The best way to determine breeding values for economically important traits is by using Expected Progeny Differences (EPDs). EPDs are computed using the bull's measurement along with measurements from any relatives. Additionally, EPDs account for differences in environmental (management) conditions. Therefore, EPDs are a predictor of the genetics that a bull will pass on to his offspring, which is what we are interested in when we are buying a bull. The difference in EPDs of two animals of the same breed indicates the expected differences in the average performance of the offspring of those animals. For example, if bull A has a weaning weight EPD of +60 pounds, and bull B has a weaning weight EPD of +40 pounds, and they are mated to a large number of comparable cows, under similar environmental conditions, a 20-pound difference between the average weaning weights of their calves would be expected (60 pounds - 40 pounds = 20 pounds). In other words, calves sired by bull A would weigh 20 pounds more at weaning on average than calves sired by bull B, due to genetics for increased growth to weaning. It is likely some calves sired by bull B would weigh more than some calves sired by bull A, but on average, calves sired by bull A would have a weight advantage. EPDs can be either positive or negative for the measurement in question. They are easily used to make comparisons among cattle but in most cases can only be used to compare animals of the same breed.

An additional use of EPDs is to get an indication of how a bull ranks within his breed. Charts are available from each breed that show how a bull ranks within the breed based on his EPDs. Having knowledge of how a breed performs on average and knowing how a bull's calves will perform can assist in matching a bull to your management and resources. In general, EPDs are a risk-management tool and are not a perfect science. If you use EPDs for selection purposes, you can purchase bulls that do not perform as expected, but this will happen far fewer times than if you use other means of selection for performance. It is important to use EPDs alone and not in conjunction with the bull's recorded measurements or ratios. By using EPDs in combination with other measurements, you actually reduce its effectiveness as a selection tool.

Traits available for comparison vary from breed to breed. They usually include some of the following: calving ease direct, calving ease maternal, birth weight, weaning weight, milking ability (expressed as pounds of weaned calf), yearling weight, and carcass traits (hot carcass weight, fat thickness, ribeye area, and marbling score). Other traits for which EPDs are offered on some breeds are yearling hip height, mature hip height, mature weight, scrotal circumference, stayability (measure of longevity), docility, and others. The following are descriptions and implications of selection of some commonly used EPDs (not all breeds provide all the EPDs listed).

Calving Ease or Calving Ease Direct EPD

The difference in two animals' calving ease EPDs indicates the average percentage difference in calving difficulty in first-calf heifers bred. In all breeds, larger numbers indicate greater calving ease.

Implications: This is the best EPD to use in trying to reduce calving difficulty. It is recommended this EPD *not* be used in conjunction with birth weight EPDs or the bull's actual birth weight because those factors have already been taken into consideration when calculating this EPD.

Calving Ease Maternal or Maternal Calving Ease

This EPD measures the calving ease of an animal's daughters. Larger values indicate a greater likelihood that an animal's daughters will have less calving difficulty.

Implications: High calving ease maternal EPDs on a bull does not indicate that he is an easy-calving (heifer-acceptable) bull; it means his daughters should be easy-calvers. To determine an easy-calving bull, use the calving ease direct, not calving ease maternal.

Birth Weight EPD

Differences in this EPD reflect differences in the average birth weight of the two animals' offspring.

Implications: Birth weight is genetically correlated to calving ease and growth in cattle. When a calving ease EPD is available then the birth weight is of no additional value, but if the breed does not have a calving ease EPD then the birth weight EPD can be used as an indicator trait. Bottom line, if a calving ease EPD is available, it is a better indicator of potential calving difficulty and should be used instead of the birth weight EPD.

Weaning Weight (Direct or Growth) EPD

This EPD measures the genetic contribution of the parent to weaning weight with no consideration to milk. In other words, differences in weaning weight direct EPDs indicate the average genetic potential differences of the calves to grow to 205 days, assuming milking ability of the dams is the same.

Implications: Weaning weight direct is genetically correlated with calving ease, mature weight and milking ability. As weaning weight direct goes up, calving ease usually goes down, mature size goes up, and milking ability usually decreases. However, yearling weight is usually increased.

Milk (Weaning Milk or Maternal Milk) EPD

The terminology for this trait is different among the breeds but refers to the expected milking ability of a parent's daughters in pounds of weaned calf. A bull with a 10-pound advantage in weaning weight milk EPD should produce daughters that raise calves that average 10 pounds heavier due to the increased milking ability of their daughters. Bulls with higher weaning weight milk EPDs sire daughters with an advantage in milking ability and/or maternal ability.

Implications: Milking ability is genetically correlated with growth traits. As milking ability goes up, the genetic potential for growth often goes down. Avoid extremes in this trait, particularly in breeds known for superior milking ability. It is easy to produce too much milk for the level of nutrition that is being provided. If this happens, cows lose condition, which results in increased feeding or loss of reproductive performance, either of which decreases the economic potential for the herd.

Weaning Weight Maternal (Combined or Total Maternal) EPD

This EPD is simply half the weaning weight direct EPD plus the weaning weight milk EPD. This measures the daughter's ability to raise a calf to weaning (205 days), regardless of whether the growth comes from genetics for growth or milk.

Implications: Most producers know whether they need to increase the milking ability or the growth potential of their herd and should focus on the point of need.

Yearling Weight

This EPD measures genetic differences in weight at 365 days. This EPD becomes more important than the weaning weight EPD when the marketing endpoint is postweaning.

Implications: Yearling weight is unfavorably correlated with calving ease and milking ability. Yearling weight is also highly correlated with mature weight. The mature size of your cow herd will increase and milking ability will likely decrease if you select for increased yearling weight and retain replacement heifers.

Fat Thickness EPD

This is a carcass trait EPD that indicates leanness. Lower values indicate less external fat cover, which reflects a more desirable yield grade.

Implications: Use extreme caution if you use this EPD when replacement heifers will be retained. A reduction in fat thickness, while beneficial to carcass value, can cause a reduction in fleshing ability and a loss of reproductive performance in replacement heifers if bulls with extremely low values are used.

Ribeye Area EPD

This is the best easily measured indicator of muscling. Ribeye area is a factor in calculating yield grades, with larger ribeyes contributing to a more desirable grade.

Implications: Extremes should be avoided in this trait. Even though larger ribeyes produce more desirable (lower) yield grades, there is a limit to how large of rib eyes we should be producing. Because cattle can be variable in muscle expression, this EPD should be used in combination with visual appraisal for muscling through the quarters.

Marbling Score EPD

This trait has the largest role in determining the quality grade of carcasses. Larger values indicate more marbling (flecks of fat within the lean of the ribeye), which results in higher USDA Quality grades (USDA Prime and Choice; see Chapter 9: The End Product). Each whole number difference reflects one marbling score difference. Therefore, an advantage of 0.5 marbling score EPD indicates progeny by that bull should grade 50 degrees better on average.

Implications: When marketing calves "on the rail," this trait can be important because quality grade is a large factor in carcass pricing. If a producer is not receiving a premium for high-quality carcasses, this trait should not be overemphasized.

Percent Intra-Muscular Fat (IMF) EPD

This measurement is similar to the marbling score EPD; however, it is determined using ultrasound data. This EPD should be used in the same manner as the marbling score EPD, with higher values indicating animals that should produce progeny that will have better USDA Quality grades.

Implications: Same as marbling score EPD.

Mature Weight and Height EPDs

This is an indicator of mature size of an animal's daughters. Mature weight is adjusted to a condition score 6 basis. In other words, differences in this EPD reflect the mature (five to 11 years) weight differences of daughters with a condition score of 6. The mature height EPD reflects the differences in inches of the animal's daughters at maturity.

Implications: Larger cows are typically less efficient in producing pounds of calf per acre than smaller, more moderate cows. This EPD allows producers to have direct control over the mature size of their cow herd. If these EPDs are not available, the best alternative is to select for moderation in yearling weight EPD because mature size and yearling weight are closely correlated.

Scrotal Circumference EPD

Differences in scrotal circumference are reflected in the average scrotal circumference of an animal's bull calf crop.

Implications: Breeders of seedstock can use this EPD to increase scrotal circumference of bulls they plan to market since scrotal circumference is an indicator of sperm production and serving capacity. For practical purposes, this EPD should be ignored by commercial producers, and emphasis should be placed on the bull's actual scrotal measurement. This is because an actual measurement of scrotal circumference is an indicator of that bull's serving capacity, and his scrotal circumference EPD is an indicator of how large his bull calves' scrotal circumference will be. In commercial operations, we are concerned with how many cows a bull can breed, but the bull calves will be castrated so the size of their testicles is irrelevant.

Heifer Pregnancy Rate EPD

Heifer pregnancy EPDs estimate differences in daughters' ability to conceive to calve as a two year old. Just like the stayability EPD, heifer pregnancy EPDs are expressed in terms of a percentage difference. For example, two heifer pregnancy EPDs, 5 and 10, differ by 5%. Daughters of the bull with the EPD of 10 are 5% more likely to conceive than daughters of the other bull, assuming both sets of daughters are raised and managed in the same environment.

Implications: Selecting bulls with higher heifer pregnancy EPDs should result in better pregnancy rates in the herd over time. However, because reproductive traits are lowly heritable, there is very little variation or spread between bulls for this EPD, and progress toward a noticeable change will take several generations of selection.

Stayability EPD

These EPDs are the prediction of the genetic differences between daughters' probability of staying in the herd to at least the age of six years.

Implications: Selecting bulls for higher stayability values should increase the longevity of his daughters that are selected as replacements. In other words, a bull with a higher value for stayability EPD should have a higher percentage of his daughters remaining in the herd to at least age six.

Docility EPD

These EPDs expressed as a difference in yearling cattle temperament, with a higher value indicating more favorable docility. Docility is not an indicator of the bull's behavior, which must be evaluated independently, but rather is an indicator of the potential behavior of his calves. It is still important to handle cattle properly to insure good disposition, regardless of their Docility EPD.

Implications: Selecting bulls for higher docility values should increase the calmness and behavior of his calves. However, it is important to remember that the cattle must still be treated calmly and gently to get the desired result.

Table 6-4. Example of performance information on various bulls.

	Calving Ease		Weaning Weight		Yearling Weight		Maternal Milk	
SIRE	EPD	ACC	EPD	ACC	EPD	ACC	EPD	ACC
A	6	0.70	+50	0.85	+90	0.80	+26	0.75
B	15	0.70	+30	0.90	+ 72	0.85	+30	0.80
C	3	0.70	+60	0.80	+110	0.75	+15	0.70

Accuracy Values

An accuracy value (ACC) is given for each EPD calculated and is a measure of the reliability of that EPD. EPDs are never perfect, and as more information is obtained on an animal, the EPD value may change, either up or down. Accuracy values indicate the likely maximum amount an EPD may change with new information. EPDs, regardless of their accuracy values, are the best available estimate of an animal's genetic merit.

Accuracy values range from 0.00 to 1.00. As accuracy increases, the amount of possible change in an EPD related to added information becomes smaller. These ranges of possible change are both trait- and breed-specific. For a correct range of possible changes in EPDs, obtain a sire summary for the breed in which you are interested.

Young bulls (which always have relatively low accuracy) are usually purchased, and any offspring produced are crossbred or non-registerable calves. Therefore, the bull's accuracy will likely remain low unless the bull has been genomically tested, which greatly improves his accuracy (see Molecular Technologies section later in this chapter). Even low accuracy EPDs are the best available indicator of a bull's progeny's potential performance.

Expected progeny differences are useful to both seedstock and commercial producers. Beef breeders can use records to mate the "best to the best," or, perhaps more important, cattle producers can use this information to select the right bull to use on a particular cow or set of cows based on their weaknesses or strengths. For example, a commercial producer selecting a bull to breed to first-calf heifers can use calving ease direct EPDs to choose a bull that will minimize calving problems, while maintaining an acceptable level of growth and milk. EPDs allow you to make genetic change or maintain current production that is appropriate for your production goals and environment.

It is helpful to understand how each economically important trait responds to selection based on performance information (EPDs). Table 6-2 summarizes these correlations.

Table 6-4 gives information on three bulls with different performance data. Assuming all bulls are structurally and reproductively sound and visually acceptable, which bull would you select? If your only priority is to maximize growth, select bull C. If your priority is calving ease (breeding heifers) and improving milk, select bull B. If your priority is improving growth and improving milk while maintaining calving ease, select bull A. Bull selection is an individual decision based on producer needs. The best bull for one producer may not be the best bull for another.

Economically Relevant Traits

Recent emphasis in genetic evaluations has been to determine economically relevant traits (ERT) for analysis. The purpose of this effort is to provide producers with EPDs that more closely reflect economic impact on their herd. A good example is the birth weight and calving ease direct EPDs. The birth weight EPD in itself has no economic impact to a producer because calves are not sold by the pound at birth. Instead, it is used as an indicator for calving ease, which has a major economic impact. Therefore, most breeds have developed EPDs for calving ease direct so that the actual trait of economic importance can be selected for. This does not mean that seedstock producers should stop collecting birth weights or other traits that do not have direct economic impact because these traits contribute information for computing the EPDs of the economically relevant traits.

Selection Indices

Selection indices have been available for beef producers for several decades but have not been widely used. In general, selection indices allow producers to make selection decisions for several traits simultaneously based on their economic relevance. In other words, an equation is developed, and each trait is weighted according to its economic impact. A bull's EPDs can be entered into the selection index equation, and a single number is generated based on that bull's ability to pass value to his offspring. For example, the following index might be used (this is only a sample index and should not be used in practice):

I = 3*CE + 2*CW + 3*MARB - 1*FAT

Traits	Bull A	Bull B	Bull C
CE	5.0	1.3	-2.5
CW	15	10	15
MARB	0.5	0.4	0
FAT	0.7	-0.3	-0.5

I = index value
CE = Calving-Ease Direct EPD
CW = Carcass Weight EPD
MARB = Marbling EPD
FAT = Fat Thickness EPD

The index values would be:
Bull A (I) = 3*(5.0) + 2*(15) + 10*(.5) - 3*(0.7) = 47.90
Bull B (I) = 3*(1.3) + 2*(10) + 10*(1.0) - 3*(-0.3) = 34.60
Bull C (I) = 3*(-2.5) + 2*(15) + 10*(0) - 3*(-0.5) = 24.00

With this example, Bull A would be the bull of choice because he was the highest indexing. This would indicate that Bull A would produce the most profitable calves based on this index. On average Bull A's calves will have $13.30 more value than Bull B's calves ($47.90 - $34.60 = $13.30) and $23.90 more value than Bull C's calves. One important thing to remember is that all indices do not fit all producers. In this example, the calves would be used in a terminal retained ownership program. For a producer who was breeding heifers and the calves were marketed at weaning, this index would have little value and could actually be detrimental. The other important aspect of indices is that the values should be weighted according to economic value, not hunches or guesses.

The problem with selection indices is that they are typically too general and do not perfectly fit an individual's operation. When a selection index is developed, certain assumptions have to be made that may or may not be correct for an individual operation. Additionally, when indicator traits are used rather than ERTs, there is more opportunity for error.

Currently there is not a good system available in the United States for developing indices that are custom made for individual producers. However, most breeds have developed generalized indices. Just as EPDs are not a perfect science, selection indices are not exact, and the opportunity for breeding mistakes still exist. However, they will allow beef producers to select bulls based on their total economic impact if the index matches their management and marketing plan.

Visual Appraisal

Many traits of importance, including body capacity, thickness, etc., are not measured by EPDs. Also, visual inspection is necessary to determine the structural soundness of a bull. Even with all the advanced technologies, visual appraisal is a necessary step of bull selection. The following traits are some that may be considered for visual appraisal.

Temperament

The excitability of cattle is of great concern to many producers. If having calm cattle that are easily handled is a selection priority of yours, then spend time locating a bull with a good disposition. Temperament is heritable, so parents with a good disposition usually have calves with a good disposition. Many breeds now offer Docility EPDs that will assist in selecting bulls that should pass good disposition to their offspring; higher values indicate better disposition.

Two types of disposition problems are cattle that try very hard to avoid human contact and cattle that try to make direct human contact. When evaluating bulls, you should move around the cattle, on foot, at a safe distance and in close proximity to shelter if needed. Cattle that try to avoid human contact are generally on the far side of the group with their head held very high. As you move around, they will always keep themselves positioned on the opposite side of the herd. They also appear nervous and make quick, excited movements. Aggressive bulls are usually easily identified as the bull on the front side of the group that is very excited; he always faces you and may challenge you when approached.

Temperament can cause problems because of increased health risk to humans, equipment damage and injuries to other livestock. Poor temperament has been shown to decrease cattle performance and it adversely affects carcass quality. Both types of disposition problems are very dangerous, and bulls exhibiting these behaviors should not be selected.

Body Capacity

Since cattle are foragers and usually deliver a 70- to 100-pound calf, adequate body capacity is needed for the animals to consume enough nutrients for maintenance and growth. Body capacity is determined by the length and depth of body and spring of rib.

Muscling

The bull should be well muscled, which is plainly evident in a large, bulging forearm and thickness in the round. Careful evaluation should be made to determine whether thickness is due to true muscling or fat deposits. Bulls with a wide base or stance that are rounded over the top-line and thick through the lower hindquarter (stifle region) are typically well conditioned and heavy muscled. Narrow-based bulls that are flat over the top-line yet show good thickness through the hindquarter are typically fat and may even be light muscled. Location of muscling can be important. It is best if the bull has most of his muscling along the top-line and in the round. Since the most expensive cuts are toward the rear, heavy-fronted feeder calves are not desired.

Condition

Bulls should have adequate condition but should not be overfat. They should have a comparable body condition score of a 5 or 6.

Testicular Development

Testicles should be measured and be of acceptable size (see Chapter 5: Managing Reproduction, for more information on scrotal circumference). Additionally, they should be observed to determine if they are developed properly and if they are of similar size and have proper suspension. There will be slight variation in the size of the testicles of a bull, but large differences should be avoided.

Frame Size

If performance information is not available for frame size (or hip height), evaluate this trait visually. Remember, large frame bulls produce large frame calves, which are desirable as feeder calves, but will result in larger replacement females that can be more expensive to maintain.

Bull Selection Summary

If you are purchasing a bull in a sale, decide which bulls you like and how much you are willing to pay before the bidding starts. Do not sit back and see how they are going to sell and let the bull that is right for you get away. Do not make your selection decisions in the time it takes an auctioneer to sell a bull. Study the performance information ahead of time, and arrive at the sale site early enough to allow adequate time to evaluate the bulls. Any bull that does not appear "on paper" to be of potential benefit to your cow herd should be eliminated from further consideration, regardless of price or the appearance. Fads in the cattle industry are usually short-lived, and "bargain" bulls are often economic disasters in the end.

Sire selection continues after you purchase the bull. Observe the bull closely during the first few weeks of the breeding season to see if he is willing and able to mate with the cows. Bulls with a high libido (sex drive) and high fertility sire the early calves. Also, observe cows for return to heat after mating to see if they conceive. Your final step is to annually evaluate each bull's progeny. If the bull's calves are acceptable and the bull continues to pass a BSE, retain him. If the bull's calves are unacceptable, if the bull fails his BSE, or if a breed change is necessary to maintain heterosis, replace him.

Heifer Selection

Heifer selection is also important for commercial producers, but heifer selection is an easy task if proper sire selection is practiced. When replacement heifers are to be retained, bull selection cannot be overemphasized. Selection should include maternal ability, mature size moderation (particularly frame size), and calving-ease maternal, if available. From the resulting heifers, selection should be based on physical structure, body capacity, and likelihood of reaching puberty by the next breeding season (older heifers that are closer to their target weight are more likely to be ready to breed). Pelvic areas measurements can also be useful to cull heifers with undersized or misshaped pelvises (see Chapter 5: Managing Reproduction) If purchasing replacement heifers, knowledge of their sire or the reputation of the breeder is desirable.

Cow Culling

Cow culling plays a small role in the genetics of your herd and should be based solely on economic considerations. The following are likely reasons to cull cows: open, consistently poor calves or underperforming calves based on production records (young cattle—two- and three-year-olds—should not be expected to perform at the level of older cows), structural defects, or disease (see Chapter 7: Health and Management Techniques). Unusual situations in the market can alter normal culling procedures, but favorite cows that do not perform should not be kept.

Molecular Technologies

Biotechnologies have made many advances in recent years, and they are having a major impact on beef production. Most people are familiar with molecular biology used in criminal investigations that link hair, blood, or semen samples at a crime scene with a suspect. The basic principle is that every cell in an individual has the same genetic code as every other cell in that individual, and no two individuals have the exact same genetic code (with the exception of identical twins and clones).

Genomics and the corresponding Marker-Assisted or Genomic-Enhanced EPD, have become a reality. Within-breed genomic predictions based on over 50,000 markers (50K SNiP Chip) have proven to add accuracy to EPDs, particularly young bulls, for many traits. Tables 6-5 and 6-6 show the equivalence of information gained from a genomics test and the number of progeny that would be necessary to provide the same amount of genetic information on that animal from two different genetic evaluation sources. The push going forward will be the adoption of this technology by all breed associations and the development of methodology related to the use of this technology in crossbred and composite cattle. The benefit of this technology is increased EPD accuracy and the payoff to seedstock producers must come through commercial producers' willingness to pay for higher accuracy, which in turn means less risk. There is still a need to collect and routinely record phenotypic information by seedstock producers. Commercial producers need to realize that EPDs, and economic index values are the proper selection tools to be utilizing; molecular technology only makes these tools stronger, it should not replace them.

Genetic Defects Testing

In recent years several genetic defects have surfaced in several breeds. Because of molecular technologies the source of these defects have been identified and test developed to find carriers of the defective alleles. For more information on genetic defects in beef cattle, please go to https://ebeef.ucdavis.edu/ and search for "genetic defects."

Blood Typing or Parental Testing

Genomic information can provide a means of determining if an animal is from a specific mating or by a specific sire. For genetic evaluations to be correct, it is important that parentage is exact. In one-bull units, this is typically not a problem unless a bull jumps a fence. However, in range breeding conditions, there are often multiple bulls in a pasture-mating situation. If correct parentage cannot be determined, the calf crop is excluded from the genetic evaluation, or if submitted incorrectly the EPDs computed will be less precise. This technology typically is not of importance to commercial producers but can have some usage for seedstock producers.

Homozygosity Testing

The genetics for color and horned/polled are very important for many beef producers. Knowing if a bull is homozygous or heterozygous for either of these traits can have economical value to a producer.

Most breeds, even those that are traditionally red, offer a black version. This was accomplished through a process called grading-up. For beef cattle, this generally occurred by breeding an Angus to the base breed, which will result in black calves, but they are half Angus. In turn, those calves were mated back to the base breed, which results in half of that generation being black; these calves are still 25 percent Angus. The black calves from that mating were then mated back to the base breed, and the black calves retained. This process is continued until the offspring are considered purebred for the base breed (usually seven-eighths or fifteen-sixteenths of the base breed). At that point, the black bulls and cows are mated to each other to generate black (about three-fourths of the first mating) and some red offspring. Of these black calves, and in subsequent generations, some will be homozygous for the black gene, and some will be heterozygous. A homozygous bull has two black genes and will always produce black calves. A heterozygous bull has one black and one red gene so, depending on the cattle he is mated to, he can produce either black or red calves. The same is true for breeds that have the horn gene; polled bulls may be carriers and produce horned calves.

Tests are now available that can determine if a bull is a red allele carrier or a horn allele carrier. Using the technologies described above, companies can determine from a blood or hair sample if a bull is a carrier. Each breed has specific guidelines for determining color and poll/horn genotypes, and producers should contact their respective breed association for details.

Table 6-5. Progeny equivalents for genotyped non-parent animals in IGS Multi-breed genetic evaluation.

Trait	Estimated Progeny Equivalent
Birth Weight	21
Weaning Weight	22
Yearling Weight	24
Calving Ease (Direct)	15
Maternal Calving Ease	3
Milk	18
Stayability	25
Carcass Weight	6
Rib Eye Area	8
Marbling	6
Backfat	8

Provided by Mahdi Saatchi, Lead Genomicist, International Genetic Solutions (IGS). 2019

Table 6-6. Progeny equivalents for genotyped non-parent animals in Angus genetic evaluation.

Trait	Estimated Progeny Equivalent
Birth Weight	21
Weaning Weight	26
Yearling Weight	21
Calving Ease Direct	28
Milk	33
Scrotal Circumference	13
Carcass Weight	9
Rib Eye Area	12
Marbling	9
Backfat	10

Provided by Steve Miller, Genetic Research Director, Angus Genetics Inc. (AGI). 2019

Before incurring the cost of homozygosity testing, use common sense. If you examine the pedigree of an animal and either parent is homozygous recessive for that trait, you know the animal is a carrier (heterozygote). Remember that a calf gets one color gene from each parent, so if one parent has two red genes, one of those red genes is passed to that calf. If both parents are black and the calf is black, there is no way of determining homozygosity/heterozygosity other than testing. The same is true for polled/horned cattle.

Summary

In summary, there are two important practices that commercial producers should apply to their beef breeding program: crossbreeding and selection. Breeds should be selected based on their ability to achieve your production/economic goals and their ability to fit your production environment (management). These breeds should be used in a planned crossbreeding program that maintains a high level of heterosis. Once the breeds are determined, individual bulls should be selected based on the level of performance you desire for each trait of economic importance. Overall performance of the breed for these traits should be considered in determining this level. Bulls should also be appraised visually and be sound breeders.

If these steps are followed, you can customize your cow herd to meet your goals within your production environment.

Genetics Glossary

Alleles—The possible forms of genes (i.e. poll and horn alleles) at a locus. Because genes occur in pairs, one gene of a pair may have one allele and the other gene of that same pair may have a different allele.

Carrier—An animal that has two different alleles to make up its pair of genes, both the poll and horn alleles (Pp). The dominant allele (poll) masks the existence of the recessive allele (horn) so it is polled, but it carries the horn allele and can pass it on to its calves.

Dominant—Masks the characteristic of the recessive allele. Characteristic is expressed in full if either homozygous or heterozygous (i.e. poll is dominant to horn).

Double polled—Refers to mating a polled bull to a polled cow, and producing a polled calf. It is incorrect to assume that this calf is homozygous polled; one or both parents could be carriers, and if only one horn allele gets passed to the calf it will be a carrier.

Expected Progeny Difference (EPD)—Best selection tool available to evaluate a bull's genetic merit.

Gene—A gene is a specific section of DNA on a chromosome that serves a biological function. Two copies of each gene exist in an animal. Only one gene of each pair is randomly transmitted to the offspring; the offspring gets one gene from each parent, thus giving it a pair.

Genotype—The genetic makeup of the animal.

Heterosis—Advantage of crossbreeding that results in the offspring performing better than the average of the parents that produced it.

Heterozygous—The gene pair has different alleles.

Homozygous—The gene pair are matching alleles.

Horned—The presence of horns that are attached to the skull.

Inheritance mode—The passing of genes from parents to offspring and how they are expressed.

Locus—Location on the chromosome where a specific gene resides.

Phenotype—The physical appearance of the cattle. For the purposes of this article there are three possibilities: smooth polled, scurred, or horned.

Polled—Absence of horns (can be scurred).

Recessive—Is completely masked if paired with a dominant allele. Is only expressed if homozygous (both alleles are recessive).

Scurs—Horn-like tissue that is attached to the skin rather than the skull. Can vary in size from small growths to small horn-like structures.

Seedstock—Broadly refers to animals that are saved for breeding purposes. A seedstock producer typically refers to a producer that sells bulls to other seedstock producers or commercial producers. These bulls are often purebred, but can be composite or crossbred bulls.

Smooth polled—Absence of both horns and scurs.

SNiP—Single Nucleotide Polymorphism. This is the location where there are differences in the population at a single base pair. This difference may or may not have an effect on the animal.

Trait—Anything that can be measured or observed related to cattle. Weaning weight and coat color are examples of traits.