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Managing young sows in group-gestation housing systems

Yuzhi Li*, and Lee Johnston
University of Minnesota
***Corresponding Author**
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Abstract
A common problem with group-gestation housing is aggression among sows at mixing which is detrimental to both health and performance of sows. As aggression among unfamiliar pigs is necessary for developing a dominant hierarchy within a group, a certain required level of aggression in sows at mixing cannot be eliminated. Management strategies should address protecting vulnerable sows in a group from aggression to ensure their performance and welfare not being compromised. Young sows are usually subordinate and vulnerable in a group. The objective of this study was to determine effects of sorting by parity on reducing aggression and associated stress, and thereby to improve welfare and performance of young sows in group housing systems. The study was conducted at the West Central Research and Outreach Center of the University of Minnesota. A total of 180 sows and gilts from 6 breeding groups (block) were used. Within each group, 15 older females (11 multiparous sows and 4 parity-1 sows) and 15 younger females (11 gilts and 4 parity-1 sows) were mixed in a sow- or gilt-pen after weaning, and remained there throughout the entire gestation period. At mixing and before the subsequent farrowing, all sows and gilts were weighed individually, assessed for body condition scores, and measured for back fat thickness. Aggressive interactions involving young sows were video-recorded for 72 h after mixing in each pen. Injury scores were assessed on all breeding females; and salivary cortisol concentrations were determined on 2 focal young sows (parity-1) in each pen before and 48 h after mixing. Wean-to-breeding intervals, farrowing rate, and litter performance of the subsequent farrowing were recorded for all females involved in the study. Results indicate that females in gilt-pens sustained fewer injuries (6.3 vs. 9.0 of total injury score, SE = 0.54; $P < 0.001$) at 48 h after mixing than females in sow-pens. Young sows in gilt-pens fought more frequently (6.2 vs. 3.9 fights/h, SE = 0.57; $P < 0.001$) and for longer periods (67.0 vs. 29.9 s/h, SE = 19.58; $P < 0.01$), and won more fights (38 vs. 15 %, SE =8.2%; $P < 0.01$) at mixing, but had fewer injures (7.5 vs. 11.7 of total injure scores, SE = 1.73; $P < 0.001$) 48 h after mixing, gained more weight (59 vs. 36 kg; SE = 6.3; $P < 0.01$) during the gestation period, and had higher farrowing rates (94 vs. 67%; Chi-square = 4.75, $P < 0.03$) compared with young sows in sow-pens. No differences in wean-to-breeding intervals, gestation length, body condition scores, and back fat thickness were observed between young sows in sow-pens and in gilts-pens. The data suggest that young sows in gilt-pens improve their dominant status so that they did not suffer severe injuries caused by aggression at mixing compared with young sows in sow-pens. The improved dominant status of young sows in gilt-pens also contributed to better performance with improved farrowing rate and weight gain during the gestation period compared with young sows in sow-pens. By grouping young sows with gilts, young sows can be shielded

from severe injuries associated with aggression at mixing so that their welfare and performance can be improved in group housing systems.

Introduction

Mixing-induced aggression is inevitable in group housing systems, regardless of space allowance, group size, bedding, pen design, or feeding regimens. By increasing space allowance, Barnett et al. (1993) and Edwards et al. (1994) could not reduce aggression in sows at mixing. Group size did not affect aggressive interactions encountered by each individual (Turner et al., 2001; Schmolke et al., 2004; Strawford et al., 2008). Providing bedding (Whittaker et al., 1999), a protective barrier (Luescher et al., 1990) or ad libitum feeding (Spoolder et al., 1997) were not successful at reducing aggression in sows caused by mixing.

Aggression in swine at mixing is usually intense during the first few hours and drops dramatically after 24 hr (Moor et al., 1993; Schmolke et al., 2004; Turner and Edwards, 2004). A stable social group can be formed within a week (Arey 1999). The elevated aggression causes injuries (Hodgkiss et al., 1998) and increases cortisol levels in sow blood (Hemsworth et al., 2006). When grouped during the implantation period, aggression reduces conception rate (Olsson and Svendsen, 1997; Strawford et al., 2005). Young sows are usually subordinate and vulnerable in group housing systems. They lose most fights at mixing, and suffer more injuries and higher cortisol levels than mature sows (Edwards et al., 1994; Hemsworth et al., 2006; Strawford et al., 2008). The initial aggression results in the subordinate young sows becoming fearful of further conflicts while attempting to obtain feed which leads to inadequate feed intake and reproductive failure (Olsson and Svendsen, 1997). Failure of conception or lameness caused by initial aggression can result in young sows being culled prematurely, as is often observed in group housing systems (Strawford, 2006).

As aggression among unfamiliar pigs is necessary to develop a dominant hierarchy within a group, aggression among sows at mixing cannot be eliminated completely. Management strategies should focus on protecting vulnerable sows from aggression. In most production systems, gilts are usually housed separately in group housing systems to prevent aggression from older sows. However, after farrowing, parity-1 young sows are usually housed in pens with older sows. Average body weights of parity-1 sows are about 75% of body weights of mature sows (Li and Gonyou, unpublished data), and are more similar to body weight of gilts than mature sows. So it may be appropriate to house parity-1 sows in gilt pens rather than in sow pens to reduce social stress. In this study, we investigated effects of sorting by parity on aggression and associated stress in young sows housed in groups.

Objectives

The overall objective of the project was to determine effects of sorting by parity on aggression and associated stress in young gestating sows housed in groups. Specific objectives were to investigate:

1. Aggressive interactions involving young sows in Control (unsorted sows) and Treatment (gilts and parirty-1 sows only) pens.
2. Injuries and cortisol concentrations of young sows (parity-1) after mixing in Control and Treatment pens.
3. Difference in reproductive performance of young sows between Control and Treatment pens.

Procedures

Animals and Facilities

The study was conducted at the University of Minnesota's West Central Research and Outreach Center in Morris, MN during December, 2009 through August, 2011. All gestating sows and gilts (Yorkshire × Landrace) were group-housed in a straw-bedded hoop barn. The barn had 4 pens, each accommodating 15 sows or gilts with individual feeding stalls. Space allowance in each pen was 43 ft^2 (4.0 m^2) excluding the area occupied by feeding stalls. Sows and gilts were bred in batches. Every 10 weeks, 35 to 40 females were bred within 5 days. Sows and gilts were fed 5.5 lb (2.5 kg) once daily of a corn-soybean meal based gestation diet formulated to meet NRC (1998) nutritional requirements for gestating sows and gilts.

Experimental Design:

A blocked, nested split-plot design (Douglass, 2004) was used for this study, with the treatment (sow-pen or gilt-pen) as the main plot, and parity-1 sows nested within each treatment in the sub-plot. Every 10 weeks at weaning, two groups of 15 females were assigned to and mixed in each of the two treatment pens (See below) within a block. The study was conducted in 6 blocks of 10 weeks, yielding 6 replicates for each treatment. In total, 180 sows and gilts were used for data collection, with 90 animals assigned to each treatment. Sows and gilts remained in their assigned group throughout the whole gestation period. All sows had been housed in groups during their previous gestation. The gilts were group-housed in pens for at least 4 weeks before being assigned to the study to ensure they were familiar with the housing system.

Experimental Treatments

Control group. The control group was a typical sow group as usually observed in a commercial setting, consisting of parity-1 and multiparous sows. Each pen consisted of 4 parity-1 females and 11 multiparous (parity 2 to 10) sows. Since familiarity to each other affects aggression among sows at mixing, each pen had approximately 1/3 unfamiliar dyads (unfamiliar pairs of animals). Unfamiliar is defined as sows that have not been housed in the same group during the last 6 weeks (Hoy and Bauer, 2005).

Treatment group. The treatment group consisted of only parity-1 sows and gilts. The proportions of parity-1 sows and unfamiliar dyads in each treatment pen were similar to those in control pens. This group was designed to protect parity-1 sows from aggression of mature sows.

Data Collection:

To determine effects of treatments on aggression, associated stress, and reproductive performance, the following data were collected:

Aggression at mixing. Sow behavior at mixing was video-recorded in all control and treatment pens. Immediately after mixing, aggressive interactions among sows in each pen were recorded for 72 h using a digital camera (Hi-Res Bullet Cams 2505, Sony, Taiwan), which was connected to a computer with a DVR device and video-recording software (Geo Vision Multicam Digital Surveillance System V8.2; USA Vision Systems Inc, Irvine, CA). The video recording was viewed continuously to analyze all fights involving parity-1 sows during each period of 0 to 6 h, 6 to 24 h, 24 to 48 h, and 48 to 72 h after mixing. Due to technical reasons, video-recording in one block was not successful, so data from 5 blocks were analyzed. The frequency, duration, and outcomes (winner, loser, and unsolved) of fights were registered using the method of Turner et al. (2006). An unsolved fight was defined as a stand-off fight without a clear winner or loser. Intensity of aggression was assessed by parallel pressing, head-to-head knocking, and head-to-body knocking according to the methods of Jensen (1980). Parallel pressing was defined as sows that stand side by side and push hard with the shoulders against each other, generally performed with frequent bites. Head-to-head knocking was defined as a sow delivering rapid knocks with the snout against the head, neck, or ears of the receiver, generally performed with bites as accessory features. Head-to-body knocking was defined as a sow delivering rapid knocks with the snout against any parts of the body behind the ears of the receiver, generally performed with bites as accessory features. The intensity of aggression is the highest in parallel pressing, the lowest in head-to-body knocking, and intermediate in head-to-head knocking (Jensen, 1980). Total duration and frequency of pressing and knocking, and outcomes of fights during each period were calculated for all young sows in each pen.

Injury scores. All sows in each pen were assessed for scratches before and 48 h after mixing. Scratches were assessed using the methodology of Hodgkiss et al. (1998). The assessment combined scores of 0 to 3 from 12 surface regions of the body: 2 ears, snout, 2 shoulders, 2 flanks, 2 hindquarters, the back, the tail, and the vulva. The scoring system was: 0 = no injury (skin unmarked: no evidence of injury from aggressive behavior), 1 = slight injury (< 5 superficial wounds), 2 = obvious injury (5 to 10 superficial wounds and/or <= 3 deep wounds), 3 = severe injury (> 10 superficial wounds, and/or > 3 deep wounds). Previous studies (Turner et al., 2006; Stukenborg et al., 2011) indicated that dominant pigs usually sustain more skin lesions at the front part of their body, and subordinate pigs have more skin lesions at the rear part of the body. To assess the relationship between outcome of fights and injuries caused by fighting, an injury score for the head (by adding injury scores on the two ears and the snout), an injury score for the shoulders (by adding injury scores for the two shoulders), an injury score for the remaining parts of the body (by adding injury scores on the flanks, the hindquarters, the back, the tail, and the vulva), and a total injury score for each animal was calculated. The possible maximal scores for the head, for the shoulders, for the remaining parts of the body, and for each sow were 9, 6, 21, and 36, respectively.

Salivary cortisol. Saliva samples were obtained from 2 sows of parity-1 in each pen between 1300 and 1400 h on the same days that injuries were assessed. Saliva was collected using absorbent cotton swabs with minimal disturbance to the sows. To avoid cortisol level being elevated by handling stress, each saliva sample was collected within 3 min of approaching the sow. Saliva was removed by centrifugation, and frozen at -20°C for subsequent analysis. Cortisol concentration was determined by radioimmunoassay according to the methods of Cook et al. (1997). However, due to some unknown reasons the analysis of cortisol concentrations was not successful. Currently, we are investigating the assay procedures in detail to determine causes of the unsuccessful analysis. We will re-analyze the samples again once we are confident about the assay. So the results of cortisol concentrations will be submitted later.

Body condition. Individual body weight, body condition score, and backfat thickness were recorded on all animals before mixing and before moving for the subsequent farrowing. The method to assess body condition score followed that of Coffey et al. (1999) which has been adopted by the National Pork Board in the PQA Plus program. Body condition was scored 1 to 5 as: **1 =** Emaciated (back bone and pin bones are visible); **2** = Thin (back bone and ribs can be easily detected with pressure); **3** = Fit (back bone and ribs can be barely felt with firm pressure); **4 =** Fat (back bone and ribs cannot be detected with pressure); and **5 =** Very fat (obviously over weight). Backfat thickness was measured using an ultrasonic scanner (Lean-meater, Renco; Minneapolis, MN, U.S.A.) at the P2 position which was 65 mm down the left or right side from the midline, at the level of the head of the last rib, according to the SOP of the NSW Government (2011).

Performance. Standard production data, including weaning to first breeding interval (defined as wean-to-breeding interval), gestation length (from the day of the first breeding to the day of farrowing), weight gain during gestation, farrowing rate (the number of sows farrowed as a percentage of number of sows bred) and litter performance of the subsequent farrowing (total litter size, live litter size, mummified, and still born pigs per litter) were collected on all sows and gilts.

Data analysis:

All data were tested for normal distribution by using the Univariate Procedure of the SAS program (SAS Inst. Inc, Cary NC; 2005). Data that were not distributed normally were transformed using logarithm (X' = Log10(X+0.1)) to achieve normal distribution (Zar, 1999). The Frequency procedure with Chi-square test of SAS was used to examine effects of treatment on farrowing rate. To analyze all other variables, the Glimmix procedure of SAS was used. Within the Glimmix procedure, the Poisson Generalized Linear Model was used for analysis of injury scores, litter performance, body condition scores, and frequency of aggressive interactions, and outcomes of fights; and the Gamma Generalized Linear Model was used for analysis of wean-to-breeding intervals, gestation length, body weight, and weight gain during gestation, the duration of aggressive interactions and cortisol concentrations in saliva (intend). For analysis of aggressive interactions involving young sows, effects of treatment, time period after mixing, and their interactions were tested with pen used as the experimental unit and block as a random effect. For other variables, effect of treatment was tested with block as the random effect and individual sow as the experimental unit. Treatment effect on parity-1 sows was tested from the sub-plot terms of the statistical model, with individual parity-1 sow nested within each pen served as the experimental unit. Treatment effect on injury scores after mixing were analyzed by using the injury score before mixing as a co-variate. In all cases of the Glimmix analysis, differences between means were tested by the Tukey test. Significant differences were identified at $P < 0.05$ and trends at $P < 0.10$.

Results

Among the 180 breeding females used in the study, 2 sows died during the gestation period. Data on aggressive interactions at mixing, injury scores before and after mixing, body weight, condition scores and backfat thickness before mixing were collected on 180 sows and gilts. Data on wean-to-breeding interval and farrowing rate were collected from the remaining 178 sows and gilts. Among the 178 sows involved in the entire gestation period of the study, 129 sows and gilts were pregnant and farrowed (Table 1). Data of body weight, condition scores and backfat before farrowing, weight gain during gestation, and litter performance were collected on the 129 sows that farrowed.

Comparison of all females between treatment and control pens

Performance. Farrowing rate of all females in treatment pens was similar to farrowing rate in control pens (88 vs. 83%; P > 0.10; Table 1). However, farrowing rate for parity-1 sows was greater in treatment pens (gilt-pens) compared with parity-1 sows in control pens (sow-pens; 94 vs. 67%; Chi-square = 4.75; P = 0.03). There was no difference in farrowing rate between multiparous sows in control pens and gilts in treatment pens.

Females in treatment pens gestated for similar days and produced similar litters (total litter size, live litter size, still born and mummified pigs) as females in control pens (Table 2). Females in treatment pens had less body weight at mixing and before farrowing, but gained greater weight during gestation compared with females in control pens (all P < 0.001). Body condition scores before farrowing, and back fat thickness at mixing and before farrowing were greater for females in treatment pens compared with females in control pens (all P < 0.05). No difference in body condition scores was observed at mixing between the two groups.

Injury scores. Before mixing, no difference in injury scores between treatment and control groups was observed. After mixing, females in treatment pens had fewer injuries on their head (P = 0.02) and body (P < 0.001), and had lower total injury score (P < 0.001), compared with females in control pens (Table 2). Interactions between treatment and sow parity in injury scores for the head, the body, and for an individual female were observed. Within treatment pens, parity-1 sows had greater injury score for the head (2.2 ± 0.38 vs. 1.0 ± 0.16; P < 0.001), and for the individual sow (7.8 ± 0.82 vs. 5.7 ± 0.52; P < 0.001) than gilts. No difference in injury scores for the shoulders between parity-1 sows and gilts in gilt-pens was observed. In control pens, parity-1 sows had greater injury score for the body (7.0 ± 0.75 vs. 3.7 ± 0.36; P < 0.001) and for the whole individual sow (11.9 ± 1.13 vs. 7.9 ± 0.68; P < 0.001) compared with older sows.

Comparison of young (parity-1) sows between treatment and control pens

Aggression involving young sows at mixing. Fights involving parity-1 sows (referred to as young sows thereafter) were more evident during the first 6 h after mixing compared to other periods of the 72 h observation time (Fig. 1 and Fig. 2). The total duration and frequency of all aggressive interactions were greater during the first 6 h compared with those for other periods (all P < 0.001). Since no interactions between treatment and time after mixing for any aggressive interactions (both duration and frequency) were observed, treatment effect was tested for total duration and frequency of aggressive interactions during the entire 72 h of the observation period. Compared with young sows in control pens, young sows in treatment pens fought for longer period and won more fights (Table 3). The total duration of head-to-body knocking (P = 0.02) and head-to-head knocking (P < 0.001) was longer, and the total duration of parallel pressing tended to be longer (P = 0.09) for young sows in treatment pens, compared with young sows in control pens. Young sows in treatment pens won more these aggressive interactions (all P < 0.05) compared with young sows in control pens. Young sows in treatment pens also lost fewer fights of head-to-head knocking and head-to-body knocking (both P < 0.05) than young sows in control pens. No differences in the frequency of head-to-body knocking, head-to-head knocking, and parallel pressing between treatment and control groups were observed.

Performance. No differences in wean-to-breeding intervals, gestation length, and litter performance were observed in young sows between treatment and control pens (Table 4). Young sows in treatment pens had similar body weight at mixing, but were heavier (P < 0.01) before farrowing, and gained greater weight (P < 0.01) during gestation compared to young sows in control pens. Body condition scores and back fat thickness at mixing and before farrowing were not different for young sows between treatment and control pens.

Injury scores. Before mixing, no differences in injury scores were observed in young sows between treatment and control pens (Table 4). After mixing, the injury score for the body ($P < 0.001$) and the total injury score for the individual sow ($P < 0.001$) were lower in young sows in treatment pens compared to young sows in control pens. No differences were observed in injury scores for the head and shoulders after mixing in young sows between treatment and control pens.

Discussion

The major findings of this study include that young sows in gilt-pens fought for longer periods of time at mixing and won more fights, but had fewer scratches, gained greater weight during the gestation period, and had higher farrowing rate compared with young sows in sow-pens. In group housing systems, dominant pigs usually fight for longer periods and win most fights, but sustain fewer scratches compared to subordinate pen-mates (Strawford et al., 2008; Stukenborg et al., 2011). So it is not surprising that young sows in gilt-pens fought for longer periods, won more fights, and sustained fewer scratches compared with young sows in sow-pens because they may act as dominant sows in gilt-pens but as subordinate sows in sow-pens. It could be the body weight of young sows that made them dominant in gilt-pens, because body weight (or size) is one of the factors affecting the dominance hierarchy of a sow in a group (Turner et al., 2006; Strawford et al., 2008; Stukenborg et al., 2011). Compared with gilts, the young sows in the gilt-pens were heavier at mixing (201 ± 7.8 vs. 173 ± 6.2 kg; $P < 0.001$) and before farrowing (256 ± 8.4 vs. 231 ± 6.8 kg; $P < 0.001$), indicating that the young sows were likely heavier than gilts throughout the whole gestation period. The heavier the weight, the bigger the body size (Body Size = $k\ BW^{0.73}$; Petherick and Phillips, 2009). So the dominance hierarchy of the young sows in gilt-pens may be simply due to their heavier body weight or bigger size compared to the gilts. Similarly, young sows in sow-pens were subordinate because they were lighter both at mixing (207 ± 7.8 vs. 264 ± 6.2 kg; $P < 0.001$) and before farrowing (234 ± 9.5 vs. 296 ± 7.0 kg; $P < 0.001$) than their pen-mate sows.

To achieve the dominant status, sows may need to fight with more opponents (Turner et al., 2006; Stukenborg et al., 2011). This might be the reason that dominant sows fighting for longer periods compared with subordinate sows. In this study, young sows in gilt-pens were involved in 3 times more parallel pressing than young sows in sow-pens. Parallel pressing is the most intense aggressive interaction and outcomes of the fight contribute to the determination of ranking status of the sow in a group (Turner et al., 2006). Young sows in gilt-pens won 46% of the parallel pressing fights compared to 18% wins for their counterparts in the sow-pens. This further indicates that young sows in gilt-pens gained more dominant status than young sows in sow-pens. In addition, young sows in gilt-pens also won greater proportion of fights involving head-to-head knocking and head-to-body knocking compared with young sows in sow-pens. Being defeated in fights is another indicator of subordinate for a sow in a group (Langbein and Puppe, 2004). Young sows in gilt-pens were defeated less frequently in fights of head-to-head knocking and head-to-body knocking, again suggesting the improved dominant status of these young sows in gilt-pens, than young sows in sow-pens.

Young sows in gilt-pens sustained fewer scratches than young sows in sow-pens 48 h after mixing in this study. In fact, the total injury score for an individual sow and the injury score for the body in all females after mixing were lower in gilt-pen compared with sow-pens

(Table 2). This implies that overall aggressive interactions at mixing could be less intense in gilt-pens compared with sow-pens. These results were consistent with previous studies (Pitts et al., 2000; Strawford et al., 2008; Li et al., 2011) that mixing-induced aggression among pigs increased as pigs aged. In our study, young sows sustained more scratches than their pen-mates (gilts or sows) after mixing in both gilt-pen and sow-pen. In gilt-pens, the average injury score for an individual young sow was 7.5 (± 0.82), higher than the average injury score for a gilt (5.7 ±0.52; $P < 0.001$). Similarly, in sow-pens, the average injury score for a young sow was 11.9 (± 1.13), higher than the average injury score for a sow (7.9 ± 0.52; $P < 0.001$). In other words, regardless of their status in a pen, young sows had more injuries after mixing, compared to their pen-mates. Within gilt-pens, young sows had more scratches on the head than gilts; whereas in sow-pens, young sows sustained more scratches on the body compared with sows. Turner et al. (2006) demonstrated that subordinate sows that lost most of the fights at mixing usually sustain more scratches in the rear part of their body. This is because after being defeated, subordinate sows can be attacked at the rear part of the body during retreat from the fight. In contrast, dominant sows that won most of the fights usually have more scratches at the front part (head, neck and shoulders) of their body (Turner et al., 2006; Stukenborg et al., 2011) because dominant sows use the front part of their body to attack opponents. These authors suggested that dominance status of a sow can be assessed based on the locations of the injury caused by aggression. Our results support their hypothesis that subordinate young sows in sow-pens were more frequently defeated in fights and sustained mores scratches on the rear part of their body; and dominant young sows in gilt-pens won more fights and had more scratches on their head. Although the total injury score was higher for young sows in both gilt-pen and sow-pen compared with their pen-mates, young sows in gilt-pens had much lower total injury scores compared with young sows in sow-pens. The lower total injury score is indicative of less severe injuries caused by aggression in the young sows in gilt-pens compared with young sows in sow-pens. These results indicate that by grouping young sows with gilts we can protect young sows from intense aggression and severe injuries associated with the aggression.

Young sows in gilt-pens also gained more weight during the gestation period and had higher farrowing rate compared with young sows in sow-pens. This difference in weight gain and farrowing rate might be associated with reduced social stress in young sows in gilt-pens compared with in sow-pens. Previous studies have demonstrated that social stress can reduce growth rate in pigs (Schouten, 1991), and dominant pigs can gain more weight than subordinate pigs in a group (Wellock et al., 2003; Manteuffel et al., 2010). In our study, young sows in both gilt-pen and sow-pen consumed the same amount of feed because all females were provided the same base amount of feed (2.5 kg/d) in individual feeding stalls throughout the whole gestation period. So we believe that feeding program was not the reason for the difference in weight gain of young sows between the two treatment groups. Instead the improved weight gain in young sows in gilt-pens could result from improved dominance status and reduced injuries caused by aggression at mixing. The improved dominant status and reduced injuries was associated with improved farrowing rate in young sows in gilt-pens compared with young sows in sow-pens. In gilt-pens, 94% of young sows farrowed; whereas in sow-pens only 67% of the young sows farrowed. Even though the total number of young sows involved in this study was limited, we observed that grouping young sows with gilts can improve farrowing rate. Our results agree with the results reported by Olsson and Svendsen (1997) that mixing-induced social stress can reduce farrowing rate in gilts. No differences in wean-to-breeding intervals, gestation length, and litter performance were observed in young sows between the two treatment groups in our study.

In our study, most of the fights involving the young sows occurred during the first 6 h after mixing, as observed in previous studies with group-housed gestating sows (Li et al., 2011). The total duration of head-to-body knocking, head-to-head knocking and parallel pressing during the first 6 h were 3.4, 3.4 and 29.1 times greater, respectively, than the averages for the remaining periods of the 72 h after mixing. Similarly, the frequency of head-to-body knocking, head-to-head knocking and parallel pressing during the first 6 h were 2.4, 2.3 and 13.0 times greater than the averages for the remaining periods of the 72 h, respectively. Since parallel pressing is the most intense aggressive interaction, the prevalence of parallel pressing during the first 6 h suggests that controlling aggression to improve well-being and performance in group-housed gestating sows should be focused on the initial 6 hours after mixing.

Summary

This study demonstrated that injuries caused by aggressive interactions at mixing were greater in sow-pens than in gilt-pens. Young sows (parity-1) in sow-pens suffered more injuries than contemporaries housed in gilt-pens. By grouping young sows with gilts, young sows can be shielded from severe injuries caused by initial aggression. Young sows fought more frequently and for longer periods of time at mixing, won more fights, but sustained fewer scratches on their bodies in gilt-pens compared with young sows in sow-pens. Young sows in gilt-pens also gained greater weight during the gestation period, and had higher farrowing rates than young sows in sow-pens. Our data suggest that young sows were more dominant in gilt-pens than in sow-pens, which was associated with less injuries caused by aggression at mixing, improved farrowing rate, and greater weight gain during gestation than young sows in sow-pens. No differences in body condition scores, back fat thickness, wean-to-breeding intervals and litter performance were observed between young sows in gilts pens and sow-pens.

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TABLE 1. FARROWING RATE OF SOWS IN A GROUP-GESTATION HOUSING SYSTEM

	SOW-PEN[1]	GILT-PEN[2]		
Number of pens	6	6		
Number of sows				
Total used for breeding	90	90		
Not returned to estrous	18	9		
Not pregnant	12	10		
Farrowed*	58	71		
Farrowing rate*, %			Chi-square	*P* - value
Pen average	83	88	0.69	0.40
Parity-1 sows	67	94	4.75	0.03
Sows or gilts	88	85	0.22	0.64

[1] Each sow pen consisted of 4 parity-1 sows and 11 multiparous (parity 2 to 10) sows.

[2] Each gilt pen consisted of 4 parity-1 sows and 11 gilts.

* Farrowing rate was defined as the number of females farrowed as a percentage of the number of females bred. Two sows died during gestation were excluded.

TABLE 2. PERFORMANCE OF SOWS IN A GROUP-GESTATION HOUSING SYSTEM

	Control	Treatment		
	SOW-PEN[1]	GILT-PEN[2]	Pooled SE	*P* - value
Number of pens	6	6		
Number of sows and gilts/pen	15	15		
Wean-to-breeding intervals, d	4.4	5.8	0.37	<0.001
Gestation length, d	116.1	116.2	0.21	0.80
Litter size, piglets/litter				
Total born	11.8	11.6	0.37	0.70
Born alive	10.9	11.0	0.37	0.86
Still born	0.8	0.5	0.16	0.20
Mummified piglets	0.05	0.04	0.032	0.83
Body weight, kg				
At mixing in gestation pens[3]	248.8	180.2	6.18	<0.001
Before farrowing[4]	282.8	237.5	7.28	<0.001
Gain during gestation[4]	32.6	58	7.01	<0.001
Body condition scores				
At mixing in gestation pens[3]	3.0	3.0	0.08	0.73
Before farrowing[4]	3.0	3.3	0.12	0.05
Backfat thickness , mm				
At mixing in gestation pens[3]	15.6	17	0.66	0.01
Before farrowing[4]	16.7	18.6	1.26	0.01
Injury scores[3,5]				
Before mixing				
Head[6]	0.1	0.1	0.09	0.58
Shoulders[7]	0.2	0.2	0.1	0.68
Body[8]	0.2	0.2	0.06	0.22
Total[9]	0.5	0.4	0.20	0.22
*After mixing**				
Head	1.7	1.3	0.23	0.02
Shoulders	2.7	2.5	0.29	0.42
Body	4.6	2.4	0.24	<0.001
Total	9.0	6.3	0.54	<0.001

[1] Each sow pen consisted of 4 parity-1 sows and 11 multiparous (parity 2 to 10) sows.

[2] Each gilt pen consisted of 4 parity-1 sows and 11 gilts.

[3] Data collected on all females

[4] Data collected on females that farrowed

[5] Injury score system used: 0 = no injury (skin unmarked); 1 = slight injury (less than 5 superficial wounds); 2 = obvious injury (5 to 10 superficial wounds or up to 3 deep wounds or both); 3 = severe

injury (more than 10 superficial wounds or more than 3 deep wounds or both).

[6] For the purpose of injury assessment, body surface was imaginarily divided into 12 regions: the snout, 2 ears, 2 shoulders, 2 flanks, 2 hindquarters, the back, tail, and vulva. An injury score for head was calculated by combing injury scores for the snout and 2 ears with a maximum possible score of 9.
[7] An injury score for the shoulder was calculated by combining injury scores for 2 shoulders, with a possible maximum score of 6.
[8] An injury score for the body was calculated by combining injury scores for 2 flanks, 2 hindquarters, the back, tail, and vulva, with a maximum possible score of 21.
[9] A total injury score was calculated by adding injury scores for the 12 regions, with a maximum possible score of 36.

* Injury score before mixing was used as a co-variate.

TABLE 3. AGGRESSIVE INTERACTIONS INVOLVING YOUNG SOWS DURING THE FIRST 72 h AFTER MIXING IN SOW-PENS AND GILT-PENS

	Control	Treatment		
	SOW-PEN[1]	GILT-PEN[2]	Pooled SE	*P* - value
Number of pens	5	5		
Number of young sows[3]/pen	4	4		
Head-to-body knocking				
Frequency, number/h	1.1	1.5		
Transformed data[4]	0.924	1.231	0.2308	0.34
Total duration, s/h	12.5	19.0		
Transformed data[4]	1.849	2.433	0.2487	0.02
Win[5], %	12.2	32.1	7.89	0.02
Defeat[6], %	87.7	64.5	9.11	0.01
Head-to-head knocking				
Frequency, number/h	0.6	1.1		
Transformed data[4]	0.304	0.625	0.1921	0.28
Total duration, s/h	3.4	4.0		
Transformed data[4]	0.244	1.025	0.3802	<0.001
Win %	14.4	35.8	8.31	0.03
Defeat, %	80.6	60.7	10.01	0.04
Parallel pressing				
Frequency, number/h	0.1	0.4		
Transformed data[4]	0.231	0.895	0.2781	0.49
Total duration, s/h	14.0	43.9		
Transformed data[4]	0.592	1.779	0.4838	0.09
Win, %	18.3	46.4	9.79	0.02
Defeat, %	52.6	48.0	13.2	0.70
Total aggressive interactions				
Frequency, number/h	3.9	6.2	0.57	
Transformed data[4]	1.207	1.822	0.1520	<0.001
Total duration, s/h	29.9	67.0	19.58	
Transformed data[4]	2.589	3.249	0.2604	0.01
Win, %	15.0	38.1	8.23	0.01
Defeat, %	73.4	57.8	10.13	0.06

[1] Each sow pen consisted of 4 parity-1 sows and 11 multiparous (parity 2 to 10) sows.

[2] Each gilt pen consisted of 4 parity-1 sows and 11 gilts.

[3] Young sows were defined to as parity-1 sows.

[4] Data were transformed using logarithm (X'= log10 (X+0.1)) to achieve normal distribution.

[5] The opponent sow or gilt retreated from the aggressive interaction.

[6] The young sow retreated from the aggressive interaction.

TABLE 4. PERFORMANCE OF YOUNG SOWS[1] IN SOW-PENS AND GILT-PENS

	Control	Treatment		
	SOW PEN[2]	GILT PEN[3]	Pooled SE	*P* - value
Total number of young sows	24	24	-	-
Number of young sows farrowed	12	18	-	-
Wean to breeding interval, d	5.1	4.7	0.39	0.20
Gestation length, d	115.6	116.2	0.45	0.38
Litter size, piglets/litter				
Total born	11.5	11.3	0.87	0.87
Born alive	10.3	10.7	0.86	0.74
Still born	0.82	0.46	0.22	0.21
Mummified piglets	0.06	0.04	0.05	0.86
Body weight, kg				
At mixing in gestation pens[4]	207	201	4.8	0.34
Before farrowing[5]	232	257	6.2	0.01
Gain during gestation[5]	36	59	6.3	0.01
Body condition scores				
At mixing in gestation pens[4]	3	2.8	0.35	0.61
Before farrowing[5]	2.9	3.1	0.46	0.81
Backfat thickness, mm				
At mixing in gestation pens[4]	15.9	14.8	0.94	0.19
Before farrowing[4]	16.1	16.4	1.53	0.71
Injury scores[4,6]				
Before mixing				
Head[7]	0.3	0.1	0.07	0.12
Shoulders[8]	0.2	0.1	0.1	0.17
Body[9]	0.4	0.2	0.09	0.14
Total[10]	0.9	0.4	0.2	0.27
After mixing[11]				
Head	1.9	2.1	0.37	0.51
Shoulders	3.3	2.6	0.56	0.17
Body	6.7	2.8	1.1	<0.001
Total	11.7	7.5	1.73	<0.001

[1] Young sow was defined as parity-1 sows.

[2] Each sow pen consisted of 4 young sows and 11 multiparous (parity 2 to 10) sows.

[3] Each gilt pen consisted of 4 young sows and 11 gilts.

[4] Data were collected on all young sows that weaned to the gestation pens.

[5] Data were collected on young sows that farrowed.

[6] Injury score system used: 0 = no injury (skin unmarked); 1 = slight injury (less than 5 superficial

wounds); 2 = obvious injury (5 to 10 superficial wounds or up to 3 deep wounds or both); 3 = severe injury (more than 10 superficial wounds or more than 3 deep wounds or both).

[7] For the purpose of injury assessment, body surface was imaginarily divided into 12 regions: the snout, 2 ears, 2 shoulders, 2 flanks, 2 hindquarters, the back, tail, and vulva. An injury score for head was calculated by combing injury scores for the snout and 2 ears, with a maximum possible score of 9.

[8] An injury score for the shoulder was calculated by combining injury scores for 2 shoulders, with a possible maximum score of 6.

[9] An injury score for the body was calculated by combining injury scores for 2 flanks, 2 hindquarters, the back, tail, and vulva, with a maximum possible score of 21.

[10] A total injury score was calculated by adding injury scores for the 12 regions, with a maximum possible score of 36.

[11] Injury scores were assessed 48 h after mixing in gestation pens; and the injury score before mixing was used as a co-variate.

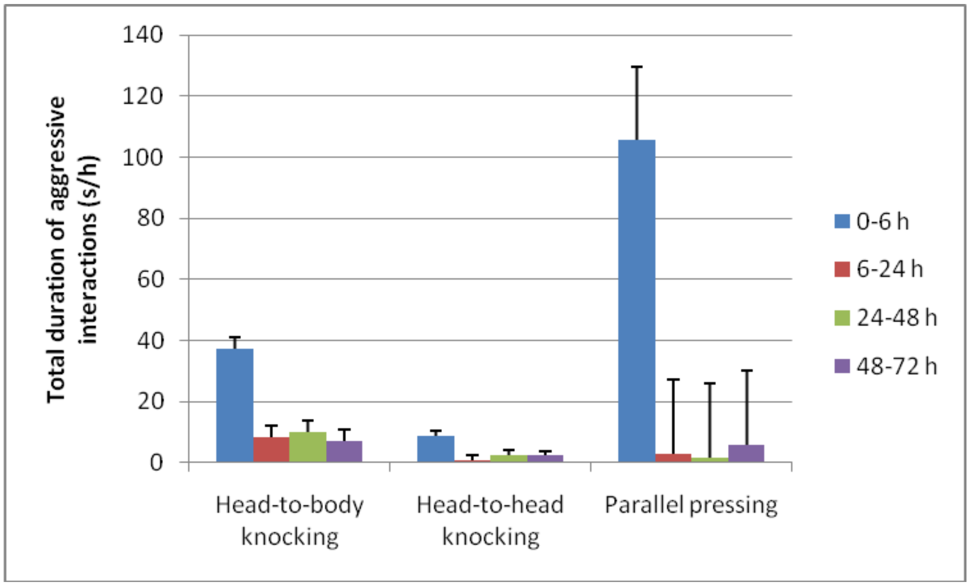

Fig. 1. Total duration of aggressive interactions involving parity-1 sows during the first 72-h after mixing in a group-housing system. Means of head-to-body knocking ($P < 0.001$), head-to-head knocking ($P < 0.001$) and parallel pressing ($P < 0.01$) for the period of 0-6 h were greater than those for the other periods.

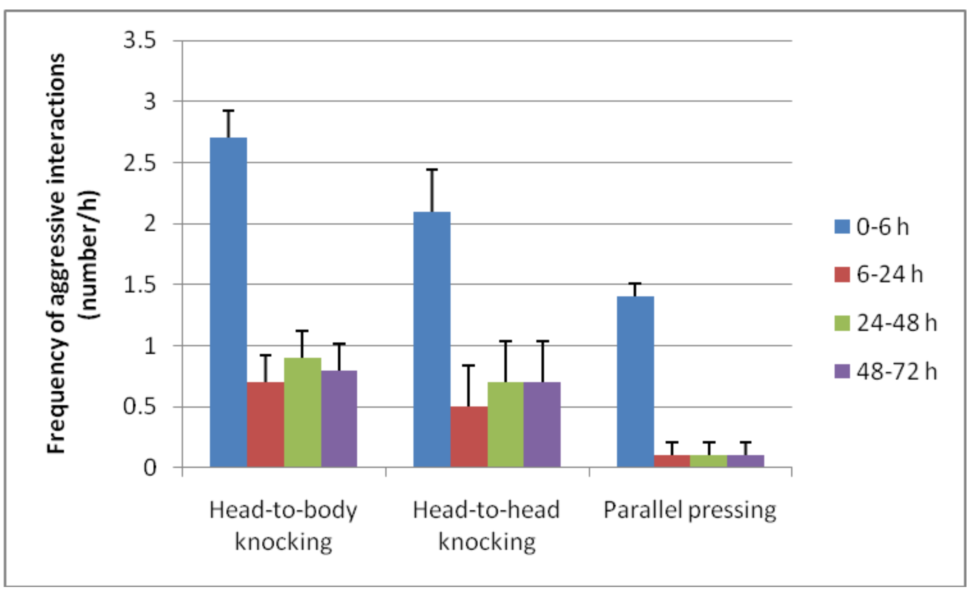

Fig. 2. Frequency of aggressive interactions involving parity-1 sows during the first 72-h after mixing in a group-housing system. Means of head-to-body knocking ($P < 0.01$), head-to-head knocking ($P < 0.01$) and parallel pressing ($P < 0.001$) for the period of 0-6 h were greater than those for the other periods.