

Effects of group-size-floor space allowance during the nursery phase of production on future litter size and retention of sows through three parities¹

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ABSTRACT: We previously reported that reduced floor space allowance caused by increasing the number of gilts per pen decreased growth and affected blood chemistry and immunology. The current objective was to determine effects of nursery group-size-floor space allowance on future litter sizes and retention in the breeding herd through three parities in sows. A 3 × 3 factorial arrangement of treatments was employed with 2,537 gilts classified as large (6.92 ± 0.06 kg), medium (5.60 ± 0.06 kg), or small (4.42 ± 0.06 kg), and placed in nursery pens of 14, 11, or 8 pigs to allow 0.15, 0.19, or 0.27 m² floor space/pig, respectively. After the nursery and grow-finish periods, 1,453 gilts selected for breeding were relocated to one of 11 sow farms. Total litter size and pigs born alive increased ($P < 0.01$) with increasing parity and total litter size was 12.94, 13.28, and 13.99 (SE = 0.13) and pigs born alive was 12.21, 12.64, and 13.23 (SE = 0.11) for Parities 1, 2, and 3, respectively. There was a tendency ($P = 0.08$) for a quadratic relationship of group-size-floor space allowance and total litter size (13.39, 13.54, and 13.27 [SE = 0.13] for gilts allowed 0.15, 0.19, or 0.27 m² floor space/pig, respectively). A linear

effect of size of pig at weaning ($P = 0.03$) on pigs born dead was detected and was 0.64, 0.75, and 0.75, for small, medium, and large size pigs, respectively. There was no effect of group-size-floor space allowance on the percentages of gilts completing zero ($P = 0.36$), one ($P = 0.35$), two ($P = 0.32$), or three ($P = 0.50$) parities. In contrast, the percentage of small gilts that failed to complete one parity was greater ($P < 0.05$) and the percentage completing one parity ($P < 0.05$) was less than for either large or medium gilts. Abortion rate was greater ($P < 0.01$) in gilts classified as small (2.51%) or medium (1.36%) at weaning compared with those classified as large (0.20%). Size at weaning did not affect the proportion of gilts completing two ($P = 0.88$) or three ($P = 0.72$) parities. Group-size-floor space allowance during the nursery phase of production did not have remarkable effects on future litter sizes or retention in sows. Likewise, size of pig at weaning did not affect litter size and pigs born alive. Compared with larger pigs, however, more pigs classified as small at weaning and entering the breeding herd did not complete a parity and displayed a greater abortion rate.

Key words: floor space, litter size, nursery, retention, pigs

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INTRODUCTION

The environments to which gilts are exposed prenatally (Estienne and Harper, 2010) or early postnatally (Flowers, 2008) affect future reproductive capacity. For example, farrowing rates and number of pigs born live over three parities were greater for sows raised in litters of seven piglets vs. 10 piglets during lactation. Flowers (2008) suggested that compared with counterparts raised in larger litters, gilts raised in smaller litters had less competition and improved access to nutrition during a critical period of development that resulted in better reproductive performance as an adult. Because pigs on commercial swine farms are weaned after only a 3- to 4-wk suckling period, it is reasonable to speculate that characteristics of the nursery environment may influence reproduction as well. Crowded nursery pens negatively affect pig growth performance (Kornegay and Notter, 1984; Wolter et al., 2000; Brumm et al., 2001) and alter a variety of physiological and hematological systems (Callahan et al., 2017). Kim et al. (2008) found that live pigs born/litter numerically decreased in second parity sows previously exposed to crowding in the nursery. This finding, however, has not been substantiated in trials employing large numbers of experimental animals. Thus, the objective of the study reported herein was to determine, in a commercial production system, the effects of group-size-floor space allowance during the nursery phase of production on litter size and retention in the breeding herd through three parities in sows.

MATERIALS AND METHODS

Farms owned and operated in North Carolina by Smithfield Hog Production Division (Rose Hill, NC) were the sites for the experiment. The Institutional Animal Care and Use Committee of Virginia Tech (Blacksburg, VA) approved the experimental protocol.

Animals, Housing, and Experimental Design

Callahan et al. (2017) described in detail the methods used to rear the pigs during the nursery

phase of production. Briefly, maternal line gilts (Smithfield Premium Genetics, Rose Hill, NC) ($n = 2,537$) (22.3 ± 3.2 d of age [mean \pm SE] and 5.6 ± 0.6 kg BW) from 13 consecutive weekly groups of weaned pigs were utilized. After weaning, gilts were placed in an enclosed nursery barn divided into seven rooms utilizing negative pressure mechanical ventilation and hanging gas furnaces for supplemental heat. Pen floors were woven wire. Rooms contained 40 pens each measuring 1.52×1.52 m. A single nipple waterer was located in each pen. One fence line feeder served two pens with four 15.2-cm-wide feeder spaces for each pen. Pigs received ad libitum access to water and feed formulated for a three-phase dietary program by Smithfield Hog Production Division nutritionists to meet or exceed the requirements for nutrients (NRC, 2012).

Each week, weaned gilts and nonstudy barrows filled a single room. A 3×3 factorial arrangement of treatments included three body sizes at weaning and three floor space allowances. Gilts were visually classified as large (6.92 ± 0.06 kg), medium (5.60 ± 0.06), or small (4.42 ± 0.06), and placed in one of three blocks of six pens each. Floor space treatments (0.27 , 0.19 , and 0.15 m²/pig) were then randomly assigned within each block with two replicate pens per block. The 0.19 m²/pig floor space allowance, achieved by placing 11 pigs in the pen, was normal for this particular nursery. Different floor space allowances were then achieved by placing eight (0.27 m²/pig) or 14 (0.15 m²/pig) pigs/pen. Group size and floor space allowance were confounded because both changed for each treatment. We therefore refer to the treatments as group-size-floor space allowance. There were 851 small, 861 medium, and 825 large pigs, and 1089, 823, and 625 gilts for the 14 gilts/pen (0.15 m²/gilt), 11 gilts/pen (0.19 m²/gilt), and 8 gilts/pen (0.27 m²/gilt) treatments, respectively.

Fifty-six gilts (2.2 %) died during the 56-d nursery phase of production (Callahan et al., 2017), resulting in 2,481 gilts being moved to grow-finish. At the end of the grow-finish phase of production, 1,453 gilts (58.6%) were selected for breeding and each was sent to one of 11 sow farms.

Regardless of the sow farm, females were managed according to standard Smithfield Hog Production Division protocols, and farm staff had no knowledge of prior treatments of gilts. Upon arrival, gilts were permitted daily fence-line contact with mature boars for detection of estrus and were bred at second or third estrus. After weaning of each litter, sows were allowed daily boar exposure as well. Gilts and weaned sows were inseminated on the same day that estrus was detected and then every 24 h for the duration of standing estrus. An insemination was performed using a standard trans-cervical AI catheter (Golden Pig; IMV, Maple Grove, MN) and 2.0×10^9 morphologically normal and motile sperm cells in 80 to 85 mL of extender.

Statistical Analyses

Litter data (total pigs and pigs born alive or dead) were subjected to repeated measures ANOVA using the mixed model procedure of SAS (SAS Institute Inc., Cary, NC). The model included parity (one, two, or three), nursery treatment (group-size-floor space allowance [14, 11, or 8 pigs per pen]), and size of pig (small, medium, or large) when entering the nursery, parity \times treatment, parity \times size, treatment \times size, and parity \times treatment \times size as possible sources of variation. Sow farm was included as a random variable and individual sow served as the experimental unit. For all females selected for breeding and producing zero, one, two, or three parities, overall pigs produced and overall pigs produced alive or dead were summed, and these values, along with the number of parities completed, were subjected to ANOVA using a model that included treatment, size, and treatment \times size as possible sources of variation. Data were checked for normality and homogeneity of variance using tests available in the MIXED procedure of SAS, and these conditions were met for the data used for analyses. Individual means were compared using the LSMEANS option of PROC MIXED and were adjusted using the Tukey–Kramer procedure. Results are reported as least squares means (\pm SE).

Effects of pig size at weaning and group-size-floor space allowance on the percentages of gilts not completing a single parity and various reasons for such as recorded by barn personnel (removed, heat-no service, did not conceive, pregnancy check negative, not-in-pig, or abortion) were analyzed using chi-square procedures. Chi-square procedures also determined effects of pig size and group-size-floor space allowance on the percentages of gilts

that completed or were removed after one, two, or three parities, and reasons for removal (poor body condition, farrowing difficulty, farrowing productivity, lameness, management, reproductive failure, or other). Values were considered significantly different at $P < 0.05$ and trends were declared at $P < 0.10$.

RESULTS

Table 1 summarizes the main effects of parity, gilt size at weaning, and group-size-floor space allowance, on total born and the number of pigs born alive or dead. Two- and three-way interactions among parity, gilt size, and group-size-floor space allowance did not affect ($P > 0.1$) these reproductive characteristics. Both total born and the number of pigs born alive increased linearly ($P < 0.01$) with increasing parity, and there was a quadratic effect of parity ($P = 0.01$) on pigs born dead. Pig size at weaning did not affect ($P = 0.64$) total born. There was, however, a tendency ($P = 0.08$) for group-size-floor space allowance to affect total litter size in a quadratic fashion. Pig size at weaning ($P = 0.98$) and group-size-floor space allowance ($P = 0.18$) did not affect number born alive. There was a linear effect ($P = 0.03$) of size of pig at weaning on pigs born dead. The number of pigs born dead was not affected ($P = 0.63$) by group-size-floor space allowance.

Litter characteristics for all gilts selected for breeding and that completed zero, one, two, or three parities, and the number of completed parities are contained in Table 2. Group-size-floor space allowance \times pig size at weaning did not affect ($P > 0.45$) these characteristics. Total born alive or dead and parities completed were not affected ($P > 0.22$) by size of pig at weaning or group-size-floor space allowance. Moreover, no linear or quadratic relationships were detected with one exception. There was a tendency ($P = 0.09$) for a linear effect of size of pig at weaning on pigs born dead.

A greater ($P < 0.05$) proportion of gilts that were classified as medium or large at weaning were selected for entry to a sow farm and completed one parity compared with small-size gilts (Table 3). Size of gilt at weaning did not affect the proportion of sows completing two ($P = 0.88$) or three ($P = 0.72$) parities. Group-size-floor space allowance did not affect the proportions of gilts selected for breeding ($P = 0.31$) or that completed one ($P = 0.35$), two ($P = 0.32$), or three ($P = 0.50$) parities.

Table 4 contains the main effects of pig size at weaning and group-size-floor space allowance on

Table 1. Main effects of parity of sow, pig size at weaning*, and floor space allowed† during the nursery phase of production on mean litter size through three parities

	Parity of sow					Size of pig at weaning					Nursery floor space allowance, m ² /pig				
	1	2	3	SE	P	Small	Medium	Large	SE	P	0.15	0.19	0.27	SE	P
No. of Litters	1338	1046	895	–	–	969	1159	1151	–	–	1408	1044	827	–	–
Total Born ^{a,b}	12.94	13.28	13.99	0.13	< 0.01	13.33	13.43	13.45	0.13	0.68	13.39	13.54	13.27	0.13	0.19
Born Alive ^a	12.21	12.64	13.23	0.11	< 0.01	12.68	12.69	12.70	0.12	0.98	12.68	12.81	12.59	0.12	0.30
Born Dead ^{c,d}	0.73	0.64	0.77	0.07	0.04	0.64	0.75	0.75	0.07	0.04	0.71	0.74	0.69	0.07	0.63

*Pigs visually classified as small, medium, or large at weaning and weights averaged 4.42, 5.60, and 6.92 kg, respectively.

†Gilts placed in nursery pens of 8, 11, or 14 animals resulting in floor space allowances of 0.27, 0.19, or 0.15 m²/pig.

^aThere was a linear effect of parity ($P < 0.01$) for both total born and number born alive.

^bThere was a tendency ($P = 0.08$) for a quadratic effect of group-size-floor space allowance on total born.

^cThere was a quadratic effect of parity ($P = 0.01$) on pigs born dead.

^dThere was a linear effect of size of pig at weaning ($P = 0.03$) on pigs born dead.

Table 2. Main effects of size of pig at weaning*, and floor space allowed† during the nursery phase of production on overall total born, born alive, and born dead through three parities and average number of parities completed

	Size of pig at weaning					Nursery floor space allowance, m ² /pig				
	Small	Medium	Large	SE	P	0.15	0.19	0.27	SE	P
No. of Sows	438	515	500	–	–	612	467	374	–	–
Total Born	29.26	29.94	30.47	0.73	0.48	30.53	30.05	29.09	0.78	0.34
Born Alive	27.85	28.36	28.84	0.70	0.58	28.96	28.46	27.64	0.74	0.38
Born Dead ^a	1.42	1.57	1.63	0.09	0.22	1.58	1.60	1.45	0.10	0.47
Parities completed	2.21	2.25	2.29	0.05	0.49	2.30	2.24	2.21	0.05	0.39

*Pigs visually classified as small, medium, or large at weaning and weights averaged 4.42, 5.60, and 6.92 kg, respectively.

†Gilts placed in nursery pens of 8, 11, or 14 animals resulting in floor space allowances of 0.27, 0.19, or 0.15 m²/pig.

^aThere was a tendency ($P = 0.09$) for a linear effect of size of pig at weaning on pigs born dead.

Table 3. Main effects of size of pig at weaning* and group-size-floor space allowance† on reproductive events in gilts

Events, number (%)	Size of pig at weaning				Group-size-floor space allowance, m ²			
	Small	Medium	Large	P	0.15	0.19	0.27	P
Entered nursery	851	861	825	–	1,089	823	625	–
Died in nursery [‡]	23 (2.70)	17 (1.97)	16 (1.94)	0.48	24 (2.20)	19 (2.31)	13 (2.08)	0.96
Exited nursery [‡]	828 (97.30)	843 (98.02)	810 (98.06)	0.48	1,065 (97.80)	804 (97.69)	612 (97.92)	0.96
Selected for entry to a sow farm [‡]	438 (51.47 ^a)	515 (59.81 ^b)	500 (60.61 ^b)	< 0.01	612 (56.20)	467 (56.74)	374 (59.84)	0.31
Completed one parity	389 (88.81 ^a)	477 (92.62 ^b)	472 (94.40 ^b)	< 0.01	568 (92.81)	432 (92.51)	338 (90.37)	0.35
Completed two parities	313 (71.46)	369 (71.65)	364 (72.80)	0.88	453 (74.02)	327 (70.02)	266 (71.12)	0.32
Completed three parities	267 (60.96)	313 (60.78)	315 (63.00)	0.72	387 (63.24)	285 (61.03)	223 (59.63)	0.50

*Pigs classified as small, medium, or large at weaning and weights averaged 4.42, 5.60, and 6.92 kg, respectively.

†Gilts placed in nursery pens of 8, 11, or 14 animals resulting in floor space allowances of 0.27, 0.19, or 0.15 m²/pig.

[‡]As a proportion of pigs entering nursery.

^{||}As a proportion of pigs selected for entry to a sow farm.

^{a,b}Within pig size, events with values that have different superscripts differ ($P < 0.05$).

removal reasons in gilts that failed to complete a single parity, and in sows that were removed from the breeding herd after completing one, two, or three parities. The proportion of gilts that were classified as small at weaning that ultimately entered the breeding herd and that failed to complete

a parity was greater ($P < 0.05$) than the proportions of medium- and large-size gilts. The proportions of small- and medium size gilts that were removed after aborting a litter were also greater ($P < 0.05$) than the proportion of large-size gilts. The proportion of gilts failing to complete a parity was not

Table 4. Main effects of size of pig at weaning* and group-size-floor space allowance[†] on reproductive events in gilts

Events, number (%)	Size of pig at weaning				Group-size-floor space allowance, m ²			
	Small	Medium	Large	<i>P</i>	0.15	0.19	0.27	<i>P</i>
Selected for entry to a sow farm	438	515	500	–	612	467	374	–
Failed to complete a parity [‡]	49 (11.19 ^a)	38 (7.38 ^b)	28 (5.60 ^b)	< 0.01	44 (7.19)	35 (7.49)	36 (9.63)	0.36
Removed [‡]	14 (3.20)	11 (2.14)	11 (2.20)	0.51	13 (2.12)	14 (3.00)	9 (2.41)	0.65
Heat no service [‡]	10 (2.28)	5 (0.97)	6 (1.20)	0.20	7 (1.14)	9 (1.93)	5 (1.34)	0.55
No conceive [‡]	3 (0.68)	1 (0.19)	2 (0.40)	0.50	3 (0.49)	0 (0.00)	3 (0.80)	0.18
Pregnancy check negative [‡]	7 (1.60)	8 (1.55)	6 (1.20)	0.85	8 (1.31)	4 (0.86)	9 (2.41)	0.16
Not in pig [‡]	4 (0.91)	6 (1.19)	2 (0.40)	0.38	5 (0.82)	3 (0.64)	4 (1.07)	0.79
Abortion [‡]	11 (2.51 ^c)	7 (1.36 ^c)	1 (0.20 ^b)	< 0.01	8 (1.31)	5 (1.07)	6 (1.60)	0.80
Removed from herd after completing one, two, or three parities [‡]	175 (39.95)	223 (43.30)	203 (40.60)	0.53	245 (40.03)	199 (42.61)	157 (42.00)	0.67
Poor body condition [‡]	6 (1.37)	5 (0.97)	6 (1.20)	0.85	3 (0.49)	8 (1.71)	6 (1.60)	0.12
Farrowing difficulty [‡]	2 (0.46)	2 (0.39)	2 (0.40)	0.99	3 (0.49 ^c)	2 (0.43 ^c)	1 (0.27 ^a)	0.09
Farrowing productivity [‡]	0 (0.00 ^c)	7 (1.36 ^b)	8 (1.60 ^b)	0.04	5 (0.82)	3 (0.64)	7 (1.87)	0.17
Lameness [‡]	32 (7.31)	31 (6.02)	27 (5.40)	0.47	36 (5.88)	33 (7.07)	21 (5.61)	0.63
Management [‡]	8 (1.83)	12 (2.33)	13 (2.60)	0.73	14 (2.29)	11 (2.36)	8 (2.14)	0.97
Reproductive failure [‡]	82 (18.72)	117 (22.72)	108 (21.60)	0.31	131 (21.41)	93 (19.91)	83 (22.19)	0.71
Other [‡]	45 (10.27)	49 (9.51)	39 (7.80)	0.40	53 (8.66)	49 (10.49)	31 (8.29)	0.47

*Pigs classified as small, medium, or large at weaning and weights averaged 4.42, 5.60, and 6.92 kg, respectively.

[†]Gilts placed in nursery pens of 8, 11, or 14 animals resulting in floor space allowances of 0.27, 0.19, or 0.15 m²/pig.

[‡]As a proportion of pigs selected for entry to a sow farm.

^{a,b}For size of pig at weaning, values for farrowing productivity marked with different superscripts differ ($P < 0.05$).

^{c,d}For group-size-floor space allowance, values for farrowing difficulty marked with different superscripts tend to differ ($P < 0.09$).

influenced ($P = 0.36$) by group-size-floor space allowance.

Neither size of pig at weaning nor group-size-floor space allowance affected the percentages of sows removed from the breeding herd after completing one, two, or three parities with two exceptions. The percentage of sows removed for poor farrowing productivity was greater ($P < 0.05$) for medium- and large-size pigs than for small pigs. There was a trend ($P = 0.09$) for gilts that had been allowed 0.15 or 0.19 m² floor space each in the nursery to have a greater proportion of sows removed for farrowing difficulty compared with gilts allowed the greatest amount of floor space.

DISCUSSION

A large-scale swine operation in North Carolina was the site for the investigation reported here. In general, animal performance equaled or exceeded that expected for these types of production systems. For example, average total litter size and the number of pigs born alive were approximately 13.3 and 12.6, respectively. Knauer and Hostetler (2013) conducted an analysis of production data generated by approximately 1.8 million sows in the United States between 2005 and 2010 and reported an

average total litter size of 12.5 and average number of pigs born alive of 11.3. Consistent with previous reports (Koketsu et al., 2017), total litter size and the number of pigs born alive increased in the current study from Parity 1 to Parity 3. However, some researchers have reported that pigs born alive decreased from Parity 1 to Parity 2, apparently a consequence of low feed intake by sows during the first lactation (Hoving et al., 2010). In the current investigation, there was no indication of a second parity decline in performance. In fact, there was a quadratic relationship such that the number of pigs born dead was less in Parity 2 sows compared with either Parity 1 or Parity 3 sows.

For this research, it was not possible to alter sizes of the nursery pens employed. Group sizes of 14, 11, or 8 gilts/pen resulted in floor space allowances of 0.15, 0.19, or 0.27 m²/pig, respectively. The authors acknowledge that group size and floor space allowance were confounded. Nevertheless, as reported by Callahan et al. (2017), crowding achieved by increasing the number of gilts per pen negatively affected growth performance during the nursery phase of production. Other researchers (Lindvall, 1981; Brumm et al., 2001; Smith et al., 2004) also changed group size to investigate effects of space allowance on growth in nursery pigs. Based

on a review of the scientific literature, [Kornegay and Notter \(1984\)](#) concluded that increasing group size from two to 15 nursery pigs/pen had minimal effects on growth. Thus, decreased ADG during the nursery phase of production displayed by gilts employed in the current investigation ([Callahan et al., 2017](#)) was probably more of a consequence of decreased floor space allowance than increased group size.

Although the main objective of this investigation was to determine future reproductive performance and retention in the breeding herd for gilts allowed different amounts of floor space, the experimental design also allowed an assessment of these characteristics in females differing in size upon entry to the nursery. This basic information may be useful for further refinement of gilt development protocols in commercial pork production systems. Although decreasing floor space allowance by increasing group size negatively affected pig growth in the nursery ([Callahan et al., 2017](#)), there were no effects of crowding on future litter sizes through three parities in sows, with one exception. There was a tendency for a quadratic relationship such that pigs allowed 0.19 m² of floor space each had 1 to 2 % greater total litter sizes than pigs in the 0.15 or 0.27 m²/pig groups through three parities. The biological significance of this finding remains to be determined but, interestingly, the greatest total litter sizes were in gilts from the group-size-floor space allowance considered normal for the facility utilized (0.19 m²/pig) and not for the gilts allowed greater floor space. As indicated previously, little scientific information exists regarding the effects of group-size-floor space allowance in the nursery on future reproduction in gilts. However, the current results are consistent with those from an earlier study which indicated group-size-floor space allowance (15 or 22 gilts per pen resulting in 1.13 or 0.77 m² floor space/pig, respectively) during the grow-finish period had no effects on litter size and removal rates over three parities ([Young et al., 2008](#)). In the [Young et al. \(2008\)](#) study, however, a greater proportion of gilts attained puberty, and attained puberty at a younger age, when allowed the greater amount of floor space.

When compared with smaller individuals, pigs that are heavier at weaning generally display superior nursery and grow-finish growth performance ([Dunshea et al., 2003](#); [Magnabosco et al., 2015](#)). Birth weight and weight at weaning are positively correlated ([Dunshea et al., 2003](#)) and [Magnabosco et al. \(2016\)](#) reported that compared with heavier

birth-weight individuals, gilts weighing less than 1 kg at birth (and by inference smaller at weaning) produced fewer pigs over three parities. Although large gilts at weaning had greater uterine weight at the end of the nursery phase compared with small and medium gilts ([Callahan et al., 2017](#)), in the current study, there were no significant effects of gilt size at weaning on total litter sizes and number of pigs born alive through three parities. Interestingly, there was a linear component to the effect of size on number born dead, with values approximately 17% greater in medium and large pigs, compared with small pigs. This finding is consistent with an earlier report in which slower growing gilts had statistically fewer pigs born dead for Parity 1, and numerically fewer pigs born dead for Parities 2 and 3, compared with faster growing gilts ([Young et al., 2008](#)).

In commercial swine herds, annual sow removal rates due to death and culling exceeded 50% from 2005 to 2010 ([Knauer and Hostetler, 2013](#)). Replacement gilts generally require a minimum of three parities to pay for associated investment costs ([Stalder et al., 2003, 2004](#)), yet average parity at culling ranges from three to four ([Stalder et al., 2004](#); [Hoge and Bates, 2011](#)). [Knauer et al. \(2012\)](#) reported that reproductive failure, including failure to cycle, failure to farrow, and inability to conceive, was the most common culling reason for Parities 1 to 5. Foot and leg injuries/lameness is also a common culling reason for younger sows (Parity 0 to 3) ([Lucia et al., 2000](#); [Stalder et al., 2004](#); [Anil et al., 2009](#)). Lame sows tend to have fewer litters (<3) and greater baby pig losses (27.7%) compared with nonlame sows (4.5 litters and 12.4% pig loss) ([Anil et al., 2009](#)).

The results of the current investigation are consistent with previous work ([Lucia et al., 2000](#); [Stalder et al., 2004](#); [Anil et al., 2009](#); [Knauer et al. 2012](#)) in that reproductive failure and lameness were the leading reasons for sow removal. Other than a tendency for gilts that were allowed the least amount of floor space during the nursery phase of rearing to have a greater removal rate due to farrowing difficulty, nursery floor space allowance did not affect sow retention through three parities. Likewise, space allowance during grow-finish had no effect on removal rate ([Young et al., 2008](#)).

As mentioned before, size of pig at weaning has a positive relationship with postweaning growth. In the current study, the proportion of gilts selected for breeding was less for gilts classified as small at weaning compared to medium- and large-size gilts.

The proportion of selected small-size gilts that completed one parity was also less (and the proportion that failed to complete a parity was greater) than the other two groups. Although abortion rate was greater in small-size gilts than large size individuals, the proportion of these females that were removed for farrowing productivity was less than the proportions of medium- or large-size gilts.

There have been equivocal results concerning effects of rate of growth during rearing on sow longevity. Hoge and Bates (2011) found that gilts that grew slower and were fatter had a decreased risk of being culled. Similarly, Knauer et al. (2010) found that increased ADG was associated with decreased sow retention to four parities. On the other hand, Stalder et al. (2004) found no relationship between ADG and longevity in U.S. Landrace populations. Increased backfat thickness has been shown to be positively associated with increased longevity (Stalder et al., 2004; Knauer et al., 2010). However, Serenius and Stalder (2007) found that backfat thickness at 100 kg had no effect on the risk of a sow being culled.

In summary, group-size-floor space allowance during the nursery phase of production did not have remarkable effects on future litter sizes or retention through three parities in sows. Likewise, size of pig at weaning did not affect total litter size and pigs born alive. More pigs classified as small at weaning and that entered the breeding herd did not complete a parity and displayed a greater abortion rate, compared with larger pigs.

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