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Plasma FSH Concentration in Young Boars and Gilts from Lines that Differ in Ovulation Rate and Litter Size

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Summary and Implications

Four experiments were conducted to determine whether boars and gilts from selected lines that differ in ovulation rate and litter size also differ in plasma concentrations of Follicle Stimulating Hormone (FSH). Plasma FSH was studied because it is a potential indicator trait of ovulation rate. Plasma concentrations of FSH in young boars and gilts differed between the select and the control line. It is likely that this difference is due to a correlated response to selection for ovulation rate. Therefore, plasma concentration of FSH in young boars and gilts may be a trait that can be used effectively to indirectly select for ovulation rate. Additional data to more precisely estimate the genetic relationships are needed before selection for FSH is recommended.

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Introduction

One Nebraska research focus has been to identify methods to enhance the rate of response to selection for litter size. The industry practice is to select replacement boars and gilts based on litter size records of the dam and other female relatives. But based on results of our research and that done at the USDA Meat Animal Research Center (MARC), greater rate of response will occur if selection is for ovulation rate and uterine capacity.

Litter size at birth is modeled as the minimum value of the number of viable eggs ovulated and the capacity of the uterus to carry fetuses to parturition. In some females, the number of eggs ovulated is less than uterine capacity and ovulation rate limits litter size. In other females, ovulation rate is greater than uterine capacity, and the number of pigs at parturition equals the number of fetuses the uterus can support. In these females uterine capacity limits litter size.

According to the model, response in litter size to selection for ovulation rate and uterine capacity exceeds response from direct selection for litter size. This kind of selection is done experimentally by measuring ovulation rate with the techniques of laparotomy or laparoscopy. By knowing both ovulation rate and litter size, selection is for the optimum combination of the two traits. However, methods to measure ovulation rate are not practical in industry herds.

A further limitation of current practices of selection for litter size is that there is no direct measure of litter size in males. Boars are selected based on records of dams and sibs. Male selection contributes more to rate of response than female selection because intensity of selection is greater in males. However, to fully realize the increased response the trait must be measured directly in males.

Selection for ovulation rate and uterine capacity could be practiced more easily if a trait that accurately predicts ovulation rate could be measured in both boars and gilts at a young age. Selection for the indicator trait would increase ovulation rate and selection for litter size would increase uterine capacity. Traits would be weighted to maximize the response in litter size.

Follicle Stimulating Hormone (FSH) is a potential indicator of ovulation rate. This hormone stimulates development of follicles that eventually ovulate in females and stimulates development of sperm cells in males. We were encouraged regarding the potential of plasma FSH as a useful predictor of ovulation rate, especially in boars, by results of experiments at MARC. Boars of the Chinese Meishan breed had considerably greater concentrations of FSH in their plasma than did boars of a composite population of Large White, Landrace, Yorkshire, and Chester White. These populations differ greatly in litter size. A major component of this difference is the greater ovulation rate of the Meishan.

The objective of the experiments reported herein was to determine whether boars and gilts from lines that differ in ovulation rate, number of fetuses, and litter size at birth also differ in concentrations of plasma FSH. Four experiments, three with boars and one with gilts, were done. Blood samples were collected over a range of ages because the optimum age at which to sample was not known.

Methods

Pigs were from a select (line I) and a control (line C) line established from a cross of Large White and Landrace. Line I was selected 10 generations for an index of increased ovulation rate and increased embryonic survival to 50 days of gestation. Line C was selected randomly. After 10 generations, gilts of line I averaged 6.7 more eggs ovulated, 3.3 more fetuses at 50 days of gestation, and 3.1 more fully formed pigs at birth than gilts of line C. Index selection ended at the 10th generation. After that there was one generation of random selection and then selection was for increased litter size in line I. Selection continued to be random in line C. Pigs for this experiment were from generations 12 and 13.

Experiment 1. Boars from generation 12 were used. They were randomly selected when they were 56 days of age (1 per litter, 4 from each of 15 half-sib families) from line I (n = 61) or line C (n = 60). They were placed in a modified open front building with 10 pigs per pen. *Ad libitum* access to feed was provided. A blood sample was taken from each boar at 90, 120, and 150 days of age. These ages were chosen because they span the interval during which boars reach puberty. Testis growth is rapid and boars achieve the ability to produce sperm cells during this period.

Experiment 2. Boars used in this experiment also were from generation 12, but they were the replacement boars that had been selected to be breeders. Selection was random in line C and included one boar of each of 15 half-sib families. Boars from line I included one boar from each of the 14 largest litters. There was a total of 60 line I litters. Because boars were selected on their dam's litter size record, and not on any trait measured on them, they represent progeny of an additional generation of selection. This additional generation should enhance the ability to detect a response in plasma FSH to selection for litter size. These boars were raised in the same building as boars described in Experiment 1 until they were approximately 200 d of age. They were then moved to the breeding area, where they were housed in crates. Boars began mating when they were 225 to 250 days of age. A single blood sample from each boar was taken at approximately 11 months of age to study line differences in boars that were more mature than those used in Experiment 1.

Experiment 3. Boars for this experiment were from generation 13. They were the replacement boars selected to be breeders. The selection criteria were the same as described for Experiment 2. However, two boars, a primary breeder and an alternate, were selected from each of the 15 half-sib families of line C. Two boars from each of the 14 largest litters of line I were selected. A single blood sample was drawn from each boar at 150, 180, and 210 days of age. These ages were chosen because they are intermediate to those used in Experiments 1 and 2.

Experiment 4. Gilts were used in this experiment. They came from generation 12. One gilt was randomly selected from each litter (n = 45, line I; n = 35, line C). At 56 days of age they were placed in a modified open front building with 10 pigs per pen. They were allowed ad libitum access to feed. A blood sample was drawn from each gilt at 50, 90, and 130 days of age. The gilts were prepubertal. Plasma FSH has a characteristic curve during the estrous cycle. By sampling prepubertal gilts, it was not necessary to time the sampling relative to day of estrus. However, plasma FSH is pulsatile in prepubertal gilts. This pulsatility increases variation among gilts when only one sample is taken but does not bias mean differences between lines.

Concentration of FSH in plasma of each blood sample was determined by radioimmunoassay procedures. Data were fitted to appropriate statistical models that accounted for the random effects of half-sib families and the effects of line. Age at time of sampling and the interaction of age with line were also fitted to data from Experiments 1, 3, and 4.

Table 1. Plasma concentrations, mean ± SE (ng/mL), of FSH in boars.

	Line I[a]		Line C[b]		
Age, d	n	Mean	n	Mean	Difference
		Experiment 1			
90	59	71 ± 3	60	66 ± 3	5 ± 4
120	60	89 ± 5	60	75 ± 5	14 ± 7*
150	55	111 ± 7	60	81 ± 7	31 ± 10**
		Experiment 2			
330	14	206 ± 33	15	155 ± 32	51 ± 46
		Experiment 3			
150	30	139 ± 16	28	136 ± 16	4 ± 23
180	29	150 ± 23	28	131 ± 23	20 ± 32
210	30	146 ± 14	28	128 ± 14	18 ± 20

[a]Selected for index of increased ovulation rate and embryonic survival.
[b]Selected randomly.
* P < .05
**P < .01

Table 2. Plasma concentrations, mean ± SE (ng/mL), of FSH in gilts in experiment 4.

	Line I[a]		Line C[b]		
Age, d	n	Mean	n	Mean	Difference
50	45	1016 ± 36	35	814 ± 41	203 ± 54**
90	42	997 ± 37	35	783 ± 41	214 ± 55**
130	41	542 ± 38	35	441 ± 41	101 ± 55†

[a]Selected for index of increased ovulation rate and embryonic survival.
[b]Selected randomly.
† P < .10
**P < .01

Results and Discussion

Boars. Boars of line I had greater concentrations of plasma FSH than line C boars at each age (Table 1). Line x age interactions were not significant in either Experiment 1 or 3. The line differences were significant only at 120 (P < .05) and 150 (P < .01) days of age in experiment 1. Line differences were greatest in the more mature boars used in Experiment 2. However, the differences were not significant because the sample size was small. Results for Experiments 1 and 3 were inconsistent. The greatest difference in concentration of FSH between lines was for 150-d old boars in Experiment 1. But means of the lines at this age in Experiment 3 were similar. The differences in results for the two experiments might be explained by sampling variance. There were fewer observations in the third experiment and, therefore, these means have greater sampling variance.

Workers at MARC found that plasma FSH concentrations were greater in mature Meishan boars than in a composite population of domestic breeds. These breeds differ significantly in ovulation rate. Based on their results, we hypothesized that concentration of plasma FSH in the boar is genetically correlated with ovulation rate.

Our results confirm a positive genetic relationship between ovulation rate of females and plasma FSH concentration of male relatives. The correlation appears to be greatest when plasma FSH of boars is measured between 120 and 150 days of age. The magnitude of this correlation could not be determined precisely from the results of this experiment. Average ovulation rate is approximately 6.5 eggs more for line I than line C gilts; however, ovulation rate was not measured on contemporary gilts to these boars. The differences in ovulation rate, the known selection differential for ovulation rate in the selection experiment, and the range of differences found in concentrations of plasma FSH in this study were used to calculate the possible range of genetic correlation between ovulation rate and concentration of plasma FSH. The range for the correlation was between .25 and .75. If the genetic correlation is .75, selection for plasma FSH concentration in boars to increase ovulation rate will be effective. But if the correlation is .5 or less, this method of selection will not be effective.

Gilts. Line I gilts had greater plasma concentrations of FSH than line C gilts at 50 (P <.01), 90 (P < .01), and

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130 ($P < .10$) days of age (Table 2). Concentration of FSH declined ($P < .01$) with age, but line by age interaction was not significant.

Concentration of FSH in plasma is regulated by feedback of ovarian hormones on the hypothalamus, the control center for secretion of gonadotrophin hormones and the anterior pituitary gland which secretes FSH. Other workers have found that there is little ovarian regulation of FSH synthesis in gilts before 50 days of age. Because lines I and C differed at 50 days the mechanism by which selection altered plasma concentration of FSH is probably due to differences in FSH synthesis.

Concentration of FSH in line I gilts was approximately 25 percent greater than in line C gilts. A genetic correlation between ovulation rate and FSH close to 1.0 would have to exist to cause a difference this large. Therefore, plasma FSH concentration in young gilts may be a useful predictor of ovulation rate. It is more easily measured than ovulation rate and, therefore, could be more easily incorporated into a selection program.

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