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EC77-217 Selection and Crossbreeding for Commercial Pork Production

William T. Ahlschwede

James Heldt

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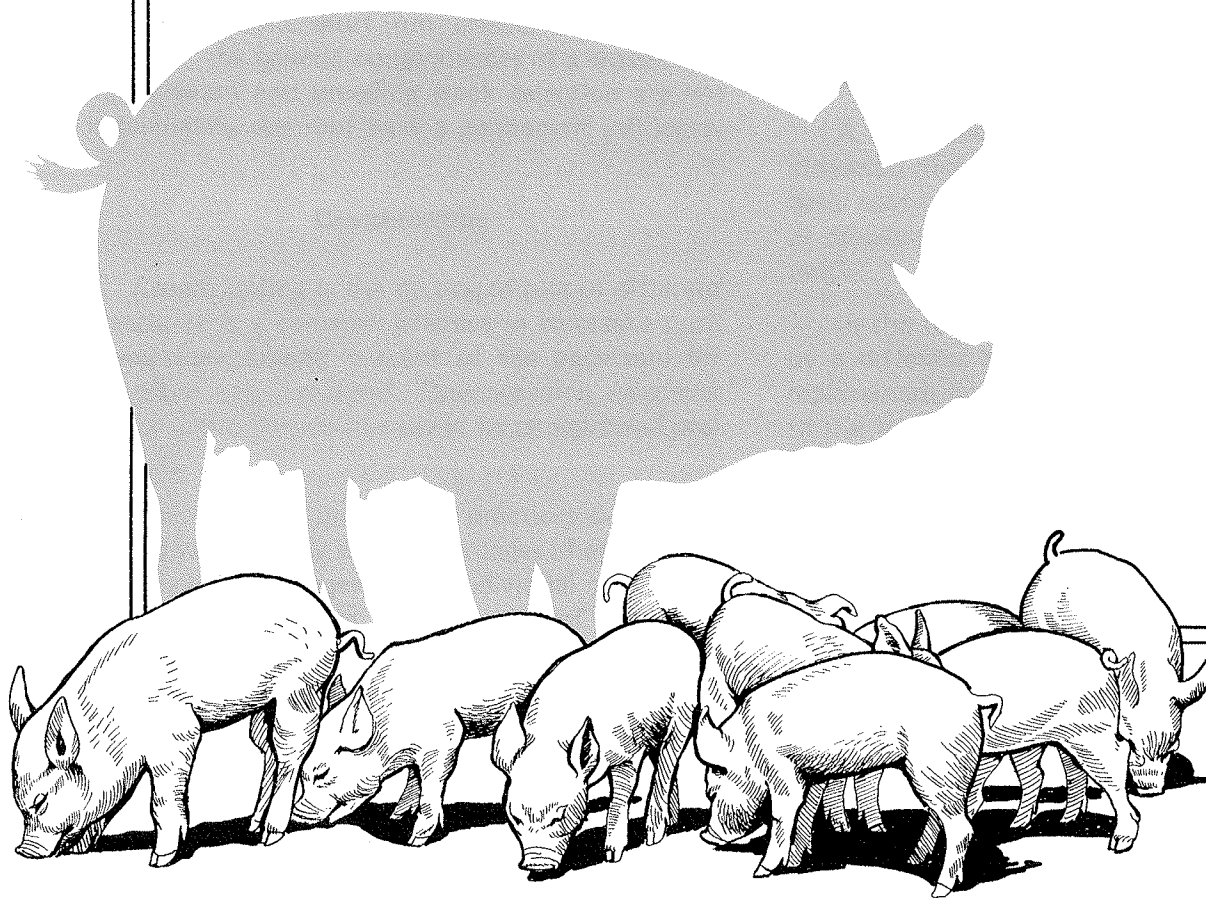
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Selection and Crossbreeding for Commercial PORK PRODUCTION



EXTENSION WORK IN "AGRICULTURE, HOME ECONOMICS AND SUBJECTS RELATING THERETO,"
THE COOPERATIVE EXTENSION SERVICE, INSTITUTE OF AGRICULTURE AND NATURAL RESOURCES,
UNIVERSITY OF NEBRASKA-LINCOLN, COOPERATING WITH THE COUNTIES AND THE U.S. DEPARTMENT OF AGRICULTURE
LEO E. LUCAS, DIRECTOR

SELECTION and CROSSBREEDING for COMMERCIAL PORK PRODUCTION

William T. Ahlschwede
Extension Livestock Specialist (Swine)
James D. Heldt
District Extension Specialist (Livestock)

Introduction

Commercial pork producers must produce lean quality pork at prices attractive to the consumer—and still earn a profit. Careful use of a good crossbreeding program and wise breeding stock selection will help.

Many management and husbandry decisions have immediate short run effects on profit. In contrast, the genetic consequences of a crossbreeding program and breeding stock selection are not immediately seen but have a permanent influence.

Crossbreeding

Crossbreeding is the mating of pigs of different breeds. It is a common practice in Nebraska pork production. Ninety percent of the hogs sold for slaughter are crossbred. Crossbreeding improves overall performance compared to straightbred production.

Research and production practices during the last 40 years clearly show advantages of crossbreeding. Major advantages are in individual pig vitality and in reproductive performance of crossbred sows. Crossbred pigs are more active at birth, more likely to live, start faster and reach market weight sooner than straightbred pigs. Crossbred gilts and sows are more likely to breed, farrow larger litters and wean larger litters than purebred females.

These advantages of the crossbred over the purebred are called hybrid vigor or heterosis. These advantages are the reason that crossbreeding is recommended for commercial production.

Crossbreeding does not improve feed efficiency of growing finishing pigs or improve carcass composition or quality.

Even though the advantages of crossbreeding are many, crossbreeding alone does not insure either success or profit for pork producers. Crossbreeding is just one of many management tools which can be used to make profits more likely. The advantages of crossbreeding are best utilized when a good crossbreeding system is used, the most profitable breeds are chosen and the best individuals are used as breeding stock.

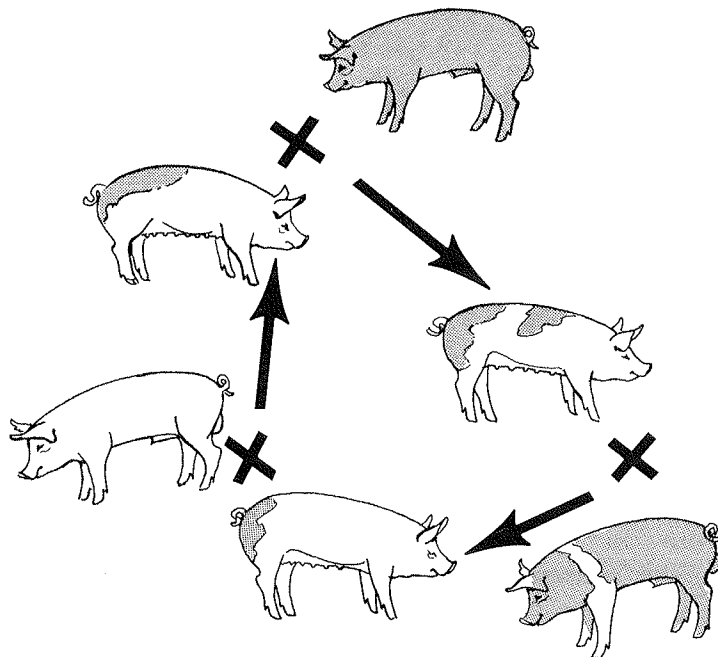
What Is a Crossbreeding System?

A crossbreeding system is the production of crossbred pigs following a planned procedure. Two basic crossbreeding systems are used—the rotational crossing system and the terminal crossing system.

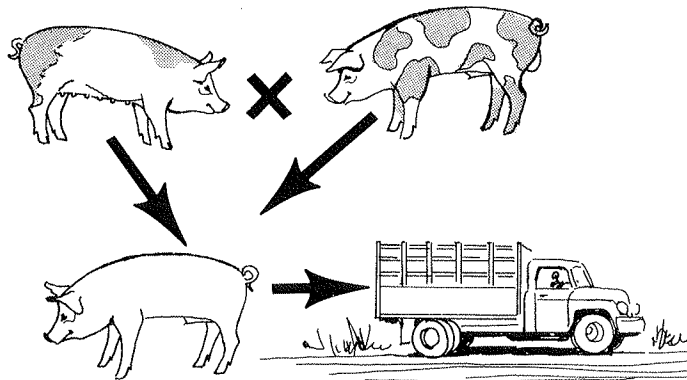
In the rotational system, market hogs are sired by a different breed of boar each generation and replacement gilts are kept from the market crosses. In the terminal cross system, market hogs are sired by the same breed of boar every generation. Replacement gilts are not kept from the market cross. Terminal crosses have increased in popularity in recent years.

How Does the Rotational System Work?

Rotational crosses are characterized by rotating or changing the breed of sire each generation. Rotational crosses may involve two, three, four or more breeds. Replacement gilts are kept from the crossbred stock each generation. Major advantages of the system are that it is easy to follow and replacement gilts are selected from the crossbreds produced. As more breeds are used in the rotation, the program can become more flexible as to breed choice and sow management. Repeating a breed of boar in consecutive generations reduces heterosis and should be avoided.



Rotational cross. Replacement gilts come from the previous cross.



Terminal cross. All offspring marketed.

What Are Three Breed Rotations?

The three breed rotation is probably the most popular crossbreeding system. Boars from three breeds are used in rotation. Females are bred to the breed of boar they are least related to. Rotational crosses are most easily managed if the sow herd and boar are replaced as a group. If the sow herd is replaced as a group, only one breed of boar is needed. If sows are continuously replaced with gilts, the sow herd will represent several generations and more than one breed of boar will be required.

When culling and replacement are done continually, using more breeds in the rotation avoids the necessity of having more than one breed of boar. Boar breeds are changed annually. During any given year, all sows and gilts are bred to the same breed of boar. If few sows are kept for more than five litters a four breed rotation with annual boar changes will work well. If large numbers of sows are kept for six or more litters, a five breed rotation would be desired.

What Is the Terminal Cross System?

A terminal cross is a specific cross in which all pigs produced are sold for slaughter. Typically, no breeding stock would be kept from the crossbred pigs produced. The male and female parents would represent different breeds.

With the terminal cross, either the boar or the sow can be crossbred or purebred. The most common terminal crosses use crossbred sows (usually F_1 - two breed first cross) and straightbred boars. If crossbred boars are used, they should represent breeds not found in the sows.

The terminal cross is the system of choice for feeder pig production where replacement gilts are not kept.

What Are the Advantages of Terminal Crosses?

Terminal crosses provide maximum levels of heterosis because sire and dam represent different breeds. Terminal crosses also allow producers to combine the advantages of breeds without experiencing some of the disadvantages. Ideally, in a terminal cross, the sows used should wean large litters of pigs which grow rapidly and efficiently and produce meaty carcasses. F_1 females would often be used. The sire should produce fast growing efficient pigs which produce excellent carcasses. Since no replacement gilts are kept from the cross the litter size of the sire breed is not an important consideration.

An additional advantage of the terminal cross is that the same breed of boar and sow is used each generation. This means that even with overlapping ages and groups of sows, only one breed of boar is required. This system produces a consistent product from year to year.

What Are the Disadvantages of Terminal Crosses?

The primary disadvantage of the terminal cross

is gilt procurement. Replacement gilts are not kept from the market crosses. For most producers this means buying replacement gilts. The extra expense of finding and buying special (genetically superior and of the right breeds) crossbred gilts for use in the terminal cross is often discouraging to commercial pork producers. The additional health risk of buying replacement gilts is another problem.

An alternative to buying special crossbred gilts is producing gilts for the terminal cross. This requires a second breeding herd and breeding program. With this scheme, a small group of straightbred females would be kept to produce F₁ crossbred gilts. These gilts would be used as the females in the terminal cross. This requires maintaining two breeds of boars, a group of purebred sows and the crossbred sow herd.

Breed Selection

What Factors Should Be Considered?

Breeds should be selected based on their expected performance in crosses. Breed performance records for postweaning gain, feed efficiency, backfat thickness and carcass merit are increasingly available. Table 1 summarizes breed performance from three years of testing at the National Barrow Show.

Table 2 shows breed averages in feed efficiency for growing finishing pigs based on recent boar test station performance. Although commercial producers should not expect these levels of feed efficiency for barrows under farm conditions, the breed differences can be expected to be similar.

For traits such as feed efficiency, backfat thickness and carcass merit which express little heterosis the straightbred performance is a good

Table 2. Feed efficiency of breeds reported from boar test stations.

Breed	Feed Required Per Unit Gain ^{a/}
Berkshire	2.69
Chester White	2.61
Duroc	2.52
Hampshire	2.57
Landrace	2.79
Poland China	2.65
Spot	2.62
Yorkshire	2.54

^{a/}Performance of boars fed in small pens with daily attention and well balanced diets. Market hogs in commercial operation would be expected to use 20-30% more feed.

indicator of the breed's crossbred performance. As an example, Poland China-Hampshire crosses would be expected to have less fat than Landrace-Spot crosses. For rate of gain which is affected by heterosis, the breed averages give some indication of what to expect in crosses.

For traits related to reproduction and pig vitality which show considerable heterosis, breed averages are not as useful in predicting crossbred performance. Little critical information is available to use in choosing between breeds for these traits, on either a straightbred or crossbred basis. The data available deals mainly with Hampshire, Yorkshire and Duroc breeds.

Some indication of the breed performance for litter size and mothering ability is given in Table 3. Values in the table refer to performance of crossbred females which are half of the breed indicated and half of several other breeds. The numerical values are based on a complete review of

Table 1. Breed averages from 1973, 1974 and 1975 national barrow show.

Breed	No. ^{a/}	ADG ^{b/}	Back Fat ^{c/}	Carcass Length ^{c/}	Loin Eye Area ^{c/}	% Ham
Berkshire	127	1.45 (.66)	1.23 (3.12)	30.8 in (78.2 cm)	4.72 sq in (30.5 sq cm)	15.7
Chester White	161	1.35 (.61)	1.22 (3.10)	30.5 (77.5)	4.68 (30.2)	16.8
Duroc	431	1.52 (.69)	1.24 (3.15)	30.9 (78.5)	4.70 (30.3)	16.7
Hampshire	331	1.39 (.63)	1.06 (2.69)	31.3 (79.5)	5.05 (32.6)	16.6
Landrace	87	1.44 (.65)	1.40 (3.56)	31.1 (79.0)	4.32 (27.9)	16.4
Poland China	118	1.38 (.63)	1.21 (3.07)	30.3 (77.0)	5.08 (32.8)	16.9
Spot	213	1.48 (.67)	1.28 (3.25)	31.0 (78.7)	4.69 (30.3)	16.8
Yorkshire	193	1.39 (.63)	1.23 (3.12)	31.6 (80.3)	4.59 (29.6)	16.4

^{a/}Number which completed test and for which carcass data were available.

^{b/}ADG (Average Daily Gain) adjusted to reflect expected performance of those which did not complete test - lb (kg).

^{c/}Adjusted to 220 lb (99.8 kg) live weight.

recent crossbreeding research. Since the number of experiments and the number of litters are limited, care must be used in making conclusions from these data. The shaded areas of Table 3 are based on breed reputation rather than research information, and must be regarded as "hearsay".

Table 3. Breed performance in crosses for litter size and mothering ability.

<i>Crosses Involving</i>	<i>Litter Size Born</i>	<i>Mothering Ability</i>
½ Berkshire	9.7	Below
½ Chester White	10.7	Average
½ Duroc	10.7	Above
½ Hampshire	10.4	Below
½ Landrace	9.9	Above
½ Yorkshire	10.6	Average
½ Poland	Below	Below
½ Spot	Average	Average

What About Hybrid or Crossbred Boars?

Hybrid boars are crossbred boars, usually a specific cross. Hybrid or crossbred boars should not be confused with private breeds which have been developed and sold by some breeding stock companies. Crossbred boars are simply boars whose parents were not of the same breed.

Can Crossbred Boars Be Used to Advantage?

Crossbred boars have received considerable attention in recent years. If used properly in a crossbreeding program, they can have advantages. Little research information is available comparing purebred and crossbred boars for breeding performance or the effect on the crossbred pigs of using a crossbred boar. Experience with crossbreeding allows us to recognize several possible advantages and disadvantages of using crossbred boars.

What Are Advantages of Using Crossbred Boars?

There are two possible advantages. Based on general understanding of heterosis, crossbred boars might be expected to be more aggressive breeders than straightbred boars. There is evidence of hybrid vigor for breeding performance.

Second, a crossbred boar might match the other breeds in the crossing system better than a boar from another pure breed. The crossbred would contribute the performance average of two breeds to the cross. This average might be a more

profitable inclusion in the cross than an available straightbred. As an example, a Landrace-Hampshire crossbred boar might be used instead of Hampshire in a Yorkshire, Hampshire, Duroc rotational cross.

What Are Disadvantages of Using Crossbred Boars?

The major disadvantages are lack of supply of performance tested crossbred boars and the difficulty in maintaining a crossing system when using crossbred boars.

If care is taken, crossbred boars can be used in a crossbreeding program which retains all of the advantages of heterosis.

How Do Crossbred Boars Fit Into the Crossing System?

In a terminal crossbreeding program, the boar can be crossbred without sacrificing any of the system advantages. The boar should represent different breeds than the sow. In a rotational cross, a crossbred boar can be substituted for any of the breeds provided the crossbred boar does not represent breeds already in the rotation. Rotational crosses using only crossbred boars will yield little reduction in heterosis if the breed type of the crossbred boar changes each generation.

Can Crossbred Boars Be Accurately Selected?

Selection procedures are given in detail elsewhere in this bulletin. Performance records of boars should be compared only with other boars in the same breed group. Differences in boar performance records are expected to be equally meaningful for both purebred and crossbred boars. Differences between two Duroc x Chester White crossbred boars are as likely to be transmitted to their offspring as are differences between two Duroc boars. The records of a Duroc boar and a Duroc x Chester White crossbred boar cannot be accurately compared.

Selection

What Is Selection?

Selection is the deliberate choosing of animals to be parents of the next generation. Selection is an important decision made by the pork producer. Selection determines the genetic potential for performance of the next pig crop. If replacements are kept from that pig crop, they in turn will transmit their genes to their offspring.

Selecting genetically superior (better performing than herd average) individuals will improve average performance. This is an important consideration, since genetic changes caused by selection are permanent.

Is Selection Important?

A crossbreeding system and selection work hand in hand. Crossbreeding improves performance of those traits with heterosis, providing the system is followed. Once a crossbreeding system is started, genetic improvement in performance can only come through breeding stock selection. The effects of this selection accumulate and improvement continues generation after generation if wise selections are made.

What Trait(s) Can Be Improved by Selection?

Most economically important traits of pigs can be improved by selection of breeding stock. Some traits can be improved more easily than others. This ease of improvement is called the heritability of the trait.

The heritability of a trait indicates how much of the selection differential for that trait will be passed on to the offspring. Little genetic improvement can be expected if selected breeding stock are superior only in a low heritable trait.

Heritability figures in Table 4 show that carcass and growth traits are more easily improved by selection than are reproductive traits.

Table 4. Heritability estimates.

<i>Level of Heritability</i>	<i>Trait</i>	<i>Average Percent</i>
High	Carcass length	65
	Leg length	60
	Percent ham (of carcass wt.)	60
	Loin eye area	50
	Percent lean cuts	50
	Backfat thickness	45
	Age at puberty (gilts)	40
	Ovulation rate	35
	Feed efficiency	35
	Growth rate (weaning to market)	30
	140 day weight	25
	Age at 220 lb (99.8 kg)	25
	Weaning wt.	15
	Birth wt.	10
	Number farrowed	10
Low	Number weaned	10

What Is Selection Differential?

Selection differential is the superiority of those selected relative to the group from which they were selected. This generally relates to an objectively measured trait such as weight, backfat thickness, feed/gain, or an index of measured traits. Subjectively scored traits such as soundness can also have selection differentials. These traits do not have numerical measures like backfat or weight, but can be assigned numerical scores (1-3 or 1-5 etc.).

What Traits Should Be Considered for Selection?

Select breeding stock for traits which are economically important and can be improved by selection. Of those characteristics listed in Table 4 which show medium to high heritabilities, feed efficiency, fat thickness and rate of gain are most related to profit. Since producers usually are interested in improving profit, all of these traits should be considered.

On What Basis Should Selection Be Made?

Performance test results are the best basis for selecting breeding stock for commercial pork production. The record of the individual being selected is the most accurate measure of performance that will be transmitted to its offspring. Occasionally, records will be available on relatives of the individual in consideration. The performance of full-sibs (littermates) and half-sibs (sired by the same boar) can be used to get some indication of the genetic value of an individual, but are not as valuable as an individual's own performance. For a trait with medium heritability such as rate of gain, the records of 8 full-sibs or 100 half-sibs are required to provide as much information as the individual's own performance.

What Is a Performance Test?

Performance testing is measuring individual performance of a group of individuals. The most common form of performance testing in Nebraska is weighing and backfat probing by breeders when stock reach approximately market weight. The weights might be reported as weight at 140 or 154 days of age, age when the pig reaches 220 lb (99.8 kg) or average daily gain during the growing-finish stage. Backfat probes are usually reported at either 200 (90.7 kg) or 220 (99.8 kg) pounds.

At the boar test station, feed efficiency records on small pens of boars and barrows are also kept. Since both genetic and management factors affect pig performance, it is important that all individuals in the herd are performance tested and the herd averages reported. The herd average provides the basis for judging individual selection differentials.

What About Progeny Testing?

Progeny testing provides a method for choosing among sires based on performance of their offspring. Progeny testing requires an added year to the age of a boar before a decision can be made. There usually is a limited number of progeny tested sires to choose from.

What If Feed Efficiency Records Are Not Available?

Feed efficiency is one of the most important traits for which selection is effective. However, few boars and gilts have individual records for feed efficiency. Fortunately, feed efficiency is related to other traits which often are measured. Favorable genetic correlations exist between feed efficiency and gain and between feed efficiency and backfat probe. Selecting for improved gain and improved backfat thickness will also improve feed efficiency.

Why Isn't Carcass Evaluation Being Emphasized?

Few commercial producers have the opportunity to select directly for carcass value, even though carcass quality improvement is important. Carcass characteristics are highly heritable. By selecting for reduced fat thickness, major changes in carcass value can be made. Carcass evaluation is an important part of comprehensive breed improvement programs. Look for breeders who monitor and improve the carcass merit of their herds when choosing your boars.

What About Visual Appraisal?

Visual appraisal is an important aid to selection. It should be used to supplement performance test records. Visual appraisal is a supplement to and not a substitute for performance testing. For traits associated with soundness, it is the only evaluation method available. Visual assessments cannot be accepted for traits which can be easily measured, like weight and fat thickness.

What Is Soundness?

Soundness is freedom from defects and relates to an individual's ability to function in a desired manner. Structural soundness relates to the ability to walk and move about. Breeding animals need to be sufficiently strong in their feet and legs to breed without difficulty. This relates to both structural deficiencies and injuries. Breeding animals must also be free from anatomical defects of the reproduction system. For gilts soundness also relates to a functional mammary system. Gilts need a sufficient number of functional nipples to nurse large litters.

How Does Soundness Enter the Selection Process?

Commercial producers should avoid selecting unsound breeding stock. Since some of the details of soundness are speculative, they should not unduly influence selection. Selection for soundness should be aimed at avoiding production risks.

Structural Soundness—Avoid "buck-kneed" or "post-legged" breeding stock. "Post-legged" boars have difficulty mounting sows. "Post-legged" sows have difficulty getting up and down in farrowing crates. Buck-kneed pigs do not last long in breeding herds. Lamé and stiff walking stock should be avoided.

Mammary System—Most producers prefer gilts and sows with at least six well developed evenly spaced udder selections on each side. Gilts with inverted or scarred teats should not be bred (Fig. 1).

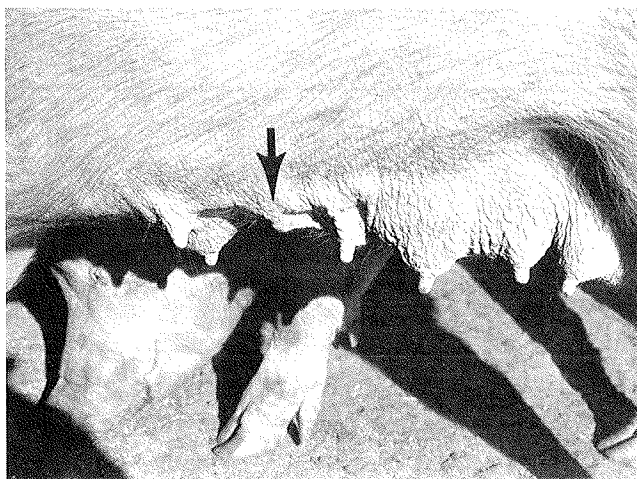


Figure 1. Non-functional udder section caused by concrete burn soon after birth.

Reproductive System—Most anatomical defects of the reproductive tract are not visible. In gilts small vulvas may indicate infantile reproductive tracts. Gilts which do not show proper development of the exterior genitalia should not be saved

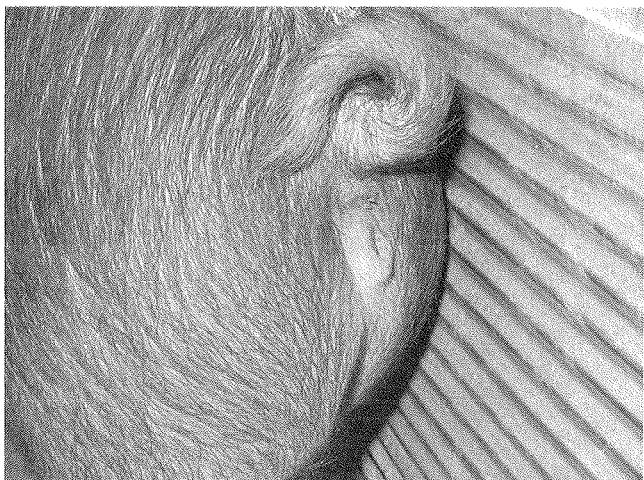
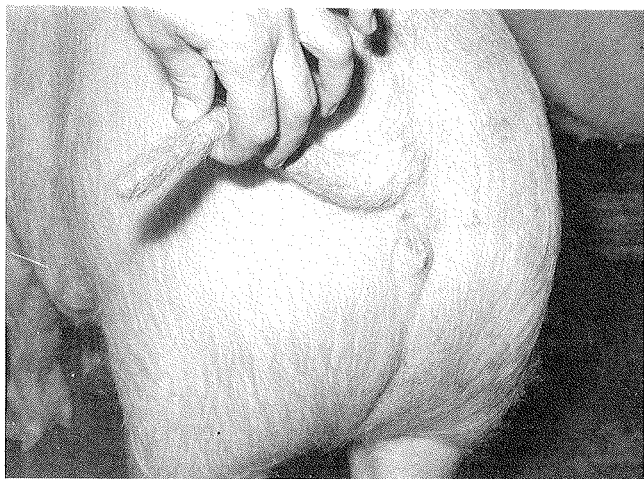
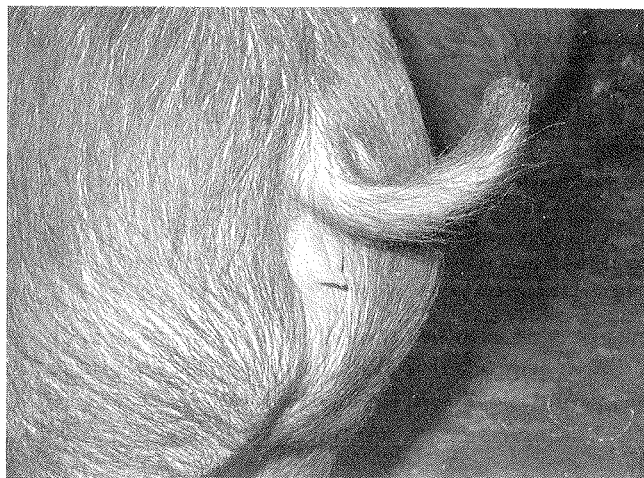


Figure 2. Gilts with normally developed external genitalia (a) should be saved. Gilts with small (b) or abnormal (c) vulvas should not be saved for breeding.

(Fig. 2). Boars also need to show proper development of the testes and penis. Test matings may be necessary to find anatomical defects of young boars. Limp penis and adhered penis are two potential problems which can be detected at a test mating.

How Do You Decide Which Boars to Buy?

There are many aspects to boar buying, several decisions to be made. These decisions involve choosing a breed, a breeder and then which boars. The choice of breed is based on the crossbreeding system being used. The choice of system usually involves choosing the breeds to be used and when they will be used. The choice of breeder should be based on health status, reputation, availability of boar with performance test records and the herd's history of testing and improvement.

Choosing breeders who have production facilities similar to yours may eliminate some soundness problems. Once the breeder is chosen, the choice of boars should be a rational decision weighing the performance test record against the price.

What Procedure Is Recommended for Buying Boars?

Once the breeder has been chosen, a two-step procedure is recommended for boar buying. The first step is to inspect the performance test record of the boars for sale and select the boars with the best records available. Also choose some alternate boars on the records. The second step is to inspect the boars chosen on their record to determine if they are sufficiently sound to function in your operation. If the first chosen boars are not sound, make your selections among the alternates.

Which Gilts Should Be Selected?

The sow herd makes the same genetic contribution to the pig crop that the boar makes. In addition, the sow herd determines the herds level of production by farrowing and weaning the baby pigs. Replacement gilts should be chosen which can be expected to perform well in both of these areas. It is recommended that the fastest growing leanest gilts that are sound and from large litters be kept for herd replacements.

Selecting these gilts requires that gilts born in large litters be identified at birth (Fig. 3) and their birth dates recorded. The gilts should be weighed and probed for backfat thickness at 180-200 pounds (81.6-90.7 kg). At that time the gilts should be inspected for unsoundnesses and placed on restricted feed. Fenceline contact with a boar at this time will help insure normal sexual development.

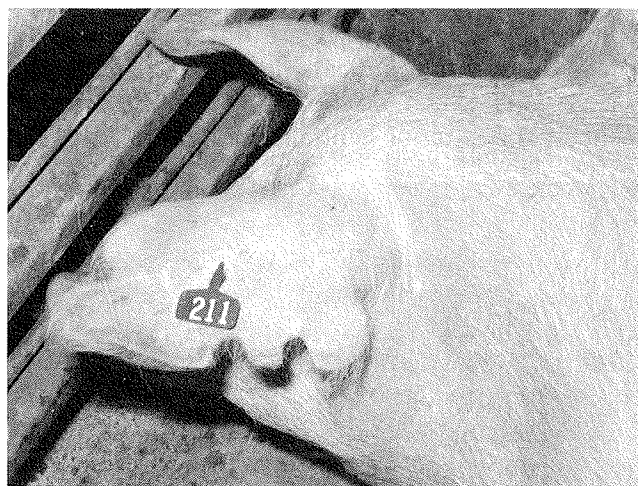


Figure 3. Ear notching gilts from large litters at birth provides permanent identification. Ear tags can be used to supplement notches in the breeding herd.

