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Crossbreeding Systems for Beef Production

Stephen P. Hammack*

Crossbreeding is the dominant breeding system for beef production in Texas. A large number of crossbred cattle though are the result of haphazard breedings which are not likely to increase efficiency.

Benefits of Crossbreeding

Heterosis

Heterosis, or hybrid vigor, is often believed to be the only benefit of crossbreeding. Heterosis is the difference in the performance of crossbreds and the average of their parental breeds. For instance, two breeds, one with a weaning weight of 400 pounds and the other with a weaning weight of 600 pounds, have an average weaning weight of 500 pounds. If crosses between these breeds averaged 525 pounds, heterosis would be 25 pounds or 5 percent. Heterosis is highest when parents are the least related genetically.

Heterosis is generally small for any one production trait, but the cumulative effect of heterosis on total population is significant. If crossbreeding is to be of any practical importance, the total performance of crosses must be higher than that of the **best** parent or crossing is useless.

Breed Combinations

Favorable breed combinations produce more desirable traits than either purebred parent, so benefits might be obtained from crossing even if there were no heterosis. There are many examples of favorable breed combinations. In portions of Texas the environmental adaptability of Brahmans is combined with qualities of other breeds, such as early maturity and carcass desirability. News breeds can be formed by crossing existing breeds and intermating to fix type.

Complementarity

The concern here is to match desirable features, as in breed combinations, and to eliminate, or reduce, undesirable effects which might be found in a breed. This can only be accomplished as part of a total mating system, but both the strengths and weaknesses of breed combinations are expressed by individual animals.

An example of complementarity is the use of large, fast-growing, muscular bulls on small, highly fertile, productive cows. With this system, calves are expected to be reasonably fast-growing while minimizing the nutritional costs of maintaining the breeding herd.

Mechanics of Crossbreeding Systems

Crossbreeding begins with the mating of two pure breeds. High productivity in the purebred base results in the most productive crossbreds, in fact, high producing purebreds may easily exceed mediocre crosses.

An F_1 is usually understood to be the cross of two breeds. A better definition is an F_1 is the first generation resulting from the cross of two genetically unlike parents. Heterosis is highest in F_1 crosses, but this is not limited to crosses of just two breeds.

As an example, assume we cross three types of females—straight Hereford, straight Angus and Angus-Hereford crosses—with a Brahman bull and save the heifers for replacements. The Brahman X Hereford and Brahman X Angus heifers are examples of typical F_1's. According to the definition, the Brahman X Angus-Hereford females are also F_1's and heterosis should be the same for these three types of cows. The fact that one of the heifer groups had a cross-bred parent is irrelevant because the sire (Brahman) was unrelated to both breeds represented

*Extension beef cattle specialist, The Texas A&M University System.

in the cow (Angus and Hereford). Heterosis is reduced only when the same genetic material is found in both sire and the dam.

The breeders utilization of any crossbred is determined by the type of system used. Terminal systems end at some planned point while rotations are intended to be continuous.

Terminal Systems

Terminal systems are sometimes called specific crosses and can include first-crosses. For instance, if Charolais bulls were used on Angus cows and the producer marketed all the calves, keeping no replacements, this would be a terminal cross. These types of systems are fairly common but there is one important ingredient missing—the crossbred cow.

A good proportion of the benefit from heterosis is derived from the crossbred female. A **three-breed terminal** cross is one way to realize this benefit by mating F_1 cows to a sire of a third breed (Figure 1). Similar results would be expected from F_1 cows comprised of *more* than two breeds as long as the terminal sire is unrelated to the breeds represented in the cow. These crosses and the three-breed terminal are called **multi-breed terminal** crosses. It is important to remember multi-breed terminals utilizing crossbred cows offer the opportunity to obtain high levels of heterosis, favorable breed combinations and complementarity.

Rotation Systems

In a **two-breed rotation,** or criss-cross, F_1 females are bred to bulls of the same breed as one of the parent breeds, called a backcross. In subsequent generations, females are bred to bulls of the breed other than their sire. Eventually there will be two distinct groups which must be maintained separately during breeding unless artificial insemnination is practiced exclusively. These two group will contain about 2/3 of the genetics of the sire and 1/3 of the remaining breed.

In a **three-breed rotation,** the first-cross females are not backcrossed, as in a two-breed rotation, but rather are mated to a third breed as in a three-breed terminal cross. In a rotation, these three-breed cross females are retained and bred back to one of the breeds used in the first cross of the rotation.

Three breeding groups are eventually developed with each group containing about 4 parts (57 percent) of the breed of the sire, 2 parts (28 percent) of the breed of the dam's sire and 1 part (14 percent) of the remaining breed. Again, females are mated to sires of this remaining breed to maximize heterosis (Figure 2).

Mating plans of rotations can be confusing unless the producer remembers individual cows are not moved continuously from one breeding group to another. The breed composition of a female determines her mating. Females are mated to the breed to which they are least related, and this scheme continues as long as the cow is in the herd. Variations from this pattern might be performed but they would not be a true rotation.

Any rotation system results in decreased heterosis because of the backcross feature at which point the same breed appears in **both** the sire and the dam. After a rotation is stabilized, heterosis of a two-breed rotation is reduced to about 67 percent of maximum. A three-breed rotation should retain about 86 percent heterosis and a four-breed rotation about 93 percent.

Features of Crossbreeding Systems.

Terminal Systems

In terminal systems, replacements are not produced unless separate herds are maintained for this purpose. If production of all replacements for a three-breed terminal cross is desired, there must be a herd to produce purebred females and a herd for the production of F_1 females to be used in the terminal cross herd. Twenty to thirty percent of the total females in the system will be required in each of the first two groups, leaving about 50 percent in the terminal group.

Terminal crosses offer the advantages of eliminating, or reducing, the producer's role in production of replacements. If the operator of a terminal cross does not produce all of the replacements, someone else must perform this function. With usual levels of reproductive performance and female replacement rate, at least 1/3 to 1/2 of the matings in a total system are to produce replacements. This is true whether the system is straightbreeding, rotation crossing or terminal crossing.

Specialized breeds and types may also be used in a terminal cross. If they are not part of a terminal cross, then efficiency and production are reduced and another simpler system should be chosen.

Rotation Systems

Replacement females are produced in a rotation system so the only introductions required are sires. The producer then controls the development and management of replacement females. Remember that each breed in these systems appear at some point on both the sire and dam sides, so highly specialized sire and dam breeds should not be chosen for rotations. The breeds chosen should not be weak in any important production characteristic because, unlike terminal systems, undesired traits cannot be masked in rotations.

Small Herd Systems

Efficient systems involve several breeds and numerous breeding groups, or the use of artificial insemination. Special considerations are necessary for small herds or large herds which cannot be split into numerous breeding groups.

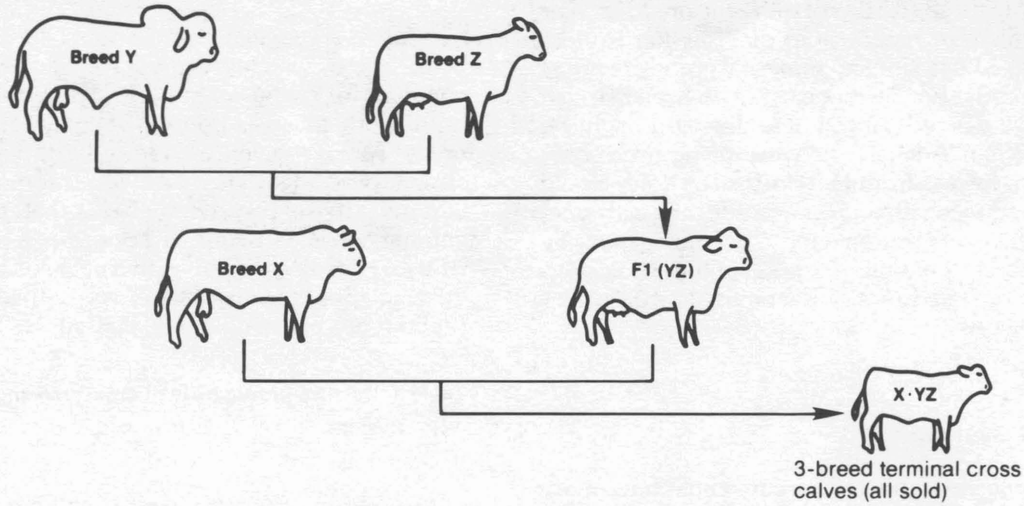

Figure 1. Three-breed terminal crossbreeding system.

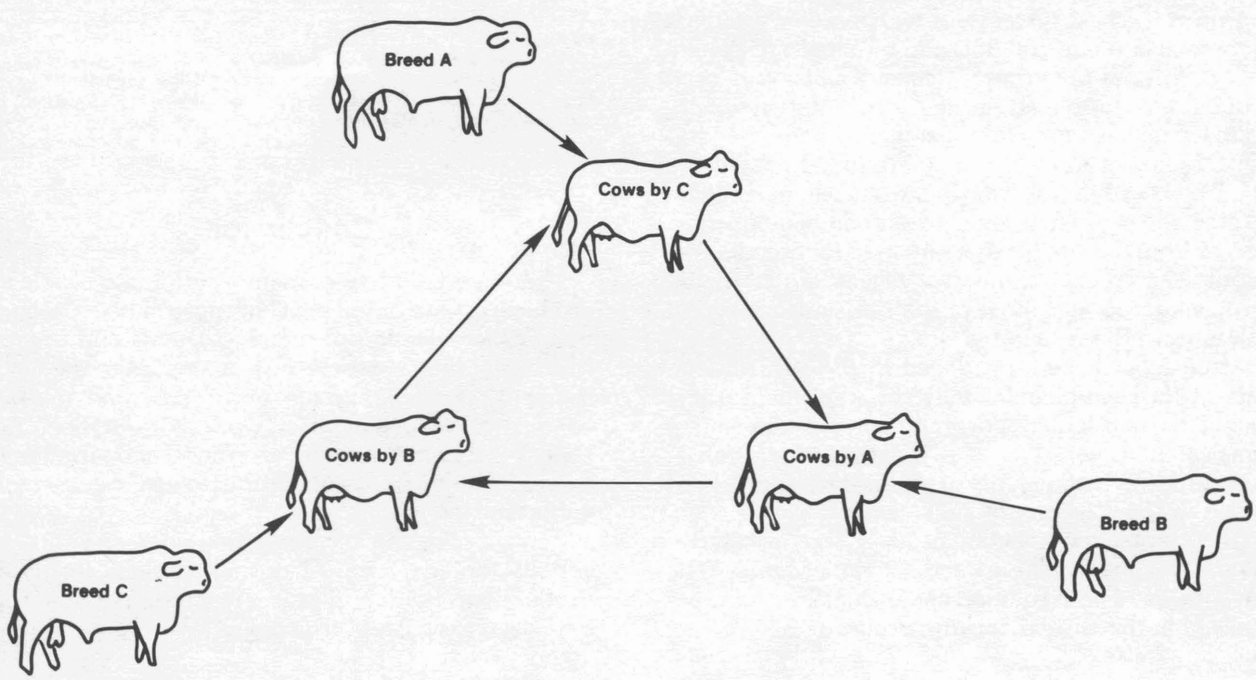

Figure 2. Three-breed rotational crossbreeding system.

One-Herd Systems

Herds with this type of management, whether one-bull herds or very large herds, are restricted in their choice of systems. Perhaps the simplest scheme is to purchase replacement females for mating to a terminal sire. With only one bull, or one breeding pasture, a normal rotation cannot be carried on; however, rotation can be approximated by changing the breed of sire on a scheduled basis. Such breeding plans are called approximate or sire rotations.

In a two-breed sire rotation where heifers are bred to calved at two years of age, heterosis is maximized by changing bulls every two years (to avoid breeding heifers back to their sire) or every three years if calving at three. This assumes that heifers are bred to the same bull as the remainder of the herd. (Regardless of the type of breeding system, straight or cross, commercial females should **not** be bred back to their sire as inbreeding depression, the opposite of hybrid vigor, will likely occur.)

In sire rotations, heterosis will be reduced as some females will be bred to a bull of the same breed as their sire. To maximize heterosis in the cow herd retain only females whose sire and maternal grandsire are of different breeds. For instance, if a two-breed British system were desired, Angus and Hereford might be included. When Angus bulls were being used, only replacement heifers from Hereford-sired cows would be saved and vice-versa. Some producers with one-herd, multiple-sire programs try to accomplish this by using both breeds of bulls at the same time; however, verification of breed of sire becomes difficult under these conditions.

Two-Herd Systems

Herds large enough to require two bulls have more flexibility in crossing. Choices include purchasing replacements, using a normal two-breed rotation or performing a terminal cross with the producer maintaining one herd to produce F_1's for use in another herd for terminal crossing.

One of the best systems for two breeding groups is a combination sire rotation and terminal sire system called a criss-out-cross. Replacements for both groups are produced in the sire rotation where younger females are maintained and then moved to the terminal group when they are four to five years old. The breed of bull used in the sire rotation should be changed every two years. In this combination most heifers from the sire rotation are kept for breeding, so about 70 percent of the sale calves are from the terminal group and most of the remainder are male calves from the rotation group.

Since most heifers produced in the sire rotation part of this combination must be kept for replacements, there is little opportunity for selection among females; however, this is of relatively little consequence as the vast majority of genetic change in a herd is due to the selection of sires.

This combination system may seem complicated at first but the mechanics are actually rather simple. The advantages of both rotation and terminal systems are realized in this **sire rotation-terminal.**

Choosing a Crossbreeding System

A crossbreeding system should be chosen with care. Some systems are very efficient but are too complex for many operations. The best measure of herd productivity is pounds of calf weaned per cow bred. Table 1 gives an idea of the increase over straightbreeding that might be accomplished from various crossing systems. Note that the basis of comparison is a straightbred *Bos taurus* (European or British) breeding system with a value of 100. Systems utilizing *Bos taurus* and *Bos taurus-Bos indicus* (Zebu-type) breeding are evaluated.

Table 1. Relative productivity of crossbreeding systems[1].

System	B. taurus[2]	B. taurus-B. indicus[3]
Straightbred	100	
F_1	105	110
Rotations	115	125
Terminals	115	125
Rotation + Terminal	120	135

[1]Based on production at weaning per cow bred.
[2]British and/or European breeds only.
[3]Brahman or Zebu-type and British types included.

Averages taken from: (1) Frank, D.E. 1980. "Breed and heterosis effects of American Zebu Cattle". *J. Animal Sci.* 50:1206 (2) Gregory, K.E. and Cundiff, L.V. 1980. "Crossbreeding in beef cattle: evaluation of systems". *J. Animal Sci.* 51:1224. (3) Koger, Marvin 1980. "Effective crossbreeding systems utilizing Zebu cattle". *J. Animal Sci.* 50:1215 (4) Long, Charles R. 1980. "Crossbreeding for beef production: experimental results". *J. Animal Sci.* 51:1197.

Conclusion

There are a variety of mating systems available to producers. One of the big challenges in beef production is the selection of mating systems and breeds which best match genetic characteristics to the environment, available forage and feeds, and market conditions. A system which works for one operator might have disastrous effects on another operation. A mismatch of these factors produces inefficiencies too important too ignore.

For a discussion of production characteristics of various breeds, see Choosing Breeds for Beef Production, B-1512, Texas Agricultural Extension Service, Texas A&M University.

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