BREEDING AND GENETICS

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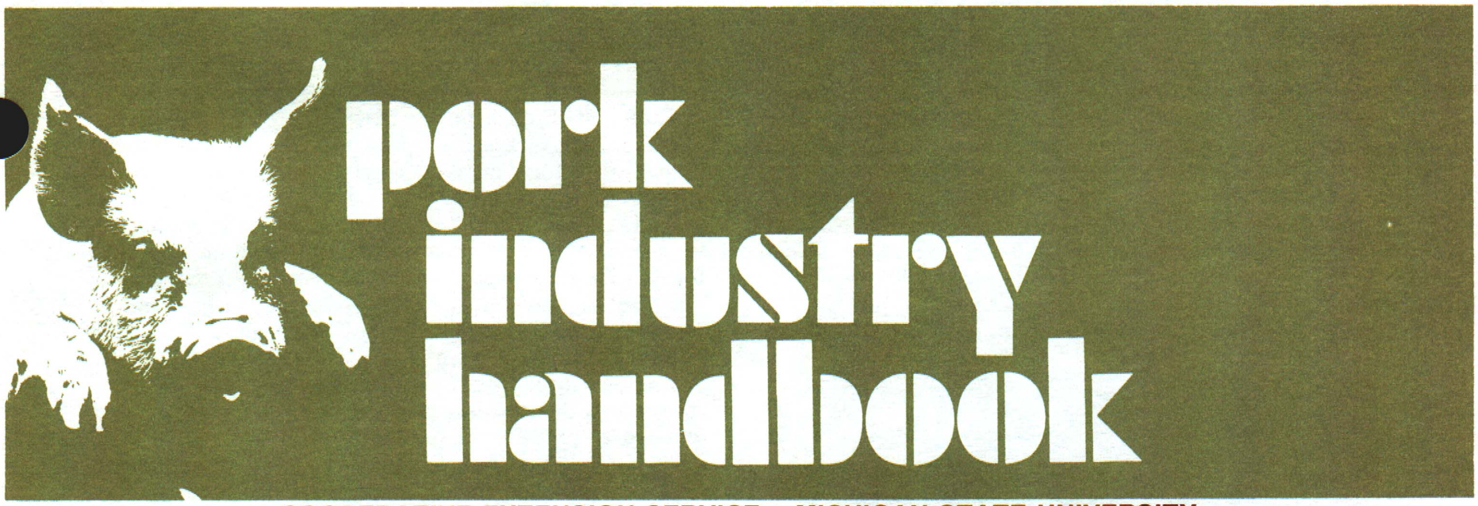

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Selection Guidelines for the Seedstock Producer

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The role of the seedstock industry is to provide the commercial swine industry with healthy, genetically superior breeding animals. If the commercial industry is to make genetic progress, it must come through the seedstock producers. Therefore, seedstock producers must concentrate their selection efforts on economically important traits, base their selections on measured performance and maintain the use of visual appraisal where it is appropriate and effective. A planned, effective breeding program is therefore essential to genetic progress. Furthermore, these producers must maintain sufficient production volume to meet the needs of their desired customers as well as provide the genetic diversity between lines that will allow the commercial producer to maximize heterosis and utilize the superior characteristics of each breed or strain through systematic use in a crossbreeding program.

Traits to Measure

Sow Productivity Traits

The economic importance of these traits has long been recognized as extremely high. Litter size, number of pigs weaned, 21-day litter weight, and litters per sow per year all have a tremendous economic impact on the profitability of both commercial and seedstock breeders alike. However, these traits have been found to be more influenced by environment than genetics. The selection approach has been to cull families and individuals that perform poorly, to avoid inbreeding, and to keep replacement females from sows with superior records. Sire selection for reproduction has not been as vigorously pursued. As a result, genetic progress for reproduction has been slow. However, based on the success of the dairy and beef industries in selection for milk production and weaning weight, the future for sire and dam selection based on all available records of reproduction by all relatives holds much promise in the swine industry.

Because of the low heritability of these traits, every effort must be made to reduce environmental differences between litters so that measured differences are genetic in nature and can be more efficiently used in selection. The farrowing of sows in "all-in, all-out groups" is to be encouraged. This will make it more convenient to equalize litter size and provide each sow an equal opportunity to raise a standard number. It also provides a better measurement of 21-day litter weight, which will be a more equitable method of measuring mothering ability and milk production. This also reduces the negative environmental effects of a gilt being raised in a very large litter, not receiving adequate nourishment, and as a result, not reaching her genetic potential for reproduction.

The number of live pigs farrowed per litter (NBA) should be used as a measure of prolificacy, while 21-day litter weight (LW21) should be used as a measure of milking and mothering ability (See Figures 1 and 2). These two traits (NBA and LW21) can be combined to form an index of sow productivity (SPI), which can be used for selection. Due to the large environmental differences between farrowing groups on the same farm, sow performance should be evaluated relative to the average of her farrowing group. This is called a contemporary group deviation. Such an evaluation permits ranking and comparison of sows from various farrowing groups. Such an index is

$$\mathrm{SPI} = 100 + 6.5\,(\mathrm{NBA} - \overline{\mathrm{NBA}}) + (\mathrm{LW21} - \overline{\mathrm{LW21}}).$$

Prior to calculation of the index, NBA should be adjusted for parity and LW21 should be adjusted for parity, age at weighing, and number nursed. These procedures can be found in more detail in the NSIF (National Swine Improvement Federation) Guidelines for Uniform Swine Improvement Programs.

Producers must also utilize all the records that each sow has because the heritability of each trait increases with the number of records as does the accuracy of the genetic evaluation. If the SPI is 20% heritable with a single record, the heritability based on two records is 32%; for three records, the heritability is 40%. Using all the records on a sow will then speed up genetic progress because of greater heritability and accuracy of selection.

Production Traits

The primary production traits considered are growth rate and feed efficiency. Their heritabilities are moderate, and they will certainly respond to selection. Selection for growth rate requires only an accurate birth date and scales on which to weigh the pigs (See Figures 2 and 3). Growth can be measured in many acceptable ways: days to reach a given weight, average daily gain (ADG), weight per day of age or weight at a fixed age. What is important is that growth rate is measured accurately and carefully adjusted to some constant basis, such as days to 230 lb. (DAYS).

Since feed costs generally account for 60 to 70% of the total production costs of the commercial producer, feed efficiency (F/G) is an extremely important trait. A genetically superior boar for F/G can save a producer several tons of feed through improved efficiency of his offspring. However, measurement of feed efficiency is much more difficult than traits mentioned previously. To calculate feed efficiency, both gain and feed consumption must be measured. The measurement of feed consumption is not as convenient as with some other traits. The procedure most used for direct measurement of feed efficiency is to test pens of pigs that are half-sibs (from the same sire) or litter mates. The feed used by the pigs to grow from about 70 to 230 lb. is measured for each pen. Gain is measured as the difference between the on and off-test pen weights. Feed efficiency is then expressed as the ratio of pounds of feed required to produce a pound of gain in that pen of pigs. Such ratios cannot be accurately compared from farm to farm or across contemporary groups. Only contemporary group deviations should be used for genetic evaluations.

An alternative to direct selection for feed efficiency is to indirectly select for the trait. This means that feed efficiency is improved by selecting for other traits (such as faster growth with less fat) that are desirably correlated with feed efficiency. This selection approach has been shown to be effective in improving feed efficiency and is much more adaptable to the management programs at most seedstock farms.

Figure 1. Number of live pigs farrowed is a measure of prolificacy.

Carcass Traits

The economic importance of carcass traits such as backfat (BF), loin muscle area (LMA) and percent muscle has increased in recent years because of an increase in the use of value-based marketing schemes based on the NPPC Lean Guide to Pork Value. These carcass traits are highly heritable and also can be estimated on the live animal; thus, genetic change is easily made when desired.

Backfat has been measured accurately on live animals for a number of years. This measure of carcass composition can be reliably obtained by either a metal ruler or with ultrasonics (See Figures 4a and 4b). Backfat on the live pig may be measured at market weight at one to three

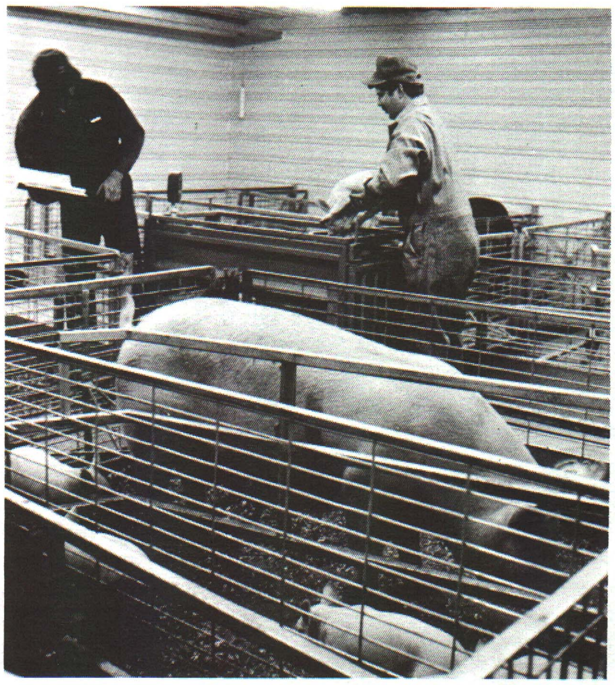

Figure 2. Weighing at 21 days (photo credit: National Hog Farmer magazine).

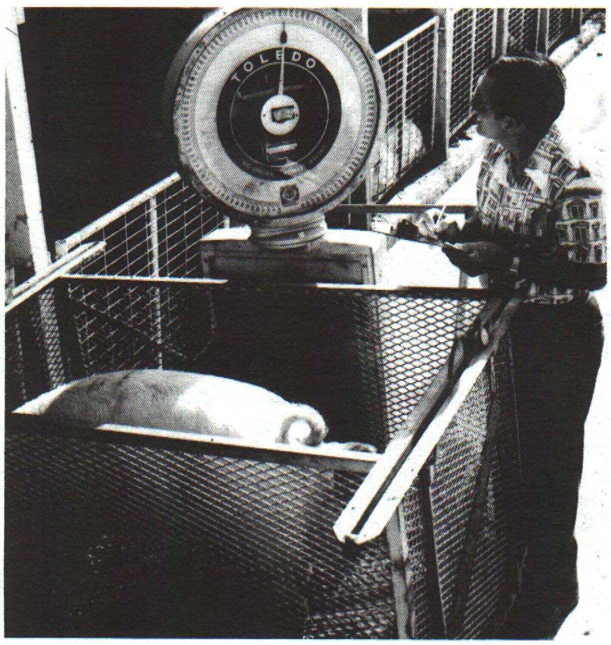

Figure 3. Weighing pigs on a performance testing program.

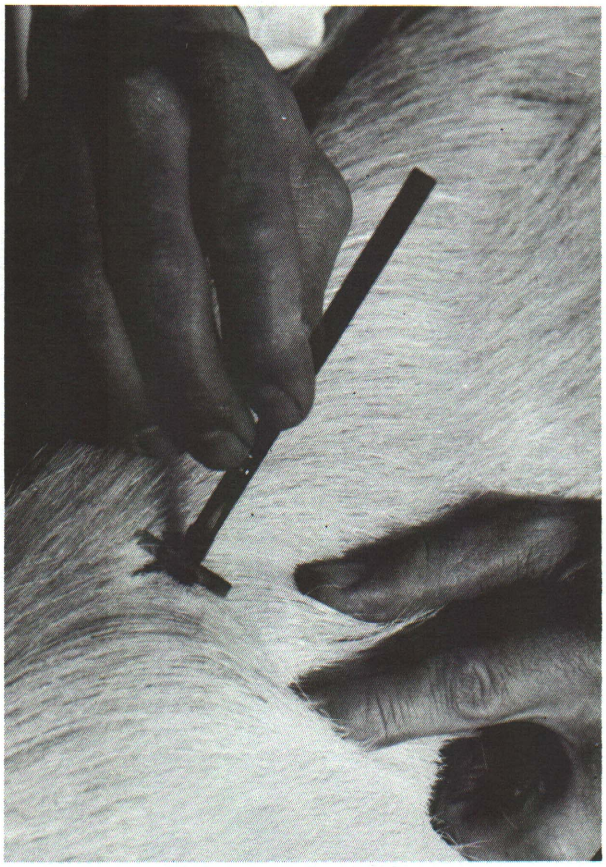

Figure 4a. Metal ruler measuring backfat thickness.

Figure 4b. Ultrasonically measuring for backfat thickness.

locations along the topline of the pig about 2 inches off the midline. If a single measurement of BF is used, the preferred sites are the tenth or last rib. The three measurement sites used in calculating average BF are just behind the shoulder, tenth or last rib, and above the stifle. Numerous reports have demonstrated the probe to be a better predictor of carcass merit than carcass fat measurements taken along the midline. The measured value of the live animal probe is commonly less than the measurements taken on the carcass. This should not be alarming since they are taken at slightly different locations. The live animal is measured just behind the shoulder (5th or 6th rib) while the carcass is measured at the first rib. Also, fat is deeper on the midline than two inches off the midline.

While fat measurements taken by ultrasonics are of great value in predicting composition, similar measures of loin muscle area have not been as accurate. There are, however, some new and more sophisticated ultrasonic machines currently used in research that show potential for accurate measurement of loin muscle area on the live animal. However, these machines are still quite expensive and are not in widespread use. When a trained, experienced ultrasonic operator is estimating loin muscle area, selection of potential breeding animals with larger LMA should be considered only within contemporary groups in the same herd.

Porcine Stress Syndrome

Frequencies of pale, soft, and exudative (PSE) pork carcasses and of death caused by porcine stress syndrome (PSS) are lower today than in the 1970's. However, these problems still persist and can be severe in herds selecting for extremes in muscling without using objective tests to screen against the problem.

The inheritance of PSS has been shown to be a single gene recessive, which means that preventing PSS pigs from becoming herd replacements will lower the occurrence of affected offspring. However, the expression is not 100%, and accurate tests to identify the carrier are not yet available; therefore, ridding the population of the gene is not possible at this time. Creatine phosphokinase (CPK) testing has been proven to have good applicability in the field when used properly. Visual appraisal will screen out many obvious susceptible animals, but it will not identify many susceptible animals that will not react to stress because of low energy states. Visual appraisal will select against stress-resistant heavily muscled animals. Despite the inherent problems, direct selection against this problem can keep the occurrence of PSS animals to a minimum and is warranted due to the economic impact.

Visual Appraisal

While most performance traits can and should be objectively measured, some traits of economic importance must be evaluated using visual appraisal. One of the greatest needs of the swine industry is for more structurally sound, durable breeding animals capable of withstanding the rigors of rearing and breeding inside modern building systems. This trait can and should be evaluated using visual appraisal of the animal as it walks on a hard surface. One of the overlooked advantages of central test stations may be their emphasis on leg soundness. This may be the severe test needed to identify the genetically sound animals. Recent studies show that leg soundness is moderate in heritability and therefore responsive to selection. Soundness should be an easy trait to improve through selection if breeders decide to cull unsound boars that are restricted in their movement and lack the proper flex at the hock and set to the shoulder and evenness of toe size.

One can also exert some selection for reproductive soundness using visual appraisal. The breeder can avoid potential reproductive problems if gilts and boars are culled that exhibit characteristics suggesting problems in reproduction. Gilts should have adequate sized and normal-shaped vulvas. Underlines of both boars and gilts should contain an adequate number of teats that are properly spaced and developed to nurse a litter. Abnormal teats such as pin nipples or inverted nipples should be selected against. Furthermore, boars should display adequate testes size and an aggressive male behavior suggesting a normal sex drive and ability to breed. Visual appraisal cannot accurately predict which animals will be superior for reproduction, but allows producers to better avoid potential problems.

Caution should be exercised to ensure that breeders do not place too much emphasis on "indicators of performance" instead of measuring performance itself. A combination of performance records with visual appraisal will be better than either method by itself.

The Basis for Selection

The seedstock producer must have clear goals and a planned breeding program. The main objective must revolve around producing what the commercial operator needs. The seedstock producer must have this goal foremost in mind and that of selling to other breeders a distant second. If the first objective is met, the second will follow.

Selection is the primary directional force available for creating genetic change. No shortcuts exist. Selection can be simply thought of as increasing the number of good genes and decreasing the number of bad genes. Most economic traits are controlled by hundreds of pairs of genes. Therefore, the odds of getting all gene pairs in any perfect combination is virtually impossible. Only planned selection will permit an increased frequency of desirable genes. However, this process is impaired because both genetics and environment make pigs different. The latter includes all aspects of health, nutrition, and management and masks the accurate evaluation of the genetic potential of an animal.

Breeding Program Essentials

Performance Records under a Standard Environment

Records are valuable when used as a basis for selection in the breeding program, while those obtained only for merchandising and promotion will not contribute to long-term genetic improvement. To be of value, records must be carefully obtained and pigs evaluated under a comparable environment. The breeder who gives a small group of pigs preferential treatment is deceiving only himself. If this procedure is used, the breeder cannot compare the performance of these "fitted" pigs to the others in the herd that are treated in a more normal manner.

The ultimate objective in a genetic improvement program is to predict each animal's breeding value and keep only the best ones. Breeding value is a measure of an animal's genetic merit and therefore its ability to transmit desired genetic traits to the resulting offspring. Proper records on an individual and on its relatives will help a great deal in predicting breeding value.

When the heritability is moderate to high (as with production and carcass traits), the most rapid rate of improvement is through performance measurement and selection based on the performance of the individuals being considered for selection. Thus, the breeding value of an animal for most traits can be predicted at the young age of 5-6 months and will generally result in more rapid genetic progress than selection based on sib or progeny tests or on pedigree information. Regardless of the types of facilities available, individual performance tests can be conducted on the farm if all animals are handled similarly. Onfarm testing is an essential element of a program of rapid genetic improvement since it permits testing of a larger sample of the potential breeding population than is possible using only central test stations.

The principle of using onfarm records to identify the genetically superior animals is quite simple. It is a matter of standardizing the environment and then measuring the traits to provide an estimate of the animal's breeding value. If an animal is better because of environment, it will breed worse than its performance suggested. If it received a poorer than average environment, it will probably breed better than expected. Therefore, it is important to reduce environmental effects so that the performance of an animal will be more indicative of how it will breed. These environmental effects become extremely important when trying to compare animals in different herds.

Table 1 illustrates an important concept of ranking animals in different herds or environments through use of ratios. For instance, one can answer the question of which is the genetically superior boar for days to 230 lb. Is it boar 3 who reached 230 lb. in 139 days or is it boar 4 who reached 230 lb. in 150 days? By knowing the average performance of the herd, one can use the formula for calculating a ratio:

$$\text{Ratio (superiority)} = \frac{\text{Herd average}}{\text{Individual's record}} \times 100$$

Example

$$\text{Boar 3} \quad \text{Ratio} = \frac{150}{139} \times 100 = 108$$

$$\text{Boar 4} \quad \text{Ratio} = \frac{170}{150} \times 100 = 113$$

Because boar 4 scores 113 or 13% better than the average, he would be expected to be superior to boar 3 who scored 108 or 8% above average. One could conceivably use this concept to rank all 6 boars. It may be surprising to note that boar 6 who reached 230 lb. in 187 days is predicted to be superior to boar 1, who required only 170 days to 230 lb. Other traits can be evaluated in the same way. This method is reasonably valid because the greatest part of differences between herd performance are environmental rather than genetic. However, across-herd evaluation programs, as they become available, will provide more accurate comparisons of animals in different environments.

To compare animals within a group more objectively, indexes have been developed by the NSIF for use in testing stations and farm programs. The index

$$I=100+80(ADG-\overline{ADG})-80(F/G-\overline{F/G})-85(BF-\overline{BF})$$

allows comparison of animals tested at the same location as part of a similar test group. The index

$$I = 100 + 112\,(ADG - \overline{ADG}) - 120\,(BF - \overline{BF})$$

is recommended for testing programs in which feed efficiency records are not obtained. Observe that each trait is deviated from the test group average for that trait and multiplied by a weighting factor. The average animal indexes 100. About 20% of the animals should exceed 120 index points, and 20% fall below the recommended

Table 1. Ratio concept to evaluate different environments.

Herd information	Animal	Days to 230 lb.	Ratio to herd avg.	Rank
Herd A	1	170	88	6
(Avg. 150 days/230)	2	150	100	4
	3	139	108	2
Herd B	4	150	113	1
(Avg. 170 days/230)	5	168	101	3
	6	187	91	5

minimum culling level of 80. For breeders interested in a combination of reproductive, production and carcass traits, NSIF also has available appropriate indexes.

Artificial Insemination

Artificial insemination (AI) can greatly enhance genetic progress when genetically superior animals are used. It will allow for a greater selection differential resulting in faster genetic change. Furthermore, the use of AI semen across herds will increase the genetic ties between herds for greater accuracy in selection decisions.

Exerting Selection Pressure

Only boars in the upper 10% of a herd in performance can be expected to be real improvers. Considerable variation exists within any herd. Many animals are average, a few are superior, and there will always be a few of which the breeder is not too proud. Selection differential or selection pressure is largely a function of percent animals kept. Identify those superior animals through use of records, and keep only the smallest possible fraction for maximum progress.

Rapid Generation Interval

If the same boars and sows are used in a herd without replacement, no genetic improvement will be made. The herd can go neither backward nor forward, genetically. Replacing poor-reproducing sows with the most promising young gilts will speed genetic change, particularly if the sows are re-evaluated on the basis of their progeny and performance records to ensure that the poorest are culled.

How fast you improve is determined by the formula:

$$\text{Improvement per year} = \frac{\text{Heritability x selection differential}}{\text{Generation interval}}$$

The selection differential represents the superiority of the animals kept above the average of their contemporary test group. The generation interval is the average age of the breeding herd. Hence, turning over the herd as rapidly as possible while keeping the very best animals for replacement should constitute an optimal program for the seedstock producer. The use of complete, accurate records will maximize heritability.

The same rules apply to the herd boars that will provide 50% of the germ plasm for the next generation. Of course, not all young boars will be better than their sires. However, even superior sires, if kept too long, may hold back potential progress since their best performing sons, if from genetically superior sows, should have higher breeding values.

References

Additional references are available from National Swine Improvement Federation by writing 101 Peters Hall, Institute of Agriculture, St. Paul, Minnesota 55108. Publications include "Guidelines for Uniform Swine Improvement Programs," "Why Test?" and "Selection Indexes and Ratios."

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