

Effects of inductive methods on dunging behavior of weaning pigs in slatted floor pens

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Abstract: The excreta of pig is generally utilized to induce pigs to excrete in particular area, which reduces the subsequent work required to clean pens. This paper discussed a new induction device design based on the biological characteristics of pigs. Using different induction materials in the devices, the frequency and location of the excretory behavior of pigs through five treatments and a control group were compared. According to the results, different induction methods had significant ($p < 0.05$) effects on frequency and duration of excretory behavior. Compared to the conventional induction method, the induction devices were significantly ($p < 0.05$) more effective in training pigs to excrete in the assigned area, the most effective material used in the induction devices was feces. If the inductive feces had been preserved in the air for a longer time, the effect of inducing excretory behavior would have been more obvious. Empty devices did not work to induce pigs to excrete in the induction area.

Keywords: animal behavior, weaning pigs, slatted floor pen, pig training, excretory behavior, inductive material

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1 Introduction

A pig's excretory behavior and location has a profound influence on hygiene, which is important for indoor swine production systems^[1]. Pigs are born with the habit to urinate and defecate more often in the same

dunging area, and prefer to move away from their selected lying area in order to find a colder, safer and secluded location for excretion^[2-5]. Pigs will investigate their living space after being introduced into a new environment, so that they can determine the locations of areas such as the feeding trough, water fountain, lying area and dunging area, etc. Once the pigs establish these areas, the specific locations of these areas will not change easily, given that the pigs are not moved into a new environment^[6,7]. However, if the environment changes due to a group transfer, pigs will establish new functional living areas^[8]. Knowledge of a pig's excretory behavior and the methods of pre-establishing an area for defecation before pigs are introduced into new pens possesses practical significance. This knowledge makes it so that the design of housing systems keeps the soiling of a housing pen at a minimum, reducing the cleaning work necessary to maintain a sanitary pen.

As swine systems continue to advance, weaning and

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raising pigs in feeding pens has become the prevailing method of swine production^[9-11]. However, due to improper pen design or unreasonable management, pens are becoming uniform and barren. This gives pigs an inappropriate micro-environment, where they cannot accurately position and recognize areas for eating, sleeping and excreting. This inappropriate micro-environment means that the degree of contamination of pens and much work may need for removing manure^[12-15]. With the increasing cost of labor, it is important to find an effective method to limit pig excretion to a specific area in intensive swine production systems.

In conventional swine production, feces are usually placed in the pen before the pigs are introduced, so that it guides them to a certain area to excrete in^[16,17]. Although this approach is somewhat effective in guiding a pig's excretion, the method in itself can increase the area of pollution in the pen, as well as increase the chance of disease transmission and cross infection^[18]. So far, there are not many studies about establishing a fixed area for pig excretion using appropriate induction methods^[19,20]. The objective of this research is (1) to design a guiding device based on a pig's acute sense of smell and (2) to clarify the effects of different inductive methods and how they reduce the contaminated surface area of slatted floor pens.

2 Materials and methods

2.1 Animals and housing

Sows were confined in individual pens during gestation, and were introduced to farrowing crates one week before farrowing. Piglets are weaned at four weeks of age, then transferred to a nursery house once they are six weeks of age. The piglets are housed in groups of eight per pen. The experiment was conducted in the same nursery house. Forty-eight healthy piglets (six weeks of age) born in the same period and fed in the same farrowing house were selected as the experimental objects. These piglets, with similar weights and the same gender (female), are the Series II Suzhong pigs.

This experiment was conducted in the swine breeding farm, located in Zhuzhen Town, Nanjing City, Jiangsu province, China. The experimental piglet house was divided into two rows, with sixteen pens in total. Three aisles extended west to east, on both sides of the two rows (see Figure 1). Piglets were raised in high-rise, fully slatted floor pens that were 2.2 m×2.0 m×0.7 m (L×W×H). The slurry channel is located in the central part of the house, with two slurry pits on both sides under the slatted floor pen. Manure and urine in the house is cleaned by manually flushing the entire pen with water once a day. The excrements are then carried to the biogas digester.

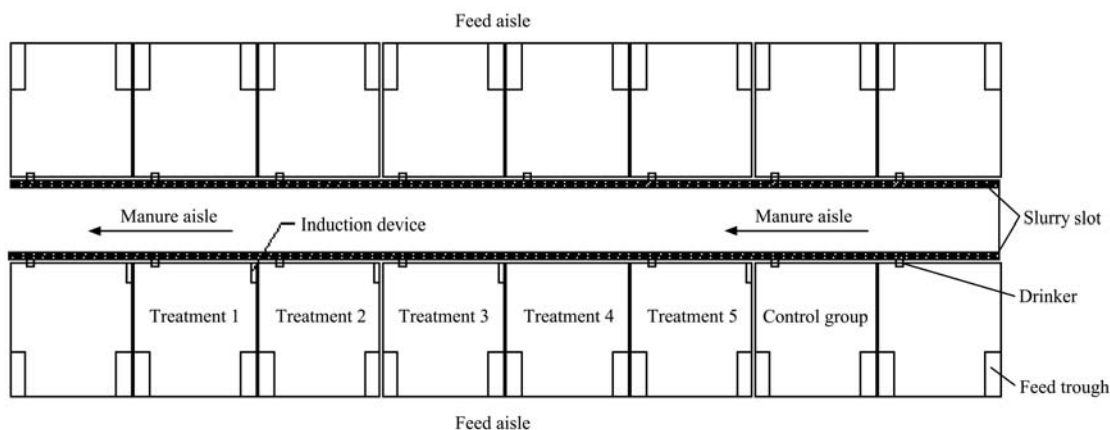


Figure 1 Layout of the experimental pens

All pigs received the same nutrition and management regimes. They were fed twice per day by one keeper at 08:30 and 14:00, while water was available at any time. The temperature in the experimental house was regulated with windows on side walls and a heater at south end of

the house. The experiment was carried out in winter, during which the windows of the house were shut except in the noontime. During noontime, the windows were opened for 0.5 h due to higher outdoor temperatures. No other training measures were used to influence

excretory behavior of the piglets during the experimental process.

The average indoor temperature during the test was $(20.0 \pm 0.06)^\circ\text{C}$, while the average outdoor temperature was $(7.0 \pm 0.04)^\circ\text{C}$. The average relative humidity was $72\% \pm 0.34\%$.

2.2 Design of the inductive device

Piglets start leaving the nest to urinate and defecate once they are two to six days of age^[14,21], as they grow older, they move further from the resting area^[21]. The method currently used by the swine farms to induce excretory behavior of pigs is to place a small amount of feces in the corner of a pen before the piglets were introduced. An inducing device is designed on the basis that pigs are sensitive to smell, not only to isolate animal waste, but also to train the excretory behavior of the pigs^[22]. Figure 2 gives the structure and dimension of the device, which is a rectangular box. The ends are covered to avoid vertical diffusion of smell, and the bottom is perforated to release odors. It provides a constant source of odor to induce piglets to excrete in the area after an inducing material is placed into the box.

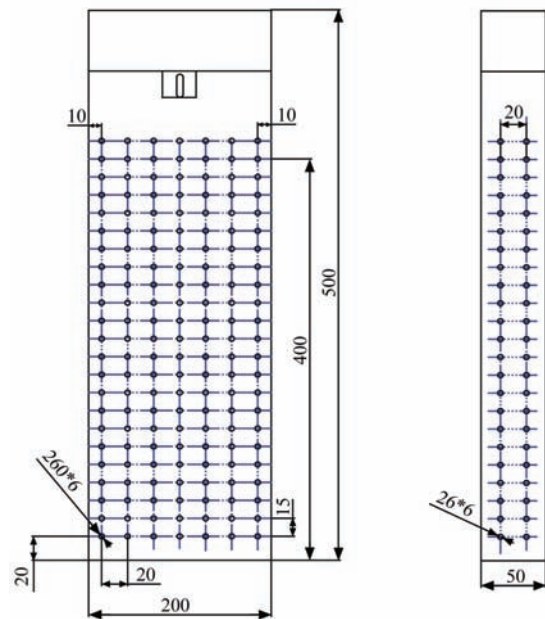


Figure 2 Structure and dimensions of the guiding air box (Unit: mm)

2.3 Experimental treatments

When the pigs were moved to the nursery pens, they were randomly distributed to the six pens, with eight pigs to each pen. The setting of experimental treatments is shown in Table 1. Inductive devices were placed within the pens of Treatments 1, 2, 3 and 5.

Table 1 Settings of experimental groups

Treatment	Inductive materials	Site of materials collection	Time of materials collection	Time to put in inductive box	Notes
1	(0.75±0.03) kg of piglet feces	under slatted floor in the experimental house	the day of introduction	3 h before introduction	
2	(0.75±0.03) kg of piglet urine	under slatted floor in the experimental house	3 h before introduction	1 h before introduction	a
3	-	-	-	-	b
4	(0.75±0.03) kg of piglet feces	under slatted floor in the experimental house"	the day of introduction	-	c
5	(0.75±0.03) kg of piglet feces	under slatted floor in the experimental house"	3 d before introduction	3 h before introduction	d
Control group	-	-	-	-	e

Note: a: The urine was preserved in a plastic bottle, in which towel and cloth pieces were wet by the urine; b: No measures were taken to the induction box after it being placed in the corner of the pen; c: The inductive materials were put on the slatted floor at the corner of pen; d: Feces were preserved for 3 d in air; e: None measures were taken to the pen before the piglet introduction.

Based on the positions of the guiding device, drinker and feeder as shown in Figure 3, the experimental pen is divided into 12×16 rectangles. Each rectangle is 16.6 cm long and 13.8 cm wide. As a result, the floor of the pen was divided into 192 (12×16) blocks in order to analyze the effect of different inductive methods on the excretory behavior of pigs. For the purpose of finding out the area where piglets excrete, each block is represented through a Cartesian coordinate system, where the area in question is expressed as $X-Y$. X ranges from 1 to 12 and Y ranges

from 1 to 16 (Figure 3). The ratio between defecation and urination in the induction area denotes the ratio of excretory behavior that occurred in the induction areas, and provides the total observed counts of excretory behavior. Excretion area denotes the area where excretory behavior occurs, and includes urination area and defecation area. The percentage of the excretion area is the ratio of the number of excreted blocks to the number of the total blocks.

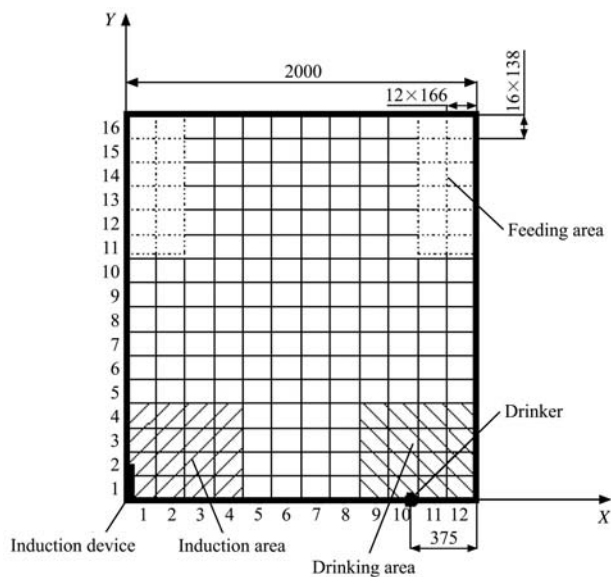


Figure 3 Division of the experimental pen floor (Unit: mm)

2.4 Behavior observations

In this study, behaviors of experimental pigs were documented using digital video recorders (DS-7816H-SNH, Hangzhou HIKVISION Digital Technology Co. Ltd., China) and cameras (WV-CL 350, Panasonic Corporation, Osaka, Japan), which were placed above each nursery pen. The behavior of the pigs was documented for 51 h, from introduction to three days after introduction. The time and position of 1086 excretory behaviors were recorded. The piglets were marked during transfer to the nursery house in order to observe and identify individuals.

2.5 Statistical analysis

For convenience of data analysis, fragments containing excretory behavior were isolated. The clips of excretory behavior were saved in AVI format and analyzed by Observer 8.0 software (Noldus Information Technology, the Netherlands). The statistical analysis was performed using IBM SPSS 15.0 (IBM Corporation, 2006).

3 Results and discussion

3.1 Effect of guiding methods on frequency and duration of excretory behavior

Based on the statistics of excretion time in the induction area, it can be seen in Table 2 that none of excretory behavior in the induction area fell under Treatments 2 and 3. This shows that the smell of the urine in the induction device cannot attract the piglets to

excrete in the induction area, and that an empty induction device has no effect on drawing piglets to the induction area either. Compared to the Control group, Treatments 1, 4 and 5 attracted more piglets to urinate and defecate in the induction area, showing that using feces is the most efficient induction material to attract piglets to excrete in this area.

Table 2 Frequency and duration of defecation and urination behavior in the induction area under different treatments

Experimental treatments	Defecation ratio in the induction area (Mean±SE)		Urination ratio in the induction area (Mean±SE)	
	Times/%	Duration/%	Times/%	Duration/%
1	79.41±7.6 ^a	79.91±6.22 ^a	74.85±2.41 ^a	74.24±4.10 ^a
2	0 ^b	0 ^b	0 ^b	0 ^b
3	0 ^b	0 ^b	0 ^b	0 ^b
4	46.11±17.11 ^{ab}	44.93±25.5 ^{ab}	16.39±2.17 ^b	23.63±4.01 ^b
5	80.21±6.81 ^a	81.78±4.67 ^a	75.35±2.53 ^a	75.28±3.90 ^a
Control group	45.29±12.19 ^{ab}	45.27±11.46 ^{ab}	49.44±15.29 ^{ab}	47.24±21.58 ^{ab}
<i>p</i> -value	0.006	0.001	0.000	0.013

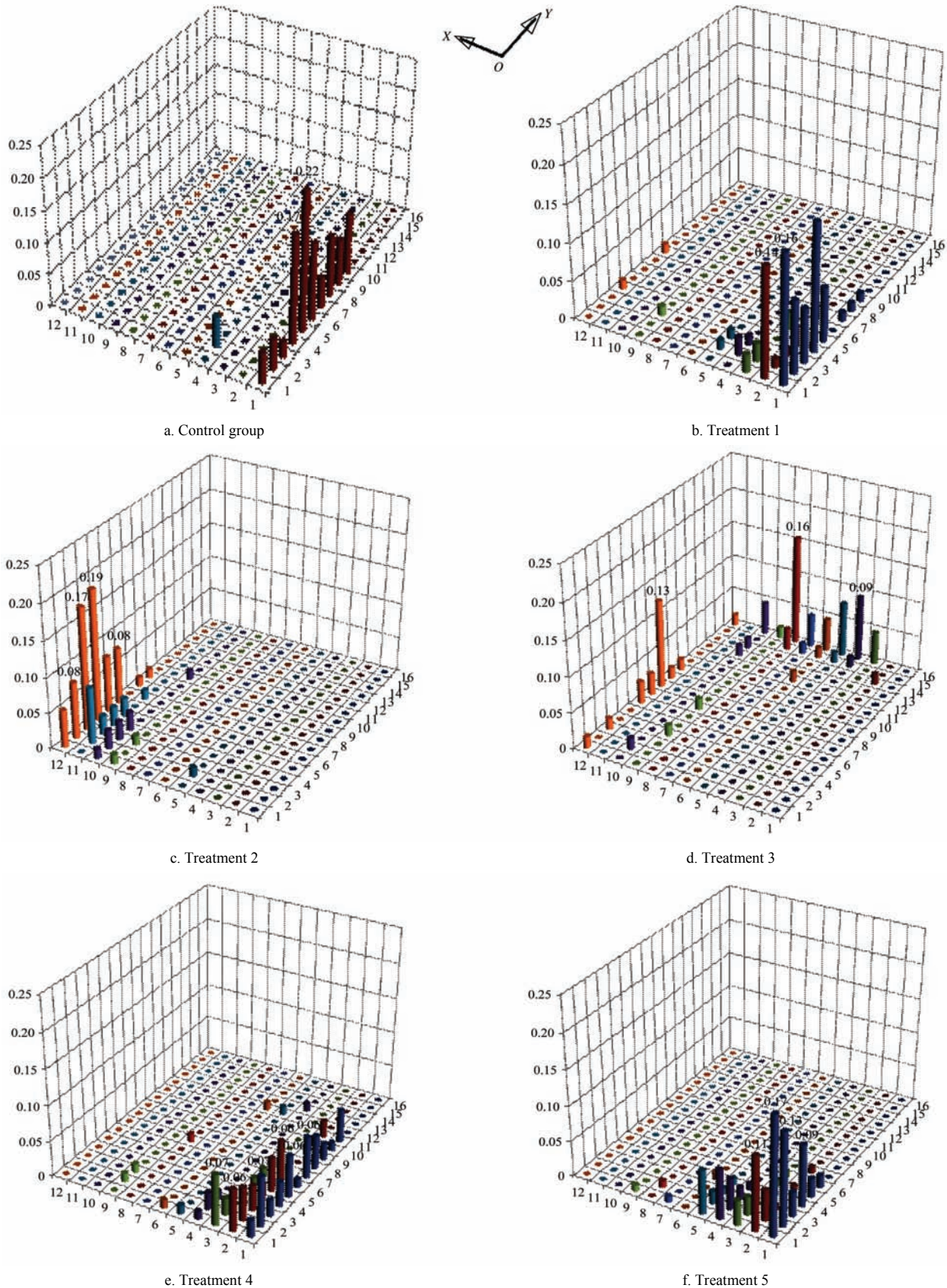
Note: Different letters (a, b, c) in the same row indicate significant difference within treatments ($p < 0.05$).

Results from the analysis showed that different induction patterns had significant ($p < 0.05$) effects on frequency and duration of excretory behavior, including defecation and urination. According to the SPSS multiple comparison, when using feces as the guiding material for Treatments 1, 4 and 5, the frequency of excretory behavior in the induction area was significantly ($p < 0.05$) higher than that of the Control group, indicating that feces was an effective inducing material which could be used in the pen. As for Treatments 1 and 5, using inductive box filled with feces, the times of urination behavior in the induction area were significantly ($p < 0.05$) higher than that for conventional inductive method, which placed pig feces directly into a specific area in the pen like Treatment 4. It is important to note that in Treatment 2, the possible reason for the significantly lower ($p < 0.05$) of frequency and duration of excretion in the induction area is because of the highly volatile substances in the urine. Substances such as ammonia evaporate too quickly, and have the disadvantage of not guiding the pigs to a fixed position of excretion after a certain amount of time. If the inductive feces had been preserved in air for a longer period of time, the effect of inducing excretory behaviors would have been more obvious.

3.2 Effect of inductive methods on the excretory location of the pen floor

The coordinate figure of the 3D columns

perpendicular to the *X-Y* plane (Figure 4) show the proportion of excretions in each block versus the total times in the pen.



Note: Each 3D column perpendicular to the *X-Y* plane represents the proportion of the times of excretory behavior in that block versus the total times of excretion in the pen. Colors of columns on the same *X* line are mutual.

Figure 4 Excretion distribution under different induction methods

Excretory behavior mainly occurred in blocks 1-4 and 1-5 under the control group, the proportions of which are 0.17 and 0.22, respectively. There were 29 excretory points, accounting for 15.10% of the pen area. Most of the excretory blocks (95.12%) were distributed in intervals of 1 on the X line, indicating that piglets tended to excrete in the boundary of two adjacent pens if no induction methods were used. The area of the excretory blocks was 13.02% of the pen area, with concentrations on blocks 1-1, 1-2 and 4-1, the sum of the three accounting for 47.52% of the total times of excretion. This indicates that piglets tended to excrete in the pen corner under Treatment 1. In Treatment 2, most excretory blocks were near to the drinking area. The majority of excretion was distributed in blocks 12-4 and 12-5, the proportions of which were 0.17 and 0.19, respectively. The excretory blocks made up 10.93% of the pen area. There was almost no excretion in the induction area, and piglets tended to excrete in the boundary of the two adjacent pens. The times of excretion in the $X=12$ accounted for 68.00% of the total times as shown in the Figure 4. Treatment 3 was different from those corresponding to the other experimental treatments. Most excretory behaviors occurred in block 9-16, which was close to the trough. The excretory area was 14.58% of the total area. Piglets tended to excrete in the area near the trough, which was away from the induction device. It is important to note that there were almost no excretory behaviors in the induction area. The excretion points in Treatment 4 were mainly distributed in the induction area, in which the times of excretion occurred on $X=1$ line was 41.67% of the total times, indicating that piglets tended to excrete in the boundary of the two adjacent pens near the induction device. Most excretory behaviors occurred in blocks 1-2 and 3-1, the proportions of both being 0.07. The excretory area was 17.71% of the total area. In Treatment 5, the excretion points were mainly distributed in the induction area. There were also several excretory points in the drinking area on occasion. Excretion became more frequent in the area closest to the induction device. The proportions of the times of excretions in blocks 1-1, 1-2 and 2-1 versus total times were 0.15, 0.14

and 0.11, respectively. The excretory area was 15.10% of the total pen area. Piglets tended to excrete in the boundary of two adjacent pens if no induction methods had been used. In addition, the excretion area for the treatment groups was closer to the wall of the pen compared to the control group. As stated by Herman^[23], pigs naturally separate dunging from other behaviors when offered a pen with functional areas, as to minimize the contamination of other areas. Piglets chose to excrete near the trough and drinking area when the device was empty, showing that it was unable to induce piglets to excrete in the designated areas while empty. When there was urine in the device, piglets chose to excrete in the drinking area and away from the induction device. When there were feces in the device, piglets chose to excrete near the device. It is important to note that the longer the inductive feces were preserved in air, the more concentrated the excretory points were. Excretion in boundary area between two pens was also analyzed. Pigs sought corners as dunging areas so that they would not be disturbed while they defecated and/or urinated^[14,22].

4 Conclusions

Induction methods had a significant effect on both frequency and duration of excretion; when using feces as a guiding material, the frequency and duration of excretion in the induction area was significantly higher than that of urine. When compared to the control group, the frequency of excretion was much smaller. This suggested that compared to the conventional method, the induction devices were more efficient in training pigs to excrete in the assigned area.

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[References]

- [1] Aarnink A J A, Schrama J W, Heetkamp M J W, Stefanowska J, Huynh T T T. Temperature and body weight affect fouling of pig pens. *Journal of Animal Science*, 2006; 84(8):

- 2224–2231. doi: 10.2527/jas.2005-521
- [2] Andersen H M L, Pedersen L J. The effect of feed trough position on choice of defecation area in farrowing pens by loose sows. *Applied Animal Behaviour Science*, 2011; 131(1-2): 48–52. doi: 10.1016/j.applanim.2011.01.005
- [3] Baxter M R. Environmental determinants of excretory and lying areas in domestic pigs. *Applied Animal Ethology*, 1982; 9(2): 195. doi: 10.1016/0304-3762(82)90194-8
- [4] Beattie V E, Walker N, Sneddon I A. An investigation of the effect of environmental enrichment and space allowance on the behaviour and production of growing pigs. *Applied Animal Behaviour Science*, 1996; 48(3-4): 151–158. doi: 10.1016/0168-1591(96)01031-3
- [5] Baxter S. Intensive pig production: environmental management and design. Granada Technical Books, 1984.
- [6] Damm B I, Pedersen L J. Eliminative behaviour in preparturient gilts previously kept in pens or stalls. *Acta Agriculturae Scandinavica Section a-Animal Science*, 2000; 50(4): 316–320. doi: 10.1080/090647000750069511
- [7] Guo Y, Lian X, Yan P. Diurnal rhythms, locations and behavioural sequences associated with eliminative behaviours in fattening pigs. *Applied Animal Behaviour Science*, 2015; 168: 18–23. doi: 10.1016/j.applanim.2015.01.011
- [8] Lin Y, Chen G, Shi Z. Optimization of cross section of concrete narrow-gap slatted floor for fattening pig house. *Transactions of the CSAE*, 2013; 29(2): 217–223. (in Chinese with English abstract)
- [9] Guy J H, Rowlinson P, Chadwick J P, Ellis M. Behaviour of two genotypes of growing–finishing pig in three different housing systems. *Applied Animal Behaviour Science*, 2002; 75(3): 193–206. doi: 10.1016/S0168-1591(01)00197-6
- [10] Hacker R, Ogilvie J, Morrison W, Kains F. Factors affecting excretory behavior of pigs. *Journal of Animal Science*, 1994; 72(6): 1455–1460.
- [11] Scott K, Chennells D J, Campbell F M, Hunt B, Armstrong D, Taylor L, et al. The welfare of finishing pigs in two contrasting housing systems: Fully-slatted versus straw-bedded accommodation. *Livestock Science*, 2006; 103(1-2): 104–115. doi: 10.1016/j.livsci.2006.01.008
- [12] Vermeer H M, de Greef K H, Houwers H W J. Space allowance and pen size affect welfare indicators and performance of growing pigs under Comfort Class conditions. *Livestock Science*, 2014; 159: 79–86. doi: 10.1016/j.livsci.2013.10.021
- [13] Wang K, Wei B, Zhu S, Ye Z. Ammonia and odour emitted from deep litter and fully slatted floor systems for growing-finishing pigs. *Biosystems Engineering*, 2011; 109(3): 203–210. doi: 10.1016/j.biosystemseng.2011.04.001
- [14] Wechsler B, Bachmann I. A sequential analysis of eliminative behaviour in domestic pigs. *Applied Animal Behaviour Science*, 1998; 56(1): 29–36. doi: 10.1016/S0168-1591(97)00075-0
- [15] Watson T S. Development of eliminative behaviour in piglets. *Applied Animal Behaviour Science*, 1985; 14(4): 365–377. doi: 10.1016/0168-1591(85)90060-7
- [16] Shi Z, Li B, Chen G, Xi L. Technology and key techniques for clean production in pig loose housing breeding. *Transactions of the CSAE*, 2006; 22(12): 180–184. (in Chinese with English abstract)
- [17] Guo Y, Lian X, Yan P. Diurnal rhythms, locations and behavioural sequences associated with eliminative behaviours in fattening pigs. *Applied Animal Behaviour Science*, 2015; 168: 18–23. doi: 10.1016/j.applanim.2015.01.011
- [18] Collins Jr E R, Kornegay E T, Bonnette E D. The effects of two confinement systems on the performance of nursing sows and their litters. *Applied Animal Behaviour Science*, 1987; 17(1-2): 51–59. doi: 10.1016/0168-1591(87)90007-4
- [19] Li Y, Li B, Shi Z. Effects of size, shape and partition type of pen on excretory behavior of domestic pigs. *Transactions of the CSAE*, 2008; 24(11): 206–211. (in Chinese with English abstract)
- [20] Li Y, Li B, Shi Z, Zhou D. Selection site of pigs excretion and its effects on pollution extent of pen. *Transactions of the CSAE*, 2006; 22(14): 108–111. (in Chinese with English abstract)
- [21] Petherick J C. A note on the space use for excretory behaviour of suckling piglets. *Applied Animal Ethology*, 1983; 9(3-4): 367–371.
- [22] Buchenauer D, Luft C, Grauvogl A. Investigations on the eliminative behaviour of piglets. *Applied Animal Ethology*, 1982; 9(2): 153–164. doi: 10.1016/0304-3762(82)90191-2
- [23] Vermeer H M, Altena H, Vereijken P F G, Bracke M B M. Rooting area and drinker affect dunging behaviour of organic pigs. *Applied Animal Behaviour Science*, 2015; 165: 66–71. doi: 10.1016/j.applanim.2015.01.007