Tools for Economic Improvement Beyond EPD

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Throughout this manual, the goal has been to improve the profitability of beef production through proper sire selection and genetic improvement. The first step in using genetic improvement to increase profitability is to identify the economically relevant traits (ERT), those traits that directly influence the sources of income and/or the costs of production. To make this identification, the producer must identify a breeding objective that details how they market their animals, the performance of their animals, as well as the role of their product in the industry.

Once the breeder has identified the ERT that are appropriate for their production system, there are typically a number of EPD to consider. Given that multiple traits likely need simultaneous improvement, an objective method for determining relative importance and economic value of each trait would further ease the animal selection process. To fully understand the utility and application of these advanced selection tools, breeders need a basic understanding of two concepts: 1. Single-trait selection and its weaknesses, and 2. Methods for multiple-trait selection which consider the production system but may not address the economic value of each trait. Understanding of these two concepts provides a foundation upon which to base improvements in selection methodologies. This chapter outlines the pitfalls of single-trait selection, considers different methods for multiple-trait selection, and ends with guidelines for use of selection tools for improving profitability of beef production.

Single- and Multiple-trait Selection

Single-trait selection can produce rapid genetic change. Consider how frame size has changed from the 1960's to now—originally moving from small animals to the large frame scores seen in the seventies and eighties, and back to the more moderately sized animals today. No doubt, selection works.

Unfortunately, single-trait selection typically results in undesirable changes in correlated traits as well. For instance, at the same time the industry was focused on changing frame size, mature weight and cow maintenance requirements were changing as well because they are genetically related, or correlated, to frame score. As a result, the single-trait selection for increased frame size resulted in greater feed requirements and eventually animals that were not well suited for many environments. Those not suited often ended up as thin cows, who were invariably late bred or not pregnant at all. Another unwanted change resulting from single-trait selection on frame score was an increase in birth weight and calving difficulty. All of these were the result of correlated response to single-trait selection on frame size. Single-trait selection is not advisable—breeders must approach genetic improvement holistically and from a systems perspective to change many traits simultaneously and achieve the goal of improved profitability.

Multiple-trait selection, considering more than one trait at a time, is the first step towards gaining a systems perspective, but even multiple-trait selection leaves the breeder with several challenges. First, as additional traits are emphasized in a selection program, the rate of improvement in any one trait decreases. Second, the unfavorable correlations between many traits are still present. For instance, there is an unfavorable genetic correlation between calving ease and weaning weight, both of which are ERT in many production systems. Calving ease tends to decrease as weaning weight is increased. This introduces a new problem—which of these two traits should be emphasized most in a genetic improvement program? These two problems are difficult to overcome without more sophisticated multiple-trait selection tools.

The best methods for evaluating a genetic improvement program's effects on profitability also consider the effects of time. The length between the selection decision and payback resulting from that decision often spans many years, and in a perfect system, the potential effect on profitability would be evaluated before the selection decision is made. Take the example of a breeder who is selling weaned calves and retaining a portion of the heifers as replacements; the sale weight ERT is weaning weight, but weaning weight is positively (and unfavorably) correlated to mature weight, an indicator of cow maintenance requirements. Selection for increased weaning weight will increase mature size, thereby potentially increasing the overall feed requirements of the herd over time and in turn, increasing costs of production. This scenario illustrates the need for selection decisions and genetic improvement goals to be evaluated in the context of the complete timespan for ramifications of the selection decision. Many producers do not consider the long-term effects of a selection decision, but rather consider what that particular sire will add to next year's calf crop. As an example, increasing weaning weight can increase revenue but could lead to a corresponding increase in mature cow weight of retained heifers; the latter will not be observed for several years, while the increase in sale weight could be realized in the first calf crop.

From an industry-wide perspective, the potential impacts from a single selection decision made by the seedstock breeder requires considerable time before those gains are realized by the seedstock breeder's commercial customer, as illustrated in Figure 1. The seedstock breeder makes a selection and mating decision in spring; the offspring are born the following year and weaned. Bull calves are selected for development in that same year. In year 3, the bulls chosen for development are sold and used in the commercial herd. The offspring of these commercial matings are born in year 4. If those offspring are sold as weaned calves; the first income for the commercial producer arrives 4 years after the seedstock breeder's original selection decision. If the commercial producer retains ownership of the calves, the first income may not be realized until year 5. Therefore, seedstock mating decisions made today will not have an economic impact on commercial producers for at least 4 years and maybe longer depending on the trait, management practices, and marketing scheme.

The illustration in Figure 1 does not begin to consider the long-term effects of replacement females kept in the seedstock or the commercial herd. Assuming cows may reach 12 years of age before being culled, the original selection decision in year 1 may influence calves produced 16 years after the seedstock breeder's original decision if we consider the female replacements. As will be outlined below, good selection decision tools consider the long-term effects of selection decisions.

There are a variety of traditional methods for multiple-trait selection, many of which are implemented by producers, although they may not use this terminology to identify their methods. Each method has strengths and weaknesses.

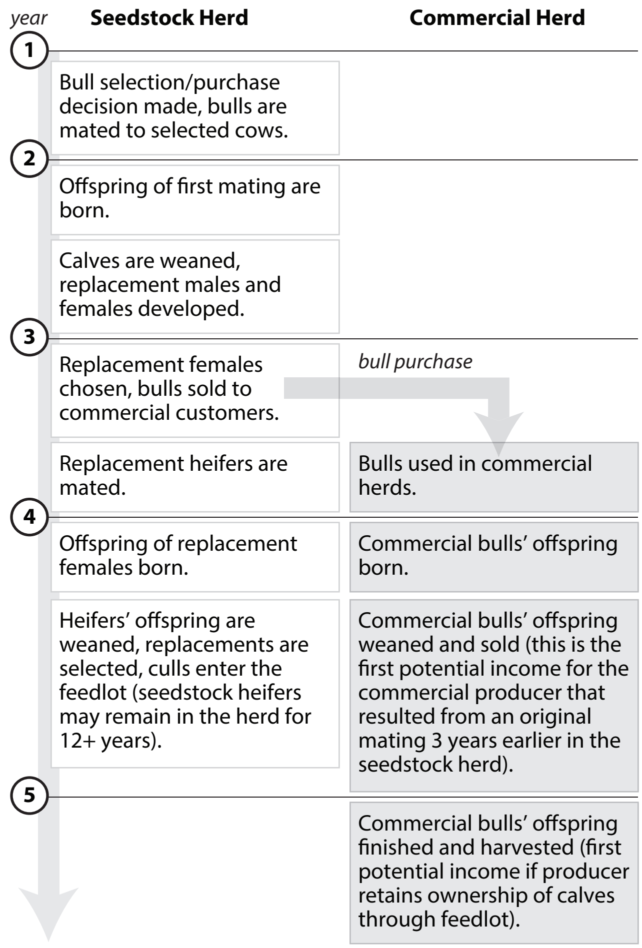
Multiple-trait Selection Methods

Tandem selection. Perhaps the simplest method for multiple-trait selection is tandem selection. With this method, just like a tandem axle truck or trailer, selection for one trait is followed by selection for another trait. All selection pressure is put on a single trait of interest until the performance of the herd reaches a level that the breeder desires, at which point another trait upon which to focus selection is chosen. For instance, a breeder may put all emphasis on improving marbling until a target level for percent choice is attained. At that point, the breeder realizes that performance in another trait, such as growth, needs improving and subsequently changes selection focus from marbling to growth. This method is rarely used in a strict sense because selection on one trait can produce unfavorable change in correlated traits as we discussed earlier. As a result, maintaining acceptable production levels for all traits is difficult with this method.

Independent culling. The second and likely most common method for multiple-trait selection is independent culling. With this method, a breeder chooses minimum or maximum levels for each trait that needs to be improved. Any animal not meeting all criteria is not selected for use in the breeding program. To illustrate, consider a herd where the average weaning weight EPD is +25 and the average calving ease direct EPD is +3. If the producer is interested in improving weaning weight but does not want to increase calving difficulty, that producer might set a minimum threshold of a +35 WW EPD and a minimum CED EPD threshold of +3. Any potential sire not meeting both of those criteria would not be selected. Clearly, there are more than just two important traits as in this example, and accordingly as additional traits are added, culling levels are set for each. This method is widely used due to the ease of implementation. Most breed association websites provide tools for sorting bulls on EPD with a user-defined set of standards (minimum and/or maximums). Using these web-based tools is analogous to implementing the independent culling method of multiple-trait selection.

Determining the appropriate culling level or threshold for each breeder is the most difficult aspect of this method as objective methods for identification are not widely available. Another drawback of this method is that as additional traits are added, criteria for other traits likely must be relaxed in an effort to find animals that meet all criteria. In the above WW/CED example, consider adding another trait such as marbling score EPD. If the breed/population average is +.06, the breeder might want to select only sires with a minimum marbling score EPD of +.5. To meet this marbling score standard, the weaning weight standard may have to be lowered to +30 (from the original +35) and the calving ease lowered to a +2 (from the original +3). This "lowering of standards" reduces the rate of progress in any one trait, similar to other multiple-trait methods. However, once thresholds are identified, application of this method is very easy, making this method quite popular.

Figure 1. Timeline illustrating time for the commercial producer to realize effects on profitability from a selection decision made in the seedstock supplier's herd.



One major disadvantage to both tandem selection and independent culling is that neither of these methods objectively incorporate the costs or income value associate with a unit change of each trait—they do not account for the economic importance of each trait, and as a result do not simplify the evaluation of potential replacements based on probable effects on profit. The foundational method for overcoming this problem and for incorporating the economics of production into selection decisions and genetic improvement was developed by Hazel (1943) and is commonly referred to as selection indexes.

Incorporating Economics Into Multiple-trait Selection

Hazel developed the concept of aggregate merit which represents the total monetary value of an animal in a given production system due to the genetic potential of that individual. Henderson (1951) reported that the same aggregate value could be calculated through weighting EPD by their relative economic value. These EPD, weighted by their relative economic values are summed to produce the aggregate value for each individual. It is important to differentiate between the "objective," or "goal," and the selection criteria, or index. The goal traits represent a listing of ERT that are drivers of profit for a particular breeding objective. These may or may not have associated EPD. The selection criteria represent the traits that can actually be selected for (i.e., have EPD). These two lists of traits, the goal and the selection criteria, need not be identical. In other words, it is possible to make progress toward a specific goal without EPD for each of the goal traits. This requires that the EPD in the index, if not the goal traits, are genetically correlated or indicators of the goal traits.

Historically, the greatest challenge for the delivery of these indexes has been the determination of the economic values for weighting the EPD (or traits). The economic value for an individual trait is the monetary value of a one-unit increase in that trait, while other traits directly influencing profitability remain constant. For instance, the economic weight for weaning weight would be the value of a one-pound increase in weaning weight, independent of all other traits, or put another way, the value of a one-pound increase in weaning weight holding all other traits constant. This may seem relatively straightforward, but problems arise in the ability to accurately assess value and changes caused by genetic correlations. Relative to assessing the value of a one-pound increase in weaning weight it must be recognized that increases in weaning weight result in increased feed requirements, partially offsetting the increased income from the greater weaning weights. Accounting for these increased costs and revenue from improved weaning weight to derive the economic value is difficult at best.

The estimation of the relative economic values requires detailed economic information on the production system. Because costs of production change from producer to producer, these economic values also change from producer to producer. In some regions, breeders may have access to relatively cheap forages or crop residue during winter whereas others may be forced to buy relatively expensive, harvested forages to maintain the cow herd during these forage shortages. In these two scenarios, the value, or cost, associated with increases in maintenance feed requirements are not the same. The difficulty in obtaining detailed economic and production information from individual breeders has resulted in the development of generalized indexes that use information from surveys of groups of producers and/or governmental statistics on prices received and costs of production generally averaged over some period of time. While this is a very good alternative to breeder-specific indexes, the use of this generalized information can result in misleading economic weights from one production enterprise to the next. For instance, the relative economic value of calving ease depends upon the current levels of calving difficulty in a herd. Consider an extreme example: if one producer assists no heifers during calving and another has a 50% assistance rate, the former would have a relatively low economic value for improved calving ease as current levels warrant no additional genetic change, whereas the latter producer would put considerable economic value on genetic improvement of calving ease. A result of the requirement for detailed economic and herd performance information has produced low adoption rates for many breeder-specific (customizable) indexes. Although generalized indexes are a very reliable proxy, many breeders are reluctant to use them because they feel indexes remove control over the direction of genetic change in their herd and that the economic assumptions might not be germane to their production system. Simply put, indexes take the "art" out of animal breeding.

Even with low adoption rates, those breeders and producer groups that have chosen to implement indexes have witnessed rapid genetic and economic improvement. There are two documented examples of the genetic improvement resulting from the implementation of this technology. The first of these was reported by MacNeil (2003) and was based on an index of

I = yearling weight – (3.2 * birth weight)

as proposed by Dickerson et al. (1974). This index was designed to improve the efficiency of beef production by 6% as opposed to selection on yearling weight alone. The index was calculated to reduce increases in birth weight and associated death loss resulting from the increase in birth weight and to simultaneously reduce increases in mature weight and feed requirements usually associated with increasing yearling weight. After 11 years of selection based on this index, MacNeil et al. (2003) reported positive genetic change in direct and maternal effects on 365-day weight and a negligible, slightly positive change in birth weight. MacNeil also implemented independent culling levels for birth weight and yearling weight in another selection line. The independent culling line exhibited no increase in birth weight, but the increase in yearling weight was only half of that achieved with index selection (MacNeil et al., 1998).

Selection index methodology is also used in many other animal industries including the pig, poultry, and dairy industries. In the swine industry, application of these technologies in one breeding program has resulted in nearly $1 more profit per head marketed per year (Short as quoted in Shafer, 2005).

Application of Selection Index Methods in North America

In North America, the majority of breed associations publish index values for a variety of production systems. These include general-purpose and terminal indexes. Within each category, the specificity of the available indexes varies. At one end, a "generalized" index is meant to fit the needs of all members of the group (or breed). At the other end of the spectrum are indexes designed for use in specific production systems with specific production costs, revenue streams, and performance levels. At the extreme, this end of the continuum results in a specialized index for each breeder's specific production system, so that a seedstock producer might have a different index appropriate for each of their customers' production systems, hence the term "specialized." Most published U.S. beef breed association indexes are generalized—some more than others. Hereafter the term "generalized" index will be used to refer to an index that is designed for use across multiple breeders for specific marketing situations. It is beyond the scope of this manual to review every index currently published, and with the anticipated release of more indexes by several associations, such a discussion would be outdated very quickly after publication. This discussion will be limited to "points of consideration" to be used when evaluating strengths and weaknesses of association-provided (generalized) indexes and how to decide whether to implement selection on a particular index or not.

The first step is to identify the most appropriate index for a particular breeder or production system (or your production system). To successfully execute this step, the breeder must have identified the primary use of their animals (breeding or harvest). If the breeder is a seedstock producer, they should be considering how their customers, the commercial producers, will be marketing the offspring of the animals the seedstock breeder wishes to sell. If the breeder is a commercial producer, they must consider how the offspring of those sires will be marketed. The age at which those offspring will be marketed, and the end purpose of those market animals are also important considerations. For instance, different traits will likely be emphasized if animals are sold at weaning, sold at the end of the feedlot phase, or retained for breeding. Essentially, identification of the appropriate index starts with the identification of the economically relevant traits for that producer's production system (as outlined in the previous chapter) and is followed by selection of the index that includes those economically relevant traits, or their appropriate indicator traits of EPD for the ERT are not available. Just like using the ERT to reduce the amount of information that must be considered when making a selection decision, the goal of any index is to combine EPD to make selection more straightforward. Use of an inappropriate index may not produce genetic improvement that yields greater profit.

The other important component necessary to choose the appropriate index is consideration of the current genetic and production level of the herd. For instance, if replacement heifers are kept from within the herd, do they have as high conception rates as yearlings? What percentage of calving difficulty does the herd experience? Knowledge of these production characteristics helps determine the appropriate index and helps determine whether (as will be discussed below) other criteria should be included in making selection decisions beyond the index.

Use of Indexes

In comparison to how long EPD have been available, the development and application of indexes in the U.S. beef industry is relatively new and as a consequence the use of indexes in the beef cattle industry is not as widespread as in other livestock industries. Admittedly, there are other criteria to use when selecting sires. For example, there are critical thresholds that must be met to ensure that a bull can pass on his genetics. Candidate sires should be sound, meaning that they have passed a breeding soundness exam and have adequate foot and leg structure to travel and breed cows. Once these phenotypic thresholds are met, identifying an appropriate index and using it is key.

Indexes are designed to increase net profit. In order to accomplish this, producers must select the appropriate index to use based on their own breeding objectives. Below are three critical considerations to determine which index is the most appropriate.

Retention of replacement heifers. If replacement heifers are to be retained, the index used should make this assumption. The index should include maternal traits such as calving ease maternal (or total maternal), milk, female fertility traits (e.g., heifer pregnancy, stayability or sustained cow fertility), and some proxy for feed consumed by the cowherd (e.g., mature cow weight). If replacement heifers are not retained, a terminal index should be used. A terminal index would include traits related to growth and carcass and would not include any maternal traits. Using a terminal index when replacement heifers are retained not only ignores maternal traits but could also lead to increases in mature cow size given the emphasis placed on post-weaning growth.

Sale point of terminal calves. Even if replacement heifers are retained, some fraction of calves (steers plus cull heifers) will be sold. Some producers may sell calves at weaning, while others may background calves, and others retain ownership through the feedlot phase. Ideally, the index used would mirror the sale point of the producer. Even in the case when calves are sold at weaning, post-weaning growth and carcass traits should not be ignored. Selling calves at weaning that are profitable in the post-weaning phase help to create future demand for feeder calves.

Breeding heifers. If producers are exposing bulls to heifers, some degree of attention should be directed to calving ease. The amount of emphasis placed on calving ease direct in this situation is related to both economic considerations and the producer's tolerance to risk. Regardless, an index that places some emphasis on calving ease direct should be used. If this is not possible, then calving ease EPD should be used in addition to the chosen index.

Once the appropriate index has been selected, strict application of the index system would necessitate that sire selection decisions be made solely on this information. However, there may be economically relevant traits not in the index. For traits not in the index, the breeder will need to apply appropriate selection pressure to EPD in addition to the index. An example might be breeding heifers for the production of terminal calves. If the terminal index does not contain EPD for calving ease direct, then the breeder should use both the terminal index and calving ease direct EPD to select bulls.

Breeders often ask about the risks associated with using an index that weights traits using economic parameters that might differ from the economic values experienced by a particular breeder or enterprise. Fortunately, small errors or differences in economic weights are likely to have little effect on overall genetic improvement provided no single trait dominates the index (Smith, 1983; Weller, 1994). Problems arise when a single trait dominates an index and large changes occur in the importance of that trait. Indexes are generally robust to differences in economic assumptions given it is the relationship between cost and revenue, and resulting relative importance, that are important. If two indexes include the same set of EPD but use different economic assumptions, the correlation between the two indexes (or rank of animals using the two indexes) is expected to be high.

Another issue not addressed in the above that may arise with the release of multiple, generalized indexes by a single group (i.e., breed association) is the potential for "double counting" and overemphasizing a particular trait. For instance, let's assume an index is being used that is appropriate for a cow/calf operation marketing weaned calves, and retaining replacement females and the index accounts for changes in feed requirements in the cow herd. If the breeder then also selects on another index that also accounts for genetic changes in feed requirements, the breeder could be overemphasizing the importance of feed requirements. In this case, it would likely result in over-penalizing animals with greater growth potential. If the breeding goals are vast (i.e., raising replacement females and selling terminal offspring) then a general-purpose index that matches this objective and includes terminal and maternal traits would be recommended. Again, selecting the single most appropriate index, is the best approach for implementation of this technology.

Conclusion

The goal of selection indexes is to ease the process of multiple-trait selection and to combine the economics of production with selection to improve profitability. The successful use of selection indexes depends upon choosing an index that most closely mirrors the breeding objective of a particular enterprise. Selection of the appropriate index is key to success.

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