Department of Animal Sciences

swine

Swine Testing and Genetic Evaluation System: Concepts

By A. P. Schinckel, T. S. Stewart, and D. L. Lofgren
Department of Animal Sciences, Purdue University, USDA-ARS, and USDA Extension Service

In the competitive swine business, the future will belong to the efficient. Seedstock that pork producers can depend on will be tested, productive, and predictable. The pork industry is responding to the challenge and has undergone some dramatic changes in the past few years.

Poultry, pork's major competitor at the marketplace, has made rapid genetic improvements—ones that have resulted in lower production costs, which in turn resulted in an expanded demand for poultry meat. Likewise, pork producers know that if they are to remain in business, they've had to become aware of their production costs and measures of production efficiency, including feed conversion, litter size, pigs weaned per sow per year, and days to market. Emphasis on carcass leanness has increased as packers initiated purchase programs based on estimated carcass value.

To properly serve the total pork industry, swine seedstock producers must become concerned about measures of production efficiency. Genetic improvement of purebred swine herds can lead the way to more efficient pork production and improve pork's competitiveness with other protein sources. At first glance, successful animal breeding programs within each class of livestock may seem quite different; however, closer examination shows four common features of genetically successful poultry, dairy, beef, or swine programs:

1. reliable data recording procedures;
2. appropriate data analysis and genetic evaluation procedures;
3. consistent selection of purebred breeding stock toward identifiable and commercially relevant objectives (combination of traits); and,
4. procedures for multiplying and disseminating genetic improvement from selected purebreds into commercial production.

It is apparent that successful swine breeding programs result from the development and implementation of these four features. The development of the Swine Testing and Genetic Evaluation System (STAGES) project was initiated among Purdue University, U.S.D.A. Agricultural Research Service, U.S.D.A. Extension Service, National Association of Swine Records, the purebred associations, and the National Pork Producers Council. STAGES computer programs have been implemented on national breed association computers to serve their members.

Basic Concepts of STAGES

Several concepts are important to understanding selection procedures. The first concept is that genetic variability exists within the swine population and is transmitted to progeny and descendants. Thus, for seedstock herds to improve, genetically superior individuals must be selected; however, it is important to realize that the true genetic merit (breeding value) of each individual is not known. Selection must be based upon estimates of the animal's genetic merit from available performance data.

The concept of breeding value is based on the fact that genes occur in pairs. The true genetic merit (breeding value) of the animal is the effect of all of its genes upon relevant traits. Selected individuals transmit a sample of one-half of their genes, or breeding value, to each offspring. For this reason, one-half of the breeding value is the expected progeny difference.

Genetic evaluation programs express the genetic merit estimates as expected progeny deviations (EPDs), which are indicators of the animal's breeding value, or true genetic merit. The expected progeny deviation is an estimate based upon performance and sibling or progeny data. The EPD is equal to one-half the breeding value (EPD = 1/2 EBV) of either sires, dams, or progeny. Thus, EPD measures the effects of the particular genes an animal is expected to transmit to his/her offspring. It is an estimate of how future progeny of the sire (or dam) are expected to perform relative to the average performance of the contemporary group when mated to individuals of average performance and when the resulting progeny are treated alike. The EPD for the mating of a specific male to a specific female is the sum of the EPDs of the two parents.

The most important aspect of progeny deviations is the reliability in predicting future progeny performance from the sample of performance records currently available. Therefore, the EPDs are regressed toward the average expected progeny deviation, which is zero, depending on the number and distribution of individual, sibling, ancestral and/or progeny performance records. EPDs will deviate more from the average as additional records are included. EPDs take into account the heritability of the particular trait (or the heritabilities and associations of the traits within an index). These are in the same units of measure as the trait. Deviations can be either a plus deviation or a minus deviation; for example, a boar with a EPD of -3.0 for days from weaning to market would be expected to sire offspring that reach market three days faster than the average boar. A sire with a positive 3 EPD for pounds of lean will produce offspring with 3 pounds more lean (3/185 or 1.62% higher fat-free lean index) than offspring from a sire with average EPDs.

Because the EPDs are regressed toward the average, depending on the number and distribution of records, EPDs are directly comparable even though the numbers of records and the resulting accuracy values are different. This allows the seedstock producer to compare young performance tested boars with older progeny tested sires and young replacement gilts with older sows. These comparisons facilitate replacement decisions.

Contemporary Groups

A contemporary group is a group of animals of similar age and of the same breed or cross, who receive similar treatment, and who have equal opportunity to perform and express their true genetic potential. Accurate genetic evaluation is possible when individuals are compared to others in the same contemporary group. Participants who collect performance information are the only ones who know how animals in their respective herds should be grouped. It is paramount that within a contemporary group the animals be treated as uniformly as possible including similar pen space and diet.

Contemporary groups should exist during a short enough duration in time that the environment is kept as uniform as possible; however, contemporary groups should include enough animals to form a reliable basis of comparison. The producer must compromise between small, short-duration contemporary groups and larger, long-duration contemporary groups. The optimal strategy is to include as many animals as can be fairly compared. For example, a contemporary group might include those sows farrowing within a one month period in the same facility, or a group of young boars within one month of age that have been raised together. Different genetic groups should be treated as if they are different contemporary groups, i.e., if some females are mated to purebred and others are mated to produce F1 progeny, they must be submitted as two different contemporary groups.

Complete Herd Testing

The complete objectives of STAGES can be met only if the whole herd is tested. Complete herd testing allows each individual to be evaluated more accurately through the accumulation of additional information on relatives (parents, progeny, and siblings) and larger contemporary groups. As the percentage of animals tested declines, the accuracy of each individual's genetic evaluation decreases. Testing a limited sample of the herd yields limited and possibly biased information. Testing a small percentage of the animals can distort the EPDs and the index values.

Growth and backfat records should be obtained on all animals including intact boars, gilts, and barrows. Weight and backfat of castrated barrows should be recorded and included in the analysis, even though their evaluation as breeding stock is not of concern. Measurements on these animals contribute to a more accurate evaluation of their parents and siblings.

Sow productivity records should include all purebred sows with either purebred (registered and unregistered) or crossbred litters. However, purebred sows with purebred litters and purebred sows with crossbred litters should be submitted as two contemporary groups.

Selection Objective

To meet the genetic needs of their commercial producer customers, purebred breeders should select a balanced combination of economically important traits.

STAGES indexes weight the EPDs to calculate three bioeconomic indexes: sow productivity, maternal, and terminal sire. The indexes consider the intended use of the seedstock in crossbreeding systems and the relative economic value of each trait. Although feed efficiency was not included in the selection indexes, it was considered in the economic objective.

Sow Productivity Index (SPI). A bioeconomic index ranks individuals for reproductive traits. SPI weights the EPDs for number born alive, number weaned, and litter weight relative to their economic values. Each point of SPI represents $1 per litter produced by every daughter of a sire.

Maternal Line Index (MLI). An index for seedstock used to produce replacement gilts for crossbreeding programs. MLI weights EPDs for both terminal and maternal traits relative to their economic values, placing approximately twice as much emphasis on reproductive traits relative to postweaning traits. Each MLI represents $1 per litter produced by every daughter of a sire.

Terminal Sire Index (TSI). A bioeconomic index ranks individuals for use in a terminal crossbreeding system. TSI includes only EPDs for postweaning traits. It weights the EPDs for backfat, days to 250 pounds, pounds of lean, and feed/pound of gain relative to their economic values. Each TSI represents $1 for every 10 pigs marketed or 10 cents per pig produced by a particular sire.

Seedstock producers should select their replacement boars and gilts based on the index in which their seedstock is mainly used. For example, if a seedstock producer has breeds that are primarily used in specific crossbreeding systems, the maternal breed should be selected on the maternal index and the terminal sire breed on the terminal sire index.

Index Changes

To account for the changes in the pork industry and to refine the direction of future genetic selection, the STAGES indexes underwent evaluation and change. The first change was to increase the weight off-test from 230 to 250 lbs. to reflect the current increased average market weights. Growth rate is now evaluated as days to 250 pounds. Backfat depth is adjusted to 250 lbs. live weight. The economic value for feed conversion assumes pigs are fed to 250 lbs. live weight. Additionally, an EPD is now calculated for loin muscle area adjusted to 250 lbs. live weight.

The second change is that an EPD for pounds of lean adjusted to 250 lbs. live weight (LBLEAN) is calculated based upon the backfat depth and loin muscle area EPDs. The equation used is LBLEAN EPD = (-20.3 x Backfat EPD, in.) + (3.41 x Loin Muscle Area EPD, in^2).

The third change in the STAGES index was the development of a curvilinear economic relationship between carcass value and measurements associated with leanness. In 1997, representatives of four major pork processors were confidentially interviewed as to their current and anticipated future carcass merit buying systems. Currently, one pork processor actually reduces the premium for pigs with less than .67 in. (17) backfat thickness due to an increased incidence of pork quality problems in extremely lean carcasses. One pork processor pays no additional premium for pigs under .60 in. backfat thickness. All four pork processors independently agreed on the following issues:

- Extremely lean carcasses, greater than 52 to 53% fat-free lean, have an increased incidence of numerous pork quality problems regardless of the stress gene status of the pigs.
- The optimal backfat range is .65 to .80 in. backfat.
- Pigs with 1.1 in. or greater backfat thickness will be discounted to a greater extent in the future because these pigs produce less lean cut-out value per man-hour of processing labor, are more variable in lean cut weights, and have increased amounts of seam fat.

The current and future anticipated carcass merit systems were scaled to a common value ratio basis where carcass value = base price x value ratio. A base price of $112.50 was assumed for a pig of 84 lbs. of lean adjusted to a 185 lb. carcass weight (LBLEAN; 250 lbs. live weight). The value ratio was transformed to a value index. The maximum carcass value index (1.00) was attained at 94 lbs. LBLEAN.

An example was calculated assuming a base price of $112.50 per pig (250 lbs. live weight). The relationship between carcass value and LBLEAN is shown in Figure 1. The slope of the dollar value at a specific value for pounds of lean is the marginal value of the next incremental pound of lean. Table 1 shows the incremental value per incremental LBLEAN or per incremental .1 in. change in backfat depth. The marginal value becomes smaller as the pigs become leaner and becomes zero at 94 lbs. of LBLEAN.

The new STAGES indexes will utilize this curvilinear relationship between carcass value and the EPDs for pounds of lean. The terminal sire index will use a base LBLEAN value of 86 lbs. so the economic value for backfat at a 0 EPD for backfat will be $11.44 per inch, similar to the value of $10.86 used previously. A base value of 91 lbs. for LBLEAN will be used for the maternal line index that will reduce the economic value of backfat to about 50% that of the old MLI index. It is important to realize that as the pigs become leaner, the EPDs for LBLEAN will increase as the component EPDs for backfat depth and loin muscle area change. As the EPDs for LBLEAN increase, the additional economic (dollar) value of each one pound incremental increase in LBLEAN will become smaller. Because the maternal line index uses a higher base (LBLEAN value of 91 versus 86 for the terminal sire index), the very leanest individual boars and gilts will be given a decreased economic value and emphasis in the MLI.

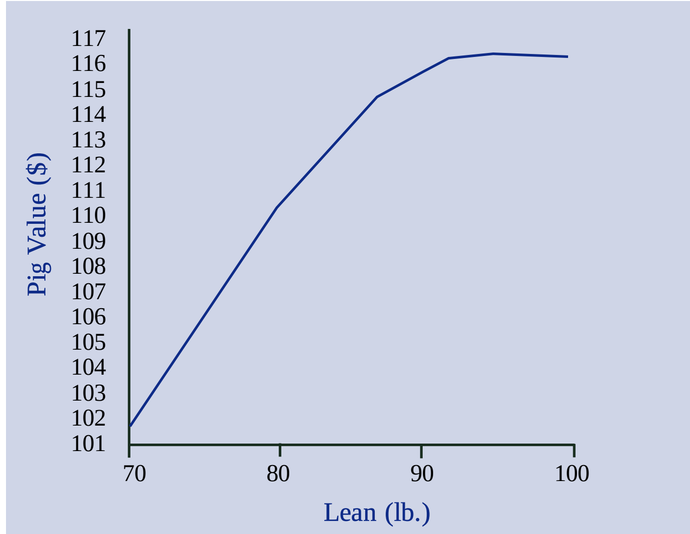

Figure 1. Relationship of carcass value to pounds of fat-free lean.

Within-Herd Genetic Trends

Across-herd genetic evaluations for purebred swine breeds have been available for several years. Breeders have used these EPDs when making decisions about which sows to keep in the herd, which herd boars to use for breeding, and which outside boars to purchase or use with AI. As a result, selection has produced genetic progress in individual herds and in the breed as a whole.

Genetic trend graphs and reports have been made available to breeders. The trend for the breed gives information on the breed as a whole. Within-herd genetic trend reports are also available. These give the average EPDs for all animals used in a given herd, for each year of birth. Two pieces of information in these reports

Lbs. fat-free lean	Marginal value per lb. lean	Marginal value per .1 in backfat
83	.684	1.389
84	.649	1.317
85	.610	1.239
86	.564	1.144
87	.514	1.044
88	.460	.933
89	.400	.813
90	.336	.683
91	.268	.543
92	.194	.394
93	.115	.234
94	.032	.065
94.4	0.0	0.0

Table 1. Marginal values of each additional pound of fat-free lean or one-tenth less backfat at different pounds of fat-free lean (adjusted to 185 carcass weight).

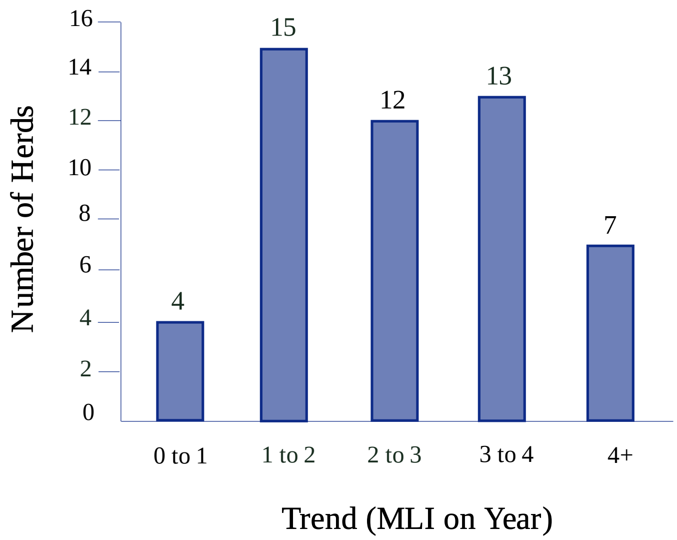

Figure 2. Distribution of genetic trends (MLI on Year) for 51 Yorkshire herds.

are extremely useful to the breeder. The average EPD in the last year or two can be compared to the breed average, to see whether the herd is superior to the breed as a whole. The trend over time tells the breeder how much progress has been made.

The Maternal Line Index (MLI) was examined for Yorkshires. The genetic trend was calculated as the regression of MLI on year. These were calculated for each herd and for the breed as a whole.

The MLI genetic trend for the Yorkshire breed, from 1987 to 1997, was 2.29, meaning that the average MLI in the breed has increased 2.29 index points per year. Genetic trends for 51 individual herds ranged from 0.09 to 5.39. The distribution of these trends is in Figure 2. The 51 trends had a mean of 2.55 and a standard deviation of 1.25. Herds have been quite varied in the amount of genetic progress which they have made. Some herds have apparently been using the EPDs quite extensively in making selection decisions, and have made dramatic genetic progress. Other herds have apparently not used EPDs in making selection decisions; they have not made much progress in several years.

Figure 3 shows the MLI trends from 1991 to 1997 for the Yorkshire breed and for the herds with the highest and lowest regressions of MLI on year. Interestingly, in 1992, the two herds and the breed all had an average MLI of 105. However, they diverged sharply after that point. By 1997, the breed average was 120. The herd with the highest rate of improvement averaged 132, 12 index points above the breed. The herd with the lowest rate of improvement averaged 108, 12 index points below the breed. Indexes are economic, and a 12 point difference in MLI means $12 difference in the value of litters produced by daughters of those animals. Daughters of animals from the high herd will produce litters worth $12/litter more than daughters of animals from a breed-average herd, and $24/litter more than daughters of animals from the low herd.

Because of the large advantage of using high-indexing maternal sires versus average or below average sires, it is important that commercial producers identify the highest overall individuals—and these individuals will most commonly be obtainable from herds with the higher rates of genetic progress.

Summary

Implementation of STAGES provides more accurate and more complete genetic evaluation of the nation's purebred swine herds. Careful selection of superior individuals based on STAGES analyses has resulted and will continue in accelerated genetic improvement that will, in turn, result in more efficient commercial swine production.

Before purchasing boars or gilts, commercial producers will identify purebred producers who are utilizing STAGES, in its entirety, and they will then select superior individuals from those herds as replacements.

Pork producers should be willing to pay a premium price for genetically improved seedstock, not simply because of its increased value to produce commercial progeny, but to offset performance testing costs incurred by seedstock producers. Commercial pork producer support of seedstock producers who are utilizing STAGES and producing genetic progress necessary to guarantee their continued existence in the competitive marketplace and lead to a more efficient pork production system.

For further information, contact the National Swine Registry.

National Swine Registry
1769 U.S. 52 North
P.O. Box 2417
West Lafayette, IN 47996-2417

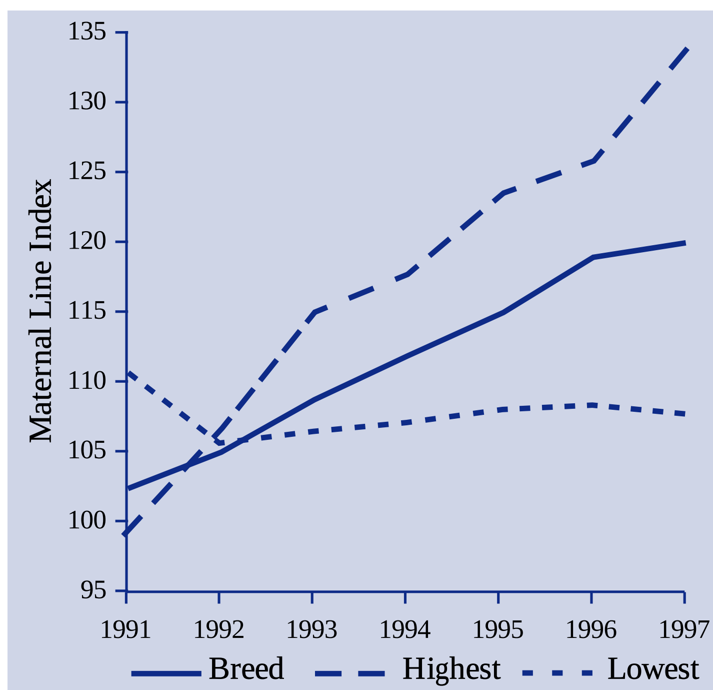

Figure 3. Average Maternal Line Index (MLI) for the breed, and for the herds with the highest and lowest regressions of MLI on year.

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