AN ANALYSIS OF FACTORS AFFECTING THE EFFICIENCY OF GAINS IN PIGS FROM BIRTH TO WEANING

T H E S I S

submitted by:

JAN CORNELIS BONSMA

To the Agricultural Faculty of the University of Pretoria in partial fulfillment of the requirements of Master in Science in Agriculture.

Signed: J.C. Bonsma

Ames, Iowa, U.S.A.
October 10th, 1936.

TABLE OF CONTENTS.

TABLE OF CONTENTS (Cont.)

I N T R O D U C T I O N.

Although many considerations are involved in raising hogs economically, it can be safely said that the food required to produce a unit of gain in the liveweight on the suckling pig represents the greatest portion of the entire cost of production up to weaning time. Thus food consumption per unit of gain is closely associated with the success or failure of a hog enterprise.

Several workers (1 and 2) have found that 76% to 84% of the cost of producing a market hog is made up of feed cost. Those factors which tend to increase the feed required to produce a pound of gain in the suckling pigs will increase the cost of producing a weanling pig and also a market hog.

In the present investigation consideration is given to various conditions which influence the amount of feed consumed by suckling pigs to produce a pound of gain in liveweight from birth to weaning time.

Because feed prices vary from year to year and even from month to month, no attempt has been made to express in cash terms the cost of producing a pound of gain in the liveweight of a weanling pig. Instead, the feed cost of production in this study is expressed in pounds of grain concentrates required to produce one pound of gain in the liveweight of the suckling pigs from the time of birth until weaning time.

Litterweight at weaning time, or gain made by the entire litter during the suckling period, is one of the elements which determines the cost of production. It is also an important consideration which the breeder should remember in selecting his breeding stock.

The cost of producing a weanling pig is influenced by genetic factors which determine to some extent the fertility, the ability to raise pigs and the milk production of the brood sows, and the size of the pigs at birth. Environmental conditions exert a marked influence on the full expression of a brood sow's genetic potentiality for production. Therefore feeding and management partly determine the size of litters at birth and affect the sow's ability to produce milk; they also influence the growth rate of suckling pigs.

The effect of several factors on the feed cost to produce a pound of gain in the liveweight of the suckling pigs were analysed and discussed in this study. The total effect of inheritance and environment on the cost of production was approached by comparing differences in the feed requirements to produce a pound of gain in the suckling pigs of the two breeds, Large Blacks and Duroo Jerseys. It was also determined within a breed by comparing the feed costs to produce a unit of gain in the weanling pigs from different Large Black female strains. The following related problems were also considered in the investigation: 1) the boar's effect on the cost of production; 2) the relation of the age of the sow, weight of the sow and change in weight of the sow during the lactation period to the feed cost of production;. 3) the influence of rations vermicides, seasons and years on the economy of production of weanling pigs was studied; 4) an attempt was also made to determine in how far (if any) management and selection improved the efficiency of production during the duration of the trials. A detailed description of the various factors studied will be found under the section dealing with the "Analysis of Data".

REVIEW OF LITERATURE.

Since litter size at weaning time is of the utmost importance in the economic production of weanling pigs, it is obvious that factors which influence litter size have a direct bearing on the feed required to produce a pound of gain in the suckling pigs. This circumstance is clearly reflected in the literature on the subject.

WENTWORTH AND AUBEL (3) from results on the study of inheritance of litter size came to the conclusion that litter size was determined to a small degree by inheritance and that numerous non-genetic factors limited the full expression of the genetic possibilities of brood sows.

In comparing breeds with one another, JOHANSSON (4) was convinced that heredity is an important factor in determining litter size. He also concluded that the size of litters is partly determined by heredity but that non-genetic factors play an even greater rôle.

LUSH, ANDERSON, CULBERTSON AND HAMMOND (5) working on the reliability of some measures of the productiveness of individual brood sows held that: "Each litter of pigs is in small part an expression of the sow's productivity and in large part a result of environmental conditions (mostly temporary and mostly unknown)".

SIMPSON (6), after mating European wild boars of the Schwarzwald type to Tamworth and Berkshire sows, stated that the wild litter size is dominant.

WENTWORTH AND LUSH (7) in their investigations on the inheritance of litter size found a direct influence of the sire on the size of the litters of his offspring. "It may be considered that litter size in swine like fecundity in poultry is dependent upon certain factors which

can be inherited in part through the male parent".

McPHOE (8) found no correlation between the size of litter in which a sow is farrowed and the size of litter produced by her.

BUCHANAN SMITH (9) wrote as follows on the inheritance of litter size: "Prolificacy is inherited probably in a straight forward though perhaps not too simple a manner. The sire and the dam would seem to play an equal part.

"In the production of a specific litter the boar if he be normal and in good condition may have little effect on the number produced by the sow. But he has an effect probably in every way as great as the sow on the size of litters that the gilts of which he is father are going to have".

EVVARD AND DOX (10) in discussing the effects of nutrition on litter size, stated that proteins added to a maize ration during breeding time favourably influences the number of young.

EVVARD AND CULBERTSON (11) recommend that sows be flushed before the boar is brought to them; this is to stimulate the production of a greater number of ova for later fertilization, resulting in larger litters.

In the literature concerning the inheritance of fertility very little definite information was found. The only point most writers seemed to agree on is that environmental factors limited the full expression of genetic possibilities.

CARROLL (12) did some work on the influence of the sows age on the cost of producing weanling pigs. He concluded that "Increased age tends to give larger litters and permits getting rid of sows with inferior breeding and maternal characteristics". He also observed that the

number of pigs alive at weaning time was larger for sows than for gilts.

Investigations by CARMICHAEL AND RICE (13) indicated that the total weight of the litter increased with each succeeding litter up to the fourth due to an increase both in the number of pigs per litter and in the weight of the individual pigs.

JOHANSSON (4) thought it quite clear that averages for the first, second, and third litters are not comparable in numbers to those from fourth, fifth and sixth.

Results obtained by W.E. JOSEPH (14) indicated that old sows raise pigs at less cost than yearling sows. Older sows raise more pigs in the second and third litters than in the first litter.

In working on age as a factor in brood sow performance, RUSSEL (15) found that the gilt, or one-year-old sow, leads in the per cent. of pigs weaned to number farrowed, which to some extent means that she is a better caretaker than the older sow. In this, however, she is closely followed by the two-year-old sow, but because of the smaller number of pigs farrowed she loses out to the two-year-old sows in the actual number of pigs weaned. Johansson (4) held that the size of litter increases up to the fourth and decreases after the sixth farrowing.

According to SINCLAIR AND SYROTUCK (16): "It has been regarded as a fundamental principle that the size of the litter increases with the age of the sow until a maximum is reached to be followed by a decrease in prolificacy". They conclude that the nearest approach to perfect maternal instinct is to be found in the case of the three-year-old sow raising on the average a fourth litter. The degree of farrowing efficiency falls off rapidly after a sow reaches the age of three years.

DAVIDSON AND DUCKHAM (17) found that mature sows weaned larger and heavier litters than gilts.

In summarizing this part of the discussion, it may be said that investigators are unanimous in the belief that litter size increases with the age of the sow until she reaches an age of about three years. They also agree that the sow's ability to raise pigs increases up to about the fourth farrowing and then decreases.

Studies have also been conducted on the influence of seasons upon litter size and number of pigs raised.

CARMICHAEL AND RICE (15) wrote as follows: "The time of the year at which pigs are farrowed does not seem to exert any very noticeable influence with any regularity upon length of gestation period, size of litter or weight of pigs".

EVVARD AND CO-WORKERS (18) found that spring pigs require slightly less food per unit of gain than fall pigs did.

FERRIN AND McCARTY (19) found that the amount of feed required to produce gains was practically the same for pigs farrowed at two different seasons.

GRIMES, SEWELL AND COTTIER (20) stated that sows farrowed more pigs per litter during the fall but raised a greater number of pigs per litter during the spring when green feed was more plentiful and weather conditions more favourable for suckling pigs.

JOHANSSON (4) reached the following conclusions: "The time of the year in which the farrowing occurred did not have any marked influence on the number of pigs born; but the death rate of young pigs was lower in summer than in the winter and the total weight of litters was highest in summer months".

According to BUCHANAN SMITH (21) the general conclusion arrived at by continental and American writers is that during the winter months litter size is higher and that more females than males are born during the warm weather.

MENZIES MITCHEN (22) held that: "There appears to be no significant variation in the number of pigs farrowed throughout the year; but a higher percentage of pigs farrowed during April to September (summer) period survive at six weeks than those born during the remaining six months of the year, the survival being one pig per litter greater".

Most of the investigators found only a very small difference between the number of pigs born per litter during the different seasons. They all agree to the fact that more pigs survived during the summer period.

A few investigators have worked on the influence of litter size on the cost of raising weanling pigs.

GRIMES, SEWELL AND COTTIER (20) concluded that the average amount of food used to produce one pound of gain in liveweight of the suckling pigs decreased as the litter size increased.

JOSEPH (14) found that the cost was approximately twenty per cent. more for each pound of pig at weaning time for litters averaging 4.4 pigs than for those averaging 6.5 pigs.

From the relatively small amount of work done in this direction, one may conclude that one of the most important factors in keeping down the cost of weanling pigs is the number of pigs raised.

That most sows change weight during the suckling period is known, but very little work has been done

to show how the change in the sow's weight during the suckling period is related to the cost of producing weanling pigs.

McKENZIE (21) wrote as follows on the change in a sow's weight during the lactation period: "It is noted that following the loss at farrowing those sows suckling small litters tended to gain in weight rather than lose throughout the eight-week lactation period. On the other hand sows suckling relatively large litters lost weight rapidly each week of the lactation period and did not begin to gain until the third week after weaning". This investigator found that litter size determines the change in a sow's weight during the lactation period. A few men have done some experimental work on the effect of a sow's milking ability on the gains made by the suckling pigs.

CARL THOMPSON (24) pointed out that pigs from sows producing the heaviest flow of milk made more rapid gains not only throughout the suckling period but for 60 days following the suckling period.

BONSMA AND OOSTHUIZEN (25) found a highly positive correlation of .5921 $\pm$ .0607 between the average amount of milk available and average weekly gains per piglet. These findings seem to indicate that the sow's milk production will affect the gains made by suckling pigs.

Several workers have studied the influence of crossbreeding and purebreeding on the cost of producing market hogs.

SHEARER AND CULBERTSON (26) observed that cross-bred pigs made a somewhat larger daily gain, .599 pounds as compared with .555 pounds, during the suckling period and weighed a little over two pounds more per pig at weaning time.

WINTERS, KISER, JORDAN AND PETERS (27) found in a six-year study of crossbreeding swine that the cross-bred litters averaged from one-third pig to two pigs larger at weaning. Furthermore, on the average each pig weighed from 5-7 pounds more at weaning time and the litters weighed from 39-96 pounds more. These results would indicate that from an economic point of view it may under certain conditions be advisable to crossbreed swine.

Although it is not exhaustive, the preceding review of literature will suffice to give the reader some idea both of the amount and the scope of the work which has been done on the cost problem of producing weanling pigs.

SOURCE OF DATA.

The experiment discussed in this study was started at the Pretoria University Experimental Farm in 1925, principally for the purpose of finding out the feed cost of producing weanling pigs. The first investigations (29) stressed the effects of different rations on the cost of producing weanling pigs. During the period 1925-1934, data was obtained on 171 Large Black litters and 58 Duroc Jersey litters.

The data thus obtained make it possible not only to determine the effects of different rations on the cost of production but also to isolate various other factors which are closely associated with the cost of production.

The data were first recorded in a field book, which was used for daily observations and notes on pigs. Secondly the data in the field book were posted in a permanent record book under the following headings:

1. Breed of the sow.
2. Name and identification number of the sow.
3. The ration on which she was fed.
4. The date of service.
5. The date of farrowing.
6. Name of the sire of the litter.
7. The date of beginning of the experiment.
8. Date of weaning.
9. The number of pigs farrowed dead and alive.
10. Number of pigs weaned.
11. The number of pigs that died before weaning time and their weights.
12. Weights of litter at fortnightly intervals.
13. Weight of sows at fortnightly intervals.

14. The dates of weighing the sows and litters.
15. Total feed consumed by the sow from the date of breeding until farrowing time.
16. Total feed consumed by the sow and the litter from farrowing to weaning time.
17. The age of the sow at the time of farrowing.

(a) Management of dry sows.

The dry sows were run together in groups of not more than four in half acre camps, furnished with a hog house. The dry sows were fed a maintenance ration of about 3.5 to 4 lb. of concentrates per sow daily. The dry sows were hand fed twice daily.

(b) Management of the brood sows.

The nursery sows were kept separately in camps. The amounts of feed fed varied very much, and was determined largely by litter size, age of the suckling pigs, the condition of the sow and piglets and the milking ability of the sows. These sows were fed three times daily at 6.30 a.m., 11 a.m. and 5 p.m. The amount of feed was measured out in buckets containing approximately a known weight. A monthly supply of feed was made up for every sow, kept separately, and marked by having the sow's name and number on it. Weekly supplies of 105 lb. were stored in separate bags. The amount of food consumed was obtained by weighing the food which was left over at the end of the week and subtracting it from the initial weight at the beginning of the week.

The camps in which the sows and litters were run were about 50 x 25 yards. In each camp was a portable sleeping house, which was always kept well bedded with sawdust. Each camp contained some natural grass and some kikuyu pasture. Each camp also had a suitable drinking

trough of cement containing an abundant supply of clean water. A suitable wallow was kept wet by the overflow water from the drinking trough.

The pigs had constant access to a mineral mixture composed of the following elements:

100 lb. charcoal, 40 lb. ash, 40 lb. bone meal, 8 lb. salt, 5 lb. lime, 1½ lb. sulphate of iron. The sulphate of iron was dissolved in hot water and poured over the mixture.

The dry sows were weighed every week, and the sows with litters were weighed at two-week intervals from the first week after birth until weaning time.

METHOD OF ANALYSING THE DATA.

In attempting to determine the influence of various factors on the amount of feed required to produce one pound of gain in liveweight of weanling pigs, the simultaneous variation of two variables usually termed correlations were used in analysing some of the data. This method was used in all cases where the variables were expressed quantitatively.

In order to determine whether the differences between the various amounts of feed required to produce a unit of gain as influenced by the various factors studied were significant, tests for the significance of means and mean differences were calculated. The measure of variability used was the Standard Deviation and the Standard Error of the mean.

The significance between differences was determined by dividing the Standard Error of the mean differences in the difference between the means. The value obtained in this way was compared with the "t" value found in Fisher's (30) table of "t" values. Odds of .01 are regarded as highly significant.

The following data were analysed statistically to determine the influence of each factor on the amount of feed required to produce one pound of gain in the liveweight on pigs raised to weaning time:

1. Litter size.
2. Breeds.
3. Family groups or female strains.
4. The boar.
5. Age of the sow at farrowing.
6. Farrow number.
7. Weight of the sow at farrowing.

8. Change in weight of the sow during the lactation period.
9. Crossbreeding and purebreeding.
10. Influence of time (years).
11. Seasons.
12. Use of Vermicides.
13. Rations.

The following additional factors may have had an influence on the food consumption per pound of gain, but the available data did not permit statistical analysis:

1. The number of stillborn pigs.
2. Creep feeding of the suckling pigs.
3. The use of wallows for the sows and litters in warm weather.

DISCUSSION.

A. Influence of Litter Size at Weaning Time on the Feed Required to Produce one Pound Gain in Liveweight of Pigs from Birth to Weaning Time.

Among the many considerations involved in the economic production of breeding and market hogs, one of the most important single factors is that of litter size at weaning time. The cost of production in pounds of grain required to produce one pound of gain in body weight is obtained from the ratio between the total weight of the litter at weaning time and the total weight of concentrates consumed by the brood sow and the litter during the lactation period. It is obvious, therefore, that if a pig dies before weaning time that the grain consumed by this pig is debited to the pigs weaned. It follows that any loss of pigs during the lactation period increases the cost of production.

The older the age at which the suckling pig dies the greater is the increase in the cost of production of the living pigs.

The following table (Table No. 1) shows the relation between the cost of production in litters in which no pigs died after the first week and litters in which pigs died during some later stage of the suckling period. Only litters in which 5, 6, 7 and 8 pigs were weaned could be studied in this manner because there were no litters in the 4 + class and the number of classes where less than four and more than eight pigs were weaned were too small to justify statistical analysis.

TABLE 1.

The influence of mortality of suckling pigs after the first week on the feed cost of production per pound of gain in liveweight from birth to weaning time.

Pigs weaned per litter	No. of litters	No. of pigs born	No. of pigs weaned	Percentage weaned	Average cost of production in pounds of gain	Standard deviation	Standard error of the means	"t" value	"t" value for significant odds
5	22	165	110	66	4.082	.562± .119	.313	2.255	2.042
5+	10	82	50	61	4.788	.912±.289			
6	32	285	192	67	3.726	.530±.094	.178	1.028	2.021
6+	7	78	42	53.8	3.909	.403±.153			
7	32	312	224	71.8	5.706	.456±.208	.231	1.025	2.014
7+	10	91	70	76.9	3.942	.690±.218			
8	26	265	208	78.4	3.572	.566±.112	.397	.428	2.042
8+	4	46	32	69.5	3.742	.241±.120			

The plus sign (+) indicates that in those litters pigs died after the first week of the lactation period.

From Table 1 it is clear: 1) that loss of pigs during the lactation period increases the cost of production, and 2) that the cost of production per pound of gain in weanling pigs is largely determined by litter-size at weaning time.

J.G. Grimes, W.E. Sewell and G.J. Cottier (20) of the Alabama Agricultural Experiment Station found that pigs raised in litters of two cost Ø9.50 each, while pigs raised in litters of nine cost only Ø2.26 each. W.E. Joseph (14) of the Montana Experiment Station found that the cost was approximately 20% more for each pound of pig at weaning time for litters averaging 4.4 pigs than for those averaging 6.5 pigs. These results agree with the results obtained in this study.

The cost of production in pounds of grain required to produce one pound of gain in liveweight goes down as litter size increases. A very highly significant positive correlation of .9008 was obtained between litter size at birth and at weaning time. A highly significant negative correlation of -.492 was obtained between litter size at weaning time and the cost of producing a pound of gain in liveweight of the suckling pigs.

According to the tables of "r" (X) values obtained from "Correlation and machine calculations" by H.A. Wallace and George W. Snedecor (31) a correlation of -.138 for 200 degrees of freedom would be highly significant. It is therefore justifiable to regard a negative correlation of -.492 for 221 degrees of freedom as very highly significant.

The average cost in pounds of grain to produce a pound of gain in the liveweight in litters weaning 2, 3,

---

(X) "r" : correlation coefficient.

4 and 5 pigs is 4.676, with a standard deviation of 1.203 (plus-minus) .141. The average cost in the case of litters weaning more than five pigs is 5.565 pounds of grain per pound of gain in liveweight, with a standard deviation of .534 plus-minus .0438. The difference in cost in pounds of grain to produce a pound of gain in liveweight between the two lots of weanling pigs compared is highly significant.

The conclusion drawn from this is that it costs much less to produce a pound of gain in the liveweight in pigs from large litters than in pigs from small litters. Table 2 and Graph I illustrate what was brought out by the significant negative correlation between litter size and feed requirements per unit of gain, namely that the cost of production goes down as litter size increases.

The close relationship which exists between litter size at weaning time and the number of pigs born illustrates how important fertility is in the economic production of pigs.

The number of pigs weaned is also determined by the sows' milking ability, and her ability to raise pigs. It is, therefore, necessary to select for fertility, milk production and ability to raise pigs, in sows if the hog enterprise is to be successful.

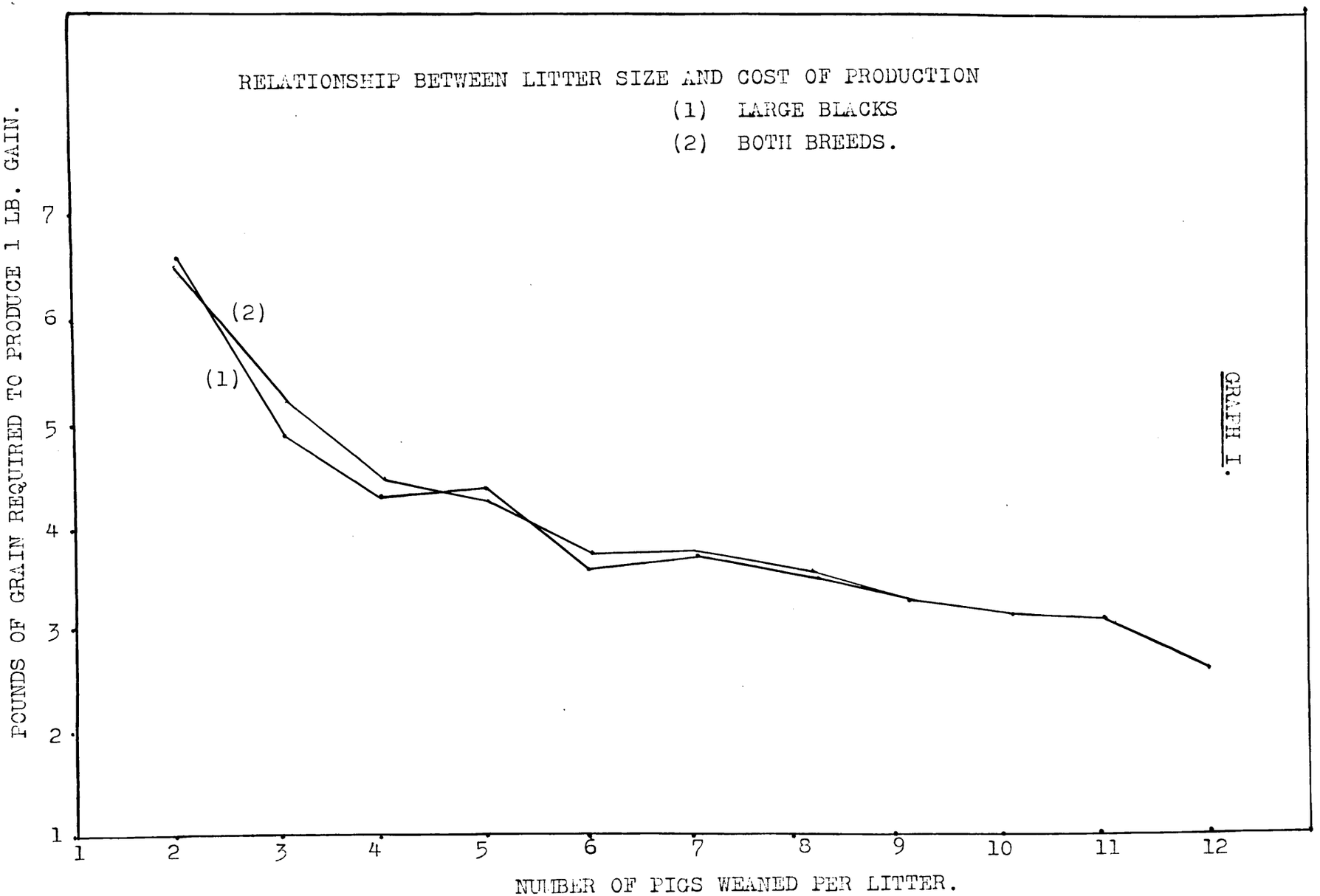
TABLE 2.

The influence of litter size at weaning time on the average amount of feed required to produce a pound of gain in the suckling pigs from birth to weaning time.

Average number of pigs weaned per litter	Number of litters	Average(A) amount of feed required to produce 1 lb. gain in liveweight	Standard deviation	Standard error of the means	"t" value	"t" value required for significant odds .01
2	11	6.55	.904±.274	1.131	1.105	2.069
3	13	5.30	.707±.197	.982	.857	2.021
4	16	4.46	.963±.240	.886	.191	2.008
5	32	4.29	.807±.145	.519	1.019	1.994
6	39	3.76	.506±.080	.514	0	1.990
7	42	3.76	.883±.131	.517	.307	1.994
8	30	3.60	.452±.083	.491	.469	2.008
9	18	3.37	.557±.131	.979	.173	2.030
10	19	3.20	.930±.214	.886	.056	2.086
11	1	3.15	0			
12	1	2.66	0			

(A) The averages for the small litters and the large litters.

3.959	72	4.676	1.203±.141	.148	7.394	1.972
7.620	150	3.565	.534±.044			



GRAPH I.

B. Cost of Production Between the Two Breeds.

In an endeavour to determine whether any significant difference in the cost of producing weanling pigs existed between the two breeds used in these trials, namely, the Large Blacks and Duroc Jerseys, the cost of production in pounds of grain to produce a pound of gain in liveweight in the suckling pigs was analysed for 171 Large Black litters and 58 Duroc Jersey litters. Table 3 summarizes the results.

The cost of production in the case of Large Blacks was 10% less than in the case of Duroc Jerseys; while the difference is not statistically significant, from an economic standpoint, a 10% difference is worthy of consideration.

In the attempt to find the reason for the greater economy of production of Large Black weanling pigs, certain breed comparisons were made. As litter size is one of the most important factors influencing the cost of production this was studied. No significant difference was found between the two breeds in number of pigs born. However, a significant difference in the number of pigs weaned per litter was found. Tables 4 and 4A summarize the results of these findings.

Another factor of the utmost importance in the economical production of weanling pigs is litter weight at weaning time. The Large Black litters on the average weighed 61.99 lb. heavier than the Duroc Jersey litters. This difference is statistically very significant. Table 5 summarizes these results.

The weights of the individual pigs at weaning time were also compared. The Large Black pigs were on an average 2.35 lb. heavier than the Duroc Jersey pigs. This difference in weight is on the borderline of being statisti-

TABLE 3.

The concentrates required to produce a pound of gain in the liveweight of the suckling pigs.

Breed.	Number of litters	Pigs weaned	Pounds of grain required to produce 1 lb gain	Standard deviation	Standard error of the means	"t" value	"t" value for significant odds .01
Large Black	171	1128	3.731	1.84±.014	.6916	.566	1.970
Duroc Jerseys	58	343	4.125	1.27±.177			
TOTAL:	229	1471	3.815	1.87±.012			

GRAPH II.

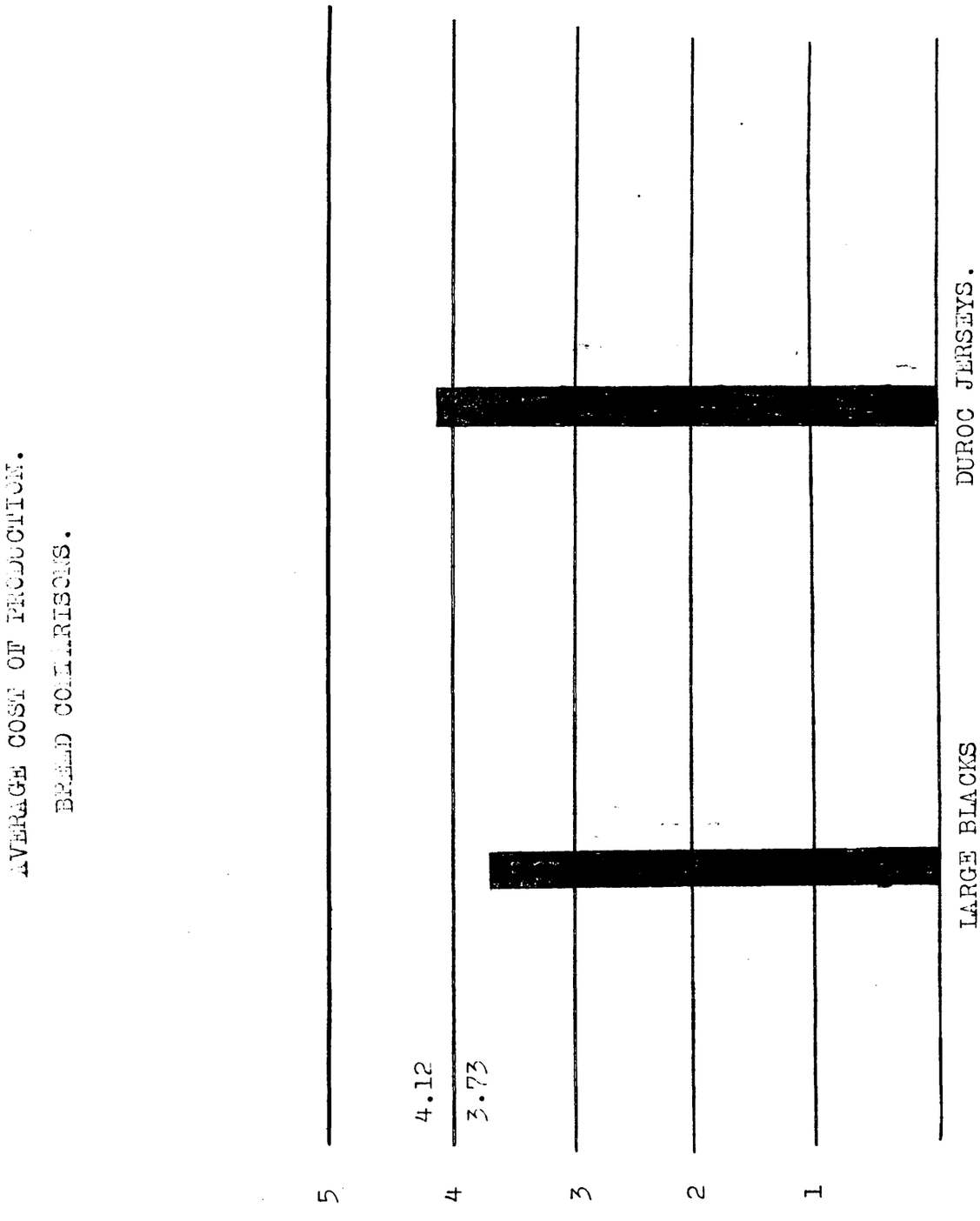


TABLE 4.

The average litter sizes at birth between the two breeds.

Breed.	Number of litters	Average number born per litter	Standard deviation	Standard error of the means	"t" value	"t" value required for significant odds
Large Blacks	171	9.18	2.76± .212	.326	.552	1.970
Duroc Jerseys	58	9.00	2.81± .369			

TABLE 4A.

The average number of pigs weaned per litter between the two breeds.

Breed.	Number of litters	Average number weaned per litter	Percentage weaned	Standard deviation of number weaned	Standard error of the means	"t" value	"t" value required for significant odds
Large Blacks	171	6.59	71.8	233± .178	.333	2.05	1.970
Duroc Jerseys	58	5.91	65.6	2.14± .281			

cally significant. See Table 5A. From these results it is obvious that in these instances it was much more economical to produce Large Black pigs to weaning age than Duroc Jerseys.

Since no significant difference was found in the size of the litters of the two breeds, a difference in fertility can not be regarded as a cause for the difference in the cost of production. However, a significant difference between the two breeds was found in the numbers of pigs weaned per litter. Thus, one of the main reasons for the increased cost of production in the Duroc Jersey weanling pigs is mortality among the suckling pigs during the lactation period.

As the brood sows with their litters received similar treatment during the lactation periods this difference in mortality in the suckling pigs is probably due to the inferior nursing qualities of the Duroc Jersey sows. Unfortunately we have no data on the difference in milk production between those two breeds. The difference in the weaning weight of the pigs is partly nutritional and partly genetic (difference in average size of the breeds).

It was observed however, that in general the Duroc Jerseys were more nervous and bad tempered than the Large Black sows. These qualities undoubtedly caused some increase in mortality.

TABLE 5.

The average litter weights at weaning time between the two breeds:

Breed	Number of litters	Average litter weight at weaning time	Standard deviation	Standard error of the means	"t" value	Required "t" value for odds .01
Large Blacks	171	348.29	34.37±2.66	5.319	11.65	1.970
Duroc Jerseys	38	286.30	33.02±4.33			

TABLE 5A.

The average weight of the individual pigs at weaning time.

Breed	Number of litters	Average weight per pig at weaning	Standard deviation	Standard error of the means	"t" value	Required "t" value for significant odds
Large Blacks	171	53.70	9.43± .722	1.33	1.740	1.976
Duroc Jerseys	58	51.45	8.68±1.139			

C. Variation in Cost of Production between Family Groups or Strains.

Pig breeders stress the selection of brood sows for high fertility and high milk production. A question arising in this connection is the extent to which these factors are inherited.

Most writers agree that inheritance is an important factor in determining litter size but non-genetic factors play an even greater rôle. In this study the fertility and economic production of weanling pigs in five different family groups were analysed. The family groups or female strains are indicated by a name and the individual sow is identified by the name and ear number.

The family study was confined to the Large Blacks, of which 160 litters could be classified in distinct groups. All the sows were served by the same boar during the same period of time; therefore, a pig in the Virtue family may be sired by the same boar as a pig in the Diana family.

Since the boars used were obtained from other herds, it is not likely that a Virtue sow was served by a boar out of one of the other female strains. All the progeny from the family strain were named after the dam plus a series number, no distinction having been made between pigs related on the sire's side.

In comparing the economy of production of a pound of gain in liveweight in weanling pigs from birth to weaning time, it was found that three groups produced weanling pigs at much lower cost than the other two family groups. Table 6 and Graph III summarize these results.

The results obtained showed that the three low-cost family groups required much less feed to produce a pound of gain than did the high cost groups. Various

TABLE 6.

Summary of variation in the cost of production expressed in pounds of grain to produce a pound of gain in liveweight in the weanling pigs from the different family groups of Large Blacks.

Family group	Number of litters	E Average feed consumed	E of average feed consumed	Average cost in pounds of grain to produce 1 lb gain	Standard deviation
Cape	52	218.02	955.63	3.948	1.17 ± .162
Cornette	19	81.78	361.08	4.154	.627 ± .144
Diana	24	89.94	384.29	3.610	.675 ± .138
Bella	17	62.94	240.50	3.570	.638 ± .155
Virtue	48	175.73	730.36	3.481	1.45 ± .209

TABLE 6A.

Averages for the two high feed requirement groups and the three low-cost groups.

Family group	Number of litters	Average cost in lb. of grain to produce 1 lb.gain.	Standard deviation	Standard error of the means	"t" value	"t" value required for significant odds
HIGH COST Cape & Cornette	71	4.00	1.05 ± .124	.174	2.71	2.609
LOW COST Diana, Virtue & Bella	89	3.53	1.15 ± .122			

GRAPH III.

COST OF PRODUCTION IN DIFFERENT FAMILY GROUPS.

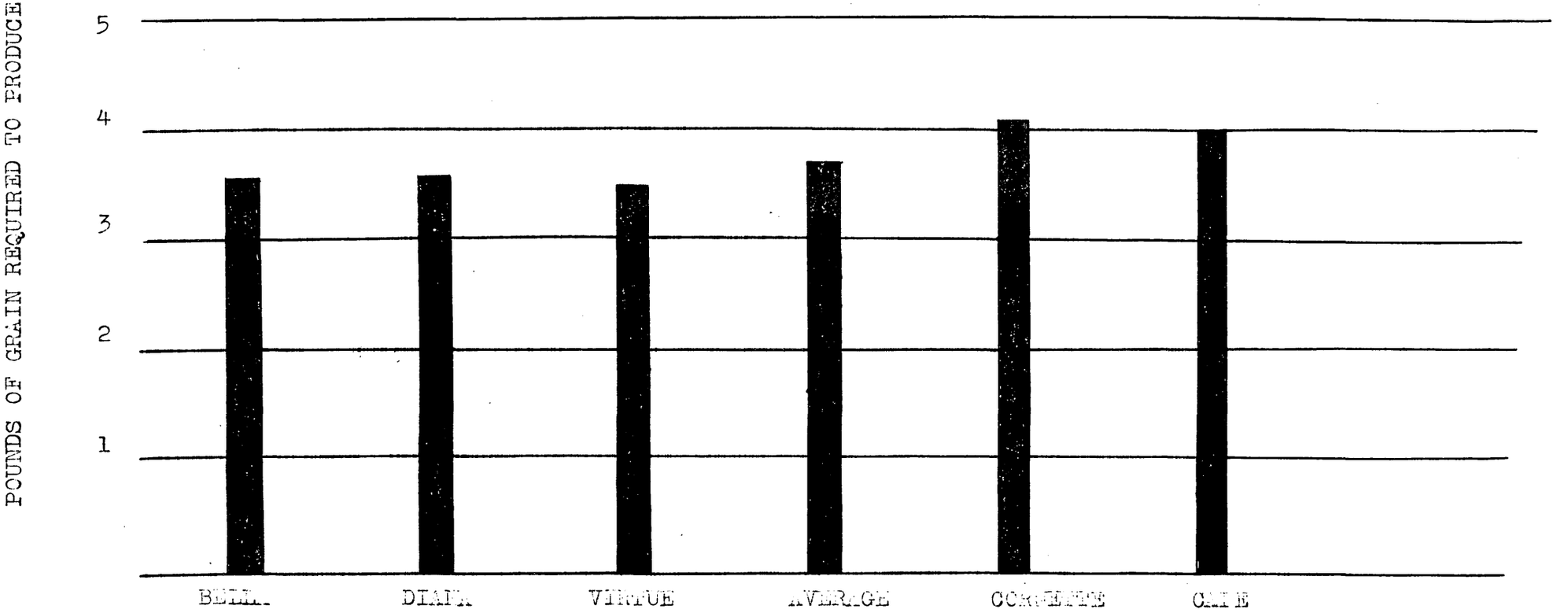


TABLE 7.

Variation in the number of pigs born, number alive first week and number weaned.

Family group	Average number born per litter	Standard deviation	Average number alive per litter at end of first week	Standard deviation	Average number weaned per litter	Standard deviation	Percentage of number born alive first week	Per-centage weaned
Cape	8.70	3.05± .424	6.26	2.24± .310	5.92	2.29± .317	71.9	68.0
Cornette	8.63	2.21± .508	7.00	1.82± .418	6.31	1.73± .397	81.1	73.1
Diana	9.25	2.62± .555	7.25	2.02± .405	7.88	1.90± .388	78.3	76.5
Bella	10.35	2.49± .604	8.05	2.30± .558	7.88	2.26± .548	77.8	76.2
Virtue	9.50	2.75± .397	7.40	2.13± .307	7.02	2.09± .302	77.8	75.8

TABLE 7A.

Averages for three low-cost groups and two high-cost groups.

Family groups	Av. No born per litter	Standard deviation	Av. No. alive first week	Standard deviation	Av. No. weaned per litter	Standard deviation	Standard error of the means born	Standard error of the means alive first week	Standard error of number weaned
Low-cost	9.60	2.7 ± .320	7.48	2.13± .252	7.20	2.08± .247	.44 "t"	.34 "t"	.33 "t"
High-cost	8.68	2.8± .296	6.46	2.15± .227	6.03	2.16± .229	2.10	3.00	3.54

GRAPH IV.

SOWS GROUPED IN FAMILIES.

(1) NUMBER BORN. (2) NUMBER ALIVE FIRST WEEK. (3) NUMBER WEANED.

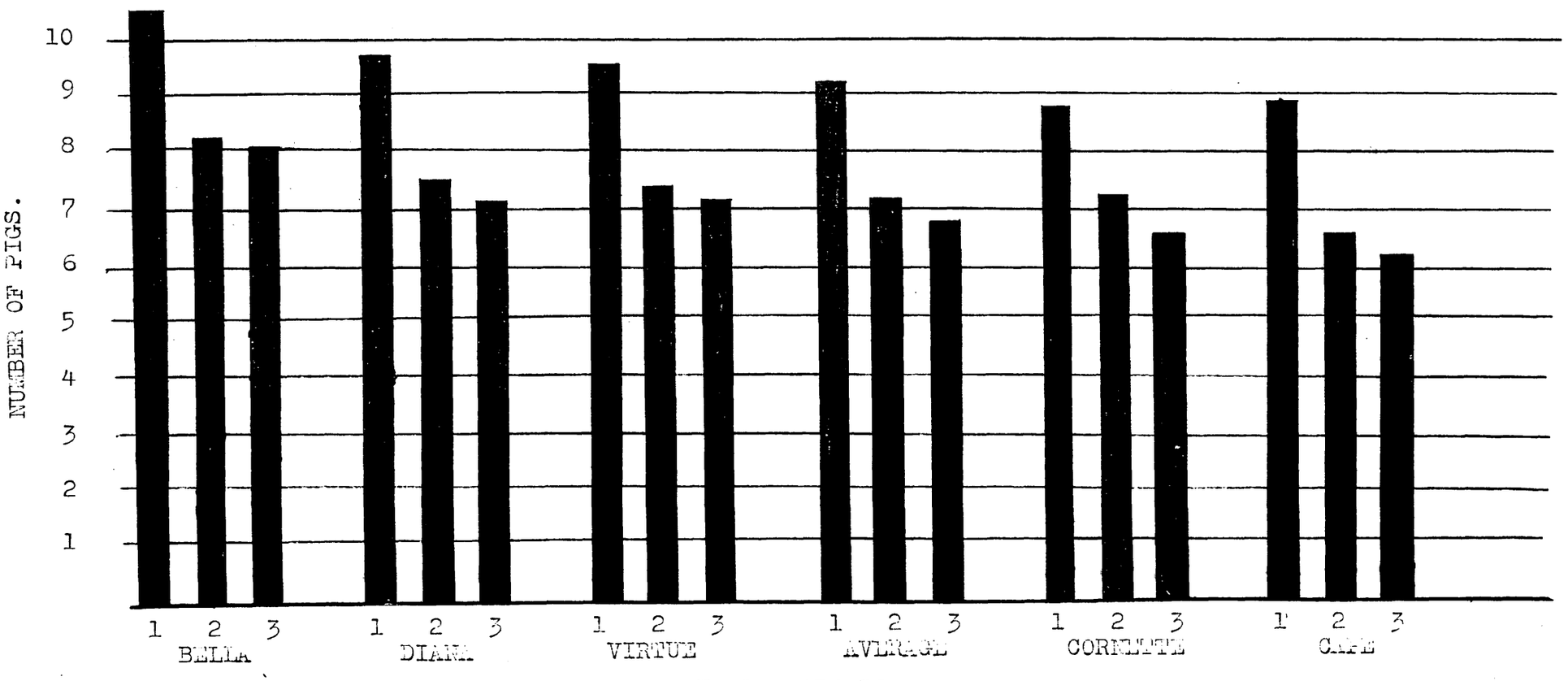


TABLE 8.

Summary of correlation ratios between weight weaned and weight of feed consumed in the different family groups.

Family group	EA^2 E of the average weight weaned	Ex^2 E of the average amount of feed consumed	EAX cross products wt. weaned x wt. fed	M_A Average weight weaned per litter	M_x Average amount of grain fed	Correlation ratio "r"
Cape	5751365	85045053	21723703	316.3	1240	.8004
Cornette	1872085	2920859	7501623	300.0	1266	.6402
Diana	3551240	45144434	12549658	371.0	1342	.8691
Bella	2921839	35981738	10146771	403.2	1440	.8047
Virtue	7353960	84311096	24481361	373.4	1300	.8602

Formula used "r" = $$\frac{EAX - EA(Mx)}{\sqrt{EA^2 - EA(M_A)}\ \sqrt{EX^2 - EX(M_x)}}$$

reasons may be suggested why these family groups differ so widely in the cost of producing weanling pigs. Size of litter at birth and at weaning time is of the utmost importance in determining the cost of producing weanling pigs. The family groups were, therefore, compared for fertility and nursing ability. It was found that the three low-cost groups produced larger litters at birth than the two high-cost groups. In the low-cost family groups (Bella, Virtue, Diana) a higher percentage of pigs were alive at the end of the first week and also a higher percentage of pigs were weaned than in the two high cost groups (Cape and Cornette). Table 7 and Graph IV summarize these findings.

The statistical treatment of these results indicates that there is a significant difference between the number of pigs born in the two high-cost groups and the three low-cost groups.

The difference between the two groups in the number of pigs alive at the end of the first week is equally significant. The low-cost groups weaned much larger litters than did the high-cost groups.

In correlating the weaning weight of the pigs with the feed consumed it was found that the low-cost groups had higher correlation ratios for weight weaned and feed consumed than had the high-cost groups. This indicate s that the low-cost groups made more efficient use of the feed consumed. The higher mortality of the suckling pigs in the high-cost groups also caused a feed loss. (See Table 8).

These results coincide with the results obtained by F.N. Bonsma and P.M. Oosthuizen on the milk production in Large Black sows. The three strains in the low-cost groups gave more milk than the two strains in the high-cost group. They obtained the following results:

TABLE 9.

Female strain	No.of sows	No. of lactations	Av. litter size	Av.total milk yield (lb.)	Av. total milk per piglet (lb.)
Cape	2	3	3.8	208.9	70.98
Cornette	3	6	6.2	330.3	55.12
Diana	4	7	7.5	257.9	47.72
Bella	5	6	7.9	552.2	69.87
Virtue	7	16	7.2	427.0	59.33

This comparison of family groups or strains brings out several points clearly:

1. The ability to produce large litters is inhereited. Therefore by selecting for fertile strains and for productivity of individual sows it would seem possible to decrease the cost of production. Since the sows in this experiment were kept under similar environmental conditions and also received very similar treatment, we are justified in assuming that the difference in litter size was at least partly due to genetic differences in fertility.
2. The sows in the different female strains differ in nursing qualities and milk production; this explains the difference in mortality between the groups during the suckling period.

Pig breeders should stress milking qualities of sows. Unfortunately the only basis they have for selecting good milking sows is the external characteristics of a well formed udder and large, well placed teats.

In a nursing sow the growthiness and weight of the suckling pigs at 3 or 4 weeks may be used as an index of the milking ability of the sow.

D. The Influence of the Boar on the Cost of Production.

A normal boar in good breeding condition apparently will not materially influence the size of the litter produced by a sow. The boar may, however, influence the size of the pigs at birth and by doing so influence the cost of production. It should be noted, however, that the boar probably has an effect in every way as great as the sow on the size of litters produced by his gilts.

During the collecting of the data it was thought that the female progeny from the boar Moorddrift Admiral produced weanling pigs more economically than their mothers. It was, therefore, decided to discover any possible differences in the cost of producing weanling pigs between the sows and those of their daughters sired by Moorddrift Admiral.

It is impossible to determine how he influenced the birth weight of the pigs because no birth weights were taken. However, the number of pigs born per litter, the number of pigs alive at the end of the first week, and the number of pigs weaned by dams and daughters sired by Moorddrift Admiral were compared. (See Table 10).

No significant difference was found between the number of pigs born, alive at end of first week, and the number weaned between the dams and their daughters by Moorddrift Admiral.

The two groups were also compared for cost of production, but here also no significant difference was found. (See Table 11).

The weaning weights of the pigs were compared. If the boar Moorddrift Admiral had had a marked influence on the inheritance of size, the pigs sired by him should have been heavier than the pigs farrowed by his daughters.

TABLE 10.

Comparison between the number of pigs born, alive first week and weaned between dams and daughters of Moorddrift Admiral.

Item.	No. of litters	Av. No. born per litter	Standard deviation	Standard error of the means	Average number weaned per litter	Standard deviation	Standard error of the means
Dams	34	9.20	2.67± .457		6.70	2.26± .387	
Daughters) sired by) Md.Admiral)	41	8.93	2.79± .389	.63	6.93	2.26± .353	.52

TABLE 11.

The comparison between the amounts of feed required to produce a unit of gain in the suckling pigs in the two groups.

Item.	Number of litters	Total weight weaned	Total weight of feed consumed	Average amount of feed required per lb of gain	Standard deviation	Standard error of the means
Dams	34	12962	45469	3.50	.67 ± .116	.23
Daughters sired by Md.Admiral	41	14969	51539	3.44	1.30± .203	

The results, however, showed no significant difference between the average weaning weights of the pigs in the two groups.

TABLE 12.

Average weight of pigs at weaning time.

Item.	Av. weight of pigs at weaning time.	Standard deviation	Standard error of the means
Dams	55.96	9.43 ± 1.62	2.19
Daughters by) Moorddrift) Admiral)	52.70	9.54 ± 1.50	

All these comparisons fail to prove that Moorddrift Admiral had any marked influence on the cost of production either in litters of which he was the sire or in litters produced by dams of which he was the sire. The data did not permit the study of more boars, because in all other cases only a very limited number of offspring were retained in the herd. Thus it was impossible to study the difference in cost of production between dams and daughters by a particular boar.

E. Influence of the Age of Sows on the Cost of Production.

It is common knowledge among swine breeders that older sows raise larger litters and also produce the gains in suckling pigs more economically than young sows. The sows in this study were classified into age groups separated by six-month intervals.

In studying the cost of production very little difference was found in the different groups between 1.5 and 3.5 years old. The cost of production in the groups over 3.5 years old was higher than that of the other groups. These results are in accordance with the findings of Russel (15). Table 13 and Graph V summarize these results.

The differences in cost of production between the different groups is not statistically significant. In correlating the age of the sows with the number of pigs born an insignificant negative correlation of -.0090 was obtained. A significant negative correlation of -.2688 was found between the age of the sows and the number of pigs weaned. From these correlations one may conclude that the age of the sows does not have a great influence on the number of pigs born. Old sows are not so efficient mothers as sows younger than 5.5 years of age.

A comparison between the litter sizes at birth in the different age groups shows that no significant differences exist between the number of pigs born.

TABLE 13.

Age of the sow as a factor in the cost of producing weanling pigs.

Age of sows in years at farrowing time	No. of litters	Average cost in lb. of grain to produce a lb. of gain	Standard deviation	Standard error of the means
1 -1.5	34	3.45	.764 ± .132	.189
1.5-2	30	3.56	.762 ± .142	.306
2 -2.5	24	3.67	1.33 ± .277	.319
2.5-3	20	3.30	.595 ± .136	.252
3 -3.5	24	4.04	1.05 ± .218	.246
3.5-4	12	3.78	.418 ± .125	.245
4 -4.5	14	4.05	.801 ± .217	.365
4.5 & over	10	4.75	.936 ± .293	.332

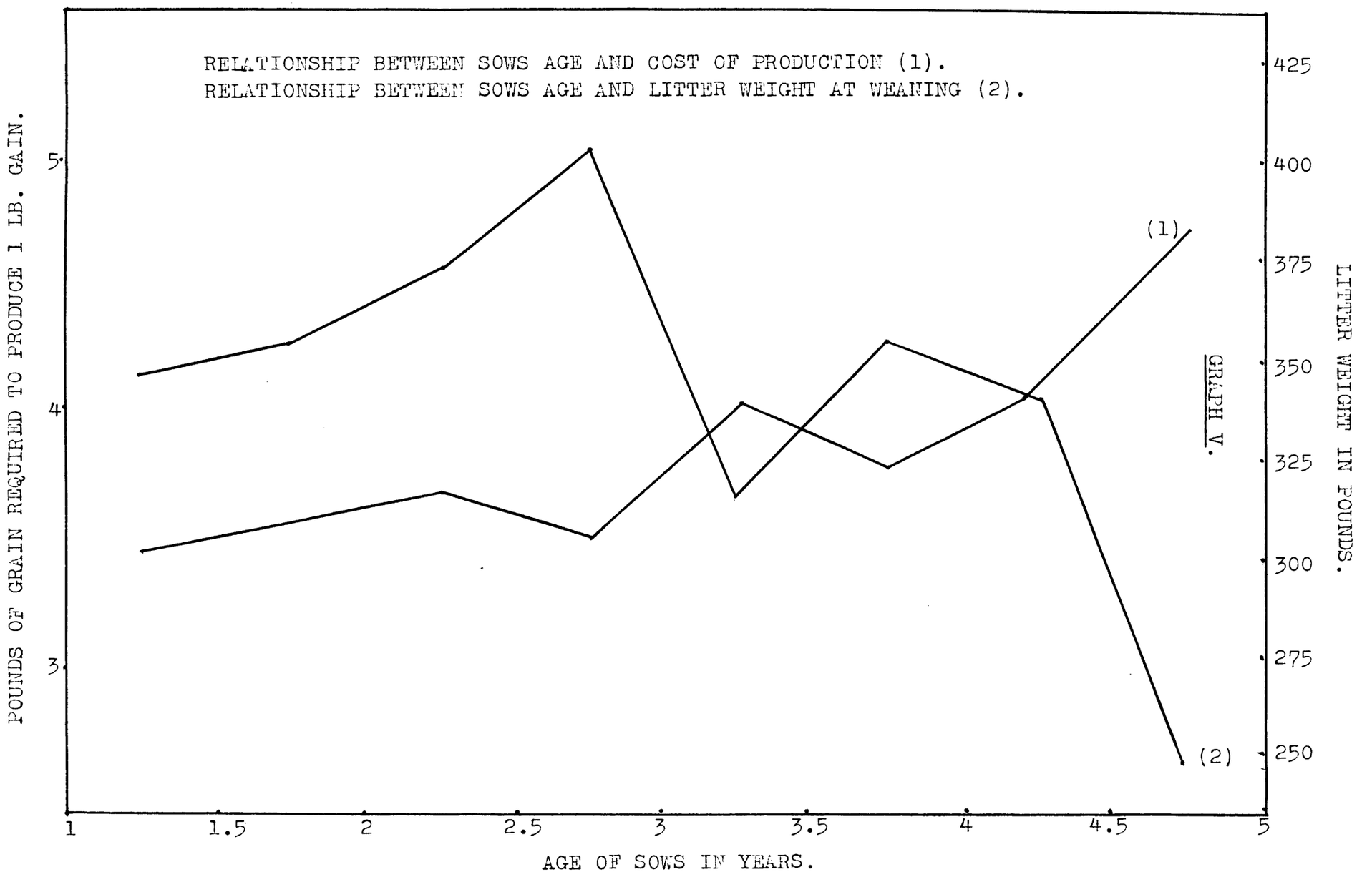
Averages for the groups under 3.5 years and the groups over 3.5 years of age.

Age group				
1 - 3.5	132	3.61	.948 ± .0082	.58
Over 3.5	36	4.13	1.00 ± .0277	

The litter sizes increased after the second year and decreased after the third year. The sow usually reached her optimum fertility during the third year. These results agree with results obtained by other workers.

Sinclair and Syrotuch (16) reported that "The nearest approach to perfect maternal instinct is to be found in the case of the three-year-old sow raising on an average a fourth litter.

Table 14 and Graph VI summarize these results.



GRAPH V.

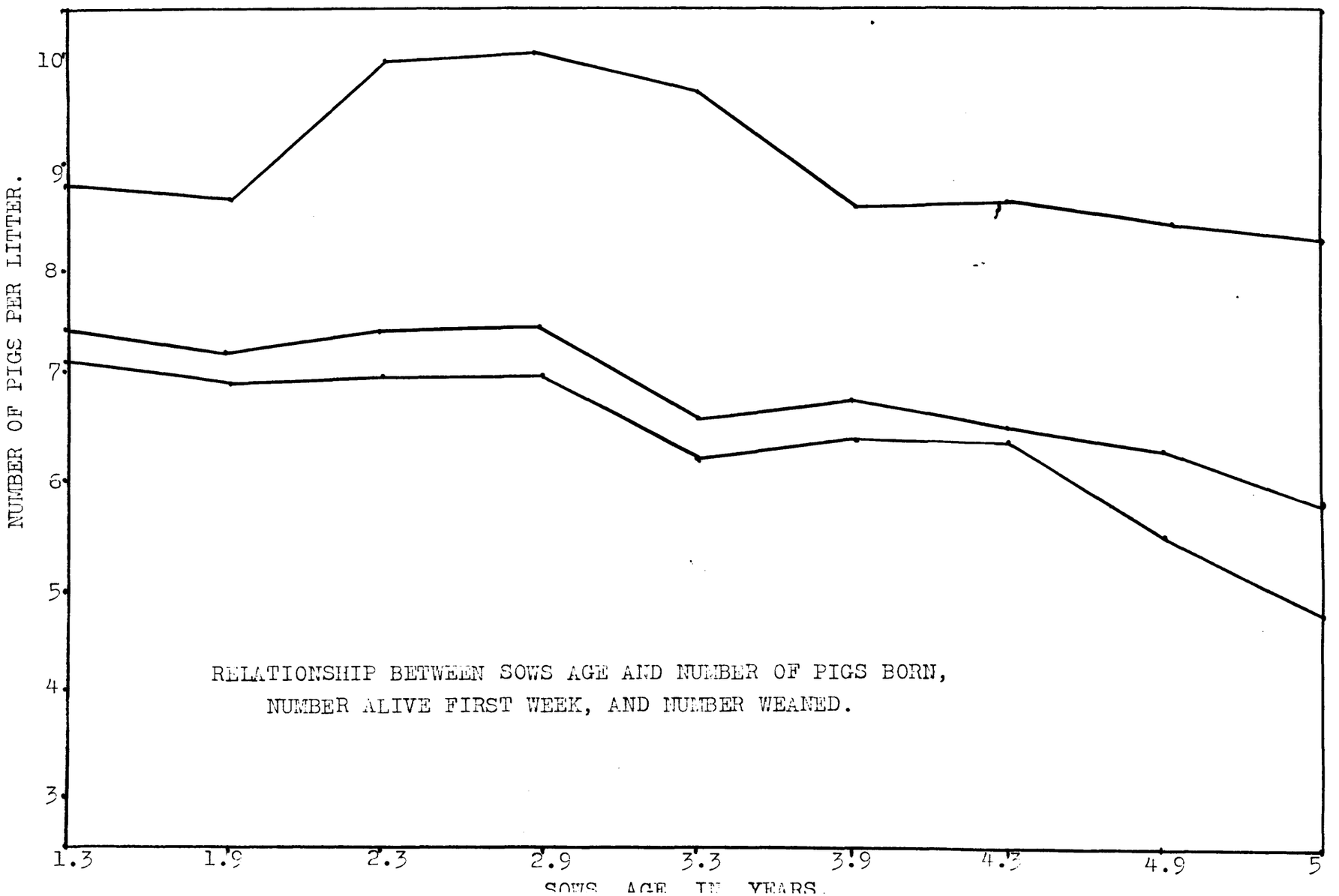
TABLE 14.

Relationship between sow's age and number of pigs born.

Age group in years	No. of litters	No. of pigs born	Standard deviation	Standard error of the means
1 - 1.5	34	8.82	2.801 ± .480	.654
1.5- 2	30	8.66	2.426 ± .445	.699
2 - 2.5	24	10.01	2.652 ± .547	.756
2.5- 3	20	10.10	2.360 ± .527	.825
3 - 3.5	24	9.70	3.100 ± .639	1.125
3.5- 4	12	8.60	3.225 ± .932	1.139
4 - 4.5	14	8.70	2.455 ± .656	1.340
Over 4.5	10	8.30	3.713 ± 1.175	1.340

In comparing the litter sizes at weaning time in the different age groups, it was found that the number of pigs weaned by the sows older than 3.5 years was smaller than by the sows under 3.5 years. The difference in litter size at weaning time between the group of sows under 3.5 years and the goup over 3.5 years is highly significant. This data is summarized in Table 15.

Sows, therefore, appear to decrease in maternal efficiency after they have reached an age of 3.5 years. The litters weaned in the groups younger than 3.5 years are heavier than those from sows older than 3.5 years. The individual weights of the pigs varied little from litter to litter. The pigs weaned by the old sows were usually a bit heavier because they were from smaller litters. These results indicate that the period of optimum production in the life of a sow is from the age of two to three and one half years. There is a sharp increase in cost of production after the fourth year. Therefore in trying to produce weanling pigs most economically, the hog raiser should keep



GRAPH VI.

RELATIONSHIP BETWEEN SOWS AGE AND NUMBER OF PIGS BORN, NUMBER ALIVE FIRST WEEK, AND NUMBER WEANED.

the best brood sows until they are four years old. After that age they should be disposed of unless they are phenomenal producers. If the productive sows are disposed of at a younger age than four years the average herd age will fall below the age of optimum production and thus the cost of producing weanling pigs will rise.

TABLE 15.

Relationship between the sows age and the number of pigs weaned per litter.

Age of sows in years	No. of litters	No. of pigs weaned	Standard deviation	Standard error of the means
1 - 1.5	34	7.1	2.13 ± .365	.47
1.5- 2	30	6.9	2.20 ± .403	.63
2 - 2.5	24	7.0	2.38 ± .486	.69
2.5- 3	20	7.05	2.16 ± .485	.62
3 - 3.5	24	6.2	1.91 ± .390	.68
3.5- 4	12	6.4	1.96 ± .566	.76
4 -4.5	14	6.4	1.91 ± .510	.81
Over 4.5	10	4.7	2.00 ± .636	

TABLE 15A.

The relationship between the average number of pigs weaned per litter between the group of sows under 3.5 years and the group over 3.5 years old.

Age group	No. of litters	No. of pigs weaned p.litter	Standard deviation	Std. error of the means	"t" value	"t" value required for significant odds
1 - 3.5	108	6.871	2.15 ± .206	.39	2.39	1.974
Over 3.5	60	5.940	2.10 ± .271			

It also seems probable that the age farrowing is more important than the farrow number. In managing a swine herd, every effort should be made to get as many litters as possible during the period when the sows are from one and one-half to three years old, the period during which their maternal efficiency is at its optimum. Up to about three and a half years increasing age tends to give larger litters. The older age also permits the culling of sows with inferior fertility and maternal characteristics.

F. The Influence of the Farrow Number on the Cost of Production of Weaning Pigs.

The present investigation tends to show that farrowing efficiency of sows increases up to the fourth farrowing and decreases rapidly after that. This is not quite in agreement with the findings of Johansson ( ) who found that the farrowing efficiency decreased after the sixth farrowing. The reason for this discrepancy may be due to the fact that in this study the sows at the fourth farrowing were on the average as old as Johansson's sows at the sixth farrowing. In this study pigs were weaned at 12 weeks, a circumstance which makes it rather difficult to get two litters from a sow during a year. Statistical analysis of the data show that the number of pigs farrowed in litters of the first four farrowings was highly significantly larger than in later litters. The number of pigs weaned per litter in the first four farrowings was also highly significantly greater during the first four farrowings than in the later farrowings. Table 16 and Graph VII summarise these results.

The average weight per pig weaned in the different farrowings did not differ significantly. The pigs weaned in the later litters were slightly heavier than the ones from the earlier farrowings. These results are statistically insignificant.

TABLE 16.

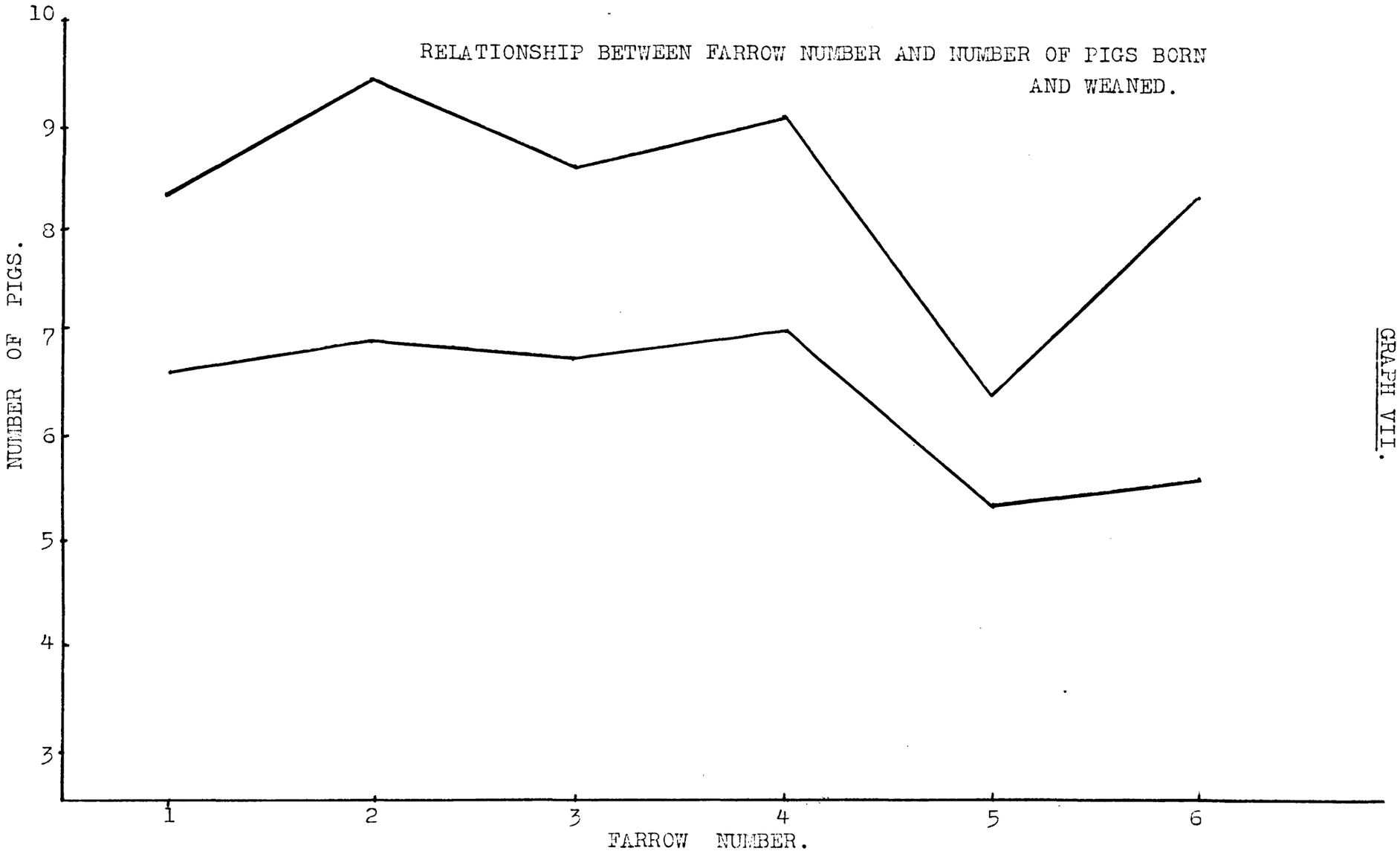
Number of pigs born and weaned in succeding farrowings of the same sow.

Farrow number	No. of litters	Av. No. of pigs born per litter	Standard deviation	Standard error of the means	Av. No. weaned per litter	Standard deviation	Standard error of the means
1st	50	8.34	1.88 ± .265	.99	6.62	2.21 ± .312	1.100
2nd	38	9.44	3.28 ± .532	.77	6.86	3.10 ± .503	.665
3rd	30	8.57	3.02 ± .551	.95	6.70	2.29 ± .417	.404
4th	17	9.05	3.19 ± .774	.98	7.00	1.96 ± .475	.635
5th	8	6.37	3.12 ± 1.11	.85	5.35	1.90 ± .671	1.170
6th	5	8.30	.57 ± .330		5.60	2.30 ± 1.33	

TABLE 16A.

Average for first four farrowings and farrowings after the fourth.

Farrow number	No. of litters	Av. No. of pigs born per litter	Standard deviation	Standard error of the means	Av. No. weaned per litter	Standard deviation	Standard error of the means
1-4	135	8.79	2.77 ± .239	.58	6.76	2.46 ± .213	.613
4-5	11	6.90	1.75 ± .527		5.36	1.91 ± .575	



GRAPH VII.

TABLE 17.

Average weaning weight of individual pigs from succeeding farrowings.

Farrow number	No. of litters	No. of pigs weaned	Av. wt. per weanling pig (lb)	Standard deviations	Standard error of the means
1	50	331	51.89	8.66 ± 1.23	1.83
2	38	261	51.30	8.42 ± 1.37	3.20
3	30	201	49.99	15.8 ± 2.88	3.40
4	17	119	51.30	7.20 ± 1.74	4.80
5	8	42	59.40	12.5 ± 4.41	6.70
6	3	17	52.30	4.15 ± 2.39	

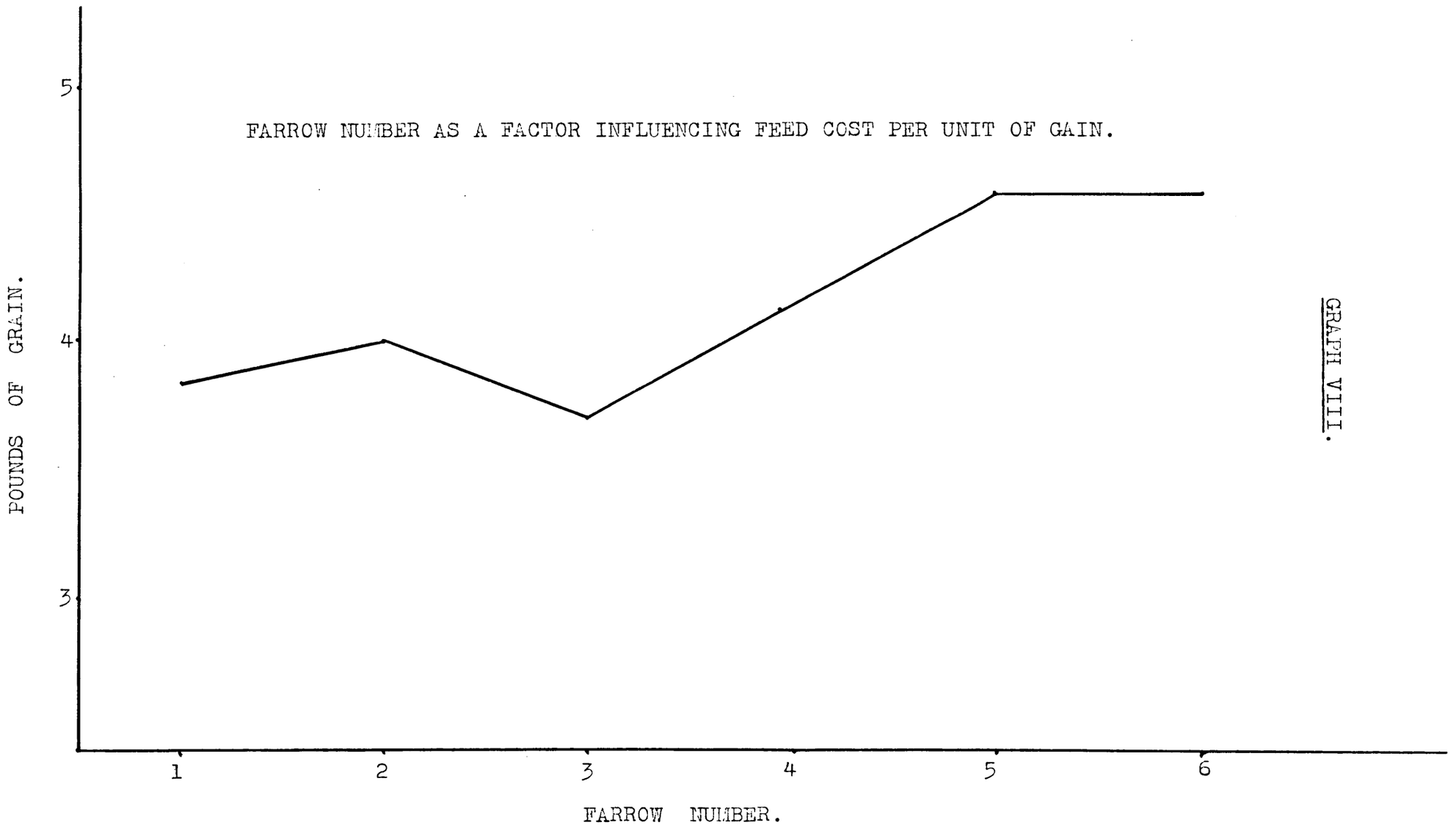
The average cost of production varied slightly between the groups of the first four farrowings. There was a sharp increase in the cost of production after the fourth farrowing. The lowest cost of production was found in the third farrowing group.

TABLE 18.

Variation in the cost of producing a pound of gain in the weanling pigs from succeeding farrowings.

Farrow number	Av. cost in lb. grain to produce 1 lb. of gain	Standard deviation	Standard error of the means
1	3.86	.99 ± .141	.203
2	3.98	.91 ± .148	.269
3	3.70	1.2 ± .218	.386
4	4.15	1.3 ± .315	.451
5	4.58	.92 ± .325	.583
6	4.57	1.2 ± .693	

FARROW NUMBER AS A FACTOR INFLUENCING FEED COST PER UNIT OF GAIN.



GRAFH VIII.

The differences are not statistically significant. By combining the results obtained from the influence of age and farrow number on the cost of production we may conclude that sows farrowing their second, third, and fourth litters at an age of from 2 to 3.5 years old are the most economical producers of weanling pigs.

G. Influence of the Weight of Sows on the Cost of Production of Weanling Pigs.

In selecting sows for breeding and production purposes the hog raiser is often confronted by the question whether to select heavy or light sows for the economic production of pigs.

In correlating the weight of sows with the number of pigs weaned a highly significant negative correlation of -.4713 was obtained. From this we may conclude that the heavier sows wean fewer pigs than the lighter sows. The correlation coefficient between the weight of sows up to 450 pounds and the number of pigs born is insignificant, being .0018. The correlation coefficient between the weight of sows and the number of pigs born is an insignificant negative correlation of -.0041. From these correlation coefficients we can conclude that the weight of the sows does not influence the number of pigs born per litter, but that it does have a direct bearing on the number of pigs weaned. The highly significant negative correlation between the weight of the sows and the number of pigs weaned indicates that as the weight of the sows increases beyond the optimum point there is a corresponding decrease in the number of pigs weaned per litter, that is, the natural efficiency decreases. In studying the data it was found that sows between 330 and 450 pounds in weight not only produced the largest litters but also weaned the largest litters.

Table 19 summarizes these results.

From these data we can conclude that there is no significant difference between the number of pigs born in the different weight classes. There is, however, a significant difference between the numbers of pigs weaned, the difference between the 400 to 450 pound class and the 450 to 500 pound class being highly significant.

TABLE 19.

Relationship between weight of sows and the number of pigs born and weaned per litter

Weight group (lb.)	No. of litters	Av. No. born per litter	Standard deviation	Standard error of the means	Av. No. weaned	Standard deviation	Standard error of the means
250-300	12	9.30	2.18 ± .630	.790	7.00	2.16 ± .624	.775
300-350	26	8.30	2.59 ± .508	.649	6.38	2.53 ± .497	.570
350-400	36	9.80	2.43 ± .405	.527	7.05	1.36 ± .226	.397
400-450	64	9.25	2.71 ± .339	.761	7.00	2.25 ± .280	.542
450-500	19	9.16	2.97 ± .681	1.125	5.88	2.02 ± .464	.695
Over 500	14	7.86	3.54 ± .893		5.07	1.944 ± .518	

The average number of pigs weaned in the groups weighing under 450 pounds is 6.90 with a standard deviation of 2.09 ± .178. That for the groups over 450 pounds in weight is 5.50 with a standard deviation of .90 ± .156. The standard error of the means is .237, giving a very highly significant "t" value of 5.90.

From the data we find that in the heavy groups of sows a high mortality of pigs occurred during the first week of suckling. The heavy sows were clumsy and overlaid more pigs than the lighter sows. The litter weights of pigs at weaning time increased until the sows reached the weight of 400 pounds, then there was a slight decline in litter weight at weaning time in the 400-450 class. But after the sows reached a weight of 450 pounds there was a very rapid decrease in weight of the litters at weaning time. These data are summarized in Table 20 and Graph VIII.

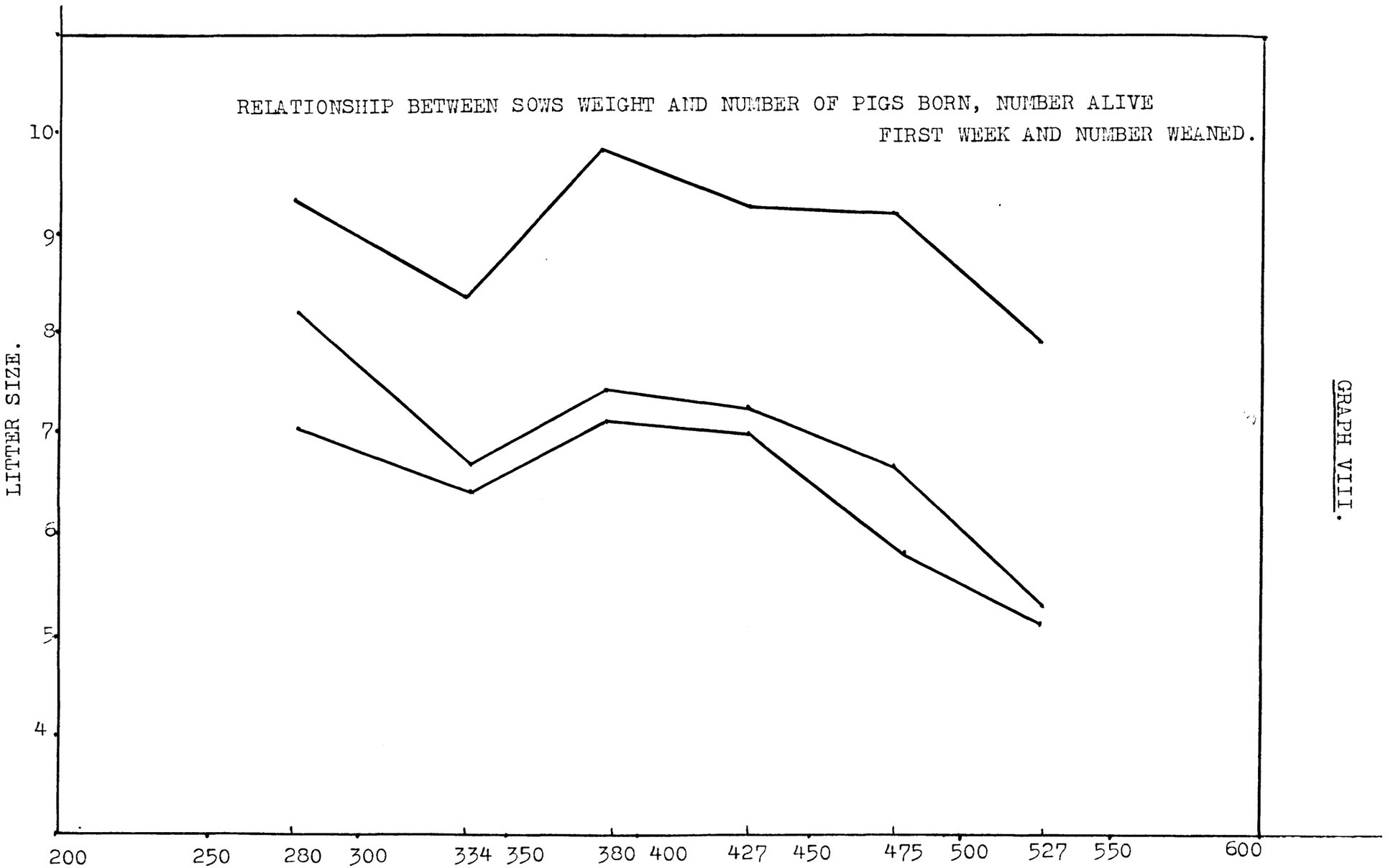
Sows weighing between 380-400 pounds produce gains most economically in the suckling pigs. The cost of production rises rapidly after the sows reach a weight of 450 pounds. From a producer's point of view there would be no point in keeping sows weighing over 450 pounds for production purposes. The maintenance requirements of such sows is high and their milk producting efficiency and capacity for motherhood declines.

TABLE 20.

The average number of pigs born, alive at the end of the first week and weaned per litter in the different weight classes.

Weight class	Number born	No.alive at end of first week	Number weaned	Percent-age alive first week	Percent-age weaned
250 - 300	9.30	8.16	7.00	87.7	75.2
300 - 350	8.30	6.61	6.38	79.9	76.8
350 - 400	9.80	7.38	7.05	75.3	71.7
400 - 450	9.25	7.25	7.00	78.3	75.6
450 - 500	9.16	6.68	5.89	72.9	64.3
Over 500	7.86	5.21	5.07	68.2	64.3

Table 21 and Graph IX clearly show that the maximum efficiency in production of weanling pigs is obtained in sows between 350 and 450 pounds in weight.



GRAPH VIII.

TABLE 21.

Relationship between weight of sows and weight of litter at weaning time and cost of production in pounds of grain to produce one pound gain in liveweight.

Sow's weight group (lb.)	No. of litters	Weight weaned per litter	Standard deviation	Standard error of the means	Av. cost in lb.of grain to produce 1 lb. gain	Standard deviation	Standard error of the means
250 - 300	12	314.16	53.6± 14.88	27.7	3.90	.602± .175	.276
300 - 350	26	314.50	119.7± 23.5	28.2	3.66	1.09± .214	.230
350 - 400	36	379.00	93.4± 15.6	21.2	3.43	.506± .072	.156
400 - 450	64	365.00	114.8± 14.35	25.9	3.75	1.06± .132	.238
450 - 500	19	318.00	94.0± 21.6	32.9	3.92	.866± .199	.290
Over 500	14	302.00	93.2± 24.4		4.22	.794± .213	

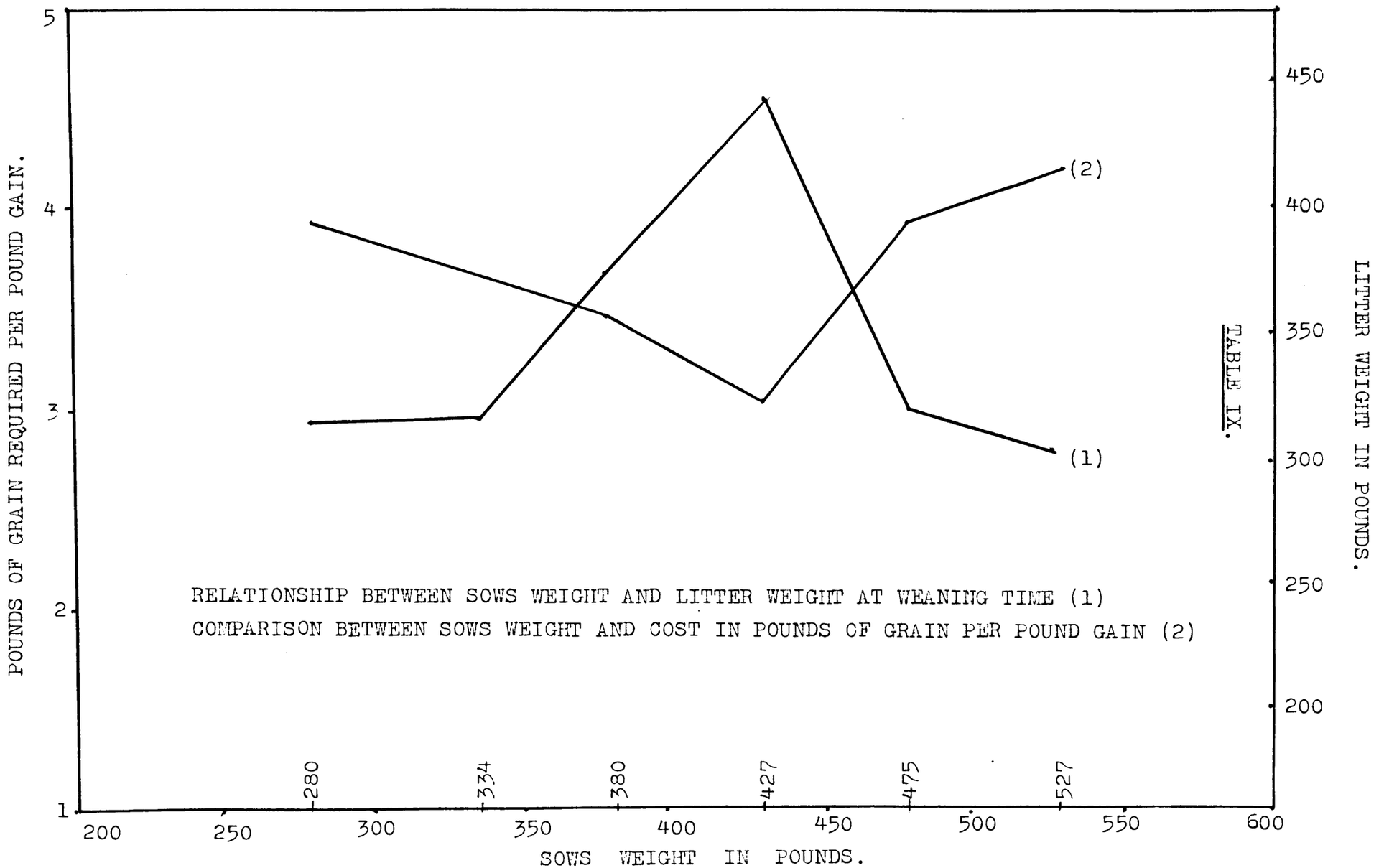


TABLE IX.

RELATIONSHIP BETWEEN SOWS WEIGHT AND LITTER WEIGHT AT WEANING TIME (1)
COMPARISON BETWEEN SOWS WEIGHT AND COST IN POUNDS OF GRAIN PER POUND GAIN (2)

H. The Influence of Change in Weight of Sows during the Lactation Period on the Food Cost to Produce Weanling Pigs.

In the earlier experiments conducted at the Pretoria University Experimental Farm, the attempt was made to keep the lactating sows at a constant weight. Thus in reality the sows with small litters were not full fed during the lactation period.

Good sows "milk down" and the more feed given them (within limits) while they are lactating, the more milk they can produce. The milk production of some of the sows kept at constant weight was therefore reduced. The reduced milk flow could have no other influence than slower gains and increased mortality in the suckling pigs. The sows kept at a constant weight and the sows gaining more than 25 pounds in weight weaned the lowest percentage of pigs. There is a significant difference between the number of pigs weaned in the group that gained less than 25 pounds and the constant group; and also between the groups that lost weight and the constant group. Table 22 summarizes these results.

No statistically significant difference was found between the number of pigs born in different groups (Table 22A). The sows losing the most weight produced the heaviest litters at weaning time. This is to be expected, since the large litters suckle the sows "down". The sows that gained most weight and the sows that remained constant in weight produced the lightest litters at weaning time. Table 23 and Graph X summarize these results.

In correlating the change in the weight of sows with the litter weight at weaning time a significant negative correlation of -.2697 was found. From this correlation coefficient we may conclude that sows that

TABLE 22.

Relationship between 1) the change in the weight of the sows and 2) the number of pigs born, alive at the end of first week, and number weaned.

Change in weight groups	No. of litters	No. of pigs born per litter	No. alive at end of first week	No. of pigs weaned	Percentage alive at end of first week	Percentage weaned
Lost 25+ lb.	26	10.1	8.0	7.6	78.7	74.9
Lost 25- lb.	29	9.4	7.5	7.4	79.1	78.1
Constant	36	8.5	6.4	5.9	75.0	69.1
Gained -25	43	9.2	6.9	6.6	76.0	71.7
Gained +25	57	9.1	6.7	6.3	74.3	69.8

TABLE 22A.

Change in sow's weight	No. of litters	Av. No. born per litter	Standard deviation	Standard error of the means	No. weaned per litter	Standard deviation	Standard error of the means	"t" required for significant odds
-25+	26	10.1	3.11± .611	.749	7.6	2.21± .434	.585	2.008
-25-	29	9.4	2.33± .433	.633	7.4	2.10± .390	.516	2.000
0	36	8.5	2.93± .488	.622	5.9	2.01± .335	.441	1.990
+25-	43	9.2	2.52± .384	.612	6.6	1.86± .284	.481	1.990
+25+	37	9.1	2.89± .475		6.3	2.35± .386		

gained weight during the lactation period weaned the lightest litters.

In comparing the cost of producing gains in weight in the weanling pigs from the different groups the results indicate that the sows which lost weight produced the gains more economically than sows that kept a constant weight or those that gained weight. The sows that gained weight were less productive and their smaller litters were unable to suckle them down.

There are several reasons why the "constant" group produced gains at high cost. In the first place, the sows were not full fed. As a result the weanling pigs were also not full fed. Full-fed pigs usually make faster and more economical gains than pigs that are not on full feed. These results agree with the findings of Ferrin ( ) from Minnesota Agricultural Experiment Station. He found that full-fed pigs consumed less feed for 100 lb. of gain from birth to marketing time than pigs on a limited ration.

The sows that remained at a constant weight when full-fed were old and heavy sows having litters so small that they were unable to suckle the sows down. These old, heavy sows were the most uneconomical producers of weanling pigs. They required high maintenance rations and made no gains in liveweight.

Table 24 summarizes these results in the cost of production. The differences in the cost of production are not statistically significant.

We may draw several conclusions from these results:-

1. It does not pay to keep a brood sow on a limited ration, gains are made more slowly and at a higher cost in the weanling pigs.

2. Old and unproductive sows remain at a constant weight or gain weight during the suckling period. The weanling pigs from these sows require more feed to produce a pound of gain.

TABLE 23.

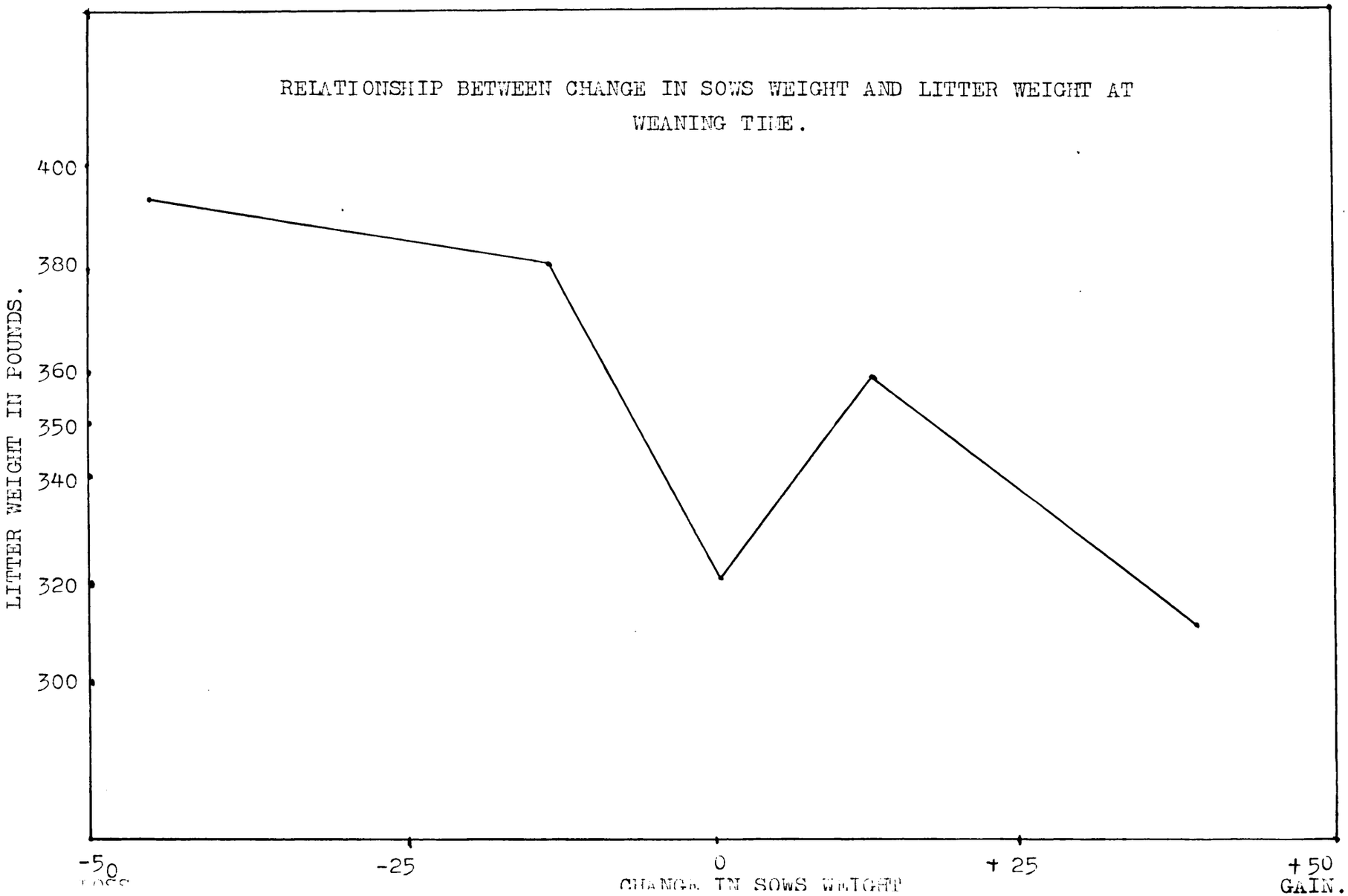
Relationship between change in weight of sows during the lactation period and litter weight at weaning time.

Change in weight of sows group	No. of litters	Average weight of litters	Standard deviation	Standard error of the means	"t" value	"t" value required for significant odds	Av. individual weight of pigs at weaning
-25+	26	392.95	122.5± .240	30.5	.38	2.008	51.6
-25-	29	381.27	101.4± 18.25	28.8	2.11	2.000	51.8
0	36	320.41	131.4± 21.90	26.4	1.47	1.990	54.6
+25-	43	359.21	97.8± 14.95	24.0	2.01	1.990	54.0
+25+	37	310.90	114.7± 18.87				49.1

TABLE 24.

Relationship between change in weight of sows and the average cost to produce a pound of gain in liveweight in the suckling pigs.

Change in weight of sows groups	No. of litters	Average cost of production	Standard error of the means	"t" value	"t" value required for significant odds
-25+	26	3.29			
-25-	29	3.49	.188	1.07	2.008
0	36	3.99	.262	1.91	2.000
+25-	43	3.69	.175	1.72	1.990
+25+	37	4.08	.239	1.63	1.990



GRAPH X.

I. The Relative Economy of Producing Gains in Liveweight in Crossbred and Purebred Pigs.

It is generally considered that crossbred pigs make more rapid and more economical gains than purebreds. In this study 41 purebred litters and 36 crossbred litters farrowed during the same period of time were compared to determine the differences in feed requirements to produce a pound of gain. (The crossbred litters were evenly distributed among the family groups so that they would not complicate the family study. Only purebred sows were kept for breeding purposes in the family group).

In comparing the litter sizes at birth at the end of the first week and at weaning time it was found that the crossbred litters were slightly larger at all times than the purebred litters. These results agree with those of Ferrin of the Minnesota Agricultural Experiment Station. He found that at weaning time crossbred litters averaged from a third to two pigs larger than purebred litters. In this study the crossbred litters averaged .66 pigs larger at weaning time. Statistically these differences are not significant. (See Table 25).

At weaning time the litter weight of the two groups was exactly the same. When the individual weights of the weanling pigs were compared, the purebred pigs averaged 5.4 pounds heavier than the crossbreds. This difference is statistically highly significant.

TABLE 25.

The average litter size at birth, at the end of the first week, and at weaning of the two groups.

Group	No. of litters	Av. No. born	Standard deviation	Standard error of the means	Av. No. alive first week	Standard deviation	Standard error of the means	Av. No. weaned	Standard deviation	S.E. of the means
Pure-breds	41	8.69	2.43± .379	.589	7.01	2.08±.325	.502	6.5	1.96±.306	.476
Cross-breds	36	9.80	2.69± .448		7.70	2.30±.383		7.2	2.18±.363	

TABLE 26.

The relationship between the two groups in litter weight and the individual weights of the pigs at weaning time.

Group	No. of litters	Litter weight at weaning time (lb)	Av. individual wt. at weaning time	Standard deviation	Standard error of the means	"t" value
Pure-breds	41	367	36.6	9.55± 1.46	1.768	3.054
Cross-breds	36	367	51.2	5.97± .995		

These results are contrary to expectations. One would think that because of hybrid vigour the crossbred pigs would be heavier at weaning time than the purebreds. In comparing the feed requirements to produce a pound of gain in the suckling pigs the crossbreds are slightly more economical than the purebreds. The difference in the amount of feed required to produce a pound of gain is, however, not statistically significant.

TABLE 27.

The average cost in pounds of grain to produce a pound of gain in the suckling pigs in the two groups.

Group	No. of litters	No. of pigs weaned	Average cost to produce a pound of gain	Standard deviation	Standard error of the means
Pure-breds	41	266	3.35	1.25± .195	.79
Cross-breds	36	238	3.46	.888± .148	

From these results we observe that it may be advisable under certain conditions to breed crossbred hogs. The litters are slightly larger and the pigs make slightly more economical gains.

J. Trend in the Feed Cost of Producing Gains in the Suckling Pigs during the Progress of the Experiment.

Time plays an important rôle in the successful production of hogs. If the pig breeder selects for increased fertility and maternal ability in his brood sows he may in the course of time increase the litter size, both at birth and at weaning time. Improvement will, however, be very slow. By selecting for fertility alone one might be able to increase the litter size by ½ a pig in 10 years (32). Selection based on two or more characteristics will be even much slower.

If the hog plant becomes infected with worms or other parasites the cost of producing weanling pigs may rise. In studying the cost of producing a unit of gain in weanling pigs in 171 litters during the ten-year period 1925-1934, no significant difference was found between the costs of one year and the next year. There were fluctuations in cost of production from year to year, there being an indication that the cost of production decreased during the last five years. There were no statistically significant differences between litter sizes at birth and at weaning time from year to year. The percentage of pigs weaned per litter during the last four years was slightly higher than the previous years, but in this respect there is also considerable fluctuation from year to year. Table 28 summarizes these results.

In grouping the first five years together (1925-1929) and the last five years (1929-1934) and comparing the averages, several interesting facts are brought out. During this period of time the average litter size at birth increased by .10 of a pig and by .15 a pig at weaning time.

TABLE 28.

Yearly fluctuations in the number of pigs born and weaned per litter and cost of production.

Year	Number of litters	No. of pigs born	No. of pigs weaned	Percentage weaned	Average litter size at birth	Average litter size at weaning	Average cost in pounds of grain to produce 1 lb..of gain.
1925	10	94	66	70.2	9.4	6.6	3.48
1926	23	209	145	69.3	9.1	6.3	3.95
1927	18	169	127	75.2	9.4	7.1	3.86
1928	23	227	167	73.5	9.9	7.3	4.13
1929	17	133	94	70.7	7.8	5.5	4.18
1930	13	132	85	64.4	10.2	6.5	3.67
1931	22	194	136	71.1	8.8	6.3	3.54
1932	20	194	151	77.8	9.7	7.6	3.36
1933	18	153	116	75.8	8.5	7.0	3.66
1934	7	66	49	74.3	9.4	7.0	3.07
TOTALS	171	1571	1168				

This is approximately the rate of improvement to be expected when selection is based on several factors. These results are not statistically significant. It seems possible that the selection that took place during the period of time was more successful in improving the motherly qualities of the sows than their fertility. This would be expected because some selection for maternal qualities can take place before the sows farrow. Table 29 summarizes these results.

In comparing the average amount of grain concentrates required to produce a unit of gain in liveweight of the weanling pigs it was found that during the last five years .47 pounds less grain was required to produce a pound of gain. This difference is statistically very highly significant. The Table 30 summarizes these findings.

Increased litter size cannot satisfactorily explain this difference in cost of production. In comparing the weaning weight of the pigs, it was found that the weanling pigs during the last five years weighed on an average 4.37 pounds heavier at weaning time than the pigs during the first five years. This difference is statistically highly significant. Table 31 summarizes these results. They substantiate the assumption made earlier in this study that the selection for increased maternal efficiency attributed to this decrease in cost of producing gains in the suckling pigs.

A point of special interest in the study of the data during the period of years is that the poor milking strains, the Cape and the Cornette, were gradually eliminated from the herd. This decrease in the cost of production may be attributed to selection for fertility and productivity of the sows and perhaps to a small extent to improved herd management.

TABLE 29.

Comparison between the average number of pigs born and weaned during the periods 1925-1929 and 1929-1934.

Years	No. of litters	No.of pigs born	No.of pigs weaned	Percentage weaned	Av. No. weaned per litter	Standard deviation	Standard error of the means	Av.No. weaned	Standard deviation	Standard error of the means
1925-29	91	832	599	72.00	9.14	2.91± .306	.422	6.58	2.22± .232	.331
1929-34	80	739	539	72.94	9.24	2.60± .290		6.73	2.11± .238	

TABLE 30.

Comparison of the cost of producing a pound of gain in the suckling pigs during the two five-year periods.

Five-year periods	No. of litters	Average cost in lb. grain to produce 1 lb. gain	Standard deviation.	Standard error of the means	"t" value	"t" value required for significant odds.
1925-1929	91	3.96	.528± .055	.0935	5.02	2.601
1929-1934	80	3.49	.676± .076			

TABLE 31.

Change in the weight of the individual at weaning time during the two five-year periods.

Five-year periods	No. of litters	Average weight of the weanling pigs	Standard deviation	Standard error of the means	"t" value	"t" value required for significant odds.
1925-1929	91	50.27	8.98± .942	1.425	3.066	2.581
1929-1934	80	54.64	9.57± 1.07			

K. Variations in Litter Size and Cost of Production during the different Months and Seasons.

Litters farrowed during the spring months, August, September and October, were larger than litters farrowed during other months. This fact can be explained on the basis that when bred during the late summer sows are in better condition and shed more ova. Breeding in late summer has the same effect as flushing the sows at other seasons.

The litters born during the spring months were larger both at birth and at weaning time than the other litters. The average litter weight was higher and the individual weights of the pigs were heavier than that of litters farrowed during the other months. The cost of production based on pounds of grain required to produce a pound of gain was lower in the pigs born during the spring than in pigs born during any other period. Table 32 summarizes these results.

The pigs born during the spring months derive the full benefit from the young grass, which is high in protein value during the early summer. The sows in all probability also milk heavier when on young green pasture.

During the other months there was very little difference between the number of pigs born in litters. The data indicates that the litters born during November, December and January and in June and July are slightly smaller than other litters. Small litters would be expected during the first three months mentioned since sows bred during June, July and August will shed fewer ova because of the lack of green feed. From these results we may assume that sows shed fewer ova during the two hottest summer months, January and February, which results in smaller litters during June and July.

TABLE 32.

Monthly variations in the number of pigs farrowed and weaned, and in litter and individual weights of pigs in 171 Large Black litters.

Month	No. of litters	Av. No. born per litter	Av. No. weaned per litter	Percentage weaned	Av. litter weight at weaning	Individual weight at weaning	Av. cost in lb. of grain to produce 1 lb. gain
January	11	8.36	6.72	80.3	360.4	53.5	3.618
February	12	9.00	6.42	71.3	301.0	46.9	3.935
March	19	9.90	7.00	70.7	380.1	54.5	3.601
April	16	9.06	6.80	75.0	349.1	50.8	3.894
May	13	10.00	6.30	63.0	326.1	51.7	3.788
June	19	8.47	6.47	76.3	332.1	51.3	4.020
July	7	8.10	6.85	84.5	337.4	49.2	4.010
August	16	9.25	6.30	68.1	356.3	56.4	3.590
September	10	10.20	7.00	68.6	381.0	54.4	5.400
October	15	10.10	7.50	74.3	388.3	51.6	3.440
November	16	8.69	5.80	67.4	325.2	65.0	3.860
December	17	8.70	6.06	69.6	338.4	55.8	3.490
Averages	171	9.22	6.69	72.5	350.3	52.3	3.730

By studying the data obtained from the 171 Large Black litters, one is led to believe that the best time for breeding sows would be the months of March, April and May and again during October and November.

The monthly distribution of numbers of litters was too small to study the monthly variations in Duroc Jerseys.

A study of the seasonal variations in the numbers of pigs born, weaned and the cost of production, indicates that spring and autumn litters are larger both at birth and at weaning time than summer or winter litters.

The highest percentage of pigs was raised from spring litters, although the autumn litters did almost as well. Winter litters raised the lowest percentage of pigs. Table 33 and Graph XI give the average seasonal results.

The difference between the number of pigs born during spring and summer is on the borderline of being statistically significant. The difference between the number of pigs weaned between these two seasons is also statistically significant. All other seasonal variations are statistically insignificant.

The cost of production is lowest during the spring months and reaches the highest point during winter, especially during July. Table 34 and Graph XIV summarize these results. The differences between these groups are statistically insignificant. The Duroc Jerseys differed from the Large Blacks in the seasonal variations in the number of pigs born. The Durocs farrowed larger litters during the autumn. They weaned larger litters during the spring, and spring litters produced more economical gains in weights.

TABLE 33.

The average number of pigs born and weaned during the different seasons in 229 litters.

Season	No. of litters	Total No. Born	Total No. weaned	Percentage weaned	Av. No. born per litter	Standard deviation	S.E. of the means	Av. No. weaned	Standard deviation	Standard error of the means
Spring	53	504	364	72.2	9.5	2.25± .346	.52	6.86	2.62± .363	.45
Summer	58	493	348	70.5	8.5	3.0 ± .394	.52	6.00	2.10± .275	.37
Autumn	57	535	381	71.2	9.4	2.6 ± .344	.51	6.68	1.86± .282	.40
Winter	61	552	378	68.4	9.0	2.9 ± .371	.51	6.19	2.50± .320	.48

TABLE 34.

The average seasonal costs for all breeds (229 litters)

Season	No. of litters	Av. cost to produce 1 lb gain	Standard deviation	Standard error of the means	"t" value	"t" value required for significant odds
Spring	53	3.55	1.29± .177	.7	.285	1.984
Summer	58	3.75	1.27± .166	.7	.057	1.976
Autumn	57	3.79	.69± .092	.6	.500	1.979
Winter	61	4.096	1.98± .138	.5	.600	1.979

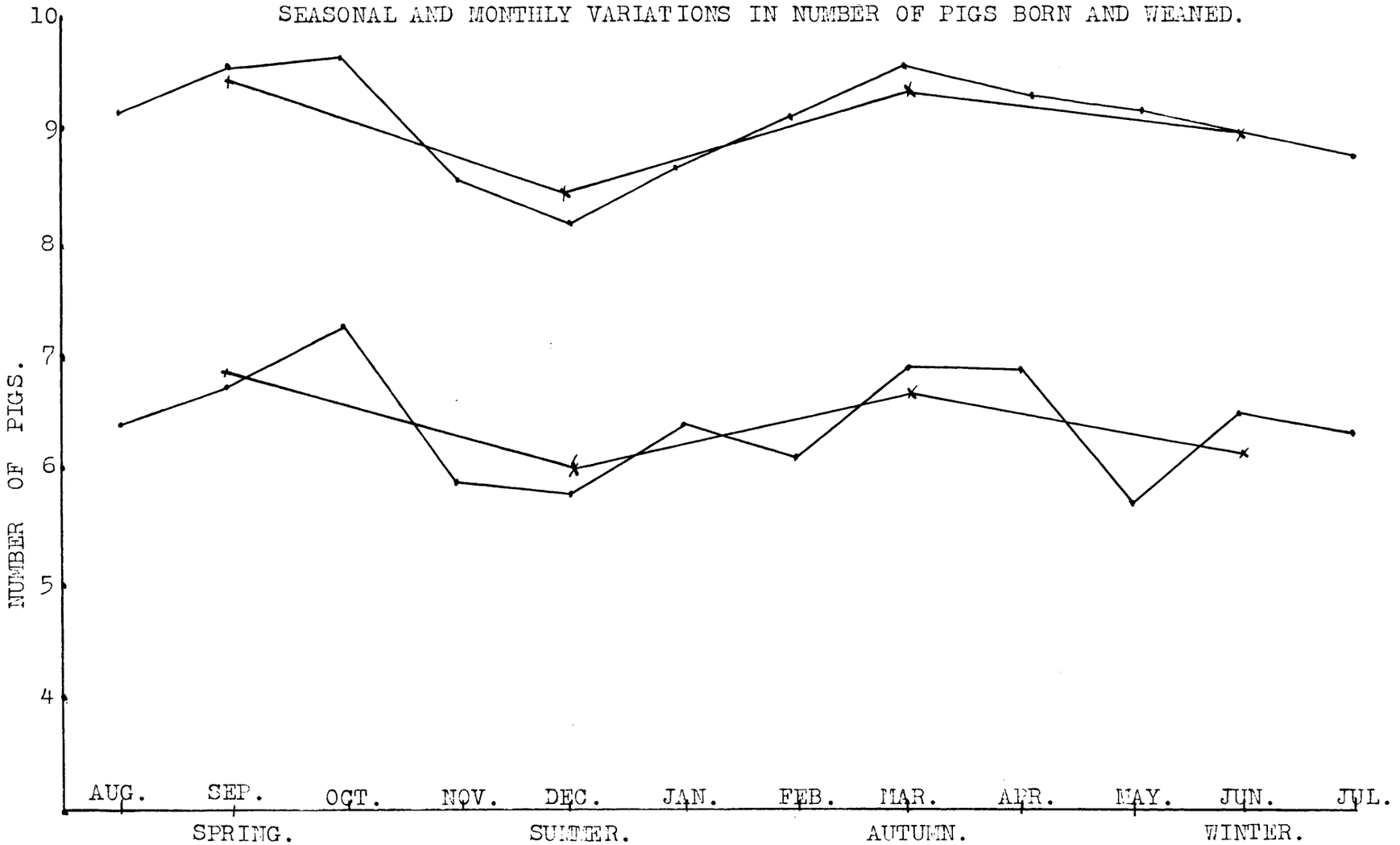
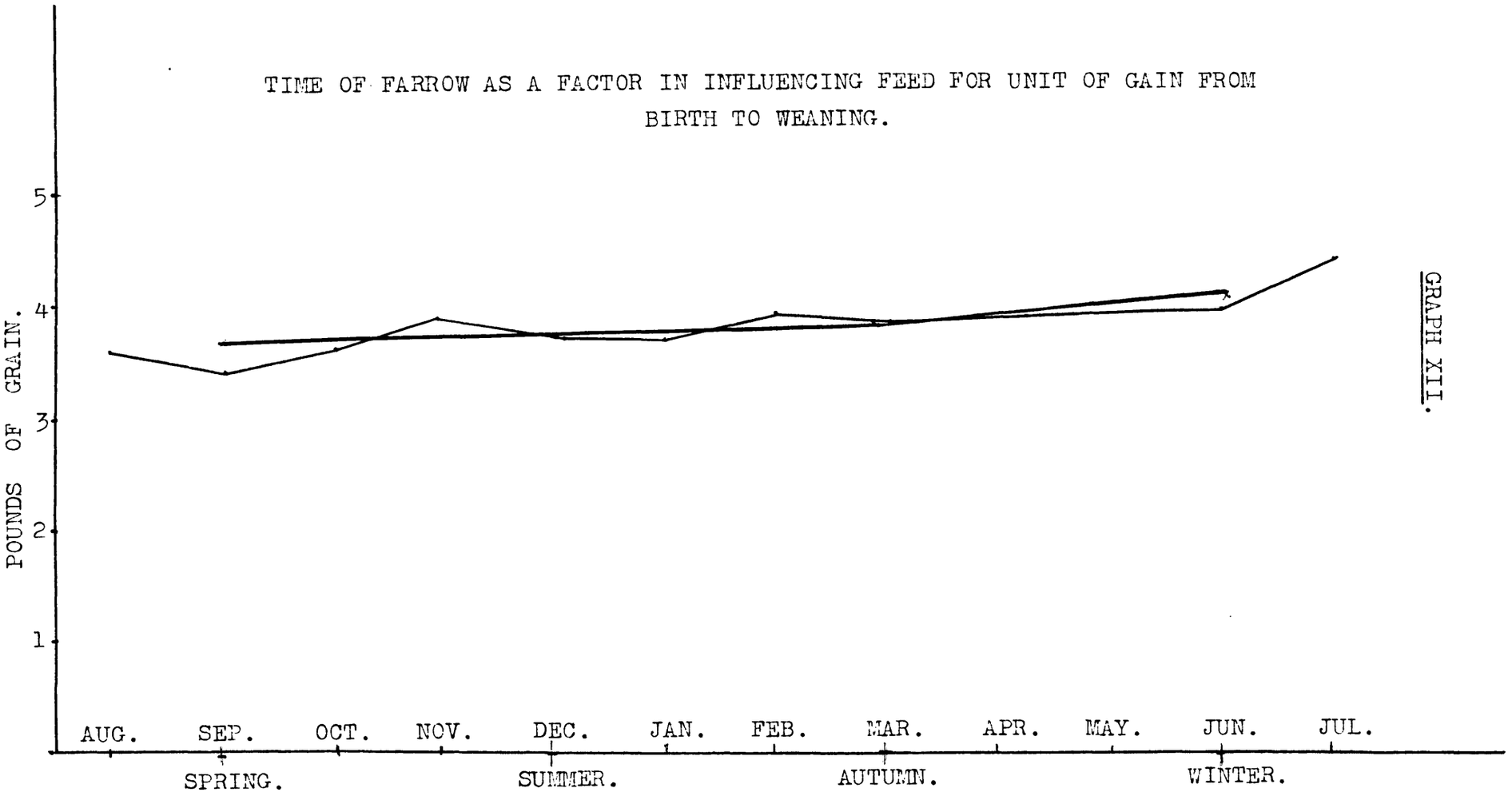


TABLE XI.

TIME OF FARROW AS A FACTOR IN INFLUENCING FEED FOR UNIT OF GAIN FROM BIRTH TO WEANING.



GRAPH XII.

In summarizing the results obtained from the 229 litters which were evenly distributed through the four seasons, we may conclude that spring litters are larger and make more profitable gains than litters farrowed during the other seasons.

The herd should be managed in such a way that as few sows as possible farrow during December and January, and June and July. It follows that the best time to breed the sows is during March, April and May and during October and November.

L. The Influence of Vermicides on the Cost of Gains made by Suckling Pigs.

Thirty-five litters received vermicides, Santonin, Chenopodium and Potassium Iodide as a preventative against worm infestation. Thirty-four litters received no treatment. In comparing the two groups in regard to litter weight at weaning time and cost of production no significant difference was found either in the cost of production or litter weight at weaning time.

The control pigs required slightly less food for a unit of gain in liveweight and the control litters also weighed 21 pounds on the average heavier than the pigs that received the vermidice. Table 35 summarizes these results.

The differences are not statistically significant.

From these results it would appear that there is no benefit in treating suckling pigs with vermicides unless the pigs are worm infected.

TABLE 35.

Comparison between groups that received vermicides and control groups.

Group	No. of litters	No. of pigs weaned	Av. litter weight at weaning	Standard deviation	S.E. of the means	Av. cost to produce 1 lb. gain in weight	Standard deviation	S.E of the mea
Vermicide	35	235	342	91.2± 15.4	24.63	4.02	.804 ± .137	.20
Control	34	235	363	112.0± 19.2		3.88	.866 ± .149	

M. The Efficiency of Rations in the Economy of Producing a Unit of Gain in the Liveweight of the Weanling Pigs.

Three rations were used at certain periods of time in an endeavour to determine which ration would be the most economical to use in the production of weanling pigs. As this study expresses the cost of production in the amount of gain concentrates required to produce a unit of gain, this comparison will determine which ration was most efficient in producing a unit of gain.

The three rations, each one of which was comparatively good, were made up as follows:

Series ration 2:

Maize oil cake	40%
Pollard	30%
Ground barley	20%
Meat meal	10%

This ration had a nutritive ratio of 1:3.14 and a starch equivalent of 74.70.

Series ration 4:

Maize oil cake	24%
Pollard	24%
Maize germ meal	24%
Ground barley	12%
Wheat bran	12%
Blood meal	3%
Bone meal	1%

This ration had a nutritive ration of 1:3.99 and a starch equivalent of 67.44.

Series ration 5:

Maize oil cake	32%
Pollard	32%
Maize bran	32%
Blood meal	2%
Bone meal	2%

This ration had a nutritive ratio of 1:5.26 and a starch equivalent of 67.10.

The analysis revealed no statistically significant differences in the amounts of feed required to produce a pound of gain in liveweight in the weanling pigs.

Ration 5 required somewhat more grain to produce a unit of gain, but the pigs on ration 5 were slightly heavier at weaning time than the pigs fed on the other rations. Apparently the weanling pigs could eat more of ration 5 during the same period of time than of the other rations.

It is obvious that all three rations were equally efficient in producing a unit of gain and that current prices of the ingredients making up these rations should determine which rations to use.

Only 80 litters could be used in determining these results, because only that number were fed on the three rations denoted as series 2, 4 and 5. Later litters were fed on a modification of 5. Previous workers (53) had determined which of these rations 2, 4 or 5, was most efficient for suckling pigs from an economic point of view. Table 36 summarizes these results.

Although ration 5 has the highest cost in terms of feed for gain, the pigs fed on ration 5 weighed more at weaning time than pigs fed on the other rations. Analysis of the data failed to reveal significant differences.

TABLE 36.

The efficiency of rations in the production of a unit of gain in the liveweight of suckling pigs.

Ration	No.of litters	Av.cost in lb. grain to produce 1 lb gain	Standard deviation	S.E. of the means	"t" value	Av. weight of weanling pigs	Standard deviation	S.E. of the means	"t" value	"t" value required for significant odds
2	20	3.95	.536± .120	.069	.202	51.5	8.37± 1.87	3.36	.092	2.03
4	13	3.94	.660± .185	.072	1.13	51.0	10.1± 2.80	2.32	1.771	1.99
5	57	4.03	1.02± .135	.057	1.40	55.1	9.88± 1.51	3.12	1.216	1.99

N. Minor Considerations in the Economic Production of Weanling Pigs.

(1) Stillborn pigs have an important influence on the economic production of weanling pigs, since the number of pigs born dead in a given herd may often vary from 5 to 15 per cent of the total number of pigs produced in a single farrow.

Why some of the young should die near the close of their foetal life is unknown. In this study, pigs which on examination were considered normally developed but which had died prior to birth were regarded as stillborn pigs. A highly significant positive correlation of .6787 was found between the number of pigs born and the number of still-births.

The highest percentage of still-births was found in the small litters. The lowest percentage was found in litters of average size having about 6, 7 or 8 pigs. If the percentage of still-births in the herd increases above 10 per cent, one should suspect either faulty feeding and management of the brood sows during the gestation period, or a lethal factor in the herd boar. The results obtained from this study agree favourably with those of other investigators, Table 37 summarizes the results obtained by other workers as well as the results of this study.

(2) Another factor which may influence the feed requirements of suckling pigs to produce a pound of gain is the use of the creep feeding system.

Creep feeding would, however, not have much influence on the economic production of pigs in this study because the brood sows with their litters were kept in large enough camps to enable the suckling pigs to have free access to feeding troughs without interference from the sows.

TABLE 37.

Percentage of still-births in different herds.

	McPhee & Zeller U.S.D.A.	Kuhlman South Dakota	Winters Minnesota	Kitchen East Anglian Records	Pretoria University
Pigs born alive	8991	1722	1535	1131	1395
Pigs still-born	497	142	125	73	99
Percentage alive	94.48	91.2	91.9	94	93.38
Percentage still-born	5.52	8.8	8.1	6.0	6.62

The rations used were also suitable for suckling pigs. Creep feeding would be advantageous in the economic production of pigs when the sows are heavy and old. By creep feeding the suckling pigs, the rations of the sows may be cut down to maintenance; they may even be fed on separate rations. Since creep feeding involves extra labour, this factor may counterbalance the gains made in the lowered feed costs.

It seems therefore that creep feeding would not make any difference in the cost of production of weanling pigs if the brood sows with litters are kept in large enough camps and an ample supply of feed is available for the pigs to consume at all times.

(3) Another factor which seemed to have some influence on the gains made was the use of hog wallows. During the course of this experiment a few litters were kept in camps where there were no facilities for wallowing. It was thought that the pigs in these camps made less efficient use of their feed than did the other pigs. Unfortunately no data were collected on this factor. It seems possible that the heat may have interfered with the amount of feed consumed by the pigs as well as with the metabolism of the feed consumed which might not have been the case if the pigs had had access to wallows.

SUMMARY.

(1) There exists a highly significant positive correlation of .9008 between litter size at birth and at weaning time.

(2) A highly significant negative correlation of -.492 was found between the cost of feed per unit of gain and litter size.

(3) There exists a real difference in the cost of production in litters where pigs died after the first week of suckling and litters in which no mortality occurred after the first week. The latter required less feed per unit of gain.

(4) The cost in pounds of grain to produce a pound of gain in the suckling pigs was significantly lower in Large Black litters than in Duroc Jersey litters.

(5) There is no real difference between size of litter at birth in the two breeds of hogs, but there is a real difference between the numbers of pigs weaned. The Large Black litters were sifnificantly heavier at weaning time than the Duroc Jersey litters.

(6) A statistically significant difference was found in the number of pigs born, the number alive at the end of the first week, and the number weaned between the Cape and the Cornette strains and the Virtue, the Bella, and the Diana strains. The latter three families were more fertile and had greater ability to raise suckling pigs.

(7) The difference in the feed required to produce a pound of gain in liveweight of the suckling pigs was significantly less for the three strains, the Virtue, the Bella, and the Diana, than it was for the Cape and the Cornette strains.

(8) As indicated by the correlation coefficient between

feed consumption and units of gain made, more efficient use of feed was made by the Bella, the Diana and the Virtue strains than by the Cape and the Cornette.

(9) No real difference was found between the litter sizes and cost of producing gains between dams and their daughters sired by the boar, Moorddrift Admiral.

(10) An insignificant negative correlation of -.0090 was found between the age of a sow and the number of pigs farrowed.

(11) A significant negative correlation of -.2688 was obtained between the age of a sow and the number of pigs weaned.

(12) A real difference was found between the number of pigs born during the first four farrowings and later farrowings.

(13) A highly significant difference was obtained between the number of pigs weaned from the first four farrowings and subsequent farrowings. The latter litters were smaller.

(14) No statistically significant difference was found between the farrow number and the individual weights of pigs at weaning time.

(15) The feed required to produce a unit of gain in live-weight of the suckling pigs decreased up to the third farrowing and increased sharply after the fourth farrowing.

(16) A highly significant negative correlation of -.4715 was found between the weight of a sow and the number of pigs weaned.

(17) There was no correlation between the weight of a sow and the number of pigs born per litter.

(18) A very highly significant difference was obtained

between the number of pigs weaned in the groups of sows weighing less than 450 pounds and those weighing over 450 pounds. The latter group weaned the smaller litters.

(19) Sows between 350 and 450 pounds gave birth to larger litters and weaned larger litters than sows of lower or higher weights. The litters also weighed heavier at weaning time than those from other groups.

(20) The feed requirements to produce a pound of gain in the suckling pig increased markedly after the sows reached a weight of 450 pounds.

(21) The sows that lost most weight during the lactation period were the sows that farrowed and raised the largest litters.

(22) A significant negative correlation of -.2697 was found between the change in the weight of the sow and the litter weight at weaning time.

(23) The difference between the feed required to produce a pound of gain in the suckling pigs is significantly less in the groups of sows losing weight than in the other groups.

(24) No statistically real difference was found between the feed cost to produce a pound of gain in the purebred and in the crossbred weanling pigs.

(25) The crossbred litters were slightly larger at birth and at weaning time than purebred litters.

(26) The individual purebred pigs averaged 5.4 pounds heavier than the crossbred pigs at weaning time.

(27) The average litter size at birth increased by .1 pig during 5 years and by .13 pig at weaning time.

(28) The average weaning weight of individual pigs was 4.37 pounds heavier during the last five years than the previous five years.

(29) The average feed requirements for a unit of gain in liveweight in the weanling pigs was .47 pounds less during the last five years than during the first five years.

(30) Larger litters were born during the months of September and October than any other month.

(31) The highest percentage of pigs were weaned during the spring months.

(32) Spring pigs required less feed per unit of gain than pigs born during other seasons of the year, but these differences were not statistically significant.

(33) No difference in feed requirements per pound of gain or in litter weight was found between the pigs that received a vermicide during the suckling period and those that did not receive any.

(34) No significant difference was found in the efficiency of the three rations used in producing a pound of gain in liveweight in the pigs during the suckling period.

(35) There were 6.62% of the pigs born in the herd that were still-born.

CONCLUSIONS.

(1) From the results obtained by correlating litter size and the feed required to produce a pound of gain in liveweight in the suckling pigs, we may conclude that the feed cost decreases as litter size increases. This principle is very important, as other workers have estimated that the feed costs make up 76.5 to 84.5 per cent of the cost of producing a merket hog.

(2) Mortality of pigs during the suckling period increases the feed costs of the surviving pigs in the litter. Twenty-two and six-tenths per cent of the pigs died during the first week and only 5.72 per cent during the remainder of the suckling period.

(3) There are some indications that there exists a real difference in the feed required to produce a pound of gain in liveweight betw een Duroc Jerseys and Large Blacks. From the results obtained in this study we may conclude that it is more economical to produce Large Black pigs up to weaning age.

(4) Some family strains are more fertile and have greater maternal efficiency than others. In that respect the Bella, the Virtue and the Diana strains were superior to the Cornette and the Cape. The more fertile strains and sows with superior maternal qualities produced gains in suc' ling pigs at less feed cost up to weaning age.

(5) No definite conclusions could be drawn from the influence the Large Black boar Hoorddrift Admiral had on the herd. We may safely say he had no marked influence, either good or bad.

(6) The results indicate that with increasing age, the fertility of the sow does not decrease as rapidly as her nursing ability and milk production. Sows older

than three and one half years wean less pigs than younger sows; when the sows get old, a greater percentage of pigs die during the suckling period, especially the first week.

The feed required to produce a unit of gain in the weanling pigs was higher for sows older than 4 years.

(7) The size of litters at birth and at weaning time increases up to the fourth farrowing; after the fourth farrowing the litters get smaller. The amount of feed required to produce a pound of gain in the suckling pigs increased decidedly after the fourth farrowing.

(8) Heavy sows weighing over 450 pounds wean smaller litters than sows below that weight. The weight of the sow has a greater influence on the number of pigs weaned than on the number born. The sows weighing between 350 and 450 pounds gave birth to the largest litters and weaned the highest percentage of pigs at lowest feed costs.

(9) Sows that have large litters and that milk heavily lose most weight during the lactation period. These sows produce weanling pigs at lower feed costs per pound gain than sows that gain weight or remain at a constant weight during the lactation period.

(10) The results obtained in this study show no difference between the costs of producing a pound of gain in purebred pigs or crossbreds.

(11) The fertility of the herd and motherly efficiency of the sows during the past five years was superior to that of the previous five years. However, the differences are small.

(12) The cost of producing a pound of gain in the liveweight of the suckling pigs went down during the last five

years; .47 pounds less grain was required to produce a pound of gain in liveweight.

(13) Litters born during September and October were larger and required less feed to make equal gains than pigs born at other periods of the year. There would be a definite advantage in breeding sows during March, April and May and also during October and November.

(14) No beneficial effects were obtained by treating the suckling pigs with vermicides. We may conclude that the worm infestation was not bad or that the worms were not removed.

(15) The three series rations, numbers 2, 4 and 5, did not differ significantly in efficiency of producing a pound of gain in liveweight. All three rations were good rations. If an extremely poor ration had been fed no doubt an extreme effect would have been observed.

(16) The percentage of still-born pigs found in this herd was approximately the same as is found in other well managed herds. We may conclude that it was by no means abnormally high.

LITERATURE CITED.

1. Carroll, Hull, Laible and Rice.
Illinois Bulletin 321.

2. Wilcox, R.H., Carroll, W.E. and Hormung, T.C.
Some important factors affecting costs in hog production. Illinois Bulletin 390.

3. Wentworth, Edward N. and Aubel C.E.
Inheritance of fertility in swine.
Jour. of Agric. Res. 5: 1145-1160. 1916.

4. Johansson, I.
Problems in breeding for high prolificacy. 1930.
The Pig Breeders' Annual 1931-32, pp. 80-87.

5. Lush, Jay L., Arthur L. Anderson, C.C. Culbertson and W.E. Hammond.
The reliability of some measures of productiveness of individual brood sows.
Proc. of Amer. Soc. An. Prod. 1933.

6. Simpson, Q.I.
Fecundity in swine.
Am. Breeders' Assoc. Vol. 7, pp. 261-275. 1912.

7. Wentworth, E.N. and Lush, Jay L.
Inheritance of litter size.
Jour. of Agri. Res., Vol. XXIII, No. 7.

8. McPhee, H.
Size of litter as a selection index in swine.
Proc. Amer. Soc. An Prod. 19.

9. Smith, Buchanan.
The Pig Breeders' Annual, 1930-31; 46

10. Evvard, John M. and Arthur Dox.
Amer. Jour. Physiol. June 1, 1914, No. 3.

11. Evvard, John M. and Culbertson, C.C.
Iowa Circular 81.

12. Carroll, W.E.
Illinois Res. Bul. 390, pp. 20.

13. Carmichael and Rice.
Variation in farrow with special reference to birth weight of pigs.
Illinois Bulletin 226.

14. Joseph, E.W.
Feeding brood sows and growing the litters.
Montana Bul. 163, May 1924.

15. Russel, E.Z.
Age as a factor in brood sow performance.

16. Sinclair, R.D. and Syrotuck, M.
Age as a factor in swine reproduction.
Scien. Agric. Vol. VIII, No. 8, April 1928.

17. Davidson, H.R. and Duckham, A.N.
East Anglian Pig Recording Scheme.
1st Report issued June 1929.

18. Evvard, John M.
Proc. Amer. Soc. An. Prod. 1927.

19. Ferrin, E.F. and McCarty, M.A.
Proc. Amer. Soc. An. Prod.

20. Grimes, J.C., Sewell, W.E. and Cottier, C.J.
Some factors affecting the cost of raising pigs to weaning age.
Alabama Circular 68. July 1934.

21. McKenzie, F.F.
Growth and reproduction in swine.
Missouri Res. Bul. 118.

22. Kitchen, A.W. Menzies.
Third report on East Anglian Pig Recording Scheme
July 1930.

23. Thompson, Carl.
The effect of milk consumption on the growth of suckling pigs.

24. Bonsma, F.N. and Oosthuizen, P.M.
Milk production in Large Black sows.
South African Jour. Science Vol. XXXII, 1935.

25. Shearer, F.S. and Culbertson, C.C.
Crossbreds versus purebreds in producing market hogs.
Iowa State College Leaflet 20.

26. Winters, Kiser, Jordan and Peters.
Six years of crossbreeding swine.
Minnesota Res. Bull. 216.

27. Crampton, W.E.
Estimating statistically the significance of differences in comparative feeding trials.
Scien. Agr. Vol. XXII. No. 1. September 1932.

28. Foster, James C.
Statistical methods of analysis applied to feed lot gains in lambs.
Colorado Agric. College Tech. Bul. 10, 1934.

29. Fisher, R.A.
Statistical methods for research workers.
4th Ed. Oliver and Boyd. London and Edinburgh, 1932.

30. Wallace, H.A. and Snedecor, George W.
Correlation and Machine Calculation.

31. Lush, Jay L. and Arthur L. Anderson.
Proc. of Amer. Soc. of An. Prod. 1935, p. 266.

32. Murray, C.A.
Thesis submitted to Animal Husbandry Division of the Transvaal University College. 1927.

ACKNOWLEDGMENTS.

The author wishes to acknowledge his obligation and to express his sincere appreciation to Professor Arthur L. Anderson of the Iowa State College Animal Husbandry Staff for the valuable suggestions and kindly criticisms given in the conduct of this study.

Acknowledgment is also made to Professor Jay L. Lush, Professor A.M. Bosman and Mr. F.N. Bonsma for kind advice.

The author furthermore wishes to extend his hearty thanks to Mr. E.S. Dawson and Mr. J.J. Veenstra of the staff of the Pretoria University Experimental Farm for collecting the data and permitting him to use the records upon which this study was based, and for helpful suggestions during the early stages of the work.

Finally, the writer wishes to express his gratitude to every one who has assisted him in any way in making this work possible.
