Comparison of two housing systems on behaviour and performance of fattening pigs

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ABSTRACT

The aim of this study was to compare the effects of different housing systems on behaviour and growth performance of fattening pigs. Forty Duroc × Meishan pigs aged 100 d were assigned into two housing systems: indoor deep litter (DL) housing (4 pens with 5 pigs/pen) and indoor pen with outdoor playground (PG; 4 pens with 5 pigs/pen). Pig behaviour, body weight, and feed intake were recorded and analysed. Results showed that DL pigs spent more time exploring (DL: 231.0 vs. PG: 178.0 s/h, \(P < .01\)), while PG pigs were more aggressive (PG: 6.6 vs. DL: 0.4 s/h, \(P < .01\)) and engaged in higher levels of abnormal behaviour (PG: 20.0 vs. DL: 3.2 s/h, \(P < .01\)), specifically stereotyped behaviour and mouth-holding/biting tail. No difference was observed for the final body weight and feed conversion efficiency. The results of this study suggest that the DL system improves pig welfare at aspects of exploratory behaviour and abnormal behaviour compared with the PG housing system under the conditions studied, providing a basis for the selection and design of optimum housing systems for pigs.

1. Introduction

In China, concrete floor with an associative open or semi-open playground (PG) is a general rearing mode for fattening pigs (Guo et al. 2015). Alternatively, the deep litter (DL) housing system is another rearing practice for hogs and emerging rapidly in China. The deep litter bedding is generally made of rice hulls, sawdust, straw, or other agricultural by-products, which are inexpensive and easy to obtain. Pigs reared in DL system eliminate on the surface of deep litter, followed by mixing with bedding materials and either decomposition or fermentation. Compared with conventional housing systems with fully slatted floors, both DL and PG systems have potential advantages in pig welfare by partly increasing environmental enrichment for pigs (Morrison et al. 2007; Guo et al. 2015).

Previous studies have shown that diverse rearing systems can influence pig behaviour (Morrison et al. 2003; Scott et al. 2006; Botermans et al. 2015; Tozawa et al. 2016) and/or growth performance (Morrison et al. 2007; Dourmad et al. 2009). Even though both DL system and PG system are perceived as being welfare friendly for pigs, there is limited scientific evaluation regarding the differences of behaviour, welfare, and performance for pigs reared in these two housing systems. Therefore, the purpose of this study was to evaluate the effects of two housing systems (DL vs. PG) on these indicators, providing additional information for the better design of pens. It was hypothesized that behaviours, welfare, and performance of pigs would be affected by the housing systems.

2. Materials and methods

2.1. Animals

Forty Duroc × Meishan crossbred healthy pigs (20 castrated males and 20 females; BW = 20.13 ± 0.69 kg) of the same age (around 100 d) were used in this study, which was conducted on the Taicang Swine Breeding Farm, Suzhou city, Jiangsu Province, China. This study was performed from August to November (northern hemisphere autumn) 2011. All procedures involving animals were approved by the Experimental Animal Care and Use Committee of Nanjing Agricultural University.

2.2. Treatment and housing

At the beginning of this study (100 d of age), pigs were weighed and removed from their nursery rooms, and then allotted into one of the two groups: deep litter (DL) and playground (PG). Each group consisted of four identical neighbouring pens (5 pigs per pen) that were balanced with respect to body weight and gender. Pigs were fed the same commercial diet twice per day (08:00 and 15:00, respectively) by one keeper until the pigs reached marketing time (~200 d). Pens were cleaned once per day during the feeding time in the morning by the same keeper (3–5 min). During the whole experimental period, pigs were allowed to access water ad libitum through nipple drinkers.

The DL pens were in a fully-enclosed house which had solid wood roofing and concrete walls on four sides (Figure 1(A)). The dimension of each DL pen was 4.0 × 2.5 m, which consisted of the concrete floor area (1.5 × 2.5 m) and the deep litter area...
A window with 1.5 m wide and 1.8 m high was constructed at the back of each DL pen that allowed lighting and gas exchange. The DL pen had concrete walls on four sides, with the low iron fences on both sides (2.5 m wide × 1.2 m high) of the deep litter area and the front of the pen (0.62 m wide × 1.2 m high) for passage. The deep litter of about 1.5 m depth consisted of rice hulls, sawdust, and straw. Pig excrement was mixed with bedding materials allowing either decomposition or fermentation. The deep litter bedding was loosened and replenished as required every 15 d to prevent hardening and keep the hygiene condition.

All floors in the PG groups were made of concrete. The dimension of each PG pen was 6.5 × 2.5 m (Figure 1(B)). Each PG pen was divided into two parts by a low wall of 1.88 m wide: an indoor area of 4.0 × 2.5 m and its neighbouring outdoor playground of 2.5 × 2.5 m. The indoor area was in a single-row half-open house which had solid wood roofing and concrete walls on three sides, while the outdoor playground adjacent to the indoor part was in the front of the house. The PG pen had low concrete walls (1.2 m high) on four sides, with a low iron fence (0.62 m wide × 1.2 m high) at the back of the pen for passage.

2.3. Behaviour observation

Pig behaviour was continuously video-recorded in a real-time mode using a digital video recorder (DS-7816H-SNH, Hangzhou Hikvision Digital Technology Co. Ltd., China) with twelve cameras (WV-CL 350, Panasonic Corporation, Osaka, Japan) for 13 d (from 20 October to 1 November 2011 with 10 clear d and 3 cloudy d; the outside temperature ranged from 18°C to 23°C). The age of pigs during the video-recording period was 114–130 days old. Each camera was used to monitor one indoor area or outdoor playground to ensure that there was no visual blind spot. All cameras were positioned 3.0 m high above the floor. Pigs’ behaviours were continuously observed through the video using the Observer XT 10.5 software (Noldus Information Technology, The Netherlands) by one experienced observer. Scan sampling method was used to collect individual behavioural data from the video. In a total of 15 behaviours for the experimental pigs were recorded in this study. The definition of each behaviour was described in Table 1. Behavioural time budget referred to the proportion of time engaged in each behaviour, which was calculated by dividing the sum of duration of each behaviour by the total time of observation.

2.4. Production performance evaluation

The weight of experimental pigs and the feed intake were measured every 30 d until the end of the experiment by pen as the unit. The average daily gain, the average daily feed intake, and the feed conversion ratio (dividing feed intake by live weight) for pigs were calculated and compared between the DL group and the PG group.
2.5. Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics (version 20.0, IBM Corporation). The Kolmogorov–Smirnov test was used to check the normality of the data. All the data were normally distributed and were presented as mean ± standard error of mean (SEM). The two-tailed t-test was used to analyse the behavioural and performance differences between the DL system and the PG system. Pens were treated as independent units for the statistical analyses. P-value less than .05 and P value less than .01 were considered statistically significant and very significant, respectively.

Table 1. Description of behaviours recorded over the study period.

| Behaviour            | Description                                                                 |
|----------------------|-----------------------------------------------------------------------------|
| Inactive behaviours  | Trunk is contact with ground and no weight is supported by any limb.        |
| Sit-resting          | Body is in an upright position, with hindquarters and two forefeet contact with ground. Weight is supported by hindquarters and two forelegs. |
| Stand-resting        | Weight is supported by four limbs. No movement.                             |
| **Active behaviours**|                                                                             |
| Running              | A rapid four-beat gait with forward movement. Lasting longer than 1 s.      |
| Walking              | A slow four-beat gait with forward movement. Lasting longer than 2 s.       |
| Playing              | Pig jumps in the air or runs back and forth in the pen doing buckjumps.    |
| Exploring pens       | Pig’s snout approaches (less than 5 cm) or digs any part of the pen.        |
| Drinking             | Pig manipulates the nipple drinker.                                         |
| Elimination          | Pig defaecates or urinates.                                                 |
| Comfort              | Rolling, rubbing body on the wall or the floor, stretching body, shaking body, or yawning. |
| Giving social activity| Rubbing or snout-touching another pig’s body in the same pen.               |
| Giving aggressive activity| A pig aggressively rams or thrusts other pigs with head or snout.          |
| Stereotyped behaviour| Chewing with nothing in its mouth, opening its mouth to hold or bite bars of the fence, or walking back and forth in a fixed route. Lasting longer than 3 s with rhythm. |
| Mouth-holding/ biting tail | Mouth-holding or biting another pig’s tail.                        |
| Mouth-holding/ biting ear | Mouth-holding or biting another pig’s ear.                      |

Table 2. Behaviours for pigs housed in deep litter (DL) system or playground (PG) system during the observation period (mean ± SEM).

| Behaviour                          | DL  | PG  | SE  |
|------------------------------------|-----|-----|-----|
| Inactive behaviour (% of total time) |     |     |     |
| Lie-resting                        | 87.0| 85.3| 1.3 |
| Sit-resting                        | 1.60| 7.40| 1.60|
| Stand-resting                      | 0.8a| 1.4b| 0.1 |
| Total inactive behaviour           | 89.5| 87.3| 0.5 |
| **Active behaviour (time for each pig spent in one hour)** |     |     |     |
| Running (s)                        | 1.4 | 1.5 | 0.3 |
| Walking (s)                        | 58.1| 46.7| 3.1 |
| Playing (s)                        | 0.1a| 0.9b| 0.1 |
| Exploring pens (s)                 | 23.10| 17.04| 12.0 |
| Drinking (s)                       | 25.1a| 19.2b| 1.5 |
| Elimination (s)                    | 21.0| 19.7| 1.2 |
| Comfort (s)                        | 22.7| 17.5| 3.2 |
| Giving social activity (s)         | 21.2c| 60.4d| 2.7 |
| Giving aggressive activity (s)     | 0.4c| 6.6d| 0.4 |
| Total active behaviour (s)         | 380.9| 349.6| 14.0 |
| Abnormal behaviour (time for each pig spent in one hour) |     |     |     |
| Stereotyped behaviour              | 0.1c| 8.0d| 0.9 |
| Mouth-holding/biting tail (s)      | 0.9c| 9.5d| 0.6 |
| Mouth-holding/biting ear (s)       | 2.3 | 2.6 | 0.5 |
| Total abnormal behaviour (s)       | 3.2c| 20.0d| 1.5 |

Note: Within a row, means with different letters of ‘a’ and ‘b’ are statistically different (P < .05), while means with different letters of ‘c’ and ‘d’ are significantly different (P < .01).

3. Results

3.1. Effects of housing system on pig behaviours

Results of the time budget of the observed behaviours were shown in Table 2. During the continuously video-recorded observation period, pigs reared in DL pens spent more time sit-resting (P < .05) and less time stand-resting (P < .01) compared with pigs reared in PG pens. No difference was observed for the time pigs spent in lie-resting and total inactive behaviour (P > .05).

During the whole observation period, pigs in DL pens spent less time playing (P < .05) and engaged in less social and aggressive activity (P < .01). Moreover, DL pigs spent more time drinking than that of PG pigs (P < .05), and pigs housed in DL pens spent 53.0 s more time per hour exploring the pen compared with pigs housed in PG pens (P < .01). There was no difference in the time pigs spent running, walking, elimination, and comfort when housed in DL system or PG system (P > .05).

Compared with pigs housed in PG pens, a pig housed in DL pens spent 16.8 s less time per hour exhibiting abnormal behaviours (P < .01). Specifically, pigs housed in DL pens spent less time performing the stereotyped behaviour and the mouth-holding/biting tail behaviour (P < .01). No time difference was observed for a pig holding/biting another pig’s ear by its mouth when housed in DL system or PG system (P > .05).

3.2. Pen exploration postures for DL pigs and PG pigs

During the pen exploration process, postures of pigs were also recorded, which were classified into lying, standing, and moving. Results showed that percentage of pen exploration postures was different when pigs were housed in DL or PG system (Figure 2). The moving, standing, and lying postures for pigs housed in DL system accounted for 38.1 ± 3.34%, 38.1 ± 3.85%, and 23.8 ± 2.36%, respectively; while the moving, standing, and lying postures for PG pigs accounted for 57.1 ± 6.35%, 36.0 ± 4.52%, and 6.9 ± 2.53%, respectively. When exploration, PG pigs had higher moving posture (P
and significantly lower lying posture compared with that of pigs in DL system ($P < .01$).

### 3.3. Average daily gain, feed intake, and feed conversion ratio

As shown in Table 3, during the whole experimental period (100–200 d of age), there was no difference in the average daily feed intake, the average daily gain, the feed conversion efficiency, the initial body weight, and the final body weight for pigs housed in DL system or PG system ($P > .05$).

| Item                        | DL         | PG         |
|-----------------------------|------------|------------|
| Initial body weight (kg)    | 20.06 ± 1.25 | 20.00 ± 0.81 |
| Final body weight (kg)      | 77.56 ± 2.03  | 76.85 ± 1.71  |
| Average daily feed intake (g/d)| 1495 ± 27.20 | 1421 ± 37.20 |
| Average daily gain (g/d)    | 573 ± 8.05   | 569 ± 13.20  |
| Feed conversion efficiency  | 2.60 ± 0.02  | 2.50 ± 0.08  |

### 4. Discussion

Single factor studies have been conducted to reveal the effects of environmental enrichment (Beattie et al. 2000; Tozawa et al. 2016), group size or rearing densities (Oh et al. 2010; Vermeer et al. 2014) on pig behaviour and performance. In fact, different housing systems often involve multiple factors that may affect pig behaviour, such as pen space, group size, flooring, enrichment, etc. However, there is still a lack of information concerning these factors and pig behaviour in multi-factorial experiments. In the present study, the DL housing system and PG housing system with vary space were compared under the conditions studied, in which the genetics, age, weight, group size, feed, and location were similar. Our study provides the first evidence about the effects of the DL system and PG system on behaviour, welfare and performance for pigs, indicating DL system improves pig welfare at aspects of exploratory behaviour and abnormal behaviour.

In this study, ethogram observation was conducted and inactive behaviour, active behaviour and abnormal behaviour were analysed under DL or PG housing system. For inactive behaviour, pigs housed in DL pens preferred sit-resting than stand-resting, which might be due to the usage of soft deep litter substrates compared with the hard concrete floor. No difference was observed for lie-resting percentage and the total inactive behaviour. Meanwhile, the active behaviour containing running, walking, playing, exploring pens, drinking, elimination, comfort, giving social activity and giving aggressive activity was observed in the study. DL pigs spent more time drinking. The enclosed house environment might contribute to a higher indoor temperature (Song et al. 2013), thus resulted in higher levels of drinking behaviour.

Furthermore, pigs housed in DL pens spent more time exploring and less time giving aggressive activity and exhibiting abnormal behaviour. Exploring the environment via snouts is one of the strongest intrinsic behaviours for swine (Tozawa et al. 2016). Research has demonstrated that the appropriate environmental abundance for pigs may arouse the expression of their natural behaviours, including the exploratory behaviour, etc (Elkmann and Hoy 2009). The ability of pigs to explore their surroundings and their information-based activities reflect their welfare status (van de Weerd and Day 2009), and the expression of exploratory behaviours has been used in pig’s welfare assessment (Morrison et al. 2007).

Expression restriction of natural species-specific behaviours may cause chronic psychological stress for animals (Pearce and Paterson 1993). In the barren environment, the pig still displays an inherent motivation to explore. In such cases, the exploratory behaviour is usually re-directed at the limited number of substrates available, namely pen-mates and pen components (Scott et al. 2006), leading to behavioural problems such as aggression (Beattie et al. 1996; Olsen et al. 2002; Presto et al. 2009) as well as tail-biting or other abnormal behaviour (Scott et al. 2006; Presto et al. 2009; Jensen et al. 2010). Abnormal behaviours are signs of suffering due to the thwarting of a need (Jensen and Toates 1993). In addition to increased pen exploration for DL pigs, our results indicated that PG pigs spent more time interacting with their pen-mates and there was no difference on the total time pigs spent on pen exploration and individual interaction for pigs housed in DL system or PG system. In the present experiment, PG pigs re-directed exploratory motivation towards pen-mates in the relative barren environment, resulting in higher pen-mate interaction time compared with that of DL pigs. The elevated time for pen-mate interaction in PG system provided the possibility for the increased abnormal behaviours for pigs housed in PG pens. This is consistent with previous studies that environmental enrichment may increase the time of pigs interacting with their pens, and reduce behaviours directed towards pen-mates (O’Connell and Beattie 1999). The enhanced exploratory behaviours as well as less aggressive activities and abnormal behaviours for DL pigs indicated that the DL system was more effective in improving the welfare condition compared with the PG system. Interestingly, pigs housed in PG system also showed more social activities and playing behaviour (an indicator of positive emotion), which might be related to additional playground field in PG house.

In summary, our results suggest that DL housing of pigs effectively enhanced the environmental enrichment, leading to more pen exploration and less pen-mate interactions compared with PG housing system. Moreover, lower pen-mate interactions resulted in less abnormal behaviours for pigs housed in DL pens. Although the DL or PG rearing system did not affect the production performance, the use of deep litter bedding effectively increased the environmental enrichment and partly improved pig’s welfare conditions. In a time whereby increased meat-animal production is needed, determining the optimum and appropriate production regimens which also consider animal welfare and enrichment are vital. New mechanisms of pig housing, will lead to enhanced animal growth and development, especially if the physiological and psychological needs of the animals are considered.

### Disclosure statement

No potential conflict of interest was reported by the authors.
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