



Fact Sheet Number 14

Genetic Improvement of Sire and Dam Lines for Enhanced Performance of Terminal Crossbreeding Systems

Introduction

Profitability of a pork production system relies on reducing the cost per unit of output that is achieved. There are opportunities to increase the profitability of the pork production system by genetic improvement of performance traits. Selection of superior individuals as parents within breeds and choice of breeds or composite lines to be used in crossbreeding systems are the general tools that breeders have available to bring about this genetic improvement. The use of genetically selected sire and dam lines enhances the performance of terminal crossbreeding systems. In this publication, the potential for greater genetic improvement through the use of specialized sire and dam lines is discussed.

Need for Specialized Sire and Dam Lines

Performance traits that determine the efficiency of the system can be grouped into two categories. Reproductive traits such as age of puberty, fertility and litter size are expressed only in breeding animals. Production traits such as growth rate, feed efficiency, and carcass composition are expressed in market animals as well as animals destined for the breeding herd. Most pork quality traits are only expressed in market animals. Genetic improvement of both reproduction and production traits through selection of superior parents is

possible to varying degrees depending on the heritability of the trait, the amount of variation among potential replacements and, most importantly, the superiority of the chosen replacements. Commercial producers receive the benefits of such selection primarily by purchasing breeding stock or semen from seedstock producers who operate effective selection programs within their herds.

Crossbreeding is also an important part of commercial production systems because of the improvement in efficiency from heterosis and the potential to exploit differences between breeds or lines. A terminal, static cross (Figure 1) in which all offspring are market animals takes greatest advantage of differences in the strengths of lines or breeds. Lines that have superior genetic merit for reproductive traits provide females for the crossbreeding system, while lines with superior merit for production traits provide boars. In this way, market offspring with high genetic potential for production traits can be produced while maintaining high genetic merit for reproductive traits in the sow herd.

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Because of the significant benefits of maternal heterosis gained by using crossbred females, pure breeds or lines with superior genetic potential for reproductive traits are often used in static or rotational crosses, or to produce composite lines, from which crossbred females are generated for the terminal phase of the system. Although of less economic importance, the benefits of paternal heterosis from using crossbred boars can be gained when pure breeds or lines genetically superior for production traits are crossed, or composite lines are used, to produce boars for the terminal phase. As long as the breed or lines used on the sire side of the terminal cross are different from those used on the dam side, the market offspring can be expected to benefit from 100% of available heterosis.

Selection Objectives

Commercial producers may identify existing breeds, lines within breeds, or composite lines, shown to be superior for specific traits that determine their most useful role in a crossbreeding system. Results from evaluation studies involving a large, representative sample of each breed or line are most useful in this process. Seedstock producers can improve existing sire and dam lines for their respective role in a crossbreeding system and can develop new specialized lines to fill specific roles in a crossbreeding system by using specialized selection objectives.

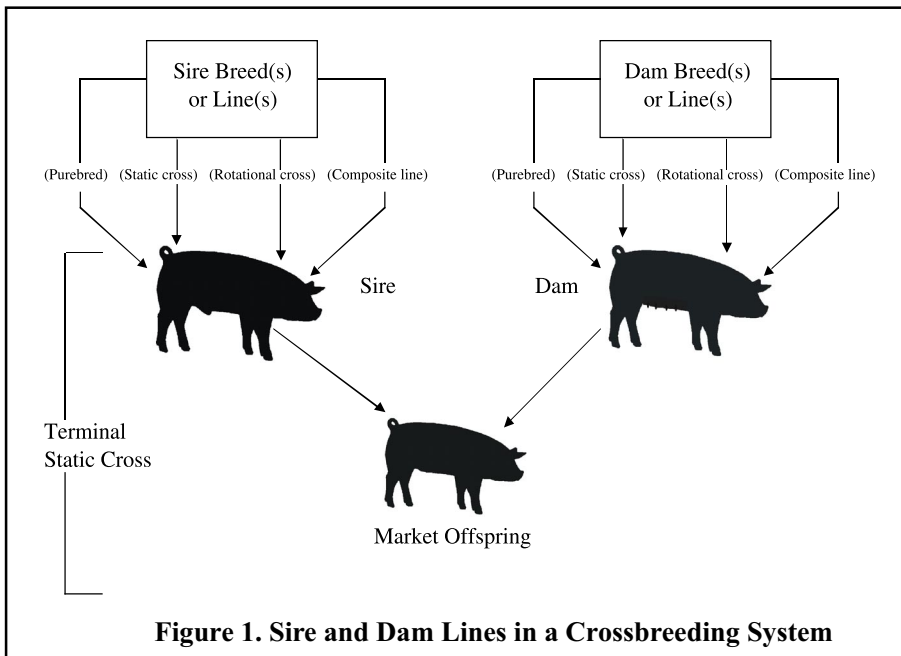


Figure 1. Sire and Dam Lines in a Crossbreeding System

Sire lines provide terminal sires that contribute a random half of their genes to each market offspring. The genes influencing reproduction that are transmitted from these boars are never expressed in their market offspring. Consequently, the primary selection objective in the sire lines should be improving genetic merit for the production traits of economic importance in market animals. Some small amount of secondary emphasis may be put on reproductive traits to maintain an acceptable level of genetic merit in breeding females within the sire line.

Reproductive traits are, of course, expressed in all breeding females used as parents in the terminal cross, while these same females contribute half of their genetic merit for production traits to each of their market offspring. As a result, the primary selection objective in dam lines designed to provide females for the maternal side of the terminal cross should be increased reproduction performance. Some emphasis should also be put on these females' contribution to the genetic merit for production performance of their market offspring.

These specialized selection objectives are designed to produce lines that can be advantageously combined in a terminal, static cross. The opportunity for maximum genetic merit in a terminal cross is enhanced when using lines in which special-

ized objectives have been followed versus lines in which the selection objective has been general and more equal emphasis has been given to all traits. More selection pressure can be directed toward each trait of interest in specialized sire lines because fewer traits are emphasized within the line. Specialized lines offer an even greater advantage over lines selected for general merit when there are antagonistic genetic relationships between some of the traits of interest. This is the case with some reproductive and production traits. For example, the genetic relationship between litter size and both backfat thickness and feed efficiency is estimated to be mildly antagonistic in some lines.

Selection for Production and Reproduction

In the application of the specialized selection objectives described above, the production and reproductive traits to be included in each objective and the relative emphasis to be put on each must be determined. As was mentioned earlier, the potential for response to selection is determined by the heritability of the trait, the amount of phenotypic variation that exists for the trait among animals available for selection as parents and the intensity with which those parents are selected (NSIF-FS9).

Production traits generally respond well to selection. The estimated heritabilities of postweaning gain and days to 250 pounds are approximately 35% and 25%, respectively. The efficiency of gain, in terms of pounds of feed per pound of body-weight gain, is expected to respond to selection also (heritability estimates range from 25 to 30%). Feed efficiency is a more difficult measurement to make, but it can be expected to respond in a favorable direction as a result of selection for decreased backfat and days to 250 pounds because of the favorable genetic relationships of feed efficiency with fat thickness and postweaning gain. Carcass characteristics, such as backfat thickness, loin eye area and percent lean have estimated heritabilities of greater than 40% and are most responsive to selection.

In recent years, market price criteria have begun to emphasize the lean meat content of each market animal. Consequently, the rate and efficiency of lean tissue growth, rather than of body-weight gain, have become production traits of major economic importance. These traits can be expressed as lean tissue growth rate (lean/day) and lean tissue feed conversion (lean/feed). The amount of lean gained can be estimated with measurements of backfat and postweaning gain or days to 250 pounds. Each trait is moderately heritable and will respond to selection. Research is continuing in an effort to determine optimum selection methods for lean tissue growth rate and lean tissue feed conversion. In general, an optimal approach maximizes improvement in lean tissue growth rate without excessive feed intake and wasteful deposition of fat.

Also, as backfat is decreased and desired levels of leanness are achieved, pork quality traits (e.g., color, intramuscular fat, water holding capacity, tenderness, taste) will become more important. Although some quality traits may be moderately heritable, they presently cannot be measured in the live animal and are expensive to measure from carcasses. Alternative selection methods based on molecular information would be useful in this case and research is underway to identify genetic markers for pork quality traits.

Most reproductive traits are less heritable than production traits, but still respond to selection. The estimated heritabilities of litter size at birth and at weaning are 10%. Genetic improvement of litter size is also hampered by the fact that an individual record is not available for maternal reproductive traits when selecting among boars and is not available for females when selecting among young gilts. However, the large variation in litter size provides the potential for some response to selection for litter traits, especially when ancestral and sib information is used. Measurement of total litter weight at 21 days of age is designed to reflect the sow's mothering and milking ability at a point prior to large intake of creep feed by the litter. Estimates of the heritability of 21-day litter weight range from 15 to 20%. Animals with genetic potential to reach puberty at an earlier age can contribute to improved conception rates and lower costs associated with feeding open gilts. Age at puberty has an estimated heritability of 35% and has been shown to decrease significantly in response to selection.

The accuracy of selection for each of the production and reproductive traits can be improved by including all available performance records on each individual's relatives across many herds. Procedures are currently available, through various state and national programs, that allow seedstock producers to select replacement boars and gilts on the basis of their own performance, as well as all information available on their relatives (NSIF-FS12). Information from these various sources are combined to estimate each animal's genetic merit in the form of an estimated breeding value (EBV) or expected progeny difference (EPD). These procedures may be especially valuable in improving the accuracy of selection for some of the more lowly heritable reproductive traits.

While breeders need to know the potential response in each of these production and reproductive traits if selection is practiced, they will also want to consider the relative dollar value of response in each trait. Some method to combine what is known about the potential for selection and the economic value of each trait is needed to come up

with the selection criterion that best summarizes the special objective of the line.

Selection Indexes

When striving to improve more than one trait simultaneously, use of a selection index is most efficient (NSIF-FS10). The index is an optimum weighting of the traits of interest, based on some specific selection objective. The economic value, heritability and amount of phenotypic variation associated with each of the traits involved, along with the phenotypic and genetic correlations among those traits of interest are considered to determine the weightings for the index. In effect, the index considers the potential for response to selection for each trait, the economic value of each trait as stated in the selection objective and the correlated changes expected in other traits when each trait is changed through selection. The relative economic importance of each trait will be partly determined by the selection objective in the line in which the index is to be used.

Several programs provide specific indexes for use in a terminal sire line, a maternal (dam) line and a line following a general selection objective (See Figure 2). The index designed for use in a terminal sire line concentrates its weightings on the postweaning traits, days to 250 pounds and backfat thickness. Although feed efficiency

is not directly measured when using this index, selection emphasis is put on feed efficiency through its genetic relationship with days to 250 pounds and backfat. An alternative index might include measurements of feed intake (e.g., made with feed intake recording equipment) in addition to those of backfat thickness and days to 250 pounds for more optimum improvement of lean tissue feed conversion. The index recommended for use in a maternal line puts the largest weightings on the reproductive traits of litter size and 21-day litter weight, but also places some emphasis on the production traits. The general index is designed for lines providing boars used in rotational cross systems where reproductive and production traits are essentially of equal importance.

As discussed earlier, improvement of backfat thickness to optimum levels and increasing consumer demand for quality may shift relative economic value from leanness to pork quality traits in some sire lines. In the near future, information on molecular genetic markers for quality traits may be added to the selection index or used in two-stage selection with the index. Improved leanness and a narrow margin between feed intake and potential for lean gain may also make traits of reproduction such as rebreeding performance and second parity litter size more important in some

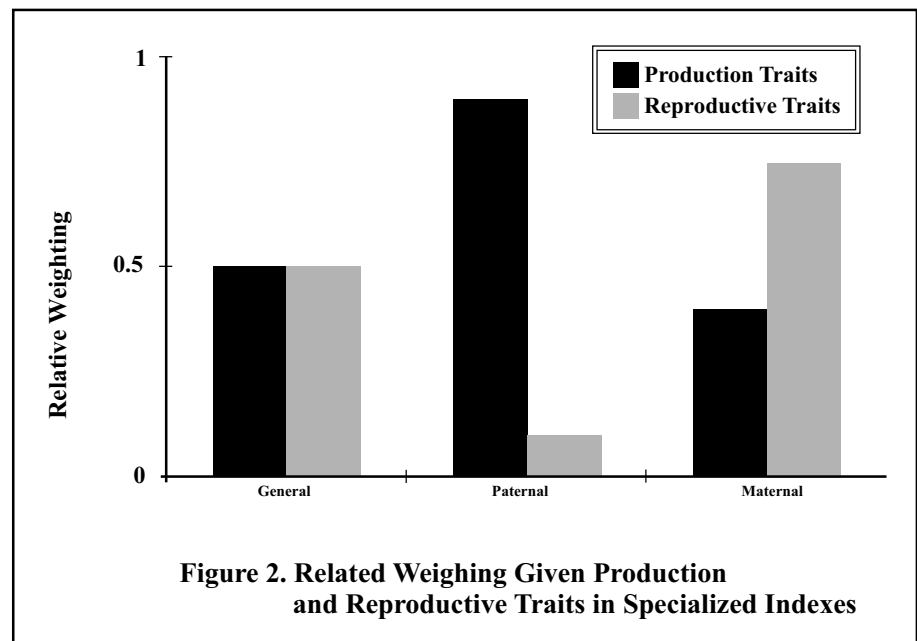


Figure 2. Related Weighing Given Production and Reproductive Traits in Specialized Indexes

lines. Only specialized sire and dam lines will allow breeders to effectively balance genetic merit for maximum efficiency of production, quality and the reproductive performance of the sow herd. Communication between seedstock producers, their commercial customers and the pork processor to which animal sales are targeted is essential so that selection objectives in each line appropriately reflect market preferences.

Differences in Selection Schemes

A selection scheme is the way a specialized selection index is applied, once it is decided upon. The most effective selection scheme used in a herd depends on the special objective to be followed. In terminal sire lines, where primary emphasis is on production traits with relatively high heritabilities, selections based on each individual's performance can be made quite accurately. Consequently, replacement rates should be high in these lines to turn generations quickly and incorporate animals into the breeding herd that reflect the progress from selection. Artificial insemination can be used to keep replacement rates high while maintaining intense selection. Collection of additional information that will aid in the evaluation of production traits, such as individual or pen feed efficiency and sib carcass information, may also be considered.

In general, selection for reproductive traits requires larger herds because the number of sows farrowing together becomes the contemporary group. For accurate genetic evaluations, each contemporary group should contain at least 20 females of the same breed or line and contain females from two or three different sires. The optimal selection criteria for a maternal line is a maternal index that weighs estimates of genetic merit (EBV's or EPD's) for

reproduction and postweaning traits relative to their economic importance. The genetic merit estimates and index values can be compared across parities even though the amount of information used in the estimates might vary. For example, a gilt off-test with a maternal index value of 115 is expected to be equal in overall genetic merit to a first-, second- or third-parity sow with a 115 maternal index.

The optimal approach to selection would be to select females, gilts or sows, based on their maternal index value. The last (lowest) indexing gilt selected should have the same maternal index value as the lowest first-, second- and third-parity sows that are selected for rebreeding for an additional litter. This type of selection compromises between accuracy of selection and generation interval to maximize overall economic improvement per year. This program will lead to selection of a breeding herd of younger females.

Producers with smaller herds can implement a small-scale type of hyperprolific sow program to improve genetic merit for reproductive traits. A hyperprolific sow program involves selection of the very highest ranking sows (upper .1 to .2%) for a large, perhaps nationwide, population. Top third-parity sows would be identified based on a maternal index. These selected sows could then be mated to the top young boars based on the same maternal index. One or more boars from each designed mating would be tested for postweaning performance. The highest indexing boars based on a maternal index would be mated to recently identified hyperprolific sows and the process repeated.

Summary

Use of specialized sire and dam lines in a crossbreeding system involving a terminal cross offers the potential for genetic improvement above that realized with use of a general selection objective. When determining selection objectives for their herd, seedstock producers must consider the current strengths of their breed or line and the specific roles the animals they sell will serve in the crossbreeding systems of their customers. Commercial producers implementing a terminal cross need to identify the breeds or lines with characteristics that will best fulfill the sire and dam line roles in the cross and then purchase boars within each breed or line from seedstock producers who have followed selection objectives consistent with those roles. Commercial producers will be under increasing pressure to meet the quality demands of the consumer in order to insure a market for their animals. Communication between seedstock supplier, commercial producer and pork processor will be essential to design and implement specialized selection objectives that allow the producer to meet these demands in an efficient manner.

Development of sire and dam lines may also provide opportunities for the future. Specialized lines may someday be used in conjunction with embryo transfer techniques by transferring sire line embryos into dam lines with superior embryo survival. In itself, the presence of diverse genetic lines will guarantee flexibility in the industry as management practices and market conditions change.

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