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Nutrition During Gilt Development and Genetic Line Affect Reproductive Rate Through Parity 1

Twenty-five percent energy restriction during development delays sexual development of gilts but has no effect on reproductive rate of those reaching sexual maturity.

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Summary

Effects of allowing gilts ad libitum access to feed until breeding age or developing them with 25% energy restriction from 123 days of age to breeding on reproductive success through parity 1 were studied with a total of 639 gilts of two lines that differ in lean growth and reproduction. Gilts of the two lines had common sires, an industry maternal line, but dams were from different populations. One line of gilts, LW x LR, represented standard industry Large White x Landrace cross females. The other gilts, L45X, were daughters of Nebraska selection Line 45 that has been selected 27 generations for increased litter size with additional selection for increased growth and decreased fat in the last seven generations. More L45X than LW x LR gilts (95 vs. 88%, $P < 0.01$) and more gilts developed with ad libitum intake than with restricted intake (96 vs. 86%, $P < 0.01$) expressed puberty by 226 days of age. For gilts that expressed puberty, mean age at puberty was 6 days less ($P < 0.01$) for L45X than LW x LR gilts, but did not differ between gilts on the two developmental regimens. For all gilts, the likelihood of expressing puberty increased with increasing weight at 123 days of age. It was also greater for gilts that attained heavier weights with greater backfat at 226 days of age, but the effect varied among lines and gilt developmental regimens. Increasing weight and backfat at 226 days of age increased the likelihood of producing a parity 1 litter for L45X gilts developed with restricted feeding, but not for other groups. Number of live born pigs per litter was affected by line, being greater for L45X gilts ($P < 0.05$), but not by gilt developmental regimen. Neither line nor gilt developmental regimen affected maternal ability as measured by number and weight of pigs weaned. A 25% energy restriction during gilt development decreases the likelihood that gilts express estrus by 226 days of age, but has little effect on subsequent reproductive performance.

Introduction

It has been shown in several species that prolonged periods of energy restriction initiated postweaning, without limiting other nutrients, often results in increased longevity that is approximately proportional to the level of restriction. However, reallocation of nutrients often occurs such that animals cannot combine high rates of fecundity with extended lifespans. Research with mice has shown that this outcome is not always true. A recent publication of one experiment contains data showing that female mice restricted in energy intake postweaning lived longer without a reduction in reproductive rate.

Today's commercial gilts are often managed to achieve weights of at least 136 kg (300 lb) with adequate backfat at breeding, although the amount of backfat that is adequate is not well defined. These targets are often achieved with management practices that include ad libitum access to feed. However, consistent with the findings in mice, a series of reports containing data from experiments at the USDA Meat Animal Research Center demonstrated that moderate feed restriction during prepubertal development of gilts may increase reproductive efficiency through first parity.

Optimum gilt development regimens may depend on the prolificacy and lean growth rate of the genetic line. We initiated an experiment with the overall objective of estimating the effects of 25% restriction of energy vs. ad libitum access to feed from 123 days of age to breeding on reproduction and longevity through parity 4 of females of two lines that differ in rate of lean growth and litter size. The experiment was done in four replications with a total of 661 gilts. The *2008 Nebraska Swine Report* contained articles summarizing effects of line and gilt developmental regimen on growth of gilts to 226 days of age and subsequent reproductive performance of females through parity 4 for gilts of replications 1 to 3. Since that report, replication 4 gilts produced parity 1 litters, providing a complete dataset through parity 1. The objective of this experiment is to summarize effects of line and energy restriction on reproductive performance through parity 1. Effects of variation in measures of growth (weight, backfat, and longissimus muscle area at different ages) on the likelihood of expressing puberty and producing a parity 1 litter are also presented.

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Materials and Methods

Gilt populations

Two populations of gilts were used. One was the Large White x Landrace crossbred female used regularly in the University of Nebraska–Lincoln swine nutrition program. The project gilts were the progeny of Large White-Landrace cross sows that had been inseminated with semen of industry maternal line (L_M) boars and are designated as LW x LR cross. Gilts that were progeny of UNL selection Line 45 sows that had been inseminated with semen of the same L_M boars used to produce LW x LR gilts comprised the other population. These gilts are designated as L45X. Line 45 has been selected 27 generations for increased litter size with additional selection for increased growth and decreased backfat in the last seven generations. Based on previous data, L45X gilts were expected to be more prolific than LW x LR gilts but to also have somewhat slower growth and greater backfat thickness.

Gilt Management and Dietary Regimens

The experiment was done in four replications in which project gilts were born in batches during December 2004 and January 2005 (Rep 1), May 2005 (Rep 2) and November 2005 (Rep 3), and May and June 2007 (Rep 4). A total of 661 gilts began the experiment (157 to 185 gilts per replication) at 60 days of age; 639 of them completed the growth phase of the experiment that ended at 226 days of age.

Dams of project gilts were managed alike during the farrowing/lactation period. After weaning, all gilts were managed alike in the nursery until approximately 60 days of age (21 kg (46 lb)). They were then moved to the grow-finish facility where they were penned (10/pen) by line-treatment designation. All gilts were allowed ad libitum access to a corn-soybean meal-based diet and were managed alike until 123 days of age. A 3-phase growing-finishing diet was used: phase 1, 1.15% lysine (60 days to 80 lb); phase 2, 1.0% lysine (80 to 130 lb); and phase 3, 0.90% lysine (130 lb to 123 days).

At 123 days of age, pens of gilts on the ad libitum regimen (A) were allowed ad libitum access to a corn-soybean meal based diet (0.70% lysine, 0.70% Ca, 0.60% P) until they were moved into the breeding barn. Gilts treated with the restricted intake regimen (R) received a corn-soybean meal based diet at approximately 75% of the energy intake as A-fed gilts until moved into the breeding barn. Energy restriction was achieved by predicting intake with a quadratic equation of average daily feed intake on body weight of A-fed gilts. The predicted ad libitum intake (based on the projected body weight for the upcoming two-week period) was multiplied by 0.75 to determine the daily feed intake for R gilts. The diet contained 0.93% lysine, 1.0% Ca, and 0.80% P. All vitamins and minerals, except selenium, were increased so that daily intake of these nutrients per unit of body weight was expected to be equal for gilts on both diets. Additional details of the diets and management are in two articles in the *2007 Nebraska Swine Report.*

During the growing period, gilts were weighed and backfat and longissimus muscle area were recorded every 14 days until final measurements were recorded at an average age of 226 days. Beginning at approximately 140 days of age, gilts were moved by pen to an adjacent building where boar exposure and estrus detection occurred. Date of first observed estrus and each additional estrus were recorded.

Breeding and Lactation Management

Gilts in good health and that could be mated at third or later estrus during a predetermined breeding period were identified as breeders and moved to the breeding barn at approximately 230 days of age. Breeding commenced approximately 10 days later. A breeding period of 25 days (Rep 1), 24 days (Rep 2), 26 days (Rep 3), and 28 days (Rep 4) was used to match the unit's production schedule. Gilts were checked twice daily for estrus and were inseminated each day that they were observed in estrus. Insemination was with semen of boars from a commercial terminal sire line. Gilts were in pens of approximately eight per pen until inseminated and then were moved to gestation stalls. Gilts that did not express estrus, those that were mated but diagnosed open with an ultrasound pregnancy test 50 days postbreeding, and those that were diagnosed pregnant but did not farrow a litter were culled. Lame gilts and those in poor health also were culled.

While in the breeding barn and during gestation, all gilts were fed a standard corn-soybean meal based diet (13.8% protein, 0.66% lysine) at the rate of 4.0 lb daily until 90 days of gestation when feed intake was increased to 5.0 lb daily. At approximately 110 days of gestation, females were placed in farrowing crates in rooms of 12 crates per room and fed 6 lb daily of a corn-soybean meal based lactation diet (18.5% protein, 1.0% lysine). Sows were provided only a small amount of feed on the day they farrowed, 6 lb during the second day and 10 lb during the third day of lactation, and then were given ad libitum access to feed. Total number and number of live pigs were recorded for each sow. Pigs were fostered among litters without regard to line or gilt developmental regimen to reduce variation in number nursed per sow. Litters were weaned at an average age of approximately 17 days and number weaned and total litter weight were recorded.

Traits and Data Analysis

Gilts completing the growth test were coded as 0 if they had not expressed a pubertal estrus and 1 if they had. Then, based on females designated for breeding, they were coded as 1 if they farrowed a litter at parity 1and 0 if not. These scores, which are measures of success/failure to reproduce, were fitted with general linear models designed for binomial data to determine the importance of line, gilt treatment, and interaction of line with treatment. Then, weight, backfat, and longissimus muscle area at 123

Table 1. **Number of gilts that did and did not express pubertal estrus, number designated as breeders, and number of breeders that did and did not produce a parity 1 litter.**

		Expressed pubertal estrus		Parity 1 litter		
Line	Trt[1]	Yes	No	Breeders	Yes	No
LW x LR	A	159	15	139	107	32
LW x LR	R	133	38	123	97	26
L45X	A	143	4	129	112	17
L45X	R	132	15	119	96	23
Total		567	72	510	412	98

[1]A = ad libitum regimen, R = restricted intake regimen

Table 2. **Mean reproductive rates for Large White x Landrace (LWxLR) and Line 45 cross (L45X) gilts developed with ad libitum feeding (A) or 25% energy restriction (R).**

		Pr[1] Pubertal estrus[1]		Age puberty[2]		Pr P1 litter		Total born/litter[3]		Live born/litter[4]	
Line	Trt	Avg	SEM	Avg	SEM	Avg	SEM	Avg	SEM	Avg	SEM
LwxLR	A	0.93	0.05	177.8	3.7	0.73	0.04	12.65	0.36	11.04	0.34
LwxLR	R	0.80	0.05	176.2	3.7	0.75	0.04	12.31	0.38	11.00	0.35
L45X	A	0.98	0.01	170.0	3.7	0.84	0.04	12.56	0.36	11.37	0.33
L45X	R	0.90	0.03	172.1	3.7	0.80	0.04	13.54	0.38	12.21	0.35
LwxL	R	0.88	0.03	177.0	3.5	0.74	0.03	12.48	0.29	11.02	0.25
L45	X	0.95	0.02	171.0	3.5	0.82	0.03	13.05	0.29	11.79	0.25
	A	0.96	0.01	173.9	3.5	0.79	0.03	12.61	0.27	11.20	0.24
	R	0.86	0.03	174.2	3.5	0.77	0.03	12.92	0.29	11.61	0.25

[1]Pr = probability
[2]Line, P = 0.006; trt, P = 0.0001
[3]Line x trt, P = 0.05
[4]Line, P = 0.03

Table 3. **Mean number weaned and litter weaning weight for Large White x Landrace (LWxLR) and Line 45 cross (L45X) gilts developed with ad libitum feeding (A) or 25% energy restriction (R).**

		Number weaned per litter[1]		Litter weaning weight, kg[2]	
Line	Trt	Mean	SEM	Mean	SEM
LwxLR	A	9.38	0.22	45.36	1.20
LwxLR	R	9.04	0.22	43.18	1.23
L45X	A	9.18	0.21	42.91	1.19
L45X	R	9.24	0.22	45.62	1.24
LwxLR		9.46	0.28	45.45	1.70
L45X		9.30	0.28	45.26	1.70
	AL	8.90	0.28	40.37	1.67
	R	9.19	0.30	45.99	1.81

[1]Line, P = 0.23; trt, P = 0.81
[2]Line, P = 0.21, Trt, P = 0.12

and at 226 days of age were fitted as co-variables to determine how they affected the likelihood of expressing puberty or farrowing a litter. Effects of age at puberty on likelihood of farrowing a litter also were estimated. Covariate effects were estimated by predicting mean probabilities at various levels of the covariates and predicted means were graphed to illustrate relationships.

Results

A total of 639 gilts completed the growth phase of the experiment. Of these gilts, 567 expressed an estrus by 226 days of age and 510 were designated as breeders. Of the 57 gilts that expressed estrus but were not designated as breeders, 20 were randomly culled, five within each line x treatment combination, to reduce breeding numbers to fit the production capacity. The remaining 37 gilts were culled for health or because they expressed estrus so late that they could not be mated at third or later estrus. This culling was not related to line or treatment. Distributions of gilts with a pubertal estrus and that farrowed a litter across lines and treatments are in Table 1.

Table 2 contains the probability that gilts expressed estrus, mean age at puberty for those that did express estrus, the probability that gilts designated for breeding produced a parity 1 litter, and mean litter size for those that farrowed. Both line and gilt developmental regimen significantly affected the proportion of gilts that expressed a pubertal estrus. The probability that gilts expressed a pubertal estrus was 0.95 for Line 45X gilts and 0.88 for LW x LR gilts ($P = 0.006$). The probability of expressing pubertal estrus also was greater for gilts developed with ad libitum access to feed than those developed with restricted energy intake (0.96 vs. 0.86, $P = 0.0001$). The interaction was not significant as effects of gilt developmental regimen were similar for both lines.

For those gilts designated as breeders, the probability of producing a litter was greater for L45X than for LW x LR gilts, although the difference was not significant ($P = 0.33$). For gilts designated as breeders, the developmental regimen they had been on did not affect the likelihood they farrowed a parity 1 litter.

Interaction of line and gilt developmental regime existed for total number of pigs farrowed per litter, but not for live pigs per litter. Total born per litter was greater for LW x LR gilts developed with ad libitum access to feed than when developed with restricted intake, but the reverse occurred for L45X gilts as those developed with restricted intake farrowed more total pigs. This interaction did not exist for live pigs per litter, but L45X gilts produced more live pigs than LW x LR gilts (11.79 vs. 11.02, $P = 0.03$). Gilt developmental regimen did not affect live pigs per litter.

Number of pigs weaned per litter and litter 17-day weaning weight were

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standardized for the number of pigs after pigs were fostered among litters, and thus do not reflect line and treatment differences in live pigs per litter (Table 3). After this standardization, neither line nor gilt development regimen significantly affected number or weight of pigs at weaning, even though litter weaning weight was 14% greater ($P = 0.12$) for gilts developed with restricted energy intake than for those developed with ad libitum intake. Thus, given an opportunity to raise the same number of pigs, gilts of the two lines developed with either regimen did not differ greatly in maternal ability.

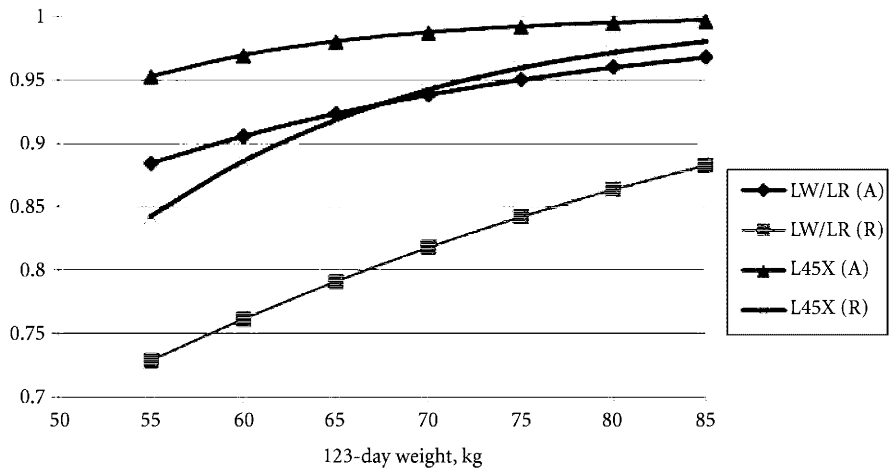

Figure 1. Effect of 123-day weight on probability of pubertal estrus.

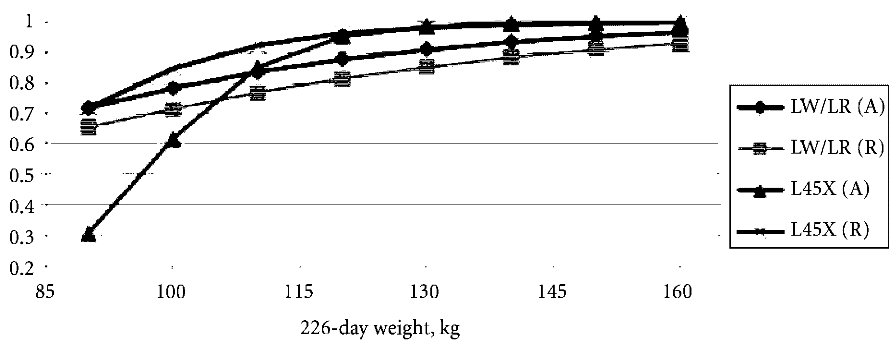

Figure 2. Effect of 226-day weight on probability of pubertal estrus.

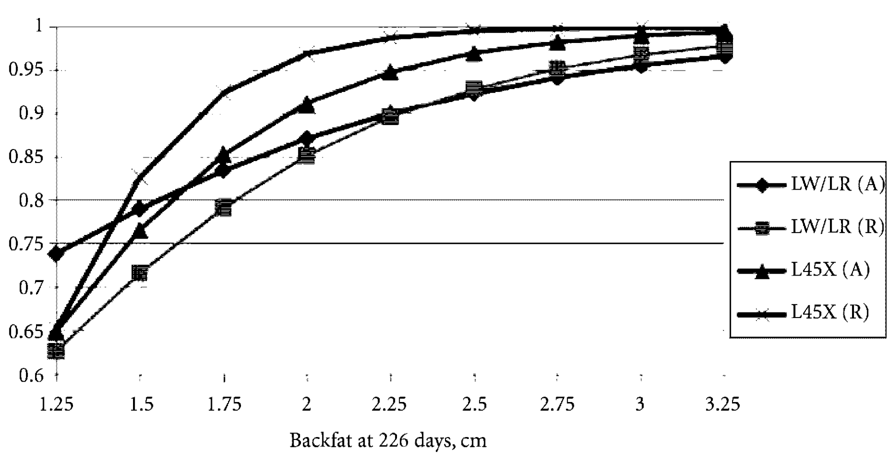

Figure 3. Effect of 226-day backfat on probability of pubertal estrus.

Relationships between weight at 123 days of age and the probability of expressing a pubertal estrus are illustrated in Figure 1. Response was curvilinear, but in general, the probability of expressing pubertal estrus increased with increasing 123-day weight. The effect was greatest ($P = 0.04$) for L45X gilts developed with restricted energy intake. The effect was not significant in other groups ($0.10 \leq P \leq 0.15$), but trends were similar in that increasing weight was associated with greater probability of reaching puberty. Therefore, heavier gilts at 123 days of age had a greater chance of attaining puberty by 226 days of age and when restricted in energy intake, heavier gilts at the start of the restriction period were more likely to attain puberty than lighter gilts, especially the L45X gilts. Backfat at 123 days was not associated with the likelihood of attaining puberty.

Final weights and scan backfats and longissimus muscle areas were recorded after estrus checking was terminated. However, weight and backfat at 226 days of age were related with the probability a gilt expressed estrus. A strong relationship with weight existed in each line by treatment class ($0.002 \leq P \leq 0.06$), but was greatest for L45X gilts developed with ad libitum access to feed. The probability of expressing estrus was less than 0.6 for L45X gilts that weighed less than 100 kg at 226 days of age. At all weights, the probability of having expressed puberty was 0.65 or greater for all other groups, but it increased with weight up to approximately 120 kg.

The relationship of backfat at 226 days with the probability of having expressed pubertal estrus was similar to that of 226-day weight (Figure 3) but was not significant for any class ($0.11 \leq P \leq 0.35$). The overall trend ($P = 0.11$) was that as backfat increased, the probability of having expressed estrus increased, but depth of backfat at the end of the growing

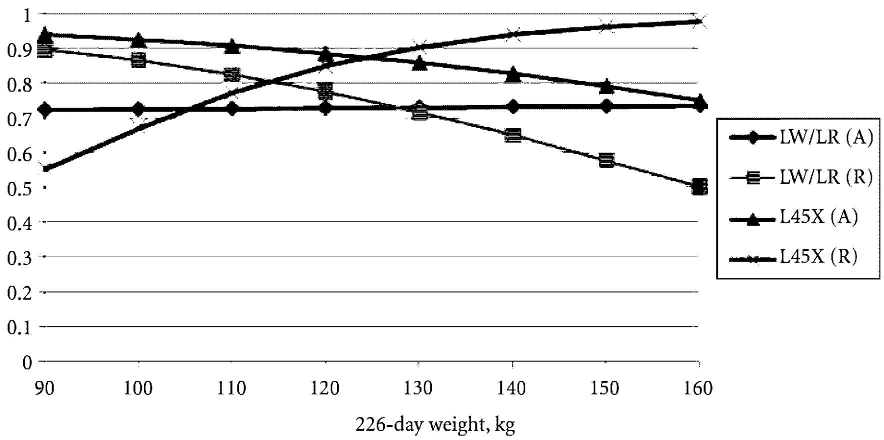

Figure 4. Effect of 226-day weight on the probability gilts produced a parity 1 litter.

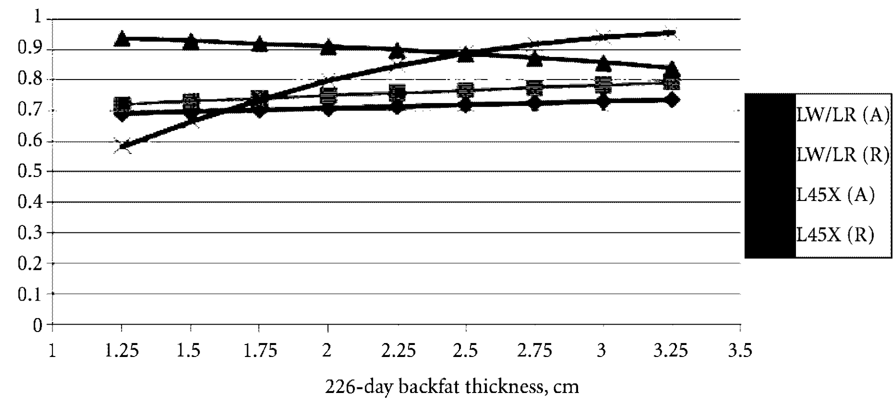

Figure 5. Effect of backfat at 226 days on probability of farrowing a litter.

period was not strongly associated with whether gilts attained puberty. Longissimus muscle area at 226 days was not related with whether gilts attained puberty in any group ($0.09 \leq P \leq 0.22$).

Relationships of 226-day weight and backfat with the probability a gilt farrowed a parity 1 litter are in Figures 4 and 5, respectively. The effect of weight was somewhat odd. For three groups, all except L45X gilts developed with restricted energy intake, the probability of farrowing a litter decreased with increasing weight. However, none of those relationships were significant ($.09 \leq P \leq 0.95$). For L45X gilts developed with energy restriction the probability of farrowing a litter increased ($P = 0.03$) with increasing 226-day weight. Similarly, increased backfat at 226 days was associated with increased probability of farrowing a litter only in L45X gilts developed with restricted energy intake ($P = 0.03$). The probability increased for this group with increasing backfat thickness. The effect was not significant in other groups ($P > 0.15$).

The implications of this research are that if gilts are targeted for breeding at second or later post-pubertal estrus and to farrow by 365 days of age, then the replacement gilt pool must be approximately 10% larger to produce a specified number of litters than if gilts are developed with ad libitum feed intake. Management of gilts early in life is also important. Increased 123-day weight, but not backfat or longissimus muscle area, was associated with increased likelihood of attaining puberty, regardless of which gilt development management regimen was used. For gilts that could be bred at second or later post-pubertal estrus, the likelihood they farrowed a litter and their litter size were not affected by the developmental regimen. It is commonly thought that the likelihood of reproductive success increases for gilts with greater weights and backfats when they enter the breeding herd. However, this result occurred only for L45X gilts developed with restricted energy intake. Therefore, weight and backfat of breeding age gilts are not good predictors of subsequent reproductive performance.

[1]Rodger K. Johnson and Phillip S. Miller are professors; Roman Moreno is a graduate student and research technician in the Animal Science Department; Matthew W. Anderson is manager; and Jeffrey M. Perkins, Kelsey Rhynalds, Trevor J. Glidden, Donald R. McClure, and Thomas E. McGargill are technicians at the UNL Swine Research Farm.