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Effects of Increasing Standardized Ileal Digestible Lysine During Gestation on Growth and Reproductive Performance of Gilts and Sows Under Commercial Conditions

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Effects of Increasing Standardized Ileal Digestible Lysine During Gestation on Growth and Reproductive Performance of Gilts and Sows Under Commercial Conditions

Abstract

A study was conducted on a commercial sow farm to evaluate the effects of increasing dietary standardized ileal digestible (SID) lysine (Lys) intake in gestation on sow performance and piglet birth weight. A total of 936 females (498 gilts, 438 sows; Camborough, PIC, Hendersonville, TN) were group-housed (approximately 275 females per pen) and individually fed with electronic sow feeders (ESF). Scales were located in the alleyway after the feeding stations returning into the pen. Females were moved from the breeding stall to pens on d 4 of gestation and were allotted to 1 of 4 dietary treatments on d 5. Dietary treatments included increasing SID Lys intake (11, 13.5, 16, and 18.5 g/d). Gilts and sows received 4.6 and 5.1 lb/d, respectively, (5.3 and 5.7 Mcal NE/d) of feed throughout the entire study. Dietary treatments were achieved by different blends of low (0.48% SID Lys) and high (0.88% SID Lys) Lys diets via ESF based on the females' set feed allowance. Initial and final BW and backfat were obtained on d 4 and 112 of gestation. Individual piglet BW was obtained within 12 h of birth on litters from 895 females. Data were analyzed using the GLIMMIX procedure of SAS.

Body weight at d 112 of gestation increased within each parity group (linear, $P < 0.001$) as SID Lys increased with gilts and sows consuming 18.5 g/d SID Lys weighing 16 and 11 lb more, respectively, than gilts and sows consuming 11 g/d SID Lys. There was no evidence for differences in d 112 backfat depth. Average total born for gilts and sows was 15.3 and 16.0, respectively with no evidence for differences among treatments. However, the percentage of pigs born alive increased ($P = 0.006$) with increasing SID Lys intake for sows but not in gilts. This is explained by the treatment × parity group interaction ($P = 0.043$) for percentage of stillborn pigs. In gilts, there was no evidence for differences among treatments in the percentage of stillborn pigs; however, in sows, as dietary SID Lys intake increased, the percentage of stillborn pigs decreased (linear, $P = 0.002$). Increasing SID Lys intake during gestation did not affect the percentage of mummified fetuses, total born, or born alive piglet birth weight in this study. In addition, increasing SID Lys intake during gestation did not affect subsequent reproductive performance. In conclusion, increasing dietary SID Lys intake in gestation increased female BW, without changing backfat or total born litter weight, indicating these females are depositing more lean tissue. The impact on female reproductive performance suggests that increasing SID Lys intake may increase the percentage of piglets born alive by reducing the number of stillborns in sows, but not in gilts.

Keywords

gilt, gestation, lysine, sow

Cover Page Footnote

Appreciation is expressed to Thomas Livestock Company (Broken Bow, NE) for providing the animal and research facilities and to Tim Friedel, Steve Horton, and Jose Hernandez for technical assistance. We would also like to thank ADM Animal Nutrition (Decatur, IL) and Genus PIC (Hendersonville, TN) for their financial and onsite support.

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Effects of Increasing Standardized Ileal Digestible Lysine During Gestation on Growth and Reproductive Performance of Gilts and Sows Under Commercial Conditions[1]

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Summary

A study was conducted on a commercial sow farm to evaluate the effects of increasing dietary standardized ileal digestible (SID) lysine (Lys) intake in gestation on sow performance and piglet birth weight. A total of 936 females (498 gilts, 438 sows; Camborough, PIC, Hendersonville, TN) were group-housed (approximately 275 females per pen) and individually fed with electronic sow feeders (ESF). Scales were located in the alleyway after the feeding stations returning into the pen. Females were moved from the breeding stall to pens on d 4 of gestation and were allotted to 1 of 4 dietary treatments on d 5. Dietary treatments included increasing SID Lys intake (11, 13.5, 16, and 18.5 g/d). Gilts and sows received 4.6 and 5.1 lb/d, respectively, (5.3 and 5.7 Mcal NE/d) of feed throughout the entire study. Dietary treatments were achieved by different blends of low (0.48% SID Lys) and high (0.88% SID Lys) Lys diets via ESF based on the females' set feed allowance. Initial and final BW and backfat were obtained on d 4 and 112 of gestation. Individual piglet BW was obtained within 12 h of birth on litters from 895 females. Data were analyzed using the GLIMMIX procedure of SAS.

Body weight at d 112 of gestation increased within each parity group (linear, $P < 0.001$) as SID Lys increased with gilts and sows consuming 18.5 g/d SID Lys weighing 16 and 11 lb more, respectively, than gilts and sows consuming 11 g/d SID Lys. There was no evidence for differences in d 112 backfat depth. Average total born for gilts and sows was 15.3 and 16.0, respectively with no evidence for differences among treatments. However, the percentage of pigs born alive increased ($P = 0.006$) with increasing SID

[1]Appreciation is expressed to Thomas Livestock Company (Broken Bow, NE) for providing the animal and research facilities and to Tim Friedel, Steve Horton, and Jose Hernandez for technical assistance. We would also like to thank ADM Animal Nutrition (Decatur, IL) and Genus PIC (Hendersonville, TN) for their financial and onsite support.

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Lys intake for sows but not in gilts. This is explained by the treatment × parity group interaction ($P = 0.043$) for percentage of stillborn pigs. In gilts, there was no evidence for differences among treatments in the percentage of stillborn pigs; however, in sows, as dietary SID Lys intake increased, the percentage of stillborn pigs decreased (linear, $P = 0.002$). Increasing SID Lys intake during gestation did not affect the percentage of mummified fetuses, total born, or born alive piglet birth weight in this study. In addition, increasing SID Lys intake during gestation did not affect subsequent reproductive performance. In conclusion, increasing dietary SID Lys intake in gestation increased female BW, without changing backfat or total born litter weight, indicating these females are depositing more lean tissue. The impact on female reproductive performance suggests that increasing SID Lys intake may increase the percentage of piglets born alive by reducing the number of stillborns in sows, but not in gilts.

Introduction

Sow herds continue to increase in productivity, with some of today's most prolific females producing 35 pigs per sow per year. One of the major concerns with this increase in litter size is the resulting decrease in piglet birth weight. This has led to a growing emphasis on redefining nutrient requirements for sows, specifically dietary Lys.

Previous research has indicated that an increase in dietary Lys during mid to late gestation increased litter birth weight[5,6]; however, total born from these studies ranged from 9.3 to 11.1 pigs per litter. The average total born reported for 2015 industry productivity analysis[7] was 13.5 ± 1.0. A more recent study from a prolific commercial sow farm (14.5 total born) indicated that increasing SID Lys intake following d 90 of gestation did not significantly affect piglet birth weight.[8] These results indicate the need for a better understanding of the effects of increased dietary Lys throughout gestation on sow weight gain, reproductive performance and specifically piglet birth weight. Therefore, the objective of this study was to evaluate the effect of SID Lys intake during gestation on weight gain and reproductive performance of gilts and sows.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The experiment was conducted at a commercial sow farm in central Nebraska. Females were individually housed in stalls (gilts: 1.8 × 6.9 ft and sows: 2.0 × 7.5) from d 0 to 4 of gestation, then were group-housed from d 4 to 112 of gestation. Pens for gilts provided 20.0 ft^2 per gilt and those for sows provided

[5]Yang, Y., S. Heo, Z. Jin, J. Yun, P. Shinde, J. Choi, B. Yang, and B. Chae. 2008. Effects of dietary energy and lysine intake during late gestation on lactation on blood metabolites, hormones, milk composition and reproductive performance in multiparous sows. Archives of Animal Nutrition. 63:10-21. doi: 10.1080/17450390701780227.

[6]Zhang, R. F., Q. Hu, P. F. Li, L. F. Xue, X. S. Piao, and D. F. Li. 2011. Effects of lysine intake during middle to late gestation (day 30 to 110) on reproductive performance, colostrum composition, blood metabolites and hormones of multiparous sows. Asian-Aust. J. Anim. Sci. 24,8:1142-1147. doi: 10.5713/ajas.2011.10449.

[7]Stalder, K. J. 2015. Pork industry productivity analysis. National Pork Board, Des Moines, IA.

[8]Gonçalves, M. A. D., K. M. Gourley, S. S. Dritz, M. D. Tokach, N. M. Bello, J. M. DeRouchey, J. C. Woodworth, and R. D. Goodband. 2016. Effects of amino acids and energy intake during late gestation on high-performing gilts and sows on litter and reproductive performance under commercial conditions. J. Anim. Sci. 2016. 94:1993-2003. doi:10.527/jas2015-0087.

22.0 ft^2 per sow. Each pen was equipped with 6 electronic feeding stations (ESF; Nedap Velos, Gronelo, Netherlands) allowing for up to 45 females per station and 28 nipple waterers to provide *ad libitum* access to water. Females were group-housed in dynamic groups (275 females per pen), meaning serviced sows were entering the group (approximately d 4 of gestation) as the sows due to farrow were exiting (approximately d 112 of gestation). This occurred over a 3 to 4-wk period, thereafter, the pen remained static (no movement of newly bred sows into the pen) until the sows reached d 112 of gestation and the process repeated. Each pen was equipped with a scale (5.7 ft long × 3.5 ft wide, Nedap Velos, Gronelo, Netherlands) located in the alleyway following the feeding stations and prior to returning to the pen for individual sow weight collection every time the sow exited the feeding station.

The study was conducted over a 159-day period, from early March to late August, 2017. A total of 1,150 females (Camborough, PIC, Hendersonville, TN) were enrolled in the study, of which 936 completed. Females were removed from the data set due to death or culling decisions, removal from the pen, or adjustments in feed intake attributed to body condition evaluation. At d 4 of gestation, as females were moved from the breeding stall to pens, females were weighed, and backfat measurements were collected at the last rib, 3 inches from the mid-line of the back using a Lean-Meater (RENCO, Minneapolis, MN). Females were blocked by BW within each day of enrollment and were randomly assigned to 1 of 4 dietary treatments within block. Dietary treatments were corn-soybean meal-based and consisted of increasing SID Lys intake (11, 13.5, 16, and 18.5 g/d). Gilts and sows received 4.6 and 5.1 lb/d (5.3 and 5.7 Mcal NE/d), respectively of feed throughout the entire study. Dietary treatments were achieved by different blends of a low (0.48% SID Lys) and high (0.88% SID Lys) Lys diet via the ESF based on the females' set feed allowance. Low and high Lys diets were achieved by changing the amounts of corn and soybean meal. Dietary energy (NE, kcal/lb) was the same across the low and high Lys diets and all other nutrients met or exceeded the NRC (2012) requirement estimates (Table 1). Experimental diets were manufactured at the Thomas Livestock Feed Mill in Merna, NE.

On d 112 of gestation, as females were moved from the pens to the farrowing house, they were weighed and backfat measurements were collected. Upon entry into the farrowing house, females were provided with *ad libitum* access to a lactation diet containing 1.20% SID Lys. Individual piglet BW was obtained within 12 h of birth on litters from 895 females. Piglets born alive, stillborn, and mummified fetuses were identified and weighed. The coefficient of variation (CV) of birth weight within litter was calculated by dividing the individual piglet birth weight standard deviation (SD) by the average piglet birth weight of that specific litter for both total piglets born and piglets born alive. Due to the commercial setting, cross fostering occurred regardless of dietary treatment immediately after piglets were weighed. Thus, the number of pigs reported in this study as weaned is a measure of nursing pressure exhibited on the sow. Subsequent performance (farrowing rate, total born, number born alive, mummies, and stillborn piglets) were collected from sows remaining in the herd on their subsequent parity using the PigCHAMP Knowledge Software (Ames, IA). Adjusted farrowing rate was reported and excludes bred females that died or were removed for non-reproductive reasons. The wean-to-estrus interval (WEI) was also determined as the number of days between weaning and when sows were first serviced. The percentage bred by 7 d after weaning was also calculated.

Chemical Analysis

Low and high dietary treatment samples were collected weekly during the time of feeder calibration. In addition, dietary samples were collected for each treatment via ESF each week. This was done by designating a known RFID transponder to each of the dietary treatments for both the gilt and sow daily feed allowances. The total diets were dispensed by the ESF into the feeder bowl, mixed, and samples were then collected. All samples were analyzed weekly at a commercial laboratory (Ward Laboratories, Kearney, NE) for dry matter, crude protein, calcium, and phosphorus (Table 2). At the conclusion of the trial, 6 composite samples of the low and high dietary treatments were analyzed for complete amino acid concentration (University of Missouri Experimental Station Chemical Laboratories, Columbia, MO; Table 3).

Data Analysis

Prior to data analysis, descriptive statistics in the form of means were generated using the PROC MEANS statements in SAS (Version 9.4, SAS Institute Inc., Cary, NC). Data were analyzed using generalized linear mixed models whereby the linear predictor included dietary treatment, parity group (gilts and sows) and all interactions as fixed effects, as well as the random effect of block. As specified, models recognized the individual female as the experimental unit for this study. Day 4 BW, d 112 BW, d 4 backfat, d 112 backfat, total born, total born piglet BW, born alive, born alive piglet BW, and number weaned were each fitted assuming a normal distribution of the response variable. In these cases, residual assumptions were checked using standard diagnostics on residuals and were found to be reasonably met. Day 4 BW was used as a covariate in the analysis for d 112 BW, improving the model fit (BIC). The percentage of piglets born alive, stillbirths, mummified fetuses, and the percentage of litters with one or more stillbirths, females bred by 7 d after weaning, farrowing rate, and adjusted farrowing rate were each analyzed using a binomial distribution. Two sows were deleted from the data set with stillborn values of 9 and 10. These two observations generated studentized residuals more extreme than +/- 3 standard deviations and were thus deemed as outliers and consequently removed from the data set. Furthermore, the CV of birth weight within the litter considering total piglets born and piglets born alive were approximated with a β distribution, as all observed values lay between 0 and 1. Overdispersion was assessed using a maximum-likelihood-based Pearson χ^2/degrees of freedom statistic and accounted for as needed.[9] The final models used for inference were fitted using restricted maximum likelihood estimation. Degrees of freedom were estimated using the Kenward-Rogers approach. Estimated means and corresponding standard errors (SEM) are reported for all interactive means. Results were considered significant at $P \leq 0.05$ and marginally significant at $0.05 > P \leq 0.10$.

Results and Discussion

Chemical analyses of dry matter, crude protein, calcium, phosphorus, and amino acids were similar to the formulated values (Tables 2 and 3). There was no evidence for

[9]Stroup, W. W. 2012. Generalized linear mixed models: Modern concepts, methods and applications. CRC Press, Boca Raton, FL.

differences ($P > 0.05$) among dietary treatments on d 4 sow BW, which validates the randomization of females to treatment (Table 4).

There was no evidence for an interaction between treatment and parity for d 112 BW ($P > 0.05$) (Table 4). Body weight at d 112 increased within each parity group (linear, $P < 0.001$) as SID Lys intake increased with gilts and sows consuming 18.5 g/d SID Lys weighing 16 and 11 lb more, respectively, than gilts and sows consuming 11 g/d SID Lys. There was no evidence for differences ($P > 0.05$) in d 4 or d 112 backfat among dietary treatments for gilts or sows. On average, gilts and sows gained 1.8 and 3.4 mm, respectively, of backfat throughout gestation. These results showing increased weight gain without backfat gain suggest that females deposited more lean tissue with increasing SID Lys intake. Our results were not consistent with Zhang et al.[6] who reported that increasing dietary Lys from d 30 to 110 of gestation not only increased sow body weight but also backfat thickness. It is unknown if the duration of feeding increasing dietary Lys is the result of these discrepancies or the result of another unknown factor.

There was no evidence for any effects of dietary treatments on farrowing rate or adjusted farrowing rate ($P > 0.05$) during the treatment period. Average total born for gilts and sows was 15.3 and 16.0 with no evidence for differences ($P > 0.05$) among treatment groups. Similarly, there was no evidence for differences in the number of piglets born alive; however, the percentage of piglets born alive increased ($P = 0.006$) with increasing SID Lys intake among sows.

There was evidence for a treatment × parity group interaction ($P = 0.043$) for percent of stillborn piglets. For sows, increasing SID Lys intake decreased (linear, $P = 0.002$) the percentage of stillborn piglets with no difference observed in gilts. There was no evidence for differences among treatment groups for the percentage of mummified fetuses. There was no evidence for differences ($P > 0.05$) among treatment groups for total born piglet birth weight or born alive piglet birth weight. This is in contrast to results from previous research where an increase in Lys intake in mid to late gestation increased piglet birth weight.[5,6] Born alive piglet birth weight averaged 2.8 lb for gilts and 2.9 lb for sows. There was marginal evidence for a treatment by parity group interaction ($P = 0.073$) for the within litter birth weight CV for total piglets born. For gilts, within-total born litter birth weight CV decreased then increased (quadratic, $P = 0.029$) with increasing SID Lys intake, though no difference was observed in sows. There was no evidence for differences in the within-litter birth weight CV for piglets born alive among dietary treatments. There was no evidence for differences ($P > 0.05$) among treatment groups for the number of piglets weaned or in the percentage of females bred by 7 d after weaning. There was marginal evidence that increasing gestation SID Lys intake from 11.0 to 13.5 g/d increased WEI, thereafter decreasing WEI from 13.5 to 18 g/d (quadratic, $P = 0.096$).

For the subsequent reproductive cycle, there was no evidence ($P > 0.05$) for any effects of dietary treatments on farrowing rate, adjusted farrowing rate, total number of piglets born, number of piglets born alive, percentage of piglets born alive, percentage of stillborn piglets, percentage of mummified fetuses, or piglets weaned.

In conclusion, our results demonstrate that increasing SID Lys intake in gestation increases female BW likely through lean tissue deposition, without increasing adipose tissue deposition. In sows but not in gilts, increasing SID Lys intake may increase the number of piglets born alive by reducing the number of stillborn pigs. Increasing SID Lys intake did not affect piglet birth weight in this study.

Table 1. Diet composition of low- and high-lysine diets (as-fed basis)[1]

	Standardized ileal digestible lysine, %	
Ingredient	0.48	0.88
Corn	71.80	53.20
Soybean meal, 46.5% crude protein	4.20	20.80
DDGS,[2] 8.0% oil	20.00	20.00
Beef tallow	---	2.10
Monocalcium phosphate, 21% P	1.10	1.00
Limestone	1.60	1.50
Salt	0.50	0.50
Liquid lysine, 50%[3]	0.28	0.28
L-Threonine	---	0.09
L-Tryptophan	0.01	---
Methionine hydroxyl analogue	---	0.02
Sow vitamin premix	0.13	0.13
Trace mineral premix	0.15	0.15
Sow add pack	0.10	0.10
Choline chloride, 60%	0.11	0.11
Dye[4]	0.05	0.05
Total	100	100
Calculated analysis		
Standardized ileal digestible (SID) amino acids, %		
Lysine	0.48	0.88
Isoleucine:lysine	85	77
Methionine:lysine	47	35
Threonine:lysine	77	77
Tryptophan:lysine	21	21
Valine:lysine	108	88
Total lysine, %	0.60	1.05
Net energy, kcal/lb	1,135	1,134
Crude protein, %	13.8	20.2
Calcium, %	0.85	0.85
Phosphorus, %	0.60	0.65
Available phosphorus, %	0.47	0.47

[1]Diets were fed from d 4 to 112 of gestation.
[2]DDGS = distillers dried grains with solubles.
[3]ADM (Decatur, IL).
[4]Different colored dyes were added to distinguish among diets at the farm.

Table 2. Chemical analysis of the diets (as-fed basis)[1]

	Standardized ileal digestible lysine, g/d			
Item, %	11	13.5	16	18.5
Dry matter	86.50	88.89	89.06	89.13
Crude protein	14.70	16.37	17.96	19.86
Calcium	0.93	0.92	0.96	0.93
Phosphorus	0.62	0.61	0.63	0.64

[1]Diets were collected weekly and analyses were conducted by Ward Laboratories (Kearney, NE).

Table 3. Total amino acid analysis of low and high treatment diets (as-fed basis)[1]

	Standardized ileal digestible lysine, %	
Item, %	0.48	0.88
Total amino acids, %		
Lysine	0.66	1.10
Isoleucine	0.54	0.85
Leucine	1.50	1.89
Methionine	0.25	0.33
Methionine and cystine	0.53	0.70
Threonine	0.49	0.82
Tryptophan	0.11	0.20
Valine	0.67	0.98
Histidine	0.37	0.53
Phenylalanine	0.68	1.00

[1]Diets were collected weekly and pooled to make composite samples. Six composite samples for the low and high dietary treatments were used for analysis. Total amino acid analyses were conducted by University of Missouri Experimental Station Chemical Laboratories (Columbia, MO).

Table 4. Effects of increasing standardized ileal digestible (SID) lysine intake in gestation on sow growth and piglet birth weight[1]

	Gilts				Sows							
	SID lysine intake, g/d				SID lysine intake, g/d					Probability, $P <$		
Item	11.0	13.5	16.0	18.5	11.0	13.5	16.0	18.5	SEM	Treatment × parity	Linear	Quadratic
N	120	124	129	125	115	109	110	104	---	---	---	---
Parity	1.0	1.0	1.0	1.0	4.4	4.3	4.1	4.3	---	---	---	---
d 4 BW, lb	357.0	356.1	356.3	357.5	469.6	466.6	469.8	469.7	4.08	0.875	0.576	0.316
d 112 BW, lb[2]	471.9	477.2	481.5	488.3	556.3	551.3	564.9	567.5	3.74	0.185	<0.001	0.218
d 4 backfat, mm	17.8	17.8	17.8	17.9	11.8	11.7	11.8	11.9	0.27	0.995	0.711	0.749
d 112 backfat, mm	19.6	19.7	19.6	19.5	15.0	15.1	15.3	15.5	0.32	0.719	0.515	0.986
Farrowing rate, %[3]	94.4	95.1	96.5	95.1	94.6	92.5	97.8	90.8	2.29	0.691	0.747	0.402
Adjusted farrowing rate, %[3,4]	94.4	97.1	96.5	95.1	94.6	94.6	97.8	92.3	2.35	0.719	0.941	0.310
Total born, n	15.3	15.3	15.3	15.3	15.8	16.2	15.9	16.1	0.31	0.910	0.774	0.741
Born alive, n	14.3	14.5	14.5	14.4	14.6	15.1	14.9	15.3	0.29	0.737	0.280	0.583
Born alive, %[3,5]	94.0	95.3	94.8	94.5	92.8	93.6	93.8	95.2	0.62	0.152	0.030	0.538
Stillborn, %[3,6]	2.8	2.2	3.0	2.9	4.6	3.3	3.5	2.3	0.54	0.043	0.109	0.762
Litters with stillborn, %[3,7]	33.9	26.3	33.6	31.3	44.9	36.4	40.0	30.4	4.85	0.553	0.271	0.709
Mummified fetuses, %[3]	3.2	2.4	2.2	2.6	2.5	3.1	2.6	2.5	0.45	0.311	0.221	0.661

continued

Table 4. Effects of increasing standardized ileal digestible (SID) lysine intake in gestation on sow growth and piglet birth weight[1]

	Gilts				Sows							
	SID lysine intake, g/d				SID lysine intake, g/d					Probability, $P <$		
Item	11.0	13.5	16.0	18.5	11.0	13.5	16.0	18.5	SEM	Treatment × parity	Linear	Quadratic
Total born												
Piglet birth weight, lb	2.72	2.76	2.75	2.77	2.89	2.82	2.92	2.82	0.05	0.328	0.823	0.700
Birth weight CV, %[8]	23.5	21.6	20.3	21.8	24.3	25.8	24.9	25.6	0.87	0.073	0.346	0.229
Born alive												
Piglet birth weight, lb	2.78	2.81	2.79	2.81	2.94	2.87	2.97	2.87	0.04	0.719	0.955	0.725
Birth weight CV, %[9]	19.6	18.9	17.8	18.9	21.8	22.9	22.2	23.3	0.64	0.194	0.826	0.249
Piglets weaned, n	13.3	13.5	13.3	13.4	12.7	12.8	13.0	12.9	0.12	0.495	0.361	0.387
Wean-to-estrus interval, d[10]	4.8	5.5	5.0	4.8	4.3	4.5	4.2	4.1	0.26	0.851	0.297	0.096
Females bred by 7 d after weaning, %[3,11]	95.1	91.5	96.1	97.1	97.5	94.7	98.9	98.8	2.71	0.927	0.362	0.548
Subsequent performance[11]												
Farrowing rate, %	88.0	94.5	89.3	90.3	91.6	92.5	89.9	94.2	3.65	0.705	0.886	0.813
Adjusted farrowing rate, %	90.4	94.5	90.3	91.3	91.6	94.6	92.1	94.3	3.34	0.961	0.997	0.599
Total born, n	15.0	15.1	15.7	15.0	16.1	16.0	16.7	16.1	0.34	0.981	0.339	0.140
Born alive, n	14.3	14.3	15.0	14.4	15.2	15.1	15.8	15.1	0.33	0.996	0.265	0.146
Born alive, %	95.5	95.0	95.7	95.9	94.2	94.9	94.7	94.3	0.72	0.629	0.547	0.814
Stillborn, %	1.8	2.3	1.8	2.3	3.1	2.4	3.0	3.2	0.55	0.402	0.544	0.434
Mummified fetuses, %	2.8	2.8	2.8	2.0	3.0	3.1	2.6	2.8	0.49	0.672	0.174	0.569
Piglets weaned, n	12.9	12.9	13.0	13.0	12.5	12.1	12.5	12.3	0.26	0.771	0.767	0.826

[1]A total of 936 females (498 gilts, 438 sows; Camborough, PIC, Hendersonville, TN) were used in a 159-d trial. Reproductive performance and individual piglet birth weights were obtained on litters from 895 females.
[2]Day 4 body weight (BW) was used as a covariate. Linear, $P < 0.001$ for treatment within gilts and linear, $P < 0.001$ for treatment within sows.
[3]Variables were analyzed using a binomial distribution.
[4]Adjusted farrowing rates exclude bred females that died or were removed for non-reproductive reasons.
[5]Linear, $P = 0.006$ for treatment within sows.
[6]Linear, $P = 0.002$ for treatment within sows.
[7]If a female had greater than or equal to 1 stillborn, this variable was recorded as 1. If the female didn't have any stillborns, this variable was recorded as 0.
[8]Quadratic, $P = 0.029$ for treatment within gilts.
[8,9]Variable analyzed using a beta distribution. CV = coefficient of variation.
[10]Quadratic, $P = 0.090$ for treatment within gilts.
[11]Subsequent analysis performed on 733 females.