January 1998

Follicular Development in Gilts Selected for High Ovulation Rate and Embryo Survival Versus Randomly Selected Control Line Gilts

Hui-Wen Yen
University of Nebraska-Lincoln

Rodger K. Johnson
University of Nebraska-Lincoln, rjohnson5@unl.edu

Dwane R. Zimmerman
University of Nebraska-Lincoln

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Summary and Implication

The patterns of follicular development during the proestrous period were compared in gilts selected for an index of high ovulation rate and high prenatal survival (White Line-2, WL-2) and randomly selected controls (White Line-1, WL-1) on days 0, 2, 3, 4, 5 and estrus after induced luteolysis with PGF2α on day 13 (day 0) of the estrous cycle. Numbers of follicles (F) equal or greater than 2 mm in diameter were categorized and recorded as follows: small (SF, 2 to 2.9 mm), medium-1 (M1F, 3 to 4.9 mm), medium-2 (M2F, 5 to 6.9 mm) and large (LF, equal or above 7 mm). The population of SF was greater in WL-1, whereas the population of M1F was greater in WL-2 gilts during the early follicular phase. The SF and M1F populations declined rapidly in both lines between days 0 and 4. White Line-2 gilts maintained a larger pool of M2F between days 0 and 4. Medium-2 follicles declined in both lines between days 4 and 5, but the loss of M2F was much greater in WL-2 gilts. Large follicles developed earlier and accounted for a greater percentage of the follicles in WL-1 gilts to day 4. The reverse was true on day 5 and at estrus. White Line-2 gilts tended to have greater numbers of large follicles than WL-1 gilts at estrus. White Line-2 gilts maintain a larger pool of M2F during most of the follicular phase and must select a greater number of these follicles during the late follicular phase to achieve their ovulation rate advantage. It is possible the M2F population is healthier in WL-2 gilts.

Introduction

Variation in litter size is determined by the number of follicles that ovulate and release viable ova, the percentage of ova fertilized by sperm and the percentage of beginning embryos and fetuses that survive in utero during gestation and are born alive.

Selection for high ovulation rate alone (Relax Select, RS line) in the University of Nebraska gene pool population increased ovulation rate

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by about 3.2 ova over randomly selected control (C) line gilts but increased pigs born alive less than one pig per litter after nine generations of selection. The limited litter size response led to the design of a second selection experiment where selection was based on an index of the ability of females to maintain large litters to day 50 of gestation (percent prenatal survival) and ovulation rate (see Johnson, Nebraska Swine Report 1990). This experiment utilized a Large White x Landrace composite population and has proved more effective at increasing both ovulation rate and litter size. The mean ovulation rate for the select line (17.04) was about three ova higher than the mean for the control line (14.07) after five generations.

The objective of this study was to determine what changes in follicular development allow select line gilts to achieve substantially greater ovulation rate. The pattern of follicular development during the follicular phase of the estrous cycle was compared in gilts selected for an index of ovulation rate and prenatal survival (White Line-2, WL-2) and randomly selected control gilts (White Line-1, WL-1).

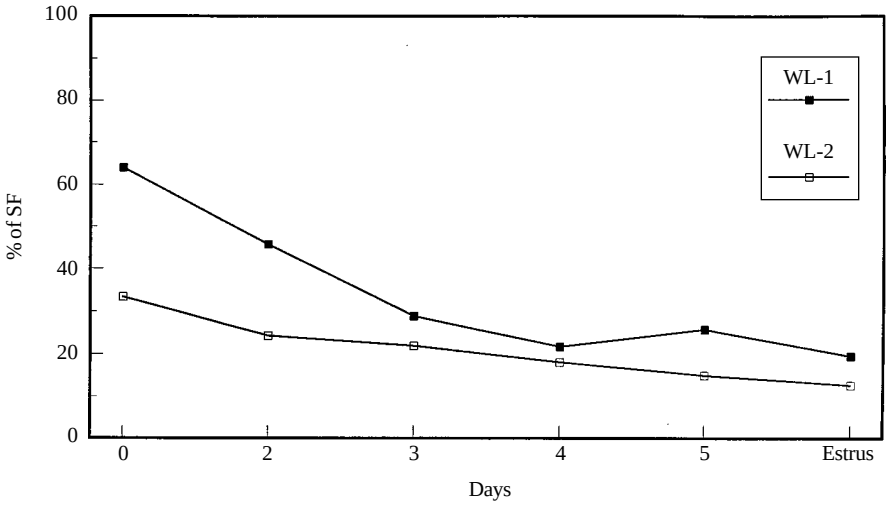

Figure 1. Line difference in relative percentage of small follicles (SF) following PGF2-alpha on d 13.

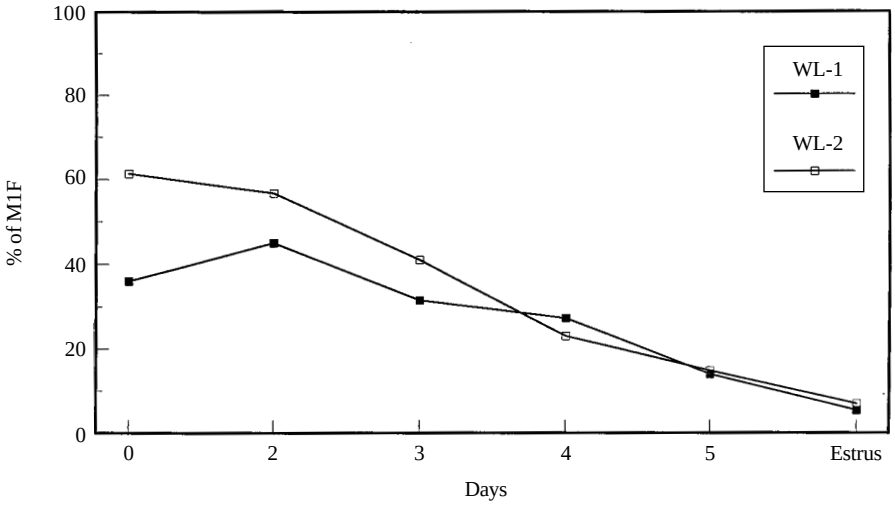

Figure 2. Line difference in relative percentage of medium 1(M1F) follicles following PGF2-alpha on d 13.

Materials and Methods

Seventy-two tenth generation WL-1 and WL-2 gilts were used to compare the pattern of follicular development. Gilts were assigned randomly within sire for ovary recovery on days 0, 2, 3, 4, 5 and estrus after induced luteolysis (regression of corpora lutea) with PGF2α (10 mg Lutalyse) on day 13 (d 0) of the estrous cycle. Gilts from WL-1 and WL-2 represented the progeny of 11 and nine sires, respectively. These gilts were eight to 11 months of age and weighed between 209 and 330 pounds when evaluated. They had experienced two or more estrous cycles before assignment to experiment. Distribution of gilts by line and day (d) of evaluation were: d 0 (n = 7 WL-1 and 5 WL-2), d 2 (n = 7 WL-1 and 6 WL-2), d 3 (n = 5 WL-1 and 6 WL-2), d 4 (n = 5 WL-1 and 6 WL-2), d 5 (n = 7 WL-1 and 6 WL-2) and estrus (n = 5 WL-1 and 7 WL-2).

Ovaries were recovered at slaughter and placed in .9 percent saline on ice. The numbers of corpora ablicantia (CA) were recorded as a measure of ovulation rate at the previous estrus. Numbers of follicles (F) equal or greater than 2 mm in diameter were categorized and recorded as follows: small (SF, 2 to 2.9 mm), medium-1 (M1F, 3 to 4.9 mm), medium-2 (M2F, 5 to 6.9 mm) and large (LF, equal or greater than 7 mm). Follicle numbers for different size categories were not normally distributed, so the data concerning follicle numbers were converted to relative percentage for each gilt (dividing number of follicles in a given size category by the total number of follicles in all four size categories) before the data were analyzed statistically.

Results and Discussion

Overall, WL-2 gilts ovulated 6.6 more follicles than WL-1 gilts at the pretreatment estrus (20.4 versus 13.8, $p<.01$). This difference is similar to those reported in earlier summaries.

During the early follicular phase, the population of SF was greater in WL-1 gilts whereas the population of M1F was greater in WL-2 gilts (Table

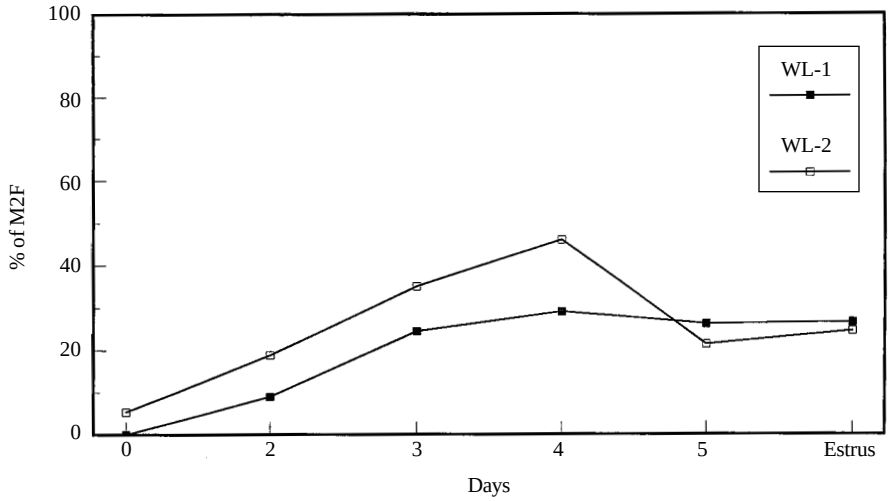

Figure 3. Line difference in relative percentage of medium 2 (M2F) follicles following PGF2-alpha on d 13.

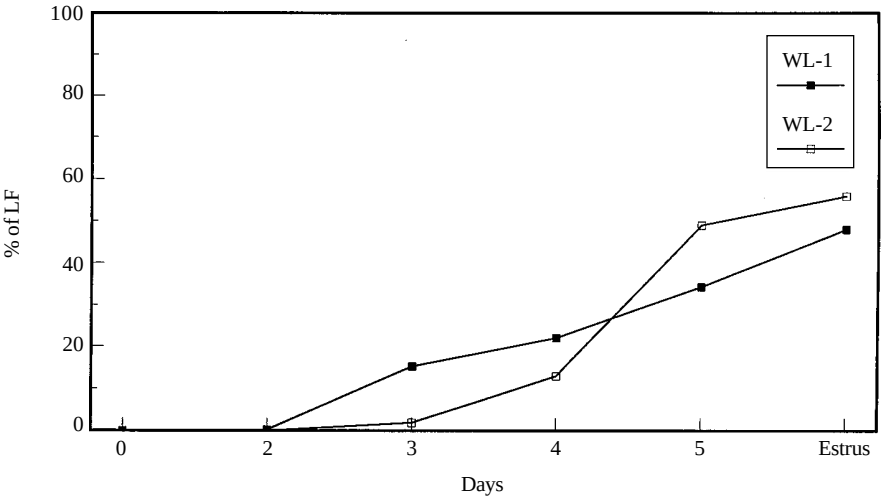

Figure 4. Line difference in relative percentage of large follicles (LF) following PGF2-alpha on d 13.

1). The relative percentages of SF and M1F declined over time in both lines (Figure 1 and Figure 2). However, the decline of SF between days 0 and 4 was greater for WL-1 than WL-2 gilts (64 to 19 percent versus 33 to 13 percent, line x day, p<.03). In contrast, the decrease in M1F between days 0 and 4 was greater in WL-2 than WL-1 gilts (61 to 6 percent versus 36 to 7 percent, line x day, p<.04). The decline of SF and M1F may be due to a move into the next larger category of follicles or to degeneration (atresia) and disappearance from the surface of the ovaries.

Medium-2 follicles appeared earlier (day 0 versus day 2) in WL-2 than in WL-1 gilts and WL-2 gilts maintained a larger pool of M2F during the early to mid-follicular phase (Table 1). The larger pool of M2F in WL-2 gilts during this period may be a reflection of rapid movement of M1F into the M2F pool between days 0 and 4. The relative percentage of M2F increased between days 0 and 4 in both lines (WL-1, 0 to 29 percent; WL-2, 5 to 46 percent), and then declined to estrus (Figure 3). The loss of M2F was more abrupt in WL-2 than in WL-1 gilts between days 4 and 5 (46 to 21 percent versus 29 to 26 percent, line x day, p<.07).

Some LF had developed on day 3 in both lines and, as expected, the relative percentage of LF increased from day 3 to estrus in both lines (Figure 4). Large follicles accounted for a greater relative percentage of the follicles in WL-1 than WL-2 gilts on days 3 and 4 (day 3, 15 versus 1.9 percent; day 4, 21.9 versus 12.9 percent). The reverse was true after day 4. This resulted from the more rapid increase in LF development in WL-2 gilts between days 4 and 5 (line x day, p<.06). The timing of the rapid increase in LF between days 4 and 5 was related to the timing of rapid decline in M2F in WL-2 gilts and probably reflects the rapid maturation of M2F into LF during this period.

The number of LF observed at estrus tended to differ between the two lines (WL-1, 10.8 versus WL-2, 14.7; p<.1) but did not reflect the expected ovulation rate of either line (Table 2). Both lines must continue selecting ovulatory follicles from the M2F pool

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Table 1. Mean numbers of small, medium and large follicles following PGF2-alpha on day 13 (day 0) of the estrous cycle[a]

		Day 0		Day 2		Day 3		Day 4		Day 5		Estrus	
Follicle[b]	Size (mm)	WL-1	WL-2	WL-1	WL-2	WL-1	WL-2	WL-1	WL-2	WL-1	WL-2	WL-1	WL-2
SF	2 to 2.9	55.7	28.4	33.8	14.5	15.8	15.0	7.4	8.5	7.4	5.5	4.2	3.1
M1F	3 to 4.9	26.1	51.6	32.1	33.3	19.0	26.5	9.0	11.6	4.7	4.5	1.5	1.8
M2F	5 to 6.9	0	4.8	5.7	11.5	13.0	20.0	10.6	21.8	8.4	7.3	6.0	5.8
LF	7	0	0	0.1	0	2.0	1.3	6.6	4.8	8.1	14.9	10.8	14.7

[a]WL-1 = white line gilts which served as randomly selected controls; WL-2 = white line gilts selected for an index of ovulation rate and prenatal survival.
[b]SF, M1F, M2F and LF = small, medium 1, medium 2 and large follicles, respectively.

Table 2. Line differences in number of corpora ablicantia (CA) and larger follicles on estrus following PGF2-alpha on day 13 of the estrous cycle

	Follicle Size[a]		
Line[b]	M2	L	No. CA[c]
WL-1	6.0	10.8	13.8
WL-2	5.8	14.7	20.4

[a]M2F, 5 to 6.9 mm; LF ≥ 7 mm.
[b]WL-1 = white line gilts which served as randomly selected controls; WL-2 = white line gilts selected for an index of ovulation rate and prenatal survival.
[c]Ovulation rate at pretreatment estrus.

in order to achieve final ovulation rates comparable to those, expressed at the previous estrus. All of the M2F in WL-2 gilts and about half of M2F in WL-1 gilts present at estrus must mature into ovulatory follicles to achieve the expected ovulation rates of each line.

Conclusion

Follicular dynamics have changed in response to genetic selection for high prenatal survival and high ovulation rate. WL-2 gilts develop M2-F earlier in the follicular phase and achieve a larger pool of M2-F than WL-1 gilts from which to select LF during the early to mid-proestrous period (day 0 to 4). Large follicles, on the other hand, develop earlier and in greater numbers in WL-1 than in WL-2 gilts during the mid-proestrus period (days 3 and 4). However, between day 4 and day 5 of the proestrous period, a rapid selection and maturation of M2-F into LF occurred in WL-2 gilts. These changes were much less pronounced in WL-1 gilts. Based on the number of large follicles at estrus, WL-2 gilts have achieved only part of their ovulation rate advantage over WL-1 gilts and neither genetic line has developed the number of large follicles needed to achieve expected ovulation rates. Both lines must continue to select follicles from the remaining pool of M2F to achieve expected ovulation rates. Selection rate would have to be much greater in WL-2 than WL-1 gilts (approximately 100 percent versus 50 percent) to achieve the ovulation rate levels of the previous estrus. For this to occur, essentially all of the M2F pool of follicles in WL-2 gilts would have to be healthy and viable. The second phase of this study is designed to compare the health status of different sized follicles in WL-1 and WL-2 gilts during the proestrous period. This research is still in progress.

[1]Hui-Wen Yen is a graduate student and Rodger K. Johnson and Dwane R. Zimmerman are professors in the Animal Science Department.