RESEARCH REPORT
ANIMAL WELFARE

Title: Retrofit an optimized gestation stall system based on sow well-being: A pilot study – **NPB #07-026**

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Industry Summary

Sow housing has become a controversial welfare issue for pork producers. We cannot begin to implement costly alternative housing systems without scientific data that support these changes that could have an impact on sow well-being. The long-term objectives of this project was to design, optimize and implement sow housing and management systems that will enhance sow well-being while sustaining productivity and profitability of swine production (Continuation proposal was funded by NPB in 2009 and is in progress). In **Exp. 1**, a pilot study was conducted to determine the impact of a modified gestation stall, the FLEX stall—a prototype stall in which the width of the stall could be easily expanded while the length was fixed on sow performance, productivity, and behavior throughout gestation. A standard non-adjustable stall was used as the control (STALL). In **Exp. 2**, the impact of the FLEX, STALL, and Free Access system (FREE) were used to determine the impact that these 3 housing environments had on sow productivity, behavior and other physiological measures throughout gestation.

Data from **Exp. 1** (STALL vs. novel gestation stall FLEX) indicate that sows in STALL perform more oral-nasal-facial (ONF), sham-chewing, drinking behavior than sows in FLEX stall. Sows in FLEX stall sat more often and had more lesions on right side of body than did sows kept in STALL. Sows in FLEX stall had more piglets born and a tendency for more piglets to be born alive than did sows in STALL. Data from **Exp. 2** (STALL vs. FLEX vs. FREE (individual stall and pen area) indicate that sows kept in FREE had more lesions than did those sows in either STALL or FLEX stalls. Sows in FLEX and FREE had more male piglets than did sows in STALL. While sows kept in FLEX had greater piglet mortality than did sows in either STALL or FREE system, these sows also gave birth to more total piglets. Sows kept in FREE had greater cortisol response later in gestation than did either sows in STALL or FLEX. Both behavior and immune status were affected by gestation environment. Data specifically registered from sows kept in FREE indicate that sow preference as to where they spend their time (pen or stall) varies from sow-to-sow. Day of gestation also impacts sow preference as to where she spends her time with sows spending more time in stall as days of gestation increase. Cortisol response was impacted by gestation environment; increasing FLEX stall width reduced stress status (decrease cortisol) of sow within 24 h after expanding width.

These data indicate that housing components may impact productivity, behavior and physiological responses of the dry sow. Specifically, simple alterations to the physical aspect of the stall (width increase) resulted in changes in behavior, stress response and litter productivity among sows kept in that particular environment. This research implies that we must first determine impact of housing components on sow well-being and then optimize the best system before we implement housing systems that unwittingly compromise well-being.

Scientific abstract

New housing systems are being implemented without scientifically evaluating the impact these alternative systems have on well-being. Thus, we hypothesize that slight modifications of the stall may influence sow well-being, thus the objective (experiment 1) was to evaluate the effects a modified-gestation stall has on behavior and productive performance of dry sows. While the objectives of experiment 2 were to evaluate a) the effects of 3 housing systems on sow physiology and more specifically b) the utilization of individual vs. group space in the free access stall treatment. Exp. 1, on d23±5 of gestation 16 multi-parious sows were allocated to either a standard stall (STALL) or adjustable stall (width only; FLEX); fixed dimensions for STALL; 55.9cm × 218.4cm and FLEX; 48cm × 215.9cm. Sows kept in FLEX stall, once placed in the stall, width was adjusted based on sow body size to achieve 2cm of space between bottom bar and sow's udder while lying in full lateral recumbency at early-gestation, mid-gestation, and late-gestation. Widths were 51.9±0.56 (early-gestation), 57.8±0.64 (mid-gestation), and 62.3±0.61 (late-gestation), respectively; length was constant. Behavior was registered using continuous video-records. Lesions were recorded on d25±5, 45±5, and 112±5 of gestation. In Exp. 2, on d30 of gestation 12 multi-parious sows were allocated to standard crate (STALL; control), adjustable crate (FLEX), or free access stall-pen (FREE). On d89 of gestation, FLEX width was adjusted to achieve 2cm space between sow and stall. Immune and endocrine status was measured on days 0, 30, 31, 89, 90 (FLEX only) and 110 of gestation. For Exp. 2b, live behavioral observations among sows in FREE system were registered for 60-min on d30, 45, 60, 75, 89, and 103 of gestation. Data were analyzed using Proc MIXED with repeated measures (SAS). In Exp. 1 sows in STALL performed more oral-nasal-facial (ONF) and sham-chewing than sows in FLEX ($P<0.0001$). Sows in STALL also performed more stereotypies later in gestation than sows in FLEX ($P<0.0001$). Sows in FLEX sat more often than did sows in STALL ($P<0.05$). Sows in STALL drank more often than did sows in FLEX ($P<0.05$). Body lesions (right side) were greater among sows in FLEX stall than for sows in STALL ($P<0.05$), but lesions decreased from gestation d25 to 112 among all sows ($P<0.05$). Sows in FLEX had more piglets born ($P<0.01$) and tended to have more piglets born alive ($P<0.10$) than did sows in STALL ($P<0.01$). In Exp. 2a, sows in FREE had greater lesions than sows in either STALL or FLEX on d45, 60, 75, and 89 of gestation ($P<0.05$). Sows in FLEX stall and FREE system had more male piglets than sows in STALL ($P < 0.10$). Sows kept in FLEX stall had greater piglet mortality than sows in either STALL or FREE ($P < 0.05$). On d110, neutrophil phagocytosis was greater ($P<0.05$) among sows in FREE system than sows in FLEX stall. Sows in FREE and FLEX stall had less concanavalin A- ($P<0.001$) and lipopolysaccharide- ($P<0.05$) induced proliferative responses at d31 and throughout gestation. Sows kept in FREE system had greater neutrophil-to-lymphocyte ratio on d31, 89, and 110 of gestation compared to d30 (baseline) of gestation ($P<0.05$). Sows kept in FREE system had greater ($P<0.05$) **c**ortisol on d89 than previous days of gestation. In part b of Exp. 2, regardless of day of gestation, some sows spent a greater ($P<0.05$) amount of time in group-pen area than in individual stall. Later in gestation, fewer sows spent more time in the group-pen than on d30 ($P<0.05$). These data indicate that alternative housing systems can affect performance, productivity, behavior, immune function and physiology of the sow throughout gestation. Thus it is important to assess the impact of housing components on sow-well being with the intent to improve animal welfare.

Introduction: An overview of the researchable question and its importance to producers.

Adequacy of housing systems for the gestating sow is a major public issue, driven primarily by public perceptions and regulations promulgated in Europe, not by science. New innovative approaches are needed to satisfy the concerns of outside special interest groups and to minimize the economic disadvantages that would be incurred by the swine industry if the current housing systems were banned. The factors that are empirically proven to enhance the success of such systems must be identified so that we can provide producers with information needed to make decisions on how to implement this new technology in existing production systems or incorporate into new buildings while sustaining profitability. Producers must have scientifically developed optimal production schemes and systems that will enable the industry to improve the health, productivity, and reproductive efficiency of the individual pig while sacrificing neither animal well-being nor profitability. The knowledge and data from these studies will provide producers with guidelines and strategies that will enable them to make changes without compromising the well-being of the sow.

Objectives:

The long term objectives of this project are to design, optimize and implement sow housing and management systems that will enhance sow well-being while sustaining the productivity and profitability of swine production. The *specific objectives* of this proposal were to: **1**) design a housing system that can be retro-fitted to provide the same animal capacity as in existing housing facilities, yet constructed so as to allow flexibility in stall dimensions to address welfare issues of physical size of the stall and the freedom of sows to move and **2**) to assess the practicality of these systems and the impact on sow welfare using an integrative approach.

1. Project Objectives

The objectives of this study were as follows with responsibility for each objective shown in parenthesis:

A. Develop an adjustable sow stall for use in existing sow gestation facilities that will better accommodate extremes in sow size (University of Wisconsin)

B. To determine the impact of the adjustable stall on sow well-being by assessing physiological and psychological needs of the sow (University of Illinois)

C. To determine the impact of providing sow freedom to leave stall on well-being (University of Illinois)

Materials and Methods.

In Exp. 1 (University of Wisconsin), sows of different parities (8 sows with 2 replicates) were used to assess the functionality and practicality of the FLEX stall for sows of different sizes. Comparisons were made between sows kept in a novel Flex-stall (FLEX; n= 8 sows) and those n standard 2 x 7 foot fixed stalls (STALL; n = 8 sows). Sows were bred and placed in the stall post AI. Pregnancy was confirmed at d28 via abdominal ultrasound. In the FLEX-stall, the center width of the stall was adjusted to accommodate individual sow based on sow body size and weight as prescribed by McGlone et al. (2004). No adjustments were made in the standard fixed STALL. With proper adjustment the new stall allows for space at the critical location (sow's midsection) throughout gestation and provides flexibility for adjustments to individual sows within a row of stalls.

On d23±5 of gestation, sows were allocated to either a standard stall (STALL) or adjustable stall (width only; FLEX); fixed dimensions for STALL; 55.9cm × 218.4cm and FLEX; 48cm × 215.9cm. For sows in FLEX, once placed in the stall, width was adjusted based on sow body size to achieve 2cm of space between bottom bar and sow's udder while lying in full lateral recumbency at early-gestation, mid-gestation, and late-gestation. Widths were 51.9±0.56 (early-gestation), 57.8±0.64 (mid-gestation), and 62.3±0.61 (late-gestation), respectively; length was constant. Behavior of each sow was recorded for 48h upon entry into the stall and after stall-width adjustment for early- and mid- gestation, using real-time digital video recorders. The behaviors were registered and analyzed using 5-min scan sampling and continuous sampling include (but not limited too): lying, standing, drinking, ONF, other postural changes, body locations (including protrusion of body part(s) into adjoining sow's stall zone) and use of stall space. Also, one individual made adjustments to the Flex-stall at designated periods and provide assessment of the accuracy in stall widths and ease of adjustments. Thus, we will assess the ease and practicality of managing a sow in the adjustable stall, so the amount of time required for adjustments can be included in management decisions. Sow BW and gain will be recorded along with standard sow and piglet productivity data.

In next series of experiments (Objectives 2 & 3, University of Illinois) a) we evaluated the impact of the established functional stall (developed in first series of experiments) on sow well-being by assessing physiological and psychological needs of the sow and the impact that the freedom of movement had on well-being. Four sows each were assigned to either the 1) standard stall; STALL, 2) flex-stall; FLEX, or 3) free-access stall; FREE. Even though, this is a pilot study we need to replicate this study a minimum of 4 times to provide meaningful data, results from this are from block 1 only. Parity 2 to 4 sows were used to control for parity effects based on earlier data (Salak-Johnson et al., 2007) these are the sow parities that were most affected in our published research and project funded by NPB. Sow body weight and gain, backfat depth, and body size were assessed at d0 (weaning), d30, 89, and 110 of gestation. Lesions severity scores were recorded every other week once sows were placed into their assigned treatment environment (d30). Performance and productivity data were collected. Physiologic traits such as cortisol, cytokines, and functional aspects of the immune system (i.e., NK cytotoxicity) were measured. More specifically, endocrine measures were made on days 0, 30, 31, 89, 90 (FLEX only) and 110 of gestation. More specifically for part b of Exp 2 a full sequential analysis of sow behavior was achieved by registration of live observations of sows residing in FREE. Behaviors measured include: stress-related behavioral profiles, agonistic encounters, use of the stall space and entries in and out of the free-stall. These ethograms reflect the sows' psychological needs.

RESULTS

Project Objective A Results:

Sow Performance

- Sows kept in FLEX (10.8±1.5) stalls had a greater ($P<0.05$) number of lesions on the right side of their body than did those sows kept in standard STALL (5.9±1.5).
- As day of gestation increased, number of lesions on the right side of the body decreased for all sows ($P<0.05$). (d25, 11.5±1.5; d45, 7.6±1.5; d112, 5.8±1.5, respectively). Regardless of treatment sows had less ($P<0.05$) lesions across entire body from d25 (24.1±2.5) to d112 (14.1±2.5) of gestation.
- Sow body weight was affected by day of gestation ($P < 0.05$), as day of gestation increased body weight increased. (d25, 203.1kg; d58, 208.5kg; d76, 216.9kg; d112, 243.4kg). Sow body weight gain was also affected by day of gestation ($P < 0.05$), as day of gestation increased sows body weight gain increased. (d21-d45, 3.61kg; d45-d58, 2.5kg; d58-76, 9.8kg; d76-d89, 11.1kg; d89-d98, 10.1kg; d98-d112, 10.9kg).
- Sow measurements across hips and ribs were not affected by individual stall type or day of gestation.

Litter Performance

- Total piglets born were affected by stall type with sows kept in FLEX (14.3±0.67) having greater (P<0.01) number of piglets born than did sows kept in STALL (11.3±0.67).
- Sows kept in FLEX (12.9±0.95) stall tended to have a greater (P<.10) number of piglets born alive than did sows kept in stall STALL (10.3±0.95).
- There were no significant differences in the litter traits: number of mummies, stillborns, or weaned, and birth, wean, or weight gain, or mortality.

Table 1. Effects of housing system on litter performance

	FLEX	STALL	P-value
Total born alive	14.25[a]	11.25[b]	0.0072
Live born	12.88	10.25	0.0701
Still born	1.250	1.00	0.7942
Mummy	0.1250	0	0.3343
No. weaned	11.5	9.75	0.1786
Birth weight	1.55	1.64	0.6035
Wean weight	7.34	7.61	0.5283
weight gain	5.79	5.98	0.6073
mortality	1.38	0.50	0.1640

[a-d]Within a row, means without a common superscript letter differ ($P < 0.05$)

Sow behavior

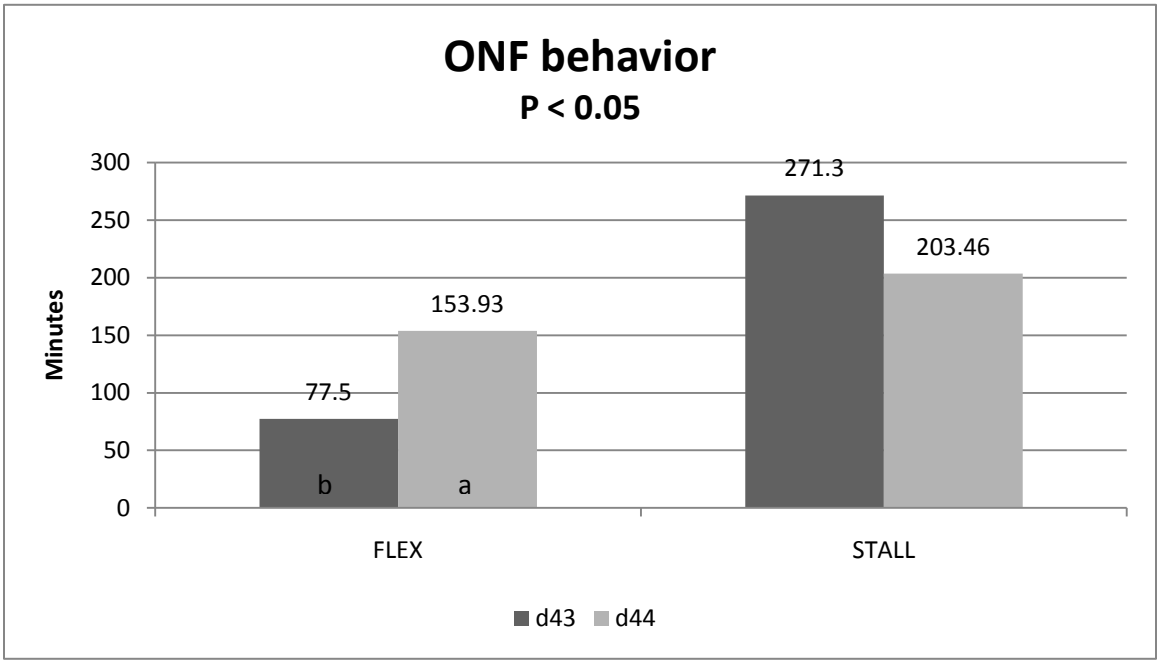
- On d22 of gestation sows kept in STALL (93.2) performed more (P<0.05) ONF (oral-nasal-facial) behavior than did sows kept in FLEX stalls (49.4). Also, on d44 of gestation sows kept in STALL (203.46) performed more (P<0.05) ONF behavior than did those sows in FLEX (153.93) stalls.
- As day of gestation increased ONF, sham-chewing, and standing and sitting behaviors all increased regardless of treatment ($P < 0.05$).
- As width of FLEX stall was increased, sitting behavior increased ($P < 0.05$) (Graph 2.)

Table 2. Effects of housing system on behavior

	FLEX	STALL	P-value
ONF (oral-nasal-facial)	68.1[b]	117.5[a]	0.0001
Sham chewing	64.18[b]	125.37[a]	0.0001
Standing	1370.6	1149.2	0.4803
Sitting	401.1[b]	136.44[a]	0.0039
Lying	4855.64	3628.72	0.1741
Eating	140.33	82.34	0.5914
Drinking	35.6[b]	55.9[a]	0.0150

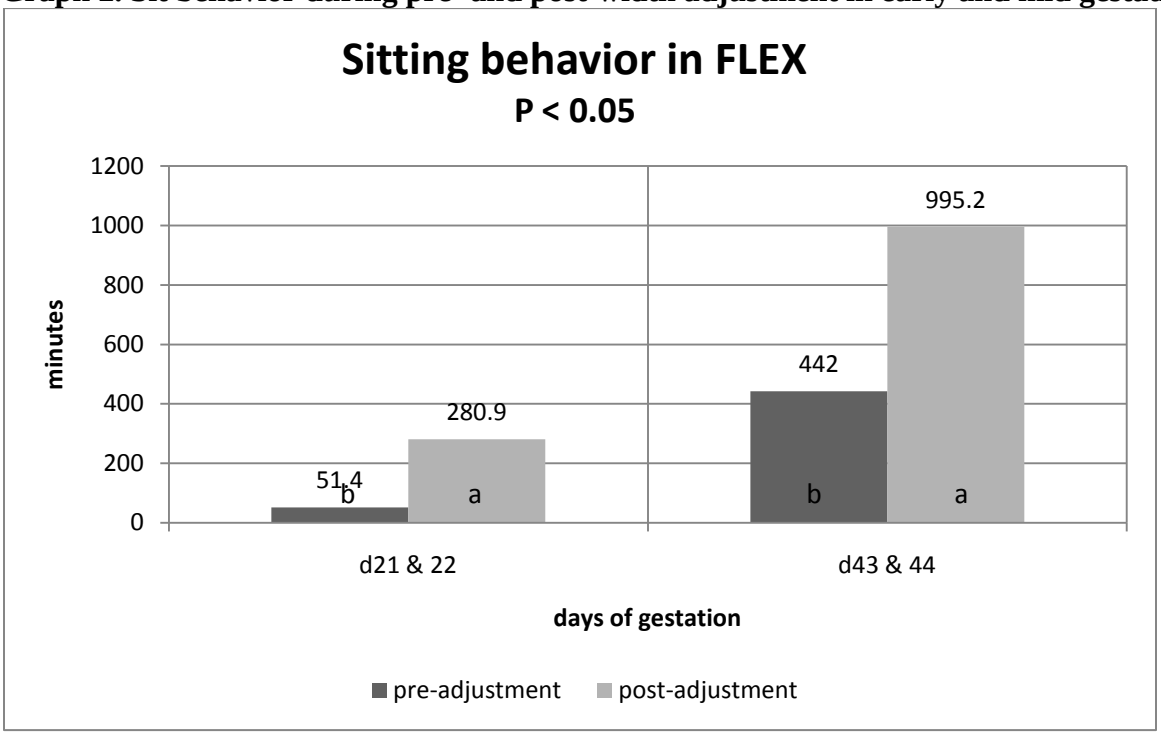
[a-d]Within a row, means without a common superscript letter differ ($P < 0.05$)

Graph 1. Day effects on ONF behavior amongst FLEX and STALL kept sows



[a-d]Within a day, means without a common superscript letter differ ($P < 0.05$)

Graph 2. Sit behavior during pre- and post-width adjustment in early and mid gestation



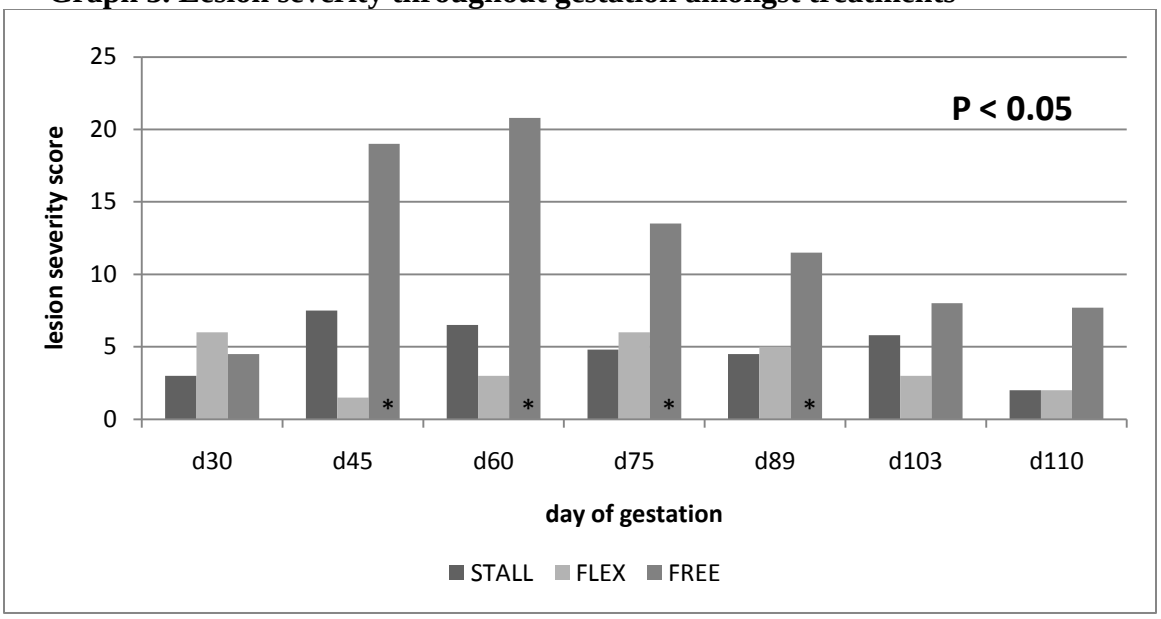
[a-d]Within a day, means without a common superscript letter differ ($P < 0.05$)

Project Objective B Results:

Sow performance

- Sows kept in STALL (7.5±2.0) had greater (P<0.05) lesion scores than sows in FLEX (1.5±2.0) on d45 of gestation. Sows in FREE had greater (P<0.05) lesions than sows in either STALL or FLEX on d45, 60, 75, and 89 of gestation (Graph 3). Lesion scores did decrease among sows kept in FREE after d60 of gestation (P<0.05).
- All sows had a significant increase in body weight gain from d30 (210±5.7) to d89 (229.5±5.7) of gestation regardless of treatment (P<0.05).
- Regardless of treatment all sows had lower lesion score and BCS on d0 (weaning; 2.2±1.2) compared to d45 (9.3±1.2), d75 (8.1±1.2), d89 (7±1.2), d103 (3.9±1.2) (P<0.05).

Graph 3. Lesion severity throughout gestation amongst treatments



*Within a day, means significant difference to others($P < 0.05$)

Litter performance

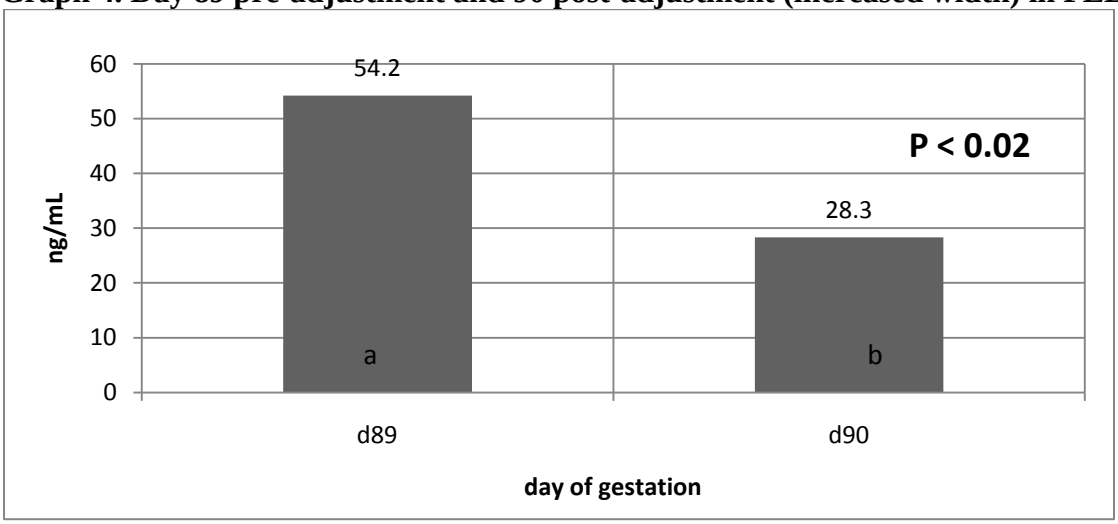
- Sows kept in FLEX (6±1.1) and FREE (6±1.1) had more (P<0.10) male piglets than sows in STALL (3±1.1).
- Sows in FLEX (2±0.35) had greater (P<.0.05) piglet mortality than sows in either STALL (0.3±0.35) or FREE (0.3±0.35).

Sow Physiology

- Total white blood cell count decreased (P<0.02) from d30 to 31 among sows kept in either STALL or FREE system. Percentage of lymphocytes also decreased (P<0.05) from d30 to 31 among sows kept in FREE and remained low throughout gestation compared with other treatments. Sows in FLEX also had less lymphocyte on d110 of gestation than previous days (P<0.05).
- Sows in FREE had greater percentage of monocytes on d110 of gestation than sows in STALLS (P<0.0018) and tended to have greater percentage than sows in FLEX (P<0.10).

- Sows kept in FREE had an increase (P<0.05) in segmented neutrophils from d30 to d31 of gestation. Sows in either FREE and FLEX stall had greater (P<0.05) percentage of segmented neutrophils on d110 of gestation compared with previous days of gestation. Sows in FREE also had greater (P<0.05) greater N:L ratio on days 31, 89, and 110, of gestation compared to d30 (baseline).
- Phagocytosis was less (P<0.03) among sows kept in STALL from d30 to 31, but on d110 sows kept in FREE had greater (P< 0.05) phagocytosis than those sows kept in FLEX.
- Sows in FREE had greater (P<0.05) cortisol on d89 than on previous days of gestation. Cortisol decreased (P<0.05) among sows kept in FLEX from d89 (54.18ng/ml±6.8) to 90 (28.3ng.ml±6.8) of gestation (Graph 4).

Graph 4. Day 89 pre-adjustment and 90 post-adjustment (increased width) in FLEX treatment only



[a-d]Within a row, means without a common superscript letter differ ($P < 0.02$)

Table 3. Day of gestation effects on immune and endocrine traits for sows.

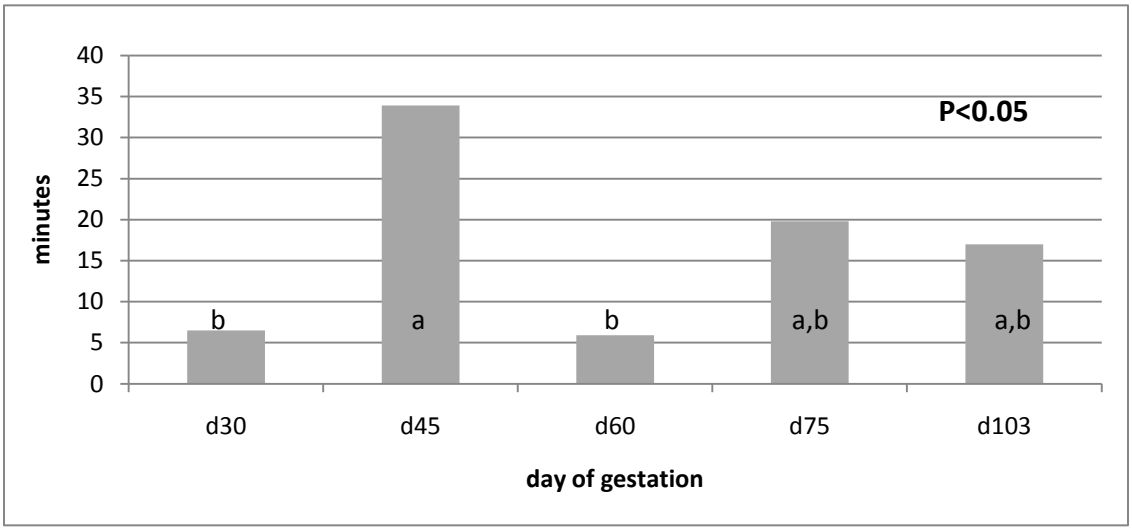
	Day of Gestation					
	0	30	31	89	110	P-value
WBC 10^7	2.27[a,b]	2.65[a]	0.95[b]	2.57[a]	2.74[a]	0.001
Lymphocyte 10^7	4.75[a]	1.15[c]	2.99[b]	2.68[b]	2.38[b]	0.05
Neutrophil 10^7	28.14[a]	4.36[b]	7.90[b]	4.93[b]	6.13[b]	0.0001
% lymphocyte	47.67[b,c]	59.25[a]	51.83[b]	50.83[b]	40.31[c]	0.001
% Eosinophil	2.58[b]	4.5[a,b]	5.83[a]	5.08[a]	3.97[a,b]	0.05
% monocyte	3.67[b]	1.3[c]	2.0[b,c]	4.58[a,b]	5.78[a]	0.05
% segmented	41.08[b,c]	33.08[b,c]	39.92[b]	36.3[b,c]	48.2[a]	0.05
% banded	5.0[a]	2.0[b]	1.42[b]	2.08[b]	2.94[b]	0.05
N:L	0.99[b]	0.62[c]	0.86[b]	0.83[b,c]	1.3[a]	0.05
Phagocytosis, %	55.19[b]	55.80[b]	47.99[c]	70.35[a]	48.56[b,c]	0.05
Cortisol ng/mL	49.9[a]	28.0[b]	39.8[a,b]	56.9[a]	51.4[a]	0.05
RPMI	22.9	19.4	31.5	25.7	22.8	0.39
C5a	26.9[d]	53.9[c,d]	142.6[a]	114.3[a,b]	87.1[b,c]	0.05
IL-8	22.2[d]	48.1[c]	164.6[a]	94.9[b,c]	52.9[c,d]	0.05

[a-d]Within a row, means without a common superscript letter differ ($P < 0.05$)

Sow behavior

- Some sows spent greater (P<0.05) amount of time in group-pen area than in stall. But, later in gestation, fewer sows spent more time in group-pen area than on d30 (Graph 5).

Graph 5. Pen preference for sows kept in FREE system throughout gestation



[a-d] means without a common superscript letter differ ($P < 0.05$)

Discussion

Experiment 1:

Results indicate that sow performance in influenced by stall type. Lesions were greater among those sows in FLEX but only on the sow's right side which may be indicative of greater space (due to increasing width) being correlated with sow preference of the side she lays on. Sow productivity was also influenced by stall type. Specifically, with those sows being kept in FLEX stall having more piglets born and a tendency for more piglets born alive than sows in traditional STALL. These data indicate that it may be possible to improve litter productivity with even the slightest modification of the stall component of a housing system.

Several behaviors were influenced by the type of stall the sows were kept in during gestation. Specifically, behaviors such as ONF and sham chewing were performed less among sows that were kept in the FLEX prototype stall compared with those in the traditional STALL. "Stereotypic" behavior is known as repetitive behavior with no specific purpose (this is a debatable issue), however, some scientists believe these type of behaviors to be a coping mechanism. If this theory is correct, we can hypothesize that sows in traditional STALL may be performing these behaviors more often to cope with their environment and/or these are innate behaviors that actually are expressed differently depending on the environment in which sow is kept. However, the only difference in these two stalls was simply that the width could be adjusted in the FLEX stall. Both stall types did not have horizontal bars on which that sow could bar-bite, thus the absence of bars may have increased sham-chewing. Other maintenance behaviors were affected by treatment, such as drinking. Sows in STALL spent more time drinking than sows kept in FLEX stall. We do not know how much water was actually consumed and if during this observation period if sows were actually drinking. It is possible, that sows were simply "playing" with water instead of ingesting, however the sows in STALL spent more time engaged in this behavior. Within both stall environments, sows had the same water delivery and feeding systems and were in the same environment (with an empty space in between each stall). In fact these sows were located next to each

other. Sitting behavior was also influenced by stall treatment; with sows in FLEX sitting more than sows in STALL. As width of the FLEX stall was increased throughout gestation, sitting behavior increased throughout gestation. It appears that sitting behavior may be positively correlated with increase in space, thus as amount of space (width) is increased, sows have more space to sit. The re-positioning of sitting to standing to laying requires more space for a larger sow, so by increasing the width this may make it easier for a sow to sit.

Day of gestation impacted several measures, as day of gestation increased lesion scores decreased and stereotypic behaviors increased among all sows. Stereotypic behaviors increasing could be a result of increase "stress" related to pregnancy. Another theory could be that the longer amount of time she spends in one environment without any new stimulus could be influencing the sows to grow bored and increase these repetitive behaviors.

Experiment 2:

Results within indicate that sow performance and productivity can be influenced by physical components of a housing system. Sows kept in FREE stall had significantly more lesions, which one would expect since these animals can interact with one another. Since social hierarchy is established in a group situation by aggressive encounters lesion scores go upon introduction of sows to the group pen – as day of gestation increased, lesion severity decreased indicating that dominance order was established for the most part. Sow productivity was influenced by stall design as well, with sows in FLEX stall and FREE system giving birth to more male offspring than did sows kept in STALL. It is believed that sex is determined prior to d30 of gestation, thus is it possible that the housing environment may influence the "survival of the fittest", thus maybe female mortality in-utero is greater in FLEX and FREE kept sows. Despite the fact, that more piglets were born to those sows kept in FLEX stall, these sows had greater mortality between birth and weaning, however this was not significant.

Physiological measures were influenced by treatment such that total WBC count decreased among sows kept in FREE and STALL 24h after being placed into their assigned treatment, which indicates either suppression of the immune system due to stress of or a homeokinetic response. For sows kept in FREE stall environment, N:L ratio also increased after being placed into this environment and remained elevated throughout gestation. This often is use as an indicator of acute stress however, N:L ratio stayed elevating possibility indicative of perceived stress in the long-term. This stress response by the sows in the FREE environment may be due to social tension for the duration of gestation. The decrease in cortisol among sows kept in FLEX environment may indicate that in late gestation, increasing the space the sow has available to make postural adjustment with ease may accommodate a "need" thus reducing her stress response. Behavioral results in FREE kept sows indicates that day of gestation impacts preference of location, whether individual stall or group pen. Individual preference is influenced most likely by dominant or submissive status of the sow. Further analyses needs to be done to determine if this is correct.

Taken together, these data begin to provide support that physical components of a housing system may impact dry sow well-being.