RESEARCH REPORT

ANIMAL SCIENCE

Title: Effects of Nutrition During Gilt Development on Sow Lifetime Productivity of Two Prolific Maternal Lines; **NPB #04-178**

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Industry Summary: Reducing sow culling rates could greatly reduce costs of production in US swine herds. Little previous research has been done to determine whether management of gilts during the development period affects their subsequent longevity as sows. This project found that restricting intake of gilts during the development period resulted in fewer gilts of a lean, fast growing line with two or more estrus periods ready to enter the breeding herd by 235 d of age, but did not affect this proportion of the slower growing line. However, for both lines, restricting intake during the gilt development period enhanced the lifetime production of those females that did enter the breeding herd. Gilts developed with restricted intake produced 15% more live pigs through Parity 4 and weaned 17% more total weight of pigs than those developed with ad libitum intake. Economic analyses are needed to determine the net effect of these two management regimens on herd efficiency.

Scientific Abstract: Reducing sow culling rates could greatly reduce costs of production in US swine herds. Little previous research has been done to determine whether management of gilts during the development period affects their subsequent longevity as sows. Gilts of two prolific lines that differed in lean growth rate were developed with ad libitum access to feed during the entire growing period or with daily restriction of feed to 75% of ad libitum from 123 d of age to breeding. The lines were LW/LR industry cross females or a cross of the NE selection line Line 45 with an industry maternal line (L45X). The same sires were used across both types dams of gilts so that project females of the two crosses were half sibs. Restricting intake reduced weight and backfat deposition similarly in both lines. Weights of gilts entering the breeding herd were 143.3 and 120.3 kg for LW/LR gilts developed with ad libitum or restricted intake, respectively, and 140.8 and 116.8 kg for L45X gilts. Tenth rib backfat depths at these weights were 2.79 and 1.90 cm for LW/LR and 2.88 vs 1.84 for L45X gilts. Significantly fewer LW/LR gilts developed with restricted feeding expressed pubertal estrus during the development period than LW/LR gilts fed ad libitum (78.0 vs 91.5%). Gilt management regimen did not affect the proportion of L45X gilts that expressed pubertal estrus (94.2 vs 97.1% for restricted and ad libitum fed gilts, respectively). Output per breeding female was greater for L45X gilts and for gilts developed with restricted intake. L45X gilts produced 2.37 ($P < 0.01$) more live pigs per breeding female through Parity 4 than LWxLR females. Gilts developed on the restricted feeding regimen produced 2.93 ($P < 0.01$) more live pigs per breeding female than those developed on the ad libitum regimen. When output was expressed per female with a Parity 1 litter, L45X gilts produced 0.79 ($P = 0.24$) more live pigs through Parity 4 than LW/LR. Females developed on the restricted feeding regimen produced 3.7 ($P < 0.01$) more live pigs than those with ad libitum access to feed. An increase in weight at 226 d was associated with increased likelihood of a Parity 1 litter only for L45X gilts developed with restricted feeding (increase in probability of 0.0068 ± 0.0031/kg of weight). An increase of backfat at 226 d was associated with increased likelihood of producing a Parity 1 litter only for LW/LR gilts (ad libitum = 0.013 ± 0.006/mm; restricted = 0.031 ± 0.009/mm). Weight and backfat at Parities 1 and 2 did not affect the likelihood of another litter, but greater weight loss from farrowing to weaning a Parity 1 litter reduced ($P = 0.07$) the liklihood of a Parity 2 litter. Restricting intake during the gilt development period resulted in fewer gilts expressing puberty so that they could be mated at 2^{nd} or later estrus by 235 d of age, but enhanced the lifetime production of females that entered the breeding herd.

Introduction: Many variables contribute to variation in sow mortality and lifetime production, including housing systems, management during gilt development, sow management practices, and use of different genetic lines. In this project, we focused on whether nutritional regimens during gilt development affect longevity and whether the effect differs between two prolific lines that differ in rate of lean growth.

It is generally recommended that gilts be managed to achieve weights of 136 kg (300 lb) or more at breeding and that gilts have adequate backfat at breeding, however, the amount of backfat that is adequate is generally not specified. Producers accomplish these targets with various management practices. Gilts may be developed with ad libitum access to feed until weights of 230 to 250 lb, then feed intake is limited until breeding, with a flush just prior to breeding. Other producers maintain gilts with ad libitum access to feed right up to breeding to ensure target weights are achieved. In most cases, breeders attempt to mate gilts at their second or third post-pubertal estrus and mate sows for subsequent litters within five to 10 days of weaning after a 15 to 23-d lactation period.

Optimum gilt development regimens, however, may depend on the prolificacy of the genetic line and on its rate of lean growth. We initiated an experiment to address the effects of two nutritional regimens during gilt development on sow reproduction and longevity. These regimens were 1) providing ad libitum access to feed during the entire growing period until one week before breeding commenced, and 2) providing ad libitum access to feed until 123 days of age; thereafter until one week before breeding commenced, feed was restricted to 75% of that consumed by gilts on Regimen 1. Nutrients in the diet of Regimen 2 were increased so that gilts consumed the same amounts of protein, vitamins, and minerals per unit of body weight as those on Regimen 1.

Mothers of the gilts were 1) an industry Large White x Landrace cross (LW x LR) or 2) sows of the Nebraska Index Line (L45) that has been selected mainly for increased litter size with some selection for lean growth. Sows of these two lines were inseminated with semen from boars of an industry maternal line; the same boars were used across sow lines. Thus, the experimental gilts were paternal half sibs, with 50% of their genes coming from the industry maternal sire line and the other 50% coming from either industry LW x LR or L45. Both LW/LR and L45 are prolific, but LW/LR have greater rate of lean growth. The experiment was designed to determine whether gilt nutritional development strategies affect longevity and lifetime productivity differently for these two kinds of crossbred females. The output of females developed on these two regimens is reported herein.

Production traits will be used in economic modeling to determine differences in these two management systems on herd economic efficiency.

Objectives: To determine whether alternative gilt development strategies affect longevity and lifetime productivity of two prolific maternal lines.

Materials & Methods:

Production of experimental gilts. Litters from which project gilts were selected were born in three replications. Replication 1 gilts were born beginning December 2004 through the first week of January 2005. Replication 2 gilts were born during May 2005, and Replication 3 gilts were born during November 2005. Dams of these gilts were from two distinctly different maternal lines (see below) that were inseminated with semen from boars of an unrelated industry maternal line (L_M). Project gilts were selected randomly from these litters when pigs were 56 d of age. When possible, at least two gilts were selected per litter so that gilts of each litter could be assigned to each of the two gilt development regimens.

Gilt Population I (LW x LR): Population 1 gilts were the progeny of L_M boars and females of the Large White-Landrace female population that is used routinely in the UNL swine nutrition research program. It is maintained using artificial insemination in a rotation cross between industry Large White (LW) and Landrace (LR) lines. These females are designated as industry LW x LR cross. A total of 260 project gilts were selected from a total of 119 litters, 20 litters in Replication 1, 68 in Replication 2, and 31 in Replication 3.

Gilt Population II (L45X): Population 2 gilts were progeny of the same L_M boars that sired LW x LR gilts. Their mothers were from Generation 23 of the Nebraska line (Line 45) that has been selected for increased litter size. This population is designated L45X. Selection over the generations in the Nebraska line included combinations of ovulation rate, uterine capacity, and litter size at birth. During the last six generations, Line 45 also was selected for increased growth rate, decreased backfat, and increased longissimus muscle area.

A total of 216 project gilts from 87 litters (45, 19, and 23 litters in Replications 1, 2, and 3, respectively) were used. Within each replication, litters were sired by 9 to 10 L_M boars. Thus, the gilts within each replication were half-sib families that contained both LW x LR and L45X gilts.

Management of gilts. At birth, pigs from litters the gilts were born in were crossfostered both within and between sows of the two populations to reduce variation in number of pigs nursed by dams. Litters were weaned at an average age of 13.3 days (Replication 1), 16.7 days (Replication 2), and 15.7 days (Replication 3), with a range from 11 to 19 days. At weaning, pigs were placed in a nursery with 30 pigs per pen where they remained until approximately 56 days of age. Standard nursery diets and management were used.

Gilts were moved from the nursery to a modified-open-front, curtain-sided building (MOF) at an average age of 56.2 days (Replication 1, range = 48 to 61 days), 53.8 days (Replication 2, range = 46 to 63 days), or 72.2 days (Replication 3, range = 61 to 80 days). They were weighed and placed in pens of 10 head per pen by population, age, and litter. All pens were identical with 1/3 slatted and 2/3 solid surface, providing approximately 8.5 sq ft per gilt. Gilts of LW x LR and L45X populations were assigned to alternate pens and littermates were assigned to different pens (e.g., Pens 1 and 3 contained littermates, Pens 2 and 4 contained littermates, etc.) Within each of these pairs of pens within populations, one pen was randomly assigned to Treatment 1 (see below), the other received Treatment 2.

Treatments. Gilts received the same diet and management from when they were placed in the MOF until an average age of 123 days. During that time, they had ad libitum access to a standard corn-soybean meal diet. A three-phase feeding regimen was used. Phase 1 diet contained 1.15% lysine and was fed from 56 days of age to when pigs in a pen averaged 80 lb body weight, Phase 2 diet contained 1.0% lysine and was fed from 80 lb to mean weight of 130 lb, Phase 3 diet contained 0.9% lysine and was fed until gilts were 123 d of age when they were placed on experimental dietary regimens.

Treatment 1 was a feeding regimen in which gilts were provided ad libitum access to feed in a self-feeder during the entire period from 123 d of age until they were moved to the breeding barn approximately one week before breeding commenced. The diet was corn-soybean meal-based and formulated to contain 0.70% lysine, 0.70% Ca, and 0.60% P. All other nutrients met or exceeded requirements for developing gilts outlined in the UNL/SDSU Swine Nutrition Guide (2000).

Gilts on Treatment 2 received a daily allotment of feed by weight that was 75% of that consumed by gilts on Treatment 1. The diet was formulated similar to the diet described for Treatment 1 except that it was fortified to contain 0.93% lysine, 1.0% Ca, and 0.8% P. All trace minerals, except selenium, and vitamins were also increased to compensate for reduced feed intake. Daily intake of all nutrients except energy was expected to be similar for gilts on both diets. The daily allotment was adjusted at two-week intervals and was based on average daily feed intake of gilts of the same population with ad libitum access to feed.

When moved to the MOF and at two-week intervals thereafter, feed delivered to each pen during that interval was recorded, and beginning and ending feeder weights were recorded. Average daily feed intake (ADFI) for pens of gilts with ad libitum access to feed (T1 and T2 before 123 d of age, T1 after 123 d of age) in each pen during each two-week period, and the mid-weight (MW) of gilts in that pen ((mean beginning weight + mean final weight)/2) were calculated. After each weigh-day, quadratic regression equations of ADFI on MW were calculated separately for LW x LR and L45X gilts. Beginning at 123 d of age, predicted MW of gilts in each pen on Treatment 2 during the next two-week period was calculated from past growth and used in the regression equation to calculate the expected average feed intake for the pen if ad libitum access to feed was permitted. The average daily allotment for gilts in that pen during the next period was set at 75% of that value. The allotment of feed was placed on the solid flooring daily in two feedings, one-half at approximately 8:00 am and one-half in late afternoon. At the end of the trial, Replication 1, 2, and 3 gilts averaged 235.8, 218.3, and 225.7 days of age, respectively.

Traits. Gilt weight was recorded at two-week intervals from the beginning to the end of the feeding period, and backfat (BF) and longissimus muscle area (LMA) at the 10th rib were recorded at two-week intervals from when gilts were placed on the feeding regimen at 123 days of age until the end of the feeding regimen.

Beginning when mean age of pigs in each pen was 140 d, heat-checking to determine age at puberty commenced. It was accomplished once daily by moving pigs from each pen to an adjacent building where they were exposed to a boar and observed for the standing response indicative of estrus. The day of first observed estrus was considered to be age at puberty. Heat checking continued until the end of the trial or until all gilts in the pen had been observed in estrus at least twice. Length of estrus, the number of consecutive days they remained in estrus, and the intervals between estrous periods were recorded.

All gilts that had expressed estrus and could be mated at 2^{nd} or later estrus were moved to the breeding facility approximately one week after the feeding period ended. Gilts were approximately 235 days of age. They were observed twice daily for estrus and were inseminated each day they were in estrus with pooled semen from an industry terminal sire line. A restricted breeding period of 25 days (Rep 1), 24 days (Rep 2), and 26 days (Rep 3) was used to match the unit's production schedule. Gilts that did not express estrus, those that were mated but diagnosed open with an ultrasound pregnancy test 50 days post-breeding, and those that were diagnosed pregnant but did not farrow a litter were culled. In addition, lame gilts and those in poor health were culled.

After weaning litters, all sows were returned to the breeding area, checked for estrus daily, and inseminated with pooled terminal sire semen each day they were in estrus. The breeding period for sows ranged from 24 to 32 d across replicates from when the first sow in a replication farrowed and was such that all sows were given at least 10 days to express estrus and be inseminated. Sows that did not express estrus during that period were culled.

All gilts and sows were fed alike during the breeding, gestation, and lactation periods. Diets were formulated according to the UNL/SDSU Swine Nutrition Guide (2000). From when they were moved to the breeding area until inseminated, gilts were flushed with approximately 6 lb of feed daily. Gilts and sows received approximately 4.0 lb of feed during the gestation period until approximately 90 days of gestation when daily allotment of feed was increased to approximately 5.0 lb. Pregnant females were moved to farrowing rooms at approximately 110 days of gestation. A limited amount of feed was fed on the day of farrowing and the following day and then sows were allowed ad libitum access to feed until weaning their litters at approximately 17 days (range of 11 to 20 days).

Sows were weighed and 10^{th} rib backfat was recorded when they were moved to the farrowing room and when they weaned their litter.

Analyses: Final gilt development weight, backfat and loin area, and age at puberty were analyzed with a model including line, gilt development regimen, their interaction, and the random effects of litter and replication. Sow weight, backfat, and litter traits were analyzed with a model that accounted for line, gilt development treatment, and their interaction. Replication effect was accounted for as a random effect and because littermate gilts were assigned to treatments, effects of litter gilts were born in and repeated measures on sows were accounted for as random effects. Pigs were transferred among litters within one day of birth. Number of pigs after transfer and age of litters at weaning were included in models for number and weight of pigs at weaning to adjust to average number nursed by sows and to average weaning age. Differences in survival rate during the gilt development period were tested with chi-square.

Reproductive success rates were analyzed using non-linear mixed models assuming binomial distributions. Gilts that expressed estrus during the development period were coded as 1, those that did not were coded as 0. Then, based on females designated for breeding, each female was coded as 1 if she farrowed a litter at Parity 1, Parity 2, Parity 3, and Parity 4 and 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. Performance variables were fitted as covariates to estimate their effect on whether sows reproduced. Variables fitted for Parity 1 scores were gilt final test weight, backfat, longissimus muscle area, and age at puberty. Variables fitted to Parity 2 scores were the sow's Parity 1 total litter size born, total weight of litter weaned, pre-farrowing sow weight and backfat, sow weight and backfat at weaning, and weight and backfat loss from farrowing to weaning. These same variables recorded in Parity 2 and Parity 3 sows were fitted in models analyzing success/failure to produce a Parity 3 and a Parity 4 litter.

Total number of pigs produced per female through Parity 4 was calculated for each sow based first on all females that entered the breeding herd (those females that did not produce a Parity 1 litter were credited with a 0), and second based only on those sows that produced a Parity 1 litter. These two measures of lifetime production, designated LNBA1 and LNBA2, were fitted to models to estimate line, treatment and interaction effects. Total weight of litter weaned was analyzed similarly, but with a model that assumed normality.

Results:

Figure 1 illustrates feed intake during each 14-day period for gilts of each line-replication-diet subclass. Intake for gilts on restricted intake averaged approximately 80% of that of gilts with ad libitum access to feed. Figure 2 illustrates weight at each age for gilts of each line-diet subclass, averaged across replications, and backfat and loin eye at each age are illustrated in Figures 3 and 4, respectively. LWxLR gilts grew faster ($P < 0.05$) than L45X cross gilts, whereas L45X cross gilts had more backfat at the same weight. Restricting feed intake caused similar reductions in weight and backfat for gilts of both lines. Gilts on both treatments had similar loin eye area relative to body weight. Therefore, restricting daily intake of energy, without restricting intake of other nutrients, reduced rate of fat deposition, but did not affect muscle development.

Figure 1. Average daily feed intake, kg, for LWxLR and L45 cross gilts during each two-week period from 53 to 235 d of age fed ad libitum (A) throughout or ad libitum to 123 d and restricted (R) thereafter

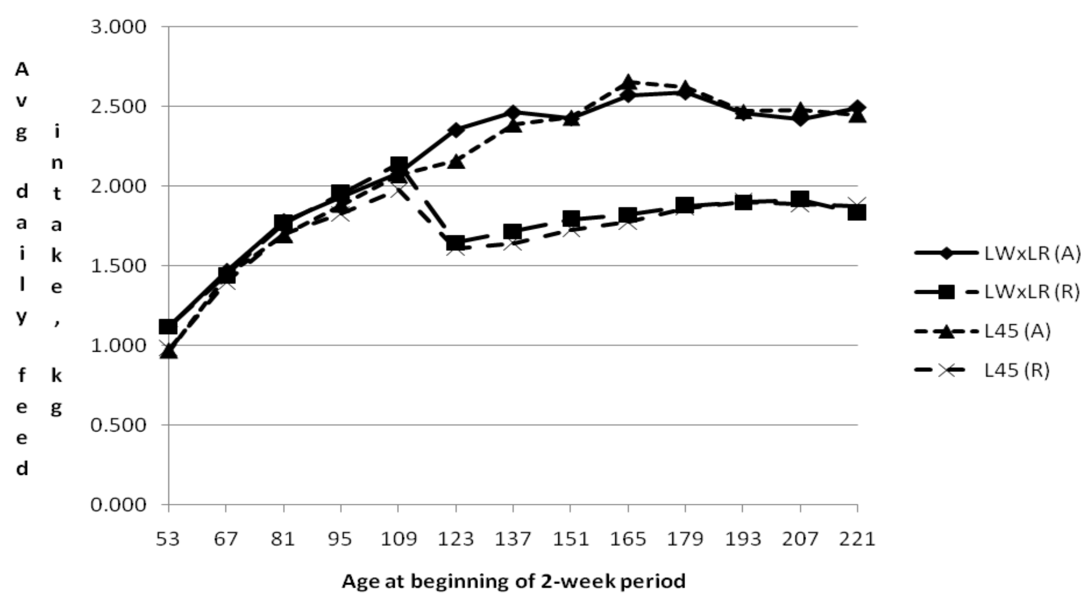

Figure 2. Weight, kg, for LWxLR and L45 cross gilts during each two-week period from 53 to 235 d of age fed ad libitum (A) throughout or ad libitum to 123 d and restricted (R) thereafter

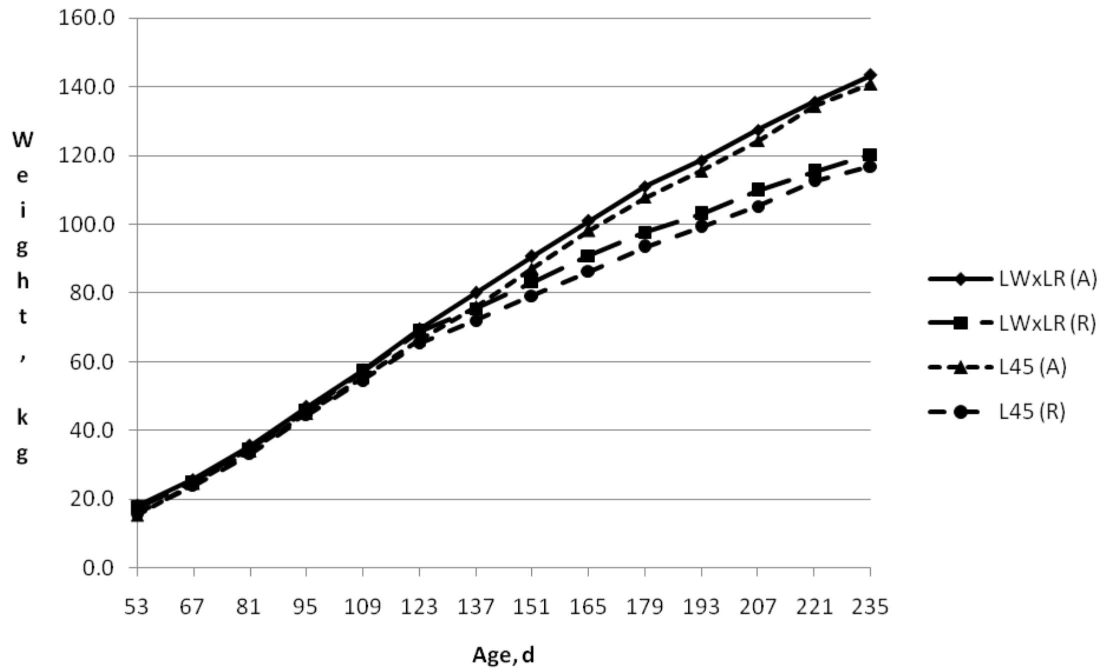

Figure 3. Backfat, cm, for LWxLR and L45 cross gilts during each two-week period from 123 to 235 d of age fed ad libitum (A) throughout or ad libitum to 123 d and restricted (R) thereafter

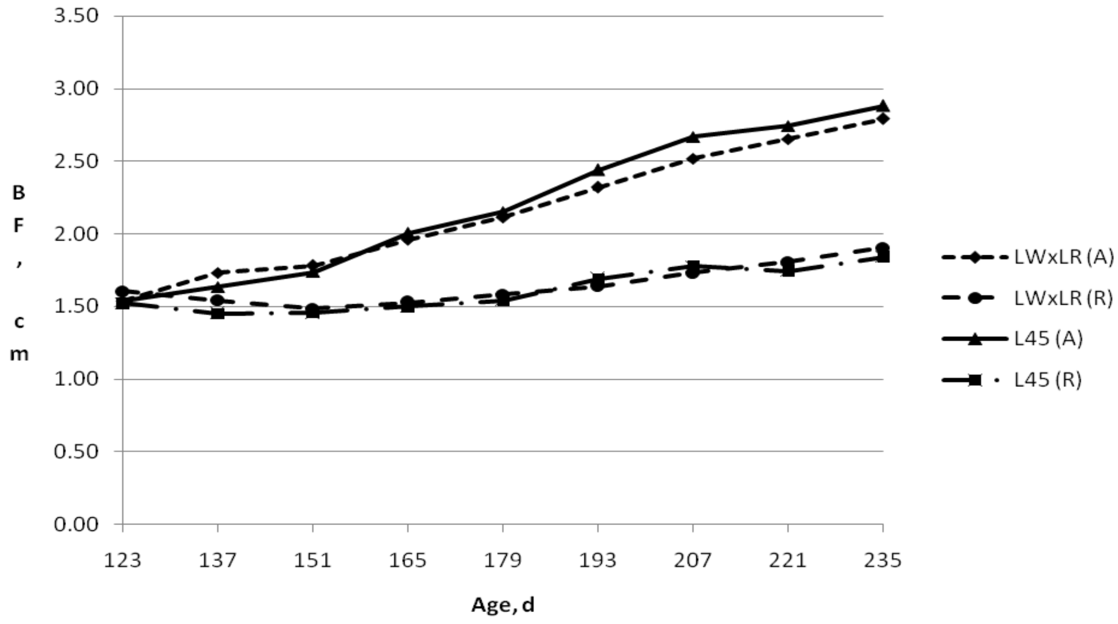

Figure 4. LMA, cm², for LWxLR and L45 cross gilts during each two-week period from 123 to 235 d of age fed ad libitum (A) throughout or ad libitum to 123 d and restricted (R) thereafter

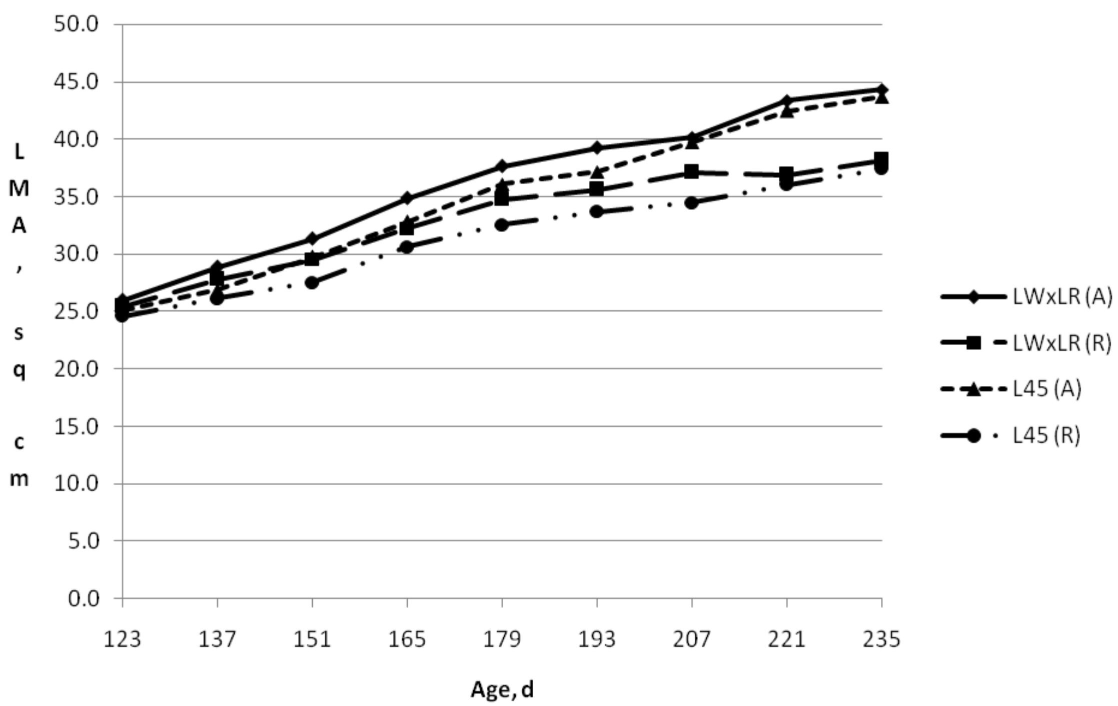

Table 1 contains numbers of gilts of each line and treatment at each stage of the experiment. Losses during the gilt development period due to unthrifty pigs and death of pigs averaged 1.9% and did not differ between lines or between gilt development treatments. However, percentage of gilts expressing estrus differed ($P < 0.05$) between lines, averaging 96% for L45X gilts and 87% for LW x LR gilts. Gilt development regimen did not affect proportion of L45X gilts that expressed puberty. However, 91.5% of LW x LR gilts developed with ad libitum access to feed expressed puberty whereas only 78% of those developed with restricted feed intake expressed puberty ($P < .05$).

Table 1. Number of gilts at beginning (d123) and end (d226) of the developmental period, number expressing pubertal estrus (AP) and number of litters at each parity

	Developmental period			Litters at each parity			
Item	D123	D226	AP	P1	P2	P3	P4
LW x LR	260	256	217	147	91	68	35
L45 X	211	206	197	149	85	65	31
AL	235	232	218	156	83	62	35
R	236	230	196	140	93	71	31
Total	471	462	414	296	176	133	66

Table 2 contains lifetime production for females of the two genetic types and for females developed on the two gilt developmental regimens. When output was expressed per breeding female, there was no interaction between genetic type of gilt and gilt development regimen. L45X females produced 2.4 live pigs more per breeding female than LW x LR females ($P < 0.01$) and total weight of litters weaned was also 6.1 kg greater. Gilts developed with restricted feed intake produced 2.9 live pigs more ($P < 0.01$) during their lifetime than gilts developed on ad libitum intake and they produced more total litter weight at weaning (103.3 vs 88.4 kg; $P < 0.01$).

Table 2. Summary of reproductive success rate for LW x LR females and females developed with either ad libitum, AL, or restricted, R, intake

Item	No. Breeding females	Total No. Litters	Litters/breeding female	Live born pigs per breeding female	Total litter weaning weight per breeding female, kg
LW x LR	198	355	1.79	20.45	92.56
L45X	181	349	1.93	23.01	98.69
AL	199	345	1.73	20.28	88.44
R	180	359	1.99	23.22	103.28

Table 3 contains mean weight and backfat at farrowing and weaning through parity 3. LW x LR sows were heavier than L45X sows at Parity 1 and 2, but lines did not differ significantly in backfat. Females developed with ad libitum intake during the gilt development period weighed more and had more backfat at Parity 1 than those developed with restricted feeding, but females developed on the two treatments did not differ in weight or backfat thereafter. An increase in weight at 226 d was associated with increased likelihood of a P1 litter only for L45X gilts developed with restricted feed intake (0.0068 ± 0.0031/kg). An increase of backfat at 226 d of age was associated with increased likelihood of producing a P1 litter only for LW × LR gilts (ad libitum= 0.013 ± 0.006/mm; restricted = 0.031 ± 0.009/mm). Weight and backfat at P1 and P2 did not affect the likelihood of another litter, but greater weight loss from farrowing to weaning reduced (*P* = 0.07) the liklihood of a P2 litter.

Table 3. Probabilities associated with line and treatment effects and mean sow farrowing weight, kg, (FWt) and backfat, mm, (FBF) and sow weaning weight (WWt) and backfat (WBF) at Parities 1, 2, and 3

	Parity 1					**Parity 2**					**Parity 3**			
	FWt	FBF	WWt	WBF		FWt	FBF	WWt	WBF		FWt	FBF	WWt	WBF
	P-values													
Line	0.01	.64	.03	.4		.02	.5	.12	.18		.42	.5	.43	.69
Trt	0.01	<.01	.67	<0.01		.63	.4	.96	.79		.99	.8	.93	.83
Line*trt	0.19	.88	.09	0.17		.21	.9	.86	.58		.23	.6	.56	.80
	Means													
LW/LR	209	24.6	164	21.2		216	21	187	19.0		219	18	201	17.0
L45X	203	24.3	157	20.6		207	20	183	18.1		217	18	198	16.7
AL	208	26.1	160	22.0		211	21.0	185	18.6		218	18	200	16.9
R	203	22.8	161	19.8		212	20.0	185	18.5		218	18	200	16.8

Discussion:

Gilts of the two lines were affected similarly by restricted feed intake, but their reproduction was different. Restricting feed intake during the gilt development period did not affect the proportion of L45X gilts that expressed puberty, but it significantly reduced this proportion for the faster growing, leaner LW/LR cross gilts. Therefore, restricting feed intake was detrimental to the early development of one line, but not the other.

Lifetime productivity of the lines differed and it was affected by gilt development feeding regimen. L45X gilts produced 2.37 (*P* < 0.01) more live pigs than LWxLR females per breeding female through Parity 4. Gilts developed on the restricted feeding regimen during development produced 2.93 (*P* < 0.01) more live pigs per breeding female than those developed on the ad libitum regimen. When output was expressed per female with a Parity 1 litter, L45 X gilts produced 0.79 (*P* = 0.24) more live pigs than LW/LR and females developed on the restricted regimen produced 3.7 (*P* < 0.01) more live pigs than those on ad libitum.

Weight and backfat had different effects in the two lines on whether females reproduced. An increase in weight at 226 d was associated with increased likelihood of a P1 litter only for L45X, restricted gilts (0.0068 ± 0.0031/kg). An increase of backfat at 226 d was associated with increased likelihood of producing a P1 litter only for LW × LR gilts (AL= 0.013 ± 0.006/mm; R = 0.031 ± 0.009/mm). Weight and backfat at P1 and P2 did not affect the likelihood of another litter, but greater weight loss from farrowing to weaning reduced (P = 0.07) the liklihood of a P2 litter.

Restricting intake during the gilt development period affected genetic lines differently. In the leaner line, fewer gilts expressed puberty so that they could be mated at 2nd or later estrus by 235 d of age, but restricting intake did not affect proportion of gilts expressing puberty in the slower growing line. However, in both lines restricting intake enhanced the lifetime production of females that entered the breeding herd.

Publications.

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