1993

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

Keith E. Gregory, Larry V. Cundiff, and Robert M. Koch

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) carcass composition, (3) milk production, 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$_1$ level.

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$_1$’s 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$_1$’s 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).

To use F$_2$’s (e.g., AB-CD or AB-AD) or a composite breed based on equal contribution by four breeds (e.g., ABCD) in such 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$_1$’s (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$_1$’s 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 78% 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 AB-AD) 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.

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Panel 1: Pure breeds

Panel 2: Two breeds rotation

Panel 3: Rotation of different F_1's or 4 breed composite

Optimum assumes that the two F_1's used are of similar genetic merit.