THE EFFECT OF INBREEDING OF SOWS ON THEIR MILK PRODUCTION AND THE DEVELOPMENT OF THEIR LITTERS

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INTRODUCTION

The animal breeders have watched with interest the breeding program followed by the corn breeders during the last 30 years. They have become extremely interested in the progress of this program since the corn breeders have been able to increase the yield of their corn by the use of hybrids produced by crossing highly inbred families. There has been much speculation in recent years as to whether the animal breeder can develop in livestock inbred families which will manifest hybrid vigor when they are crossed.

The Regional Swine Breeding Laboratory was originated in the fall of 1936 under the provisions of the Bankhead-Jones Act of 1935. The first problem to be attacked by this laboratory was the improvement of swine by the use of breeding systems which are similar to the ones used by the corn breeders. This work at the present is under way at six of the Agricultural Experiment Stations.

Inbreeding tends to lower the vigor and the individual merits of animals, as has been demonstrated in numerous inbreeding experiments. The corn breeders have found the same thing happens in their inbred families. When crosses are to be made between inbred lines, one of the inbreds will have to be used as the mother. The corn breeders have not been able to find many inbred lines that make good dams, and as a result have resorted to the crossing of first crosses in order to take advantage of mothers having hybrid vigor. The question

naturally arises as to whether highly inbred animals will be good enough mothers to raise their offspring.

It is the aim in this study to compare the milk production of inbred and outbred sows, to compare the growth rate of their pigs up to weaning time, and to determine the best criterion to use in selecting sows for high milk production.

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REVIEW OF LITERATURE

There is a wide variation in the average daily and total milk production of sows as reported by various workers. The lowest production was recorded by Thompson (22) in 1931 with Poland China sows with an average of 2.03 pounds of milk per day per sow for a lactation period of eight weeks. The highest milk production per sow was reported by Donald (10) at the University of Edinburgh (1932) with an average of 12.11 pounds of milk per day. However, Donald measured the milk production during only the fourth week of the lactation period which is generally thought to be one of the highest weeks.

According to Hughes and Hart (15) Schmidt and Lauprecht obtained an average of 11.6 pounds of milk per day per sow in 1926, and Ostetag and Zuntz recorded an average of 11.4 pounds of milk per day per sow for a lactation period of eight weeks. These results are very similar to Donald's observations.

Carlyle (3) reported an average daily milk production of 6.31 pounds for Berkshire sows, 4.86 pounds for Poland China sows, and 5.17 pounds for Razorback sows.

Dechambre (8) in 1934 reported an average daily milk yield for 84 days for Berkshire sows of 6.31 pounds, for Poland China 4.86 pounds, and for Yorkshires 4.94 pounds.

Carlyle (3) and Hickman (13) report that some sows gave double that of others.

A summary of the results of several investigators is shown in Table I. The average daily yield of 304 lactations was 6.61 pounds with an average litter number of 7.73 pigs.

Table I Milk Production of Sows Reported by Various Workers

No. sows	Avg. No. pigs per litter	Daily milk prod. (lbs.)	Total lbs. of milk in lactation 8 wks.	10 wks.	12 wks.	Reported by
1	-	3.40	-	-	-	Von Gohen (1865) Germany 1/
1	7.0	5.60	-	392.0	-	Davies (1904) Wisconsin
3	-	11.40	638.4	-	-	Ostetage & Zuntz (1908) 1/
1	9.0	10.20	-	-	-	Schmidt & Lauprecht 1/
1	7.0	11.60	-	-	-	" " "
1	9.0	7.20	404.9	-	-	" " "
1	8.0	8.20	460.5	-	-	" " "
1	6.0	10.70	600.0	-	-	" " "
20	8.3	6.90	388.2	-	-	" " "
4	-	6.90	-	481.0	-	Ohligmacher 1/
7	-	6.50	-	457.7	-	"
2	7.5	7.70	-	539.0	-	Hughes & Hart (1935) Calif.
200	-	10.36	576.6	-	-	Olofsson & Larsson (1930) Sweden
2	9.0	2.03	113.6	-	-	Thompson (1931) Oklahoma
1	9.0	3.09	173.0	-	-	" " "
1	8.0	4.04	226.2	-	-	" " "
-	-	5.30	-	-	441.8	Dechambre (1934)
22	8.57	7.20	401.5	-	-	Schneider (1934) Germany
1	6.0	5.80	243.6	-	-	Henry & Woll (1897) Wis.
1	6.0	4.10	-	-	287.0	" " " " "
1	10.0	12.11	-	-	-	Donald (1932) Scotland
1	13.0	9.86	-	-	-	" " "

(Continued on next page)

Table I - Continued

No. sows	Avg. No. pigs per litter	Daily milk prod. (lbs.)	Total lbs. of milk in lactation 8 wks.	10 wks.	12 wks.	Reported by
11	7.9	5.70	319.2	-	-	Contescu & workers (1938) Germany
6	7.5	7.15	400.4	-	-	" " " " "
1	7.0	5.40	-	302.4	-	Henry & Woll (1897) Wisconsin
1	8.0	5.50	-	308.0	-	" " " " "
-	-	6.50	-	-	-	Bonsma & Oosthuizen (1935) S.Afr.2/
1	5.0	4.18	234.1	-	-	Carlyle (1903) Wisconsin
1	7.0	5.38	301.3	-	-	" " "
1	8.0	7.18	402.1	-	-	" " "
1	10.0	7.30	408.8	-	-	" " "
1	9.0	6.65	372.4	-	-	" " "
1	6.0	5.38	301.3	-	-	" " "
1	6.0	5.39	301.8	-	-	" " "
1	6.0	5.81	325.4	-	-	" " "
1	6.0	3.65	204.4	-	-	" " "
1	10.0	7.96	445.8	-	-	" " "
1	8.0	4.00	224.0	-	-	" " "
1	5.0	4.45	248.2	-	-	" " "
Total Avg.	7.73	6.61	348.6	413.4	364.4	

1/ Reported by Hughes and Hart (15)

2/ Reported by Garner and Sanders (11)

Lactation Curves of Sows

In dairy cattle a lactation curve has been established, but as yet there seems to be a question about the lactation curve of sows.

In general, the conclusions of Schneider (20) and Henry and Woll (12) are that milk production is highest during the third and fourth weeks of lactation with very little decrease in the flow of milk the fifth and sixth weeks.

Observations on milk production were made by Contescu, Roman, and Breahan (4) for 11 Mangalita and six Large White sows. They reported that in the majority of cases the yield of milk rose to the third week and then slowly declined, however, in two animals the peak was reached in the fourth week of lactation.

Henry and Woll (12) reported the milk yield was not large immediately after farrowing and at weaning time, while Olofsson and Larsson (19) of Sweden reported that the maximum yield occurred within the first 10 days after farrowing with Large White sows.

Factors Effecting Milk Production of Sows

According to Hughes and Hart (15) Schmidt and Lauprecht in 1926 reported that sows receiving a high-protein ration produced more milk than those on a low-protein ration; that sows suckling 8.5 or more pigs per litter yielded more milk than those having fewer pigs. They found, too, that sows suckling their third to sixth litters produced more milk than sows in their first and second lactations. They also

reported that sows with a higher protein ration gave more milk in the middle of lactation than those on a lower protein ration; that older sows produced more milk in the early part of lactation, whereas the young sows gave the same amount in the latter as the first part of the period.

Contescu, Roman, and Breahan (4) reported that one group of four Mangalita sows and six Large White sows produced a much higher yield of milk than seven other Mangalita sows. They were inclined to ascribe it to the fact that the higher producing sows were younger. The average total amount of milk received per Mangalita pig in the first group was 53.35 pounds, the Large White pigs received 48.06 pounds, and 41.38 pounds of milk was consumed by the pigs suckling the seven Mangalita sows.

Kvasnitzky (16) concluded from his study of the functions of mammary glands that the increase of the number of times of suckling during the day from 10-12 to 14-16 may increase the daily milk production of the sow.

Variation of Growth Rate of Suckling Pigs

There are several factors which influence the rate of growth of suckling pigs at various periods. The most extensive investigations are reported by Olofsson and Larsson (19), of Svalou, Sweden in 1930. In all 200 litters of Large White pigs were included. The average daily milk yield per sow from the second to the eighth week was 10.36 pounds. This is considerably above the average, indicating the sows were exceptionally good milk producers.

They also reported that the pigs averaged 2.8 pounds at birth and 28.88 pounds at eight weeks of age; that pigs from small litters were heavier at birth and gained more rapidly during the first few weeks than pigs from larger litters, but after five weeks the difference in gain was insignificant.

Mengies-Kitchin (17) reported a definite negative correlation between the weight of the pig at six weeks and the age at which they reach bacon weight, but the post weaning growth rate for heavy pigs is not necessarily greater than that for lighter pigs.

The daily gains in weight of pigs increased until they reached 198 pounds in weight, except during the fourth and fifth weeks, according to reports of Olofsson and Larsson (9).

According to Dechambre (8) daily gains increase up to the second week and decrease the third and fourth week, and increase again considerably thereafter. The 22 sows that suckled these pigs increased in daily milk production up to the end of the fourth week and gradually declined to weaning time. The pigs decreased in daily gains the third and fourth week while the milk production was increasing, and the pigs increased in daily gains after the fourth week while the sows decreased in daily milk production.

This indicates that the pigs received enough milk to grow to capacity the first two weeks, but were large enough the third and fourth weeks that the milk supply limited their rate of growth and they were too young to consume enough feed to make up the difference, but after four weeks they

consume enough feed to increase in daily gain in spite of the decrease in daily milk production of the sows.

Contescu, Roman and Breahan (4) reported that during the third week Mangalita pigs grew as fast as the Large White pigs, but during the fourth to the eighth weeks their growth rate was less, in spite of the fact that in one group of Mangalita pigs the milk consumption was higher than in the Large White pigs. The amount of milk required to make one pound of gain in Mangalita pigs was 2.11 pounds as compared with 1.79 pounds for the Large White pigs. The difference became greater after the fifth week when the pigs were given supplementary feed. At weaning, however, some of the best Mangalita pigs were nearly as heavy as the best Large White pigs, which indicated that heredity is a factor in determining weaning weight. However, Donald (9) concluded that the variability in weight of weaning pigs largely depended on the variation in the amount of milk obtained by the individuals during suckling.

According to Thompson (22) pigs with the same birth weight made daily gains in proportion to the quantity of milk received during the suckling period. Pigs making rapid gains before weaning also made rapid gains for 60 days after weaning.

Distribution of Milk in the Udders of Sows

It has been pointed out on several occasions that the best teats are the front ones. One can tell a good mammary gland from a poor one, but may not easily place them all in

their correct order according to yield. An example of the distribution of milk in the udder of a sow observed by Donald (10) for a week is given in Table II. The last two pigs suckled a pair of teats each. Although the largest yield was obtained at the anterior end, there was no clear gradation from one end to the other, nor was there close agreement between the yields of members of each pair of teats.

Table II

Distribution of Milk in the Udder of the Sow

Total amount of milk in pounds from each teat for a week of observations on one sow (by Donald).

	Anterior				Posterior	
Teat No.	1	2	3	4	5	6
Right Side	9.65	9.87	5.23	9.55)	8.19	5.96
Left Side	11.46	6.98	10.71	5.66)		
Total of Pair	21.11	16.85	15.94	15.11	8.19	5.96

Effect of Birth Weight on Gains

The importance of having large, vigorous, thrifty pigs farrowed was emphasized by Mohler (18) in 1932 in a study of accumulated data of the Bureau of Animal Industry on the records of 1,430 pigs. He stated that there is a correlation between pigs farrowed alive and the percentage surviving to weaning; that the heavier the weight of the pigs farrowed alive the more rapid the gains made. The results showed that a difference of 2.5 pounds in the birth weight gave an advantage in favor of the heavier pigs of 12 percent for pigs

farrowed alive, and 53 percent for those surviving to weaning. Not only did the pigs with the heavier birth weight also gain more rapidly to weaning, but they continued to do so throughout subsequent feeding periods of 112 days. Pigs with birth weight of 1.5 pounds made average daily gains to weaning of 0.38 pounds and subsequent gains of 1.18 pounds, as compared with average daily gains of 0.63 and 1.44 pounds for the pigs with a birth weight of four pounds, during the corresponding periods.

Effect of Weaning Weight on Gains

Very few data are available to show whether the weaning weight is a true indication of the subsequent feeding ability of the animal.

Blissett and Duncan (1) reported that data from New Zealand showed a decided value for the weaning weight as an indication of subsequent development, for pigs at sixteen weeks of age were approximately two and one-half times as heavy as their weight at eight weeks.

Blissett and Duncan (1) also reported results of an experiment in Scotland in which 616 pigs were weighed at eight weeks, again at approximately 200 pounds, and again prior to dispatch at the bacon factory.

They made a statistical analysis of the data. The 616 pigs were divided into six groups according to weight. Table III shows the mean increase in weight per pig per day in pounds.

No significant difference in the mean increase in weight after weaning was detected between Group II and Groups I, III, and IV, but the difference between Group II and Groups V and VI were clearly significant as also were the differences between Group VI and Groups III and IV.

Table III

The Effect of Weaning Weight on Subsequent Daily Gains of Pigs by Blissett and Duncan (1)

Group	Number of Pigs in Each Group	Range of Weaning Weights of Each Group	Mean Increase in Weight Per Pig Per Day after Weaning
I	41	Over 45 lbs.	1.146 lbs.
II	74	From 40 to 45 lbs.	1.180 "
III	156	" 35 " 40 "	1.145 "
IV	162	" 30 " 35 "	1.150 "
V	114	" 25 " 30 "	1.127 "
VI	69	Under 25 lbs.	1.098 "

It can be seen from this table that the greatest mean increase took place in pigs weighing from 40 to 45 pounds at weaning. The smallest mean increase took place in pigs weighing between 25 and 30 pounds and less than 25 pounds at weaning. The results showed that the weight at weaning has some effect on the subsequent rate of growth of the pig.

Effect of Litter Size and Milk Consumption on Gains

Smith and Donald (21) reported that there is a range in litter size in which there are no differences in average wean-

ing weight, but on either side to the extreme of litter size the average weaning weight is greater or less than in the central part of the range as is shown in Table IV.

Smith and Donald (21) reported that from the observations of Bonsma and Oosthuizen (1935) and Dschaparide (1936) the amount of milk received per pig falls off with increasing litter size, although the total production of the sows increased, and assuming that there are changes in the efficiency with which a pig can deal with varying quantities of milk the average weaning weight may be the result of the function of these two variables.

It may be supposed that the amount of milk a pig receives will vary according to the size of the litter on the basis that increasing stimulus by suckling more teats will not result in equal but in diminishing increments of milk, and when the number in a litter exceeds the number of teats, the available milk must be shared. It may also be supposed that after the maintenance requirements are satisfied, the growth of a pig will be in direct proportion to the amount it receives until the quantity reaches a certain point, after which the gain in weight per unit of milk consumed over maintenance requirements will gradually fall as the quantity of milk increases.

Figure I is the results of the observation of Smith and Donald (21) showing the average weaning weights of the various size litter. The figures in parenthesis are the number of litters observed.

Assuming that weight at weaning was a function of amount of milk obtained and the efficiency with which it was utilized, the change in average weight with change in litter size, shown in Figure I, was interpreted in the following way. Over the range of 7-11 in litter size, increased economy of gains has offset any reduction in milk supply. In litters larger than 12 this did not happen, and the average weight decreased. In litters smaller than seven the reduction in economy of gain is more than offset by the rapidly increasing quantity of milk and the average weight increased.

Hugenroth (14) in 1937 reported that records on six sows tended to confirm the observations that the teats neglected by the first litter are utilized by the weakest pigs of subsequent litters. Such pigs never attained the

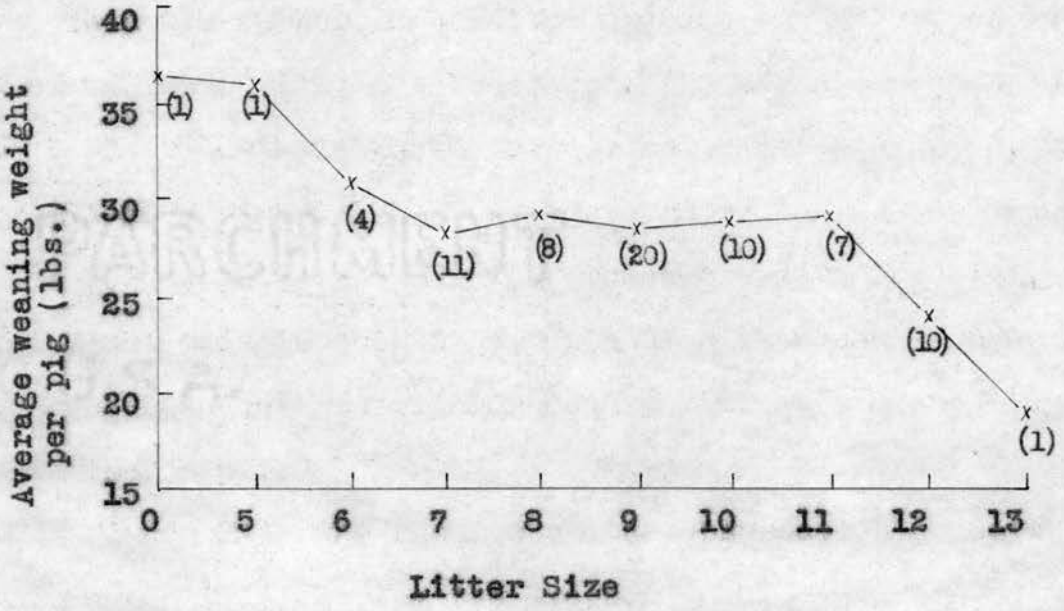


Figure I. Average Weaning Weights of Various Size Litters (Number of pigs in brackets)

weight of their litter mates. The teats did not give a normal yield, indicating that deficient sows should be culled. Hugenroth states that it is possible to correlate the number of teats suckled and the weekly gain in weight of the pigs.

Davies (22) of Wisconsin observed the weights of pigs every night and morning, and reports that pigs gain 70.89 percent of their weight at night.

Variation in Efficiency of Utilization of Milk

In 1937 at the University of Edinburgh, Scotland Donald (10) obtained the milk production of two sows for a period of seven days. Suckling took place at intervals of approximately two hours during the day and three hours during the night.

The larger pigs in this experiment usually obtained the most milk, but there was an even closer proportionality between the increase in live weight and the amount of milk obtained.

Donald raised the question whether the larger pigs with their greater rations are more or less economical than the smaller pigs. The largest pigs were the most efficient according to the Efficiency Quotient, which is after the manner of Palmer and Kennedy and modified by Winters and McMahon (24).

The same clear superiority was not shown when body-weights were left out of account. Therefore, Donald approached

the question from another angle, that is by estimating the maintenance-requirement in terms of milk for each pig and using the quantity obtained in excess of this, which he called productive milk, for the efficiency calculation, efficiency being defined as the ratio of productive milk to live-weight increase, or the number of grams of productive milk required for one gram live-weight increase. The smaller the number the more efficient the pig.

As maintenance-requirements for such small pigs could not be found, Donald arrived at 800 grams of milk to maintain a two-kilogram pig for a week by indirect deduction. He checked his figures by using the basal metabolism for a two-kilogram animal, given by Brody, Procter and Ashworth (2) as 117 calories per day and converted this into grams of milk per week. If one gram of digestible milk nutrients is equivalent to four calories, and if in sow's milk there are 25.5 percent total digestible nutrients, 803 grams of milk per week would be required. He thought this was sufficiently close agreement, as the purpose was to expose differences in efficiency rather than actual values.

Donald gave the following formula for obtaining the maintenance-requirements of pigs for a week.

Maintenance-requirement equals $M \left(\frac{W}{2000}\right)^{0.73}$ when M equals 800 grams, and W equals the initial weight plus half the live-weight increase of a given pig. In accordance with the results of Brody, Procter and Ashworth (2) the maintenance was presumed to be proportional to the 0.73 power of the live-weight.

The relation between the amount of milk available for growth and the actual increase in weight is brought out very clearly in Figure II, which shows a strong correlation between the two.

Figure II also gives the suggestion that the animals receiving the most milk in excess of their maintenance-requirements, were converting it less efficiently than those receiving less. Donald brought this out more easily by plotting productive milk against efficiency, as is shown in Figure III.

If efficiency were the same for all levels of feeding, the curve should remain approximately horizontal. Since the curve drawn from the observation shows a definite upward

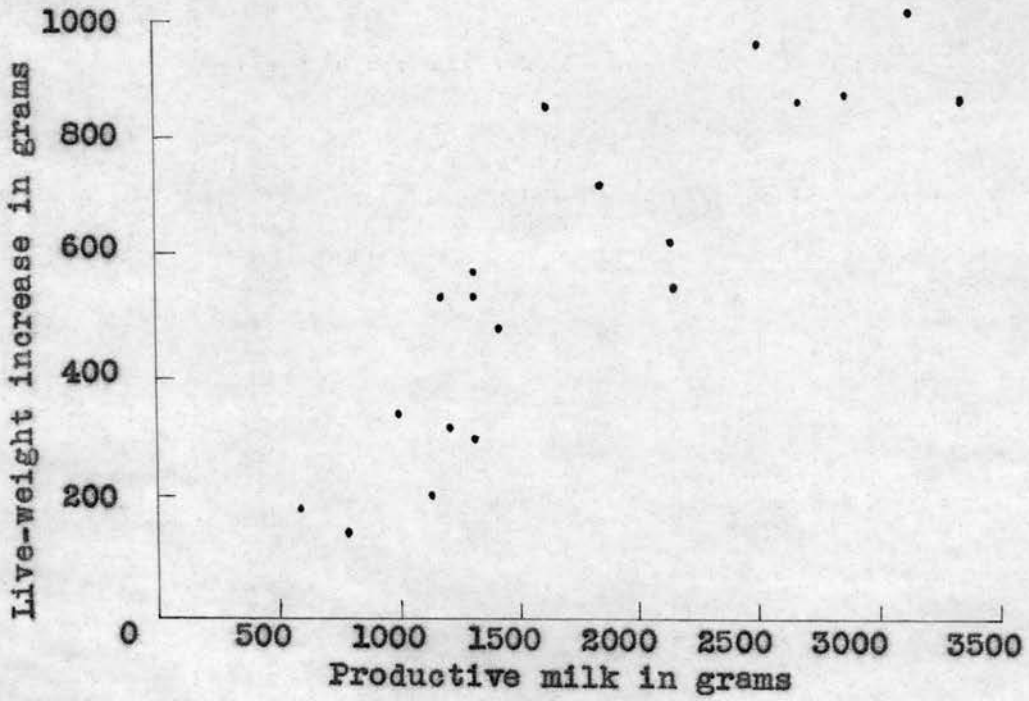
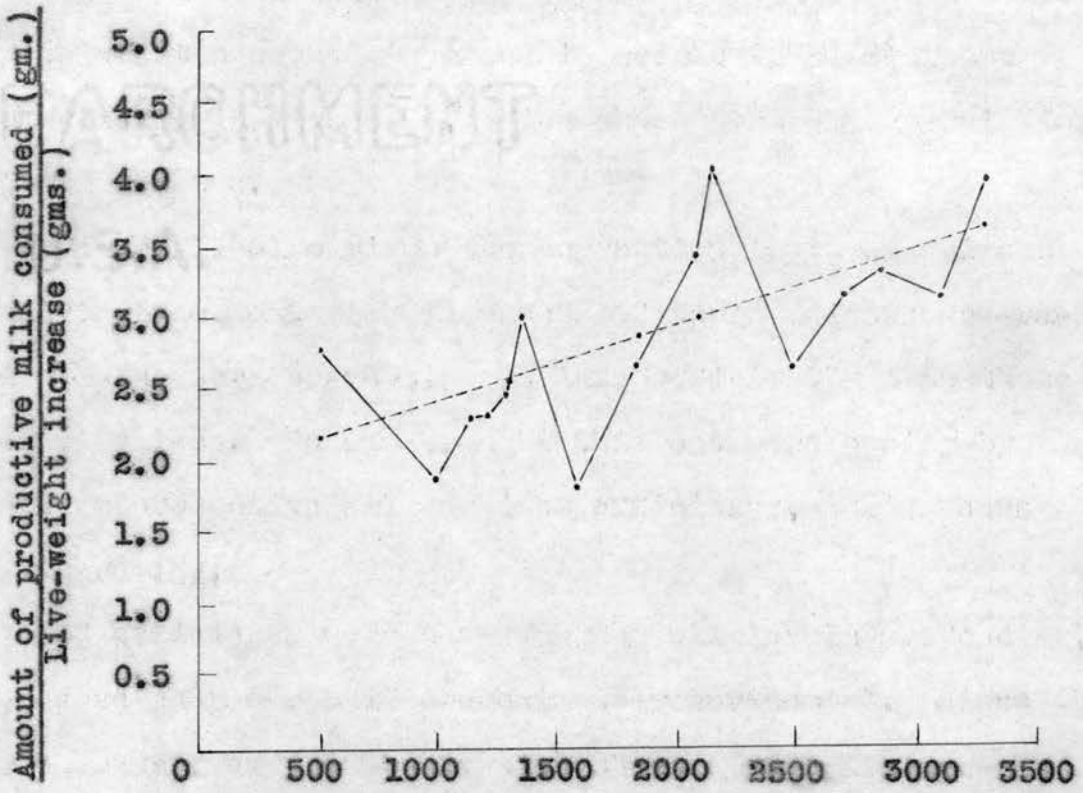


Figure II. Relation Between Live-Weight Increase and Amount of Productive Milk Consumed (by Donald (10).



.____.____ maintenance-requirement 800 grams of milk per week for a two-kilogram pig.

----.---- regression of $\frac{\text{productive milk consumed}}{\text{live-weight increase}}$ on amount of productive milk. The value of the regression coefficient is 0.52 for a change of 1000 grams in the amount of productive milk consumed, and its significance is beyond the 1 percent point.

Figure III. Relation Between Total Amount of Productive Milk Consumed in Seven Days and the Amount of it Required per Unit Live-Weight-Increase. (By Donald.)

slope it would appear to indicate that the pigs which had the largest amounts of productive milk were making less economical use of it than pigs which had less.

Comparison of the Rate of Growth of Inbred and Outbred Pigs

In 1929 at the Oklahoma experiment station, Craft (5) observed that inbred pigs from inbred Duroc sows were 12

percent lighter than outbred pigs at birth, but were only 3 percent lighter at weaning. However, from weaning to 225 pounds the outbred pigs grew faster. These results indicate that the inbred sows were giving more milk than the outbred sows.

Willham (23) in 1938 reported that both inbred and outbred pigs from inbred Duroc sows, at the Oklahoma station, made lower daily gains up to 180 days of age than pigs produced by outbred sows, indicating that the milking ability of the inbred sows handicapped their pigs.

Since the sows in the experiment reported by Willham in 1938 are decendants of the sows used by Craft in 1929, it would seem that the inbred sows were losing their milking ability as they became more highly inbred.

Observations by Various Workers on the Suckling Habits of Pigs

Observations by Davies (6), Henry and Wool (12), Carlyle (3), and Donald (10), were that pigs usually suckle about every two hours during the day and every three or four hours during the night. As they became older the intervals between suckling became as long as six hours.

Carlyle (3) observed that during an experiment when intervals between suckling periods became longer that the sow and pigs became excited. Many workers stated that sows and pigs became accustomed to the experiment very soon.

The author observed that some sows became accustomed to the unusual treatment much sooner than others. Litters

from nervous sows also seemed to object to the handling much more than litters of much less nervous sows.

METHOD

Observations on milk consumption were made approximately the tenth, twenty-ninth, and forty-eighth days after birth. Pigs were taken away from the sow for a period of three hours and then each weighed, suckled, and weighed again and taken from the sow another three hours. This was continued for a period of 24 hours, and assumed the average for a 19 day period, nine days before and nine days after each observation. The intervals between suckling were increased to four hours on the twenty-ninth day and to six hours on the forty-eighth day.

Because the sows and their litters were on wheat pasture, observations of milk production for the forty-eighth day of lactation were only carried on for a period of 12 hours. This was done because it was thought that if the sows were deprived of their customary wheat pasture for as much as 24 hours it would cause a decline in milk production, therefore not giving a true representative sample of their average milk production.

The greatest difficulty was found to be the tendency of the pigs to urinate after they had suckled, but this was overcome by turning them out of their bedding and making them stand for some minutes in the dunged area of the pen before weighing and suckling. The weight of each pig was read off quickly, and then the pigs delivered together to the sow. Suckling took place promptly and the pigs were removed as soon as their behavior indicated that the udder was empty.

During suckling the position of each pig on the udder was noted and recorded, and also which pigs robbed from their neighbor. The pigs were then weighed again as quickly as possible.

The first weighing was often unsatisfactory because both sow and the litter were disturbed by the unusual treatment. The rate of adjustment, however, was remarkably rapid.

As the pigs became older and the sows and their litters were together on pasture, it was not uncommon for pigs to suckle sows not their mothers, which at times caused some pigs to get more than their share of milk.

RESULTS AND DISCUSSION

The data for this study have been obtained from three inbred Duroc sows and 11 outbred Duroc sows at the Oklahoma experiment station.

Characters studied on 56 pigs from birth to weaning were: Birth weight, 21 day weights, weaning weights, daily gains from birth to weaning, daily gains the first 21 days, daily gains from 21 days to weaning, score at weaning, and average daily milk consumption of each pig.

The data in Table IV show that the milk production for the inbred sows averaged higher than that of the outbred sows for the first and second periods and for the total average, but the average for the third period was slightly higher for the outbred sows. Because of the great variation in milk production of the outbred sows the difference in the average milk production of the outbred and inbred sows was not significant.

The results secured on milk production of inbred and outbred sows based on the amount of milk per pig in the litter have been compared. The differences obtained were not significant.

There was no significant difference in the average milk production of gilts and sows during the first period nor the total average for the eight weeks of lactation. There also was no significant difference in the average amount of milk produced on the basis of the number of pigs per litter.

Table IV

Average Daily Milk Production of Inbred and Outbred Sows

Sow No.	Percent of inbreeding	No. pigs in litter	Daily avg. lbs. of milk prod. 1st.per.	2nd.per.	3rd.per.	Avg.
57	0.4308	4	4.45	5.34	2.82	4.23
Tex. III	0.03125	4	4.45	2.65	2.60	3.23
561	0.4032	5	5.40	-	-	-
Avg. of Inbreds		4.33	4.77	4.00	2.71	3.73
559	0	2	1.58	1.27	1.26	1.37
554	0	2	1.05	1.47	1.47	1.33
L5	0	2	1.53	1.87	1.37	1.59
364	0	3	4.84	2.40	3.00	3.41
361	0	4	4.51	3.36	3.69	3.85
C3	0	4	3.29	3.04	1.54	2.63
Tex. III	0	5	6.34	2.28	3.84	4.15
L14	0	5	3.79	3.53	2.34	3.22
541	0	7	8.07	5.05	2.91	5.34
C1	0	8	5.34	5.67	4.28	5.10
L2	0	9	6.30	4.92	4.44	5.22
Avg. of outbreds		4.64	4.24	3.17	2.74	3.38
Total average		4.57	4.35	3.30	2.73	3.43

However, sows and gilts with large litters had a tendency to give more milk than sows with small litters.

Complete records were obtained on 56 pigs. These pigs consumed a daily average of .83 pounds of milk during the first period, 69 pounds of milk during the second period, and during the third period they consumed an average of .62 pounds of milk daily. The analysis of variance showed that this decrease in milk consumption from period to period is highly significant.

The variation between weighings on the first period of milk production was analyzed and an intra class correlation between weighings of the same pig was deduced.* This correlation was .44, which indicated that there was a tendency for the same pigs to consistently receive a high or low amount of milk each time they suckled.

There was a correlation of .63 between birth weight and 21 day weight, and a correlation of .441 between birth weight and daily gains the first 21 days; both correlations are significant. Pigs that have the fastest prenatal growth also have the fastest growth after birth to 21 days. This same superiority of growth rate of large pigs at birth continued through to weaning because a correlation of .512 was obtained between birth weight and weaning weight, and also the significant correlation of .448 between birth weight and gains from birth to weaning.

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*Intra class correlation equals

$$\frac{\text{Total mean square} - \text{Mean square within pigs}}{\text{Total mean square}}$$

Pigs seemed to inherit the character for rate of growth. This inherited character seemed to influence the growth rate of the pigs from 21 days to weaning as well as from birth to 21 days. This was concluded from the significant correlation of .52 obtained between gains from birth to 21 days and gains from 21 days to weaning.

The pigs which were larger and growing faster seemed to rob the smaller pigs and also seemed to get the best teats, for there was a significant correlation of .28 between gains for the first 21 days and the milk consumed the first 21 days.

Since the correlation between birth weight and gains for the first 21 days was much higher than the correlation between daily milk consumed the first 21 days and gains the first 21 days, it would seem that the faster growing pigs used their milk more efficiently. The data in Table V bears out this statement. More milk was required per pound of gain on slower growing pigs.

Table V Efficiency of Use of Milk by Pigs Making Various Gains During the First 21 Days

No. Pigs	Pounds of Gain the First 21 Days	Lbs. of Milk Used Daily Per Lb. of Gain
7	Pigs gaining from 4.0 to 5.9 lbs.	.1304 lbs.
21	" " " 6.0 to 7.9 "	.1193 "
22	" " " 8.0 to 9.9 "	.0970 "
5	" " " 10.0 to 11.0 "	.0805 "

No correlation existed between average daily milk consumed from birth to weaning and weaning weight of the pigs and no correlation existed between milk consumption and daily gains from birth to weaning. After 21 days the pigs growth depends mostly on the amount of feed he utilizes other than milk.

At weaning time pigs were scored on the following points: Vigor, health, and thriftiness; quality; length of body; details of conformation; animal as a whole; and market grade.

Each of the six points has a score varying from 1 to 9, the score of 9 for each point being a perfect score. The pig's score is the total of the six points.

The score of these pigs varied from 23 to 43 with an average score of 35.93. There was no correlation between birth weight and score at weaning or between 21 day weight and score at weaning. Apparently the weight of the pig at birth or 21 days is no indication of how good a pig he will be when weaned, because too many factors, which entered in after he was 21 days old, determined his development. However, the rate of gain from birth to weaning and weaning weight seemed to influence the type of pig at weaning, for there was a high correlation of .84 between daily gains from birth to weaning and the score at weaning, and a correlation of .89 between weaning weight and score at weaning.

Table VI shows results secured by comparing inbred litters on inbred sows with inbred litters on outbred sows

Table VI Summary of Inbred Litters Produced by Inbred and Outbred Sows and Outbred Litters Produced by Outbred Sows

Inbred sows	In breeding of litter	Avg. weight in pounds of pigs			Avg. daily gains in pounds			Score at weaning	Avg. daily milk consumed in lbs. per pig	
		Birth	21 days	Weaning	Birth to 21 days	21 days to weaning	Birth to weaning		First 21 days	Avg. of all periods
57	.4829	2.5	10.1	25.0	.360	.426	.401	38.50	1.117	.978
Texas I	.1563	2.9	7.9	22.3	.267	.411	.357	33.25	.659	.657
Avg. of inbred pigs on inbred sows	.3196	2.7	9.0	23.7	.314	.419	.379	35.87	.888	.818
Outbred sows										
559	.1737	2.0	8.8	15.5	.321	.193	.241	24.50	.790	.684
554	.1737	2.3	11.3	22.0	.429	.306	.352	29.50	.859	.704
364	.1737	2.8	10.8	21.5	.381	.396	.334	30.75	1.124	.895
361	.1737	2.1	9.1	24.0	.333	.497	.391	37.25	1.020	.928
Texas III	.03125	2.9	9.1	19.8	.297	.306	.302	30.60	.840	.688
L14	.2500	2.3	10.3	25.6	.379	.438	.380	37.00	.758	.641
541	.1737	3.0	11.1	26.8	.394	.450	.426	36.17	1.082	.764
Avg. of inbred pigs on outbred sows	.1643	2.5	10.1	22.2	.362	.357	.361	32.25	.925	.758
Avg. of all inbred pigs	.1988	2.5	9.8	22.5	.351	.370	.354	33.06	.916	.771
L5	0	2.8	12.5	30.5	.462	.516	.496	39.25	.683	.796
C3	0	2.9	12.4	32.9	.451	.586	.438	38.25	.772	.640
C1	0	3.0	10.8	30.0	.379	.548	.482	38.56	.668	.639
L2	0	2.9	11.4	27.8	.402	.469	.444	39.89	.701	.578
Avg. of outbred pigs on outbred sows		2.9	11.8	30.3	.424	.530	.465	38.74	.706	.663
Avg. of all pigs on outbred sows		2.4	10.7	27.0	.384	.420	.390	35.52	.845	.723
Total average		2.68	10.47	25.87	.373	.445	.411	35.93	.882	.706

and outbred litters on outbred sows. The average daily gains of the inbred litters on the inbred sows was very similar to the gains made by the inbred litters on the outbred sows. They also received approximately the same average amount of milk.

The outbred litters made better average gains than all the inbred litters, and the outbred litters received less milk, indicating they made more efficient use of milk than all the inbred litters. This would indicate that the inbred litters have genes for slow growth. The outbred litters had a higher average birth weight, higher average 21 day weight, higher average weaning weight and higher score at weaning than the inbred litters. Outbred pigs seemed to have an advantage over inbred pigs from the start and maintained their superiority from birth to weaning.

Slightly inbred pigs had a lower score at weaning than higher inbred pigs, indicating that better type was fixed as heterozygosity was decreased. However, outbred pigs scoring higher than all the inbred pigs is probably because vigor and ability to make faster gains had more affect on the score of the pig at weaning than the increase in homozygosity had on the score of the inbred pigs.

As is shown in the data of Table VII, the distribution of milk in the sow's udder is quite variable. There does not appear to have been any more milk secreted on the average in one portion of the udder than in any other part. There was an even distribution of the number of pigs suckling the first five teats and very few suckled the sixth

Table VII Distribution of Milk in the Sow's Udder

Teat Number	Anterior 1	2	3	4	5	6	Posterior 7	Total
Left side:								
No. pigs observed	6	6	7	5	7	1	1	33
Average daily milk produced	.665	.742	.707	.586	.642	.735	.436*	.678
Right side:								
No. pigs observed	4	4	4	5	3	2	1	23
Average daily milk produced	.729	.671	.862	.718	.625	.929	.342*	.697
Total No. pigs observed	10	10	11	10	10	3	2	56
Total Avg. daily milk produced on R. and L. side	.697	.707	.789	.652	.634	.832	.389	.688

*Average of first period only, as pigs died soon after 21 days.

and seventh teats. More pigs suckled on the left side than suckled on the right side, indicating that the sow seems to usually lie on her right side.

More data needs to be obtained on the milk production of inbred and outbred sows. Putting outbred pigs on inbred sows and inbred pigs on outbred sows should be a good test of the suckling proclivities of a sow. A larger number of sows than was available at the time this experiment was conducted, should be used in order to make reliable conclusions.

CONCLUSIONS

1. There was no difference between inbred and outbred sows as far as milk production was concerned.

2. Gilts gave as much milk as sows.

3. Sows with large litters had a tendency to give larger quantities of milk than sows with small litters.

4. Milk production the first 21 days seemed to be the most important period of lactation, for this was the only period in which there was a correlation between gains and milk consumed.

5. Pigs with similar breeding grew in proportion to the quantity of milk they received.

6. Pigs with high growth rate the first 21 days used their milk more economically than pigs with slow growth.

7. According to the score of the pig at weaning, pigs with high growth rate were the best pigs at weaning.

8. Inbred pigs grew slower than outbred pigs, regardless of the inbreeding of the dam. This indicates inbred pigs inherited the character for slow growth.

9. Outbred pigs used their milk to a better advantage than the inbred pigs.

10. The best criterion for selecting sows with high milk production is the rate of growth of their litters the first 21 days.

11. Inbred sows should make good mothers for the first cross between different inbred lines.

SUMMARY

Milk production was measured on three inbred Duroc sows and 11 outbred Duroc sows at the Oklahoma Experiment Station. Observations were made on the tenth, twenty-ninth, and forty-eighth days of lactation. Each pig was weighed before he suckled and again immediately after he finished suckling. The difference in weighings being the amount of milk obtained by each pig.

Daily average milk production varied from 1.37 pounds to 5.34 pounds with an average of 3.43 pounds. Sows with larger litters tended to give more milk than sows with smaller litters.

An analysis of variance of the daily milk production disclosed that the variance between inbred and outbred sows on the average is not significant. Also the variance of milk production on the per pig basis between inbred and outbred sows is not significant.

Total milk production of sows and gilts were compared. A comparison was also made of milk produced per pig in the litter. The difference in variation was not significant, according to analysis of variance, in either comparison.

Records on 56 pigs show that they definitely received less milk the second period than the first and still less the third period than the second period. Therefore, the conclusion can be drawn that the ability to utilize feed at an early age would be a decided advantage to the young pigs.

There was a tendency for the same pigs to receive a large or small amount of milk each time he suckled. This indicated that some teats secreted larger quantities of milk than others.

Larger pigs at birth had a tendency to be larger than the rest at 21 days and also at weaning. These pigs with large birth weight also made greater daily gains to 21 days and greater total average daily gains to weaning. Pigs receiving more milk were larger at 21 days and grew faster the first 21 days, however there is no correlation between milk consumption and weaning weight or average daily gain from birth to weaning.

Pigs which made faster gains the first 21 days used less milk per pound of gain than the slower growing pigs.

Each pig was scored at weaning on vigor, health, and thriftiness; quality; length of body; details of conformation; animal as a whole; and market grade. The score of these pigs varied from 23 to 43 with an average score of 35.93. A high correlation existed between the weaning weight and the score at weaning. This indicated that the fastest growing pigs were the better pigs at weaning.

Inbred pigs on inbred sows and inbred pigs on outbred sows received similar amounts of milk and made very similar gains. However, outbred pigs on outbred sows received less milk, but made faster gains than the inbred pigs and weighed more at 21 days and weaning. Outbred pigs also had a higher birth weight than the inbred pigs.

Increased inbreeding seemed to favor a high score at weaning, however the vigor and faster growing ability of outbred pigs seemed to have more influence on the type at weaning than did the decrease in heterozygosity of the inbred pigs.

Much more work must be done on the effect of inbreeding of sows on their milk production before one can formulate any reliable conclusions. Data on a larger number of inbred sows, than was available at the time this experiment was conducted, should be used.

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