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ECONOMICALLY RELEVANT TRAITS AND SELECTION INDICES[1]

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IMPLICATIONS

Sire selection should focus on that which is economical. This requires a true accounting of the traits that generate revenue or incur a cost within a specific beef cattle enterprise. Once the drivers of profit have been identified, sire selection should focus on the suite of traits that impact profitability. The use of bio-economic selection indices can dramatically reduce the complexity of multiple trait selection and aid in sire selection towards increased profitability. 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. Although there have been previous attempts to deliver decision support tools to the beef industry, there is renewed interest in generating web-based software to aid in sire selection that contemplates across-breed EPD, heterosis, and the economic drivers of a particular enterprise. Producers that have more detailed knowledge of economic costs and returns will benefit more from such a tool.

INTRODUCTION

I have often wondered if an advanced degree in psychology might have served me better in my extension role. Sire selection, as all too commonly practiced, is not rooted in science but rather guided by a seemingly opaque process that is unique to the "eye of the beholder". Why is it that when buying seed corn science is inherently adopted by farmers, but when buying bulls it seems to be cast aside? Now you understand why I have pondered if a degree in psychology might have been worthwhile. I have also wondered if trophies for corn at sate fairs were always smaller than trophies for steers or bulls and we continue to pay for that injustice.

Sire selection does not need to be overwhelming or complex. Centuries of work by geneticists and statisticians have allowed for the development of tools 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?

Once these three 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).

ECONOMICALLY RELEVANT TRAITS

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. Table 1 provides a list of currently available EPD indicating which are ERT and which are indicator traits.

Table 1. List of EPDs published by beef breed associations characterized as economically relevant (E) or indicator (I) traits.

Calving ease direct[E]
Birth weight[I]
Weaning weight direct[E]
Yearling weight[E]
Yearling height[I]
Maternal weaning weight[E]
Gestation length[I]
Calving ease maternal[E]
Mature height[I]
Mature daughter weight[E]
Scrotal circumference[I]
Heifer pregnancy[E]
Udder[I]
Teat[I]
Carcass weight[E]
Percent retail cuts[E]
Marbling[E]
IMF[I]
Rib-eye area[I]
Fat thickness[I]
Rump fat thickness[I]
Tenderness[I/E]
Days to finish[E]
Residual average daily gain[I]
Residual feed intake[I]
Dry matter intake[E]
Stayability[E]
Maintenance energy[E]
Docility[I]

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., 2014; Bennett and Gregory, 2001). Genomic predictors (Molecular breeding Values or Molecular Value Predictions) can also be though 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.

ACROSS BREED EPD

Expected Progeny Differences published by one breed are inherently not comparable to those published by another breed. This is due to several factors including differences in arbitrary base adjustments used by each breed and differences in selection intensity for a specific trait in one breed compared to another. Consequently, producers who wish to compare bulls of different breeds must utilize across-breed adjustment factors. Notter and Cundiff (1991) developed methods to compare birth weight, weaning weight, and yearling weight EPD from different breed associations utilizing data generated from the Germplasm Evaluation program at the US Meat Animal Research Center (USMARC). The development of a common base to adjust growth traits, combined with breed association EPD, allows producers to compare sires from different breeds and make informed selection decisions. The methods used to estimate the additive across-breed adjustments has evolved over the years to include random sire and dam effects, the use of mixed models to estimate regression coefficients, and the inclusion of heterosis estimates (Van Vleck et al., 2007). The regression coefficients are obtained regressing progeny records from USMARC on breed association derived EPD (Van Vleck and Cundiff, 2005). Heterosis estimates are used to adjust progeny records to a base of 100% expected heterozygosity, since the objective is presumed to be the comparison of sires of different breeds to produce crossbred calves (Van Vleck et al., 2007).

Currently the USMARC calculates across breed adjustment factors for 18 breeds for four or more traits including: birth weight, weaning weight, yearling weight, maternal milk, marbling score, ribeye area, and fat thickness. Producers can use these additive adjustment factors to adjust EPD to a common Angus base. Across-breed adjustments are updated annually to capture differences in base changes, genetic trends, and the addition of more data generated in the GPE. Each year new across-breed adjustment factors are released at the Beef Improvement Federation meeting. Current across-breed adjustment factors can be found at www.beefimprovement.org.

The calculation of across-breed adjustments relies on breed solutions from the analysis of records at USMARC GPE and on the average of within-breed EPD from the breed association (Kuehn and Thallman, 2012). The basic calculations are as follows:

$M_i = USMARC(i)/b + [EPD(i)_{YY} – EPD(i)_{USMARC}]$

and the breed table factor A_i to add to the EBV of breed i is equal to:

$A_i = (M_i – M_x) – (EPD(i)_{YY} – EPD(x)_{YY})$

where USMARC(i) is the USMARC breed of sire solution (1/2 breed solution) of breed i that is converted to an industry scale (divided by b) and adjusted for genetic trend. The pooled regression coefficient (b) of progeny performance at USMARC regressed on EPD of sire. $EPD(i)_{YY} – EPD(i)_{USMARC}$ is the difference between the average within-breed EPD for breed i to a base year (YY, which is two years before the update) and the weighted average EPD for sires of breed i that have descendants with records at USMARC. The base breed (x) in this case is Angus. $EPD(i)_{YY} – EPD(x)_{YY}$ is the difference between the average within-breed EPD for breed i and the average within-breed EPD for Angus. It is important to note that the pooled regression coefficient is approximately 1 in most cases (12^{th} rib fat is slightly lower at 0.86), illustrating that selection based on EPD are effective at generating phenotypic change in crossbred calves.

There are several EPD that are considered ERT that do not have across-breed adjustment factors. This is due to the complexity of the underlying models used to derive EPD for traits like calving ease, heifer pregnancy, and stayability. An underlying issue relative to the development of across-breed EPD for traits such as calving ease direct and maternal is correctly accommodating the differences in models used by various beef breed associations in the estimation of EBV for these traits. All breeds use a multi-trait model fitting birth weight, but some use a linear-linear model while others use a threshold-linear model. Even within these two broad categories of model specification other differences exist. Some breeds combine categories, thus shrinking the number of potential scores on a linear scale. For breeds that utilize a probit function treating calving ease as a threshold character, the point at which calving ease is centered on the underlying scale differs. Also, the mean incidence of difficulty (e.g., 50%, 80%, etc.) at which the back-transformed EPD is calculated from the underlying EPD can be different. To correctly estimate breed differences towards the development of adjustment factors for breeders to use when comparing animals of different breeds for calving ease direct and maternal this larger issue of scaling must be addressed. Differences due to sire sampling undoubtedly impact these estimates. For breeds where sampled sires' EPD deviate from their breed's mean, EPD of calves born in a reference year (e.g. 2011), estimates should be adjusted for the sampling bias. However, this requires rescaling. Furthermore, sires that were born several decades ago may have had calving ease recorded in some breeds, but not in others. Genetic trend will be underestimated in breeds which began recording calving ease more recently and the disparity in data between breeds could bias estimates of breed differences.

Initial work has been completed to estimate across-breed adjustments for calving ease direct and maternal (Ahlberg et al., 2014), but additional work is needed for other trait complexes and to develop a delivery system for these adjustment factors.

Implementation of existing across-breed EPD has been through a table of additive adjustment factors. The scaling differences between breeds makes this approach problematic for traits like calving ease. An updated delivery model (perhaps web-based) would be required to effectively implement across-breed EPD. It would also allow substantial improvements to the system for other traits.

Several beef breed associations now have EPD generated through International Genetic Solutions (IGS), the genetic evaluation arm of the American Simmental Association. This has lead to the pervasive thought that across-breed adjustment factors are not needed for those breeds that have their EPD derived from the multi-breed evaluation of IGS. Unfortunately this is not true. The general structure of the USMARC data allows for breed comparisons that are simply not possible from breed association field data. In breed association field data it is rare to find animals of differing breeds and composites in the same contemporary group. This is critical in order to get reliable breed solutions that underpin reliable across-breed EPD. Consequently, a logical step moving forward is for entities like IGS to utilize USMARC breed and heterosis estimates in their genetic evaluation.

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 US 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.

Table 2. Breed association selection indexes, market progeny endpoints and breeding system[1].

Breed	Index Name	Progeny Endpoint	Breeding System
Angus	$W (Weaning)	weaned feeder calves	A
Angus	$EN (Maintenance Energy)	replacement heifers	M
Angus	$F (Feedlot)	live fed cattle	T
Angus	$G (Grid)	beef carcasses sold on a CAB grid	T
Angus	$B (Beef)	beef carcasses from retained ownership sold on a CAB grid	T
Charolais	TSPI (Terminal Sire Profitability Index)	beef carcass sold on grid	T
Gelbvieh	$Cow	replacement heifers	M
Gelbvieh	EPI (Efficiency Profit Index)	feedlot efficiency	T
Gelbvieh	FPI (Feeder Profit Index)	beef carcass sold on grid	T
Hereford	BMI$ (Baldy Maternal Index)	beef carcass sold on grid; replacement heifers retained	A
Hereford	BII$ (Brahman Influence Index)	beef carcass sold on grid; replacement heifers retained	A
Hereford	CHB$ (Certified Hereford Beef Index)	beef carcass sold on CHB grid	T
Hereford	CEZ$ (Calving Ease Index)	matings to replacement heifers	M
Limousin	MTI (Mainstream Terminal Index)	beef carcasses sold on grid	T
Red Angus	HerdBuilder	beef carcass sold on grid; replacement heifers retained	A
Red Angus	GridMaster	beef carcasses sold on grid	T
Simmental	API (All Purpose Index)	beef carcasses sold on grid; replacements retained	A
Simmental	TI (Terminal Index)	beef carcasses sold on grid	T

[1] Adapted from Weaber fact sheet available at www.eBEEF.org.
T=terminal, A=all-purpose, M=maternal

The majority of economic index values are rigid (i.e. not catered to individual enterprises). A much more desirable method would use individualized index values where the bull with the highest index value may differ from one herd to the next, depending on how the animal fits the specific needs of each enterprise. While this would lead to more accurate identification of parents for the next generation, this approach suffers from two shortcomings. Firstly, this requires commercial bull buyers to have the requisite information needed to inform such an index. Detailed information related to costs, in particular, are often a challenge to for most commercial producers to truly account for making a catered index less valuable. The second challenge is related to how seedstock suppliers advertise such a fluid index. For example, it is possible to advertise that a bull is in the top 1% of the breed for $B, but if an index parameters are partially defined by the prospective bull buyer or semen user the most desirable bull for that producer may not be the best for other producers. Although decision support software to enable user defined indices has been attempted in the past (e.g. DECI) the amount of information needed to parameterize the model was too cumbersome for most commercial producers. A more comprehensive approach that contemplates across-breed sire selection, breed-specific heterosis, and user defined costs and returns, is the objective of a current grant application.

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