GENETIC SELECTION VS. VISUAL APPRAISAL: IS IT A CONUNDRUM?

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IMPLICATIONS

The goal of commercial sire selection should be to improve enterprise level profitability via genetics. This requires a true accounting of the traits that generate revenue or incur a cost within a specific beef cattle enterprise and a focus on the tools that identify genetic differences between candidate sires. Once the drivers of profit have been identified, sire selection should focus on the suite of traits that impact profitability. In many cases genetic predictions in the form of Expected Progeny Differences (EPD) are available to guide animal selection. Knowledge of which traits should be under selection and what level of genetic potential is desirable is required to make optimal selections. The use of bio-economic selection indices can dramatically reduce the complexity of multiple trait selection and aid in sire selection towards increased profitability. Some traits, however, do not have EPD available. In those cases, use of phenotypic information in the form of production data or evaluation of conformation maybe useful.

Definition of production goal and use of genetic prediction tools aligned with that goal is essential. It is critical to use selection indices that match the intended production system. Using a terminal index in an enterprise that retains replacement heifers would not be advisable. Producers should also leverage breeding systems to capitalize on breed complementarity and the value of heterosis.

INTRODUCTION

Sire selection does not need to be overwhelming or complex. Selection should utilize the most effective and reliable tools to generate improvement in the traits of interest. Centuries of work by geneticists and statisticians have allowed for the development of tools (Expected Progeny Differences and Selection Indices) that help producers make decisions relative to the next bull you purchase; do not ignore them.

The key questions that every rancher needs to answer are:

1) What are my breeding/marketing goals?
2) What traits directly impact the profitability of my enterprise?
3) Are there environmental constraints that dictate the level of performance that is acceptable for a given trait in my enterprise?
4) How are females replaced in my herd? (Raised or purchased)

Once these four questions are answered, sire selection becomes much simpler. The answers to these questions inherently lead a producer to the traits that are economically relevant to their enterprise. We call these traits Economically Relevant Traits (ERT).

GENETIC SELECTION TOOLS: BASICS OF AN EPD

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, genomic data, and progeny information. As additional sources of information become available, the accuracy of the EPD value increases.

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 from 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 in which 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. Although all of them have the same pedigree estimate, they differ considerably in terms of performance and consequently their EPDs, once they have a record, differ due to Mendelian sampling. Current methodology behind the estimation of Mendelian sampling effects can be found in the Beef Improvement Federation Guidelines at www.beefimprovement.org/library/06guidelines.pdf.

When using EPD, it is important to understand that the role of EPD is to provide a measure of comparison within a breed. EPD describe the relative merit or potential of individuals for a given trait. EPD do not directly describe what the animal's own phenotype will be, but rather expected difference in the averages of progeny. To compare animals across breeds, estimates from the U.S. Meat Animal Research Center (USMARC) can aid in determining differences between EPD of different breeds. These across breed adjustment factors, adjusted to an Angus base, are updated annually and can be found at www.beefimprovement.org/proceedings.html.

THE VALUE OF EPD COMPARED TO RAW DATA AND RATIOS

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 birth weight or weaning weight. 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 phenotypes (e.g., weights, scan data, etc.) are not comparable from animal to animal since they have not been adjusted for systematic effects such as age of the animal, age of the animal's dam, breed composition, etc., nor do they provide any clue as to how much better or worse an animal is genetically 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, which is presented as an EPD. 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).

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

The objective of buying a bull is to purchase an animal that will enhance the genetics of his offspring. Selection based on raw phenotypes such as actual weights or ultrasound 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 intramuscular fat percentage (IMF) figures. The question remains, are the more desirable IMF scan figures due to genetics or the fact that they received more feed? The reality is it could be the added feed only, or some combination of added feed and increased genetic potential. In looking only at the phenotypes we cannot be certain. 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 EPD eliminate environmental differences and quantify genetic differences.

ECONOMICALLY RELEVANT TRAITS

There are many EPD available to select from, and not all are pertinent to a given commercial enterprise. Consequently, producers need to identify the traits that are economically relevant to their production system. The formalization of the phrase Economically Relevant Traits can be traced to Golden et al. (2000). Fundamentally these are traits that are directly associated with a revenue stream or a cost. All traits that are not ERTs are indicator traits, or a trait that is genetically correlated to an ERT but not an ERT itself.

Classic examples of indicator traits include ultrasonic carcass measurements, birth weight, and scrotal circumference. Ultrasonic carcass measurements are a non-destructive measure of traits such as intramuscular fat percentage (IMF). Producers do not receive premiums for IMF levels, rather premiums (and discounts) are applied to quality grades. Assuming that carcass maturity values are the same, actual carcass marbling is the driver of quality grade. Although IMF is genetically correlated to carcass marbling, (MacNeil et al., 2010) it is not the ERT. Birth weight is another great example of an indicator trait. Selection to decrease birth weight in an attempt to reduce the prevalence of dystocia is practiced by numerous commercial bull buyers. However, birth weight does not have a direct revenue source or cost associated with it. The trait that does have a cost associated with it is calving ease (or difficulty). Calving ease is related to the level of assistance needed during a calving event. Although the two are related, the genetic correlation between calving ease and birth weight is only between -0.6 and -0.8, suggesting that birth weight only explains 36-64% of the genetic differences between animals for calving difficulty (Ahlberg et al., 2016; Bennett and Gregory, 2001). Genomic predictors (Molecular breeding Values or Molecular Value Predictions) can also be thought of as indicator traits. As the genetic correlation between the MBV (or MVP) increases, the more valuable it is as an indicator. However, these genomic predictions do account for all of the genetic differences between animals.

The challenge that confronts producers is selecting on multiple traits simultaneously, some that may be ERT and others that may be indicator traits, to improve enterprise level profitability. While there are many methods to practice multiple-trait selection, the most efficient method is through the use of economic index values.

BIO-ECONOMIC INDEX VALUES

Hazel (1943) summarized the need to formalize a method of multiple trait selection in the opening paragraph of his landmark paper on the topic of selection indexes:

The idea of a yardstick or selection index for measuring the net merit of breeding animals is probably almost as old as the art of animal breeding itself. In practice several or many traits influence an animal's practical value, although they do so in varying degrees. The information regarding different traits may vary widely, some coming from an animal's relatives and some from the animal's own performance for traits which are expressed once or repeatedly during its lifetime....These factors make wise selection a complicated and uncertain procedure; in addition fluctuating, vague, and sometimes erroneous ideals often cause the improvement resulting from selection to be much less than could be achieved if these obstacles were overcome.

Although Hazel's work in the area of selection indices was groundbreaking, the U.S. beef industry was slow to adopt a tool that had the potential to greatly simplify sire selection and place emphasis on that which is economically important. Economic indices are the preferred tool for multiple trait selection. A bio-economic index (H) is simply a collection of EPDs that are relevant to a particular breeding objective, whereby each EPD is multiplied by an associated economic weight (a). For example, the economic index value H can be written as:

$$H = EPD_1a_1 + EPD_2a_2 + EPD_3a_3 + \ldots + EPD_na_n$$

where EPDs 1, 2, and 3 are multiplied by their corresponding economic weight and summed. Consequently, a high index value does not necessarily mean that an animal excels in all EPD categories given that superiority in trait can compensate for inferiority in other traits depending on how the EPDs are weighted in the index. A high index value should be thought of as excelling in the ability to meet a breeding objective. It is important to note, however, that before proper use of an index can be ensured, a breeding objective must be clearly identified. For example, the use of an index such as the American Angus Association's Dollar Beef ($B) in an enterprise that retains replacement heifers can lead to adverse effects, given that sire selection pressure has been placed on terminal traits via $B. A detailed listing of available selection indices can be found at www.eBEEF.org.

WHEN SHOULD A PRODUCER USE PHENOTYPIC SELECTION OR VISUAL APPRAISAL?

There are two examples where the actual phenotype of a bull is important relative to their ability to pass on their genetic potential for other traits. These examples are the results of a breeding soundness exam and feet and leg structure. In smaller, more intensive, production systems actual temperament (docility) could also be considered among this list due to human welfare concerns.

A breeding soundness exam (BSE) on yearling bulls provides a useful measure of the potential breeding ability of a young bull. The BSE measures scrotal size and evaluates a semen sample for the percent of forwardly motile sperm, as well as sperm morphology. Defectively formed sperm have bent or broken tails, proximal droplets, abnormal head shape, white blood cells (from infection) and other defects. If a bull has a low percentage of forwardly motile sperm or a substantial number of defective sperm his fertility is compromised. Turning out infertile or low fertility bulls will contribute to low conception rates. To date, no U.S. beef breed organization produces genetic evaluations that include male fertility traits other than scrotal circumference, although a number of studies suggest low to moderate heritability for various semen attributes (Christmas, 2010; Meyer et al., 1990). Undoubtedly, environmental effects including cold or heat stress, disease, nutritional status and injury affect fertility and libido. Producers should either purchase fertility tested bulls or have bulls tested prior to exposure to cows to assure that bulls capable of settling cows are used in breeding pastures. Bulls should be BSE tested before each breeding season. A BSE exam provides a phenotypic observation that is a reflection of the bull's genetics and environmental effects that may affect breeding capacity and fertility.

Given the requirement that natural service sires be able to move around breeding pastures, another area of selection that merits phenotypic selection is feet and leg conformation or more importantly the avoidance of severe structural issues. Some cattle producers make an argument in favor of selection for other physical attributes such as stature, body depth, topline, muscle shape, and 'balance' as important characteristics of an animal. These attributes are very subjective in nature and outside the showring market, have a limited, if not null, relationship to profitability. That said, feet and leg structure, and selection for improved or adequate foot and hoof structure can be economically important. If, for instance, a young herd bull develops lameness or a foot defect that makes him have decreased libido or creates medical conditions, he's effectively infertile in the sense that he won't service many cows. Bulls or cows that develop feet and leg issues result in early involuntary culling and often exit the herd prior to achieving their break-even cost causing capital loss for the business. Reduction in the number of cattle that experience lameness and culling also improves welfare of the animals in our stewardship. Improved longevity and production in dairy cattle has been associated with improved feet and leg quality (Dekkers, 1994). On the beef side, a number of studies have demonstrated the moderate heritability of feet and leg structure in beef cattle (Jeyaruban et al., 2012; Jensen, 2017). These studies provide evidence of the level of genetic control breeders can have over feet and leg quality. Moreover, they suggest with effective selection tools, breeders can substantially, and fairly rapidly, improve feet and leg quality in beef cattle. Ultimately, these traits have a logical impact on cow longevity and may provide valuable indicator trait data for selection indexes or longevity EPD.

CONCLUSION

The reality is that not all beef cattle producers will use EPD and economic selection indices to select herd bulls. Rather, many will defer to an almost ancient method of visual appraisal with the ignorant belief that their eye can parse genetic and environmental effects. Producers who value economic returns likely already use EPD and economic selection indices. Those who fall in this category of profit-focused producers who still rely on visual appraisal should recognize that EPD are 7-9 times more effective at generating response to selection as compared to actual phenotypes. Moreover, although most (if not all) beef producers practice some form of multiple-trait selection most likely do it in an inefficient manor and/or make it too complex. Use economic selection indices that fit your breeding objective, they are simple to use and effective. There are phenotypes (e.g., male fertility, feet and leg structure) which directly impact the ability of a bull to pass on his genetic potential to the next generation. There is merit in phenotypic evaluation to ensure that a bull "passes" these thresholds. A breeding soundness exam and a relationship with a trustworthy seedstock supplier are useful tools to ensure bulls meet these thresholds.

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