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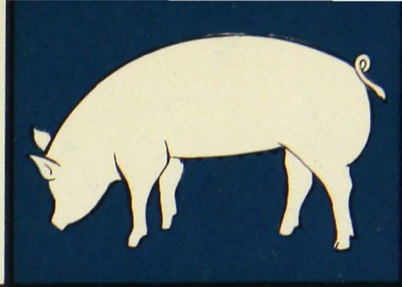
Genetic Improvement through Swine Selection



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On-the-farm testing is designed to help swine producers select breeding stock that can produce prolific pigs that gain rapidly and efficiently and provide acceptable end products for the consumer.

Recent improvement in the production of large, fast growing litters has been the result of superior feeding and management practices. Of course, improvements in nutrition and management do not become part of a hog's inheritance. But permanent improvement can be attained by selecting parental stock with the best genetic makeup for those economic traits. Performance records made under constant environmental conditions are the best indicators of this genetic potential.

Today, swine breeders have become more conscious of the importance of a good swine breeding program and the role heredity plays in the improvement of performance and carcass desirability. If maximum genetic gain is to be made, breeding stock cannot be selected on the basis of sight alone. Modern selection programs must place emphasis on overall performance records.

Facts To Remember

New genes are not created — breeders merely try to find those combinations of genes that produce a superior individual. To produce superior offspring, mate individuals that excel in desired characteristics and gene combinations. The amount of genetic improvement gained depends on four factors: (1) heritability of the trait, (2) amount of selection pressure, (3) genetic association of selected traits, and (4) generation interval.

Differences between animals result from genetic and environmental causes. Environmental variations are not transmitted from parents to offspring, but they may mask hereditary variations. So environmental conditions must be controlled as much as possible if comparisons are to be made in selecting prospective breeding stock.

Genetic progress is slow, but faster improvement can be made by selection for highly heritable traits. Characteristics such as carcass merit, structural soundness, and growth rate are medium to high in heritability estimates, while reproductive traits such as litter size and birth rate are relatively low. Concentrate on traits of major economic importance. When you select several traits, expect slower improvement in each trait. Research has shown that if two traits are considered, selection for either of the two can be only 70 percent as intensive as when selection is practiced for only one trait. If three traits are considered, selection can be only 58 percent as intense as for one trait. More selection pressure is possible in sire selection than in female selection since in most swine herds one sire is used for 20-25 females.

Generation interval, the average age of the parents when their progeny is born, is approximately 2 years in most swine herds. The expected yearly progress made for each selected trait is determined by:

$$\frac{\text{selection differential x heritability}}{\text{generation interval}}$$

Sex of the pig affects muscling and gainability. A comparison of 692 barrow-gilt littermate pairs tested at Minnesota swine evaluation stations is given in table 1. On the average, gilts have 0.1-0.2 inch less backfat, about 0.4-0.5 square inch more loin-eye area, and about 1 percent more ham than littermate barrows. Boars normally probe 0.2-0.3 inch less backfat than littermate gilts. Boars usually grow faster on less feed than barrows or gilts, while barrows reach 220 pounds sooner than gilts.

Table 1. Performance of 692 barrow-gilt littermate pairs at Minnesota swine evaluation stations

	Barrows	Gilts
Daily gain, pounds	1.90	1.73
Age at 220 pounds, days	158	166
Carcass length, inches	29.50	29.80
Backfat thickness, inches	1.54	1.44
Loin-eye area, square inches	3.93	4.43
Percent ham and loin of live weight	26.05	27.31
Percent ham of live weight	14.30	15.05

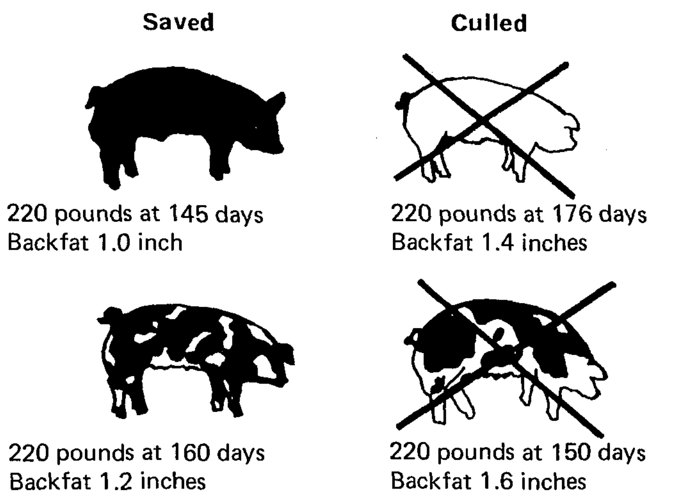


Figure 1. Under the independent culling system, the individual must meet minimum requirements for each trait or it is culled.

Type Of Selection

Selecting for improvement in one trait at a time is called "tandem selection." The breeder selects for improvement in one trait, raising it to the desired level. Selection is then begun for a second trait. Generally this method is not useful for livestock improvement.

Eliminating abnormalities or undesirable traits such as inverted nipples or extremely weak legs usually is necessary. A breeder sets minimum requirements for each trait and practices "independent culling" (figure 1). Under this system, the individual must meet minimum requirements for each trait or it is culled.

Since selecting for a combination of traits is important, combining the independent culling level and a "selection index" is the most practical program. The selection index allows high performance in one trait to offset slightly deficient performance in another trait. The amount of emphasis given to each trait depends on:

1. **Economic value.** Emphasize traits that will increase profits. It is unrealistic to spend time and money improving a trait that doesn't increase profitability.

2. **Heritability.** Pay most attention to the highly heritable traits. Heritability is the portion of the average superiority of selected parents that is passed on to their offspring. It is an estimate of the proportion of the total variation that is due to heredity. The balance of the variation is due to environment. When we say that carcass length is 60 percent heritable, we mean that about 60 percent of the variation in the herd is due to heredity and 40 percent is due to environment. The average estimated heritabilities for some economically important traits in swine are given in table 2. The estimates show that sow production traits are relatively low, so improvement in these traits will be slow.

Table 2. Heritability estimates

Level of heritability	Characteristic	Average percentage
High	Carcass length	60
	Percent ham (based on carcass weight)	60
	Percent fat cuts (based on carcass weight)	60
	Backfat thickness	50
	Loin-eye area	50
	Percent lean cuts (based on carcass weight)	50
Medium	Meat tenderness	30
	Meat color	30
	Marbling in loin	30
	Firmness of meat	30
	Feed efficiency	30
	Growth rate (weaning to market)	30
	Five-month weight	25
Low	Weaning weight	15
	Number farrowed	10
	Number weaned	10
	Birth weight	5

How heritability information is used to predict progress expected through selection:

Assume that the backfat thickness for your present pig crop is 1.5 inches at 220 pounds, and the replacement gilts selected for your breeding herd from this group average 1.1 inches of backfat. These gilts are mated to an on-the-farm tested boar from your herd raised under similar conditions. The boar probed 0.9 inch backfat at 220 pounds.

The gilts saved have 0.4 inch less backfat than the herd average ($1.5 - 1.1 = 0.4$) and the boar has 0.6 inch less ($1.5 - 0.9 = 0.6$). This difference between the selected breeding stock and the average of the herd from which animals were selected is called the selection differential. Comparisons of selection differentials are valid only when pigs are from the same population and are raised under similar conditions.

By selecting breeding stock with less backfat, a breeder attempts to decrease the backfat thickness of his herd. In the case of backfat thickness, only 50 percent of the selection differential is heritable and could be transmitted to the offspring. The predicted average backfat thickness for the pig crop resulting from these matings is calculated in this manner:

Present pig crop average	Selection differential of breeding stock saved	Heritability of trait	Predicted average backfat of next pig crop

$$1.50 - \left[\frac{\overset{\text{gilts}}{(0.4} + \overset{\text{boars}}{0.6)}}{2} \times .50 \right] = 1.25$$

From the selection shown above, the next pig crop should have 0.25 inch less backfat than the average of the herds from which the boar and gilts were selected. Figures within the brackets (average selection differential times heritability) determine the change expected. This change is added or subtracted from the present average, depending on the direction in which selection is practiced.

3. **Correlations among traits.** Traits under selection pressure often are correlated. Genetic correlations are used to measure the extent to which two traits are controlled by the same genes. Some genetic correlations reveal a slight antagonism between meatiness and meat quality, but the magnitude of these correlations is quite low. So superior meaty hogs of acceptable quality can be produced, but both traits must be emphasized to accomplish improvement. From limited information regarding the genetic correlations between different traits, it appears that most relationships tend to be compatible and do not handicap selection for a desirable combination of traits.

Traits To Consider

If swine selection is used to improve overall genetic merit, performance and production of each animal must be measured and recorded. Since it is useless to select for traits that have no economic importance, a sound selection program should emphasize only the important traits. Sow productivity, feedlot performance, carcass merit, and soundness generally are considered of greatest importance in hog production.

Sow Productivity

Sow productivity is a measure of reproductive ability (prolificacy), milking ability, and mothering ability. Number of pigs farrowed and weaned and individual pig and litter weights at weaning are the most common measures of sow productivity. Litter weaning weight probably is the best single measure.

Litter weights at 3-5 weeks of age are a better measure of milking ability than weights at 6-8 weeks. The important thing is to get litter weights at an age that fits individual management procedures and your breed association's production registry programs. Most breed associations require certain standards to qualify for production registry. These breed production standards are listed in table 3. Figures 2 and 3 are charts for adjusting weaning weights to 21-day and 56-day weight bases, respectively.

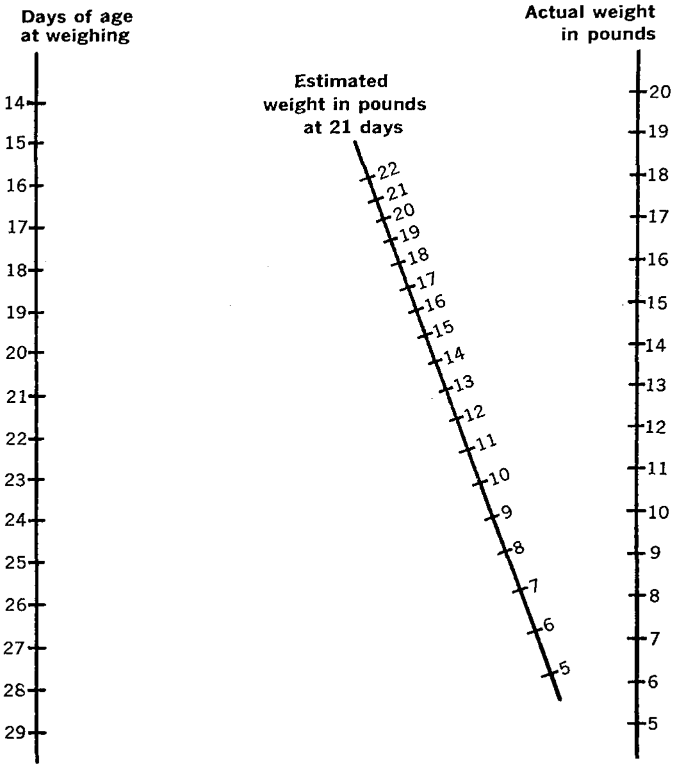


Figure 2. Adjusted 21-day weight chart. Lay a ruler or any straightedge from a point on the left scale, which represents the age of the pig, to a point on the right scale, which represents the pig's weight. The intersection of this line and the center scale shows the estimated weight of the pig at 21 days of age.

Table 3. Breed production registry standards

Breed	Birth				21 days				56 days			
	Gilt		Sow		Gilt		Sow		Gilt		Sow	
	Number of pigs	Weight, pounds	Number of pigs	Weight, pounds	Number of pigs	Weight, pounds	Number of pigs	Weight, pounds	Number of pigs	Weight, pounds	Number of pigs	Weight, pounds
Berkshire	8	22	9	26	..	..	..	..	..	..	..	..
Chester White	8	22	9	26	8	95	8	105	..	..	..	..
Duroc	8	22	9	28	..	..	..	..	..	..	..	..
Hampshire												
Standard	..	..	..	..	..	..	..	..	8	275	8	320
Pacesetter	..	..	..	..	..	..	..	..	9	355	9	400
Landrace												
Standard	..	..	..	..	8	90	8	90	..	..	..	..
4-Star*	..	..	..	..	8	120	8	120	..	..	..	..
Poland China	8	22	9	26	..	..	..	..	..	..	..	..
Spotted	8	22	9	26	8	95	8	105	8	275	8	320
Tamworth	..	..	..	..	8	75	8	90	..	..	..	..
Yorkshire	..	..	..	..	8	95	8	105	..	..	..	..

* Star litter recognition ranges to 10-star. An additional star is added for each 30-pound increase in 21-day weight and each 100-pound increase in 56-day weight.

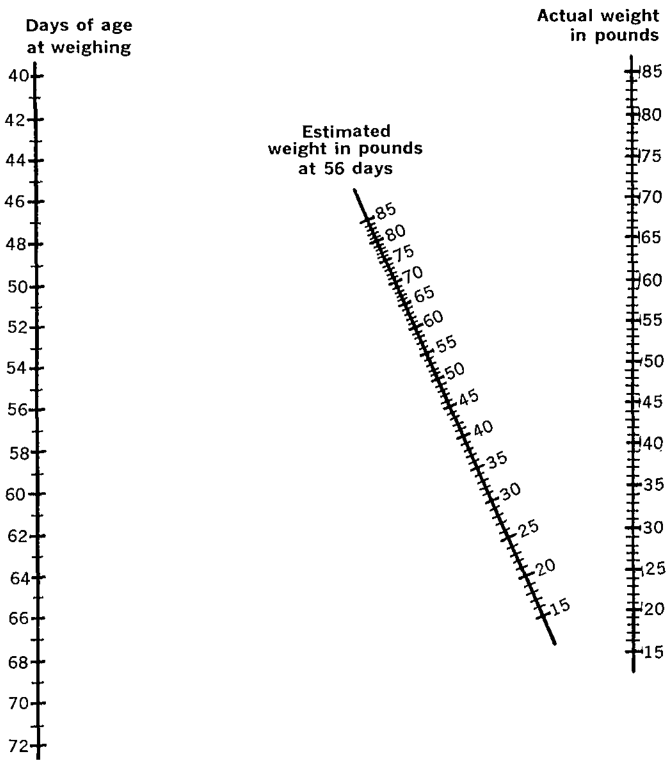


Figure 3. Adjusted 56-day weight chart. Lay a ruler or any straightedge from a point on the left scale, which represents the age of the pig, to a point on the right scale, which represents the pig's weight. The intersection of this line and the center scale shows the estimated weight of the pig at 56 days of age.

A sow's production record for one litter often is not a good indication of what her next litter will be like. This fact is due to low repeatability for size and weight of different litters and the low heritability of single production records. Therefore, selection for sow productivity is more effective when more than one record by the same sow is considered.

Feedlot Performance

Rate of Gain. Fast gaining pigs cut production costs by reaching market weight at an earlier age. For example, marketing 100 hogs 10 days earlier saves the producer 1,000 hog feeding days. The economics of feeding hogs for fewer days must be figured on an individual farm basis to determine feed costs, labor, interest on investment, depreciation, increased risk of death, and the marketing outlook.

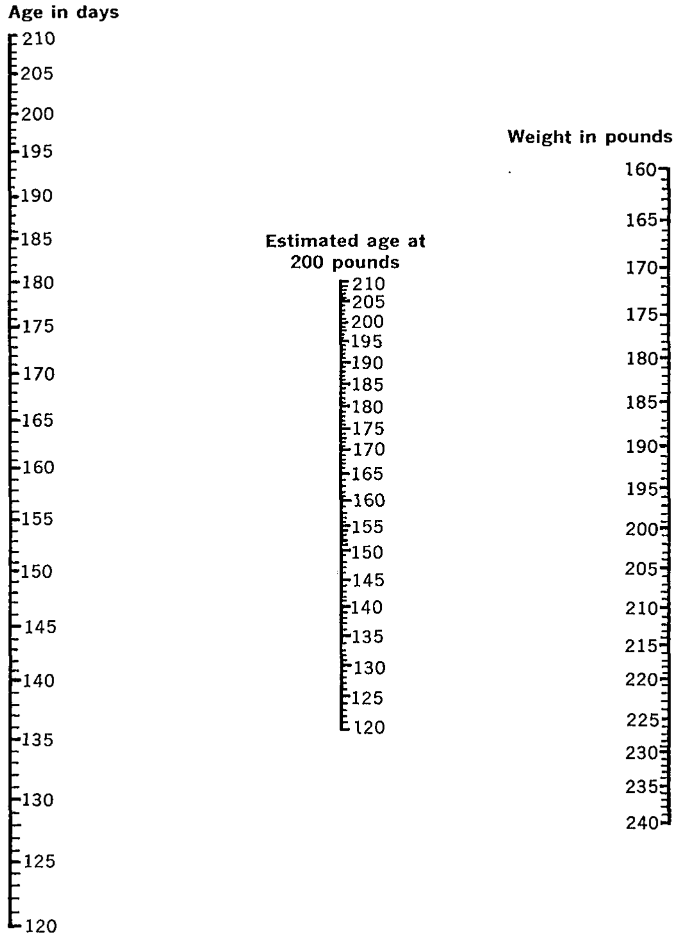
Rate of gain often is used as an indirect measure of feed efficiency. Fast gaining pigs usually require less feed per pound of gain. Measuring feed conversion directly on prospective breeding stock is impractical, but by selecting the faster gaining individuals one indirectly selects the more efficient ones. Though less accurate than direct selection for feed efficiency, this indirect selection often is the only practical method.

Rate of gain is 25 percent heritable, which permits improvement by selection. For example, if boars and gilts that weight 20 pounds above the herd average at 5 months of age are selected, a 5-pound improvement can be expected in their offspring. Age at 220 pounds is the most convenient way to measure growth rate. This weight is obtained when pigs are approaching market weight and takes into account both the before and after weaning gains. To meet certification standards, pigs must weigh 220 pounds or equivalent at 180 days. Use figure 4 to estimate age in days at 200 pounds. A scale enables you to get necessary production records, and it improves systematic marketing of hogs at desirable and economical weights. (Conversion factor for adjusting to 220 pounds = 2 pounds per day.)

Feed Efficiency. Less feed needed per pound of gain means lower production costs. Improved feed utilization results in greater net profit or smaller net loss in bad price years. But the benefits of improved efficiency often are an unseen saving unless you keep accurate feed records.

Feed conversion is about 30 percent heritable, which is high enough to make selection effective. But feed utilization is more difficult to measure than rate of gain. It requires either individual feeding or feeding of small

Figure 4. Chart for estimating age at 200 pounds. Lay a ruler or any straightedge from a point on the left scale, which represents the age of the pig, to a point on the right scale, which represents the pig's weight. The intersection of this line and the center scale shows the estimated age of the pig when his weight is 200 pounds. (Conversion factor for adjusting to 220 pounds = 2 pounds per day.)



progeny groups, which demands additional equipment and labor.

When possible, on-the-farm feed conversion records should be kept on a litter basis or on a representative sample of the herd. These records should be supplemented by those of representative samples of pigs at the swine evaluation station that were sired by the same boar and are to be fed out under uniform conditions. Some breeders have found test station feed efficiency records and on-the-farm growth records to be the most practical tools for feed efficiency selection in their herds.

Carcass Merit

Meatiness. A meaty pig has a high percentage of muscle per pound of live weight. This in turn means:

- A high value product.
- Less surplus fat on the market.
- Sustained market demand for pork.

Backfat thickness, loin-eye area, and yield of lean cuts of ham and loin are associated with meatiness. Average heritabilities for these carcass traits range from 30 to 60 percent, indicating that fairly rapid progress can be made through selection. Except for backfat thickness, however, these traits can be measured and appraised only on slaughtered hogs. So carcass merit measurements must be made on relatives of stock selected for breeding.

Probed backfat thickness, a good indication of carcass backfat and overall meatiness, can be measured on the live animal. The only equipment needed is a snare to catch the hog, a sharp knife or scalpel blade, and a narrow 6-inch metal ruler with 1/10-inch graduations (figure 5). Make a small incision in the skin, insert the ruler, and push it through the fat layer (figure 6). A layer of connective tissue ("false lean") often is present about halfway through the fat layer, particularly over the shoulder. Extra pressure is needed to penetrate this layer. Figure 7 shows the probing sites on the live hog.

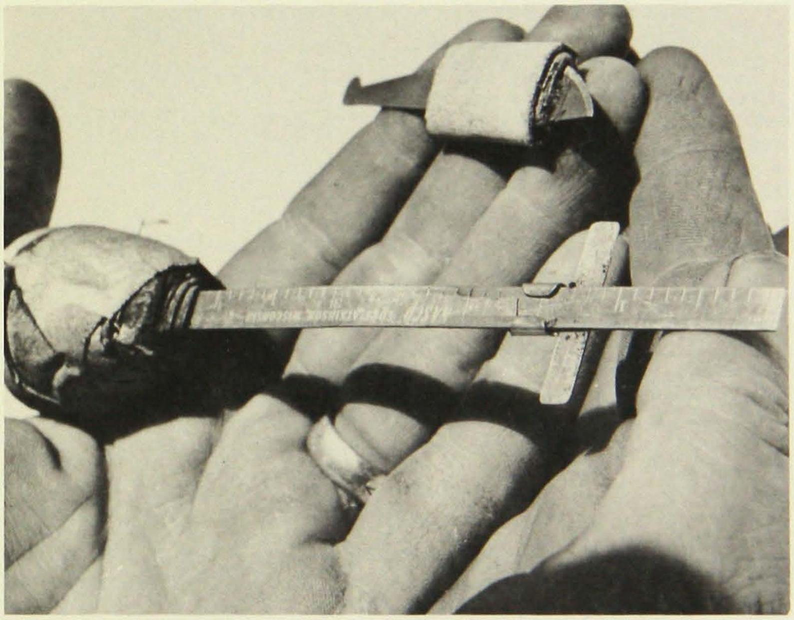


Figure 5. Probing tools include a knife or scalpel and a thin steel ruler with 1/10-inch graduations.

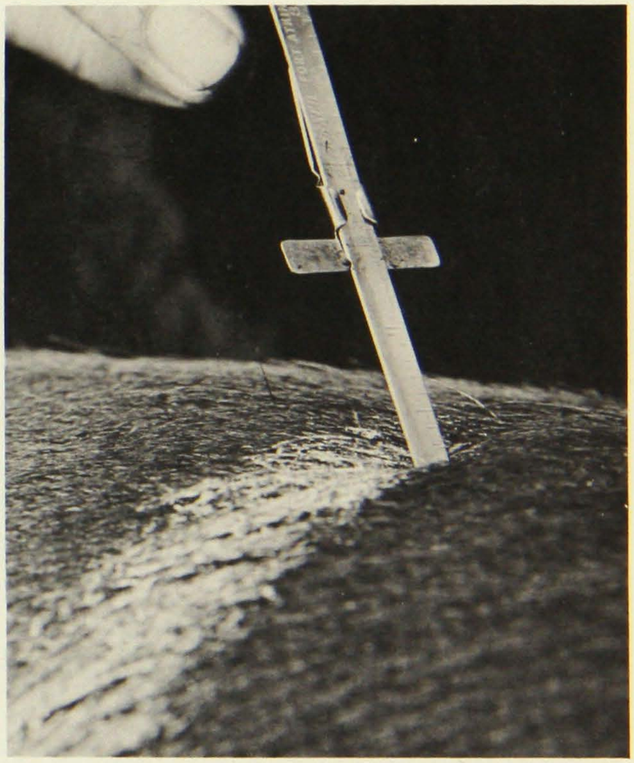


Figure 6. Probe about 2 inches from the midline of the pig's back and crosswise to the pig. Insert steel ruler in cut and slant bottom end toward middle of pig's body, forcing ruler through fat down to the muscle. Push clip of ruler against skin, remove ruler, and read measurement.

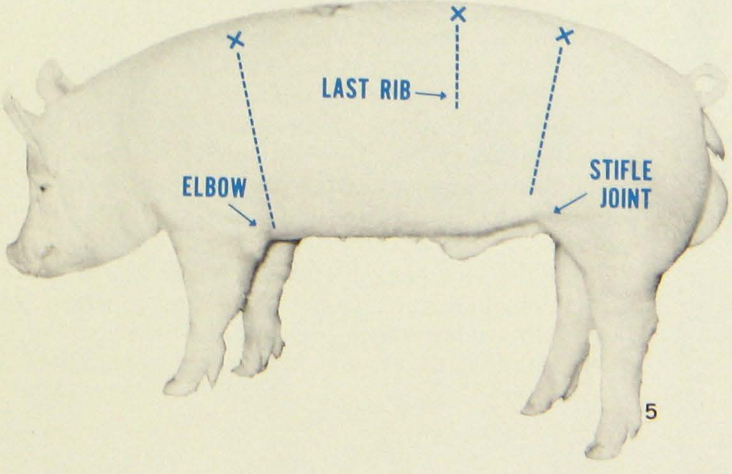


Figure 7. Probe each hog at three locations: midpoint of shoulder above elbow; middle of back where last rib joins the vertebrae; rump, straight above the stifle joint.

A leanmeter also can be used to measure backfat thickness on the live hog, but the blade and ruler method is less expensive and quite accurate. Ultrasonic measurements are used by some research personnel and producers to evaluate muscling in live hogs.

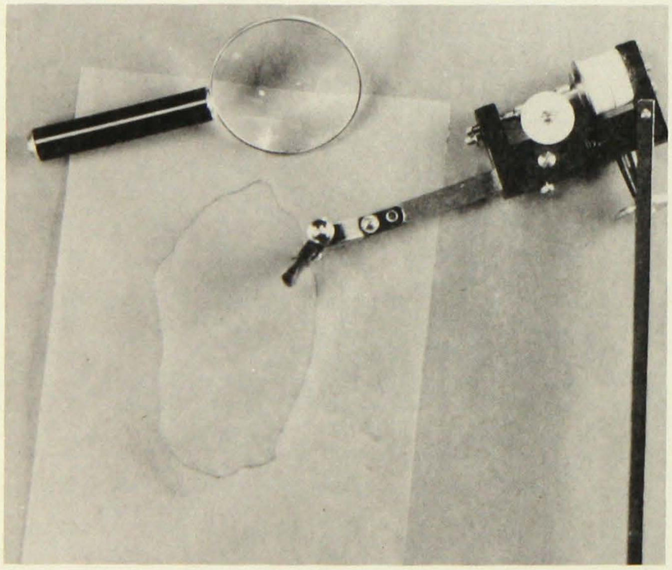
Loin-eye area measured between the 10th and 11th ribs is a common measure of carcass meatiness. A large loin-eye area means large pork chops and is a fair indicator of overall meatiness. Figure 8 shows how loin-eye area is measured and figure 9 shows an approximate 6.5 square inch loin-eye area. To meet certification standards, the longissmus dorsi muscle (loin-eye) must measure at least 4.50 square inches at 220 pounds.

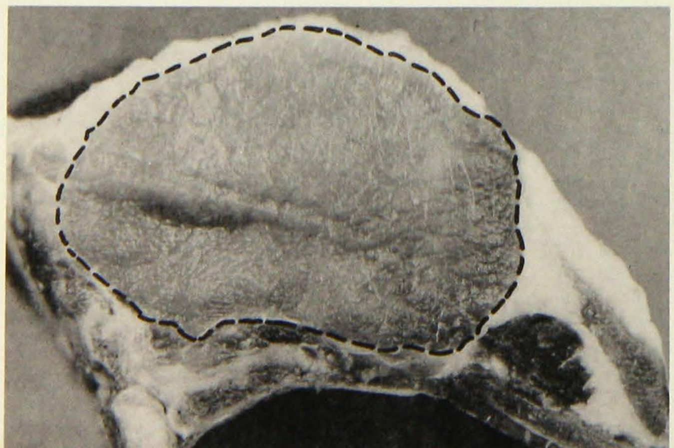
A high yield of lean cuts means less trimmable fat and more edible meat. The aim is to get a high proportion of the carcass in the high priced ham and loin cuts. Yield often is expressed as a percentage of four lean cuts (ham, loin, picnic, and Boston butt) or as a percentage of primal cuts (four lean cuts plus belly).

Carcass length also is normally included as a desirable carcass trait, but it has little relation to muscling in the carcass. A minimum length of 29.5 inches is required to qualify for certification standards (figure 10). A medium length carcass may be desired for production purposes, but length should not be overemphasized to the detriment of other traits.

Figure 8 (top). A planimeter is used to measure loin-eye area. Loin-eye area is measured between the 10th and 11th ribs after the carcass has been chilled correctly for 24 hours. The loin is cut at an exact right angle and the short end of the loin is set on a table with the newly exposed loin-eye at the top. A piece of acetate is then placed over the exposed loin-eye and the main muscle is traced. Only the loin-eye muscle and not the adjacent lean area is included in this measurement.

Figure 9 (bottom). An approximate 6.5 square inch loin-eye area.





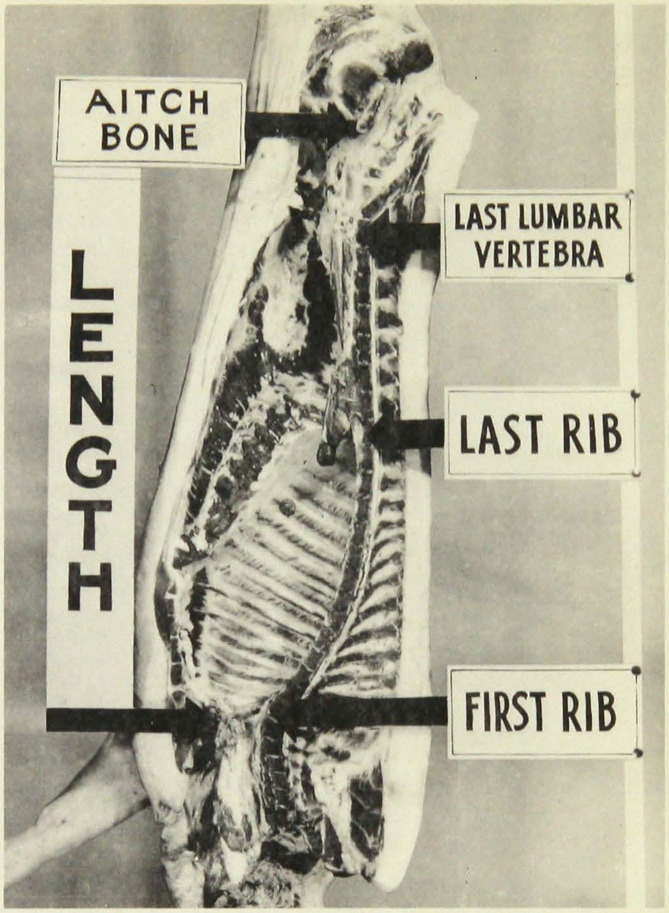


Figure 10. Carcass length and backfat thickness measurements. Length is measured from the lower point of the aitch bone to the forward edge of the first rib. Backfat is measured opposite the first rib, last rib, and last lumbar vertebra. The average of the three backfat measurements is used.

Soundness

Underlines, feet and legs, and freedom from abnormalities must be considered in selecting breeding stock. Figure 11 shows a desirable gilt with acceptable soundness.

Mammary characteristics are heritable. Number and spacing of nipples should be considered in selecting both boars and gilts. Most breeders consider 12 well spaced, well developed nipples to be minimum. Breeding stock with inverted or blind nipples should be culled. Otherwise, this characteristic may occur in so many of the offspring that many females will have little breeding value.

Straight, well placed, sound feet and legs are a must, especially where hogs are to be raised on concrete. Select hogs with a wide stance both fore and rear; strong, medium length pasterns; and heavy bone. Much foot and

Table 4. Suggested guide for selecting breeding stock

Characteristic	Boars	Gilts
Age at 220 pounds	150 days or less	165 days or less
Pounds of feed required per hundredweight of gain	Less than 300 pounds	Less than 320 pounds
Probed backfat thickness	Less than 1.0 inch at 220 pounds	1.3 inches or less at 220 pounds
Cutout information on relatives:		
Carcass length	At least 29.5 inches	At least 29.5 inches
Backfat thickness	1.3 inches or less	1.5 inches or less
Loin-eye area	At least 4.75 square inches	At least 4.5 square inches
Percent ham and loin:		
Of live weight	At least 25 percent	At least 25 percent
Of carcass weight	At least 36 percent	At least 36 percent
Soundness:		
Underline	Minimum of 12 functional teats	Minimum of 12 functional teats
Feet and legs	Straight, well placed, strong	Straight, well placed, strong

leg trouble can be avoided by selecting parents sound in these respects.

Abnormalities such as shakes, hernia (either scrotal or inguinal), or cryptorchidism (one or both testicles retained in abdomen) occur often enough to deserve attention. A breeder never can be sure that his herd is free from genes that might be responsible for these conditions.

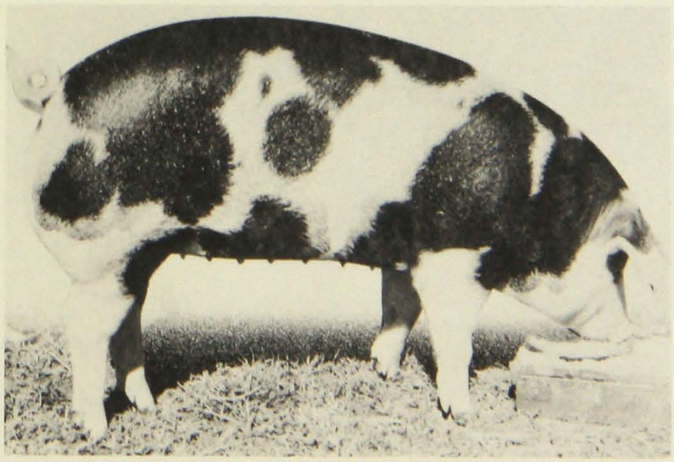
Table 4 contains some characteristics and guides for replacement gilt and herd sire selection.

Selection Methods

Various selection methods can be used. The method you choose will depend on the records required and the ease of collecting data.

Pedigree Selection. Pedigree selection is a useful tool when selecting young animals before their individual performance is known. Since breeders of specific pathogen free (SPF) swine have regulations that prohibit selection of herd sires from non-SPF herds, pedigree selection of bred sows has become one of the primary means of herd sire selection.

Figure 11. A desirable gilt with acceptable soundness.



Pedigree information also is useful when selecting for traits that are sex limited — milking ability in the sow or sperm motility in the boar, for example. Traits that are expressed late in life, such as longevity, make pedigree information essential.

The relative emphasis placed on pedigree selection decreases with the amount of information obtained on the individual. Too often pedigree selection is overemphasized and remote ancesters are given too much credit. Remember, only 25 percent of the individual's genes are similar to those of his grandsire or granddam.

Individual Selection. Individual breeding value can be determined on such traits as rate of gain, backfat probe, and feed efficiency (usually obtained on a sire basis). Records of these traits should be supplemented with production and carcass data from full or half sibs. Individual selection will result in the most rapid genetic improvement if the heritability of selected traits is medium to high.

Family Selection. Family selection can be used to support individual selection for low heritable traits such as sow productivity. Select gilts with an outstanding record from a family known to be superior.

Litter Selection. Litter selection is a method used to measure the breeding value of the parents. Traits such as rate of gain and backfat probe can be measured individually, while feeding pigs in litter groups provides feed efficiency data. Detailed carcass records on such characteristics as backfat, length, loin-eye area, and percentage of ham and loin can be collected on two or more representative individuals from the litter.

Some breeders prefer to obtain litter information on two representatives from each litter. Since sex differences do influence performance, sex distribution of test barrows and gilts should be equal. However, most purebred breed associations will accept either barrows or gilts for certification.

Progeny Selection. Progeny testing is one of the most accurate methods of measuring the genetic merit of a sire or dam. Every additional offspring that is produced and evaluated is another sample of the genes transmitted by the parents.

The accuracy of a progeny test depends on unbiased comparisons. Therefore, when comparing sires, follow these suggestions:

1. Mate boars to a random group of dams. The sows should be comparable in age and genetic background. For example, don't breed all gilts to one sire and older sows to another sire. Gilts generally have smaller litters and give less milk than older sows, which influences sire performance.

2. Select a representative sample of each progeny group. Don't choose the very best or poorest pigs in the litter.

3. Provide the same management and nutrition for all the progeny groups. Many breeders enter progeny groups in the central evaluation stations. At these locations, the environment is uniform and accurate comparisons can be made.

4. Use equal sex distribution. Although sex corrections can be made, a more valid test results if one barrow and one gilt are tested from each litter.

5. Make enough comparisons. Since the accuracy of a progeny test is determined by the heritability of the trait, more progeny are needed to accurately measure rate of gain than for the various carcass traits. The minimum number of progeny required to certify a sire is two pigs from five different litters where not more than two of the dams are full sisters or dam and daughter.

Litter Record Card

Breeder ______ Address ______ Breed of litter ______

Sow ______ Registration number ______ Date bred ______ Number farrowed: Alive ______ Dead ______

Boar ______ Registration number ______ Date farrowed ______ Date weaned ______ Number weaned ______

Pig number	Sex	Birth notes	Weaning weight		Weight for age			Backfat probe										
			Actual	Adjusted	Date	Actual	Adjusted	Weight	Unadjusted	Adjusted	Daily gain	Age at 220 lb.	Feed efficiency	Carcass length	Carcass backfat	Loin-eye area	Percent ham and loin	Remarks
Total																		
Average																		

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