THE EFFECT OF INBREEDING
ON THE
LITTER SIZE OF SWINE

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By

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THE EFFECT OF INBREEDING ON THE LITTER SIZE OF SWINE

INTRODUCTION

Livestock breeding is a building process by which animal breeders are constantly improving every kind of domestic animal. One of the most important tools available for the animal breeder in improving livestock is inbreeding. At present there is still a wide difference of opinion among animal breeders as to the merits of inbreeding. Since the time of Robert Bakewell in the middle of the eighteenth century, the process of mating closely related animals has been used to some extent in establishing and improving most of the major breeds of livestock.

It must be recognized, however, that inbreeding has its limitations, and harmful effects are the result in many instances. The degree to which inbreeding can be used depends largely on the skill of the breeder in selecting animals with desirable genes and the intensity of the inbreeding. Intensive selection must be used with inbreeding if beneficial results are to be achieved. Generally inbreeding results in a decline in individual merit, but occasionally an exceptionally good individual is found. The advantages of inbreeding are usually more evident when an individual of one inbred line is crossed with an individual of another inbred line. This combines the desirable genes of the two animals in the offspring,

which in certain instances may be more desirable than either of the parents. The results, however, of crossing inbred lines are not always favorable.

Inbreeding tends to promote homozygosity because it increases the probability of an offspring receiving duplicate genes from both sire and dam. By increasing homozygosis, inbreeding makes many recessive genes homozygous, and therefore selection can be more effective. Homozygosity is the most important factor in prepotency and the breeding worth of an animal is greatly increased if he is prepotent for desirable traits.

Litter size of swine is a slightly hereditary characteristic as recent studies seem to indicate (Lush and Molln, 1942; Stewart, 1945). Inbreeding is a very powerful and useful tool that can be used in breeding for characteristics that are only slightly hereditary because its effects are not limited by the breeder's inability to recognize the effects of environment, dominance, or epistasis for the additive effects of genes.

The size of litter in swine is extremely variable even when comparing females of the same age and breeding, litter mates, or litters from the same female. Many factors, both hereditary and environmental, have an effect on the size of litters of swine, and even though litter size has a heritability of only +.17 (Lush and Molln 1942), inbreeding may be one means of eliminating part of the hereditary variability.

Because of the increasing amount of work that is being done in swine inbreeding and because litter size is so important in any breeding program with swine, this study will be an attempt to show how different degrees of inbreeding affect the litter size.

REVIEW OF PREVIOUS INVESTIGATIONS

Inbreeding in General

Since 1918-19, when Helen D. King reported her studies of inbreeding in rats, there have been many reports on inbreeding experiments of laboratory and farm animals. The reports indicate varying degrees of success in the experiments.

King (1918) stated that rats which were inbred by 25 generations of brother x sister matings were superior to the outbred control rats in fertility and average size of litters born. King concluded that inbreeding in rats had little if any harmful effect on sex ratio, fertility, size of litters born, and vigor when care was taken in selecting breeding stock and controlling the environment.

Wright (1922) reported after thirteen years of inbreeding guinea pigs by brother-sister matings that there was, in general, a marked decline in frequency and size of litters, percentage born alive, and percentage raised to weaning in the inbred stock as compared to the non-inbred control stock from the same foundation. Among the inbred stock, there were several families that had not apparently suffered any great

degeneration. Wright was not able to determine just how much of the decline in his inbred stock was due to inbreeding and how much was due to environmental conditions, but concluded that about 90 per cent of the variations in litter size was due to external conditions.

Eaton (1940), reporting on his studies of inbreeding in mice, found that on the average the random bred strains were superior to the inbred strains in percentage of successful matings, size of litters, and number raised to 120 days of age. Although one or more lines of inbred mice were equal, or superior, to the random bred mice in all respects except size of litters.

According to Hays (1934), apparently nothing is to be gained from the standpoint of fecundity by inbreeding poultry. From experiments at the Regional Poultry Research Laboratory, Waters (1945) concluded that there need be no decrease in hatchability because of inbreeding if rigid selection is maintained. Knox (1946), working at the Beltsville, Maryland Station, also reported that inbred strains of poultry could be raised without a decrease in hatchability, fertility, mature body weight, or annual egg production, when care was taken in selecting the birds for the inbreeding program.

Several reports of experiments in inbreeding dairy cattle have been made during the past 28 years, but the aims of the experiments have been to find the effects of inbreeding on milk production, mature body weight, size at birth, and type rather than on fertility or fecundity. Since the results

of the experiments have no direct bearing on this study, no further mention will be made of them.

Inbreeding experiments with sheep have also been reported a number of times since 1920, but their purpose has not been to find the effects of inbreeding on fertility in most instances. Ritzman and Davenport (1931) studied the effects of inbreeding on fertility in sheep. They summed up their work by saying,

> It appears that in most families of sheep there is a general tendency toward decadence. However, there occasionally appears an outstanding individual in a family, but the inferior animals usually outnumber the good ones.

Winters et al (1943) have maintained a closed flock of sheep since 1936 and report that they have improved the flock in appearance as a commercial flock by mild inbreeding and intensive selection.

Inbreeding in Swine

Swine have been the farm animals used most extensively by animal breeders in their study of the effects of inbreeding.

Hays (1919) made a report on a swine inbreeding program that was started at the Delaware Experiment Station in 1908 and continued until 1918. His results showed that inbreeding caused a decrease in certainty of pregnancy, size of litters, and an increase in mortality rate.

After King (1918) and Wright (1922) reported the results of their studies on inbreeding, many animal breeders again

recognized the possibility of utilizing inbreeding effectively in animal improvement and soon several experiments on inbreeding farm animals began.

In 1922 the U.S. Bureau of Animal Industry initiated inbreeding experiments with the Chester White, Poland China, and Tamworth breeds. Retzer et al (1940) reported the results from the Chester White inbreeding experiment. As a consequence of inbreeding through seven generations, the general trend in size of litters at birth, 28 days, and 70 days was downward. The differences in the inbreeding of the litters seemed to have had a greater effect on litter size at the various ages than did differences in the inbreeding of their sires and dams. There was also a tendency for litter size to increase with an increase in age of dam to about 3½ years, after which it remained practically constant to the age of 5½ years. The inbreeding experiment with Poland China swine had to be discontinued after the second generation due to decrease in litter size, high mortality, and excessive proportion of males in the inbred lines. The inbred lines of Tamworths had to be discontinued after the fourth generation due to lack of fecundity.

Godbey and Starkey (1932) inbred Berkshire swine for five years and found no correlation between the coefficient of inbreeding and birth weight of pigs, but found a negative correlation between degree of inbreeding and weaning weight of pigs.

Hughes (1933) also inbred Berkshire swine at the California Experiment Station. His results do not agree with

other workers in some respects. He practiced brother x sister mating without loss in vigor or size of litters farrowed, although there was a slight but general decrease in litter size after 1923 which he attributed partially to the fact that the litters were the first from the sows being studied. The eighteen inbred litters farrowed after 1922 averaged 1.64 pigs more per litter than the 71 litters farrowed between 1919 and 1926 in the Berkshire herd maintained by the college.

Hodgson (1935) started seven inbred lines of Poland China swine in 1924 at the Southeast Experiment Station of the University of Minnesota, located at Waseca, Minnesota. Three of the lines were lost in the first generation and one in the third generation. The other three lines were developed into highly inbred lines by brother x sister matings during five, six, and eight generations. Two of the lines could probably be successfully carried on indefinitely. Hodgson reported difficulty in obtaining matings between some of the litter mates, and smaller litter size and greater mortality among the inbreds than among the outbreds.

Willham and Craft (1939) reported the following results as obtained after eight generations of approximately half brother x half sister matings in Duroc Jersey swine at the Oklahoma Experiment Station:

1. The inbred litters decreased from 8.9 pigs in the first generation to 5.3 pigs in the eight generation. The control stock of outbred litters showed no decrease during

the same period and averaged 9.3 pigs per litter.

2. There was no appreciable difference in the number of stillborn pigs in either group.

3. The inbred sows weaned on the average 2.3 fewer pigs than the outbred sows.

4. The percentage of pigs surviving to weaning decreased as the percentage of inbreeding increased. In the first generation of inbreeding, 76 per cent of the pigs reached weaning age; in the eighth generation, only 44 per cent of the pigs reached weaning age.

5. The inbred sows bred just as regularly as the outbred sows.

6. Mortality rate during growing and fattening period was highest in the inbred group.

Winters et al (1943) reported the following concerning the swine inbreeding program started at the Minnesota Experiment Station in 1937:

1. With no change in the inbreeding of the litter, each additional one per cent increase of inbreeding in the sow was accompanied by a decrease of 0.058 pigs born alive per litter.

2. Rate of gain between weaning and the 200 pound weight decreased as the per cent of inbreeding increased.

3. There was a definite tendency for the offspring of each generation to revert to a performance lower than that of the parents and toward the population mean.

Stewart (1945), studying the records of 749 inbred Poland

China and Minnesota No. 1 gilts farrowing the first time at approximately one year of age, found that litter size increased with an increase in age of dam at farrowing, with the greatest effect of age being shown in the period prior to twelve months. Gilts farrowing at 320 days averaged one pig less and those farrowing at 410 days about one-half pig more than those farrowing at one year. Stewart also found that litter size decreased with an increase in the inbreeding of the dam but apparently was unaffected by the inbreeding of the litter. An increase of ten per cent in the inbreeding of the dams of the same age resulted in an averabe decrease of about 0.6 pigs per litter. Stewart (1945) also reported studies on repeatability and heritability of prolificacy in swine. The mean estimate of heritability, determined by three different methods, was 13.6 per cent for live pigs farrowed and 14.5 per cent for total pigs farrowed. The estimates of repeatability were 12.8 per cent for live pigs and 15.3 per cent for total pigs farrowed. These estimates of heritability are approximately the same as those reported by Lush and Molln (1942) and are well within the range of estimates of heritability of 0.10 to 0.44 as reported by Lush and Molln (1942) in their review of previous studies on the subject.

OBJECTIVES OF INVESTIGATION

This study was undertaken as an attempt to determine the effects of age and inbreeding of dam and inbreeding of off-

spring on mortality rate, number of stillborn pigs, and litter size at birth, 21 days, 56 days, and 180 days of age.

SOURCE OF DATA AND METHODS OF PROCEDURE

The data used in this study were taken from the Oklahoma swine breeding project conducted in cooperation with the Regional Swine Breeding Laboratory of the U. S. Department of Agriculture. The data were gathered over a period of ten years, 1937 to 1946, inclusive, and included records of all litters reaching 180 days of age during that period. There were 573 litters farrowed in five inbred lines and a number of out-crosses of purebred Duroc swine. The inbreeding experiment on Duroc swine was started in 1923 by W. A. Craft, and part of the animals reported in this study are descendants of inbred stock from this earlier experiment.

Three inbred lines were started in 1937, one in 1938, and one in 1942. One line (line 2) was discarded in 1941 due to low fecundity and high mortality. A second line (line 4) was culled in 1943 because of a high incidence of inverted nipples in the line.

In 1945, one line (line 1) was out-crossed to unrelated, inbred individuals and a new line (line 7) was established from this cross.

During the period from 1937 to 1946 several boars and sows from other herds were brought into the herd for introduction into existing lines or to be used as foundation stock for new lines.

The inbreeding program has been a flexible one with no fixed rate of advancement of inbreeding in any of the lines. In some lines the inbreeding has been advanced very rapidly, and in others very slowly. Occasional out-crosses have been made in some of the lines and many crosses between lines have been made in testing the performance of the lines. Intensive selection has been practiced whenever possible, but at times there was little chance for selection because of small litters, high mortality, or physical defects.

Rations and management have been standardized insofar as practical. Sows were placed in the central farrowing house a few days previous to farrowing. Within a few days after farrowing, the sows and litters were hauled from the farrowing house to individual houses on temporary pasture which had not been used by hogs for two years. Each season four pigs from each of sixteen litters were fed a standard ration in a small, dry lot, from weaning to 225 pounds. The remainder of the pigs were fed in self feeders in pasture plots or dry lots.

Records were maintained on each pig farrowed on the standard forms of the Regional Swine Breeding Laboratory. Each pig was identified soon after birth by an individual ear mark. For the purposes of this study litter records were available on the total number of pigs born, number of pigs born alive, and number of pigs alive at 21 days, 56 days, and 180 days.

The 573 litters in this report were classified six

different ways for study and statistical analysis. One group of 122 non-inbred litters from non-inbred sows was used as a control group for comparisons. These non-inbred sows included a number of foundation sows of the inbred lines and other sows which were purchased from other herds. The age of these sows ranged from one to four and one-half years.

Two classifications were made according to the coefficient of inbreeding of the sows. One included all of the 573 litters studied. The inbreeding of the litters and age of the sow were disregarded. The other group contained 262 non-inbred litters from sows with coefficients of inbreeding ranging from .0005 to .5350. Two other classifications were made according to the inbreeding of the litters. One contained all 573 litters. The inbreeding and age of the dams were disregarded. The second group was made up of 234 inbred litters from non-inbred sows. The last two classifications were made according to the age of the sows. One group contained all litters studied. The inbreeding of dams and litters was disregarded. The second grouping was made up of 122 non-inbred litters from non-inbred sows.

The inbreeding coefficients used in this study were computed according to the formula devised by Wright (1922).

A series of multiple regression equations with partial regression coefficients were worked out on the entire group of litters studied. International Business Machines were used for most of the machine computations.

RESULTS OF INVESTIGATION

A Comparison Between Non-inbred and Inbred Sows Producing Non-inbred Litters

In Table I, comparisons were made between litter sizes of 122 non-inbred litters from non-inbred sows and 140 non-inbred litters from inbred sows. The 140 non-inbred litters were farrowed by sows that had a coefficient of inbreeding ranging from .0050 to .5350. Classification of sows was made according to their per cent of inbreeding. Differences in ages of sows were not taken into consideration because all groups contained sows of varying ages.

Table I. Effect of Inbreeding of the Sow on Litter Size of Non-Inbred Litters

Per cent Inbreeding of Dam	No. Litters Farrowed	Average No. of Pigs Per Litter				Ave. No. Stillborn Pigs Per Litter
		Birth	21 Days	56 Days	180 Days	
0	122	9.9	6.9	6.8	6.3	.74
1-5	18	9.1	7.1	7.0	6.8	.39
6-10	16	9.1	7.1	6.8	6.4	.44
11-15	18	8.3	6.8	6.7	6.2	.22
16-20	11	8.1	6.6	6.4	5.9	.00
21-25	5	8.0	6.4	6.4	5.2	.20
26-30	9	7.6	6.3	6.2	5.9	.67
31-35	15	8.8	6.1	5.9	5.5	.55
36-40	10	10.3	7.1	6.8	6.7	.60
41-45	29	8.6	7.5	7.3	6.2	.28
46-50	7	8.7	5.6	5.4	4.4	1.14
41-55	2	7.5	6.5	6.5	5.5	.00
Inbred Sows	140	8.7	6.8	6.7	6.1	.39
Total	262	9.2	6.9	6.7	6.2	.55

The average size of litters farrowed by the non-inbred sows was larger than the average litter size of all classes of inbred sows except the group inbred 36 to 40 per cent. The average size of the ten litters farrowed by the sows inbred 36 to 40 per cent was 0.4 pig larger than the litters from non-inbred sows. The average size of the 122 litters from non-inbred sows was 1.2 pigs larger than the 140 litters from inbred sows. The sows inbred 51 to 55 per cent farrowed the smallest litters but they were only 0.1 pig smaller than the average of the litters from sows inbred 26 to 30 per cent. There was a steady decline in size of litters farrowed as the inbreeding of the sows increased from 0.5 to 31.0 per cent. At that point, an increase in litter size began and reached a peak when the sows were inbred 36 to 40 per cent as shown by Figure I.

There was only 0.1 pig difference in litter size at 21 days in favor of the non-inbred sows. The general trend for litter size at 21 days was slightly downward as the inbreeding of the sows increased from 0.5 to 36.0 per cent. The average litter size at 21 days from sows inbred 36 to 40 per cent showed an increase of 1.0 pig per litter over litters from sows inbred 31 to 36 per cent. The largest litter size at 21 days (7.5 pigs) was produced by sows which were inbred 41 to 45 per cent. This was 0.6 pig larger than the average of the litters from non-inbred sows and 0.7 pig larger than the average litter size of all inbred sows. The trend of litter size at 56 days was practically identical with that at 21 days

as shown by Figure I. The average litter size of all litters from non-inbred sows was only 0.1 pig larger than that of all litters from inbred sows. At 100 days, the average litter size of non-inbred sows was 0.2 pig larger than litters from inbred sows. The trend of litter size was downward as inbreeding of dams increased from 0.5 to 25.0 per cent. At that point an increase in litter size began as inbreeding of the dams increased. The peak of 6.7 pigs per litter at 130 days was reached when the sows were inbred 36 to 40 per cent. Figure I shows the decline in litter size at 130 days was sharp after the inbreeding of dam reached 36 to 40 per cent. The only exception was for the limited number of sows inbred over 51 per cent.

The litters from non-inbred sows contained 0.74 stillborn pigs per litter as against 0.39 for litters from inbred sows. There was a definite tendency for the more highly inbred sows to farrow more stillborn pigs.

Table II gives a comparison of livability between the group of 132 non-inbred litters from non-inbred sows and 140 non-inbred litters from inbred sows.

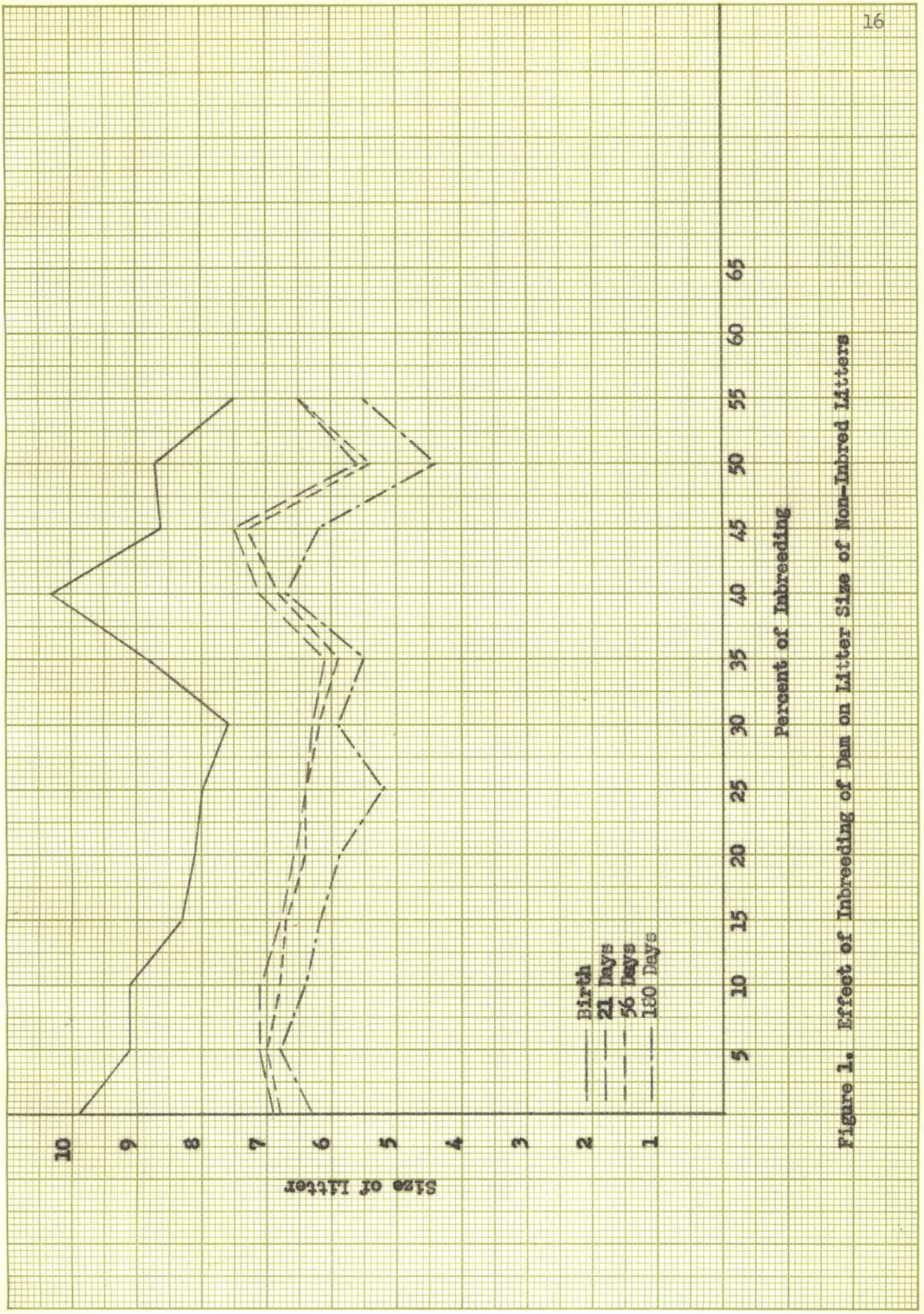

Figure 1. Effect of Inbreeding of Dam on Litter Size of Non-Inbred Litters

Table II. Effect of Inbreeding of Dam on Livability of Non-Inbred Litters

Percent of Inbreeding of Dam	Total Number of pigs Farrowed	Percent of Pigs Alive			Percent of Stillborn Pigs per litter
		21 Days	56 Days	180 Days	
0	1203	70.3	68.5	63.6	7.5
1-5	163	78.5	77.3	74.9	4.3
6-10	146	78.1	74.0	70.6	4.8
11-15	150	81.3	80.0	74.7	2.7
16-20	89	80.9	78.7	73.0	0.0
21-25	40	80.0	80.0	65.0	2.5
26-30	68	83.8	82.3	77.9	8.8
31-35	132	69.7	67.4	62.1	6.1
36-40	103	68.9	66.0	65.1	5.8
41-45	248	87.1	85.1	72.6	3.2
46-50	61	63.9	62.3	50.8	13.1
51-55	15	86.7	86.7	73.3	0.0
Inbred Sows	1215	78.7	76.6	70.1	4.5
Total	2418	74.7	72.6	66.9	6.0

There were 1203 non-inbred pigs farrowed by non-inbred sows as compared to 1215 non-inbred pigs from inbred sows. At 21 days 78.7 per cent of the pigs farrowed by inbred sows were alive as compared to 70.3 per cent from the non-inbred sows. Livability of pigs from only three classes of inbred sows was lower than these from non-inbred sows. All three classes were farrowed by sows inbred over 31 per cent. Livability was highest for the pigs from the 41 to 45 and 51 to 55 per cent inbred sows. The livability of pigs at 56 days was 8.1 per cent higher for inbred sows than non-inbred sows. The trend of livability at 56 days was the same as it was at

21 days. The pigs from inbred sows had a livability of 70.1 per cent at 180 days as compared to 63.6 per cent for pigs from non-inbred sows. Livability for pigs from only two classes of inbred dams was lower than that for pigs from non-inbred dams. The lowest livability was 50.8 per cent for pigs farrowed by sows inbred 46 to 50 per cent.

The percentage of stillborn pigs was higher for non-inbred sows than for inbred sows, but among the inbred sows there was a tendency for a greater percentage of stillborn pigs to be farrowed by the highly inbred sows.

A Comparison Between Non-inbred and Inbred Sows Producing Both Inbred and Non-inbred Litters

In Table III the dams are classified according to the percentage of inbreeding. The average litter size at four different ages is shown for all litters (both inbred and non-inbred) from these dams. There were 234 litters from non-inbred sows and 339 litters from inbred sows which ranged in coefficient of inbreeding from .005 to .535. No allowance was made for differences in age of sow or inbreeding of litters from the sows in the different classes.

Table III. Effect of Inbreeding of Dam on Litter Size

Per cent Inbreeding of Dam	No. Litters Farrowed	Average No. of Pigs Per Litter				Ave. No. Stillborn Pigs Per Litter
		Birth	21 Days	56 Days	180 Days	
0	234	9.2	6.5	6.2	5.6	.60
1-5	40	9.3	7.1	6.9	6.3	.35
6-10	48	9.7	6.6	6.2	5.7	.85
11-15	49	8.4	6.4	6.1	5.4	.45
16-20	39	8.3	6.5	6.3	5.7	.26
21-25	28	8.6	6.0	5.6	4.5	.29
26-30	26	7.9	5.8	5.7	5.2	.50
31-35	25	8.8	5.6	5.5	4.7	.52
36-40	26	9.4	5.3	5.0	4.4	.81
41-45	43	8.6	7.1	6.9	5.6	.35
46-50	12	8.1	5.4	5.1	3.6	.75
51-55	3	8.0	6.7	6.7	6.0	.00
Inbred Dams	339	8.8	6.4	6.1	5.3	.49
Total	573	9.0	6.4	6.2	5.4	.53

The average size of the litters from non-inbred sows was larger than the average of all inbred sows at birth, 21 days, 56 days, and 180 days. The litters from sows inbred up to 11 per cent were larger at birth and all ages than the average of the litters from non-inbred sows. The sows inbred 36 to 40 per cent also farrowed 0.2 pig larger litters than the non-inbred sows. At 21 days, the litters from sows inbred 16 to 20 per cent were slightly larger than litters from non-inbred sows. The litters from sows inbred 41 to 45 per cent were 0.6 pig larger than litters from non-inbred sows. The litters from sows inbred 51 to 55 per cent were larger than the litters from non-inbred sows at 21 days and maintained a slight advan-

tage at 56 and 180 days.

The average number of stillborn pigs per litter was 0.49 for litters from all inbred sows and 0.60 for litters from non-inbred sows. The highly inbred sows had a tendency to farrow more stillborn pigs than sows which were inbred less than 25 per cent, although the six to ten per cent inbred sows farrowed more stillborn pigs than any other group.

The trend at all ages, as shown in Figure II, was for average litter size to remain fairly constant for sows inbred up to ten per cent. Average litter size of sows inbred 11 to 15 per cent began a decline that reached a low of 7.9 pigs farrowed per litter for sows inbred 26 to 30 per cent. The peak for litter size of all inbred sows was for sows inbred 36 to 40 per cent. The peak at 21 and 56 days was reached by litters from sows inbred 41 to 45 per cent.

Table IV gives a comparison of livability of litters from non-inbred sows and inbred sows. Comparisons were made between groups containing all litters farrowed. Differences in ages of sows and inbreeding of litters were not considered.

Table IV. Effect of Inbreeding of Dam on Livability of Pigs

Percent of Inbreeding of Dam	Total Number of pigs Farrowed	Percent of Pigs Alive			Percent of Stillborn Pigs per litter
		21 Days	56 Days	180 Days	
0	2156	70.2	67.5	61.0	6.5
1-5	371	76.8	74.1	67.7	3.8
6-10	464	67.9	64.4	58.6	8.8
11-15	411	76.2	73.0	64.5	5.4
16-20	325	78.2	75.4	68.0	3.1
21-25	240	70.4	65.0	52.9	3.3
26-30	205	73.7	72.2	65.9	6.3
31-35	220	64.1	62.7	53.6	5.9
36-40	243	56.4	53.5	46.5	8.6
41-45	370	83.0	80.3	64.9	4.1
46-50	97	67.0	62.9	44.3	9.3
51-55	24	83.3	83.3	75.0	0.0
Inbred Dams	2970	72.6	69.7	62.8	5.6
Total	5126	71.6	68.8	60.9	6.0

The livability was slightly lower at 21, 56, and 180 days for 2156 pigs farrowed by non-inbred sows than the average of 2970 pigs farrowed by inbred sows. At 21 days, the livability of pigs farrowed by sows inbred six to ten, 31 to 40, and 46 to 50 per cent was lower than the livability of pigs farrowed by non-inbred sows. The pigs from sows inbred 36 to 40 per cent had the lowest livability of all groups at all ages. The livability at 56 days was highest for pigs from sows inbred 41 to 45 and 51 to 55 per cent. At 180 days, the livability was highest for pigs from 51 to 55 per cent inbred sows.

The percentage of stillborn pigs from non-inbred sows was 6.7 per cent as compared to an average of 5.6 per cent for pigs

Figure 11. Effect of Inbreeding of Dam on Litter Size of Non-Inbred and Inbred Litters

farrowed by inbred sows. The highest percentage of stillborn pigs was farrowed by sows inbred 46 to 50 per cent, followed closely by the six to ten per cent inbred sows.

Comparisons between Non-Inbred Litters and Inbred Litters from Non-inbred Sows

Table V gives the comparisons between litter sizes at different ages of 122 non-inbred litters from non-inbred sows and 112 inbred litters from non-inbred sows. The coefficient of inbreeding of the litters range from .0050 to .3750. The ages of the sows was disregarded because sows of different ages farrowed litters in all groups.

Table V. Effect of Inbreeding of Litters on Size of Litters from Non-inbred Sows

Per cent Inbreeding of Dam	No. Litters Farrowed	Average No. of Pigs Per Litter: Birth	21 Days	56 Days	180 Days	Ave. No. Stillborn Pigs Per Litter
0	122	9.9	6.9	6.8	6.3	.74
1-5	5	6.6	5.6	5.6	5.2	.00
6-10	15	9.5	7.1	6.6	6.3	.40
11-15	22	8.9	6.1	5.7	5.3	.82
16-20	29	7.8	5.9	5.6	4.9	.24
21-25	34	8.6	5.2	5.0	4.0	.56
26-30	5	9.4	7.8	6.8	4.2	.00
31-35	1	9.0	8.0	8.0	7.0	.00
36-40	1	7.0	6.0	6.0	5.0	.00
Inbred Litters	112	8.5	6.0	5.6	4.9	.45
Total	234	9.2	6.5	6.2	5.6	.60

The average litter size of non-inbred litters was larger at birth by 1.4 pigs, at 21 days by 0.9 pig, at 56 days by

1.2 pigs, and at 180 days by 1.4 pigs than the average of the inbred litters. No group of inbred litters was as large at birth as the non-inbred litters. At 21 days, the group of litters inbred six to ten per cent was 0.2 pig larger than the average of the non-inbred litters. The group of litters inbred 26 to 30 per cent averaged 0.9 pig larger than the non-inbred litters. The litter inbred 31 to 35 per cent was 1.1 pig larger than the average of the 122 non-inbred litters and remained larger at 56 and 180 days. Only the group of litters inbred six to ten per cent and the one litter inbred 31 to 35 per cent was larger than the average of the non-inbred group at 180 days.

The average number of stillborn pigs in the non-inbred litters was .74 as compared to .45 for the inbred litters.

Table VI gives a comparison of livability of non-inbred and inbred litters farrowed by non-inbred sows. Differences in age of the sows was not taken into account.

Table VI. Livability of Pigs Farrowed by Non-inbred Sows

Percent of Inbreeding of Litters	Total Number of pigs Farrowed	Percent of Pigs Alive			Percent of Stillborn Pigs per litter
		21 Days	56 Days	180 Days	
0	1203	70.3	68.5	63.6	7.5
1-5	33	84.9	84.9	78.8	0.00
6-10	142	74.7	69.7	66.9	4.2
11-15	196	67.9	64.3	59.7	9.2
16-20	226	76.1	71.3	63.3	3.1
21-25	293	60.1	58.0	46.8	6.5
26-30	47	83.0	72.3	44.7	0.0
31-35	9	88.9	88.9	77.8	0.0
36-40	7	85.7	85.7	71.4	0.0
Inbred Litters	953	70.1	66.3	57.8	5.3
Total	2156	70.2	67.5	61.0	6.5

Figure 111. Effect of Inbreeding of Litter on Litter Size of Litters from Non-Inbred Sows

The livability of 1203 non-inbred pigs was very little higher than that of 953 inbred pigs at 21 days. Only two classes of inbred pigs had a smaller livability than the non-inbred pigs at 21 days. The livability of non-inbred pigs at 56 days was 68.5 per cent as compared to 66.3 per cent for inbred pigs. Only the groups inbred 11 to 15 and 21 to 25 per cent had lower livability than the average of the non-inbred group. At 180 days, the livability of the non-inbred group was 5.8 per cent larger than the average of the inbred groups. The four groups of litters inbred 11 to 30 per cent had lower livability than the non-inbred group.

The average percentage of stillborn pigs was 5.3 per cent for the inbred groups and 7.5 per cent for the non-inbred group.

Comparison Between Non-inbred and Inbred Litters From All Sows

Table VII shows the effect of inbreeding of litters on litter size when the inbreeding and age of dam were disregarded. The comparison was made between 262 non-inbred litters from inbred and non-inbred sows and 311 inbred litters of various degrees of inbreeding from inbred and non-inbred sows.

Table VII. Effect of Inbreeding of Litter on Litter Size

Per cent Inbreeding of Litters	No. Litters Farrowed	Average No. of Pigs Per Litter: Birth	21 Days	56 Days	180 Days	Ave. No. Stillborn Pigs Per Litter
0	262	9.2	6.9	6.7	6.2	.55
1-5	25	8.0	5.9	5.6	5.0	.08
6-10	43	9.6	6.9	6.5	5.9	.47
11-15	45	9.5	6.5	6.2	5.3	.73
16-20	57	7.6	5.7	5.3	4.8	.30
21-25	60	8.9	5.3	5.1	4.2	.80
26-30	24	8.9	7.1	6.5	5.5	.50
31-35	12	10.0	6.6	6.5	5.1	.42
36-40	8	8.3	5.9	5.8	4.0	.63
41-45	21	8.7	5.6	5.5	4.2	.67
46-50	8	7.5	5.1	4.8	3.3	.13
51-55	6	6.7	3.8	3.7	1.7	.50
56-60	2	9.0	7.5	5.5	3.5	.50
Inbred Litters	311	8.7	6.0	5.7	4.8	.52
Total	573	9.0	6.4	6.2	5.4	.53

The average size of the non-inbred litters was 0.5 pig larger than the average of the inbred litters at birth. At 21 days, the non-inbred litters averaged 0.9 pig larger than the inbred litters. The average of the non-inbred litters was 1.0 pig larger than the inbred litters at 56 days. At 180 days, the non-inbred litters were 1.4 pigs larger than the average of the inbred groups. Number of stillborn pigs per litter was .55 for the non-inbred group as compared to .52 for the inbred litters.

At birth, three groups of inbred litters were larger than the average of the non-inbred litters. The group of litters inbred six to ten per cent was 0.4 pig larger, and the group inbred 31 to 35 per cent averaged 0.8 pig more per litter than

the non-inbred group. The average of the litters inbred 51 to 55 per cent was the smallest of all groups and was 2.5 pigs smaller than the average of the non-inbred group. At 21 days, the group of litters inbred 26 to 30 per cent was 0.2 pig larger than the average of the non-inbred group. The two litters inbred 56 to 60 per cent averaged 0.6 pig larger than the non-inbred litters. The smallest average litter size, 3.8 pigs, was for the litters inbred 51 to 55 per cent. None of the groups of inbred litters were as large at 56 and 180 days as the average of the non-inbred groups.

Figure IV shows the general downward trend of litter size at all ages as the coefficient of inbreeding of the litters increased.

Table VIII shows the effect of inbreeding of litters on livability. Comparisons were made between the livability of 2418 non-inbred pigs and 2708 inbred pigs whose coefficient of inbreeding ranged from .0050 to .5800. Inbreeding and age of sows were disregarded.

Table VIII. Effect of Inbreeding of Litter on Livability of Pigs

Percent of Inbreeding of Litters	Total Number of pigs Farrowed	Percent of Pigs Alive			Percent of Stillborn Pigs per litter
		21 Days	56 Days	180 Days	
0	2418	74.5	72.6	66.9	6.0
1-5	201	73.6	69.7	62.7	1.0
6-10	413	71.4	67.6	62.0	4.8
11-15	429	68.3	65.0	55.9	7.7
16-20	431	74.9	69.8	63.1	3.9
21-25	534	59.4	56.9	47.2	9.0
26-30	214	79.9	73.4	61.7	5.6
31-35	120	65.8	65.0	50.8	4.2
36-40	66	71.2	69.7	48.5	7.6
41-45	182	64.3	63.2	48.4	7.7
46-50	60	68.3	63.3	43.3	1.7
51-55	40	57.5	55.0	25.0	7.5
56-60	18	83.3	73.3	46.7	5.6
Inbred Litters	2708	69.0	65.4	55.5	6.0
Total	5126	71.6	68.8	60.9	6.0

The livability of non-inbred pigs was higher at 21 days, 56 days, and 180 days than that of inbred pigs. Only the groups of pigs inbred 16 to 20, 26 to 30, and 56 to 60 per cent had a higher rate of livability at 21 days than the non-inbred group. The groups of pigs inbred 26 to 30 and 56 to 60 per cent had a higher livability rate than the non-inbred pigs at 56 days. None of the inbred groups had as high a survival rate to 180 days as did the non-inbred group.

The percentage of stillborn pigs was the same in the inbred and non-inbred litters.

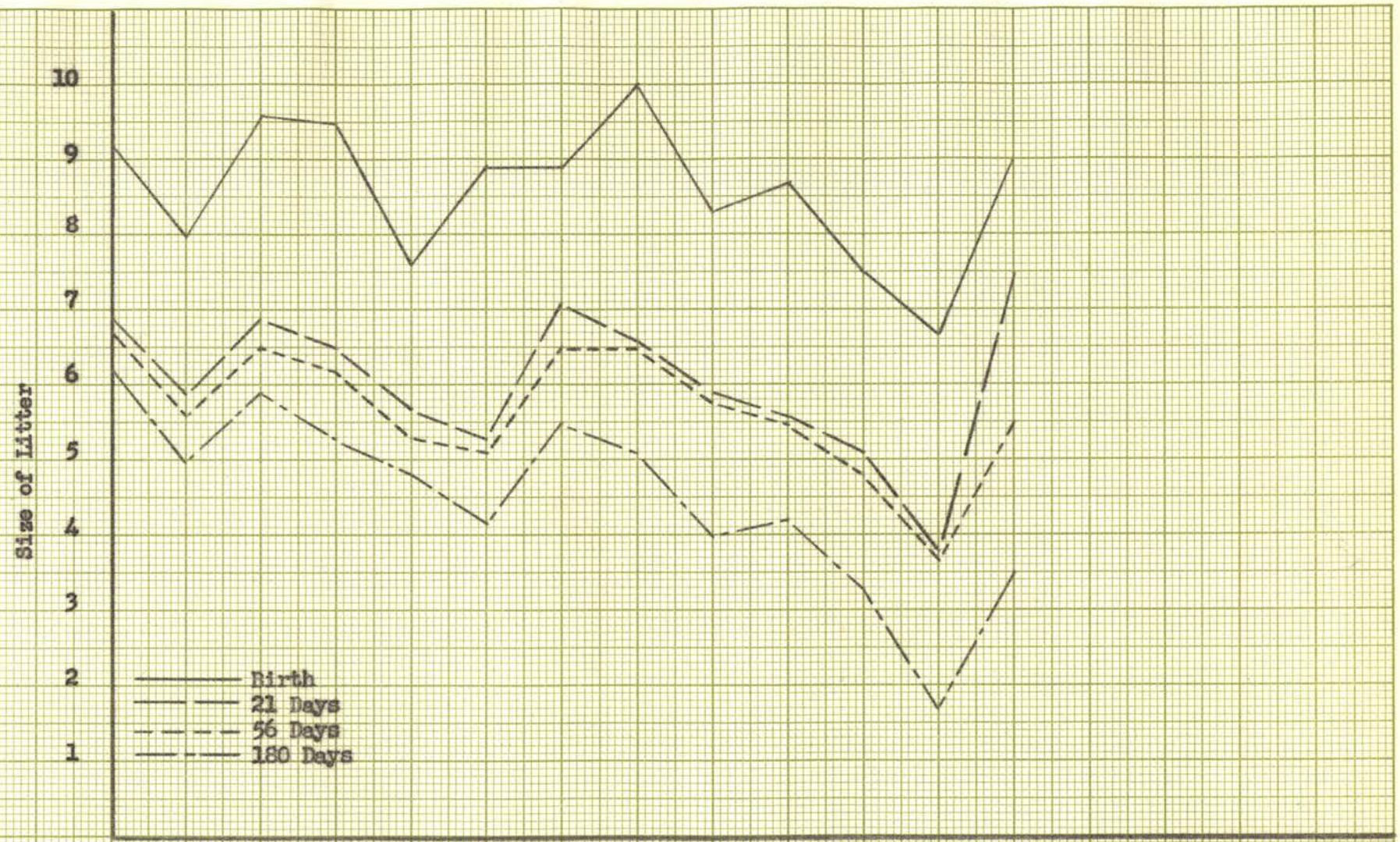

Figure IV. Effect of Inbreeding of Litter on Litter Size

The Effect of Age of Sow on Litter Size

The effect of age of sows on litter size is shown in Table IX. Only non-inbred litters from non-inbred sows were included in this table. Sows ranged in age from one to four years.

Table IX. Effect of Age of Sow on Litter Size of Non-inbred Litters from Non-inbred Sows

Age of Sow (years)	No. of Litters Farrowed	Average No. of Pigs Per Litter: Birth	21 Days	56 Days	180 Days	Ave. No. Stillborn Pigs Per Litter
1.0	51	8.8	6.8	6.6	6.0	.67
1.5	34	9.4	7.0	6.9	6.4	.29
2.0	22	11.6	7.2	6.9	6.5	1.09
2.5	10	11.5	7.5	7.3	6.9	1.30
3.0	2	12.5	6.5	6.5	6.5	.50
3.5	2	14.5	5.0	4.5	4.5	3.50
4.0	1	12.0	6.0	6.0	6.0	1.00
Total	122	9.9	6.9	6.8	6.3	.74

The number of pigs farrowed per litter steadily increased as the sow increased in age up to 3.5 years. The small number of litters farrowed by sows over 2.5 years of age cannot be used as an accurate measure of sows productivity at those ages. The steady increase in number of pigs farrowed as the age of dam increases up to 4.0 years of age agrees with the finding of other workers.

The number of pigs in each litter at 21, 56, and 180 days increases with the age of the dam until she reaches 2.5 years. Beginning with 3.0 years, the size of litters at 21,56, and

180 days falls off as the age of the dam increases. The small number of sows used in this study that were 3.0 years old or over cannot be used as an accurate measure for making any inferences about litter sizes from aged sows. In a study of this same herd, Laben (1947) observed that the sows retained in the herd after one and one-half years of age were intensely selected on the basis of their previous production. The large litters produced by sows over 1.5 years of age is probably a partial result of this selection.

Table X. Effect of Age of Sow on Livability of Non-inbred Litters from Non-inbred Sows

Age of Sow (years)	Total Number of pigs Farrowed	Percent of Pigs Alive			Percent of Stillborn Pigs per Litter
		21 Days	56 Days	180 Days	
1.0	446	77.6	74.9	68.8	7.6
1.5	320	74.4	73.8	68.1	3.1
2.0	256	61.7	59.8	65.9	9.4
2.5	115	65.2	63.5	60.0	11.3
3.0	25	52.0	52.0	52.0	4.0
3.5	29	34.5	31.0	31.0	24.1
4.0	12	50.0	50.0	50.0	8.3
Total	1203	70.3	68.5	63.6	7.5

The percentage of pigs alive at all ages was highest for pigs farrowed by 1.0 year old sows. There was a steady decline in livability of pigs at all ages as the age of the sow increased.

The percentage of stillborn pigs increased as the age of the dam increased, except for the one litter from a 4.0 year old sow. An accurate comparison cannot be made between the single litter from the 4.0 year old sow and the average of

several litters from sows of other ages.

Table XI shows the effect of age of sow on litter size when no consideration was given to the effect of inbreeding of dam and litters.

Table XI. Effect of Age of Sow on Litter Size

Age of Sow (years)	No. of Litters Farrowed	Average No. of Pigs Per Litter: Birth	21 Days	56 Days	180 Days	Ave. No. Stillborn Pigs Per Litter
1.0	233	7.9	6.1	5.8	5.1	.45
1.5	160	8.7	6.4	6.2	5.5	.31
2.0	90	10.5	6.9	6.6	5.9	.79
2.5	50	11.0	6.9	6.7	6.2	.84
3.0	24	9.9	5.9	5.8	5.1	1.04
3.5	10	9.7	6.7	6.5	6.3	1.00
4.0	6	9.5	7.0	6.8	5.0	.67
Total	573	9.0	6.4	6.2	5.4	.53

The average size of litters at birth, 21, 56, and 180 days increased as the age of the sow increased from 1.0 to 2.5 years. At birth, a decline in litter size began when sows reached 3.0 years of age, and continued through 3.5 and 4.0 years. The size of litters at 21 days from 3.0 year sows was lowest of all classes. The litters from 3.5 year sows were only 0.2 pig smaller than those from 2.0 and 2.5 year sows. The litters from 4.0 year sows were larger than any other groups. At 56 days, the litters from 1.0 year sows were smallest, and those from 4.0 year sows were the largest. The litters from 4.0 year sows were smallest at 180 days, and those from 3.5 year sows were the largest.

The average number of stillborn pigs per litter had a

tendency to increase as the age of the sows increased.

Table XII gives the comparisons between livability of pigs farrowed by sows of different ages. Inbreeding of dams and litters was not taken into consideration in this part of the study.

Table XII. Effect of Age of Sow on Livability of Pigs

Age of Sow (years)	Total Number of pigs Farrowed	Percent of Pigs Alive			Percent of Stillborn Pigs per Litter
		21 Days	56 Days	180 Days	
1.0	1849	77.1	73.2	63.9	5.6
1.5	1391	74.0	71.4	63.3	3.6
2.0	945	65.7	63.3	56.3	7.5
2.5	550	62.7	60.7	56.2	7.6
3.0	237	59.9	59.1	51.5	10.6
3.5	97	69.1	67.0	65.0	10.3
4.0	57	73.7	71.9	52.6	7.0
Total	5126	71.6	68.8	60.9	6.0

The livability of pigs at 21 days decreased as the sows increased in age from 1.0 to 3.0 years. An increase in livability of pigs at 21 days began for those pigs from 3.5 year sows and continued for the group of pigs from 4.0 year sows.

At 56 days, the per cent of pigs alive followed the same pattern as that for pigs at 21 days.

The trend of survival rate at 180 days was downward as the age of sows increased, except for the 3.5 year sows. The percentage of pigs alive at 180 days was slightly higher for the 3.5 year sows than for any other age group.

The per cent of stillborn pigs increased as sows grew older. The only exception was for the 4.0 year sows. The

small number of pigs farrowed by 4.0 year sows does not make a good comparison.

Regression Study

A regression study was made of the effects of inbreeding and age of dam and inbreeding of offspring on litter size at birth, 21 days, 56 days, and 180 days. The entire group of 573 litters was used in the study. A series of standard partial regression coefficients and multiple correlation coefficients were computed according to methods used by Snedecor (1946).

Table XIII. Partial Regressions of Pigs Farrowed (4), Pigs Alive at 21 Days (5), Pigs Alive at 56 Days (6), and Pigs Alive at 180 Days (7), on Per cent Inbreeding of Dam (1), Per cent Inbreeding of Offspring (2), and Age of Dam (3).

Partial Regressions			
Birth	21 Days	56 Days	180 Days
$b'41.23 = -.1385$	$b'51.23 = -.0557$	$b'61.23 = -.0568$	$b'71.23 = -.0894$
$b'42.13 = -.1038$	$b'52.13 = -.1749$	$b'62.13 = -.2033$	$b'72.13 = -.2885$
$b'43.12 = .3212$	$b'53.12 = .0167$	$b'63.12 = .1258$	$b'73.12 = .1048$

Table XIV. Multiple Correlation Coefficients Between Inbreeding of Litter, Inbreeding of Dam, Age of Dam and Litter Size at:

Birth	21 Days	56 Days	180 Days
$R^2 = .3491$	$R^2 = .1936$	$R^2 = .2830$	$R^2 = .3288$
$R^2 = .1219$	$R^2 = .0375$	$R^2 = .0801$	$R^2 = .1081$

The regression of number of pigs farrowed per litter on inbreeding of dam independent of inbreeding of offspring and

age of dam was -.1385. The regression of size of litters farrowed on inbreeding of offspring independent of inbreeding and age of dam was -.1038. The regression of number of pigs farrowed per litter on age of dam independent of inbreeding of dam and offspring was .3212. The multiple correlation coefficient was .3491 which was highly significant. Twelve per cent of the variance in litter size at birth was due to inbreeding and age of dam and inbreeding of litters.

The partial regression coefficients show that inbreeding of the dam had a slightly greater affect on the size of litter farrowed than the inbreeding of the litters. This agrees rather closely with the comparisons of average litter size as shown in Tables I and V.

The regression of litter size at 21 days on inbreeding of dam independent of age of dam and inbreeding of offspring was -.0557. The regression of size of litter independent of age and inbreeding of dam was -.1749. The regression of litter size at 21 days on age of sow independent of inbreeding of dam and offspring was .0167. The multiple correlation coefficient of .1936 was highly significant. The amount of variance accounted for by the three independent variables was only about four per cent.

The regression of litter size at 56 days on inbreeding of dam independent of age of sow and inbreeding of litter was -.0568. The regression of litter size at 56 days on inbreeding of litter independent of age and inbreeding of dam was -.2033. The regression of litter size at 56 days on age of

dam independent of inbreeding of dam and offspring was .1258. The multiple correlation coefficient for litter size at 56 days was .2830, which is highly significant. The variance due to the three independent variables was eight per cent.

The regression of litter size at 180 days on inbreeding of dam independent of inbreeding of litter and age of dam was -.0894. The regression of litter size at 180 days on inbreeding of litters independent of age and inbreeding of dam was -.2885. The regression of litter size at 180 days on age of dam independent of inbreeding of dam and litter was .1084. The multiple correlation coefficient was .3288 which is highly significant. Eleven per cent of the variance in litter size at 180 days was due to age and inbreeding of dam and inbreeding of litters.

The standard partial regression coefficients for litter size at 21, 56, and 180 days show the same trend as shown in Tables I and V. The trend was for inbreeding of offspring to have more effect on litter size than inbreeding of the dam.

DISCUSSION

It is realized that the data used for this study were taken from an experiment which was not specifically designed for this type of study. However, statistical classification of the large amount of data (573 litters) does permit certain valid conclusions pertaining to the effect of inbreeding both of the litter and the sow on litter size. The effect of age, inbreeding of dam, and inbreeding of litter were confounded in the average litter sizes that were computed from all litter studies. Classification of all the non-inbred litters according to the inbreeding of dam eliminated the effect of inbreeding of the litter on litter size at all ages. The age of dam probably had little effect on this classification since there was a fairly equal proportion of different aged sows in all inbreeding classes.

A similar type of classification was made for inbred litters from non-inbred dams to study the effect of inbreeding of litter on litter size at all ages. This classification eliminated the inbreeding of the dam, and again the ages of dam were fairly well distributed among the different classes of litters.

Comparisons were made between the results obtained from the two types of classification to get the relative effect of inbreeding of dam and litter on litter size at all ages. The results agreed with those reported by other workers who have

made similar studies on the effect of inbreeding in swine.

In these data, the intensive selection of sows on the basis of their prolificacy would tend to magnify the effect of age of dam. The unusually high partial regression coefficients for age of dam are likely caused by this intense selection of dams as well as by the increase in age of the dam. These regression coefficients do not properly evaluate the effect of dams age on litter size, but it was necessary to consider dam's age in the multiple regression equation in order to eliminate its possible effect on the other independent variables (inbreeding of dam and inbreeding of litter).

Hybrid vigor in some of the non-inbred litters from highly inbred sows may also bias the results in Table I. This hybrid vigor seems to have had an effect in increasing the litter size of the non-inbred litters from sows inbred 31 to 40 per cent. Many of these sows were from Line I which from other unpublished data seemed to have been prepotent for large litter size.

The average litter size of the 122 litters used for a control group was larger than the breed average as given by Lush and Molln (1942). Some of the dams of these litters were the result of line crosses and thus were probably above average in prolificacy and mothering ability.

The large litter size of some classes of highly inbred litters (Table V) was probably partially due to the fact that most of the parents were selected from large litters for brother x sister matings.

The extremely large litter size of the non-inbred litters from non-inbred dams three years old or over was probably due to the small number of litters in those classes and to the fact that these sows had been retained in the herd because of their prolificacy.

The regression study and comparison of averages gave similar results for the relative effects of inbreeding of sow and inbreeding of offspring on size of litter farrowed. The regression study indicated that the inbreeding of the dam had a slightly greater effect than inbreeding of litter on size of litter farrowed. A slightly greater effect on size of litter farrowed might be attributed to the inbreeding of offspring in making a comparison of Table I and Table V. The slight difference in the results of the two methods of study could be due to the fact that the averages of Table I and V contained only a part of the litters used in the study while the regression study was made on the entire group of 573 litters.

The results obtained from the regression study and those from the comparison of averages agreed as to the relative effect of inbreeding of dam and offspring on litter size at 21, 56, and 180 days. Both studies indicated that the inbreeding of offspring had a considerably greater effect than inbreeding of dam on litter size at 21, 56, and 180 days. A comparison of average litter size at 21, 56, and 180 days show that inbreeding of offspring caused a progressively greater decrease in litter size than did inbreeding of dam as age of offspring increased from 21 to 180 days. A comparison of the standard

partial regression coefficients show the same trend.

There was a definite tendency for the livability of non-inbred pigs from inbred sows to be higher at all ages than for pigs of all other classifications. The higher livability of the non-inbred pigs from the inbred sows can be attributed, at least partially, to the hybrid vigor resulting from mating the inbred sows to unrelated boars, frequently from a different inbred line.

As the sows increased in age, the size of litter farrowed became larger. The large litters in this study were farrowed by sows over 2.5 years of age. The above average litter size for sows over 1.5 years of age was probably due to intense selection as well as to the natural result of an increase in age of sow. Intense selection based on production records was used in determining which sows were retained in the herd for additional litters.

Even though the older sows farrowed larger litters, they raised a smaller percentage of them to weaning than the 1.0 and 1.5 year sows. The increased size and sluggishness of the older sows resulted in more losses from overlaying and injury to the pigs by the sow.

The standard partial regression coefficients of litter size on age of sow independent of inbreeding of dam and offspring show that a large amount of the size of litter farrowed was due to the age of the dam. They also show that the number of pigs alive at 21 days was only slightly affected by the age of the dam, and the number of pigs alive at 56 and 180 days

was affected to a greater degree than at 21 days, but less than at birth, by age of sow. These standard partial regression coefficients show the same trend as that shown by the comparison of average litter size of sows of different ages.

This study has shown that the inbreeding of sow and litter and age of sow have a definite effect on the litter size of swine at all ages.

SUMMARY AND CONCLUSIONS

1. Data on 573 litters were analyzed to determine the effect of inbreeding of the sow, inbreeding of the litter, and age of dam on litter size at birth, 21, 56, and 180 days.
2. A control group of 122 non-inbred litters from non-inbred sows was used for comparison with the inbred litters from inbred and non-inbred sows and non-inbred litters from inbred sows. The average litter size of the control group was 9.9 pigs at birth, 6.9 pigs at 21 days, 6.8 pigs at 56 days, and 6.3 pigs at 180 days.
3. The percentage of stillborn pigs was 7.5 for non-inbred pigs from non-inbred sows, 5.6 per cent for pigs farrowed by inbred sows, 6.5 per cent for pigs from non-inbred sows, 6.0 per cent for inbred pigs farrowed by all sows, 6.0 per cent for non-inbred pigs from all sows, and 4.5 per cent for non-inbred pigs from inbred sows.
4. Inbreeding of litter had a greater effect on litter size than inbreeding of dam. The average litter size of 140 non-inbred litters farrowed by inbred sows was 8.7 pigs at birth, 6.8 pigs at 21 days, 6.7 pigs at 56 days, and 6.1 pigs at 180 days. The average litter size of 112 inbred litters farrowed by non-inbred sows was 8.5 pigs at birth, 6.0 pigs at 21 days, 5.6 pigs at 56 days, and 4.9 pigs at 180 days.

5. Inbreeding of offspring had a greater effect on mortality rate than inbreeding of dam. The livability of 1215 non-inbred pigs from inbred sows was 78.7 per cent at 21 days, 76.6 per cent at 56 days, and 70.1 per cent at 180 days. For 953 inbred pigs farrowed by non-inbred sows, livability was 70.1 per cent at 21 days, 66.3 per cent at 56 days, and 57.8 per cent at 180 days.
6. Inbreeding of offspring caused a progressively greater decline in livability than inbreeding of dam as age of offspring increased from birth to 180 days.
7. Average litter size of non-inbred pigs from non-inbred dams was larger by 1.2 pigs at birth, 0.1 pig at 21 days, 0.1 pig at 56 days, and 0.2 pig at 180 days, than all non-inbred litters from inbred sows.
8. Livability of non-inbred pigs from inbred sows was consistently higher at all ages than livability for non-inbred pigs from non-inbred dams.
9. The average size of non-inbred litters from non-inbred sows was consistently larger than that of inbred litters from non-inbred sows. The average size of non-inbred litters from non-inbred sows was larger by 1.4 pigs at birth, 0.9 pig at 21 days, 1.2 pig at 56 days, and 1.4 pig at 180 days than that of inbred litters from non-inbred dams.
10. Size of litter farrowed increased as the age of dam increased to 3.5 years. The size of litter raised to 21, 56, and 180 days increased as age of sow increased to

2.5 years.

11. The percentage of pigs raised to 180 days was generally smaller for sows 2.0 years old and over than for sows 1.0 and 1.5 years old.

12. The number of stillborn pigs per litter increased as age of sows increased.

LITERATURE CITED

Bartlett, J. W., R. P. Reece, and O. L. Lepard.
The Influence of Inbreeding on Birth Weight, Rate of Growth, and Type of Dairy Cattle. Jour. Ani. Sci. 1: 206-212. 1942.

Comstock, R. E. and L. M. Winters.
A Comparison of the Effects of Inbreeding and Selection on Performance in Swine. Jour. Ani. Sci. 3: 380-389. 1944.

Craft, W. A.
Swine Breeding Research at the Regional Swine Breeding Laboratory. U.S.D.A. Misc. Publ. 523. 1943.

Eaton, O. N.
Crosses Between Inbred Strains of Mice. Jour. Hered. 32: 393-395. 1941.

_____
Effects of Crossing Inbred Lines of Guinea Pigs. U.S.D.A. Tech. Bul. 765. 1941.

_____
Quarter Century of Inbreeding in Guinea Pigs. Jour. Exp. Zool. 63: 261-290. 1932.

Godbey, E. G. and L. V. Starkey.
A Genetic Study of the Effects of Intensively Inbreeding Berkshire Swine. South Carolina Sta. Rpt. 1932. 1932.

Hays, F. A.
Inbreeding Animals. Dela. Agri. Expt. Sta. Bul. 123. 1919.

_____
Effect of Inbreeding on Fecundity in Rhode Island Reds. Mass. Agri. Expt. Sta. Bul. 312. 1934.

Hetzer, H. O., W. V. Lambert, and J. E. Zeller.
Influence of Inbreeding and Other Factors on Litter Size in Chester White Swine. U.S.D.A. Circ. 570. 1940.

Hodgson, R. E.
An Eight Generation Experiment in Inbreeding Swine. Jour. Hered. 26: 209-217. 1935.

Hughes, E. H.
Inbreeding Berkshire Swine. Jour. Hered. 24: 199-203. 1933.

Knox, C. W.
The Development and Use of Chicken Inbreds. Poultry Sci. 25: 262-272. 1946.

Laben, Robert C.
(Unpublished Thesis) The Amount and Effectiveness of Selection in an Inbred Swine Herd. Oklahoma A. & M. College Library. 1947.

Lush, J. L. and C. C. Culbertson.
Consequences of Inbreeding Poland China Hogs. Iowa Agri. Expt. Sta. Annual Report. Part 1. 80-82. 1937.

_____
Animal Breeding Plans. Ames, Iowa: Collegiate Press Inc., 1945.

_____ and A. E. Molln.
Litter Size and Weight as Permanent Characteristics of Sows. U.S.D.A. Tech. Bul. 836. 1942.

Margolin, S. and J. W. Bartlett.
Influence of Inbreeding upon the Weight and Size of Dairy Cattle. Jour. Ani. Sci. 4: 3-12. 1945.

Maw, A. J. G.
Crosses Between Inbred Lines of the Domestic Fowl. Poultry Sci. 21: 548-553. 1942.

McPhee, E. L., E. Z. Russell, and John Zeller.
An Inbreeding Experiment With Poland China Swine. Jour. Hered. 22: 393-403. 1931.

Ritzman, E. G. and C. B. Davenport.
Some Results of Inbreeding on Fecundity and Growth in Sheep. N. Hamp. Expt. Sta. Tech. Bul. 47: 1-27. 1931.

Snedecor, George W.
Statistical Methods. Ames, Iowa: The Collegiate Press Inc., 1946.

Stewart, H. A.
The Inheritance of Prolificacy in Swine. Jour. Ani. Sci. 4: 359-366. 1945.

_____
An Appraisal of Factors Affecting Prolificacy in Swine. Jour. Ani. Sci. 4: 250-260. 1945.

Waters, N. F. and W. V. Lambert.
Inbreeding in the White Leghorn Fowl. Iowa Res. Bul. 202. 1936.

_____
The Influence of Inbreeding on Hatchability. Poultry Sci. 24: 329-334. 1945.

_____
The Influence of Inbreeding on Sexual Maturity. Poultry Sci. 24: 391-395. 1945.

Willham, O. S. and W. A. Craft.
An Experimental Study of Inbreeding and Outbreeding Swine. Okla. Tech. Bul. 7. 1939.

Winters, L. M., R. E. Comstock and D. L. Dailey.
The Development of an Inbred Line of Swine (Minn. No. 1) from a Crossbred Foundation. Jour. Ani. Sci. 2: 129-137. 1943.

_____, P. S. Jordon, and R. E. Hodgson.
Preliminary Report on Crossing of Inbred Lines of Swine. Jour. Ani. Sci. 3: 371-380. 1944.

_____, R. E. Comstock, R. E. Hodgson and others.
Experiment with Inbreeding Swine and Sheep. Minn. Agri. Expt. Sta. Bul. 364. 1943.

Woodward, T. E. and R. R. Graves.
Some Results of Inbreeding Grade Guernsey and Grade Holstein-Fresian Cattle. U.S.D.A. Tech. Bul. 339. 1933.

Wright, S. and O. N. Eaton.
Persistance of Differentiation among Inbred Families of Guinea Pigs. U.S.D.A. Tech. Bul. 103: 1-45. 1929.

_____
The Effects of Inbreeding and Crossbreeding on Guinea Pigs. U.S.D.A. Bul. 1090 and 1121. 1922.

_____
Coefficients of Inbreeding and Relationship. Amer. Nat. 56: 330-338. 1922.

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