INFLUENCE OF AGE OF DAM AND SEASON ON SOW PRODUCTIVITY AND THE CORRELATION BETWEEN THE PRODUCTIVITY OF FIRST AND SECOND LITTERS IN SWINE

By

KENNETH L. APPLE

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Oklahoma State University

Stillwater, Oklahoma

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Thesis Approved:

L. T. Omtvedt
Thesis Adviser

E. J. Turman

N. Durham
Dean of the Graduate College

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INTRODUCTION

Sow productivity is the most important single trait in a commercial swine operation today. Heritabilities for traits associated with reproduction in swine are generally low and have shown a greater response to improved feeding and management practices than to selection. The maintenance cost for the breeding herd is fairly constant, however, regardless of the size and quality of litter produced. Therefore, maximum profit depends on culling the less productive sows and replacing them with more productive individuals.

Efficient culling methods are essential to an economically sound breeding program. Early detection of substandard producers and their subsequent removal from the breeding herd should accelerate herd improvement and greatly reduce loss suffered through maintenance of low producers over an extended period of time. If the first litter performance is a fairly reliable indicator of her future performance, poor producers can be culled from the breeding herd on the basis of first litter records and thus increase overall production of a herd.

This study was initiated to investigate the influence of age of dam and season on sow productivity and to study the correlations between first and second litters for litter size, livability and growth rate.

LITERATURE REVIEW

Investigations involving the influence of age of dam and season of year on productivity traits in swine, the relationships between productivity traits and the repeatability of production records are reviewed in this section.

Age Of Dam Effect. Age at breeding has been shown to influence litter size. Warnick et al. (1951) reported an increase in ovulation rate at each succeeding heat period in gilts from the first to fourth heat. The effect of age on ovulation rate and litter size was investigated by Squiers et al. (1952) using 279 gilts ranging in age from 164 to 301 days. The number of ova shed was found significantly correlated with the age at which estrus was observed ($r=0.31$), an increase of 10 days age being associated with a linear increase of 0.35 of ovum shed. Age was also significantly correlated with litter size at 25 days ($r=0.33$), an increase of 10 days in age at breeding resulted in an increase of 0.5 embryo present. Litter size at 25 days increased 0.61 pig for each increase of 10 days in age of gilts bred at mean age (226-days) when 154-day weights were held constant. Lasley (1957) observed similar increases in litter size, as did Turman et al. (1966) who reported ovulation rates to increase by approximately one egg for each six weeks increase in age of gilts. Rathnasabapathy et al.

(1956) found that each 10 day increase in age at breeding resulted in 0.48 more ova shed.

Early work by Carmichael and Rice (1920) showed that the number of pigs farrowed per litter was larger for sows than for gilts. Olbrycht (1943) reported an average of 1.07 more pigs per litter for sows farrowed first at 17 months as compared to those first farrowing at 12 months of age. Stewart (1945a) and Johansson (1929) reported that litter size increased with age of dam up to about 15 - 16 months of age, with most of the increase occurring between ages 9 and 12 months. Keith (1930) found that, in general, the size of litter increased with the age of the dam up to about four and one-half years, after which a gradual decrease occurred. Morris and Johnson (1932) concluded from a study of 1,035 litters of Poland pigs that litter size increased with increase in age of dam up to sixty months. Results from a study by Olbrycht (1943) showed a similar increase in size of the litters reared up to and including the fourth litter, after which there was a slow decrease in number of pigs reared per litter. Omtvedt et al. (1965) reported an average of 10.8 pigs for sows compared to 9.8 pigs for gilts in a study involving 301 sows and 390 gilts. The Oklahoma study showed that each 10 day increase in age of gilt at breeding resulted in an increase of 0.16 pig farrowed per litter. Shelby (1967) reported age of dam to have it's greatest effect at birth. In his study, age of dam seemed to have a curvilinear effect on litter size at

birth with litter size increasing rapidly from 10 to 24 months and then less rapidly until a peak was observed at 36 months. Earlier investigations by Bartolini (1949) involved 75 sows divided into three groups, the first being served at ages 169 to 273 days, the second from 274 to 427 days and the third from 428 to 665 days. Highest average litter weights (10.6 kg.) and the most pigs per litter (9.3) were obtained from the second group; within this group the sows served between 379 and 399 days gave the highest average litter weight (12.9 kg.). The third group showed the greatest degree of variation in both number and weight. Olbrycht (1948) and Moxley and McMillen (1949) reported litter size increases up to the fourth or fifth litters. Olbrycht (1948) using data from 1560 litters reported litter size to be maximal in the fifth litter with an average of 11.9 pigs. The optimal litter size (litters in which the greatest number of pigs were reared) was 12.63 pigs. MacDonald et al. (1963) and Mazaraki (1962) observed age of dam to have no significant effect on the number of pigs alive at weaning.

Wiggins et al. (1950) reported gilts which conceived at the third heat period farrowed 1.4 more pigs than gilts which conceived at the second heat and 2.5 more pigs than those which conceived at the first heat. Noriskog et al. (1944) analyzed data on 2,396 pigs and 312 dam-litter pairs in order to investigate factors of heredity and environment affecting the growth curve of swine. Pigs farrowed from

sows were found to be about four pounds heavier at weaning than pigs from gilts and the advantage was maintained to 168 days of age. The variance arising from age difference of dams accounted for 22 percent of the total intra-line and year variance in weaning weight. The Minnesota workers concluded age differences to have no influence on gains after weaning while their influence on weight after weaning declined only gradually. Noland (1964) found age-of-dam effects to be significant for birth weight and weaning weight, total pigs farrowed, total live pigs farrowed, litter birth weight and total pigs weaned per litter. Blunn et al. (1949) studied the effect of sow age on total number of pigs farrowed, number of pigs born alive, total weight at weaning and 168 days of age. Age of sow was found to be one of the most important factors in determing the size of the litter farrowed and the number of pigs born alive. The data of 331 sows and 561 litters indicated age of sow to be more important in determining the total size of litter farrowed and number of pigs born alive than either inbreeding of the dam or litter.

Olbrycht (1943) determined the absolute number dying before weaning increased with the number at birth and with the age of the sow. In this study, the variability in pigs born, reared and died was greater between sows than within sows. Perry (1956) found the average number of pigs born rose with successive pregnancies to a maximum of more than 15 in the sixth and seventh litters and declined thereafter.

The average number born alive reached a maximum of more than 14 in the fifth litter and declined thereafter, the decline being less marked among pigs born alive than among all pigs including stillbirths. Carmichael and Rice (1920) reported that older sows farrowed a greater percentage of dead pigs than did the younger sows. From a total of 5,778 pigs, 8.1 percent of those farrowed by first and second litter sows were dead or immature compared to 12.3 percent for sows three years old or older.

Corrections for age-of-dam differences have been computed by some workers for the more important productivity traits. Lush and Molln (1942) suggested that the best whole-number correction for age differences was that of adding two pigs to the litter farrowed by one-year-old sows and one pig to the size of litter farrowed by one and one-half year-old sows. This age correction removed 86 percent of the sum of squares for age differences in their study. Skyervold and Odegard (1960) corrected sow yield figures for age of dam using a presupposed heritability of 0.1 and a repeatability of 0.2 for the number of pigs at birth and weight of pigs at 21 days (sow yield). Age correction factors were obtained by making additions to the mean litter size at birth of 0.6 pigs for first litter, 0.5 pigs for second litters, 0.3 pigs for third litters and additions to mean of weight at 21 days of 0.3 kg. for first litter, 0.2 kg. for second litters, and 0.1 kg. for third litters.

Seasonal Effect. Swine breeders have consistantly

observed differences in litter size between fall and spring litters. Gossett and Sorensen (1959) noted spring-farrowed gilts tended to be more efficient than fall-farrowed groups of gilts. Ovulations in the spring-farrowed group were 19 percent greater and the number of 40 day-old embryos was 28 percent greater in gilts farrowed during this season. Wallace and Combs (1962) summarized two year's data involving 224 litters and 2211 pigs and reported a consistent advantage in conception rate, number of pigs weaned per litter and weaning weights when breeding occurred during the cooler months with management and nutritional factors similar during all farrowings. Stefanjuk (1940) compared the size of litters born in the spring (Feb.-July) and in the fall (Aug.-Jan.) from sows having one to five litters and found that spring litters averaged 0.36 to 1.77 more pigs farrowed than fall litters. Shelby (1967) and Noland et al. (1964) found season to have important effects on the number of pigs at birth, number of pigs at weaning and weight of the litter at weaning.

Repeatability of Productivity Traits. Repeatability may be described as the correlation between reccurrent expressions of a characteristic by the same animal. From a study including 1560 litters, Olbrycht (1943) concluded the variation of number born and reared from litter to litter of the same sow was regular and predictable from the ordinal number of the litter. Evaluation of sows based on their first litter performance was a good predictor of future

performances, but future breeding effeciency could be more accurately determined based on the first sow litter performances. Krider et al. (1946) found that heritable differences in weight of swine increased steadily from five percent at birth to 24 percent at 180 days, whereas the percentage of the variance due to non-heritable differences between litters decreased from 40 at birth to 14 at 180 days. The non-heritable variation among littermates accounted for 46 to 62 percent of the variance in weight at all ages. Nordskog et al. (1944) determined environmental effects peculiar to individual pigs accounted for approximately one-half of the total variance during the periods involved in their study. The heritabilities of gains at 28, 56, 84, and 112 days post-weaning were estimated at 18, 28, 39, and 45 percent respectively. Cummings et al. (1947) computed heritability estimates in a Minnesota swine study including 532 daughter-dam comparisons. Heritability estimates determined by this work were: survival from birth to weaning, 40 percent; size of litter at birth, 22 percent; total litter weight at birth, 36 percent; size of litter at weaning, 32 percent; and total weaning weight of the litter, 7 percent.

Keith (1930) estimated correlations between the size of litter farrowed at a given age of the dam and the size of litter farrowed at latter ages. A correlation ($r=0.29$) was reported to exist between the size of the second litter and the average size of later litters. Stewart (1945a) estimated heritability of litter size at 8.8 to 17.6

percent, with estimates of repeatability of 12.8 percent for live pigs and 13.3 percent for total pigs farrowed. In an additional study, Stewart (1945b) analyzed data obtained from the Minnesota swine breeding project of 1937 to 1943, inclusive, to determine repeatability of litter size and, in turn, obtain an estimate as to the upper limits of heritability. Estimates of repeatability were obtained from correlations between size of first and second litters or from regression coefficients of the size of the second litter on the size of the first. Two hundred twenty-two females that had produced a second litter were used in this study with 145 farrowing their second litters when approximately 24 months of age and the remaining 76 farrowing second litters at about 18 months. Repeatabilities of 0.13 were obtained for both number of live pigs farrowed and number of total pigs farrowed. Lush and Molln (1942) computed repeatability coefficients for number of pigs farrowed, number of pigs weaned and weaning weight of the litter. Sow-litter data from stations in eight states were compiled and analyzed with average repeatability coefficients determined for number of pigs farrowed, 0.15; number of pigs weaned, 0.16; and weaning weight of litter, 0.13. Standard errors of these averages ranged from between 0.02 and 0.03 for number farrowed to about 0.05 for weaning weight of litter. From these findings it was concluded that the sow's future ability would be only about one-sixth as far above the average of the herd as her records were, if they were selected on

only one record. Selection should gain materially if based on averages of all litters a sow has produced with about a 31 percent larger increase in productivity if based on averages of two litters and when based on three litters would make about 50 percent more progress per selection than if based on one litter only.

Skjervold and Odegard (1960), in a study of the estimation of sow yield (litter size and litter weight at 21 days), determined that for characteristics that can be measured several times during an animal's life, the heritability will increase in approximate proportion to the number of litters on which the mean is based. This increase in heritability is here dependent on the repeatability of the character in question. Repeatability estimates used in this study were 0.2 for both litter size in pigs and weights of pigs at 21 days of age. Lasley (1957) observed litter size for 87 sows that had previously farrowed two litters, the study showed repeatability of litter size to be 0.15 between first and second litters, 0.10 between second and third litters and 0.06 between first and third litters.

Urban et al. (1965) analyzed records of 3,781 litters from a three state area to determine the effects of environment and heredity on five productivity traits. All observations were corrected for environment and breed effect. Estimates of repeatability were: number of pigs born alive, 0.165 $\pm$ .025; number living through the first day, 0.132 $\pm$ .025; number alive at weaning (56 days), 0.057 $\pm$ .026;

total weight of the litter at weaning, 0.050 ± .025 and number of pigs at 154 days, 0.070 ± .026.

Associations Between Productivity Traits. English workers, Smith and Donald (1957), concluded that no general relation existed between litter size and weaning weight. Only a small correlation between weaning weight and subsequent rate of growth was observed in their study and it was determined to be of slight value in estimating subsequent performance. Comstock and Winters (1942) reported measures of postweaning growth to be more useful in selection for growth rate in swine than measures of growth rate embracing the entire period from birth to market weight. Further conclusions were that since the two postweaning growth rates appeared to be equally heritable, rate of gain from weaning to 200 pounds should give better results because it favors the heavy weaning pig. Weaver and Bogart (1943) reported that an increase in the number of pigs weaned per litter increases the total litter weight, but does not necessarily lessen the average weight per pig at weaning. The Missouri workers found a direct relationship to exist between weight of pig at weaning and feedlot performance, birth weight and weight at weaning (56 days) and between birth weight and daily gain from birth to weaning. Fredeen and Plank (1962) found birth weight to have a vital bearing on survival. In these data, pre-weaning mortality was 44 percent for pigs weighing 2.5 pounds or less at birth and 12 percent for pigs larger than 2.5 pounds. Total pre-weaning mortality was 29

percent with 8 percent born dead and 20 percent dying between 21 days of age. Mortality between 21 days and weaning at 42 days was approximately 1 percent. Litter size at weaning was found to have a significant ($P<.01$) effect on weaning weight (42 days) and had no measurable effect on post-weaning growth as measured by age at slaughter (195 $\pm$ 3 pounds). Blunn et al. (1954) studied interrelationships of birth, 56-day and 154-day weights in pigs. Results of this study indicated that a knowledge of 56-day weight accounted for only 40 percent of the variance in 154-day weight. Selecting heavy pigs at 56-days in order to increase weight at 154-days could, thus, be expected to have only a low efficiency. Principally as a result of the number of pigs in the litter, the relationship between total litter weights at 56 and 154-days of age was found to be high while birth weights were determined to be relatively poor indicators of future weights or gains. Omtvedt et al. (1966) reported litter weaning weight was determined to a larger extent by the number of pigs in the litter at weaning than by the weight of the pigs at weaning. Their study revealed that litter birth weight was determined to be largely a function of number of pigs in the litter ($r=0.82$). An increase in litter birth weight was associated with an increase in preweaning death loss, litter size at weaning and litter weaning weight, but with a decrease in pig weaning weight. An increase in pig birth weight was associated with an increase in survival rate ($r=0.28$) and pig weaning weight

(r=0.54), and with smaller litter size at weaning (r=-.32). The same study demonstrated that the number of pigs weaned per litter was closely associated with litter weaning weight (r=0.79), and individual pig weaning weight decreased as litter size at weaning increased (r=-.51). Vogt et al. (1963) studied genetic correlations between growth rate and feed efficiency, litter size and weaning weight and reported no antagonistic genetic correlations that would hinder progress from selection. They obtained genetic correlations of 0.06 between growth rate and litter size, -.22 between growth rate and feed efficiency and 0.47 between growth rate and weaning weight. These workers concluded that selection for one should evoke a desirable correlated response in the other.

MATERIALS AND METHODS

Data for this study were taken from records of the "zero selection" control line (OK24) at the Ft. Reno Livestock Experiment Station. Hampshire, Duroc, Landrace and Beltsville No. 1 breeds served as the foundation of this crossbred line which has been closed since 1959. The line is propagated by selecting two boars of average weight and thriftiness at 21 days of age and two average gilts at weaning from each litter. Final selection of one boar and one gilt from the pair saved from each litter is delayed until post-weaning rate of gain and probed backfat thickness information is available on all the boars and gilts initially chosen. The boar and gilt from each pair that is nearest the average for gain and probe is retained for breeding. All final selections were made with special emphasis on obtaining selection differentials of as near zero as possible for both growth rate and probed backfat thickness. To reduce inbreeding effect and gene drift, one boar is used per gilt and no matings were permitted where a common ancestor appeared in the first or second generation on either side.

This investigation included 232 litter records (2,385 pigs farrowed) and extended over a period of twelve seasons (fall 1961 to spring 1967, inclusive). Only litters resulting from repeat matings were used in this study. Fall

litters were farrowed by sows bred during April and May while spring litters were produced by sows bred during October and November. Age designations, as used in this study, were made according to age of dam at farrowing with gilts farrowing first litters at approximately one year of age and sows farrowing second litters at about one and one-half years of age. The distribution of observations by age of dam and season are shown in Table I.

TABLE I

NUMBER OF LITTER OBSERVATIONS BY YEAR, AGE OF DAM AND SEASON

Year	SPRING		FALL	
	1st. Gilt	2nd. Sow	1st. Gilt	2nd. Sow
1967		11		
1966	11	9	11	11
1965	14	11	9	14
1964	5	14	11	5
1963	10	12	14	10
1962	13	6	12	13
1961			6	
Totals	53	63	63	53

The ration fed to the breeding herd is shown in Table II, and was hand fed during gestation and self-fed during lactation at the level described in Table III.

TABLE II

BREEDING HERD RATION

Ingredient	Pounds per Ton
Wheat	727
Milo	728
Ground alfalfa hay	300
Soybean meal (44%)	150
Molasses	50
Dicalcium phosphate	30
Trace mineral salt	10
Vitamin-mineral premix	5
Total	2,000

TABLE III

DAILY FEED INTAKE FOR SOWS AT

VARIOUS PERIODS OF REPRODUCTION

Period	Sows lb.	Gilts lb.
200 lbs. to month before breeding		$3\frac{1}{2}$ - 4
One month before breeding	7 - 8	$5\frac{1}{2}$ - 6
Breeding to month prior to farrowing	5 - $5\frac{1}{2}$	$3\frac{1}{2}$ - 4
One month prior to farrowing	6 - $6\frac{1}{2}$	5 - $5\frac{1}{2}$
Farrowing to weaning	Full Fed	Full Fed
Weaning to month before breeding	6 - $6\frac{1}{2}$	4 - $4\frac{1}{2}$

All sows in this study were placed in confinement 109 days post-breeding and maintained there until their litters were weaned at six weeks. Each pig was individually weighed and ear notched for identification within 24 hours after birth. Pigs were next weighed at 21 days of age and then given access to creep. All pigs were weighed and weaned at approximately 42 days of age.

All pigs were raised in confinement from birth to market weight and were self-fed during the postweaning period. A ground ration containing wheat, milo, soybean meal (44%) and alfalfa meal was used during the feeding period from weaning to about 200 pounds market weight. The ration protein content was approximately 16 percent for pigs from weaning to 100 pounds and 14 percent for pigs from 100

pounds to finishing.

Pigs were removed from test at weekly intervals as they reached approximately 200 pounds. The age in days at 200 pounds for each pig was calculated by dividing the number of pounds the pig weighed below (or above) 200 pounds when taken off test by his post weaning average daily gain and then subtracting this figure to (or adding it to) his actual age in days when removed from test.

Means for the different litter traits were computed on a within year basis and averaged over all years for gilts and sows following two farrowing sequences: (1) sows farrowing first litters in the spring and second litters in the fall and, (2) sows farrowing first litters in the fall and second litters in the spring. This method of grouping allowed a comparison of litter performance levels as influenced by age of dam, season of farrowing and sequence of farrowing.

Standard errors of the means were obtained by taking the square root of pooled mean squares divided by their appropriate sample size for a particular farrowing sequence or group and dividing it by the square root of sample size.

Correlation coefficients were determined between a sow's first litter and her second litter on a within year and farrowing sequence basis. The sums of the squares were then combined within sequence of farrowing and a pooled correlation coefficient obtained for each of the 14 traits considered in this study for each farrowing sequence. Overall

correlations were obtained by pooling all sums of the squares, regardless of season or farrowing sequence. The statistical procedure used in this study was according to Steel and Torrie (1960).

RESULTS

Age of Dam Effect.

The performance for first and second litters is summarized according to farrowing sequences and combined first and second litter averages in Tables IV and V.

Litter Size: The number of live pigs at birth, 21 and 42 days was greater for sows than for gilts. In the overall study, gilts averaged 9.7 live pigs per first litter compared to 11.1 for their second litters. Gilts farrowing their first litters in the spring and their second in the fall revealed less difference between first and second litters than those that farrowed first in the fall and second in the spring. Litter size difference between gilt litters farrowed first in the fall and second in the spring were 0.9, 1.3, and 1.4 pigs greater at birth, 21 and 42 days, respectively, than the differences between first litters in the spring and second in the fall.

Carmichael and Rice (1920) reported that the number of pigs farrowed per litter was larger for sows than for gilts. Stewart (1945a) and Johansson (1929) demonstrated that litter size showed an increase with age of dam up to about 15 - 16 months of age. Omtvedt et al. (1965) reported an average of 10.8 pigs for sows compared to 9.8 pigs for gilts. Keith

TABLE IV

A COMPARISON OF FIRST LITTER AND SECOND LITTER PERFORMANCE FOR SPRING TO FALL AND FALL TO SPRING FARROWING SEQUENCES

	Spring Fall			Fall Spring			Overall		
	1st.	2nd.	S.E.	1st.	2nd.	S.E.	1st.	2nd.	S.E.
No. of Records	53	53		63	63		116	116	
Birth Records									
No. live pigs/litter	10.5	11.4	0.82	9.0	10.8	0.86	9.7	11.1	0.84
No. stillborn pigs/litter	0.3	0.5	0.23	0.3	0.3	0.19	0.3	0.4	0.22
Pig weight, lbs.	2.8	3.0	0.14	2.9	3.2	0.15	2.9	3.1	0.14
Litter weight, lbs.	28.8	33.8	2.12	25.3	33.4	2.24	26.9	33.6	2.18
21-Day Records									
No. live pigs/litter	9.0	9.2	0.72	7.6	9.1	0.71	8.2	9.2	0.71
Percent survival	86.5	82.7	0.05	85.8	86.3	0.05	86.1	84.6	0.05
Pig weight, lbs.[1]	11.4	12.1	0.95	11.6	12.9	0.94	11.5	12.6	0.67
Litter weight, lbs.[1]	95.0	93.6	11.65	79.1	125.4	10.99	85.5	112.6	8.04
42-Day Records									
No. live pigs/litter	8.9	9.1	0.70	7.5	9.1	0.72	8.1	9.1	0.71
Percent survival	85.4	81.6	0.05	84.3	86.0	0.05	84.8	84.0	0.05
Pig weight, lbs.	26.1	27.9	1.18	26.4	30.3	1.27	26.3	29.2	1.23
Litter weight, lbs.	228.0	248.1	16.84	190.0	268.9	18.77	207.3	259.5	17.91

[1]Means based on 25 litters for spring to fall sequence and 31 litters for fall to spring sequence.

TABLE V

A COMPARISON OF FIRST AND SECOND LITTER POST WEANING PERFORMANCE FOR SPRING TO FALL AND FALL TO SPRING FARROWING SEQUENCES

	Spring 1st.	Fall 2nd.	S.E.	Fall 1st.	Spring 2nd.	S.E.	Overall 1st.	Overall 2nd.	S.E.
No. of Records	37	37		42	42		79	79	
Post wean. daily gain, lbs.	1.56	1.68	0.05	1.63	1.56	0.05	1.60	1.61	0.05
Age at 200 pounds, days	159.8	151.2	4.21	154.7	154.8	3.26	157.0	153.2	3.74

(1930), Morris and Johnson (1932), Olbrycht (1943), Moxley and McMillen (1949), Wiggins et al. (1950), Noland (1964) and Shelby (1967) also reported that litter size increased with increased age of dam.

Pigs Born Dead: The number of stillbirths was slightly higher for sows than for gilts. However, this difference was observed only in the gilts in the spring to fall farrowing sequence. In the overall study, gilts farrowed an average of 0.3 stillborn pigs compared to 0.4 for sows.

Results obtained in this study would tend to substantiate the report by Carmichael and Rice (1920) that older sows farrowed a greater percentage of dead pigs than did younger sows.

Survival Rate: Death losses were higher among sows than among gilts. Gilt litter survival rates to 21 and 42 days of age were 86.1 percent and 84.8 percent, respectively, compared to 84.6 percent and 84.0 percent, respectively, for sow litters. Second litter sows exhibited highest survival rates in the fall to spring sequence compared to the reverse for spring to fall. A 3.8 percent advantage in survival rate for first litters was noted in the spring to fall farrowing groups at 21 and 42 days compared to advantages of only 0.5 percent at 21 and 1.7 percent at 42 days for sows and gilts in the fall to spring sequence.

Results from this study would tend to agree with an earlier study by Olbrycht (1943) who determined the absolute number dying before weaning to increase with the number at

birth and with the age of the sow.

Pig Weights: Individual and litter weights were heavier for second litters than for first litters at birth, 21 days and weaning. Second litter pig weights were 0.2, 1.1, and 2.9 pounds heavier than those for first litter pigs at birth, 21 and 42 days, respectively, while sow litters held an advantage of 6.7, 27.1, and 52.2 pounds over gilt litter weights for the same periods of growth.

These results are in agreement with a study by Nordskog et al. (1944) showing that pigs farrowed from sows were about four pounds heavier at weaning than pigs from gilts and the advantage was maintained to 168 days of age.

Post Weaning Gain: Pigs from second litter sows showed no advantage over first litter pigs for average daily gain. Post weaning performance means, contained in Table V, show second litter pigs averaged gains of 1.61 pounds per day compared to a 1.60 pound average for first litter pigs. However, average daily gains increased between first litters in the spring and second litters in the fall by 0.12 pounds per pig per day while the fall to spring sequence showed a 0.07 pound reduction in daily gains per pig from first to second litters.

In this study, pigs born to sows reached market weight of 200 pounds approximately four days sooner than did those pigs from gilt litters. Second litter pigs reached 200 pounds 8.6 days earlier than did those farrowed by gilts in the spring to fall sequence while practically no difference

was observed between first and second litters in the fall to spring group.

Seasonal Effect.

Litter performance for first, second and combined litters are summarized for spring and fall seasons of farrowing in Tables VI and VII.

Litter Size: Overall number of live pigs per litter was greater at birth, 21 and 42 days for litters farrowed in the spring than in the fall. Gilt litters farrowed first in the spring were consistantly larger than first litters born in the fall (10.5 pigs vs. 9.00 pigs). Average litter size at 21 and 42 days was 1.4 pigs greater for spring farrowing gilts compared to first litters in the fall.

Stefanjuk (1940) compared the size of litters born in the spring and in the fall from sows having one to five litters and found that spring litters averaged 0.36 to 1.77 more pigs farrowed than fall litters. No differences were observed in number of stillbirths in spring and fall litters.

Survival Rate: Gilt litters farrowed in the spring experienced slightly fewer death losses to 21 and 42 days than did gilt litters in the fall while second litters in the spring showed higher survival rates to 21 and 42 days than did fall farrowed second litters for the same periods. Combined gilt and sow litters farrowed in the spring exhibited a 2.0 percent and 2.7 percent higher survival rate to 21 and 42 days of age compared to first and second

TABLE VI

COMPARISON OF SPRING AND FALL FARROWED LITTERS FOR GILTS AND SOWS

	SPRING				FALL			
	Gilts	Sows	Combined	S.E.	Gilts	Sows	Combined	S.E.
No. of Records	53	63	116		63	53	116	
Birth Records								
No. live pigs/litter	10.5	10.8	10.6	0.79	9.0	11.4	10.1	0.89
No. stillborn pigs/litter	0.3	0.3	0.3	0.24	0.3	0.5	0.4	0.20
Pig weight, lbs.	2.8	3.2	3.0	0.13	2.9	3.0	3.0	0.15
Litter weight, lbs.	28.8	33.4	31.3	2.10	25.3	33.8	29.2	2.26
21-Day Records								
No. live pigs/litter	9.0	9.1	9.1	0.71	7.6	9.2	8.3	0.72
Percent survival	86.5	86.3	86.4	0.05	85.8	82.7	84.4	0.05
Pig weight, lbs.[1]	11.4	12.9	12.3	0.62	11.6	12.1	11.8	0.72
Litter weight, lbs.[1]	95.0	125.4	113.2	8.02	79.1	93.6	84.9	8.06
42-Day Records								
No. live pigs/litter	8.9	9.1	9.0	0.70	7.5	9.1	8.2	0.72
Percent survival	85.4	86.0	85.7	0.05	84.3	81.6	83.0	0.05
Pig weight, lbs.	26.1	30.3	28.4	1.20	26.4	27.9	27.1	1.26
Litter weight, lbs.	228.0	268.9	250.3	17.91	190.0	248.1	216.4	17.91

[1]Means based on 25 litters for spring gilts and fall sows, 31 litters for fall gilts and spring sows.

TABLE VII

A COMPARISON OF SPRING AND FALL FARROWED LITTERS FOR POST WEANING PERFORMANCE

	SPRING				FALL			
	Gilts	Sows	Combined	S. E.	Gilts	Sows	Combined	S.E.
No. of Records	37	42	79		42	37	79	
Post wean. daily gain, lbs.	1.56	1.56	1.56	0.05	1.63	1.68	1.65	0.05
Age at 200 pounds, days	159.8	154.8	157.1	3.89	154.7	151.2	153.1	3.57

litters born in the fall.

Pig Weights: Individual pig and litter weights were heavier for combined gilt and sow litters born in the spring. First litters farrowed in the spring were 3.5, 15.9, and 38.0 pounds heavier at birth, 21 and 42 days, respectively, than were first litters farrowed in the fall. However, first litter pigs born in the fall showed individual weight advantages of 0.1, 0.2, and 0.3 pounds over first litter pigs in the spring at birth, 21 and 42 days of age, respectively.

Post Weaning Gain: Fall farrowed pigs gained faster and reached 200 pound market weights at an earlier age than did pigs farrowed in the spring. First litter pigs farrowed in the fall gained 0.07 pounds more per day and reached market weight 5.1 days earlier than did pigs born to gilts in the spring, while second litter pigs farrowed in the fall gained 0.12 pounds more per day and reached market weights 3.6 days sooner than did second litter pigs born in the spring.

Correlation Between First and Second Litter

Pooled correlation coefficients for first and second litters are summarized according to farrowing sequences in Table VIII. Correlations for each year and farrowing sequences is given in Appendix Table IX.

Litter Size: Significant ($P<.05$) correlations of 0.39 and 0.33 were obtained between first litters farrowed in the

TABLE VIII

POOLED CORRELATION COEFFICIENTS FOR FIRST AND SECOND LITTER PERFORMANCE FOR SPRING TO FALL AND FALL TO SPRING FARROWING SEQUENCES

	1st. 2nd. Spring-Fall	1st. 2nd. Fall-Spring	Overall
No. of repeat matings	53	63	116
Birth Records			
No. live pigs/litter	.39*	.26	.31*
No. stillborn/litter	.00	.09	-.06
Pig weight	.47*	.24	.34*
Litter weight	.49*	.33*	.39*
21-Day Records			
No. live pigs/litter	.33*	.15	.21*
Percent survival	-.14	-.18	-.16
Pig weight[1]	.33	.36	.34*
Litter weight[1]	.16	.05	-.05
42-Day Records			
No. live pigs/litter	.28	.16	.18*
Percent survival	.09	-.05	.01
Pig weight	.36*	.41*	.39*
Litter weight	.30*	.17	.15
Post Weaning Performance			
Daily gain[2]	.42*	.24	.22*
Age at 200 pounds[2]	.54*	.32	.43*

[1]Means based on 25 and 31 litter pairs for spring to fall and fall to spring, respectively.
[2]Means based on 37 and 42 litter pairs for spring to fall and fall to spring, respectively.
*Significant correlation, ($P<.05$)

spring and second litters farrowed in the fall for number of live pigs at birth and 21 days, respectively. Significant ($P<.05$) correlations of 0.31 and 0.21 were found between first litters and second litters for live pigs at birth and 21 days respectively.

Correlations between first and second litters for litter size at birth were higher in this study than those reported in earlier studies, while the correlation for live pigs at 21 days closely approximated an earlier estimate for the same period of litter growth. Sow and litter data from stations in eight states were compiled and analyzed by Lush and Molln (1942) with an average repeatability coefficient of 0.15 determined for the number of pigs farrowed. Lasley (1957) observed litter size for 87 sows that had previously farrowed two litters and reported repeatability of litter size to be 0.15 between first and second litters. Keith (1930) estimated a correlation coefficient of 0.34 between first and second litters in a study involving 222 litters of four different breeds. Stewart (1945a) estimated repeatability of litter size at 12.8 percent for live pigs farrowed. In an additional study, Stewart (1945b) estimated repeatability of litter size from records of 222 females having produced a second litter and reported a repeatability estimate of 0.13 for number of live pigs farrowed. Urban et al. (1965) reported a repeatability estimate of 0.16 for number of live pigs born. Skjervold and Odegard (1960) reported a repeatability estimate of 0.20 for litter size at 21 days of

age.

Pig Death Losses: No associations were found for incidence of stillbirths or survival rates between first and second litters. While not significant, both incidence of stillbirths and survival rates produced negative correlation coefficients of -.06 and -.16, respectively, and would agree with mean differences showing increased stillbirths and reduced survival rates in second litters compared to first.

Pig Weights: First litter pig weights were associated with individual weights in subsequent litters. Positive correlations for pig weights at birth, 21 and 42 days were found significant ($P<.05$) between all first litters and all second litters. The degree of association was greater in the spring to fall farrowing sequence for pig weights at birth while the association was greater between the fall to spring sequence at 21 and 42 days.

Litter Weights: The degree of association between first and second litters for total litter weight tended to decrease as litter age increased from birth to 42 days. Litter birth weights for first litters were significantly ($P<.05$) correlated with second litter birth weights at 0.49, 0.33, and 0.39 for spring to fall, fall to spring and overall, respectively.

Skjervold and Odegard (1960), in a study of estimation of sow yield, determined the repeatability estimate for litter weight at 21 days to be 0.20. Estimates from this study

failed to reach this level of association for 21 day weights.

Post Weaning Performance: Significant correlations were found between all first and all second litters for both age at 200 pounds and average daily gain. Overall correlations of 0.22 and 0.43 were found between all first and all second litters for average daily gain and age at 200 pounds, respectively, while the degree of association was greatest between first litters in the spring and second litters farrowed in the fall.

DISCUSSION

Results obtained in this study indicate sow productivity to be affected by age of dam and season of farrowing. While age of dam comparisons showed second litter performance to be superior to that of first litters, the size of this difference was dependent on whether the first litter was farrowed in the fall or spring. Seasonal comparisons made between first litters in the spring and first litters in the fall would perhaps be the most meaningful measure of seasonal effect. Spring and fall comparisons made beyond the first litter were subjected to age of dam affect, thus reducing their value for selection emphasis.

Spring litters were generally found to be superior to those farrowed in the fall for litter size, litter weight and livability with exceptions of post weaning average daily gains and average age at 200 pounds. The postweaning advantages found for fall litters may possibly be attributed to less competitive conditions existing in the smaller fall litters and the fact that the growth to finishing period was during the cooler months of the year.

Farrowing sequences appeared to exert an influence on differences found between first and second litters. Environmental temperatures may, in part, account for the influence exerted by sequence of farrowing. Increased age of

dam appeared to adjust somewhat for seasonal effects as spring and fall second litters failed to exhibit the wide differences found between first litters farrowed during the spring and fall seasons.

Comparisons made between the farrowing sequences revealed smaller mean differences and higher correlations to exist between first litters farrowed in the spring and second litters in the fall for litter size, weight and growth compared with fall to spring sequences. As a guide for culling on a first litter basis in the sow herd, a gilt's first litter performance in the spring appears to offer the best indication of her future production capabilities. The variation in fall to spring farrowing sequences, evidenced by large mean differences and lower associations between first and second litter performance, would suggest that factors, other than age of dam and season, influenced this sequence of farrowing. These data would indicate that the repeatability of performance between first and second records of performance are not real high and first litter performance is not a good indicator of future performance.

SUMMARY

Data for this study involved 232 litter records of 2,385 pigs from the "zero selection" control line (OK24) at the Ft. Reno Livestock Experiment Station. First and second litter records resulting from repeat matings for 116 sows were collected over a six year period beginning in 1961. The objectives of this study were to investigate the influence of age of dam and season of farrowing on productivity traits and to determine the correlations between first and second litters for various traits. Means were computed on a within year basis and averaged over all years. Correlation coefficients were determined between first and second litters for sows farrowing their first litters in the spring and second in the fall and for those farrowing first in the fall and second in the spring.

The number of live pigs at birth, 21 and 42 days was greater for sows than for gilts. Second litters averaged 1.4, 1.0, and 1.0 more pigs per litter than first litters at birth, 21 and 42 days, respectively. Individual and litter weights were heavier for second litters than for first litters. Sow litters weighed an average of 6.5, 27.1, and 52.2 pounds more than gilt litters at birth, 21 and 42 days, respectively. The number of stillborn pigs and litter death losses tended to increase slightly from first to second

litter. Average daily gains were slightly higher for pigs farrowed by sows than for those farrowed by gilts resulting in pigs born to sows reaching 200 pounds approximately four days earlier than did pigs from gilt litters.

Number of live pigs per litter was greater at birth, 21 and 42 days for litters farrowed in the spring. Pigs from fall farrowed gilt litters were heavier from birth to weaning, gained faster and reached market weights sooner than did first litter pigs farrowed in the spring. No difference was observed in number of stillbirths in spring and fall first litters while gilt litters in the spring did experience slightly fewer litter death losses to 21 and 42 days than did first litter in the fall.

First litters were significantly ($P<.05$) correlated with second litters for number of live pigs at birth and 21 days ($r=0.31$ and $r=0.21$, respectively). Significant ($P<.05$) positive correlations for pig weights were found between first and second litters at birth, 21 and 42 days, while the degree of association between first and second litters for total litter weight tended to decrease with increased age of the litter. Overall correlations of 0.22 and 0.43 were found between first and second litters for average daily gain and for average age at 200 pounds, respectively.

Correlation estimates obtained from these data were higher in some cases than those reported in earlier studies. More intense associations might be expected in this study as full-sib litters produced by genetically similar females

constituted the data analyzed. Age of dam and season of farrowing were demonstrated to exert a marked influence on productivity traits in this study. Of the two farrowing sequences, compared, mean differences were smaller between gilt litters farrowed in the spring and second litters in the fall for litter size, weight and growth. Correlations were higher between those litters farrowed first in the spring and second in the fall for litter size, weight and growth than for those litters farrowed in the fall to spring sequence.

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APPENDIX

TABLE IX

CORRELATION COEFFICIENTS BETWEEN FIRST AND SECOND LITTERS FOR SPRING TO FALL AND FALL TO SPRING FARROWING SEQUENCES

	1st. SPRING - 2nd. FALL	1st. FALL - 2nd. SPRING
No. of Records	53	63
	Number Live Pigs Born	
Year		
1961		.06
1962	.65	.44
1963	.43	.36
1964	.81	.38
1965	.34	-.56
1966	.24	-.57
Pooled	.39	.26
Overall		.31
	Number Stillborn	
Year		
1961		.00
1962	.00	.00
1963	.00	.00
1964	.00	.00
1965	.00	.00
1966	.00	-1.00
Pooled	.00	.09
Overall		-.06

TABLE IX (continued)

	1st. SPRING - 2nd. FALL	1st. FALL - 2nd. SPRING
	Individual Pig Birth Weight	
Year		
1961		-.47
1962	.73	.20
1963	.40	-.02
1964	.49	.30
1965	.31	.27
1966	.83	.28
Pooled	.47	.24
Overall		.34
	Litter Birth Weight	
Year		
1961		.36
1962	.74	.81
1963	.39	.52
1964	.22	.01
1965	.32	.08
1966	.47	-.21
Pooled	.49	.33
Overall		.39
	Number Live Pigs at 21 Days	
Year		
1961		-.46
1962	.43	.15
1963	.01	.08
1964	.29	.07
1965	.20	.08
1966	.56	-.55
Pooled	.33	.15
Overall		.21
	Percent Survival to 21 Days	
Year		
1961		0.12
1962	.17	-.45
1963	.13	-.34
1964	.23	.21
1965	-.27	-.14
1966	-.39	-.41
Pooled	-.14	-.18
Overall		-.16

TABLE IX (continued)

	1st. SPRING - 2nd. FALL	1st. FALL - 2nd. SPRING
	Number Pigs at 42 Days	
Year		
1961		-.53
1962	.37	.29
1963	-.07	.06
1964	-.13	.10
1965	.18	.18
1966	.57	-.55
Pooled	.28	.16
Overall		.18
	Percent Survival to 42 Days	
Year		
1961		-.66
1962	-.01	-.10
1963	-.04	-.16
1964	.91	-.15
1965	.29	.36
1966	-.09	-.04
Pooled	.09	-.05
Overall		.01
	Individual Pig 42 Day Weight	
Year		
1961		.54
1962	.47	-.16
1963	-.14	.19
1964	.12	.57
1965	.35	.02
1966	.56	.68
Pooled	.36	.41
Overall		.39
	Litter 42 Day Weight	
Year		
1961		.73
1962	.14	.32
1963	.26	-.12
1964	-.04	-.10
1965	.22	.52
1966	.37	.03
Pooled	.30	.17
Overall		.15

TABLE IX (continued)

	1st. SPRING - 2nd. FALL	1st. FALL - 2nd. SPRING
No. of Records	25	31
	Individual Pig Weight at 21 Days	
Year		
1961		
1962		
1963		
1964		.53
1965	.59	.15
1966	-.24	.05
Pooled	.33	.36
Overall		.34
	Litter 21 Day Weight	
Year		
1961		
1962		
1963		
1964		-.23
1965	-.03	.29
1966	.37	-.13
Pooled	.16	.05
Overall		-.05

TABLE IX (continued)

	1st. SPRING - 2nd. FALL	1st. FALL - 2nd. SRPING
No. of Records	37	42
	Post Weaning Daily Gain	
Year		
1961		.52
1962	.45	-.79
1963	.26	.40
1964	.28	.44
1965	-.54	.20
1966	.67	.33
Pooled	.42	.24
Overall		.22
	Average Age at 200 Pounds	
Year		
1961		-.01
1962	.43	-.53
1963	.28	.67
1964	.33	.99
1965	-.35	.38
1966	.84	.49
Pooled	.54	.32
Overall		.43

VITA

Kenneth L. Apple

Candidate for the Degree of

Master of Science

Thesis: INFLUENCE OF AGE OF DAM AND SEASON ON SOW PRODUCTIVITY AND THE CORRELATION BETWEEN THE PRODUCTIVITY OF FIRST AND SECOND LITTERS IN SWINE

Major Field: Animal Science

Biographical:

Personal Data: Born at Louisville, Kentucky, November 12, 1937, the son of Mrs. Gussie Loughridge.

Education: Graduated from Central High School of Marlow, Oklahoma in 1955. Received Associates Degree from Cameron Jr. College in Lawton, Oklahoma, June 1961. Received the Bachelor of Science Degree from Oklahoma State University, with a major in Agricultural Education, June 1963.

Professional Experience: Entered the Oklahoma State University Extension Service June, 1963, serving as Assistant County Agent in Jefferson County until September, 1966.

Date of Completion: January, 1968