UTILIZING CROSSBREEDING TO INCREASE NET HERD EFFICIENCY

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Crossbreeding has become the dominant system of breeding for beef production in Texas. However, many crossbred cattle are the result of haphazard breeding which does not fully utilize the potential for crossbreeding. The guidelines presented here are based on our experience in Texas but are expected to have relevance in Australia.

BENEFITS OF CROSSBREEDING

Heterosis: Heterosis or hybrid vigour is often believed to be the only benefit of crossbreeding. Heterosis is defined as the difference in performance between crossbreds and the average of their parental breeds. For instance, two breeds may have average weaning weights of 400 pounds for one breed and 600 pounds for the other, for an average of 500 pounds. If crosses between these breeds averaged 525 pounds, heterosis would be 25 pounds or, as usually expressed, 5 percent in this example. Heterosis tends to be highest when parents are genetically least related. Heterosis is usually small for any one production trait but the cumulative effect of heterosis on total herd production may be substantial. Also, if crossbreeding is to be of practical importance, the total performance of crosses must be higher than that of the best parent breed.

Breed Combinations: Favourable breed combinations may produce more desired traits than either pure bred. Therefore, benefits might be obtained from crossing even if there was no heterosis. There are many examples of favourable breed combinations. In much of Texas the environmental adaptability of Brahmans is combined with the desired qualities of other breeds such as earlier maturity and carcase desirability. Breed combinations are the basis for the formation of new breeds by crossing existing breeds and intermating to fix type.

Complementarity: Here we are concerned not only with matching desirable features, as in breed combinations, but also with reducing undesirable effects which might be found in a breed. This can only be accomplished as part of a total breeding system, whereas breed combinations are expressed by individual animals. An example of complementarity is the use of large, fast growing, muscular bulls on smaller, highly fertile cows. With this system, calves are reasonably fast growing while nutritional costs of maintaining the breeding herd are minimised.

MECHANICS OF CROSSBREEDING SYSTEMS

The crossbred progeny of two pure breeds or two genetically unlike parental types may be defined as an F_1 and heterosis tends to be highests in F_1 crosses. As an example, assume there are three types of females: Hereford, Angus and Angus-Hereford crosses. Cross a Brahman bull on all three types of cows and save the heifers for replacements. The Brahman x Hereford and Brahman x Angus cows are examples of what is typically called an F_1. However, the Brahman x Angus-Hereford is also an F_1, according to the definition above, and heterosis should be similar for all three of these types of cows. The fact that one of these types had a crossbred parent is irrelevant because the sire (Brahman) was unrelated to both breeds represented in the cow (Angus and Hereford). Heterosis is reduced only when the same genetic material is found in both the sire and the dam. Actions beyond the first cross determine the type of system. Classification of systems depends a great deal on the intent of the breeder. Terminal systems end at some planned point while rotations are intended to be continuous.

Terminal Systems: These are sometimes called specific crosses. A first-cross could be terminal if desired. For instance, if Charolais bulls were mated to Angus cows and the producer marketed all 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 cows. 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. Here, two-breed F_1 cows are bred to a third sire-breed. 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. Such crosses as this and the three-breed terminal might be called multi-breed terminal crosses. An important point to remember is that multi-breed terminals offer the opportunity to obtain high degrees of heterosis, favourable combinations, and complementarity.

Rotation Systems: These schemes are also called criss-cross. In a two-breed rotation, F_1 females are bred to bulls of 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 herds, which must be maintained separately, during breeding unless A.I. is practised. One of these two herds will contain about 2/3 of one breed and 1/3 of the other breed; and vice versa for the other herd.

In a three breed rotation, the first-cross females are not back-crossed, as in a two-breed rotation, but rather are mated to a third breed. Up to this point the system is mechanically like a three-breed terminal cross. However, 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 herds are eventually developed, each herd containing about four parts (57%) of the breed of the sires, two parts (28%) of the breed of the dam's sire, and one part (14%) of the remaining breed. Again, females are mated to sires of this remaining breed. That is, cows are mated to the breed to which they are least related, and this mating continues as long as the cow is in the herd. Any rotation system results in some decreased heterosis because of the backcross feature at which point the same breed appears in both sire and dam. After a rotation is stabilised, heterosis of a 2-breed rotation is reduced to about 67% of maximum. A 3-breed rotation should retain about 86% heterosis and a 4-breed about 93%.

FEATURES OF CROSSBREEDING SYSTEMS

Terminal Systems: In these systems replacements are not produced unless separate herds are maintained for this purpose. If it is desired to produce all replacements for the three-breed terminal cross there must be (1) a herd to produce pure bred females, (2) a herd to produce F_1 females and (3) a herd for the terminal crossing. About 20 to 30% of the total females in the system will be required in each of the first two groups, leaving about 50% in the terminal group. The second notable feature of a terminal cross is that specialised breeds and types may be used (matching specialised breeds is called complementarity). Indeed, if this feature is not part of a terminal cross then the full potential is not realised.

Rotation Systems: Replacement females are produced as part of a rotation system so the only introductions required are sires. Remember that each breed in these systems appears at some point on both the sire and dam sides. Thus, highly specialised sire and dam breeds should not be chosen for rotations. Instead, none of the breeds chosen should be weak in any important production traits. Undesired traits cannot be masked as in terminal systems.

One-Herd Systems: Herds of this type of management, whether one-bull or very large herds, are restricted in their choice of systems. With only one breeding pasture a normal rotation cannot be carried on. However, a three-breed rotation can be approximated by changing the breed of bull every three years. To maximise heterosis, and eliminate breeding a heifer to her sire, replacements should be saved from the last two years of a three-year cycle. In Texas this system is called a "poor-boy" rotation. If more than three compatible breeds are available, "poor-boys" can be even more useful. With six breeds, bulls can be changed every two years, heifer replacements may be saved from every calf crop, and a cow can be kept in the herd until she is almost 12 years old without being bred back to her breed of sire.

Two-Herd Systems: Herds with two separate breeding herds have more flexibility in crossing. Probably the best system is a combination "poor-boy" rotation and terminal sire system, sometimes called a criss-out-cross. Here replacements for both groups are produced in the "poor-boy" rotation, where females are bred while young and then moved to the terminal group when four to five years old. The breed of bull used in the "poor-boy" should be changed every two years. In this combination most heifers from the rotation are kept for breeding, so about 70% of sale calves are from the terminal herd and 30% are male calves from the rotation. Since most heifers produced in the rotation part of this combination must be kept for replacements, there is little opportunity for selection for performance among females. However, this is of little consequence as the majority of genetic change in a herd is due to the selection of sires. Also in this combination, replacements are produced from the youngest females in the herd. There is evidence to suggest that heifers raised by first and second-calf females may turn out to be the highest producing cows. This combination system may seem complicated upon casual inspection but the mechanics are actually rather simple. All things considered, most of the advantages of both rotations and terminals are realised in this "poor-boy" terminal.

CHOOSING A SYSTEM BASED ON BREED CHARACTERISTICS

A crossbreeding system should be chosen with care. Some systems are more efficient than others but are more complex. One measure of herd productivity is pounds of calf weaned per cow bred. Table 1 gives an approximation of the increase over straightbreeding that might be accomplished from various crossing systems. The basis of comparison is a straightbred *Bos taurus* (European or British) herd with a value of 100. Crossbreeding systems, including *Bos taurus* breeds only and those including *Bos indicus* (Zebu type) breeding are presented.

TABLE 1: Relative Productivity of Crossbreeding System[1]

Crossbreeding 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 weaned weight per cow bred

[2]British and/or European breeds only

[3]Brahman or Zebu-type and British/European types included

Many traits are important in beef production. Some of the most important are: environmental adaptability, fertility, calving ease, maternal ability, rate and efficiency of gain, carcase merit, market acceptance, and longevity. Accurate comparisons of all traits for all breeds do not exist. However, mature size, milking potential, species and breed can be easily estimated and used to estimate many production traits.

Mature Size: As mature size increases, so does size at any stage of life. Increased mature size is related to later maturity, longer gestation, heavier birth weight, faster gain and heavier weaning weight. In the feedlot, cattle of large mature size have faster, more efficient gain, lower marbling, less fat, and improved cutability if cattle are fed to the same age or for the same length of time; however, if fed to similar carcase grades (degree of finish), these differences among cattle of different mature size are eliminated or greatly reduced.

Milk Production: The primary beneficial effect of heavier milking in a beef cow herd is to increase weaning weights. However, heavy milking cows may become thin if nutrition is inadequate, and thin cows are less likely to come into heat and conceive. A cow that is both large and heavy milking is risky under marginal nutritional conditions. The optimal body size and milking level in a beef cow herd is closely related to the quantity and quality of forage and other feedstuffs. Optimal size and milk level tend to be greater for better conditions.

Species: There are several characteristics of *Bos indicus* or Zebu type cattle which are not related to their size or milking ability. In comparison to *Bos taurus* or British-European types, *Bos indicus* are: (1) adapted to the stresses of the tropics and sub-tropics; (2) low in birth weight and somewhat lower in vigour early in life, (3) later maturing but longer lived; (4) rarely afflicted with calving problems; and (5) lower in carcase quality, especially marbling, but generally acceptable in eating quality. It should be noted that calves sired by *Bos indicus* and out of *Bos taurus* dams are not smaller size and do not lack vigour.

BREED COMPARISONS

Many experiments have compared various breeds of cattle, but meaningful comparisons of large numbers are rare.

The most extensive comparisons have been conducted over the past 12 years at the U.S. Meat Animal Research Center. This work has included some 20 breeds and over 10,000 animals. The basic conclusions of their work are:-

(1) Crossing between Hereford and Angus to produce F_1 calves resulted in an increase of about 5 percent in pounds of calf weaned per cow bred.

(2) The use of larger breeds of sires on Angus and Hereford cows was not advantageous at weaning because increased calving difficulty offset, or exceeded, the benefit of heavier weaning weight.

(3) In the feedlot, large, growthy types were no more efficient and produced carcases with slightly higher yield of retail meat than British types when fed to the same finish.

(4) There was remarkable similarity of the eating quality of meat produced from all breed types. Acceptable eating quality required some minimum time on feed.

(5) Increased production per cow at weaning was realized from different types of cows. Compared to Angus-Hereford cross cows the following increases were observed: Jersey-cross, 5%; certain exotics (Chianina, Gelbvieh, Maine-Anjou, Pinzgauer, Simmental, Tarentaise) and large-dairy (Brown Swiss, Holstein) crossbred cows, 10 to 15%; Brahman-cross, 25%. The productivity of the Brahman-cross cow even as far north as central Nebraska (approximately equivalent to Tasmania in north vs. south latitude) is noteworthy.

CHOOSING BREEDS FOR SYSTEMS

In view of the relationships discussed above and the features of various crossing systems, breeds may be characterised as follows:-

Terminal Sire Breeds: (e.g. Charolais, Chianina and Limousin). Breeds that should be used mainly as terminal sires; considerably above average in size and muscling and medium or below in milk production. Included here are the Continental European beef breeds.

Maternal (Terminal Dam): (e.g. Guernsey and Jersey). In this group are breeds average or below in size and above average in milk production; that is, they are high producers in relation to their size. These breeds are also rather light-muscled and include the smaller-sized, lower-producing traditional dairy breeds.

Maternal and Rotation (e.g. Angus, Brahman, Brangus, Devon, Hereford, Red Poll, Sahiwal and Shorthorn). Breeds in this group are medium in both size and milk production. Included are the traditional British beef breeds, traditional British dual-purpose breeds, Zebu, and the smaller of the Zebu-British breeds. Any of these breeds should fit well in the same rotation system because of their general similarity in body size. There are no extremes in this group so their production can be exceeded by other types but management problems are minimal with these "general-purpose" breeds.

Maternal, Rotation and Terminal: (e.g. Beefmaster, Brown Swiss, Charbray, Holstein, Santa Gertrudis, and Simmental). Cattle in this group have the highest performance of any class, if conditions are right. Included are the highest producing traditional dairy breeds, the largest of the exotic dual-purpose breeds, and the largest breeds of British-Zebu or European-Zebu background. These breeds are all of large size and heavy milk potential. Because of their size they fit well as terminal sires. As cows, either in rotations or as terminal dams, these breeds can potentially wean the heaviest calves of any group. However, the combination of large size and heavy milking results in the highest nutritional requirements for any type of females. Thus, these breeds might be considered "all-purpose" but only if management and nutrition are intensive.

CONCLUSIONS

A variety of systems and breeds are used by successful producers, while these same combinations may be unsuccessful for others. The right system and breeds depend on the production conditions and management. Also, a breeding program is just one part of a successful total management plan. One of the challenges in beef production is to select breeding systems and breeds which best match breed characteristics to the environment, available forage and other feeds, management capabilities and market conditions. The final question should be, "Which combination of breeds will produce the highest net income?"