How best to achieve genetic change?

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Introduction

Genetic *change* is easy to achieve through selection. Selection typically leads to simultaneous change in a number of traits with not all traits changing in a favorable direction. Genetic *improvement* is much harder to achieve than genetic change. It requires the aggregate economic value of positive and negative changes in individual traits to be favorable, and greater than the costs of recording and evaluating animals.

Genetic improvement doesn t come about by chance. It doesn t come about from the act of pedigree and performance recording. It doesn t come about simply from the creation and distribution of sire summaries. Genetic improvement at an *enterprise* level comes about when those in a position to undertake selection have clear *goals* and access to relevant *tools*. Genetic improvement at *industry* level depends upon improvement at the *enterprise* level and relies further on *market signals* being transmitted along the lengthy and circuitous chain from the consumer through the packer, feedlot operator, backgrounder, cow-calf producer to the seedstock breeder.

It is easy to demonstrate genetic *change* has occurred in the beef cattle industry in recent years. Many sire summaries include graphs of genetic trends in individual traits such as weights at various age, scrotal circumference and calving ease. It is apparent there has been considerable emphasis on liveweight. Selection for liveweight has tended to: increase growth rates and weight at almost any age, including birth weight (with increased calving difficulty) and mature cow size (with increased maintenance feed costs) while reproductive performance has decreased. Unlike some other livestock industries the impact of these changes on profit is not immediately apparent, nor has it been repeatedly quantified and communicated. What has been the aggregate value of these changes on the cow-calf and other sectors? How does the value of these changes compare to the costs that were incurred in obtaining it? Who paid the costs and who were the greatest beneficiaries of these changes? A leading edge industry should know the answer to these questions.

Where have we gone wrong ?

One explanation for our current circumstances is that we have developed tools such as EPDs without an agreed *vision* for the nature, scope and responsibility for delivery in the *long term*. We have delivered EPDs in a knee-jerk fashion — first for weaning and yearling weight because data were easily collected. Later we added birth weight and then calving ease because selection for growth led to an increase in the incidence of difficult births. Then we added scrotal circumference to try (but fail) to arrest the decline in

reproductive performance. Along the way we added other traits such as temperament, carcass and various ultrasonic measurements. We developed these evaluations because we knew how to do them, had the data and we failed to see the unintended consequences of selection on some of these characteristics because we did not have the time or the money to research them properly before their delivery to industry. The industry became the guinea pig and suffered some of the consequences of premature adoption. We concentrated on statistical problems in evaluation and in computational procedures for setting up and solving equations and did little to assist breeders and producers in quantifying the ramifications of using our evaluations in their selection. If we had our time over again, we would probably all make the same mistakes. But at CSU we have a vision to change some of this in the future. We will be heavily reliant on Federal funding support from the National Beef Cattle Evaluation Consortium. The degree to which the industry is ready to get behind and contribute to these efforts is also yet to be tested but we are motivated to try.

Current use of EPDs

Many producers have admitted using EPD systems to ensure that they do not unintentionally change various attributes of their animals while selecting for one or more traits they recognize as having particular importance. Pedigree and performance recording is a costly enterprise, and is largely a wasted investment if its main use is to avoid selection. No doubt, producers have been burnt in the past when selection for certain attributes has led to unintentional deterioration in other attributes.

What can we do better ?

Developing selection objectives. First, we need to remind ourselves that EPDs are a means to an end and not an end in themselves. A logical approach to animal improvement must begin with the goal, then the development of a breeding objective that reflects the list of traits that influence the goal and thereby identifies the characteristics which we need to measure on our animals. We don t want to think in the other direction (as we have in the past), starting with some characteristics we can measure, generating an EPD and then hoping its addition will make our toolkit more valuable. We want to design the tools we need for the job, rather than limit our job to the tools that happen to be available today.

There are few tools in existence that can assist a producer with a defined goal to identify their breeding objective. There are no such tools readily available for use in the US beef industry. Despite the existence of considerable knowledge of the economics of cow-calf operations, backgrounding systems, feedlot finishing and packing plants, none of this information is readily available in a format that will assist a producer in identifying the list of traits and/or their relative emphasis for use in a breeding program. We would like to change this. We have started this work in relation to researching some prototype days to finish EPDs. These EPDs reflect the fact that finishing costs are most closely related

to the number of days an animal spends on feed, to reach some desired weight, fat or marbling endpoint. It appears that the value of particular weight, fat and marbling EPDs can vary notably depending upon the management of the cattle with respect to the finish endpoint.

Predict phenotypes rather than progeny differences (PDs). Consumers gain satisfaction from phenotypes, not EPDs. Decision makers are usually more comfortable interpreting phenotypic performance than interpreting EPDs. When we analyze pedigree and performance records, we obtain estimates of various effects, including effects of age, contemporary group and genetic effects. We have grown accustomed to using estimates of only two of these effects, namely direct and maternal breeding values, expressed as EPDs to communicate the results of our endeavors. The invention of EPDs was a clever discovery to communicate, for a particular trait, the effects of a sire in respect to the performance of his offspring. This works very well for the direct effect of a trait such as weaning or yearling weight but is more difficult to interpret for maternal characteristics or for some of the more recently developed rate traits such a heifer pregnancy or stayability. What would be more helpful, would be to use the knowledge of the effects from the mixed model analyses along with any other available knowledge to predict the phenotypic performance that will likely result from the use of particular sires in your herd with your production and management circumstances. Then this information will allow the ramifications and economic implications of the use of particular sires to be more readily assessed and taken into account by the breeding decision makers.

For example, suppose we select for a weight trait such as yearling weight. This is likely to result in a correlated increase in mature cow weight and in cow maintenance requirements. If we keep the size of our breeding cow herd constant, we have increased our total feed requirements. In a grazing scenario, if we had surplus feed available to support these larger cows we must have previously overlooked a management opportunity to increase cow numbers. Selection is a slow and inefficient method to make changes that could more quickly be achieved by changing management. If our stocking rate or carrying capacity was previously optimized, then it will be necessary to reduce cow numbers or introduce more supplementary feeds into the system in order to properly feed our improved herd without compromising the environment. Most breeders and producers are not in a position to readily determine the correlated response in mature weight following selection on yearling weight, nor can they easily determine the implications to annual or seasonal feed requirements. We should be taking advantage of the knowledge of other animal scientists, such as nutritionists, and incorporating their models in concert with our evaluation systems. Such plans are behind our drive for a maintenance EPD and the construction of days to finish EPDs.

As another example, consider the interpretation of stayability EPDs. Stayability relates to the proportion of first-calf heifers that are still present in the herd at age six. An average stayability is about 50%. A positive EPD for stayability reflects the presence of genes for an increased ability to repeatedly avoid voluntary and involuntary culling. A bull with an EPD for stayability of 5% is expected to have, on average, 5% more of his daughters still present in the herd at age six. Clearly a positive EPD is favorable and stayability is likely

to have a significant impact on herd profit. But what are the actual ramifications of using a bull with a 5% EPD in your herd? What does such a rate EPD mean in terms of income and costs. If this question cannot be readily answered, how can one expect to rank animals for the combined effect of stayability and some other trait, such as liveweight or calving ease? Realistically, the interpretation of stayability relies on knowledge of the current herd age structure in order to determine the age structure at various times in the future as a result of using bulls with better or worse stayability EPD. The age structure will influence the average sale weight of the calf crop as cow age has a significant influence on weaning weight. The age structure will influence the annual requirement for replacements and the number of cull cows. The sensible approach to assessing the impact of stayability is achieved through the use of a computer-based decision support tool that allows the user to view the age structure of their herd and the likely (phenotypic) inputs (eg feed requirements) and outputs (eg sale animals) that are expected on an annual basis. Such a decision support tool should preferably be delivered via the world-wide web.

Web delivery. Web delivery of decision support tools will enable transparent on-line access to sire summaries and customization of the information that is displayed from those summaries. With an ever-increasing list of EPDs, it makes no sense to overwhelm the bull breeder or bull buyer with this information. The information age should make bull selection easier, not more difficult. A tiered system of information delivery should allow the user to focus on the traits of most interest to them, but still allow access to any other supporting information available on an individual.

Web delivery facilitates the prototyping of new EPDs and can speed up the rate at which these are rolled out to the industry. Some of the new EPDs can be presented in many different ways and it requires some degree of trial and error to identify the approach that make the most sense to users. Some producers may find value in calculating functions of EPDs, for example, calculating a postweaning gain EPD from the difference between the yearling weight and the weaning weight EPD. A maintenance energy EPD could be calculated as a function of various weight and condition score EPDs. An economic index of two or more EPDs can be obtained by multiplying each EPD by its relative economic value. All of these operations are difficult to achieve using paper-based sire summaries, but are straight forward on a web-based delivery system.

Web delivery allows graphical methods of displaying EPD information. It is very difficult to rapidly inspect a variety of numerical values from a published table but the same information displayed in bars or some other graphical form can be quickly interpreted.

One of the recently popularized approaches for analyzing longitudinal data such as weights taken at various stages of life is by random regression. This procedure has the advantage that weights from any age can be included in analyses and improve the accuracy of predicting weights at other ages. Furthermore, the solutions can be used to predict the weight of an animal at any arbitrary age, or the model can be fit in a manner that enables prediction of the number of days an animal will take to reach a particular

finish endpoint. This approach might generate far too many EPDs to be published in printed form, but would provide ready customization for different users via an online web-based delivery system.

Most sire summaries and animal breeding courses go into some detail to discuss the interpretation of EPD accuracies. The calculations and formal interpretation of accuracy are not straightforward for the average user. Web delivery of EPDs allows visualization of EPD accuracy, for specific traits and/or specific bulls.

Account for breed and crossbred effects. Every animal breeding undergraduate class has been taught for many years that the performance of outcrosses between animals of different breeds will be influenced by heterotic effects as well as by the proportion of genes represented from each of the breeds. Numerous studies have been undertaken in recent decades to determine breed and heterosis effects, for example the successive phases of the MARC germplasm evaluations. In order to predict the future performance of any such crosses, it is necessary to add the breed effects, heterosis and relevant EPDs for each trait of interest. Notwithstanding the difficulties of breed by environment interaction in extrapolating results to your own herd, there are currently no readily available decision support tools that combine the available information on selection and crossbreeding in a way that aids objective decision making.

Summary

Over the last three decades, breeders have been provided with better tools to describe the likely performance of offspring with respect to some attributes of their cattle. However, the scope of available tools is far short of existing scientific knowledge. An opportunity exists to capture current knowledge and make it more accessible to decision makers in the context of selection. This includes knowledge relating to feed requirements, finishing characteristics, heterosis and breed effects (among others) in a production systems setting. Web delivery is critical to making such new tools available to bull breeders and bull buyers in a cost-effective manner. Colorado State University, along with some of its Center for Genetic Evaluation of Livestock (CGEL) clients and the National Beef Cattle Evaluation Consortium, has begun developing and implementing such a vision.