User Indexes vs $ Index

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Introduction

Using a profit function is just one of several ways to develop a selection index. When Smith introduced the concept of a selection index in 1936, he proposed a simple equation of the phenotypic deviation of each trait being weighted by the heritability and a relative value. The relative value was a number to indicate the difference in value among traits. Smith overlooked the difficulty in actually determining the relative value of traits as well as a couple other complicating issues.

Issues to Consider in Developing Selection Indexes

When developing a selection index, four types of information are needed. The heritability of the trait indicates what proportion of the phenotypic performance is transmittable to the offspring. The amount of performance information available for each individual will also affect the response to selection. We typically quantify the amount of information as the accuracy of a genetic prediction. Increasing the amount of information results in a larger proportion of the phenotypic deviation being partitioned to the transmittable bit and in effect acts as if the heritability of the trait were large. Some writers have used the term Effective Heritability as an alternative to accuracy. The third type of information needed to develop useful indexes is the correlations among the traits of interest. We need to know how the traits interrelate before we can decide how to manipulate them to produce improvement. The last piece of information is Smith's relative value among traits. We want to create change in the traits that will generate the largest combined value.

Separate the Genetic and Economic Steps

With the advent of the BLUP statistical methods, is has been convenient to separate the tasks of estimating the genetic component (EBV) from the economic weightings when constructing indexes. The BLUP step takes into consideration the heritability of the traits, the correlation among traits and all performance information available on an individual and all it's relatives. So, the selection index can be reformulated as the summation of the EBVs for an animal weighted by the value of each trait. So breeders utilizing a BLUP based system can concentrate on determining the value of each trait.

Defining Economic Values, or Dividing the Pie

To paraphrase Shakespeare, "How many days is a pig worth?" That is the question! Tis better to grow faster or be more prolific? Breeders have a limited opportunity to make genetic improvement each generation. The limits are imposed through the amount of selection intensity that can be applied to a population. By and large, the selection intensity is a function of the reproductive rate of a species and there is not much a breeder can do to alter the total selection intensity (Some impact results from use of A.I and/or superovulation). What breeders can control is how the selection pressure is divided among various traits. The good news is that each generation, you get a new allocation of selection intensity that you can "spend" on a different combination of traits as you wish. It is the cumulative effect of selection over several generations that determines the success of a breeder. Spending your selection intensity is much like spending your paycheck. You must decide how much you are going to spend on food, housing, utilities, transportation and entertainment, to name a few. Breeders must decide if they want all their improvement in one trait or do they want a smaller amount of improvement in a trait so they can have some improvement in other traits.

In the classic selection index, we need to determine the value of each trait we wish to improve. The typical starting point is to use the gross dollar value for a unit of each trait. The astute breeder soon realizes that gross value does not tell the whole story. Other considerations include: cost of production associated with each trait; the number of expressions of a trait (litter size is expressed once per litter, but growth rate is expressed by each pig in the litter); the non-linearity in value of a trait (which is why we need market specifications); and the fact that value is that of pigs to be produced in the future, and different traits will be expressed at differing times in the future. So to accurately determine the value of each trait, a detailed economic model (profit function) of pork production needs to be developed.

Since we have separated the genetic and economic steps in developing our index we can simply use our profit function and input the EBVs along with the economic inputs such as feed, labor and facilities costs and market values to determine the profitability resulting from the genetic potential of each pig. If a breeder wishes, the results of that profit evaluation could be used to determine the weighting factor applied to each trait and then those factors could be used in calculating the classic selection index. The result will be the same and the extra step is unneeded.

Linear vs Non-Linear Values

Non-linearity enters into the index through two routes. One is demonstrated by traits which do not have a constant value over the entire range of performance. Backfat is an example of this. Because of the pricing grid, there are thresholds where the trait changes value. Between thresholds, there is not much change in value among animals with similar fat levels. (Some value is associated with feed efficiency.) The other way non-linearity becomes and issue is when two traits are not additive but are rather have a multiplicative relationship. Litter size and growth traits exhibit this type of relationship. The value of changing growth performance per pig, is multiplied when we also consider the litter size as well.

Alternative Approaches

There are several alternative approaches to solving the selection weightings problem.

Restricted selection indexes can be used to address the non-linear and correlated change issues. The breeder determines the maximum amount of change that will be tolerated for a set of traits and restricts selection to achieve those limits. Birth weight in cattle is a good example. Birth weight in and of itself has little value. But, let birth weights get too big as a result of correlated response for selection to increase yearling weight, and you have the potential for a big economic loss of both the calf and the cow. However, within the set of restrictions, there still needs to be a definition of relative value so the problem has not been simplified.

Desired change is an approach that is currently popular among sheep and cattle breeders. The breeder determines how much change is wanted in each trait and these are used as the weightings. It seems to me that this is just a restating of the issue. How can I state how much change I want until I know how much a trait is worth. In practice, this has also led to some unreasonable desires (and we all have some of those).

Reciprocal means is an approach where the mean value of the "other" trait is used as the weighting. This is simple for the two-trait situation but leads to difficulties in extending it to multiple traits. It will lead to applying equal value among the traits as change is generated.

This brings up the issue of composite vs component traits. Frequently breeders measure traits that are really a composite of several other traits. An obvious example is litter weight, which is a composite of litter size and individual pig weight. Of course, litter size could be also broken into components of ovulation rate, pig survival, etc. The gross value of the composite trait may not truly reflect the value of the components. A breeding objective needs to have sufficient detail to accurately reflect the value of the traits measured.

But back to the point, regardless of what method is used to apply the relative value among traits in the selection index, the issues of accurate economic assessment must be addressed. If a breeder chooses to bypass the economic evaluation and just apply arbitrary weighting, the response produced will be just that, arbitrary. If they do perform an economic appraisal, they will end up at the same point as the profit function.

What is an Index Unit Worth Anyway?

Probably the most useful single feature of profit function derived indexes is the interpretability of the index. The index units are Dollars ($). In the case of PIGBLUP, the index indicates the dollar value of each litter produced by a parent. The value is derived from the sale of pigs to market and use as replacement breeders based on the market distribution supplied by the user. Therefore, the genetic trend for $index can be used to track the value of the genetic progress per litter produced by the line. Keep in mind that the $index is an EBV so you need to average the values for a sire and dam, or if only one animal is considered, divide the EBV by 2. The difference index units can also be used as a guide in pricing breeding stock. The index predicts the returns expected if the animal is used as a breeding animal. Plug in a desired return on investment and a prediction of how many litters a boar or sow will produce and you can approximate a fair price for breeding stock.

Other forms of indexing typically have units with no direct interpretation. Therefore, you have no guide as to how to value the difference in genetic potential between two animals.

Directing the Compass

In all this, I do not want to imply that a breeder should just use the default economic inputs provided in PIGBLUP. Those figures are for an average pork producer driving down the middle of the road. Breeders should input their own economic values to reflect their own circumstances and that of their customers. That way you are determining your own genetic destiny.

And speaking of destiny, the success of the breeding program will ultimately depend on the breeder's ability to predict the future. How good is your crystal ball? With a well-researched and formulated selection objective, breeders can reduce the points on the compass from 360 degrees to something less. While you may not get to the exact perfect point, you will at least get a whole lot closer than if you went in the opposite direction.