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Milk Production and Related Performance Factors in Sows

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ABSTRACT

Milk production of sows of inbred Landrace, Poland, and Duroc breeds and Landrace x Poland crossbreds was determined once each week for six weeks by weighing their pigs before and after nursing. Average milk production for the six-week lactation period was Landrace 306 pounds, Poland 266 pounds, Duroc 236 pounds and Landrace x Poland 300 pounds.

The peak in milk production was reached the fourth and fifth weeks by sows of the Landrace breed, the fourth week by sows of the Poland breed, the third week by sows of the Duroc breed, and the second and third weeks by sows of the Landrace x Poland cross. The milk production of sows for the lactation period was significantly correlated on a within-breed or cross basis with the weight of the litter at six weeks and a within-breed coefficient of regression of 0.37 pound in litter weight was indicated for each additional pound of milk produced by the sows. The age of the sow at farrowing was not significantly correlated with her milk yield, size of the litter at birth, or with the average size of the litter suckled.

In general, sows of the different breeds and crosses tended to rank in reverse order in weight losses to the order they ranked in milk production; i.e., Duroc sows gained an averageof 4.6 pounds while the Poland, Landrace, and Landrace x Poland sows lost an average of 6.1, 22.0 and 29.2 pounds, respectively. The milk production of the sow did not influence the consumption of creep feed by her litter. The amount of supplemental creep feed consumed was not significantly related to the number of pigs in the litter but was significantly related to the total weight of the litter.

Milk Production and Related Performance Factors in Sows

A. D. Allen, John F. Lasley, and Leland F. Tribble

INTRODUCTION

The weight of the litter at weaning is one of the most important economic traits in swine. It is dependent largely on the fertility of the sow and her level of milk production.

Many studies have been made at the Missouri Agricultural Experiment Station relative to fertility in swine. More recently a study was made of milk production in sows of certain inbred lines and crosses. This bulletin reports the results of this study, together with a comprehensive review of research work on this subject that has been conducted by other workers in all parts of the world.

REVIEW OF LITERATURE

A large volume of data has been accumulated on milk production in sows over a period of years although the majority of workers used relatively small numbers of animals and did their work under a wide variety of conditions. This review has been arranged according to references on milk production in sows together with some of the factors thought to affect milk production.

Milk Production in the Sow

The ratio of weight gain to birth weight is higher in pigs than in the offspring of other domestic animals. Pigs often more than double their birth weight by the end of the first week of life and often triple it at the end of the second week. The milk production of the sow plays a very important role in these rapid weight gains of pigs early in life.

Apparently there is almost as much variation among individual sows as in cows in the ability to produce large amounts of milk. Smith (1952b) stated that studies of milk production in sows are at the same stage as those of milk production in cows 50 years ago. The reasons given for this were that measure-

ments of milk yields in sows are laborious and if done on a very extensive basis require much specialized equipment.

The first test to determine milk production of sows by weighing pigs before and after suckling was conducted by von Gohren (1865), according to Schmidt and Lauprecht (1926). Since that time similar studies have been conducted. Data relative to milk production by sows as reported by several workers are summarized in Table 1. The averages vary from 3.4 to 16.18 pounds per day in various experiments. Total milk production for the period of eight weeks has been found to vary from 401 to 701 pounds per sow.

Milk production varies in the sow during various periods of lactation. Henry and Woll (1897) reported that milk yield was small immediately after parturition but gradually increased with a maximum flow being reached about the fourth week of lactation. Most workers agree that the peak in milk production is reached at the third, fourth, or fifth week with a gradual decline thereafter (Carlyle, 1903; Davis, 1904; Schmidt and Lauprecht, 1926; Hempel, 1928; Olofsson and Larsson, 1930; Hughes and Hart, 1935; Albig, 1939; Filmer, 1950; Niwa, *et al.,* 1951; Greenslade, 1952; Smith, 1952b; Berge and Indreb, 1953; and Lalevic, 1953). Individual sows vary in the time required to reach a peak in milk production whereas others seem to maintain an optimum level until the eighth week of lactation once they reach their peak.

The average increase of milk production in sows to a peak between the third and fifth week of lactation would be in keeping with what is known about the nutrient requirements of baby pigs. Since pigs are very small during the first few days of life, their capacity to consume milk would be limited, but would increase as they grew larger with increasing age. During these first few weeks of life the pigs would be almost entirely dependent upon milk for their nutrients (Greenslade, 1952). Finally, however, after the peak in milk production is passed, the pigs are old enough and large enough that they can consume supplemental feeds and are not entirely dependent on milk for their source of nutrients.

Smith (1952a) suggested that the control of the shape of the lactation curve by feeding or management could well result in control of the intake of supplementary feed by the litter. Smith (1952b) also found in a study of litter behavior that in the fifth to the seventh, and to some extent in the eighth week, the pigs will first suckle the sow and then go to the creep for additional feed. After this they go to sleep until time for the next suckling. He concluded that the pigs eat the additional creep ration because they are not receiving a sufficient amount of milk from the sow rather than taking less milk because they are eating supplementary feed.

The process of suckling by pigs has been described in detail by research workers. Hughes and Hart (1935) and Donald (1937b) reported that they observed three distinct stages in suckling by pigs. The first stage was a preliminary period during which individual pigs sought a teat and stimulated the flow of

TABLE 1--MILK PRODUCTION OF SOWS[1]

No. of Lactations	Avg. No. of Pigs in Litter	Daily Milk Production Lbs.	Production During Lactation			Authority
			8 Wks. Duration Lbs.	10 Wks. Duration Lbs.	Other Duration Lbs.	
1		3.4				von Gohren (1865)[3]
4	6.8	5.2		364.0		Henry & Woll (1897)
12	7.2	5.4			464.9[2]	Carlyle (1903)
1	7.0	5.6		389.2		Davies (1904)
3		11.4	638.4			Ostertag & Zuntz (1908)
1	9.0	10.2				Schmidt & Lauprecht (1926)
1	7.0	11.6				Schmidt & Lauprecht (1926)
1	9.0	7.2	404.9			Schmidt & Lauprecht (1926)
1	6.0	10.7	600.0			Schmidt & Lauprecht (1926)
1	8.0	8.2	460.5			Schmidt & Lauprecht (1926)
36	8.3	6.9	388.2			Schmidt & Lauprecht (1926)
4		6.9		481.0		Ohligmacher[3]
7		6.5		457.7		Ohligmacher
2	7.5	7.7		539.0		Hughes & Hart (1935)
43		11.7				Wells, Beeson & Brady (1940)
22	8.57	7.1	401.0			Schneider (1934)
25	7.8	7.4				Borowsky & Kwasnitsky (1932)
4	8.5	10.34			508.5[4]	Olofsson & Larsson (1930)
22	8.8	7.35	411.6			Hempel (1928)
61	7.1	12.07	674.0			Smith (1952)
28	8.5	16.18	701.2			Berge & Indreb (1953)

1. Smith (1952)
2. 12 Week Lactation
3. Quoted by Schmidt and Lauprecht (1926)
4. 7 Week Lactation

milk by massaging the udder. During this period many of the pigs ran around and touched the snout of the sow. Quite suddenly the second stage began during which the pigs suckled rapidly and did not massage. The third stage followed shortly and consisted usually of an extended amount of time of massaging the udder as in the first stage but included more actual suckling. All of the stages varied in length of time, but the third stage often lasted 15 minutes or was practically eliminated.

The first stage in suckling is thought to yield no milk; the third stage yields only small amounts; while the bulk is obtained in the second period. Turner (1952) stated that during the first stage, the stimulus of nursing and massaging caused the discharge of the "let down" hormone from the posterior lobe of the pituitary gland. The milk is unavailable to the pigs until the contraction of the myo-epithelial cells surrounding the alveoli and ducts occurs and expells the milk.

Carlyle (1903) observed that the actual nursing time varied from one to two minutes with fully half of the time spent in getting the flow of milk started. Hughes and Hart (1935) observed that the pigs actually obtained milk for a period of 60 seconds, whereas Donald (1937a) estimated this stage to vary between 35 and 45 seconds.

A number of workers have studied the interval of time that elapses between the nursings by the pigs. Some of these studies summarized by Smith (1952b) are given in Table 2. In general, the nursing interval varies from 60 to 90 min-

TABLE 2--SUCKLING INTERVAL IN MINUTES[1]

Authority	Early in Lactation	Late in Lactation
Vinogradsky (1939)	72	90
Schneider (1934)	60	90
Wells, Beeson, and Brady (1940)	60	Variable
Shepperd (1929)	62	62
Smith (1952a)	60	75

[1]Smith (1952b)

utes with the majority being close to 60 minutes in length. Shepperd (1929) observed that the nursing interval during the day was similar to that at night, while Smith (1952b) found the night nursing interval to be slightly but not significantly longer.

The fact that pigs usually nurse at intervals of about one hour would suggest that any factor that would result in longer intervals might reduce the total amount of milk produced. In most investigations, nursing intervals of two or more hours have been used. Olofsson and Larsson (1930) investigated milk production of sows by weighing the pigs more frequently than did other workers. In the first week they allowed pigs to suckle 24 times in 24 hours, in the second week, 19 times, and in the third week 15 times per day. This technique of

more frequent sampling showed a greater milk yield than was generally found by other workers.

Studies of individual teat yields in the sow have resulted in some interesting observations. Hempel (1928) found that the milk yield was the highest in the foremost pair of teats and decreased progressively in posterior pairs. Wohlbier (1928) found that the amount of milk coming from different teats varied widely. He felt that this variation was due largely to the constitution of the pigs with the most vigorous pigs obtaining the most milk. The most vigorous pigs, he felt, evacuated the teat more completely, thus providing a favorable stimulus to the productive capacity of the gland. Weak pigs were unable to empty the teat and, therefore, gave little stimulus to production. After a few days, the teats occupied by the vigorous pigs were clearly recognized. In those teats not suckled, the milk production soon ceased.

Some Factors Affecting Milk Yields of Sows

Since the amount of milk produced by sows varies so widely, it is of interest to review some of the factors which may be responsible for this variation.

The age of the sow is one of the factors which has been studied in considerable detail. Data from various workers summarized in Table 3 indicate that milk yield increases up to the third litter and possibly to the fifth or sixth. Milk yield has not been observed in the same sows, however, for more than three consecutive litters.

TABLE 3--INFLUENCE OF AGE OF SOW ON MILK YIELD

Age When Yield Was Highest	Authority
Third to Sixth Lactations	Schmidt and Lauprecht (1926)
Third Lactation*	Dschaparidse (1936)
Third Lactation*	Smith (1952a)
Third to Sixth Lactations	Wells, Beeson, and Brady (1940)
Third Lactation	Berge and Indreb (1953)

*Yield measured for only 3 lactations

Many investigators have observed that the amount of milk which a sow produces is dependent upon the number of pigs she suckles (Schmidt and Lauprecht, 1926; Olofsson and Larsson, 1930; Hughes and Hart, 1935; Wells, Beeson and Brady, 1940; Kovacs, 1954; Dschaparidse, 1936, and Thompson, 1931). Berge and Indreb (1953) reported that the average daily milk production of sows with small litters was 8.4 pounds whereas in sows with litters of 12 pigs it was 21.9 pounds. The average of 1.76 to 2.65 pounds of milk per pig per day was recorded with the pigs from the smaller litters receiving the larger amounts. Lalevic (1953) reported that the production of sows suckling six pigs was 295.3 pounds of milk while in those suckling fewer pigs it was 280.0 pounds during the entire lactation period. He found a positive correlation between number of pigs per litter and the amount of milk produced by the sow.

Breed differences in milk producing ability of sows have been indicated by some investigators. Where the breeds have been indicated they are shown in Table 4. Since different investigators have used different methods of measuring milk production and conditions have been quite variable between different experiments, it is not known how significant the differences between the breeds might be. In a few cases, however, where several breeds were used in the same study, breed differences did exist. It is recognized, too, that definite differences in milk production could exist between different strains within each breed.

Some Factors Dependent Upon Milk Yield of Sows

The weight gains made by pigs are, of course, greatly dependent upon the amount of milk produced by the sow. Zeller, Johnson and Craft (1937) stated that a sow's performance beyond the number of pigs farrowed may be thought of as a combination of a progeny test of the sow and a measure of her direct nutritional influence on her litter. As the pigs become older, their own genes become increasingly important for a given character, and their performance is more of a measure of the transmitting ability of the sow and less of her direct environmental influence.

Berge and Indreb (1953) observed that the weight gain of the first three to four weeks was chiefly determined by the milk yield of the sow and that improved fertility in sows must be accompanied by a higher milk production or an earlier use of supplementary feed if the weight gains are to be maintained.

The weight gain for the first four weeks of lactation for each 10 pounds of milk was calculated for 32 litters by Hempel (1928) and was found to average 3.29 pounds. The variation between litters ranged from 2.42 to 5.48 pounds. This marked range in different litter requirements for each pound of gain was thought to be due more to the influence of environmental factors than to differences in the composition of the milk of the sows.

Thompson (1931) observed that pigs with lighter birth weights consumed less milk daily than pigs with heavier birth weights. In pigs of approximately the same birth weight, those receiving a greater supply of milk made greater gains during the suckling period and for the next 60 days following the suckling period.

The amount of milk produced per pig and the weight per pig were found to be closely correlated by Berge and Indreb (1953). They found no correlation, however, between the size of the litter and weight gains per pound of milk. The coefficient of correlation between daily milk production and daily litter gain was found to be between 0.80 and 0.90. Within sows, the correlation with respect to milk yield was 0.15. This is approximately the heritability of milk yields of sows.

Smith (1952b) divided the eight week lactation period into two parts to show the total sow and litter intake of nutrients. He found that it required 3.9 feed unis fed almost entirely through the sow to produce 1 pound of gain in the pigs in the first period and 2.7 units in the second period. He assumed the

TABLE 4--MILK PRODUCTION BY BREEDS[1]

Authority	Breed	No. of Lactations	Litter Size	Avg. Daily Prod. Per Sow Lbs.	Avg. Total Production Per Sow Lbs.
Carlyle (1903)	Berkshire	4	7.7	6.31	354.3
Carlyle (1903)	Poland China	4	7.5	4.86	372.2
Carlyle (1903)	Razor Back	4	6.3	5.17	289.5
Schmidt and Lauprecht (1926)	Landschwein	26	8.3	6.9	388.2
Hempel (1928)	Landschwein	22		7.35	411.6
Schneider (1934)	Edelschwein	22	8.3	7.16	401.2
Olofsson and Larsson (1930)	Yorkshire	4	8.5	10.34[2]	508.5[3]
Bonsma & Oosthuizen (1935)	Large Black	52	6.67	6.55	366.7
Smith (1952a)	Berkshire	15	7.4	14.4	808.0
Berge & Indreb (1953)	Landrace	27	8.44	16.18	701.20
Dechambre (1934)	Berkshire			6.30	449.39
Dechambre (1934)	Poland China			4.85	428.12
Dechambre (1934)	Yorkshire			4.65	

1. Mostly by Smith (1952b)
2. Average for period between 2nd and 8th week.
3. Total for 7 weeks.

sows were equally efficient over the two periods and suggested that the increased efficiency of the pigs in the second four-week period was due to the fact that they ate more supplementary feed. The conversion of feed into milk by the sow and then its conversion to gains by the pigs is less efficient than when pigs make their gains by eating the feed directly.

When sows produce large quantities of milk, it is very difficult for them to eat enough feed to prevent weight losses during lactation. Since the number of pigs suckled also seems to be related to the amount of milk produced, various workers have studied the relationship between weight gains or losses and the size of litters suckled by the sows.

McKenzie (1928) observed that sows suckling small litters tended to gain rather than lose weight. Hostetter (1929), in a more extensive investigation, obtained similar results. In his investigation, 171 sows lost weight during lactation and weaned an average of 6.9 pigs per litter with an average weaning weight of 29 pounds per pig. The remainder of the group, or 68 sows, gained an average of 27 pounds each during lactation and weaned litters averaging 5.6 pigs, with an average weaning weight of 27 pounds; Zeller, Johnson and Craft (1927), Burger (1952), Niwa, *et al.* (1951), and Schafer and Granz (1955) obtained similar results.

Other workers have related milk production to actual gains or losses by sows during lactation. Richter, *et al.* (1928), noted that heavy milking sows lost a considerable amount of weight during the first four weeks of lactation, then they neither gained nor lost weight for a period of time, and then gradually gained weight until weaning. Hughes and Hart (1935) found that 10 sows which produced 7 or more pounds of milk daily lost an average of 59 pounds of body weight. Seven sows which produced between 5 and 7 pounds of milk lost 23 pounds, and 5 sows which produced less than 5 pounds of milk daily lost 25 pounds during lactation.

PROCEDURE

Four experiments concerning milk production of sows were carried out; the first in the spring of 1954 with eight Duroc sows and one Landrace sow; the second in the fall of 1954 with seven Landrace and three Poland sows; the third in the spring of 1955 with seven Duroc sows and seven Landrace x Poland crossbred sows; and the fourth in the fall of 1955 with six Landrace, four Duroc, five Poland, and two Landrace x Poland crossbred sows.

The breeding of the litters produced by the sows is shown in Table 5.

Adjustments of the sows and litters to the unusual conditions of the milk production experiments were very good in almost all cases. However, a few litters failed to gain weight during a nursing interval. This would infrequently be due to the urination of the pigs but it was largely due to fighting among the pigs and their not having stimulated the sow sufficiently to cause the "letdown"

TABLE 5--BREEDING OF THE PROGENY INVESTIGATED AT DIFFERENT SEASONS OF THE YEAR
(Number of Litters Shown in Parenthesis)

FEMALES:	Landrace	Duroc	Poland X Landrace	Poland
MALES:				
Landrace	(1) 1954 Spring (6) 1955 Fall			(3) 1954 Fall
Duroc		(8) 1954 Spring (3) 1955 Fall	(7) 1955 Spring (2) 1955 Fall	
Poland X Landrace		(7) 1955 Spring (1) 1955 Fall		
Poland	(7) 1954 Fall			(5) 1955 Fall

of milk. The time during which milk can be drawn from the sow's udder is short and prompt action by the pigs is necessary to obtain the maximum amount once the sow has been stimulated to produce the "let down" hormone.

A tendency for the pigs to stop nursing and to urinate was overcome by moving them to the area in the pen where they normally urinated, prior to weighing, and returning them to the sow. The amount of weight loss possible by the pigs urinating was checked and this loss during the period the pigs were on trial varied from 0.02 to 0.04 pounds, increasing as the pigs grew older. Defecation caused very slight losses, usually less than 0.01 of a pound.

The scale used was graduated in hundredths of a pound and had a dampened movement to aid in compensating for the restlessness of the pigs while on the scale platform. It was the Weightograph, Model 1804, manufactured by the Howe Scale Company, Rutland, Vermont.

The pigs were separated from the sow early in the morning on the test day and were returned to the dams one hour later and permitted to nurse. No weights were recorded at this time. After this period of standardization, the pigs were allowed to suckle at two-hour intervals during the remainder of the time until a total of four test periods had been completed.

The weight losses or gains of the sows were determined by weighing the sows on the days that milk production was checked at a time that would not disturb them unnecessarily.

We have little knowledge as to whether the milk produced in these experiments actually corresponds to the amount received by the pigs under conditions other than those of the test. The use of mechanical means of milk removal would provide little information to answer this question. A 24 hour test period

possibly would aid somewhat in solving this problem but for practical reasons a test period of this length had to be replaced by the method described. Preliminary investigations at this station indicated that an eight hour test period would give consistent results over different lactations in different seasons. However, this tells nothing of the relationship between the amount of milk produced during the test period and the amount of milk produced during the remainder of the 24 hour period. This source of variation is difficult to eliminate when working under circumstances which accompany experiments of this nature.

The amount of milk produced during the test period was assumed to be the amount produced under normal conditions in one-third of the 24 hour period. This in turn was assumed to be the daily amount produced by the sow during a seven day period to obtain weekly milk production.

RESULTS

Milk Production in Sows.

The amount of milk produced during a six-week lactation period by sows of different breeds and crosses used in this study is shown in Table 6. Highly sig-

TABLE 6--AMOUNT OF MILK PRODUCED PER LITTER BY SOWS OF DIFFERENT BREEDS AND CROSSES DURING A SIX-WEEK LACTATION PERIOD

(Mean ± Standard Deviation)

Period of Lactation	Pounds of Milk Produced Per Litter			
	Durocs (n = 19)	Landrace (n = 14)	Poland (n = 18)	Landrace X Poland (n = 9)
First week	33.2+ (14.4)	43.4+ 13.8	41.9+ (11.4)	41.2+ (13.2)
Second week**	37.8+ (14.3)	50.3+ (10.4)	43.0+ (6.4)	57.1+ (17.7)
Third week	50.6+ (18.1)	53.2+ (11.3)	48.4+ (17.4)	57.8+ (10.7)
Fourth week*	40.8+ (13.8)	56.1+ (14.6)	52.6+ (14.8)	51.0+ (9.8)
Fifth week**	39.7+ (15.3)	57.1+ (17.0)	40.9+ (12.8)	46.1+ (7.6)
Sixth week	35.4+ (10.2)	45.9+ (10.3)	39.0+ (13.4)	45.0+ (20.3)
Total**	236.2+ (50.1)	306.2+ (44.3)	265.9+ (51.3)	299.9+ (55.8)

*Breed differences significant ($P < .05$)
**Breed differences highly significant ($P < .01$)

nificant differences between sows of the different breeding groups were observed ($P < .01$), for milk production during the entire lactation period. Differences between the breeding groups were not significant, however, during the first, the third, and the fourth weeks of lactation.

The Duroc sows produced an average of 236.2 pounds of milk during the

six-week period, which was the smallest for the breeds and crosses studied. Landrace sows produced the most, averaging 306.2 pounds.

Considerable variation between breeds was observed in the week of lactation when the peak in milk production was reached. The Duroc sows reached their peak during the third week of lactation with a decided rise and fall in production before and after that time. The Landrace x Poland crossbred sows were at the peak of their milk production at both the second and third week of lactation and had decreased very little at the fourth week. In other words, the crossbred sows were much more persistent in milk production than the Duroc sows.

The Poland sows reached a definite peak in milk production during the fourth week of lactation. The Landrace sows were the latest, reaching their peak of milk production at the fourth and fifth week with little difference in the two weeks in the amount of milk produced.

Highly significant differences ($P < .01$) were found between breeds and crosses in total litter weight (Table 7) and in the average number of pigs per litter (Table 8). The Polands weaned an average of 6.0 pigs per litter, the smallest number; the Landrace x Poland crossbred sows weaned the largest number with 8.8 pigs per litter. The Landrace sows, however, weaned the heaviest litters, probably because they produced the most milk during the lactation period.

TABLE 7--AVERAGE LITTER WEIGHTS IN POUNDS FOR SOWS OF DIFFERENT BREEDS AND CROSSES USED FOR MILK PRODUCTION STUDIES
(Mean ± Standard Deviation)

Period of Lactation	Durocs (n = 19)	Landrace (n = 14)	Poland (n = 8)	Landrace X Poland (n = 9)
First week*	39.1±10.8	40.6±6.3	36.4±5.4	49.7±11.3
Second week**	54.2±11.1	60.2±8.9	51.0±8.7	68.7±13.2
Third week**	70.9±15.3	79.7±13.1	62.0±19.8	86.3±15.8
Fourth week*	86.5±20.1	101.9±22.2	77.4±25.7	98.3±16.0
Fifth week*	107.7±25.1	130.9±31.9	95.5±31.6	119.0±18.9
Sixth week*	135.6±29.7	171.6±41.8	126.1±44.4	156.9±27.4

*Differences between breeds signigicant ($P < .05$)
**Differences between breeds highly signigicant ($P < .01$)

TABLE 8--AVERAGE LITTER SIZE FOR SOWS OF DIFFERENT BREEDS AND CROSSES USED FOR MILK PRODUCTION STUDIES
(Mean ± Standard Deviation)

Period of Lac ation	Durocs (n = 19)	Landrace (n = 14)	Poland (n = 8)	Landrace X Poland (n = 9)
First week**	7.8±1.0	8.4±0.8	8.0±0.9	10.0±1.2
Second week**	7.4±1.3	8.0±1.0	7.4±0.5	9.6±1.4
Third week**	7.3±1.3	7.7±1.0	6.4±1.4	9.4±1.5
Fourth week**	7.2±1.4	7.6±1.2	6.1±1.6	9.0±1.7
Fifth week**	7.1±1.4	7.5±1.3	6.0±1.5	8.9±1.6
Sixth week**	7.0±1.4	7.5±1.3	6.0±1.5	8.8±1.6

**Differences between breeds highly significant ($P < .01$)

Table 9 shows the average milk production per pig suckled during each week of lactation and the average for the entire lactation period. Poland sows produced the largest amount of milk per pig on this basis, but they were followed very closely by the Landrace sows. The Duroc and the crossbred Landrace x Poland sows produced about the same amount of milk per pig, but this was 7 to 8 pounds less than the production of the Poland or the Landrace sows. Total milk production was greater in the crossbred Landrace x Poland sows than in the Duroc sows, however, because they weaned an average of 1.8 more pigs per litter.

TABLE 9--POUNDS OF MILK PRODUCED PER PIG BY SOWS OF DIFFERENT BREEDS AND CROSSES

Period of Lactation	Durocs (n = 19)	Landrace (n = 14)	Polands (n = 8)	Landrace x Polands (n = 9)	Total
First week	4.26	5.17	5.24	4.12	4.70
Second week	5.11	6.29	5.81	5.95	5.79
Third week	6.93	6.91	7.56	6.15	6.89
Fourth week	5.67	7.38	8.62	5.67	6.59
Fifth week	5.59	7.61	6.82	5.18	6.30
Sixth week	5.06	6.12	6.50	5.11	5.70
Total	32.62	39.48	40.55	32.18	35.97

Table 10 gives pounds of creep ration consumed per litter by pigs of the different breeding groups. No significant difference was observed between pigs

TABLE 10--POUNDS OF CREEP FEED CONSUMED PER LITTER BY PIGS FROM DIFFERENT BREEDS AND CROSSES
(Mean ± Standard Deviation)

Period of Lactation	Durocs (n = 19)	Landrace (n = 14)	Polands (n = 8)	Landrace x Polands (n = 9)
First week	0	0	0	0
Second week	0	0	0	0
Third week	1.5±0.5	1.4±0.6	1.9±2.2	1.7±0.7
Fourth week	3.4±1.7	5.7±3.6	4.4±4.3	3.4±2.4
Fifth week	7.3±3.7	16.5±9.3	9.1±6.7	8.4±2.6
Sixth week	15.7±9.6	29.0±15.3	21.9±11.5	29.3±9.5
Total	27.7±12.5	52.6±27.1	37.2±23.5	42.9±10.3

Breed differences were not significant

in the different breeding groups for this trait. The pigs were offered a creep ration beginning the fourteenth day after farrowing. The pigs consumed less than 2 pounds of creep ration per litter during the third week of lactation. By the fourth week, creep feed consumption had increased to between 3 and 4 pounds per litter. Creep feed consumption increased rapidly each week thereafter until 16 to 30 pounds were consumed per litter during the sixth week of lactation.

The average weekly increase in creep feed consumption together with the pounds of milk produced by the sows per pound of pig gain are shown in Fig-

ure 1. These data illustrate very clearly that when creep feed consumption by the pigs increases there is a corresponding decrease in the amount of milk required to produce a pound of pig gain. During the fourth week of lactation, creep fed consumption had become great enough so that it was evident that much of the gains the pigs were making were on feed other than milk from the sow.

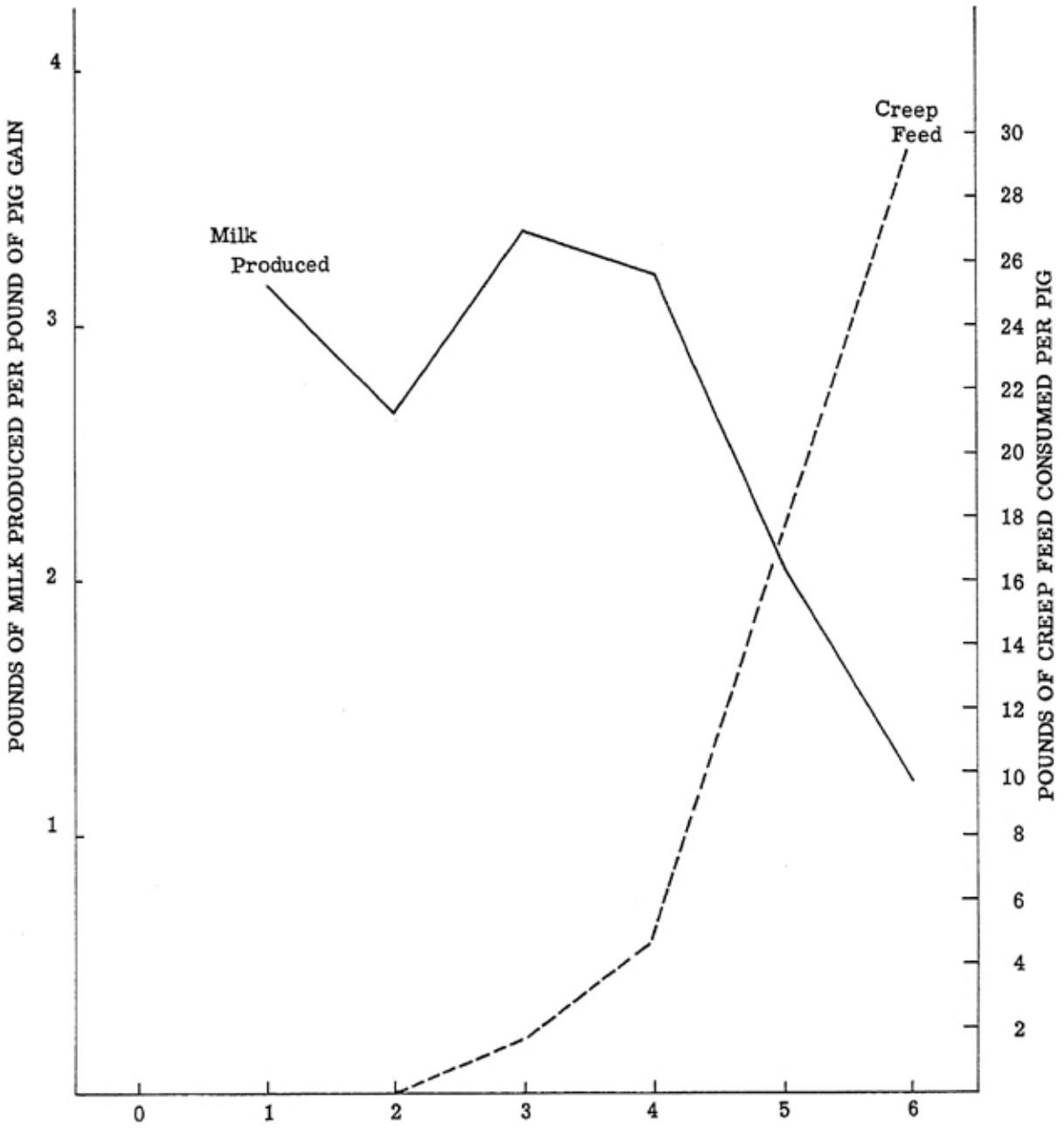

Figure 1.
Creep Feed Consumption and Milk Production of Sows.

Relationship Between Total Milk Production and some Other Performance Factors.

Many different factors may be responsible for variations in milk production in sows. The experiments reported here were designed to study the influence of some of these on milk production in the sows. The factors discussed are those which would have a direct effect on milk production.

A. Litter size during lactation. Table 11 gives coefficients of correlation between total milk production and the number of pigs per litter during lactation. The Landrace x Poland sows weaned an average of 8.8 pigs per litter yet they did not produce the largest amount of milk. The Poland sows weaned the smallest number of pigs, 6.0 per litter, but they gave about 30 pounds more milk per sow during lactation than the Duroc sows.

TABLE 11--CORRELATION BETWEEN TOTAL MILK PRODUCTION AND LITTER SIZE DURING LACTATION

Breed or Cross	No. of Litters	Avg.** Milk Prod.	Avg.** Litter Size	Coefficient of Correlation "r"	Coefficient of Regression "b"
Durocs	19	236.2	7.0	.38	15.35
Landrace	14	306.2	7.5	.13	5.58
Polands	9	265.9	6.0	.78*	36.04
Landrace x Poland	8	299.9	8.8	.37	14.54
Gross (all breeds)	49			.45***	17.94
Between Breeds	3			.59	21.92
Within Breeds	46			.38**	15.86

*Probability of chance occurrence less than .05
**Probability of chance occurrence less than .01
***Probability of chance occurrence less than .001

The Polands were the only group in which there was a significant correlation between litter size and total milk production. When all breeds were grouped together and the gross correlation coefficient determined, it was very highly significant ($P<.001$). The corresponding regression coefficient for the pooled data was 17.94 pounds of milk, indicating this much increase in milk production for each additional pig in the litter during the lactation period. On a within-breed basis, the coefficient of correlation was still highly significant ($P<.01$) and the regression coefficient was 15.86 pounds of milk.

Data summarized in Table 9 show that an average of 35.97 pounds of milk was produced per pig when information on all sows was pooled. The regression coefficient for milk production and litter size is approximately one-half this amount, which shows that milk production did not increase in a manner directly proportional to the number of pigs in the litter, but in a decreasing manner as litter size increased. Thus, as the litters increased in size there was a smaller amount of milk produced per pig.

This observation is in agreement with that of Dschaparidse (1936) who stated that the size of the litter influenced milk production but the increase was

not in proportion to the size of the litter. Possibly this might be explained by the fact that the teats vary widely in the amount of milk they produce (Wohlbier, 1928 and Hempel, 1928), and when litters are small only the most productive nipples remain functional. As the litters increase in size some of the less productive nipples are functional, which might explain the results obtained in this experiment. Another influencing factor could be that there is a physiological limit in the total amount of milk the sow can produce, and larger litters would mean that less milk could be produced per pig. The first explanation given would seem to be the most likely one but both could be involved.

B. Age and weight of sow at farrowing. The correlation between the age of the sow and the amount of milk she produced was studied in detail. Coefficients of correlation were determined within each breed, in all breeds and crosses combined, and on a within-breed basis. All of the coefficients of correlation were very low and none was significant. Thus, variations due to the age of the sows in this study were not very important.

The probable reason for the lack of correlation between the age of the sow and milk production was that within each breed there was very little variation in age. The Landrace x Poland sows were the youngest with an average age of 13.0 months with a standard deviation of 2.8 months. The Landrace sows were the oldest, averaging 25.1 $\pm$ 3.1 months; the Polands were next, averaging 21.5 $\pm$ 3.7 months; and the Durocs averaged 15.7 $\pm$ 3.3 months.

Other workers have found differences in milk production due to age, but in most cases they worked with sows in which there was a wider age range (Schmidt and Lauprecht, 1926; Wells, Beeson and Brady, 1940; Berge and Indreb 1953 and Smith, 1952a). In most experiments, milk production was measured in the same sows during several successive lactation periods, whereas in this study milk production was measured in different sows in different seasons.

No significant relationship could be found between the weight of the sow at farrowing and the amount of milk produced. All correlation coefficients were very small or negative and none were statistically significant.

Relationship of Total Milk Production to Backfat Thickness at 200 Pounds and Weight at 154 Days of Age.

The previous discussion was in reference to factors which might be directly responsible for variations in milk production in the sow. This discussion will be confined to measurements of growth rate and backfat thickness in the sows during the growing-fattening period. It is more likely that a significant correlation between total milk production and one or both of these traits would not be a cause or effect relationship, but an association due to a common source or cause.

A. Amount of backfat at 200 pounds. Backfat thickness was determined in the sows at 200 pounds by probing through the fat and skin with a metal ruler. Three measurements were taken, one just back of the shoulder, a second near

the hip bones and a third mid-way between the hip bones and the tail head. These three were averaged to give the backfat thickness in each of the sows.

The data on this portion of the study are summarized in Table 12. The Duroc sows possessed an average of 45.4 millimeters of backfat at 200 pounds

TABLE 12--CORRELATION BETWEEN SUBCUTANEOUS BACKFAT AT 200 POUNDS AND TOTAL MILK PRODUCTION BY SOWS

Breed or Cross	No. of Sows	Avg.** Milk Prod.	Avg.** Bf. Thick	Coefficient of Correlation "r"	Coefficient of Regression "b"
Durocs	19	236.2	45.4	-.11.	-.99
Landrace	14	306.2	35.0	-.05	-.71
Polands	8	265.9	37.8	-.99*	-15.3
Landrace x Poland	9	299.9	35.9	.36	+6.16
Gross (all breeds)	49			-.46***	-4.23
Between breeds	3			-.992***	-6.64
Within breeds	46			-.066	-.78

*Probability of chance occurrence less than .05
**Probability of chance occurrence less than .01
***Probability of chance occurrence less than .001

or 10.4 mm. more than the Landrace which had the thinnest backfat. The Poland and Landrace x Poland sows were approximately the same in backfat thickness. Differences between the sows of the various breeds in backfat thickness were highly significant ($P<.01$).

All of the correlation coefficients were negative with the exception of within the Landrace x Poland crossbred sows although all were not statistically significant. When data on all breeds were grouped together, a very highly significant negative correlation was found ($P<.001$) between backfat thickness at 200 pounds and milk production of the sows. On a within-breed basis, however, the coefficient of correlation was very low and not significant. The between-breed coefficient of correlation was very highly significant ($P<.001$), indicating that the gross correlation was more largely due to breed rather than to an individual characteristic within the breeds. The results obtained need to be studied further to confirm these findings, for if they are correct this would suggest that gilts with less backfat at 200 pounds should later prove to be the better mothers by giving more milk for the pigs during the lactation period. A possible explanation of this finding, could be that metabolism in the fatter gilts was such that they tended to convert their feed to more fat and a similar situation probably existed when they were lactating in that they tended to convert feed to fat rather than to milk.

B. Weight of gilts at 154 days of age. In this group the Polands made the fastest gains, weighing an average of 197 pounds at 154 days of age; the Landrace grew the slowest, weighing an average of 148 pounds at this age. Analysis of variance showed that the gilts of the different breeds varied significantly ($P<.01$) in weight at 154 days of age.

Correlation coefficients for weight of gilts at 154 days and their milk production as sows were determined for the various breeds and in pooled data for all breeds. No significant correlation was found although the correlation coefficient for the pooled data of -0.23 approached significance at the 5 percent level. The within-breed correlation coefficient was only 0.02 whereas the between-breed coefficient of correlation was -0.68. Although the latter was not significant, the evidence suggests a trend toward poorer milk production in gilts from breeds with the faster growth rate to 154 days of age.

The Relationship between Milk Production and other Performance Factors in Sows.

This portion of the study was designed to determine which of the factors might be affected by the amount of milk produced by the sows during the lactation period. Possibly they also had an affect on total milk production.

A. Weight of the litter at weaning. Since at least during a considerable portion of the lactation period the pigs are entirely or largely dependent on the milk produced by the sow, one would expect a strong correlation between litter weight at weaning and the amount of milk produced by the sow. Correlation and regression coefficients for these two traits are summarized in Table 13 along with average milk production and average litter weight at six weeks for sows of the different breeds and crosses.

TABLE 13--THE CORRELATION BETWEEN MILK PRODUCTION IN SOWS AND THE WEIGHT OF THEIR LITTERS AT SIX WEEKS

Breed or Cross	No. of Sows	Avg.** Milk Prod.	Avg.* litter wt.	Coefficient of Correlation "r"	Coefficient of Regression "b"
Durocs	19	236.2	135.6	.64**	.38
Landrace	14	306.2	171.6	.42	.40
Polands	8	265.9	126.1	.77	.67
Landrace x Poland	9	299.9	157.0	.18	.09
Gross (all breeds)	49			.58***	.39
Between breeds	3			.80	.45
Within breeds	46			.51***	.37

*Probability of chance occurrence less than .05
**Probability of chance occurrence less than .01
***Probability of chance occurrence less than .001

The Landrace sows produced the most milk and had the heaviest litters at weaning. The Durocs gave the smallest amount of milk but their average litter weight was about 9 pounds heavier than that of the Polands. The differences between the breeds in the average weight of their litters at six weeks of age were significant ($P<.05$).

All correlation and regression coefficients were positive, showing that sows producing the most milk also tended to wean the heaviest litters. The gross and the within-breed correlations were very highly significant ($P<.001$) with the

regression coefficients showing from 0.37 to 0.39 pounds more milk produced per pound of extra litter weight at weaning.

B. Weight changes of sows during lactation. Sows of the various breeds and crosses varied significantly ($P<.01$) in the amount of weight they lost during the lactation period as shown in Table 14. The Duroc sows actually gained an

TABLE 14--THE CORRELATION BETWEEN MILK PRODUCTION AND WEIGHT CHANGES OF SOWS DURING LACTATION

Breed or Cross	No. of Sows	Avg.** Milk Prod.	Wt.** change lbs.	Coefficient of Correlation "r"	Coefficient of Regression "b"
Durocs	19	236.2	4.6	-.68**	-.39
Landrace	14	306.2	-22.0	-.43	-.20
Polands	8	265.9	-6.0	-.34	-.21
Landrace x Poland	9	299.9	-29.2	-.17	-.09
Gross (all breeds)	49			-.58***	-.30
Between breeds	3			-.92*	-.41
Within breeds	46			-.46***	-.25

*Probability of chance occurrence less than .05
**Probability of chance occurrence less than .01
***Probability of chance occurrence less than .001

average of 4.6 pounds during lactation whereas all of the other sows lost weight. The Landrace x Poland crossbred sows lost an average of 29.2 pounds and they were followed closely by the Landrace which lost an average of 22 pounds per sow. The sows of these two breeding groups also gave the most milk and weaned the largest litters.

The relationship between milk production and weight changes in sows during lactation is also shown in Table 14. All correlation and regression coefficients were negative, indicating that the larger the amount of milk produced the greater the amount of weight lost by the sows. This was true on both a between-breed and a within-breed basis. The within-breed correlation coefficient was very highly significant ($P<.001$); the sows lost an average of 0.25 pounds in weight for each additional pound of milk they produced during the lactation period.

C. Creep feed consumption by the pigs. One question of considerable academic importance is whether or not there is any relationship between milk production in the sow and the amount of creep feed consumed by the pigs. Many persons are of the opinion that litters from sows which give a small amount of milk will consume more of a creep ration than those from sows which give a large amount of milk.

The relationship between milk production by sows and the creep feed consumption by their pigs is shown in Table 15 for all breeding groups used in this experiment. Nearly all of the coefficients of correlation were positive, which suggests that there was a tendency for litters from sows which gave the most

TABLE 15--RELATIONSHIP ("r" VALUES) BETWEEN WEEKLY MILK PRODUCTION AND CREEP FEED CONSUMPTION BY PIGS

Breed	No. of Sows	Week of Lactation			
		3	4	5	6
Durocs	19	.35	.28	.12	-.17
Landrace	14	-.02	.25	.32	.01
Polands	8	.32	.27	.35	.29
Landrace x Poland	9	-.55	.58	.30	.61
Gross (all breeds)	49	.15	.36**	.44**	.28*
Between breeds	3	.05	.83	.96*	.99**
Within breeds	46	.15	.28	.25	.14

*Probability of chance occurrence less than .05
**Probability of chance occurrence less than .01

milk to consume the most creep feed. The gross correlation coefficients for the fourth, fifth and sixth weeks were significant ($P<.05$), but when the correlations were calculated on a within-breed basis all coefficients were lower and not significant although still positive. The relationship would appear to be more of a breed than an individual sow and litter characteristic.

No attempt was made in this study to determine the exact amount of the sow's feed eaten by the pigs. Observations from time to time indicated that this was considerable and could have had an imporant influence on the amount of creep feed consumed by the pigs. For an accurate measure, a specially designed experiment would have to be conducted to prevent pigs from consuming some of the sow's ration.

Efficiency of Production of Sows of Different Breeds and Crosses.

Another objective of this study was to determine if sows from various breeds and crosses differed in the efficiency with which they produced milk and gains in the pigs in their litters. Data relative to this phase of the study are summarized in Table 16.

A significant difference ($P<.05$) was noted in sows from the different breeds and crosses in the amount of feed consumed during the six-week lactation period. The Poland sows consumed an average of 435 pounds of feed, compared to 486 pounds by the Durocs. The others ranked between the Durocs and Polands in feed consumption. The significance of these observations is not fully understood, but they suggest a difference in appetites. It is of interest that the Duroc sows which ate the most feed during the lactation period also produced the least milk. As a result, they did not lose weight during lactation but actually gained an average of 4.6 pounds per sow. Sows in the other breeding groups lost weight, on the average, during lactation.

Feed consumption by the sows for each pound of milk produced varied from a low of 1.52 pounds in the Landrace to a high of 2.17 pounds in the Durocs. Breed and cross differences were highly significant ($P<.01$). Landrace x Poland crossbred sows were almost as efficient in this respect as were the Landrace, requiring an average of 1.57 pounds of feed per pound of milk produced.

TABLE 16--EFFICIENCY OF PRODUCTION OF SOWS OF DIFFERENT BREEDS AND CROSSES

	(19) Durocs	(14) Landrace	(9) Landrace x Polands	(8) Polands
Average feed consumed* per sow during lactation	486±12.16	465±7.22	459±4.00	435±13.08
Avg. milk production per sow**	236±11.47	306±11.76	300±18.66	266±18.03
Feed consumed by sow per pound** of milk produced	2.17±.13	1.52±.06	1.57±.09	1.70±.14
Feed consumed per sow per pound* of litter gain in weight	4.56±.33	3.29±.26	3.66±.25	4.60±.53
Milk consumer per litter* per pound of gain	2.10±.09	2.17±.14	2.37±.25	2.68±.23
Creep feed consumed per pound of pig gain	0.25±.03	0.34±.03	0.33±.02	0.33±.06
Feed consumed by sow* and litter per pound of litter gain	4.81±.34	3.64±.25	3.99±.22	4.93±.53

*Probability of breed differences being due to chance less than .05
**Probability of breed differences being due to chance less than .01

The amount of feed required by the sows to produce a pound of gain in the pigs varied from a low of 3.29 pounds for the Landrace sows to a high of 4.60 pounds in the Polands and 4.56 pounds in the Durocs. The Landrace x Poland sows required 3.66 pounds of feed per pound of pig gain. These differences in sows of the different breeding groups were significant ($P<.05$).

The efficiency with which pigs made their gains during the nursing period is indicated by the amount of milk and creep ration required for each pound of gain. Breed and cross differences in milk required per pound of gain were significant ($P<.05$), but no significant breed or cross difference was noted in the amount of creep feed required per pound of pig gain. The Duroc pigs required 2.10 pounds of milk per pound of gain, compared with 2.68 pounds required by the Poland pigs. These were the extreme differences, Landrace pigs requiring 2.17 pounds and the pigs from the Landrace x Poland sows, 2.37 pounds of milk per pound of pig gain. Duroc pigs also ate less creep feed per pound of gain (0.25 lbs); pigs from sows of the other breeds and crosses were practically equal in this respect, consuming approximately 0.33 pounds of creep feed for each pound of gain.

These data are of interest because they indicate that even though Duroc pigs were the most efficient in the utilization of both milk and creep feed, the Duroc sows were among the least efficient in converting feed to milk. The Poland sows ranked with them in this respect. Landrace sows, on the other hand, were highly efficient in converting feed to milk, and their pigs were very efficient in converting feed to weight gains.

Another method used to determine the efficiency of production of sows and pigs of the different breeding groups was to determine the amount of feed consumed by both pigs and sows per pound of pig gain. This did not include milk production but included the feed consumed by the sow and the creep feed consumed by the pigs. Significant differences ($P<.05$) were noted in the breeding groups in this respect. The Polands were the least efficient, requiring 4.93 pounds of total feed per pound of pig gain. They were followed rather closely by the Durocs who required 4.81 pounds of feed per pound of litter gain. The Landrace were the most efficient breeding group, requiring only 3.64 pounds of feed per pound of litter gain. This was a difference between the Landrace and the Polands of 1.29 pounds with the Landrace requiring 26 percent less feed per pound of pig gain.

The data showed very clearly that sows from different breeds and crosses varied significantly in the efficiency of pig production in this experiment.

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