Mixing gilts in early pregnancy does not affect embryo survival

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Abstract

There is general acceptance that mixing sows during the first 3 weeks of gestation is detrimental to embryo development and survival. However, there is a paucity of data describing the influence of group housing and remixing during the first 14 days of gestation on pregnancy outcomes. Using 96 purebred maternal (Large White)/terminal (Duroc) line gilts, the current study determined the effects of regrouping, and the timing of regrouping, during the pre-implantation period on embryo mortality. The study was conducted in 2 blocks, with 12 gilts allocated to each of 4 treatments in each block. At 175 days of age, the combination of PG600 and 20 min of daily physical boar contact was used to stimulate puberty, with boar contact resuming 12 days after first detection of oestrus and gilts receiving two artificial inseminations (AIs), 24 h apart, at their second oestrus. After their first AI gilts were allocated to one of four treatment groups (n = 12 gilts/treatment). Gilts in one treatment group were housed individually in stalls (STALL). The remaining gilts continued to be housed in their pre-AI groups and were either not remixed (NOMIX), or remixed to form new groups on day 3/4 (RMIXD3/4) or day 8/9 (RMIXD8/9) of gestation (day 0 = day of first detection of second oestrus and first insemination). Group-housed gilts were housed in groups of 6, with a space allowance of 2.4 m²/gilt. All gilts were fed once a day (2.2 kg/gilt). Reproductive tracts were collected on day 26.6 ± 0.13 of gestation, and the number of corpora lutea (CL) and viable embryos counted. Pregnancy rate was similar across all treatments, averaging 94.5% across the four treatment groups. The number of embryos present on day 26 of gestation was unaffected by housing treatments (P > 0.05); gilts in the STALL, NOMIX, RMIXD3/4 and RMIXD8/9 groups possessed 13.2 ± 0.67, 12.9 ± 0.66, 14.1 ± 0.46 and 13.8 ± 0.57 embryos, respectively. Similarly, embryo survival rates were 0.91 ± 0.04, 0.85 ± 0.04, 0.91 ± 0.02 and 0.87 ± 0.05 for the STALL, NOMIX, RMIXD3.4 and RMIXD8/9 groups, respectively (P > 0.05). In conclusion, the current data indicate...
that individually housing gilts immediately after their first AI does not improve embryo survival. There also appear to be no adverse effects on embryo development or survival when group-housed, mated gilts are remixed during the first 10 days of gestation.

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1. Introduction

Exposure to environmental, social and nutritional perturbations during the first 3 weeks of gestation can have detrimental effects on embryo development and survival (van der Lende et al., 1994; Turner and Tilbrook, 2006). Consequently, individual dry sow stalls were introduced to facilitate the control of feed intake and avoid aggressive interactions between sows which can be detrimental to pregnancy outcomes (den Hartog et al., 1993; Morrison, 2005). Approximately 60–70% of Australia’s breeding sows spend at least a portion of their pregnancy in individual housing (Barnett et al., 2001). However, there is contradiction within the available literature as to whether individually housing sows during pregnancy has a beneficial effect on pregnancy rates and litter size (Peltoniemi et al., 1999; Bates et al., 2003; Morrison, 2005; Kongsted, 2005). Further, individual housing of pregnant sows has been associated with chronic stress and a significant reduction in piglet birthweight (Varley and Stedman, 1994), thus leading to increasing pressure to develop alternative housing strategies for pregnant gilts and sows (Barnett et al., 2001; Karlen et al., 2007). Although mixing mated sows prior to, and during, implantation can reduce conception rates and/or litter size (van der Lende et al., 1994; Arey and Edwards, 1998), recent evidence indicates that exposing gilts to moderate levels of repeated, acute, induced stress during the first 3 weeks of gestation has little effect on reproductive performance (Razdan et al., 2004a,b; Soede et al., 2006, 2007). However, reports on the effects of mixing mated gilts to form stable, fixed groups during the pre-implantation period on conception rates and/or embryo survival are scarce. Consequently, the current experiment had two objectives: first, to investigate whether group housing during the first 4 weeks of gestation impairs embryo survival; second, to determine the effects of regrouping, and the timing of regrouping, during the first 10 days of gestation, on embryo survival.

2. Methods

This experiment was conducted at the University of Adelaide, Pig and Poultry Production Institute (PPPI) at Roseworthy, South Australia, with approval from the animal ethics committee of The University of Adelaide. The experiment used 96 gilts, and was conducted in two replicates: replicate one ran from September to December 2006 (spring/summer) and replicate two ran from February to May 2007 (summer/autumn).

2.1. Animals, housing, feeding and puberty stimulation

Purebred maternal (Large White)/terminal (Duroc) line gilts were used in this study. From 126 days of age until the attainment of puberty, gilts were housed in fixed groups of 20 in grower sheds. Average weight within groups was similar, and there was a space allowance of 1.4 m²/gilt. The grower sheds contained no male pigs, were partially slatted and were fitted with adjustable side blinds. Based on the timing of pubertal attainment, 12 gilts were selected from each pen of
20, and these gilts were weighed, stratified according to weight and allocated to eight smaller, partially slatted pens, with a space allowance of 2.4 m$^2$/gilt. Each of the smaller groups was formed using gilts from the same pen of 20, with gilts remaining in these stable, fixed groups until their second oestrus. From 126 days of age until their second artificial insemination (AI) gilts received approximately 4 kg/day of a female finisher diet (13.0 MJ DE, 15.5% protein, 0.6 g available lysine/MJ), while from their second AI through to slaughter gilts received approximately 2.2 kg/day of a dry sow diet (13.0 MJ DE, 14% protein, 0.5 g available lysine/MJ).

2.2. Experimental design

From selection at 126 days of age until the commencement of puberty stimulation gilts had no contact with male pigs. At 175 days of age, the combination of PG600 (400IU of Pregnant Mare Serum Gonadotrophin and 200 IU of human Chorionic Gonadotrophin; Intervet, Australia) and 20 min of daily, physical boar contact was used to stimulate puberty. Specifically, all gilts were restrained and injected subcutaneously with PG600 behind the ear. Following injection, each group of gilts, as penned, was taken to a detection-mating area (DMA), where they received 20 min of supervised full contact with a vasectomized boar. Gilts received boar exposure until the attainment of puberty, and then from approximately day 12 of the oestrous cycle until their second oestrus. Boar exposures began at 08:00 h, with three vasectomized boars, greater than 10 months of age, used in rotation. The DMA consisted of four pens measuring 3 m $\times$ 3.5 m and lined on two sides by inward facing boar pens. Oestrus was defined as the exhibition of a standing reflex, either in response to the manual application of pressure to the gilt’s back (the back pressure test), or mounting by the boar. The attainment of puberty was defined as the first signs of a standing reflex, and oestrous cycle length was expressed as the number of days from the start of the pubertal oestrus to the start of the second (first post-pubertal) oestrus.

At their second oestrus, gilts received two artificial inseminations, 24 h apart. All AIs took place in the DMA, with fence-line contact with a boar during the procedure. Insenminations were performed as per standard industry practice using disposable spirette catheters, with each insemination consisting of an 80 ml dose of fresh, extended semen ($3 \times 10^9$ spermatozoa per inseminate; $\leq 4$ days old). Semen used for this experiment was purchased from a commercial artificial insemination collection centre (SABOR Pty. Ltd, Clare, South Australia).

After their first AI, 96 gilts were selected based on the timing of their second oestrus and allocated to one of four treatment groups ($n = 12$ gilts/treatment/block). Gilts in one treatment group were housed individually in stalls (STALL) measuring 0.62 m $\times$ 2.2 m. The remaining gilts continued to be housed in their pre-AI groups and were either not remixed (NOMIX), or remixed to form new groups on day 3/4 (RMIXD3/4) or day 8/9 (RMIXD8/9) of gestation (day 0 = day of first detection of second oestrus and first insemination). Remixing occurred on a single day prior to feeding, with each remixed group containing no more than two gilts from each of the original pre-AI groups. Group-housed gilts were housed in groups of 6, with a space allowance of 2.4 m$^2$/gilt. All gilts were fed once daily, with the ration spread on the floor of the pen/stall.

2.3. Animal measurements: liveweight and reproductive parameters

Gilts were weighed at 126 and 175 days of age, as well as at their second oestrus, on the day of mixing and at slaughter. Gilts were slaughtered at a commercial abattoir and the reproductive tract of each gilt was recovered. Due to logistical issues, all the gilts from each replicate were slaughtered on the same day; 26.6 ± 0.13 days after their first mating (mean ± S.E.M.). The ovaries
were weighed, and the number of corpora lutea (CL) counted. The number of CL was taken to represent the number of oocytes ovulated at the oestrus of AI. The uterus was trimmed of mesentery and dissected, the number of viable and non-viable embryos recorded, and embryo crown-to-rump length measured. Embryos were described as viable or non-viable based on their gross morphology and crown-to-rump length—embryos were classified as non-viable if their crown-to-rump length was more than two standard deviations less than the mean for that gilt. The total number of viable embryos observed in both uterine horns was expressed as total embryo number. Embryo survival was calculated based on the total number of viable embryos, and expressed as a percentage of the number of CLs observed in both ovaries. The uterine horns were weighed after removal of all conceptus tissue to provide an empty uterine weight.

2.4. Statistical analysis

Values in the text are expressed as mean ± standard error. A general analysis of variance model, with block built in and day of gestation at slaughter included as a co-variate, was used to study the effects of early pregnancy housing treatment on ovulation rate, embryo number and embryo survival, as well as crown-rump length and empty uterine weight. Between treatment differences were examined using least significant difference. Correlations between variates were determined using a general linear regression approach. All analyses were performed using Genstat, eighth edition.

3. Results

3.1. General results

Of the 96 gilts allocated across the four treatments, a total of four gilts were removed from the analyses. Gilts were removed due to lameness following remixing (2 gilts), loss of an ovary at the abattoir (1 gilt) and for possessing only a single uterine horn (1 gilt). Consequently, the data presented below relate to 24, 23, 22 and 23 gilts from treatment groups STALL, NOMIX, RMIXD3/4 and REMIXD8/9, respectively. Gilts in the RMIXD3/4 and RMIXD8/9 were mixed on day 3.2 ± 0.17 and 8.7 ± 0.13, respectively, after their first AI.

The period from PG600 injection to first exhibition of oestrus was similar for all treatments, and there was no difference between treatments in gilt liveweight (Table 1). Gilts allocated to the RMIXD8/9 treatment group had a significantly shorter first oestrous cycle than their counterparts in the RMIXD3/4, NOMIX and STALL groups: 20.0 ± 0.15 versus 21.3 ± 0.22, 21.4 ± 0.36, and 21.3 ± 0.28 days, respectively (P < 0.05). All gilts were slaughtered on the same day, and as a

Table 1
Days to puberty, as well as liveweight at puberty, second oestrus and slaughter for gilts that were housed in stalls (STALL), in their original pre-AI groups (NOMIX) or remixed on days 3/4 (RMIXD3/4) or days 8/9 (RMIXD8/9) of gestation

<table>
<thead>
<tr>
<th>Gestation housing treatment</th>
<th>STALL</th>
<th>NOMIX</th>
<th>RMIXD3/4</th>
<th>RMIXD8/9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days to puberty</td>
<td>4.5 ± 0.15</td>
<td>4.5 ± 0.10</td>
<td>4.5 ± 0.16</td>
<td>4.3 ± 0.12</td>
</tr>
<tr>
<td>Weight at puberty (kg)</td>
<td>115.2 ± 2.14</td>
<td>115.3 ± 2.05</td>
<td>118.5 ± 2.0</td>
<td>117.4 ± 2.0</td>
</tr>
<tr>
<td>Weight at AI (kg)</td>
<td>131.9 ± 1.32</td>
<td>132.4 ± 1.79</td>
<td>135.8 ± 1.72</td>
<td>132.4 ± 2.14</td>
</tr>
<tr>
<td>Weight at slaughter (kg)</td>
<td>144.9 ± 2.09</td>
<td>145.5 ± 1.95</td>
<td>147.0 ± 1.72</td>
<td>145.4 ± 2.02</td>
</tr>
</tbody>
</table>
Table 2
Reproductive parameters at day 26 of gestation of gilts that were housed in stalls (STALL), in their original pre-AI groups (NOMIX) or remixed on days 3/4 (RMIXD3/4) or days 8/9 (RMIXD8/9) of gestation

<table>
<thead>
<tr>
<th>Gestation housing treatment</th>
<th>STALL</th>
<th>NOMIX</th>
<th>RMIXD3/4</th>
<th>RMIXD8/9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gestation day at slaughter</td>
<td>26.3 ± 0.25a</td>
<td>26.1 ± 0.34a</td>
<td>26.2 ± 0.17a</td>
<td>27.7 ± 0.13b</td>
</tr>
<tr>
<td>Ovulation rate</td>
<td>14.6 ± 0.45</td>
<td>14.6 ± 0.29</td>
<td>15.4 ± 0.41</td>
<td>15.3 ± 0.43</td>
</tr>
<tr>
<td>Number of embryos</td>
<td>13.2 ± 0.67</td>
<td>12.9 ± 0.66</td>
<td>14.1 ± 0.46</td>
<td>13.8 ± 0.57</td>
</tr>
<tr>
<td>Embryo survival</td>
<td>0.91 ± 0.04</td>
<td>0.85 ± 0.04</td>
<td>0.91 ± 0.02</td>
<td>0.87 ± 0.05</td>
</tr>
<tr>
<td>Embryo length (mm)</td>
<td>19.8 ± 0.87</td>
<td>18.9 ± 0.72</td>
<td>19.0 ± 0.39</td>
<td>22.0 ± 0.33</td>
</tr>
<tr>
<td>Empty uterine weight (kg)</td>
<td>1.07 ± 0.05</td>
<td>1.12 ± 0.05</td>
<td>1.25 ± 0.04</td>
<td>1.11 ± 0.03</td>
</tr>
</tbody>
</table>

Means (a and b) within rows are significantly different (P < 0.05).

result, reproductive tracts were collected from RMIXD8/9 gilts significantly (P < 0.05) later in gestation than RMIXD3/4, NOMIX and STALL gilts (Table 2).

3.2. Reproduction

The data presented in Table 2 demonstrate that gestation housing treatment did not affect ovulation rate, embryo number or embryo survival. Pregnancy rates were unaffected by gestation housing treatments (P > 0.05), with 96, 92, 91 and 100% of NOMIX, STALL, RMIXD3/4 and RMIXD8/9 gilts pregnant at the time of reproductive tract collection. When day of gestation at slaughter was included as a co-variate, both mean embryo crown-rump length and empty uterine weight were similar for all four treatments (Table 2). There was a significant (P < 0.01) positive correlation between day of gestation at slaughter and both mean crown-rump length (R = 0.46) and empty uterine weight (R = 0.26).

4. Discussion

In the current experiment, reproductive performance was extremely good regardless of gestation housing treatment: 94% of gilts were pregnant, with an average of 13.4 embryos present on day 26 of gestation, equating to an embryo survival rate of 89%. Neither pregnancy rate nor embryo survival was improved by individually housing gilts immediately after first insemination. Importantly, no adverse effects on embryo development or survival were observed in response to remixing previously group-housed gilts to form stable, fixed groups on day 3/4 or 8/9 of gestation.

The data from this experiment contradicts previous reports of higher return rates and lower litter sizes following grouping of mated sows on days 3–10 of gestation (reviewed by Arey and Edwards, 1998). However, it supports the small body of recent evidence indicating that inducing stress or mixing during the pre- and peri-implantation period does not impair gilt reproductive performance. These studies demonstrated no detrimental effects on reproductive performance when individually housed gilts experienced repeated periods of induced, acute stress during days 3, 4, 9, 10, 13 and 14 of gestation (Soede et al., 2007), or when group-housed gilts were remixed weekly during the 3 weeks prior to and after insemination (Soede et al., 2006). However, repeated regrouping of 20 week old gilts significantly reduces incidences of fighting after gilts are remixed for the third time (van Putten and Bure, 1997), and Soede et al. (2006) reported a reduction in the incidences of aggressive encounters with each subsequent regrouping, suggesting a reduction
in the stress experienced when gilts were remixed during early gestation. It could, therefore, be suggested that regrouping gilts for the first time during early gestation, as utilised in the current study, constitutes a greater stressor than the repeated regrouping treatments of Soede et al. (2006), and is more representative of what happens within the pig industry.

However, the present data agrees with that of Harris et al. (2006), who, using small numbers of gilts, reported similar litter sizes when gilts were housed in stalls or mixed to form fixed groups of four within 7 days of mating. The dimensions of the individual stalls, and the space allowance/gilt for animals housed in groups were similar between the current study and that of Harris et al. (2006). However, the group pens of Harris et al. (2006) did contain full length individual stalls, which may have reduced incidences of agonistic encounters during feeding. It is noteworthy that the small group sizes (≤ 6 gilts) and space allowance of 2.4 m²/gilt used in both our study and that of Harris et al. (2006) represent housing conditions under which the duration, but not the intensity, of aggressive encounters between unfamiliar sows is likely to be reduced (Arey and Edwards, 1998; Barnett et al., 2001). Limited data also indicates that reproductive performance is unaffected when sows are housed with a space allowance in excess of 2.0 m² (Barnett et al., 2001).

In conclusion, the current experiment demonstrates that group housing gilts during the first 26 days of gestation does not adversely affect pregnancy rates or embryo survival. Importantly, based on the current data, it is suggested that mixing gilts to form stable groups during the first 10 days of gestation is not detrimental to reproductive performance. However, the effects of remixing during the implantation period remain to be established, and the impact of mixing gilts under conditions when space is more limited is unknown.

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