

**Title:** Effects of Space Allowance on Group-Housed Dry Sows –  
**NPB # 02-173**

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**Abstract:** These experiments were designed to determine the effect of (1) differential effects of individual—crate and group—pens, and (2) impacts of space allowance for group-kept dry sows while keeping group size constant on dry sow performance, productivity and health. This study focused on the effects of grouping and floor space allowance on numerous physiological and productivity indicators of sow welfare. There were many significant treatment, parity, day, and interactions on the various measures assessed in this study. There were significant differences between sows kept in crates and groups (regardless of floor-space), which included scores for lameness and body lesions ( $P < 0.001$ ). Those kept in groups had higher lameness and lesion scores. Among group-kept sows, floor-space allowance influenced these scores ( $P < 0.001$ ). As floor-space allowance increased, lameness scores increased while lesion scores decreased. Number days on experiment also influenced lesions among group-kept sows ( $P < 0.001$ ) with scores drastically increasing across the first 10 days of the experiment. The highest scores being recorded among those grouped at 15 ft<sup>2</sup>. Gestation days influenced lesion scores among group-kept sows. There were no effects on the majority of sow- and litter-related performance and productivity measures, except for BW, BF depth, and litter size. Sows in groups were heavier than those in crates ( $P < 0.05$ ); with those at 25 and 35 ft<sup>2</sup>/sow being the heaviest. Sows kept at 25 ft<sup>2</sup> had the deepest BF. There was a trend ( $P < 0.07$ ) among sows kept at 35 ft<sup>2</sup> to have larger litters than those kept in crates or at 25 ft<sup>2</sup>/sow. Lying was higher among group-kept sows than those kept in crates ( $P < 0.05$ ), but sitting was higher among sows in crates. ONF behaviors were higher among sows in crates and those kept at 25 ft<sup>2</sup>. Walking increased with increasing space among sows kept in groups ( $P < 0.001$ ). N:L, phagocytosis, and % neutrophils was higher among sows kept in crates; whereas, sows kept at 15 ft<sup>2</sup> had highest NK. Floor-space influenced % neutrophils and N:L; as space decreased these measure increased ( $P < 0.05$ ). Also, as space increased B-cell proliferation increased but NK decreased ( $P = 0.01$ ). Other measures were not influenced by treatment or space allowance. In general, sows in crates performed similar to those in groups. Despite the differences in lesion scores, BW, immune and behavior among treatments overall performance and productivity were not influenced. Moreover, despite these statistical differences it is important to note that the magnitude of differences for some of these measures may not be relevant from a “biological” standpoint.

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**Introduction:** The most common accommodation for pregnant sows in the US is the individual crate. Keeping pregnant sows in crates has become a major public issue. This concern has been driven primarily by the recent ban of individual crates implemented in several European countries. This ban was based more on public perceptions than on conclusive scientific findings, leading to an increase in pressure on the US pork producers to consider potential alternatives to the gestation crate.

Few studies have investigated the impacts of keeping pregnant sows in individual crates or groups on sow productivity and litter performance. Farrowing rates by sows kept in crates or groups during gestation do not differ. Most reports indicate that sows kept in individual gestation crates have equal or greater reproductive performance as those sows kept in groups. Farrowing rate or weaning-to-estrus interval has been reported to be from 0.7 to 1.1 days shorter in sows kept in crates compared to those kept in gestation groups. Others have reported that neither estrus detection rate nor duration of estrus is influenced by keeping environment during pregnancy.

Studies of pregnant sows in loose-housing systems have largely ignored effects of floor-space allowance on well-being. Neither any impacts of grouping on dry-sow well-being nor appropriate grouped-sow space allowance is known. Thorough investigation and understanding of grouping dry sows must precede such a system being either recommended or required. Otherwise, sow well-being, health and performance may be unintentionally reduced.

**Objectives:** To determine (1) differential effects of individual (crate) and group housing (pen) and (2) impacts of space allowance for group-kept dry sows while keeping group size constant on dry sow performance, productivity and health.

**Materials and Methods:** Crossbred primiparous and multiparous sows derived from PIC genetic lines kept at the University of Illinois were used to assess group- and individual-housing conditions during pregnancy. Treatment groups which consisted of five sows each, were randomized across body weight (BW), body condition score (BCS), backfat (BF), and parity (PAR) at ~day 25 of gestation. Treatments consisted of sows in groups at 15 ft<sup>2</sup>/sow, 25, or 35; or individual crates (14 ft<sup>2</sup>/sow) for two successive parities across 6 groups. The number of farrowings per replicate ranged between 154 (rep 1) and 65 (rep 2; one experimental group not replicated). Pen partitions were constructed of metal-slat panels and floors were partially solid and slatted, which was consistent across treatments. Sows kept in groups were floor-fed as a group each morning. Sows in crates were individually fed at the same time.

Prior to the study, all sows were kept in individual crates after the previous litter was weaned, and were artificially inseminated within 24 h after estrus onset and once again 24 h later. Newly bred sows were kept in crates until the experiment started. Using abdominal ultrasound, pregnancy was confirmed, at this time sows were moved to their assigned treatment location, until ~d110 of gestation. Sows were moved to the farrowing facility and placed in individual farrowing crates. All litters were weaned at 19±2 d of age, and sows were returned immediately to the breeding area. Multiple sow- and litter-related traits were recorded on 219 farrowings across 2 parities. Sow-related traits included BW on d25 (start of trial) and d110 of gestation and on d131 (end of lactation), BF depth, days till rebred, and proportion culled. BF was taken using a longitudinal ultrasound scan anterior to the last rib each time BW was recorded. Using a method modified after de Koning (1985), BCS (1=lowest, 5=highest) was assessed every 3 days for the first 2 weeks of the experiment (Period 1), then weekly thereafter (Period 2). Sow BW gain adjusted for BF and overall gains at different time points were calculated. Litter-related traits included numbers of pigs born alive and male and female pigs born alive, respectively; ratio of males:females within litter; and proportions of pigs born dead, stillborn, or mummified, respectively. Litter performance was assessed taking into account cross-fostering, essentially adjusting for

number of pigs gained or removed from a litter. Litter weaning BW, mean pig BW and mean BW gained between birth-weaning were also calculated.

Lesion scores were recorded at the start of the experiment (~d25 of gestation), every 3 d for the first 2 wk (Period 1). After the first 2 wk of the study, lesion scores were recorded weekly throughout gestation and once again at the end of lactation (Period 2). Lesion scores were recorded for each of the following body locations: head, ears, neck, chest/breast, shoulders, back, udder, rear, vulva, perineum, legs and hooves. Sows were lesion scored each time based on the presence or absence of a new or old lesion in conjunction with severity of the wound, thus a sow could receive a score from 0 (normal, no lesions) to 6 (severe wound, open wound) on any particular day. In addition sows could be assigned combined lesions score which means they could be assessed a score as high as 16 (which is a combined score). Lameness scores were assigned once the sow was in a standing position and started moving resulting in a rating scale of 0 (none), 1 (slight) or 2 (marked).

Behavior data was collected from sows at ~d 90-110 of gestation. Behavior was recorded for 72 h. Initially, behavior data were collected using 5 min scan samples per hour for 24 h resulting in 24 time periods. These 24 time periods were combined and resulted in 6 overall periods which were reflected of the time of day. The following behaviors were recorded lay, sit, stand, walk, eat, drink, oral-nasal-facial, agonistic encounters. A new behavior category was created in order to analyze the combination of behaviors (e.g., oral-nasal-facial while standing). Furthermore, detailed sequential analysis, duration and frequency of behaviors were analyzed using the Observer software.

Blood samples were taken at d 25, 90, 108, and 110 of gestation. Sows were nose-snared and 20 mL of blood were collected by anterior vena cava puncture (procedure lasted ~1 min). Total white blood cell (WBC) and neutrophil (NE) and lymphocyte (LY) numbers and leukocyte differentials were assessed using whole blood and blood smears. Cortisol was measured using a commercially available RIA kit. Plasma IgG was measured using an enzyme-linked immunosorbent assay. A flow-cytometry-based assay was used to measure the % engulfment of fluorescent beads by neutrophils (phagocytosis; PHAG). The ability of neutrophils to migrate in response to chemoattractants (C5a and IL-8) was assessed using an *in vitro* chemotaxis (CHTX) assay. Metabolic activity of lymphocytes was measured by stimulating cells with mitogens, ConA and LPS. The ability of a sub-population of lymphocytes to kill tumor cells (natural killer cell cytotoxicity; NK) was measured using a non-radioactive cytotoxicity assay.

Data were analyzed using mixed-effects model except for binary trait proportion of cull and those lesion scores which included numerous zeros were analyzed using Chi-square test. The mixed effects model included the fixed effects of grouping and space or TRT, PAR and the interaction. Random effect of replicate assessed over two pregnancies was included in the model. Mixed effects repeated model was used on day that also included the fixed effect of day at measurement.

## **Results: Sow and litter-related traits**

Lameness and getting up – There were no differences in getting-up scores among treatment groups. However, there were effects of TRT and PAR on and TRT × PAR interaction for lameness scores. Overall, sows kept in crates had lower ( $P < 0.001$ ) lameness scores than sows kept in groups. Among group-kept sows, lameness scores increased with increasing space allowances ( $P < 0.001$ ), thus the more space per sow, the higher her lameness score.

Lesion scores – Period 1 (day 0 -13) – There were significant TRT and PAR effects on and TRT × PAR interactions for lesion scores. In essence, the lower and/or higher parities within a treatment group tended to have higher lesion scores. Despite the TRT × PAR effects on lesion scores, this final report will focus on the effects of keeping sows in crates or pens and effects of floor-space allowances on body lesion scores. Overall, sows

kept in groups had the highest lesion scores across the various regions of the body compared to those sows kept in crates ( $P < 0.0001$ ). Lesion scores on the ears, neck, shoulders, back, sides, rear, perivulva (vulva and perineum regions combined), front legs and hind legs were effected by TRT during period 1. Floor-space allowance significantly influenced lesion scores among sows kept in groups. Lesions scores across the various body regions increased as space decreased ( $P < 0.05$ ).

Within groups, space allowance influenced lesions scores especially during the first 13d on experiment. Essentially, as space allowance decreased lesion scores increased. This affect was consistent throughout period 1. Overall, sows kept at 15ft<sup>2</sup>/sow had the highest sides, shoulders, rear, back and perivulva lesion scores than those sows kept at 35ft<sup>2</sup>. Among sows kept in groups at 25 and 35 ft<sup>2</sup>, there were no significant differences in lesion scores for the sides, shoulders, back or perivulva regions.

Lesion scores for sows kept in crates remained relatively consistent throughout the first 2wk of the experiment. Conversely, lesion scores increased substantially from d0 to 3 among sows kept in groups, with scores remaining elevated until at least d10 or 13 on experiment. Lesion scores on the ears, neck, sides, shoulders, back and perivulva were highest from d3 to 13 post-treatment than on d0 ( $P < 0.001$ ). Often the highest scores were recorded on d10 post-treatment, regardless of floor-space allowance. Despite the decrease in scores at d13, sows kept in groups at 15ft<sup>2</sup>/sow, scores were often higher than other treatment groups at d13.

Period 2 (days 20 (45 of gestation) to 86 (111 of gestation) – There were significant TRT effects on lesion scores during period 2. Overall, lesions on the ears, neck, shoulders, sides, back, rear, perivulva, and front and hind legs were higher among sows kept in groups ( $P < 0.0001$ ). Often scores were higher in sows kept at 15ft<sup>2</sup>/sow – so as floor-space allowance decreased lesion scores increased. Lesions on the ears, neck, shoulders, sides, and rear were highest in sows grouped at 15ft<sup>2</sup>/sow. Among sows kept in groups at 25 or 35ft<sup>2</sup>/sow, lesion scores on the shoulders, back, rear, perivulva, and hind legs were not different.

Lesion scores on the ears, neck, and shoulders tended to decrease as days in each gestation environment increased. Typically, lesion scores decreased across days on experiment but as gestation days increased scores increased. Side and rear lesions decreased significantly from gestation days 45-80 (exp. d20-55), but increased once again at ~d87 of gestation (exp. d62). Lesions on the rear actually increased substantially at ~d60 of gestation (exp. d34) and remained higher until farrowing. Lesions on the neck, shoulders, perivulva, and legs increased at ~d101 of gestation (exp. d76). Neck lesions remained consistently higher (until ~d 108 of gestation) among sows kept at 15 and 25 than those at 35 ( $P < 0.0001$ ). During period 2, lesion scores on the back were lower compared to those scores recorded during period 1. Overall, sows kept in groups had higher back lesion scores than those kept in crates. Sows kept at 35ft<sup>2</sup> had the lowest back lesion scores compared to those kept at 15 or 25 ft<sup>2</sup>. Side lesions remained consistent across ~d45-80 of gestation (exp. d20-55), but increased among group-kept sows from ~d87-108 of gestation (exp. d62-83).

Performance and Productivity – There were PAR effects and TRT × PAR interactions for several performance and productivity measures but only TRT effects will be reported. Sow body condition scores (BCS) were slightly higher ( $P < 0.0001$ ) among sows kept in crates than those kept in groups, regardless of parity. Among sows kept in groups, those kept at 15ft<sup>2</sup>/sow had the lowest BCS ( $P < 0.0005$ ) than those kept at either 25 or 35. Sow BW and BF depth were significantly influenced by TRT. Overall, group-kept sows had heavier BW than sows kept in crates. At ~d110 of gestation and ~d131 (end of lactation), sows grouped at 25 and 35 ft<sup>2</sup> were heavier ( $P < 0.05$ ) than all other sows. Among group-kept sows those kept at 25 and 35 ft<sup>2</sup>/sow were heavier ( $P < 0.0001$ ) than those sows kept at 15 ft<sup>2</sup>. However, BW gain from gestation d25 to 110 did not differ among treatment groups, but there was a tendency ( $P < 0.07$ ) for group-kept sows, regardless of space allowance, to

gain more BW during this period than sows kept in crates. There was a tendency ( $P < 0.08$ ) for grouped sows kept at 25 ft<sup>2</sup>/sow to gain more BW while losing less BW at the end of lactation. Sows kept in groups at 35 ft<sup>2</sup>/sow lost the most BW ( $P < 0.05$ ). Overall, BF (adjusted for BW) was significantly influenced by TRT, those kept at 25 ft<sup>2</sup>/sow had the deepest ( $P < 0.0001$ ) BF.

There was a tendency ( $P < 0.07$ ) for TRT to influence litter size. Sows kept in groups at 35ft<sup>2</sup> tended to have larger ( $P < 0.05$ ) litter sizes than those kept in crates. Among group-kept sows, those at 35ft<sup>2</sup> tended to have larger litters compared to those kept at 25 but not 15. There was a tendency ( $P < 0.10$ ) for TRT to affect the numbers of pigs weaned (adjusted for cross-fostering), where those kept at 35 ft<sup>2</sup> weaned more ( $P < 0.05$ ) pigs compared to those sows in crates or kept at 25 ft<sup>2</sup>, but piglets from sows at 35 tended gain less BW from birth to weaning.

**Behavior** – Scan sampling of maintenance behaviors revealed significant TRT and Time of Day effects on several behaviors. There were treatment effects on various behaviors based on 5 minute scan sampling ( $P < 0.05$ ). Overall, sows kept in groups were observed lying more often than those in crates. Frequency of sitting behavior was higher among sows kept in crates than those in groups ( $P < 0.0001$ ). Within groups those sows kept at 15ft<sup>2</sup>/sow sat more often than those at 25 or 35. Drinking was observed more often among crated sows than those kept in groups ( $P < 0.05$ ). Standing and eating behaviors were not influenced by TRT. However, sow BW did influence standing behavior; as BW decreased, standing increased ( $P < 0.05$ ).

Treatment influenced ONF behaviors ( $P < 0.05$ ). Sows kept in crates and those kept in groups at 25 ft<sup>2</sup> were observed more often engaged in ONF behaviors. The highest ONF behaviors were displayed in the time periods prior to feeding and immediately following the disappearance of feed. Among group-kept sows, those at 25 ft<sup>2</sup> were engaged more often in ONF behaviors than those at 15 or 35. Space allowance influenced walking behavior. As space allowance increased the number of times sows were engaged in walking was increased. Time of day influenced behaviors as well. \*Sequential analysis is not complete.

**Cortisol and Immune measures** -- There were no significant TRT or PAR effects on plasma cortisol. There was a tendency for group-kept sows to have higher cortisol than sows in crates ( $P = 0.08$ ). CORT was highest on day 3 post-treatment, regardless of treatment. Total WBC counts and % differentials were influenced by TRT ( $P < 0.05$ ). Sows kept in crates had higher % NE, whereas those kept in groups had higher % LY ( $P < 0.05$ ). Those sows kept at 35 ft<sup>2</sup> had the highest % LY. Sows in crates had higher N:L than those kept in groups ( $P < 0.05$ ). There was a significant difference in the ability of NE to engulf PHAG. Ability of B-cells to proliferate in response to LPS was highest in sows kept in groups at 35 ft<sup>2</sup> and those kept in crates ( $P = 0.02$ ), but not effect on T-cell proliferation. NK cytotoxicity (25:1) was influenced by TRT, sows kept at 15 ft<sup>2</sup> had the higher ( $P < 0.05$ ) percent cytotoxicity than other treatment groups.

Days of gestation had an effect on % neutrophils, lymphocytes, and N:L ratio. At d108 and 110 of gestation sows had significantly higher % neutrophils than at d28 or 90 of gestation ( $P < 0.0001$ ). Conversely, % LY were higher at d 28 and 90 of gestation ( $P < 0.0001$ ). N:L ratio was highest at d110 of gestation compared to all other days ( $P < 0.0001$ ). NE CHTX was higher at d3 of the study and d90 of gestation. Space allowance significantly influenced NE (%) and N:L. NE increased as space allowance/sow decreased ( $P < 0.05$ ). Conversely, space allowance did not influence LY (%). Sows kept at 15ft<sup>2</sup>/sow tended to have a higher N:L ratio than those kept at 35ft<sup>2</sup>/sow ( $P = 0.08$ ), thus as space decreased the N:L ratio increased. Among group-kept sows, as space increased, B-cell proliferation increased ( $P = 0.01$ ) where as NK cytotoxicity decreased ( $P = 0.01$ ).

**Discussion:** The results of the research reported here, first confirm that dry sows kept in crates had reproductive performance similar to those in groups. Reproductive performance

of sows and productive performance of piglets were virtually similar regardless of gestation environment. As for sow BW and BCS, despite the statistical differences among treatments, these measures were within acceptable range and the magnitude of the biological differences was not that high (in most cases). Potential explanations for the discrepancy between BCS and BW could be that sows in gestation crates retained less dietary metabolizable energy because they have less opportunity to huddle with one another during cool periods and that comparing BCS between to different gestation environments could be distorted by one's perception. Group-kept sows at the lowest floor-space allowance generally had lower BCS, BW, and BF values but these values among these sows are within acceptable ranges. In addition, lesion scores were significantly higher among sows kept in groups during gestation and among those kept at the lowest floor-space allowance but this did not have an overall impact on their performance or productivity.

Gestation environment and space allowance influenced behavior and immune measures. Behavior differences were between sows kept in crates and those in pens were observed for lying, sitting and drinking behaviors. Group-kept sows were observed lying more often whereas those in crates tended to sit more often. Space allowance influenced walking behavior; such that those with the most space-allowanced engaged more often in walking. This increase in walking bouts may contribute partially to the increase in BW. Sow BW did influence standing bouts, sows of heavier BW stood less often. Immune measures that are indicative of potential activation of stress were higher among sows kept in crates, but did not influence their overall performance and productivity. In fact, despite higher N:L ratio and percent NE, sows in crates had higher NE phagocytosis. Space allowance also influenced these same measures; as floor-space/sow increased, NE and N:L decreased. Floor-space influenced other measures of the immune response as well. It is difficult to interpret whether or not these immune response differences will have a negative or positive impact on sow health but one may assume it does not compromise performance or productivity. Overall, we can not determine from these studies if these changes have an effect of other aspects of dry sow-well being.

**Lay Interpretation:** These data provide further support that sow performance and productivity between those kept in crates and groups is similar. Overall, differences found between sows kept in crates and those in groups during gestation do not appear to compromise their well-being as assessed by various physiologic, behavior and performance/productivity measures. Despite these differences most often values for all treatment groups were within acceptable ranges. On the other hand, among group-kept sows it does appear that those kept at 15ft<sup>2</sup>/sow well-being could be compromised. It is obvious that lesion scores are greatly influenced by floor-space allowance and potentially days of gestation. More importantly, sows kept in groups at 15ft<sup>2</sup>/sow had higher body lesion scores than those kept at other space allowances. If lesion scores are an indicator of well-being, one would not suggest keeping sows in groups at 15ft<sup>2</sup> per sow. Immune response between sows kept in crates and groups and among groups at different space allowances existed. However, these differences did not compromise their performance or productivity. There are still questions that remain to be resolved about the impact of gestation environment on sow well-being.

**Effects of gestation environment and space-allowance on some sow- and litter-related traits.**

| Variable                     | <u>Pens (ft<sup>2</sup>/sow)</u> |                          |                          |                        | TRT     | Crate<br>vs<br>Group | <u>Contrast</u> |           |
|------------------------------|----------------------------------|--------------------------|--------------------------|------------------------|---------|----------------------|-----------------|-----------|
|                              | Crate                            | 15                       | 25                       | 54                     |         |                      | Linear          | Quadratic |
| BCS                          | 3.7±.09 <sup>a</sup>             | 3.2±.08 <sup>c</sup>     | 3.4±.08 <sup>b</sup>     | 3.4±.09 <sup>b</sup>   | <0.0001 | 0.0001               | <0.0001         | <0.0005   |
| BW d 110, kg                 | 233.3±6.4 <sup>d</sup>           | 238.4±5.8 <sup>d,e</sup> | 244.9±5.8 <sup>e,f</sup> | 253.8±6.4 <sup>f</sup> | <0.005  | <0.05                | 0.005           | NS        |
| Mean BW, kg                  | 223.2±4.9 <sup>d</sup>           | 223.4±4.6 <sup>d</sup>   | 230.9±4.7 <sup>e</sup>   | 235.4±4.9 <sup>e</sup> | <0.0001 | 0.01                 | <0.0001         | NS        |
| BW change (d 25 to 110), kg  | 24.9±4.6                         | 31.5±3.6                 | 34.2±3.6                 | 36.8±4.6               | NS      | <0.07                | NS              | NS        |
| BW change (d 25 to 131), kg  | 17.5±4.4                         | 20.7±3.4                 | 27.2±3.5                 | 17.8±4.4               | NS      | NS                   | NS              | <0.08     |
| BW change (d 110 to 131), kg | -7.4±4.4 <sup>d</sup>            | -10.3±3.5 <sup>d,e</sup> | -7.0±3.5 <sup>d</sup>    | -19.2±4.4 <sup>e</sup> | NS      | NS                   | 0.11            | <0.08     |
| BF adjusted for BW, cm       | 0.76±.02 <sup>a</sup>            | 0.77±.02 <sup>a</sup>    | 0.86±.02 <sup>b</sup>    | 0.79±.02 <sup>a</sup>  | <0.0001 | <0.05                | NS              | <0.0001   |
| Litter size, no              | 11.9±.56 <sup>a</sup>            | 12.4±.56 <sup>a,b</sup>  | 11.6±.55 <sup>a</sup>    | 13.5±.57 <sup>b</sup>  | 0.06    | NS                   | NS              | NS        |
| Born alive, no               | 9.5±.42 <sup>a</sup>             | 9.9±.42 <sup>a,b</sup>   | 9.4±.41 <sup>a</sup>     | 10.5±.43 <sup>b</sup>  | NS      | NS                   | NS              | NS        |
| Wean, no                     | 8.2±.26 <sup>a</sup>             | 8.6±.25 <sup>a,b</sup>   | 8.2±.26 <sup>a</sup>     | 8.9±.27 <sup>b</sup>   | <0.10   | NS                   | NS              | NS        |

<sup>a,b,c</sup>Means with different superscripts within rows differ at P < 0.001.

<sup>d,e,f</sup>Means with different superscripts within rows differ at P < 0.05.