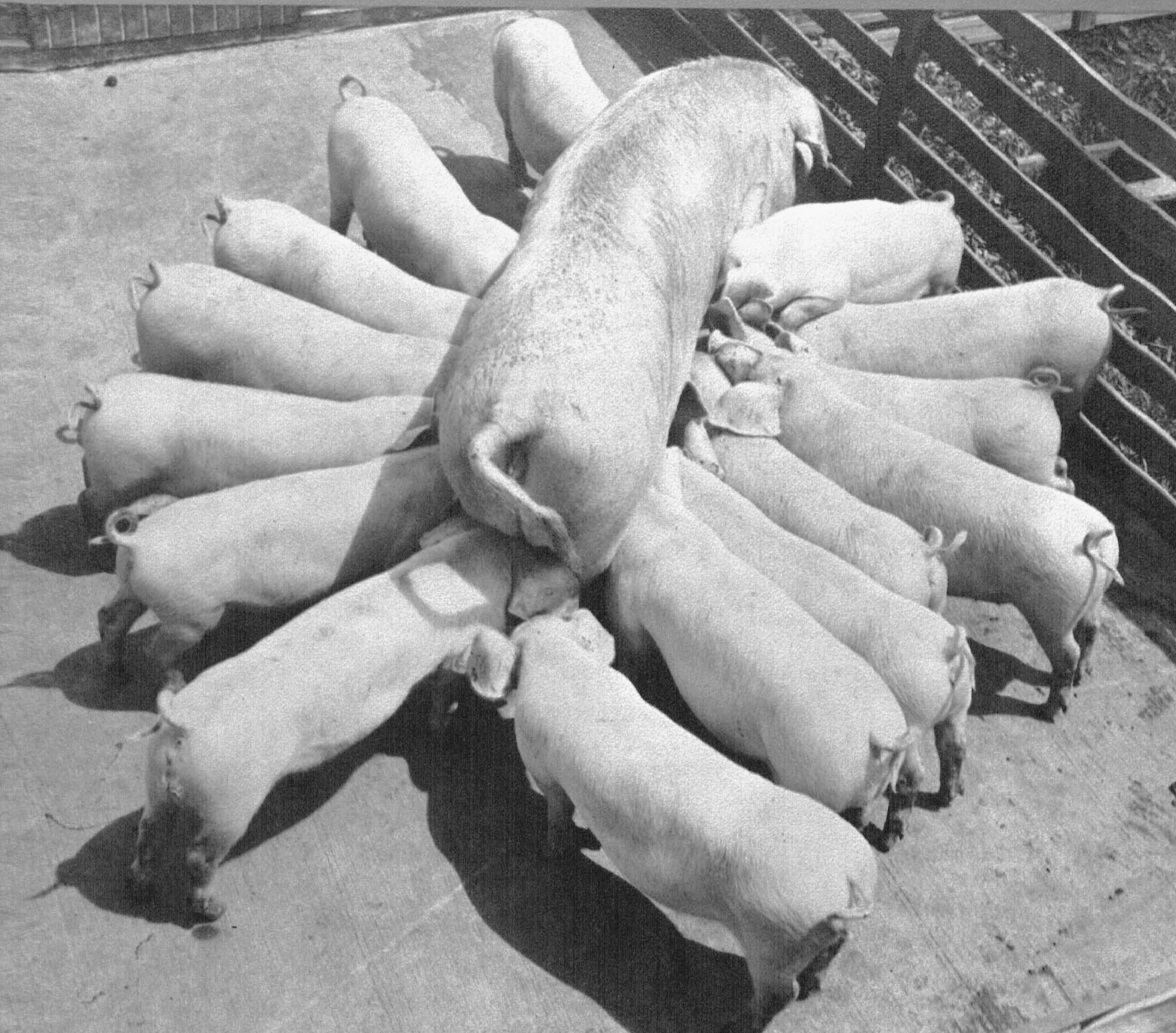
Improvement of Swine Through Breeding



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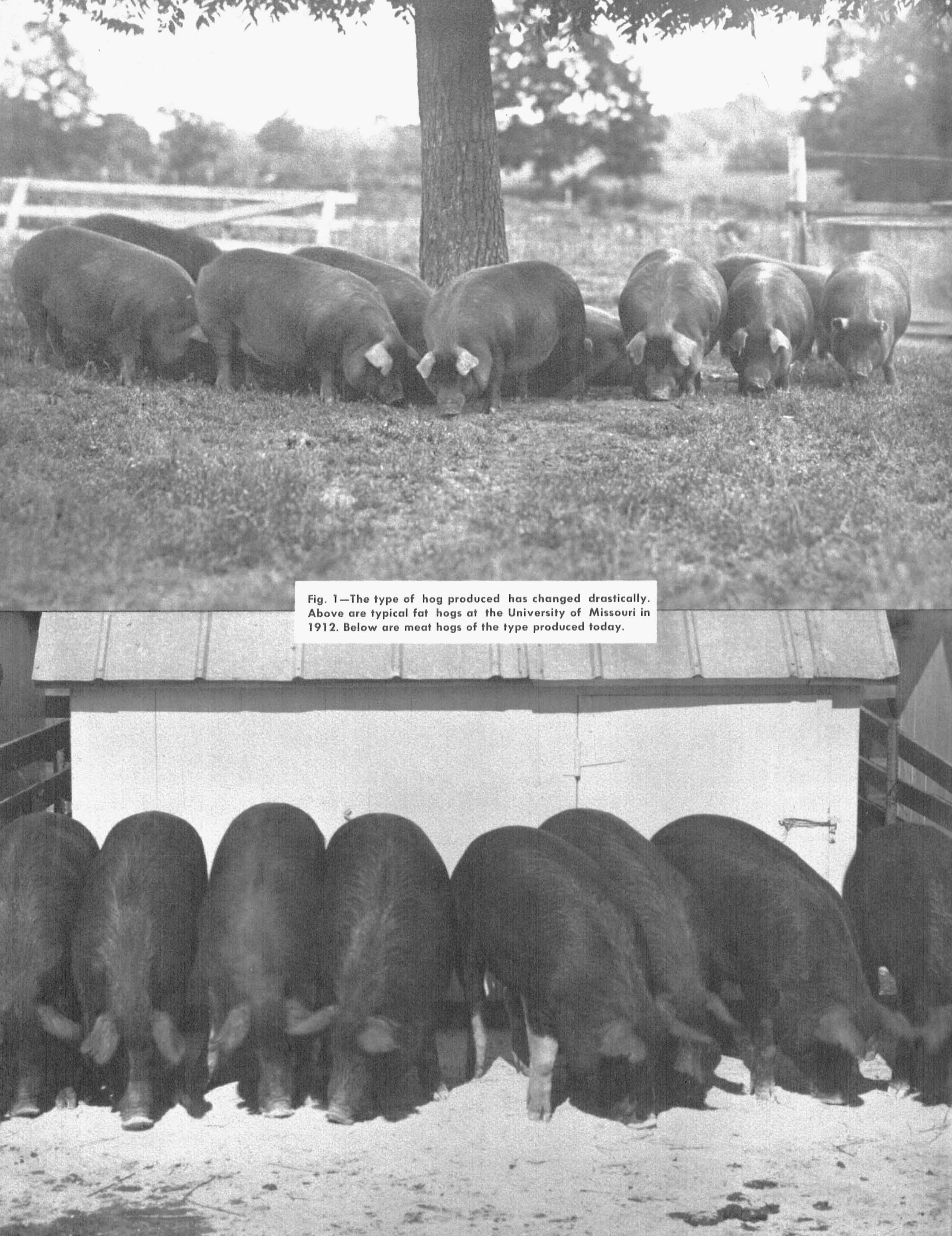

Fig. 1—The type of hog produced has changed drastically. Above are typical fat hogs at the University of Missouri in 1912. Below are meat hogs of the type produced today.

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CONTENTS

● Missouri farmers produce between 200 and 250 million dollars worth of hogs each year. This represents from 26 to 33 percent of the total yearly income from livestock and livestock products in this state.

As a pork producer are you getting your share of this huge income from hogs? Are you using the best methods of production possible? Are you producing the "meat type" hog? If your answer to any of these questions is no, you can profit by using the breeding plans outlined in this bulletin.

The efficiency of pork production has increased greatly in the last ten years. This is due to the application of new findings in breeding, feeding, management, and disease control. The application of improved breeding methods is receiving more attention of late.

Improvements through breeding can be made by both purebred and commercial swine producers. Breeders of purebreds can make improvements by selecting the best and mating the best to the best. Such progress may be slow but can be very important over a period of five to ten years. Crossbreeding is used by the commercial pork producer to take advantage of hybrid vigor or "heterosis."

Hybrid vigor refers to the improved average performance of the offspring over the average of their parents. Some traits in swine show hybrid vigor, others do not. Improvements because of hybrid vigor come rapidly and add to those made through selection within the pure breeds used for crossbreeding. The upper limit of improvement from crossbreeding is soon reached, however. It then becomes a matter of trying to maintain this advantage in later generations.

Proper breeding methods can increase the annual income from swine in Missouri by millions of dollars. A product more suitable to the consumer can also be produced through breeding. It is the purpose here to outline some basic genetic principles and to recommend breeding practices for more efficient swine production.

Cover Photo: Courtesy of Cowdena Farms, Trimble, Mo.

Some Genetic Principles

Most of us are familiar with the term "inheritance." We all understand that this means the ability of parents to transmit their own characteristics to their offspring. We also understand that each individual receives one-half of its inheritance from its father and one-half from its mother. We do not understand so clearly the methods whereby each parent is able to transmit this inheritance to its offspring. An explanation of these methods is now in order and to help clarify certain principles involved in the breeding and improvement of swine.

The bodies of animals are made up of billions of building blocks called cells. Any one of these is so small that it can be seen only with the aid of the microscope. Each cell consists of cytoplasm and a nucleus (Figure 1). The cytoplasm may take many shapes and forms but the nuclei of all cells are very similar.

The nucleus is the portion of the cell involved in inheritance. Within the nucleus are small thread-like structures called chromosomes. The chromosomes are made up of many chemical compounds called genes. The genes are the particles of inheritance that are transmitted from parents to their offspring. The chromosome may be pictured as a long string of beads, with each bead representing a single gene. Each chromosome may carry hundreds or even thousands of genes.

Chromosomes occur in the body cells in pairs. The chromosomes of each pair are alike in size and shape (sort of twins) and are called *homologous* chromosomes. *Homo* means equal or alike and *logous* means proportion. A further characteristic of homologous chromosomes is that one of each pair came from the father and the other from the mother. Only one of each chromosome pair is passed from an individual to any one of its offspring. Which one this is depends upon chance alone.

Since the genes are carried on the chromosomes, they also occur in pairs in the body cells. Only one of each pair finds its way into a spermatozoa or an ovum. To illustrate how parents transmit genes they possess to their offspring, let us use the mule-footed condition in hogs as an example. We will let (F) represent the gene for the mule-footed condition since it is dominant and (f) the gene for normal or split hoof. Dominance means that one gene overshadows or covers up the expression of another gene (recessive) located on the same portion of the homologous (twin) chromosome. If we were to cross a pure mule-footed boar with a normal-footed sow the results would be as illustrated in Figure 2.

We can see by this example that all of the offspring of such a mating will have mule feet, even though they also carry one gene for normal feet. Although the pigs all show the mule-footed condition as their sire, they are not the same as he is, genetically. They will not breed true; that is, they will not always produce mule-footed offspring. The sire was of genotype *FF* and was pure or *homozygous*, while his offspring are of genotype *Ff* and are *heterozygous*. *Genotype* means the actual genetic make-up of an individual. *Homo* means alike or equal but *hetero* means unequal. *Zygous* means to join. So an individual possessing two like genes joined together by the union of the spermatozoa and the ovum at the time of fertilization is homozygous. One possessing two unlike genes is heterozygous.

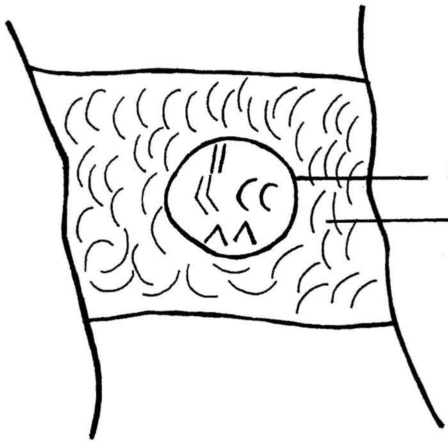

Fig. 2—Diagram of a cell.

Now, let us illustrate what happens when we mate two individuals which are mule footed but are heterozygous (Ff). This is illustrated in Figure 3. When two heterozygous individuals are mated, they produce offspring in the ratio of three mule-footed to one normal-footed. Of the mule-footed offspring, however, one is homozygous, or pure for the condition, and two are heterozygous. All three of these have the same *phenotype,* meaning they look alike and can't be told apart from their outward appearance. These heterozygous *(Ff)* individuals will not breed true. To determine the genotype of the mule-footed individuals they can be mated with those that have normal feet. If five offspring are produced from such a mating and none of them have normal feet, the genotype of that mule-footed parent is probably *FF.* If any one of the offspring has normal feet, the genotype of the mule-footed parent has to be *Ff.*

The foregoing illustration involving a single pair of genes does not explain the inheritance of most of the important traits in swine because the mode of inheritance is much more complex than this. It does show, however, how the genes are transmitted from the parents to their offspring in the spermatozoa and the ovum. It also shows how they recombine, by the law of chance, in all possible combinations in their offspring. The only requirement

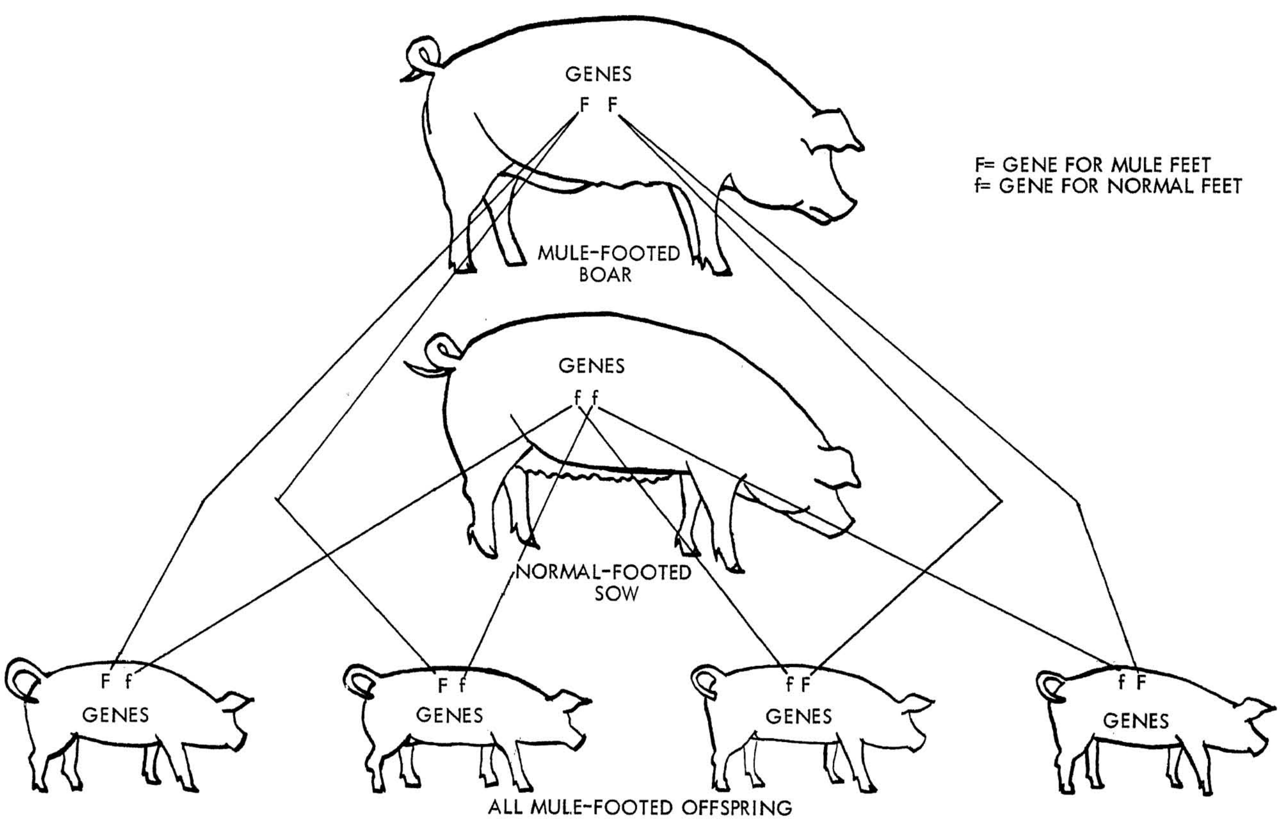

Fig. 3—Diagram showing the kind of offspring produced by mating pure mule-footed boar with a pure normal-footed sow.

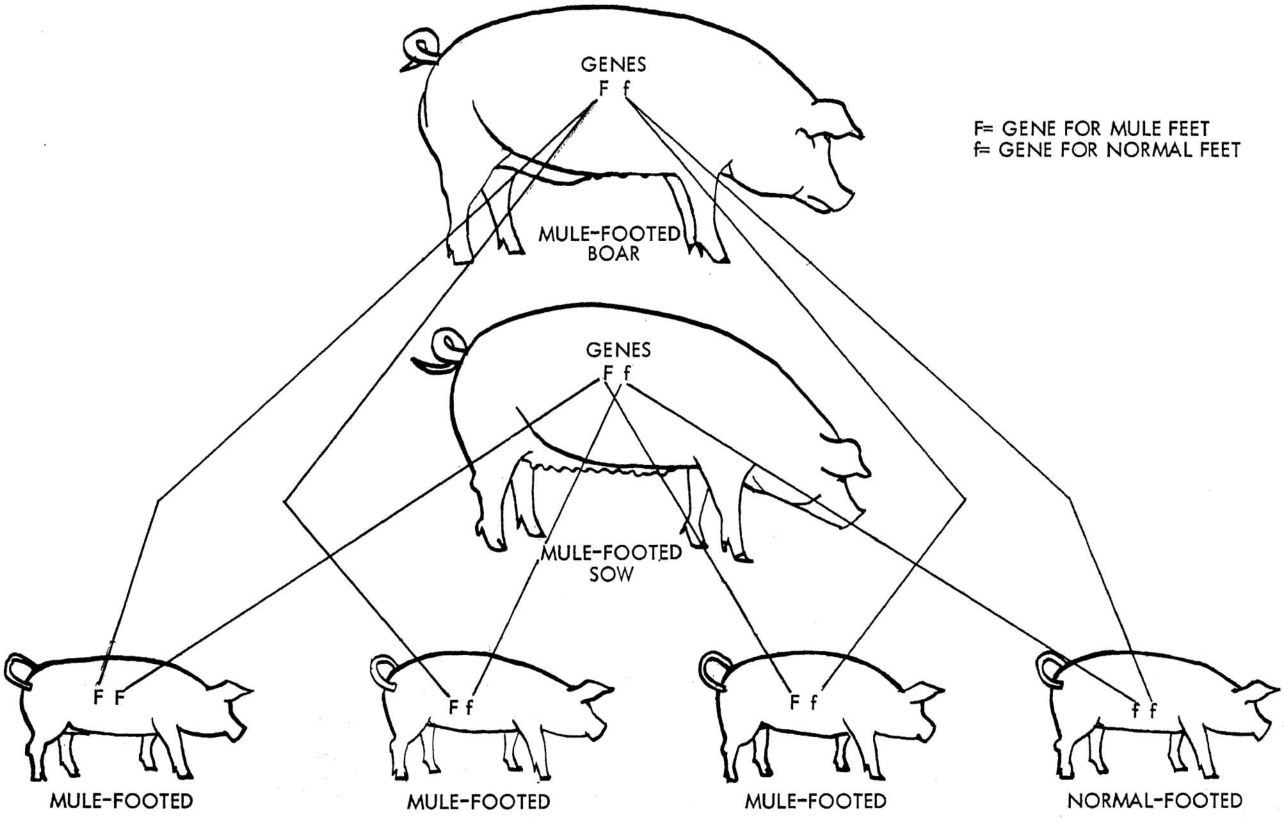

Fig. 4—Diagram showing the kind of offspring produced by mating an impure (heterozygous) boar with an impure (heterozygous) sow.

for genes to segregate and recombine in this way when many different pairs of genes are involved is that the different pairs be carried on different pairs of homologous chromosomes. The way genes express themselves in different combinations can be quite different, however.

Complex Inheritance

Many pairs of genes affect the important economic traits in swine. Among such traits are litter size, rate and economy of gains, and carcass quality. Though many gene pairs are involved, each pair on the homologous pairs of chromosomes of the male and each pair on the female chromosome pairs divides and recombines as in the previous examples.

Genes may express themselves in several ways. But, in general, just two kinds of inheritance are involved. One kind is where the number of desirable genes an individual possesses determines his superiority. In this case some genes contribute something to the superiority of an individual but others do not. We call those that result in superiority *contributing* or *plus* genes. Those that do not contribute something toward superiority are called neutral genes.

Plus genes each add something to the superiority of a trait, but each effect is separate and all effects add up. This additive effect is similar to that which we would get from adding small pellets of a red dye to a gallon of clear water. One pellet added to the water would make it light red, two would make it a little darker red until finally several pellets would make the water very dark red. Thus, one plus or desirable gene would make the animal grow faster than if he possessed only neutral genes. Two plus genes would make him grow a little faster whereas a dozen plus genes would make him grow exceedingly fast if the right environment were supplied.

Obviously, then, the animals which grow the fastest are those which have the most plus genes for fast growth. Therefore, we must find animals possessing the superior genes and then must mate them to produce superior offspring. Breeding for improvement through this kind of inheritance simply means that we find the best and mate the best to the best.

In the second kind of inheritance it is not so much the number of plus genes the individual possesses that determines his superiority. It is how the many genes act in different combinations that is important. This kind of inheritance is responsible for the *nicking* effect so often mentioned by animal breeders. This refers to a favorable combination of the genes of two parents in such a way that their offspring are superior to either parent. It is the principle used in the production of hybrid seed corn, and is responsible for the occurrence of hybrid vigor.

Figures 5 and 6 illustrate the two different types of inheritance. The first kind shown in Figure 5 is where the average of the offspring equals the average of the

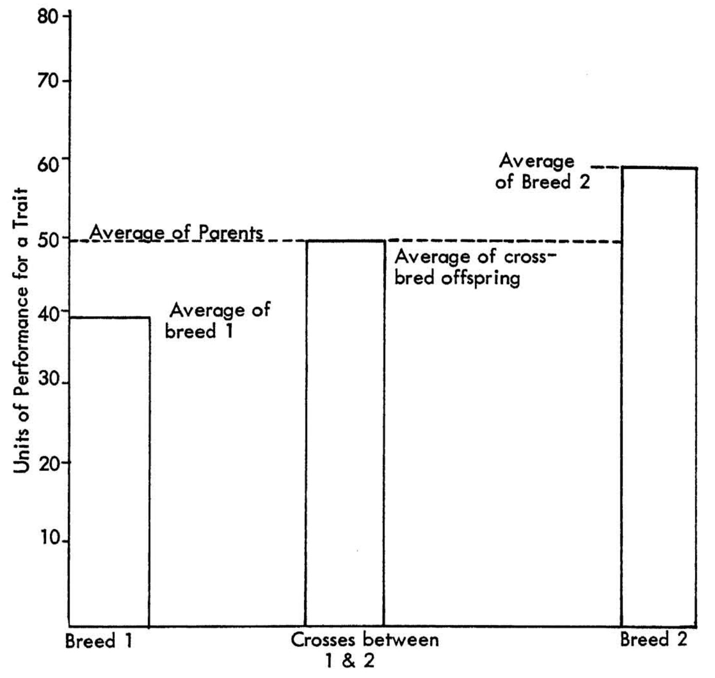

Fig. 5—Performance of crossbred offspring when two breeds are crossed that differ in performance where the assumption is made that the crossbred pigs do not show hybrid vigor. Carcass quality seems to be inherited in this way.

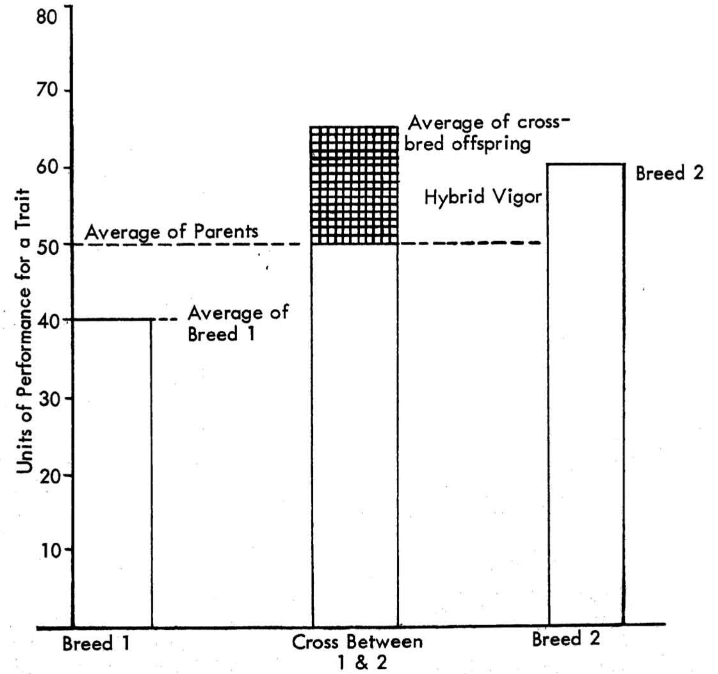

Fig. 6—Performance of crossbred offspring where hybrid vigor results when two breeds are crossed that differ in performance. The degree of hybrid vigor is shown by the crosshatched portion of the bar graph. Litter size at weaning seems to be inherited in this way.

parents. This shows no hybrid vigor and for improvement we need to use parents which are as superior as possible. The second kind of inheritance is shown in Figure 6. The average of the offspring is superior to the average of the parents. This increase over the parental average is called *hybrid vigor* or *heterosis*. It is dependent upon the "nicking" ability of the parents. Even though hybrid vigor is shown, the over-all performance of the crossbred offspring depends upon both the average of the parents and the degree of hybrid vigor expressed for each trait.

The influence of these two kinds of inheritance on the economic traits in swine will be discussed more fully in another section of this bulletin.

Traits of Economic Importance

Many traits in swine are given attention in a selection program. But the more traits you select for the less progress you make in selection for any one trait.

If it is necessary to limit the number of traits selected for, which should be used? The answer is those which determine the dollars in profit returned to you after the hogs are sold. These will be discussed in the following section.

Litter Weight at Weaning

This is one of the most important traits because large litters of healthy pigs must be reared to weaning before they can be fed to market weights. Litter weight at weaning is a reflection of the fertility of the sow, her mothering and milking ability, and the vigor and growing ability of the pigs. It also reflects the general over-all health of the individuals involved.

You can measure litter weight at weaning by weighing each of the pigs at a definite age or near that age and totaling the weight of all pigs. A simple type of bathroom scale will serve for this purpose. The age at weaning should be the same for all litters in the herd. Until recently, the age at weaning most often used was 56 days. Now that excellent starter and pre-starter rations have been developed, many farmers are weaning pigs at ages varying from three to five weeks. Weighing at six to eight weeks is recommended at present when you are weighing for the purpose of selecting breeding stock.

If you are busy and can't find time to weigh all litters when they reach 56 days of age, you can use adjustment factors in Table 1.

Example

If we weigh a litter at 60 days of age and it weighs 300 pounds, this can be multiplied by the factor of .9006 to adjust to a 56 day basis. The adjusted weight would be 300 times .9006 or 270 pounds.

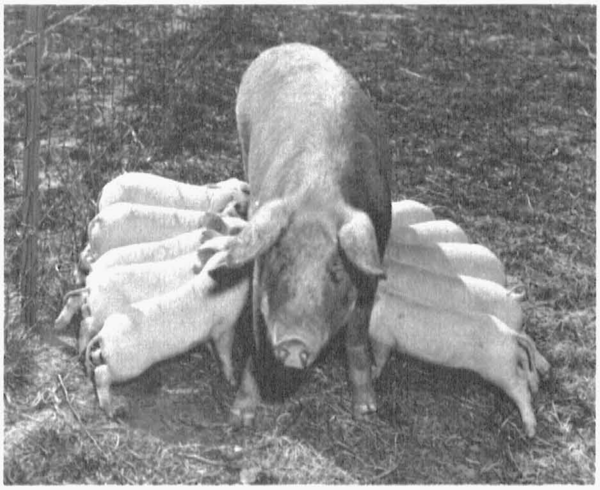

Fig. 7—Large litters of healthy pigs at weaning are essential for profit.

TABLE 1

CORRECTION FACTORS FOR ADJUSTING LITTER WEIGHTS TO A 56-DAY BASIS

Age When Weighed	Multiply Total Litter Weight by This Factor to Adjust to 56 Days
50	1.1801
51	1.1471
52	1.1154
53	1.0849
54	1.0555
55	1.0272
56	1.0000
57	.9738
58	.9485
59	.9241
60	.9006
61	.8779
62	.8560
63	.8359

Litter weight at weaning is about 17 percent heritable, as shown in Table 2. This means that genetic improvement would be very slow by selection within a pure breed and by mating the best to the best. The low heritability for this trait also means that about 83 percent of the variations in this trait are due to environment, such as feeding, management and disease. Attention to these factors are necessary to improve this trait. In spite of the low heritability of this trait, replacement stock should still be selected in so far as possible from the heaviest litters.

TABLE 2

AVERAGE VALUES FOR THE HERITABILITY ESTIMATES FOR TRAITS IN SWINE*

	Average
Items of conformation:	
Length of body	61
Length of legs	64
Number of vertebrae	74
Nipple number	60
Scores for conformation	26
Performance characters:	
Number of pigs farrowed	15
Number of pigs weaned	19
Weight of litter at weaning	17
Weight of pig at five months	21
Growth rate from weaning to 200 lbs.	30
Economy of gains weaning to 200 lbs.	38
Items of carcasses:	
Length	61
Loin eye area	48
Backfat thickness	46
Belly thickness	61
Percent of ham	58
Percent of fat cuts	60
Percent of shoulder	47
Percent of lean cuts	34

*These are averages for many studies made in different parts of the world.

Litter weight at weaning may be improved considerably by crossbreeding. This is shown in Table 9. Averages of many trials show that a three-breed rotation cross gives a 51 percent improvement in litter weight at weaning over the pure breeds used in the cross. The improvement through crossbreeding results from a greater survival rate and increased vigor of the crossbred pigs and the superior fertility and mothering ability of the crossbred sows. The figures presented in this Table are averages, which means that in some crosses the improvements are greater and in other less than this average figure.

Improvement in litter weight at weaning from crossbreeding is probably greatest when the environmental conditions are not so good. This would be because the crossbred pigs are more capable of withstanding adverse conditions than are the purebreds.

Rate and Efficiency of Gains

Rate of gain per day may be measured in two different ways. One is to weigh the pigs when they reach an age of near 154 days. The weight can be adjusted to a 154-day basis by using the following formula when weights aren't taken on the exact day:

$$\text{Adjusted weight} = \frac{(\text{Actual weight} + 154) \quad (199)}{\text{Actual age} + 45} - 154$$

The 154-day weight is actually an accumulation of gains from the time of conception.

It may be desirable in some instances to have figures on the rate of gain from weaning to 154 days. This can be calculated by subtracting the 56 day weight of each pig from its 154 day weight and dividing this by 98. Or, you may prefer to measure rate of gain from weaning to a market weight of near 200 pounds; this may be done by dividing the total gain after weaning by the actual number of days fed.

Rate of gain is medium to low in heritability. Some progress can be made in selecting to improve this trait. Crossbreeding improves growth rate to a certain extent as shown in Table 9, but most of the improvement comes from the two-breed cross.

The measurement of *efficiency of gain* for each individual pig is more difficult than the measurement of rate of gain. It requires individual feeding which is expensive. It also requires additional equipment. Measurement of the efficiency of gain on an individual basis is probably justified only for a few of the most promising herd boar prospects. If figures on individual efficiency of gain cannot be obtained, the next best thing is to obtain records for each litter or for about four pigs from each litter.

Efficiency of gain is about 30 to 40 percent heritable, indicating that some progress may be made in selection to improve this trait. Inbreeding and crossbreeding affect feed efficiency very little. It is probable that if feed wastage could be prevented entirely and feed records made more accurate, this trait might be much more highly heritable than indicated. If true, selection for this trait under ideal conditions should result in much improvement.

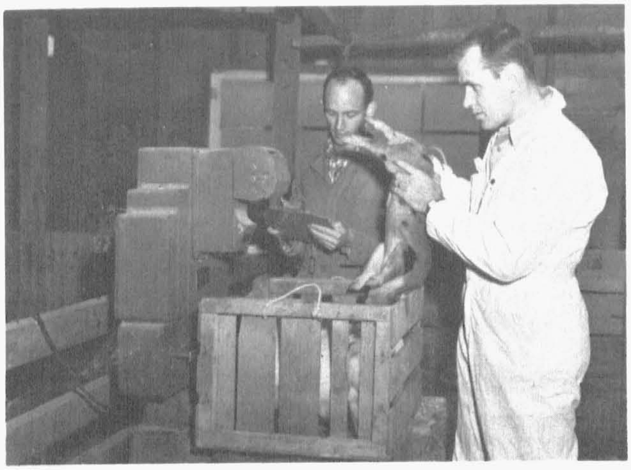

Fig. 8—Weigh each pig at weaning. A simple bathroom scale will do if a larger, stock scales like this isn't available.

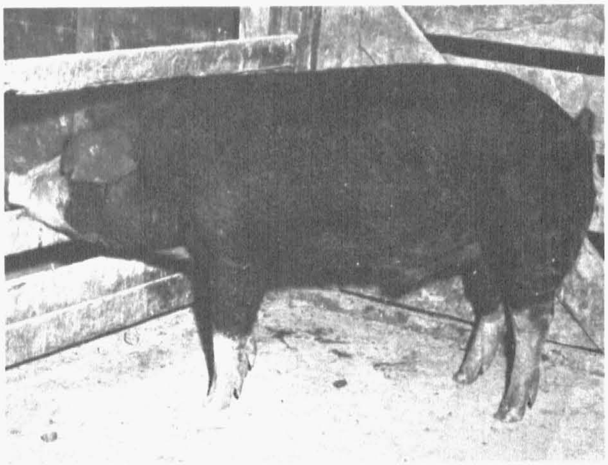

Fig. 9—Performance test the most desirable boar pigs at weaning and select the best for breeding. Besides making rapid and efficient gains from weaning to 175 pounds, this boar tested only .85 inches of backfat.

Fast gains in pigs are also efficient gains. Selection for one should improve the other. Rate of gain is easily measured by taking beginning and ending weights of pigs on feed. It can be measured in any individual pig in the herd even though all are fed in a group.

The recommended practice to improve efficiency of gain is to obtain individual feed conversion records on a few of the most outstanding herd boar prospects. The most efficient can then be kept for breeding. When individual feeding to obtain efficiency of feed utilization is not possible or practical, selection for fast growth rate will also result in an improvement in the efficiency of gains.

Carcass Quality

The pork we eat is the end point of all swine production. The quality of pork determines how much we like it and thus influences the demand. The demand influences the price and, of course, the price received influences the profit to producers. Thus, we must produce the kind of pork the consumer wants.

Consumers want more lean and less fat in pork products. The best way to produce this kind of pork is by breeding for the *meat type* hog. The meat type hog is not a slow-gaining, skinny individual that carries little fat. It is one that makes fast and efficient gains, is well developed in the high priced cuts such as the ham and loin and has a small amount of fat in proportion to lean. Yet, it has enough fat to make the lean meat acceptable.

In breeding for carcass quality, we must find the meat type individuals and must mate them together. The ideal procedure for finding meat type breeding animals would be to measure carcass quality in the live animal. Then, the best animals could be used for breeding. The best estimate of meatiness in the live animal now available is probably the backfat probe. All prospective breeding animals should be probed for backfat thickness at a weight near 200 pounds. If this can't be done, the backfat thickness may be adjusted to 200 pounds with the factors in Table 3.

TABLE 3

FACTORS FOR ADJUSTING BACKFAT THICKNESS IN THE LIVE HOG TO A STANDARD 200 POUND LIVE WEIGHT.

Weight Pounds	Correction Factor	Weight Pounds	Correction Factor
175	1.0697	201	.9973
176	1.0670	202	.9946
177	1.0643	203	.9918
178	1.0616	204	.9892
179	1.0589	205	.9866
180	1.0562	206	.9839
181	1.0535	207	.9813
182	1.0507	208	.9787
183	1.0480	209	.9761
184	1.0452	210	.9735
185	1.0426	211	.9709
186	1.0396	212	.9684
187	1.0369	213	.9658
188	1.0338	214	.9633
189	1.0309	215	.9608
190	1.0280	216	.9581
191	1.0251	217	.9554
192	1.0223	218	.9527
193	1.0194	219	.9500
194	1.0166	220	.9473
195	1.0138	221	.9446
196	1.0100	222	.9419
197	1.0082	223	.9392
198	1.0054	224	.9365
199	1.0027	225	.9338
200	1.0000		

Note: To correct to a standard 200 pound weight, weigh the pig and measure its backfat. Then multiply the total of the backfat probe by the factor opposite his actual weight.

Boars and gilts from large litters of fast growing pigs and of desirable "meat type" and with the least amount of backfat should be kept for breeding. Backfat thickness is 45 to 50 percent heritable and experiments in which selection has been for thinner backfat have been successful. Rate of gain was not reduced in these experiments as backfat became thinner.

Carcass quality is dependent upon a number of factors. Items most often measured are body length, backfat thickness, area of loin eye, and the percentage of lean cuts. Standards adopted by the various breed associations are shown in Table 4.

Carcass quality can be measured after slaughter in littermates of prospective breeding animals. Littermates have about 50 percent of their genes in common. If littermates have good carcass quality, their full brothers and full sisters probably also have good carcasses. Almost all carcass traits are highly heritable (see Table 2). Therefore, selection for improved carcass quality should be successful.

TABLE 4

REQUIREMENTS FOR MEAT CERTIFICATION

1. Litter must qualify for production registry.
2. Two pigs from a litter must be slaughtered. These two pigs must meet the following requirements:
   (a) Weigh at least 200 pounds at 180 days of age.
   (b) Must weigh less than 220 pounds at slaughter.
   (c) Must meet the following carcass measurement requirements:

       Length ------minimum of 29 inches.
       Backfat -----maximum of 1.6 inches.
       Loin eye ----minimum of 4.00 square inches.

Finding Superior Breeding Stock

First, perhaps, we should ask what is superior breeding stock? The answer to this is *those which are best in the traits of economic importance* mentioned in the preceding section. This section discusses procedures used to find superior breeding stock.

Variation. This is the raw material with which the breeder has to work. All of us are aware of the fact that animals vary in the way they look and the way they perform. Even full brothers and full sisters don't look or perform alike. Some grow fast and some grow slow. Some are fat and some are thin. We have become so accustomed to this variation that when we see two individuals that look alike, such as identical twins, they are an oddity and attract our attention.

Data from the Missouri Swine Testing Station illustrates the extreme variation in rate of gain. Sixty-nine boars were fed the same ration at the same place by the same persons. Yet, the daily rate of gain varied from a low of 1.70 in one boar to a high of 2.53 in another (Table 5). There is little doubt which boar would be superior if other traits are equal in the two boars.

TABLE 5

DATA FROM THE MISSOURI SWINE TESTING STATION SHOWING HOW PIGS VARY IN AVERAGE DAILY GAINS EVEN THOUGH THEY ARE FED THE SAME.

Average daily gains	Number of pigs in this class
1.61 to 1.70	1
1.71 to 1.80	11
1.81 to 1.90	11
1.91 to 2.00	9
2.01 to 2.10	14
2.11 to 2.20	11
2.21 to 2.30	5
2.31 to 2.40	2
2.41 to 2.50	5

When we stop to think how animals vary in the different traits, we naturally are curious as to what causes this variation. For practical purposes, we can say that all variations in animals are due to differences in *heredity* or in *environment.*

Hereditary variations are due to differences in genes and combinations of genes that the animals possess. They receive these genes from their parents; they will transmit a sample half of each pair of genes they possess to each of their offspring. If they don't possess superior genes they can't transmit them to their offspring.

Environmental variations are due to differences in the way individuals are fed or managed or to the diseases with which they might have come in contact. Environment affects individuals from the time of conception until they are marketed. No two individuals have exactly the same environment even though we do our best to supply them with the same. Variations due to environment are not transmitted from parents to their offspring. Since heredity and environment both affect the same traits in animals we have the problem of deciding which one is responsible for an animal being superior. What is desired, of course, is animals that are superior because of their inheritance.

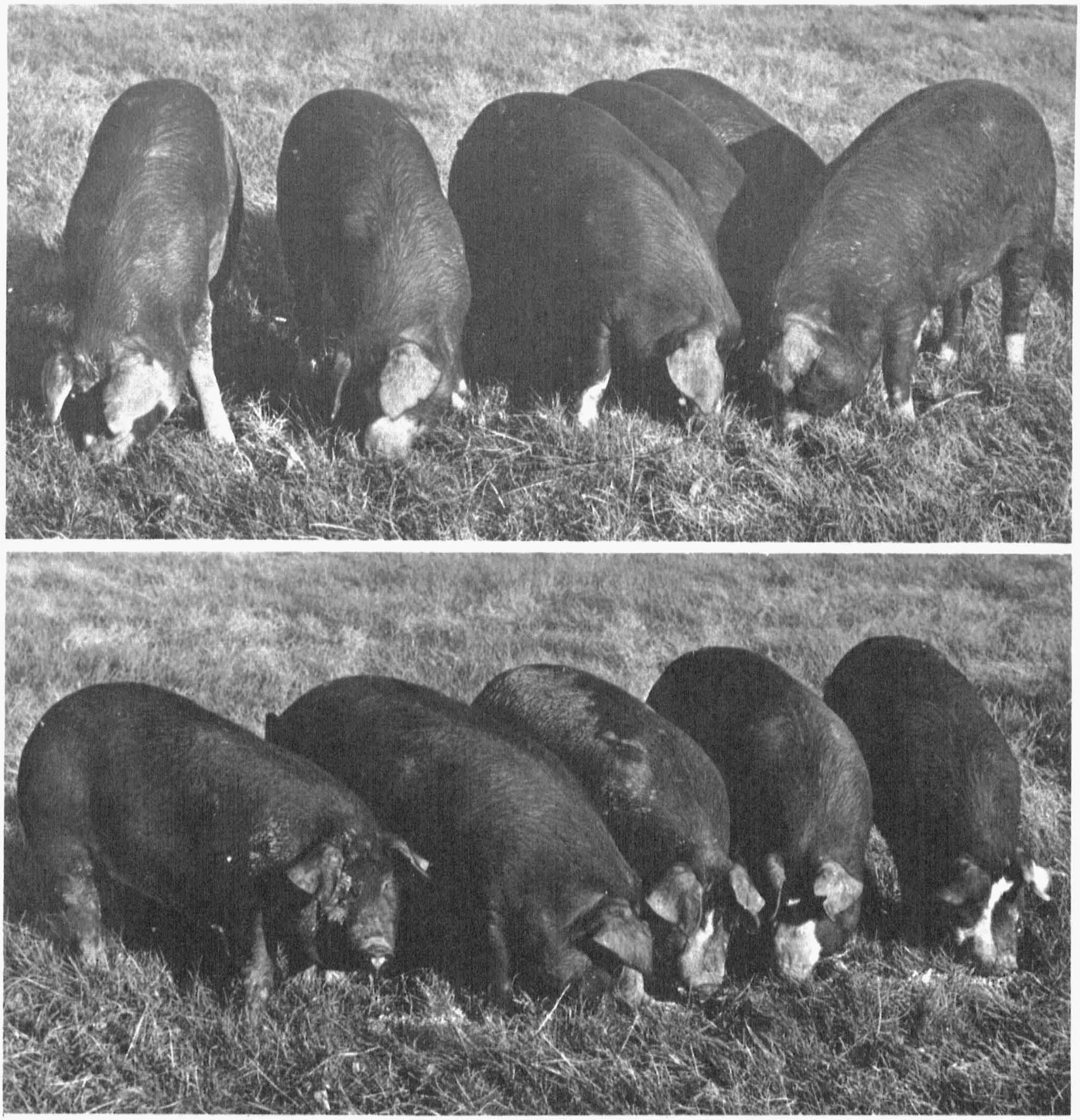

Fig. 10—Type differences among two strains of breeding gilts within the same breed fed under similar conditions. Inbreeding and selection made this difference.

Ways to Remove Some Environmental Variations

We have no sure-fire way of telling how much of the variation in animals is due to heredity or to environment. We *can* do some things and use some information that make our estimates more accurate. We can compare individuals under as nearly the same conditions as possible. They can be fed for the same period of time, the beginning and ending weights can be nearly the same, they can be fed at the same time at the same place and the same feed by the same man. Some adjustments can also be made for differences in their age, the age of their dam, and sometimes differences due to sex.

This will tend to decrease the proportion of the total variation due to environment and increase the proportion due to heredity. We can not entirely eliminate the environmental variations, however, even though we pay attention to all of the factors mentioned.

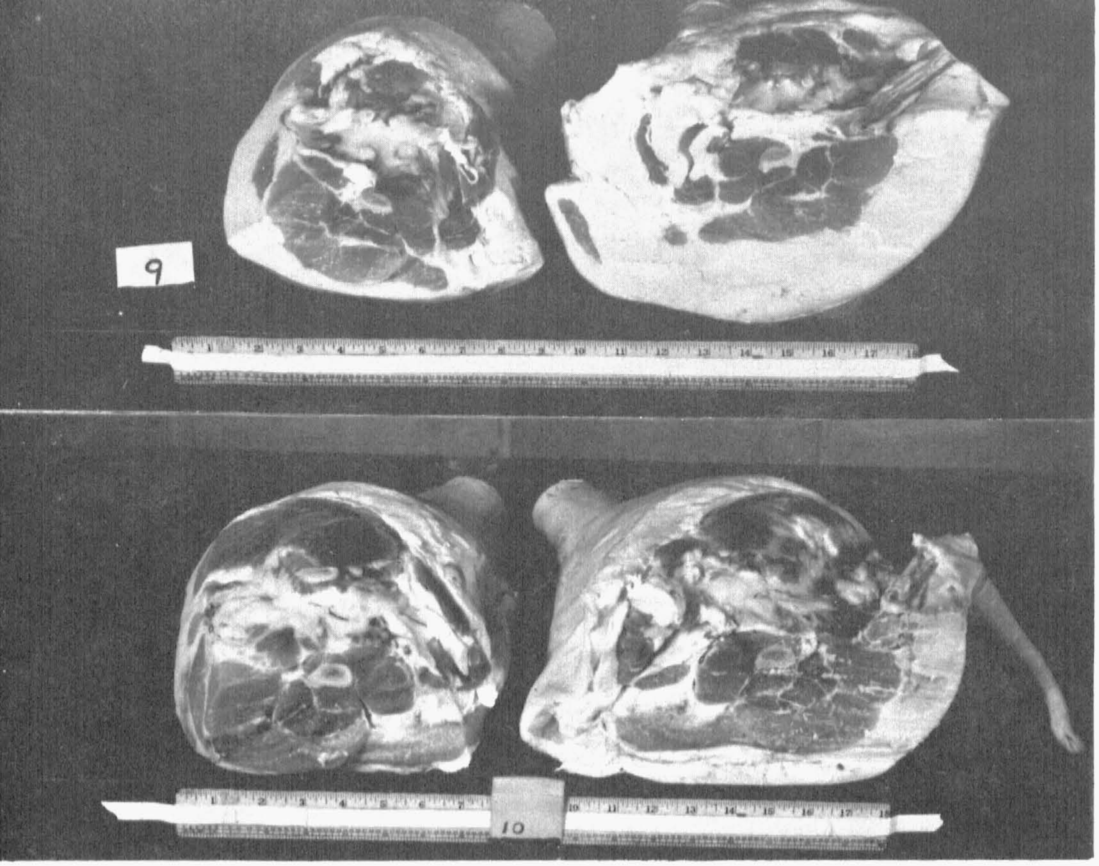

Fig. 11—The percent of lean in the carcass often varies widely even within the same breed. Which ham would you rather have for your table?

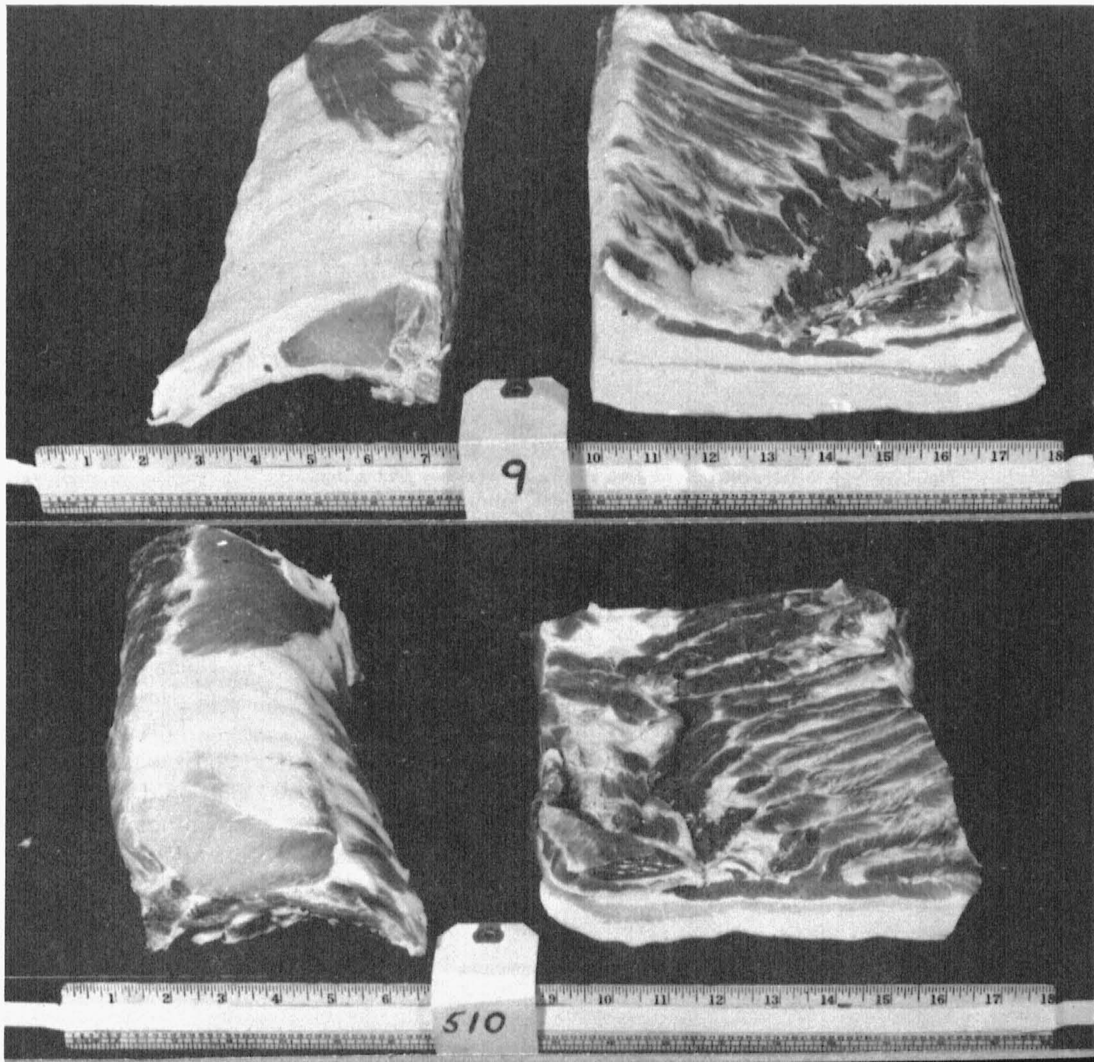

Fig. 12—The area of the loin eye varies among fat hogs as does the amount of lean in the bacon. Loin eye area is one of the measurements used in the requirements for meat hog certification.

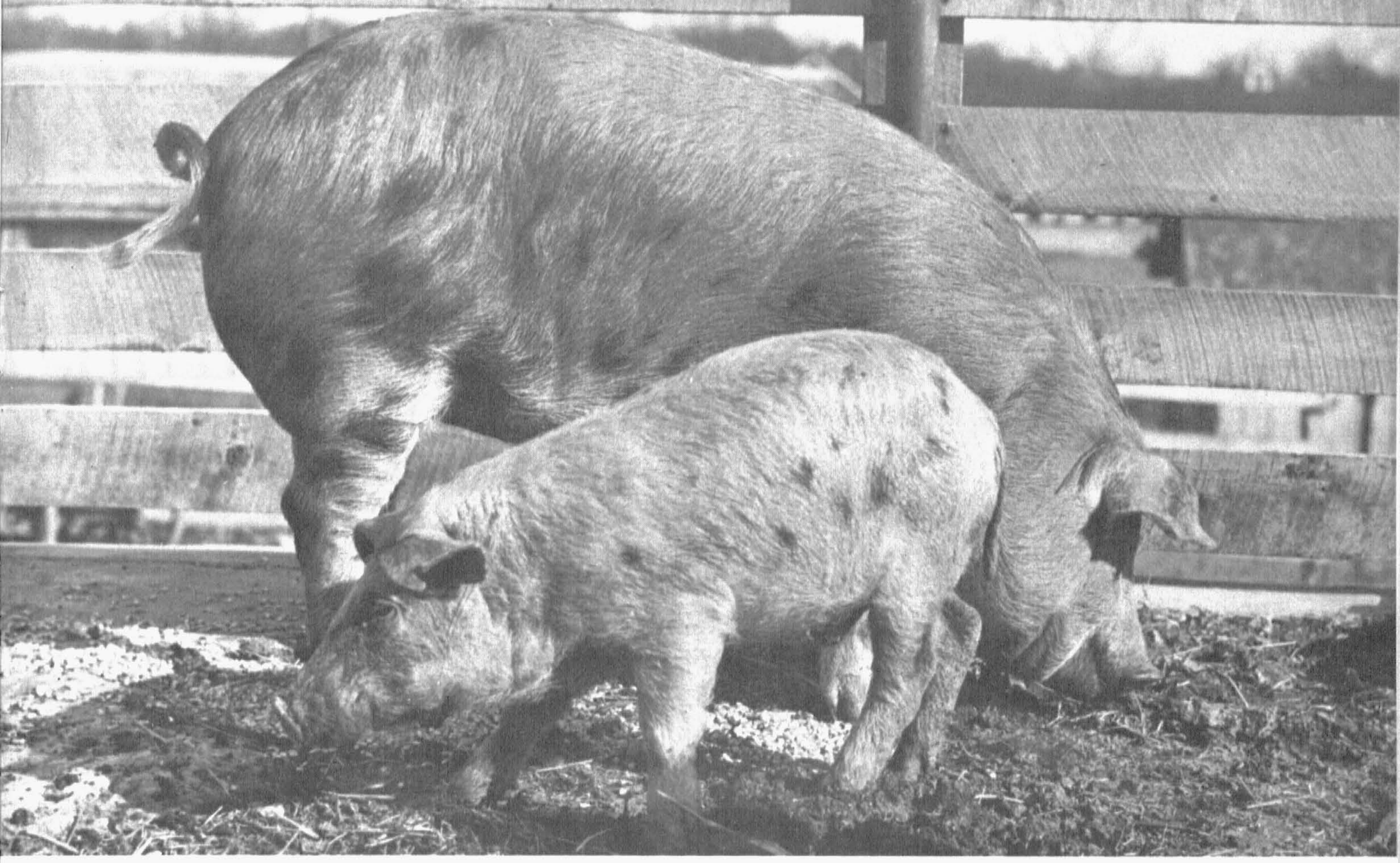

Fig. 13—Extreme variation between two littermates. The difference may be due to both hereditary and environmental factors.

Heritability estimates tell us something about the proportion of the total variation in animals that is due to heredity and environment. These estimates are made after as many of the causes of environmental variations as possible have been removed. In Table 2 the average heritability estimate for rate of gain is 30 percent. This means that about 30 percent of the variation in a herd is due to heredity and 70 percent is due to environment.

Heritability estimates vary for different traits and from one experiment to another for the same trait. The average of several experiments, however, tells us something about the amount of progress we can expect to make in selection. If the trait is highly heritable, mating the best to the best will result in improvement in that trait in the offspring. If the trait is lowly heritable, little progress is usually made by mating the best to the best. In fact, more improvement is likely to be made in that trait by crossbreeding or by mating the less closely related parents.

Methods of Detecting Superior Animals. The first step in finding superior breeding stock is to work out a system of identifying each individual pig. Such a system is given in Figure 14. The next step is to decide on the system of record keeping you will follow. A practical system and form is shown in Figure 15. This also shows what records to keep. All prospective breeding animals should be compared under standard conditions. Finally, those which are the best should be kept for breeding purposes. The number kept depends upon the number of replacements needed. The larger the proportion of the total pig crop you keep for breeding, the smaller the amount of average superiority they will hold over the herd they are from. Since fewer boars are needed, they

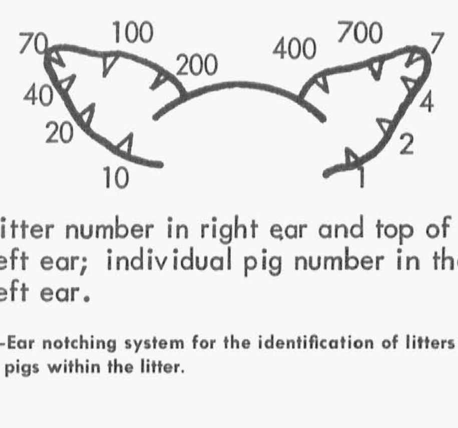

Fig. 14—Ear notching system for the identification of litters and individual pigs within the litter.

Fig. 15

SAMPLE RECORD KEEPING FORM

Litter Record

Sow Number ____________________ Date farrowed ____________________ Sire ____________________

No. farrowed ____________________ No. born alive ____________________ No. weaned ____________________

No. marketed ____________________

Litter Number ____________________

Pig No.	Sex	Birth Wt.	Weaning Wt.	Age at 200 lbs.	B.F. probe 200 lbs.	Comments

can be more superior on the average than the replacement gilts.

Since very few breeders keep their own boars for breeding, most of your own records will be used for gilt selection. However, the same kind of records should be used in selecting a herd boar from someone else's herd. The boar's sale value should be in accordance with performance records.

Records on the individual and its full brothers and sisters may be used in selecting young animals for breeding. An outstanding individual from an outstanding litter is a much better prospect than an outstanding individual from a mediocre litter. The individual from the outstanding litter is probably superior because he has superior genes. He should have the ability to transmit these to his offspring.

This isn't likely to be true of the outstanding individual from a mediocre litter. Be wary of him. The chances are that he is superior because of a lucky combination of genes. He can't transmit this lucky combination of genes to his offspring so they are likely to be less desirable than he.

Records on the *progeny* of an individual are helpful in determining the kind of inheritance an individual carries. But because the individual has to be of considerable age by the time he or she is progeny-tested, such information is of little value in selecting young animals. The exception to this is that we should try to select outstanding individuals from outstanding litters and from outstanding parents. Furthermore, once animals are found which produce superior offspring they should be used for this purpose as long as they are able.

Mating Systems for Swine Improvement

We pointed out in an earlier section that variation is the raw material with which an animal breeder has to work. He can't create new genes. He just tries to find those animals that possess the desirable genes and then mates them to produce the next generation. Since the superiority of an individual is not always dependent upon the kind of genes it possesses but also on how the genes are combined (hybrid vigor) there is more to swine breeding than finding those individuals which are best and mating them together.

Different forms of inbreeding and crossbreeding are the tools the breeders have at their disposal to mold their

Fig. 16—The backfat probe is an excellent method of selection for more meat and less fat in our breeding herds.

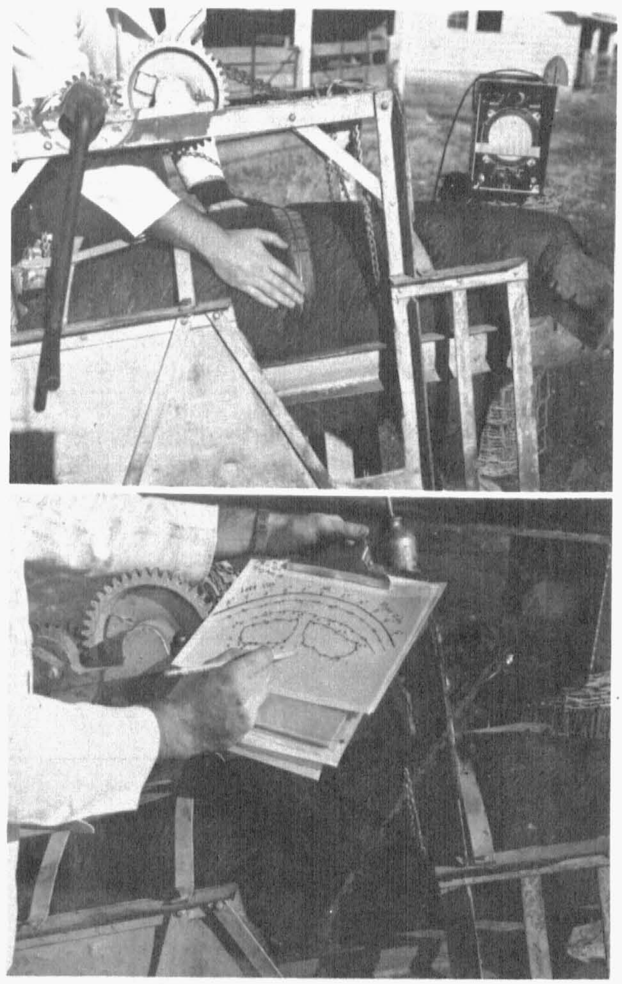

Fig. 17—Methods of estimating loin eye area in the live hog with the sonoray machine are being developed. Here is a sonoray in action.

raw material. How to use these and what to expect from them are the subject of this section.

Inbreeding

This kind of mating system results from mating individuals more closely related than the average of the population from which they come. The closer the parents are related, the more highly inbred are their offspring. The greater the amount of inbreeding, the more striking are the inbreeding effects.

Inbreeding brings out recessive or detrimental genes if they are carried by the original non-inbred stock. Inbreeding also generally causes a decline in vigor or in those traits closely related to physical fitness. This is shown in Table 6.

The main reason for producing inbred lines is to increase their breeding purity and to use them in crosses. If they are made pure, genetically, and individuals are found that combine well (or nick) in crosses, they can be used again and again with similar results when the same lines are again crossed. As in hybrid corn, inbred lines are usually low in performance and should not be used as pure lines for commercial production. They must be used in crosses. Even when crossbreeding, it may not be profitable to use inbred sows. Their performance may be low in producing and raising the crossbred pigs. More satisfactory results are obtained when inbred boars are mated to crossbred sows. These principles are illustrated by data in Table 7.

The use of inbred boars may give unsatisfactory results. The main reason for this is that some inbred boars may lack sex drive and a larger proportion of them may be infertile than is true of non-inbred boars. This difficulty varies among different inbred lines.

The combination of three or more inbred lines by using inbred boars on linecross females often gives excellent results. The data in Table 8 illustrate this point. The big question, however, is whether or not the added

TABLE 6

CHANGE IN PERFORMANCE FOR EACH 10 PERCENT INCREASE IN INBREEDING IN SWINE

Inherited Characteristic	% Change for each 10% increase in inbreeding in: Litter*	Dams**	Litter+dam
Litter size at birth	-.20	-.17	-.38
Litter size at 21 days	-.35	-.31	-.65
Litter size at 56 days	-.38	-.25	-.63
Litter size at 154 days	-.44	-.28	-.72
Pig wt. at birth (lbs.)	.02	-.06	-.03
Pig wt. at 21 days (lbs.)	.08	-.11	-.03
Pig wt. at 56 days (lbs.)	..03	-.06	.08
Pig wt. at 154 days (lbs.)	-3.44	-.13	-3.57

* Litter effects calculated when inbreeding of dam was adjusted to zero.

** Dam effects calculated when inbreeding of litters was adjusted to zero.

TABLE 7

A COMPARISON OF THE PERFORMANCES OF INBRED AND CROSSBRED SOWS WITH PIGS OF THE SAME BREEDING*

Breeding of boars Breeding of sows Breeding of pigs	Landrace x Poland Duroc L. x P. x D.	Duroc Landrace x Poland L. x P. x D.
Size of litters at farrowing	6.93	9.94
Size of litters at weaning	5.66	8.39
Litter weight at 56 days	206.00	326.00
Avg. Wt. per pig at 56 days	35.45	38.87
Avg. Wt. per pig at 154 days	188.07	191.64

*The Landrace x Poland sows were mated to inbred Duroc boars and the inbred Duroc sows (inbred 27.60 percent) were mated to Landrace x Poland boars. Thus, all pigs were one-half Duroc, one-fourth Poland and one-fourth Landrace. The breeding of the pigs was the same but the sow performance made the difference.

TABLE 8

DATA SHOWING THAT THE WAY GENES ARE COMBINED HAS AN IMPORTANT INFLUENCE ON PERFORMANCE

	Calculated Average*	Actual Average*
Number of litters	188	60
Litter size at birth	7.87	9.94
Litter size at 56 days	5.31	8.39
Litter size at 154 days	4.79	8.06
Litter weight at birth	25.15	32.33
Litter weight at 56 days	183.47	326.12
Litter weight at 154 days	773.76	1544.58
Weight per pig at birth	3.20	3.25
Weight per pig at 56 days	37.05	38.87
Weight per pig at 154 days	161.87	191.64

*All pigs were one-half Duroc, one-fourth Poland and one-fourth Landrace. The actual average was for crossbred pigs sired by a Duroc boar out of crossbred Landrace x Poland sows. The calculated average was derived by using the performance of inbred lines but giving one-half of the weight from the Duroc and one-fourth weight from the two other breeds. All litters were adjusted to a gilt litter basis.

performance from crossing inbred lines from different breeds over that obtained from crossing pure breeds that are not highly inbred is enough to pay for forming the inbred lines. More research is needed to answer this important question. Perhaps for the present we should concentrate on improving the breeds we now have and use the best purebred individuals for crossing for commercial hog production.

Crossbreeding

This mating system refers to the mating of parents from two or more different breeds. It is the mating system most often used by the commercial swine producer. Crossbreeding effects are opposite to those of inbreeding. They improve most the traits which are related to physical fitness. Table 9 shows the percentage improvement of crossbreds over the average of purebreds that make up the crosses for certain traits. The economic trait improved the most by crossbreeding is total litter weight at weaning. The improvement is due to more pigs farrowed, especially by crossbred sows, and by the higher survival rate of crossbred pigs. Growth rate is improved some by crossbreeding but feed efficiency is improved very little. The same is true of most of the carcass traits. Actually, it may be that crossbred pigs have a little more backfat than the average of the two purebreds making up the cross.

TABLE 9

AVERAGE PERFORMANCE OF CROSSBRED SOWS AND PIGS COMPARED TO PUREBREDS OF THE BREEDS USED IN THE CROSSES

Traits	2-Breed Cross as % of Purebreds	3-Breed Cross as % of 2-Breed Cross	3-Breed Cross as % of Purebreds
Added vigor due to crossbreeding in:	Pigs	Sows	Sows and Pigs
Litter size at birth	99	108	107
Litter size at 56 days	119	123	142
Weight per pig at 56 days	107	100	107
Weight per litter at 56 days	128	123	151
Post-weaning rate of gain	107	100	107
Post-weaning efficiency of gains	99	101	100

*Breeds were purebred but not inbred.

Fig. 18—One of the main disadvantages of crossbreeding is variation in coat color. Yet much of this can be controlled by a knowledge of genetics and by making proper breed crosses.

Fig. 19—Crossbred sows make excellent mothers and wean large litters of thrifty pigs.

Several systems of crossbreeding may be used for commercial swine production.

A. Two-Breed Cross. This is a system used quite often by swine producers. Purebred females of one breed are mated to a boar of another breed. When replacement females are needed, purebreds are either produced by the sows in the herd or they are purchased from another breeder.

Production of replacement animals from the most productive sows in the producer's herd may have advantages because the performance of these sows is known and the breeder can do a better job of selecting replacement stock. There may be still another advantage in this system over purchasing of replacement gilts in that there is less danger of introducing some new disease on the farm or the pigs may have acquired a certain amount of resistance to diseases already prevalent on that farm.

The two-breed cross does not take advantage of the superiority of crossbred sows over that of purebreds. The only advantage gained is that from hybrid vigor in the pigs as shown in Table 9.

B. The Backcrosses. This mating system is actually a follow up on the two-breed cross. Selected gilts from the two-breed cross may be kept as sows and then mated to an unrelated boar of one of the two original breeds. In the next generation, selected crossbred gilts may be mated to an unrelated boar of the other breed. This system may be continued for several generations.

The backcross system of mating utilizes hybrid vigor from the crossbred sows but some vigor may be lost in the backcross pigs since they are more than 50 percent of one breed. The fact that one needs to work only with two breeds may be of some advantage if excellent boars from the two breeds are available.

C. Three-Breed Cross. This breeding system involves the mating of selected crossbred gilts from the two-breed cross to boars of a third breed. This probably makes optimum use of hybrid vigor in both sows and pigs as shown in Table 9. Gilts from the three-breed cross may be mated to boars of one of the breeds used in the initial two-breed cross in later generations boars from the three different breeds may be used in rotation on the crossbred gilts. In some instances, a boar from a fourth breed may be used, but it is doubtful if any improvement in hybrid vigor is realized beyond the three-breed cross. Any improvements made would have to be the result of using more superior boars.

Some people are afraid that the use of a three-breed sire rotation cross system for several generations may result in a "running out" in performance. This is not true if a special attempt is made to use the most superior sows and boars possible in such a crossbreeding program.

Breeds to Use in Crosses.

This is a question asked many times by pork producers. The important point is to use the best individuals available within the breeds to be crossed. The breeds used will depend a great deal upon the quality of purebred boars available. Since the wider apart the breeds are in relationship the greater the hybrid vigor, it may be well to use a boar from one of the European breeds between two of our own American breeds. An alternative is to use some of the new American breeds based largely on Landrace foundation crosses between two standard American breeds. Performance tested boars from Meat Certified litters should be preferred if they can be purchased.

Breeding Plans for Swine Producers

The breeding plans to be discussed will fall into two definite classes. One for the breeder of purebreds and one for the commercial producer supplying hogs for the market.

PLAN FOR PUREBRED SWINE PRODUCTION.

The breeder of purebreds is actually the seed stock producer for all swine production. It is his job to produce pure breeding stock which will be as superior as possible for all traits. The pure breeds must be especially superior in those traits which do not show improvement from hybrid vigor. Two of these traits are *efficiency of gains* and *carcass quality*. *Weaning weight* and *daily gains* from weaning to market weight are affected some by hybrid vigor but these traits, too, should be selected for in the pure breeds.

Essentially, the task of the purebred breeder is to find those animals which are superior in the important economic traits. The use of information from swine testing stations, Production Registry and the Certified Meat Hog program is helpful in locating strains within each breed which are superior. Even so, accurate records must also be kept on each individual and each litter within the herd to locate the superior animals.

SUGGESTED PLAN FOR THE PUREBRED BREEDER TO FOLLOW:

GENERAL CONSIDERATIONS

1. Identify each litter and individual within each litter by an ear-marking system or by some other practical means.
2. Keep accurate records on the performance of all individuals within the herd whether this is for the growing-fattening period or for the litter production by the sows.
3. Cull sows that wean two successive litters considerably lighter than the average of all sows in the herd.

SELECTION OF GILTS

1. Cull gilts from small litters and from litters which show considerable variation in meat type qualities or in age at 200 pounds or where some pigs in the litter have definite defects such as hernia or cryptorchidism.
2. Cull gilts from the larger and more uniform litters which have less desirable meat type and fewer than 12 well developed and well spaced teats. If carcass data are available for litter-mates, use this information in discarding litters which have less desirable type.
3. Calculate an index on the remaining gilts and keep those with the highest index. Table 10 gives a suggested index and explains its use.

SELECTION OF BOARS

1. Give preference to boars from Certified Meat Type litters and those which have met Production Registry requirements. Boars from testing stations which rank in the upper 5 to 10 percent of all boars on the basis of an index also would be preferred.

TABLE 10

EXAMPLE OF INDEX FOR SELECTING BOARS AND GILTS

$$\text{Index} = 500 + 30G - 100F - E$$

Where,

(G) is the average daily gain in pounds.

(F) is backfat thickness in inches.

(E) is feed required to produce 100 pounds of gain.

The index for a boar that gained 1.70 pounds per day on 320 pounds of feed per 100 pounds of gain and that had 1.40 inches of backfat at 200 pounds would be:

$$\text{Index} = 500 + 30(1.70) - 100(1.40) - 320 \text{ or } 91.$$

2. Select boars that are themselves superior in meat type and which have strong feet and legs.
3. If an index is not used, a boar should be from a litter of at least eight pigs weaned, should weigh at least 200 pounds at five months of age and should probe 1.2 inches or less in backfat at 200 pounds. He should have made 100 pounds of gain from weaning to 200 pounds on 300 pounds or less of feed.
4. A special attempt should be made to select a boar which is especially strong in the points in which the sows are weakest.
5. And, finally, when a truly outstanding boar is found, based on the appearance and performance of his offspring, this boar should be used for improvement in some herd and not sold for slaughter.

Fig. 20—Litters vary widely in uniformity and desirability. Select breeding stock from outstanding individuals within large, uniform litters such as those in the picture at left. Avoid selecting breeding stock from litters that lack uniformity such as those at right.

PLAN FOR COMMERCIAL SWINE PRODUCTION

Since commercial pork production requires the maximum in efficiency of production, some systematic system of crossbreeding is recommended. But even here it is important to use superior breeding stock. Most breeders will retain females from their own herd for breeding purposes. They have the records of them and their close relatives. Such home grown females also are more likely to be adapted to a farm's conditions. *Insofar as possible, keep the same records and select in the way recommended for purebred breeders.* Select replacement gilts and boars in the same way recommended for purebreds (see preceding section).

Start crossbreeding programs with females that are prolific and good mothers, and that have desirable conformation and meatiness. These females should be mated to a purebred boar from another breed, preferably one with a good record of performance and carcass quality.

When a new generation of sows is to be retained, save the best crossbred gilts as outlined for purebreds. Mate these to a select boar from a third breed.

Use boars from at least three breeds in rotation on selected, superior, crossbred sows. This will take advantage of hybrid vigor in both sows and pigs. After the three-breed cross is made, however, you try merely to maintain the advantage obtained from hybrid vigor. Any improvements in performance and in carcass quality in later generations are most likely to come from the use of superior breeding animals and not from additional hybrid vigor.