Comparison of Selection Indices

A highly qualified panel, representing beef, poultry, pork and diary industries, compare notes on selection.

Coordinated by Wade Shafer, ASA Director of Performance Programs.

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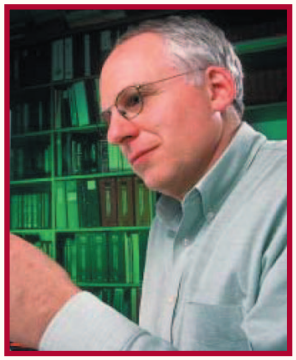

Dr. Mike MacNeil (Beef)
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The Register: Would you give us a brief history of the economic selection index in your industry?

Emslie

While it is difficult to pinpoint exactly when selection indices were first used in the poultry breeding industry, it is generally recognized that "in the late 1940s. . . a few of the breeders began to develop poultry breeding as a business" (Hunton, 1990). Certainly by the mid-50's, progressive poultry egg breeders were applying index and complex breeding strategies to their selection programs. Subsequently, Cornell's Dr. Henderson's BLUP methodology was widely adopted in EPD estimation for many animal species including poultry. The power to use it most effectively had to wait on progress in computing power, a necessary ingredient in the complex optimizing of information from multiple relatives and performance traits. Most pig breeding companies started in the 60s and used selection index theory from the start. BLUP was introduced in the late 80s. Today, the most advanced breeding programs have access to adequate computing power for regular updating of selection indexes. PIC, the pig breeding division of Sygen, for instance, updates EPD estimates twice a day from the latest performance measured all over the world. Furthermore, the potential exists to incorporate selection index estimation within a breeding program that can include mating optimization (PICmate) and the use of genetic markers.

MacNeil

Selection index is not a particularly new technology. In the animal production industries, it roots are usually traced to Hazel and Lush in the early 1940s. Henderson later showed that selection indexes could be derived by weighting EPD with appropriate economic values. Since then, much work has gone into developing technology for selection based on economic merit and breeding objectives have been applied in several agriculturally important species including, dairy cattle, poultry, and swine. Adoption of selection index technology by the beef cattle industry has been more recent, with implementation starting about 15 years ago and accelerating through today.

Faust

The dairy industry has used selection indices to identify genetically superior sires and dams for more than 20 years. Breed associations have developed indices that are aimed somewhat more towards seedstock producers (TPI™ from Holstein USA and JPI/PTI from Protein Dairy Breeds) and the Animal Improvement Program Laboratory of USDA focuses their indices towards commercial dairy farms (NM$, FM$, CM$). Over time, indices have been expanded to incorporate more traits that contribute to total lifetime merit of dairy cows. Today, selection indices available for the dairy industry have incorporated production (yield) traits, functional traits such as udder conformation, health traits, reproductive traits, calving ease, and longevity traits.

Short

Significant improvements in economically important traits have occurred in the swine industry through the use of economic indexes. Some of the earliest indices used in the industry were for the improvement of traits such as backfat, growth rate and feed efficiency. Selection indices were also used to improve litter size, an economically important trait but one that could only be measured in females. With the widespread adoption of Best Linear Unbiased Prediction (BLUP) genetic evaluation procedures in the late 1980s, selection indexes could now easily include many traits that may or may not be measured on all animals. Since BLUP utilizes relationships among all animals and genetic correlations between traits, it is now possible to generate expected progeny differences (EPDs) for all traits on all animals regardless of whether the trait is recorded on each animal. This is especially appealing for sex-limited traits such as litter size or traits

that can't be measured on the live animal like meat quality.

Pig Improvement Company (PIC) has been a leader in the use of both quantitative and molecular genetics in its genetic improvement program. Prior to 1991, PIC used traditional selection index methods to improve lean yield, growth rate and feed efficiency. Best Linear Unbiased Prediction was implemented in 1991 for the three traits above plus litter size. In the mid 1990s, BLUP evaluations were expanded to included meat quality traits and other sow productivity traits. Refinements have been continued such that our current evaluation includes growth rate, feed efficiency, leanness (measured through ultrasonic backfat and muscle depth), leg soundness, reproductive traits (litter size, litter weaning weight, number of teats, still-born rate, age at first farrowing), piglet and sow mortality, meat quality traits (pH, color and marbling) and congenital defects. PIC has had an extensive molecular genetics program since the early 1990s and several genetic markers are included in the statistical process to generate EPD. Data from crossbred pigs are also included in the evaluations and breeding objectives are now defined with the goal being to optimize genetic improvement in the crossbred terminal pig as opposed to the pure lines which are used to produce the terminal pig. All of these traits are evaluated with BLUP on a daily basis from data housed in a central database in Franklin, KY. Evaluations include approximately 1.8 million animals from 12 different genetic lines in PIC nucleus herds from around the globe.

Table 1. Improvement of performance in livestock species from the sixties to the present

Species	Trait	Performance*		
		Sixties	Present	% Change
Pigs	Pigs weaned/sow/year	14	21	50
	Lean %	40	55	37
	Feed Conversion Ratio	3.0	2.2	27
	Kg lean meat per ton of feed	85	170	100
Broilers	Days to 2 kg	100	40	60
	Breast meat %	12	20	67
	FCR	3.0	1.7	43
Layers	Eggs per year	230	300	30
	Eggs per ton of feed	5000	9000	80
Dairy	Milk production/ cow/lactation (kg)	6,000	10,000	67
'Average'				>50

* The figures vary greatly between regions and production systems. The table provides an indication of the change rather than accurate estimates.

The Register: What impact has the use of economic selection indices had on your industry?

Emslie

Average annual egg production over the last 45 years has increased by about 33%. Recently, Havenstein et al. (2003) reported that genetics, nutrition & other management changes over the past 44 years resulted in a 2001 broiler that required about 1/3 the time and 1/3 feed to produce an 1,815 g market bird. He estimated that about 85-90% of the change in growth rate was due to genetics and 10 -15% to changes in nutrition. Use of a selection index would have played a greater role in poultry meat improvement during the last two decades than earlier. Table 1 gives a general overview of achievements in pigs, poultry and dairy cattle breeding (Van der Steen et al., 2004)

MacNeil

It is fairly clear that some recent implementations of selection index technology, like the Circle A Angus Sire Alliance have been well received and have facilitated the evaluation of candidates for selection. The selection index evaluations have clarified some of the confusion that results in attempting to consistently and objectively trade-off differences in the several EPD produced for each animal. Selection index evaluations have also resulted in increased sales of semen from highly evaluated bulls.

Dr. Marj Faust
(Dairy)
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Faust

Because of the huge genetic impact that individual bulls have on the dairy population, balance in selection is critical. The dairy industry has a somewhat undeserved reputation of selecting for a single trait – milk production. In truth, indices have helped our industry to evolve towards a much more balanced and comprehensive approach to selection. With selection indices, the dairy industry has made great strides in improving functional traits like feet and leg conformation and udder conformation while continuing to improve protein and fat yields. Now that the dairy industry has genetic measures for female fertility and health/longevity traits these have been added to the indices to further broaden our definition of a balanced selection approach. The internal ABS Selection Index addresses our customers' current as well as future concerns, because a genetic company like ABS Global makes selection decisions that impact the industry 5-10 years into the future. **(Continued)**

Dr. Tom Short
(Pork)
PIC USA
Franklin, KY

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Short

0With all the traits that are evaluated and the different global markets where we sell breeding stock, the importance of optimally combining individual trait EPD into overall economic indexes becomes apparent. Indices may be as simple as containing only a single trait or as complex as incorporating a dozen different traits. Our approach is to use specialized indexes for sire and dam lines. For example, at PIC dam lines are selected on indexes including traits associated with maternal performance such as litter size, litter weaning weight, leg soundness, number of teats and piglet and sow mortality. Sire lines are selected using indices including growth rate, lean yield, feed efficiency and leg soundness. Specific line objectives may also include meat quality traits and congenital defects. Weighting factors in the overall economic index for each trait are marginal economic values derived from a profit function that considers both costs and returns for each trait.

To examine the expected response from the use of a specific index, genetic parameters (heritabilities and genetic correlations of included traits) and marginal economic values are evaluated in a genetic prediction model to determine the response of each trait. Individual marginal economic weights may be modified to produce the desired genetic response for a particular trait. Once implemented, economic indexes are evaluated periodically to reflect changes in market conditions or inclusion of new traits.

This approach has been very successful in improving economically important traits in PIC products. Table 1 shows genetic trends over the last 3 years for several traits. These trends indicate that cumulatively over this 3 year period, pigs require 6.3 fewer days to market weight, have .78 mm less backfat, 1.65 mm greater loin depth and 0.9% higher carcass lean. Over the same period, in parent gilts litter size has increased by 0.42 pigs/litter and weaning weights increased by .48 kg. If days to market are valued at $.12/day, feed efficiency at $13.86/unit (90 kg gain and $.154/kg feed cost) and lean percent at $1.27/%, this equates to a $.95/pig annual economic improvement. If PIC genetics influence forty million market pigs/yr in the U.S., this represents a $38.2 million increase in revenue as a result of the PIC genetic improvement program.

Table 1. Annualized genetic trends in commercial market pigs between 2000 and 2003.

Trait	Response
Days to 110 kg (days)	-2.1
Feed conversion ratio (units)	-.023
Ultrasonic P_2 backfat (mm)	-.26
Ultrasonic loin depth (mm)	.55
Lean percent (%)	.30
Total number born[1] (piglets)	.14
Litter weaning weight[1] (kg)	.16

[1]Measured in parent females.

The Register: Several beef cattle breed associations currently have, or are in the process of developing, economic selection indices for their membership's use. What advice would you give to seedstock producers on the use of selection indices?

Emslie

A selection index is a proven way to manage a lot of information simultaneously in a biologically and genetically sound manner. It is not a replacement for good common sense and still requires that judgment be employed where biological and economic parameters are difficult to estimate. There are now tools to permit us to incorporate those judgment-based factors into a decision-making process with selection indices. It does, however, require consensus in the industry with respect to the direction in which breeding should impact performance. Today's computing power and well-proven tools permit new adopters of this technology to leapfrog over many of the obstacles that poultry breeders and others have had to deal with in the evolution of this technology. The strategy with which this technology can best be applied in beef cattle is subject to the specific husbandry practices of the industry and therefore should include tools which optimize available resources.

MacNeil

Selection index is one more tool for breeders to use in making selection decisions. They are predictions of the economic merit of seedstock, in the future. Thus, like every forecast, it is more appropriate to use the selection index evaluations as guidelines rather than as absolute criteria.

For the most part, selection indexes in use today are linear functions of the EPD. Thus, there is some tendency to select animals with extreme EPD values. When a breeder's experience indicates that extreme values for a particular EPD are not suited to their production environment or system, it may be appropriate to update the selection process using those personal experiences.

There are also traits that may be important in the selection process that are uncorrelated with traits for which EPD are presently calculated or for which no relative economic values are calculated. At present, consideration of these traits still must be independent of the selection index evaluations.

Faust

Selection indices can be very powerful tools for balancing selection on a number of related and unrelated traits. However, when bulls differ considerably for individual traits and yet have similar index values, skepticism about the index can result. For example, consider these two real dairy bulls with identical NM$ (Net Merit Dollars) index values (+560 NM$) — Bull A has a transmitting

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ability (equivalent to an EPD) of 1879 lbs. of milk; Bull B has a transmitting ability of only 575 lb. of milk. In fact, this outcome is an example of selection indices working correctly — these two bulls differ considerably in genetic merit for milk as well as many other economically important traits. The index is correctly tallying all of the economic 'pluses' and 'minuses' of the two bulls and concluding that a head-to-head comparison of their daughters for profitability would end in a dead heat. Selection indices were designed to consider animals' genetic merits for different traits and to weigh all of these different traits according to their economic impact for the farm/ranch business. This isn't to say that economic values used in the index must be exactly the same as farm/ranch values. In fact, rankings from somewhat different indices are quite similar as long as the relative economic values of traits are similar (e.g. relative values of 3:1 and 4:1 for protein:fat will yield highly similar rankings; relative values of 3:1 and -3:1 will yield different rankings). When the appropriate index is identified which values traits according to the farm/ranch production costs and end breeding goals, the resulting index values for bulls (and cows) are the best single measure of their overall genetic merit. Additional farm/ranch specific criteria, such as eliminating bulls with more calving difficulty when selecting sires for heifer breedings, should be applied after the best index value bulls have been identified. Economic selection indices can be quite powerful tools to aid producers and the industry in achieving more balanced and comprehensive approaches to selection.

Short

As the Table above demonstrates, selection on economic indexes is a powerful tool to increase overall economic return. However, caution needs to be taken in a few critical areas. First, only economically important traits need to be included in the index. The beef industry is faced with the same situation as both the swine and dairy industries in that EPDs are generated for many traits. Basic genetic theory tells us that as the number of traits selected for increases, the response in each trait decreases. Therefore it is very important to determine which traits have merit and include only those traits. It is also important to ensure that the economic values of the individual traits being considered are appropriate. Where economic values have fluctuated over time, averages may be appropriate. It is better to use average values than to constantly change the index due to peaks and valleys in economic conditions. Obviously, if a change in the value of a trait occurs that is likely to persist for some time, modifications would need to be made to the index. It is also important that genetic parameters used to generate EPDs are appropriate and if possible estimated from the populations where the EPDs are generated. Most of today's larger beef breeds have sufficient data to estimate genetic parameters from their own data. Exceptions might include traits such as meat quality or carcass characteristics.

The success of economic indexes will ultimately be determined by their usage among breeders. PIC has been successful in it's genetic improvement program as a result of having closed populations with optimum line sizes, structured performance testing programs, accurate data recording systems and by using index selection as the primary genetic improvement tool. The beef cattle industry can also generate beneficial results from the use of economic indexes if they get widespread acceptance among producers, which requires establishing a common goal that considers traits important to each of the different segments of the industry. Ultimately, the process needs to lead to a product that is both profitable to produce and desirable to consumers! ◆