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# Crossbreeding in Beef Cattle

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Improving the productivity and efficiency of a commercial beef production operation through genetic methods can be accomplished in two ways. One is by selection within a breed to improve economically important traits that contribute to the overall productivity of the straight breeding operation. The other method is implementing a crossbreeding program utilizing more than one breed.

In order for a straight breeding operation (single breed) to make genetic improvement in traits of economic importance, they must utilize selection. Improvement by this method is dependent on the heritability of the trait in consideration, which is the proportion of the measurable difference observed between animals for a given trait that is due to genetics (and can be passed to the next generation). Improvement by selection for growth and carcass traits is an excellent method since those traits are moderately to highly heritable. However, some of the most important traits related to beef cattle production are reproduction and calf survivability and they are lowly heritable traits, which means the success of a selection program for these traits will be very limited.

A crossbreeding program offers two primary advantages compared to the use of a straight breeding (single breed) program. One of those advantages is the phenomenon called heterosis or hybrid vigor. Heterosis occurs when different purebred breeds are mated together. Purebred cattle can be considered inbred as a result of breed formation and selection for certain distinguishable characteristics within a particular breed. They may share some of the same ancestors in their pedigree, which increases the probability that they have more homozygous gene pairs for some traits. This can have a negative effect of reduction in some reproduction and fitness traits, which is called inbreeding depression. When different purebred breeds are mated together, the crossbred progeny are less inbred than their parents as a result of increased heterozygosity and a reduction in some of the effects of accumulated inbreeding. As a result of increased heterozygosity of some gene pairs, the calves perform at a level above the average of their parents in some traits, which is called heterosis or hybrid vigor and is the result of the recovery of accumulated inbreeding depression in pure breeds.

Heterosis or hybrid vigor refers to the superiority in performance of the crossbred animal compared to the average of the straight bred parents. It may be calculated using the following formula:

**% Heterosis = [(crossbred average – straight bred average) ÷ straight bred average] x 100**

For example, if the average weaning weight of the straight bred calves was 475 pounds for Breed A and 535 pounds for Breed B, the average of the straight bred parents would be 505 pounds. If Breed A and Breed B were crossed and the resulting calves had an average weaning weight of 525 pounds, heterosis would be calculated as:

$$[(525 - 505) \div 505] \times 100 = 4\%$$

This 4 percent increase, or 20 pounds, in this example is defined as heterosis or hybrid vigor.

The amount of heterosis expressed for a given trait is inversely related to the heritability of the trait. 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 factors and a small percentage is due to genetic differences. However, these traits exhibit the greatest response to heterosis. Generally, the greatest benefit from heterosis is realized for traits that are lowly heritable, traits like reproductive performance of the cow and livability of the calf. Growth traits like weaning, yearling and birth weights are moderately heritable and have a moderate response to heterosis. Highly heritable traits like mature weight and carcass traits exhibit very little response to heterosis. Table 1 illustrates the relationship between heritability and heterosis.

**Table 1. Relationship Between Heritability and Heterosis**

| Trait | Heritability | Level of Heterosis |
|---|---|---|
| Carcass/end product<br>Skeletal measurements<br>Mature weight | High | Low (0 to 5%) |
| Growth rate<br>Birth weight<br>Weaning weight<br>Yearling weight | Medium | Medium (5 to 10%) |
| Maternal ability<br>Reproduction<br>Health<br>Cow longevity<br>Overall cow productivity | Low | High (10 to 30%) |

The other advantage of a crossbreeding program is referred to as complementarity of different breeds. Breed complementarity allows a breeder to capitalize on the strengths of one breed in a particular trait to compensate for a deficiency in that particular trait in another breed. No single breed excels in all of the traits that affect profitability in a commercial beef cattle operation. Complementarity results when desirable traits of different breeds are blended into a crossbred animal. An example of this might be a high-growth, muscular sire of one breed bred to a high carcass-quality, lower muscled female of a different breed to produce offspring that blend muscling, growth and carcass quality into a crossbred animal.

## Types and Effects of Heterosis

There are three types of heterosis in beef cattle — individual, maternal and paternal. The individual type is measured as the advantage of an individual crossbred animal over a purebred animal in a particular trait. Individual heterosis is measured in traits of survivability, growth and carcass. Maternal heterosis is the result of the advantage of a crossbred dam above the purebred female in traits such as fertility, mothering ability and growth. Paternal heterosis is the advantage of a crossbred bull over a purebred bull.

Many research projects have been conducted to determine the results of heterosis in beef cattle. One of the classic projects was initiated at the Fort Robinson Beef Cattle Research Station in Nebraska in cooperation with the USDA MARC. This project, which was started in 1957 and concluded in 1976, included three British beef cattle breeds of Angus, Hereford and Shorthorn. This study spanned four generations of cattle breeding to generate straight bred and $F_1$ crossbred calves and straight bred and $F_1$ crossbred females. Results of this project are illustrated in Table 2. In the initial phase of this trial, some of the straight bred cows produced straight bred calves, and some of the straight bred cows produced crossbred calves to determine the advantage of crossbred calves over straight bred calves when both types of calves were produced by straight bred cows. Crossbred calves compared to straight bred calves had an 8.5 percent advantage in total pounds of calf weaned per cow exposed at breeding. This advantage of crossbred calves over straight bred calves was due to greater survivability from birth to 2 weeks of age, increased percentage of calves alive at weaning, and heavier weaning weights.

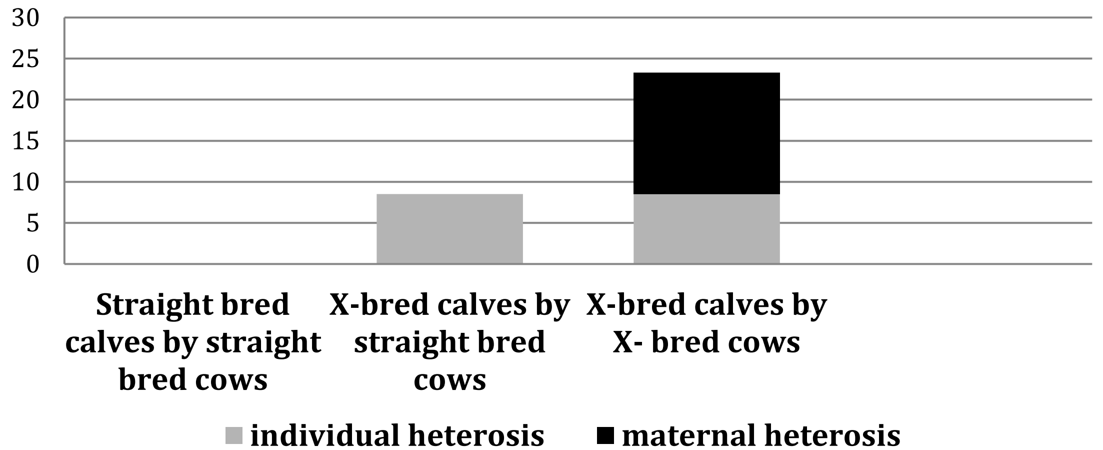
In comparing the advantage of an $F_1$ crossbred cow over a straight bred cow, both types of cows were bred to produce crossbred calves. The difference between the two types of cows could be attributed to the advantage of an $F_1$ crossbred cow over a straight bred cow since both types were producing crossbred calves. The $F_1$ crossbred cows produced 14.8 percent more pounds of calf weaned per cow exposed over the straight bred cows due to their higher conception rate at first service, mothering ability, weaned calving percentage, and growth rate of their calves. When the advantage of individual heterosis on survival and growth of the crossbred calves and the advantage of maternal heterosis on reproduction and maternal ability of crossbred cows are all combined, the pounds of calf weaned per cow exposed to breeding was increased by 23.3 percent over straight bred cows producing straight bred calves. Almost two-thirds of this advantage was attributable to the maternal heterosis of crossbred cows. Another advantage of a crossbred cow over a straight bred cow is longevity. This experiment comparing crossbred cows with straight bred cows was terminated when the cows ranged in age from 12 to 15 years. At the end of the experiment 24 percent of the original crossbred females remained in the herd compared to 11 percent of the original straight bred females.

**Table 2. Effects of Individual and Maternal Heterosis Expressed in Beef Cattle for Various Traits in Hereford, Shorthorn and Angus Cattle**

| TRAIT | INDIVIDUAL | MATERNAL |
|---|---|---|
| % Calf Crop Weaned | 3.4 | 6.6 |
| Calf Survival | 1.7 | 2.0 |
| Birth Weight | 2.7 | 1.6 |
| Wean Weight | 4.7 | 4.2 |
| Lbs. Calf/cow exposed | 8.5 | 14.8 |

Cundiff & Gregory 1977

**Figure 1. Cumulative Heterosis Effects for Lbs. Calf Weaned Per Cow Exposed (Cundiff & Gregory 1977)**




These results shown in Figure 1 are an example of crossbreeding with British beef cattle breeds. The crossbred calves produced by straight bred cows exhibited an 8.5 percent heterosis advantage of pounds of calf weaned per cow exposed over the straight bred calves produced by straight bred cows. The crossbred calves out of $F_1$ crossbred cows captured both the individual heterosis and the maternal heterosis from the crossbred cows and had an increase of 23.3 percent more pounds of calf weaned per cow exposed over the straight bred calves out of straight bred cows. Crossbreeding trials with Brahman and European (continental) breeds have shown even greater cumulative increases over the average of the straight bred parents for both individual and maternal heterosis.

Improvement of production and efficiency in a commercial cow-calf operation can be best realized by having both a crossbred calf and a crossbred cow. The advantage of the crossbred calf (individual heterosis) is due to increased livability along with an increase in weaning weight. The greatest advantage for a crossbreeding program is realized in the crossbred cow (maternal heterosis) due to increased fertility, calf livability, calf weaning weight and cow longevity. The combination of these result in a significant increase in pounds of calf weaned per cow maintained. The other advantage of a crossbreeding program is the ability to take advantage of the strengths of two or more breeds to produce offspring that optimize performance in different traits.

**Table 3. Advantage of Crossbreeding System over Straight Bred 50-Cow Herd with 80% Calf Crop and 550 lb. Average Weaning Weight**

| Breeding program | Lbs. calf/cow | Total pounds/herd |
|---|---|---|
| Straight bred | 440 Lbs. | 22,000 Lbs. |
| Straight-bred cows X different breed bull (+8.5%) | 477 Lbs. | 23,870 Lbs. |
| $F_1$ Cross-bred cows X bull of 3rd breed (+23.3%) | 542 | 27,126 Lbs. |

(Using data of 8.5 percent individual and 14.8 percent maternal heterosis)

The results shown in Table 3 are an example of the possible increase in productivity of a 50-cow herd that has an average weaning weight of 550 pounds and an 80 percent calf crop weaned. In a simple crossbreeding program by mating straight bred cows to a bull of another breed compared to a straight breeding program and only capturing individual heterosis in the crossbred calves is the equivalent of an extra 1,870 pounds of calf weight to sell. That is equal to an additional 4.25 more 440-pound claves to sell at weaning. The three-way cross using a bull of a third breed bred to $F_1$ females captures both individual and maternal heterosis. This system compared to a straight breeding program represents an increase in 5,126 total pounds of calf weight to sell at weaning. That is the equivalent of an extra 11.65 additional 440-pound calves to sell at weaning, while still only having to maintain 50 cows.

Since heterosis is a phenomenon of recovering inbreeding depression, maximum heterosis is realized in the first cross of distinctly different breeds. Subsequent backcrossing will reduce the expected amount of realized heterosis due to the likelihood of increasing homozygosity of some gene pairs. Maximum heterosis is realized when the crossbred individual possesses no more than 50 percent of any one breed. Table 4 shows the different levels of maximum heterosis expected from different breed combinations of a crossbred individual. Obtaining maximum heterosis is not always feasible or attainable in a simple program as it requires a number of strict management programs. Details of various crossbreeding systems to optimize heterosis will be discussed in the fact sheet covering Crossbreeding Systems for Beef Cattle.

**Table 4. Percentage of Maximum Heterosis in Different Crossbred Percentages**

| Crossbred % | % Maximum Heterosis |
|---|---|
| 50 : 50 | 100 |
| 50 : 25: 25 | 100 |
| 15/32 : 17/32 | 93 |
| 9/16 : 7/16 | 87.5 |
| 3/8 : 5/8 | 75 |
| 5/16 : 11/16 | 62.5 |
| 75 : 25 | 50 |
| 3/16 : 13/16 | 37.5 |
| 7/8 : 1/8 | 25 |

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