The effect of pre-weaning housing on the play and agonistic behaviour of domestic pigs

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Abstract

The effect of the pre-weaning housing system on play behaviour before weaning and agonistic behaviour after weaning and during the fattening period was investigated in 32 litters of domestic pigs. Three pre-weaning housing systems were compared: poor crate (standard farrowing crate without straw), enriched crate (crate with straw, 20% larger), and, as a control, a farrowing pen (pen with straw, 60% larger than the poor crate). At the age of 1, 2 and 4 weeks, play behaviour (locomotor and social play) was recorded for 3 h. Four weeks post-partum, piglets were weaned and two litters from the same housing system were mixed in a new pen, with the stocking density corresponding to density in the pre-weaning poor crate. During mixing, the frequency of agonistic behaviour and the proportion of abnormally ended fights (chasing and biting to the hindquarters of the opponent) were recorded for 3 h, and after 6 h, the number of wounds was counted. Four focal pigs from each litter were chosen (two female and two male) and their agonistic interactions were measured during a food competition test at the age of 3 and 6 months. The pre-weaning housing system tended to have an effect on the frequency of locomotor (GLMM, \( p < 0.1 \)) and social play (GLMM, \( p < 0.1 \)) with piglets from the more enriched environments playing more frequently. The pre-weaning housing system did not affect the frequency of agonistic behaviour (GLMM, ns), the number of wounds after mixing (GLMM, ns) or the proportion of abnormally ended fights (GLMM, ns). During the food competition tests at 3 and 6 months pigs reared in the enriched pens were much less aggressive than the pigs reared in both types of crates (GLMM, \( p < 0.01 \)). Our results suggest that the enrichment of the pre-weaning environment through straw and enlarged space probably stimulate pre-weaning play behaviour and substantially reduces the tendency of pigs to behave aggressively during food competition later in life. However, aggression during post-weaning mixing of piglets does not seem to be affected by pre-weaning enrichment.

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1. Introduction

In intensive pig husbandry, young pigs are typically housed in an extremely barren environment. Such an impoverished environment may have immediate negative effects on pig welfare (De Jonge et al., 1996; O’Connell and Beattie, 1999). It has been demonstrated that piglets in barren environments engage in more manipulative behaviour, such as biting, nosing and massaging of their pen mates compared to piglets in larger pens with straw bedding (Lammers and Schouten, 1985; Beattie et al., 2000; De Jong et al., 1998; O’Connell and Beattie, 1999). Furthermore, poor rearing conditions may disturb the development of important social skills, as it has been shown that piglets housed in such an environment behave more aggressively than pigs housed in an enriched environment (De Jonge et al., 1996; O’Connell and Beattie, 1999). Most of the researchers who have compared the influence of housing systems have focused on the period after weaning or during fattening (Beattie et al., 2000; De Jong et al., 2000; De Jonge et al., 1996; O’Connell et al., 2004; Olsson et al., 1999). Very few researchers have assessed the influence of pre-weaning housing on the behaviour of the piglets. For instance, Beattie et al. (1996) and O’Connell and Beattie (1999) examined the manipulative and agonistic behaviour of suckling piglets housed in different environments.

One important and, yet, poorly understood aspect of the welfare of pre-weaning piglets is their social behaviour. Play behaviour is a prominent part of the social interactions in piglets as it is in most mammalian young (Fagen, 1981). Play behaviour can be considered as an indicator of welfare (Lawrence and Appleby, 1996; Newberry et al., 1988), since it has been shown to be sensitive to adverse physical and environmental conditions (Müller-Schwarze et al., 1982; Siviy and Panksepp, 1985). Play is a cognitively demanding activity that results in reduced vigilance towards external threats and, therefore, should occur only under relatively safe conditions (Špinka et al., 2001). During the suckling period, piglets are often kept in a small area without straw. Piglets could be more frustrated and stressed in such a housing environment (Morméde et al., 1990) and, therefore, display a lower frequency of play behaviour. Further, even if the piglets would be as motivated to play in the barren environment as in nature, the physical restriction of movement as a result of the small pen dimensions may hamper the performance of play behaviour. Besides the dimensions of the pen, provision of bedding, such as straw, may also stimulate play behaviour. The reason for this is that straw can change in location and structure in reaction to the piglets’ behaviour and, thus, adds an element of unpredictability to the environment, which is important for play (Špinka et al., 2001). As far as we know, there has been only one study comparing the ontogeny of play behaviour in pigs from different commercial housing systems (Blackshaw et al., 1997). In that study, two types of farrowing crates and an open pen were compared, all having the same area and all lacking straw. Little difference in play behaviour was found. Therefore, there is a need for researchers to compare piglet play in commercially used housing systems that differ in the two key features, namely, space and availability of straw.

A pre-weaning housing system may also influence the negative side of the social interactions among piglets, namely, their agonistic behaviour. Agonistic behaviour is important for the establishment of a dominance hierarchy among new group members (Meese and Ewbank, 1973). In domestic pigs, an increase in agonistic behaviour occurs after the mixing of unacquainted pigs after weaning. This aggression is primarily connected to the formation of dominance hierarchies (Jensen, 1994). Post-weaning aggression presents a significant cost to animal welfare and economic efficiency (Jensen and Wood-Gush, 1984; Fraser and Rushen, 1987; Arey and Edwards, 1998) due to stress or injury. According to several researchers, post-weaning aggression is significantly more frequent in pigs reared in poor conditions compared to those reared in an enriched condition.
Pre-weaning housing systems may not only affect the aggression that occurs immediately following the mixing of litters at weaning, but also the agonistic behaviour that occurs in the long term. If the social skills necessary for conflict resolution are underdeveloped in piglets from a poor environment, this will probably result in more intense aggression in certain situations, such as competition for food.

The aim of this study was to assess whether three housing systems during the suckling period influence three aspects of piglets’ social behaviour: (i) the play behaviour of piglets before weaning, (ii) the agonistic behaviour caused by mixing of litters after weaning and (iii) the food related agonistic behaviour of pigs during the fattening period.

2. Methods

2.1. Animals and housing

The experiment was conducted between 2001 and 2003 at the experimental unit of the Research Institute of Animal Production in Prague, Czech Republic. Thirty-two litters born to 15 cross-bred sows (Large White × Landrace sows, inseminated by Hampshire or Pietrain × Hampshire boars), ranging between 2nd and 11th lactation (mean = 5), were observed. Littersize at weaning was 10.8 ± 1.6 (mean ± S.D.). We attempted to observe three subsequent litters from one and the same sow in three different environments (see below), but this was not fully possible due to the culling of the sows from the herd. Hence, seven of the sows contributed to the data set with three litters in three different environments, four sows with two litters in two environments and three sows with just one litter. Due to technical problems during the recording, some litters had to be excluded from some of the analyses. Thus, the number of subjects differed between the tests. The actual numbers of litters and piglets included in the analyses are given in Table 1.

We choose two commercial and one control housing system for the lactating sows with their litters. After weaning, the housing system was the same for all piglets.

The three pre-weaning housing systems were:

1. Standard farrowing crate (poor crate). The crate was positioned in a pen (1.6 m × 2.5 m) with a slatted metal floor. The rear part (0.6 m × 1.6 m) of the pen was separated by a solid partition with a doorway, equipped with a heat lamp and contained a solid floor for the piglets. No straw was provided in this area.
2. Enriched farrowing crate with straw (enriched crate). It was an ellipsoid-farrowing crate (2.2 m × 1.4 m) divided by bars in the middle, which allowed the sow to walk around. The crate was positioned in a concrete-floored, straw-bedded (2.2 m × 2.0 m) pen, which included the heated nest area (1.0 m × 0.5 m) for the piglets.
3. Enriched farrowing pen with straw (enriched pen). This pen was used as a control housing system. It was a straw-bedded, concrete-floored pen (2.5 m × 1.9 m), which allowed free movement for the sow. A creep area (0.9 m × 1.9 m) with a heat lamp for piglets was also provided.

The main differences between the three housing systems were: provision of straw in the enriched pen and enriched crate, free sow movement in the enriched pen, possibility for the sow to walk around in enriched

<table>
<thead>
<tr>
<th>Video recordings and test</th>
<th>Poor crate</th>
<th>Enriched crate</th>
<th>Enriched pen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Play behaviour at age 1, 2 and 4 weeks</td>
<td>107 (9 litters)</td>
<td>106 (11 litters)</td>
<td>130 (11 litters)</td>
</tr>
<tr>
<td>Agonistic behaviour after mixing</td>
<td>112 (10 litters)</td>
<td>98 (10 litters)</td>
<td>117 (10 litters)</td>
</tr>
<tr>
<td>Number of wounds</td>
<td>115 (10 litters)</td>
<td>96 (10 litters)</td>
<td>114 (10 litters)</td>
</tr>
<tr>
<td>Food competition test (focal pigs)</td>
<td>22 (6 litters)</td>
<td>21 (6 litters)</td>
<td>24 (7 litters)</td>
</tr>
</tbody>
</table>
crate and a larger area for the piglets in the enriched pen and the enriched crate in comparison to the poor crate (6.4 m² versus 4.9 m² versus 4.0 m²).

The weaning procedure and the housing after weaning were as follows: At the age of 4 weeks (median 28 days) post-partum (p.p), sows were separated from the litters and piglets stayed in the home pen for 1 day. On the second day, two litters from the same housing system were mixed together in a new straw-bedded pen (3.0 m × 2.8 m). At week 12 p.p, the same groups of pigs were then moved into larger pens (4.2 m × 4.2 m) with slatted floors and no straw.

The piglets were ear-notched at day 1–2 p.p and marked with numbers on their backs for individual identification. All males were castrated between 14–18 days p.p, in accordance with production practices in the Czech Republic. Sows were fed a standard lactation diet twice a day and creep feed was available to the piglets from 5 days of age. During the post-weaning period, pigs were fed ad libitum. From the age of 12 weeks p.p feed was provided 4 times per day. For all experimental pens, natural light entered the rooms through windows.

2.2. Videorecordings

The undisturbed behaviour of the piglets was recorded for 3 h (0900–1200) for 1 day during week 1, week 2 and week 4. Closed-circuit video cameras, positioned 2 m above the pens, and microphones were connected via cables to VCRs in an adjacent room.

Immediately after mixing, the behaviour of weaned piglets was recorded for 3 h (0800–1100 a.m.). About 6 h after mixing, the number of wounds on the body of piglets was counted. Wounds were defined as raised or broken skin with redness and/or scars that were at least 1 cm in length. They were counted on the: head and ears, neck, body and legs. For each of the body parts, a semiquantitative scale was used to simplify the recordings: zero points = no wounds; one point = 1–5 wounds; two points = 6–10 wounds, three points = 11–15 and four points = over 15 wounds. For statistical evaluation, the sum of the points (0–4 for each body part up to a sum of 5 × 4 = 20 points) was calculated.

The long term effects of the pre-weaning housing system on agonistic behaviour were studied in a food competition test at the ages of 3 and 6 months. In the home pen, feeders were turned off 16 h before the test. Four focal pigs in each litter (two males, two females, chosen as the heaviest as the lightest for each sex at 4 weeks p.p) were brought to an experimental room without straw (6.7 m²). The pigs were then given 15 min to habituate to the room. After this, a small amount of food was provided in the two opposite corners of the experimental room and the behaviour was recorded for 10 min.

2.3. Video analysis and behavioural variables

The frequency of locomotor play and social play was analyzed for every individual piglet per litter during weeks 1, 2 and 4 from the video tapes. For the analysis of locomotor play, we used “play markers”, i.e., movement elements, which are specifically used in the play context (Newberry et al., 1988). For social play, we used the definition of Dobao et al. (1984/1985). All definitions of the recorded behavioural patterns are given in Table 2.

From the video tapes we analyzed the frequency of agonistic behaviour after mixing for every individual piglet (see Table 3 for behavioural definitions).

The frequency of agonistic interactions during the food competition test was analyzed using the software Observer 5.0 Video-Pro (Noldus). We counted all displacements of the pigs from the feeding place, head thrusts, biting and chasing (see Table 3). For the statistical analyses, all social interactions were counted together.

2.4. Statistical analysis

For the statistical analyses, litters were considered as the experimental units. That is, the average value calculated over all the piglets in a litter entered the analysis as a single data point. The effects of
housing on the play and agonistic behaviour and the number of wounds were tested using a mixed linear model (Proc Mixed, SAS version 9.1). The data were logarithmically transformed to improve their normality.

A repeated measures analysis was used for the analysis of play behaviour. The dependent variables were frequency of locomotor and social play, and the fixed effects were the classes of housing system (poor crate, enriched crate and enriched pen), age of piglets as the repeated factor (1, 2 and 4 weeks) and the interaction between housing and age. The identity of the mother was taken as a random effect.

For the analysis of agonistic behaviour and the number of wounds after mixing, the dependent variables were the frequency of agonistic behaviour, the proportion of abnormally ended fights and the number of wounds. The effects were the classes of housing system and the continuous variable of littersize. The identity of the mother and the pair of mixed litters were taken as random effects.

A repeated measures analysis was also used in the analysis of agonistic behaviour during the food competition test. The dependent variable was the frequency of agonistic behaviour and the fixed effects were the classes housing system, the age of the pig as the repeated factor (3 and 6 months) and the interaction between housing and age. The identity of the mother and the pair of mixed litters entered the model as random effects. The denominator degrees of freedom were calculated according to the Kenward–Rodger method, as recommended for this type of mixed model by the SAS system (version 9.1).

The pairwise differences of the housing system treatments were assessed using least-square means if a significant treatment effect was detected. These were computed for each treatment and their difference was tested with a t-test adjusted through the Tukey-Kramer (Bonferroni) method for multiple comparisons.

Table 2
Ethogram of play behaviour recorded during the pre-weaning period

<table>
<thead>
<tr>
<th>Play behaviour</th>
<th>Description of behaviour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locomotor play (= individual play)</td>
<td></td>
</tr>
<tr>
<td>Scamper</td>
<td>A sequence of at least two forward hops in rapid succession</td>
</tr>
<tr>
<td>Pivot</td>
<td>A jump or whirl with vertical and horizontal bouncy movements</td>
</tr>
<tr>
<td>Toss head</td>
<td>Vigorous latero-rotationary movements of the head</td>
</tr>
<tr>
<td>Flop</td>
<td>A rapid drop from an upright position to sternal or lateral recumbence</td>
</tr>
<tr>
<td>Social play (= play of two or more piglets)</td>
<td></td>
</tr>
<tr>
<td>Pushing</td>
<td>Pushing the opponent with the head or shoulder</td>
</tr>
<tr>
<td>Nudging</td>
<td>Gentle snout contact</td>
</tr>
</tbody>
</table>

Table 3
Ethogram of agonistic behaviour recorded immediately after mixing and during the food competition test

<table>
<thead>
<tr>
<th>Agonistic behaviour</th>
<th>Description of behaviour</th>
</tr>
</thead>
<tbody>
<tr>
<td>After mixing</td>
<td></td>
</tr>
<tr>
<td>Fighting (lasting more then 2 s)</td>
<td>The pig uses vigorous side-to-side movements of its head to hit any part of the head or body of another pig.</td>
</tr>
<tr>
<td>Abnormal ending of a fight</td>
<td>Chasing and biting to the hindquarters of the opponent</td>
</tr>
<tr>
<td>During the food competition test</td>
<td></td>
</tr>
<tr>
<td>Displacement from the food</td>
<td>Actively displacing another pig from the feeding place</td>
</tr>
<tr>
<td>Headthrust</td>
<td>Ramming or pushing another pig with the head with or without biting</td>
</tr>
<tr>
<td>Biting</td>
<td>Aggressively biting any part of another pig</td>
</tr>
<tr>
<td>Chase</td>
<td>Actively pursuing another pig</td>
</tr>
</tbody>
</table>
3. Results

3.1. Play behaviour during the pre-weaning period

The pre-weaning housing system tended to have an effect on the frequency of locomotor play (Fig. 1; $F_{(2,19.2)} = 2.71, p < 0.1$) Further there was no effect of age ($F_{(2,29.3)} = 1.31, \text{ns}$) or housing $\times$ age interaction ($F_{(4,34.3)} = 1.62, \text{ns}$) on the frequency of locomotor play.

Similarly, the pre-weaning housing system tended to have an effect on the frequency of social play (Fig. 2; $F_{(2,23.7)} = 2.63, p < 0.1$) with piglets in the enriched pen playing slightly more frequently than the piglets in the poor crate. Neither the age of the piglets ($F_{(2,28.9)} = 0.72, \text{ns}$) nor the housing $\times$ age interaction ($F_{(4,33.8)} = 1.30, \text{ns}$) had an effect on the frequency of social play.

3.2. Agonistic behaviour after mixing

The pre-weaning housing system had no significant effect on the frequency of agonistic behaviour after mixing ($F_{(2,16)} = 1.56, \text{ns}$), on the proportion of abnormally ended fights ($F_{(2,17.1)} = 0.16, \text{ns}$) or on the number of wounds ($F_{(2,11.7)} = 1.78, \text{ns}$).

Littersize had no effect on the frequency of agonistic behaviour ($F_{(1,29.3)} = 1.18, \text{ns}$), but tended to have an effect on the proportion of abnormally ended fights ($F_{(1,25.8)} = 2.99, p < 0.1$) and on the number of wounds ($F_{(1,8.9)} = 3.63, p < 0.1$). The tendency suggests that with increasing littersize there is a decreased proportion of abnormally ended fights and number of wounds.

3.3. Food competition test

The pre-weaning housing system had a significant effect on the frequency of agonistic interactions during the food competition test ($F_{(2,9.56)} = 10.18, p < 0.01$). The differences of the least-squares means showed that the pigs from the enriched pen displayed a lower frequency of agonistic interactions than the pigs from either the poor or the enriched crates (Fig. 3). The age of the pigs ($F_{(2,19)} = 2.41, \text{ns}$) and the interaction of housing $\times$ age ($F_{(2,19)} = 2.41, \text{ns}$) had no effect on the frequency of agonistic interactions.

![Figure 1](image1.png)  
Fig. 1. Frequency of locomotor play (number of events per pig during 3 h) in piglets kept in three different pre-weaning environments. LS Means ± S.E., †$p < 0.1$. 
4. Discussion

4.1. Play behaviour during pre-weaning period

Our prediction at the outset of this study was that piglets from more enriched environments tend to perform more locomotor and social play. In accordance with this, we found in this study that the pre-weaning housing system had a tendency to influence piglet play behaviour during the first few weeks after birth.

The three pre-weaning housing systems differed in three aspects: the addition of straw, the provision of extra space and the freedom of the sow to move. The enriched crate had straw, but only differed from the poor crate in terms of space by 20% and the movement of the sow was still very limited. The enriched pen had both straw and substantially more space (60%) than the poor crate, plus free movement of the sow. It is impossible to judge from the current results which of the aspects were responsible for the increased play. The study by Blackshaw et al. (1997) suggested that the inner design of the farrowing crate by itself has little effect on the occurrence of play. In that study the housing conditions of the piglets was the same (same pen size without...
straw), except for the type of crate, and only small treatment effects were found. On the other hand, it has been reported that housing piglets together with piglets from other litters or giving temporary access to a new environment are much more effective in terms of stimulating play behaviour (Donaldson et al., 2002).

In the present study we did not find any effect of the age of the piglets on their pre-weaning play. Contrary to this, Newberry et al. (1988) reported a peak in locomotor play at about 4 weeks and a peak in social play somewhat later in time. An explanation for this discrepancy may lie in the difference between the restrictive types of housing utilized in our study, where piglets were kept in a smaller space without contact with other litters, and the semi-natural environment used in the Newberry et al. (1988) study.

4.2. Agonistic behaviour after mixing

We found that during the post-weaning mixing the piglets from the three pre-weaning housing systems did not differ in their frequency of agonistic behaviour or in the number of skin injuries. These results contrast the findings of other researchers (Beattie et al., 2000; De Jonge et al., 1996; O’Connell and Beattie, 1999; Olsson et al., 1999) who reported more aggression between pigs from poor housing systems. One reason for this discrepancy might have been a considerable methodological difference. In the present study, we applied the routine practice of mixing after weaning and did not make use of any special experimental manipulation. The previously cited studies used social confrontation tests to compare the agonistic behaviour of the alien focal piglets from the poor and the enriched environments. In agreement with our results, O’Connell et al. (2004), who weaned piglets at 8 weeks of age, did not find a significant difference in the aggression and level of injury between the piglets from the poor and the enriched housings after mixing. One explanation for the lack of difference between differently raised piglets could be that the sudden separation from the mother and mixing with alien piglets in a new environment is enormously stressful for all piglets and, thus, overshadows any difference arising from the pre-weaning environment. This routine mixing practice is much different from the weaning process that occurs under semi-natural conditions (Jensen, 1988). The agonistic behaviour during mixing may not be a suitable method for detecting the influences of pre-housing housing systems. Nevertheless, the weaning plus mixing stress is exactly what most piglets on commercial farms are exposed to. Therefore, the lack of difference in our study indicates that moderate enrichment of the pre-weaning environment does not alleviate the stress from mutual aggression associated with post-weaning litter mixing. Further, our results suggest that contact with other piglets before weaning may be more important for reducing agonistic behaviour than the pre-weaning housing system.

The proportion of “abnormally” ended fights in the piglets reared in the three environments did not differ. In fact, most of the piglets from all of the pre-weaning housing systems ended fights in this “abnormal” way, which was characterized by chasing and biting the hindquarters of their opponents (Lammers and Schouten, 1985). This behaviour may have been occurring when the piglets were unable to terminate an agonistic interaction by escaping. Pitts et al. (2000) suggested that a reduction in relative space would be expected to lead to such a protracted abnormal phase at the end of a fight. The number of wounds on the piglets from the three environments did not differ. However, littersize tended to affect the proportion of “abnormally” ended fights and the number of wounds. With an increasing number of piglets per litter, the proportion of “abnormally” ended fights and the number of wounds tended to decrease. It has previously been shown that the aggressiveness of pigs from larger groups (groups of 20 pigs
versus groups of 80 pigs) towards a novel individual is reduced in paired encounters (Turner and Edwards, 2004). It is possible that pigs may have become more selective in the larger groups to which group members they chose to fight with or that they generally restrict fighting because establishing a dominance relationship with so many animals is too costly (Andersen et al., 2004). In the present study in larger groups, the fight duration may have been shorter due to frequent interruption, such as when the fighting partners bounce to other penmates. It is therefore possible that the shorter fight durations decreased the probability of the incidence of “abnormally” ended fights and, thus, decreased the probability that an injury would be inflicted.

4.3. Food competition test

The pre-weaning housing system affected the frequency of agonistic interactions of the pigs when they were exposed to a food competition situation. The pigs reared in the enriched pen fought much less than the pigs reared in both types of crates. Similarly, De Jonge et al. (1996) and Olsson et al. (1999) recorded a lower frequency of aggression in pairs of gilts that came from an enriched condition during food competition and during social confrontation after 30 weeks. These results show that enrichment of the pre-weaning environment can reduce aggressive behaviour of pigs in competitive situations later in life even though housing conditions after weaning were the same for several months. However, the effect was only found for the piglets from the enriched pen and not those from the enriched crate, thus indicating that the enrichment must surpass a certain level (in our case, 60% more space and a free movement of the sow) to induce this long-term effect.

5. Conclusion

Enrichment of the pre-weaning environment through enlarged space, provision of straw and more movement for the sow tended to have a positive effect on pre-weaning play but had no effect on the level of aggression during post-weaning mixing. Aggression during experimental food competition tests later in life was reduced in piglets reared in the most enriched environment, thus indicating that long-term welfare benefits might be achieved through a moderate enrichment of the pre-weaning environment.

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