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Texas Adapted Genetic Strategies

Breeding Systems for Beef Production

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There are three steps in establishing a logical genetic strategy for beef production. First, determine the production and marketing conditions and match applicable levels of animal performance to these conditions. Second, choose a breeding system. Third, select genetic types, breeds, and individuals within breeds for compatibility with the the first two considerations.

Beef cattle producers face two types of mating or breeding decisions: 1) which animals are allowed to reproduce; and 2) which males are bred to which females.

Mating Plans

Mating plans can be based on: 1) randomness; 2) genetic relationship (*pedigree*); or 3) performance or visual appearance (*phenotype*).

Random Mating. *Random mating* does not mean random selection. Rather, individuals are selected for breeding. Then they may be mated in one multiple-sire group, or both males and females can be randomly gate-cut into separate breeding groups. Random mating is a rather common procedure, especially if it is difficult to maintain more than one breeding group.

Pedigree. All individuals in a genetic population (such as a herd, family line, or breed) are related to some extent. One pedigree plan mates individuals more closely related than the average of the population; it is termed *inbreeding*. Long-term inbreeding in a closed herd may increase genetic uniformity, but inbreeding usually reduces performance, especially in fertility and survival. This is called *inbreeding depression*. One type of inbreeding is *linebreeding*, which is used to concentrate the genetic influence of some line or individual while minimizing increases in inbreeding.

Mating animals less related than average is called *outbreeding* or, more commonly, *outcrossing*. Outcrossing of lines within a breed can restore performance lost to inbreeding depression. Mating of individuals of different breeds is called *crossbreeding*. It often increases performance above what might be expected from the parent breeds. This effect is called hybrid vigor or *heterosis*. It is commonly thought that outbreeding increases variability, but well-planned outcrossing or crossbreeding produces uniform progeny.

Phenotype. These plans are based on performance or visual appearance, not pedigree, and are called *assortative*. Mating of individuals most alike in performance or appearance is *positive assortative* mating. Examples are mating the heaviest males to the heaviest females or the shortest males to the shortest females. Compared to random mating, this results in more variation in progeny, fewer progeny near average, and more extremes. This plan is used mainly in hopes of producing a few extreme animals in order to quickly change a population. Positive assortative mating is sometimes called “mating the best to the best,” a sound concept if parents are truly superior in all important factors.

Examples of the opposite plan, *negative assortative*, are mating the heaviest males to the lightest females or the shortest males to the tallest females. Consequences of this scheme, compared to random mating, are decreased variation, more individuals near average, and fewer extremes. If average performance in offspring is optimum, then this plan is useful. Often these types of matings are used to correct problems. For example, in a herd with milk production levels too high for existing forage resources, sires of lower milking genetics would produce better adapted replacement heifers. Unless dramatic genetic change is needed, negative assortative mating often is a sound strategy.

Crossbreeding

Crossbreeding begins with the mating of two pure breeds. The term F_1 is usually applied to progeny of such a cross. A more useful definition of F_1 is the progeny of parents with no common genetic background. Genetic superiority in purebred parents results in the most desirable crossbreds. In fact, superior purebreds may easily exceed the performance of crosses from mediocre purebred parents. There are three benefits of crossbreeding over restriction to a single breed (*straightbreeding*). These are heterosis, breed combination, and complementarity.

Heterosis. Heterosis is measured as performance of crossbred progeny compared to the average of purebred parents. Heterosis is usually positive. It is highest in progeny of least related parents. For instance, there is greater heterosis in crossing the genetically dissimilar Hereford and Brahman breeds than in crossing the more similar Hereford and Angus.

Heterosis is reduced when the same breed is a constituent of both parents. As an example, if cattle sired by Angus and out of Hereford are bred back to one of these breeds (*a backcross*), the resulting progeny average 50 percent less heterosis than the F_1 Angus – Hereford. If the F_1 is bred instead to a third breed, then heterosis of progeny can be either higher, the same, or lower, depending on the genetic relationship of the third breed to Angus and Hereford.

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If, instead of a backcross, you mate two F_1s of the same breed makeup, the progeny, called *F_2*, also average 50 percent reduction of heterosis from the F_1. But if you intermate those F_2s, producing an *F_3*, there is no additional loss of heterosis, on the average, beyond that experienced in going from the F_1 to F_2. Heterosis is reduced beyond the F_3 generation only to the extent that inbreeding occurs.

Characteristics differ in heterosis. Heterosis is highest in fitness traits such as fertility, livability, and longevity. It is intermediate in milk production, weight gain, feed efficiency, and body size. It is lowest in carcass traits. Heterosis is highest in factors affecting efficiency in dams.

Breed Combination. Even if heterosis was not a factor, there could be benefits merely from combining breeds with different characteristics to produce a superior package. For example, females with genetics for high carcass quality but small body size and low rate of gain could be mated to sires with genetics for large size and fast weight gain but low carcass quality, resulting in progeny acceptable in both traits. In many instances, favorable combinations are the most important benefit from crossbreeding.

Complementarity. The mating just discussed might be called complementary, as it combines parents with differing strengths and weaknesses to produce desirable progeny. However, what if the females in the example were as large in body size as could be efficiently maintained on that particular forage resource? The smaller body size of these females is an advantage for cow adaptability, in this situation, but a disadvantage in progeny gaining ability. The disadvantage is countered with large, fast-gaining sires. But the heifers from that mating would not be useful for replacements in that herd, as they would be too large in body size. The only way to exploit this mating in that environment is to continually use a particular genetic type of female and a different type of sire. This technique is called *complementarity*, and it is possible only with a particular breeding system, discussed below.

Types of Breeding Systems

There are two basic breeding systems. If the source of replacement females is heifers produced in the herd there is a *continuous* system. If heifers are not put back in the herd this is a *terminal* system. Differences in these systems must be well understood or serious mistakes can be made.

Continuous. A continuous system produces its replacement females but requires an external infusion of sires (unless inbreeding is involved, and that is rarely desirable in commercial production). Since replacement females are retained in this system, the cowherd has genetics of both sires and dams. Therefore, if sires have traits that are undesirable in brood cows, they cannot be hidden in a continuous system. Both sires and dams in continuous systems should be similar in important traits, without any undesirable characteristics. Genetic extremes generally are not compatible with continuous breeding systems.

Terminal. In a terminal system, both replacement females and sires must come from external sources; they are either purchased or come from another herd. However, since heifers produced in terminals are not retained for breeding, there is more flexibility in choice of genetic types. Specialized maternal and sire types can be used in terminals, since undesirable traits can be masked in a properly designed system.

A combination of relatively small dams bred to larger sires in a terminal system fully exploits complementarity. However, breeds similar in body size also are useful for terminals in some cases. An example is where climatic conditions favor females of heat-tolerant breeds, many of which are relatively low in carcass quality. Sires from breeds known for high carcass quality, most of which are no larger than medium in size, might be the best choice in this case. Some complementarity in body size and weight gain is given up for female adaptability.

Continuous Systems

Straightbreeding. Here the same breed of sire and dam is used continually, so progeny usually are rather uniform in appearance. Straightbreeding is particularly useful in producing parents for crossbreeding. The biggest shortcoming of commercial straightbreeding is the absence of heterosis, which is usually too important to ignore.

True Rotations. *True rotation* systems use two or more breeds and the same number of breeding groups. The simplest rotation is a two-breed, sometimes called a *criss-cross*. A different breed of sire is used continually in each of the two breeding groups. Replacement heifers are moved or rotated for breeding from the group where they were produced to the other group, where they remain for all of their lifetime matings. Figure 1 shows a two-breed true rotation. In a rotation of three or more breeds, a heifer is placed in the breeding group with the breed of sire to which the heifer is least related. This ensures minimal loss of heterosis in progeny.

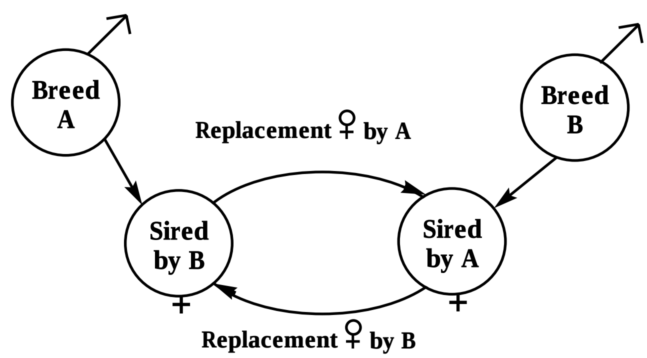

Figure 1. A two-breed true rotation.

Because they require multiple breeding groups, true rotations are rather complicated unless artificial insemination is used. (A. I. simplifies many of the mechanics of most crossbreeding systems.) Understand that, once a true rotation is fully in place, all breeding groups are present every year. Also, a compromise must be made between complementary matings and uniformity between groups. You cannot maximize both in rotations. Because of these complexities and limitations, true rotations are uncommon.

Sire Rotations. *Sire rotations* are sometimes called rotations in time. Instead of rotating females among multiple breeding groups, as in true rotations, sire breeds are changed periodically in a single group. A sire breed might be used for from one to several breeding seasons, most commonly for two or three. Ordinarily, a single sire breed is used during a breeding season to produce more uniform progeny and simplify identification of the genetic content of potential replacement females.

Heterosis is lower in sire rotations than in true rotations, though the reduction is slight in well planned systems. Highest heterosis is maintained by keeping replacement heifers out of dams that are least related to the heifer's breed of sire. This merely requires identifying a dam's breed of sire, if a single breed of sire is used in a breeding season.

Sire rotations are much simpler to conduct than true rotations, because there is only one breeding group. This is one of the most common breeding systems. Unfortunately, in many cases such plans are conducted haphazardly, with little thought given to a logical schedule.

Terminal Systems

Static Terminal. In a *static terminal*, replacement females must come from outside, either by purchase or creation in another herd. It is simplest to purchase replacement females because then only one breeding group is needed for the terminal cross. This is a particularly simple plan when purchases are limited to females that have calved at least once or twice, in which case there are no heifers that require separate facilities and easy-calving sires.

A straightbred terminal is mechanically possible, but there usually is no good reason to do so because there are no benefits of crossbreeding. A possible exception is if a strong market exists for some straightbred and the breeder does not wish to or can not develop heifers.

A two-breed static system produces heterosis in crossbred calves, using straightbred males and females of different breeds. However, such a system forfeits the considerable heterosis of crossbred dams.

A three-breed terminal is more efficient. It uses two-breed F_1 cows and a third breed of sire. First, straightbred females with desirable maternal traits are produced. Then these are crossed with another maternal breed to produce the F_1. Then the F_1 females are used in a terminal cross. Figure 2 shows a three-breed static terminal system.

In a complete static system, about one-fourth of the females are straightbred, about one-fourth produce the F_1, and only about one-half of the females are in the terminal portion. Someone must perform all these functions in order for three-breed terminals to be possible, and this requires time and expense. The unique advantage of static terminal crossing is the exploitation of complementarity. The main disadvantage is in the creation of replacement females.

Rotation Terminals. A rotation terminal is actually a combination of the two basic systems, designed to solve some of the problems of providing replacement females for static terminals. Here, a rotation system produces replacement females both to keep itself going and for use in a separate terminal. In most instances, middle-aged females (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 large in body size.

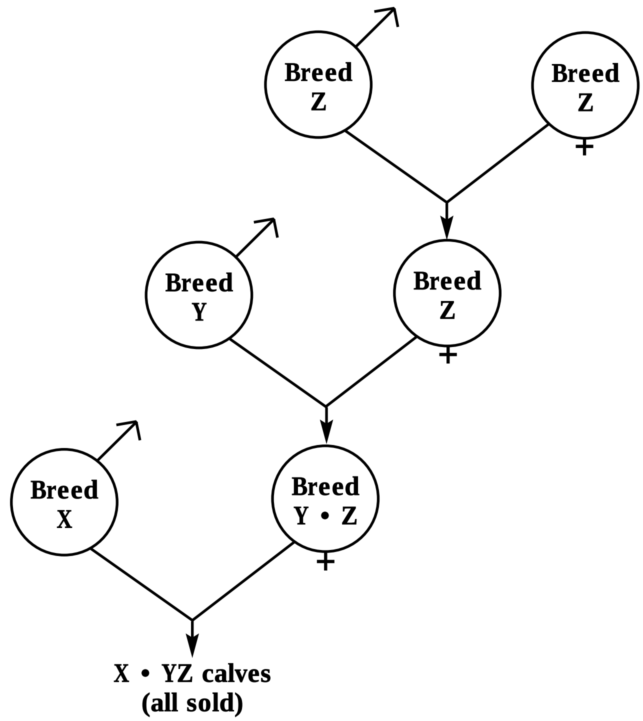

Figure 2. A three-breed static terminal.

For a sire rotation, only two breeding groups are needed, one for the sire rotation and one for the terminal cross.

Heterosis is relatively high in these rotation terminals, because all progeny and breeding females are crossbred. However, a high percentage of the rotation heifer progeny must be retained for replacements, so there is little opportunity for selection of females. Approximately 65 to 75 percent of sale calves are from the terminal, with most of the rest being male calves from the rotation.

Composites and Synthetics

A *composite* breed is formed from two or more established breeds, usually in exact percentages that vary depending on the goals of the breed. There is specific attention to retaining heterosis as generations progress. The primary motivation for creating composites is to create desirable breed combinations while producing heterosis without continual crossbreeding. The term *synthetic* is sometimes used interchangeably with composite. However, a synthetic as used herein refers to a population formed from a pool of two or more breeds, but with no particular breed percentages or special effort to retain heterosis. It is important to note that restriction to some composite or synthetic is not the same as straightbreeding of long-established breeds, since some heterosis is still realized. A complete discussion of composites and synthetics is being prepared for a future Texas Agricultural Extension Service publication.

Breeding Systems and Breeding Groups

The choice of breeding systems depends partly on the number of separate breeding groups that can be maintained. The development, breeding, and calving of heifers is conducted most efficiently in a management group separate from older females, using easy-calving sires.

One breeding group. One-breeding-group herds, ranging from those requiring only one bull to large, multiple-sire herds, have several choices of breeding systems. Of course straightbreeding is an option. A static terminal cross could be run, with F_1 females being purchased. A sire rotation could be implemented, using breeds that are similar in functional characteristics. A fourth option for one breeding group is the use of a composite or synthetic.

Two breeding groups. Two groups offer other choices including: 1) a true two-breed rotation; (2) straightbreeding in one group to produce females for use in another group to create special-market F_1 replacement females; 3) straightbreeding in one group to produce females for a two-breed static terminal cross in another group; 4) purchasing straightbred females for creation of an F_1 in one group, to be used in a three-breed static terminal cross in another group; and 5) sire rotation in one group, producing replacement females for a terminal cross in another group.

Three breeding groups. There are three options that require three breeding groups. One is a true three-breed rotation. Another is a true two-breed rotation generating replacement females for a terminal cross. The third is to carry out all three matings for a complete three-breed static terminal cross: production of straightbred females, creation of F_1 females, and the terminal cross.

Multiple breeding groups are more complex to manage, and for each breeding group there is a different genetic makeup in market animals. This can reduce marketing flexibility. Also some genetic combinations may be less valuable than others. Consider these factors before implementing systems requiring multiple breeding groups.

Table 1. Breeding system production efficiencies.

System	Advantage[1]
2-breed true rotation	16
3-breed true rotation	20
2-breed sire rotation	12
3-breed sire rotation	16
2-breed composite[2]	12
4-breed composite[2]	18
2-breed static terminal (complete)	9
3-breed static terminal (complete)	20
3-breed static terminal (buy F_1 females)	28
3-breed sire rotation or composite[2] + terminal cross	24

[1]Average percent increase over straightbreeding in pounds of calf weaned per cow exposed, using only *Bos taurus* breeds (British and Continental European). Crossing *Bos taurus* and *Bos indicus* (Zebu) can increase these values by 50 to 100 percent, depending on the environment.

[2]Substituting a synthetic for a composite reduces values slightly to moderately, depending on heterosis retained.

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Efficiencies of Breeding Systems

To compare breeding systems at the cow-calf level a simple measure of production efficiency is pounds of calf weaned per cow exposed to breeding, which combines reproductive efficiency and calf weight. Table 1 compares several breeding systems on this basis. Values shown are percentage increases above continuous straightbreeding. These increases are due to average levels of heterosis and any progeny weight increase from large terminal sires.

As shown in the table, simple continuous systems requiring a single breeding group (sire rotations, composites, and synthetics) can increase efficiency by about 10 percent to 20 percent. Most of the more complicated plans (true rotations, terminals and combinations) increase efficiency about 15 percent to more than 25 percent. These are significant advantages over straightbreeding.

The measure of efficiency used in Table 1, pounds of calf per cow exposed, does not consider the cost of production. If high levels of reproduction and calf weight increase costs (particularly nutrition costs), the advantage of crossbreeding is reduced. Research indicates that, when all costs are included, the total economic advantage may be reduced to approximately two-thirds to three-fourths of the levels shown in Table 1, still an important advantage.

Another profit variable with some genetic basis is relative sale price. In choosing a breeding system, consider possible effects on the major profit factors: 1) number of animals to sell; 2) pounds per animal; 3) price per pound; and 4) total cost of production.

It is a major challenge for beef cattle producers to select breeds and breeding systems compatible with climate, forage conditions, general management practices, and market demands. For a discussion of genetic types and breeds of cattle, see the TAEX publication, L-5206, “Cattle Types and Breeds – Characteristics and Uses.”

When selecting a breeding system, give careful thought to the entire process. Do not embark on the first stage of a system without planning for subsequent stages. A system that works well for one producer might be completely unsuitable for another. Breeding systems should be chosen only after considering all relevant factors.

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