Optimising

DR HELENA THERON | SA Stud Book

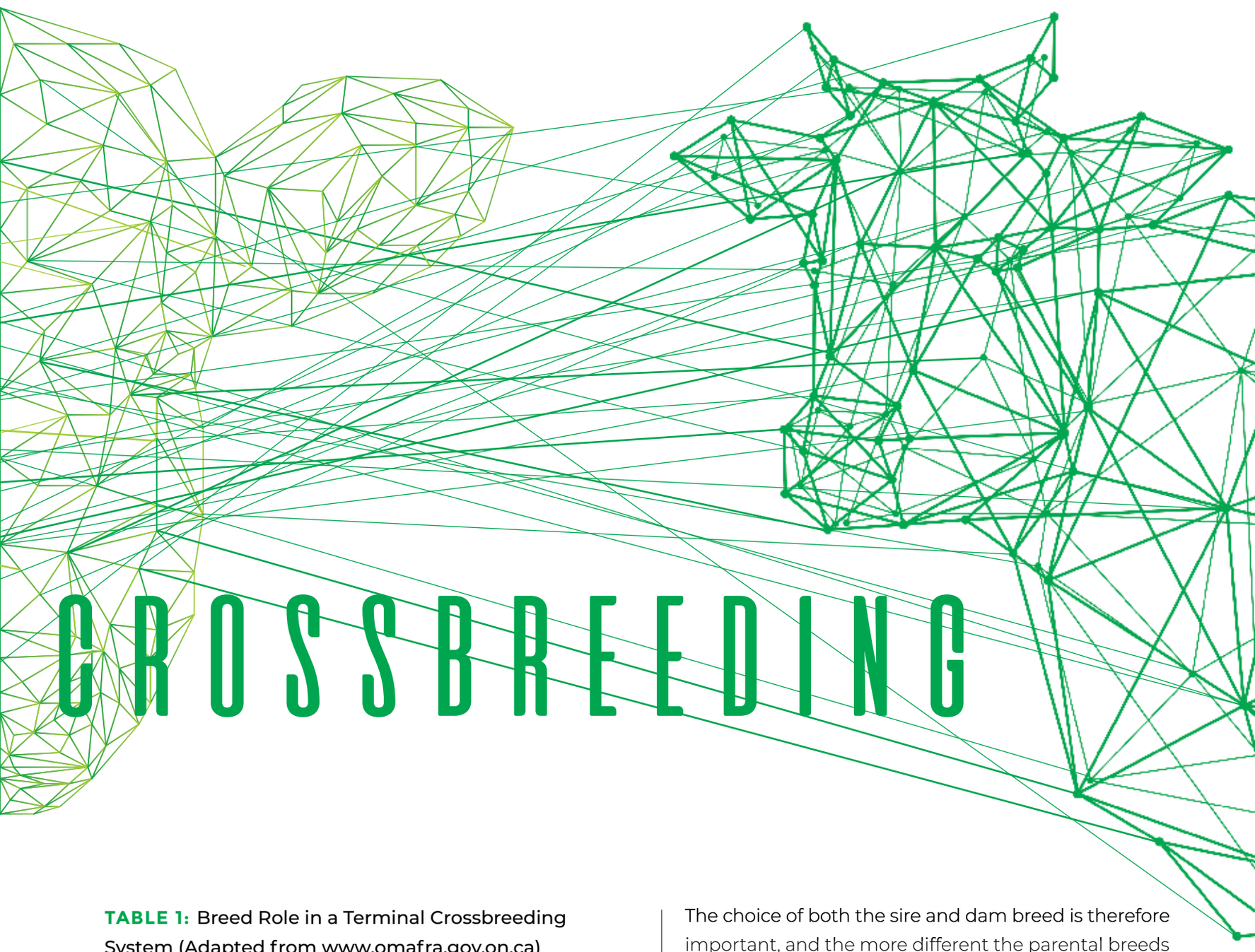
The term crossbreeding refers to the mating of animals from different breeds and has always been common practice in beef cattle production. Two aspects need to be considered to get the best advantage from crossbreeding, namely hybrid vigour (heterosis) and breed complementarity, which is often overlooked.

Breed Complementarity

Although all breeds are superior for some of the economically important traits, no breed is excellent in all traits. Crossbreeding takes advantage of breed complementarity, where the strengths of one breed complement or mask the weaknesses of another breed. In a Terminal Crossbreeding system, for example, a bull from a breed with superior growth is used on small-framed, low maintenance cows with good mothering ability and adequate milk (Table 1). Calves then have both the advantage of the mother's milk and the sire's growth.

TABLE 1

	Milk Production
Dam breed	Medium to High
Sire breed	None



CROSSBREEDING

TABLE 1: Breed Role in a Terminal Crossbreeding System (Adapted from www.omafra.gov.on.ca)

Mature Size	Ability to Store Energy[1]	Adaptability to Stress[2]	Calving Ease	Retail Yield
Low to Medium	Medium to High	Medium to High	High	Low to Medium
High	Low	Medium to High	Medium	High

1. Ability to store fat and regulate energy requirements with changing (seasonal) availability of feed.
2. Physiologic tolerance to heat, cold, internal and external parasites, disease, mud and other stress.

The choice of both the sire and dam breed is therefore important, and the more different the parental breeds are, the more heterosis would be expected from the mating. The Nguni is well-known as a mother line and performs well in crossbreeding systems, as was shown in a study by Scholtz and Theunissen, where Nguni cows were crossed with Simmentaler, Charolais and Chianina sires. They found that calving difficulties were limited, and birth weights were restricted to the mid-parent value or below. Crossbreeding did not have a negative effect on cow performance such as weight change and fertility, but cow productivity increased. In most cases, the weaning weight of cross-bred calves was the same or exceeded that of the pure sire breed, and the feed conversion ratio was always better than either of the two parent breeds.

In Table 2 is examples of the performance of some breeds. It would, however, be advisable to not only look at breed characteristics but also select bulls on superior breeding values as there is a lot of variability found within breeds as well.

TABLE 2: Example of breed evaluation for cattle breeds in Texas, USA. Note that considerable individual variation exists within breeds, and breed performance in South Africa may be different than in the USA (http://animalscience.tamu.edu/).

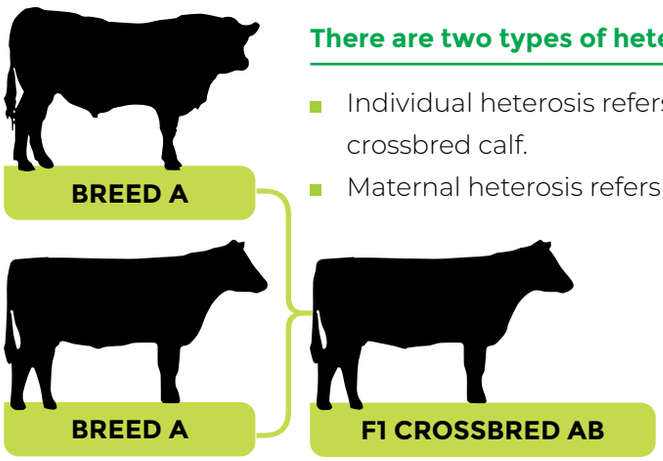
Breed	Body Size	Milking Potential	Age at Puberty	Hot Climate Adaptability	Fleshing Ability	Muscle Expression
Angus	Medium	Medium	Early	Medium	High	Medium
Hereford	Medium	Low	Medium	Medium	High	Medium
Charolais	Very High	Low	Late	Medium	Medium	Very High
Chianina	Very High	Very Low	Late	Medium	Low	High
Braunvieh	High	High	Early	High	Medium	High
Beefmaster	High	Medium	Late	Very High	High	Medium

Hybrid vigour (heterosis)

Hybrid vigour, also known as heterosis, is the tendency of crossbred individuals to show qualities superior to the average of their parents. Heterosis is not the same for all traits and generates the largest improvement in low heritable traits, such as reproduction and longevity (Table 3).

TABLE 3: Heritability and heterosis for important traits.

Level of Heterosis	Heritability	Trait
High (10 to 30%)	Low	Maternal Ability; Conception; Reproduction; Health; Calf survival; Cow longevity; Overall cow productivity
Medium (5 to 10%)	Medium	Growth rate; Birth weight; Weaning weight; Yearling weight; Milk production
Low (0 to 5%)	High	Mature weight; Skeletal measurements; Carcass weight



There are two types of heterosis, namely individual and maternal heterosis.

- Individual heterosis refers to the growth seen in the first-generation (F1) crossbred calf.
- Maternal heterosis refers to the improved production of a F1 cross-bred cow. They often have increased calving percentages, wean heavier calves and have greater longevity.

Crossbreeding systems, therefore, aims to benefit from both types of heterosis.

Hybrid vigour yields its greatest advantages in first-generation crosses (F1) because hybrid vigour is not transmitted from generation to generation without continued crossbreeding. Heterosis results when alleles (genes) from two different breeds are paired in offspring. If a Nguni cow is for example mated to an Angus bull, the resultant F1 Nguni-Angus calf will have one set of chromosomes from the Nguni cow and one set from the Angus bull, so at every location in the genome where Nguni alleles are present, Angus alleles are also present.

Hybrid vigour is lost

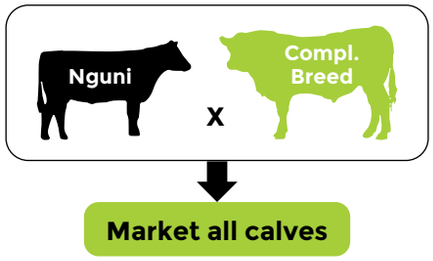
If two F1s are mated, the favourable combinations deteriorate due to recombination. Some areas in the genome will have Angus alleles with Angus alleles and some areas will have Nguni alleles with Nguni alleles. The F2 progeny will be somewhere between Nguni and Angus, depending on the random alleles it received from its parents. The heterosis effect is lost and is never as high as it was in the F1 cross. However, the mating of crossbred animals does result in the retention of some heterosis.

The term 'terminal' is often used in crossbreeding systems, implying that all progeny are slaughtered, as they have maximum heterosis and therefore maximum production, but they will not transmit their superior production to their progeny, as the favourable gene combinations will be lost.

In a two-breed terminal crossbreeding system, only individual heterosis is utilized. In terms of hybrid vigour, the ultimate female is the first-generation cow (F1) from the mating of two purebreds from different breeds. The ultimate crossbreeding system, however, which utilizes both maternal and individual heterosis, is the three-breed terminal crossbreeding system. This system results in a maximum (100%) heterosis.

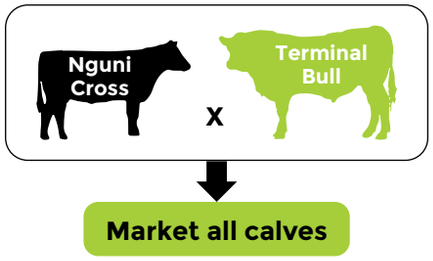
Utilizing Individual Heterosis: Two-breed Terminal Crossbreeding System

This is a simple, basic crossbreeding system, where purebred Nguni cows are bred to a complementary breed bull, e.g. Angus, Sussex or Charolais. Calves have 100% individual heterosis but no maternal heterosis. The downside of this system is that it is not sustainable, as purebred Nguni replacement heifers either must be purchased, or homebred. All F1 progeny are marketed, or the F1 heifers can be used or sold as replacement heifers for a 3-breed Terminal Cross, depending on the sire breed used.



Utilizing both Individual and Maternal Heterosis: Three-breed Terminal Crossbreeding System

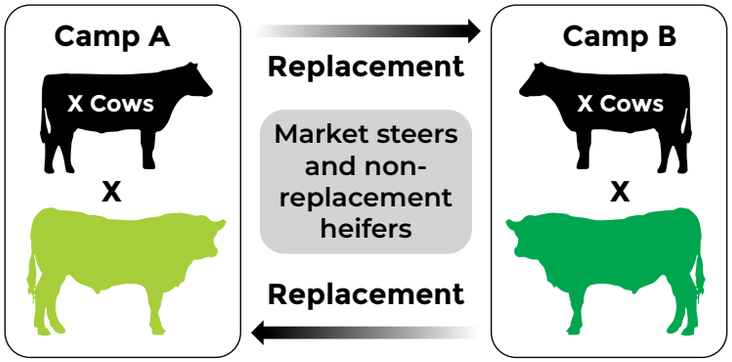
The most hybrid vigour of any crossbreeding scheme will be obtained from mating for example crossbred F1 Nguni cows to a terminal sire from another breed. The calf benefits from 100% individual as well as 100% maternal heterosis. However, all F1 progeny are marketed, as the heterosis effect that they have, will not be transmitted to their progeny. All F1 replacement heifers should therefore be purchased or home bred and be environmentally adapted with the necessary maternal capacities. For maximum production in the progeny, the terminal sires are selected only on growth and carcass with no attention to maternal traits.



The challenge, therefore, to maintain a 100% heterosis advantage is to maintain a continuous supply of F1 crossbred heifers as a purebred parent population would need to be maintained or replacements would need to be purchased elsewhere, which most producers are reluctant to do. This problem is overcome by various crossbreeding systems which have some degree of heterosis but sometimes can become very complicated. Two systems that are relatively simple but retain a large degree of heterosis are hereby described.

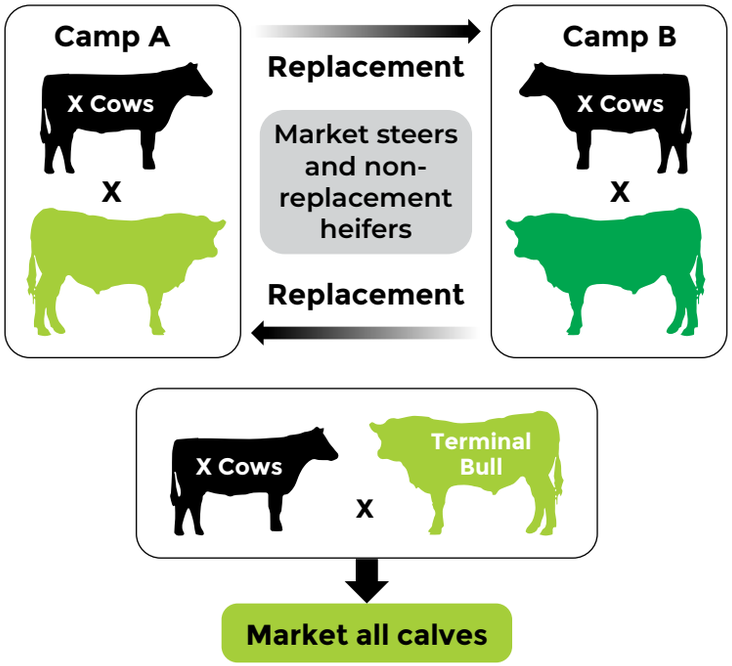
Examples of Crossbreeding Systems that maintain some heterosis:

1. Two-breed Rotational Crossbreeding System



This system is effective and relatively simple. For example, females sired by a Nguni bull are mated to an Angus bull, and females sired by an Angus bull are mated to a Nguni bull. Heterosis stabilizes at 67% of individual and maternal heterosis after about 6 generations. As replacement heifers sired by both breeds are retained, both breeds should therefore have maternal characteristics. As two sires are required, at least 50 cows and two camps are needed.

2. Three-breed Roto-Terminal Crossbreeding System



This system is an extension of the two-breed rotational system with a terminal sire added. Heifers are placed in the two-breed rotation to produce replacement heifers, and the older cows are mated to a terminal sire to produce calves that are all marketed.

The breeds used in the two-breed rotation must still be selected for the criteria specified in the 2-breed rotational program, while the terminal sires can be selected for increased growth and carcass traits to maximize production from the cowherd. This system requires more labour, management, and breeding pastures than a two-breed rotation but retains around 90% of the heterosis of the optimal three-breed terminal cross described above.

CONCLUSION

A crossbreeding system should take advantage of breed complementarity and heterosis. Although the individual change in some traits is small, it has been found that lifetime production can increase by more than 20% in programmes designed to capture both individual heterosis in crossbred calves and maternal heterosis in crossbred cows. It is also important to select all bulls on breeding values for the desired traits – starting correctly will also increase gains.

References

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