AN ABSTRACT OF THE THESIS OF

Robert Edward Knott for the degree of Master of Science in Animal Science presented on February 22, 1980.

Title: Cycling and Reproductive Phenomena in Gilts.

Abstract approved: Redacted for privacy

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Purebred Yorkshire gilts from a confinement managed herd were reared to test weights away from the sow and boar herd. Thirty-eight gilts weighing between 73 and 80 kilograms constituted group A gilts; 38 gilts weighing between 91 and 100 kilograms constituted group B gilts; and 47 gilts weighing 114 kilograms or more, constituted group C gilts. In each experimental group, approximately ten animals were mixed to provide new pen mates for all, and were moved to the broodstock barn where each group was assigned a pen; at all times throughout the study, one contiguous boar was located between those pens of gilts. Each day, gilts were removed from their pens and checked for estrus by direct boar contact for approximately 15 minutes; also, estrual status was estimated by vulvular ratings. Groups A and B were allowed to mate at their third occurrence of estrus; group C gilts were allowed to mate at their first exhibition of estrus. Twenty-five days postmating, the gilts were slaughtered and their reproductive tracts were removed for inspection of their ovaries and uterine contents.

No significant differences ($P<.01$) occurred among the groups for ovulation rates, embryonic survival rates, total embryos, average daily gain measured three weeks prior to breeding, average days between estrual cycles, age at breeding, nor weight at breeding

(P<.01). At mating, group A was lightest and group C was youngest; group B, which represents the traditional breeding weight, was oldest and heaviest, but did not differ in performance.

With weight, chronological age and sexual age of the groups held constant, the only significant association between chronological age, breeding weight or average daily gain with either ovulation rate or embryo survival was between breeding weight and average daily gain and the two measures of reproductive performance. These results indicate that sexual age is more important than chronological age as a determiner of ovulation rate and embryo survival.

Cycling and Reproductive Phenomena in Gilts

by

Robert Edward Knott

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

Commencement June 1980

APPROVED:

Redacted for privacy

Professor of Animal Science in charge of major

Redacted for privacy

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Date thesis is presented February 22, 1980

Typed by Robert Edward Knott for Robert Edward Knott

ACKNOWLEDGEMENTS

Greatful appreciation is extended to my mother and father, Mr. and Mrs. William J. Knott, for their unselfish contributions of time and support throughout my college career; to Dr. David C. England, undergraduate and graduate professor and advisor, who always had a few quick minutes even in extreme emergencies; to Mr. Dennis Rock, O.S.U. meats lab personnel, who always was able to kill my gilts; to Mr. Roy Fancher, Mr. Mark Udgen, and Mr. Earl Bishop, the swine center personnel, for their assistance in completing the study; to Paul Bellatty and Calvin Walker, co-graduate students and friends, who helped whenever needed; to Assefaw Tewolde, fellow graduate student, who helped in my analysis; and to my fiancee, Terry Alley, for her love and encouragement during these past two years.

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Cycling and Reproductive Phenomena in Gilts

STATEMENT OF THE PROBLEM

Swine are a multiparous mammal which will mate at any time of the year. Their average gestation period is 114 days, and they usually don't mate during lactation. They generally will mate within one to three weeks after weaning of the litter.

Sows are generally maintained in the herd for an average of three to five farrowings. A substantial number of circumstances can cause removal of the sow sooner. Circumstances such as injury to nipples, mastitis, crippling, a low number of pigs born or reared per litter and a large number of other factors can lead to culling the sow following weaning of any of her litters. On the average, commercial producers using a confinement system of production cull approximately 30 percent of their sows per year and replace them with gilts.

In the past, it has generally been recommended that gilts be bred on third estrus. This practice has resulted basically from research conducted by Warnick et al (1951) which showed that gilts ovulated more ova at the second estrus than at the first. Each succeeding estrus resulted in a gradual, but statistically non-significant increase in ovulation. Fairly recent research by Brooks and Cole (1973) showed that gilts mated on their third estrus farrowed an average of only 0.5 more pigs per litter than gilts bred on their first estrus; this was not a significant difference. Libal and Wahlstrom (1974) found similiar results and stated that gilts bred at third estrus had no significant advantage in numbers of pigs born and raised compared to gilts bred on their first estrus.

Gilts usually exhibit third estrus at about seven and one-half to eight and one-half months of age. If gilts are bred at this time, they farrow their first litter at approximately one year of age. At present, many commercial producers believe that it is not practical to wait until the third heat period to breed gilts. Stewart (1945) found that age and weight at mating accounted for four percent of the variation in size of first litters, but together they are the most reliable components used in selection for fertility. Robertson et al (1951) suggest that number of heat periods have more influence on ovulation rates than does age of the gilts at breeding.

With today's highly sophisticated confinement management, any time saved can have beneficial economic effects. The best management requires ability to schedule gilts into the breeding regime at specific times in order to utilize facilities and personnel most effectively. It would be advantageous to be able to predict the time at which gilts will be in heat after introduction into the breeding herd.

PURPOSE OF THE STUDY

The main objectives of this experiment were associated with evaluation of a response to a regime intended to stimulate gilts to exhibit initial estrus at earlier ages and lower weights. The study examined consequences of reducing gilt age and weight at breeding. Objectives were to determine:

1) Number of days from first exposure of gilts of three different initial weight groups (73 to 80, 91 to 100 and 114 or more kilograms) to occurrence of their first estrus.

2) The overall regularity of estrus cycles in the first two groups (the third group, 114 kiolgrams and above, was bred on first estrus.

3) Number of ova ovulated and percent embryo survival to 25 days postmating in each of the three groups.

4) Association between variables such as age, weight and average daily gain with cycling phenomena, ovulation rate and embryo survival.

If management regimes which reduce age and size at mating can be instituted without adverse effects on litter productivity, results of this study will have directly applicable benefits in production programs.

LITERATURE REVIEW

Many questions have and will be asked concerning the logistics and feasibility of early gilt reproduction; there are many factors involved. Some of these factors are much more important than others; most affect litter size in some way. Ovulation rate and embryo survival are the main factors affecting litter size, but in turn, nutrition, sexual maturity, uterine capacity, age and weight at puberty, season of birth, breed, genetics, and environmental conditions all intertwine to affect various aspects of litter size. This literature review isn't intended to explain all phenomena involved; it is only intended to give an unbiased overview of the work already completed by various researchers.

In 1842, Bischaff stated, "in polytocous mammals, the number of corpora lutea usually corresponds to the number of embryos" (Parks, 1952). Perry and Rowland (1962) performed laparotomies between two and 40 days of pregnancy to determine the number of corpora lutea present. From their work, they found that the number or corpora lutea usually corresponded to the number of ova shed.

Longnecker et al (1968) by laparotomy exposure, marked 339 corpora lutea in 30 mated gilts with India ink three days after the onset of estrus. Upon postmortem ovservation of the ovaries 40 days after the initial marking, 335 corpora lutea were present. They stated that this discrepancy may show that occassional incomplete formation or regression of individual corpora lutea occurs in pregnant gilts. Their conclusion was that counting corpora lutea provides a reliable estimate of ovulation rate.

Several authors have however reported discrepancies. Allen et al (1947) reported that experimental error accounted for approximately seven percent of the variation in prenatal mortality rate based on corpora lutea counts. Reitmeyer and Sorenson (1965) reported approximately 22 percent of the total number of corpora lutea present on day 40 of gestation were actually accessory corpora lutea which generated post-conception.

Nutrition has several effects on the attainment of puberty and ovulation rate. Working with one-year-old gilts of Yorkshire, Poland China, and their reciprocal crosses, Clark et al (1972) reported that gilts fed ad-libitum ovulated an average of two more ova than gilts fed a maintenance diet of 1.82 kilograms per day. Schultz et al (1965) used 96 crossbred gilts to study the effects of two levels of feeding; two trials constituted the study. In trial one, 64 gilts were fed either or various combinations of 2.72 kilograms per day and 1.82 kilograms per day. A factorial design of high-high (HH), high-low (HL), low-high (LH) and low-low (LL) was used; in a pre- and post-mating sequence, each treatment started at the estrus prior to mating and the feed levels in the HL and LH groups were changed to the opposite level at mating. The HH and LH treatments in trial one had a significantly higher ($P<.05$) percent embryonic survival than did the HL and LL groups. Trial two had 32 gilts which were divided into a high group, which received a high level of feed (3.64 kg/day) and the low treatment group, which was fed the standard 1.82 kilograms per day. The high pre-breeding group had significantly more corpora lutea than the low group.

Puberty can also be affected by age and weight of the gilts. Robertson _et al_ (1951) found the average age at puberty in Chester White and Poland China gilts to be 201 days with a range from 167 to 250 days. Their average weight was 89 kilograms with a range of 89 kilograms. Reddy _et al_ (1958) reported similiar results for age at puberty with a mean age of approximately 200 days with a range from 169 to 256 days. George and England (1974) set up pubertal tests in three groups of gilts of different weights and ages. Average days to estrus following exposure to boars daily for 30 days was significantly less in the heaviest and oldest group while age at puberty was lower in the lighter and younger groups.

Robertson _et al_ (1951) reported that gilts with a rapid average daily gain tended to attain sexual puberty earlier than slower growing gilts. Calculated correlation coefficients between age at puberty and weight at 154 days was -0.29 ($P<.01$). Blunn and Bass (1939) reported that fastest growing rats reached puberty faster than slower growing rats. Engle _et al_ (1937) reported that rats from small litters attained sexual maturity at a earlier age. Pay and Davies (1973) state that once puberty was acquired, lower growth rate did not affect the frequency of estrus.

Hughes and Cole (1975) reported that occurrence of early puberty in gilts can be affected by any of the following: movement of gilts; ad-libitum feeding; boar contact and the genetic differences among sire groups. Zimmerman (1978) reported that movement from intensive confinement helped in the attainment of puberty by gilts. Late boar exposure at older ages, leads to more syncronization of pubertal estrus. When boar exposure at younger age occurs, greater ovarall reductions in average age at first estrus is evident. Vandenbergh (1969) reported that male odor can stimulate occurrence of puberty at an earlier age; male influence is discussed further in a section on boar effects.

Clark et al (1970) tested age of puberty in Poland China, Yorkshire, and their reciprocal crosses. They reported that the crossbreds achieved puberty at an earlier age compared to the purebreds. Wiggins et al (1950) reported that season of birth had a significant effect on sexual development in gilts; spring born gilts tended to reach puberty slower than gilts born during other seasons.

Cunningham and Zimmerman (1973) stated that ovulation rate measured at the same estrus is highly heritable (r=0.52±.05) and that selection should be effective in increasing ovulation rate. They counted corpora lutea for five generations by performing lap-oratomies on 109, 124, 97, 107 and 144 gilts (in generations zero through five) to determine whether selection for ovulation rate was effective. They compared their results to a control line and found that in the select line, ovulation rate increased from 8.0 to 10.1 corpora lutea while the control line only increased from 8.4 to 9.4 corpora lutea.

Boylan et al (1961) estimated heritability of ovulation rate to be somewhat different than that reported by Cunningham and Zimmerman. Their estimate of heritability was much lower (r=0.03±.07) and none of their estimates were significantly different from zero. A plausible explanation for differences in the two studies may be that Boylan used litter size, which is affected by embryonic mortality, for his measure of heritability, whereas Cunningham and Zimmerman measured heritability through direct observation of ovulation rate. Later, Zimmerman and Cunningham (1975) selected gilts for ovulation rate during five generations and found it to be quite advantagous in that gilts selected for ovulation rate actually ovulated more ova than did gilts not selected for it. Newton _et al_ (1977) reported that selection for increased ovulation rate did not significantly affect age and weight at puberty. They also concluded that direct selection for ovulation rate is effective.

Land (1970) found ovulation rate in swine and weight at six weeks of age in various groups to have positive correlations ranging from 0.33 to 0.58. Warnick (1951), however, reported the correlation to be approximately -0.24. Reddy _et al_ (1958) found signigicant correlations of ovulation rate with age at breeding (r=0.56) and with weight at breeding (r=0.35). They also found that litter size had a high correlation with the number of ova (r=0.38).

Sherritt (1962) made four broad statements concerning the matter:

1) The weight of the litter weaned by the female had a negative effect on the age of the daughter at farrowing.

2) Weight of the dam's litter at weaning had a significantly negative effect on age of the daughter at farrowing.

3) Increased age of a gilt at farrowing resulted in 0.009

more pigs produced per day of age of gilts.

4) Age of a gilt had a significantly positive effect on the number of pigs farrowed and a significantly negative effect on the total weight of the litter weaned.

Sexual maturity can depend upon the number of estrual periods gilts have exhibited. Wise and Robertson (1953) reported some of the effects of number of estrual periods on reproductive performance in gilts. They reported mean weights and ages at puberty to be 87 kilograms and 212.5 days of age. When determining ovulation rates at various heat cycles, they reported ovulation rates for the first, third, and fifth estrual cycles to be 14.0, 12.2, and 12.5 respectively. They concluded that the decrease at third estrus compared to the first estrus was caused by a drop in daily feed allowance once puberty was achieved. Conception rates were 80.4, 95.0, and 96.6 percent for the respective cycles.

Warnick _et al_ (1951) stated that "the reproductive efficiency of gilts as measured by ovulation rate and fertilization rate increases with advanced sexual age." There tended to be a slight but non-significant advantage in conception rates in gilts bred during their first or second heat cycles versus their third cycle.

Stewart (1945) found that litter size of gilts increases linearly up to 12 months of age, then increases at a decreasing rate until the gilt is approximately 16 months old. Gilts which farrowed at 11 months had one less pig than those farrowing in their twelfth month of age. Comparable gilts farrowing at 14 months produced only 0.5 pigs more per litter than the 12 month old gilts.

Breed and parentage within breeds can affect reproductive performance of gilts. Clark _et al_ (1972) found that at one year of age, Poland China gilts had 1.8 fewer ova per ovulation than Yorkshires. Baker _et al_ (1958) reported that Poland China gilts had 1.4 fewer corpora lutea than Chester White gilts. Kirkpatrick _et al_ (1967) reported results which agree with Baker in that Chester White gilts had a higher ovulation rate that did Poland China gilts.

Johnson and Omtvedt (1973) reported that Druoc, Hampshire, and Yorkshire gilts had an average of 0.5 more corpora lutea than did crosses of these breeds, but the crosses produced more live embryos (10.6 versus 10.0) at 30 days of gestation. Of the breeds in the experiment, there was no significant differences in ovulation rates nor in embryo survival. Single cross gilts mated to boars of a third breed had a significantly greater embryo survival (84.4 versus 78.8 percent; $P<.05$) than did purebred gilts mated to produce two-breed, crossbred litters.

Stewart (1945) reported litter size to drop as percent inbreeding of the dam increased, but the percent inbreeding of the litter had no significant effect ($P<.05$). Bereskin _et al_ (1968) also found this relationship, but also reported total litter weight and average weight of pigs born alive to drop as percent inbreeding of the dam increased.

Wilson _et al_ (1962) reported that both the sire of the dam and the sow line affected gilt production. Reddy _et al_ (1958) reported that sire effects contributed a significant part of the apparent variation in the ovulation rate of his progeny.

Perry (1960) stated, "It appears that the individual sow is liable to a characteristic incidence of embryonic loss in successive litters, imposed by factors which must either be inherited or else acquired before puberty. Embryonic mortality was not found to be related to the sire with which the female was mated."

Johnson (1976) reported that up to 30 days after breeding, no significant breed differences were found in the percent fertilization nor embryonic survival for 237 gilts mated to 45 boars of Yorkshire, Duroc and Hampshire breeds. Crossbred litters had, on the average, one pig more at farrowing and at weaning when either Yorkshire or Duroc boars were used as the sire. Johnson also found that when purebred gilts were mated to produce crossbred litters, heterosis resulted in 0.76 more pigs per litter at weaning; crossbred gilts mated to a third breed weaned one more pig per litter than the purebreds producing crossbred progeny.

Lessiter (1975) ranked seven breeds according to average pigs born per litter. They were as follows:

Rank	Breed	Pigs Born per Litter
1	Yorkshire	11.13
2	Landrace	10.52
3	Duroc	9.66
4	Chester White	9.53
5	Hampshire	8.78
6	Poland China	8.07
7	Berkshire	8.07

Boars contribute many effects that alter gilt reproduction. Brooks and Cole (1973) reported that the boar's presence alone doesn't induce ovulation in the gilt, but rather the gilts mating behavior towards a boar enables mating. In an earlier study, Brooks and Cole (1970) reported that the boar can influence occurrence of puberty. They exposed gilts to boars at gilt age of either 165 or 190 days of age and initiated estrus. At the earlier age, a better degree of syncrony of estrus was achieved when there was a rotation of boars instead of just one boar used. Of the gilts initiated at a younger age, 11 or the 12 gilts subjected to rotating boars reached estrus within eight days, while nine of the 11 gilts in the older initiation age group reached estrus by day 14.

Zimmerman _et al_ (1974) reported that gilts of 125 or 165 days of age, when moved to a new location and exposed to intact boars for periods of 10-15 minutes per day, reached puberty significantly sooner than gilts just moved, but not exposed to boars. Older gilts tended to attain puberty faster following initiation of treatment than did the younger gilts. Zimmerman _et al_ (1976) allotted gilts in four groups: those just mixed with other gilts (M); those mixed and transferred (MT); those mixed, transferred, and relocated (MTR); and those mixed transferred, relocated, and exposed to a boar. The M and MT groups were comparable in attaining puberty and had little difference in ovulations; the MTR group had significantly ($P<.05$) increased number of ovulations compared to the M and MT groups. Addition of male exposure resulted in even greater increases in ovulation which was significant at P<.01. Exposure of gilts to boars at too young age hindered onset of puberty in studies by Zimmerman et al (1969). Pubertal age for gilts first exposed at 103 days or 126 days of age and for gilts not directly exposed to a boar were: 160.5, 148.1, and 182.6 days respectively.

Hughes and Cole (1976) reported that delaying the introduction of a boar beyond 160 days of age is unnecessary since at this age, the reproductive mechanisms are sufficiently developed to respond fully to the male stimuli.

Bourn et al (1974) working with gilts of two age groups from different pens, mixed them, hauled them 2.8 kilometers, and exposed them to a boar for 10 to 15 minutes per day. The 135 day-old group exhibited better syncronization at first estrus with 71 percent showing estrus in their first week of estrual occurrence.

Hughes and Cole (1975) reported that neither age nor weight at puberty affected ovulation rate, conception rate at second estrus, nor embryonic survival at 20 days into gestation. They also reported that gilts sired by one boar reached puberty significantly earlier (P<.05) than did the offspring of the three other boars in the experiment.

Kinsey et al (1976) studied male presence as a stimulatory effect on age at puberty in gilts. Treatments of audio contact, visual contact, olfactory contact, physical contact, and combinations of these were initiated at 165 days of age and estrus symptoms were recorded. Audio stimuli without visual contact hastened puberty similiar to contiguous contact of the male. In Kinsey's study, olfactory contact alone or in combination with audio contact retarded puberty; Vandenbergh (1969) stated that male odor can stimulate occurrence of puberty.

Attainment of puberty is also affected by season of birth. Wiggins et al (1950) reported a season-of-birth effect on age at puberty. Of the gilts born in April, 14.6 percent of the gilts slaughtered were sexually immature; for those born in July, October, and January, 23.8, 44.6, and 18.8 percent respectively, were immature. Season of farrowing had an influence on age at puberty with spring born gilts reaching sexual maturity slower than those born in other seasons. Gossett and Sorenson (1959), however, reached different conclusions. They reported that fall-farrowed gilts reached sexual maturity approximately 10 percent (non-significantly) earlier than spring farrowed gilts. Spring-farrowed gilts did exhibit a 19 percent higher ovulation rate (13 versus 10.9 corpora lutea; $P<.05$) and 28 percent more live embryos at 40 days into gestation than did fall-farrowed gilts. Sorensen et al (1961) reported that spring-farrowed gilts were non-significantly two days older than fall-farrowed gilts and were 5.5 kilograms heavier ($P<.01$) than fall-farrowed gilts at puberty. Wise and Robertson (1953) stated that season of farrowing was unassociated with the age at which gilts reached sexual maturity.

Edwards et al (1968) in studies dealing with effects of environmental temperature, especially heat stress prior to breeding and in early gestation, reported no significant differences in number of corpora lutea nor in conception rates. Control animals were placed in temperature controlled chambers set at

23.4 degrees Celsius while the experimental group spent 17 hours per day at 38.9 degrees Celsius and the remaining seven hours at 32.2 degrees Celsius. This regime was followed until five days prior to the expected heat period. The one significant difference ($P<.05$) was the number of live embryos at 30 days postmating which was lower in gilts exposed to high temperatures during a zero to 15 day period directly following mating; after 15 days of gestation, embryo survival was not significantly affected.

Warnick et al (1965) reported that gilts kept at 60 degrees Farenheit averaged 1.9 more embryos at day 25 of gestation than did gilts maintained at 90 degrees Farenheit; the number of corpora lutea was not significantly different.

Uterine capacity has an effect on gilt performance. Bazer et al (1968) used 53 crossbred gilts as recipients in an embryo transplant study intended to reveal uterine capacity as it affects litter size. The number of live embryos at 96 days into gestation was an average of 9.9 for both the control groups and the embryo-transplanted group. The gilts receiving 16 transferred embryos had an average of 8.8 pigs; the gilts receiving 28 embryos had an average of 9.9 pigs. Bazer states that there must be proper syncrony between embryonic and uterine development for survival of the embryo.

Rampacek and Ulberg (1973) reported no significant differences in the normal embryos among three genetic groups of embryo transplant recipient gilts (eight Durocs, eight Yorkshires, and eight crossbreds). Average numbers of corpora lutea for the respective breeds were 14.8, 12.9, and 13.9; average number of embryos alive at 25 days post-implantation were 16.8, 18.1, and 20.8 embryos respectively.

Several reproductive abnormalities can alter the gilts ability to farrow litters. Wilson et al (1949) investigated the causitive factors impairing fertility in swine. Seventy-nine gilts were utilized in the study; all had had previous fertility problems. During the course of the experiment, 53.2 percent of these conceived, but were still considered hard settlers; the remaining animals were hindered by various abnormalities. The most important abnormalities included tubal aberrations, cystic ovaries, and blind or missing parts of the reproductive tract. Warnick et al (1949) used 63 remale swine that also had had previous fertility problems; 53.4 percent of the gilts failed to conceive. The main reasons for failure to conceive included bilateral tubal aberrations, bilateral missing reproductive tract segments, and cystic ovaries. The remaining females failed to settle for no apparent reasons. Warnick concluded that, "the major cause of rebreeding in gilts appeared to be a failure of fertilization due to genital abnormalities."

Wiggins et al (1950) examined genital tracts of approximately 3,000 open gilts and found that 5.1 percent of mature open gilts had genital abnormalities. Squiers et al (1952) also reported similiar results with seven percent of 359 gilts having such abnormalities.

Embryonic mortality can cause impaired results in gilt performance. Johnson (1976) reported that embryo survival for two-breed and three-breed, crossbred litters were significantly different (78.8 percent versus 84.5 percent; $P<.05$). Perry and Rowlands (1962) found 95 percent of all the ova recovered by day 10 of gestation were fertile. Embryonic death accounted for loss of 28.4 percent of the ova by the eighteenth day of conception and for 34.8 percent by the fortieth day. In another study, Squiers et al (1952) reported that for gilts bred once in early estrus, only 65 percent of the initially shed ova were present as embryos by day 25 of gestation. Similiar results were reported for gilts later in the heat period and for sows. Gilts, however, experienced an 11 percent greater embryo death loss prior to farrowing than did sows; gilt total embryonic death loss was 46 percent. Baker et al (1958) expressed the opinion that embryo mortality is a greater factor in determining litter size than is ovulation rate.

Different mating schemes can affect conception results too. Rich et al (1968) reported no differences in ovulation rate between hand-mated and lot-mated gilts. Hand mated gilts had more embryos ($P<.10$), a lower percent of dead embryos ($P<.10$) and a higher percent embryo survival ($P<.05$) at 35 days postmating. Their explanation for this was that hand-mated gilts received less harrassment than did the lot-mated gilts. Squiers et al (1952) reported that exposure of gilts to a second boar service one day following initial mating, increased conception rate among gilts from 66 to 89 percent with a small increase in litter size. Reddy et al (1958) reported that a second service, approximately 24-hours after the first service, reduced the prenatal death loss, but non-significantly.

Future production of gilts mated at earlier ages and weights have varied. Wise and Robertson (1953) studied the effects of sexual age on the reproductive performance in gilts. They used 24 fall-farrowed Duroc gilts of which four provided information on ovulation rate and fertility while the remaining 20 gilts provided an estimate of ovulation rates and embryonic mortality. Ovulation rates for the first, third, and fifth heat periods averaged 14.0, 12.2, and 12.5 respectively. Their explanation for the drop in ovulation rate from first to third and fifth heat periods was due to a drop in feed allocation once the older gilts went into a limited feed period prior to slaughter. Fertilization rates for the three heat periods were 80.4, 95.0, and 96.6 percent respectively. Embryonic mortality for the three heat periods was 24.3, 31.6, and 6.7 percent respectively.

Libal and Wahlstrom (1976) also found early mated gilts to be inferior to normally mated gilts in that only 64 percent of gilts mated at 202 days farrowed; 86 percent of gilts mated at 246 days of age farrowed. The 246 day old breeders farrowed heavier pigs at their second farrowing, although there was no significant difference in gestation weight gain. The number of pigs born alive and weaned favored the 246 day old group, but not by a significant amount. One advantage of the younger group was that all of the gilts exhibited estrus within ten days while only 79 percent of the older gilts did so within a 21 day period.

Warnick _et al_ (1951), when studying puberty phenomena in inbred gilts, found conception rates during the first three heat periods to be not significantly different (58.9, 80.0, and 55.0 percent respectively). Brooks and Cole (1973) reported conception rates for early mated gilts to be 81.8 percent while conventional matings reached a 94.4 percent conception rate; a non-significant difference in number of pigs born or weaned existed between the two groups. England and George (1974) found lighter gilts had significantly fewer embryos at 25 days postmating, however, no significant differences were found in number of corpora lutea. In a more recent study, Eisen et al (1977) reported the effects of early pregnancy on postnatal performance of mice. These authors state that early pregnancy does not adversely affect conception rate, litter size, or progeny birth rate. Baker et al (1978) studied the effect of mating ewe lambs on their lifetime production and reported that 74 percent of the females that were bred as lambs, produced slightly, but not significantly, fewer lambs at their second lambing. They concluded that it is feasible and practical to lamb at one year of age to allow faster identification of breeding value and also for economic opportunities.

METHODS

A. Gilt Allotment

Purebred Yorkshire gilts were allotted to three different weight groups. At allotment, group A gilts individually weighed between 73 and 80 kilograms and consisted of 38 animals; group B, which indivivually weighed between 91 and 100 kilograms, consisted of 38 animals; and group C, which weighed at or above 114 kilograms each, consisted of 47 animals. Weight was the primary criteria of allotment to the different groups; no secondary considerations were given to age or sire, but each group was composed of animals from two or more separate pre-experimental housing groups. Due to variation in the size of gilts within litters, groups A and B frequently contained litter-mates. For the most part, each replicate group consisted of ten gilts per pen-replicate. There were four, four and five replicates for groups A, B and C respectively.

At the initiation of each trial and at weekly intervals throughout the trial, gilts were weighed. Each gilt, once allotted, received 2.73 kilograms per day of the O.S.U. maintenance diet consisting of 69 percent wheat or barley (whichever at the time was most economically feasible), 15 percent alfalfa, 14 percent soybean oil meal, 1.5 percent dicalcium phosphate, 0.2 percent limestone, 0.05 percent trace mineralized salt and 0.25 percent of a commercial vitamin-mineral suppliment.

B. Change of Housing

All of the gilts in the study were reared away from the broodstock barn in groups of eight to ten per pen until allotment weights were reached; they were then allotted to their specific groups and moved to the broodstock barn. Each group had an assigned pen, approximately four by five meters, where at all times a boar was within sound, sight, smell, and could have nose contact with the gilts. Once the gilts were assigned to the testing pens, a two-day adjustment period was allowed in which the gilts could establish their social order through fighting and adjusting to their new penmates before checking for occurrence of estrus was initiated.

C. Boar Allocation

No special consideration was given to the genetic background or weights of the boar used for stimulus by contiguous presence, but only boars of suitably low weights were used for heat detection and mating.

The same boar, at any given time, was allocated for contiguous stimulation of the three groups of gilts; pens were arranged so that groups A, B and C could all be in simultaneous contiguous contact with the boar. Several boars were used for heat detection and breeding; boars small enough to minimize the probability of injury to the gilts were used during these periods.

D. Boar Exposure

Groups A and B were allowed to cycle until they exhibited their third heat period before they were bred, while group C was bred at first occurrence of estrus; except for this, the same regime was followed for all of the groups.

Each of the gilts had 24-hour-a-day contiguous contact with a boar in an adjacent pen with no direct contact with the boar except for a 20 minute period each day. Gilts were separated from the contiguous boar by a metal panel constructed of vertical pipes which allowed nose-to-nose contact and exposure to the sights, smells and sounds of the boar. During the 20 minute period of direct contact, groups A and B, separately, were moved to one of the three by three meter breeding pens; two gilts at a time were then placed in an adjacent breeding pen with a boar for a 20 minute heat detection period. During the first two heat periods, mating was not allowed for groups A and B. When these gilts stood, without reluctance, for mounting, a rating of three was given (rating system is explained in a later section). When the gilts had reached their disignated breeding cycle, mating was allowed and breeding weights and dates were recorded. For 25 days after mating, gilts were exposed to the same heat detection regime; if rebreeding did not occur, the gilts were weighed, tatooed and slaughtered. Those that rebred were checked for another 25 days; if still not settled, they were either slaughtered for examination of their reproductive tracts or sold on the commercial market.

For those slaughtered for data collection, reproductive tracts were removed; by careful examination of the ovaries, the number of ovulation could be counted and recorded by counting the number of corpora lutea present on each ovary. Following the ovulation count, the uterine horns were dissected and inspected for live and dead embryos and for abnormal areas of the endometrium which would be indicative of embryo resorption.

For those gilts slaughtered which had not settled by their second breeding, reproductive tracts were removed and checked for tubular aberrations, cystic ovaries, immature ovaries or other physical indications of non-conception.

The regime involved for each group of gilts was as follows:

1) Allotment of gilts from various rearing groups to their respective weight groups.

2) Change in location from the rearing barn to the broodstock barn.

3) Weighing of gilts at initiation of each trial, weekly, at breeding and at slaughter.

4) Twenty-four-hour-a-day non-direct contact with a boar.

5) Daily rating of each gilt for indication of estrual status.

6) Mating of gilts at designated heat periods.

7) Gilts slaughtered 25 days postmating unless rebreeding occurred.

8) Examination of reproductive tracts of gilts slaughtered.

E. Visual Estimate of Estrual Status

Estrual status was measured by the criteria of acceptance of the boar to mount or by visual estimate of vulvular swelling and redness. A rating from zero to three was assigned to each gilt daily with zero being no swelling or redness of the vulva and not allowing the boar to mount, a rating of one being slight swelling and or reddening of the vulva and not letting the boar to mount, a rating of two being swelling and redness of the vulva but not allowing the boar to mount and a rating of three being vulvular redness and swelling and allowing the boar to mount.

F. Boar Use

Two gilts at a time were placed in a breeding pen with a boar. If the gilts were not to be bred, but allowed the boar to mount, the boar would be pushed off and that gilt would be removed from the pen. After the boar had tested six gilts for heat or had bred one gilt, they were replaced by a different boar; boars were only allowed to mate once daily. Boars were used early in the mornings after feeding, especially during the warmer months, to avoid the mid-day heat or lack of aggressiveness often occurring during this period.

Mounting was encouraged and when copulation was intended, assistance in intromission was provided. This was needed more with groups A and B than with group C due to the size of the gilts.

G. Statistical Methods

Differences among groups were analyzed by analysis of variance; with use of the F-test for significance of differences for each variable. Variables found not to be significantly different among groups were then combined for calculation of coefficients of correlation and for analysis by multiple regression (Steel and Torrie, 1960)

RESULTS AND DISCUSSION

Groups A, B and C initially contained 38, 38 and 47 gilts respectively, of which 29, 30 and 37 provided data for the experiment. Nine gilts from group A didn't produce any data for the study. Three of these gilts exhibited heat and mated, but failed to come back into heat after 25 days and when examined, weren't pregnant; three were sold on the commercial market because of their physical conditions didn't allow mating (crippling, sickness or exterior genital deformaties); and the other three failed to acquire vulvular ratings above a rating of zere, therefore, were slaughtered at the O.S.U. meats laboratory for reproductive tract examinations. Of these, one had a tubular blockage and two had small, immature ovaries. Group B produced eight gilts that didn't produce any data for the study. Two of these gilts exhibited heat and mated, but failed to come back into heat after 25 days and when examined, weren't pregnant; three were sold on the commercial market due to abnormal physical status; and the other three showed no signs of estrual progressiveness. These three gilts were slaughtered for examination of reproductive tracts; one had a tubular aberration and the other two had small, non-ovulating ovaries. Group C had ten gilts who didn't add data to the experiment. Three gilts were sold due to physical conditions; two exhibited heat and were mated, but failed to come back into heat and weren't pregnant; one kept rebreeding and was slaughtered for examination only to find a cyctic ovary; and the other four showed no signs of estrual progressiveness. These four gilts were slaughtered for examination; one had a tubular abberation and the other three had small, immature ovaries.

Table 1 summarizes the means, ranges and standard deviations for the variables measured in the three groups. Group A gained an average of approximately 40 kilograms between allotment prior to puberty and mating at third estrus. Their average daily gain during the heat cycle prior to mating was 0.60 kilograms per day; this was higher, but not significantly different, than weight gains for the other two groups which were 0.5 and 0.2 kg/day for groups B and C respectively. Group A also had the highest ovulation rate with 13.3 ova per ovulation versus 13.0 for group B and 12.6 for group C; the most live embryos with 11.6 versus 11.2 and 10.7 for groups B and C respectively; and also the highest percent embryo survival with 88 percent versus 86 and 88 for groups B and C respectively. Even though group A showed more favorable results for most of the variables, none were significant ($P<.05$).

As shown in table 2, visual evaluation of vulva appearance as an indication of estrual status was accurate in 86 to 94 percent of the ratings prior to date of standing heat; accuracy is defined as subsequent daily progression toward standing heat after occurrence of a rating higher than zero. Ratings were based on subjective daily appraisal without referral to ratings on previous days.

Table 3 presents cumulative percentages of gilts expressing estrus during various periods from first day of treatment. Thirty-two percent of group A gilts, 40 percent of group B gilts and 35 percent of group C gilts exhibited estrus before ten days on experiment had elapsed. Sixty-three percent of group A gilts, 45 percent of group B gilts and 35 percent of group C gilts

TABLE 1. DESCRIPTIVE STATISTICS OF GILTS OF THREE WEIGHT GROUPS AND THEIR REPRODUCTIVE PERFORMANCE

	Group A			Group B			Group C		
	Mean	Range	Std.Dev.	Mean	Range	Std.Dev.	Mean	Range	Std.Dev.
Number of initial gilts	38	---	---	38	---	---	47	---	---
Percent of gilts conceiving and slaughtered	76	---	---	79	---	---	79	---	---
Percent of gilts removed[a]	10.3	---	---	10.0	---	---	8.1	---	---
Percent of gilts not achieving third estrus	10.3	---	---	6.7	---	---	8.1	---	---
Percent not pregnant[b] at slaughter	10.3	---	---	10.0	---	---	10.8	---	---
Weight at breeding (kg)[c]	110.0	21.0	7.0	119.0	39.5	10.5	117.0	29.0	6.7
Days to first estrus	14.2	19.0	5.4	15.0	52.0	11.8	15.7	25.0	9.0
Intervals between heat[c,d] periods (days)	21.0	32.7	7.7	21.0	10.0	4.5	---	---	---
Ovulation rate[c]	13.3	5.0	1.6	12.9	10.0	2.7	12.6	8.0	2.3
Embryos[c]	11.6	8.0	2.1	11.1	11.0	2.7	10.7	8.0	2.7
Embryo survival (%)[c]	88	42	10	86	45	10	84	30	12
Age at breeding (days)[c]	227	57	13.5	244	55	13.9	217	85	17.0
ADG three weeks prior[c] to breeding (kg)	0.60	0.40	0.10	0.50	0.20	0.20	0.20	0.70	0.20

[a] Injuries or functional inability.

[b] Based on gilts mated.

[c] Statistics measured only on gilts slaughtered at completion of the experiment as intended.

[d] Not measured for group C due to breeding on first estrus.

experienced estrus between day 11 and day 20; five percent of groups A and B, and 26 percent of group C gilts didn't exhibit estrus until 21 to 30 days on experiment. By day 30, all of group A gilts, 90 percent of group B gilts and 96 percent of group C gilts experienced estrus. Of the gilts not showing heat by day 30, ten percent of group B and four percent of group C gilts exhibited estrus between days 31 to 51. Libal and Wahlstrom (1976) found similiar results in that 100 percent of younger gilts exhibited estrus by day 10 while only 79 percent of the older gilts did so within a 21-day period.

TABLE 2. ACCURACY OF ESTRUAL APPRAISAL USING VISUAL CRITERIA[a].

Vulva Score[b].	(%) of Accuracy
0	88
1	86
2	94
3	100

[a]Based on gilts which completed the experiment.

[b]0 meaning no swelling or redness of the vulva and not standing for the boar.
1 meaning slight swelling and or reddening of the vulva and not standing for the boar.
2 meaning swelling and redness of the vulva and not standing for the boar.
3 indicating gilts which stood for mounting.

Average estrual regularity of groups A and B were quite similiar; group A exhibited cycling phenomena throughout the experiment with a mean of 21 days between heat periods. They exhibited their first estrus an average of 14.2 days after initiation of the trial and exhibited their second estrus 19.8 days later (day 34); they were bred an average of 19.5 days later (day 53.5 of the exper-

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iment). Group B also had regular cycling with a mean of 21.3 days between heat periods. On the average, group B exhibited their first estrus 15.1 days from initiation into the study; their second estrus period came 22.5 days later (day 37), and they were bred, on the average, 21.5 days later (day 59 of the trial). Data for the two groups were analyzed for significant differences; none were found at P<.05.

TABLE 3. AVERAGE DAYS FROM INITIATION UNTIL FIRST ESTRUS BY GILTS WHICH CYCLED IN EACH GROUP.

	Days on Experiment			
	1-10	11-20	21-30	Over 31
Cumulative Percent:				
Group A.	32	95	100	100
Group B.	40	85	90	100
Group C.	35	70	96	100

Group A, even though younger and lightest, had the highest ovulation rate, but not significantly so (P<.05). Brooks and Cole (1973) reported that heavier gilts had non-significantly higher ovulation rates. As seen in table one, group A had an average ovulation rate of 13.3 ova; group B had 13.0, and group C had 12.6 ova per ovulation. These groups had average daily gains of 0.6, 0.5 and 0.2 kilograms respectively during the period preceeding mating. Wise and Robertson (1953) reported ovulation rates of 14.0, 12.2 and 12.5 for heat periods one, three and five respectively; their explanation for the decrease in ovulation rate with succeeding heat periods was the decrease in feed allocation after the older gilts went on limited feeding prior to slaughter. In the present experiment, all gilts were fed alike, but gains were lower for the larger gilts.

Wise and Robertson (1953) also reported embryonic survival rates for gilts mated at first or third heat periods to be 75.7 and 68.4 percent respectively. Results of embryo survival at day 25 into gestation from this study showed no significant differences ($P<.05$) between the groups with 88, 86 and 84 percent survival for groups A, B and C respectively. Libal and Wahlstrom (1976) found that 64 percent of gilts mated on first heat farrowed, whereas 86 percent of gilts which had previously exhibited two heat cycles farrowed. No such comparison could be made from this study due to its design.

Since no significant differences were found among groups for the variables studied, all three groups were considered as one populat ion for calculation of correlation coefficients by use of linear regression. Table 4 shows the magnitude of these correlations.

No significant positive correlation ($r=-.05$) was found between age and ovulation rate of gilts at the same sexual age (groups A and B) nor age and embryo survival ($r=.21$) in these groups. Reddy _et al_ (1958) found significant correlations between age at breeding and ovulation rate ($r=.56$) in gilts slaughtered at second estrus. Age at breeding in our study was also found not significantly correlated with embryonic survival ($r=.21$) in gilts of the same sexual age. George and England (1974) reported a significant increase in embryonic survival for six to seven and

TABLE 4. CORRELATION COEFFICIENTS AMONG VARIOUS AGE, WEIGHT AND GAIN STATISTICS WITH VARIOUS REPRODUCTIVE TRAITS IN GILTS

	BWT[b]	ADG[c]	ADH[d]	OR[e]	ES[f]
AGE[a]	.13[g] .14[h]	.18 .18	.11 .10	-.05 .45**	.21* .29*
BWT[b]	---	.16 .16	.24 .23	.40** .36**	-.10 -.16
ADG[c]	---	---	.09 .09	.36** .37**	.05 .05
ADH[d]	---	---	---	.20 .24	.23 .20
OR[e]	---	---	---	---	.27 .24

[a]Age at breeding.

[b]Breeding weight.

[c]Average daily gain measured three weeks prior to mating.

[d]Average days between heat cycles.

[e]Ovulation rate.

[f]Embryo survival.

[g]For the whole table, line one represents correlations computed on groups A and B.

[h]For the whole table, line two represents correlations computed on groups A, B and C.

*,**Significant at P<.05 and P<.01 respectively.

seven to nine month-old gilts versus gilts five to six months old, but no significant differences between the six to seven and seven to nine month-old groups occurred. In the present study, a significant positive correlation of r=.40 (P<.01) was found between breeding weight and ovulation rate in gilts of the same sexual age. Reddy et al (1958) reported a correlation of r=.35 in their study in which gilts were of the same sexual age. In the present study, age and breeding weight were not significantly associated nor were days to first estrus or intervals between succeeding estrual occurrences.

As average daily gain during the period prior to mating increased, so did ovulation rate; r=.36 within groups A and B and r=.37 for groups A, B and C combined. The faster growing gilts tended to produce more ova; this suggests that gilts from group A would ovulate more eggs since they were the gilts with the highest average daily gain. Results are in agreement with this expectation; group A had the highest ovulation rate and average daily gain, but not significantly so for either.

When comparing age at breeding and ovulation rate among the three groups, table 1 indicates that ovulation rate doesn't change as age increases, but in table 4, there is a significant positive correlation between age and ovulation rate; this seems to be contradictory. When a correlation coefficient was calculated excluding group C, a non-significant correlation occurred. This suggests that sexual age may be more important than chronological age in so far as ovulation is concerned; group C was youngest both sexually and chronologically and had lower ovulation rates; group A and B were of similar sixual age, but were different in chronological age; they had similar ovulation rates.

Table 5 contains the results of a step-wise multiple-regression analysis of relationships among the various variables. In this analysis, only breeding weight and average daily gain in the period prior to breeding were significantly associated with reproduction; this association was with ovulation rate only. For breeding weight and ovulation rate, r=.38; average daily gain and ovulation rate, r=.49. These associations of average daily gain and breeding weight with ovulation rate are consistent with the generally accepted view and experience that a higher plane of nutritional status is associated with increased ovulation. The lack of a negative association of these traits with embryo survival is not in agreement with the majority of findings reguarding influence of energy intake and embryo survival.

As revealed from this study, managerial manipulation of gilts to breed at younger ages and at lighter weights can result in favorable ovulation, conception and embryo survival performances. By breeding gilts at their second estrus, or better still at their first estrus, the producer could save the expense of feeding replacement gilts the extra 21 or 42 days it would take for the gilts to exhibit their traditional third heat cycle breeding time. Performance of group C indicates that mating gilts at younger ages or first estrus produced mating and early pregnancy results similiar to traditional mating at third estrus (group B).

Researchers have reported that it is not easy to predict the exact time a gilt will exhibit first estrus (ranges have been reported from 135 to 235 days of age). If a good average could be determined where the producer could utilize a weight-age correlation at which gilts were to exhibit first estrus, gilt allotment would be a simple weight factor. Beyond this concept, if the producer

TABLE 5. ASSOCIATION BETWEEN TRAITS REVEALED BY MULTIPLE-REGRESSION ANALYSIS.

	BWT[b]	ADG[c]	ADH[d]	OR[e]	ES[f]
AGE[a]	.10	.22	.03	.17	.19
BWT[b]	---	.21	.22	.38**	-.01
ADG[c]	---	---	-.08	.49**	.13
ADH[d]	---	---	---	.23	.19
OR[e]	---	---	---	---	.20

[a]Age at breeding.
[b]Breeding weight.
[c]Average daily gain measured three weeks prior to mating.
[d]Average days between estrual periods
[e]Ovulation rate
[f]Embryo survival
*,**Significant at P<.05 and P<.01 respectively

could tell how long it takes from first allotting a gilt to the breeding herd until whe exhibits heat, this too would facilitate a more advantagous production scheme.

By utilizing these concepts, the producer would be able to sell those gilts subjected to this management scheme which don't meet the standards set for his gilts. He would be able to sell these gilts at a weight within the favorable market weight range, and would thus avoid getting docked for heavy gilts.

SUMMARY AND CONCLUSION

Gilts of three different weight groups were moved from a growing barn into the broodstock barn where approximately ten gilts from each group were placed in designated pens. Group A and B (73-80 kilogram gilts and 91-100 kilogram gilts respectively) were observed and checked daily for estrual status; they were then bred on their third estrus. The heaviest group, group C (gilts initially weighing 114 kilograms or more) followed the same management regime except that they were bred on their first estrus. Twenty-five days postmating, if rebreeding did not occur, the gilts were slaughtered and their reproductive tracts were removed and inspected for ovulation rate and embryo survival.

Several findings emerged from this experiment:

1) There was no significant differences among the groups in ovulation rates, embryo numbers, embryo survival rates, age at breeding, weight at breeding, average days between heats and average days from initial stimulus until estrus ($P<.01$).

2) By utilizing contiguous and daily direct contact with a boar, 32, 40 and 35 percent of groups A, B and C respectively, exhibited estrus during the first ten days of the study; 95, 85 and 70 percent by day 20; 100, 90 and 96 by day 30; and the remaining ten percent of group B and the remaining four percent of group C did so after 30 days.

3) For age at breeding, there was a significant positive correlation with ovulation rate and embryo survival ($P<.01$ and $P<.05$ respectively) when the population was groups A, B

C, in which weight and chronological age were not significantly different but in which group C was of younger sexual age. When, however, groups A and B which were not different from each other in any of the three variables constituted the population, there was no significant association of age with ovulation rate nor with embryo survival.

4) There was a significant correlation between ovulation rate and breeding weights and between ovulation rate and average daily gain three weeks prior to breeding ($P<.01$).

5) Visual appraisal of characteristics of the vulva as a means of establishing estrual status was highly accurate in reflecting the stage of estrus.

Gilt age presented some surprising results. Once gilts were initiated into the study, they responded to boar stimuli quite well. If group A gilts would have been bred on their first estrus, they would have been approximately 34 days younger than group C gilts (184 days of age compared to 217 days of age respectively). Nine-five percent of group A gilts exhibited estrus within 20 days from initiation and were younger and weighed less than any other group at breeding. Since there was no significant differences in performance between group A and the other groups, it can be concluded that these gilts advanced normally in reproductive age at younger chronological age by initiating them at approximately 73 to 80 kilograms into a regime which initiated occurrence of first estrus.

Boar presence, a change in gilt housing and mixing of gilts combine to create similiar results in the three groups; weight and age differences didn't alter performance. Thus, in-so-far as occurrence of estrus, ovulation, conception and embryo survival during early pregnancy are concerned, all three groups exhibited similiar results and each of the variant procedures (groups A and C) offer producers the opportunity to breed gilts at younger ages and thus, reduce feed costs without adverse effects to 25 days of pregnancy. Studies involving the entire gestation period, lactation, subsequent breeding and resultant litter productivity are needed before overall effects on reproductive efficiency will be known; such studiey are needed as the basis for advising producers.

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