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Title WEIGHTS AND NURSING POSITIONS OF PIGS AND MILK PRODUCTION OF INDIVIDUAL UDDER SECTIONS OF SOWS

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Milk production data used in this thesis were collected in the spring and fall of 1962 using sows and litters from the O. S. U. herd of Berkshire and Yorkshire swine. The data were used to determine the differences, if any, between the udder sections one thru seven with regard to birth weight, weaning weight and milk intake of pigs nursing at the various sections; and the association of birth weight, weaning weight, milk intake and udder nursing position one with the other.

A significant difference was found between the birth weights of pigs nursing udder sections one and seven ($P<.05$) and udder sections two and seven. The only udder sections significantly different ($P<.05$) for weaning weight of pigs were sections one and seven. A significant difference ($P<.02$) for milk intake of pigs existed between udder

sections one and six and udder sections four and six.

Highly significant ($P<.01$) coefficients of correlation were found for: (1) milk intake with weaning weight, (2) birth weight with weaning weight and (3) milk intake with weight at third week of lactation. Nursing position was significantly associated ($P<.05$) with weaning weight and ($P=.05$) with milk intake.

No differences in average milk production were found between spring and fall seasons or between Berkshire and Yorkshire sows. Sows in each breed and udder sections within sows differed significantly for individual levels of milk production.

In 13 percent of the milk intake observations, pigs were found to have switched from the udder section previously recorded as a permanent position. A frequency of seven percent of the observations taken were found to be of pigs nursing two or more teats at a single nursing.

The largest pig in the litter was nursing anteriorly to the smallest pig 63% of the time and the smallest pig was anterior to the largest pig 30% of the time. The largest pig was on the most anterior teat being nursed in the litter 36% of the time and on the most posterior teat being nursed six percent of the time. The smallest pig was on the most anterior teat being nursed 18% of the time and on the most posterior 27% of the time.

No correction of weaning weights for nursing position appear justified for a selection program. The high variability of milk production by glands at each position suggest that improved uniformity of performance and increased efficiency of selection may be obtained by supplemental milk feeding of low birth weight pigs and/or poor performing pigs.

WEIGHTS AND NURSING POSITIONS OF PIGS AND MILK PRODUCTION OF INDIVIDUAL UDDER SECTIONS OF SOWS

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WEIGHTS AND NURSING POSITIONS OF PIGS AND MILK PRODUCTION OF INDIVIDUAL UDDER SECTIONS OF SOWS

INTRODUCTION

Milk production of the sow is in many respects like that of the cow. The study of sow's milk, however, is about 50 years behind the research concerning cow's milk (33, p. 110). A big reason for studying the milk production of cows is the direct use of the milk as food for humans. The study of sow milk production, on the other hand, has only an indirect effect on man inasmuch as sow milk is not used directly for human consumption but instead is involved in production of meat animals used for human food.

Through increased knowledge of the milking ability of sows and of the constituents of sow's milk it may be possible to select the more desirable milkers. By selecting sows with better milking capacity, improved efficiency and increased quantity of pork production can occur.

The young pig does not start eating creep feed to any large extent until 3-4 weeks of age. After the 3rd-4th week of lactation, sows generally begin to decline in volume of milk produced (1; 2, p. 14; 3, p. 99; 5, p. 365; 8, p. 12; 15; 17; 19; 21; 22; 28). Growth of the pigs will have been markedly influenced by this age by the

milk production of their dam. These influences will continue to affect growth performance throughout the period to market weight.

The runt pig has long been a problem to many producers. In the past it has been a common opinion that it was easier, and in many cases more economical, to either kill such pigs or to allow them to die in the first few days after farrow. This idea is not very sound in modern pig production. More pigs saved and raised means more money to the producer. "As an average, the profit on four or five pigs marketed is required to pay the cost of carrying the sow, and this cost is substantially the same whether the sow raises two pigs or 10. Profits then begin with the sixth pig" (9, p. 131). Increased knowledge of sow's milk and of the sow's milking ability may result in practices that better cope with the problem of runt pigs.

This study has been undertaken to find if there is any set pattern in milk production of individual udder sections of sows. If there is a significantly different milk supply at the different udder sections, pig weights will vary accordingly inasmuch as each pig regularly nurses a given udder section. We may be able to correct individual pig weights for this environmental influence and thus increase selection efficiency.

Through knowledge of the production and constituents of sow's

milk, much progress has been made by nutritionists in formulating rations and sow's milk replacer for baby pigs. Continued collection of data can contribute to more efficient feeds and feeding programs for young pigs.

By studying milk production, especially individual udder section production, new and better methods of swine-raising practices may be developed. If we can increase production by saving more pigs, having larger pigs produced at weaning, making faster post-weaning gains, or improving selection efficiency by more accurately interpreting the variation in weaning weights, then both the producer and consumer will benefit in the long run.

REVIEW OF LITERATURE

Much research has been done on milk production in swine. The first experiment to which reference was found in which milk production of sows was determined was conducted by Von Gohren in 1865 (2; 5, p. 361). In this experiment milk production was determined by weighing pigs before and after nursing. Since that time this method has been used extensively (5, p. 362; 8, p. 8; 13, p. 349; 19; 22; 23; 24; 27, p. 203; 34, p. 1059; 36). Two variations may be employed in using this method of collecting milk production data. One method is to weigh the pigs as a litter, getting total milk production of the sow. This tells nothing about the milk production of individual udder sections. The other method is to weigh each pig separately and in this way one can check the relationship of birth weight of pig with milk intake, nursing position and weaning weight. The method of weighing the pigs before and after nursing necessitates the accurate and expedient weighing of the pigs, especially after they have nursed, to insure that they do not urinate or defecate between weighings. In Donald's (13, p. 349) opinion, the best method of weighing the pigs is by the use of a gram direct reading balance scale with a tightened movement. He further found the reading of the scale should be done quickly to get the most accuracy. Allen,

Lasley and Tribble (2, p. 12) also noted that the scale needed a dampened movement to keep an excess amount of movement on the dial from obscuring the reading.

The urination and defecation problem has been overcome in some cases by the forced movement of the pigs just before weighing the first time (1; 27, p. 203). It was estimated by Donald (13, p. 349) that urination caused about 10-30 gram loss in weight and that defecation caused about a five gram loss.

Comstock et al. (10, p. 380) postulated that there is a possibility that the differences observed in milk production per gland, when weighing pigs before and after nursing, arises not from variations in productivity but from variations in the appetites of the pigs. This theory was advanced from information obtained by comparing milk production from reviewed literature with actual weights of pigs taken by Comstock et al. With this theory it would have to be assumed that the baby pig, at least at first, receives all the milk it wants or needs. The different udder sections would thus adjust, in the early part of lactation, to the amount of milk being taken by the pig.

Another method now in use for obtaining milk for estimation of production and for analysis of composition is the use of a milking machine (18; 19; 28). An injection of oxytocin (28) or other product

giving an oxytocic effect is needed to cause milk flow when using the milking machine. Pitocin, a product manufactured by Parke, Davis and Company containing ten international units of oxytocic principle of the posterior lobe of the pituitary gland, has been used with much success by some of the workers (3, p. 102; 6; 7).

When using the milking machine, it was found by Pond, Van Vleck and Hartman (28) that milk flowed about five minutes. This is in contrast to the total time spent by the pigs per nursing. The latter has been found to be on the average 1-1 1/2 minutes (12; 23). Hartman, Ludwick and Wilson (19) found that the milk flow reduced sharply after 2-3 minutes of machine milking with hormone stimulation, but that another 10% of milk could be collected if the glands were massaged when the reduction occurred.

The peak production of the lactation period seems to be during the 3rd-4th week (2, p. 14; 5, p. 365; 8, p. 12; 17, p. 64; 19; 21; 22; 25; 28; 35, p. 68). Some variation in this has been reported. Kovacs (24) found the peak milk flow during the second week of lactation. He also found that it held fairly constant until about the sixth week and then dropped off. Racz (29) found that the milk flow remained fairly constant until the 7th-8th week and then dropped off rapidly. Allen and Lasley (1) found a breed difference in the time of peak production during lactation. The peak was reached in the

third week by Duroc and Landrace X Poland sows. The peak was reached in the fourth week by Poland sows and in the fifth week by Landrace sows.

Two general quantities of daily milk yield have been reported with a difference of about 10 pounds. The lowest range reported was a 4-6 pound daily yield (8, p. 14; 11; 22; 23). The higher range was 11-15 pounds daily (3, p. 107; 35, p. 65; 37, p. 9).

The amounts of milk obtained by nursing and by machine indicates a wide variation in milk production per gland. The variation in the amount of milk being taken in by the pig could be due to appetite, disease etc. but the milking machine should empty the gland fully if it is in good working order.

Smith (33) postulates that the quantity of milk taken at any one nursing is only about 30-50% of the total milk in the gland. Barber, Braude and Mitchell (3, p. 107) reported the amount of milk made available to the young depended a great deal on the amount of milk ejection hormone secreted in response to suckling stimulus. They further reported that much of the time not all the milk is taken because the stimulus is not always great enough.

The total milk yield has been found to be correlated in a positive manner with the number of pigs in the litter (3, p. 110; 5, p. 364; 15; 24; 25; 37) but milk production does not increase

proportionally with increase in litter size. In other words, as litter size increases, total quantity of milk per pig decreases (2, p. 17; 3, p. 10; 5). Thompson (36) on the other hand, found that the number of pigs per litter did not affect the amount of milk available per pig.

It is commonly thought that a good milking sow will lose weight and look run down during lactation. It has been found that the increase in litter weight to four weeks is correlated with the decrease in live weight of the sow (2, p. 21; 30).

Using Durocs, Polands, Landrace and Landrace X Polands, Allen, Lasley and Tribble (2, p. 13) and Allen and Lasley (1) found a highly significant breed difference in the amount of milk produced over the entire lactation period. The Landrace sows produced the most followed by the Landrace X Poland crossbreds. Poland sows were third in production with Duroc sows giving the least. Carlyle (8, p. 14) also found a difference in the amount of milk given by different breeds. He found that Berkshires gave the most, Polands were intermediate with Razor Backs giving the least.

Milk yield of sows during a single lactation has been reported to increase with the number of farrowings (29). Two to three year old sows produce the most milk according to Wells, Beeson and Brady (37) but Allen and Lasely (1) and Allen, Lasely and Tribble

(2, p. 18) found that the age at farrowing was not significant. The third litter of pigs, no matter what the age of the sow, stimulates the greatest milk flow according to Dschaparidse (15).

According to Carlyle (8, p. 7) the older, larger sows appeared to be the best brood sows. Allen and Lasely (1) found the sows that gave the most milk lost the most weight during lactation. They also had some evidence that the gilts with the thickest backfat at 200 pounds gave the least milk.

Wells, Beeson and Brady (37) found that a variation in milk production exists between families. A breeder using a good selection program may be able to increase level of milk production in his herd by finding the good milking families.

Birth weight seems to have an effect on the amount of milk consumed (29), with the lighter pigs consuming less milk daily than the heavier birth weight pigs (13, p. 351; 36). If the pigs start out at approximately the same weights, then the ones receiving the most milk make the most gains throughout lactation and for approximately 60 days thereafter (36). The initial weight may at first affect the amount of milk consumed but weights after about three weeks of suckling are controlled principally by the productivity of the nipple suckled (14, p. 33). Comstock et al. (10) and Racz (29) found a correlation of growth of pigs and milk flow up to the sixth week of

lactation.

Low milk consumption may be a factor contributing to high mortality and slow preweaning growth in pigs with low birth weight (16).

In general, each pig has his own place at the sow's udder and returns to it each time he nurses (8, p. 9; 12). By the end of the second week all the pigs seem to have a set pattern and have their nursing position established (3, p. 104). According to Donald (14), weight appears to be the most important single factor in determining the distribution of the pigs along the udder.

Donald (12) studied the nursing habits of the pigs and found the pigs on the front or on the rear udder section rarely out of order but the pigs nursing the middle section were quite often out of place. If one pig was on a wrong position usually at least one other pig was also. Most of the switching was from positions R2 and R3 and normally within the same horizontal row. When the sow laid on the opposite side from normal, about 1/2 the pigs were confused as to their normal positions.

Observations have indicated a preference of the suckling pigs to suckle the front teats (3, p. 104; 5, p. 376). One reason that has been advanced for this is the postulation that front teats give more milk than the rear ones (3, p. 110; 5, p. 376; 8, p. 9; 13, p. 357;

17, p. 64; 18; 21).

Racz (29) stated that if the teats give equal volumes of milk then the pigs develop uniformly but if the production of the individual teats varies the litter will lack uniformity. Bonsma and Oosthuizen (5, p. 376) concluded that the weaker pigs were forced to use the posterior teats because the larger and more vigorous pigs took over the front teats. Barber, Braude and Mitchell (3, p. 104) also found that the larger pigs were usually on the front teats but they questioned if the larger pigs took possession of the front teats or whether they got larger because of more milk. Hartman and Pond (18) found the pigs nursing the anterior teats tended to make the most gain.

Another reason postulated for the front teats being preferred was the protection the front legs tend to give to the young pig (3, p. 104; 12).

In contrast to the theory that the largest pigs nurse the front teats, England et al. (16) found that pigs do not secure permanent nursing positions from front to rear according to birth weights. These researchers found that the larger rather than the smaller pigs nursed the posterior positions; the center sections-positions three and four were being nursed by pigs with the lowest average birth weights.

Hartman, Ludwick and Wilson (19), using both hormone stimulation with machine milking and individual pig nursing, found no significant association between location of udder section front to rear or left to right with milk yield. They further found no significant differences between the weight of the pigs at six weeks and the positions nursed. Hartman, Ludwick and Wilson (19) and Donald (12) concluded that there is no selection by the pigs for location or milk yielding of any individual udder section. Pond, Van Vleck and Hartman (28), milking by machine, also found no significant difference among glands, within sows, for milk yield.

Hartman, Ludwick and Wilson (19) postulated that the larger pigs emptied the glands more thoroughly thus stimulating greater milk production in these sections.

In collecting data on total milk production of sows the average nursing interval and duration have been determined. Lowered milk production was noticed when too long an interval between nursings was used in data collection (3, p. 97; 37). If shorter intervals are used the sow generally will not allow the pigs to suckle at each intended time. Dschaparidse (15) found that sows having naturally shorter suckling intervals gave a higher total yield. A nursing interval of about one hour seems to be the most accurate for an average natural nursing litter (3, p. 99; 19; 27, p. 203; 31; 34, p.

1059; 35, p. 65; 37). A number of investigators have used intervals ranging from 1 1/2 hours to six hours (1; 5, p. 363; 8, p. 8; 11; 13, p. 351; 22; 23; 36). Many of the workers used longer intervals at night than during the day (8, p. 8; 11; 13, p. 351; 22). Some of the more recent workers have found very little difference in day and night intervals (3, p. 99; 19).

Longer nursing intervals, ranging from ten minutes to four hours more than those imposed at the first of lactation, were used in advanced stages of lactation by some of the workers (3, p. 101; 19; 23; 26, p. 180; 27, p. 203; 35, p. 65; 37, p. 9). Sheppard (31, p. 108-109) found that any excitement seemed to lengthen the nursing interval but that age and breed did not affect it.

Three stages in the nursing process have been recognized by Barber, Braude and Mitchell (3, p. 102) and by Donald (12). Two of the stages recognized by them were the same but the third was different. The first period recognized in both cases was the preliminary or nosing period. During this time the pigs sort themselves out and massage the udder. Donald postulates that there sometimes seems to be some sort of communication between pigs and sow by the action of the little pigs touching the sow's snout which was noticed by Donald and also by Barber, Braude and Mitchell (p. 104). The second stage noticed in both cases was the nursing or actual milk

flow stage. At this time the pigs are quiet and gentle and rapid suckling takes place. A third stage noticed by Barber and coworkers was a period lasting an average of 21.4 seconds, when the pigs remained perfectly quiet between the nosing and actual nursing period. The third period noticed by Donald was a final stimulating and suckling stage combined, where little milk was consumed, before the sow terminated the nursing period. The average total nursing time found by Donald was 35-45 seconds. Barber, Braude and Mitchell timed each period and found an average of 85.1 seconds for nosing and 18.5 seconds for milk ejection. Hughes and Hart (23) described a pattern similar to those found by Donald and by Barber and coworkers but did not separate the different periods. They did measure what appeared to be the actual nursing period and found an average time of 60 seconds.

Barber, Braude and Mitchell (3, p. 97) found that the sow would not voluntarily eject milk in response to any stimulus other than that of the suckling pigs. Milk let down has been induced by injecting oxytocin (3, p. 102; 6; 7; 28). Once the sow has been stimulated by the pigs and milk begins to flow, the pig must be prompt because the milk flow time is short (2, p. 12). If the pig does not start nursing the instant the milk begins to flow, a reduced intake reading may occur. This may be a reason for some of the small

intake readings and also for some of the variation in intake.

If the pigs are weaned at young ages supplementary feed needs to be given. Barber, Braude and Mitchell (3, p. 114) found that pigs gain better when fed sow's milk or milk replacer ad lib than when nursing the sow. They further stated that pigs eating less milk eat more creep and start eating it at an earlier age. Contradictory to this, Allen and Lasley (1) found that pigs eating the most milk also ate larger amounts of creep feed.

Smith (33, p. 114) found that as the pigs began eating creep feed they set a pattern of nursing and creep feed eating. The pigs first nurse the sow then go to the creep feeder and eat enough creep feed to finish filling themselves. They then sleep until time for the next nursing at which time the cycle is repeated. Smith emphasized that the pigs eat the creep because they are not getting enough milk and not that they eat less milk because they are getting the creep feed. Allen, Lasley and Tribble (2, p. 16) concluded that the creep feed consumption by the fourth week of lactation was great enough that total gains by the pigs after this were more from the creep feed than from the sow's milk.

The oldest method of getting milk samples for testing was by milking by hand several teats while pigs nursed other teats (3, p. 103; 8, p. 9; 11; 23, p. 313; 35, p. 66). This usually turned out to be

quite laborious and not much milk was received. The method now being employed to a larger extent is milking by machine (35, p. 66).

If milk production studies are going to be maximally useful and meaningful, knowledge must also be gained on the selection of desirable milk producing animals and on the relationship of milk production to different weights such as birth weight, weaning weight and post weaning weights. Comstock et al. (10, p. 379) stated that selection for growth would be most successful when the animals, from which selection is to be made, receive the optimum quality of feed in as large a quantity as can be utilized. In general, the growth rate of normal pigs receiving unlimited feed increases as the body weight increases, at least until the onset of puberty (10, p. 383). The distribution of individual weights become increasingly wider as the pigs grow older and the initially small animals fall farther and farther behind (32, p. 292).

Blunn, Warwick and Wiley (4) studied interrelationships of birth, 56 day and 154 day weights of 1, 894 pigs. The average within-litter correlations were birth weight-weaning weight r = 0.53, birth weight-154 day weight r = 0.40 and 56 day weight-154 day weight r = 0.63. Comstock et al (10, p. 387) states that a strong possibility exists that post weaning growth rate may be a better measure of ability to grow prior to weaning than weaning weight

itself. Hazel, Baker and Reinmiller (20) found that growth rate of pigs in early post-natal life has a positive association with growth in subsequent periods.

MATERIALS AND METHODS

Litters from two farrowing seasons of the O.S.U. swine herd were used to collect the information used in this study. Twenty litters were used from the spring 1962 farrowing and 12 litters were used from the fall 1962 farrowing. The number of pigs nursing per litter varied from five to 12.

Collection of data was delayed until the second week of lactation to increase the percentage of pigs that had become established at a permanent nursing location. After this, weights were taken on the same day of the week, one week apart, up to the sixth week of lactation. Due to unavoidable circumstances, weighings were occasionally a day early or a day late. In the fall collection one whole week was skipped due to broken scales. These irregularities should not introduce errors because averages and not totals are being used in the analysis of the data.

The pigs were shut away from the sow for approximately one hour before being allowed to nurse. At the prescribed time, just before the hour was up, each pig was individually weighed. The sow and pigs were then turned together at which time the sow would normally lie down immediately and suckle the pigs. The nursing position of each pig was observed and recorded. If nursing did not

occur when the sow was turned in with the litter, she was turned back out for about another half hour.

If a pig was observed urinating or defecating between weighings, the data for that pig for that weighing was discarded from the final analysis. It appeared that urination gave about a 15-30 gram loss and that defecation gave about a 3-5 gram loss in weight.

It was necessary to identify pigs during nursing and to record the position at which each nursed. The identification of the pigs while nursing was a problem. The use of spots of different colored paint to identify each pig easily and quickly during nursing proved to be inadequate because of the difficulty of rapidly and accurately decoding the color coding. Direct reading of the individual ear notches, by which each pig is routinely identified in the herd, was then used. This method works quite well if someone who is thoroughly familiar with the notching is doing the reading. Little time is allowed during nursing for deciding which pig is which; the identification must be established quickly and accurately. The most satisfactory system consisted of writing the number of each pig on its back with red livestock marking chalk; the ease and accuracy of identifying and reading the numbers of each pig was greatly enhanced. This method saved enough time to permit a second check of the nursing position during most nursing periods. The chance for error in recording the

position nursed by each pig was thereby considerably reduced. A few cases of conflicting positions were recorded. These conflicts did not appear to be related to any particular area of the udder and were omitted from analysis.

The scales used was a Toledo direct reading counterbalance type graduated in grams. A basket was built and secured to the weighing side. The weight of the basket was offset by weights on the counterbalance side. The movement of the scales needed to be dampened to eliminate large, fast movement of the needle as the pig moved around when on the scale. Readings needed to be taken quickly because generally the longer the pig remained in the basket the more restless he became, making it harder to get an accurate reading. The difference between the before and after nursing weights was taken as the amount of milk consumed.

The data were analyzed by standard analysis of variance, student's t-test and correlation coefficients. Where necessary the data were corrected for litter size before analysis; the other data were analyzed without this correction.

RESULTS AND DISCUSSION

A knowledge of individual udder section milk production may be of help to swine producers in the selection and management of their herds. Significant differences ($P < .02$) for milk production were found between sections one and six and between sections four and six (Table 1). Differences in milk production between other sections were found to be non-significant (Table 1). By looking at the means only (Table 2) it might be concluded that udder sections one and four give more milk and udder section six gives less milk than any other section. The test of significance does not bear this out (Table 1). The conclusion may be reached that the pigs belong to two different populations insofar as milk intake is concerned. The pigs nursing on udder sections one and four comprise the population with high milk intake. The pigs nursing on udder section six comprise the population with low milk intake. Pigs on sections two, three, five and seven could be included in either the high or low population because they are not significantly different from either one. A classification of intermediate could be applied to the sections falling between the two distinct populations of high and low milk intake pigs.

The correlation coefficient of nursing position with milk intake ($r = -0.131$) is negative and significant ($P = .05$) (Table 3). The

Table 1 Udder section positions found to differ significantly ($P < .05$)(student's t-test) from each other in birth weight, weaning weight or milk intake of pigs.

Udder Section Positions	Mean Birth Weights	P Value	Mean Weaning Wts.	P Value	Mean Milk Intakes	P Value
1 vs 6	--		--		43.9 & 35.1	$P < .02$
1 vs 7	2.61 & 2.30	$P < .05$	35.24 & 31.3	$P < .05$	--	
2 vs 7	2.70 & 2.30	$P < .02$	--		--	
4 vs 6	--		--		43.1 & 35.1	$P < .02$

Table 2 Means, number of observations, standard deviations, and coefficients of variation of birth weights, weaning weights and milk intake per nursing by pigs nursing at the different udder section positions.

Udder Section[1] Position	1	2	3	4	5	6	7	Total
Birth weight[2]								
Mean	2.61	2.70	2.63	2.64	2.61	2.55	2.30	2.60
No. of observations	55	41	37	38	28	25	19	243
Standard deviations	0.61	0.57	0.73	0.69	0.70	0.64	0.45	0.60
Coefficients of variation	0.23	0.21	0.28	0.26	0.27	0.25	0.20	0.23
Weaning weight[2]								
Mean	35.2	33.8	33.8	35.2	32.8	33.2	31.3	34.0
No. of observations	54	41	37	37	28	24	19	240
Standard deviations	6.8	6.3	6.6	6.2	4.8	6.4	8.5	6.2
Coefficients of variation	0.19	0.19	0.20	0.18	0.15	0.19	0.27	0.18
Milk intake[3]								
Mean	43.9	39.6	39.3	43.1	41.4	35.1	38.7	41.0
No. of observations	155	93	86	105	54	54	23	570
Standard deviations	22.7	17.7	21.3	18.5	20.3	21.0	21.2	20.5
Coefficients of variation	0.51	0.45	0.54	0.43	0.49	0.60	0.55	0.50

[1]Sections numbered in order from front to rear.

[2]Birth weights and weaning weights in pounds.

[3]Milk intakes in grams.

Table 3 Associations, with and without correction for number of nursing pigs, between mean birth weights, weaning weights, milk intakes and nursing positions and regression coefficients for these traits with correction for number of nursing pigs.

Traits	No correction for litter size		Corrected for litter size		
	r	P	r	P	Regression Coefficient
Milk intake-birth wt.	r = 0.109	P >.05	r = 0.095	P >.05	--
Milk intake-weaning wt.	r = 0.318	P<.01	r = 0.304	P<.01	0.113
Birth wt.-weaning wt.	r = 0.427	P<.01	r = 0.433	P<.01	4.90
Nursing pos.-milk intake	r =-0.132	P =.05	r =-0.131	P =.05	-1.134
Nursing pos.-birth wt.	r =-0.085	P >.05	r =-0.092	P >.05	--
Nursing pos.-weaning wt.	r =-0.146	P<.05	r =-0.162	P<.05	-0.520
Milk intake-3rd week wt.	r = 0.341	P<.01			

magnitude of the correlation coefficient may have been altered by the intake means fluctuating from section to section in other than a linear fashion. The negative correlation is in complete accord with the theory that the front teats do give more milk, as postulated but not established by some of the other workers (3, p. 10; 5, p. 376; 8, p. 9; 13, p. 357; 17, p. 64; 18; 21). On the other hand Hartman, Ludwick and Wilson (19) found no significant association of nursing position and milk yield when using either machine milking or individual pig nursing.

The regression coefficient of nursing with intake is -1.134. This means that for every change of the nursing position from front to rear there is on the average 1.134 grams less milk per nursing taken in by the pig nursing that position.

Weaning weight and milk intake are significantly correlated ($P < .01$) (Table 3). The highest mean weaning weights (Table 2) are for pigs nursing the sections providing the largest milk intakes. The rest of the weaning weight means are not in any specific discernible order with regard to milk intake. In fact the pigs with the next to lowest mean weaning weight received the second highest mean intake of milk (Table 2). The high correlation ($P < .01$) should be an indication that the weaning weight and milk intake have a highly linear relation. The correlation of weaning weight and milk intake may be

distorted because of the fact that nursing position and intake are significantly associated ($r=-0.132$, $P=.05$) and birth weight and weaning weight are correlated significantly ($r=0.427$, $P<.01$). Birth weights and weaning weights of pigs nursing position one were significantly heavier than weights of pigs nursing position seven ($P<.05$)(Table 1). Weaning weights of pigs nursing positions four and seven were not significantly different even though positions one and four have the same mean weaning weight. The magnitude of differences required to achieve significance with position seven is higher because of the smaller sample size at position four. The significant differences between position one and position seven for weaning weight may tend to over emphasize the magnitude of the correlation coefficient for weaning weight and milk intake because of the negative association between nursing position and milk intake.

Birth weight and weaning weight are significantly associated with each other in the present study ($r=0.433$, $P<.01$)(Table 3). This is in agreement with Blunn, Warwick and Wiley (4) who found a significant correlation coefficient ($r=0.53$, $P<.01$) between birth weight and weaning weight.

Nursing position and birth weight and milk intake and birth weight show no significant association (Table 3). With birth weight and weaning weight showing a significant positive association and milk intake and weaning weight also showing a significant positive

association, milk intake and birth weight would be expected to be significantly associated also. This means that the pigs that are heaviest at birth are heaviest at weaning even though there is no evidence that size of pig at birth plays any role in the amount of milk intake per nursing between two and six weeks of age. A higher intake of creep ration by the pigs that were larger at birth appears to be a logical means whereby these pigs could wean heavier without higher milk intake. The available milk supply may more nearly satiate the appetite of pigs of low birth weight than of high birth weight. Smith (33, p. 114) has indicated that pigs nurse first and then eat creep feed to satisfy the remainder of their appetite.

It may be that the pigs that are largest at birth utilize the milk taken in more efficiently than do pigs of lower birth weight.

Mean birth weights of pigs nursing at the different udder sections show no set pattern. Udder sections one and seven are significantly different ($P < .05$) and udder sections two and seven are also significantly different ($P < .02$) only at a different level (Table 1). This could be taken as evidence that smaller birth weight pigs actually do nurse on the rear teats, however birth weights of pigs nursing at all other positions are not significantly different from those nursing any of the other positions. This may tend to indicate that the difference found at position seven is due to a small sample size for position

seven. Bonsma (5, p. 376) found the smaller, weaker pigs nursing on the rear sections. This was observed within four or five days after birth. England et al (16) found just the opposite; that is, the larger pigs were nursing the posterior teats with the smallest pigs in the center on sections three and four.

The coefficient of correlation for nursing position and birth weight was not significant (Table 3).

The season of farrowing, spring and fall, appeared to be of little consequence. The average intake per nursing per pig was 40.1 grams in the spring and 42.3 grams in the fall.

No significant difference was found between the Berkshire and Yorkshire breeds (Table 4) for per nursing milk production. A highly significant difference ($P < .005$) was found however between sows within each breed (Table 4) for average individual pig nursings. This is in agreement with Pond, Van Vleck, and Hartman (28) who found a highly significant difference ($P < .01$) among sows in milk yield as early as two to three days after farrowing.

In some cases a pig was observed nursing more than one teat. Such data were not used in the analysis to determine udder section milk production. There appears to be no set pattern as to the sections that are being suckled together. An average of seven percent of the total observations taken were of pigs nursing two or more

Table 4 Analysis of variance of effects of breeds, sows within breeds, and udder section positions within sows on milk production per udder section.

Source of Variation	Degrees of Freedom	Mean Square	F	Significance Level
Breeds	1	365.47	0.3023	P>.05
Sows within Breeds	29	1,208.962	2.5461	P<.005
Positions within Sows	130	474.814	1.334	P<.01
Within positions	416	355.917		

sections.

Switched udder sections create a problem in deciding whether it is an error in recording or if it is actually a change or mistake by the pig. It was found that 15% of the observations were either switched udder sections by the pig or errors in recording. No apparent pattern of switching was noticed and no one or two teats seemed to have a monopoly on the incidence of switching. Lactation weeks two and five had the most switching when fall and spring observations were pooled. In the fall, the highest incidence of udder switching was during the second and fourth weeks of lactation; in the spring farrowed litters, udder section switching was most frequent during the second and fifth weeks of lactation. During the first and second weeks of lactation the pigs are still establishing themselves on permanent nursing positions. During the fourth and fifth weeks of lactation, milk production is beginning to decline and the pigs may be searching for a teat that is more productive to better satisfy their hunger. The peak milk production of lactation seems to be about the third to fourth week (2, p. 14; 5, p. 365; 8, p. 12; 17, p. 64; 19; 21; 22; 25; 28; 35, p. 68) which would explain the need for more milk during the 4th-5th week of lactation. In this study, the highest average milk yield was observed in the fourth week of lactation.

It was observed that more pigs nurse the front sections than the

rear sections, after the permanent nursing positions are established. This is hard to explain because it was observed that at birth the pigs will all try to nurse the rear teats. The most logical answer is that the front teats give more milk and the pigs determine this in the sorting process during the first two weeks of lactation. The coefficient of correlation in this study (Table 3) shows that the milk production nursing position relationship is significant. Other workers have found that the front teats appear to give the most milk (3, p. 110; 5, p. 376; 8, p. 9; 13, p. 357; 17, p. 64; 18; 21).

According to Donald (14) weight appears to be the most important single factor in determining the distribution of the pigs along the udder. In this thesis study, birth weight does not appear to influence the selection of permanent nursing positions with the possible exception of position seven. The coefficient of correlation for nursing positions and birth weight (Table 3) is not significant. In some cases the total litter that is nursing is made up of pigs from more than one sow. This may be caused by a sow not having milk when she farrows or from a sow dying at time of farrow or shortly thereafter. This may affect the distribution of the pigs on the udder section. The student's t-test analysis of the different udder section means showed a significant difference of section one with section seven ($P < .05$) and of section two with section seven ($P < .02$) (Table 1) respectively for birth

weights of pigs nursing at these positions. Birth weights at none of the other positions were significantly different from each other at the five percent level.

An observations was made on the pig with the smallest birth weight in the litter and its relative permanent position with all other nursing pigs. Specific attention was attended the relation to each other of pigs of smallest and largest birth weights. The same was done for largest-birth-weight pigs. When examining all litters, no matter how many pigs per litter, 21 of a total of 33 litters had the largest pig nursing a position in front of the position nursed by the smallest pig. In ten of the 33 litters the smallest pig was ahead of the largest pig; twice they were nursing at identical positions, one on the right and one on the left. Twelve of the litters had the largest pig on a front teat and nine of the litters had the smallest pig on the last section being nursed by that litter.

The number of pigs nursing on any one sow did not influence any of the traits studied in this thesis except weaning weight (Tables 3 and 5). However this study was based on means and the traits if studied by totals may show a significance between litter sizes.

With the information gained in this study it appears that there would be no basis for recommending a selection program based on correction of pig weights for the milk output of specific udder

Table 5 Analysis of variance for significance of differences in mean milk intakes, birth weights, weaning weights and nursing position locations for litters with varying numbers of nursing pigs.

Source of Variation	Degrees of Freedom	Mean Square	F	Significance Level
Between				
Intake	6	235.953	0.853	P>.05
Birth weight	6	0.580	1.953	P>.05
Weaning weight	6	201.259	5.288	P<.005
Nursing position	6	1.058	0.285	P>.05
Within (Error Terms)				
Intake	213	276.542		
Birth weight	213	0.299		
Weaning weight	213	38.234		
Nursing position	213	3.713		

sections. With the exception of udder sections one and four with six there are no differences in milk production between them. With standard deviations half as large as the means (Table 2) not much uniformity of milk production could be expected within specific udder section locations.

The information that milk intake and weaning weight are significantly associated can be used as a basis for recommending a program of feeding extra milk to the smaller pigs. The significance of this recommendation is compounded by the knowledge that birth weight and weaning weight are significantly associated, as are milk intake and weaning weight.

SUMMARY AND CONCLUSIONS

1. Significant difference ($P < .02$) existed between udder sections one and six and between udder sections four and six for milk production. Nursing position and milk intake were found to be associated ($P = .05$) in a negative manner. A high standard deviation indicates much variation in the milk output from gland to gland at each of the different udder section positions. Positions within sows showed a highly significant difference ($P < .01$). The conclusions are drawn that individual udder sections vary a great deal among sows and between sows and there is a lowly significant negative correlation, for sows as a whole, between nursing position and milk intake by pigs.

2. The student's t-test showed significant differences between udder sections one and seven ($P < .05$) and between udder sections two and seven ($P < .02$) for birth weights of pigs nursing at these positions. The nursing positions and birth weights are not significantly associated for the udder as a whole. The conclusion is drawn that birth weight does not determine position nursed.

3. The relationship of birth weight to amount of milk consumed was determined by calculation of a correlation coefficient. No significant association at the five percent level was found. The conclusion is that birth weight is not related to amount of milk intake.

4. A significant correlation exists between nursing position and weaning weight with the anterior positions tending to wean the heaviest pigs and the posterior positions the lightest. A test of significance showed mean weaning weights to be significantly different for pigs nursing sections one and seven.

5. Weaning weight and milk intake are highly significantly correlated. Intake and weight at the third week of lactation are also highly associated. It thus appears that more milk results in higher gains and that lower milk intake is not compensated for by increased creep consumption.

6. Because birth weight and weaning weight and milk intake and weaning weight are correlated in a positive manner, it follows that milk intake and birth weight would also be expected to be correlated but they are not. This leads to the conclusion that, with the random selection of pigs for nursing position and the high variation in gland milk production, heavier weaning weights depend upon heavy birth weight pigs by chance getting high producing glands and/or consuming higher amounts of creep feed. There is a possibility that the heavier pigs utilize their feed more efficiently but present data do not provide for or permit such conclusions.

7. No difference between the Yorkshire and the Berkshire breeds for milk production was found. Season of farrow was

concluded to have no effect on milk production.

8. No selection advantage or correction factor could be advised for pigs nursing at the different sections because significant differences in milk intake existed only for positions one and four with position six. Equally important, the standard deviation indicates a large variability of milk production by different glands at each position. Because milk intake and weaning weight and birth weight and weaning weight are significantly associated the management practice of feeding low birth weight pigs extra milk or milk replacer throughout the nursing period, or until adequate size is reached, could be advised.

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