AgriLIFE EXTENSION
Texas A&M System

E-189
01/11

Texas Adapted Genetic Strategies for Beef Cattle IV: Breeding Systems

Angus cow in a straightbred system.

F_1 Brahman-Hereford cow in a terminal system.

Stephen P. Hammack*

A logical genetic strategy for a beef cow herd should include four steps. First, determine your production conditions (including climatic, forage and marketing) and the levels of animal performance that fit those conditions. Second, choose a breeding system. Third, identify the biological types and breeds within those types that are compatible with the first two considerations. And fourth, select for breeding the most useful individuals within those breeds.

There are about 75 breeds of cattle in the United States, with 15 or so most common. Commercial cow/calf producers who confine themselves to one breed have *straightbred* herds. If more than one breed is used, the herd is *crossbred.*

Straightbreeding

Straightbreeding simply means using the same breed for both sires and dams. Depending on the background of the breed, straightbreds generally have more uniform visible characteristics than most crossbreds. Straightbreeding is the simplest system to operate.

Inbreeding occurs over time in any breed, particularly in breeds closed to outside breeding stock. This can reduce performance (called inbreeding depression), especially in traits such as fertility, livability, and longevity. One type of inbreeding is *linebreeding,* which can, through carefully planned matings, elevate the influence of a genetic line or individual while minimizing inbreeding over all.

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Texas Adapted Genetic Strategies

Crossbreeding

Crossbreeding begins with the mating of two purebreds of different breeds. This results in first-cross progeny, termed F_1. There are three potential benefits of crossbreeding—*heterosis, favorable breed combinations,* and *complementarity.*

Heterosis

Heterosis, also called *hybrid vigor,* occurs when the performance of crossbred progeny is different (usually better) than the average of their parent types, as shown in the example in Figure 1. This example illustrates *direct heterosis,* the effect of a crossbred individual's gene combinations on its performance. There can also be *maternal heterosis,* or the indirect effect of a crossbred dam's gene combinations that influence her calf's performance through the maternal environment she provides.

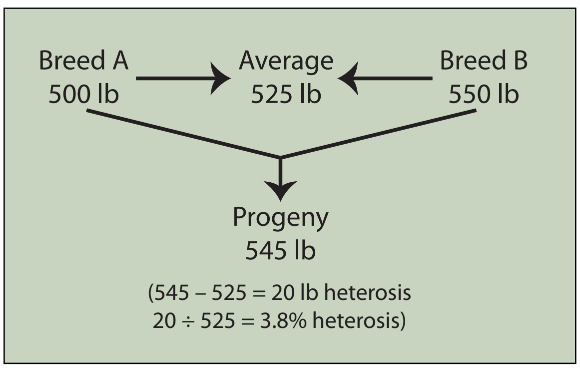

Figure 1. Heterosis.

Heterosis is the opposite of inbreeding depression, so it is greatest in the progeny of least related parents. For instance, there is greater heterosis in crossing the less related breeds Hereford (created in the British Isles) and Brahman (created from cattle originating in south central Asia) than in crossing the more closely related breeds Hereford and Angus (both originating in the British Isles).

Heterosis is reduced when both parents contain the same breed. There is no loss of heterosis if the parents share no breed in common, whether the parents are purebreds or crossbreds.

If an F_1 is bred to either of its parent breeds (called a *backcross*), heterosis in its progeny is about half of that expressed in the F_1. If the F_1 is not backcrossed but is bred to a third breed, or an unrelated crossbred, there should be no loss of heterosis in its progeny because the sire and dam have no breed in common as in a backcross.

If two F_1s of the same cross are mated, the progeny, called *F_2*, should have about half the heterosis of the F_1. However, if F_2s and subsequent generations of this cross are intermated, their progeny average no additional loss of heterosis except for any inbreeding that might develop over time. This is a factor in creating combination breeds or using a composite breeding system as discussed later.

Characteristics express heterosis differently. Heterosis tends to be highest in fertility, livability, and longevity; intermediate in milk production, weight gain, feed efficiency, and body size; and lowest in carcass traits.

Even with the benefit of heterosis the crosses from mediocre parents usually do not perform as well as superior purebreds. So, the most productive crossbreds come from genetically superior parents.

Favorable Breed Combinations

Even without heterosis there can be benefits merely from combining breeds. For example, breeds with high carcass quality are generally not well adapted to tropical conditions, and those that do have good tropical adaptability usually have relatively low carcass quality. Crossing breeds of these two types can produce progeny with an acceptable intermediate level of both traits. Such favorable breed combinations can be the most important benefit of crossbreeding. They are the primary motivation for creating new breeds by combining existing breeds, as discussed in the Combination Breeds section.

Complementarity

Complementarity requires dissimilar sires and dams. Complementarity results not only from the favorable combination of different types but also from the **manner** in which they are combined. As stated, the progeny of a breed with high carcass quality crossed with a breed with tropical adaptability have a blend of those traits. But the most productive and efficient way to conduct this cross is to use **sires** with high carcass quality and **dams** that are adapted to tropical conditions. The reverse is not as effective because the dams are not well adapted and it is the dams that must perform year-round under prevailing conditions.

Another example of complementarity is the use of large sires on smaller dams. The result is that dams produce a higher percentage of their weight, and do it more efficiently, than if they were bred to sires of similar size. This type of complementarity also can be realized in straightbreeding by using genetic variation within a breed. But it is done more effectively with crossbreeding.

Types of Breeding Systems

There are two basic breeding systems in commercial production. If replacement females are produced in the herd the system is *continuous.* If heifers are not put back in the herd, but are brought in from outside, the system is *terminal.*

Calves from continuous systems have two functions: Some heifers are saved for replacements and go back into the herd, while the rest of the calves are grown and/or finished to produce beef. But all calves from terminal systems have only one use—the production of beef. (A small segment of producers specialize in producing replacement females to be marketed to other producers.)

There can be combinations of continuous and terminal systems. Producers should understand the differences in these systems to avoid inefficient and costly mistakes.

Continuous

Since a continuous system produces its replacement females, it requires only external sires to avoid inbreeding. Because replacement females are retained, the cow herd has genetics from both sires and dams. If sires have genetics for traits that are undesirable in brood cows, those traits are perpetuated in the cow herd. Therefore, both sires and dams should have a similar level of expression of important traits, without any undesirable characteristics. Genetic extremes generally do not fit. Continuous systems can be either straightbred or crossbred.

Terminal

In a terminal system, replacement females come from outside the terminal-cross herd. Replacements can be either purchased or produced in another herd. Since heifers are not retained for breeding there is more flexibility in choosing types of sires and dams. Genetics for maternal ability are irrelevant in terminal-cross sires because their female progeny are not saved for replacements. However, genetics for maternal ability are important in sires that produce the females used for a terminal cross.

Terminal crossing is the only system in which complementarity can be realized. However, merely implementing a terminal system does not guarantee complementarity; sires and dams must be different and they must possess complementary traits. Specialized types can be used in terminal systems to take maximum advantage of complementarity by exploiting their strong points while minimizing or eliminating weak points. Terminal systems are usually crossbred but can be straightbred.

Continuous Crossbreeding Systems

True Rotations

True rotation systems use two or more breeds and the same number of breeding groups. The simplest true rotation uses two breeds and is sometimes called a *crisscross* (Fig. 2). A different breed of sire is used in each of two breeding groups. Replacement heifers are moved (rotated) from the group where they were produced to the other group, where they are mated to the breed that is not their breed of sire to minimize loss of heterosis in the system. Females remain in that breeding group, with the same breed of sire, for all of their lifetime matings. Over time, females in the two groups gravitate toward a composition of two-thirds of the breed of their sire and one-third of the other breed. If a rotation has three or more breeds, a heifer is moved to the breeding group with the breed of sire to which she is least related to ensure minimal loss of heterosis.

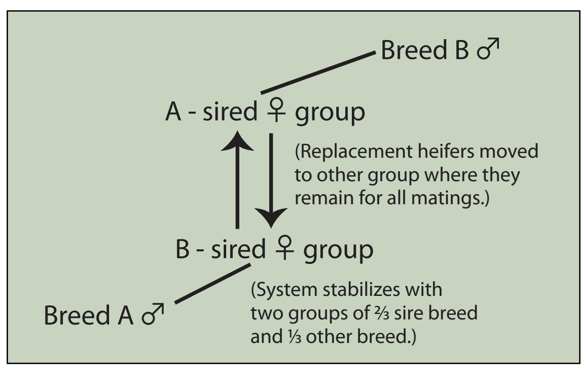

Figure 2. True 2-breed rotation.

Because they require multiple breeding groups, true rotations increase the complexity of a breeding program. (Artificial insemination can simplify the mechanics, but not the management, of some crossbreeding systems.) Also, a compromise must be made between complementary matings and uniformity among groups. Because of these complexities and limitations, true rotations are uncommon, especially those involving more than two breeds.

Sire Rotations

Sire rotations are sometimes called rotations in time. Instead of rotating heifers out of the breeding group where they were produced to another breeding group, as in true rotations, sire breeds are rotated periodically in a single breeding group. The number of years a sire breed should be used depends partly on how often heifers are put back in the herd. As is true with all breeding systems, severe inbreeding should be avoided; therefore, sires should be changed at least when necessary to avoid breeding them to their daughters.

There is less heterosis in sire rotations than in true rotations, though the reduction is slight in well-planned systems. Loss of heterosis is minimized by: 1) keeping replacement heifers out of dams least related to the heifer's breed of sire, and 2) minimizing breeding to the breed of sire.

Instead of using known breed composition, some producers use visible breed characteristics and other visible features to determine whether to keep a heifer for a replacement; this can reduce phenotypic variability, but also reduces heterosis.

Sire rotations are easier to conduct than true rotations because there is only one breeding group. This is a common way to crossbreed. Unfortunately, many sire rotations can not really be called systems because they are implemented haphazardly with no logical plan for changing sires.

Terminal Crossbreeding Systems

Static Terminal

In a static terminal system, replacement females are either purchased or produced in another herd. Purchasing females simplifies the operation of this system because the only breeding group needed is for the terminal cross. A straightbred terminal is possible, but there usually is no good reason to do so (unless a producer does not want to save and manage heifers in a continuous straightbred system) because the benefits of crossbreeding are absent.

A two-breed static system, using purebred sires and dams of different breeds, produces direct heterosis in crossbred calves. However, this system forfeits the considerable advantages of maternal heterosis from crossbred dams.

A three-breed terminal is more productive and efficient. Two breeds with desirable maternal traits are crossed to produce adapted and productive F_1 dams, which are bred to sires of a third breed in a terminal cross. Figure 3 shows a complete three-breed static terminal system. In the complete system, about one-fourth of the dams must be straightbred, about one-fourth are needed to produce the F_1, and only about one-half are available for the terminal cross.

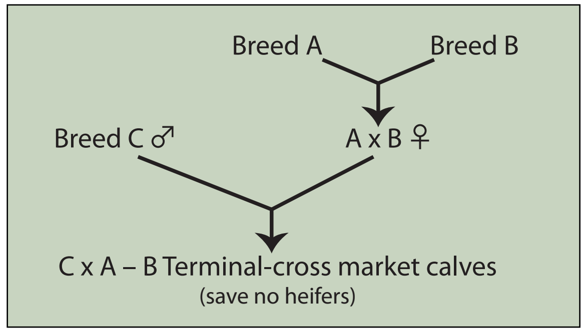

Figure 3. 3-breed terminal cross.

Static terminal crossing is the only system that can have maximum heterosis in both cows and calves, favorable breed combinations, and the bonus of complementarity. However, these advantages are tempered by the necessity of purchasing replacement females or producing them outside the terminal cross.

Rotation-Terminal

A rotation-terminal combines continuous and terminal systems. It is one way to provide crossbred replacement females for static terminals. A rotation system, either true rotation or sire rotation, produces replacement females both to keep itself going and to use in a separate terminal herd. Middle-aged dams (4 to 6 years old) are moved out of the rotation to the terminal because they are less prone to calving problems if terminal sires are relatively large.

You must have multiple breeding groups for rotation-terminal systems—one or more for the rotation, depending on whether it is a true rotation or sire rotation, and one for the terminal cross. (A rotation-terminal system can be approximated in one breeding group by using a multiple-sire-breed system, discussed below.) About half of the dams are needed in the rotation to provide enough replacements for the entire system, leaving about half of them for terminal crossing. Approximately two-thirds to three-fourths of sale calves come from the terminal, with most of the rest being male calves from the rotation.

Heterosis is relatively high in rotation-terminals because all progeny and dams are crossbred. However, since a high percentage of females from the rotation must be retained to provide replacements for both the rotation and the terminal, there is little opportunity to select individual females for breeding.

Combination Breeds

Existing breeds are sometimes blended to form *combination breeds,* with new packages of traits. Because these breeds are formed by crossbreeding, there is some residual heterosis; how much depends on how many breeds are included, in what portions they are included, and how much inbreeding occurs as the breed develops. So with these combination breeds it may be possible to obtain some heterosis using a single breed in a straightbred system.

The first of these combination breeds in the U.S. was the American Brahman, created by combining several *Bos indicus* (humped) breeds imported from India or Brazil. A number of breeds have been created in the southern U.S., especially in Texas, by combining different biological types. Most of these contain Brahman and British or, in a few cases, Brahman and Continental European breeds; they are generally called American breeds. More recently, some British and Continental combinations have been made; these are less common but are increasing in number.

Other Systems

The breeding systems discussed so far all use a single breed of sire in a breeding group. There are alternatives.

Multiple Sire Breed

More than one sire breed can be used concurrently in a single breeding group. For example, sires of two British breeds could be used in a continuous system. To reduce loss of heterosis and decrease phenotypic variability, retained replacement heifers should be intermediate in appearance, as much as possible. Or, British-breed and American-breed sires could be used. If so, heifers with a more American-breed appearance should be retained if that type is better adapted to the prevailing production conditions. These systems are similar to two-breed rotations.

A sire breed with desirable maternal characteristics and a terminal-sire breed could be used with heifers retained from the maternal-type sires, if they can be visually identified. More than one maternal-type sire breed could be used, either concurrently or in rotation over the years, to gain some maternal heterosis. These plans are similar to static terminal or rotation-terminal crossing.

Multiple-sire-breed systems have shortcomings. There is less heterosis than in similar but more controlled systems. If large terminal sires are used there is no way to prevent their matings of some of the younger females, so calving difficulty may increase. Genetic variability among individuals is greater, but phenotypic variability may not be greater if close attention is paid to the selection of replacement females. The number of calves born relative to the ratio of sire breeds can vary from year to year, so the supply of potential replacement heifers also can vary. Large, extensively managed herds might be most likely to implement multiple-sire-breed systems.

Hybrid Sires and Composites

Just as there is heterosis for reproductive traits in females, there is also heterosis in males for semen quality and quantity, mating capacity, and longevity. Using hybrid sires can be a relatively simple way to create combinations of traits not available in established breeds. Some seedstock producers specialize in producing hybrid bulls. For the most part these combine different types, such as British-Continental or British-American. Several breed associations have registries for hybrids.

Finding a reliable source of suitable hybrid bulls can be difficult. There is a general feeling that hybrid bulls produce more variable progeny, but some research (particularly at the U.S. Meat Animal Research Center in Clay Center, Nebraska) has challenged this impression, at least for quantitative characteristics such as body weight. There usually is not as much reliable genetic evaluation available for hybrid bulls, although some breed associations include hybrids.

In recent years there has been some interest in a breeding system called composites, which is often confused with creating combination breeds. As originally conceived by the U.S. Meat Animal Research Center, the composite system involved creating hybrids and then intermating them specifically to maintain as much heterosis as possible in succeeding generations. The intent was not to create a new breed. For a more complete discussion of combination breeds and composites, see another publication in this series, E-180, *Texas Adapted Genetic Strategies for Beef Cattle—VI: Creating Breeds.*

Distinctions between combination breeds, hybrids, and composites are often blurred. In many ways they can be used in the same manner in planning and implementing a breeding system. Table 1 compares the features of breeding systems.

Table 1. Features of breeding systems.

Breeding system	Calf heterosis	Cow heterosis	Complementarity	No. breeds / breeding groups	Calf uniformity (11)
Straightbred (1)	None	None	None	1 / 1	Very high
Straightbred (2)	Low	Low	None	1 / 1	High
Rotation	Med-High	Med-High	None	2-3 / 1-3 (9)	Low-Med
Terminal only (3)	Very high	None-Low	High	2 / 1	High
Terminal only (4)	Very high	Very high	High	3 / 1	Med-High
Complete terminal (5)	Medium	None-Low	Medium	2 / 2	Low-Med (12)
Complete terminal (6)	High	Medium	Medium	3 / 3	Low (12)
Rotation + terminal	High	Med-High	High	3 / 2 or 3 (10)	Medium
Multiple sire-breed (7)	Low-Med	Low-Med	None	2 / 1	Low-Med
Multiple sire-breed (8)	Med-High	Low-Med	Medium	3 / 1	Low
Composite	Med-High	Med-High	None	2-4 / 1	Med-High

(1) Breeds with no retained heterosis
(2) Combination breeds, containing some retained heterosis
(3) Using straightbred females purchased or produced in another herd (cow heterosis is Low if females are a combination breed containing some retained heterosis)
(4) Using F_1 females purchased or produced in another herd
(5) Producing straightbred females in one group for terminal cross in another group (cow heterosis is Low if females are a combination breed containing some retained heterosis)
(6) Producing straightbred females in one group to create F_1 females in another group for terminal cross in another group
(7) Using two general-purpose sire breeds concurrently
(8) Using two general-purpose sire breeds, concurrently or rotated over time, and one terminal sire breed
(9) One group if sire rotation; two or three groups (depending on number of breeds) if true rotation
(10) Two groups if sire rotation; three groups if true two-breed rotation
(11) Across all breeding groups in the system
(12) Uniformity within breeding groups is High to Very High

Breeding Systems and Breeding Groups

The choice of a breeding system depends partly on the number of separate breeding groups a producer can or will maintain. If feasible, regardless of the breeding system, the development, breeding and calving of heifers should be conducted in a separate management group using easy-calving sires.

One Breeding Group

One-breeding-group herds, ranging from those needing only one bull to large herds that require multiple bulls, have the following choices of breeding systems:

- straightbreeding with either a traditional or combination breed
- static terminal cross with purchased straightbred or crossbred females
- sire rotation
- multiple-sire-breed
- composite

Two Breeding Groups

Two groups can be used in these systems:

- true two-breed rotation (or rotation of two composites or hybrids)
- straightbreeding (of traditional or combination breeds) in one group to produce females for a two-breed terminal cross in another group
- sire rotation, multiple-sire-breed, or composite in one group to produce replacement females for a terminal cross in another group
- purchase of straightbred females for creation of F_1 replacements in one group to be used in a terminal cross in another group

Three Breeding Groups

Three groups can be used in these systems:

- true three-breed rotation
- true two-breed rotation (or rotation of two composites or hybrids) in two groups to produce replacement females for a terminal cross in a third group
- complete terminal, with straightbred females produced in one group to be used for creating F_1 females in a second group to be used for terminal crossing in a third group

Multiple breeding groups are more complex to manage. And, each group in a multi-group crossbreeding system has a different breed composition, which can reduce marketing flexibility because fewer like calves are produced. Also, some breed combinations may be less valuable than others. Weigh these possible disadvantages against any expected economic benefit before implementing systems that require multiple breeding groups.

Efficiencies of Breeding Systems

A standard measure of efficiency of cow-calf production is pounds of calf weaned per bred cow, which combines fertility, livability, and calf weaning weight. Using this measure, the U.S. Meat Animal Research Center compared breeding systems. The basis for comparison was the straightbreeding of traditional breeds, which do not have any retained heterosis.

Continuous crossbreeding systems requiring only a single breeding group can increase efficiency by 10 to 15 percent. Crossbreeding systems using multiple breeding groups, or three-breed terminal crossing in one group using introduced females, can increase efficiency by 15 to 30 percent. These estimates are for systems using British and Continental breeds in temperate environments. In harsh tropical or subtropical environments, including types native to these locales, especially *Bos indicus,* can be even more efficient because animals have more heterosis and greater adaptability. These are significant advantages.

In choosing a breeding system for commercial beef cow herds, consider the major factors that affect production efficiency and financial return, including:

- number of animals available to market,
- average pounds per animal marketed,
- average price per pound, and
- total cost of production.

Production efficiency and financial return are usually greatest when these factors are balanced, and not when one factor dominates to the exclusion of the others.

Summary

After choosing a breeding system, producers should determine what breeds and individuals within breeds fit their climate, forage, general management practices, and market. For a discussion of breeds, see E-190, *Texas Adapted Genetic Strategies for Beef Cattle—V: Type and Breed Characteristics and Uses* and E-191, *Texas Adapted Genetic Strategies for Beef Cattle—VII: Sire Types for Commercial Herds.* For information on selecting individual animals, see E-164, *Texas Adapted Genetic Strategies for Beef Cattle—VIII: Expected Progeny Difference (EPD).*

Regardless of the size of the cow herd, the use of single breeding groups is by far the most common practice in Texas. Therefore, the prevailing breeding systems are straightbreeding (of both traditional and combination breeds) and purchasing replacement females for a terminal cross, with some implementation of sire rotations or concurrent use of multiple breeds of sire.

When choosing a breeding system, give careful thought to the entire process. Do not embark on the first stage of a system without understanding and planning for subsequent stages. A system that works well for one producer or one set of production and market conditions might be unsuitable for another producer or different conditions.

For Further Information

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Issued in furtherance of Cooperative Extension Work in Agriculture and Home Economics, Acts of Congress of May 8, 1914, as amended, and June 30, 1914, in cooperation with the United States Department of Agriculture. Edward G. Smith, Director, Texas AgriLife Extension Service, The Texas A&M System.
Revision