Ultrasound & Genetic Evaluations

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Matt Spangler grew up on a diversified crop and livestock farm in south central Kansas where his family still continues to farm and run a cow/calf operation. He graduated from Butler County Community College where he was a member of the livestock judging team. From there he attended Kansas State University where he was a member of the 2000 livestock judging team. After receiving his bachelor's degree in Animal Science from KSU he went to Iowa State University and received his master's degree in Animal Breeding and Genetics. He received his Ph.D. at the University of Georgia in Animal Breeding and Genetics and recently finished a one year appointment as an Assistant Professor of Animal Science at the University of Tennessee at Marin. He is currently a Beef Genetics Extension Specialist at the University of Nebraska.

This paper was presented at the Ultrasound Guidelines Council Educational Program held in Lincoln, Neb. on July 28-29, 2008. This program was designed to provide ultrasound field technicians with current information regarding ultrasound technology, carcass anatomy, genetic evaluations, and cattle handling.

Basics of an Expected Progeny Difference (EPD)

Similar to weight traits (birth, weaning, yearling), ultrasound traits must be recorded within certain age windows. Animals scanned outside of defined age windows will not have their own record incorporated into an EPD calculation. This allows for a fair comparison of animals.

Too often those involved with ultrasound get caught up in the absolute value of scan figures. The objective of ultrasound is to correctly rank animals and to accurately depict the differences between them.

Expected Progeny Differences (EPDs) provide a measure by which animals within a breed can be compared to one another for their genetic potential as parents for specific traits. EPDs incorporate multiple sources of information, including: pedigree (parental and collateral relatives), an animal's own record, and progeny information. With additional sources of information become available the accuracy of the EPD value increases.

Prior to a National Cattle Evaluation (NCE) animals are given interim EPDs (examples below). During a genetic evaluation, all pedigree information would be included.

Where EPDI is the EPD for some individual I, EDPS is the EPD for the sire of animal I, EPDD is the EPD for the dam of animal I. The phenomena of mendelian sampling arises due

Table A.

Pedigree estimate:

Sire REA EPD = 0.20 Dam REA EPD = 0.10

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

Pedigree estimate + animal record:

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

to the fact that each parent passes 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.

Current methodology behind the estimation of Mendelian sampling effects can be found in the Beef Improvement Federation Guidelines at *http://beefimprovement/guidelines.html.*

There are EPDs for marbling, ribeye area, and fat. Although there is not a specific rump fat EPD, it is included in genetic evaluations. Most breeds use both rump fat and 12th rib fat together in their calculation of a Fat EPD.

When using any of these EPDs it is important to understand that the role of EPDs is to provide a measure of comparison. Therefore, knowledge of breed averages and percentile ranks are critical in order to determine how much better one animal is compared to other animals within the same breed. To compare animals across breeds, estimates from the Meat Animal Research Center (MARC) can aid in determining differences between carcass EPDs of different breeds.

Accuracy Values and Possible Change

Theoretically, accuracy is the correlation between an animal's predicted EPD and its true EPD. However, it is much simpler to think of it as a measure of risk indicating how much an animal's EPD may change with the inclusion of additional information. Accuracy is not an indication of how variable a particular sire's calves will be but rather how the estimate of an animal's EPD is likely to change. The possible change values, such as those in Table 1, are reported as standard deviations.

Assume that a young Charolais sire has a marbling EPD of 0.10, with an accuracy of 0.20. Using the values in Table 1, we would expect that 2/3 of the time his true EPD would

Table 1. **Accuracy related to possible change in Charolais cattle**

BIF Accuracy	*Ribeye Area Possible Change*	*Marbling Score Possible Change*
0	0.46	0.24
0.1	0.41	0.22
0.2	0.37	0.20
0.3	0.32	0.17
0.4	0.28	0.14
0.5	0.23	0.12
0.6	0.18	0.10
0.7	0.14	0.07
0.8	0.09	0.05
0.9	0.05	0.02

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fall within +/- 0.20 (one standard deviation) of his predicted EPD or between -0.10 and 0.30. There is a 1 in 6 chance that his true EPD is below -0.10 and a 1 in 6 chance that his true EPD is above 0.30.

As the accuracy value increases, the amount by which his EPD is likely to change decreases. Since possible change values are dependant on the amount of genetic variation for a specific trait, they can change as genetic parameters are updated and are only useful within breed (i.e. an Angus bull with an accuracy of 0.30 may have a different possible change value than a Charolais bull with the same accuracy value for the same trait).

Importance of Contemporary Grouping and Complete Recording

Correct contemporary grouping is a key component of accurate genetic evaluations. A contemporary group is defined as animals of the same breed and sex that experience the same management (environment). Contemporary group size is important as well. Small contemporary groups do not allow for ideal comparisons between animals. For instance, if a horse wins a race by two lengths but there were only two horses in the race, it is difficult to determine how 'good' the winner really is. Similarly, single animal contemporary groups make comparisons impossible because the animal's genotype and environment are confounded.

Single animal contemporary groups are edited from the data and are not included in genetic evaluations. Since large contemporary groups are advantageous to an accurate genetic evaluation, scanning an entire group of animals is more desirable than selectively choosing animals to be scanned.

In the past, hopefully not in the present, there has been the perception by some producers that they should only scan their 'best' animals, the thought being that the animals they report will look 'good' and all 'bad' animals will not be reported (and yes, it is cheaper to scan fewer animals).

Unfortunately, this thought process negatively affects the records that are turned in. EPDs are a comparative tool. Think of it this way, if only the top six football teams in the Big 12 Conference are compared, then the sixth ranked team will appear as though it is the worst, when in reality it is in the middle of the road or potentially ranked sixth out of twelve. Furthermore, the top ranked team, although still superior, may not look as good because it is not compared to all teams. Similarly, the top IMF bull may be the top IMF bull regardless of whether all animals are scanned or not, but the value of his superiority will certainly be less if only select animals are scanned.

EPDs Compared to Raw Data and Ratios

There is no doubt that many producers ignorantly place more emphasis on raw ultrasound measurements than EPDs. Raw measurements account for both genetic and environmental effects and consequently, the genetic ability of a sire 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 we see, or measure, such as the actual scan data for REA or IMF. Both genetics and the environment influence these values and since we are interested in identifying animals based on their potential as parents, the environment should not be included in the tool we use 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 temporary environmental effects. In genetic evaluations we are able to account for the additive genetic component. This is used in determining the heritability which is simply the quotient of the additive variance divided the by total phenotypic variance.

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

Although the estimates of heritability of traits differ by breed, ultrasound measures generally have heritability estimates between 0.30 and 0.40.

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 better scan figures. The question remains, are the more desirable 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 EPDs will help sort the wheat from the chaff in that EPDs eliminate environmental differences and quantify genetic differences.

Ultrasound vs. Progeny Testing and Carcass Data

The premise of ultrasound is simple: It provides a non-destructive means of collecting carcass information without the expense of progeny testing. Prior to the advent of ultrasound for the measurement of carcass traits, producers were forced to collect carcass data.

This process created two problems: The expense of carcass data collection, and the inability to collect records on breeding animals. Consequently, breeding animals would have only a parent average EPD (low accuracy) until they themselves had progeny that had been slaughtered and had carcass data collected on them.

If you think about this in terms of a bull's age and possible change, then young sires (yearlings and two-year olds) would be selected based on EPDs with accuracy values of around 0.05. From the table above this would mean a possible change of +/- 0.23 for a marbling EPD in the Charolais breed. When the bull finally has carcass data from progeny at age 3 or 4 then the estimate of his EPD becomes more accurate. This situation causes either incorrect mating/selection decisions or the inability to use a sire as much as desired until he is older.

Indicator Traits vs. Economically Relevant Traits

Measurements taken on a live animal via ultrasound and those taken from the carcass once that individual has been harvested are not the same. Ultrasound is a very good indicator trait for carcass measurements, (genetic correlations of 0.70 or greater) but carcass traits are economically relevant since producers are paid on carcass traits and not ultrasound measures.

The largest difference is between Percentage Intramuscular Fat (IMF) and marbling score. IMF is an objective measure of the amount of fat in the muscle tissue. Marbling score is subjectively determined by the amount of fat in the muscle tissue, the texture of the fat and the distribution of the fat. The fact that texture and distribution are taken into account explains why there are differences. The advent of machine grading instead of actual USDA graders may show that the two measurements (carcass and ultrasound) are more similar. However, research is this area is currently lacking.

Combining Ultrasound and Carcass Measurements

Several breeds (e.g., North American Charolais Foundation, Red Angus Association of America, and others) combine ultrasound and carcass data together and report only one EPD on a carcass basis.

For example, a marbling score EPD may actually include both carcass marbling score and %IMF records as measured by ultrasound. Although this process may seem confusing it is quit simple and provides some key benefits such as a reduction in the number of EPDs included in a sire evaluation and correctly identifying those traits that are economically relevant (carcass) as opposed to those that are indicators (ultrasound).

These EPDs are reported in carcass units and are not directly comparable to past EPDs that were solely carcass or solely ultrasound based. Under this system, an animal with x number of progeny with carcass records will have a higher accuracy value than an animal with the same number of progeny that all have ultrasound records.

This is because the ultrasound records

are considered to be indicator traits. For some breeds, such as Angus who recently released combined EPDs in their fall 2008 NCE, this provides an opportunity for a change in modeling. In the past, carcass EPDs were predicted using a sire/maternal grandsire model while ultrasound EPDs were predicted using an animal model. The key difference being that an animal model takes into consideration the direct contribution of the dam.

The new combined EPDs that have been released by Angus will now be predicted using an animal model.

EPDs and SNPs…

What, When, Who, and Where

EPDs account for all sources of within-breed genetic variation but these sources are not defined (i.e., genes unknown). More recently, several Single Nucleotide Polymorphisms (SNPs) have been identified that have a potential effect on several traits of interest.

Current commercially available genetic tests, (SNP panels) will test for particular genotypes for a limited number of genes. These tests do not account for all of the genetic variation, but do define where the genetic variation is coming from and allow for information to be garnered very early in life before a phenotypic record can be measured.

The heritability of EPDs clearly explain the percentage of the phenotypic variation that is explained. Unfortunately, similar information concerning DNA maker tests is less clear. Ultrasound information has been easily included into breeding schemes while SNP data has not been seamlessly integrated into genetic evaluations due to the theoretical and computational complexities and due to the lack of scientific information quantifying their effect on the trait of interest.

At the current time, if SNP information is utilized in a breeding scheme, it should be used in concert with the collection of phenotypic records and EPDs. Using limited DNA marker information as a replacement for EPDs could have serious consequences and may lead to incorrect selection and mating decisions.

As molecular information becomes a regular part of bull sale catalogs, it can become confusing when EPDs seem to be at odds with DNA tests. Confusion abounds when a young sire has an undesirable marbling EPD and an exciting genotype for a SNP panel. This can easily happen since the current SNP panels do not account for all the genetic variation.

It is possible that an animal has the most desirable alleles that are tested for in a commercial marker test, but the remaining alleles that were not accounted for by the test are undesirable. Further confusion is created by the manor in which many of the results from these tests are reported, such as a 1-10 scale, or a number of stars. Unfortunately, these types of scoring systems do a very poor job of depicting genetic differences between potential parents.

Companies are beginning to tackle these questions openly and have started to report molecular breeding values (MBVs) (although many different phrases are currently being used; e.g., Estimated Molecular Value (EMV)) that are similar to an EPD in that they are reported in units of the trait. Some companies are also developing breed specific panels as opposed to the 'one size fits all' panels that some currently used.

There is still a lot of work to be done in this area to alleviate the confusion that has built up since these tests have been commercialized. Exciting new developments including whole genome selection may offer ways of not only identifying the source of genetic variation at the molecular level but also have the potential to describe a significant amount, if not all, of the additive genetic variation.

As we move forward with this exciting new technology, I would sincerely hope that the companies developing these tests are able to work with independent scientists to validate discoveries and with breed associations to integrate this information into the existing framework of National Cattle Evaluations.

The combination of these two sources of information, molecular and phenotypic data, could lead to increased accuracies for young sires and information for traits which at the current time we have no way (or at least a cost effective way) of measuring.

More information regarding validation of these panels and a complete list of tests that are available can be found on the following websites:

- National Beef Cattle Evaluation Consortium *http://www.ansci.cornell.edu/nbcec/*
- University of California Davis Animal Science *http://animalscience.ucdavis.edu/animalbiotech/Biotechnology/MAS/index.htm.*

Role of the Ultrasound Guidelines Council (UGC)

The UGC plays a critical role in the genetic evaluation process by ensuring the collection of quality data. The certification process (field technicians, lab technicians, and ultrasound systems) ensures the credibility of ultrasound data that enters into EPD calculations.

I am afraid that some technicians may believe that they are providing a service only to the breeders that they work with and similarly that labs believe they are only providing a service to the technicians that they interpret for. Nothing could be farther from the truth.

If you scan or interpret images from one breed, it has an influence on every breeder within that breed and every commercial ranch that purchases seedstock within that breed. To that end, it is paramount that all involved with this industry work in concert to continually make improvements, validate technology, and continually educate themselves.

For additional information, visit these sites –
http://www.ansci.cornell.edu/nbcec/ or *http://animalscience.ucdavis.edu/animalbiotech/Biotechnology/MAS/index.htm.*