



Expected Progeny Difference (EPD) in Beef Cattle

*Stephen P. Hammack and Joe C. Paschal**

When evaluating prospective breeding animals, it is helpful to have an estimate of their genetic transmitting potential, commonly called breeding value. For most production traits, this is best done by comparing records of performance.

The first performance records of beef cattle were primarily weights or weight gains measured at weaning or yearling ages. Sound comparisons of individuals were often impossible because of sources of variation, such as age, sex, age of dam, and management conditions. Although standard adjustments were developed to account for some of these variations, this was not always possible, especially for differences in management, location, season, and year. Even with appropriate adjustments, it was still necessary to limit comparisons to animals managed alike in a contemporary group. To facilitate comparisons, ratios of performance within a contemporary group were sometimes calculated, but these ratios still contained unaccounted-for differences between groups.

Progress in genetic selection came with the development of Estimated Breeding Value (EBV), which used contemporary-group ratios. EBV improved accuracy by adding to the animal's own records that of relatives and progeny. EBV also incorporated heritability, the average part of the difference in a trait from transmittable genetic content, which is not the same for all traits. However, EBV still consisted mostly of within-group records. Because this was frequently ignored, faulty comparisons were sometimes made of EBVs from different groups or herds.

National Sire Evaluation

A more reliable estimate of breeding value came with the advent of Expected Progeny Difference (EPD). As with EBV, the basis of EPD continued to be within-contemporary-group ratios but with more scope and precision. However, the choice of "Expected" in the term can be misleading as it implies a high degree of certainty, which may or may not be accurate. "Predicted" or "estimated" would have been better terms than "expected."

The first practical implementation of EPD came through National Sire Evaluation (NSE), conducted by some breed registry associations. Widespread use of popular artificial insemination (A.I.) sires, particularly in breeds first available in the United States in the late 1960s, allowed them to serve as so-called Reference Sires, the benchmark in NSE. The first National Sire Summary was published by one of those breeds in 1972, comparing EPDs of 13 sires.

The only sires that could be included in NSE were those with adequate numbers of progeny managed in contemporary groups where at least one Reference Sire was represented. And some often incorrect assumptions reduced the validity of the estimates. One of these assumptions was that sires are not genetically related. Another was that sires are mated to females of equal genetic merit. It was assumed that no progeny are culled before all records are collected. It also assumed that breed averages for traits do not change over time.

National Cattle Evaluation

Refined mathematical techniques and expanded computing capacity have made possible National Cattle Evaluation (NCE), which compares animals in a breed more reliably than with NSE. All major breed associations now have such programs. Using NCE, breed-association EPD programs now include:

- The individual's own record, records of relatives, and progeny
- An adjustment for differences in the genetic merit of mates
- Genetic correlation (calculated genetic relationship between traits) to improve estimates
- An accounting for genetic change over time and genetic relationships among individuals
- More valid estimates in some cases because some associations now require Total Herd Reporting, so records are provided on more individuals
- Adjustments for differences between contemporary groups in environment and management, such as climate and nutrition
- Current EPDs that are directly comparable within a breed for all individuals (males and females) in all locations and management systems across all years

Furthermore, any individual with progeny in more than one contemporary group is, in effect, a reference. There are no more Reference Sires.

EPD Traits

Four traits are reported by all of the breed associations that conduct EPD analyses:

- **Birth Weight**—Weight in pounds at birth, excluding maternal influence. Birth weight is the most important factor in Direct Calving Ease (see below)
- **Weaning Weight**—Weight in pounds at 205 days of age, excluding maternal influence (evaluated as Milk below)

*Professor and Extension Beef Cattle Specialist and Professor and Extension Livestock Specialist, Texas Cooperative Extension, The Texas A&M University System

- **Yearling Weight**—Weight in pounds at 365 days of age, excluding maternal influence
- **Milk**—Expressed as pounds of weaning weight (not pounds of milk) due to maternal influence of an individual's daughters, excluding genetics for growth to weaning (evaluated as Weaning above). The use of "milk" is another inaccuracy, since this is an estimate of all maternal influence on weaning weight, milk production being the major element. Total Maternal EPD also is reported by some breeds, calculated as Milk EPD + $\frac{1}{2}$ Weaning EPD. In most cases, it is advisable to ignore Total Maternal and consider separately the components, Weaning and Milk.

Other traits reported for some breeds are:

- **Direct Calving Ease**—Calculated as percent unassisted births or as a ratio. This is an estimate of a calf's ease of birth, excluding maternal factors (evaluated as Maternal Calving Ease below). Direct Calving Ease depends primarily on the size of the calf. In breeds calculating Direct Calving Ease, it should be emphasized instead of Birth, which only indirectly estimates calving ease.
- **Maternal Calving Ease**—In percent of unassisted births or a ratio. It is the ease of calving of females, excluding factors associated with the calf (evaluated as Direct Calving Ease above). This essentially involves the size, internal structure, uterine environment, etc., of the calving female.
- **Gestation Length**—In days; is related to birth weight, calving ease, and calving interval
- **Yearling Height**—In inches, another estimate of genetic size; a predictor, along with weight traits, of mature body size
- **Scrotal Circumference (SC)**—In centimeters; a predictor of mass of sperm-producing tissue and sperm normality. Also, SC is positively related to younger age at puberty in males and their female relatives.
- **Carcass Weight**—In pounds, another measure of body size
- **Marbling**—In USDA marbling degrees, the primary factor in USDA Quality Grade
- **Ribeye Area**—In square inches between the 12th and 13th rib; a predictor of total amount of muscle. Ribeye area is highly related to carcass weight and other measures of body size.
- **Fat Thickness**—In inches over the ribeye at the 12th/13th rib; a predictor of total carcass fat. Fat is the most important factor in percentage red-meat yield (cutability).
- **Retail Product (RP)**—In percent; a measure of cutability, which is evaluated in the carcass as USDA Yield Grade
- **Grid Merit**—In dollars; total value based on a carcass marketing "grid," which includes varying prices for differences in Quality Grade and Yield Grade
- **Ultrasound measures**—For Ribeye Area, Ribeye Fat Thickness, Rump Fat Thickness, Retail Product, and Ribeye IMF (intramuscular fat, in percent), which is a predictor of marbling
- **Mature Daughter Height and Weight**—In inches and pounds; measure of mature cow size
- **Docility**—In percentage; deviation from the probability of behavior score being either docile or restless, as opposed to being nervous, aggressive, or very aggressive
- **Heifer Pregnancy**—In percentage; pregnancy rate when exposed to calve first at two years of age
- **Stayability**—In percentage deviation from a 50 percent probability of females remaining in the herd to at least six years of age. This involves all factors in culling of females, so is thought to be related to structural soundness, fleshing ability, reproductive efficiency, and general fitness.

Interpreting EPD

EPD values are calculated as average relative deviations, not actual levels, of the unit of measurement of the trait. Assume that one bull has a Birth EPD of +4.2 and another bull of the same breed has -2.0. This means that, if these bulls were used on genetically equal females managed under equal conditions, the first is predicted to sire calves averaging 6.2 pounds heavier at birth than the other bull (the difference between +4.2 and -2.0). As another example, if one bull has a weaning EPD of +32 and another has +17, the predicted average difference between the two bulls is 15 pounds in weight of their calves at weaning.

EPD does not predict absolute performance. If a bull has +4 Birth, this does not predict that he would increase birth weights by 4 pounds, nor would a bull with -1 Birth decrease birth weights by 1 pound. The two bulls are predicted to sire calves averaging 5 pounds difference. The actual average weights, depending on other factors, might be 75 pounds and 70 pounds or 95 pounds and 90 pounds or any other average difference of 5 pounds. EPD predicts comparative differences, not level of performance.

Breed associations calculate their own EPDs that are comparable only within the breed. (Note: EPDs of individuals of the same breed can be legitimately compared even if they are to be mated to another breed, or crossbred, as long as the proposed mates are the same. For example, the EPDs of two Charolais bulls can be compared for use on Brahman-cross females.) There are some adjustment factors for comparing EPDs from different breeds, but these comparisons are less reliable than within-breed EPDs. Also, in most cases, producers should first determine which breeds to include in a genetic program and then decide which individuals to select from within those breeds. To assist in choosing applicable breeds, see the publication in this series L-5206, "Cattle Types and Breeds: Characteristics and Uses."

All breed associations establish a base, when the breed-average value for a trait is zero. The date and method of establishing the base varies for each breed, and selection tends to change genetic level in a breed over time, usually increasing the level. So, the breed-average EPD of recently-born individuals is generally not zero. For example, the most recent average Yearling EPD in one breed is +11 but is +56 in another breed. These breed averages cannot be compared, that is, the values do not mean the second breed averages 45 pounds heavier.

Current breed averages can be used to see where an individual stands within a breed and how a breed has changed over time. Also, maintaining a fixed base provides a benchmark to help determine what level of EPD in a breed might be appropriate for particular production condi-

tions. This benchmark would not be available if the breed average was re-set as zero when EPDs are re-calculated. Associations update and report EPDs and breed averages once or twice a year. The most recent reports should be used, and EPDs from different reports cannot be compared.

Accuracy and Possible Change

Suppose two individuals are reported to have Weaning EPDs of +22 (.62) and +34 (.41). The values in parentheses are for Accuracy, which range between 0 and 1. (In the case of so-called interim EPDs, based only on pedigree data or pedigree plus the individual's record, Accuracy usually is not calculated.) Accuracy is influenced by the number of records, genetic relationship of individuals providing the records, heritability of the trait, and number of contemporary comparison groups.

Accuracy is not related to variation in progeny. Progeny of low Accuracy parents will vary no more, on the average, than progeny of high Accuracy parents. Also, difference in parental EPD is not related to progeny variation. For example, consider a sire and dam both with Yearling EPD of +40 compared to a sire with +60 and a dam with +20. On the average, there is no difference in progeny variation from these two matings, and both sets of progeny are predicted to average +40.

EPDs may change over time as more records (primarily progeny) are accumulated. Breed associations regularly update and report Possible Change Values, measures of the average amount that EPDs (for a particular trait and accuracy) could change. For a given accuracy, the true progeny differences of approximately 2/3 of all animals evaluated are expected to fall within the range of the EPD plus and minus the Possible Change Value. But approximately 1/3 of the animals evaluated may have true values outside that range. Therefore, "Possible Change" is another misleading term because it implies incorrectly that greater change is not possible. However, for any range of Possible Change, the true progeny difference is much more likely to be toward the center of the range than the extremes.

Assume a breed reports Possible Change in Weaning EPD as shown in Table 1.

Table 1. Possible Change Values for Weaning EPD*

Accuracy	.1	.3	.5	.7	.9
Possible Change	16	13	9	6	2

*This is only an example. Possible Change varies for every breed and trait.

From this example table, for EPD of +30 with Accuracy of .3, the Possible Change is ± 13 (EPD of +17 to +43), so about 2/3 of animals with this EPD and Accuracy are expected to have true progeny differences between +17 and +43. With Accuracy of .7 and EPD of +30, the Possible Change is ± 6 (EPD of +24 to +36). Thus, higher Accuracy equals higher predictability. Note in the table that Accuracy of .9 predicts almost no change in EPD, but Accuracy this high is possible only for individuals with hundreds of progeny records.

The anticipated direction of any future change is not related to the magnitude of the current EPD. That is, a numerically high EPD is as likely to change to an even higher value as it is to move downward. A low EPD is also as likely to change to an even lower value as it is to move

upward. These considerations are taken into account in the calculations.

So what is more important—EPD or accuracy? EPD is an estimate of true breeding value in relation to other individuals in a breed. Accuracy is a measure of confidence that the EPD is the true breeding value. If the situation calls for large and rapid change in a trait, then the EPD is more important, even if Accuracy is low. But if predictability is more important, higher Accuracy individuals should be selected. Regardless of Accuracy, EPD is the best estimate available of true breeding value.

Genetic Potential

How much potential is there for genetic change within a breed? Table 2 shows the distribution and range within a breed for Yearling EPD.

Table 2. Percentile breakdown for Yearling EPD*

Percentile	1%	5%	20%	50%	80%
EPD	+ 63	+ 51	+ 37	+ 24	+ 11

*An example only. Current breed average is at the 50th percentile (+24). The entire breed range is from -43 to +95.

This table shows an example of the percentage of a breed with different levels of EPD. Based on the upper end of the range (+95), it would be possible to find a particular sire with an EPD 71-pound (95-24) above breed average. However, only 1 percent of the individuals in the breed have EPDs of +63 or higher. Finding a sire just 27 pounds (51-24) above average requires restricting selection to the top 5 percent of the breed. Broadening to the top 20 percent of sires reduces the difference to just 13 pounds (37-24) above average. So, while there may be a large range of genetic expression in a breed, the majority of EPDs will be near the average.

Making a lot of change quickly in several traits requires use of unusual, outlying sires. For example, a search of one breed with 1,655 active A.I. sires found only three sires in the top 10 percent for low Birth EPD and high Weaning, Yearling, and Milk EPDs. And those three sires might be undesirable in other important traits. Fastest genetic change can be made by using superior sires from a breed noted for high expression of the particular trait. However, other changes might accompany a substitution of breeds. Considering the number of things that should be considered in sire selection, only small change may be feasible in any one trait in a short time.

Does EPD Work?

What evidence is there to confirm the theory of EPD? Georgia researchers compared a control breeding group with a selection group using sires from the top 1 percent in a breed for Yearling EPD. Heifers by these sires were returned to the selection herd in the six years of the study as base cows were phased out. After six years, 70 percent of the females in the select line had been produced in the study, and select-line progeny averaged 95 pounds heavier at yearling than controls. In addition, weaning weight was 68 pounds heavier and yearling hip height was 2.4 inches taller. Unfortunately and as expected, birth weight also was 6.8 pounds heavier.

In a Virginia study, two sire groups were used with average differences in EPD of 2.2 for Birth, 9.9 for Weaning, and 13.9 for Yearling. Their progeny average difference was

4.7 pounds at birth, 16 pounds at weaning, and 26 pounds at yearling. In another Georgia study, two sire groups were selected that differed by an average of 6.3 in Birth EPD; their progeny differed by 8.6 pounds at birth. Arkansas scientists compared parental EPD of two breeds with actual progeny values for growth traits; close relationship was found and, in one breed, progeny response for weaning weight exceeded that predicted from EPD.

Michigan researchers compared sires that were high for Yearling EPD with sires low for Birth EPD and high for Milk EPD. Steer calves by the high-Yearling-EPD sires were significantly heavier at birth (10.1 pounds), heavier at weaning (30 pounds), and taller (0.6 frame score). There was no significant difference in dystocia. Yearling heifers by the high-Yearling-EPD sires were significantly taller (0.3 frame score) and had larger pelvic area (8 sq. cm.), but there was no significant difference in birth weight, weaning weight, yearling weight, yearling condition score, or reproductive tract score.

In other Georgia work, a group of nine large scrotal circumference (SC) sires (average yearling SC of 36 cm) and nine small SC sires (average 28 cm.) was classified into high, average, and low SC EPD groups. The high and low groups averaged in the very top and bottom of their breed for SC EPD, but were similar in Birth, Weaning, and Yearling EPDs. Male progeny of low-SC EPD sires had less testicular mass. A greater percentage of heifers by high-SC EPD sires reached puberty at 11 to 13 months of age, and their average age at puberty was younger. Selection of sires using SC EPD was more effective than actual SC in reducing age at puberty in daughters, confirming that EPD is a better estimator of true breeding value than individual performance alone. In contrast, a similar study in Missouri found no significant difference in age at puberty of heifers by high- and low-SC EPD sires.

Because Milk EPD is measured indirectly as differences in weaning weight, researchers have been particularly interested in whether Milk EPD reliably predicts actual milk production and in the relationship between Milk EPD and growth of suckling calves. A Virginia study reported a significant correlation between actual milk production of daughters and the Milk EPD of their sires. Kansas researchers studied two breeds and found that females produced an average of 56 pounds more total lactation milk and 4.3 pound more weaning weight for every 1 pound of their own Milk EPD. A South Dakota study reported 13 pounds total milk for every 1 pound of daughter's-sire Milk EPD and 1.2 pounds weaning weight for every 1 pound of sire total Maternal EPD (Milk EPD + 1/2 Weaning EPD).

Collaborative work between researchers in Alberta and Colorado and a separate South Carolina study found moderate to high genetic correlations between Milk EPD and both milk production and weaning weight. Later, South Carolina workers reported that two groups of females differing by 20 pounds in Milk EPD produced calves weaning 52 pounds different, even though calves were by the same sires. Recent work conducted in five southeastern states compared daughters of sires that were either high or low for Milk EPD but similar in growth EPDs; high-Milk EPD daughters produced 1.4 pounds more 12-hour milk yield and 30 pound heavier progeny weaning weights.

An Oklahoma study compared high- and low-Milk Angus and Polled Hereford sires. The two Angus sire-groups differed by 33 pounds for Milk EPD, and the two Polled Hereford groups varied by 27 pounds. Females sired by high-milk Angus (compared to low-Milk) produced 400 pounds more total-lactation milk, their calves weighed 1.8

pounds less at birth but 42 pounds more at weaning, mature females weighed 51 pounds less, and their body condition score (BCS) at weaning was 0.4 units lower. While Polled Hereford-sired, high-Milk females produced 206 pounds more milk, their calves weighed 1.1 pounds less at birth and 18 pounds more at weaning, but mature cows differed by only 5 pounds and 0.1 BCS. The authors cautioned that selection for high milk EPD (at least in moderate- to high-milking genetic types) may reduce body condition with possible adverse effects on reproductive efficiency.

Other studies have found a high correlation between interim EPD values of young bulls and their eventual high-Accuracy EPD values. In general, research has confirmed that EPD is a valid and useful estimate of true breeding value. Results of selection using EPD for various measures of carcass merit can be found in another publication in this series, E-165 "Genetic Selection for Beef Carcass Merit."

Using EPD

Suppose four producers are looking for sires of a particular breed.

- **Producer A** has F1 Brahman-cross cows weighing 1200 pounds to 1300 pounds in moderate body condition. Calves are often retained through the feedyard. All replacements are purchased.
- **Producer B** has a group of yearling heifers to breed. All calves will be sold at weaning. No replacement heifers will be saved.
- **Producer C** sells at weaning and wants to increase weaning weights but not cow size. Cows usually stay in good body condition without much supplementation. Replacement heifers are saved to go back into this herd.
- **Producer D** saves heifers to go back into the herd and feeds out some calves. The producer is satisfied with current levels of calving ease, weaning weight, and postweaning performance.

All four producers have used sires of this breed. Potential sires are shown in Table 3. For reference, the current breed-average EPDs are shown. Which of these potential sires should be selected?

Table 3. Selecting a sire using EPD

Sire No.	Birth EPD	Weaning EPD	Yearling EPD	Milk EPD
1	- 2.8	+ 5	+ 19	+ 2
2	+ 5.2	+ 42	+ 61	- 5
3	+ 2.3	+ 24	+ 40	+ 8
4	+ 1.7	+ 16	+ 29	+ 18
Breed average	+ 1.9	+ 18	+ 35	+ 7

- **Producer A** would benefit most from growth potential, so long as carcass weights are not excessive. Milking ability is irrelevant, since replacements are not saved. With large, Brahman-cross cows, calving difficulty (predicted from Birth) is of little concern. Therefore, the best choice is probably Sire 2, which is highest in Weaning and Yearling.
- **Producer B** should give primary consideration to calving ease. Sire 1, with the lowest Birth, is the best choice for that purpose. Although sire 1 is lowest in Weaning and Yearling, in this case growth potential is

secondary to calving ease. And no replacement heifers are saved, so Milk is not a factor.

- **Producer C**, to increase weaning weight but not cow size, appears to need increased milk production in heifers going back in the herd. The body condition of the herd indicates that higher milking ability can probably be supported on existing production conditions. Sire 4, highest in Milk and around breed average in Birth, Weaning, and Yearling, is probably the best choice.
- **Producer D** does not seem to need significant change in any of these traits. Sire 3 is near breed average in Birth and Milk and a little above average in Weaning and Yearling. This is probably the best choice among these four sires for this producer.

So, the best choice depends on the particular set of circumstances and what is needed from a sire. Many other production characteristics are important besides the four discussed above that are common to all breeds reporting EPD. Where EPD is available for other important traits, it should be the primary selection criterion for that trait. For traits without EPD, other valid measures of comparison should be used.

Production conditions and markets dictate appropriate levels of animal performance. As just one example, where forage is sparse or low in quality, mature cow size or milking potential may need to be moderated. Producers with experience using particular breeds in their production conditions have a better idea of appropriate levels of EPD within those breeds.

EPDs can be directly compared for all animals (male and female), from all locations and management conditions, across all years, within an entire breed. For the traits where available, EPDs are the most accurate and most useful of all records to estimate true breeding value.

References

For information on genetic management, consult "Texas Adapted Genetic Strategies for Beef Cattle" (L-5423), "Genetic Strategies for Beef Cow Herds" (L-5341), and the more detailed publications in the Texas Adapted Genetic Strategies series. These publications can be obtained from county Extension offices or accessed on the Extension Web site <http://agpublications.tamu.edu/> and the Texas A&M Extension Animal Science Web site <http://animalscience-extension.tamu.edu/>.

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