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A Pilot Study: Behavior and Productivity of Gestating Sows in Width-Adjustable Stall

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Abstract

The housing of dry sows in individual gestation stall is a critical welfare concern facing the swine industry. The objective of this study was to evaluate the effects of a width adjustable stall (FLEX) on sow behavior and productivity. After pregnancy was confirmed, sows were allotted to FLEX stall (n=8) or standard gestation STALL (n=8) for 1 gestation period over 4 blocks. Throughout gestation, FLEX stall width was adjusted to achieve 2.5cm space between sow and stall when lying in full lateral recumbence without simultaneously touching sides of stall. Behavior was recorded for 24-h periods before, during, and after width adjustments were made. Frequency of skin lesions were recorded on d 25±5, 45±5, and 112±5 of gestation. Sows housed in STALL performed more oral-nasal-facial (ONF) and sham-chew behaviors compared to sows in FLEX ($p<0.0001$). Sows in FLEX sat more than sows in STALL ($p<0.05$). Sows in STALL tended ($p<0.10$) to drink more than sows in FLEX. Sows in FLEX had more lesions on the right side of the body than sows in STALL ($p<0.05$), but as gestation progressed, number of lesions decreased. Sows in FLEX had more piglets born ($p<0.01$) and born alive ($p<0.10$) than sows in STALL. Overall, sows in FLEX stall spent less time performing ONF and sham-chew behaviors, but more time laying and improved productivity. Thus, it may be plausible to improve sow well-being in terms of behavior, performance, and productivity by increasing the width of the individual gestation stall, especially for larger bodied sows.

Keywords: Behavior; Dry sows; Stall; Well-being

Introduction

The most controversial issue facing the swine industry today is how the gestating sow ought to be accommodated. The use of the 0.61m × 2.13m individual gestation stall is still the most common housing system in North America. Many scientific evaluations indicate in terms of performance, productivity, health, and well-being that sows housed in individual stall as compared to group-pens have similar values across measurement criteria [1-3]. Despite the many benefits of the current standard gestation stall, the major drawback is the restrictive space allowance, which hinders the freedom of sow movement and the ability to perform all natural behaviors. In the US, the acceptable requirements for the use of the stall has primarily focused on adequate stall space which allows the sow to easily lie down in full lateral recumbence without simultaneously touching both sides of the stall. Most often, late-gestation seems to be a critical time for sows housed in stall with greater incidence of lameness [4] and greater lesion scores among sows in both standard stall and free access stall [5,6] which may be partially explained by restricted movement and space allowance [7].The body size of the sow has increased due to genetic selection [8], but other factors such as parity, body weight (BW), and stage of gestation affect sow body size [7, 9]. The current standard stall has been shown to be long and wide enough to accommodate the majority of sows while standing, but does not adequately accommodate larger-bodied sows while lying [7,9]. According to Li and Gonyou [10], the minimum stall width to accommodate all sows is 61 cm, while McGlone [9] suggested that the minimum width of 69.3 cm would be required to accommodate them while lying. Restricted stall space impedes postural changes, resulting in larger sows taking more time to make postural changes [11] and spending more time lying [10,12]. As pregnancy progresses, the sow's body depth becomes deeper and at the end of pregnancy her body depth can exceed 12.7cm [7]. Heavier sows spend more time lying and are less time active due to restricted stall space, especially at end of pregnancy [12]. For the most part, the current gestation stall provides enough space to accommodate the body size of the sow, but falls short in accommodating the dynamic space requirements. Thus, it seems plausible that modifications in the design of an individual gestation stall that allows more freedom to move, such as increasing stall width or designing a stall that could accommodate the changing body size of the pregnant sow, may improve sow well-being. Therefore, the primary objective of this pilot study was to evaluate the effects of increasing stall width throughout gestation on small and large dry-sows on behavior and productivity.

Materials and Methods

Animals, housing, and experimental design

Sixteen crossbred (Large White × Landrace) multiparous sows were allotted to either a standard stall (STALL) or width-adjustable stall (FLEX) based on sow body weight (BW). The experiment consisted of 4 replications with treatment groups being equally distributed across blocks. Sows were classified as large or small based on BW. Large sows had a mean BW of 234kg and small sows 174kg. Prior to the start of the study, all sows were housed in standard gestation stall after their previous litters were weaned. Sows were

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Table 1: Behavioral Ethogram.

Behavior	Description
Oral-nasal-facial (ONF)	Any contact with the snout/mouth with an inanimate object excluding food or water
Sham-chew	Continuous chewing while no feed or substrate is present in the mouth
Sit	Animal is supported primarily by rump and hind legs with front legs extended
Stand	Animal is supported by body mass via all four limbs
Lay	Not supported by any limbs. Full contact with ground.
Lay (IN)	Lying with all four limbs in the stall
Lay (OUT)	Lying with one or more limbs out of the stall
Eat	When feed is present, contact with the snout/mouth to the feed
Drink	Stationary contact with the snout/mouth to water in trough
Postural changes	Any major transition causing a change in the overall location or placement of the body mass within the stall. Lying-sitting-standing (vice versa)

inseminated within 24-h after onset of estrus, and then again 24-h later. Pregnancy was confirmed via abdominal ultrasound, and then sows were moved to their respective assigned stall treatments. Sows remained in their respective treatment groups until approximately d 108±4 of gestation, when sows were moved to the farrowing facility. Throughout the study, sows were housed in the University of Wisconsin Swine Research and Teaching Center (SRTC). All animal procedures were approved by the College of Agricultural and Life Sciences Animal Care and Use Committee, University of Wisconsin-Madison.

Stall length for both stall types were fixed at 216cm, but the widths differed. The width of the STALL was fixed at 61cm, while the width of the FLEX was adjustable and varied from 48.1 to 68.6 cm. The width of the FLEX stall was adjusted to achieve enough space that allowed a sow to lay in full lateral recumbence without simultaneously touching the sides of the stall. Using sow mid-girth measurements (top of the back to bottom of the udder), the width of the FLEX stall was expanded to achieve an additional 2.5cm of space between the bottom of the sow's udder and floor of the stall.

Measurements were taken every 21 days until gestational day 70, and then again every 12±2 days until sows were moved to farrowing facility. It is important to note, that width adjustments were only made when space criteria were not met. The FLEX stall used in this study were designed by John Kane in collaboration with the University of Wisconsin SRTC. Sows were kept in a well-insulated, mechanically ventilated, enclosed gestation wing of SRTC during the breeding and gestational periods. Supplemental heat was provided by thermostatically regulated heaters during the cold seasons, but room temperature during the warm seasons were subjected to the exterior climates as only mechanical exhaust fans were available to regulate the upper temperatures.

Sows were individually fed a diet in which nutrient concentrations met or exceeded requirement estimates (NRC, 1998). During gestation, each sow was fed 1.9kg/d of a corn-soy-based diet having a calculated composition (as-fed) of 12.6% CP and providing a calculated ME density of 3,423 kcal/kg. All sows were fed between 0630 and 0800 each day. Each stall had a water trough in front of it. Lactating sows were fed 5.2kg/d of a corn-soy based diet with a calculated composition (as-fed) of 18.2% CP and 3,449kcal of ME/kg.

Lesions and performance measures

Total number of lesions on the left and right sides of the body were recorded at the beginning of the experiment (d 21), on days of mid-girth measurements, and at the end of the experiment (d 111). Sow BW and BW gain were recorded on the same days that sow mid-girth measurements were made. Litter traits included number of piglets born and born alive, stillborn, piglet mortalities between birth and weaning, and the number of pigs weaned. Individual piglet birth BW and weaning BW were recorded, and average BW gain from birth-to-weaning was calculated.

Behavioral measures

Behavior was recorded using a Geovision GV-1240 video capture combo card and viewed using EZViewLog500 in real-time. Behavior was recorded for 24-h prior to FLEX width adjustment and for 48-h, including day of and day after adjustments. Using continuous video recording, behavior was observed and registered for l2-h periods (period 1, 0600-1000; period 2, 1000-1400; period 3, 1400-1800) on day prior to, day of, and day after the FLEX stall adjustments were made. The behaviors registered and analyzed included: Oral-Nasal-Facial (ONF), sham-chew, sit, stand, lay, lay (IN), lay (OUT), eat, drink, and postural changes (Table 1). Behavioral durations were assessed for all behaviors, with the exception of postural changes for which frequency of change was registered.

Statistical analysis

Data were analyzed using the Mixed Models procedure of SAS/STAT® software, version 9.2 for Windows® (SAS Institute Inc., Cary, NC). Normal distribution of residuals and homogeneity of variances were tested and assumptions for analysis of variances were fulfilled. The model included fixed effects of stall (FLEX or standard), sow size (large or small), and stall x sow size interaction. A random effect of block was included in the model to account for potential environmental and management differences across sows kept in individual stall. Standard error of the mean (SEM) values are associated with least squares means as calculated in the Mixed Models procedure. The p-value <0.05 were considered significant, and p-values>0.05 and <0.10 were considered as tendency for significance.

Results

Interactive effect of stall and sow size

Stall × sow size interaction occurred for sow productivity and

Table 2: Interactive effects of stall type and sow size on performance traits for gestating sows housed in either a width adjustable stall (FLEX) or standard gestation stall (STALL).

	Stall Treatment					
	Large sows, 234 kg		Small sows, 174 kg			
Measure	FLEX	STALL	FLEX	STALL	SEM	P-value
Sow weight gain, kg	44.0	35.8	45.0	33.7	6.6	0.74
Total Born	15.5	11.8	13.0	10.8	0.87	0.40
Total Live Born	13.8	11.3	12.0	9.3	1.34	0.92
No. weaned	11.5	11.0	11.5	8.5	1.23	0.33
Piglet birth wt., kg	1.6	1.8	1.5	1.5	0.17	0.71
Piglet wean wt., kg	8.1[a]	7.5[a]	6.6[b]	7.7[a]	0.34	0.03
Piglet weight gain, kg	6.5[a]	5.7[b]	5.1[b]	6.2[a]	0.25	0.005
Mortality, No.	2.3[a]	0.25[b]	0.50[b]	0.75[b]	0.53	0.05

[a-b]Within a row, means without a common superscript letter differ (p<0.05)

performance traits (Table 2). Average piglet wean weight was greater (p<0.05) for large sows kept in either stall type and small sows in STALL compared to small sows kept in FLEX. Piglets born to large sows kept in FLEX gained more BW (p<0.005) compared to large sows in STALL or small sows in FLEX. Large sows kept in FLEX had greater piglet mortality (p=0.05) when compared with sows in other treatments.

Main effect of stall on behavior and other traits

The type of gestation stall affected mean durations of several sow behavioral traits (Table 3). Duration of ONF and sham-chew behaviors (p<0.0001), and drink behavior (p<0.05) were less for sows kept in FLEX compared to sows in STALL. Durations of sit and lay behaviors were greater (p<0.0001) for sows kept in FLEX than for sows in STALL; whereas, sows in STALL spent more (p<0.05) time lying (IN) than did sows in FLEX. Mean frequencies of postural changes were greater (p=0.005) for sows kept in STALL than for sows in FLEX (3.6 vs. 2.7±0.20, respectively).

The type of gestation stall affected several performance behaviors (Table 4). Sows kept in FLEX gained more BW from gestational days 24±3 to 46±3 (p<0.005) and today 63±3 (p<0.05) than did sows in STALL. Sows kept in FLEX had more total piglets born (p<0.005) and born alive (p=0.06) than did sows in STALL. Skin lesion scores were similar between sows kept in FLEX and standard stall, with exception for lesion scores on right side being greater (p<0.05) among sows kept in FLEX than sows in STALL (Table 4). All other production traits were similar between sows kept in either stall type.

Day of width adjustment on behavior

The mean stall widths for sows in FLEX were 51.9 (start), 57.8 (~d45), and 62.3 (~d90) cm with a mean total adjustment of 10.13 cm. A FLEX stall x day of width adjustment occurred for sow behavior among sows in FLEX (Table 5). Twenty-four hours after the 1st stall width adjustment (~d45 of gestation) was made, lay behavior increased (p<0.001), while ONF, sham-chew, and drink behaviors all decreased amongst sows in FLEX stall (p<0.001). Conversely, 24-h after the 2nd width adjustment (~d90 of gestation), sit behavior increased (p<0.05) and lay behavior decreased (p<0.0005). Frequencies of postural changes were similar among sows kept in FLEX following stall width adjustments.

Table 3: Main effects of housing sows in either a width-adjustable stall (FLEX) or standard gestation stall (STALL) on mean behavioral durations of gestating sows during 0600 h till 1800 h on gestational days 21, 45, and 94 (LSM ± SE).

	Stall treatment		
Behavior[1]	**FLEX**	**STALL**	**P-value**
ONF	61 ± 4[b]	117 ± 5[a]	< 0.0001
Sham-Chew	45 ± 3[b]	118 ± 5[a]	< 0.0001
Sit	651 ± 83[a]	144 ± 77[b]	< 0.0001
Stand	1995 ± 355	2611 ± 323	0.20
Lay	2400 ± 216[a]	1605 ± 195[b]	0.007
Lay (IN)	749 ± 115[b]	1259 ± 117[a]	0.002
Lay (OUT)	1514 ± 215	2074 ± 440	0.25
Drink	28 ± 8[b]	52 ± 4[a]	0.012
Eat[2]	298 ± 28[a]	93 ± 16[b]	<0.0001

[a-b]Within a row, means without a common superscript letter differ (p<0.05).
[1]Behavior traits are presented as mean duration in secs per 4-h time periods which include 0600-1000h; 1000-1400h; and 1400-1800h.
[2]Duration of eat behavior only represents the time period between 0600-1000h when sows were eating.

Discussion

The major criticism of the standard gestation stall is the restricted stall space which hinders freedom of movement and inhibits expression of all normal behaviors, especially the ability of the sow to turn-around, exercise, and express social behaviors. Therefore, the main focus of this pilot study was to assess the impact of stall space and sow body size on the well-being of gestating sows using behavior and productivity as relevant welfare indicators [13]. The results reported herein indicate that the type of gestation stall for housing sows during gestation can impact behavior, performance, and productivity. More specifically, sows housed in width-adjustable individual stall (FLEX) spent more time sitting and laying and less time performing ONF and sham-chew behaviors, and had improved sow and litter-related traits than did sows in standard gestation stall. These results imply

Table 4: Main effects of housing sows in either a width-adjustable stall (FLEX) or standard gestation stall (STALL) on selected sow- and litter-related traits and mean skin lesions of dry sows (LSM ± SE).

	Stall Treatment			
Measure	**FLEX**	**STALL**	**SEM**	**P-value**
Total weight gain, kg	45.3	35.5	4.5	0.15
Weight gain 43d post-trt, kg	15.4[a]	9.5[b]	1.8	<0.05
Weight gain 60d post-trt, kg	25.9[a]	16.7[b]	2.7	<0.05
Weight gain 73d post-trt, kg	36.0	24.6	4.6	0.10
Total born	14.3[a]	11.3[b]	0.6	0.01
Total born alive	12.9[a]	10.3[b]	0.9	0.06
Mortality, No.	1.38	0.5	0.4	0.16
No. weaned	11.5	9.8	0.8	0.18
Total Lesion score1	20.1	16.7	2.3	0.31
Lesion score, right	11.1[a]	6.2[b]	1.4	<0.05
Lesion score, left	8.9	10.5	1.8	0.55

[a-b]Within a row, means without a common superscript letter differ (p<0.05)
[1]Lesion scores were recorded at approximately gestational days 25, 45, 58, 76, 89, 98, and 112.

Table 5: Effects of adjusting the width of the FLEX stall at gestational days 45 and 90 on mean behavioral durations for 24-h periods before, during, and after width adjustments (LSM ± SE).

	FLEX width adjustment						
	1st adjustment (~ d45 of gestation)			2nd adjustment (~ d90 of gestation)			
Behavior[1]	before	during	after	before	during	after	P-Value
Sit	820 ± 283	697 ± 189	327 ± 189	328 ± 122[b]	1562 ± 141[a]	933 ± 192[c]	0.0115
Lay	510 ± 111[b]	2245 ± 376[a]	2753 ± 354[a]	6201 ± 671[a]	3551 ± 316[b]	1859 ± 218[c]	0.0003
ONF	79 ± 10[b]	105 ± 9[a]	34 ± 6[c]	46 ± 10	51 ± 6	61 ± 7	<0.0001
Sham chew	21 ± 14[b]	110 ± 6[a]	14.8 ± 5.5[b]	26 ± 8	32 ± 5	37 ± 12	<0.0001
Drink	43 ± 10[a]	37 ± 9[a]	16 ± 6[b]	9 ± 4	21 ± 3	22 ± 3	<0.0001

[a-c]Within a row means without a common superscript letter differ at ($p<0.05$).

[1]Sows were video-taped for 72-h periods, which included 24-h before, during and after on gestational days 45 and 90, but behavior was only registered from 0600h until 1800h per 24-h time period.

that providing sows with more stall space, especially larger-bodied sows may be beneficial for gestating sows housed in individual stall throughout gestation.

In the US, the acceptable requirements for the use of the individual gestation stall mainly focuses on providing enough stall space that allows the sow to easily lay down in full lateral recumbence without the necessity for the head to rest on a raised feeder, the rear quarters to contact the back of the stall, and for both sides to contact the stall sides simultaneously (National Pork Board 2002). Data from a large sample of sows indicate that the conventional stall is long and wide enough to accommodate the majority of sows while standing, but over 62% of sows would require a stall width of 69.3cm to 72.4cm while lying [7,9]. Others suggest that gilts and small body sized sows should be housed in stalls at minimum of 60 cm wide while large sows in late gestation may require 78cm of stall width [10]. The minimum stall width to accommodate all gestating gilts and sows should be 61cm. Conversely, these data do not support with the average stall width of 61cm to meet the needs of smaller or larger bodied sows. Of course our sample size is not as large as work by McGlone. Regardless, these data imply that providing sows more stall space around gestational days 45 and 90 affects both sit and lay behaviors of the gestating sow. The increase in time spent lying and sitting among sows in flex stall may partly be due to the extra stall width space as the extra stall width space may have made it easier for the sows to sit and lay. Moreover, while laying these sows spent more time with their legs outside than within the stall, which may reflect improved sow comfort and well-being. Sitting or standing inactive for long periods of time may be indicative of poor welfare, while lying may reflect improved well-being. Surprisingly, sows in the standard stall made more postural changes, especially during the 1400-1800h time period, but spent less time lying and sitting. The duration of standing was similar between sows in both stall types. Sows in standard stall spent less time lying? but while lying these sows tended to lay more often with their legs within the stall.

Keeping sows in stall that are adjusted relative to their body size resulted in more frequent transitions from standing-to-lying and sitting-to-standing and took less time to complete a postural change especially when transitioning from standing-to-sitting [11,12]. Conversely, sows in the flex stall which provided stall space more relevant to their body size tended to make fewer postural changes than did the sows with less stall space. We speculate that sows in the flex stall made fewer postural changes because they spent more time sitting and laying without increasing standing behavior which may indicate that sows were more comfortable in these postural positions, due to the increased space allowance. Researchers found that sows kept in 70cm wide stall, made fewer postural changes and lay behavior was not affected [10], while sows in this study spent more time lying in the flex stalls which were not as wide. Taken together, these data imply that more stall space can impact postural behaviors but the estimated stall width by previous researchers may not be the ideal width space allowance needed to accommodate the average-bodied sow or the smaller-bodied sow.

For the gestating sow, there is much debate whether individually housing sows in stall causes more stereotypic behavior compared to other housing accommodations, thus poorer well-being. Stereotyped behavior is commonly defined as “a repeated, relatively invariate sequence of movements which has no obvious purpose” [14]. As stereotypies are often associated with a barren environment [15] many use them as a critical measures of sow well-being [3]. The two most common stereotypies displayed by gestating sows are ONF and sham-chewing, but it is difficult to define which ONF behaviors are and are not stereotypies. Certain patterns of ONF behaviors are displayed in anticipation of feeding, thus are common amongst sows in all housing environments with substrate availability also influencing stereotypies [1]. Dailey and McGlone [16] found that sows in various housing environments performed similar frequencies of total ONF behaviors toward the substrate available (e.g., bars, dirt, etc.) during a 24-hour period, implying that sows were motivated to perform ONF behaviors regardless of housing environment. In the present study, the mean durations of ONF and sham-chew behaviors differed between the two stall environments, which was most likely a result of stall space and stall design. Sows in standard stall performed significantly more ONF and sham-chew behaviors, especially during 1400h to 1800h time period, which is also the time of day in which they made more postural changes. In fact, after the 1st width adjustment, duration of both ONF and sham-chew behaviors decreased among sows in flex stall and remained low late in gestation when the 2nd width adjustment occurred. Thus, providing sows additional space in the flex stall did affect both postural and stereotypic behaviors. However, it is plausible that the sows in the standard stall displayed more ONF and sham-chew behavior, not because of restricted space but other environmental factors, such as the design of the stall and/or water-feeding delivery system. Sows in flex stall may have displayed more ONF behaviors that were reflective of post-feeding behaviors these sows displayed more ONF behaviors after feed disappearance. Also these sows spent more time "eating" which may have been classified as feeding behavior and not ONF behavior. In this study, both types of stall were equipped with vertical bars, as opposed to horizontal bars. Perhaps, sows developed alternative stereotypies such as sham-chewing because they were unable to bar-bite and/or manipulate other components such as water or feeding devices.

Sow performance and productivity measures were also used to assess sow well-being. But in this pilot study the sample size was relatively small for assessing production data, thus, these results should be viewed with caution. Increased stall space resulted in improved sow body weight gain and litter performance traits amongst sows kept in the flex stalls, especially among larger-bodied sows but end body weight was similar among sows regardless of treatment. Previously, Estienne and Harper [17] reported a greater number of pigs born alive for sows housed in stall throughout the entire gestation period, it is surprising that sows in flex stall had better reproductive performance than did sows in standard gestation stall. Despite the trend for large sows in flex stall to have more live piglets with greater BW gain and wean weights, they also tended to lose more piglets post-farrowing. Embryonic failure and return to estrus, two major factors associated with reproductive performance [18,19], were not measured within. Piglet mortality rate was greater amongst sows housed in flex stalls than in standard stalls. But, larger-bodied sows tended to have more and heavier piglets than did smaller sows housed in flex stalls. Post-farrowing, piglet mortality may have been due to maternal crushing during lactation. Andersen et al. [20] found that an increase in piglet mortality due to maternal crushing increases as litter size increases. The behavioral results obtained from this study indicate that sows housed in a flex stall tended, on average, to sit more than sows housed in standard stall. Perhaps when sows were moved to the farrowing stall, they attempted to sit more often based on previous experience of being able to sit while in the flex stall, and thus, the behavior led to crushing of more piglets during lactation among larger-bodied sows. As the numbers of piglets born alive and piglet mortality amongst smaller sows housed in flex stall and that of large sows kept in a standard stall were not different, may provide further evidence that the larger-bodied sows that were kept in the flex stalls, once they were moved to farrowing crates had limited space, thus sit behavior was hindered.

Both positive and negative aspects are associated with all housing systems currently used [1-3]. The current results provide support that modification of the individual gestation stall may result in better sow well-being in terms of behavioral and performance measures. More stall space resulted in increased lay and sit behaviors, reduced ONF and sham-chew behaviors, and greater productivity amongst gestating sows housed in flex stalls. Apparently housing environment per se and other factors such as sow size and stall design can also affect these various welfare metrics. Moreover, these data imply advantages for swine producers to house larger sows in flex stall, while smaller sows may benefit from less space. Redesigning the individual gestation stall, specifically by increasing stall space, to better accommodate the gestating sow may result in improved sow well-being.

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