Use of Expected Progeny Differences (EPDs) in Beef Cattle Selection

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INTRODUCTION

Selecting the right animals for breeding is one of the most impactful decisions a cow-calf producer can make to improve herd productivity, profitability, and long-term sustainability. Visually evaluating cattle for structural soundness, rib shape and capacity, and muscle expression are important in identifying breeding stock that will remain productive and pass on desirable traits to future generations. Expected Progeny Differences (EPDs) provide additional measures of appraisal to accurately and reliably predict the performance of an animal's offspring. This bulletin explains EPDs, how they may be used, and how beef producers can incorporate them into practical selection decisions to meet their herd goals.

WHAT ARE EPDs AND HOW ARE THEY USED IN SELECTION?

Expected Progeny Differences predict the average future performance of an animal's progeny when compared with the average future progeny of another animal within the same breed. In other words, they are the best estimate of the genetic merit of an animal for a particular trait. As such, EPD use allows producers to compare the genetic potential of breeding animals. Many EPDs are calculated by each breed association for individual animals and most associations provide online access and search capability of their EPD database.

Breeding objectives vary among herds, but one constant goal when selecting animals is to improve profitability by enhancing traits of future calf crops. Using EPDs to aid in the decision-making process is a proven way to select for improvement in traits measured, and not solely rely on an animal's phenotype or physical appearance. Two animals that are genetically similar may perform differently if their environments differ. For example, it would be difficult to predict whether a bull observed to grow to a heavier weaning weight will also sire calves with higher weaning weights or if the difference was due primarily to the environment.

Expected Progeny Differences also quantify the genetic potential of animals that would otherwise be impossible to determine visually. For example, traits like fertility, marbling, and feed efficiency cannot be observed by simply looking at the animal. Because EPD calculations include individual performance, related animal performance (pedigree), progeny performance (when available), and genomic measures, they are the single most reliable tool for producers looking to generate change from selection[1].

To ease selection choices using EPDs, beef cow-calf producers need to answer these questions:

- What are my breeding and marketing goals?
- What traits directly impact my enterprise profitability?
- What are the environment and resource constraints that dictate minimum, maximum, and optimum trait performance levels within my enterprise?

Answers to these questions simplify animal selection and will lead to identification of the traits that are economically relevant to their operation.[1] We call these an economically relevant trait (ERT) when the trait is tied directly to revenue (e.g., sale value, grid premium) or cost (e.g., calf mortality, cow feed requirement)[2].

Note that indicator traits are not ERT, but aid in the prediction of an ERT. For example, birth weight (BW) is an indicator trait for calving ease (CE) which is an ERT. Although poor CE may have a direct effect on calf mortality and therefore profitability, there is no direct economic cost associated with BW. This means selection is more effective at improving profitability if selection pressure is focused on ERT. Table 1 lists EPD traits offered by selected breed associations, whether they are considered ERT, and hypothetical EPDs of bulls A and B used later in this document to illustrate EPD use.

Table 1. Expected Progeny Difference (EPD) traits by selected beef breeds, Economically Relevant Trait (ERT) designation, and example EPDs

	Breed[a]						EPD example	
EPD trait	Angus	Hereford	Red Angus	Simmental	Charolais	ERT[b]	Bull A	Bull B
Calving ease direct (CED, CE)	●	●	●	●	●	✓	12	8
Birth wt. (BW)	●	●	●	●	●	×	1	-1.2
Weaning wt. (WW)	●	●	●	●	●	✓[c]	60	72
Yearling wt. (YW)	●	●	●	●	●	✓[d]	100	120
Yearling height (YH)	●	●				×	0	0.5
Scrotal circumference (SC)	●	●			●	×	0.5	1.15
Dry matter intake (DMI)	●	●	●			✓[e]	-0.1	0.4
Average daily gain (ADG)			●	●		×	0.20	0.40
Residual average daily gain (RADG)	●					×	0.30	0.25
Mature height (MH)	●					×	1	0.5
Mature wt. (MW, MCW)	●	●				✓	75	100
Maternal milk (MM, MILK)	●	●	●	●	●	✓[c]	20	15
Total maternal (MTL, M&G)		●			●	✓[c]	55	70
Heifer pregnancy (HPG, HP)	●		●			✓	10	13
Udder suspension (UDDR)	●	●			●	×	1.34	1.16
Teat size (TEAT)	●	●			●	×	1.25	1.00
Calving ease maternal (CEM)	●	●	●	●	●	✓	12	8
Stayability (STAY, SCF, FL)	●	●	●	●		✓	16	20
Yield grade (YG)			●	●		✓	-0.44	-0.34
Marbling (Marb)	●	●	●	●	●	✓[f]	1.00	0.50
Ribeye area (REA, RE)	●	●	●	●	●	×	0.60	1.2
Fat thickness (FAT, BF)	●	●	●	●	●	×	0	0.03
Carcass wt. (CW)	●	●	●	●	●	✓	60	50
Warner-Bratzler Shear Force (SF)				●		×[g]	-0.48	-0.17
Maintenance energy (ME)			●			✓	2	4
Docility (DOC)	●			●		✓	15	12
Hair shed (HS)	●					×	0.70	0.24
Pulmonary arterial pressure (PAP)	●					×	0.61	-1.72
Claw set (CLAW)	●					×	0.40	0.36
Foot angle (ANGLE)	●					×	0.45	0.35

[a]EPD are available for most breeds, but only example breeds are listed.
[b]Economically Relevant Traits (ERT) are directly associated with revenue or cost and are indicated by ✓. The ERT designation here is generalized. Whether or not a trait is an ERT is dependent on the specific production system.
[c]For production systems marketing calves at weaning.
[d]For production systems marketing yearling cattle (such as after backgrounding).
[e]For production systems that retain ownership of calves post-weaning.
[f]Marbling is considered an ERT because of its strong relationship with Quality Grade (an ERT).
[g]Shear force is not an ERT unless the production system is paid a premium or discount based on tenderness level.

EPD PRACTICE – COMPARING BULL A TO BULL B[3]

Expected Progeny Differences are not a direct measure of an animal's own performance, but rather a predictor of the average future performance of an animal's progeny when compared with the average future progeny of another animal within the same breed. To illustrate this point, refer to the Bull A and Bull B columns of Table 1 while reading the following EPD definitions.

Calving ease direct: This EPD measures the difference in the percentage of unassisted births. It predicts how easily a sire's progeny will be born when bred to heifers. A higher value indicates easier calving. Heifers bred to Bull A are expected to experience 4% more unassisted births than those bred to Bull B.

Birth weight: Bull A's progeny are expected to weigh 2.2 lb more at birth than Bull B's progeny.

Weaning weight: Bull A's progeny are expected to weigh 12 lb less at weaning than Bull B's progeny.

Yearling weight: Bull A's progeny are expected to weigh 20 lb less as yearlings than Bull B's progeny.

Yearling height: Yearling height is obtained by measuring hip height. Hip height at a known age is sometimes converted to a frame score (1-10 scale). Taller cattle may also be heavier, requiring more feed, and may not be suitable for backgrounding systems. Bull A's progeny are expected to stand 0.5 inches shorter than Bull B's progeny at a year of age. This would equate to approximately 0.25 less frame score.

Scrotal circumference: This trait correlates positively with sperm production and negatively with age at puberty in daughters. Bulls with larger scrotal circumferences (up to a point) tend to be more fertile and sire earlier-maturing daughters. Bull A's sons are expected to have 0.65 cm smaller scrotal circumference than Bull B's sons.

Dry matter intake: Bull A's progeny are expected to consume 0.5 lb less feed dry matter daily than Bull B's progeny.

Average daily gain: This EPD predicts postweaning weight gain between 205-day adjusted weaning and yearling weight. Bull A's progeny are expected to gain 0.2 lb less daily than Bull B's progeny. Over a period of 160 days (to a year of age), this would amount to 32 lb difference in weight.

Residual average daily gain: RADG measures gain efficiency when animals consume the same amount of feed. Bull A's progeny are expected to gain 0.05 lb more daily than Bull B's progeny. Refer to MSU Extension materials on feed efficiency for more detail.[4]

Mature height: Bull A's progeny are expected to mature 0.5 inches taller in hip height than Bull B's progeny.

Mature weight: Bull A's progeny are expected to weigh 25 lb less at maturity than Bull B's progeny.

Maternal milk: This EPD predicts the dam's milk production influence on weaning weight. Bull A's daughters are expected to raise calves that wean 5 lb heavier than those sired by Bull B. Selecting for high milk production may increase weaning weight, but may reduce fertility under limited feed resources.

Total maternal or Maternal milk & growth: This trait predicts the combined genetic contribution of maternal milk and calf growth. It is calculated as Milk EPD + (0.5 × WW EPD). Bull A's daughters are expected to raise calves that wean 15 lb lighter than Bull B's daughters.

Heifer pregnancy: Bull A's daughters are expected to be 3% less likely to become pregnant as heifers than Bull B's daughters.

Udder suspension: Udder scores range from 1 (pendulous, less desirable) to 9 (tight, more desirable), indicating the amount of udder support. Bull A's daughters are expected to score 0.18 points higher, indicating better udder suspension than Bull B's daughters.

Teat size: Teat scores range from 1 (large, balloon-shaped) to 9 (very small). Bull A's daughters are expected to average 0.25 points higher on the scoring scale—more desirable—than Bull B's daughters.

Calving ease maternal: As first-calf heifers, Bull A's daughters are expected to deliver calves with 4% more unassisted births than Bull B's daughters.

Stayability (STAY), Sustained cow fertility (SCF), and Functional longevity (FL): These traits predict the productive lifespan of daughters. Red Angus and Simmental breeds use STAY (productive through age 6), Herefords use SCF (productive through age 12), and Angus uses FL (number of calves by age 6). Bull A's daughters are expected to remain productive through the relevant age benchmarks 4% less often than Bull B's daughters.

Yield grade: Lower USDA Yield Grade values reflect more lean meat yield. Bull A's progeny are expected to have yield grades 0.10 units lower—more desirable—than Bull B's progeny.

Marbling: Higher marbling scores indicate greater potential for USDA Quality Grade premiums. Bull A's progeny are expected to score 0.50 units of a quality grade higher than Bull B's progeny.

Ribeye area: At harvest, Bull A's progeny are expected to have ribeye areas 0.60 square inches smaller than Bull B's progeny. Greater ribeye areas reflect greater size or greater lean meat yield.

Fat thickness (FAT, BF): At harvest, Bull A's progeny are expected to have 0.03 inches less subcutaneous fat thickness between the 12^{th} and 13^{th} ribs than Bull B's progeny. Excess fat thickness is not desirable for carcass cutability, but sufficient fat is required for optimal reproduction in females.

Carcass weight: Bull A's progeny are expected to produce carcasses that are 10 lb heavier than Bull B's progeny.

Tenderness: Reported in pounds of Warner-Bratzler Shear Force, lower values indicate more tender beef. Bull A's progeny are expected to have shear force values 0.31 lb lower (more tender) than Bull B's progeny.

Maintenance energy: Expressed in Mcal/month with lower values being more desirable. Bull A's progeny are expected to require 2 fewer Mcal/month than Bull B's progeny.

Docility: This trait reflects yearling temperament, where scores range from 1 (docile) to 6 (aggressive). Bull A's progeny are expected to score a 1 (docile) 3% more often than Bull B's progeny. However, because docility is a threshold trait, this difference may be negligible in herds lacking poor temperament issues.[5]

Hair shed: Lower scores reflect earlier shedding of winter hair, aiding in heat tolerance and adaptability to grazing endophyte-infected fescue. Bull A's progeny are expected to shed later, with scores 0.46 points higher than Bull B's progeny.

Pulmonary arterial pressure: High PAP indicates greater susceptibility to brisket (high-mountain or high-altitude) disease. Bull A's progeny are expected to have PAP values 1.11 mm Hg higher than Bull B's progeny, suggesting poorer high-altitude adaptability.

Claw set: A lower EPD reflects more ideal claw symmetry with evenly spaced toes. Bull A's progeny are expected to score 0.04 points poorer than Bull B's progeny.

Foot angle: A lower EPD reflects a more ideal foot angle, roughly 45 degrees between the pastern and the ground. Bull A's progeny are expected to score 0.1 points higher—less desirable—than Bull B's progeny.

Bioeconomic selection indexes

Beef cattle bioeconomic selection indexes combine multiple ERT (and occasionally indicator traits) into a single economic value. An example set of bioeconomic selection indices and their component traits are shown in Table 2. Choosing the right index depends on the producers' goals. For example, if replacement heifers are retained, maternal traits like calving ease, fertility, and cow maintenance should be used, or if heifers are not retained, a terminal index focused on growth and carcass traits is more appropriate. Sale endpoint also matters—whether at weaning or after finishing—since it influences which traits are most economically important. Though indexes are powerful yet simple tools, they may not include all ERT for a given production scenario, so producers may choose to apply additional selection pressure using individual EPDs.

Table 2. Bioeconomic selection indexes and their component traits in selected beef breeds

Bioeconomic selection index	Traits included in the index
Angus	
Cow Energy ($EN)	MILK, MW
Maternal Weaned Calf Value ($M)	CED, CEM, WW, MILK, HP, DOC, MW, CLAW, ANGLE
Weaned Calf Value ($W)	BW, WW, MILK, MW
Feedlot Value ($F)	WW, YW, CW, DMI
Grid Value ($G)	CW, MARB, REA, FAT
Beef Value ($B)	YW, DMI, CW, MARB, REA, FAT
Combined Index ($C)	CED, YW, CEM, MILK, MW, DOC, HP, CLAW, ANGLE, DMI, CW, REA, MARB, FAT
Angus-On-Holstein ($AxH)	CED, YW, YH, DMI, CW, REA, FAT, MARB
Angus-On-Jersey ($AxJ)	CED, YW, DMI, CW, REA, FAT, MARB
Hereford	
Baldy Maternal Index (BMI$)	SCF, WW, MCW, MILK, DMI, CW, MARB, REA
Brahman Influenced Index (BII$)	SCF, WW, MCW, MILK, DMI, CW, MARB, REA
Certified Hereford Beef (CHB$)	ADG, DMI, CW, MARB, REA, FAT
Red Angus	
Profitability and Sustainability (ProS)	CED, CEM, WW, YW, MILK, MW, HPG, STAY, ADG, DMI, CW, MARB, REA, FAT
HerdBuilder (HB)	CED, CEM, WW, MILK, MCW, HP, STAY
GridMaster (GM)	ADG, CW, DMI, MARB, FAT, REA
Simmental	
Dollar Gain ($GN)	DMI, ADG
All-Purpose Index ($API)	CE, MCE, BW, WW, YW, MILK, MWW, STAY, ADG, CW, MARB, YG, REA, BF
Terminal Index ($TI)	CE, BW, WW, YW, CW, MARB, YG, REA, BF
Charolais	
Terminal Sire Index (TSI)	BW, WW, YW, REA, CW, MARB, FAT

USE OF EPD PERCENTILE RANKS

Using the EPD percentile rank one may gauge where that animal's trait falls within the breed's population. Lower percentiles indicate the more desirable direction for most traits (e.g., lower birth weight, higher weaning weight).[6] For example, if a bull ranks in the top 30^{th} percentile for weaning weight, which means he has a greater weaning weight EPD than 70% of bulls in the breed. Recognize that top percentiles can be misleading if applied in improper contexts. Maximizing traits by selecting animals with the lowest percentiles may not select animals that optimally match environmental resources. For example, a bull with a milk EPD percentile of 50% may produce daughters whose milk production is better suited to match limited feed resources and maintain their reproductive potential than those sired by a bull with a top 10 percentile ranking.[7]

IMPORTANCE OF EPD ACCURACY

Accuracy is the degree of confidence associated with an individual animal's EPD, and it serves to represent the amount of information available to compute an EPD.[8] The accuracy reported for an EPD ranges from 0 to 1, where a low accuracy (less confidence) is near 0, and a high accuracy (high confidence) is near 1.

Although EPDs are a useful method for selecting animals based on their value as parents, they are predictions, meaning the true genetic merit of the animal is not known with complete certainty.[1] So, understanding accuracies is essential to understanding how to use EPDs to improve herd genetics.

EPD accuracies are updated whenever new data are added to the evaluation. Performance records from the animal itself, its sire and dam, relatives, and progeny, as well as genomics, all may inform the animal's EPD and increase its accuracy.[1]7 Breeders that regularly collect phenotype data (e.g., weights, heights, carcass ultrasound) increase EPD accuracy by increasing the data that enters the EPD calculation.

One challenge for producers purchasing yearling bulls is the lack of progeny records, resulting in relatively low accuracy values. In this case, genomic testing may be used to enhance accuracy by determining what alleles the animal inherited from its parents.[3]8 Genomic information—DNA-based data collected from a tissue, hair, or blood sample—can greatly improve the accuracy of EPDs, especially in young animals that lack progeny data. When included in national cattle evaluations, these data generate genomic-enhanced EPDs (GE-EPDs), which provide accuracy levels comparable to having performance records from 8 to 35 offspring, depending on the trait (Table 3). This added precision enables producers to make earlier, more confident decisions when selecting or culling breeding stock. Genomics are especially valuable for traits that are difficult or costly to measure—such as fertility, feed intake, or mature weight—and for accelerating herd improvement. While not a replacement for phenotypic data, genomics are a powerful complement that enhances traditional selection tools.

Table 3. Progeny equivalents (PE) with genomically enhanced EPDs for Angus cattle[9]

Trait	PE	Trait	PE	Trait	PE
Maternal milk	38	Heifer pregnancy	16	Scrotal circumference	11
Weaning weight	25	Dry matter intake	15	Docility	10
Calving ease direct	24	Yearling height	14	Marbling score[a]	10
Birth weight	22	Mature weight	14	Ribeye area[a]	10
Yearling weight	20	Carcass weight[a]	13	Hair shed score	9
Backfat thickness[a]	20	Foot claw set	12	Mature height	9
Calving ease maternal	18	Foot angle	12	Pulmonary arterial pressure	7

[a]Carcass trait PE equate to actual carcass harvest data, not ultrasound scan equivalents.

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