*To improve a breed or herd or an individual offspring, the first thing to be considered must be the component parts of net worth or value. The successful purebred breeder must know how to evaluate and select for those components, those traits that are responsible for his product's value.*

**Second in a series designed as a guide to basic genetics.**

# Genetic Improvement Trait Evaluation and Selection

by Thomas B. Turner, Ph.D.
Darrell L. Wilkes

The economic value of a beef animal or a beef herd or of an entire breed is based on the sum total of several traits. To consider improving a breed or herd or individual offspring we must first look at the component parts of net worth or value that we are going to call traits.

There are many traits that are important to the beef cattle producer. Among these are reproductive ability, soundness, growth rate, feed efficiency, breed character and many, many others. Our success in improving any of these traits depends in part on our ability to measure them accurately.

Some traits are measured objectively and some subjectively. A trait, for example, like type score is generally considered to be a subjective trait in that it is one man's opinion. Whereas we could consider hip height an objective trait; that is, one man's measurement of hip height should be very close to another man's measurement of the same hip.

**Process of Establishing Goals**

Evaluating traits and deciding which ones to incorporate into a breeding program, in essence, becomes the process of establishing goals for breed or herd improvement. Since the purpose of seed stock development is for use in the commercial beef industry, goals should be consistent with the economics of beef cattle production. Let's examine what makes a trait important and how we might establish the relative emphasis it should receive in a breeder's herd.

**1. Heritability**—What an animal appears to be is a combination of its genotype or genetic makeup and its environment. The relative agreement between phenotype (appearance) and genotype is measured by the coefficient of heritability or simply heritability ($h^2$). This applies of course to a particular trait. Since we do not actually know the genotype of an animal for such complex traits as weaning weight, yearling weight or frame score—to name only a few—we must rely on records of relatives to estimate heritability. For example, paternal half sibs are expected to have one-fourth of their genes in common. Given this, we use statistical methods for determining the degree to which these paternal half sibs resemble one another compared to the degree of resemblance between unrelated individuals (for some particular trait).

Unfortunately, a reliable estimate of heritability is obtainable only from very large contemporary groups and then only when a large number of sires have been used (in the case of a paternal half sib analysis). This leads to the result that most of us cannot obtain accurate heritability estimates in our own herds and consequently must rely on "canned" estimates. In most cases, however, these so-called "canned" estimates are not too far off and can be used with a reasonable degree of confidence.

We will discuss in a later article the reasons why heritability estimates may be different in different herds. For the time being, we need to give a partial listing of heritability estimates and describe how they can be interpreted.

**Heritability Estimates**

| | |
|---|---|
| Female Reproduction | 10-20% |
| Weaning Weight or Mothering Ability | 20-25% |
| Gain After Weaning | 35-40% |
| Yearling Weight | 40-50% |
| Feed Conversion | 30-35% |
| Carcass Cutability | 25-30% |
| Quality Grade | 25-30% |
| Mature Weight | 60-80% |
| Skeletal Size | 60-80% |

Interpretation of these estimates is straightforward. As a lead in, the following is one of our favorite exam questions for undergraduate students in animal breeding: "If the average yearling weight in a herd is 1,000 lb. and heritability for yearling weight is .50, is it proper to say that 500 lb. are due to genetics and 500 lb. are due to environment?".

Most of us have the intuitive notion that this is not a proper interpretation. What is the proper interpretation? We should say that 50% of the *difference* between any two animals, or between an individual and the average of the group, is due to genetics and 50% is due to the environment (when $h^2$ = .50).

Although we will discuss heritability in more detail in later articles, we now have the background to pose a very important question: Should we try to improve traits that are lowly heritable? This brings us to our next consideration.

**2. Economic Value**—Certainly, in deciding whether a trait is important or not and then determining the relative emphasis it should receive we would first ask what the economic value of the trait is. From the preceding table we can see that estimates of heritability for reproduction are low, but certainly we know that the economic value for reproduction is high. So, this trait should probably still be considered for improvement.

We also know that weaning weight has economic value because gains made during the nursing period are generally inexpensive when compared to those during the feeding period. Post-weaning gain is also economically valuable because of high cost of production which involves interest, labor, etc. Also, fast gaining cattle are generally more efficient or have better feed conversion.

Improvement in carcass cutability should save money because depositing additional fat is an expensive, wasteful process. Quality grade under today's marketing system has an obvious economic benefit. Increasing mature size has a negative economic value because of increased maintenance costs. This is not to say that the smaller the mature size the better, but simply that we would like to increase weaning and yearling weights without offsetting that progress by having to feed bigger cows.

There are also some traits that may have economic value to some breeds or particular breeders but may not be justified in the commercial beef industry. An example here would be a breed color pattern. Improvement of such a trait may help sales or marketability within a pure breed but does little to improve the profit picture in the industry as a whole.

**3. Genetic Correlation**—When selection for one trait causes a change in another trait, we can say that they are correlated. The genetic correlation between two traits is the correlation between gene effects influencing them. To put it another way, when two traits are affected by some of the same genes we say that they are correlated genetically.

Genetic correlations may be either positive or negative and either of these cases can be good or bad. For example, we know that as we improve yearling weight we will also improve weaning weight. Therefore, we might choose not to include weaning weights in a selection program that included yearling weight. On the other hand, we know that improving yield grade will probably reduce quality grade and that improving yearling weights will increase birth weights and mature weight. Both of these put us in a bit of a dilemma. How to handle these problems will be discussed under selection systems.

Knowing about genetic correlations should help us to decide whether we need to include a trait in our selection program and how much emphasis it should receive. The following table has the average genetic correlations among several traits.

**Genetic Correlations**

| | Birth Weight | Weaning Weight | Feedlot Gain | Yearling Weight |
|---|---|---|---|---|
| Birth Weight | 1.0 | .58 | .56 | .64 |
| Weaning Weight | .58 | 1.0 | .58 | .69 |
| Feedlot Gain | .56 | .58 | 1.0 | .86 |
| Yearling Weight | .64 | .79 | .86 | 1.0 |

*Petty & Cartwright 1966*

**4. Amount of Variation**—The amount of progress that can be made in any trait is dependent upon the amount of variation present. The difference between the selected animals and the herd average is called selection differential or reach. The greater the selection differential, the faster the progress. This is discussed in much more detail in the next article which deals with the rate of improvement.

**5. Current Levels of Performance**—In deciding whether to include a trait in our selection program we must also decide if it needs improvement. Perhaps quality grade has always been excellent in your herd. Then there is little reason to try to improve it. If you've had no problems with structural unsoundness then its selection should not be included. The conscientious breeder will certainly want to keep a watchful eye on any changes or trends which may be occurring in these traits although their inclusion in making selection decisions may not be important.

We'll see later that the greater the number of traits in a selection program, the less the progress is for each. So, if any trait is at an acceptable level of performance, a good hard look should be given before including it. All five preceding factors should be considered in determining the relative emphasis a trait should receive, or indeed, whether it should receive any emphasis at all. These decisions can only be made by the breeder himself in reference to his own program. The fact that several respected breeders boast of their selection for a particular trait is not justification for doing the same.

### Selection Systems

Now that each trait has received a thorough examination and a decision has been made as to which ones should be improved, the next logical step should be a look at ways to make improvement in these traits. We will look at three selection systems that allow us to improve more than one trait.

The first of these is called tandem selection. Here the individual traits are improved successively. Trait A is improved first, then trait B, and so on. This is really single trait selection. No emphasis is placed on B or any other trait while selecting for trait A. Many breeders have adopted this principle in that for a period of time most of their emphasis is on one trait until a reasonable level is achieved after which other traits receive attention.

The progress made by tandem selection can be misleading. For example, if you select for trait A for five years, trait B for five years and trait C for five years you must realize that the progress made in any one of these traits, while it may seem astonishing at the time, has actually taken not five years but, in effect, has taken 15 years. Secondly, if the traits you are selecting for show negative genetic correlations between one another, the final analysis may show that no progress at all has been made in any of them. In the pure form tandem selection is not utilized very much in the industry. Most studies show this to be the least efficient of the three methods we will discuss.

### Independent Culling Levels

The second method is independent culling levels. This means that for an individual to be selected it must meet certain minimums for several traits. This minimum is independent between traits. For instance, a breeder could demand that bulls weigh 700 lb. at weaning and 1,100 lb. at a year. If a bull then, is less than 700 lb. at weaning, he will be rejected regardless of his yearling performance.

This selection system tends to decrease the intensity for any one trait. The more traits included, the less the intensity for any one. Indeed, when a large number of traits are considered many average individuals are kept while an individual exceptionally outstanding for one trait may be disregarded because it measures slightly less than the minimum for another trait.

Another problem with this system is that it considers all traits alike when we know that each is different in its economic importance, heritability and so on. There may even be an unfavorable genetic correlation between some traits. This basic system is, however, what most breeders use. Most make modifications in their own self-imposed minimums to avoid disregarding otherwise excellent individuals. In doing so, some objectivity is lost because we are not certain that we have been equally considerate of other close cases; also this is *approaching* the most desirable selection system known as index selection. While these mental adjustments may not be based on any real numbers, they are a reflection of a breeder's intuition and these authors are not about to dismiss the importance of that intuition.

### Selection Index

The most effective selection system is a selection index. We mentioned above that when a breeder introduces "fudge factors" into the selection system of independent culling levels he is roughly approaching a selection index. We refer to this as a breeders index and although it is not a truly proper index, it is probably better than independent culling levels for simultaneously improving two or more traits.

The selection index combines all traits in the selection program while it considers heritability, genetic correlations and relative economic values. It also gives us one number which allows the ranking of prospective replacements rather easily. The selection index is a very versatile tool for selecting cattle and it can be tailored to each individual herd. For example, I may be pleased with the birth weights I am now getting in my herd but I would like to improve yearling weight and frame score. Although it would require a few hours work on a calculator (or a few seconds on a computer), an index could be constructed which would hold birth weight at a constant level while making the most rapid possible improvement in yearling weight and frame score.

On the other hand, I might decide that I could let birth weight increase by 1% per year. In this case I could construct a different index which would allow birth weight to increase at this rate while making the most rapid possible improvement in yearling weight and frame score.

### Complex Mathematical Steps

The problem with a selection index is that it is hard to construct in that the mathematical steps are generally too complex. Indexes prepared by universities and others are generally not specific enough for the individual herd. Relative economic values must be the breeder's own since only he knows how much an additional unit of each trait is worth to him. As a result, the selection index is not used very much. However, with continued advancements in electronic wizardry we may soon see the day when universities or breed associations can take a breeder's own input traits and their economic importance to him and almost immediately give him the index equation. Each calf's performance for the trait could be simply entered into the equation and the process would be complete.

### Select Traits Then Choose Animals

In summary, the breeder has two types of selection. First, he must select the traits he feels are important. This type of selection basically defines the goals of the breeding program. This implies that each trait should be carefully studied before being included. We have discussed several things which should be considered when deciding which traits to include (heritability, economic value, genetic correlations, etc.).

The second type of selection involves choosing those animals with exceptional merit for the trait(s) being considered. As an introduction to this type of selection, we have outlined several methods of selection which allow the breeder to improve more than one trait: Tandem selection, independent culling levels and index selection. This is usually of considerable interest to cattle breeders since few of us have the luxury of being concerned with only one trait.

*In the next article we will deal with aids to selection such as pedigree information, progeny tests and so on. Once we have decided which traits to select for and which selection system to use, we must concentrate our efforts on accurately estimating the breeding value of each animal for each trait.*