The Role of Economically Relevant and Indicator Traits

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Selection is the process breeders use to produce genetic change, realizing that genetic change and genetic improvement are not necessarily the same. Producers can change many traits genetically but change does not necessarily mean improvement. Improvement implies the production of superior animals and for livestock production the definition of superior animals are those with greater profitability.

This manual explains underlying genetic mechanisms, concepts of selection, and tools that can be used to make better selection decisions to help producers meet their goals. The assumption throughout is that the goal of sire selection and beef enterprises is profitability.

The difference between indicator and economically relevant traits (ERT) and the ability to distinguish between the two are keys to improving profitability. By identifying the economically relevant traits, selection focus can be narrowed, resulting in faster genetic improvement and improved profitability. In the end, the goal of focusing selection on ERT is to increase the probability that breeders will make selection decisions that make them more profitable. This chapter establishes guidelines for identifying the economically relevant and indicator traits and provides a suggested list of ERT for commercial production systems. A subsequent chapter will discuss selection on multiple ERT and assessing the economic value of genetic improvement in those ERT.

Importance of the distinction

The rate or speed with which breeders can improve a specific trait is determined by four factors: generation interval, genetic variability, selection intensity and selection accuracy. Beef cattle producers have little control over genetic variability and limited control over generation interval. The generation interval, or the rate at which one generation of animals is replaced by the next, is largely limited by the reproductive rate (single births) and relatively late sexual maturity in beef cows and the need to generate replacements. The breeder has most control over the generation interval in males and over the remaining two factors: selection accuracy and intensity in both sexes.

Increased accuracy of selection is achieved using EPD rather than actual performance. EPD are calculated using all available performance information from animals within a database. By using all available data rather than only individual performance greater accuracy of selection is achieved and as accuracy increases, so does the rate at which genetic improvement is made. In the future as results from DNA tests are included in EPD calculations, even greater levels of accuracy will be achieved on young animals.

Use of EPD for selection decisions also improves the intensity of selection. Animals from different herds can be compared on a genetic level without sacrificing accuracy of selection because EPD account for genetic and environmental differences between contemporary groups. The ability to compare animals from different herds expands the pool from which producers can choose replacements—no longer are they limited to comparing animals from within the herd of a single seedstock producer. Another way to envision the effects of an expanded pool of potential replacement animals is to take an example from high school athletics. If a team for any sport were chosen from a high school of only 100 students, and then a team was selected from a high school of 2000 students, likely the team from the school with 2000 students would be superior. The team from the larger school would be subject to more selection pressure in forming their team. (This is why there are different classes for high school sports). The same concept is at work when making selection decisions, the use of EPD expands the pool from which to select—allowing fair comparison of animals from many different herds both small and large, enlarging the pool of animals to chose from, increasing the intensity of selection and ultimately speeding the rate of genetic improvement.

Traditionally breed associations only collected performance information on birth weight, weaning weight and yearling weight and accordingly the first EPD were produced only for those traits. Since that time, breeders and breed associations have begun collecting additional performance information on a multitude of traits such as calving ease, carcass attributes, and ultrasound measures. Once data on these new traits were available, the associations and scientists' approach has been to produce EPD for those traits as well. The production of these additional EPD was rationalized as giving a more complete description of the breeding animals (Bourdon, 1998). Unfortunately, this approach led to an ever expanding list of EPD which in some cases has increased the difficulty of making selection decisions. Many producers are simply overwhelmed by the amount of available information. In several cases, the expanding list of EPD resulted in several EPD that actually represent the same trait of interest. For instance, birth weight and calving ease EPD both address the same problem—difficult calving; and ultrasound percent intramuscular fat and marbling score both address the same characteristic—marbling of slaughter animals.

In situations where several EPD are calculated for the same trait of interest, two potential problems arise. First, if the producer uses both EPD to make a selection decision, the accuracy of that selection decision actually decreases as compared to selecting solely on the true trait of interest (a mathematical proof of this concept is beyond the scope of this manual). Second, the relative economic importance of the two becomes difficult to determine. For instance, if a BW and a CE EPD are available, where should most emphasis be placed? Or, should emphasis be placed only on one of the traits?

The rapid growth in the number of EPD exacerbates another problem inherent to any genetic improvement program--the more traits that are simultaneously selected for, the slower the rate of genetic improvement in any one of those traits. For instance, a producer that sells weaned calves and purchases all replacement females likely concentrates on selecting and purchasing bulls that produce calves that are born unassisted and are heavy at weaning. If that producer decides to change the production system and begins to keep replacement females from the calf crop, heifer fertility and maternal ability become economically relevant. Rather than selecting bulls for calving ease and weaning weight; the breeder now must consider maternal ability and heifer fertility, adding two more traits to their selection criteria. This addition reduces the speed at which weaning weight (and calving ease) can be improved. As more traits are added to the list of importance, the rate of improvement in any one of those traits is decreased.

The proliferation in number of EPD and the reduced rate of improvement as more and more traits are selected for, beg for a method to simplify the selection process. So how does a producer choose those EPD that are most important to his/her production and marketing system? The distinction between economically relevant and indicator traits is the first step in simplifying the selection process.

Distinguishing Between ERT and Their Indicators

The costs of production and the income from production together determine profitability of a beef enterprise. For a commercial producer, those traits that directly influence either a cost of production or an income from production are considered economically relevant traits. For seedstock producers, the economically relevant traits are the traits that directly influence either a cost of production or an income from production for their **commercial** customers. Ultimately these commercial producers are the largest customers of the seedstock industry with approximately 830,000 cow-calf producers relying on 120,000 seedstock producers to supply genetically superior breeding animals adapted to the commercial production system (Field and Taylor, 2003). Those traits not directly related to a cost or income from production are, at best, the indicator traits and at worst superfluous.

The easiest way to distinguish between economically relevant traits and indicator traits is to ask a specific question about the trait of interest—if that trait changes one unit, either up or down with no changes in any other traits, will there be a **direct** effect on income or expense? For example, if scrotal circumference increases one centimeter, is there a direct influence on income or expense? A breeder's profitability is likely not changed if the bulls purchased for use in the herd average 1 cm larger. The profitability would come through the genetic relationship of scrotal circumference with ERTs. The primary reason for measuring scrotal circumference in yearling bulls is the relationship with age of puberty in those bulls' daughters. As yearling scrotal circumference increases, those bulls' daughters tend to reach puberty at earlier ages with the assumption that earlier age of puberty in heifers results in increased pregnancy rates at a year of age (Brinks, 1994). In a production system where replacement heifers are chosen from within the herd, one of the primary traits of interest is heifer pregnancy—do the heifers breed at a year of age in a restricted length breeding season? Age of puberty is often a large factor in determining whether a heifer becomes pregnant at a year of age, but age of puberty is only one factor involved in heifer pregnancy. In the end, heifer pregnancy is the economically relevant trait while scrotal circumference is an indicator trait for heifer pregnancy.

Table 1. Proposed economically relevant traits and suggested indicators.[a]

Economically Relevant Trait	Indicators[b]
Probability of Calving Ease	Calving ease score Birth weight Gestation length
Sale Weight[c] Weaning Direct Weaning Maternal (Milk) Yearling Weight 600 day weight Carcass weight at finish endpoint[e] Salvage Cow Weight	Birth weight 205 d weight 365 d weight Slaughter weight Carcass weight Cull cow weight
Cow Maintenance Feed Requirement	Mature cow weight Cow body condition score Milk production[d] Gut weight Liver weight
Stayability (or Length of Productive Life)	Calving records Days to calving Calving interval Milk production[d]
Heifer Pregnancy Rate	Pregnancy observations Scrotal circumference
Tenderness *(not relevant unless increased income received for more tender beef, e.g. niche markets)*	Carcass marbling score Shear Force US % intramuscular fat
Marbling Score (Quality Grade) at finish endpoint[e]	US % intramuscular fat Carcass marbling score Backfat thickness
Retail Product Weight at finish endpoint[e] *(current industry standard is yield grade)*	Carcass weight Rib-eye area Backfat thickness
Days to a Target Finish Endpoint Carcass weight endpoint Fat thickness endpoint Marbling endpoint	Carcass weight and age at slaughter Backfat thickness and age at slaughter Quality grade and age at slaughter
Feedlot Feed Requirements	Feedlot "in" weight, Slaughter weight Dry matter intake Average daily gain Relative feed intake
Survival to Market Endpoint	Disease treatment records Disposal/death records
Health/Disease Incidence	Health treatment records
Docility	Docility Scores

[a] Portions adapted from Golden et al., 2000.
[b] Indicator traits are measured to provide information to produce EPD for the economically relevant traits thereby increasing accuracy of those EPD.
[c] Sale weight is a category of EPD. The breeder should choose the appropriate economically relevant EPD that represents when calves from a mating will be marketed.
[d] Milk production will be measured using the maternal weaning weight (milk) EPD.
[e] Current carcass EPD are typically adjusted to an age constant basis, in the future, carcass EPD that represent the value of the carcass should be delivered in a manner that allows each breeder to select animals appropriate for their target market (e.g. Quality grid, muscle grid).

Birth weight and calving ease provide another example of the distinction between an economically relevant and an indicator trait. Does a one pound change in birth weight directly influence income or expense? Likely not, as that change may or may not result in increased/decreased calving difficulty. With calving ease, a 1% decrease (meaning 1 extra animal assisted for every 100 calvings) has a direct impact on profitability. Decreased calving ease results in higher labor costs, decreased calf survival (and fewer animals to sell) and delayed rebreeding for the cow resulting in younger and hence lighter calves at weaning the following year—all of which have a direct impact on profitability. Birth weight is an indicator of the economically relevant trait, calving ease.

The final example applies to those retaining ownership or receiving additional income by producing cattle with higher marbling scores. A one unit increase in marbling score has a direct impact on profitability through increased income. So what are the indicators for carcass marbling score? The most utilized indicator is percentage intramuscular fat (%IMF) as measured by ultrasound. This measurement can be taken on both male and female breeding animals at yearling age, long before any slaughter progeny are produced and harvested. The ability to measure this trait at an early age makes collection of ultrasound information very appealing. However, a one percentage point increase in percent intramuscular fat does not directly affect the profitability of the commercial producer. The commercial producer receives additional income from increased carcass marbling (there is a strong but imperfect relationship between carcass observations and ultrasound observations—a concept that is discussed further below), not increased %IMF in a breeding animal. The economically relevant trait is carcass marbling score and %IMF is an indicator that we only measure to add accuracy to the EPD for marbling score.

A *suggested* list of the economically relevant traits and their indicator traits is shown in Table 1. Sale weight is a unique case where the economically relevant trait is actually one in a category of traits. The economically relevant trait sale weight changes depending upon the marketing system, or the age at which animals are sold. The term "sale weight" was chosen as it represents all possible sale endpoints and necessitates each producer choosing which trait in the sale weight class is most appropriate. Some producers will sell weaned calves making weaning weight the economically relevant trait. Others might sell yearling cattle making yearling weight the economically relevant trait. Those producing grass fed cattle might choose 600 day weight as their economically relevant trait. In addition, most cow-calf producers sell cull cows adding another economically relevant trait, salvage cow weight, under the class "sale weight". Again, when identifying the economically relevant traits, the producer must identify when the animals are sold. If the breeder sells weaned calves, yearling weight is not the economically relevant trait. Table 1 is merely a suggestion of economically relevant traits and is in no means meant to be all inclusive. Different environmental challenges will likely introduce other ERT.

Realize that identification of ERT also depends upon the levels of performance within the herd. Consider two producers, one that has a system where all heifers calve unassisted and another that assists 75% of the heifers. Calving ease would not be considered an economically relevant trait for the first producer—there is no better performance than 100% unassisted calvings. The second producer however, would consider calving ease an economically relevant trait worthy of improvement

There are instances where traits can be both an indicator trait and an economically relevant trait. Cow weight is one example. Cow-calf producers sell cull, open cows on a weight basis and as weight of that cow increases, the value of that cow increases—a one unit change in cow weight directly influences income. Mature cow weight is simultaneously an indicator of cow maintenance feed requirements. As mature size increases, feed requirements tend to increase but a one pound increase in mature size does not always increase maintenance requirements. For instance, two cows weighing the same but of different body condition likely have different maintenance requirements. Milk is another example of a trait that could be both an indicator and an economically relevant trait. The milk production of the cow is directly related to the pounds of calf produced at weaning and therefore income from the sale of weaned calves, but it is also an indicator of cow maintenance requirements. Cows with higher milk levels tend to have higher maintenance requirements even when they are not lactating.

Again, by identifying the economically relevant traits, producers take the first step towards simplifying selection decisions by reducing the number of EPD to consider and focusing on improving performance in traits directly related to profitability.

Application to Currently Available EPD

Many ask why there are EPD for indicator traits that are not directly related to profitability. An indicator trait is measured for two reasons. First, the trait is related to an economically relevant trait, or put another way, the two traits are genetically correlated. As discussed in the chapter on genetic principles, genetic correlations represent the strength and direction of the relationship between breeding values for one trait and breeding values for another trait. From the standpoint of selection, another way to conceptualize a genetic correlation is to ask, "when selecting for improvement in one trait, such as weaning weight, how will other traits change?" For example, if selection decisions are made with the objective to increase weaning weight alone, birth weight will increase as well, due to the positive genetic correlation between the traits. This occurs because some of the genes that increase weaning weight also increase birth weight. Second, indicator traits tend to be cheap and/or easy to measure and the data may therefore be available for the calculation of EPD.

Information on indicator traits is important because the additional information adds accuracy to the EPD for the economically relevant traits. By increasing accuracy, the rate of genetic improvement in the economically relevant traits increases as should improvement in profitability.

The value of accumulating large amounts of indicator trait data on a sire or his progeny may be limited however. Physically measuring cow feed requirements or cow intake is nearly impossible, and in situations where it is possible, the techniques are cost prohibitive; however, cow weight, body condition score, and milk production (through the milk EPD) are easily measured. These three traits are indicators of maintenance feed requirements. Given the expense associated with directly measuring cow intake, we are limited to the use of these indicators for predicting feed requirements. In this scenario indicator traits and in the future DNA tests will be combined to calculate the EPD for cow maintenance feed requirements.

In other situations, the economically relevant trait as well as the indicators can be measured. Marbling score of slaughter animals and %IMF (percentage intramuscular fat as measured by ultrasound) in breeding animals are an example. Collection of indicator trait data such as %IMF is important at early ages but for the best accuracy of selection, data on the economically relevant trait, carcass marbling score, must be collected as well. An extreme example best illustrates this concept. Assume that the focus of selection is to improve carcass marbling score and assume that within the production system, or within the breed association, no actual carcass data are collected (historically this has often been the case). All available information is from the ultrasonic measurement of %IMF on breeding animals. Given that scenario, suppose a sire has been used extensively as an AI stud and has thousands of progeny with ultrasound observations. In this scenario if an EPD were calculated for %IMF on that sire, the accuracy of that EPD would likely be .99+. The %IMF EPD is for the indicator trait, however; but because there is a positive genetic correlation between %IMF and carcass marbling score (assume the genetic correlation is .80), the %IMF information can be used to calculate an EPD for marbling score, the economically relevant trait. In this scenario, where only ultrasound data are available, the accuracy of the marbling score EPD would only be .40. To increase the accuracy of the marbling score EPD, collection of actual carcass information would be required.

The previous example dealt with a sire with many observations from ultrasound measures, and a correspondingly high accuracy %IMF EPD, but no carcass data from progeny. Collecting data on %IMF is useful in early stages of a potential breeding animal's life as it can be collected long before offspring are born. This additional indicator trait data increases the accuracy of selection of young breeding animals. To attain high accuracy EPD for the economically relevant carcass trait (in this scenario, marbling score) collection of actual carcass data is imperative.

In situations where indicator trait data are used to calculate EPD for the ERT in multiple- trait models and where EPD are published for both the indicator trait and the ERT, the indicator trait EPD should not be used to make selection decisions. In this scenario, the indicator trait data have already contributed to the calculation of the EPD for the ERT, and "double counting" of the indicator trait data occurs if the indicator trait EPD is used as well as the EPD for the ERT. For instance, if EPD for birth weight and calving ease are available, only the EPD for calving ease should be used for selection purposes. Typically, the calving ease EPD is produced using birth weight and calving ease scores and the birth weight EPD is calculated using birth weight and subsequent growth observations. Birth weight observations have already been used to calculate the calving ease EPD, so if the birth weight EPD is used along with the calving ease EPD to make selection decisions, the birth weight observations are overemphasized.

The list of economically relevant traits in Table 1 is only a suggested list. In some production systems there may be other economically relevant traits. For instance, in altitudes over 6000 feet, high-altitude or brisket disease reduces survivability of genetically susceptible animals. At that altitude, another economically relevant trait would likely be susceptibility to brisket disease. Other breeders may have unique production systems that might require additional ERT.

Final Guidelines

By focusing on the economically relevant traits, producers can reduce the number of EPD they need to consider when making selection decisions. Not all breed associations produce EPD for economically relevant traits. Some associations may only produce EPD for birth weight and not calving ease, for instance. In other cases EPD for the economically relevant traits are still under development (e.g. days to a finish endpoint). Realizing these current limitations, here are some general guidelines for sifting through all of the available performance and EPD information.

1. Identify the economically relevant traits for your production and marketing system.
2. Make selection decisions based on EPD with the following order of preference for those EPD
    1. select using EPD for the ERT when available (EPD for indicator traits should not be used to make selection decisions when the EPD for the ERT is available)
    2. select using EPD on the indicator trait when EPD for the ERT are not available

    In the rare cases where phenotypic information is available but not EPD,

    3. select from within a herd on phenotype or ratios for the ERT
    4. select on phenotype or ratios for the indicator trait

When EPD are available for a trait, these are always preferable to phenotypic measures on individual animals as they account for an individual's, its relatives, and contemporaries' performance.

Conclusion

The ability to distinguish between economically relevant and indicator traits helps breeders reduce the number of EPD to consider when making selection decisions. Reducing the number of EPD upon which to make selection decisions increases the rate of genetic progress over a program that bases selection decisions on many more EPD. The EPD in this short list of economically relevant traits are all directly related to profitability, resulting in a genetic improvement objective focused on changing profitability.

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