Ultrasound Guidelines Council
Field Technician Study Guide
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Chapter IV - Ultrasound and Genetics

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Introduction

Expected Progeny Differences (EPD) allow for the comparison of animals within a breed for their genetic potential as parents for a given trait. EPD have existed in the beef industry for decades and their use has produced intended genetic change in many traits. However, some producers are still reluctant to rely on EPD when making selection decisions presumably because of a general lack of understanding of how EPD are derived and their interpretation.

Basics of an EPD

Many traits (weaning weight, yearling weight, ultrasound measurements, etc.) must be recorded within certain age windows (ranges when it is acceptable to measure animals). Animals measured outside of defined age windows will not have their own record incorporated into an EPD calculation. This allows for a fair comparison of animals. For ultrasound, age windows are determined by each breed association. Current age windows for UGC-member breed associations are summarized in chapter VIII.

Too often seedstock producers and bull buyers get caught up in the actual weights, ultrasound data, etc. when selecting sires. EPD provide a measure by which animals within a breed can be compared to one another for their genetic potential as parents for specific traits. EPD incorporate multiple sources of information, including: full pedigree, an animal's own record, and progeny information. As additional sources of information become available the accuracy of the EPD value increases. The frequency of National Cattle Evaluation (NCE, i.e., the computation of the data resulting in EPD) varies by breed association. When new information is received by a breed association, sometimes animals are given interim EPD prior to the NCE. During a genetic evaluation, all pedigree information would be included, for example:

Pedigree estimate:

Sire EPD = 0.20 → Dam EPD = 0.10 ←

Progeny EPD = (0.20+0.10)/2 = 0.15

Pedigree estimate + animal record:

$EPD_I = (0.5*EPD_S) + (0.5*EPD_D) + (0.5 *\text{Mendelian Sampling Effect})$

Where EPD_I is the EPD for some individual I, EPD_S is the EPD for the sire of animal I, EPD_D is the EPD for the dam of animal I. The phenomena of Mendelian sampling arises due to the fact that each parent passes a sample half of its alleles to its offspring and every allele has an equal likelihood of being passed on. This effect can be quantified using contemporary group deviations and is a measure of how much better or worse an animal is compared to the average of his parents. One could envision a scenario where an animal could receive only the most desirable alleles from both parents resulting in a favorably large Mendelian sampling effect or the exact opposite which could result in an unfavorably large sampling effect. Perhaps the best example is a set of flush mates from embryo transfer. Although all of them have the same pedigree estimate, they differ considerably in terms of performance. Consequently, once they have a record their EPD differ due to Mendelian sampling. Current methodology behind the estimation of Mendelian sampling effects can be found in the Beef Improvement Federation Guidelines at: http://www.beefimprovement.org/library.html.

Every animal is passed a random sample of alleles from each parent, half coming from the dam and half from the sire. We have an estimate of the average effect of what was passed from parent(s) to offspring in the form of pedigree estimates, but the certainty with which we know this estimate is correct (i.e., the accuracy) is low. As more information is collected, such as an individual's own record and data from progeny, accuracy increases. For lowly heritable traits like measures of reproduction, it can take a considerable number of offspring to reach high BIF accuracy levels, given that the BIF scale is more conservative than true accuracy (r) as illustrated in Table 1. To calculate r in the context of progeny test sires the following equation can be used where *n* is the number of progeny:

$$r = \sqrt{\frac{nh^2}{1 + (n-1)h^2}}$$

To convert BIF accuracy to true accuracy (r) the following equation can be used:

$$r = \sqrt{1 - (1 - BIF)^2}$$

Table 1. Approximate number of progeny needed to reach accuracy levels (true (r) and the BIF standard) for three heritabilities (h^2).

Accuracy		Heritability Levels		
r	BIF	h^2 (0.1)	h^2 (0.3)	h^2 (0.5)
0.1	0.01	1	1	1
0.2	0.02	2	1	1
0.3	0.05	4	2	1
0.4	0.08	8	3	2
0.5	0.13	13	5	3
0.6	0.2	22	7	4
0.7	0.29	38	12	7
0.8	0.4	70	22	13
0.9	0.56	167	53	30
0.999	0.99	3800	1225	700

EPD Definitions

	BULL A	BULL B
Carcass weight	+2.0	+20
Percent retail cuts	0	+.2
Marbling	0	-.3
Rib-eye area	+.06	+1.60
Fat thickness	-.01	-.09

Carcass weight **–** Bull B should produce calves that have 18 pounds more adjusted carcass weight.

Percent retail product **–** The calves from Bull B should yield 0.2 percent more closely trimmed, boneless retail cuts from the round, loin, rib and chuck. Some breeds may report a Yield Grade (YG) EPD. The same factors (back fat, ribeye area, and carcass weight) would be included but a lower YG is more desirable as opposed to percent retail product where a higher value is more desirable. In either percent retail product or YG fat thickness contributes the most to these two calculations. Consequently selecting for decreased YG or increased percent retail product will lead to leaner animals so caution should be used to avoid extremely lean replacement females.

Marbling – Calves from Bull A should have a .3 higher marbling score. Marbling scores range from 1.0 which is devoid of marbling and a utility quality grade to 10.9 which is abundant marbling and a prime + quality grade. For example, if calves sired by Bull B had a marbling score of 5.0 then we would expect calves sired by Bull A to have a marbling score of 5.3. Ultrasound EPD were calculated for a number of breeds for traits of ribeye area, fat, and intramuscular fat (IMF), which is correlated to marbling, but now the majority of breeds use these ultrasound measurements in the calculation of carcass EPD. So, instead of seeing both an IMF EPD and a marbling EPD you just see the marbling EPD but it has ultrasound measurements included in the calculation.

Rib-eye area – At a given end point, calves from Bull B should have rib eye areas that are 1.54 square inches larger than Bull A's calves.

Fat Thickness – At a given end point, calves from Bull A should be .08 inches fatter when measured at the 12th rib. This would be less desirable on a carcass animal, but extremely lean females going back into a cowherd may also be undesirable.

When using EPD it is important to understand that the role of EPD is to provide a measure of comparison within a breed. To compare animals across breeds, estimates from the US Meat Animal Research Center (MARC) can aid in determining differences between EPD of different breeds (Table 2). These are updated annually and can be found at http://www.beefimprovement.org/proceedings.html.

Table 2. Adjustment Factors to Estimate across-breed EPD.

Breed	Marbling Score	Ribeye Area	Fat Thickness
Angus	0.00	0.00	0.000
Hereford	- 0.33	- 0.14	- 0.050
Red Angus	- 0.06	- 0.06	- 0.051
Shorthorn	- 0.10	0.20	- 0.158
South Devon	- 0.03	0.11	- 0.118
Santa Gertrudis	- 0.60	- 0.30	- 0.137
Braunvieh	- 0.31	0.89	- 0.165
Charolais	- 0.42	0.75	- 0.233
Chiangus	- 0.48	0.60	- 0.155
Limousin	- 0.75	1.05	-------
Maine Anjou	- 0.88	1.06	- 0.208
Salers	- 0.20	0.80	- 0.214
Simmental	- 0.55	0.94	- 0.224

(2010 BIF Proceedings, Columbia, MO)

EPD compared to raw data and ratios

There is no doubt that many producers mistakenly place more emphasis on raw measurements than EPD. Raw measurements include the confounded effects of genetics and environment and consequently, the genetic ability of the animal is unknown. Below is a very simplistic equation describing the phenotype of an animal.

$$P = G + E$$

Where P is the phenotype, G is the genetic effect, and E is the environmental effect.

The phenotype is what is seen, or measured, such as the actual scan data for REA or IMF. Both genetics and the environment influence these values and because we are interested in identifying animals based on their potential as parents, the environment should not be included in the tool used to select animals. Furthermore, actual scan figures are not comparable from animal to animal since they have not been adjusted nor do they provide any clue as to how much better or worse an animal is compared to others. A contemporary group ratio does allow for comparison of animals and provides an idea of how much better or worse a particular animal's adjusted record is compared to others within the same contemporary group. The problem is that a ratio is not useful in comparing animals across herds or outside of the defined contemporary group.

The genetic and environmental components of phenotype can be further divided into additive (A), dominance (D), and epistatic (I) genetic effects and both permanent (P) and temporary (T) environmental effects.

$$P = G_A + G_D + G_I + E_P + E_T$$

Generally speaking, we only become concerned with permanent environmental effects when we think about the environmental influence a dam has on her offspring (e.g., a young dam develops mastitis and loses function in one quarter, resulting in reduced weaning weights of subsequent offspring). Contemporary groups account for some of the temporary environmental effects. In genetic evaluations we are able to predict the additive genetic component. This is used in determining the heritability (h^2) which is simply the fraction of the variance in phenotype (σ^2_P) that is explained or caused by variation in additive values (σ^2_A). The heritability can be thought of as the average phenotypic differences or superiority that is likely to be passed on genetically to the next generation.

$$h^2 = \sigma^2_A / \sigma^2_P$$

The objective of buying a bull is to purchase an animal that will enhance the genetics of his offspring. Selection based on a raw scan values places selection pressure not only on the genetic potential of an animal but also on environmental influences (herd, year, season, management, etc.). If you look at two drastically different management scenarios: 1) forage tested bulls, and 2) high concentrate fed bulls; it would be expected that the high concentrate bulls would have greater IMF figures. The question remains, are the more desirable IMF scan figures due to genetics or the fact that they received more feed? We know that the environmental benefits will not be passed from parent to offspring, only the genetics. Consequently, selection based on EPD will help sort the "wheat from the chaff" in that EPD eliminate environmental differences and quantify genetic differences.

Economically Relevant vs Indicator Traits

Economically Relevant Traits (ERT) are those for which there is either a direct cost or direct revenue stream associated with them. A classic example is the comparison of birth weight (and indicator trait) and calving ease (ERT). In the context of talking about ultrasound, the ERT are the actual carcass measurements for which there is economic incentive (i.e., carcass marbling and yield grade). The indicator traits are then the proxy via ultrasound (i.e., intramuscular fat percentage, and ultrasound measurements for fat and ribeye area). The benefit of these indicators is that they can be collected on animals that will not be harvested (i.e., breeding animals). The alternative would be to progeny test sires by feeding several of their offspring and then collecting carcass data on the progeny. Not only does this add expense, but it also adds considerable time. The usefulness of an indicator trait is, in part, determined by the genetic correlation between it and the ERT. The genetic correlations between ultrasound traits and corresponding carcass measurements are moderate to high, but less than 1 (Table 3). This means that ultrasound is a good indicator and describes part, but not all, of the variation in actual carcass measurements.

Table 3. Heritability (diagonal) and genetic correlation (off-diagonal) estimates for carcass and ultrasound traits.

	MARB	FAT	REA	CWT	IMF	UFAT	UREA	SWT
MARB	0.45				0.66			
FAT		0.34				0.53		
REA			0.33				0.63	
CWT				0.40				0.46
IMF					0.38			
UFAT						0.39		
UREA							0.33	
SWT								0.26

Adapted from MacNeil et al. (2008)

MARB = carcass marbling
FAT = carcass ribfat
REA = carcass ribeye area
CWT = carcass weight
IMF = ultrasound intramuscular fat percent
UFAT = ultrasound ribfat
UREA = ultrasound ribeye area
SWT = scan weight

Summary

Ultrasound is a useful indicator of carcass traits but selection using ultrasound information should be confined to using EPD that include various sources of genetic information, including ultrasound records. EPD represent the genetic component of an animal's phenotype that is expected to be passed on to the next generation. Studies have shown that using EPD is 7 to 9 times more effective than selecting based on actual phenotypes. While most producers think of increasing the economic efficiency of their operation by changing management systems (i.e., grazing schemes, calving dates, etc.) or utilizing different nutritional programs, the importance of correct genetic selection is all too often overlooked. If selection is based on non-genetic factors, as is the case when selecting on actual or adjusted measurements instead of EPD or economic indexes, then an in-efficiency is automatically built into the cow/calf enterprise. It is critical to understand how to interpret EPD and to know breed averages and be able to use percentile ranks in order to identify potential sires that fit the desired breeding objective.

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