PURDUE EXTENSION

pork industry handbook

Genetic Parameters and Their Use in Swine Breeding

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Introduction

The importance of decreasing costs of production increases as the swine industry becomes more competitive. Costs of production can be decreased through an organized selection program focused on genetic improvement in economic traits. The most competitive producers will use a swine-breeding program, which minimizes cost of production and maximizes return on investment. A clear understanding of genetic principles will aid producers in making selection decisions. This publication provides information about breeding values, heritabilities, and genetic correlations and how to use them in genetic improvement programs.

Breeding Values and Progeny Differences

Breeding values are a measure of an animal's value as a parent. A breeding value for a particular trait is a measure of the net effect of all genes affecting that trait. Genes occur in pairs and a sample one-half of a selected animal's genes are transmitted to its offspring. Because a sample one-half of an animal's genes are transmitted to offspring, on average, one-half of the breeding value is transmitted. One-half of an animal's breeding value is referred to as the animal's progeny difference. Expected merit of progeny from a particular mating is equal to the average of sire and dam breeding values or sum of their progeny differences. Genetic improvement in a seedstock herd is dependent upon a producer's ability to select breeding stock with an appropriate combination of superior breeding values for all economic traits. For example, a producer choosing a boar to be used as a terminal sire should be concerned with breeding values for traits such as growth rate, backfat thickness, feed efficiency, carcass lean, and meat quality. Whereas selection in maternal lines should emphasize fertility, litter size, and age at puberty in addition to growth and carcass traits. Many genes affect each of these traits.

Heritability

Selection decisions are made based on an individual's estimated breeding values that are calculated from information on that animal and/or its relatives for each trait of interest. The relative emphasis to place on each record depends on heritability, genetic correlations among traits, and the relationship of an individual with its relatives. Heritability is the proportion of differences in performance among animals that is due to differences in breeding value and is an indication of the emphasis to give an individual's performance record

in predicting its breeding value. This concept is illustrated diagrammatically in Figure 1. Heritability can range from 0 to 1.0, but heritability for most economic traits is between 0.05 and 0.5. A heritability of zero indicates a lack of additive genetic influence on the differences observed among animals. A heritability of one indicates that all differences among animals are due to additive genetic causes. Estimates of heritabilities of some relevant traits are presented in Table 1. For traits that are highly heritable, e.g., backfat thickness, performance of an animal is a good predictor of its breeding value. For traits with lower heritabilities, e.g., litter size, an individual's phenotype is a less accurate predictor of breeding value.

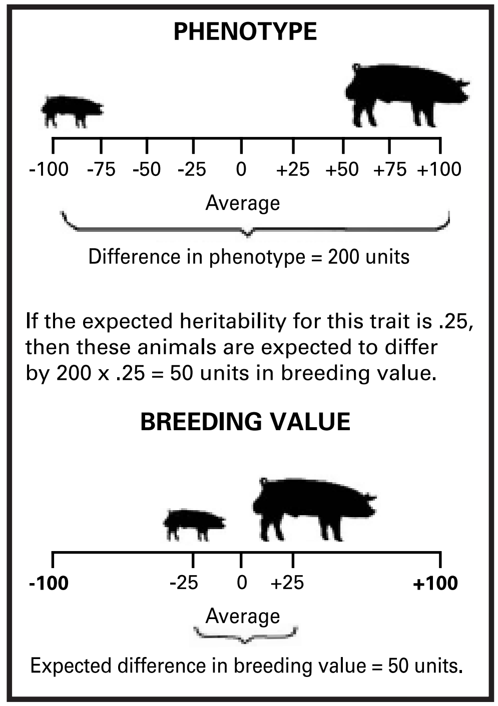

Figure 1. A diagrammatic representation of the proportion of phenotypic differences, which are expected to be due to differences in breeding value for a trait with a heritability of 0.25.

Heritability may be viewed as the proportion of average parental superiority in performance (termed selection differential) that is expected to be realized in progeny performance. This concept is diagrammed in Figure 2.

Likeness between parent and offspring is due to the sample of genes the offspring inherited from the parent. Other kinds of relatives (e.g., Half-sibs) tend to be alike because they have genes in common that were inherited from a common ancestor. There is a greater degree of resemblance between relatives for a highly heritable trait than for a lowly heritable trait. For highly heritable traits, the additive genes that control them exert more influence than do the additive genes for lowly heritable traits. Differences observed among animals for lowly heritable traits are due more to environmental influences than differences in performance for highly heritable traits. For example, a group of sibs is more likely to be phenotypically similar for backfat thickness than for number born in their first litter.

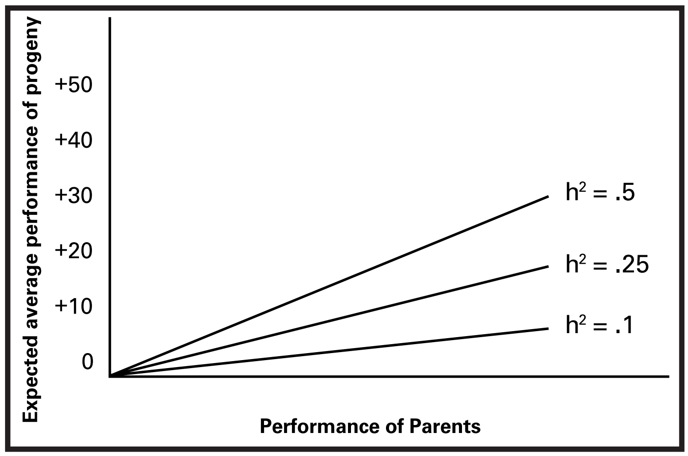

Figure 2. A diagrammatic relationship of the performance of parents and the expected performance of their progeny relative to the population mean for traits with differing heritabilities.

Differences among animals are due to both genetic and non-genetic factors. Heritability of a trait is the ratio of genetic variation to phenotypic variation. Phenotypic variation includes both genetic and non-genetic factors. Heritabilities may differ among traits or herds because of differing control of variation in the production environment. Poor control of the production environment can increase environmental variation and disguise genetic differences among animals. To maximize heritabilities and improve accuracy of breeding value estimates producers should: 1) treat animals equally, 2) take complete and accurate records, and 3) adjust records for non-genetic sources of variation such as number reared in a litter or age at weighing.

Trait	Heirita-bility
Conception rate	.30
Litter size	.10
Litter birth weight	.30
21-day litter weight	.17
Number weaned	.07
Survival to weaning	.05
Rebreeding interval	.35
Sperm quantity	.37
Sperm motility	.17
Average daily gain	.30
Feed conversion	.30
Days to 230 lb.	.25
Backfat thickness	.50
Loin eye area	.45
Carcass length	.55
Lean percentage	.48
Ultimate pH	.21
Color	.28
Drip loss	.16
Tenderness	.26

Table 1. Heritability estimates of some traits of interest to swine seedstock producers.

Genetic Correlation

Some genes influence more than one trait. These traits are correlated genetically and selection for one will cause change in the other. However, the environment also can cause traits to be correlated. These associations are known as phenotypic correlations. For example increased growth rate in pigs is often associated with increased fat deposition. The total phenotypic relationship is due to both genetic and environmental factors that affect both traits. For example, availability of food or exposure to disease organisms probably affects both growth and backfat, but some genes also affect both traits. Associations resulting from environmental factors are referred to as environmental correlations. Correlations due to genes that affect both traits are called genetic correlations. Estimates of genetic correlations among several production traits are included in Tables 2 through 5. Genetic correlations are of importance to animal breeders because they are correlations between breeding values of two traits. Genetic correlations can range from -1.0 to +1.0. Correlations may be classified in three ways: strength, sign, and whether they are favorable or unfavorable. Strength of correlation is indicated by the value itself. Correlations near –1 or 1 indicate a strong relationship. Correlations near 0 indicate a weak relationship. The sign is an indication of direction of change. A negative correlation means that as one trait increases the other decreases. A positive correlation means that the two traits tend to change in the same direction. The sign of the genetic correlation does not indicate whether the relationship between traits is favorable, only the statistical relationship. For example, the genetic correlation between feed conversion and average daily gain is negative (Table 3). Because fast gains tend to be associated with low feed required per unit of gain, this illustrates a negative statistical relationship, but favorable economic relationship.

Item Birth	Litter wt	# Weaned	Litter 21-day wt
Number born	.62	.73	.45
Litter birth weight		.71	.68
Number weaned			.87

Table 2. Genetic correlations among sow productivity traits.

Item	Feed Conversion	Backfat Probe
Days to 230 lb.	60	-.25
Average daily gain	-.53	.12
Feed conversion		.30

Table 3. Genetic correlations among performance traits and among sow productivity traits.

Item	Loin Eye Area	Carcass Length	% lean
Backfat	-0.4	-0.2	-0.7
Loin eye area		-0.2	0.65
Carcass length			0.2

Table 4. Genetic correlations among carcass traits.

Item	Color	Drip Loss	Tenderness
pH (24 hours)	-0.5	-0.7	0.5
Color		0.5	-0.15
Drip loss			-0.15

Table 5. Genetic correlations for meat quality.

A genetic correlation between traits will result in a correlated response to selection. A favorable correlation results in selection for one trait improving another. An unfavorable correlation between traits increases the difficulty of making simultaneous improvement in both traits. However, unless the correlation is very high and undesirable, both traits can be improved by selecting animals with desirable combinations of EBVs for both traits, or by proper weighting of traits in a selection index.

Relationships of average daily gain with feed conversion and backfat (Table 3) illustrate this concept. Direct selection for only increased average daily gain is expected to result in selection of replacements with favorable breeding values for feed conversion because of the favorable correlation between traits. Selection for growth rate is thus expected to improve feed utilization because faster growing animals tend to be more efficient. If selection were solely for average daily gain, a tendency for selected animals to have unfavorable breeding values for backfat would be expected. In this situation care must be taken to choose animals with favorable breeding values for both traits.

A plot of breeding values for backfat and average daily gain is presented in Figure 3. The two animals with the highest breeding values for average daily gain (1 and 2) have unfavorable breeding values for backfat. Animals better than average for both traits (6, 8, and 9) fall in the lower left portion of the diagram. Selection decisions when more than one trait is considered depend upon relative importance of traits. With knowledge of the genetic correlations, optimal selection decisions can be achieved using multiple-trait indexes of breeding values.

Implications

Knowledge of breeding values, genetic correlations, and the relative economic importance of traits of interest is used to calculate selection indexes. Selection indexes are the best method for determining an animal's relative genetic value. There is a growing trend in the swine industry to select animals to meet a particular market. Indexes exist that specifically target maternal traits, paternal traits or a desired market. Additional indexes may be developed for export verses domestic markets.

Economic weights used to calculate each index will differ; however, genetic parameters are not likely to change. Breeding values and genetic correlations are population measures, which are independent of the economic value of traits. A greater understanding of genetic parameters will help producers understand and utilize genetic information.

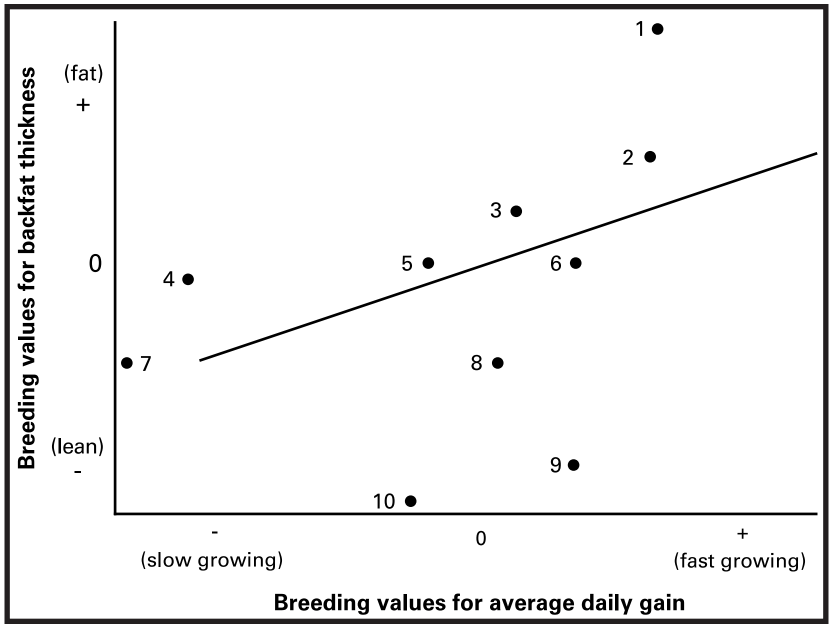

Figure 3. A plot of breeding values for backfat thickness and average daily gain with a genetic correlation between traits of .25.