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The Effects of Space Allowance and Toy Provision on the Growth, Spatiotemporal Distribution of Behavior, and Pen Cleanliness of Finishing Pigs

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Abstract: Excretion and lying are key behavioral factors that cause pen fouling, thereby affecting pig welfare, pathogen fecal–oral transmission, and air quality in pig housing. This study investigated the effect of space allowance and toy provision on the spatiotemporal distribution of pigs' excreting and lying behavior, as well as the score of floor cleanliness in finishing pig pens. A total of 144 Landrace × Yorkshire × Duroc hybrid fattening pigs were randomly assigned to 12 part-slatted pens at stocking densities of 0.75, 1.05, and 1.35 m^2/pig with 12 pigs per pen, and 2 pens at each density level were provided with hanging chains and rubber stars as toys. The results showed that for the average daily gain (ADG) of the pigs, the main effect of space allowance was significant ($p < 0.05$). The ADG at the stocking density level of 1.35 m^2/pig was significantly higher than 0.75 and 1.05 m^2/pig ($p < 0.05$). The ADG of the pigs at a density of 0.75 m^2/pig in the toys group was significantly higher than the no toys group ($p < 0.05$). When occupied space was limited, the provision of toys was beneficial to the growth performance of the pigs. Space allowance and toy provision did not affect the time-varying regularity of the pigs but had a certain impact on the areas where the two behaviors occurred. At a density of 1.35 m^2/pig, the excreting rate in the corner areas of the slatted floor and the lying rate in the middle area of the solid floor were significantly higher than at a density of 0.75 and 1.05 m^2/pig ($p < 0.05$). Under the conditions of this study, when the stocking density was 1.35 m^2/pig and toys were provided, the average daily gain of the pigs was the highest, and the pigs excreted more in the defined excretion area, lay more in the lying area, and the cleanliness of the lying area was also higher. In the case of space constraints, the provision of toys can offset some of the adverse effects of space constraints on pig growth and pen cleanliness.

Keywords: space allowance; toy provision; pen cleanliness; excreting; lying; finishing pigs

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1. Introduction

Sound hygiene practices are important throughout the processes of production in the pig industry. Hygiene includes measures taken to ensure a clean environment and improve the health status of the animals in order to maximize production. The cleanliness of pig pens is an important factor in improving the quality of the environment in the pig housing as well as ensuring the health of animals and human caretakers. Pig houses are the main places where harmful gases are generated; about 69–74% of NH_3 emissions from intensive pig production come from pig houses [1]. The pollution of pens directly affects the production of harmful gases in pig houses; only 9% of harmful gas emissions are directly caused by animals, while 91% come from the surface of pollutants in the house [2]. Ni et al. found that NH_3 emissions were highly correlated with fecal pollution on the ground (r = 0.852), and when the solid floor in the house was cleaner, it greatly reduced ammonia emissions [3,4]. In addition, the contamination of the floor with manure and urine affected the normal movement and rest of the pigs, which was not conducive to the health and

welfare of the animals. Numerous studies have found that pigs are at increased risk of hoof damage, infection, and exposure to ammonia emissions if the floor is heavily polluted and manure is not removed in time [5–7]. In addition, if pigs are raised in pens heavily polluted by feces and urine, the concentration of skatole and indole in the subcutaneous fat will increase, which will affect the quality of pork [8].

The cleanliness of the pens is affected by a combination of factors such as temperature, airspeed, space allowance, correct pig pen design, and training induction of animals. To prevent the pollution of the pen, it is important to control the micro-environment, ensure the comfort of the lying area, and reduce the area polluted by feces [9]. Pigs have fixed excretion and lying areas in their natural state [10]. If the stocking density (the number of animals kept in a given unit of area) is too small or too large, it is not conducive to the maintenance of the pig's fixed-point behavior. Pen contamination occurs when pigs' excretion behavior is transferred from a designated excretion area to a lying area [11]. Changes in the spatial layout and richness of the pen will also affect the cleaning of the pen. Andersen and Pedersen found that if the location of the rearing equipment was changed, the excretion behavior of the pigs also changed. For example, if the position of the lying area or the eating and drinking area changes, the excretion location will also change [12]. Adding an additional drinker to the slatted floor area outside the house can increase contamination of the pen when there is already a drinker on the slatted floor inside the pen [13]. Research shows that the stocking density is one of the important factors affecting the cleanliness of the pig pen, and it has an effect on the excreting and lying areas of pigs [14,15]. Moreover, with the rise of the concept of welfare farming in Europe and its continuous promotion around the world, adding toys is being promoted for most pig farms [16,17]. However, the effects of space allowance and toys in the areas where pig excretion and lying behaviors occur, and the resulting contamination of pens, are unclear and require further research.

This paper investigated the effect of space allowance and toy provision on the growth, spatiotemporal distribution of excreting, and lying behaviors of pigs, as well as the score of floor cleanliness of pens. It is hoped that this study will provide a theoretical basis and reference for the research of the relationship between pig behavior and cleaner production.

2. Materials and Methods

2.1. Experiment Design, Animals, and Management

The experiment was carried out in a fattening pig house at the Chongqing Academy of Animal Sciences, Chongqing City, China, from September to October 2018. The test lasted for 32 days. During the test, the ambient temperature in the piggery was 16–27 °C, and the relative humidity was 56–99%.

A 3 × 2 two-factor experimental design (three levels of stocking density × with/without toys) was used with two replicates per treatment. A total of 144 fattening pigs (Landrace × Yorkshire × Duroc) with an initial body weight of 57.0 ± 4.4 kg were selected and randomly assigned to 12 pens according to the 1:1 ratio of castrated males to females, with 12 pigs per pen for all treatments. The pens were designed with 45% slatted and 55% concrete solid floors. Before the experiment, railings on both sides of the pens were adjusted to maintain stocking densities of 0.75, 1.05, and 1.35 m^2/pig. There were four pens per density level, two of which were supplied with welfare toys consisting of bite chains and star rubber. Toys in the pen were hung 0.5 m above the two corners of the slatted floor area.

Pigs in each pen were fed a standardized amount (there was always food in the feeder) every day at 8:00 and 16:00 h via two plastic feeders on the solid floor near the aisle. Water was available ad libitum 24 h a day from the four bowl-shaped drinkers on the end wall of the slatted area. Evaporative cooling pads and air exhaust fans were installed in the pig house for ventilation and temperature and humidity regulation. The manure in the manure ditch was regularly cleaned by the mechanical scraper manure cleaning system, and the pen was cleaned manually at 7:00 a.m. and 17:00 p.m. every day.

2.2. Growth Performance

Pigs in each pen were weighed on the first and last day of the experiment using a movable monomer scale (accuracy: 0.5 kg, Meier-Brakenberg, Germany). Body weight changes were recorded, and the average daily gain (ADG) was calculated.

2.3. Pig Behavior Observation and Statistics

2.3.1. Video Image Acquisition and Pen Area Division

Both the slatted floor and the solid floor of the pen were equally divided into three areas to facilitate observations of the pigs' behavior and scoring the cleanliness of the pen (Figure 1). The solid floor was defined as the lying area, and the slatted floor was the drainage area. Both the lying area and the excretion area were equally divided into three sub-areas, where C1 represented the corner areas and M1 represented the middle area of the slatted floor. The corner areas of the solid floor were denoted as C2, and the middle areas were denoted as M2. A camera was installed above each pen, and an electronic video recording system with pixels of 1280 × 960 (Dahua Technology, Zhejiang, China) was used to automatically collect the behavior of pigs.

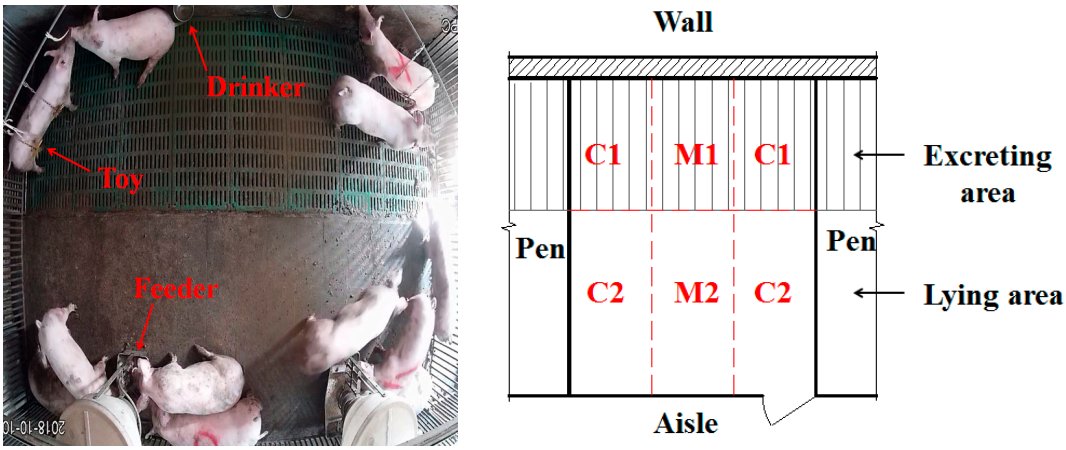

Figure 1. Design of the pen used for finishing pigs and the pen area division.

2.3.2. Excreting Behavior

Video recordings were selected on the 2nd and 20th days after group stabilization for observing the behavior of pigs. The daily 24 h excreting behavior was manually recorded by an experienced research assistant, and a total of 1636 excretion behaviors were collected in two days. Judgment criteria for excreting behavior: pigs stand still and defecate or urinate. The frequency of excretion in each area was counted, and the excretion proportion of each area was calculated. The excretion proportion of a certain area is the number of excretion behaviors in this area/the total number of excretion behaviors in all areas × 100%. Thus, the preference for excreting in each area of the pen was analyzed.

2.3.3. Lying Behavior

The video recordings on the 2nd and 20th days after regrouping were selected for manual observation. The times and areas of lying behavior were recorded by an experienced research assistant by capturing video pictures every 20 min. Judgment standard for lying behavior: pigs lie on their stomach or their backs on the solid or slatted floor for more than 3 s. The preference of pigs' lying behavior for each area during the daytime period (8:10–18:10) was analyzed, and the lying proportion of each area was calculated. The lying proportion in a certain area = the number of lying pigs in this area/the number of lying pigs in all areas × 100%. If the pig was lying on the junction of multiple areas, it was allocated to the area with more than 50% of its body. If the body proportion of the pig in each area was the same, the area where the head was located was chosen.

2.4. Floor Cleanliness Score

The video recordings of the 2nd and 20th days after group stabilization were selected to evaluate the pollution of the pens. The observation time was 7:00–8:00 (before the manure removal in the morning), 10:00–11:00 (after the pigs were fed intensively), and 15:00–16:00 (before the manure removal in the afternoon). The division of the floor area for cleanliness scoring was as described in Section 2.3.1. Each area was scored for cleanliness according to the scoring standards shown in Table 1. The feces status and the area covered by feces were comprehensively scored. Higher scores indicated more severe pen pollution. Cleanliness scoring was performed by a trained person.

Table 1. Scoring standard for cleanliness of each area in the pen.

Score	0	1	2	3
Feces present	No	Yes	/	/
Fecal state	/	Dry manure	Loose, moist feces	Large tracts of moist feces
Area covered by feces	/	>0–<33%	≥0–<66%	≥0

2.5. Data Analysis

In order to exclude the influence of the partition area, we stipulated the proportion of behavior that occurred in areas C1 and C2. The lying/defecating behavior proportion of area C1 was the average value of the two corners of the slatted floor, while C2 was the solid floor. Due to the limitations of the experimental piggery, there were only 2 pens per treatment. Therefore, it is necessary to introduce statistical methods of data. The ADG of the pigs was analyzed based on the individual pig, and the number of pigs was the number of repetitions. Behavior and cleanliness scores were based on pens, and the data from 2 days apart from each pen were statistically analyzed, which were treated as 4 replicates per treatment. Statistical analysis of the experimental data was performed, and charts were made in Excel 2010, SPSS 20.0, and OriginPro 9.0. A univariate two-way ANOVA in the general linear model was used to analyze the effects of space allowance and toys on the growth performance, behavioral areas, and pen contamination scores of finishing pigs. Significance was considered at $p < 0.05$, and the results were expressed as the mean ± SE.

3. Results

3.1. Animal Parameters

The ADG of the pigs increased with the increase in housing space irrespective of the presence or lack of presence of toys (Table 2). The main effect of space allowance was significant ($p < 0.05$). The interaction between toys and stocking density was not significant ($p > 0.05$). In the no toys group, the ADG of the pigs at densities of 1.05 m^2/pig and 1.35 m^2/pig was significantly higher than the density of 0.75 m^2/pig. At the 0.75 m^2/pig density level, the ADG of pigs in the toys group was significantly higher than the no toys group ($p < 0.05$).

3.2. Diurnal Rhythms of Lying and Excreting Behavior of Pigs

The lying behavior of the pigs was mainly concentrated from 8:00 p.m. to 6:00 a.m. of the next day, and the average lying proportion during this period was over 90% (Figure 2a). There was also a peak of lying after feeding. Between 8:00 and 10:00, and 15:00 and 18:00 daily, the herd had the least number of pigs lying, as these two periods were disturbed by events such as pen cleaning and feeding.

Table 2. Interaction effects of space allowance and toys on the ADG of pigs.

Welfare Facilities	Stocking Density	ADG
Toys Group	0.75 m^2/pig	0.91 ± 0.12 *
	1.05 m^2/pig	0.92 ± 0.09
	1.35 m^2/pig	0.98 ± 0.12
No toys Group	0.75 m^2/pig	0.80 ± 0.12a *
	1.05 m^2/pig	0.90 ± 0.12b
	1.35 m^2/pig	0.97 ± 0.11b
p-value	Stocking density	*
	Toys	NS
	Stocking density * Toys	NS

Note: ADG = average daily gain; different letters indicate significant differences ($p < 0.05$) in the same column within the same group. The * in the row of test groups indicates that the index is significantly influenced by toy provision ($p < 0.05$) at this stocking density level. The * in the *p*-value row means the difference was significant ($p < 0.05$), while NS means the difference was not significant ($p > 0.05$).

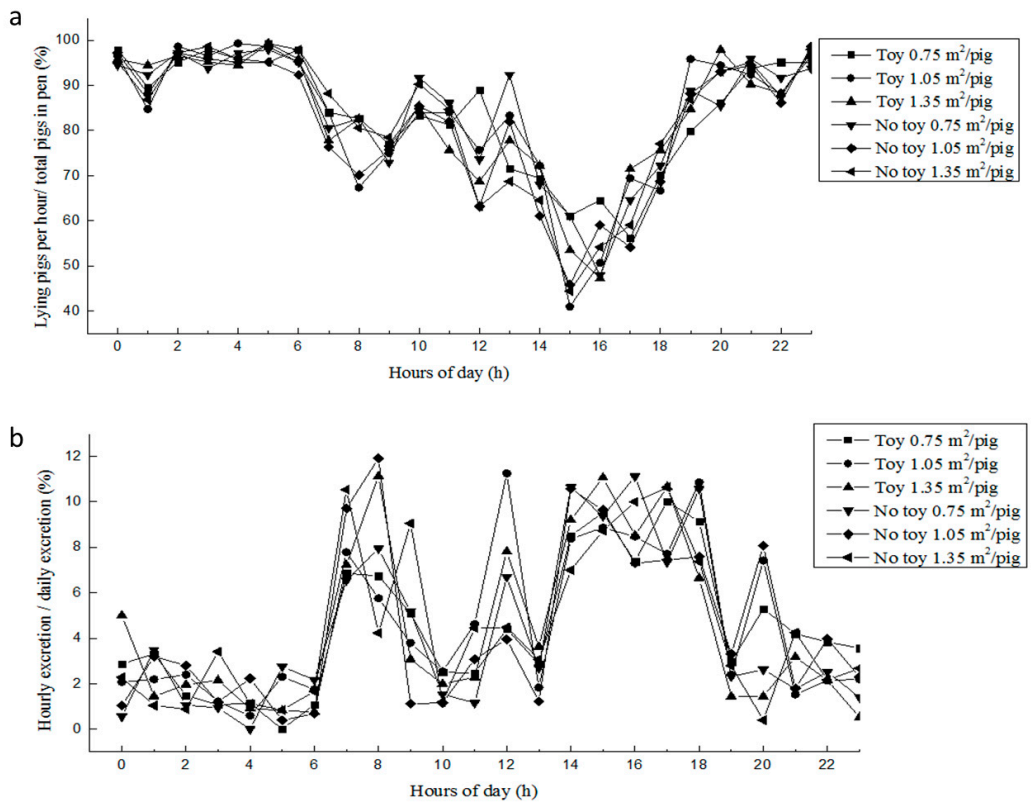

Figure 2. 24-h pattern of the lying (**a**) and excreting (**b**) behavior of pigs.

The excreting behavior of the pigs was mostly concentrated in the daytime (Figure 2b). Excretion peaks were found at 7:00–9:00 in the morning and 14:00–18:00 in the afternoon, and there was also an excretion peak around 12:00 after feeding. The least excreting behavior occurred between 4:00 and 5:00 at night.

3.3. Lying and Excreting Area Preferences of the Pigs

As shown in Figure 3a and Table 3, for the proportion of the pig's lying behavior in area C2, the main effect of stocking density was significant ($p < 0.05$), and the interaction effect of density and toys was significant ($p < 0.05$). The results of further simple effect analyses showed that in the toy group, pigs' lying proportion at a density of 0.75 and 1.05 m^2/pig in area C2 was significantly higher than 1.35 m^2/pig ($p < 0.05$). In the no toy group, the lying proportion of the pigs in area C2 at a density of 0.75 m^2/pig was significantly lower than

1.05 and 1.35 m^2/pig ($p < 0.05$). At the density level of 0.75 and 1.05 m^2/pig, the presence or absence of toys had no significant effect on the lying proportion of the pigs in area C2 ($p > 0.05$), but at a density of 1.35 m^2/pig, the lying proportion of the pigs in the no toy group was significantly higher than the group with toys ($p < 0.05$). Space allowance and toys had no significant effect on the proportion of pigs lying in area M2. Pigs preferred to lie in corner areas in all treatments, regardless of solid or slatted floors.

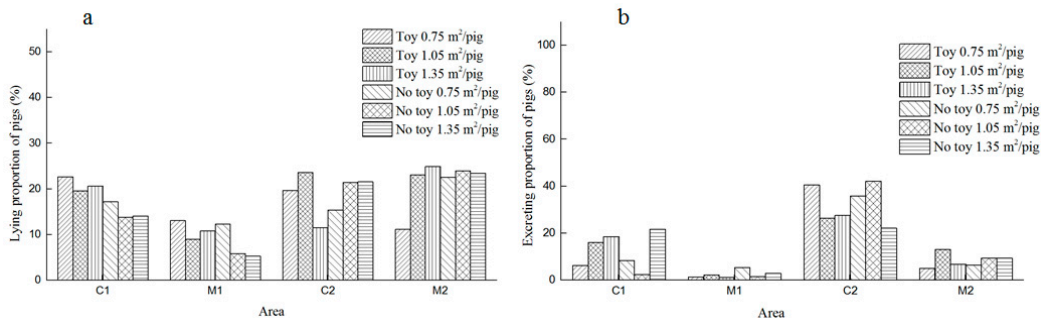

Figure 3. Lying (**a**) and excreting (**b**) proportions of the pigs in each area under different treatments. C1 = corner areas of the slatted floor; M1 = middle area of the slatted floor; C2 = corner areas of the solid floor; M2 = middle area of the solid floor.

Table 3. The effects of space allowance and toy provision on behaviors of fattening pigs (*p*-values).

Indices	Area	Stocking Density (*p*-Value)	Toy Provision (*p*-Value)	Stocking Density * Toys (*p*-Value)
Excreting behavior	M1	NS	NS	NS
	M2	NS	NS	NS
	C1	*	NS	NS
	C2	NS	NS	NS
Lying behavior	M1	*	NS	NS
	M2	NS	NS	NS
	C1	NS	*	NS
	C2	*	NS	*

Note: C1 = corner areas of the slatted floor; M1 = middle area of the slatted floor; C2 = corner areas of the solid floor; M2 = middle area of the solid floor. Stocking density * toys represents the interaction term of the two factors.

As shown in Figure 3b and Table 3, a relatively high proportion of excreting behavior of the pigs occurred in areas C1 and C2. For the proportion of excreting behavior of the pigs in area C1, the main effect of space allowance was significant ($p < 0.05$). The post hoc analysis results showed that the pigs' excreting proportion in area C1 at a density of 0.75 m^2/pig was significantly lower than 1.05 and 1.35 m^2/pig ($p < 0.05$). Space allowance and toys had no significant effect on the excreting proportion of the pigs in other areas ($p > 0.05$).

3.4. Cleanliness Score for Pig Pens

Regardless of the treatment, area C was more polluted than M (Table 4). Neither toys nor density had significant effects on the pollution score of the slatted floor area ($p > 0.05$). However, at the density levels of 0.75 and 1.05 m^2/pig, the group with toys had higher pollution scores in area C1, while at the density level of 1.35 m^2/pig, the opposite was true. For the pollution score of area C2, the main effect of toys and space allowance were both significant ($p < 0.05$). The pollution scores of area C2 in the toy groups were lower than the groups without toys. Compared to the no toy group, toy provision reduced the contamination of area C2 at densities of 1.05 and 1.35 m^2/pig. For the pollution scores of area M2, the main effect of stocking density was significant ($p < 0.05$). When the occupied

space was larger, area M2 was cleaner. There was no significant interaction between the effect of toys and density on the pollution scores of each area.

Table 4. Pen pollution scores for each area of different treatments.

	Stocking Density (m^2/pig)	C1	M1	C2	M2
Toys Group	0.75	0.96 ± 0.66	0.5 ± 0.5	1.29 ± 0.43	0.5 ± 0.5
	1.05	0.83 ± 0.51	0.67 ± 0.62	0.83 ± 0.55	0.33 ± 0.47
	1.35	0.88 ± 0.51	0.5 ± 0.5	0.79 ± 0.48	0
No toys Group	0.75	0.79 ± 0.43	0.5 ± 0.65	1.29 ± 0.59	1.25 ± 1.3
	1.05	0.63 ± 0.36	0.42 ± 0.49	1.63 ± 0.77	0.25 ± 0.43
	1.35	1.17 ± 0.42	0.5 ± 0.5	1 ± 0.41	0
p-value	Stocking density	NS	NS	*	*
	Toys	NS	NS	*	NS
	Stocking density * Toys	NS	NS	NS	NS

Note: C1 = corner areas of the slatted floor; M1 = middle area of the slatted floor; C2 = corner areas of the solid floor; M2 = middle area of the solid floor. A four-point score was used: 0 (clean), 1, 2, and 3 (heaviest fouling). The score was expressed as mean ± SE. Stocking density * toys represents the interaction term of the two factors.

4. Discussion

4.1. The Effects of Space Allowance and Toys on Pigs' Growth and Behaviors

Changes in space allowance can affect pig performance and behavioral expression. Studies have shown that as stocking density increases, the average daily weight gain of nursery pigs decreases [18–20]. Vermeer et al. compared the average daily weight gain of finishing pigs under a stocking density of 0.8 m^2/pig and 1.0 m^2/head and found that the average daily gain of the pigs was higher under a stocking density of 1.0 m^2/pig [21]. Li et al. also reported that with the increase in stocking density, the production performance of finishing and fattening pigs decreased, especially in a high stocking density environment, and the average daily weight gain of the pigs decreased significantly [22]. In this study, the average daily gain of the pigs in both the toy and the no toy groups increased with the increase in the space allowed. In pens with limited space allowance, the provision of toys was beneficial to improve the ADG of the pigs.

The space allowance and toys did not affect the time regularity of pig excretion and lying behavior. The lying behavior of the pigs in this study was mostly concentrated at night, and excretion behavior was more frequent during the day. The time rules of excretion and lying behavior were consistent with findings from other studies [5,23,24]. Pigs have the habit of excreting at a fixed location, and they generally prefer to defecate in a corner or near the fence. It was also observed in this experiment that when the conditions allowed, the pigs preferred corners as the excretion area in order to avoid disturbance. Guo et al. also found that pigs prefer to excrete in the corner and that the excretion proportion increases significantly closer to the corner, with 76.5% of the excretion occurring near the corner [23]. In addition, we also found that pigs also seem to prefer to lie down in corner areas, which may make them feel safer when resting.

In this study, at the corner of the excretion area we defined, pigs with a density of 0.75 m^2/pig had a lower proportion of excreting behavior in this area and a higher proportion of lying behavior. It showed that when the space occupation was insufficient, the pigs did not like to excrete in the excretion area we defined, but instead lie more in this area. However, the proportion of excreting behavior of the pigs in area C2 was generally higher. This may be because finishing pigs produce more heat, and lying on slatted floors helps them to increase heat dissipation. Additionally, pigs grow faster in the fattening period, and the limited feeding space may not be sufficient to meet the functional zoning requirements of pig pens. The phenomenon described above suggested that there was a relationship between the area where the lying and excretion behaviors of pigs occur and the space requirements, body weight, and indoor temperature of pigs. As pigs' body weight and pen temperature increased, the pigs desired to cool themselves by lying on the slatted

floors and thereby increased the use of the solid floor for dunging [14]. So, it is difficult to maintain the functional division of pens under high stocking density, as pigs may excrete in the lying area and lie down in the excretion area [25,26]. Therefore, in actual production, it is necessary to pay attention to the space allowance, as well as maintain a suitable ambient temperature in the pen. The right time to transfer the group is also an essential factor to consider.

A rich environment, such as toy provision and environmental enrichment materials in pens, can improve the growth proportion of pigs and have a positive effect on the behavior of pigs. Studies have shown that fattening pigs had a higher average daily feed intake and faster growth rates in pens with extra space and an area containing peat and straw compared to pens with slatted floors and the minimum recommended space allowances [27]. Likewise, in our study, the average daily gain was higher in the toy group at the same stocking density. In enriched pens (wood or rubber toys were available), where pigs spend more time engaging in positive social interactions, the overall incidence of disruptive behavior in pigs was considerably lower [28]. In pens with high density and poor environmental conditions, incidences of tail-biting behavior and aggressive behavior were significantly higher [29]. When natural twine and rubber balls were combined as enrichment materials, pigs spent less time lying or sitting, exhibited less stereotyped behavior, and demonstrated more exploratory behavior [30]. Pigs in the pen with hanging toys preferred to lie at one end of the pen near the corridor (i.e., the designated lying area), but as pigs grew older, the lying behavior in the activity area and excretion area increased [24]. In our study, the proportion of lying behavior of pigs in area C2 was higher at a density of 0.75 and 1.05 m^2/pig level in the toy group, while this proportion was higher in the no toy group at a density of 1.05 and 1.35 m^2/pig level. It showed that when the space was limited, toy provision was beneficial for pigs to maintain the functional division of the pen. In our previous and current studies, we also found a similar pattern—pigs in the growing stage tended to lie more on the solid floor (lying area), while during the fattening period, use of the slatted floor area (excretion area) as a lying area gradually increased [15].

Studies have shown that environmental enrichment plays a greater role in changing pig behavior than spatial distribution [29]. In this study, at lower stocking densities, pigs tended to excrete in the corners of the excretion area and lie down in the middle of the lying area, which was consistent with our expected functional zoning of pens. Toys installed in the corners of the excreting area were beneficial to induce pigs to excrete in the slatted floors, which was conducive to keeping the solid floor clean. This indicated that space allowance and toys have impacts on controlling where pig behavior occurs or maintaining defined pen functional zoning.

4.2. Pig Behaviors and Pen Floor Cleanliness

The excretion behavior and lying behavior of pigs are directly related to the floor cleanliness of the pig house, and the area where these two behaviors occur largely determines the contaminated area of the pen. According to pig nature, pigs prefer to lie down in a dry and clean place away from the excretion area [31]. Pig pens are contaminated when the excretion of pigs is transferred from the designated excretion area to the lying area. This can lead to poor hygiene and air quality, additional work by the breeder, disturbance of pigs' lying and excretion behavior, and increased competitive interactions [32–34]. The expected lying area and excretion area in this study are concrete solid floors and slatted floors, respectively. Only by reducing pig excretion in the solid floor area can pen cleanliness be maintained to the greatest extent.

The shape, area, layout, and welfare facilities of the pen can all influence the behavior of pigs, which in turn affect the cleanliness of the pen. The structure of pens that are too long and narrow will make it difficult for pigs to distinguish between the lying area and the excretion area, especially when the stocking density is high. The phenomenon of excretion in the lying area and lying in the excreting area may occur, resulting in worsening the hygienic conditions of the pen [11,25]. The placement of the water trough can induce pig

excretion in a specific area and improve the cleanliness of the lying area [35]. We expected that most of the excretion behavior of pigs would occur on slatted floors; instead, we observed the opposite pattern. This may be because the temperature in the pig house was high at the beginning of the experiment, and the pigs formed the habit of lying on the slatted floor area to dissipate heat and chose to excrete on the concrete solid floor away from the slatted area where they lay. Therefore, the feces and urine pollution on the cement solid floor increased. Nonetheless, pigs in the lower stocking density had higher excretion proportions and lower lying proportions on slatted floors. Both the slatted and solid floors showed a high accumulation of pig waste in the corners. In the case of higher stocking density, the pollution score of the slatted floor corner area was higher, and the opposite was true for the lower density. At lower stocking densities, the no toy groups had higher contamination scores in both slatted and solid floor corners. This suggests that toys can help induce more excretion in the slatted floor area when occupying limited space, thereby improving the cleanliness of the lying area. The cleanliness of the middle area of the lying area was more affected by the stocking density. When the stocking density was higher, the cleanliness of the middle area of the lying area was higher.

5. Conclusions

The main effect of stocking density was significant for the ADG of pigs. When the pigs occupied limited space, the provision of toys was beneficial to the growth performance of the pigs. Space allowance and toy provision did not affect the time-varying regularity of the pigs. However, we found that no matter what the treatment, the pigs seemed to prefer lying or excreting in corner areas. Space allowance and toys have positive impacts on controlling where pig behavior occurs or maintaining defined pen functional zoning. Under the conditions of this study, when the stocking density was 1.35 m^2/pig and toys were provided, the average daily gain of the pigs was the highest, and the pigs excreted more in the defined excretion area, lay more in the lying area, and the cleanliness of the lying area was also higher. In actual production, if conditions permit, providing a larger occupied space for the pigs will help improve the pen's cleanliness. In the case of space constraints, the provision of toys can offset some of the adverse effects of space constraints on pig growth and pen cleanliness.

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