

# A Series Beef Cattle Breeding

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Rick Bourdon, a Red Angus breeder currently involved in teaching and research at CSU, has designed this series (continued from last month's Journal) to help breeders understand and use available performance information.

## Part Five Estimated Breeding Values and MPPA

One of the greatest challenges for a seed stock breeder is to select the best parents and potential parents for his herd. Since breeding value is defined as the value of the animal as a parent with regard to a specific trait, the selection process really amounts to locating those individuals with the best breeding values for the desired traits. Breeding values are not directly measurable, however, so we must devise ways to estimate them. **Estimated breeding values (EBVs)** are the result—carefully constructed predictions of breeding values based on our knowledge of the mathematical relationships among sources of information.

Breeding value estimation requires a number of ingredients, the first of which is a value for the heritability of the trait being measured. Heritability tells us how good an animal's own performance is as a predictor of its breeding value. With a highly heritable trait (yearling weight for example), own performance is a good indicator of breeding value, and the EBV will rely heavily on individual performance. For lowly heritable traits (e.g. age at first calving), individual performance will contribute relatively less to the EBV.

When records on relatives are available, pedigree relationships are needed. Relationship measures the correlation

between the breeding values of two individuals for a specific trait—a correlation due to pedigree alone. The more closely two animals are related, the more important the record of one individual as a predictor of the breeding value of the other. As you would expect, records on an individual's half sibs contribute much more information to his breeding value estimate than records on his third cousins.

Genetic correlations can be used when we wish to utilize information on one trait to predict breeding values for another trait. (Breed association computer programs are not currently designed to do this, but could be.) Birth weight and yearling weight, for exam-

ple, are highly correlated genetically. Using this correlation and an individual's birth weight and yearling weight records, we can estimate breeding values for both traits that should be bet-

ter estimates than those calculated without the correlation. Another example that we might see in the future is estimation of breeding values for age at puberty in heifers using scrotal size measurements in related bulls. A fourth ingredient required for estimating breeding values is simply the number of pieces of information of each type that contribute to the estimate—the number of records from half sibs, from progeny, from a correlated trait, and so on. The larger these numbers, the more information available and the better the estimate.

Finally, we need the observations themselves—an individual's own performance and the average performance of his various relative groups. These values should represent all available information across a breed. In AHIR records, they are expressed as ratios (e.g. 103).

When all the necessary ingredients have been assembled, the procedure for estimating breeding values really boils down to weighting each source of information for heritability, relationship, genetic correlation and number of observations, and then tallying the results.

The breeding value estimate is said to be *regressed for numbers*, meaning that its range of possible values is restricted to a greater or lesser extent de-

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pending on the amount of contributing information. With lots of information, the range of estimated breeding values will be relatively large, and especially good or poor animals will have correspondingly high and low estimates of breeding value. With little information, however, it is difficult to obtain an EBV much different from average. This feature of estimated breeding values can be troublesome, especially for a breeder who owns a young, unproven animal he just "knows" is outstanding. However, it does allow comparison of EBVs of animals differing in amounts of available information—comparison that will be fair *on the average*.

The **accuracy** of a breeding value estimate is defined as the correlation between the estimate and the true, unknown breeding value. Accuracy is a function of all the factors used to weight the information contributing to

accuracy increases with increasing heritability, relationship (10 progeny contribute more than 10 half sibs) and numbers of relatives.

With high heritability, individual performance provides a fairly accurate estimate of breeding value, while with low heritability it does not. Accordingly, the importance of information on relatives is proportionately greater at low levels of heritability than at high levels. When heritability is 20 percent, 40 paternal half sibs provide almost as much information as individual performance. When heritability is 60 percent, those same 40 half sibs contribute much less information than the individual himself. We can say, therefore, that for lowly heritable traits, breeding values estimated from information on relatives are especially useful compared to individual performance records alone.

High accuracy values cannot come

to maternal half sibs increases proportionately more than that paid to paternal half sibs. This occurs because with only two maternal half sibs, the breeding value of the dam remains something of a mystery in comparison to the breeding value of the sire. With four maternal half sibs, however, there is a better balance of information from both sides of the pedigree. When progeny are added in the last two rows, the majority of emphasis shifts to them, reinforcing the concept that progeny records are the ultimate test of an individual's breeding value.

### Maternal breeding values

**Maternal breeding value (MBV)** is a breeding value for maternal ability, which is really the ability of a cow to wean a heavy calf. As such, it encompasses such traits as milk production and mothering ability.

**Table 1. Accuracy of Records on Relatives for Estimating Breeding Value of an Individual Animal\***

Relatives	Number	Genetic Relationship	Heritability		
			20%	40%	60%
Individual (IND)	1	1.00	.45	.63	.77
Paternal Half Sibs (PHS)	10	.25	.30	.36	.40
	40	.25	.41	.45	.47
Maternal Half Sibs (MHS)	2	.25	.15	.22	.26
	4	.25	.21	.28	.33
Progeny (PROG)	10	.50	.59	.72	.80
	40	.50	.82	.90	.94

\*Source: Willham and Leighton—Proceedings Beef Improvement Federation Research Symposium & Annual Meeting—1978.

**Table 2. Relative Amount of Attention that Should be Paid to Various Relative Groups in Estimating Breeding Value of an Individual Animal\***

Numbers				Percentage Attention			
IND	PHS	MHS	PROG	IND	PHS	MHS	PROG
1	10	2	0	44	42	14	0
1	20	4	0	33	46	21	0
1	10	2	10	18	17	6	59
1	20	4	20	10	14	6	69

\*Source: Willham and Leighton—Proceedings Beef Improvement Federation Research Symposium & Annual Meeting—1978.

the EBV. Higher heritability, relationship, genetic correlation and numbers of observations all increase accuracy. It is difficult to say just how accurate a breeding value estimate ought to be, but as a very rough guide, anything under 0.6 is probably not too reliable, while accuracies above 0.9 merit considerable confidence.

### Growth breeding values

The procedures currently being used to estimate breeding values for growth traits involve individual performance information and information from three groups of relatives: paternal half sibs (siblings by the same sire), maternal half sibs (siblings out of the same dam) and progeny. Tables 1 and 2 illustrate how the various relatives contribute to an individual breeding value estimate for a growth trait, and in so doing, point out some interesting concepts.

The first table lists the accuracy of a single breeding value estimate at three levels of heritability using different sources of information. Notice that

from sib data alone, even if the number of sibs is very large. This is because the sib information tells us only what genes were available to the individual of interest, not what genes it actually inherited from its parents. In other words, the performance of siblings tells us a great deal about the breeding values of our individual's parents, but it tells us nothing about how it fared in the random assortment process which created its particular set of genes. Individual performance does give us some information in this regard, however. Records from large numbers of progeny can pinpoint an individual's breeding value exactly.

Table 2 lists the amount of emphasis given to different relative groups when the information contributing to the breeding value estimate comes from various combinations of sources. As the amount of information on relatives increases, the importance of the individual's own performance declines. When the numbers of sibs are doubled in the second row, the attention paid

The information used to calculate maternal breeding values varies depending on the type of individual. For heifer or bull calves, the records used are the weaning weights of maternal half sibs, the weights of calves out of daughters of the sire, and the weights of calves out of daughters of the paternal and maternal grandsires. For a sire who has daughters in production, the weaning weights of calves out of his daughters are added, and for a cow in production, the weights of her own calves are added. To calculate the MBV, all this information is compiled and weighted for heritability, relationship and numbers of relatives in much the same manner as EBVs for growth.

The relative groups used for estimating MBV were chosen so as to make the MBV primarily a measure of milk production. However, because the information for MBVs comes from weaning weights (which are products of growth as well as milk production), MBV estimates cannot be completely independent of growth. The weaning

weights of calves out of daughters of a particular sire will reflect the half of the sire's genes for milk production which he passed on to his daughters, but they will also be influenced by the quarter of the sire's genes for growth which he passed on to his grandoffspring. Thus, as they are calculated, MBVs are not "clean" estimates of milking ability.

MBVs are not "clean" estimates of mothering ability either, for the simple reason that they do not take into account calves that did not survive to weaning. A poor mother in this sense—one who does not mother up readily or who exposes her calf to unnecessary dangers—could conceivably receive a favorable MBV if her surviving calves and those of her sisters and aunts wean heavier than average. And because MBVs are calculated only from data on surviving calves, they do not include any fertility information. Cows that do not calve on a yearly basis are not penalized.

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### **Progeny records are the ultimate test of an individual's breeding value.**

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Another general characteristic of MBVs is rather low accuracy. This is caused by several factors: the relatively low heritability of weaning weight (approximately 0.3); the fairly distant rela-

tionships between the animal for which the MBV is being calculated and the animals on which contributing information has been collected; the usually small number of paternal half sisters in production at the time the MBV is first calculated; and small numbers of relatives in general. High accuracy values for MBVs are usually available only for A.I. sires and for animals whose sires and grandsires were A.I. sires. We can see, then, the importance of widespread use of A.I. for increasing the accuracy of EBVs and MBVs in particular. Another important and sometimes overlooked factor in this regard is continual updating of breeding value estimates. As more and more information on relatives is collected, breeding value estimates, especially those with low accuracy values, will often change. The MBV that is recorded on an animal's initial performance pedigree may differ considerably from the MBV calculated a few years later.

As we have seen, MBVs are not without problems. However, if we are willing to accept that they do not measure maternal ability exactly as many of us would define the term, and if we can live with accuracy values that are low much of the time, MBVs can be useful for maternal selection.

**MPPA** stands for **most probable producing ability**. (MPPAs are not calculated or used in the AHIR program, however some state BCAs provide this information.) Like MBV, MPPA measures maternal ability using weaning weights. Also like MBV, MPPA is com-

monly expressed as a ratio and *is regressed for numbers*, in other words, adjusted to reflect the amount of information available. MPPA differs from MBV in two respects: 1) it is calculated just for producing females based on the weaning weights of their own calves only, and 2) it estimates **producing ability**, which is not just maternal breeding value, but maternal breeding value plus the effects of any environmental factors which permanently influence a cow's production.

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Producing ability is related to MBV in much the same way that individual growth performance is related to breeding value for growth. An animal's own growth performance reflects his breeding value for growth plus environmental effects which have helped or hindered his development. A cow's production reflects her MBV plus environmental effects which have caused her to be a better or poorer milker and mother. An example of a cow whose MPPA and MBV differ considerably is the cow whose relatives are good producers, but whose own production is poor due to some environmental cause—say, extreme obesity as a calf. This animal will have a high calculated MBV but a low MPPA. She probably carries the genes for good maternal ability and can produce daughters that will themselves be good producers, but she herself is unable to express those genes.

MPPA, then, estimates how well a cow will actually produce, while MBV estimates her value as a transmitter of genes for maternal ability. If you are a commercial producer and your product is weaning weight, you might consider culling cows on the basis of MPPA. If you are a seed stock producer who sells maternal breeding value, you should probably select on the basis of MBV.

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**NEXT:**  
**Sire Evaluation I: Terminology**  
**EBVs, EPDs, ACCs and PCs.**