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Understanding Expected Progeny Differences (EPDs)

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Expected progeny differences (EPDs) provide estimates of the genetic value of an animal as a parent. Specifically, differences in EPDs between two individuals of the same breed predict differences in performance between their future offspring when each is mated to animals of the same average genetic merit. EPDs are calculated for birth, growth, maternal, and carcass traits and are reported in the same units of measurement as the trait (normally pounds). EPD values may be directly compared only between animals of the same breed. In other words, a birth weight EPD for a Charolais bull may not be directly compared to a birth weight EPD of a Hereford bull (unless an adjustment is made to account for breed differences).

EPDs are reported by most major beef breed associations, and are calculated using complex statistical equations and models. These statistical models use all known information on a particular animal to calculate its EPD. This information includes performance data (i.e., weight records) on the animal itself, information from its ancestors (sire and dam, grandsire, great grandsire, maternal grandsire, etc.), collateral relatives (brothers and sisters), and progeny (including progeny that are parents themselves). In short, virtually all performance data that relate to the animal of interest are used to calculate its EPD. These performance records are adjusted for such factors as age and sex of the animal, and age of the dam prior to inclusion in EPD databases. These adjustment factors allow performance records to be fairly compared in the analysis. Additionally, genetic merit of mates is accounted in evaluating progeny information. Therefore, progeny records are not influenced by superior or inferior mates. The statistical analysis used for EPD calculation also accounts for the effects of environment (nutrition, climate, geographical location, etc.) that exist between herds. These environmental effects can be estimated due to the widespread use of artificial insemination. Through AI, the same bull can be used in several herds across the country. These common sires create genetic links between herds with differing environments and serve as the foundation for evaluation of performance data and EPD calculation across herds. For these reasons, animals with published EPDs within a breed may be directly compared regardless of their age and origin. Finally, the genetic relationships that exist between various traits are also considered in the EPD calculations.

Growth and Maternal EPDs

EPDs are most useful to directly compare individuals for a trait of interest. An example set of growth and maternal EPDs for two hypothetical bulls is shown below. In this example, assume that the two bulls were each mated to the same set of cows.

Birth Weight EPDs:

The difference in the birth weight EPD value between Bull A and Bull B is 4 pounds (5 - 1 = 4). Therefore, Bull A would be expected to sire calves that average 4 pounds heavier at birth than calves sired by Bull B. It is important to recognize that EPDs predict the expected difference in performance, not the actual performance. In other words, the EPDs for Bulls A and B suggest

	Birth Weight EPD	Calving Ease EPD	Weaning Weight EPD	Yearling Weight EPD	Maternal Milk EPD	Maternal WW EPD
Bull A	+5	+0	+20	+40	+15	+25
Bull B	+1	+5	+10	+20	+10	+15

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there will be 4 pounds difference in birth weight in their progeny when we mate them to a comparable set of cows. EPDs do not predict what the actual birth weight of the calves will be.

Research has documented that most calving difficulty is caused by heavy calves at birth. Birth weight EPDs are the most accurate indicators of genetic differences for birth weight. Therefore, considerable emphasis should be placed on birth weight EPDs when selecting bulls for use on heifers.

Calving Ease EPDs:

Some breed associations publish calving ease EPDs (Gelbvieh and Simmental most notably). This EPD predicts the ease with which a bull's calves are born to first-calf heifers. Calving ease EPDs are reported as deviations in percentage of unassisted births. In the above example, if Bulls A and B were mated to the same set of heifers, we would expect the heifers bred to Bull B to have 5% more unassisted births. In other words, we would expect fewer calving problems when Bull B was mated to heifers. Calving ease EPDs consider differences between animals in calf birth weights and actual observed levels of calving difficulty. The calving ease EPD directly predicts calving ease and should be used (when available) as the primary tool for avoiding dystocia problems in the cowherd.

Weaning and Yearling Weight EPDs:

Weaning and yearling weight EPDs are indicators of the genes for growth that will be passed from an animal to its progeny. Weaning weight EPDs predict the average difference in weaning weight of a bull's progeny compared to progeny of another bull. This weaning weight difference is predicted for a standard weaning age of 205 days. In the above example, we would expect calves sired by Bull A to weigh 10 pounds more at weaning than calves sired by Bull B. This difference in weaning weight is attributed solely to differences in genes for growth passed from the bulls to their offspring. The effect of milking ability of the cow is not predicted by this EPD. Rapid early growth is an important selection criteria for cow-calf producers since feeder cattle are sold by the pound.

Yearling weight EPDs predict the average difference in weight of a bull's progeny at a year of age (365 days). Using the EPDs for Bulls A and B above, we would expect calves sired by Bull A to be 20 pounds heavier at a year of age on the average than calves sired by Bull B. Yearling weight EPDs are the most useful indicators of growth rate of slaughter progeny in the feedyard.

Maternal Milk EPDs:

Milk EPDs are expressed slightly differently from birth and growth EPDs. Milk EPDs reflect the milking ability of an animal's daughters. This difference in milking ability is expressed as additional pounds of calf weaned by a bull's daughters. Considering the milk EPDs for Bulls A and B, we would expect daughters of Bull A to wean calves that are 5 pounds heavier at weaning than calves out of daughters of Bull B. This difference is due to the superior milk production of daughters sired by Bull A. Milk EPDs are reflected in weaning weight of a bull's grandprogeny (calves by his daughters).

Milk EPDs are important in bull selection when replacements will be retained in the herd. Optimum milk EPDs need to be determined that match the feed resources and environment of the operation. In other words, more milk is not necessarily better as heavier milking cows may require more nutritional inputs to maintain body condition and reproductive efficiency. Breed needs to be an important consideration when evaluating milk EPDs. Very high milk EPDs for bulls in breeds noted for heavy milking ability may not be advantageous.

Maternal Weaning Weight EPDs:

Maternal weaning weight EPD is sometimes referred to as the total maternal EPD or the combined maternal EPD. The meaning is the same, but different terminology for the same EPD is used by different breeds. Maternal weaning weight EPD predicts the total difference in weight of a bull's daughters' calves at weaning. A portion of this difference in weight comes from the milking ability of the bull's daughters (milk EPD), and a portion comes from the genes for growth passed from the bull to his daughters and then on to their calves. Like milk EPDs, maternal weaning weight EPDs are expressed in the weaning weight of a bull's grandprogeny. By definition, maternal weaning weight is equal to the milk EPD + 1/2 the weaning weight EPD. For Bull A in the above example, maternal weaning weight EPD = 15 + (1/2 x 20) = 25. In this case, we would expect daughters of Bull A to wean calves that are a total of 10 pounds heavier at weaning (25 – 15 = 10) than daughters of Bull B. A portion of this weight advantage is due to the superior milking ability of Bull A's daughters, and a portion is due to superior growth genes for weaning weight passed on by Bull A.

Although maternal weaning weight EPDs can be calculated when milk and weaning weight EPDs are known, most breed associations publish this EPD as well. Like the milk EPDs, maternal weaning weight EPDs are important when daughters will be retained in the herd. This EPD is the best predictor of how daughters of a bull will perform for calf weaning weight.

There are several other traits for which EPDs are available. These EPDs are not available in all breeds:

Scrotal Circumference EPDs: This EPD is expressed in centimeters and predicts difference in scrotal size that will be passed on to progeny. Bulls with larger scrotal circumference EPDs would be expected to sire daughters that reach puberty at an earlier age, and therefore have earlier calving dates. Scrotal circumference is also an indicator of the quantity of semen produced by bulls.

Gestation Length EPDs: This EPD predicts difference in gestation length (in days) for progeny of a bull. Bulls with lower gestation length EPDs are expected to sire calves that are born earlier (on the average). Shorter gestation lengths have been associated with slight decreases in birth weights and an associated improvement in calving ease. Those breeds that report EPDs for both calving ease and gestation length generally include effects of gestation length in calving ease EPD.

Stayability EPDs: This EPD predicts the probability that a bull's daughters will remain in the herd for a set period of time (commonly six years). This EPD is expressed as a percentage. Bulls with higher stayability EPDs will have an increased likelihood of their daughters remaining in the herd. Stayability EPDs are an indicator of the longevity of a bull's daughters.

Mature Daughter Weight EPDs: Expressed in pounds, this EPD predicts the difference in mature weight of a sire's daughters.

Mature Daughter Height EPDs: This EPD is expressed in inches, and predicts the mature frame size of a sire's daughters.

Carcass EPDs

As a result of an increased emphasis on the end product by the beef industry, breed associations have placed considerable emphasis on providing EPDs for carcass traits. These EPDs may be used to make desired directional change in carcass traits. Carcass trait EPDs are expressed at a constant slaughter age endpoint, usually around 480 days of age. Carcass trait EPDs are not available for all breeds, or for all bulls within a breed. As emphasis on carcass traits continues to increase, more data will become available for carcass trait EPD calculations.

Data utilized for the calculation of carcass EPDs are derived from two sources- 1) slaughter steer and heifer progeny, and 2) ultrasound scan data from primarily yearling bull and heifer progeny. Breed associations may publish carcass EPDs utilizing data from one or both of these sources. Research has demonstrated that EPDs generated from slaughter data vs. ultrasound data are very similar. Therefore, EPDs generated from either source can be effectively used for selection. An example comparison of carcass trait EPDs for two bulls is shown below.

Carcass Weight EPDs:

Carcass weight EPDs predict differences in progeny carcass weight (pounds). In the above example, Bull A should produce calves that have carcasses that are 10 pounds heavier than calves sired by Bull B. Carcass weight is an indicator of the total amount of retail product in a carcass, but is a poor indicator of carcass composition (quality and cutability).

Marbling and % Intramuscular Fat EPDs:

Marbling EPDs reflect genetic differences in marbling potential passed from a sire to his offspring. These values are expressed as a numerical marbling score. The following table relates quality grade and numerical marbling score:

	Carcass Weight EPD	Marbling EPD	% Intramuscular Fat EPD	Ribeye Area EPD	Fat Thickness EPD	% Retail Product EPD
Bull A	+20	+.20	+.15	+.50	-.04	+.5
Bull B	+10	+.00	+.00	+.25	+.00	-.3

Quality Grade	Numerical Score	% Intramuscular Fat
Prime+	10.0-10.9	
Prime∞	9.0-9.9	> 12.2%
Prime-	8.0-8.9	9.9-12.1%
Choice+	7.0-7.9	7.7-9.8%
Choice∞	6.0-6.9	5.8-7.6%
Choice-	5.0-5.9	4.0-5.7%
Select	4.0-4.9	2.3-3.9%
Standard	3.0-3.9	< 2.3%

This table indicates that a 1.0 unit change in numerical marbling score is equal to a change of a full quality grade (4.5 = Select vs. 5.5 = Choice-). In the example, Bull A would sire slaughter progeny with superior marbling scores compared to Bull B (marbling EPD +.20 vs. +.00). Higher marbling EPDs increase the likelihood of a bull's progeny attaining higher quality grades.

In a similar fashion, EPDs generated from ultrasound scan data reflect differences in chemical fat content within the ribeye muscle (intramuscular fat). Research has shown a strong relationship between marbling score and % intramuscular fat. Therefore, selection for higher % intramuscular fat EPDs would be expected to increase marbling scores and associated quality grade in slaughter progeny.

Ribeye Area EPDs:

Ribeye area EPD is expressed in square inches. Again using the example, calves sired by Bull A would be expected to have ribeyes that are .25 square inches larger than calves sired by Bull B. Ribeye area is an objective assessment of muscling, and an indicator of total muscle in the carcass or live animal. Ribeye area has been shown to have a positive influence on percentage of carcass retail product. Therefore, bulls with larger ribeye area EPDs will sire calves with more muscle and a higher percentage of carcass retail product.

Fat thickness EPDs:

Fat thickness EPDs are expressed in inches, and predict differences in carcass fat thickness between the 12th and 13th rib. For the two bulls in the example, Bull A should sire calves that have .04 inches less carcass fat cover (at a constant slaughter age) compared to calves sired by Bull B. Fat thickness is the primary indicator of saleable product in the carcass, and is also the primary factor affecting USDA beef carcass yield grades (increased fat thickness is associated with less desirable yield grades). As fat thickness increases, the percentage of carcass retail product declines.

Percent Retail Product EPDs:

Percent retail product EPDs predict differences in the yield of closely trimmed retail cuts from the carcass and are expressed on a percentage basis. Percent retail cuts is calculated from the same traits used in the USDA yield grade equation (carcass weight, ribeye area, fat thickness, and % kidney, pelvic, and heart fat). Sires with higher % retail product EPDs are expected to produce progeny with higher cutability and more desirable yield grades. In the above example, Bull A should sire slaughter progeny whose carcasses will have .8% more retail product than progeny of Bull B (+.5 vs. -.3 % retail product EPD).

Interpreting and Using EPDs

Breed Averages:

In addition to directly comparing the EPDs of bulls, it is useful to understand where a particular bull ranks within a breed for traits of interest. This ranking will give a general idea as to the genetic merit of the bull compared to others within the breed. It is important to understand that the average EPD for any trait within a breed is not 0. One reason for this is genetic trend. Genetic trend refers to the improvement in genetics that has taken place over time within a breed due to selection. Over the years, breeders have selected for increased growth, milk production, etc. As this selection has occurred, the average EPDs for bulls within a breed for these traits has also increased and the average EPD for bulls of the most recent calf crop may be considerably larger than 0. The following table depicts average EPD values for bulls from the 2002 calf crop for several breeds:

EPD Averages for Non-Parent Bulls- Spring 2002

	CE	BW	WW	Milk	YW
Angus		+2.6	+33	+17	+62
Charolais		+1.7	+14.2	+8.8	+24.3
Gelbvieh	104	+1.3	+34	+17	+61
Hereford		+3.9	+34	+12	+57
Limousin		+1.4	+12.3	+4.5	+23.1
Red Angus		+0.4	+28	+14	+49
Simmental	+2.3	+3.3	+36.0	+8.1	+59.1

Consider a bull that has a yearling weight EPD of +25. If this bull is a Charolais, he is around breed average in genetic potential for yearling weight (Charolais breed average yearling weight EPD = +24.3). However, if this bull is an Angus, his yearling weight EPD would be 37 pounds below the current breed average (Angus breed average yearling weight EPD = +62).

In this case, a yearling weight EPD of +25 would be interpreted quite differently for a Charolais bull vs. an Angus bull. This demonstrates one reason why EPDs cannot be directly compared between bulls of different breeds. Also, it important to note that the EPDs in the above table do not reflect genetic differences for the traits between breeds, as the EPDs cannot be directly compared across breeds. These average breed values are not directly comparable due to the fact that each breed calculates its EPDs from its own data set. Since the data sets (performance records, pedigrees, etc.) are independent, there are few animals that would be found in more than one breed's records used to calculate EPDs. Without these ties, and without merging data from the different breeds into one data set, the calculated EPDs are not comparable across breeds.

The previous table is valid for non-parent bulls in the Spring of 2002. Due to genetic trend, the average EPD in each breed changes on a frequent basis. Therefore, it is important to utilize the most current breed averages as a basis of comparison. Current breed averages may be found in the sire summaries available from breed associations. See the list at the end of this publication for breed association contact information.

Breed Percentile Rankings:

An understanding of where an animal ranks within its breed for a particular trait EPD is extremely valuable as a selection tool. Breed associations also publish percentile ranking tables in their sire summaries so that bulls can be specifically evaluated as to where their EPDs rank in the breed (top 10% vs. bottom 20%, etc.). Percentile rankings can be misleading if not used in the proper context. For example, a Simmental or Gelbvieh bull that ranks very high in the breed for milk EPD (top 10% for example) may not necessarily be ideal in a commercial crossbreeding program. A bull with breed average (or below breed average) genetic merit for milk may produce daughters that are more optimum in their milk production, resulting in females that are potentially a more efficient match for feed resources and may maintain more optimum reproductive potential. Similar examples could be given for other traits. Perhaps most importantly, the general merit of the breed for each trait needs to be considered along with the rank of an individual bull within that breed.

Accuracy:

Accuracy values are published for EPD values reported for an animal. Accuracy can be defined as the relationship between the estimated EPD of the animal and the "true" EPD of the animal. This relationship is expressed as a number between zero and one. As the accuracy value approaches 1.0, the reported EPD is more likely to represent the true genetic merit of the animal and is less likely to change as more progeny records accumulate. Conversely, low accuracy values (closer to zero) indicate that the reported EPD is less reliable. Accuracy is primarily a function of the amount of information available to calculate an EPD for any given trait. Information, primarily in the form of performance records, is derived from several sources to estimate EPDs on a given animal. These sources include records on the animal itself, its sire and dam, collateral relatives, and progeny records. As the volume and quality of records used in the estimation of an EPD increase, so does the confidence we have that the EPD has been estimated correctly (accuracy).

	Birth Weight EPD	Accuracy	Possible Change	"true" EPD Range
Bull A	+2.0	.25	±2.4	-0.4 to +4.4
Bull B	+2.0	.90	±1.2	+0.8 to +3.2

In the table above, Bull A and B have identical Birth Weight EPDs, but differ considerably in their accuracy values. Bull A would be typical of a yearling bull, with his EPD derived from pedigree information and his own individual performance. Most yearling bulls will have accuracy values ranging from .10 to .35 for growth traits. Bull B would be typical of a sire with a large number of progeny who has probably been used by AI in several herds. A practical way to evaluate accuracy is to put it in the context of associated possible change. Possible change defines how much we might expect the current EPD to change (plus or minus) as more information is collected and used in the estimation of the EPD. For Bull A, an accuracy value of .25 for BW EPD is associated with a possible change of ±2.4 pounds. From the definition of the possible change value, we expect there to be only one chance in three that the "true" BW EPD is less than –0.4 pounds (the EPD minus the possible change) or greater than +4.4 pounds (the EPD plus the possible change). Bull B, with a higher accuracy value, has a much lower possible change (±1.2) and therefore smaller range. We expect his true EPD to be between +0.8 and +3.2 pounds. It is important to recognize that EPDs are our best estimates of an animal's genetic worth. We never know the "true" EPD for any trait on any animal, although EPDs for bulls with high accuracies are expected to closely approach the

"true" value. Accuracy values, therefore, indicate how much we know about the animal's true genetic worth and how confident we can be in the estimated EPD.

Accuracy values can be used to manage risk in a breeding program. If the two bulls previously discussed were being considered for use on heifers, there would be much lower risk associated with the use of Bull B. Due to his higher accuracy value, it is less likely Bull B's "true" EPD will turn out to be substantially higher than the reported value. Comparatively, Bull A has a larger possible change and there is more risk that his "true" EPD could be higher than the reported value. This example illustrates a primary advantage of using high accuracy, low BW EPD sires through AI on heifers. Similar examples can be given for all EPD traits, and possible change values can be found in sire summaries of all breeds.

An important concept to understand is that EPDs, regardless of accuracy, are our most powerful tool to make genetic change in beef cattle. EPDs have been estimated to be several times more reliable than adjusted weight records, ratios, and visual appraisal. Even on young bulls with relatively low accuracy values, EPDs are our most objective indicator of the animal's genetic merit. For all practical purposes, high accuracy sires are available only through AI. Therefore, most natural service bull-buying decisions will be made using relatively low to moderate accuracy EPDs. Keep in mind when evaluating possible change that there is an equal chance that an EPD will go higher as opposed to go lower (or get "better" vs. "worse"). When evaluating young bulls, small differences in WW and YW EPD become less significant due to lower accuracy and higher possible change, permitting more overlap in the range of their "true" EPDs.

A common misconception is that accuracy is an indicator of expected variation in a resulting calf crop. Accuracy and possible change are not related in any way to progeny variation. High accuracy EPD animals would not be expected to have any more or any less variation in their calf crop compared to low accuracy EPD animals.

Summary

EPDs offer beef producers a tremendous opportunity to improve genetics within their herds. Since the majority of the genetic progress within a herd is a direct result of sire selection, EPDs should be given careful attention when choosing bulls. With the vast number of EPDs that are available for use, selection goals must be carefully established to determine which EPDs are of primary importance. Additionally, EPDs should be combined with other selection criteria, including structural and reproductive soundness, to determine which sires are most suitable for the operation.

Breed Association Contact Information:

- **American Angus Association**
  3201 Frederick Avenue
  St. Joseph, MO 64506
  phone: 816-383-5100
  www.angus.org
- **American-International Charolais Association**
  11700 NW Plaza Circle (PO Box 20247)
  Kansas City, MO 64153
  phone: (816) 464-5977
  www.charolaisusa.com
- **American Gelbvieh Association**
  10900 Dover Street
  Westminster, CO 80021
  phone: 303-465-2333
  www.gelbvieh.org
- **American Hereford Association**
  P.O. Box 014059
  Kansas City, MO 64101
  phone: 816-842-3757
  www.hereford.org
- **North American Limousin Foundation**
  7383 S. Alton Way
  Suite 100
  Englewood, CO 80155
  phone: 303-220-1693
  www.nalf.org
- **Red Angus Association of America**
  4201 N. Interstate 35
  Denton, TX 76207
  phone: 940-387-3502
  www.redangus.org
- **American Salers Assocation**
  7383 South Alton Way, Suite 103
  Englewood, Colorado 80112
  phone: 303-770-9292
  www.salersusa.org
- **Amercian Shorthorn Association**
  8288 Hascall Street
  Omaha, Nebraska 68124
  phone: 402-393-7200
  www.beefshorthornusa.com
- **American Simmental Association**
  1 Simmental Way
  Bozeman, MT 59718
  phone: 406-587-4531
  www.simmgene.com