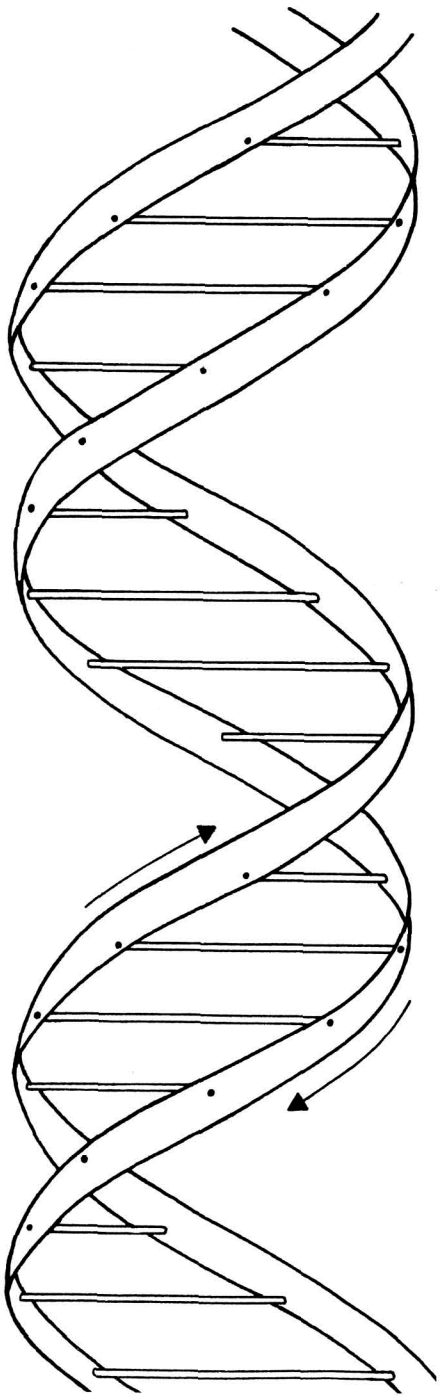
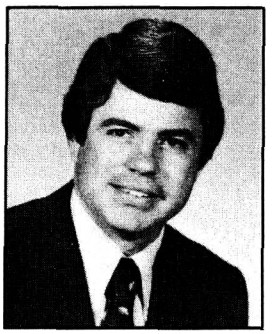
A lion's share of our market cattle in this country are crossbreds. Does it make sense to keep purebreds to produce those crossbreds or should we do away with purebreds and use crossbred breeding cattle to produce crossbred market animals?

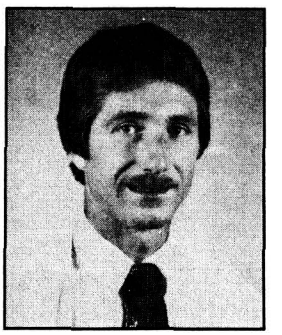
The preferred answer, at least to purebred breeders, is obvious. But to survive, purebred breeders must be able to satisfy the needs of the commercial market. Genuine genetic improvement may be the surest and safest way to do so, and that improvement hinges on an understanding of basic genetics.

In this and subsequent articles Thomas B. Turner, Ph.D., assistant professor of animal science at Ohio State University, and Darrell L. Wilkes, M.S. and Ph.D. student at that same university (and son of Angus breeders Don and Doris Wilkes, Hawk Springs, Wyo.)., are presenting a guide to basic genetics.





Thomas B. Turner, Ph.D.



Darrell L. Wilkes

First in a Series

Genetic Improvement to Insure the Future of Purebred Cattle

by Thomas B. Turner, Ph.D., and Darrell L. Wilkes

So those receiving ANGUS JOURNAL will read the forthcoming series with genuine interest, the authors have agreed that the first order of business should be to convince breeders that genetic improvement is essential to the future of any breed of cattle. The following is not intended to replace a diligent study of genetics, nor is it intended to overshadow practical experience in cattle breeding. It is intended to present a blend of the two, since most good cattle breeders apply both textbook methods and methods learned in the school of hard knocks.

Although cattle breeders set different goals for their breeding programs, we are assuming that every breeder is interested in reaching his or her goal in the shortest possible time and with the highest possible degree of certainty.

It is not our place to prescribe what those goals should be. Rather, it is our concern that they be reached with the utmost efficiency and accuracy. Even the most highly regarded cattle breeders will admit that, although they are pleased with their present position, they could have made more efficient progress if they had known yesterday what they know today about genetics.

We hope readers will accept this series in the spirit it is intended. We are simply trying to point out some basic methods that

may be used by cattle breeders to accelerate progress.

Do We Need Purebred Cattle?

Before we spend a great deal of time discussing genetic improvement, we should address the question of whether or not purebred cattle are even necessary. In an industry where many market cattle are crossbreds, an open-minded person must wonder if purebred cattle even will be here in 10-20 years. Mere tradition has little power to sustain an industry in our modern economy. Therefore, if purebred breeders cannot satisfy the real needs of the commercial industry, purebred cattle as we know them today inevitably will be phased out. It shouldn't be considered absurd or impossible that such a thing could happen. The tremendous efficiency of the poultry industry is a case in point; very few original purebreds remain now as viable breeding stock.

Genetic improvement should not be regarded as something that comes after the decision to keep purebred cattle. Rather, it should be regarded as the key factor upon which the continued existence of purebred cattle depends.

Genetic improvement should not be regarded as something that comes after the decision to keep purebred cattle. Rather, it should be regarded as the key factor upon which the continued existence of purebred cattle depends. It is a fact of life that a lion's share of the market cattle in this country are crossbreds. There is no reason to think this will change. Nor should it. The question we must address is this: Should we keep our purebreds to produce these crossbreds or should we do away with purebreds and use crossbred breeding cattle to produce crossbred market animals? The preferred answer, at least to purebred breeders, is obvious. Suffice it to say that our mutual objective is to insure this preferred outcome. Genuine genetic improvement is the surest and safest way to accomplish this task.

Why Do We Crossbreed?

Since an abundance of purebred bulls sold in this country are used in crossbreeding systems, it may benefit the purebred breeder to know a little more about the reasons for this practice.

To begin with, it may be helpful to discuss the notion of heterosis (also known as hybrid vigor), since this is an important factor in the production of crossbred cattle. Heterosis is simply defined as the amount by which the crossbred progeny differ from the average of the two purebred parents. As an example, suppose we have been able to assign a score relating to feed efficiency to each of two purebred parents of different breeds and to the resulting crossbred offspring. Let us say that we used a sire of breed A with a score of 11 and a dam of breed B with a score of 9. Clearly, the average of the two parents (sometimes referred to as the mid-parent) is 10. Finally, we define heterosis as the amount by which the score of the crossbred offspring exceeds this mid-parent value. If the crossbred offspring has a score of 11.5, we might say that heterosis for feed efficiency is 1.5. Or put in more comparative terms, we might say the crossbred offspring had a feed efficiency of 115% of the mid-parent value—or heterosis is 15%.

Although several very sensible theories have been advanced, the genetic mechanisms that bring about heterosis are not precisely known. A brief discussion of one possible explanation, though, will help us gain insight into the importance of purebred cattle.

Since most of us tend to think of genes as being either dominant or recessive, we will continue with this notion in our discussion of heterosis (although we will see this is not entirely the case). Let us suppose that the feed efficiency score previously mentioned is controlled by one pair of genes. We will refer to the corresponding alleles in each parent as either F or f, which means that in the offspring we have three possible genotypes: FF, Ff, and ff.

Not All Follow Pattern

Readers who are up on the study of genetics may be thinking that an animal with an Ff genotype will identically resemble one with an FF genotype and that an animal with an ff genotype will be less desirable. If we were dealing with pure and simple Mendelian genetics, this would probably hold true; however, not all genetic systems follow this pattern. There is very good evidence that in some cases the heterozygous individual (Ff) is actually superior to either of the homozygotes (FF or ff). Certainly, this does not hold true for all gene pairs, but there is an abundance of evidence suggesting that it happens with some. There are several reasons why this could be the case, but it is not necessary to pursue this matter further. Suffice it to say that the evidence to support this conclusion is overwhelming.

Unfortunately, many of the cold hard facts concerning heterosis have been overshadowed by a few atypical reports that might suggest crossbreeding is the cure to all ills in beef cattle breeding. These misconceptions have led to the unfortunate result that many crossbreeding systems are no more than the reckless crossing of cattle with differing heredity. Crossbreeding is not an antidote to poor heredity!

If the reader has been able to follow the argument to this point, the rest is straightforward. Suppose we have two breeds which have been genetically separated for 200 years or so. Let us say that breed A has lost the f allele and therefore possesses only the FF genotype. In addition, let us suppose that breed B has lost the F allele so possesses only the ff genotype. Clearly, when we crossbreed A with B, all offspring will have genotype Ff, which we are assuming to be superior. Hence, we have heterosis!

In actuality, it would be highly unlikely that either breed would become fixed in genotype even if they had been separated for quite some time, so it is more practical to think in terms of gene frequency. In our example, breed A may have something less than 100% F alleles, say 90% F and 10% f. If we assume a reverse role in breed B, not all offspring would necessarily exhibit heterosis, although a good share of them would be expected to. Our example is a bit over-simplified, since we are certain that feed efficiency score, whatever it may be, is controlled by more than one pair of genes.

Since traits showing low heterosis usually are highly heritable and show adequate within-breed variation, careful selection over a period of time theoretically could place nearly any breed at the top of the heap with regard to these traits. However, since the economic importance of beef cattle cannot be summarized into one trait, the true commercial value of any breed will be based on how well that breed is able to combine merits of several traits into one useful package.

Breed Development

So how does this relate to the vital importance of purebred cattle? To answer this question, one must imagine the formative processes in the development of a breed. The initial population of any of our pure breeds undoubtedly was composed of a very small number of individuals. If the frequency of a particular gene in this initial group of individuals was high, it would be high in our current population—assuming selection has not altered it and that little or no crossbreeding has occurred, which may have changed it. (One breed is different from another breed because of differences in gene frequency.) Hence, closing the herdbooks is the only likely way in which one breed really could remain genetically distinct from another..

From our earlier discussion, it should be clear that heterosis is absolutely dependent upon there being differences in the two parental breeds. Since the attainment of heterosis depends so heavily upon the existence of breeds which are genetically

distinct, it appears at once that there is a place for purebred cattle. However, this is only the first ace, and most of us require at least a pair of aces before we are comfortable in placing our bets.

Perhaps the single most important thing a purebred breeder must realize about heterosis is that some traits show a good deal of heterosis and some traits do not. Traits

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connected with reproductive fitness generally show the highest degree of heterosis, while those connected with growth traits (particularly yearling weight and frame score) are typified by a low degree of heterosis. Unfortunately, many of the cold hard facts concerning heterosis have been overshadowed by a few atypical reports that might suggest crossbreeding is the cure to all ills in beef cattle breeding. These misconceptions have led to the unfortunate result that many crossbreeding systems are no more than the reckless crossing of cattle with differing heredity. Crossbreeding is not an antidote to poor heredity! If cattle are to be useful in a crossbreeding system, they must have some true merit of their own. This is particularly true with regard to traits which do not show a good deal of heterosis.

Consistent Connection

While it may be an awesome task to memorize traits which show heterosis and those which do not, it should be comforting to know that this is not necessary. An abundance of data indicates a fairly consistent connection between heterosis and heritability—a term with which you may be more familiar. In nearly all cases, these data support the hypothesis that when heritability is high, heterosis is low and vice versa.

Heritability, of course, is a value describing the degree to which relatives resemble one another compared to the degree to which non-relatives resemble one another. It is dependent upon the relative importance of genetic variation versus environmental variation in determining the value an animal has for some particular trait. If the environmental component is high compared to the genetic component, most of the difference between two individuals will be due to the environment, and heritability will be low. If the environmental component is low, so a good share of the differences between two individuals is due to genetic differences, heritability is said to be high. Although we will deal with this in more detail later, it is worth noting here that heritability is directly associated with accuracy of selection. The more highly heritable a particular trait is, the more accurate will be the selection of animals based on their merit for that trait. This leads to the obvious result that highly heritable traits are more rapidly improved by selection.

The central point in this discussion, as mentioned before, is that some traits are not appreciably enhanced by crossbreeding. Fortunately, these are traits which usually show higher heritabilities and consequently are responsive to selection. Examples of such traits are yearling weight, 140-day ADG and frame score. In the final analysis, it seems pretty clear that any breed to be useful commercially must be capable of contributing its fair share of value to such traits in the crossbred market animals they produce. Even for those traits which show appreciable heterosis, it is not likely someone would deliberately shop around for cattle that are unusually poor in a particular trait so they could realize more heterosis when crossed with another breed with considerable merit for that trait. Recall that the mid-parent value is the reference point for measuring heterosis; therefore, we certainly would try to avoid lowering the absolute value of our reference point. This is

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the sort of thing so often obscured when evaluating the merit of a particular crossbreeding system.

Careful Selection

Since traits showing low heterosis usually are highly heritable and show adequate within-breed variation, careful selection over a period of time theoretically could place nearly any breed at the top of the heap with regard to these traits. However, since the economic importance of beef cattle cannot be summarized into one trait, the true commercial value of any breed will be based on how well that breed is able to combine merits of several traits into one useful package. An analogy would be the world's most fuel-efficient car that could not climb even the smallest hill.

As a conclusion to this first article, we should deal with the question posed in the beginning: Why use purebred breeding cattle rather than crossbred breeding cattle to produce crossbred market animals? If we can return to the numerical example regarding feed efficiency score, a few additional concepts can be explained. Recall that we had breed A (genotype FF, score 11.0) and breed B (genotype ff, score 9.0) that we crossed to produce breed AB, which all had genotype Ff and a feed efficiency score of 11.5 (15% heterosis). Now if we set up a diagram of our alternatives, we have the following:

MATING PUREBRED TO PUREBRED

Breed A		**Breed B**
Genotype FF	X	Genotype ff
Score 11.0		Score 9.0

Breed AB
Genotype 100% Ff
Score 11.5

At first glance, it would appear that we could throw away purebreds and use only crossbreds, since they have a higher score than even the best parent breed. However, if we take a look at what happens when we mate crossbreds, we will dispel that idea.

MATING
CROSSBRED to CROSSBRED

Breed AB		**Breed AB**
Genotype Ff	X	Genotype Ff
Score 11.5		Score 11.5

Breed AB
Genotype(s) 25% FF
50% Ff
25% ff
Average Score 10.75

From this example we can see that offspring produced by mating two crossbreds actually have a lower *average* score than offspring produced by mating purebreds of different breeds. Additionally, progeny from the purebred to purebred mating are more uniform than progeny produced by crossbred matings. This resultant uniformity also would be a great advantage from a management standpoint.

Increased uniformity but lower average breeding value typifies a crossbred population, while the opposite is true of the purebreds that produced them. This may be regarded as a feather in the cap for pure breeds that have something to offer individually. Certainly, as a breed, Angus cattle have true merit in more than one trait. Therefore, it seems Angus have a place in the commercial crossbreeding faction of the beef cattle industry. However, this is not the time to lean on the fence post and be satisfied.

The articles to follow will discuss in more detail what we have merely touched on here. We are not pretending to author a how-to book on cattle breeding, but we hope that some of the information we present will be helpful and that some of the questions we pose will be thought provoking.