Texas Agricultural Extension Service

People Helping People

Understanding Performance Pedigrees

During the last several years, beef cattle breed associations have been accumulating hundreds of thousands of animal records that have been sent to them by breeders. This vast amount of information, coupled with new computer and statistical technology, has enabled breed associations to produce performance pedigrees. Performance pedigrees bring traditional ancestral pedigrees to life by presenting meaningful data in a logical format. The information in performance pedigrees may be used by both commercial and seed stock producers for bull and female selection.

Performance pedigrees are meaningful because of a concept known as estimated breeding value (EBV). This fact sheet discusses the EBV concept and should help you understand performance pedigrees.

Breeding Value

EBVs are not mysterious. If you accept and understand the following basic genetic principles, then you can understand EBVs.

• Genes have their effects in pairs;
• An animal transmits a sample one-half of its genes to its progeny; and
• Only a portion of the variation measured in a trait is due to genes (this portion is termed heritability).

An EBV for an individual is determined by the heritability of the trait and production records from the individual and his/her relatives, weighted according to the genetic relationship between the individual and the relatives.

Because EBV is an estimate of breeding value, it needs to be defined. To understand where breeding value fits into the total scheme, see figure 1.

Figure 1
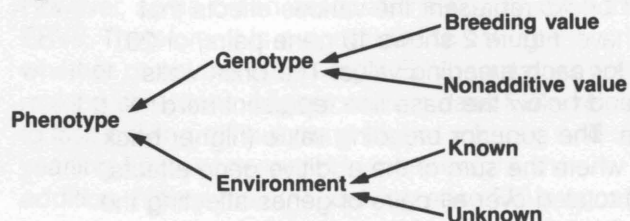
Phenotype (how the animal looks—its size, color, etc.) is determined by the animal's genotype and the environment in which it was raised. Each trait that can be measured or observed is a phenotype. For example, if a bull has an adjusted 365-day weight of 1,125 lb., his phenotype for yearling weight is 1,125 lb. Every animal has nearly an unlimited number of phenotypes, with each phenotype having a different genotype.

Environmental factors affecting phenotype may be divided further into known and unknown effects. We can make adjustments for known factors such as age of dam in calculating an adjusted 205-day weight. Adjusting for age of dam minimizes the environmental (nongenetic) effect that age of dam has on weaning weight and improves the accuracy of selection. Unknown effects, such as injury or sickness, are difficult to adjust for, but they can be minimized by managing cattle in contemporary groups (groups of cattle managed together—same age, pasture, lot, etc.)

Genotype is determined by two factors: breeding value (what genes are present), and nonadditive value (how genes are combined). The genes an animal has are determined by the genes possessed by the sire and dam, since an animal's genes are composed of a sample one-half of the sire's genes and one-half of the dam's genes.

Nonadditive value is related to the hybrid vigor or heterosis effect observed from crossing unrelated lines or breeds of cattle. Inbred cattle can have a higher breeding value than crossbred cattle, even though their actual performance (phenotype) may be lower. Because genes from the sire and dam are combined strictly by chance, the nonadditive value portion of genotype cannot be passed on from parent to offspring. The breeding value additive portion of genotype is what a parent transmits to its offspring.

A good way of depicting breeding value is the brick wall concept (figure 2) in which each brick represents a gene. Some genes have a negative effect, while others have a positive effect. The different sizes of bricks represent the various effects that genes have. Figure 2 shows 10 gene pairs, or 20 genes, for each breeding value. The brick walls above and below the base line represent herd average. The superior breeding value (higher brick wall) is where the sum of the additive gene effects (bricks) totaled over all pairs of genes affecting the trait is above herd average.

Figure 2

Superior breeding value

Inferior breeding value
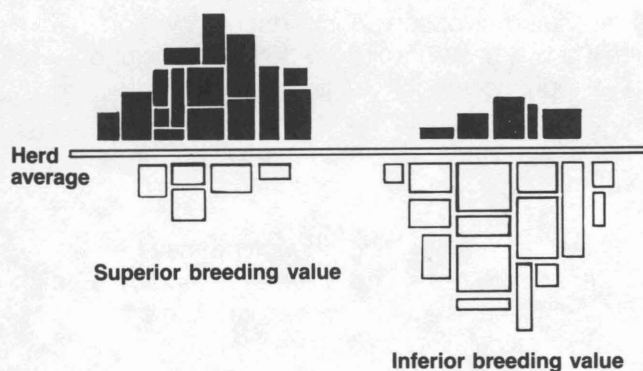
Classification of EBVs
EBVs may be classified as either direct or maternal. The differences between direct and maternal EBVs relate to the sources of data used in their calculation. Direct EBVs are calculated for calving ease, birth weight, weaning weight, and yearling weight. Maternal EBVs are calculated for calving ease and weaning weight. However, not all breed associations calculate EBVs for all these traits.

Direct calving ease EBV is an estimate of calving ease as a trait of the sire or the calf's ability to be born. Maternal calving ease EBV is an estimate of calving ease as a trait of the dam or the cow's ability to have a calf. Direct and maternal calving ease are indeed different and should be treated as two separate traits. Birth weight EBV is an estimate of genetic value for birth weight and may be used as a predictor of calving ease. Direct weaning weight EBV

is the best estimate of preweaning growth, while maternal weaning weight EBV is the best estimate of genetic value for the dam's maternal influence (primarily milk-producing ability) on progeny weaning weight. Some breed associations calculate a maternal weaning weight EBV exclusively and refer to it as the maternal EBV or MBV (maternal breeding value). It should be recognized that, while maternal weaning weight EBV is usually used as an estimate of milk production, it represents a combination of factors associated with a cow's influence on her calf's weaning weight. In addition to milking ability, these factors may include preweaning growth and mothering ability.

Direct yearling weight EBV is the best estimate of growth from birth through the yearling stage and is sometimes referred to as the growth EBV.

Information Used to Calculate EBVs
Direct EBVs are calculated by combining four sources of information: individual's own records, average ratio of paternal half-sibs (brothers and sisters by same sire), average ratio of maternal half-sibs (brothers and sisters out of same dam), and average ratio of progeny. The individual's record comes from one herd. Normally the maternal half-sib (MHS) data come from one herd unless the dam changed ownership. However, paternal half-sibs (PHS) and progeny records can be accumulated from all herds that used the individual sire and submitted the data to the breed association. The use of data collected across herds adds significantly to the validity of EBVs, making the performance pedigree such a powerful selection tool.

Table 1 shows how much emphasis is given to various combinations of information on relatives when estimating direct breeding values. Note that having data on 20 paternal half-sibs is about equal to having data on the individual's own performance.

In table 1, line two indicates that when the number of sibs is doubled, the importance of maternal sibs increases significantly, while the importance of paternal sibs goes up only slightly. This occurs because the dam side of the pedigree, while contributing half the genes, does not contribute as many records as the paternal side. The last two rows indicate the importance of including progeny data on the parents. When 20 progeny of a parent exist, 70 percent of the attention goes to the progeny average and only 10 percent to the individual's record.

Maternal EBVs are calculated for a sire using the average calving ease score or average weaning weight of the progeny of: daughters of his sire, daughters of his paternal grandsire, daughters of his maternal grandsire, and daughters of the individual sire himself.

Table 1. Percentage of attention to pay to groups of relatives in estimating direct breeding value of individual animals.

Number of animals[1]				Percentage of attention[1]			
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	28	17	6	59
1	10	4	20	10	14	6	70

[1]IND = Individual; PHS = Paternal half-sibs; MHS = Maternal half-sibs; PROG = Progeny.

If the subject animal is a young bull with no daughters in production, his dam's average progeny ratio is substituted for his daughters' progeny records. The most important source of information contributing to the maternal EBV of a proven bull is his own daughters' progeny records.

One benefit of maternal EBVs is that milk production and calving ease are lowly heritable. Therefore, the inclusion of information on relatives greatly enhances the reliability of maternal estimates. A second benefit is that an evaluation of milk production and maternal calving ease is delayed by one generation compared to growth traits. Because maternal EBVs can be calculated before daughters actually get into production, they speed up the evaluation process. Daughter information does, however, greatly enhance the accuracy of a maternal EBV, and even though milk production and maternal calving ease are sex-limited traits, maternal EBVs permit an estimate of a bull's genotype for milk production and maternal calving ease.

Figure 3 contains examples of how EBVs are presented on performance pedigrees from three breed associations.

Figure 3

American Angus Association

ESTIMATED BREEDING VALUES	WEANING		MATERNAL		YEARLING	
	EBV	ACC	EBV	ACC	EBV	ACC
	108	.68	104	.63	114	.78

American Polled Hereford Association

ESTIMATED BREEDING VALUES		ACC.
BIRTH	102	72%
WEANING	105	70%
MATERNAL	106	65%
YEARLING	104	75%

American Simmental Association

ESTIMATED BREEDING VALUES	PERFORMANCE			MATERNAL	
	GROWTH				
	103	103	102	100	104
	BIRTH WEIGHT	CALVING EASE	WEANING	YEARLING	CALVING EASE	WEANING

Note that EBVs on performance pedigrees are expressed as ratios where 100 is average. Also note that birth weight EBVs are usually inverted so that higher EBVs correspond to lighter birth weights. However, some breed associations do not invert the EBVs. Therefore, it is a good idea to ask about whether or not the birth weight EBV is inverted when making selections. Higher calving ease EBVs relate to less calving difficulty and higher weaning and yearling EBVs correspond to more weight. In addition, higher maternal calving ease EBVs equate to easier calving daughters and higher maternal weaning weight EBVs equal greater maternal influence on weaning weight.

Table 2 shows how EBVs could be used to compare the expected differences in performance of progeny from two bulls produced in the same herd.

Note that progeny weight differences represent one-half the differences in EBVs, because the sire supplies only one-half of a progeny's breeding value. The other one-half comes from the dam. Therefore, if each bull were randomly mated to a group of cows, progeny differences would represent just one-half of the differences in the true breeding value of the sires. In the example given, the differences between the two sires in yearling weight EBV is 8 percent. Because one-half (4 percent) of that difference is transmitted to his progeny, the actual difference in yearling weight is 40 lb. rather than 80 lb. Thus, if the progeny of sire A weighed 1,000 lb., the progeny of sire B would be expected to weigh 1,040 lb.

Table 2. Expected differences in progeny performance.

	Birth weight			Yearling weight			Maternal weaning weight	
Bull	Progeny weight	EBV		Progeny weight	EBV		Daughter's progeny weaning weight	EBV
	(lb.)			(lb.)			(lb.)	
A	80	100		1,000	100		500	100
B	84	90		1,040	108		515	106

As shown in table 2, bull B has a maternal EBV of 106. His daughters should wean calves that are 3 percent heavier than their contemporaries due to better maternal ability. This increase in weaning weight is in addition to any improvement that may result from above average direct weaning weight EBVs.

Accuracy
Accuracy (ACC) figures attached to breeding values tell you how closely the "estimated" breeding value predicts the "true" breeding value. An accuracy figure for an EBV is simply the correlation between the estimated and the true breeding value of an animal for a particular trait. Accuracy may range from 0 to 1.00. As ACC approaches 1.00, the EBV becomes a more reliable estimate of true breeding value. Table 3 shows the relationship between level of reliability and ACC.

Table 3. Relationship between reliability and accuracy (ACC).

Reliability level	ACC
Low	0.74 and lower
Medium	0.75 to 0.94
High	0.95 and higher

Accuracy is determined by the amount of information, the source of the information, and the heritability of the trait. Of these factors, the amount of information has the largest influence on ACC. For instance, a young bull may have an ACC for weaning weight EBV of 0.60 until progeny information is available. When his progeny information is added, the bull's ACC for weaning weight EBV will increase. How quickly it increases depends on the amount of progeny data and the heritability of the trait.

Suggestions for using performance pedigree information for female selection, cow culling, and sire selection are discussed in other BIF fact sheets. It is important to note that sire summary data are the most accurate source of information for comparing proven sires. Because of this, EBVs should be used only in the selection of young, unproven, or partially proven bulls that are not listed in sire summaries.

Summary
Breeding value is the portion of an animal's genotype that can be transmitted to his or her offspring. It is the real commodity seed stock breeders sell and commercial producers buy. Recent improvements in computer technology and statistical methodology have led to the development and application of estimated breeding value (EBV). This concept combines individual, ancestral, and progeny information into one concise estimate of true breeding value. EBV coupled with accuracy is the backbone of performance pedigrees. By providing objective, useful information, performance pedigrees give seed stock breeders and commercial producers the opportunity to make sound, accurate selection decisions.