Drinker position influences the cleanness of the lying area of pigs in a welfare-friendly housing facility

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Abstract

Understanding eliminative behaviour in pigs is a priority for designing pig facilities. Pigs prefer to lie in areas separated from where they eliminate (urinate, defecate). Welfare-friendly housing facilities include separate areas for lying (solid floors) and elimination (slatted floors). To prevent pen fouling, ways to reduce the amount of eliminative behaviour on the solid floor area are essential. This study investigated whether the position of the drinkers influences areas preferred for eliminative behaviour in growing-finishing pigs (n = 432; over two batches) assigned to one of three drinker treatments: two drinkers placed in the inner slatted area (IN group; n = 8 pens), two drinkers in the outer slatted area (OUT group; n = 8 pens), or a drinker in each of the inner and outer slatted areas (IN_OUT group; n = 8 pens). We predicted that the OUT group would have fewer elimination events on the inner solid area than the IN group. The number of eliminations in the IN_OUT group was predicted to be a compromise between the IN and OUT group patterns. In addition, we quantified the diurnal variation of lying and eliminative behaviour in different pen areas with respect to temperature, and the effect of pigs lying in eliminatory areas on eliminative behaviour. On the solid floor area, the OUT group urinated 32.5% less frequently and defecated 30.4% less frequently than the IN group. For urination preferences, the IN_OUT group was intermediate between IN and OUT groups on the inner solid floor, but not for defecation. No significant differences in lying preferences were found between drinker groups on the inner solid area. Elimination (urination and defecation) was most prevalent in the afternoon (15:00 and 14:00 h, respectively) and least prevalent during the night (03:00 and 00:02 h, respectively). A one SD increase in temperature (approximately 6°C) was associated with a 42.3% decrease in lying observations on the inner solid area, while the percentage of elimination on the solid floor increased (urination: 75.8%; defecation: 139.5%). Our results showed that the placement of drinkers in the outer area compared to the inner area resulted in less pen fouling (fewer eliminations on the solid floor) and, thus, provided pigs with a cleaner solid area for lying. This study has identified a simple method of increasing the cleanliness of pigs' dedicated lying areas, which has important implications for improving the design of pig housing facilities and maximising pig welfare.

Keywords: Pig; Drinker position; Urination; Defecation; Lying

1. Introduction

Inappropriate eliminative behaviour (urination and defecation) in pigs causes fouling of pen areas used for lying, and can have a negative effect on the environment (Aarnink et al. 1997; Ocepek and Škorjanc, 2016), human and pig health (Urbain et al., 1994), the cleanliness of pens and pigs (Andersen and Pedersen, 2011; Banhazi, 2013), and can impair farm productivity. Thus, understanding eliminative behaviour of pigs is of great importance for designing pig facilities.

Pigs are clean animals, and their natural behaviour is to distinguish between areas for lying and eliminating (Whatson, 1978; Stolba and Wood-Gush, 1989). As pigs spend about eighty percent of their time lying, ensuring comfort when lying is a priority (Ekkel et al., 2003). Introduced to a new pen, pigs choose a suitable lying area (Pouteaux, et al., 1983; Marx and Buchholz, 1989), preferably an area with a solid floor (Aarnink et al., 1997) and a warm surface (Marx and Buchholz, 1989), and without disturbance from other pigs (e.g. in the neighbouring pen; Hacker et al., 1994). Generally, pigs avoid lying in areas with draughts (Geers et al., 1986) or wet or fouled areas (Yicui et al., 2008). Since areas around the drinkers are prone to spillage of water, they are less favourable for lying (Fritschen, 1975; Baxter, 1982), although pigs do prefer to lie in close proximity to feeders (Baxter, 1982). To keep the lying area clean, pigs eliminate as far as possible from it (Stolba and Wood-Gush, 1989; Wechsler and Bachmann, 1998; Olsen et al., 2001; Ekesbo, 2011).

Pigs tend to eliminate in separate (outer) areas (Ocepek and Škorjanc, 2016), especially on slatted floor areas (Aarnink et al., 1997), as well as in cold (Hacker et al., 1994; Banhazi, 2013), bright (Taylor et al., 2006) or wetted areas (Baxter, 1982), and near walls or in the corner of their pens (Baxter, 1982; Petherick, 1983; Bate et al., 1988). Pigs have also been observed to eliminate at the pen boundaries where communication with neighbouring pigs is possible (Hacker et al., 1994), as well as areas around drinkers (as behaviours are performed sequence; Guo et al., 2015), but not so much around feeders (Baxter, 1982).

In modern, commercial, welfare-friendly pig housing systems, lying areas should consist of solid, insulated or heated floors (Aarnink et al., 1997) with closed pen partitions (Saha et al., 2010) and feeders located in the corners (Wiegand et al., 1994). Lying areas should, further, be large enough for pigs to lie comfortably during the whole growing period. By contrast, eliminating areas consist of inner and outer slatted floors (Aarnink et al., 1997; Ocepek and Škorjanc, 2016), including drinkers and open pen partitions (Fritschen, 1975). A key factor in this regard may be the placement of the drinkers. In particular, placing the drinkers over the outer slatted floor areas, as opposed to the inner slatted areas, could reduce eliminative behaviour on the inner solid floor area and, therefore, improve the quality of lying areas. However, this has not yet been studied.

Furthermore, although pigs normally do not alter their behaviour after the functional areas have been defined, there are still some mediating factors. At high ambient temperatures, pigs avoid body contact and seek cooler lying areas (the slatted floor), and begin to eliminate on the solid floor (Fraser, 1985; Huynh et al., 2005). Pig eliminative behaviour is not consistent during the day and is closely related to the diurnal activities of the pigs, with peak eliminative behaviour during the daytime (Aarnink et al., 1996; Guo et al., 2015). Whether activity patterns can mediate pigs' preferred lying and eliminating areas is still not well documented.

The objective of this study was to investigate how the placement of drinkers influences lying and eliminative behaviour in growing-finishing pigs in a welfare-friendly housing system. Three drinker positions were studied: two drinkers on the inner slatted floor area (IN group), two drinkers on the outer slatted floor area (OUT group), and one drinker on each of the inner and outer slatted floor areas (IN_OUT group). We hypothesised that the OUT group would have fewer elimination events on the inner solid floor area than the IN group. Eliminative behaviour of the IN_OUT group was predicted to be a compromise between the IN and OUT group patterns. In addition, we quantified the diurnal variation of lying and eliminative behaviour in different pen areas with respect to temperature, and the effect of pigs lying in eliminatory areas on eliminative behaviour.

2. Material and methods

The research was conducted at the Pig Innovation Centre in Sterksel (Wageningen University & Research) in accordance with guidelines of the Animal Experiments Committee of Wageningen University, the Netherlands. Dutch legislation on animal protection was adhered to.

2.1. Experimental design

We studied the impact of placing two drinkers inner (IN), two drinkers outer (OUT), and one drinker inner/one drinker outer (IN_OUT; Fig. 1) on lying and eliminative (the urination and defecation) preferences of the pigs in different floor areas (inner solid, inner slatted, outer slatted).

2.2. Animals and housing

The pig housing facility (called ‘Star+’; http://www.wur.nl/nl/show/StarPlus-stalconcept-voor-varkens.htm) consisted of one room, with an ambient temperature between 13.1 and 24.7 °C, depending mainly on outer temperature (range -2.8 to 24.8 °C). Natural light was available through special inlets (translucent air inlet valves). The house was naturally ventilated with an air outlet in the ridge of the roof over the entire length of the pig house. The outer area had a roof and was surrounded by windbreak netting (Fig. 2).

Pigs (n = 432) were assigned to one of 24 pens (8 pens per treatment over two batches: October-January, February-June) and housed in groups of 18 (9 entire males + 9 females). The pigs’ mean starting weights (± SE) and length of growing-finishing period, respectively, were 23.0 ± 0.2 kg and 100 days in the first batch, and 24.7 ± 0.2 kg and 94 days in the second batch. Each pen measured 21.9 m^2 in total (0.88 m^2/pig inner and 0.33 m^2/pig outer; Fig. 1). The indoor pen floor (5.3 × 3 m) was 75% concrete solid and the rest was slatted metal (1.0 × 3 m). The concrete, solid floor was heated during the first 6 (round 1) to 8 (round 2) weeks with temperatures of the ingoing water gradually decreasing from 35 to 25 ºC and had a 5 % slope toward the inner slatted floor. The outer slatted floor consisted from a small metal area (0.5 × 3 m) and a large concrete based area (1.5 × 3 m). A V-shaped manure belt was situated underneath the inner and outer slatted floor area (Fig. 2). The indoor area had a closed pen partition and the outdoor area had an open pen partition. Pigs had constant access to enrichment materials in each pen: rope at the front partition of the pen between the feeder, and a ball hanging on a chain halfway between the lying area at the pen partition. Ropes were replaced approximately every week, as they became too short. Straw was provided in all the pens, starting with 0.5 kg and gradually increasing to 1.5 kg per pen per day at the end of the fattening period. In half of the pens (1 pen per treatment), additional silage maize was provided starting with 3.0 kg and gradually increasing to 9.0 kg per pen per day at the end of the fattening period. Straw and silage maize were manually provided twice per day, in the morning at approximately 09:00 and in the afternoon at approximately 15:00 h, in two equal-sized portions (half of the daily amount at each time).

2.3. Feeding regime

Pigs were fed ad libitum with a standard concentrated commercial feed with a composition that fulfilled all the requirements of the pigs. There were two feeders placed per pen, one in each corner of the lying area, with the openings facing the inner slatted floor. The feeders were automatically refilled twice a day (8.00 and 17.00). Pigs had free access to two nipple drinking bowls per pen (DRIK-O-MAT, ACO Funki, Herning, Denmark).

2.4. Data collection

2.4.1. Animal parameters

The pigs were weighed individually before and after being housed in the Star+ facility. Daily gains were calculated using the data on body weights. Total feed intake and feed conversion ratio was measured per pen.

2.4.2. Climate parameters

The temperature and relative humidity were continuously measured with four loggers (Smartlink KNM-THD-RS485-C, Keithly, Gorinchem, the Netherlands) placed in the middle of indoor and outer areas on each side of the house at a height of 1.2 m.

2.4.3. Behavioural parameters

The behaviour of the pigs was continuously video-recorded for a day (00:00 - 23:59 h) every two weeks (Wednesdays; n = 13 days). A total of 12 video cameras (Samsung SCO-2080RN, 811×508P, Samsung Techwin Co., Ltd., Gyeonggi-do, Korea) were mounted on the wall, each covering two inner or two outer pen areas. Pens were divided into three floor areas (Fig. 1): inner solid, inner slatted, outer slatted.

From the videos, the following was recorded:

1. The number of urinations and defecations on each pen area (1 to3) from continuous recordings during one quarter of every hour.
2. The number of pigs lying on each pen area from instantaneous scan sampling every 15 minutes. Pigs lying on the border between two areas were assigned to the area in which the largest part of the pig was lying.

All behavioural analyses were conducted by one trained (through five months of analysing similar pilot study data) observer (MO), using Observer software (The Observer XT 10, Noldus Information Technology, Wageningen, the Netherlands).

2.5. Statistical analysis

All statistical analyses were conducted in R version 3.3.2 (R Core Team, 2016). To assess whether drinker treatment had any effect on feed conversion, initial pig weight or daily gain parameters, separate linear mixed-effect models were run using the nlme package (Pinherio et al., 2016), with the production parameters as dependent variables, and drinker group (IN, OUT, IN_OUT) and study round (1 or 2) as independent variables with a random intercept for each pen.

Missing data were present for certain observation time points of pigs urinating, defecating (18% of each) and lying (8.4%) due to video recording malfunctions and due to the fact that temperature was not recorded for the first day of the study, leaving data from 12 study days for final analysis. The behavioural parameter data had a large number of zero values (lying = 32%, urinating = 71%, defecating = 74%), violating the assumptions of standard distributions, so were analysed using zero-augmented models. The average number of lying observations each hour was a right-skewed continuous variable with a point mass at zero, so was analysed using a hurdle gamma model, which modelled the zero values with a Bernoulli distribution and the non-zero values with a gamma distribution. Urination and defecation events per hour were modelled using separate zero-inflated Poisson models, where zeros could either come from a Bernoulli distribution or a Poisson distribution. In each model, the gamma or Poisson processes were predicted (using log-links) by: observation hour (standardised by subtracting the mean and dividing by the standard deviation), floor area (inner solid, inner slatted, outer slatted), the interaction between observation hour and floor area, drinker group (IN, OUT, IN_OUT), the interaction between floor area and drinker group, temperature (standardised), and the interaction between floor area and temperature. Observation hour was included as a sinusoidal function using $\beta_{cos} cos\left(\frac{2\pi t}{24}\right) + \beta_{sin} sin\left(\frac{2\pi t}{24}\right)$ (e.g. Stolwijk et al., 1999), where β_{cos} and β_{sin} are the regression coefficients and *t* represents the hour of day. Random intercepts were included for different pens and study days to account for repeated measurements. In all models, dependent variables were weighted by the floor area size (inner solid = 15.9 m^2; inner slatted = 3.0 m^2; outer slatted = 6.0 m^2) using an offset variable (i.e. the log of area size). Since lying and eliminative behaviours were collinear with predictors in each model (e.g. temperature), the relationships between lying, urination and defecation were assessed separately using Kendall's rank correlation coefficient (τ), with 95% confidence intervals calculated using the NSM3 package (Schneider et al., 2016).

Hurdle gamma and zero-inflated Poisson models were computed using a Bayesian approach in the programming language Stan, version 2.14 (Stan code supplied in the supplementary material), using Markov chain Monte Carlo (MCMC) in the *Rstan* package (Stan Development Team, 2016). Prior distributions were chosen to be weakly informative (i.e. meaningful on the scale of the data; see the supplementary material). Each model was run with four chains of 5,000 iterations, where the first 2,500 were discarded as warm-up, leaving 10,000 MCMC samples of the posterior distribution used for inference. All models showed good convergence (all effective sample sizes > 3,000 and most > 6,000; Gelman-Rubin statistics < 1.005; trace plots well mixed). Model parameters were summarised by their means and 90% credibility intervals (90% CI), i.e. the 90% most probable parameter values (since 90% intervals are more stable than 95% CIs). Regression coefficients for predictor variables were converted from the log scale to the implied percentage change in behavioural observations using $100\ (e^{\beta}-1)$, where β is the regression coefficient. Comparisons between levels of categorical variables (e.g. drinker groups, floor areas) were made by subtracting their estimates at each step in the MCMC chain, resulting in a distribution of 10,000 credible differences. Null hypotheses were rejected when 90% CIs did not include zero.

3. Results

3.1. Animal parameters

There was no significant effect of treatment on initial body weight ($F_{2, 9} = 0.03$; $P = 0.97$; mean ± SE values for each treatment: IN = 23.84 ± 0.25 kg; OUT = 23.90 ± 0.24 kg; IN_OUT = 23.83 ± 0.24 kg), daily gain ($F_{2, 9} = 0.10$; $P = 0.90$; mean ± SE values for each treatment: IN = 913.73 ± 8.72 g: OUT = 910.70 ± 9.95 g; IN_OUT = 906.11 ± 9.25), and feed conversion ratio ($F_{2, 9} = 0.18$; $P = 0.84$; mean ± SE values for each treatment: IN = 2.53 ± 0.06 kg kg^{-1}: OUT = 2.57 ± 0.05 kg kg^{-1}: IN_OUT = 2.55 ± 0.04 kg kg^{-1}).

3.2. Lying area preferences

On average, 67.0% (90% CI: 57.7, 77.1) of lying observations per m^2 were on the inner solid area, 17.4% (90% CI: 14.9, 20.1) on the inner slatted area, and 15.7% (90% CI: 13.6, 18.0) on the outer slatted area (Fig. 3a; see Table S1 for descriptive statistics). Lying observations were least prevalent around 14:00 h on average across floor areas (0.55 observations per m^2; Fig. 3b) and most prevalent at 02:00 h (0.81 observations per m^2; Fig. 3b). Lying observations were dependent on both floor area and drinker group (Fig. 3a; Table 2). Lying observations on the inner slatted area were 25.6% (90% CI: 17.7, 33.4) more likely for the OUT group than the IN group, and 17.5% (90% CI: 8.5, 26.5) more likely for the IN_OUT group than the IN group. On the outer slatted area, lying observations were 41.3% (90% CI: 25.5, 57.9) more likely for the IN group than the IN_OUT group, and 30.2% (90% CI: 15.1, 45.1) more likely for the OUT than the IN_OUT group. No significant differences were present between drinker groups on the inner solid area (Table S2). There were interactions between temperature and floor areas (Fig. 4a-c; Table S3). A one SD increase in temperature (approximately 6°C) was associated with a 42.3% (90% CI: 36.1, 48.7) decrease in lying observations on the inner solid area (Fig. 4a) but a 89.4% (90% CI: 81.6, 97.2) increase on the outer slatted area (Fig. 3c), but no significant change on the inner slatted area.

3.3. Eliminating area preferences

3.3.1. Urination areas preferences

On average, 24.8% (90% CI: 18.2, 33.0) of urination observations per m^2 were on the inner solid area, 5.3% (90% CI: 3.7, 8.4) on the inner slatted area, and 69.9% (90% CI: 52.8, 92.7) on the outer slatted area (Fig. 5a; see Table S1 for descriptive statistics). Urination events were most prevalent at 15:00 h (0.11 observations per m^2; Fig. 5b) and least prevalent at 03:00 h (0.03 observations per m^2; Fig. 5b). Urination events were dependent on both floor area and drinker group (Fig. 5a; Table S2). Urination events on the inner solid area were 32.5% (90% CI: 5.3, 58.8) more likely for the IN group compared to the OUT group, and 24.0% (90% CI: 8.9, 39.9) more likely for the IN_OUT group compared to the OUT group. The OUT group were 19.0% (90% CI: 1.8, 34.4) more likely to urinate on the outer slatted area than the IN group. No significant differences were present between drinker groups on the inner slatted area. There were also interactions between temperature and floor area (Fig. 6a-c; Table S3). A one SD increase in temperature was associated with a 75.8% (90% CI: 44.9, 108.0) increase in urination events on the inner solid floor and a 106.0% (90% CI: 14.5, 192.7) increase on the inner slatted area, but no significant change on the outer slatted area.

3.3.2. Defecation area preferences

On average, 12.7% (90% CI: 9.8, 16.6) of defecation events per m^2 were on the inner solid area, 1.8% (90% CI: 1.1, 3.4) on the inner slatted area, and 85.4% (90% CI: 68.5, 100.0) on the outer slatted area (Fig. 7a; see Table S1 for descriptive statistics). Defecation events were most prevalent at 14:00 h (0.13 observations per m^2; Fig. 7b) and least prevalent at 00:02 h (0.05 observations per m^2; Fig. 7b). There were significant interactions between drinker group and floor area (Fig. 7a; Table S2). Defecation events on the inner solid area were 30.4% (90% CI: 3.2, 56.6) more likely for the IN group compared to the OUT group, and 33.4% (90% CI: 20.1, 47.3) more likely for the IN_OUT group compared to the OUT group. No significant differences were present between drinker groups on the inner slatted or outer slatted areas. There were also significant interactions between temperature and floor area (Fig. 8a-c; Table S3). A one SD increase in temperature was associated with a 139.5% (90% CI: 90.1, 192.0) increase in defecation events on the inner solid floor and a 168.7% (90% CI: 3.0, 321.7) increase on the inner slatted area, but no significant change on the outer slatted area.

3.4. Correlation between lying, urination and defecation

Lying had a small positive correlation with urination ($\tau = 0.07$; 95% CI: 0.06, 0.09; $P < 0.001$) and a small negative correlation with defecation ($\tau = -0.03$; 95% CI: -0.04, -0.02; $P < 0.001$) per area. Urination and defecation per area shared a moderate positive correlation ($\tau = 0.54$; 95% CI: 0.53, 0.55; $P < 0.001$).

4. Discussion

In support of previous studies, our results showed that pigs urinated and defecated as far away as possible from the areas where they preferred to rest (Stolba and Wood-Gush, 1989; Wechsler and Bachmann, 1998; Ekesbo, 2011; Ocepek and Škorjanc, 2016), in separate areas when possible (inner vs. outer; Olsen et al., 2001; Guo et al., 2015; Ocepek and Škorjanc, 2016). Specifically, our study showed that 70% of lying observations were performed on the inner solid floor, designed for lying, while the vast majority of eliminations (urinations and defecations) were performed on the outer slatted floor, designed for eliminating.

The current results provide the first demonstration that the placement of drinkers in pig pens influences lying and eliminative behaviour. Placing the drinkers in the outer instead of the inner area resulted in more than a 30% decrease in the likelihood of urination on the inner solid floor, and approximately a 20% increase in the likelihood of urination on the outer slatted floor. This is in accordance with findings that pigs prefer to urinate in areas around drinkers, which are prone to spillage (Fritschen, 1975; Baxter, 1982) especially as both behaviours are performed in sequence (Guo et al., 2015). In addition, placing drinkers in the outer area as opposed to the inner area resulted in a 30% decrease in the likelihood of defecation on the inner solid floor. As hypothesised, placing drinkers in both inner and outer slatted areas had an intermediate effect on urination preferences between groups with drinkers either outer or inner, respectively, although this was not clear for defecation. Furthermore, pigs eliminated infrequently on the inner slatted floor area, even when the drinkers were placed in the outer pen areas, suggesting that the inner area could be a dedicated lying/resting area (all solid) apart from a small drainage area used for cleaning. In summary, placing drinkers (preferably both drinkers) in separate outer areas reduced unfavourable fouling on the solid floor and, thus, provided a cleaner solid floor area for lying.

Our results also highlight that designing pens that encourage less fouling of the solid floor could reduce the negative environmental impacts of animal farming, as well as improving pig welfare on farms. Reduced fouling on the solid floor is of importance for several other reasons. Approximately 50% of nitrogen excretion is through urine and approximately 20% through faeces (Jongbloed and Lenis, 1992). As nitrogen from faeces is less susceptible to rapid decomposition than from urine (Canh et al., 1998), urine puddles on the solid floor are the main source of ammonia production from pig facilities, caused by urea degradation by the enzyme urease (Ivanova-Peneva et al., 2008). Thus, lowering urination frequency on the solid floor can reduce both negative effects on the environment (Aarnink et al. 1997; Ocepek and Škorjanc, 2016) and health problems to humans and pigs (Urbain et al., 1994). Similarly, reducing defecation on the solid floor is also favourable. Importantly, more frequent cleaning of the pens may not always be feasible.

One might assume that the placement of drinkers should influence patterns of lying, since differences in the amount of fouling by drinker group may dictate where pigs choose to lie due to the cleanliness of different floor areas. While groups with drinkers placed inner were most likely to lie outer, the previous assumption was not confirmed overall. For example, there was no statistically significant difference in the number of lying observations on the outer slatted area between groups with drinkers placed inner versus outer, and no differences were found between drinker groups for lying behaviour on the inner solid area. However, placing at least one of the drinkers outer versus having both drinkers inner did result in more lying observations on the inner slatted floor, even in groups with drinkers placed inner and outer. Patterns of activity, eliminative and resting behaviour are likely more complexly related than could be studied here, and could be amenable to investigation using more formal modelling approaches such as agent based modelling, which has been used to understand the dynamics of pig behaviour and welfare (e.g. tail biting: Boumans et al., 2016). In general, our results illustrate that the outer area is least desirable for lying and the inner solid area most desirable, irrespective of drinker position.

Although we found that placing drinkers in the outer area is favourable for less fouling of the inner solid floor, there is still variation in eliminative preferences and activity levels (prevalence of lying) in pigs throughout the day. In accordance with Aarnink et al. (1996), who reported that pigs are most active in the afternoon, the present study revealed that eliminative behaviour is also most likely at around 14:00 -15:00 h. These findings also agree with Guo et al. (2015) who found that around 50 % of elimination events occurred between 12:00 h and 18:00 h. In contrast, pigs performed least elimination during the night (minimum around 00:02 – 00:03 h), since they are least active at this moment of the day. Similarly, lying was least likely around 14:00 h and most likely around 02:00 h. This indicates that the activity level of pigs is closely related to the frequency of eliminations. We also found that all three areas were used for eliminating irrespective of daytime. This highlights a small but constant number of pigs (either the same pigs or different individuals) are persistently fouling on the inner solid floor throughout the day.

While eliminative behaviour increased at midday considerably more on the outer slatted than other areas, there was a small increase on the inner solid area as well. Since lying behaviour tended to decrease on the inner solid floor at midday, the solid floor would become less crowded, providing more open space for some pigs to eliminate, despite a clear preference to eliminate on the outer slatted area. Further studies focusing on lowering fouling of the solid pen area, especially during the peaks of diurnal variation are of importance to improve the quality of lying areas and, consequently, pig welfare.

A mediating factor affecting lying and eliminating preferences is temperature. In this study, pigs altered their behaviour with increasing temperature, by lying less on the inner solid floor and more on the outer slatted floor, and performing more eliminations on the inner solid and inner slatted floor. These patterns reflect a normal response to increasing temperature as pigs attempt to cool down. First they change their lying preference from the solid to the slatted as the slatted floor is usually cooler than the solid floor (Huynh et al., 2005) and, second, lying over the slatted floor, they expanded more of their body surface (more lying on their side) to evaporate, rather than still lying on solid floor against other pigs (Aarnink et al., 2006). Therefore, modern, welfare-friendly pig housing systems should prevent high indoor temperatures or give pigs the opportunity to cool themselves to prevent undesirable lying and excreting behaviour.

5. Conclusions

The results of this study demonstrated that the placement of drinkers in the outer area compared to the inner area of growing-finishing pigs' pens resulted in less pen fouling (fewer eliminations on the solid floor) and, thus, provided pigs with a cleaner solid area for lying. Consequently, placing the drinkers outer should also result in lower ammonia emissions, and less time needed for manual cleaning. We further confirmed the diurnal variation of lying and eliminative behaviour, as we found that lying and eliminative behaviours were sensitive to variations in temperature, although these results were dependent on the specific floor area of the pens. In summary, this study has identified a simple method of increasing the cleanliness of pigs' dedicated lying areas, which has important implications for improving the design of pig housing facilities and maximising pig welfare.

Conflict of interest

None.

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