Use of Crossbreeding and Breed Differences to Meet Specific Targets for Production and Carcass Traits of Beef Cattle

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Introduction

The specific requirements for effective use of breed differences to meet specific production and market requirements are: (1) accurate assessment of production resources in regard to availability and costs, (2) accurate assessment of market requirements; i.e., value differences in carcass composition associated with yield grade and quality grade, and (3) accurate current characterization of breeds in regard to such traits as: (a) growth rate and size, (b) carcass composition, (c) milk production, and (d) age at puberty. This information is needed to identify contributing breeds to use in alternative mating systems to achieve specific targets for production and carcass traits. The objective of the beef cattle industry is to synchronize production and carcass characteristics of breed resources with the production resources that are most economical to provide in order to maximize economic efficiency.

Information on breed differences is presented in another paper in this report, e.g., Differences Among Parental Breeds in Germplasm Utilization Project."

The large differences that exist among breeds for most bioeconomic traits are the result of different selection goals in different breeds. Results from the Germplasm Evaluation Program at the U.S. Meat Animal Research Center provide evidence that genetic variation between breeds is of a similar magnitude to genetic variation within breeds for many bioeconomic traits. The heritability of breed differences approaches 100%, whereas, the heritability of differences within breeds for major bioeconomic traits varies from less than 10% to about 50%, depending on the trait. Heritability of breed differences approach 100% because estimates of breed differences are based on the means of a large number of individuals from a representative sample. This results in averaging genetic differences between individuals within breeds. Estimates of heritability of differences within breeds are generally based on single observations of individuals for a specific trait. Thus, selection among breeds is considerably more effective than selection within breeds.

Breed differences in bioeconomic traits are an important genetic resource and can be used to achieve and maintain performance levels that are optimum for different production and marketing situations. In addition to using breed differences to optimize production and carcass traits or to meet specific targets, the mating system should be organized to achieve and maintain high levels of heterosis or hybrid vigor.

Alternative Mating Systems

Genetic variation in alternative mating systems is shown in Figure 1 expressed in genetic standard deviation units. Panel 1 (Figure 1) shows that genetic variation between breeds is approximately equal to genetic variation within breeds for some bioeconomic traits. For example, mean percentage retail product of Hereford or Angus is approximately six genetic standard deviation units less than mean percentage retail product for Charolais, Limousin and Chianina.

Panel 2 (Figure 1) shows the difference between generations at equilibrium in rotation crosses of two pure breeds that have a mean difference in a bioeconomic trait of six genetic standard deviation units. The optimum varies in different production and market situations for such traits as: (1) growth and size, (2) milk production, (3) carcass composition, and (4) age at puberty and is reflected by zero in Figure 1. If the mean of the two breeds is optimum, then one-half of the cattle would be more than one genetic standard deviation from the optimum in a rotational crossbreeding system of two pure breeds whose means differ by six genetic standard deviation units. Retained heterosis at equilibrium for a continuous two-breed rotation crossbreeding system is 67% of the F_1level.

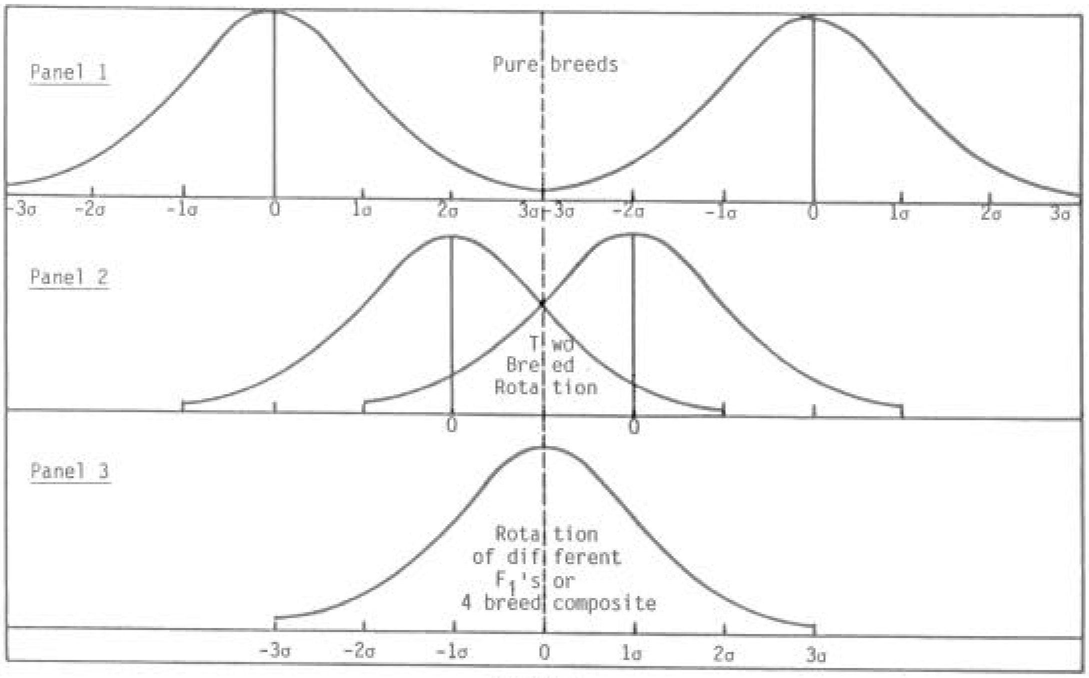
Another alternative is rotational crossbreeding of F_1 males. This alternative has some inherent long-term advantages. Inter-generation variation (Figure 1, panel 2) can be minimized in commercial production if breeds chosen to produce F_1 '5 are selected to optimize performance levels in the F_1 cross. Panel 3 (Figure 1) reflects the genetic variation expected with rotational crossing of AB and CD F_1 '5 where A and C represent a common biological type and B and D another common biological type. Then, performance is optimized in each F_1 (AB = CD) and in their rotational cross (AB-CD). Panel 3 (Figure 1) also depicts the genetic variation expected in rotational crossing of F_1 males having one breed in common (e.g., AB-AD, where B and D are the same biological type).

Panel 3 (Figure 1) shows that rotational crossbreeding using two different F_1 '5 (e.g., AB-CD or AB-AD) or a composite breed based on equal contribution by each of four breeds (e.g., ABCD) can result in populations that have about two-thirds of the animals within one genetic standard deviation of the optimum. The retained heterosis at equilibrium in a continuous rotation of sires using two different F_1 '5 (e.g., AB-CD) is 83.5% of the F_1 level. The retained heterosis at equilibrium in continuous rotation of sires from two F_1 '5 having one breed in common (e.g., AB-AD) is 67% of the F_1 level. The retained heterosis in a four breed composite with breeds contributing equally (e.g., ABCD) is 75% of the F_1 level provided the population is sufficiently large to avoid inbreeding.

Genetic variation in a composite breed with equal contributions by four breeds is approximately equal to continuous rotation of sires using two different F_1's that are approximately equal (e.g., AB=CD or AB=AD), (Panel 3).

Thus, a rotational crossbreeding system using F_1 males produced from different breeds (e.g., either AB-CD or ABAD) is preferred to a rotational crossbreeding system using two pure breeds for using breed differences to achieve a more optimum additive genetic (breed) composition. It is either superior or equal to a continuous two-breed (67%) rotational crossbreeding system for using heterosis. Similarly, a continuous rotational crossbreeding system using F_1 males of different breeds can be competitive with a composite breed based on equal contribution by four breeds for using both heterosis and breed differences to achieve an optimum additive genetic (breed) composition.

GENETIC VARIATION IN ALTERNATIVE MATING SYSTEMS



OPTIMUM
ASSUMES THAT THE TWO F_1's USED
ARE OF SIMILAR GENETIC MERIT.

TABLE 1. SIRE BREEDS USED IN GERMPLASM EVALUATION PROGRAM AT MARC

Cycle I (1970-72)	Cycle II (1973-74)	Cycle III (1975-76)	Cycle IV (1986-90)	Cycle V (1992-94)
F1 crosses from Hereford or Angus dams (Phase 2)[a]				
Hereford	Hereford	Hereford	Hereford	Hereford
Angus	Angus	Angus	Angus	Angus
Jersey	Red Poll	Brahman	Longhorn	Tuli
S. Devon	Braunvieh	Sahiwal	Salers	Boran
Limousin	Gelbvieh	Pinzgauer	Galloway	Belgian Blue
Simmental	Maine Anjou	Tarentaise	Nellore	Brahman
Charolais	Chianina		Shorthorn	Piedmontese
			Piedmontese	
			Charolais	
			Gelbvieh	
			Pinzgauer	
3-way crosses out of F1 dams (Phase 3)				
Hereford	Hereford			
Angus	Angus			

Brahman	Brangus	
Devon	Santa Gertrudis	
Holstein		

[a] In Cycle V, composite MARC III (1/4 Angus, 1/4 Hereford, 1/4 Pinzgauer and 1/4 Red Poll) cows are also included.