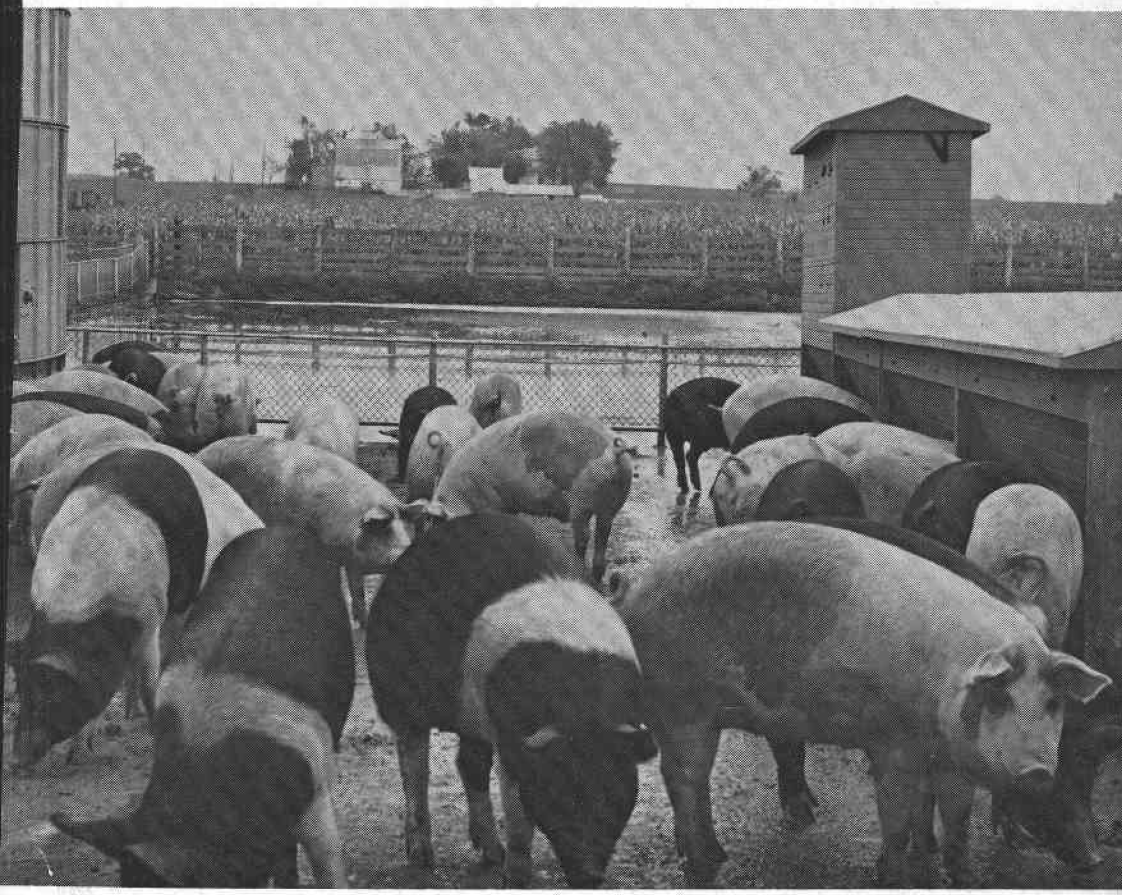
Reports of the Tenth Annual

Swine Day



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Reports of the Tenth Annual Swine Day

Contents

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Foreword

This publication is one of a series of progress reports issued at annual Swine Day programs of the Department of Animal Science, Oregon State University. In these programs it is the Department's desire to summarize current research by local staff, as well as to identify significant work conducted elsewhere. The latter role is served in this publication by the report from Dr. P. J. Dziuk of the University of Illinois.

Trends in swine research are noticeably related to changes in the business of swine production. Quality livestock are basic to the success of any animal production enterprise, and "quality" is increasingly translated in terms of performance traits. Reproduction is, of course, an important aspect of animal performance, and research into the physiology of reproduction in the sow and the effects of various chemical materials on it is a potentially productive endeavor. Moreover, since much of the actual cost of swine production relates to feed purchases, the formulation of "least-cost" rations presents an attractive opportunity for increasing economic efficiency of production. Use of the computer in such formulations greatly facilitates the many calculations necessary. Together with such technical aspects of genetics, nutrition, and physiology, the practical aspects of management continue to be significant and devices for efficient feeding and watering with the lowest labor input are important.

Some aspects of these areas of research importance to the swine industry are discussed in this bulletin. It is hoped that they will prove to be interesting and stimulating to persons concerned with swine production in Oregon.

J. E. Oldfield
Head, Department of Animal Science

Computer Formulation of Rations for Market Hogs

JOHN L. HAMSTREET AND DAVID C. ENGLAND

A recent approach to more economical production of market hogs has been the adoption of linear programming and electronic computers to produce "least-cost" rations. Rations formulated in this way have been demonstrated to be effective in reducing feed costs for swine, as well as for poultry, sheep, cattle, and mink. The procedure consists of supplying a computer with two sets of specifications: (1) the desired nutritional characteristics of the ration to be produced, and (2) the nutritional properties and cost values of possible feed ingredients. The linear program is then used by the computer to calculate a balanced least-cost ration. However, such a ration remains "least-cost" only as long as the price relationships of possible feed ingredients remain the same. A sufficient price change may result in a change of ration ingredients.

An operator with least-cost ration deliveries from his feed dealer every two weeks could possibly feed as many as six essentially different, but nutritionally equivalent, rations to grower pigs before they reach market weight. Thus, questions regarding the effect of switching rations during the feeding period on rate of gain, feed efficiency, and carcass characteristics become very important. An experiment involving two feeding trials at two different locations was conducted to answer some of these questions.

JOHN L. HAMSTREET is a graduate assistant in animal science and DAVID C. ENGLAND is associate professor of animal science, Oregon State University.

Feeding trials

In the first trial, in order to obtain dissimilar rations, restrictions were imposed so that the computer formulated the first ration using any grain except wheat or barley. The second and third rations were formulated using barley and wheat, respectively, as the only grains (Table 1). Dissimilar rations were obtained for the second trial by giving the computer free choice in determining the major grain component of the first ration. This grain was eliminated before formulating the second ration. The major grain component of rations one and two were eliminated before formulating the third ration (Table 2). It will be recognized that this is a purely experimental technique to induce ration variability. Such a procedure would not be necessary for the commercial swine producer, as he would only be interested in the first, free-choice, least-cost ration.

The first trial was started at Corvallis in November 1967 with 45 crossbred barrows which were wormed before starting the experiment. They were placed on test as soon as they reached 60 pounds and the test was continued for 12 weeks. The first trial at Hermiston was started in December 1967, with 168 crossbred barrows treated identically to those in Corvallis.

The design of the experiment called for the rations to be changed every three weeks at Corvallis and every four weeks at Hermiston. Weights of animals and feed consumed were recorded weekly at Corvallis and bi-weekly at Hermiston. In the Hermiston experiment eight pens of pigs were fed the

Table 1. Rations Trial I

Feedstuffs[1]	Ration 1	Ration 2	Ration 3	Ration 4
Barley	1,615			1,480
Wheat		1,673		
Corn			647	
Mill-run			1,083	
Bloodmeal	106	59		
Alfalfa meal		102		
Fishmeal			90	
Meatmeal				120
Soybean oil meal				180
Alfalfa				100
Prime tallow	101		25	
Molasses	158	146	135	100
Premix	20	20	20	20

[1] Units are pounds per ton of completed ration.

Table 2. Rations Trial II

Feedstuffs[1]	Ration 1	Ration 2	Ration 3	Ration 4
Barley				1,480
Corn	862	976		
Wheat			1,638	
Mill-run	811			
Milo		599		
Meatmeal	118	112	14	120
Fishmeal	33	17	84	
Feathermeal		49		
Soybean oil meal				180
Tallow	6			
Molasses	150	150	150	100
Alfalfa		77	72	100
Limestone			22	
Premix	20	20	20	20

[1] Units are pounds per ton of completed ration.

same ration for the entire period and six pens were switched. At OSU 15 groups of three pigs each were switched in a balanced design that permitted statistical analysis of the effect of switching.

Trial two was started at Corvallis in June and at Hermiston in July 1968. The same switching procedures were followed that were used in trial one.

Problems with ration formulation

A computer can give any information desired, but results are correct only if the input information is correct. Errors and inaccuracies fed into the computer will be incorporated in the answers.

One possible source of error is the nutritive value data used for the feedstuffs involved. These values are usually obtained from tabulations such as those found in *Morrison's Feeds and Feeding* or those published by the National Research Council, which are usually averages for the entire United States or for certain parts of it. As such, they may vary somewhat from the nutritive values of the feeds actually used in the ration. Such published tabular values were used in the formulation of the rations used in these trials. Feed analysis for protein, fiber, calcium, and phosphorus showed that, not only did these feedstuffs disagree with the tabular values, but they changed from batch to batch for the same ration formulation. One solution to this problem would be to analyze each feedstuff going into each ration formulation, but this poses problems of time involved. The same problem exists whether the rations are formulated by hand or by the computer.

A second source of error became apparent about three weeks into the first trial when it was noticed that feed consumption and gain values were abnormally low. As the trial progressed, several of the Corvallis pigs were lost. An analysis of the rations showed that they were severely deficient in calcium, having only .1% instead of the specified .5% minimum. Upon inspection of the computer input information, it was found that an error of a factor of 10 existed in calcium data for one of the feedstuffs. The computer had formulated balanced rations assuming a tenfold increase in calcium in that particular feedstuff and the resulting rations were calcium deficient.

At Hermiston over 20 of the pigs died or had to be taken off the experiment due primarily to duodenal ulcers. The Hermiston rations were analyzed as soon as the calcium deficiency at OSU was found. They also proved deficient, but not as much, having a calcium level of .2% instead of the specified .5% Apparently this was due to a difference in the grains used in the rations at the two sites; although the calcium content at Hermiston was below the recommended level, it was high enough that the pigs did not develop severe deficiency symptoms.

The second trial at Corvallis presented no problems, and the pigs grew rapidly and thriftily. At Hermiston there were no apparent specific problems in the second trial, but the pigs did not perform as well as expected. No pigs were lost at either site.

Results

No taste or palatability preference was exhibited by the pigs towards any of the rations except number 3 in the first trial. This may have been due to the calcium deficiency since the animals ate reasonably well until the experiment had been under way several weeks. A difference occurred in the quality of the rations used at OSU in that pellets of the corn rations broke down in the bottoms of the feeders. The cause of this difficulty was not apparent. No trouble was experienced with any of the rations at Hermiston. The feeder cups were kept clean, so there was no spoilage, but this increased the amount of these rations fed, probably due to increased wastage.

Results of the two trials at Corvallis and Hermiston are presented in Tables 3 and 4. With the exception of ration number 3 in the first trial, results indicate very little difference in performance of pigs fed the different rations. Performance on the "standard" ration (number 4) was similar to that on the other computer formulation rations. Switching of the rations had no significant adverse effect. The costs of the rations are given as determined by the computer, and they do not include the premix, mixing, pelleting, and delivery costs. The premix added (Table 5) was the same for each ration, and the mixing, pelleting, and delivering costs would also be constant. Thus, the total

Table 3. Performance Data by Rations

	Ration 1	Ration 2	Ration 3	Ration 4	Avg.
		OSU Trial I			
Average daily gain, lb.	1.89	1.90	1.37		1.72
Feed efficiency, lb./lb. gain	3.30	3.38	4.39		3.69
Cost per 100 lbs. of gain, $	9.17	8.75	10.05		
		Hermiston Trial I			
Average daily gain, lb.	1.63	1.69	1.45	1.64	1.58
Feed efficiency, lb./lb. gain	3.11	3.05	3.44	3.17	3.19
Cost per 100 lbs. of gain, $	8.65	7.90	8.39	8.75	
		OSU Trial II			
Average daily gain, lb.	1.98	2.02	2.03		2.01
Feed efficiency, lb./lb. gain	3.21	3.34	3.10		3.22
Cost per 100 lbs. of gain, $	7.87	8.81	8.65		
		Hermiston Trial II			
Average daily gain, lb.	1.44	1.33	1.54	1.58	1.45
Feed efficiency, lb./lb. gain	3.49	3.68	3.14	3.32	3.41
Cost per 100 lbs. of gain, $	8.55	9.72	8.76	8.86	

Table 4. Effect of Ration Switching

	Hermiston trials			
	Constant ration		Switched ration	
	Trial 1	Trial 2	Trial 1	Trial 2
Average daily gain, lb.	1.61	1.50	1.51	1.39
Feed efficiency, lb./lb. gain	3.19	3.42	3.17	3.39
Carcass length, in.	30.1	30.6	30.2	30.8
Backfat, in.	1.39	1.37	1.35	1.35
Loin eye area, sq. in.	4.35	3.72	4.41	3.79

Table 5. Premix

Aureo-S-P-250	2.00 lbs.
Salt	10.00 lbs.
Zinc sulphate	0.80 lbs.
Vitamin A	1,200,000 IU
Vitamin D	120,000 IU
Vitamin B_{12}	10,000 micrograms[1]
Pantothenic acid	2,000 milligrams[1]
Mill-run	20 pounds minus all above

[1] Used only in the first trial.

cost for each of the rations should be comparable on the basis of the ingredient prices that came out of the computer.

Indications are that rations can be formulated by computer on a least-cost basis within the limits of specified nutrient contents and that the switching of these rations during the feeding period will have no adverse effects on the rate of gain, feed efficiency, or carcass characteristics of swine. It thus appears that computer-formulation is a feasible procedure for both producers and feed mills as a potential tool for reducing feed costs for market hogs.

Selection for Performance Traits in Swine

David T. Spurr

It is quite generally agreed that the average productive merit of livestock is far below potential levels. In the United States an average of about 7.5 pigs are marketed at about 180 days average age for each litter farrowed. Marketing 9 to 10 pigs per litter at 150 days or less average age is within reach with modern methods of breeding, feeding, and management. The aim of the animal breeder should be to raise the average performance of herds and flocks rather than to develop one or two top individuals in a group of otherwise mediocre animals. Although it probably would be impossible to get a unanimous opinion among swine industry representatives of the characteristics that constitute good performance in hogs, most would include the following items:

1. A high level of reproductive efficiency. This would include a large number of pigs born, good survival rate, good milking ability, and proper maternal behavior or mothering ability.

2. A rapid rate of growth and the ability to utilize feed efficiently.

3. A high percentage of lean and a low percentage of fat. Fifty-four percent of the carcass weight or 41 percent of live weight, represented by trimmed ham, loin, and shoulders is an obtainable objective.

4. A high percentage of the lean cuts in the ham and loin; at least 70 percent of the total lean cut weight, or 38 percent of the total carcass weight.

5. Large loin eye areas. Five square inches at the tenth rib for a 150-pound carcass is about ideal. Larger loin eye areas could be obtained if selection were only for this, but it is doubtful if values above 5 square inches would improve the value of the carcass.

6. Firm lean of greyish-pink color and good flavor.

The breeder has, broadly speaking, only two kinds of decisions to make which will affect the inheritance of subsequent generations of animals: (1) selection of animals to become the parents of the next generation, and (2) choice of mating system—inbreed, linebreed, outcross, or crossbreed (Figure 1). This discussion will be confined largely to selection and how it can be made effective rather than how to mate the selected animals.

Economic importance of the trait

It cannot be emphasized too strongly that increasing the selection emphasis on one characteristic automatically reduces the opportunity for selection of others. Consequently, emphasis should be placed on those characteristics that have a major effect on net profit to the producer. Swine industry representatives find it difficult to agree on which traits are the most important. It is likely that all will agree, however, that the relative economic importance of various performance traits will change with time and location.

Since the importance of economic value has been stressed, it is necessary to establish a method of evaluating the various traits. Relative economic weights are measures devised to evaluate several traits with respect to each trait's economic value and phenotypic varia-

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David T. Spurr is a graduate assistant in animal science, Oregon State University.

Mating system and kind of selection

Mating like to like (assortative mating)	Random mating	Mating unlikes together (dissortative mating)
1. By pedigree inbreeding; linebreeding or staying within one family.	Mates are no more or less alike than by random chance.	1. By pedigree outbreeding—ranging from species crosses through cross-breeding to crossing strains within a breed.
2. As individuals; mating big with big, little with little, and so forth.		2. As individuals (a) to compensate for defects in the two lines (b) crossing extreme to produce intermediates

Figure 1. Systems of mating which may be combined with various kinds of selection.

tion. The economic value should reflect the expected increase in net profit as a result of one unit change in that trait. As an example, consider two traits, prolificacy and average daily gain from 60 pounds to market weight. Prolificacy can be measured as the number of pigs born alive. Average daily gain is measured in pounds per day. Consider the total cost of maintaining a sow from breeding to farrowing to be $50. If she farrows 10 live pigs, the cost of maintaining the sow could be offset by giving each pig a value of $5 at birth. If each increase of 0.1 pound per day in average daily gain increases net profit by $3 through decreased feed, labor, and overhead costs, then the economic value of 0.1 pound average daily gain per day would be $3 (Table 1).

Amount of variation present in the trait

The range or difference between the lowest and highest value is one measure of variation. Another more useful measure of variation is the standard deviation. For example, if average litter size is 10 pigs born alive per litter and the standard deviation of litter size is 2 pigs, then two-thirds of all litters will fall within the range of 10 ± 2, or 8 to 12 pigs per litter. Similarly, an average of 1.8 pounds per day in average daily gain with a standard deviation of 0.2 pounds per day indicates that two-thirds of the pigs gain between 1.6 and 2.0 pounds per day. The standard deviation is useful as it gives a measure of how much variation is present in a population without considering extreme values such as 1 or 23 pigs born alive. These extreme values may or may not be present and should not be considered in a realistic measure of variation.

By multiplying the per unit value by the standard deviation of a trait, a measure of its economic value can be obtained. When the economic value of each trait is divided by a factor such as litter size, then each factor is made relative to one base trait (Table 1). These new values can then be referred to as relative economic values (R.E.V.), or, in this case, the economic value of

Table 1. **Comparison of the Ease of Selection for Two Performance Measurements in Swine**

	Performance measurement	
	No. of pigs born alive per litter	Average daily gain
Unit	1 pig	.1 lb./ day
Economic value per unit ($)	5.00	3.00
Standard deviation	2 units	2 units
Value x standard deviation	10.00	6.00
Relative economic value	1.0	0.6
Heritability (h^2)	10%	30%
h^2 x relative economic value	10	18

the trait relative to litter size. In the example used, the economic value of average daily gain is only 6/10 of the economic value of the number of pigs born alive per litter. Thus, it appears that the number of pigs born alive is more important than average daily gain in determining net profit to the producer. Selection for increasing the number of pigs born alive is usually not very successful, but average daily gain can be improved by selecting the faster growing pigs for the breeding herd.

An attempt is made to keep the amount of variation for selected traits as high as possible with the Oregon State University swine herd. Inbreeding reduces the amount of genetic variation within a population. Genetic differences among anima's decrease as the animals become more closely related. Also, inbred animals rapidly become more sensitive to an unfavorable environment. As a consequence, they exhibit an increased amount of variation due to environmental influences while genetic differences decrease; this increases the possibility for mistakes in selection. An electronic computer is used to develop co-ancestry charts which give all the relationships among animals within the herd. These charts are used to avoid mating closely related animals. Occasionally, boars unrelated to animals already in the herd have been used to increase the amount of genetic variation.

Heritability

The term "heritability" designates the proportion of total variation of a trait among animals that is due to heredity existing in such a form that improvement will result when selection is practiced. Stated another way, heritability is that proportion of the difference between animals—measured or observed—which is transmitted to the offspring. Traits that have a high heritability can be improved rapidly by selection, but traits with a low heritability can only be improved very slowly. In general, measurements of reproductive efficiency such as number of pigs born, number of pigs weaned, and weaning weight are traits of low heritability. Measures of rate of growth and feed required per pound of gain are traits of medium heritability, while carcass measurements have high heritability (Table 2).

Low heritability of a trait does not mean that the trait is not influenced by heredity, but it indicates that most of the variability of the trait within the herd or population is caused by influ-

Table 2. Heritability of Some Performance Traits in Swine[1]

Trait	Percent of heritability	
	Range	Average
Number of pigs farrowed	0-24	15
Number of pigs weaned	0-32	12
Weight of litter at weaning, lbs.	3-37	17
Average daily gain from weaning to 200 lbs.	14-58	29
Pounds feed per pound of gain	8-72	31
Carcass length (in.)	40-81	59
Loin eye area (sq. in.)	16-79	48
Thickness of backfat (in.)	12-80	49
Percent of ham (based on carcass wt.)	51-65	58

[1] Adapted from W. A. Craft, 1958, "Fifty Years of Progress in Swine Breeding," *Journal Animal Sci.*, 17:960-980.

ences other than hereditary differences that will respond to selection. Environmental variation within a breed or even within a herd is usually quite large relative to the variation caused by genetic differences. Although the environment in which we raise our animals complicates selection, attempts to standardize environment are not usually very successful.

One area of research emphasis at Oregon State University is the development of management procedures to reduce environmental sources of variation. If environmental sources of variation can be reduced, the remaining variation will be to a larger extent the result of hereditary differences between animals.

If we multiply the heritability by the relative economic value for each of the traits, we get numbers that indicate where we should place our emphasis in a selection program. In our example, for instance, if heritability of average daily gain is 30%, we multiply 6 x 30 and get a value of 18. If the heritability of litter size is 10% we get a value of 10. These two numbers indicate that it would be easier to increase net profit by selecting for average daily gain than by selecting for number of pigs born alive.

Genetic relationship among traits

A genetic correlation among traits is the result of genes favorable for the expression of one trait tending to be either favorable (positive) or unfavorable (negative) for the expression of another trait. If the association is favorable among traits on which selection is based, the rate of improvement in total merit is increased. Conversely, if a negative genetic correlation exists between two traits, selection for one trait will improve that trait but will decrease the performance level in the other trait.

No major genetic antagonisms have been reported among the traits of economic importance in swine. Simultaneous improvement should then be possible in all traits of economic importance. Available information indicates a positive genetic correlation between average daily gain and efficiency of feed conversion. This means that, on the average, pigs that gain faster will also require less feed per pound of gain. Selection for a fast rate of gain would not decrease feed efficiency but should improve it.

Conclusion

One of the first and most important aspects of swine improvement is realistic goals based upon traits that are of economic importance and upon what is known about the genetics of these traits. Once the traits are chosen, a selection program can be inaugurated to accomplish the desired goals. Setting up realistic goals is a difficult task for a number of reasons.

✓ It is difficult to evaluate the economic importance of the various traits.

✓ It may be difficult to determine the direction in which to select for a trait to satisfy future needs.

✓ It is difficult to predict the relative costs of the various factors of production and what the market will demand in the future.

Performance testing often can be used to objectively identify superior genotypes of important economic traits. Such information can be of importance in establishing sound goals and in increasing the effectiveness of selection. Performance testing must be kept simple if it is to have wide application. It can be kept simple if important economic traits receive major emphasis. Frills or fancy points should not be stressed as their inclusion will weaken selection for the more important characters.

Effects on Pregnancy of Distribution of Embryos in the Sow's Uterus

P. J. DZIUK

Distribution and number of embryos in a sow's uterus have a marked influence on whether she continues a pregnancy to full term. The extent and nature of this influence have been studied in a number of research projects in the Department of Animal Science at the University of Illinois. Normal pregnancies were compared with pregnancies in which the number and position of embryos were experimentally altered.

Normal position of embryos

A sow's uterus can be divided into two horns, right and left, meeting at a "V" at the cervix and vagina (Figure 1).* Each horn is 3 to 5 feet long to accommodate the four to six fetuses that occupy it, much like peas in a pod.

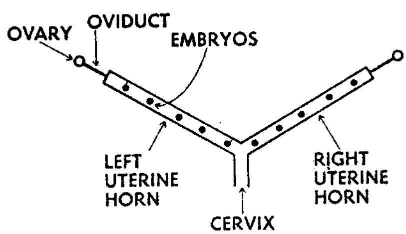

Figure 1. Diagram of sow's uterus and placement of embryos in normal pregnancy.

The embryos enter the uterus from the oviducts about the third day after mating and remain near the tip of each horn until about the sixth day (Figure 2A), when the embryos begin to move slowly away from the tip of the horn. By day 8 the embryos have reached the

* Figures are reprinted from *Illinois Research,* Univ. of Illinois Agric. Expt. Sta., Summer 1968.

P. J. DZIUK is professor of animal science, University of Illinois.

juncture of the two horns (Figure 2B and E). At this time each embryo is about $\frac{1}{8}$ inch in diameter.

The embryos continue to migrate into the other horn, so that by day 12 the embryos originating from each side have moved into both horns (Figure 2D and F) and are mixed with embryos originating from the other side. About this same time the embryos elongate into delicate threadlike structures a foot or more long. The embryos also now space themselves quite evenly throughout the uterus (Figure 1).

Soon after a gilt has been mated, she must decide whether she is pregnant, so her hormone balances can be adjusted to either maintain the pregnancy if one exists, or to prepare for the next mating if the first one was infertile. She makes this decision partly on the number and position of embryos in the uterus.

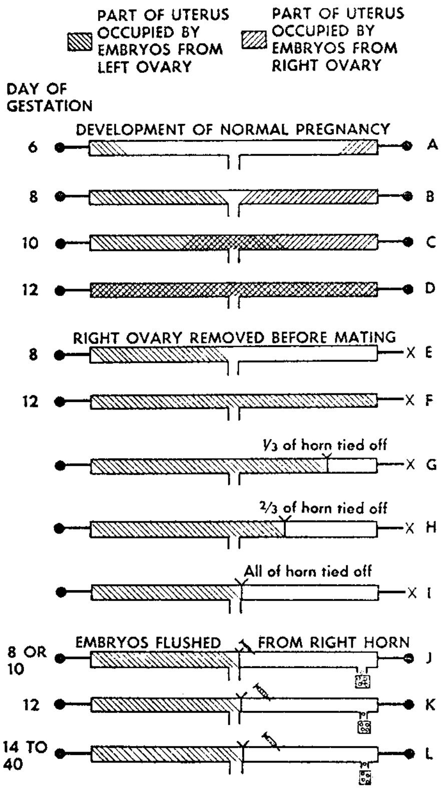

Figure 2. Movement of the embryos through uterus under various conditions.

Results of various alterations

If the uterus is completely occupied, about 65% of pregnancies will go to full term even when one ovary has been removed several days before mating and the embryos originate from only one side (Figure 2F). This percentage remains the same when, after removal of the ovary, the uterus is tied tightly to prevent embryos from entering one-third of the horn (Figure 2G).

When two-thirds of one horn is unoccupied, only 30% of the pregnancies continue (Figure 2H). When a whole horn is unoccupied, none of the pregnancies continue (Figure 2I) and the gilts come back in heat. Migration of embryos is therefore quite important in helping the gilt decide whether she is pregnant.

When only two or three embryos are present, leaving a large part of the uterus unoccupied, the pregnancy is usually undetected. It is not carried to full term but is destroyed when the gilt returns to heat.

When embryos were flushed from one horn of many different gilts 8 to 10 days after mating, the gilts all returned to heat (Figure 2J). But 30% of pregnancies continued after embryos were removed from one horn at day 12 (Figure 2K), and all pregnancies continued normally when embryos were removed at day 14 to 40 (Figure 2L). The gilt apparently decides after day 10, but before day 14, whether to continue with a pregnancy when only one horn is occupied.

The pig uterus apparently can move embryos throughout its length very efficiently and can tell to what extent it is occupied by embryos as soon as 12 days after mating. If the uterus is only partly occupied or if the number of embryos is very small, the gilt returns to heat. This probably prevents many very small litters from being carried to full term.

Effect of Dichlorvos Fed During Gestation on Birth Weight, Survival, and Subsequent Performance of Pigs

DAVID C. ENGLAND

It has long been recognized that weaning a large number of pigs per litter is a necessity for profitable swine production. The relationship of size of pigs at birth to survival and thus to efficient swine production is indicated by the following:

✓ Strength and vigor at birth are closely associated with weight at birth, with a high proportion of heavy pigs being strong and vigorous and a high proportion of small pigs being weak and lacking vigor.

✓ Strong, vigorous pigs have a high survival rate, whereas only a small proportion of weak pigs survive.

✓ On the average, about 20% of the pig crop will have birth weights of 2.0 pounds or less per pig; with ordinary care only 25 to 35% of these survive.

✓ The number of undersized pigs at birth increases as the number of pigs in the litter increases.

Previous reports from the Oregon Agricultural Experiment Station have shown that even the pigs that are small at birth can survive if given supplemental care. These pigs will grow, on the average, as rapidly and efficiently on a weight-to-weight basis as their heavier littermates once they reach an initial weight of about eight pounds and will produce carcasses with merit equal to them. (Ore. Agric. Expt. Sta. Special Reports 137, 160, and 179).

Nevertheless, the most effective way to solve the problem of high death loss due to low weight at birth would be to find ways to either increase prenatal growth, and thus avoid undersize pigs at birth, or impart increased survival ability to the newborn pig regardless of size at birth, or both. Because the dam provides the conditions that permit or limit the development of the pig prior to birth, a logical approach is to attempt to influence the unborn pig through treatment of the dam.

An experiment was conducted in which dichlorvos—the active ingredient in the anthelmintic marketed under the trade name of Atgard [R] — was included in the ration of the dam during not less than 21 days nor more than 42 days before farrowing. Dichlorvos was fed in the amount of 800 milligrams per animal per day in six pounds of a ground mixed ration. The product was mixed in as the ration was prepared at the OSU feed center. Each animal was fed individually once daily. The control animals received six pounds per animal per day of the same ration but without dichlorvos. After farrowing, all dams were fed the same lactation ration; none received dichlorvos.

All animals were confined in groups on partially slotted floors. Both the control and experimental groups contained gilts and sows and included balanced numbers of Yorkshires, Berkshires, and crossbred foundation animals. Dams were moved to farrowing crates at 110 days of gestation. All were attended at farrowing; enhancement of survival of newborn pigs was provided through individual attention to weak pigs and by transfer of some pigs, when feasible, from litters with more pigs than could be successfully nursed to litters with fewer pigs. Sporadic occurrence of "hysteria" during or following parturition resulted in some pigs being killed by their dams; there was apparently no difference in occurrence of this malady in the treated and control groups.

By a week after farrowing, each dam and the pigs nursing her were moved to a separate 8 x 10 foot pen with a partially slotted floor and remained there until the pigs were weaned at 56 days of age. Creep feed was available *ad libitum* for the pigs; the sows were hand-fed amounts approaching full-feeding. Farrowing and survival data are shown in Table 1.

The data in Table 1 indicate no real effect on prenatal death during treatment; differences as large as these in number born alive per litter and the percent born dead would be expected to occur by chance without any treatment.

Differences in birth weight and survival to weaning are significantly different between the control and treated groups and can be attributed to inclusion of dichlorvos in the ration. Estimates of vigor or strength of pigs at birth were not made.

It is of particular production importance that the increase in average weight at birth is due to a reduction in number of pigs weighing two pounds or less as well as to increased percentages of pigs that weighed three pounds or more. The 19.6% of the pigs weighing two pounds or less in litters from control sows is almost identical to the percentage found in earlier extensive studies with more than 7,500 pigs in an Indiana study (Indiana Agric. Expt. Sta. Bull. 413). The 10.0% of the pigs weighing 2.0 pounds or less in litters from the sows fed dichlorvos is a reduction of almost 50% from the untreated group and undoubtedly contributes greatly to the reduction in total loss from farrowing to weaning of only 6.9% as compared to the 16.6% for the control litters.

The economic importance of this difference in survival can be visualized from the following: Assuming a litter size of 10 pigs born alive, a loss of 16.6% of the pigs would result in an

Table 1. Farrowing and Survival Data of Pigs Associated With Feeding of Dichlorvos to the Dams[1]

Group	Total no. of litters	Avg. no. born alive per litter	Percent born dead	Avg. birth-weight (lbs.)	Percent pigs 2.0 lb. or less	Percent pigs 3.0 lb. or more	Percent pigs died before 24 hrs.	Percent pigs died after 24 hrs.
Control	28	10.0	6.0	2.58	19.6	35.2	3.6	13.0
Treated	29	9.6	7.3	2.86	10.0	51.4	2.9	4.0

[1] Fed during the last 21 to 42 days of pregnancy.

Table 2. Average Weights of Pigs at 56 Days as Associated With Pre- and Post-Parturition Dependence Upon Dams[1]

Group[2]	Total no. pigs	Average 56-day weight (lbs.)
Control	168	36
Treated	192	37
Control transferred to control	20	30
Control transferred to treated	22	33
Treated transferred to control	11	34
Treated transferred to treated	11	30

[1] Treated dams received dichlorvos during the last 21 to 42 days of gestation. Control dams received no dichlorvos.

[2] Control and treated refers to dams; no pigs were "treated." Transfers of pigs were expedient rather than designed; see text for explanation.

Table 3. Post-Weaning Performance of Pigs Born to Dams That Were or Were Not Fed Dichlorvos During Gestation

Group	Total no. pigs	Avg. daily gain (lbs.)	Feed per lb. gain (lbs.)
Control	169	1.53	3.22
Treated	161	1.57	3.15

average of 8.34 pigs weaned per litter, whereas a loss of 6.9% of the pigs would result in 9.31 pigs weaned per litter—a difference essentially of one pig per litter. If it is assumed that six pigs per litter are required to break even, the control litters have 2.34 pigs per litter as profit and the treated litters have 3.31 pigs per litter as profit—an increase of 41% in profit (not gross income).

Pigs transferred from one dam to another were transferred without regard to whether the dam was a control or treated dam. This resulted in the groups of pigs at weaning as shown in Table 2.

Comparison of the different groups shows that weights at weaning were not significantly different for pigs from control and treated dams. The lower weaning weights of transferred pigs reflects the expediency involved in transfers; pigs up to two weeks of age that were "poor doers" because of inadequate milk availability were transferred as opportunity arose. These results indicate that the beneficial effects of dichlorvos were obtained prior to birth and continued through the post-farrowing period critical for survival, but that a permanent effect on quality or quantity of milk from the dam or on growth enhancement in the pig did not persist. Further indication that the effect of the treatment was mediated through the dam to the unborn pig and did not remain as a permanent stimulus in the pig can be seen in Table 3.

The performance test period was from approximately 60 pounds initial weight to approximately 200 pounds final weight. Each pig was weighed individually; each litter was fed as a separate group for feed efficiency determination. The differences between the groups are small enough to be due to chance alone and do not indicate any effect of the pre-farrowing treatment of the dam.

In summary, it can be said that feeding dichlorvos in the amount of 800 milligrams per animal per day in a ground mixed ration to swine in the last 21 to 42 days of gestation (1) significantly increased average birth weight; (2) significantly decreased pre-weaning death losses; and (3) did not affect average weaning weight or the growth rate and feed efficiency from 60 pounds to 200 pounds. Increase in weight occurred for pigs of all sizes prior to birth; the percentage of pigs weighing two pounds or less at birth was decreased from 19.6 to 10.0 and the percentage weighing three pounds or more was increased from 35.2 to 51.4.

Water Quality and Weaning Weight of Pigs

A. D. KNIGHT AND D. C. ENGLAND

Availability of water for livestock is often an incidental consideration and usually takes form in the most convenient and readily available source. Special regard is given the problem only when special needs exist, such as having water available during freezing weather. The modern trend toward confined rearing of livestock requires that more attention be given to the watering system. Though conventional methods of supplying water in troughs or buckets are still sometimes used, automatic watering devices operating on a weight or float principle are frequently employed. Such devices decrease labor requirements and improve management for anima's in that water is available whenever desired.

In either case, the water is retained in an open receptacle which is easily contaminated with urine, feces, and other foreign materials. Such a condition is conducive to rapid multiplication and interanimal transfer of microorganisms, and may develop into an undesirable hygenic situation.

Closed watering system

Self-operated watering devices from which water flows in a manner similar to a drinking fountain now are being used by a variety of animals. Such closed-system waterers have been found to be well suited for use in dog kennels, in the commercial rearing of ranch mink, and for laboratory animals confined for experimental purposes. A waterer of this type, originally developed for use by animals such as dogs, monkeys, and apes, is currently being used at the Oregon State University Swine Center to evaluate the closed watering system approach for swine.[1]

A. D. KNIGHT is assistant professor of animal science and D. C. ENGLAND is associate professor of animal science, Oregon State University.

[1] The closed-system waterers used in this study were supplied by ATCO Manufacturing Company, 461 Walnut Street, P. O. Box 2580, Napa, Calif.

Construction and installation

The device is of simple construction and consists of a die-cast zinc alloy, chrome-plated housing and a stainless steel valve assembly.[2] (See Figure 1.)

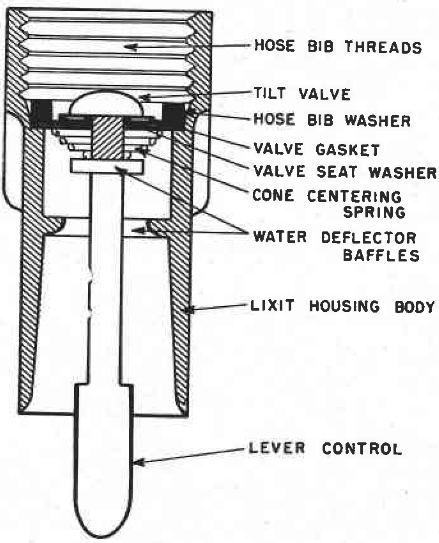

Figure 1. Schematic representation of cut-away view of closed-system watering device.

The valve assembly rests on shoulder lugs within the housing and is held in place with a heavy-duty washer. A spiral cone-shaped spring keeps the valve assembly centered and in the closed position when not in use. When the lever arm is tilted to one side by mechanical leverage, water flows through the valve and out the housing orifice. The housing is threaded for attachment to a standard faucet or garden hose. An adapter bushing is used for installation on pipe threads.

Water pressure can be turned on full or adjusted as desired. Manufacturer's specifications state that the device will operate satisfactorily under a range of water pressure from a low of 15 to 20 psi to as high as 100 to 125 psi. A reported study with dogs (Johnson and Anderson, J. American Vet. Med. Assoc., *136*:639-640) states that pressures between 30 and 60 psi did not affect the operating efficiency of the device.

Twenty-two of these waterers have been installed at the OSU Swine Barn, one in each of 12 farrowing crates and 10 growing pens. In each case, pressure-lever watering cups were detached and replaced and no additional adjustments were made. This resulted in the devices being in a horizontal position about six inches above the floor (Figure 2). The waterers in this position were apparently used as well by fully grown sows as by small nursing pigs. No training has been necessary. After installation, the devices have been readily used and there has been no apparent frustration on the part of any of the animals in their attempts to drink.

A comparison of watering systems

One of the potential advantages of a closed-watering device is that it provides drinking water directly from the water source free of filth and bacterial contamination. A pilot study involving 20 litters of pigs was conducted to determine if improved hygenic watering conditions provided by closed-system waterers would result in increased 56-day weaning weights. Ten litters were allotted from farrowing crates to pens with closed-system waterers, and ten to pens with open-system automatic waterers. All pens had slotted floors and were otherwise comparable.

The two groups were balanced as evenly as possible by size of litter and breed and age of dam. Sows were maintained on a lactation ration and litter

[2] Description of this equipment is made for clarity of discussion. It should not be implied as an endorsement of any particular brand or type.

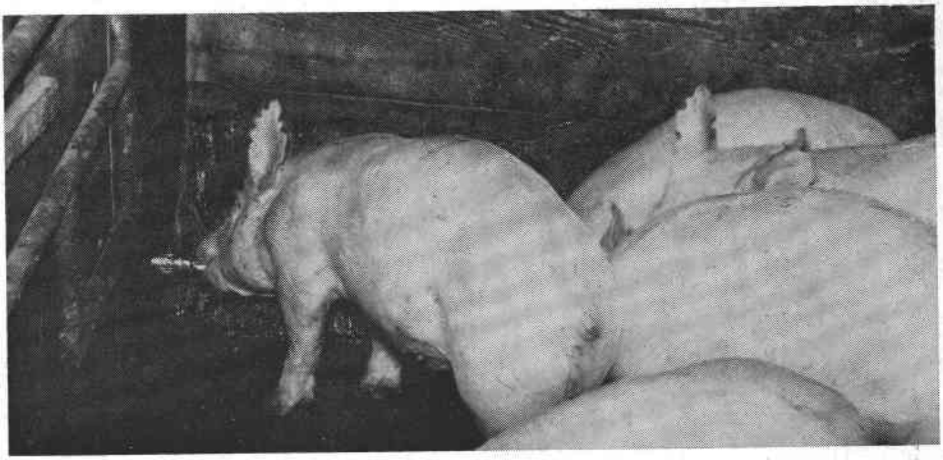

Figure 2. Pig drinking from closed-system watering device.

weaning weights were obtained at 56 days of age. Early in the course of the test period one sow of the closed waterer group died of causes unrelated to the study. Though the litter was successfully raised on a baby pig supplement, their weights were not included in the data analysis.

An average of 10.6 pigs were born to the sows on open waterers and an average of 8.9 reached 56 days of age. The closed-waterer group averaged 9.2 born and 7.7 weaned. In both groups death losses were comparable with most occurring in the farrowing crates. The average 56-day weaning weights of the open waterer group was 34.1 pounds, that of the closed waterer group was 34.6 pounds. This did not constitute a statistically significant difference.

Conclusions

Self-operated, closed-system waterers of the type described can be used successfully with swine. Though no water is visible, trial results have shown that swine readily adapt to the use of such a device. No training of any of the pigs using the waterers was necessary. Presumptions regarding long-term serviceability cannot be made, but there was no apparent damage to the waterers during the course of this study, nor were other difficulties encountered with their use.

Results did not indicate an advantage in weaning weight for litters using the closed-system waterers as compared to those using open waterers. The hygenic quality of water could produce a more apparent effect on pigs raised under other sanitary circumstances.