MP502

# Bull Selection and Management Guide

UNIVERSITY OF ARKANSAS
DIVISION OF AGRICULTURE

University of Arkansas, United States Department of Agriculture, and County Governments Cooperating

# Contents



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# Chapter 1
# The Importance of Sire Selection

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Bull selection presents an important opportunity to enhance the profitability of the beef production enterprise. For several reasons, bull selection is one of the most important producer decisions and, as such, requires advance preparation and effort to be successful. To effectively select sires, producers must not only be well versed in the use of expected progeny differences (EPDs) and understand breed differences, they must accurately and objectively assess the herd's current genetics, resources and management. Furthermore, recent advances in DNA technology and decision-support tools add complexity to selection but will ultimately enhance selection accuracy. Producers who stay up to date on advances in beef cattle genetics should profit from enhanced revenue and reduced production costs, as they best match genetics to their production situation.

## Opportunity for Genetic Change

The greatest opportunity for genetic change is with sire selection. Genetic change in cow-calf operations can occur both through sire selection and through replacement female selection in conjunction with cow culling. Most producers raise their own replacement heifers rather than purchasing from other sources. This greatly limits contribution of female selection to genetic change because a large fraction of the heifer crop is needed for replacements. Depending on culling rate in the herd, usually one-half or more of the replacement heifer candidates are retained at weaning to allow for further selection at breeding time. So even if the best half of the heifers are retained, some average heifers will be in that group. Finally, the information used to select replacement heifers in commercial herds is limited. Producers may use in-herd ratios along with data on the heifers' dams, but these types of data on females do not reflect genetic differences as well as the EPDs used to select bulls.

In contrast, whether selecting natural service sires for purchase or sires to be used via artificial insemination (AI), the amount of variation available can be almost overwhelming. Producers can find bulls that will increase or decrease nearly any trait of economic importance. Furthermore, since relatively few bulls will service a large number of cows, producers can select bulls that are fairly elite even when using natural mating. Use of AI allows commercial producers to use some of the most outstanding bulls in the world at a reasonable cost, allowing for enormous amounts of genetic change, if desired. Finally, selection of bulls is more accurate than female selection. Seedstock breeders provide genetic information in the form of EPDs, which allow for direct comparison of potential sires across herds and environments. Unlike actual measurements, EPDs consider the heritability of the trait to accurately predict genetic differences between animals. If AI is used, even greater accuracy is possible. Bulls used in AI may have highly proven EPDs, calculated from thousands of progeny measured in many herds and environments.

## Permanent and Long-Term Change

Genetic change is permanent change. Among management decisions, genetic selection differs from others in that the effects are permanent, not temporary. Feeding a supplement to meet nutritional requirements is beneficial as long as the feeding continues, and health protocols, while important, must be maintained year after year. However, once a genetic change occurs, that change will remain until additional new genetics enter the herd. Whether selecting for growth, carcass traits or maternal performance, those traits are automatically passed on to the next generation once established in the herd.

Sire selection has a long-term impact. Whether a selected sire has a favorable or unfavorable effect on the herd, if his daughters enter the herd, his effects will remain for a considerable period of time. Assuming a sire is used for four years and his daughters are retained, his impact will easily extend into the next decade. While each generation dilutes his contribution, his granddaughters and great-granddaughters may remain in the herd a quarter century after last sired calves. For this reason, purchases of bulls and semen should be viewed not as a short-term expense but as a long-term investment into the efficiency and adaptability of the beef production enterprise.

## Chapter 2

# Breed and Composite Selection

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With more than 60 breeds of beef cattle present in the United States, the question of which breed should I choose is a difficult question to answer. The top ten breeds in fiscal year 2007 reported registrations accounting for 93 percent of the pedigreed beef cattle in the U.S. These top ten breeds and their crosses represent the majority of the genetics utilized in commercial beef production, providing a hint at the breeds that possess the most valuable combinations of traits as recognized by beef producers. The breed, composite or combination of breeds employed in a breeding program can have a significant impact on the profitability of a commercial beef operation and the value of animals it produces as they move through the beef complex. The breed or biological type of an animal influences economically important production traits including growth rate, mature size, reproductive efficiency, milk yield and carcass merit.

Large differences exist today in the relative performance of various breeds for most economically important traits. These breed differences represent a valuable genetic resource for commercial producers to use in structured crossbreeding systems to achieve an optimal combination of traits matching the cow herd to their production environment and to use sire selection to produce market-targeted progeny. As such, the selection of the "right" breed(s) to use in a breeding program is an important decision for commercial beef producers. The determination of the "right" breed(s) to use is highly dependent on a number of characteristics of a farm or ranch such that not every operation should use the same breed or combination of breeds.

## Breed and Composite Defined

A common definition of a breed is a genetic strain or type of domestic livestock that has consistent and inherited characteristics such as coat color or pattern, presence or absence of horns or other qualitative criteria. However, performance traits can also be considered as common characteristics shared by individuals of a breed. In simple terms, these common characteristics are the performance traits often associated with a breed as its reputation has grown over time and represent the core traits for which a breed of livestock has been selected for over time. Breeds differ in the level of performance for various traits as a result of different selection goals of breeders.

A composite is something that is made up of distinct components. In reference to beef cattle, the term *composite* generally means that the animal is composed of two or more breeds. A composite breed then is a group of animals of similar breed composition. Composites can be thought of as new breeds and managed as such.

## Beef Breed and Composite Characterization

A great deal of research has been conducted over the last 30 years at various federal and state experiment stations to characterize beef breeds in the U.S. These studies have been undertaken to examine the genetic merits of various breeds in a wide range of production environments and management systems. During this time, researchers at the U.S. Meat Animal Research Center (MARC) have conducted the most comprehensive studies of sire breed genetic merit via their long-term Germplasm Evaluation (GPE) project. This project evaluated over 30 sire breeds in a common environment and management system. The data summarized by the MARC scientists consisted of records on more than 20,000 animals born between 1978 and 1991, with a resampling of the most popular sire breeds in 1999-2000. The various sire breeds evaluated were mated to Angus, Hereford and crossbred cows. Thus, the data reported were for crossbred progeny. During the study, Angus-Hereford crossbred calves were produced in the study as a control for each cycle of the GPE project.

One of the major outcomes of the GPE project was the characterization of sire breeds for a wide variety of economically important traits. Because all of the animals were in a common management system and production environment, the average differences observed in performance were due to genetic differences. Following the analysis of progeny data, the breeds can be divided into groups based on their biological type for four criteria: growth rate and mature size, lean-to-fat ratio, age at puberty and milk production. The breeds evaluated at MARC are grouped by biological type in Table 1. British breeds such as Hereford, Angus, Red Angus and Shorthorn are moderate in growth and mature size, relatively higher in carcass fat composition, reach puberty at relatively younger ages

**Table 1. Breeds Grouped Into Biological Type by Four Criteria[1,2]**

| Breed Group | Growth Rate and Mature Size | Percent Retail Product | Age at Puberty | Milk Production |
|---|---|---|---|---|
| Jersey | X | X | X | XXXXX |
| Longhorn | X | XXX | XXX | XX |
| | | | | |
| Angus | XXX | XX | XX | XXX |
| Hereford | XXX | XX | XXX | XX |
| Red Poll | XX | XX | XX | XXX |
| Devon | XX | XX | XXX | XX |
| Shorthorn | XXX | XX | XXX | XXX |
| Galloway | XX | XXX | XXX | XX |
| | | | | |
| South Devon | XXX | XXX | XX | XXX |
| Tarentaise | XXX | XXX | XX | XXX |
| Pinzgauer | XXX | XXX | XX | XXX |
| | | | | |
| Brangus | XXX | XX | XXXX | XX |
| Santa Gertrudis | XXX | XX | XXXX | XX |
| | | | | |
| Sahiwal | XX | XXX | XXXXX | XXX |
| Brahman | XXX | XXX | XXXXX | XXX |
| Nellore | XXX | XXX | XXXXX | XXX |
| | | | | |
| Braunvieh | XXXX | XXXX | XX | XXXX |
| Gilbvieh | XXXX | XXXX | XX | XXXX |
| Holstein | XXXX | XXXX | XX | XXXXX |
| Simmental | XXXXX | XXXX | XXX | XXXX |
| Maine Anjou | XXXXX | XXXX | XXX | XXX |
| Salers | XXXXX | XXXX | XXX | XXX |
| | | | | |
| Piedmontese | XXX | XXXXX | XX | XX |
| Limousin | XXX | XXXX | XXXX | X |
| Charolais | XXXXX | XXXX | XXXX | X |
| Chianina | XXXXX | XXXX | XXXX | X |

[1]Adapted from Cundiff et al., 1993.
[2]Increasing number of Xs indicates relatively higher levels of trait.

and are moderate in milk production. Continental European breeds with a heritage that includes milk production, including Simmental, Maine-Anjou and Gelbvieh, tend to have high growth rates, larger mature sizes, moderate ages at puberty and relatively high levels of milk production. Another group of Continental European breeds with a heritage of meat and draft purposes, including Charolais, Chianina and Limousin, tend to have high growth rate, large mature size, older ages at puberty, very lean carcasses and low milk production.

Another way to compare the relative genetic merit of breeds for various performance traits is through conversion of their EPD to a common base. This can be accomplished using the across-breed EPD adjustments published each year in the proceedings of the Beef Improvement Federation's annual meeting. These adjustments are generated by researchers at MARC. Table 2 lists the across-breed adjustment factors that are added to the EPD of an animal of a specified breed to put that animal's EPD on an Angus base (Kuehn and Thallman, 2009). Table 3 presents the average across-breed EPD of animals born in 2007 as reported from 2009 genetic evaluations from the most widely used breeds on a common genetic base (Angus). Differences in across-breed EPD averages represent genetic differences for each trait. Table 3 provides a more contemporary look at the differences in breed genetic potential for various traits and accounting for genetic trends occurring in each breed due to selection. Due to selection pressure placed on growth and maternal traits over time, many breeds have made considerable gains in those traits. In some cases, the large gains in performance have resulted in subtle changes in the overall biological type of a breed.

**Table 2. 2009 Adjustment Factors to Add to EPD of 15 Different Breeds to Estimate Across-Breed EPD[1]**

| Breed | Birth Weight | Weaning Weight | Yearling Weight | Maternal Milk | Marbling Score | Ribeye Area | Fat Thickness |
|---|---|---|---|---|---|---|---|
| Angus | 0.0 | 0.0 | 0.0 | 0.0 | 0.00 | 0.00 | 0.00 |
| Beefmaster | 7.7 | 44.2 | 44.0 | 2.6 | | | |
| Brahman | 11.2 | 36.3 | 2.2 | 29.0 | | | |
| Brangus | 4.7 | 21.9 | 19.9 | 2.4 | | | |
| Braunvieh | 7.5 | 21.4 | 12.8 | 30.6 | -0.26 | 0.78 | -0.149 |
| Charolais | 9.7 | 38.2 | 51.9 | 5.6 | -0.50 | 0.63 | -0.244 |
| Chiangus | 4.1 | -19.6 | | | | | |
| Gelbvieh | 4.5 | 1.7 | -12.6 | 9.9 | | | |
| Hereford | 2.9 | -2.8 | -16.1 | -17.5 | -0.36 | -0.24 | -0.57 |
| Limousin | 4.2 | -3.4 | -28.6 | -14.2 | -0.80 | 0.93 | |
| Maine-Anjou | 5.5 | -10.7 | -22.8 | -0.8 | -0.92 | 1.07 | -0.197 |
| Red Angus | 2.9 | -5.4 | -4.4 | -3.0 | -0.01 | -0.21 | -0.045 |
| Salers | 3.4 | 22.7 | 52.3 | 13.1 | -0.11 | 0.78 | -0.224 |
| Santa Gertrudis | 8.1 | 17.1 | | | | | |
| Shorthorn | 6.1 | 19.9 | 52.8 | 23.1 | 0.06 | 0.12 | -0.133 |
| Simmental | 5.5 | 25.0 | 22.4 | 13.7 | 0.06 | 0.92 | -0.193 |
| South Devon | 4.5 | 6.9 | -1.4 | -6.5 | -0.32 | 0.39 | -0.131 |
| Tarentaise | 2.5 | 29.7 | 17.9 | 22.2 | | | |

[1]Kuehn and Thallman, 2009.

**Table 3. Average Across-Breed EPD for Animals Born in 2007 by Breed From 2009 Genetic Evaluations and 2009 USDA-MARC Across-Breed EPD Adjustment Factors[1]**

| Breed | Birth Weight | Weaning Weight | Yearling Weight | Maternal Milk | Marbling Score | Ribeye Area | Fat Thickness |
|---|---|---|---|---|---|---|---|
| Angus | 2.2 | 43.5 | 80.0 | 20.5 | 0.31 | 0.15 | 0.01 |
| Beefmaster | 8.2 | 51.5 | 56.5 | 4.6 | | | |
| Brahman | 13.0 | 49.9 | 24.4 | 34.8 | | | |
| Brangus | 5.3 | 43.8 | 60.1 | 9.7 | | | |
| Braunvieh | 7.3 | 22.3 | 14.3 | 30.9 | -0.25 | 0.79 | -0.15 |
| Charolais | 10.3 | 61.5 | 93.1 | 12.1 | -0.47 | 0.80 | -0.24 |
| Chiangus | 5.3 | 24.6 | | | | | |
| Gelbvieh | 5.8 | 42.7 | 61.4 | 27.9 | | | |
| Hereford | 6.4 | 38.2 | 51.9 | -1.5 | -0.33 | -0.07 | -0.06 |
| Limousin | 5.9 | 39.2 | 50.5 | 7.1 | -0.80 | 1.33 | |
| Maine-Anjou | 7.4 | 29.4 | 56.3 | 19.2 | -0.71 | 1.23 | -0.20 |
| Red Angus | 3.2 | 25.8 | 50.5 | 13.1 | 0.05 | -0.16 | -0.05 |
| Salers | 4.3 | 40.5 | 81.9 | 21.5 | -0.11 | 0.80 | -0.22 |
| Santa Gertrudis | 8.6 | 21.1 | | | | | |
| Shorthorn | 8.3 | 34.2 | 76.2 | 25.6 | 0.06 | 0.10 | -0.13 |
| Simmental | 6.8 | 57.4 | 79.9 | 17.9 | -0.47 | 1.00 | -0.18 |
| South Devon | 7.1 | 46.6 | 74.1 | 14.9 | -0.06 | 0.49 | -0.12 |
| Tarentaise | 4.0 | 33.7 | 28.9 | 23.2 | | | |

[1]Adapted from Kuehn and Thallman, 2009, and Kuehn et al., 2009.

## Use of Breeds and Composites for Genetic Improvement

Inclusion or exclusion of germplasm from a breed (or composite) is a valuable selection tool for making rapid directional changes in genetic merit for a wide range of traits. Changes in progeny phenotype that occur when breeds are substituted in a breeding program come from two genetic sources.

The first source of genetic impact from a substitution of a breed comes through changes in the additive genetic effects or breeding values that subsequent progeny inherit from their sire and dam. Additive genetic merit is the portion of total genetic merit that is transmissible from parent to offspring and on which traditional selection decisions are made. In other words, additive genetic effects are heritable. EPDs are estimates of one-half of the additive genetic merit. The difference in average performance for a trait observed between two breeds is due primarily to differences in additive genetic merit.

The second source of genetic change is due to non-additive genetic effects. Non-additive effects include both dominance and epistatic effects. Dominance effects arise from the interactions of paired genes at each locus. Epistatic effects are the interaction of genes across loci. The sum of these two interactions result in heterosis observed in crossbred animals. Since each parent only contributes one gene to an offspring and dominance effects depend on the interaction of a pair of genes, a parent cannot transmit dominance effects to its progeny within a breed. However, the selection of which breeds and how much of each breed to incorporate into progeny has a large impact on dominance (or heterosis) effects which affect phenotype. Because epistatic effects arise from the interaction of genes at different loci, independent segregation of chromosomes in the formation of gametes causes pairings of genes not to always stay together from one generation to the next. Like dominance effects, epistatic effects are not impacted by mate selection but by the frequency of different alleles and their dominance effects across breeds.

Both additive and non-additive genetic effects can have a significant impact on a particular phenotype; therefore, it is important that both are considered during breed selection. Due to their different modes of inheritance, different tactics must be employed to capture the benefits of each.

Additive genetic merit may be selected for in two distinct ways. The first is by the selection of individuals within a breed that have superior genetic merit for the trait under selection. This is typically achieved through the use of EPD to identify selection candidates, although it can also be done through selection for specific alleles using DNA markers. The rate of improvement in phenotypes due to selection within breed is limited by the heritability of the trait. Heritability describes the proportion of phenotypic variation that is controlled by additive genetic variation. So, for traits with moderate to high heritability, considerable progress in progeny phenotype may be achieved through selection of superior animals within the breed as parent stock. The second approach to change additive genetic merit is through the selection of animals from a different breed(s) that excels in the trait under selection. Across-breed selection can provide rapid change in progeny phenotype given that large differences exist between breeds in a number of economically relevant traits. Selection of superior parent stock from a different breed that excels in a trait is often more effective than selection within a breed (Gregory et al., 1999), as the breed differences have a heritability of nearly 100 percent.

The use of breed differences to achieve the best overall results across multiple traits may be achieved through the implementation of the concept of breed complementarity. Breeds are complementary to each other when they excel in different traits and their crossbred progeny have desirable levels of performance in a larger number of traits than either of the parent breeds alone. Making breed and mating selections that utilize breed complementarity provides an effective way to aggregate the core competencies of two or more breeds in the progeny. Moreover, use of breed complementarity can be a powerful strategy to genetically match cows to their production environment and progeny to the marketplace. For example, a crossbreeding system that mates Charolais bulls to Hereford-Angus crossbreed cows utilizes breed complementarity. The Charolais bull contributes growth and carcass yield to progeny genetics, while the Hereford-Angus crossbred cows have many desirable maternal attributes and contribute genetics for carcass quality. When considering crossbreeding from the standpoint of producing replacement females, select breeds that have complementary maternal traits such that females are most ideally matched to their production environment. Matings to produce calves for market should focus on complementing traits of the cows and fine-tuning calf performance (growth and carcass traits) to the marketplace.

There is an abundance of research that describes the core competencies (biological type) of many of today's commonly used beef breeds as described earlier and listed in Table 1. Traits are typically combined into groupings such as maternal and/or reproduction, growth and carcass. When selecting animals for a crossbreeding system, breed should be the primary consideration. Breeds selected for inclusion in a mating program will be dependent on a number of factors, including current cow herd breed composition, forage and production environment, replacement female development system and calf marketing endpoint. All of these factors help determine the relative importance of traits for each production phase.

One of the challenges of breed selection is the interaction of the animal's genotype with its production environment. Table 4 describes common production environments by level of feed availability and environmental stress and lists optimal levels of a variety of performance traits (Bullock et al., 2002). Here, feed availability refers to the regular availability of grazed or harvested forage and its quantity and quality. Environmental stress includes parasites, disease, heat and humidity. Ranges for mature cow size are low (800 to 1,000 pounds), medium (1,000 to 1,200 pounds), and high (1,200 to 1,400 pounds). Clearly, breed choices should be influenced by the production environment in which they are expected to perform.

Crossing of breeds or lines is the primary method to exploit beneficial non-additive effects called heterosis. *Heterosis* refers to the superiority of the crossbred animal relative to the average of its straightbred parents, and heterosis results from an increase in heterozygosity of a crossbred animal's genetic makeup. *Heterozygosity* refers to a state where an animal has two different forms of a gene. It is believed that heterosis is primarily the result of gene dominance and the recovery from accumulated inbreeding depression of pure breeds. Heterosis is, therefore, dependent on crossbred animals having a greater percentage of heterozygous animals than is present in straightbred animals. The level of heterozygosity an animal has depends on the random inheritance of copies of genes from its parents. In general, animals that are crosses of unrelated breeds, such as Angus and Brahman, exhibit higher levels of heterosis due to more heterozygosity than do crosses of more genetically similar breeds, such as a cross of Angus and Hereford.

Generally, heterosis generates the largest improvement in lowly heritable traits. Moderate improvements due to heterosis are seen in moderately heritable traits. Little or no heterosis is observed in highly heritable traits. Traits such as reproduction and longevity have low heritability. These traits respond very slowly to selection since a large portion of the variation observed in them is due to environmental effects and non-additive genetic effects and a small percentage is due to additive genetic differences. But, heterosis generated through crossbreeding can significantly improve an animal's performance for lowly heritable traits, thus the importance of considering both additive and non-additive genetics when designing mating programs. Crossbreeding has been shown to be an efficient method to improve reproductive efficiency and pre-weaning productivity in beef cattle.

Improvements in cow-calf production due to heterosis are attributable to having both a crossbred cow (called maternal or dam heterosis) and a crossbred calf (called individual or calf heterosis). Differing levels of heterosis are generated when various breeds are crossed. Similar levels of heterosis are observed when members of the *Bos taurus* species,

**Table 4. Matching Genetic Potential for Different Traits to Production Environments[1]**

| Production Environment | | Traits | | | | | |
|---|---|---|---|---|---|---|---|
| Feed Availability | Stress[2] | Milk Production | Mature Size | Ability to Store Energy[3] | Resistance to Stress[4] | Calving Ease | Lean Yield |
| High | Low | M to H | M to H | L to M | M | M to H | H |
| | High | M | L to H | L to H | H | H | M to H |
| Medium | Low | M to H | M | M to H | M | M to H | M to H |
| | High | L to M | M | M to H | H | H | H |
| Low | Low | L to M | L to M | H | M | M to H | M |
| | High | L to M | L to M | H | H | H | L to M |
| **Breed Role in Terminal Crossbreeding Systems** | | | | | | | |
| Maternal | | M to H | L to H | M to H | M to H | H | L to M |
| Paternal | | L to M | H | L | M to H | M | H |

L = Low; M = Medium; H = High
[1]Adapted from Bullock et al., 2002.
[2]Heat, cold, parasites, disease, mud, altitude, etc.
[3]Ability to store fat and regulate energy requirements with changing (seasonal) availability of feed.
[4]Physiological tolerance to heat, cold, internal and external parasites, disease, mud and other factors.

including the British (e.g., Angus, Hereford, Shorthorn) and Continental European breeds (e.g., Charolais, Gelbvieh, Limousin, Maine-Anjou, Simmental) are crossed. Much more heterosis is observed when *Bos indicus* or Zebu breeds, like Brahman, Nelore and Gir, are crossed with *Bos taurus* breeds. The increase in heterosis observed in British by *Bos indicus* crosses for a trait is usually two to three times as large as the heterosis for the same trait observed in *Bos taurus* crossbreds (Kroger, 1980). The large increase is especially true with heterosis observed in the crossbred cow. The increase in heterosis is sensible as there are more genetic differences between species than within species. Heterosis effects reported in the following tables will be divided and noted into those observed in *Bos taurus* crosses or *Bos taurus* by *Bos indicus* corsses. Table 5 details the individual (crossbred calf) heterosis and Table 6 describes the maternal (crossbred cow) heterosis observed for various important production traits in *Bos taurus* crossbreds. These heterosis estimates are adapted from a report by Cundiff and Gregory, 1999, and summarize crossbreeding experiments conducted in the Southeastern and Midwest areas of the U.S. Table 7 describes the expected individual heterosis of *Bos taurus* by *Bos indicus* crossbred calves, while Table 8 details the estimated maternal (dam) heterotic effects observed in *Bos taurus* by Bos *indicus* crossbred cows. *Bos taurus* by *Bos indicus* heterosis estimates were derived from breeding experiments conducted in the southern United States.

The heterosis adjustments utilized by multi-breed genetic evaluation systems are another example of estimates for individual (due to calf) and maternal (due to a crossbred dam) heterosis. These heterosis adjustments are present in Table 9 and illustrate the differences in expected heterosis for various breed-group crosses. In general the Zebu (*Bos indicus*) crosses have higher levels of heterosis than the British-British, British-Continental or Continental-Continental crosses.

**Table 5. Units and Percentage of Heterosis by Trait for *Bos Taurus* Crossbred Calves**

| Trait | Heterosis | |
|---|---|---|
| | Units | Percentage (%) |
| Calving Rate, % | 3.2 | 4.4 |
| Survival to Weaning, % | 1.4 | 1.9 |
| Birth Weight, lb | 1.7 | 2.4 |
| Weaning Weight, lb | 16.3 | 3.9 |
| Yearling Weight, lb | 29.1 | 3.8 |
| Average Daily Gain, lb/d | 0.08 | 2.6 |

**Table 6. Units and Percentage of Heterosis by Trait for *Bos Taurus* Crossbred Dams**

| Trait | Heterosis | |
|---|---|---|
| | Units | Percentage (%) |
| Calving Rate, % | 3.5 | 3.7 |
| Survival to Weaning, % | 0.8 | 1.5 |
| Birth Weight, lb | 1.6 | 1.8 |
| Weaning Weight, lb | 18.0 | 3.9 |
| Longevity, years | 1.36 | 16.2 |
| **Lifetime Productivity** | | |
| Number of Calves | 0.97 | 17.0 |
| Cumulative Weaning Weight, lb | 600 | 25.3 |

**Table 7. Units and Percentage of Heterosis by Trait for *Bos Taurus* by *Bos Indicus* Crossbred Calves**

| Trait | Heterosis Units |
|---|---|
| Calving Rate, %[1] | 4.3 |
| Calving Assistance, %[1] | 4.9 |
| Calf Survival, %[1] | -1.4 |
| Weaning Rate, %[1] | 1.8 |
| Birth Weight, lb[1] | 11.4 |
| Weaning Weight, lb[1] | 78.5 |

[1]Adapted from Franke et al., 2005; numeric average of Angus-Brahman, Brahman-Charolais and Brahman-Hereford heterosis estimates.

**Table 8. Units and Percentage of Heterosis by Trait for *Bos Taurus* by *Bos Indicus* Crossbred Dams[1,2]**

| Trait | Heterosis | |
|---|---|---|
| | Units | Percentage (%) |
| Calving Rate, %[1] | 15.4 | -- |
| Calving Assistance Rate, %[1] | 0.8 | 1.5 |
| Calf Survival, %[1] | 1.6 | 1.8 |
| Weaning Rate, %[1] | 18.0 | 3.9 |
| Birth Weight, lb[1] | 1.36 | 16.2 |
| Weaning Weight, lb[1] | 0.97 | 17.0 |
| Weaning Weaning Per Cow Exposed, lb[2] | 600 | 25.3 |

[1]Adapted from Franke et al., 2005; numeric average of Angus-Brahman, Brahman-Charolais and Brahman-Hereford heterosis estimates.
[2]Adapted from Franke et al., 2001.

**Table 9. Individual (Calf) and Maternal (Dam) Heterosis Adjustments for British, Continental Europe and Zebu Breed Groups by Birth Weight, Weaning Weight and Postweaning Gain**

| Breed Combinations | Birth Weight (lb) | | Weaning Weight (lb) | | Postweaning Gain (lb) |
|---|---|---|---|---|---|
| | Calf Heterosis | Dam Heterosis | Calf Heterosis | Dam Heterosis | Calf Heterosis |
| British × British | 1.9 | 1.0 | 21.3 | 18.8 | 9.4 |
| British × Continental | 1.9 | 1.0 | 21.3 | 18.8 | 9.4 |
| British × Zebu | 7.5 | 2.1 | 48.0 | 53.2 | 28.2 |
| Continental × Continental | 1.9 | 1.0 | 21.3 | 18.8 | 9.4 |
| Continental × Zebu | 7.5 | 2.1 | 48.0 | 53.2 | 28.2 |

(Wade Shafer, American Simmental Association, personal communication.)

The production of crossbred calves yields advantages in both heterosis and the blending of desirable traits from two or more breeds. However, the largest economic benefit of crossbreeding to commercial producers comes from the crossbred cow. Dam heterosis improves both the environment a cow provides for her calf as well as improves her longevity and durability. The improvement of the maternal environment a cow provides for her calf is manifested in improvements in calf survivability to weaning and increased weaning weight. Crossbred cows exhibit improvements in calving rate of nearly 4 percent and an increase in longevity of more that one year due to heterotic effects. Heterosis results in increases in lifetime productivity of approximately one calf and 600 pounds of calf weaning weight over a lifetime of the cow.

Crossbreeding can have positive effects on a ranch's bottom line by not only increasing the quality and gross pay weight of calves produced but also by increasing the durability and productivity of the cow factory.

The effects of dam heterosis on the economic measures of cow-calf production have been shown to be very positive. The added value of maternal heterosis ranges from approximately $50/cow/year to nearly $100/cow/year depending on the amount of maternal heterosis retained in the cow herd (Ritchie, 1998). Heterosis expressed by dams accounted for an increase in net profit per cow of nearly $75/cow/year (Davis et al., 1994). Their results suggested that the benefits of dam heterosis on profit were primarily the reduced cost per cow exposed. Crossbred cows had higher reproductive rates, longer productive lives, and required fewer replacements than straightbred cows in their study. All of these factors contribute to reduced cost per cow exposed. Further, they found increased outputs, including growth and milk yield, were offset by increased costs.

When it comes to crossing breeds with the goal of producing high levels of maternal or individual heterosis, not all breeds are equal. Heterosis depends on an animal having two different alleles or alternate forms of a gene at a locus. The likelihood of having different copies of genes at a locus is greater in breeds that are less related than when the breeds crossed are closely related. For instance, Angus and Hereford, both British breeds, are more similar than Angus and Simmental (a Continental European breed), which are more similar than Angus (a *Bos taurus* breed) and Brahman (a *Bos indicus* breed). Since heterosis offers considerable advantages to commercial producers in terms of reproductive efficiency, productivity and economic returns, care should be given when selecting breeds for inclusion in a crossbreeding system. Just as breeds differ in the amount of heterosis generated when crossed, crossbreeding systems achieve differing levels of heterosis depending on the number of breeds and their fractions represented in each animal. A more complete discussion on crossbreeding and crossbreeding systems appears in a separate chapter in this manual.

When comparing two breeds that offer similar strengths for inclusion in a crossbreeding system, select the breed that offers the most heterosis when mated to animals of other breed(s) in your system. Table 10 provides estimates of the percentage increase in pairs of alleles at a locus that are different (heterozygosity) when various purebreds are crossed to form F1 progeny. These estimates were developed using the input data and procedures suggested by Roughsedge et al., 2001. It is easy to see that not all breeds offer the same increase in heterozygosity and, therefore, heterosis when crossed. Expected precent heterosis for cow fertility, birth weight, survival to weaning and weaning weight was computed according to the procedure outlined by Roughsedge et al., 2001. Table 11 provides the expected heterosis percentage for cow fertility observed in F1 females. Similarly, Tables 12, 13 and 14 provide the expected heterosis percentage for birth weight, survival to weaning and weaning weight, respectively. Note that this study provided no estimates of heterosis for *Bos indicus* breeds such as Brahman, Nelore and Gir as only *Bos taurus* breeds common in the United Kingdom and Continental Europe were sampled for biological material.

### Table 10. Increase in Heterozygosity of F1 Animals When Respective Breeds Are Crossed[1]

| Breed | A | C | Ch | G | H | PH | L | MA | Sa | Sh | S | SD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Angus (A) | 0.000 | 0.110 | 0.193 | 0.116 | 0.136 | 0.110 | 0.103 | 0.061 | 0.051 | 0.057 | 0.071 | 0.088 |
| Charolais (C) | 0.110 | 0.000 | 0.134 | 0.003 | 0.148 | 0.141 | 0.050 | 0.006 | 0.048 | 0.096 | 0.050 | 0.148 |
| Chianina (Ch) | 0.193 | 0.134 | 0.000 | 0.128 | 0.262 | 0.268 | 0.139 | 0.165 | 0.160 | 0.1843 | 0.162 | 0.238 |
| Gelbvieh (G) | 0.116 | 0.093 | 0.128 | 0.000 | 0.183 | 0.180 | 0.110 | 0.151 | 0.114 | 0.137 | 0.063 | 0.149 |
| Hereford (H) | 0.136 | 0.148 | 0.262 | 0.183 | 0.000 | 0.011 | 0.172 | 0.163 | 0.195 | 0.110 | 0.151 | 0.183 |
| Polled Hereford (PH) | 0.110 | 0.141 | 0.268 | 0.182 | 0.111 | 0.000 | 0.166 | 0.139 | 0.198 | 0.089 | 0.148 | 0.172 |
| Limousin (L) | 0.103 | 0.050 | 0.139 | 0.000 | 0.172 | 0.166 | 0.000 | 0.081 | 0.057 | 0.094 | 0.071 | 0.112 |
| Maine-Anjou (MA) | 0.061 | 0.096 | 0.165 | 0.151 | 0.163 | 0.139 | 0.181 | 0.000 | 0.151 | 0.057 | 0.104 | 0.116 |
| Salers (Sa) | 0.151 | 0.048 | 0.160 | 0.114 | 0.195 | 0.198 | 0.057 | 0.151 | 0.000 | 0.175 | 0.069 | 0.211 |
| Shorthorn (Sh) | 0.057 | 0.096 | 0.183 | 0.137 | 0.110 | 0.089 | 0.094 | 0.057 | 0.175 | 0.000 | 0.115 | 0.093 |
| Simmental (S) | 0.071 | 0.059 | 0.162 | 0.063 | 0.151 | 0.148 | 0.071 | 0.104 | 0.069 | 0.115 | 0.000 | 0.139 |
| South Devon (SD) | 0.088 | 0.148 | 0.238 | 0.149 | 0.183 | 0.172 | 0.112 | 0.116 | 0.211 | 0.093 | 0.139 | 0.000 |

[1]Adapted from Roughsedge et al., 2001.

### Table 11. Cow Fertility Expected Heterosis (%) for F1s First Cross

| Breed | A | C | Ch | G | H | PH | L | MA | Sa | Sh | S | SD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Angus (A) | 0.00 | 7.32 | 12.87 | 7.76 | 9.05 | 7.32 | 6.87 | 4.05 | 10.04 | 3.77 | 4.77 | 5.85 |
| Charolais (C) | 7.32 | 0.00 | 8.97 | 6.21 | 9.89 | 9.43 | 3.35 | 6.43 | 3.21 | 6.43 | 3.91 | 9.89 |
| Chianina (Ch) | 12.87 | 8.97 | 0.00 | 8.51 | 17.50 | 17.85 | 9.27 | 10.07 | 10.66 | 12.23 | 10.82 | 15.90 |
| Gelbvieh (G) | 7.76 | 6.21 | 8.51 | 0.00 | 12.23 | 12.63 | 7.32 | 10.04 | 7.61 | 9.12 | 4.20 | 9.96 |
| Hereford (H) | 9.06 | 9.89 | 17.50 | 12.23 | 0.00 | 0.74 | 11.44 | 10.80 | 13.03 | 7.32 | 10.04 | 12.23 |
| Polled Hereford (PH) | 7.32 | 9.43 | 17.85 | 12.63 | 0.74 | 0.00 | 11.05 | 9.27 | 13.19 | 5.92 | 9.89 | 11.44 |
| Limousin (L) | 6.87 | 3.35 | 9.27 | 0.00 | 11.44 | 11.05 | 0.00 | 5.41 | 3.77 | 6.29 | 4.77 | 7.47 |
| Maine-Anjou (MA) | 4.05 | 6.43 | 10.97 | 10.04 | 10.89 | 9.27 | 5.41 | 0.00 | 10.04 | 3.77 | 6.95 | 7.76 |
| Salers (Sa) | 10.04 | 3.21 | 10.66 | 7.61 | 13.03 | 13.19 | 3.77 | 10.04 | 0.00 | 11.68 | 4.62 | 14.08 |
| Shorthorn (Sh) | 3.77 | 6.43 | 12.23 | 9.12 | 7.32 | 5.92 | 6.29 | 3.77 | 11.68 | 0.00 | 7.69 | 6.21 |
| Simmental (S) | 4.77 | 3.91 | 10.82 | 4.20 | 10.04 | 9.89 | 4.77 | 6.95 | 4.62 | 7.60 | 0.00 | 9.27 |
| South Devon (SD) | 5.85 | 9.89 | 15.00 | 9.96 | 12.23 | 11.44 | 7.47 | 7.76 | 14.08 | 6.21 | 9.27 | 0.00 |

### Table 12. Birth Weight Expected Heterosis (%) for F1s

| Breed | A | C | Ch | G | H | PH | L | MA | Sa | Sh | S | SD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Angus (A) | 0.00 | 2.64 | 4.65 | 2.81 | 3.27 | 2.64 | 2.48 | 1.47 | 3.63 | 1.36 | 1.72 | 2.11 |
| Charolais (C) | 2.64 | 0.00 | 3.24 | 2.24 | 3.57 | 3.41 | 1.31 | 2.32 | 1.16 | 2.32 | 1.41 | 3.57 |
| Chianina (Ch) | 4.65 | 3.24 | 0.00 | 3.08 | 6.32 | 6.45 | 3.35 | 3.96 | 3.85 | 4.42 | 3.91 | 5.75 |
| Gelbvieh (G) | 2.81 | 2.24 | 3.08 | 0.00 | 4.42 | 4.56 | 2.64 | 3.63 | 2.75 | 3.30 | 1.52 | 3.60 |
| Hereford (H) | 3.27 | 3.57 | 6.32 | 4.42 | 0.00 | 0.27 | 4.13 | 3.94 | 4.71 | 2.64 | 3.63 | 4.42 |
| Polled Hereford (PH) | 2.64 | 3.41 | 6.45 | 4.56 | 0.27 | 0.00 | 3.99 | 3.35 | 4.77 | 2.14 | 3.57 | 4.13 |
| Limousin (L) | 2.48 | 1.21 | 3.35 | 0.00 | 4.13 | 3.99 | 0.00 | 1.96 | 1.36 | 2.27 | 1.72 | 2.70 |
| Maine-Anjou (MA) | 1.47 | 2.37 | 3.96 | 3.63 | 3.94 | 3.35 | 1.96 | 0.00 | 3.63 | 1.36 | 2.51 | 2.81 |
| Salers (Sa) | 3.63 | 1.16 | 3.85 | 2.75 | 4.71 | 4.77 | 1.36 | 3.63 | 0.00 | 4.22 | 1.67 | 5.09 |
| Shorthorn (Sh) | 1.36 | 2.32 | 4.42 | 3.30 | 2.64 | 2.14 | 2.77 | 1.36 | 4.22 | 0.00 | 2.28 | 2.24 |
| Simmental (S) | 1.72 | 1.41 | 3.91 | 1.52 | 3.63 | 3.57 | 1.72 | 2.51 | 1.67 | 2.78 | 0.00 | 3.35 |
| South Devon (SD) | 2.11 | 3.57 | 5.75 | 3.60 | 4.42 | 4.13 | 2.70 | 2.81 | 5.00 | 2.24 | 3.35 | 0.00 |

**Table 13. Survival to Weaning Expected Heterosis (%) for F1s**

| Breed | A | C | Ch | G | H | PH | L | MA | Sa | Sh | S | SD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Angus (A) | 0.00 | 1.90 | 3.34 | 201 | 2.35 | 1.90 | 1.78 | 1.05 | 2.60 | 0.98 | 1.24 | 1.52 |
| Charolais (C) | 1.90 | 0.00 | 2.33 | 1.61 | 2.56 | 2.44 | 0.87 | 1.67 | 0.83 | 1.67 | 1.02 | 2.56 |
| Chianina (Ch) | 3.34 | 2.33 | 0.00 | 2.21 | 4.45 | 4.63 | 2.41 | 2.85 | 2.77 | 3.17 | 2.81 | 4.12 |
| Gelbvieh (G) | 2.01 | 1.61 | 2.21 | 0.00 | 3.17 | 3.28 | 1.90 | 2.60 | 1.98 | 2.37 | 1.00 | 2.58 |
| Hereford (H) | 2.35 | 2.56 | 4.54 | 3.17 | 0.00 | 0.19 | 2.97 | 2.83 | 3.38 | 1.90 | 2.60 | 3.17 |
| Polled Hereford (PH) | 1.90 | 2.44 | 4.63 | 3.28 | 0.10 | 0.00 | 2.87 | 2.41 | 3.42 | 1.54 | 2.56 | 2.97 |
| Limousin (L) | 1.78 | 0.87 | 2.41 | 0.00 | 2.97 | 2.87 | 0.00 | 1.40 | 0.98 | 1.63 | 1.24 | 1.94 |
| Maine-Anjou (MA) | 1.05 | 1.67 | 2.85 | 2.60 | 2.83 | 2.41 | 1.40 | 0.00 | 2.60 | 0.98 | 1.80 | 2.01 |
| Salers (Sa) | 2.60 | 0.83 | 2.77 | 1.98 | 3.38 | 3.42 | 0.98 | 2.60 | 0.00 | 3.03 | 1.20 | 3.65 |
| Shorthorn (Sh) | 0.98 | 1.67 | 3.17 | 2.37 | 1.90 | 1.54 | 1.63 | 0.98 | 3.03 | 0.00 | 1.99 | 1.61 |
| Simmental (S) | 1.24 | 1.02 | 2.81 | 1.09 | 2.60 | 2.56 | 1.24 | 1.80 | 1.20 | 1.99 | 0.00 | 2.41 |
| South Devon (SD) | 1.52 | 2.56 | 4.12 | 2.58 | 3.17 | 2.97 | 1.94 | 2.01 | 3.65 | 1.61 | 2.41 | 0.00 |

**Table 14. Weaning Weight Expected Heterosis (%) for F1s**

| Breed | A | C | Ch | G | H | PH | L | MA | Sa | Sh | S | SD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Angus (A) | 0.00 | 1.94 | 3.42 | 2.06 | 2.40 | 1.94 | 1.82 | 1.08 | 2.66 | 1.00 | 1.26 | 1.55 |
| Charolais (C) | 1.94 | 0.00 | 2.38 | 1.65 | 2.62 | 2.50 | 0.80 | 1.71 | 0.85 | 1.71 | 1.04 | 2.62 |
| Chianina (Ch) | 3.42 | 2.38 | 0.00 | 2.26 | 4.65 | 4.74 | 2.46 | 2.91 | 2.83 | 3.25 | 2.87 | 4.22 |
| Gelbvieh (G) | 2.06 | 1.65 | 2.26 | 0.00 | 3.25 | 3.35 | 1.94 | 2.66 | 2.02 | 2.42 | 2.11 | 2.64 |
| Hereford (H) | 2.40 | 2.62 | 4.65 | 3.25 | 0.00 | 0.20 | 3.04 | 2.89 | 3.46 | 1.94 | 2.66 | 3.25 |
| Polled Hereford (PH) | 1.94 | 2.50 | 4.74 | 3.35 | 0.20 | 0.00 | 2.93 | 2.46 | 3.50 | 1.57 | 2.62 | 3.04 |
| Limousin (L) | 1.82 | 0.89 | 2.46 | 0.00 | 3.04 | 2.93 | 0.00 | 1.44 | 1.00 | 1.67 | 1.26 | 1.08 |
| Maine-Anjou (MA) | 1.08 | 1.71 | 2.91 | 2.66 | 2.89 | 2.46 | 1.44 | 0.00 | 2.66 | 1.00 | 1.84 | 2.06 |
| Salers (Sa) | 2.66 | 0.85 | 2.83 | 2.02 | 3.46 | 3.50 | 1.00 | 2.66 | 0.00 | 3.10 | 1.23 | 3.74 |
| Shorthorn (Sh) | 1.00 | 1.71 | 3.25 | 2.42 | 1.94 | 1.57 | 1.67 | 1.00 | 3.10 | 0.00 | 2.04 | 1.65 |
| Simmental (S) | 1.26 | 1.04 | 2.87 | 1.11 | 2.66 | 2.62 | 1.26 | 1.84 | 1.23 | 2.04 | 0.00 | 2.46 |
| South Devon (SD) | 1.55 | 2.62 | 4.22 | 2.64 | 3.25 | 3.04 | 1.08 | 2.06 | 3.74 | 1.65 | 2.46 | 0.00 |

## Summary

Selection of appropriate breeds for particular production system can be a challenging task. Consideration during the selection process should be given to a number of criteria (Greiner, 2002) including:

- Climate (frost-free days, growing season, precipitation).
- Quantity, quality and cost of feedstuffs available.
- Production system (availability of labor and equipment).
- Market end points and demands.
- Breed complementarity.
- Cost and availability of seed stock.

The selection of breeds and the genetics they contribute to the cow herd can have a significant impact on profitability through the aggregate effects on each of the above criteria. Clearly, breeds need to be selected to fit a specific production system, whether that is selling replacement females, weaned feeder calves or carcass components. For more producers, that production system should employ a structured crossbreeding system that utilizes two or more breeds. The breeds (and/or composites) chosen should produce calves that are appropriate for the market targeted. Moreover, the system and breeds included should provide a mechanism for the use of crossbred cows that are matched to the production environment in terms of mature size and lactation potential so as to capture the benefits of maternal heterosis. Selection of breeds that are too large and/or produce too much milk for the forage environment in which they are expected to produce may result in lower reproductive efficiency and increased supplemental feed costs. Selection of breeds provides an opportunity for the beef producer to impact both additive and non-additive genetics of the cow herd. Optimization of these two genetic components requires a disciplined approach to breed selection.

# Chapter 3

# Crossbreeding Systems

For most livestock species, crossbreeding is an important aspect of production. Intelligent crossbreeding generates hybrid vigor and breed complementarity, which are very important to production efficiency. Cattle breeders can obtain hybrid vigor and complementarity simply by crossing appropriate breeds. However, sustaining acceptable levels of hybrid vigor and breed complementarity in a manageable way over the long term requires a well-planned crossbreeding system. Given this, finding a way to evaluate different crossbreeding systems is important. The following is a list of seven useful criteria for evaluating different crossbreeding systems:

- Merit of component breeds
- Hybrid vigor
- Breed complementarity
- Consistency of performance
- Replacement considerations
- Simplicity
- Accuracy of genetic prediction

## Merit of Component Breeds

For any crossbreeding system to be effective, the breeds in the system must be well chosen. Each breed included in a crossbreeding system must bring favorable attributes to the cross. Determining the appropriate breeds to use in a crossbreeding system can be challenging. Another challenge is the availability of animals of those breeds.

## Hybrid Vigor

Generating hybrid vigor is one of the most important, if not the most important, reasons for crossbreeding. Any worthwhile crossbreeding system should provide adequate levels of hybrid vigor. The highest level of hybrid vigor is obtained from F1s, the first cross of unrelated populations. To sustain F1 vigor in a herd, a producer must avoid backcrossing – not always an easy or a practical thing to do. Most crossbreeding systems do not achieve 100 percent hybrid vigor, but they do maintain acceptable levels of hybrid vigor by limiting backcrossing in a way that is manageable and economical. Table 15 lists expected level of hybrid vigor or heterosis for several crossbreeding systems.

## Breed Complementarity

Breed complementarity refers to the production of a more desirable offspring by crossing breeds that are genetically different from each other but have complementary attributes. In beef cattle breeding, it is often stated as “big bull × small cow” complementarity. The big bull contributes growth and leanness to the offspring, and the small cow requires less feed to maintain herself. The result is a desirable market animal economically produced.

## Consistency of Performance

A crossbreeding system should ideally produce a consistent product. It is much easier to market a uniform set of animals than a diverse one. It is also

**Table 15. Expected Heterosis Levels and Breed Complementarity Attributes of Several Crossbreeding Systems**

| Crossbreeding System | Expected Heterosis | | Breed Complementarity |
|---|---|---|---|
| | Offspring | Dam | |
| Two-breed terminal cross | 100 | 0 | maximum |
| Three-breed terminal cross (using F1 females) | 100 | 100 | maximum |
| Two-breed rotation | 72 | 56 | some |
| Three-breed rotation | 91 | 70 | minimal |

much easier to manage a female population that is essentially one type than one made up of many types, each with its own requirements. Crossbreeding systems vary in their ability to provide this kind of consistency.

## Replacement Considerations

In terms of hybrid vigor, the ultimate female is an F1. Commercial producers would like to have entire herds of F1 females. How can you produce a continuous supply of F1s? One way is to maintain purebred parent populations to cross to produce F1s. A second way is to purchase all the replacements needed from a third party. Neither of these methods is optimum for most producers. A number of crossbreeding systems manage to overcome the replacement female dilemma by allowing breeders to produce replacement heifers from their own hybrid populations. However, this convenience comes at a price, a price typically paid in loss of hybrid vigor, breed complementarity and simplicity.

## Simplicity

Crossbreeding systems should be relatively simple. Expensive systems or complex systems that require an unrealistically high level of management are unlikely to remain in place for very long. More complex breeding systems often conflict with important management practices unrelated to breeding. For example, beef cattle crossbreeding systems that require many breeding pastures make grazing management difficult. It is important that crossbreeding systems fit with other aspects of cattle production. This means that crossbreeding systems should be kept simple.

## Accuracy of Genetic Prediction

The higher the accuracy of genetic prediction, the lower selection risk and more predictable the offspring. Because relatively little performance information on commercial animals is recorded and even less is reported for analysis, accuracy of prediction in a commercial operation refers to accuracy of prediction for seed stock inputs to the crossbreeding system – typically sires. In many cases, accurate EPDs are available for purebred sires, and crossbreeding systems using purebred sires benefit as a result.

## Example Crossbreeding Systems

### Terminal Cross

The simplest form of crossbreeding is a terminal cross. In this system, all offspring are marketed, making it necessary to purchase replacement heifers. If F1 replacement heifers (females that have 100 percent hybrid vigor for maternal traits) are purchased and are bred to bulls of a different breed, both cows and calves take advantage of maximum heterosis. This system also allows the most flexibility in choosing breeds to use. Replacement heifers can be purchased that are comprised of "maternal" breeds and bred to terminal or high-growth breed bulls. This type system is optimal for many cow-calf producers. This system is illustrated in Figure 1.

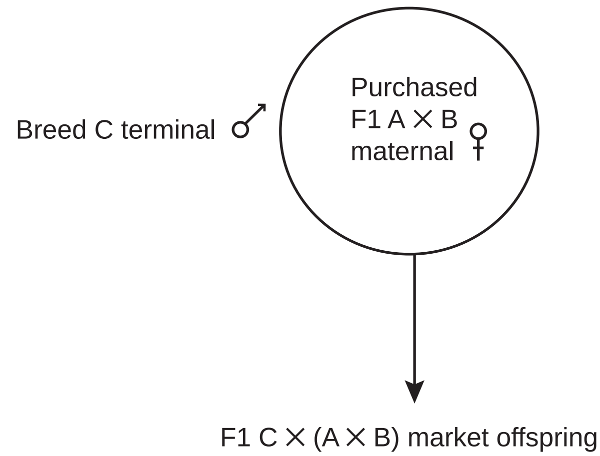



**Figure 1. Example of a terminal crossbreeding system using purchased F1 females.**

An even simpler form of this system just uses two breeds. Bulls of breed A are bred to females of breed B to produce F1 A × B offspring. These offspring will exhibit maximum heterosis, but since the females that produced these calves were not crossbreeds, the offspring were not able to take advantage of any maternal heterosis.

### Rotational Cross

**Spatial Rotations** – The classic form of a rotational crossbreeding system is a spatial rotation. In spatial rotations, all breeds are used at the same time but are separated spatially. This system requires multiple mating pastures, one for each sire breed. In a two-breed rotation (see Figure 2 for an example), two breeding pastures will be needed. A three-breed rotation would need three breeding pastures. This system is designed to produce replacements. Replacements leave the group into which they were born to join the other breeding group as a replacement. As seen in Figure 2, replacements out of sire breed A move to the group that is to be bred to sire breed B and replacements out of sire group B move to the group to be bred to sire breed A. The more breeds that are included in the rotation, the greater amount of heterosis. Each breed added also increases the level of management needed to keep the system operational.

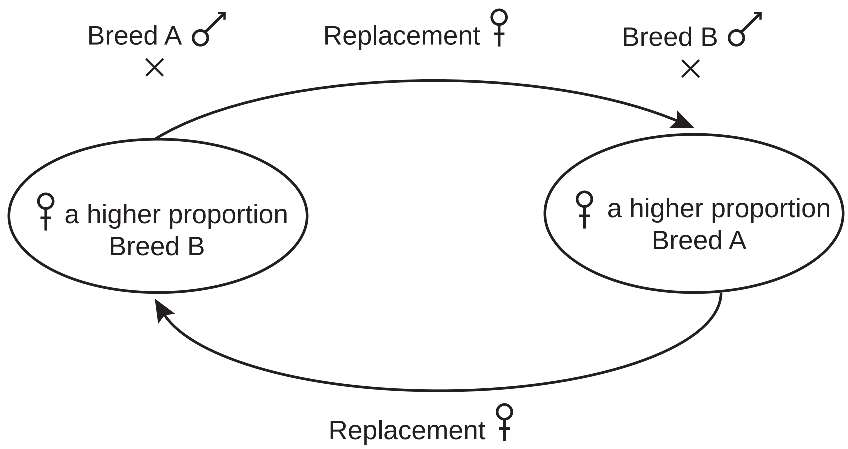


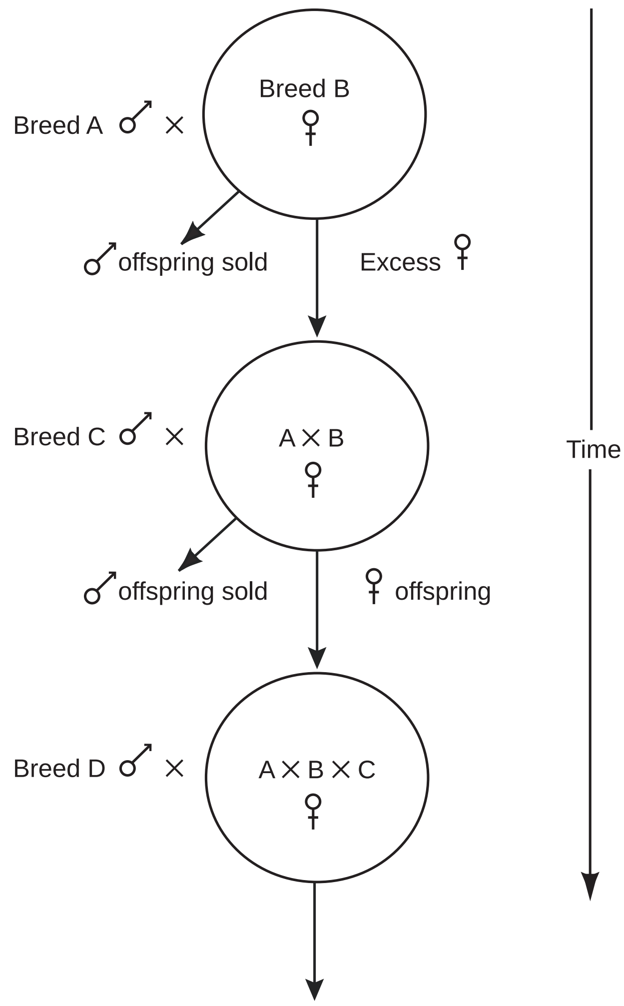

**Figure 2. Example of a spatial rotation using two sire breeds.**

**Rotation in Time** – Another commonly used form of rotational crossbreeding is rotating sire breeds across time. In this system, only one breed of sires is used at one time. Typically, sire breeds are rotated every one or two breeding cycles. This system is simpler to manage than a spatial rotation, but the level of observed heterosis is somewhat less due to increased backcrossing. This system is illustrated in Figure 3. The major problem with utilizing this system is that over time the groups of breeding females become very inconsistent in their breed makeup and performance. This introduces inconsistency in their offspring. This variation in calf performance can be a hindrance during marketing of the offspring.

## Summary

In comparing crossbreeding systems, you will notice that each system excels in some criteria, often at the expense of other criteria. Inevitably, there are trade-offs to be considered. Some systems sustain very high levels of hybrid vigor but are a management nightmare. Some take advantage of breed complementarity but cannot produce their own replacement females.

A planned mating system is the nucleus of a successful crossbreeding program. The mating system should maintain heterosis at an optimal level and permit uninterrupted production of a uniform product from generation to generation. Matching the crossbreeding system to the facilities and environment is of utmost importance. Likewise, the choice of breeds is important. The use of a crossbreeding system that produces offspring efficiently will play a large part in the profitability of cow-calf producers.




Continue rotation with another breed or breed back to Breed A and start the rotation again.

**Figure 3. Example rotation in time system using three breeds.**

# Chapter 4

# Beef Sire Selection

Selecting a herd sire is one of the most important decisions a cow-calf producer makes. A herd bull contributes half the genetic makeup of his calves and plays an essential role in herd genetic improvement. The herd bull is the most important individual in a breeding herd. A cow or heifer typically produces one calf per year, while a mature herd bull may sire 25 or more calves per year. Thus, a herd sire may contribute more to the genetic makeup of the herd in one breeding season than a cow contributes in her lifetime. Selecting genetically superior bulls is the quickest path to herd genetic improvement. The value of a bull above slaughter value is his ability to sire live calves and transmit superior genetics to the herd.

## Selection Goals

Different cow-calf operations have different goals and different resources. Yet bull selection goals for any cow herd should target an **acceptable combination of traits that complement the strengths and weaknesses of the cow herd and match markets**. When selecting a bull, consider the needs of the cow herd. Ask questions that will help match a bull to the cow herd.

- **Do weaning weights need to be improved?** If so, growth performance is a priority in the selection process.
- **Does calf crop color uniformity need improvement?** If so, color pattern inheritance is an important consideration in bull selection.
- **Will the bull be bred to heifers and is limited labor available to assist with calving?** If either is the case, calving ease is a priority.
- **Are there plans to retain ownership of calves beyond the feedlot and market them on a value-based pricing grid?** If so, attention needs to focus on carcass traits in selecting breeding animals.

Other factors that should be considered in bull selection include structural soundness, conformation, libido, disposition, scrotal circumference, sheath, frame size, muscling, breed and horn presence or absence. Try to strike a balance among various traits and avoid extremes. Base the type of bull selected on the purpose of the bull in the breeding herd. Will the bull be used as a terminal sire on mature cows, will he be bred to heifers or will he be used to sire replacement heifers?

## Selection Tools

### Visual Estimation of Breeding Value

Prior to the advent of performance testing, producers used visual evaluation to predict the breeding value of bulls for traits like growth rate and carcass composition, with variable success. The first performance-tested herds provided adjusted weights and in-herd ratios to their bull buyers, increasing accuracy of selection within one herd's offering. But only with the availability of expected progeny differences (EPDs) were bull buyers able to accurately compare animals from different herds. Nonetheless, some bull buyers continue to emphasize actual weights or in-herd ratios when selecting a herd sire.

Bull buyers often incorrectly assume that the animal with the most desirable actual performance will produce the most desirable progeny. While individual and progeny performance are related, the relationship is far from perfect. The relationship between an individual's performance and their progeny's performance depends on the heritability of the trait. For highly heritable traits, like carcass traits, relatives generally resemble each other closely, and an individual's measurement is a reasonable estimator of their progeny's performance, after adjustment for environmental effects. For moderately heritable traits, like weaning weight, the relationship weakens, and data on relatives of the prospective sire add considerable information used in calculating the animal's EPD. When dealing with traits of low heritability, like maternal weaning weight or reproductive traits, considerable information on relatives and progeny is needed to evaluate animals accurately. Regardless, EPD calculations account for the heritability of the trait, and the EPD is the single best estimate of progeny performance.

When EPDs are available, using the actual weights or ratios with or without the EPD decreases the accuracy of selection for several reasons. When the most recently calculated EPDs (including interim EPD) are available, they are the most accurate estimate of the animal's genetics for the measured traits. The animal's actual weight or measurement for the trait has already been included in the EPD calculation. The EPD calculation appropriately weights all the relevant information, including performance of ancestors and other relatives, and progeny when available. If producers use both the EPD and the actual weight in selection, they overemphasize the animal's own performance and underemphasize the performance of relatives and progeny. If an animal has a favorable EPD for a trait but a less favorable actual weight or measurement for the same trait, either there are significant environmental effects influencing the actual observation that are accounted for in the EPD calculation, or there is an overwhelming amount of evidence from relatives that the animal in question has superior genetics.

However, there may be a few instances where traits of economic importance are not included in genetic evaluations, usually because the traits are subjectively measured. For example, bull buyers may evaluate feet and leg structure, not only to ensure the bull can service cows, but also to maintain feet and leg soundness in the bull's daughters. Again, the degree to which a sire's conformation for such traits will be reflected in their progeny depends on the heritability of the trait in question. For feet and leg conformation, limited data have been collected in beef cattle.

One example of such a scoring system is the Genetic Trait Summary provided by ABS Global (Kirschten, 2002a). A sample of heritability estimates for type scores in Simmental appears in Table 16.

### Table 16. Heritability Estimates for Type Traits in Simmental Cattle (Kirschten, 2002b)

| Trait | Heritability |
|---|---|
| Stature (height) | .60 |
| Body length | .39 |
| Muscling | .42 |
| Capacity | .44 |
| Femininity | .32 |
| Rear legs (hock set) | .12 |
| Foot/pastern angle | .13 |
| Udder attachment | .23 |
| Udder depth | .35 |
| Teat size | .39 |

Heritability above 0.40 is considered high, while heritability of 0.15 or less is considered low. From the table above, height in this population is highly heritable, indicating that selecting sires that are taller or shorter in height than their contemporary group mates should result in daughters with somewhat similar characteristics. Rear leg and pastern set, in contrast, is low in heritability; so post legs and weak pasterns are more likely the result of environmental effects rather than genetics. Udder depth and teat length are moderate in heritability, offering some opportunity for improvement through visual selection. However, those traits can only be observed in females. While it may be possible to observe a bull's dam for her udder characteristics, only half of her genetics for those traits are passed to any one son, and only half of that passed from the son to his daughter. Culling the cowherd on udder traits is more likely to improve those traits than is sire selection. The exception would be when selecting AI sires that have a large number of daughters in production, if many of those daughters can be visually evaluated.

One of the traits most commonly evaluated visually by bull buyers is muscling. Koch et al. (2004) selected Hereford cattle for 20 years based on weaning weight alone, yearling weight alone or a combination of yearling weight and muscle score. Visual muscle score was shown to be at least as heritable as carcass ribeye area (0.37 vs. 0.26, respectively). The authors reported a genetic correlation of 0.54 and a phenotypic correlation of 0.19 between ribeye area and retail product percentage, a favorable result. The correlation of visual muscle score with retail product percentage was near zero (genetic = 0.06, phenotypic = -0.10), indicating visual selection for muscling would have little impact on cutability. While cattle selected on both yearling weight and muscle score had larger ribeye area compared to those selected on yearling weight alone, the differences between selection lines for retail product percentage were insignificant. Selection on ribeye area EPD, based on carcass measurements, ultrasound measurements or both will likely result in greater improvement in both carcass muscling and retail product percentage, compared to visual selection for muscling.

Obviously, bulls with overly aggressive, nervous or flighty dispositions can create management problems for producers, and should be avoided for that reason. Docility in Limousin cattle has been shown to have moderate to high heritability (0.40; Kuehn et al., 1998), indicating that the resemblance between sires and their daughters for disposition should be fairly strong. However, behavior may also be influenced by sex characteristics of males versus females. So while bulls with poor dispositions are themselves a problem, there is some likelihood that their daughters will inherit similar dispositions.

Another area in which producers might use visual evaluation or phenotypic measurement in predicting a sire's breeding value is in the area of calving difficulty, either direct or maternal. For example, a bull buyer might observe that a bull appears wider and more muscular through his shoulders, and wrongly conclude that his calves might require greater assistance at birth. Two studies at Virginia Tech evaluated the relationships between calf shape and calving difficulty, and concluded that once birth weight was considered, any measurements of the calf 's dimensions or shape provided no additional information on the ability of the calf to be born unassisted (Nugent et al., 1991; Nugent and Notter, 1991). Also, pelvic area in females, measured at a year of age, has been shown to be a useful predictor of their ability to calve unassisted (Bellows et al., 1971). However, Kriese (1995) showed that using pelvic area of yearling bulls to predict their daughter's calving ease is not useful. First, pelvic area is moderately heritable, so a sire with a larger pelvic area should transmit some but not all of that advantage to his offspring. Also, pelvic area seems to be significantly affected by developmental differences between males and females (Kriese et al., 1994), so genetics that result in a large pelvic area in males might not have the same effect in females.

### Expected Progeny Differences

Expected progeny differences (EPDs) are a useful genetic selection tool for many of the traits described below as well as many others not mentioned. Expected progeny differences provide predictions of the expected performance of the calves sired by a bull compared to the expected performance of calves sired by another bull. They are based on the performance records of an individual, its relatives and its progeny. Many breed associations publish EPDs on individual animals in sire summaries and searchable internet databases. Breed associations also publish tables that show where individual animals rank within the breed for specific traits, such as weaning weight or ribeye area.

Expected progeny differences can change over time as additional performance information is collected. Expected progeny differences come with accuracy values that give an indication of the reliability of the EPD. Accuracies range from 0 to 1, with values closer to 1 signifying higher accuracies. As more usable performance information becomes available for an animal, its relatives and progeny, the more accurate or reliable its EPDs become. Thus, a young, unproven bull with no calves will have lower accuracy EPDs than a proven sire with hundreds of calf records. Expected change tables are published by breed associations as part of national cattle evaluations to show how much variation can be expected for EPDs at specific accuracy levels.

Expected progeny differences are the best predictors of the genetic performance of an individual animal, and they are available for a growing number of economically relevant traits. Different breeds will have EPDs available for different traits; however, most breeds have basic EPDs, such as birth weight, weaning weight, yearling weight and milk. Expected progeny differences can be used to make herd genetic improvement in both commercial and seedstock operations. Genetic improvement can mean increased weaning weights and growth performance, enhanced reproductive performance and better performance on the rail – all of which can enhance the profitability and viability of a cattle operation.

### Selection Indices

Selection indices are based on multiple traits weighted for economic importance, heritability (the proportion of the differences among cattle that is transmitted to their offspring) and genetic associations among traits. In other words, a selection index is a selection tool that integrates biology and economics. A selection index may provide a balanced selection approach when selecting for more than one trait at a time.

## Selection Criteria

Beef cattle selection should be based on many factors – growth and reproductive performance, fertility, health, disposition, age, frame size, muscling, etc. Single-trait selection should be avoided when selecting a herd sire. Overemphasis on one or a few traits may reduce performance for other traits. There are several genetic antagonisms that may result in performance tradeoffs. For example, selection for high growth (high weaning and yearling weights) may simultaneously increase birth weights and calving difficulty. The reverse is also the case: growth sacrifices may be made when selecting for low birth weights. Of course, there are bulls within every breed that have the genetic potential to transmit both high growth and low birth weights to their calves. Other common performance tradeoffs include red meat yield versus red meat quality, fertility/reproduction versus growth rate/lean yield and milk yield versus cow maintenance requirement. A balanced approach to sire selection focusing on multiple economically important traits can go a long way towards herd genetic improvement.

### Frame Size

Changing the frame size of the calf crop can be accomplished through sire selection and selective culling of the cow herd. Inappropriate carcass size and weight ranked second among the “top 10 quality challenges” identified in the 2000 National Beef Quality Audit. Frame size describes the overall skeletal size of cattle and is a useful tool for evaluating the lean-to-fat ratio of an animal. It is an indication of growth and is related to slaughter weights at which cattle should attain a given amount of fat thickness. Large frame steers (frame scores 7, 8 and 9) with the genetic potential to grade Choice are expected to do so at 1,250 pounds or higher, while large frame heifers with the genetic potential to grade Choice are expected to do so at 1,150 pounds or better. Medium frame steers and heifers (frame scores 4, 5 and 6) with the genetic potential to grade Choice are expected to do so at 1,100 and 1,000 pounds, respectively. Small frame steers and heifers (frame scores 1, 2 and 3) with the genetic potential to grade Choice are expected to do so at less than 1,100 and 1,000 pounds, respectively.

Frame scores are calculated using hip height measurements. Hip heights can be measured with a hip height stick or pull-down tape measure and converted to frame size scores by calf sex and age using a frame score table. Although actual hip height may increase as an animal matures, most cattle maintain the same frame score throughout their lives. This allows one frame score to be used for an animal, regardless of when that animal's hip height is evaluated. Larger-framed cattle require more forage and feed resources than smaller-framed cattle, so matching cattle size to production resources is important. Culling extremes for frame size (large and small) can also be useful in improving herd uniformity. Bull frame size can be strategically matched to cow frame size to produce calves within a targeted frame size range. However, caution should be used when breeding a large frame bull to small frame cows or heifers due to the increased risk of calving difficulty. Some breed associations compute yearling height EPDs that can be used in predicting a sire's ability to transmit yearling height to his calves.

## Muscling

Thickness or muscling is important in beef cattle because muscle is what is sold in the retail meat case. The degree of muscling impacts yield grades, average daily gains and dressing percentages. Lightly muscled cattle are significantly discounted at sale time. Muscling can be improved through bull selection. USDA feeder cattle thickness grades used to classify muscling range from 1 to 4, with 1 being the heaviest degree of muscling.

There are several good indicators of muscling in beef cattle (Figure 4). Muscling may be evaluated in the quarter or round, stifle, gaskin, twist, shoulder, forearm and across and along the back. Do not just look in one area to determine muscling. An animal may be thick through the quarter but lack adequate muscling in the forearm. The forearm is an excellent place to look for muscling because there is usually less fat cover in this area. Extremely muscled heifers or cows may have fertility problems, so sire selection for muscling should be optimized instead of maximized. In addition, a coarse, bunchy-muscled bull may sire similar calves, causing trouble at calving.

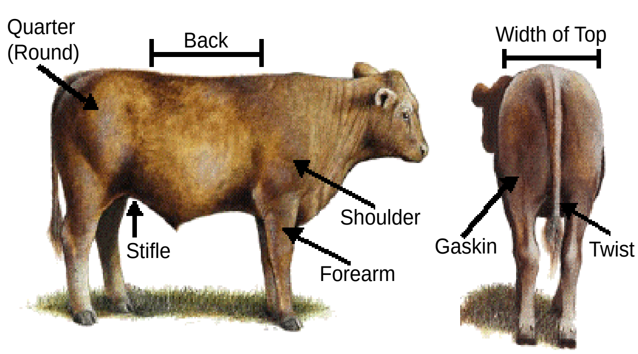



**Figure 4. Indicators of muscling in the beef animal**

## Growth Traits

Growth traits include weaning and post-weaning (yearling) growth performance. Growth performance information available on performance-tested bulls may include average daily gain, weight per day of age, adjusted weaning and yearling weights and weight ratios within contemporary groups. A contemporary group is a group of cattle of the same sex and age-managed under like conditions. An average weight ratio for a contemporary group is always equal to 100. A calf with a weaning weight ratio of 105 has a weaning weight that is 5 percent above the average of the group. A weaning weight ratio of 90, on the other hand, indicates that the calf's weaning weight is 10 percent below the average of the contemporary group. Expected progeny differences for weaning and yearling weights are a fairly standard component of national sire evaluations conducted for specific breeds.

## Carcass Traits

Carcass traits are a key consideration in bull selection, particularly when cattle ownership is retained and cattle are sold on value-based pricing grids. Table 17 lists industry targets for beef carcasses outlined during the strategy workshop of the 2000 National Beef Quality Audit. Carcass traits are moderately to highly heritable, so genetic improvements can be made in a shorter period of time than less heritable reproductive traits.

**Table 17. Industry Targets for Beef Carcasses**

| Carcass Trait | Industry Target |
|---|---|
| Carcass weight | 650 to 850 pounds |
| Quality grade | Prime, Choice or Select |
| Yield grade | 1 to 3 |

Ultrasound carcass scanning technology allows carcass information to be collected on live animals instead of having to wait until cattle are harvested. Yearling bulls out of potential herd sires may be ultrasound carcass scanned for 12th to 13th rib fat thickness, rump fat thickness, ribeye area and intramuscular fat percentage (marbling). Each of these traits is significant in the determination of red meat yield and quality, and each is at least moderately heritable.

Participants in the Arkansas Steer Feedout Program receive carcass information on calves after completion of a finishing phase. This information can be used to evaluate growth and carcass traits in the herd and compare the carcass merit of calves out of different herd sires. Expected progeny differences are also available for many carcass traits, including hot carcass weight, marbling, ribeye area, rib fat thickness and percent retail product.

## Calving Ease

Calving ease is an important consideration in the sire selection process, particularly when first-calf heifers or small-framed cows are to be bred. Labor availability may influence how a "calving ease" or "heifer" bull is valued. Birth weight has often been used as an indicator of calving ease, but there can be a lot of variation in calving ease. Birth weight is just one of many factors that affects calving difficulty in beef cattle. According to the Beef Improvement Federation, other factors affecting calving ease include age of dam, calf sex, pelvic area, gestation length, cow size, shape of calf, breed of sire, breed of dam, uterine environment, hormonal control, geographic region, season of year, environmental temperature, nutrition of dam, condition of dam, implants/feed additives, feeding time and exercise.

Birth weight and several other factors are components of calving ease EPDs. Selection based on both calving ease and birth weight EPDs is discouraged since it may put too much selection emphasis on birth weight. Emphasizing calving ease in selection rather than birth weight may make it easier to select for calving ease and growth performance at the same time. Birth weight will still be accounted for in calving ease EPDs.

The two types of calving ease EPDs are calving ease direct and calving ease maternal. Calving ease direct EPDs provide information about the expected assistance required at birth for a sire's calves and predict the ease with which a bull's calves will be born to first-calf heifers. Calving ease direct indicates the percent more or less of calves sired by a particular bull that are expected to require assistance at calving out of two-year-old heifers. For example, a bull with a calving ease direct EPD of +10 percent compared with a bull within the same breed with a calving ease direct EPD of +2 percent is expected to sire on average 8 percent (10 – 2) more calves that can be born unassisted. Calving ease maternal or daughter's calving ease EPDs, on the other hand, give an indication of the expected assistance required at calving for calves out of a sire's two-year-old daughters. In this case, the bull on which the EPD is evaluated would be the grandsire of the calf for which the necessary assistance at birth is being predicted. Calving ease maternal is also referred to as daughter's calving ease or maternal calving ease and is the ease with which a sire's daughters calve as first-calf heifers.

## Maternal Traits

Milk production is an important maternal trait that directly affects calf weaning weights. Milk EPDs are expressed as pounds of calf weaned due to the milk production of the dam, not as pounds of milk produced. Combined maternal (also referred to as maternal milk and growth, maternal weaning weight or total maternal) EPDs reflect a combination of the milking ability of a bull's daughters along with the growth potential of their calves. As milk production increases, the nutritional requirements of the dam increase. Milk production must fit the forage and feed environment to ensure that nutrient requirements of lactating cattle are met and rebreeding is not hindered by inadequate nutrition.

Calving instincts and disposition are other traits that are important in replacement female sires; however, it may be difficult to select for these traits via bull selection. A few of the other EPDs available for maternal traits include heifer pregnancy, gestation length and stayability. The availability of these EPDs will vary by breed. Reproductive traits typically have a low heritability, so selection for improved reproductive performance may be slower than selection for more heritable traits, such as carcass traits.

## Bull Fertility and Scrotal Circumference

Fertility in bulls can be assessed with a breeding soundness examination (BSE). A BSE is a practical method for identifying bulls with less than satisfactory breeding potential. Bulls not passing a BSE need to be culled from the breeding herd to prevent calf crop declines. A breeding soundness evaluation consists of a physical examination, scrotal circumference measurement and semen evaluation and is performed by a veterinarian. Ideally, a bull should have passed a BSE prior to purchase.

A BSE should be performed annually on each bull about 60 days prior to the start of the breeding season. This allows time to recheck or replace bulls receiving suspect scores. Do not use a bull that fails a BSE. Because the breeding potential of a bull can change over time, BSEs should be conducted on a regular basis. Disease, injury and environmental conditions can affect proper function of the testes and impair reproductive performance. An annual BSE is essential, especially when only one bull for the entire operation, one bull per breeding herd or a high female-to-bull ratio is used.

Measurement of yearling scrotal circumference provides an indication of a bull's sperm-producing capacity. Scrotal circumference is also negatively correlated with age at puberty of a bull's daughters and female sibs. In other words, the daughters of a bull with larger scrotal circumference should reach puberty at an earlier age than the daughters of a bull with smaller scrotal circumference. Scrotal circumference is a particularly relevant selection consideration when a bull is used to produce replacement heifers. Many breed associations publish EPDs for scrotal circumference.

## Structural Soundness

Structural soundness is important in beef sire selection to ensure that a herd sire is physically capable of effectively breeding herd females. A breeding bull will need sound feet, legs and eyes in order to seek out and find females in heat and service them. Structurally sound bulls will walk freely and easily, taking long strides, and will display flex and give in the joints. Thus, it is important to watch cattle walk to observe possible defects that may impair ease of movement and cause undue stress on bone joints. View cattle from as many angles as possible when assessing conformation and structural soundness. It may be useful to get in the pen with the cattle and move them around.

The legs of a structurally correct bull should be placed squarely at the four corners of his body. Bones should be straight and strong with the proper amount of "set" or angle to the shoulder, hock and pasterns for ample cushioning. A steep shoulder (too straight) is a good indicator of potential leg problems. A bull that is buck-kneed in his front legs will have excess stress on the shoulder. A bull that is calf-kneed in his front legs will have excess stress on his knees. An animal that is post-legged in its rear legs (not enough set to the hock) may become "stifled" and have difficulty mounting herd females. This condition is more serious than the sickle-hocked condition where there is too much set to the hind legs. Cattle may also be toed-out or cow-hocked, two additional structural problems. A narrow stance in the rear legs may affect length of stride. Hip structure also affects how easily and freely an animal moves. Cattle should be level from their hooks (hips) to their pins. Too much slope from hooks to pins is undesirable.

## Conformation

Conformation is not only important in the show ring, but it also has implications for production and marketing. Shortcomings in conformation can be passed on from a bull to his calves. Severe conformation problems need to be selected against to limit conformation problems in future calf crops.

It is important to select bulls with adequate body capacity or volume. Body capacity is assessed by looking for spring of rib, width of chest floor, length of body and depth of body. Replacement females sired need ample body volume for carrying and delivering a calf along with a large rumen for consuming large quantities of forage for calf and milk production. In addition, bulls with extremely small pelvic areas can produce heifers with unacceptably small birth canals. Sires with wide shoulders can also sire similarly shaped calves that are more likely to undergo a difficult birth.

Sex character is important in beef cattle as well. A bull should look like a bull. Bulls should be masculine, powerful in appearance, display a prominent crest and appear heavier in muscle and bone than their female counterparts. Sex should be distinguishable when looking at the head of an animal, even in a calf.

Some bulls have a predisposition to being wastier than other cattle. Excessively fat bulls often lack libido. Bulls displaying large amounts of loose hide in the dewlap or brisket, excessive depth of flank and loose hide in the twist may be predisposed to being wasty. They may exhibit patchy, uneven finish.

A well-balanced bull is stylish, eye-catching and attractive, which helps in capturing favorable interest from potential buyers. Balance implies correctness of structure and a desirable blending and proportion of body parts. The neck should blend smoothly into the shoulder, and a level topline should be exhibited. Bunchy, coarse muscling should not be present. A heavy-fronted, light-ended bull is "unbalanced."

## Sheath

Sheath character is an important trait to assess, particularly in Brahman-influenced bulls. Extremely loose, pendulous sheaths may be more prone to injury than tighter, less pendulous sheaths (Figure 5). Over-grown brush and spiny weeds are just some of the pasture hazards that may cause cuts or abrasions to a bull's sheath and penis. Bulls are at greatest risk for sheath and penis injuries during travel and mating. Sheath character is heritable, and many tight-hided, Brahman-influenced animals are available with minimal sheath and dewlap as a result of genetic selection.

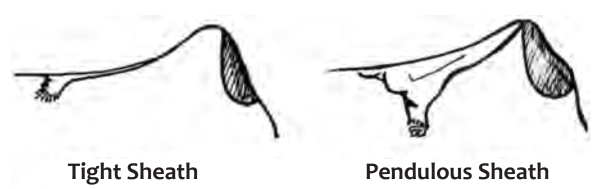



**Figure 5. Differences in sheath character**

## Polled Versus Horned

Horned calves are often discounted at sale time. Horns can cause bruising and other injuries to both cattle and cattle producers during handling. Horn-related injuries may occur during shipping as well as in the feedlot and are thus undesirable to cattle feeders. Too frequent and severe bruises ranked among the "top 10 quality challenges" for the United States fed beef supply, according to the 2000 National Beef Quality Audit. Dehorned or polled cattle also move more easily through handling facilities and take up less bunk space in the feedlot. Horns can be removed from cattle through physical means (dehorning) or through genetic selection (selection of homozygous polled breeding animals).

In British or Continental breeds of cattle, homozygous polled (PP) bulls sire only polled calves (Table 18). Homozygous means that the two alleles (parts of the gene pair) are the same. Heterozygous, on the other hand, means that the two alleles in the gene pair are not alike. Just because a bull is physically polled does not mean that it is homozygous polled. Some polled bulls are heterozygous for the horn gene (Pp) and can transmit the genetics for horn expression to their calves. It is useful to know if a polled bull is homozygous or heterozygous polled. This information may be available in breed association records. Horned bulls are homozygous horned (pp) and can only transmit the genetics for horn expression to their calves. Using a horned bull will perpetuate horn expression in the herd.

The genetics of horn expression is more complicated in cattle with Zebu ancestry, such as Brahman, Santa Gertrudis and Beefmaster. A second gene, the African horn gene, contributes to horn expression in these breeds. A proven homozygous polled bull can produce some horned calves if he is bred to horned or polled cows that carry the African horn gene.

Scurs are incompletely developed horns that are not attached to the skull. The gene for scurs is transmitted separately from the horn gene, so it has no effect on the presence or absence of horns. Not all horned cattle carry the genetics for scur expression, and not all polled cattle lack the genetics for scur expression.

## Coat Color

Feeder calf prices can be affected by coat color. This is due to perceptions that coat color is an indication of performance potential or carcass merit. Despite market perceptions, cattle with the same coat color may perform very differently postweaning and on the rail. In fact, coat color alone is not necessarily even indicative of cattle breed. For example, several breeds contain black-coated cattle including Angus, Brangus, Gelbvieh, Limousin, Maine-Anjou and Simmental. Coat color also affects perceptions of uniformity in beef cattle, and uniform groups of cattle often command market premiums. Certain value-based marketing alliances, such as Certified Angus Beef, have coat color restrictions as well.

Understanding coat color inheritance can help in designing breeding programs with specific goals for coat color. The three basic coat colors in cattle are black, red and white. Each animal possesses two genes for basic coat color, one passed down from the sire and one passed down from the dam. The gene for black is dominant over the gene for red, so cattle with one gene for black and one gene for red are black. The genes for black and white express no dominance over one another. Therefore, cattle with one gene for black and one gene for white are a black-roan color. The genes for red and white also express no dominance over one another, so cattle with one gene for red and one gene for white are a red-roan color. The gene for white is recessive. Cattle with two white genes are a true white color. There are also genes that determine whether or not the base color will be diluted. Black dilutes to gray, red dilutes to yellow and diluted white remains white. The dilution gene is dominant to the non-dilution gene. Cattle with at least one diluter gene will exhibit a diluted color, while cattle with two non-dilution genes will not have a diluted color. Additional genes determine color patterns such as spotting, brindling and white face.

**Table 18. Inheritance of Polledness or Horns**

| Sire | Dam | Calves | |
|---|---|---|---|
| Genotype | Genotype | Genotype | Polled/Horned |
| Homozygous polled (PP) | Homozygous polled (PP) | 100% Homozygous polled (PP) | Polled |
| Homozygous polled (PP) | Heterozygous polled (Pp) | 50% Homozygous polled (PP) | Polled |
| | | 50% Heterozygous polled (Pp) | Polled |
| Homozygous polled (PP) | Homozygous horned (pp) | 100% Heterozygous polled (Pp) | Polled |
| Heterozygous polled (Pp) | Homozygous horned (pp) | 50% Heterozygous polled (Pp) | Polled |
| | | 50% Homozygous horned (pp) | Horned |
| Heterozygous polled (Pp) | Heterozygous polled (Pp) | 25% Homozygous polled (PP) | Polled |
| | | 50% Heterozygous polled (Pp) | Polled |
| | | 25% Homozygous horned (pp) | Horned |
| Homozygous horned (pp) | Homozygous horned (pp) | 100% Homozygous horned (pp) | Horned |

## Breed

There is often a focus on the differences among cattle of different breeds. There are also dramatic differences among cattle within a breed for particular traits. Within each breed, there are both superior and inferior cattle. This emphasizes the importance of assessing each potential replacement on an individual basis in addition to evaluating the use of a particular breed in a breeding program. Careful consideration should be taken in choosing both breeds and cattle within breeds.

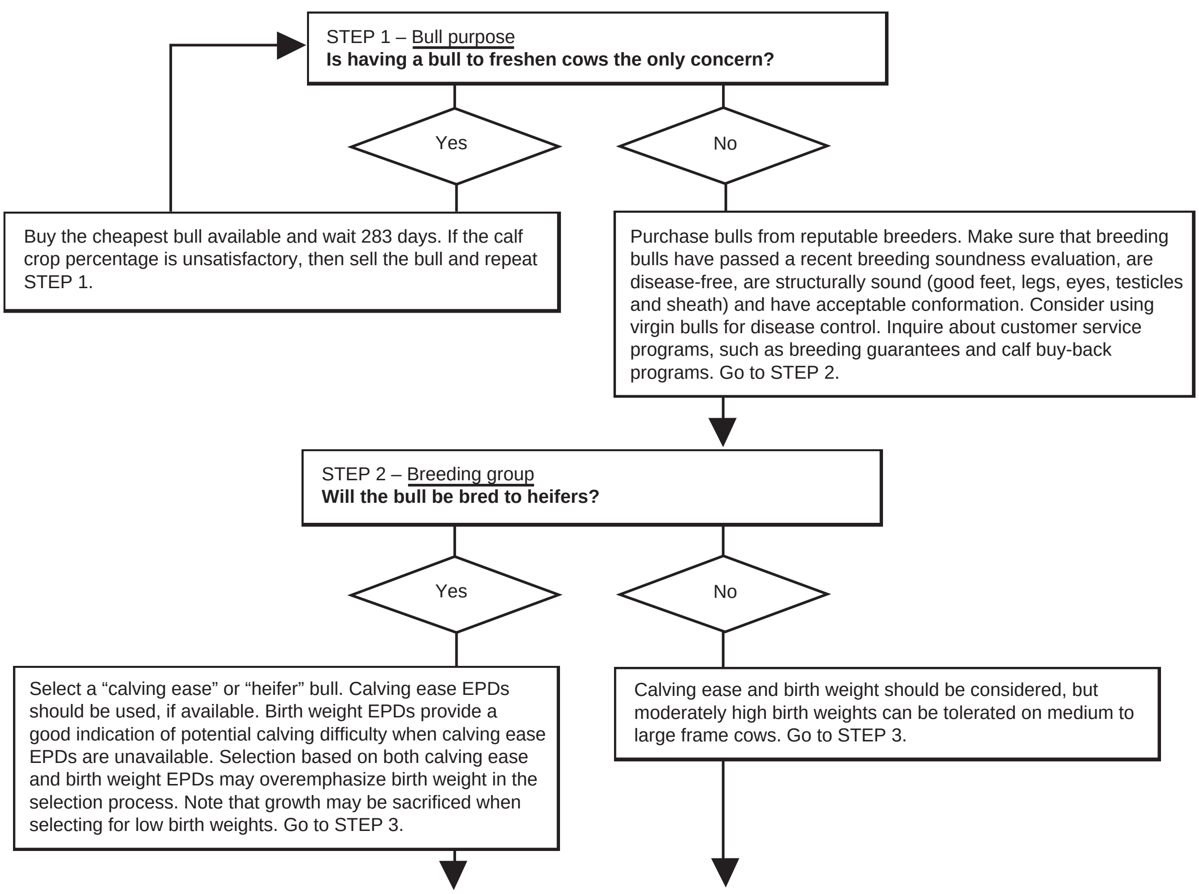
Visual estimates of breed composition may not always be accurate, but perception of breed composition often affects sale price. No breed or breed combination is necessarily always best for all production and marketing environments. A variety of breed combinations can be appropriate. It is important to be familiar with potential discounts for particular breed combinations.

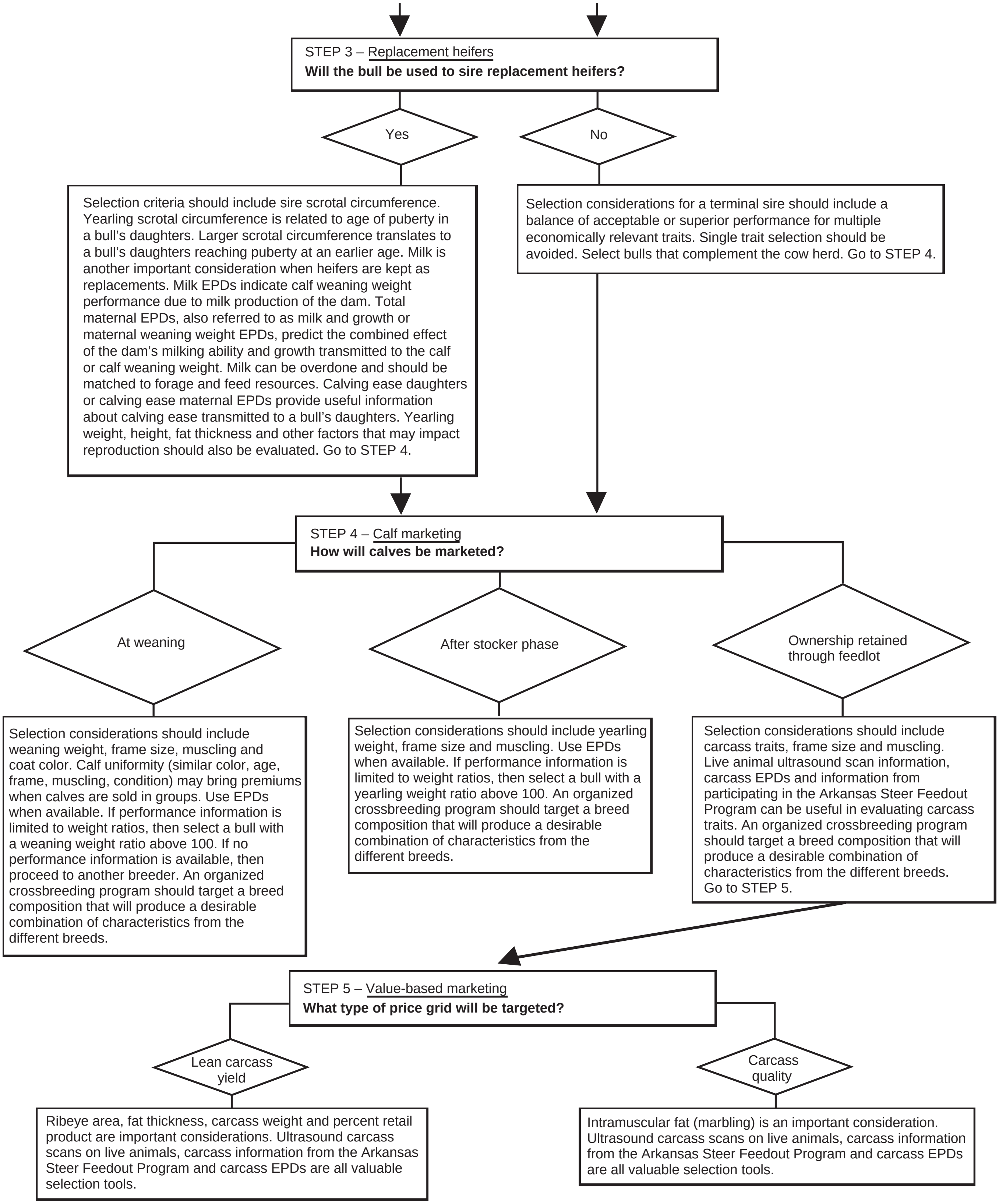
An organized crossbreeding program can capitalize on hybrid vigor while producing calves with a desirable combination of characteristics from multiple breeds. Hybrid vigor or heterosis is the amount by which the average performance for a trait in crossbred calves exceeds the average performance of the two or more purebreds mated in that particular cross. In addition, different breeds tend to excel for different traits. A well-designed crossbreeding program can combine the performance strengths among several breeds. Considerations for designing a crossbreeding program may include the current breed composition of the herd, whether or not replacement heifers will be kept, market targets, environmental conditions and forage and feed resources.

## Summary

How much information is needed in selecting a herd sire? The more information used in bull selection, the fewer surprises. It is important to use both performance information and visual appraisal in choosing a breeding bull. Selecting solely on performance numbers may ignore structurally unsound or infertile bulls that will do little for calf crop percentage and herd improvement. On the other hand, selection based only on visual appraisal may ignore the genetic potential of a bull. Visual appraisal of cattle complements the use of performance records for selecting/culling beef cattle. Information that may be useful in selecting a beef bull includes expected progeny differences, performance test information, pedigree information, recent breeding soundness evaluation results, herd health program history and bull prices (Figure 6).

**Figure 6. Bull Selection Decision Flow Chart**




STEP 3 – Replacement heifers
Will the bull be used to sire replacement heifers?
Yes
No
Selection criteria should include sire scrotal circumference. Yearling scrotal circumference is related to age of puberty in a bull's daughters. Larger scrotal circumference translates to a bull's daughters reaching puberty at an earlier age. Milk is another important consideration when heifers are kept as replacements. Milk EPDs indicate calf weaning weight performance due to milk production of the dam. Total maternal EPDs, also referred to as milk and growth or maternal weaning weight EPDs, predict the combined effect of the dam's milking ability and growth transmitted to the calf or calf weaning weight. Milk can be overdone and should be matched to forage and feed resources. Calving ease daughters or calving ease maternal EPDs provide useful information about calving ease transmitted to a bull's daughters. Yearling weight, height, fat thickness and other factors that may impact reproduction should also be evaluated. Go to STEP 4.
Selection considerations for a terminal sire should include a balance of acceptable or superior performance for multiple economically relevant traits. Single trait selection should be avoided. Select bulls that complement the cow herd. Go to STEP 4.
STEP 4 – Calf marketing
How will calves be marketed?
At weaning
After stocker phase
Ownership retained through feedlot
Selection considerations should include weaning weight, frame size, muscling and coat color. Calf uniformity (similar color, age, frame, muscling, condition) may bring premiums when calves are sold in groups. Use EPDs when available. If performance information is limited to weight ratios, then select a bull with a weaning weight ratio above 100. If no performance information is available, then proceed to another breeder. An organized crossbreeding program should target a breed composition that will produce a desirable combination of characteristics from the different breeds.
Selection considerations should include yearling weight, frame size and muscling. Use EPDs when available. If performance information is limited to weight ratios, then select a bull with a yearling weight ratio above 100. An organized crossbreeding program should target a breed composition that will produce a desirable combination of characteristics from the different breeds.
Selection considerations should include carcass traits, frame size and muscling. Live animal ultrasound scan information, carcass EPDs and information from participating in the Arkansas Steer Feedout Program can be useful in evaluating carcass traits. An organized crossbreeding program should target a breed composition that will produce a desirable combination of characteristics from the different breeds. Go to STEP 5.
STEP 5 – Value-based marketing
What type of price grid will be targeted?
Lean carcass yield
Carcass quality
Ribeye area, fat thickness, carcass weight and percent retail product are important considerations. Ultrasound carcass scans on live animals, carcass information from the Arkansas Steer Feedout Program and carcass EPDs are all valuable selection tools.
Intramuscular fat (marbling) is an important consideration. Ultrasound carcass scans on live animals, carcass information from the Arkansas Steer Feedout Program and carcass EPDs are all valuable selection tools.

Chapter 5

# Understanding and Using Expected Progeny Differences (EPDs)

Sire summaries are published by breed associations to provide current genetic evaluations on progeny-proven sires. While the sire summary formats may vary among breeds, they all are designed to use the best linear unbiased prediction procedures to produce expected progeny differences (EPDs) for all cattle that have legitimate performance records. An EPD is always the best estimate of an animal's genetic worth given the data available for analysis; so EPDs provide a genetic description of an animal for the traits included in the analysis.

## Expected Progeny Difference

One-half the estimated breeding value is the expected progeny difference (EPD). Breeding value is the value of an individual as a genetic parent. Breeding value is the part of an individual's genotypic value that is due to additive gene effects that can be transmitted from parent to offspring.

Because parents transfer a random sample of their genes to their offspring, it is impossible to control or predict whether a particular offspring will inherit a superior, average or below average sample of genes from each parent. Thus, an offspring's breeding value for a trait will be, on average, the average of its parents' breeding values for the trait. It is important to understand that the average of the parental breeding values does not determine the breeding value or performance of every offspring from a mating – just the average offspring. Estimated breeding values give an estimate of the average transmitting ability of the parent.

Expected progeny differences are useful in comparing or ranking individuals within a breed for traits of interest. They also are a prediction of future progeny performance for a specific trait of one individual compared to another individual. Thus, it is the differences in EPDs that are informative. The animal with the highest or lowest EPD is not necessarily the most desirable animal. The most desirable animal often represents a balance of EPDs for various traits. The EPD values can only be used to compare animals within a breed.

## Generating EPDs

Sire evaluation until the 1980s utilized only progeny (offspring) information. As a result, only older bulls were included in sire summaries, and EPDs could not be calculated for younger breeding stock. New animal breeding technology, as well as a new generation of computers, brought about the use of an animal model. An animal model provides techniques whereby the animal itself and all available information on relatives is included in the estimate of genetic merit. As a result, as soon as an animal reaches breeding age, EPDs are available.

Use of an animal model has some very nice features. EPDs are calculated for all animals, male and female. Preferential mating of certain individuals does not bias the results. Therefore, a popular bull can be used only on genetically superior cows and his EPD will not be inflated. This is accomplished by adjusting for the EPDs of the cows to which he is mated. Also, appropriate adjustments are made for genetic trend, genetic level of contemporary group and early culling on the basis of poor performance. For example, this adjustment allows young bulls to be directly compared to older bulls with many progeny records.

## Contemporary Groups

Proper contemporary grouping is the cornerstone of accurate genetic evaluation. A contemporary group is simply a group of cattle of the same sex raised in the same environment and measured under the same conditions. When comparing the actual performance of cattle, it is important to compare cattle from the same contemporary group. To produce accurate EPDs, it is important for producers to correctly form and identify contemporary groups in their within-herd performance programs to ensure accurate across-herd comparisons.

## Accuracy

Accuracy is a measure of confidence in an EPD. Classical accuracy is the correlation between an animal's unknown actual breeding value and a calculated breeding value. A published accuracy is a function of classical accuracy that reflects the amount of information used in calculating its associated EPD. Both classical and published accuracy values range between 0 and 1 and may be interpreted in the same way. A high accuracy (> 0.7) means that an EPD is not expected to change much as further information is gathered. A low accuracy (< 0.4) means that the EPD may change a great deal as additional progeny information is gathered. Accuracy is influenced by not only the amount of progeny data but also the distribution of those progeny across herds. Non-parent animals have lower accuracy values because no progeny information contributes to their EPDs. Published accuracies are helpful to breeders in management of selection risk. Sires whose published accuracy values are high should breed as indicated. Accuracy information allows breeders to take as much or as little risk as they like.

## Possible Change

It is important to realize that an EPD is a prediction of an individual's genetic transmitting ability for a given trait. As with any prediction, there is a margin of error, or possible change, associated with an EPD. When the accuracy is low, the margin of error is high. As more information (i.e., progeny data) becomes available, the margin of error becomes smaller. For example: If a bull has a birth weight EPD of +3.0 pounds, accuracy of 0.95 and possible change that is ±1.0 pounds, we are 67 percent certain that his actual EPD is between 2.0 and 4.0 (+3 ± 1.0).

## Pedigree Estimated EPDs

Many sale catalogs will contain EPDs for the bulls. Some bulls will appear in catalogs with limited or no EPD information. Sometimes, the weights on yearling bulls may not be reported by their breeder or they may not be usable because they did not meet certain criteria set up by the Beef Improvement Federation. When no data are available for a bull, he can still have EPDs, but they are computed based solely on his parents' EPDs. Each calf receives a random sample half of the sire's genes and a random sample half of the dam's genes. The two halves combine to form the complete genetic makeup of the calf. By understanding this halving nature of inheritance, the EPDs on parents and grandparents in the pedigree of a young bull may be used to compute Pedigree EPDs.

## Interim EPDs

Most beef cattle breed associations have genetic evaluation systems as a part of their performance recording programs. These National Cattle Evaluations (NCE) programs provide EPDs for sires, dams and non-parents on an annual or biannual basis. For calves recorded during the time period between NCE analyses, interim EPDs are calculated using the calves' pedigree index and within-herd performance. The interim EPDs provide breeders the means of making early selection decisions on calves prior to the next breed NCE analysis.

## Breed Average EPD and Base Year

Many producers believe the breed average EPD for a given trait is zero. In most cases, however, breed average is not zero. A zero EPD represents the average genetic merit of animals in the database at the time when there was sufficient information to calculate EPDs (base year). Some breed associations now set the base year to a particular year. If the breed has made any genetic change for a trait, the average EPD for the trait will no longer be zero. Breed associations publish average EPDs in sire summaries made available to the public. EPDs may increase or decrease over time compared to the base year.

## Growth Trait EPDs

### Birth Weight EPDs

Birth weight has been identified as the single most influential factor contributing to calving difficulty. In studies of birth weight data, birth weight EPD of sires has been shown to be the single most accurate genetic predictor of calf birth weight. To demonstrate how birth weight EPDs work, consider the following two bulls in Example 1.

**Example 1. Birth Weight EPD**

| | Sire A | Sire B |
|---|---|---|
| EPD in pounds | +4 | -1 |

The expected difference in the progeny of Sire A and Sire B for birth weight is 5 pounds. Sire A has an EPD of +4 and Sire B has an EPD of -1. On the average, it would be expected that the calves from Sire A would be 5 pounds heavier at birth than calves from Sire B. This is assuming that all calves are managed uniformly and are from cows of similar genetic merit and age.

### Weaning and Yearling Weight EPDs

Most beef cattle producers are interested in marketing pounds of beef. Therefore, weaning weight and yearling weight are very important traits for most commercial producers.

**Example 2. Weaning Weight EPD**

| | Sire A | Sire B |
|---|---|---|
| EPD in pounds | +20 | +40 |

The expected difference in the progeny of Sire A and Sire B for weaning weight is 20 pounds. Sire A has an EPD of +20 and Sire B has an EPD of +40. On average, it would be expected that the calves by Sire B would be 20 pounds heavier at weaning than calves of Sire A.

**Example 3. Yearling Weight EPD**

| | Sire A | Sire B |
|---|---|---|
| EPD in pounds | +40 | +80 |

The expected difference in the progeny of Sire A and Sire B for yearling weight is 40 pounds. Sire A has an EPD of +40 and Sire B has an EPD of +80. On the average, it would be expected that calves by Sire B would be 40 pounds heavier at one year of age than calves of Sire A.

# Maternal Trait EPDs

## Maternal Effects

Maternal effects are an important consideration when evaluating beef cattle performance. Maternal performance is expressed in terms of milk production. Maternal performance, however, takes into account more than just milk production. Traits such as calving instincts and behavior are also included. Therefore, maternal effects are defined as any environmental influence that the dam contributes to the phenotype of her offspring. The genetics of the dam allow her to create this environment for her calf. Maternal effects are important during the nursing period with diminishing effects through postweaning.

## Milk EPD

Weaning weight is determined by the genetics for growth in the calf and genetics for milking ability in the cow. There are separate EPD values for these components. The weaning weight EPD reflects preweaning growth of the calf, and the milk EPD reflects the milking ability of the sire's daughter expressed in pounds of calf weaned. The milk EPD that results from the separation of weaning weight into growth and milk segments is, like any other EPD, fairly simple to use.

**Example 4. Milk EPD**

| | Sire A | Sire B |
|---|---|---|
| EPD in pounds | +20 | +10 |

Sire A has an EPD of +20 and Sire B has an EPD of +10. Calves from daughters sired by Bull A would be expected to be 10 pounds heavier at weaning than calves from daughters sired by Bull B due to the difference in milk production of Sires A and B daughters. The 10 pounds are expressed in pounds of weaning weight, not pounds of milk.

## Combined Maternal EPD

Combined maternal EPD is a measure of a sire's ability to transmit milk production (milk EPD) and growth rate (weaning weight EPD) through his daughters. It predicts the weaning weight of a sire's daughters' calves.

**Example 5. Combined Maternal EPD**

| | Weaning Weight EPD | Milk EPD | Combined EPD |
|---|---|---|---|
| Bull A | +36 | +12 | +30 |
| Bull B | +32 | +16 | +32 |

The combined EPD for Bull A (+30) is computed by taking one-half the weaning weight EPD plus the milk EPD. The +30 pounds affect both the milking ability transmitted to daughters and the direct weaning growth transmitted through daughters to their calves. In a similar method, the combined EPD for Bull B is one-half times the weaning weight EPD (+32) plus the milk EPD (+16), or +32 pounds. An average difference of two pounds would be expected as the difference in weaning weight of calves out of daughters of the bulls based upon the genetic merit for growth (WW EPD) and milk (Milk EPD). Other expressions for the combined maternal EPD include combined value (CV), total maternal (TM) and milk + growth (M+G). Calculations to derive these values are all the same. The combined EPD is the best estimate to compare bulls for maternal traits.

# Carcass Trait EPDs

Carcass traits are becoming more important in the beef industry as consumers demand a more consistent quality product. Also, as value-based marketing continues to develop, carcass traits will become more important. EPDs for carcass traits predict genetic carcass differences just like growth and maternal EPDs.

## Carcass Weight EPDs

Carcass weight is a good predictor of total retail product. Carcass weight is not a good predictor of percent retail product. Selecting sires with higher carcass weight EPDs will result in progeny carcasses that produce more total retail at constant fat and age end points. The industry target weight range for carcasses is 650 to 850 pounds.

As a means of demonstrating how carcass weight EPDs work, please refer to Example 6.

**Example 6. Carcass Weight EPD**

| | Sire A | Sire B |
|---|---|---|
| EPD in pounds | +5 | +35 |

The expected difference in the progeny of Sire A and Sire B for carcass weight is 30 pounds. Sire A has an EPD of +5 and Sire B has an EPD of +35. On the average, offspring of Sire B would produce carcasses that are 30 pounds heavier than carcasses from Sire A, at an age-constant end point.

Optimum carcass weight EPDs for sires will vary according to characteristics of the cows to which the sires are mated and the overall management program. Some trial and error may be required to decide what optimum carcass weight EPDs will work most effectively with a particular cow herd. Avoiding extremes on both ends of the carcass weight EPD spectrum may be a logical alternative. Selecting sires of moderate size generally will help avoid production of carcass weights out of acceptable ranges in most cases.

## Fat Thickness EPDs

The National Beef Quality Audits identified excess external fat and excess seam fat as two of the largest contributors to lost economic opportunity in the cattle feeding industry. For the purpose of learning how to interpret EPDs for fat thickness, look at the two bulls listed below.

**Example 7. Fat Thickness EPD**

| | Sire A | Sire B |
|---|---|---|
| EPD in inches | .00 | +.10 |

The expected difference in the progeny of Sire A and Sire B for fat thickness is 0.10 inches. Sire A has an EPD of 0.00 and Sire B has an EPD of +0.10. Offspring of Sire A are expected to produce carcasses which have 0.10 inches less outside fat measured at the 12th/13th rib as compared to carcasses from offspring of Sire B.

Selecting for extreme levels of either low or high external fat could be dangerous. Intermediate levels are more optimum in most situations. While cattle that are too fat represent excessive levels of trim loss, extremely lean cattle can represent potential for fleshing ability problems in the cow herd that can lead to reproductive problems.

## Marbling Score EPDs

Marbling scores are subjective evaluations of intramuscular fat in the ribeye. At present, marbling scores are the only easily measured indicator of palatability in beef carcasses. The three components of palatability include tenderness, juiciness and flavor. While level of marbling influences juiciness and flavor, marbling is not a very good indicator of tenderness.

For purposes of calculating marbling EPDs, most breed associations will use the following table (Beef Improvement Federation).

**Table 19. USDA Quality-Grading System and Marbling Score**

| Quality Grade | Amount of Marbling | Numerical Score |
|---|---|---|
| Prime + | Abundant | 10.0 - 10.9 |
| Prime | Moderately Abundant | 9.0 - 9.9 |
| Prime - | Slightly Abundant | 8.0 - 8.9 |
| Choice + | Moderate | 7.0 - 7.9 |
| Choice | Modest | 6.0 - 6.9 |
| Choice - | Small | 5.0 - 5.9 |
| Select | Slight | 4.0 - 4.9 |
| Standard | Traces | 3.0 - 3.9 |
| Standard | Practically Devoid | 2.0 - 2.9 |
| Utility | Devoid | 1.0 - 1.9 |

The marbling score EPD is expressed in units of numeric marbling score, with higher values indicating the presence of genes for greater deposition of intramuscular fat. This results in higher than expected marbling scores and, thus, higher USDA Quality grade at a constant age.

Consider the marbling score EPDs of Sires A and B for an illustration of how to interpret these values:

**Example 8. Marbling Score EPD**

| | Sire A | Sire B |
|---|---|---|
| EPD in numeric score | -.20 | +.20 |

If bred to a comparable group of cows and processed at a constant age, the average marbling score of carcasses from offspring of Sire B is expected to be 0.40 score units higher than the average of carcasses of offspring produced by Sire A.

Generally, higher marbling score EPDs are favored. Choice-graded carcasses are typically more valuable than carcasses which grade Select or Standard, if other carcass characteristics are equal. When deciding how much emphasis to place on this trait, it should be remembered that a number of additional factors such as age of calf, days on feed and postmortem treatments can affect grading ability. The USDA marbling score, a subjective score for the amount of intramuscular fat in the longissimus dorsi (ribeye), is not a precise predictor of intramuscular fat. Research indicates that, generally, the correlation between marbling score and percent intramuscular fat (as determined by chemical extraction methods) is 0.70 to 0.75. It should be noted that the genetic correlation between marbling score and external 12th-rib fat is nearly zero. This means breeders can select for marbling and not have to worry about selecting for increased external fat when taking animals to an age-constant endpoint.

## Summary

Commercial and purebred cow-calf producers have EPDs available to them as a powerful selection tool. These EPDs allow comparisons between individuals within a breed for performance traits. The purebred breeder may obtain EPDs on each member of his herd by participating in cattle evaluation services available through respective breed associations. Commercial producers may use EPDs provided to them in sire summaries, bull sale catalogs and other sources in order to make directional change in the genetics of the beef herd. Once the appropriate breed choices are made, the producer has the opportunity to use EPDs as a tool in sire selection. EPDs allow fair comparisons of future progeny performance for bulls of the same breed. Cow-calf producers have EPDs as an opportunity to add predictability to the genetics of their cattle.

The table below provides general guidelines for using EPDs in commercial scenarios. More limited forage conditions would probably dictate the need to avoid very high EPDs for growth or milk and even more to avoid high birth weights. Growth EPDs should be geared to the needs of potential buyers. Reproductive traits, which may not have EPDs, still need to be considered in the selection process. EPDs can be a powerful selection tool for both purebred and commercial producers if used correctly.

**Table 20. Recommendations for EPDs for Various Commercial Scenarios**

| Use of Individual | Breed | Birth Weight | Weaning Weight | Yearling Weight | Milk |
|---|---|---|---|---|---|
| Terminal sire on mature cows | large carcass | not too high | high | high | not relevant |
| Bull to use with heifers | small to medium size | low | moderate | moderate | consider if keeping heifers |
| Sire replacement heifers | medium size maternal | low to moderate | moderate to high | moderate to high | varies |

## Chapter 6

# Purchasing and Management

Making informed bull purchasing and management decisions is vital to the success of a cow-calf operation. The two main purposes of breeding bulls are to contribute high reproductive performance and to transmit desirable genetics to the herd. Bull purchasing and management decisions impact both calf crop and herd genetics for many years. Bull management can be divided into the following seasons, which may vary in length depending on the operation: prebreeding or conditioning (2 months), breeding season (2 to 3 months) and post-breeding season (7 to 8 months).

## Prior to the Breeding Season

### Bull Purchasing

Plan ahead. **Purchase bulls at least 45 to 60 days before the breeding season.** This gives the bull time to adjust to new surroundings and to recover from stresses involved in sale or transportation. It also provides enough time to find another bull if it is discovered that the bull purchased is of questionable or unsatisfactory breeding potential. Do not wait until the last minute to find a bull and then immediately turn him out to pasture with the cow herd. It is important to prepare a good **strong bull pen** to hold a new bull before he arrives. Posts should be placed no more than 8 feet apart. Electric fencing may be necessary to effectively confine bulls.

Purchase bulls from **reputable breeders** who provide records of their herd health programs. Obtain available records and breed registration papers from the breeder. Inquire about performance information such as birth weight, weaning weight, yearling weight, average daily gain, weight per day of age, weight ratios, feed efficiency, size of contemporary group, frame size and scrotal circumference data from a bull test program or carcass trait (body composition) information from ultrasound scan data. Expected progeny differences (EPDs) may also be available from seedstock producers and may give an indication on how a bull's calves are expected to perform for certain individual traits relative to calves from other bulls within the same breed.

Visual appraisal of structural soundness and conformation is also useful in the selection process. Consideration should be given to the temperament (disposition) of sires used in breeding programs as well. Many breeders will supply this type of information upon request. Some breeders provide additional customer service in the form of bull guarantees or calf buy-back programs.

### Bull Leasing

Bull leasing may be an attractive option for producers interested in genetic improvement while reducing the capital investment and operating expenses needed for acquiring and keeping a breeding bull. Leasing allows a producer to use bulls that have a higher dollar value (and superior genetics in many cases) than the producer might be willing to pay if buying bulls. There are many different types of leasing arrangements available. When considering leasing as an option, compare the costs and returns from leasing a bull versus buying a bull.

It is also important to outline the responsibilities of all lease participants in enough detail to answer any questions that might arise if the bull gets sick, dies or is determined to be an unsatisfactory breeder. If any expenses are to be shared, then the contribution of each party should be decided up front. Responsibility for unexpected expenses should also be determined at the time the lease is signed. Deciding these questions ahead of time protects both the owner of the bull and the producer leasing the bull.

Leased bulls are usually only kept during the breeding season, so bull maintenance costs are not incurred outside of the time the bull is kept. Feed costs alone for one bull may run close to $350 per year. Veterinary, medicine, labor and breeding soundness examination costs will add to the cash outlay associated with keeping a bull. The bull owner should determine the costs of bull ownership in order to set a rental rate that will cover and provide a return above these costs.

Cash leasing rates typically average $500 to $700 per bull for a single breeding season; however, this will vary depending on the cattle market and the quality of the bull. Bulls can lose value as breeding animals over time. The salvage price of a bull at the end of his useful life is often much less than the initial purchase price of the bull. This lost value is referred to as depreciation and can be spread out as an annual cost over the useful life of the bull.

A $2,500 bull that depreciates to $700 loses more value each year [(2500 - 700) ÷ 6 or $300 per year over 6 years] than a $1,400 bull that depreciates to $500 [(1400 - 500) ÷ 6 or $150 per year over 6 years]. This depreciation cost difference may be factored into the lease rate so that the bull with the higher initial value and higher annual depreciation cost is offered for lease at a higher rate than the less valuable bull.

Although cash leases are more common, producers may also lease bulls on a share basis. This share basis typically involves use of a bull in return for a share of the calf crop. Returns from calf sales and, on rare occasions, returns from cull bull sales are usually shared in the same proportion as each party contributes to costs. Because the value of calf production returns will vary with market fluctuations and herd productivity, the cost of a share lease, unlike a cash lease, is subject to these changes. Share lease arrangements can be customized to individual situations. The proportions of input costs (land/pasture, labor, management, buildings, machinery/equipment, feed and other cash costs) and calf crop or cash receipts for which each lease participant is responsible can be tailored to fit the level of risk each party is willing to assume. Share leases allow the bull owner and the producer leasing the bull to share risk. Participating in this type of lease may be a way to obtain the use of bulls under situations when cash or credit is limited.

Producers with a large cow herd may want to consider owning one or more bulls in addition to using leased bulls. This helps ensure access to desirable herd sires in the event quality leased bulls are not readily available in future breeding seasons. In addition, owned bulls may be sold for salvage value at the end of their useful life in the herd to offset a portion of the initial purchase price or cost of raising homegrown bulls. However, interest and depreciation costs will be incurred with owned bulls, unlike with many leased bull arrangements.

## How Much Is a Bull Worth?

Performance information along with any expected progeny differences (EPDs) give an indication of the expected performance of a bull's calves for particular traits such as growth performance relative to the performance of calves sired by another bull or group of bulls. Using this information, educated purchasing decisions can be made regarding the purchase price differences that can be justified when comparing bulls. To illustrate differences in bull value, here is an actual scenario from the Livestock and Forestry Branch Station in Batesville, Arkansas. Bull A and Bull B were exposed to cows of similar genetic merit. Bull A sired calves that weighed on average 436 pounds at weaning. Calves sired by Bull B weighed 543 pounds on average at weaning.

Weaning weight difference between Bull B and Bull A is 543 pounds – 436 pounds = 107 pounds.

Lighter weight calves typically sell at a higher price per pound than heavier weight calves. If calves sired by Bull A could be sold for $0.92 per pound and calves sired by Bull B could be sold for $0.78 per pound, then gross returns from each bull would be as follows:

Bull A: 436 pounds × $0.92 per pound = $401 per calf sold

Bull B: 543 pounds × $0.78 per pound = $424 per calf sold

The difference in gross returns per calf would then be:

$424 (Bull B) – $401 (Bull A) = $23 per calf

If each bull can be expected to sire 25 calves per year, then the difference in gross returns per year between the two bulls would be:

$23 per calf × 25 calves per year = $575 per year

Over five years, the difference in gross returns between the two bulls would be:

$575 per year × 5 years = $2,875

If Bull B cost $1,000 more than Bull A, then it would take 20.9 months to capture the difference in purchase price with added returns from calf sales:

$1,000 ÷ $575 per year = 1.74 years or 20.9 months

Using Bull B as a herd sire beyond 20.9 months more than justifies paying the $1,000 premium for him over Bull A. This ignores interest and depreciation costs and assumes there are only weaning weight differences in the calves sired by the two bulls. If Bull B is also superior to Bull A in his ability to transmit heavier muscling, enhanced carcass characteristics or other economically important traits to his calves, then an even higher premium may be justified over the same payback period. This illustrates the financial importance of making bull-purchasing decisions based on as much useful and reliable information as is available.

## Breeding Soundness Evaluations

Breeding soundness evaluation (BSE) is a method developed to assess breeding potential of bulls for natural mating. Bulls differ in reproductive capabilities. Various studies from several states show that about 20 percent (1 in 5 beef bulls) examined were not satisfactory potential breeders. These bulls can be identified before the breeding season with a complete BSE.

In evaluating bulls for use in natural mating, three parameters have been shown to be the most reliable and repeatable. A complete BSE is normally conducted by a veterinarian and consists of a (1) physical examination, (2) measurement of scrotal size and (3) semen evaluation for sperm motility (movement) and morphology (structure and shape). The "complete" BSE is strongly recommended, although many shortcuts can be and have been made in these procedures. A complete BSE is very important in eliminating bulls with poor breeding potential. To record results of the BSE, evaluation forms such as those developed by the Society for Theriogenealogy or the University of Arkansas Cooperative Extension Service may be used. Form CES-413 is available from your local county Extension office.

**Physical Examination** – This part of the exam may be the most difficult to objectively assess. Some structural defects may have little or no influence on immediate mating ability but may predispose animals to early development of arthritis or injuries. As affected bulls age, the defect becomes more severe and serving capacity is reduced. Many hoof and sole problems result from poor conformation and may require trimming and other treatments to maintain serving capacity. Criticism of such defects often is taken as controversial opinion and may be detrimental to the veterinarian-client relationship. However, the long-term prognosis for structural unsoundness is poor. Most structural faults, such as sickle hocks and post legs, should be discriminated against since they are heritable and lead to lameness of the individual, which will impair his willingness and/or ability to travel and breed. In addition, the bull needs to be able to eat, see and smell properly. Common eye problems are pinkeye, scars and cancer eye. When detected early, pinkeye and cancer eye can be treated, and only advanced lesions interfere with a bull's breeding ability. Cancer eye has been shown to be heritable, but it is difficult to select against it because the condition does not appear until the animal is in advanced age. Nasal swelling or blocking may affect a bull's ability to smell.

Other physical traits that may be evaluated during a BSE include the degree of muscling, conformation, body condition and body size measurements, such as hip height, frame score and weight. These traits usually do not result in a bull being classified as unsatisfactory but may be a factor in his selection for breeding purposes.

A thorough examination of the male reproductive system follows the general health examination. Developmental defects, inflammation and other deviations from normal are observed. The vesicular glands, ampullae and prostate can be examined by rectal palpation, while the spermatic cord, scrotum, testicles and epididymides can be palpated externally. Some groups of young bulls have a high incidence of infection of the vesicular glands (these produce accessory fluid in the semen ejaculate). This is generally a temporary infection, but occasionally it will cause the discharge of pus into the semen, making fertility questionable. The penis and prepuce are best examined during collection of semen by using an electro-ejaculator or rectal palpation of the prostrate to stimulate erection. At this time, developmental abnormalities, warts or injuries may be detected. However, electro-ejaculation does not stimulate normal erection or ejaculation, so abnormalities with erection or copulation cannot be detected.

Developmental defects, as well as missing or underdeveloped portions of the male reproductive system, can be detected by a thorough examination. These defects are not common problems but are important because they can have severe effects on fertility. One developmental defect that will prevent a bull from servicing is persistent penile frenulum (tied back penis). This defect can be eliminated by ligation of blood vessels and cutting the adhesion. One caution in using a bull even after correction of this problem is that the condition appears heritable.

Changes in testicular tone are associated with a degenerative process and can be detected to some degree by testicular palpation. Degenerative change in the testicle is a frequent cause of infertility in all males, including bulls. This is a common occurrence following inflammatory reactions to infection. Many noninfectious factors can also contribute to this condition. Examples are frostbite and injury; or, the condition may develop with old age. Regardless of cause, the effect is reduced fertility.

**Measurement of Scrotal Size** – Measurement of scrotal circumference with a scrotal tape (Figure 7) gives a relatively accurate estimate of the semen-producing ability of a young bull. Although accuracy of this estimate declines in older bulls (greater than 4 to 5 years old), the measurement is of value even in aged bulls. In young bulls, scrotal circumference, actual testicular size and daily sperm production are all highly related. This measurement is simple, very repeatable from one technician to another and is highly heritable (i.e., 60 to 70 percent). Bulls with large testicles produce more semen and sire sons with larger testicles.

Selecting bulls with large testes also improves female fertility. Work at Colorado State University has shown that female relatives of bulls with larger testes reach puberty at a younger age. Through selecting bulls for testes size as well as growth traits, Colorado State has reduced the age at puberty, as 80 percent of the heifers reach puberty by 10 to 12 months of age and nearly 100 percent by breeding age at 14-15 months. The positive relationship between scrotal circumference and yearling weights ensures that growth traits are not compromised when selecting for both fertility and growth rate.

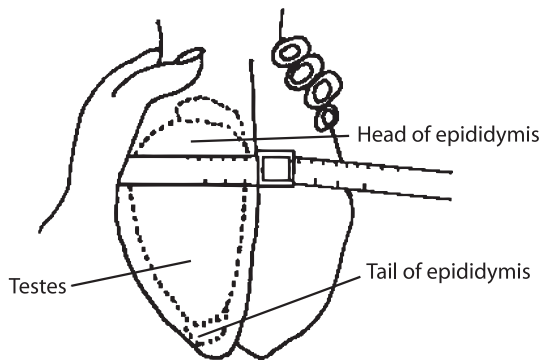



**Figure 7. Circumference measurements are taken at the widest point on the scrotum.**

There appears to be some variation between breeds as to testicular size at a given age. Brahman bulls will have smaller testes at younger ages and will reach maturity at an older age. Brahman bulls will have adult scrotal circumferences similar to other beef breeds. Management and body condition can also affect this measurement. However, most results show that a satisfactory rating on the breeding soundness evaluation is more closely related to scrotal circumference than to age, weight, body condition or breed.

Testicular hypoplasia (underdevelopment) is also evaluated during the BSE. The term implies an incomplete development of the germinal layers of the seminiferous tubules in the testicle. This defect decreases semen quantity and quality and is highly heritable. The condition may occur on one or both sides and with varying degrees of severity. One or both testicles are often less than one-third to one-half of normal size.

Diseases of the testes and epididymis are common in bulls. Despite the cause, any recognizable disease of the testes or epididymis has an unfavorable prognosis for normal fertility.

Inflammation of testes and epididymis will produce sperm damage, infertility and varying degrees of degeneration of the organs. The effect may be slight with only minor reduction in sperm production or sperm quality. These infections may go unnoticed and the organ may recover. Significant inflammation, however, may produce degeneration, scar tissue or abscesses of the organ. The testes are highly sensitive to any damage, and degeneration may develop acutely within a few days. Any regeneration may take months. The most common causes of inflammation and degeneration are thermal, trauma, local infections, systemic infections and some toxins. Aged bulls often develop testicular degeneration without any signs of inflammation.

**Semen Evaluation** – A semen sample may be collected from bulls by a variety of methods, but electro-ejaculation is the most common under normal field conditions (Figure 8). This is a harmless procedure and yields semen of acceptable quality to evaluate the bulls when compared to semen collected by other methods. Bulls that do not respond to an electro-ejaculator may produce semen when the reproductive organs are rectally palpated by a trained individual.

The two seminal characteristics that have shown to be the most reliable and repeatable in evaluating fertility under field conditions are initial spermatozoa motility (the vigor and number of cells moving in a linear progressive manner) and spermatozoa morphology (form and structure of individual sperm cells). Unfortunately, there can be a great deal of variation both within and between technicians in estimating sperm motility. Environmental factors can also have an effect on this estimate, and proper handling of the semen after collection is critical to a successful evaluation.

**Figure 8. Electro-ejaculation is the most common method of collecting semen samples.**

**Relationship of BSEs to Fertility** – A definite relationship exists between abnormal spermatozoal morphology and infertility in the bull. Note the relationships between percent normal cells and conception rate in Table 21. A system by which abnormal sperm are categorized into primary abnormalities and secondary abnormalities has proved useful for evaluating bulls. "Primary abnormalities" (abnormal head and mid-piece shapes, abnormal attachment of mid-pieces and tightly coiled tails) are thought to indicate defects in spermatozoal development. Bulls with large scrotal circumference generally have fewer primary abnormalities. "Secondary abnormalities" (separated normal heads, droplets and bent tails) indicate sperm storage problems and are considered less severe than primary abnormalities. Although these designations may not be clear cut, evaluating the percent of normal sperm cell types is well correlated with fertility.

**Table 21. Effect of Percent Normal Cells on Conception Rate[1]**

| % Normal | CR Rate (%) |
|---|---|
| <20 | 29 |
| 21-40 | 27 |
| 41-60 | 22 |
| >60 | 41 |

[1]Reproductive Management of Beef Cattle.

The system used by The Society for Theriogenealogy and the similar one used by the Extension Service classifies the breeding soundness evaluation of bulls as the following: satisfactory potential breeders, unsatisfactory potential breeders or classification is deferred. Failing any single aspect of the examination can cause a bull to be judged unsatisfactory or deferred. Bulls that have inadequate scrotal circumference or are physically unsound will receive an unsatisfactory classification. Bulls that are deferred should be reexamined in 30-60 days to confirm the original examination. This is especially true for sperm characteristics. The sperm picture presented at examination represents events that took place in the testes 60 days before, because that is how long it takes a basic germ cell to develop into a mature sperm cell. The semen evaluation, therefore, shows only the current status of sperm production, and if defects are currently observed, one cannot predict when or if a change will occur.

The BSE cannot predict conception rates either. The effect of breeding soundness categories on conception rate is illustrated in Table 22. There was great variation within categories. Some satisfactory bulls had very low conception rates, and some unsatisfactory bulls had acceptable conception rates. The BSE is to identify and eliminate unsound breeders rather than to make a prognosis on fertility. This must be understood by sellers and buyers.

The BSE also does not evaluate libido or sexual desire. The owner must observe and evaluate the bull's mating habits, or a serving capacity test should be done by experienced personnel in a controlled environment.

## Herd Health Program

Purchasing or leasing **virgin bulls** may help avoid introduction of diseases into the herd. It is recommended that your local veterinarian test bulls for vibriosis, leptospirosis and trichomoniasis, particularly if bulls were purchased from a sale barn or other facility where they may have been co-mingled with infected cattle. Keep newly purchased bulls isolated from the rest of the herd for at least three weeks after arrival. This **quarantine period** is important in preventing the introduction of disease into the herd. During the quarantine period, observe bulls for disease and feet, leg, back, eye or libido problems that may compromise breeding performance. The quarantine period may also be used to slowly adapt bulls to a new diet. To minimize the risk of digestive problems, bulls coming off a grain-based bull performance test need a hardening period to adjust to a forage-based diet prior to being turned out to pasture. Bulls to be used in multi-sire groups should be placed together ahead of turn out. This gives them a chance to become accustomed to one another and may help minimize fighting over females.

It is important to keep bulls healthy to prevent the spread of disease throughout the herd and to ensure that they are able to successfully breed

**Table 22. Effect of BSE Categories on Conception Rates[1]**

| Investigator | BSE Classification of Bull: Satisfactory | Questionable[2] | Unsatisfactory |
|---|---|---|---|
| | ---------- Conception Rate (%) ---------- | | |
| Wiltbank, 1965 | 60% | 48% | 30% |
| Chenowith, 1978 | 54% | 43% | --- |

[1]Reproductive Management of Beef Cattle.
[2]Questionable classification has been replaced with "Deferred."

females. A comprehensive herd health program should target the females in the herd as well. Consult your local veterinarian for a herd health program suited to your area. Follow Beef Quality Assurance guidelines and product label directions for proper injection sites and administration. Treating bulls for internal (worms) and external (flies, lice, grubs) parasites is an important component of a good herd health program. Parasite control should involve deworming at least twice a year, autumn grubicide application, treatment for lice around January and horn and face fly control during fly seasons. Treatment for external parasites not only prevents performance losses but also improves the appearance of the bull, which may be valuable when it comes time to market the bull.

## General Bull Health Guidelines

- IBR recommended annual (killed or intranasal)
- BVD recommended annual
- PI3 recommended annual
- BRSV recommended annual
- Leptospirosis (5-Way) recommended annual (every 3 to 6 months in some areas)
- Vibriosis optional annual (30 to 60 days before breeding)
- Trichomoniasis optional annual (30 to 60 days before breeding)
- Treat for internal and external parasites (twice a year)

## Nutrition

Bulls should be fed to meet nutritional needs and ensure reproductive performance. Bulls that are either under- or over-fed will have lower sexual activity. Herd bulls must be in good condition to be fertile and sexually active. A **body condition score of 6** (where 1 = very thin and 9 = obese) is a good target for bulls at the beginning of breeding. Bulls in a body condition score of 6 are in high moderate condition with considerable fat cover over the ribs and tail-head and firm pressure needed to feel the spine. Overfeeding and lack of exercise can result in reduced fertility as well as wasted feed and money. Bull nutrient needs differ depending on the age, size and activity level of the bull. Because yearling bulls are still growing, the nutritional requirements of yearling bulls are higher than those of mature bulls. Supplemental feed may be necessary to meet the nutritional requirements of young bulls or bulls on poor pastures. Nutrient requirements of bulls at various expected mature weights, body weights and average daily gains are listed in Table 23.

**Table 23. Nutrient Requirements of Yearling and Breeding Beef Bulls**

| Expected Mature Weight, lb | Body Weight, lb | Average Daily Gain, lb | Daily Dry Matter Intake, lb | Total Digestible Nutrients (% dry matter) | Crude Protein (% dry matter) |
|---|---|---|---|---|---|
| 1,700 | 900 | 0.44 | 22.0 | 50 | 6.0 |
| | | 3.12 | 21.5 | 80 | 10.2 |
| | 1,300 | 0.44 | 29.0 | 50 | 5.6 |
| | | 1.55 | 30.7 | 60 | 6.0 |
| | 1,700 | 0.00 | 32.9 | 46 | 5.6 |
| | | 0.44 | 35.5 | 50 | 5.4 |
| 2,000 | 1,000 | 0.49 | 23.8 | 50 | 6.1 |
| | | 3.49 | 23.2 | 80 | 10.5 |
| | 1,500 | 0.49 | 32.3 | 50 | 5.6 |
| | | 1.73 | 34.1 | 60 | 6.0 |
| | 2,000 | 0.00 | 37.2 | 46 | 5.6 |
| | | 0.49 | 40.1 | 50 | 5.2 |
| 2,300 | 1,200 | 0.54 | 27.3 | 50 | 6.0 |
| | | 3.84 | 26.6 | 80 | 10.1 |
| | 1,700 | 0.54 | 35.5 | 50 | 5.6 |
| | | 0.91 | 37.5 | 60 | 6.1 |
| | 2,300 | 0.00 | 44.5 | 46 | 5.2 |
| | | 0.54 | 47.0 | 50 | 5.1 |

# During the Breeding Season

## Breeding Management

Providing a **satisfactory breeding area** is essential. Good footing is a must. Clear pastures and paddocks of wire, scrap metal, boards and other debris that may pose an injury risk to bulls. Turn bulls out with heifers four weeks in advance of turning bulls out with the mature cow herd. The first estrus in heifers may not be fertile, and gestation may last slightly longer in heifers than in mature cows, so breeding ahead of the mature cow herd allows more time for heifers to rebreed after calving. **Observe the cow herd closely, and keep accurate records** to assure that the bull finds cows in heat, services them and that a large percentage of cows conceive to the first service. This can help in identifying and culling bulls that are not satisfactory breeders. A bull with superior genetics cannot contribute to genetic improvement in the herd unless he actively seeks out females in heat and settles them.

## Bull Power

How much bull power do you need? "Bull power" refers to the number of cows a bull can effectively service and depends on many factors. Placing a bull with too many cows to service may result in many open cows. The number of females a bull can handle depends upon bull maturity, soundness, fertility and condition as well as pasture size and length of the breeding season. Less sexually mature bulls should be placed with fewer females than their older counterparts (Table 24). In general, do not expose a young bull to more than 15 cows or heifers during breeding time.

**Table 24 . Bull Power Guide**

| Bull Age, Months | Number of Females Exposed to Breeding Per Bull |
|---|---|
| 12 to 15 | 10 to 12 |
| 15 to 18 | 12 to 18 |
| 18 to 24 | 18 to 24 |
| 24 and up | 24 to 30 |

Bulls should be well developed and at least 24 to 30 months of age before they are allowed to run with 25 to 30 cows during the breeding season. A "rule-of-thumb" for the proper bull to female ratio is one cow or heifer per month of age of the bull up to 30 months of age. For example, an 18-month-old bull could run with 18 females, and a 2-year-old bull (24 months of age) could be exposed to 24 females. It may be wise to separate bulls based on age if multi-sire breeding pastures are utilized. Older bulls may exhibit dominance over younger bulls (less than 4 years old) and allow younger bulls fewer chances to mate if allowed to run in the same breeding group. If multi-sire breeding groups are used, older bulls should be in separate groups from younger bulls.

## Controlled Breeding Season

Risk of injury to bulls is reduced and they are allowed to rest and regain condition by going to a controlled breeding season. Implementation of a controlled breeding and calving season can be accomplished over time without sacrificing production and offers several advantages over a year-round (uncontrolled) breeding and calving season. It allows matching nutritional needs of the herd to forage resources, facilitates more intense monitoring of breeding and calving, facilitates working (vaccinating, castrating, growth implanting) more calves of a similar age at once and produces calves of uniform age at sale time that can be sold in groups to capture group sale premiums. With a controlled breeding season, bulls are allowed time to rest and regain body condition that might have been lost during the breeding season. Not having bulls running with the cow herd year-round may also reduce the risk of injury to bulls. The key to implementing a controlled breeding and calving season is to **be diligent about putting bulls up on schedule**.

# After the Breeding Season

## Bull Confinement and Culling

Herd bulls should be kept in a separate paddock or pasture away from cows and heifers during the non-breeding season with plenty of exercise room, protection from severe weather, adequate shade, access to clean water and access to a mineral supplement. Provide ample feeder space if there is competition for feed from other animals in the paddock. Decisions on bull culling and acquisition will need to be made well in advance of the next breeding season. Reevaluate your herd sires on a regular basis as goals change, selection criteria is modified and new information becomes available. The conclusion of the breeding season is an excellent time to perform BSEs on bulls to aid in determining which bulls to replace in the breeding herd. Bulls may need to be culled for failure to pass a BSE, lack of libido, injuries, poor vision, undesirable conformation or inferior calf performance.

## Management Groups

Bull management needs change throughout the year. Managing bulls properly during the non-breeding season is important because bulls need this time to rest and regain condition. Maintaining adequate nutritional and health programs is a year-round challenge. Monitor pasture conditions and seasonal health concerns throughout the year, and adapt nutritional and health programs to the changing production environment. Bulls may be divided into management groups in order to more effectively meet the different nutrient needs of each group. Separating younger and older bulls may be particularly important in preventing injuries and meeting nutritional requirements. This is a good time to assess body condition scores on bulls to determine nutritional needs and tailor forage and feeding programs to ensure adequate body condition at the start of the next breeding season. Overworked bulls can lose significant body condition during the breeding season and may require extra nutrients to get back into shape before the next breeding season.

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# Glossary

**Backcrossing** – the mating of an individual (purebred or hybrid) to any other individual with which it has one or more ancestral breeds or lines in common.

**Breed** – genetic strain or type of domestic livestock that has consistent and inherited characteristics such as coat color or pattern, presence or absence of horns or other qualitative criteria.

**Breed Complementarity** – an improvement in the overall performance of crossbred offspring resulting from the crossing of breeds of different but complementary biological types.

**Composite** – the animal is composed of two or more breeds. A composite breed then is a group of animals of similar breed composition.

**EPD** – expected progeny difference.

**Heterosis** – the superiority of the crossbred animal relative to the average of its straightbred parents. Heterosis results from an increase in heterozygosity of a crossbred animal's genetic makeup.

**Heterozygosity** – a state where an animal has two different forms of a gene. It is believed that heterosis is primarily the result of gene dominance and the recovery from accumulated inbreeding depression of pure breeds.

**Hybrid** – an animal that is a cross of breeds within a species.

**Hybrid Vigor** – an increase in the performance of crossbred animals over that of purebreds, also known as heterosis.

**Selection Index** – a selection tool that integrates biology and economics. A selection index may provide a balanced selection approach when selecting for more than one trait at a time.

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