THE INFLUENCE OF VARIOUS FACTORS ON OVULATION RATE AND THE NUMBER OF EMBRYOS 30 DAYS AFTER BREEDING IN GILTS

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AFTER BREEDING IN GILTS

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TABLE OF CONTENTS

LIST OF TABLES

Table | Page

CHAPTER I

INTRODUCTION

The number of pigs raised per sow in the herd is of great economic importance to the swine producer. Many researchers have shown that the heritability of litter size in swine is low with most estimates falling in the range of 0 to 15 percent. As a result of this low heritability, selecting replacement gilts from large litters should not result in much increase in litter size. In fact, there is some evidence to suggest that gilts selected from large litters have smaller litters than gilts selected from small litters.

There is great variability in the size of litters produced by females of the same age and breeding. If a portion of this variability can be accounted for in terms of measurable factors related to prolificacy and if the relative importance of these factors can be established, selection for fertility would be more effective. If progress toward increased litter size is to be achieved, potential productivity must be evaluated before the gilts are bred.

This study was initiated to determine how the size of the litter in which a gilt is raised and her own performance are related to her ovulation rate and the size of her litter at 30 days post-breeding.

CHAPTER II

REVIEW OF LITERATURE

Ovulation rate and age at puberty are affected by many factors and ovulation rate, age at puberty and other factors also affect litter size. This review of literature is organized into sections that deal with (1) the relationship between a gilt's performance record and (a) her age at puberty and (b) her ovulation rate, (2) the heritability of ovulation rate and (3) the relationship between a gilt's performance record and the size of her first litter.

Relationship Between a Gilt's Performance Record and Her Age at Puberty and Her Ovulation Rate

It is important to know the relationship between a gilt's performance record and her age at puberty and ovulation rate so that one can increase the efficiency of production by selecting gilts, based on early performance records, that will reach puberty earlier and have a higher ovulation rate.

Warnick _et al._ (1951) studied the records of 205 gilts from 5 inbred lines (3 Chester White, 1 Yorkshire and 1 line resulting from the initial cross of Chester White with Yorkshire) to determine if weight at various ages was highly correlated with age at puberty, thus furnishing a basis for indirect selection for early sexual maturity. He found that as the age at which the weight was taken increased so did the correlation of weight with age at puberty and the correlations were significant and negative at all ages. The correlations for weight at 56 days of age and 154 days of age with age at puberty in days were -.54 and -.58, respectively. This is in close agreement with the results reported by Rio (1957) whose correlations for weight at various ages with age at puberty ranged from -.26 to -.61. Warnick and associates found that an increase of 1 lb. in 56-day weight resulted in a reduction of 2.8 days in age at puberty while an increase of 10 lbs. in 154-day weight reduced age at puberty by 6.4 days. He also found that the number of corpora lutea at first, second and third heat periods were 10.0, 10.8, and 11.9, respectively.

Robertson _et al._ (1951a) evaluated the relationship of weight at various ages with age at puberty in 49 Chester White and 37 Poland China gilts. Twenty-seven of the Chester White and 16 of the Poland China gilts were designated for slaughter at the outset of the experiment and the others were allowed to farrow. Slaughter gilts were bred on the first day of the second estrus and were slaughtered 24-48 hours after the end of the second estrus. This made it possible to count both the first and second crop of corpora lutea. Like Warnick _et al._ (1951), they found that as the age at which the weight was taken increased so did the correlation between weight and age at puberty. All correlations were negative and reached a high at 196-day weight ($r = -.38$ for Chester White and $r = -.29$ for Poland China). They also found that the two breeds averaged an increase of 1.4 eggs in ovulation rate from first to second heat.

Robertson _et al._ (1951b) conducted a similar experiment using 48 Chester White and 48 Poland China gilts. There was a negative correlation (r = -.29) between 154-day weight and age at puberty, indicating that faster growing gilts tended to reach puberty at an earlier age than slower growing gilts. They also found an increase of 2 eggs in ovulation rate from the first to second heat. Weight at puberty accounted for 13.0 percent of the variation in ovulation rate at the second heat period while age at puberty accounted for only 3.6 percent of the variation in ovulation rate. This indicates that weight is a more important factor affecting ovulation rate than is age. These results agree with Blunn (1939) who found that faster gaining rats reached puberty earlier than slower gaining rats.

Squiers et al. (1952) studied 278 gilts from 3 inbred strains (2 Poland China strains and a Hampshire strain), a Duroc line and crosses among these lines. All gilts were mated to unrelated boars and were slaughtered 25 days after conception. The number of ova shed was significantly correlated with age at first estrus (r = 0.31). The simple correlation between growth rate and number of ova shed was 0.10, which they felt would have been larger except for the rather strong tendency for faster growing gilts to be bred at an earlier age (r = -.27). It was also noted that the crossbreds tended to be bred at an earlier age than the purebreds because they grew faster and reached puberty at an earlier age. When age was held constant the correlation between growth rate and ovulation rate became 0.20 and significant. In this study, an increase of 10 days in age at breeding increased ovulation rate by 0.35 eggs while an increase of 10 lbs. in 154-day weight increased ovulation rate by 0.24 eggs.

Rathnasabapathy et al. (1956) used 66 Poland China-Landrace crossbred gilts to evaluate sexual maturity at 200 lbs. and to determine the relationship of various performance records of the gilt with her subsequent ovulation rate and litter size. Twenty-four gilts were slaughtered at 200 lbs. while a second group of 42 gilts were bred at an average age of 202 days and were slaughtered on the 55th day of gestation. Eleven of the 24 gilts slaughtered at 200 lbs. had ovulation points or freshly formed corpora lutea and the remaining 13 had no ovulation points. This indicates that most gilts had not reached sexual maturity or were only in their first estrus cycle at slaughter weight. The correlation between the gilt's birth weight and ovulation rate (r = 0.12) was not significant but an increase of 1 lb. in birth weight resulted in 0.45 more eggs ovulated. Weaning weight and 154-day weight accounted for 10.9 and 11.6 percent of the variation in ovulation rate, respectively. An increase of 10 lbs. in 154-day weight resulted in 0.45 more ova shed. The correlation between average daily gain from weaning to 200 lbs. and ovulation rate was 0.22 and nonsignificant, however, an increase of 0.10 lbs. in average daily gain tended to increase ovulation rate by 0.34 eggs. Age at breeding accounted for 10.2 percent of the variation in ovulation rate ($P < .05$) and an increase of 10 days in age at breeding resulted in 0.48 more eggs being shed. The correlation of average backfat and total gain from 200 lbs. to slaughter with ovulation rate were .22 and .27, respectively and both were nonsignificant.

Heritability Estimates of Ovulation Rate

There are very few estimates of heritability of corpora lutea or ovulation rate in the literature. Squiers et al. (1952) used data on 279 gilts to estimate the heritability of ovulation rate. They found that the sire had no effect on the ovulation rate of his daughters but that there were differences between litters within sires and differences between reciprocal crosses. This indicates a strong maternal influence on ovulation rate.

Lasley (1957) utilizing data on 87 sows also tried to estimate heritability of corpora lutea count. He obtained a heritability of 10 percent using the paternal half-sib method and noted that the maternal component of variance was larger than the sire component of variance. This also suggests a strong maternal influence or possibly that dominance or epistasis or both may contribute greatly to the genetic variation of ovulation rate.

Cunningham et al. (1972) used the laparotomy technique to select for high ovulation rate. In the fourth generation, the 206 gilts in the high ovulation line averaged 1.65 more corpora lutea than 181 gilts in the control line (15.59 vs. 13.94). This was an increase of 0.81 corpora lutea over the difference between the lines in the third generation. This response to selection indicates that ovulation rate is to some degree heritable.

Relationship Between a Gilt's Performance Record and the Size of Her First Litter

If we can establish the relationship between a gilt's performance records and the size of her first litter, we can more accurately select replacement gilts that will have larger litters. Stewart (1945) used the records of 749 inbred gilts collected over a seven year period to evaluate the effect of age and weight at breeding on the size of a gilt's first litter. All gilts were self fed until they reached market weight, at which time they were limited fed and hand mated at various ages. He found that litter size increased in a curvilinear fashion with no further increase after gilts reached 15 months of age. The effect of age was more severe in the months prior to 12 than after that age. This is in agreement with Johansson (1929) and Olbrycht (1943) who also suggested a progressive increase in litter size with an increase in age at first farrowing. Olbrycht reported an average of 1.07 more pigs per litter for sows farrowing first at 17 months compared to those farrowing first at 12 months.

Stewart (1945) reported a highly significant simple regression for number of live pigs farrowed and total pigs farrowed on age of dam in months (b = 0.367 and -.415 pigs, respectively). Korkman (1947) obtained a smaller regression of 0.24 pigs at birth for each month increase in age of dam but his gilts farrowed first at 11 and 12 months of age. Ellinger (1921) and Krizenecky (1935 and 1943) concluded that age at breeding had little effect upon the size of a gilt's first litter.

Stewart (1945) found that age at breeding and weight at breeding were highly and positively correlated (r = 0.60). The actual reduction of sum of squares for litter size obtained by mathematically adjusting all variables except weight at breeding was significant, while the reduction adjusting for everything except age at breeding was nonsignificant. This indicates that weight at breeding is a more important factor than age at breeding in determining size of first litter.

Squiers _et al_. (1952) used 278 gilts to evaluate the relationship of a gilt's growth rate and age at breeding with the number of embryos present 25 days after breeding. Age at breeding ranged from 164 to 301 days and was found to be significantly correlated with litter size (r = 0.31). Each increase of 10 days in age at breeding increased litter size by 0.50 embryos. With age held constant, the partial regression of 25-day litter size on 154-day weight was 0.0374 pigs, while the partial regression of 25-day litter size on age at breeding holding 154-day weight constant was 0.0606 pigs. The number of ova shed accounted for only 22 percent of the variation in the number of embryos indicating that factors that control mortality rate are more important in determining number of embryos than is the number of ova shed.

Rathnasabapathy et al. (1956) used 42 gilts to estimate the relationship of various measures of performance of a gilt with her subsequent litter size 55 days after breeding. He found that birth weight was not significantly correlated with litter size (r = -.24) although a 1 lb. increase in birth weight was associated with 0.93 more embryos 55 days after breeding. Weaning weight was more highly correlated with number of embryos (r = 0.15) than 154-day weight (r = -.02) although neither correlation was significant. A 10 lb. increase in weaning weight was accompanied by an increase of 0.53 embryos at 55 days. Average daily gain was nonsignificantly and negatively correlated (r = -.09) with litter size but the regression of litter size on average daily gain was -2.19 embryos. Average backfat thickness, age at breeding and gain from 200 lbs. to slaughter were negatively and nonsignificantly correlated with litter size (r = -.15, -.11 and -.09, respectively) and accounted for little variation in litter size. Ovulation rate accounted for only 3 percent of the variation in litter size indicating that factors other than ovulation rate are operating to limit litter size.

Omtvedt et al. (1965) analyzed the breeding and farrowing records on 390 gilts from five breeding groups (Beltsville No. 1, Duroc, Hampshire, Landrace-Poland cross and a multicross control line). The age at breeding, which ranged from 205 to 310 days, was positively correlated with litter size (r = .12) and with breeding weight (r = .55). When breeding weight was held constant, the correlation between litter size and age at breeding was nonsignificant indicating that the increase in litter size was due more to an increase in breeding weight than to an increase in breeding age. The correlation of litter size with breeding weight was 0.19 and each 10 lb. increase in weight at breeding resulted in 0.20 more pigs farrowed while an increase of 10 days in age at breeding was associated with an increase of 0.16 pigs in litter size.

Young and Omtvedt (1973) studied the relationship of the size of the litter a gilt came from and her own performance with the size of her first litter. The study involved 176 first litter gilts of three breed groups (Beltsville No. 1, Duroc and a multicross control line). Although not significant, gilts that were farrowed in large litters tended to farrow smaller litters than gilts farrowed in small litters (r = -.13). An increase of one pig in the litter a gilt came from reduced her first litter by 0.16 pigs. The size of the litter a gilt was weaned in was not associated with the size of her first litter. They also found that the gilt's birth weight was significantly correlated with the size of her first litter (r = 0.16), with an increase of 1 lb. in her birth weight increasing the size of her first litter by 0.75 pigs. The correlation between her 42-day weight and the size of her first litter was not significant (r = 0.10) but followed the same trend as that noted for birth weight. A 10 lbs. increase in 42-day weight was accompanied by 0.53 more pigs farrowed. Gilts that were younger at 200 lbs., thus being the faster growing gilts, tended to farrow larger litters than gilts that were older at 200 lbs (r = -.13). A decrease of 10 days in age at 200 lbs. resulted in an increase of 0.30 pigs in litter size. Backfat thickness was not consistently associated with litter size.

Revelle and Robison (1973), using 1078 two-generation and 710 three-generation pedigrees, noted a negative relationship between the size of the litter a gilt came from and the size of her first litter. They divided the pedigrees into three groups (high 18 percent, middle 64 percent and low 18 percent) based on the first generation litter size. In the two-generation pedigree they found that gilts from larger litters tended to have smaller litters than gilts from smaller litters. They noted a high, low, high oscillation in the three-generation pedigree, indicating that gilts from large litters were prevented from exhibiting their genetic superiority by the stress of being reared in a large litter. Engle (1937) also found that female rats selected from large litters reached puberty later than female rats from small litters principally because the latter group had a larger growth rate.

Revelle and Robison (1973) estimated the heritability of litter size by regressing the litter size of the daughter on the litter size of the dam and the resulting heritability using all gilts was 0.13. The heritabilities for the high, middle and low groups were -.13, 0.01 and 0.20, respectively. The heritability estimated from granddaughter-granddam regression was 0.28. If the stress of being reared in a large litter is removed, as is artifically done by regressing granddaughter on granddam, a relatively high heritability is found for litter size. Further evidence of the delay in maturation because of the competition in large litters was noted in this study in that gilts from litters of

6 to 12 pigs reached puberty at about the same age while gilts from litters of more than 12 pigs were progressively older at puberty.

CHAPTER III

MATERIALS AND METHODS

General Procedure

This study involved 241 purebred Duroc, Hampshire and Yorkshire gilts and 103 two-breed cross gilts involving the three breeds. The gilts were from Project 1444 and all matings were made at the Fort Reno Experiment Station, El Reno, Oklahoma. The data included five breeding seasons starting with the fall of 1970 through the fall of 1972. The gilts in each season are summarized by breed group in Table I. The fall breeding season started on December 1 and the spring breeding season on June 1.

TABLE I

DISTRIBUTION OF GILTS BY BREED AND BREEDING SEASON

Breed of Gilt	Breeding Season				
	F1970	S1971	F1971	S1972	F1972
Duroc	14	29	14	16	21
Hampshire	16	24	9	21	18
Yorkshire	15	8	12	13	11
Duroc-Hampshire	--	--	13	20	--
Duroc-Yorkshire	--	--	15	22	--
Hampshire-Yorkshire	--	--	11	22	--

In the fall of 1969, the three purebred seedstock herds were formed at Stillwater by obtaining 25 gilts and 5 boars for each breed. This initial breeding stock came from as many different lines as possible to provide a broad genetic base, hopefully representative of the breed. In order to maintain a relatively broad genetic base and to keep inbreeding to a minimum, two new boars of each breed were purchased each year and three old boars of each breed were kept over.

From the 1970 spring, 1970 fall and 1972 spring farrowings about 60 gilts and 6 boars of each breed were selected from the Stillwater herd and taken to the Fort Reno Experiment Station for the crossbreeding study, Project 1444. The purebred and two-breed cross gilts farrowed in 1971 spring and 1971 fall at Fort Reno provided the gilts for the third and fourth seasons. In the fall of 1970, spring of 1971 and the fall of 1972, each boar was mated to three gilts of his own breed and to three gilts of each of the other two breeds. In the fall of 1971 and spring of 1972, each boar was bred to three gilts of each crossbred or purebred group that did not contain the same breeding as the boar. Consequently, in three of the five seasons (the first, second and fifth) purebred gilts were bred to carry purebred or two-breed cross embryos. In the remaining two seasons (the third and fourth) purebred gilts were carrying two-breed cross embryos and two-breed cross gilts were carrying three-breed cross embryos. The mating system is summarized in Table II.

All gilts in this study were given creep feed at 21 days of age and were weaned at 42 days of age. Two weeks after weaning, the gilts were moved to a confinement finishing facility and were allotted by breed group into groups of 16 pigs per pen. They were given one week to adjust to their new surroundings before being weighed on test.

TABLE II

BASIC MATING SYSTEM FOR EACH REPLICATION[a]

Breeding Season				
Fall 1971 Spring 1972			Fall 1970 Fall 1972 Spring 1971	
3HH♀	each	6D♂	3DD♀	each
3YY♀	each		3HH♀	each
3HY♀	each		3YY♀	each
3YH♀	each			
3DD♀	each	6H♂	3DD♀	each
3YY♀	each		3HH♀	each
3DY♀	each		3YY♀	each
3YD♀	each			
3DD♀	each	6Y♂	3DD♀	each
3DH♀	each		3HH♀	each
3DH♀	each		3YY♀	each
3HD♀	each			

[a]D = Duroc, H = Hampshire, Y = Yorkshire; the first letter is the breed of sire and the second is breed of dam.

All gilts were self fed a 16 percent crude protein ration until they reached 220 lbs. Gilts were weighted off test on a wwekly basis as they reached 220 lbs., were probed for backfat thickness, and were moved outside to dirt lots where they were individually limited fed. In the summer the gilts received 4 lbs. of a 15 percent crude protein ration and in the winter they received 4.5 lbs. Two weeks prior to breeding, they were flushed by increasing their feed by 1.5 lbs. and after breeding, the feed was reduced to the pre-flushing level.

During the breeding season, the gilts were checked for heat daily and were hand mated. Repeat matings were made between 12 and 24 hours after the first service whenever possible. If a gilt was mated twice in the same heat period, gestation length was measured from the first service. If a gilt exhibited heat at the next cycle, she was rebred; otherwise she was assumed pregnant.

During each season, two gilts from every sire-breed group were randomly selected to carry their litter to full term. The rest of the gilts were slaughtered on a weekly basis at approximately 30 days post-breeding by Wilson and Company, Oklahoma City. The reproductive tracts were collected and dissected so that all embryos could be removed, counted and measured. The ovaries were examined for corpora lutea and each corpus luteum was assumed to represent one ovum shed.

Statistical Analysis

The initial analysis consisted of correlations of the various factors with corpora lutea count and number of normal embryos within breed within season. This was done using the computer program entitled Statistical Analysis System (SAS) developed by Barr and Goodnight (1972) at North Carolina State University. This preliminary analysis indicated that the correlation coefficients were similar for each season. The correlations for Duroc, Hampshire and Yorkshire gilts were similar but different from the correlations for the crossbred gilts which were similar to each other. Therefore, the analysis was done in four steps. The first three steps utilized the computer program entitled Least Squares and Maximum Likelihood General Purpose Program (LSMLGP) described by Harvey (1960) while the fourth step utilized the SAS program.

The object of the first step was to determine the relationship of the various factors with ovulation rate. This analysis was done on all purebred gilts and the correlation and regression coefficients were pooled over breed and season.

The second step of the analysis was done to determine if the relationship of the various factors with total number of embryos was different for purebred embryos than for two-breed cross embryos. This involved the Duroc, Hampshire and Yorkshire gilts bred in the fall 1970, spring 1971 and fall 1972 breeding seasons because these were the only seasons when purebred gilts were carrying purebred and two-breed cross embryos. Correlation and regression coefficients were pooled within breed, year and season for each group.

The object of the third part of the analysis was to determine if the relationship of the various factors with ovulation rate and total embryos was the same for purebred gilts bred to carry two-breed embryos and crossbred gilts bred to carry three-breed embryos. The gilts utilized for this analysis were from the fall 1971 and spring 1972 breeding season because these were the only seasons that involved both types of gilts. Correlations and regression coefficients were pooled within breed, year and season for each group.

The fourth phase of the analysis was to determine a heritability estimate for number of corpora lutea. The following model was used:

$$Y_{ijkl} = \mu + R_i + S_{ij} + D_{ijk} + E_{ijkl}$$

where

Y_{ijkl} = the individual observation on number of corpora lutea.

μ = the mean number of corpora lutea.

R_i = the effect of the i^{th} replication where replication was defined as year, season and breed.

S_{ij} = the effect of the j^{th} sire within the i^{th} replication.

D_{ijk} = the effect of the k^{th} dam within the j^{th} sire within the i^{th} replication.

E_{ijkl} = the error associated with the $ijkl^{th}$ observation.

The SAS program calculated the variance component for each classification and the percentage that each component was of the total. The percentage of total variation due to sires is the paternal half sib correlation. Heritability was then estimated by multiplying the paternal half sib correlation by four as described by Pirchner (1969).

CHAPTER IV

RESULTS AND DISCUSSION

This chapter is organized into sections that will discuss (1) the factors associated with the ovulation rate of purebred Duroc, Hampshire and Yorkshire gilts, (2) the factors associated with the number of normal embryos for purebred gilts with purebred embryos and purebred gilts with two-breed cross embryos, (3) the relationship between various factors and the number of corpora lutea and the number of embryos for purebred gilts with two-breed cross embryos and two-breed cross gilts with three-breed cross embryos, and (4) the heritability of number of corpora lutea.

Factors Associated With the Ovulation Rate of Purebred Duroc, Hampshire and Yorkshire Gilts

The purpose of this portion of the study was to investigate the influence of various factors on ovulation rate in Duroc, Hampshire and Yorkshire gilts. The means and standard deviations for the various measurements studied involving the 241 purebred gilts are reported by breed group in Table III. The Duroc gilts came from the largest litters at birth and the Hampshire gilts came from the smallest litters at birth. At weaning, the litters the Yorkshire gilts came from averaged about 1 pig more than the litters the Hampshire and Duroc gilts came

TABLE III

MEANS FOR ALL TRAITS EVALUATED FOR ALL DUROC, HAMPSHIRE AND YORKSHIRE GILTS FOR ALL SEASONS

	Purebred Means				Overall Standard Deviation
	Duroc	Hampshire	Yorkshire	Overall	
Number of Gilts	94	88	59	241	
Size of Litter Born In	11.33	9.91	10.73	10.66	2.55
Size of Litter Weaned In	7.53	7.36	8.44	7.69	2.20
Birth Weight, lbs.	2.92	3.23	2.56	2.95	0.56
Weaning Weight, lbs.	24.00	24.32	23.97	24.11	5.11
Avg. Daily Gain, lbs.	1.40	1.34	1.29	1.35	0.12
Age at 220 lbs., days	174.98	181.53	186.93	180.30	14.18
Probe at 220 lbs., in.	1.26	1.07	1.13	1.16	0.14
Breeding Age, days	275.47	274.72	282.29	276.86	19.95
Breeding Weight, lbs.	265.61	263.32	249.61	260.85	25.60
Slaughter Weight, lbs.	282.96	281.23	265.66	278.09	26.19
Days from 220 lbs. to Breeding	100.76	93.19	95.36	96.67	24.83
Number of Corpora Lutea	13.86	12.49	13.47	13.27	2.26
Number of Embryos	10.78	9.25	11.07	10.29	2.74

from. The gilts in each breed averaged about 24 lbs. at weaning but the Durocs gained fastest; consequently, averaged 6.55 and 11.95 days younger at 220 lbs. than the Hampshire and Yorkshire gilts, respectively. The Yorkshire gilts were about 7 days older and 14 lbs. lighter at breeding than Durocs and Hampshires. The Duroc gilts averaged more eggs ovulated than the Hampshire and Yorkshire gilts, however, at 30 days post-breeding the Yorkshire gilts averaged 0.29 and 1.82 more embryos than the Duroc and Hampshire gilts, respectively.

The preliminary analysis indicated that the correlations were similar for the three breeds and for the five seasons, therefore the correlation and regression coefficients were pooled within breed, year and season and are reported in Table IV. Neither the size of the litter a gilt was born in or weaned in was significantly correlated with her ovulation rate. This indicates that selecting gilts from large litters should not increase ovulation rate.

Age at 220 lbs. and average daily gain were significantly correlated ($P < .05$) with ovulation rate ($r = -.17$ and 0.15, respectively) with gilts that gained faster and were younger at 220 lbs. having a higher ovulation rate. This is similar to the correlation of 0.20 reported by Squires et al. (1952) between growth rate and ovulation rate when age at breeding was held constant and similar to the correlation of 0.22 obtained by Rathnasabapathy et al. (1956). In this study an increase of 0.10 lb. in average daily gain was associated with an increase in ovulation rate of $0.28 \pm .13$ ova while a decrease of 10 days in age at 220 lbs. was associated with an increase in ovulation rate of 0.27 ± 0.1 ova.

TABLE IV

CORRELATIONS OF VARIOUS FACTORS WITH OVULATION RATE AND REGRESSION COEFFICIENTS OF OVULATION RATE ON SOME FACTORS FOR ALL DUROC, HAMPSHIRE AND YORKSHIRE GILTS POOLED WITHIN BREED, YEAR AND SEASON

Y Variable	Ovulation Rate	
	Correlation r_{xy}	Regression b_{xy}
Size of Litter Born In	.026	.023 ± .059[d]
Size of Litter Weaned In	.032	.033 ± .068
Birth Weight	.030	.118 ± .267
Weaning Weight	.109[a]	.048 ± .029
Avg. Daily Gain	.151[b]	2.759 ± 1.207
Age at 220 lbs.	-.170[b]	-.027 ± .101
Probe at 220 lbs.	-.061	--
Breeding Age	.123[a]	.014 ± .008
Breeding Weight	.230[c]	.020 ± .008
Days from 220 lbs. to Breeding	.198[c]	.018 ± .006
Number of Embryos	.255[c]	--

[a] $P < .10$

[b] $P < .05$

[c] $P < .01$

[d] ± Standard error.

The correlations of breeding weight and days from 220 lbs. to breeding with ovulation rate were 0.23 and 0.20, respectively and significant ($P < .05$). An increase of 10 lbs. in breeding weight was associated with an increase in ovulation rate of 0.20 ± 0.10 eggs while an increase of 10 days in days from 220 lbs. to breeding was associated with an increase of 0.18 ± 0.10 eggs. In the ranges studied, the correlation between ages at breeding and ovulation rate was significant at the 0.10 level. However, if breeding weight was held constant, the correlation between age at breeding and ovulation rate was reduced to 0.04 and was nonsignificant indicating that the increase in ovulation rate was due more to an increase in weight than an increase in age. This agrees with Warnick *et al.* (1951) and Robertson *et al.* (1951a, 1951b) who found that weight was significantly correlated with age at puberty. Based on these data, it appears that sexual maturity is probably influenced more by weight than by age.

Birth weight was nonsignificantly correlated with ovulation rate ($r = 0.03$) but the correlation of 0.11 between weaning weight and ovulation rate was significant at the 0.10 level. Rathnasabapathy *et al.* (1956) reported the correlations of ovulation rate with birth weight and weaning weight of 0.12 and 0.33, respectively.

The correlations among all traits are reported in Table XV in the appendix. It is interesting to note that birth weight and weaning weight were significantly correlated with average daily gain, age at 220 lbs., breeding weight and days from 220 lbs. to breeding and that these were significantly ($P < .05$) correlated with ovulation rate. This suggests that one might indirectly increase ovulation rate by using birth weight or weaning weight to select for increase growth rate, increased breeding weight and decreased age at 220 lbs.

In general, these data indicate that gilts that are heavier at weaning, grow faster and reach 220 lbs. at an earlier age should have a higher ovulation rate. Also gilts that are older and heavier at breeding should ovulate more ova.

Factors Associated With the Number of Normal Embryos for Purebred Gilts With Purebred Embryos and Purebred Gilts With Two-Breed Embryos

This portion of the study was conducted to compare the relative influence of the various factors on the number of normal embryos for gilts with purebred embryos and equivalent gilts with two-breed embryos. The means and standard deviations for the 56 purebred gilts with purebred embroys (PBGPBE) and 100 purebred gilts with two-breed embryos (PBGCBE) are summarized in Table V. The two groups of purebred gilts were quite similar except that the PBGPBE averaged about 3 days older at 220 lbs. and 6.5 lbs. lighter at breeding than the PBGCBE. The PBGCBE averaged 0.33 more eggs and 0.41 more embryos than the PBGPBE. These differences were assumed to be chance deviations.

The pooled correlations and regressions are reported in Tables VI and VII. Most of the factors studied were not significantly correlated with number of embryos 30 days after breeding regardless of the type of breeding of the embryo. The number of corpora lutea accounted for 13.7 and 8.4 percent of the variation in number of embryos for the PBGPBE and PBGCBE, respectively ($P < .05$). Rathnasabapathy _et al_. (1956) and Squiers _et al_. (1952) reported that the number of ova shed accounted

TABLE V

MEANS AND STANDARD DEVIATIONS FOR ALL TRAITS EVALUATED FOR DUROC, HAMPSHIRE, YORKSHIRE GILTS FOR FALL 1970, SPRING 1971 AND FALL 1972 BREEDING SEASONS BY TYPE OF EMBRYO

	Gilts with Purebred Embryos		Gilts with 2-Breed Cross Embryos	
	Mean	Standard Deviation	Mean	Standard Deviation
Number of Gilts	56		100	
Size of Litter Born In	10.57	2.40	10.53	2.40
Size of Litter Weaned In	7.59	2.12	7.70	2.26
Birth Weight, lbs.	2.97	0.61	3.04	0.55
Weaning Weight, lbs.	23.58	4.51	24.83	5.04
Avg. Daily Gain, lbs.	1.37	0.14	1.38	0.12
Age at 220 lbs., days	177.27	12.85	173.91	13.61
Probe at 220 lbs., in.	1.13	0.12	1.14	0.16
Breeding Age, days	279.93	16.49	279.21	17.93
Breeding Weight, lbs.	254.11	23.89	260.62	26.22
Slaughter Weight, lbs.	267.93	25.02	274.32	25.79
Days from 220 lbs. to Breeding	102.66	21.29	105.30	22.46
Number of Corpora Lutea	12.89	2.11	13.22	2.17
Number of Embryos	10.12	2.24	10.53	2.72

TABLE VI

CORRELATIONS OF THE VARIOUS TRAITS WITH NUMBER OF CORPORA LUTEA AND EMBRYOS FOR DUROC, HAMPSHIRE AND YORKSHIRE GILTS IN FALL 1970, SPRING 1971 AND FALL 1972 BY TYPE OF EMBRYO POOLED WITHIN BREED, YEAR AND SEASON

Correlated Trait	Gilts with Purebred Embryos		Gilts with 2-Breed Cross Embryos	
	No. of Corpora Lutea	No. of Embryos	No. of Corpora Lutea	No. of Embryos
Size of Litter Born In	.003	-.186	.012	-.018
Size of Litter Weaned In	.100	.052	.010	.101
Birth Weight	.046	-.041	-.103	-.020
Weaning Weight	.034	.016	.012	.056
Avg. Daily Gain	.177	.158	.196	.001
Age at 220 lbs.	-.227	-.073	-.197	-.027
Probe at 220 lbs.	-.116	-.155	-.051	.007
Breeding Age	-.113	-.127	.125	.359[a]
Breeding Weight	.340[a]	-.028	.101	.167
Days from 220 lbs. to Breeding	.049	-.054	.219	.303[a]
Number of Corpora Lutea	--	.369[a]	--	.289[a]

[a] $P < .05$.

TABLE VII

COEFFICIENTS OF REGRESSION OF NUMBER OF CORPORA LUTEA AND NUMBER OF EMBRYOS ON VARIOUS FACTORS FOR DUROC, HAMPSHIRE AND YORKSHIRE GILTS BY TYPE OF EMBRYO FOR FALL 1970, SPRING 1971 AND FALL 1972 BREEDING SEASONS[a]

Independent Variable	Dependent Variable			
	Gilts with Purebred Embryos		Gilts with 2-Breed Cross Embryos	
	No. of Corpora Lutea	No. of Embryos	No. of Corpora Lutea	No. of Embryos
Size of Litter Born In	.003 ± .130[b]	-.174 ± .135	.011 ± .095	-.020 ± .120
Size of Litter Weaned In	.100 ± .146	.055 ± .156	.010 ± .101	.122 ± .126
Birth Weight	.161 ± .514	-.153 ± .545	-.403 ± .410	-.100 ± .518
Weaning Weight	.016 ± .082	.008 ± .087	.005 ± .045	.030 ± .057
Avg. Daily Gain	2.697 ± .221	2.545 ± .235	3.417 ± 1.801	.013 ± 2.308
Age at 220 lbs.	-.037 ± .024	-.013 ± .026	-.031 ± .016	-.005 ± .021
Breeding Age	-.014 ± .019	-.017 ± .020	.015 ± .013	.054 ± .015
Breeding Weight	.030 ± .012	-.003 ± .024	.008 ± .009	.017 ± .011
Slaughter Weight	----------	.002 ± .013	-----------	.016 ± .011
Days from 220 lbs. to Breeding	.005 ± .015	-.006 ± .015	.021 ± .010	.037 ± .012

[a]Pooled within breed, year and season.

[b]± Standard error.

for 2.9 and 22.1 percent, respectively, of the variation in litter size. These results indicate that in most gilts the number of ova shed is probably not the major limiting factor for litter size. Since the number of corpora lutea does not account for much variation in number of embryos, it is expected that the relationship of the various factors with number of corpora lutea will be different than their relationship with number of embryos.

The correlations between the size of litter a gilt was born in and the number of embryos she had 30 days post-breeding tended to be larger for PBGPBE than for PBGCBE (r = -.19 and -.02, respectively). In PBGPBE an increase of one pig in the size of the litter the gilt came from at birth decreased her litter size at 30 days by 0.17 ± .13 embryos. This is similar to the correlation of -.13 reported by Young and Omtvedt (1973) between the size of litter a gilt was born in and the size of her first litter. They also noted that an increase of one pig in the size of litter a gilt came from at birth reduced her first litter by 0.16 pigs. In PBGPBE and PBGCBE the size of the litter the gilt came from at weaning had no effect on her litter size and this is in agreement with Young and Omtvedt (1973). Based on these results, it appears that by 42 days of age the pigs eat enough creep feed so that the competition in large litters is no longer an important factor affecting later performance.

In PBGPBE, postweaning daily gain tended to be correlated with number of embryos (r = 0.16) but this trend was not noticed for the PBGCBE (r = .00) although correlation of postweaning daily gain with ovulation rate was similar for both groups (r = 0.18 and 0.20, respectively). The regression of number of embryos on postweaning daily gain was 2.54 ± .24 embryos and .01 ± 2.31 embryos for PBGPBE and PBGCBE, respectively. Rathnasabapathy et al. (1956) reported a correlation of -.09 between growth rate and litter size and the regression of litter size on growth rate was -2.19 pigs both of which are opposite in sign from those found in this study but were not significant. There appears to be no explanation for the differences between the results in this study and those found by Rathnasabapathy et al. (1956).

The correlation between breeding age and number of embryos was significantly different ($P < .05$) for PBGPBE compared to PBGCBE ($r = -.11$ and 0.36, respectively). Part of this difference was due to the fact that chance division of the purebred gilts, resulted in correlations of -.11 and 0.12 for ovulation rate with age at breeding for PBGPBE and PBGCBE, respectively. The regression of number of embryos on breeding age was significant ($P < .05$) for PBGCBE ($b = .05 \pm -.02$ embryos) but not for PBGPBE ($b = -.02 \pm .02$ embryos). The correlations and regressions for the PBGCBE group for number of embryos are similar to those reported by Squiers et al. (1952) and the correlation and regressions for the PBGPBE are similar to those reported by Rathnasabapathy et al. (1956).

The correlations of breeding weight and days from 220 lbs. to breeding with number of embryos tended to be different for PBGPBE compared to PBGCBE with the correlations being more positive for the PBGCBE group. In the PBGPBE group the correlations of breeding weight and days from 220 lbs. to breeding with number of embryos ($r = -.03$ and -.05, respectively) were less positive than the correlations with number of corpora lutea ($r = 0.34$ and 0.05, respectively). However, in the PBGCBE the correlations of breeding weight and days from 220 lbs. to breeding with number of embryos ($r = 0.17$ and 0.30, respectively) were more positive than the correlations with number of corpora lutea ($r = 0.10$ and 0.22, respectively). In the PBGCBE the regressions of breeding weight and days from 220 lbs. to breeding on number of embryos were $0.017 \pm .01$ and $0.037 \pm .01$. In the PBGPBE the regressions were all zero.

The fact that breeding weight and days from 220 lbs. to breeding are not as closely associated with the number of embryos for PBGPBE as for the PBGCBE may relate back to the correlation between number of corpora lutea and number of embryos which is 0.29 for the PBGCBE and 0.37 for the PBGPBE. The correlations indicate that factors other than ovulation rate, such as breeding weight and days from 220 lbs. to breeding are more closely associated with the number of embryos for the PBGCBE than for the PBGPBE.

These data indicate that an increase in the size of the litter a gilt came from decreased the size of her first litter more for PBGPBE than for PBGCBE. An increase in average daily gain tended to increase the litter size for PBGPBE but not for PBGCBE. For PBGCBE, the breeding age, breeding weight and days from 220 lbs. to breeding are positively and significantly correlated with number of embryos but are negatively and nonsignificantly correlated with number of embryos for PBGPBE.

The correlations among all traits for PBGPBE and PBGCBE are reported in Table XVI and XVII, respectively, in the appendix.

The Relationship of Various Factors With the Number of Corpora Lutea and Number of Embryos for Purebred Gilts With Two-Breed Cross Embryos and Crossbred Gilts With Three-Breed Cross Embryos

The purpose of this portion of the study was to compare the relative influence of various factors on the number of corpora lutea and number of embryos for purebred gilts with two-breed cross embryos and two-breed cross gilts with three-breed cross embryos. It has generally been noted that crossbred gilts are more productive than purebred gilts. The means and standard deviations are reported in Table VIII. The means are quite similar for the two types of gilts except that the crossbred gilts grew slightly faster and were younger at 220 lbs. The crossbred gilts averaged 16 days younger at breeding.

The pooled correlations are reported in Table IX and pooled regressions are reported in Table X. The correlation between number of corpora lutea and number of embryos was 0.48 for the crossbreds and 0.19 for the purebreds. Similarly, Rathnasabapathy et al. (1956) and Squiers et al. (1952) reported correlations for number of corpora lutea and number of embryos of 0.47 and 0.17, respectively.

In this study, even though the purebred gilts ovulated an average of 0.43 more eggs than the crossbred gilts, the crossbred gilts had 0.61 more embryos at 30 days of gestation. This is in agreement with Johnson et al. (1973) who found two-breed cross gilts when compared to

TABLE VIII

MEANS AND STANDARD DEVIATIONS FOR ALL TRAITS EVALUATED BY TYPE OF GILT FOR FALL 1971 AND SPRING 1972 BREEDING SEASONS

	Purebred Gilts with 2-Breed Cross Embryos		2-Breed Cross Gilts with 3-Breed Cross Embryos	
	Mean	Standard Deviation	Mean	Standard Deviation
Number of Gilts	85		103	
Size of Litter Born In	10.88	2.85	10.33	2.25
Size of Litter Weaned In	7.75	2.16	7.77	1.92
Birth Weight, lbs.	2.82	0.56	2.72	0.52
Weaning Weight, lbs.	23.61	5.48	23.77	4.96
Avg. Daily Gain, lbs.	1.31	0.11	1.37	0.13
Age at 220 lbs., days	189.81	15.09	184.59	12.85
Probe at 220 lbs., in.	1.20	0.14	1.24	0.15
Breeding Age, days	272.08	24.10	256.38	22.01
Breeding Weight, lbs.	265.58	26.13	262.49	26.51
Slaughter Weight, lbs.	289.22	27.92	288.70	29.77
Days from 220 lbs. to Breeding	82.58	29.20	71.79	24.97
Number of Corpora Lutea	13.56	2.49	13.13	2.31
Number of Embryos	10.12	3.08	10.73	2.98

TABLE IX

CORRELATIONS OF THE VARIOUS FACTORS WITH NO. OF CORPORA LUTEA AND NO. OF EMBRYOS FOR PUREBRED AND 2-BREED CROSS GILTS FOR FALL 1971 AND SPRING 1972 BREEDING SESONS POOLED WITHIN BREED, YEAR AND SEASON

Correlated Trait	Purebred Gilts with 2-Breed Cross Embryos		2-Breed Cross Gilts with 3-Breed Cross Embryos	
	No. of Corpora Lutea	No. of Embryos	No. of Corpora Lutea	No. of Embryos
Size of Litter Born In	.050	-.177	-.056	-.088
Size of Litter Weaned In	.011	-.118	-.007	.080
Birth Weight	.151	-.126	.253[a]	.121
Weaning Weight	.203	.154	.281[a]	.352[a]
Avg. Daily Gain	.091	.034	.188	.124
Age at 220 lbs.	-.103	-.003	-.201	-.178
Probe at 220 lbs.	-.024	.094	-.048	.069
Breeding Age	.229[a]	.024	-.035	.052
Breeding Weight	.295[a]	.131	.455[a]	.411
Slaughter Weight	--	.052	--	.443[a]
Days from 220 lbs. to Breeding	.246[a]	.024	.072	.137
Number of Corpora Lutea	--	.192	--	.483[a]

[a]$P < .05$.

TABLE X

COEFFICIENTS OF REGRESSION OF NUMBER OF CORPORA LUTEA AND EMBRYOS ON THE VARIOUS FACTORS FOR PUREBRED AND CROSSBRED GILTS IN THE FALL 1971 AND SPRING 1972 BREEDING SEASON POOLED WITHIN BREED, YEAR AND SEASON

Independent Variable	Purebred Gilts with 2-Breed Cross Embryos		2-Breed Cross Gilts with 3-Breed Cross Embryos	
	No. of Corpora Lutea	No. of Embryos	Corpora Lutea	No. of Embryos
Size of Litter Born In	.043 ± .099[a]	-.191 ± .120	-.058 ± .108	-.117 ± .139
Size of Litter Weaned In	.013 ± .131	-.168 ± .160	-.008 ± .127	.124 ± .163
Birth Weight	.667 ± .495	-.690 ± .613	1.116 ± .451	.688 ± .598
Weaning Weight	.092 ± .050	.087 ± .063	.131 ± .047	.212 ± .059
Avg. Daily Gain	2.066 ± .255	.952 ± .317	3.454 ± 1.898	2.932 ± 2.478
Age at 220 lbs.	-.017 ± .017	-.001 ± .023	-.036 ± .019	-.041 ± .024
Breeding Age	.024 ± .011	.003 ± .014	-.004 ± .011	.007 ± .014
Breeding Weight	.028 ± .010	.015 ± .013	.040 ± .008	.045 ± .011
Slaughter Weight	----------	.006 ± .012	-----------	.044 ± .009
Days from 220 lbs. to Breeding	.021 ± .009	.003 ± .012	.007 ± .010	.016 ± .012

[a] ± Standard error.

purebred gilts, had 0.50 fewer corpora lutea but 0.60 more embryos at 30 days. Since all the embryos are crossbred, this might indicate that the uterine environment of the crossbred gilt is more favorable for early embryo survival than the uterine environment of the purebred gilt. Since it has been shown that ovulation rate increases during the first few estrus cycles, the fact that the crossbred gilts were 16 days, almost a full cycle, younger than the purebred gilts may explain their lower ovulation rate.

The size of the litter a gilt was born or raised in accounted for a nonsignificant amount of variation in number of corpora lutea in both purebred and crossbred gilts. The correlations between the size of litter the gilt came from and number of embryos she carried tended to be somewhat larger than the correlations with corpora lutea but they were still nonsignificant. The correlations between the size of litter the gilt came from at weaning and the number of embryos were -.12 and 0.08 for the purebred and crossbreds, respectively. An increase of one pig in the size of the litter a gilt was weaned in was associated with a decrease of 0.17 $\pm$ .16 pigs for the purebred gilt litters but with an increase of -.12 $\pm$ .16 pigs for the crossbred gilt litters.

Young and Omtvedt (1973) found that the size of litter a gilt was farrowed in had more effect on her litter size than the size of litter she was weaned in. They found a correlation of -.13 between the size of litter she was born in and the size of her first litter with an increase of one pig in the litter at birth being associated with a decrease in her litter of 0.16 pigs.

The correlations between the gilt's birth weight and the number of corpora lutea were 0.15 and 0.25 for purebreds and crossbreds, respectively and the respective correlations for birth weight with number of embryos were -.13 and 0.12. An increase of 1 lb. in the gilt's birth weight was associated with an increase in ovulation rate for purebred and crossbred gilts of 0.67 ± .50 and 1.12 ± .45 eggs, respectively. However, it was associated with a decrease of 0.69 ± .61 embryos for the purebred gilts and an increase of 0.69 ± .60 embryos for the crossbred gilts.

Young and Omtvedt (1973) found a correlation of 0.16 between a gilt's birth weight and the size of her first litter and an increase of 1 lb. in birth weight resulted in an increase in the gilt's litter of 0.75 pigs. Rathnasabapathy _et al._ (1956) also found a positive correlation between the gilt's birth weight and the size of her first litter (r = 0.24) and an increase of 1 lb. in birth resulted in 0.93 more embryos at the 55th day of gestation.

The correlation of weaning weight with number of corpora lutea was similar for purebred and crossbred gilts (r = 0.20 and 0.28, respectively) with the correlation for crossbreds being significant. The correlation of weaning weight with number of embryos was larger for the crossbred gilts than for the purebred gilts (r = 0.35 and 0.15, respectively). The regression of weaning weight on number of corpora lutea and number of embryos was significant for the crossbred gilts (b = 0.13 ± .05 and 0.21 ± .06, respectively) but not for the purebred gilts (b = 0.09 ± .05 and 0.08 ± .06, respectively).

Rathnasabapathy _et al._ (1956) found correlations of 0.33 and 0.15 for weaning weight with number of corpora lutea and number of embryos and noted that an increase of 10 lbs. in weaning weight was associated with an increase of 0.53 more embryos. Young and Omtvedt (1973) found a correlation of 0.10 between the gilt's weaning weight and the number of embryos in her first litter and an increase of 10 lbs. in weaning weight increased litter size by 0.53 pigs.

The correlations of average daily gain and age at 220 lbs. with ovulation rate for the purebred gilts (r = .09 and -.10, respectively) tended to be smaller than those for crossbred gilts (r = .19 and -.20, respectively). The same trend was noted for the correlation of average daily gain and age at 220 lbs. with number of embryos, with the correlations being smaller for the purebred gilts (r = 0.03 and .00, respectively) than for the crossbred gilts (r = 0.21 and -.18, respectively). In general in both types of gilts, the faster gaining gilts that reached 220 lbs. at an earlier age had more corpora lutea and more embryos. This is in agreement with the results found by Squiers et al. (1952), Rathnasabapathy et al. (1956) and Young and Omtvedt (1973).

The regressions of number of corpora lutea and number of embryos on age at 220 lbs. were significant ($P < .05$) for crossbred gilts (b = -.04 ± .02 embryos and -.04 ± .02 embryos, respectively) but not significant for the purebred gilts (b = -.02 ± .02 embryos and .01 ± .02 embryos, respectively). An increase of 0.10 lb. in average daily gain was associated with an increase of 0.35 ± .20 corpora lutea and 0.29 ± .25 embryos for the crossbred gilts and an increase of 0.21 ± .03 corpora lutea and 0.09 ± .32 embryos for the purebred gilts.

Age at breeding was significantly correlated with number of corpora lutea for purebred gilts (r = 0.23) but not for crossbred gilts (r = -.03). The correlation for the purebred gilts was similar to the correlation of 0.32 reported by Rathnasabapathy et al. (1956) between breeding age and number of corpora lutea. In this study, when breeding weight was held constant, the correlation between breeding age and number of corpora lutea for purebred gilts became 0.09 and nonsignificant. This indicates that the increase in ovulation rate was more a function of weight than of age. Age at breeding was not closely correlated with number of embryos for either type of gilt. Similarly, Omtvedt et al. (1965) and Stewart (1945) found that weight at breeding affected litter size more than did age at breeding. Squiers et al. (1952) found a significant correlation of 0.31 between breeding age and litter size.

The correlation of breeding weight with number of corpora lutea was 0.30 and 0.45 for the purebred and crossbred gilts, respectively. An increase of 10 lbs. in breeding weight was associated with an increase of 0.28 ± 0.10 and 0.40 ± 0.10 corpora lutea for the purebred and crossbred gilts, respectively. Breeding weight was significantly correlated with number of embryos for the crossbred gilts but not for the purebred gilts. Consequently, an increase of 10 lbs. in breeding weight was associated with an increase in litter size of 0.46 ± 0.10 embryos for the crossbred gilts and only 0.15 ± 0.10 embryos for the purebred gilts. Omtvedt et al. (1965) found a correlation of 0.19 between breeding weight and litter size and each 10 lb. increase in breeding weight resulted in 0.20 more pigs farrowed.

Slaughter weight was significantly correlated with the number of embryos for crossbred gilts ($r = 0.44$) but not for the purebred gilts. The regression of number of embryos on slaughter weight was 0.04 ± .01 embryos and significant for the crossbred gilts but only 0.01 ± .01 embryos and nonsignificant for the purebred gilts.

The correlation of days from 220 lbs. to breeding with number of corpora lutea was significant and larger for the purebred gilts (r = 0.25) than for the crossbred gilts (r = 0.07). However, the correlation of days from 220 lbs. to breeding with number of embryos was not significant for either group but was larger for the crossbred gilts than for the purebred gilts (r = 0.14 and 0.02, respectively).

Most of the relationships of the various factors with ovulation rate and number of embryos were similar for crossbred and purebred gilts. However, breeding age, breeding weight and days from 220 lbs. to breeding were significantly correlated with the number of corpora lutea for the purebred gilts but only the correlation between breeding weight and number of corpora lutea was significant for the crossbred gilts. When breeding weight was held constant the correlation between breeding age and number of corpora lutea became nonsignificant for the purebred gilts. Birth weight and weaning weight had a significant effect on ovulation rate for the crossbred gilts but not for the purebred gilts. In the crossbred gilts only weaning weight, breeding weight and slaughter weight were significantly correlated with number of embryos and none of the traits were significantly correlated with number of embryos for the purebred gilts.

The correlations among all traits are reported in Tables XVII and XIX in the appendix for the purebred and crossbred gilts, respectively.

Estimation of the Heritability of Number of Corpora Lutea

Only the records of purebred gilts from sires that were represented by two or more daughters were utilized in this study. The analysis of variance for all Duroc, Hampshire and Yorkshire gilts is shown in Table XI. In this AOV, replication was defined as breed of sire, year and season so as to remove the effects of these factors before looking at individual sires within each replication. The sire component of variance was negative thus yielding a negative estimate of heritability. In this analysis the dam component of variance accounted for 40 percent of the total variation. These results are in agreement with those presented by Squiers _et al_. (1952) who concluded that sires had no influence on the ovulation rate of their daughters. Squiers _et al_. (1952) and Lasley (1972) also found that the maternal component of variance was larger than the paternal component. This indicates that there is a strong maternal influence on ovulation rate.

TABLE XI

ANALYSIS OF VARIANCE OF NUMBER OF CORPORA LUTEA FOR DUROC, HAMPSHIRE AND YORKSHIRE GILTS

Source	DF	Sum of Squares	Mean Square	Variance Component	Percent of Total
Total	220	1245.249	5.660	6.309	100.00
REP[a]	14	198.075	14.148	0.577	9.14
Sire/Rep	52	288.649	5.551	-0.604	0.0
Dam/Sire/Rep	79	520.051	6.583	2.553	40.46
Error	75	238.464	3.180	3.180	50.40

[a]Rep defined as year, season and breed of sire.

The data were then divided into three groups based on breed; Duroc, Hampshire and Yorkshire. The same analysis of variance was used except that replication was defined only as year and season. The purpose of this was to see if the same results could be obtained in each breed. The AOV's are reported in Tables XII, XIII and XIV in the appendix. In all three breeds, the sire components of variance were negative and the maternal component made up 29, 56, and 45 percent of the total variance for the Duroc, Hampshire and Yorkshire breeds, respectively.

CHAPTER V

SUMMARY

This study involved 241 purebred and 103 two-breed cross gilts from the first five breeding seasons of Project 1444 starting in the fall of 1970 through the fall of 1972. In the first, second and fifth breeding seasons, purebred gilts were bred to carry purebred or two-breed cross embryos. In the third and fourth seasons, purebred gilts were bred to carry two-breed embryos and two-breed cross gilts were bred to carry three-breed cross embryos. In each season one gilt from each sire breed group was randomly selected to be slaughtered 30 days after breeding. The reproductive tracts were collected and dissected so that all embryos could be removed, counted and measured. The ovaries were examined for corpora lutea and each corpus luteum was assumed to represent one ova shed.

Among the 241 purebred gilts evaluated, average daily gain and age at 220 lbs. were significantly correlated ($P < .05$) with the number of corpora lutea ($r = 0.15$ and $-.17$, respectively) and an increase of 0.10 in postweaning daily gain resulted in 0.28 more embryos. Breeding weight and days from 220 lbs. to breeding were also significantly correlated with number of corpora lutea ($r = 0.23$ and 0.20, respectively). These results indicate gilts that are heavier at weaning, grow faster and reach 220 lbs. at an earlier age ovulate more eggs. Gilts that have more time between 220 lbs. and breeding and are heavier and older at breeding also ovulate more ova.

In comparing 56 purebred gilts with purebred embryos (PBGPBE) with 100 purebred gilts with crossbred embryos (PBGCBE) many of the relationships of the various factors with the number of embryos were different. Average daily gain tended to be correlated with number of embryos for PBGPBE but not for PBGCBE (r = 0.15 and .00, respectively). An increase of 10 days in age at breeding was associated with a decrease of 0.17 $\pm$ .20 embryos for the PBGPBE but in an increase of 0.54 $\pm$ .15 embryos for the PBGCBE. However, there was no close relationship between breeding weight and number of embryos for PBGPBE (r = -.03) while there was a tendency for an increase in breeding weight to be associated with an increase in litter size among PBGCBE (r = 0.17). The correlation between days from 220 lbs. to breeding and number of embryos was 0.30 ($P < .05$) for PBGCBE but only -.05 and nonsignificant for PBGPBE. The correlations between number of corpora lutea and number of embryos were 0.37 and 0.29 for the PBGPBE and PBGCBE, respectively.

In comparing 103 two-breed cross gilts with 85 purebred gilts, most of the relationships of the various factors studied with ovulation rate and number of embryos were similar. The correlations for birth weight, weaning weight, average daily gain and breeding weight with the number of corpora lutea were larger for the two-breed cross gilts (r = 0.25, 0.28, 0.19 and 0.45, respectively) than for the purebred gilts (r = 0.05, 0.20, 0.09 and 0.29, respectively). When breeding weight was held constant, the correlations between breeding age and number of corpora lutea were nonsignificant for both purebred and crossbred gilts.

Birth weight tended to be positively related with number of embryos in crossbred gilts (r = 0.12) but the relationship was negative for purebred gilts (r = -.12). Among the two-breed cross gilts, the number of embryos were significantly correlated with weaning weight, breeding weight and slaughter weight (r = 0.35, 0.44 and 0.48, respectively) but these correlations were not as large for the purebred gilts (r = 0.15, 0.13 and 0.05, respectively). The correlation of number of corpora lutea with number of embryos was 0.48 and 0.19 for the crossbred and purebred gilts, respectively.

The heritability of corpora lutea number was estimated to be zero. The sire component of variance was negative and the maternal component of variance accounted for 40 percent of the total. These results indicate a strong maternal influence on ovulation rate.

LITERATURE CITED

Barr, A. J., J. H. Goodnight. 1972. "A User's Guide to the Statistical Analysis System." Student Supply Stores, N. Carolina State University. Raleigh, N. Carolina.

Blunn, Cecil T. 1939. The age of rats at sexual maturity as influenced by their genetic constitution. Anat. Rec. 74:199.

Cunningham, P. J., D. R. Zimmerman, E. R, Peo, Jr., T. E. Socha and W. T. Ahlschwede. 1972. University of Nebraska Annual Report to NC-103 Conference of Collaberators, Record of Proceedings, University of Missouri. July 1972.

Ellinger, T. 1921. The influence of age on fertility in swine, Proc. Nat. Acad. Sci. 7:134.

Engle, E. T., R. C. Crafts and C. E. Zeithmal. 1937. First estrus in rats in relation to age, weight and length. Proc. Soc. Exp. Biol. and Med. 37:427.

Harvey, W. R. 1960. Least squares analysis of data with unequal sub-class numbers. U.S.D.A. A.R.S. Bul. 20-8.

Johansson, I. 1929. Statistische untersuchungen uber die fruchtbarkeit ser schweine. Zeits. fur Fierzucht. und Zuchtungsb. 15:49-86.

Johnson, R. K., I. T. Omtvedt, T. W. Williams and S. D. Welty. 1973. Reproductive performance of purebred gilts with 2-breed cross litters compared to crossbred gilts with 3-breed cross litters. Okla. Agri. Exp. Sta. MP-90:173.

Korkman, Nils. 1947. Causes of variation in the size and weight of litters from sows. Acta. Agric. Suecana 2(3):253.

Krizinecky, J. 1935. The litter size in the pig in its dependence upon physiological non hereditary factors. II Influence of age of the mother sow and of the number of the litter. Ceskoslav. Akad. Zemed. Sbornik. 10:140.

Krizinecky, J. 1942. Untersuchungen uber den einflusz des alters beim ersten wurf auf die fruchtbarkeit der sausen. Zeits. fur Feirzucht. und Zuchtungsb. 52(3):20.

Lasley, E. L. 1957. Ovulation prenatal mortality and litter size in swine. J. Anim. Sci. 16:335.

Olbrycht, T. M. 1943. The statistical basis of selection in animal husbandry. I. Studies on life performance of brood sows: an analysis of variance and covariance of progeny born and reared. J. Agr. Sci. 33:28.

Omtvedt, I. T., C. M. Stanislaw and J. A. Whately, Jr. 1965. Relationship of gestation length, age and weight at breeding and gestation gain to sow productivity at farrowing. J. Anim. Sci. 24:531.

Pirchner, Franz. 1969. "Population Genetics in Animal Breeding." W. H. Freeman and Company, San Francisco, California.

Rathnasabapathy, V., J. E. Lasley and P. T. Mayer. 1956. Genetic and environmental factors affecting litter size in swine. Mo. Agr. Exp. Sta. Res. Bul. 615.

Revelle, T. J. and O. W. Robison. 1973. An explanation for the low heritability of litter size in swine. J. Anim. Sci. 36:195. (Abstract).

Rio, P. R. 1957. Genetic interpretation of heterosis and maternal effects in reproduction and growth of swine. Unpublished Ph.D. Thesis. University of Illinois, Urbana. (Quoted by Revelle).

Robertson, G. L., R. H. Grummer, L. E. Casida and A. B. Chapman. 1951a. Age at puberty and related phenomena in outbred Chester White and Poland China gilts. J. Anim. Sci. 10:645.

Robertson, G. L., L. E. Casida, R. H. Grummer and A. B. Chapman. 1951b. Some feeding and management factors affecting age at puberty and related phenomena in Chester White and Poland China gilts. J. Anim. Sci. 10:841.

Squiers, C. D., G. E. Dickerson and D. T. Mayer. 1952. Influence of inbreeding, age and growth rate of sows on sexual maturity, rate of ovulation, fertilization and embryo survival. Mo. Agr. Exp. Sta. Res. Bul. 494.

Stewart, H. A. 1945 An appraisal of factors affecting prolificacy in swine. J. Anim. Sci. 4:250.

Warnick, A. C., E. L. Wiggens, L. E. Casida, R. H. Grummer and A. G. Chapman. 1951. Variation in puberty phenomena in inbred gilts. J. Anim. Sci. 10:479.

Young, L. D. and I. T. Omtvedt. 1973. Influence of the litter in which a gilt is raised and her own performance on the subsequent reproductive performance. Okla. Agr. Exp. Sta. Res. Rpt. MP-90:177.

APPENDIXES

TABLE XII

ANALYSIS OF VARIANCE OF CORPORA LUTEA FOR DUROC GILTS

Source	DP	Sum of Squares	Mean Square	Variance Component	Percent of Total
Total	93	485.202	5.217	5.568	100.00
Rep[a]	4	55.719	13.930	0.480	8.62
Sire/Rep	25	127.125	5.085	-0.246	0.0
Dam/Sire/Rep	37	208.525	5.636	1.612	28.96
Error	27	93.833	3.475	3.475	62.42

[a]Rep is defined as year and season.

TABLE XIII

ANALYSIS OF VARIANCE OF CORPORA LUTEA FOR HAMPSHIRE GILTS

Source	DP	Sum of Squares	Mean Square	Variance Component	Percent of Total
Total	87	493.989	5.678	6.469	100.00
Rep[a]	4	44.140	11.035	0.243	3.76
Sire/Rep	25	155.098	6.204	-0.721	0.0
Dam/Sire/Rep	30	221.286	7.376	3.602	55.68
Error	28	73.464	2.624	2.264	40.56

[a]Rep is defined at year and season.

TABLE XIV

ANALYSIS OF VARIANCE OF CORPORA LUTEA FOR YORKSHIRE GILTS

Source	DF	Sum of Squares	Mean Square	Variance Component	Percent of Total
Total	58	288.712	4.978	6.500	100.00
Rep	4	12.339	3.085	-0.169	0.0
Sire/Rep	22	114.956	5.225	-1.387	0.0
Dam/Sire/Rep	12	90.250	7.521	2.941	45.25
Error	30	71.167	3.558	3.558	54.75

TABLE XV

CORRELATIONS FOR ALL TRAITS STUDIED FOR ALL DUROC, HAMPSHIRE AND YORKSHIRE GILTS FOR ALL SEASONS[a]

	Size of Litter Born In	Size of Litter Weaned In	Birth Weight	Weaning Weight	Avg. Daily Gain	Age at 220 lbs.	Probe at 220 lbs.	Breeding Age	Breeding Weight	Slaughter Weight	Days from 220 lbs. to Breeding	No. of Corpora Lutea	No. of Normal Embryos
Size of Litter Born In	1.000	.492	-.159	-.076	-.041	.033	.053	.026	-.020	-.059	-.002	.026	-.113
Size of Litter Weaned In		1.000	.004	-.085	.007	.022	.074	.035	-.094	-.093	.013	.032	-.002
Birth Weight			1.000	.379	.189	-.312	-.124	.122	.287	.357	.287	.030	-.065
Weaning Weight				1.000	.292	-.531	-.004	-.013	.269	.334	.289	.109	.090
Avg. Daily Gain					1.000	-.910	.159	-.002	.498	.458	.521	.151	.044
Age at 220 lbs.						1.000	-.067	-.032	-.531	-.523	-.601	-.170	-.021
Probe at 220 lbs.							1.000	-.129	-.008	.052	-.069	-.061	.011
Breeding Age								1.000	.388	.399	.816	.123	.127
Breeding Weight									1.000	.801	.619	.230	.119
Slaughter Weight										1.000	.623	.183	.083
Days from 220 lbs. to Breeding											1.000	.198	.115
No. of Corpora Lutea												1.000	.255
No. of Normal Embryos													1.000

[a]d.f. = 226; if $|r| > .129$ then $P < .05$ that $r = 0$.

TABLE XVI

CORRELATIONS AMONG ALL TRAITS STUDIED FOR DUROC, HAMPSHIRE AND YORKSHIRE GILTS WITH PUREBRED EMBRYOS IN FALL 1970, SPRING 1971, FALL 1972 BREEDING SEASONS POOLED WITHIN BREED, YEAR AND SEASON[a]

	Size of Litter Born In	Size of Litter Weaned In	Birth Weight	Weaning Weight	Avg. Daily Gain	Age at 220 lbs.	Probe at 220 lbs.	Breeding Age	Breeding Weight	Slaughter Weight	Days from 220 lbs. to Breeding	No. of Corpora Lutea	No. of Normal Embryos
Size of Litter Born In	1.000	.385	-.196	-.082	-.196	.208	.233	.086	.005	-.013	-.059	.003	-.187
Size of Litter Weaned In		1.000	.091	.000	.127	-.008	.033	.093	.003	-.133	.077	.100	.052
Birth Weight			1.000	.399	.068	-.152	-.209	-.099	.219	.166	.015	.046	-.041
Weaning Weight				1.000	.183	-.452	-.020	.066	.179	.231	.324	.034	.016
Avg. Daily Gain					1.000	-.893	.161	-.009	.404	.328	.532	.177	.158
Age at 220 lbs.						1.000	-.074	-.038	-.431	-.364	-.633	-.227	-.073
Probe at 220 lbs.							1.000	.113	.208	.216	.132	-.116	-.155
Breeding Age								1.000	.312	.405	.798	-.113	-.127
Breeding Weight									1.000	.813	.502	.340	-.028
Slaughter Weight										1.000	.533	.196	.019
Days from 220 lbs. to Breeding											1.000	.049	-.054
No. of Corpora Lutea												1.000	.369
No. of Normal Embryos													1.000

[a]d.f. = 47; if $|r| > .279$ then $P < .05$ that $r = 0$.

TABLE XVII

CORRELATIONS AMONG ALL TRAITS STUDIED FOR DUROC, HAMPSHIRE AND YORKSHIRE GILTS WITH CROSSBRED EMBRYOS IN FALL 1970, SPRING 1971 AND FALL 1972 BREEDING SEASONS POOLED WITHIN BREED, YEAR AND SEASON[a]

	Size of Litter Born In	Size of Litter Weaned In	Birth Weight	Weaning Weight	Avg. Daily Gain	Age at 220 lbs.	Probe at 220 lbs.	Breeding Age	Breeding Weight	Slaughter Weight	Days from 220 lbs. to Breeding	No. of Corpora Lutea	No. of Normal Embryos
Size of Litter Born In	1.000	.586	-.232	.041	-.051	.033	.050	-.195	-.230	-.247	-.176	.012	-.018
Size of Litter Weaned In		1.000	-.010	.087	.003	-.027	.112	-.045	-.144	-.151	-.019	.010	.101
Birth Weight			1.000	.398	.113	-.262	-.055	.047	.233	.282	.196	-.103	-.020
Weaning Weight				1.000	.270	-.549	.120	-.047	.250	.326	.295	.013	.056
Avg. Daily Gain					1.000	-.920	.235	-.028	.560	.555	.535	.196	.001
Age at 220 lbs.						1.000	-.183	.005	-.580	-.608	-.602	-.197	-.027
Probe at 220 lbs.							1.000	-.208	-.023	.051	-.055	-.051	.007
Breeding Age								1.000	.307	.358	.796	.125	.359
Breeding Weight									1.000	.783	.597	.101	.167
Slaughter Weight										1.000	.654	.093	.149
Days from 220 lbs. to Breeding											1.000	.219	.303
No. of Corpora Lutea												1.000	.289
No. of Normal Embryos													1.000

[a]d.f. = 91; if $|r| > .204$ then $P < .05$ than $r = 0$.

TABLE XVIII

CORRELATIONS AMONG ALL TRAITS STUDIED FOR DUROC, HAMPSHIRE AND YORKSHIRE GILTS WITH CROSSBRED EMBRYOS IN FALL 1971 AND SPRING 1972 BREEDING SEASONS POOLED WITHIN BREED, YEAR AND SEASON[a]

	Size of Litter Born In	Size of Litter Weaned In	Birth Weight	Weaning Weight	Avg. Daily Gain	Age at 220 lbs.	Probe at 220 lbs.	Breeding Age	Breeding Weight	Slaughter Weight	Days from 220 lbs. to Breeding	No. of Corpora Lutea	No. of Normal Embryos
Size of Litter Born In	1.000	.456	-.055	-.158	.098	-.080	-.007	.178	.211	.105	.179	.050	-.177
Size of Litter Weaned In		1.000	-.053	-.328	-.056	.098	.050	.144	-.067	-.029	.063	.011	-.118
Birth Weight			1.000	.344	.319	-.418	-.183	.309	.371	.532	.496	.151	-.126
Weaning Weight				1.000	.315	-.491	-.113	-.016	.277	.345	.232	.203	.154
Avg. Daily Gain					1.000	-.938	.084	.017	.451	.411	.505	.091	.034
Age at 220 lbs.						1.000	.041	-.064	-.490	-.480	-.578	-.103	-.003
Probe at 220 lbs.							1.000	-.167	-.077	-.008	-.170	-.024	.094
Breeding Age								1.000	.506	.460	.846	.229	.024
Breeding Weight									1.000	.811	.679	.295	.131
Slaughter Weight										1.000	.635	.241	.052
Days from 220 lbs. to Breeding											1.000	.246	.024
No. of Corpora Lutea												1.000	.192
No. of Normal Embryos													1.000

[a]d.f. = 79; if $|r| > .215$ then $P < .05$ than $r = 0$.

TABLE XIX

CORRELATIONS FOR ALL TRAITS STUDIED FOR 2-BREED CROSS GILTS CARRYING 3-BREED EMBRYOS IN FALL 1971 AND SPRING 1972 BREEDING SEASONS POOLED WITHIN BREED, YEAR AND SEASON[a]

	Size of Litter Born In	Size of Litter Weaned In	Birth Weight	Weaning Weight	Avg. Daily Gain	Age at 220 lbs.	Probe at 220 lbs.	Breeding Age	Breeding Weight	Slaughter Weight	Days from 220 lbs. to Breeding	No. of Corpora Lutea	No. of Normal Embryos
Size of Litter Born In	1.000	.356	-.288	-.235	-.017	.055	.189	.039	-.213	-.219	.007	-.056	-.088
Size of Litter Weaned In		1.000	-.142	.063	.161	-.159	.257	-.043	-.012	-.020	.044	-.007	.080
Birth Weight			1.000	.387	.224	-.289	-.230	.103	.354	.318	.240	.253	.121
Weaning Weight				1.000	.342	-.518	-.029	-.141	.429	.413	.143	.281	.352
Avg. Daily Gain					1.000	-.955	.071	.017	.340	.343	.506	.188	.124
Age at 220 lbs.						1.000	-.069	.046	-.347	-.340	-.474	-.201	-.178
Probe at 220 lbs.							1.000	-.164	-.058	.004	-.109	-.048	-.069
Breeding Age								1.000	.431	.357	.858	-.035	.052
Breeding Weight									1.000	.922	.559	.455	.411
Slaughter Weight										1.000	.489	.490	.443
Days from 220 lbs to Breeding											1.000	.072	.137
No. of Corpora Lutea												1.000	.483
No. of Normal Embryos													1.000

[a]d.f. = 91; if |r| > .204 then P < .05 than r = 0.

VITA

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