Preference of growing pigs for illuminance

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Abstract

This experiment investigated the preference of juvenile pigs for illuminance, and indirectly photoperiod, at two ages. The animals were equally familiar with all illuminances prior to testing. Four groups, each of four pigs, occupied a four-compartment preference chamber in which a different illuminance was applied to each compartment: minimum (2.4), 4, 40 and 400 lx. Illuminances were rearranged every 2 days to avoid positional bias. The pigs significantly preferred the dimmest illuminance (mean occupancy 7 h 20 min per 24 h, backtransformed data) and spent the least time in the brightest (4 h 49 min per 24 h), with an intermediate and similar length of time spent in the other illuminances (6 h 25 min and 5 h 25 min in 4 and 40 lx, respectively, $F_{3,127} = 8.93, P < 0.001$). The most common behaviours of the pigs when in the darkest compartment were resting and sleeping. The EU directive 2001/88 requires a minimum illuminance of 40 lx for pig production; this illuminance was neither aversive nor strongly preferred by the pigs. Our findings also suggest that pigs should be provided with an appropriate period of rest at an illuminance of 2.4 lx for at least 6 h per day. The only active behaviour affected by illuminance was defecation; the pigs preferred to defecate in the brighter illuminances. Spatial provision of minimal illuminance could potentially improve pig welfare by providing a preferred light environment for resting and also by creating a resting area distinct from dunging areas, thus improving hygiene.

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1. Introduction

Inappropriate lighting has a negative impact on the welfare of many captive animals; photoperiod, illuminance and spectrum all influence the suitability of a light source or regime. An animal’s ocular, physical and neural development, as well as its behaviour can all be influenced by the lighting under which it is raised. In laying hens, quail and turkeys, continuous illuminance leads to buphthalmia; this condition can also be induced in chicks by dim illuminances or continuous darkness (Gelatt, 1998). Continuous illuminance at 2600 lx destroys the outer segments of photoreceptors in albino rats (Birch and Jacobs, 1977), and even continuous dim illuminance induces retinal degeneration (Shear et al., 1973). Miniature pigs kept continuously under 2500 lx for over 1 month developed retinal damage, showed reduced pupillar reflex and lost 20% of their bodyweight, thought to be due to impaired vision or stress (Dureau et al., 1996). Braude et al. (1958), however, found no difference in weight gain or feed conversion rate between pigs kept under light:dark regimes of 24:0, 14:10, 10:14 and 0:24 h.

Although there are no published data for the UK pig industry, photoperiod and illuminance are thought to vary widely within pig housing. In England, the legal requirements for pigs housed under artificial lighting are: (i) that lighting with an intensity of at least 40 lx must be provided for a minimum period of 8 h per day (The Welfare of Farmed Animals (England) Regulations 2003; S.I. 2003 No. 299; following EC regulation: Council Directive 2001/88/EC) and (ii) that animals kept in buildings must have an appropriate period of rest from artificial lighting (The Welfare of Farmed Animals (England) Regulations 2000; S.I. 2000 No. 1870; DEFRA, 2003), though the duration of this period is not specified. Additionally, adequate lighting (whether fixed or portable) must be available to enable the animals to be thoroughly inspected at any time (ibid). One UK farm assurance scheme (Freedom Food, 2003) further requires that housed pigs must have access to an area that provides a minimum illuminance of 50 lx for a continuous period of at least 8 h and a continuous dark period of at least 6 h; either of these temporal minima may be reduced to correspond with seasonal changes in daylength.

The research described in this paper stresses the importance of identifying the needs and preferences of domestic animals rather than imposing conditions based on human perception and preference. The preferences of growing pigs for different illuminances and indirectly for photoperiod were determined experimentally.

2. Materials and methods

2.1. Animals and housing

Two batches of eight gilts (Large White × Landrace × Duroc) were obtained at weaning at 4 weeks of age from an outdoor herd; one batch in January 2002, the other in January 2003. They were then housed in a light-proofed indoor pen 2 m wide × 6 m long, along the length of which a light gradient was provided. Overhead incandescent bulbs (Tesco “Clear” 100 W) provided a constant gradient of illuminance from 400 lx at one end of the pen to the limit of detection of the light meter (<1 lx) at the far end (Testo light
meter, Model 545, Testo Ltd., Alton, UK), measured with the luxmeter head oriented horizontally and directed upwards at the pig’s eye-height. Every 2 days the direction of the light gradient was reversed, and the feeder was also alternated between the middle and two ends of the pen according to a balanced schedule. By moving the light sources, it was possible to avoid the pigs forming associations between illuminances and positions within the pen as well as with factors such as draughts and warm-spots. Two automatic drinkers were fixed to one of the long walls of the pen approximately 2 m from the end walls and from each other. The pen was solid-floored throughout and hygiene was maintained by daily manual removal and replacement of fouled or damp bedding.

2.2. Equipment

At 7 weeks of age, the pigs were marked individually and each batch was divided into two groups of four pigs. Each group was introduced to four adjoining compartments of a light-proofed preference chamber, as shown in Fig. 1. Dividing the chamber in this way enabled two groups to be tested simultaneously at the same age. Each compartment was bedded with wood shavings, and contained a food trough and an automatic drinker against one wall; each trough held sufficient food for four pigs for 2 days, and two chains were hung from the opposite wall to serve as environmental enrichment. All compartments received the same rate of ventilation from the same heated air source, thereby maintaining a comfortable temperature throughout the experiment. Access between compartments was by open doorways. The floor area of each compartment was 2.28 m² not including the food trough and drinker, and ceiling height was 1.2 m (further details of the design and operation of the preference chamber are given by Jones et al. (1996)).

![Fig. 1. Plan view of the preference chamber. L and R denote left and right halves of the chamber, respectively.](image-url)
Each compartment was lit by five incandescent bulbs (Tesco “Clear” 100 W), each fitted under a shade placed directly onto the Perspex compartment lid; the lights were arranged to produce an even distribution of illuminance across the compartment. The compartment lids were otherwise light-proofed using black card and tape. A different illuminance was applied to each compartment; nominally minimum (2.36 ± 1.1 lx), 4, 40 or 400 lx. Illuminance in the three brighter compartments varied by no more than 10% of the mean value away from the acute corners and food-trough wall, verified by taking measurements at 16 grid points at pig eye-height within these compartments (illuminance in the dimmest compartment with maximum light pollution was measured at approximately 200 points). The illuminances were selected to compare the required minimum of 40 lx against both higher and lower illuminances that are feasible in pig housing, as well as providing a dark location. Measurements were taken at the pig’s eye-height using a light meter (Testo light meter, Model 545, Testo Ltd., Alton, UK), oriented horizontally with the detector facing upwards in the centre of the compartment and established with no light spillage from adjacent compartments. Light spillage through the doorways created some regions of higher illuminance immediately adjacent to the doorway; e.g. an illuminance of 5.5 lx was measured 40 cm into the dimmest compartment when adjacent to the brightest compartment, aside from this spillage region all readings in that compartment were below 4 lx.

Different illuminances were established by placing layers of gel filter (Heavy Frost 129, Lee Filters, Hampshire) between the light bulb and the lid, with only minor adjustment from electronic dimmer switches. This kept the spectra as similar as possible which was verified using a spectroradiometer (Model ST2000, Ocean Optics Inc., Dunedin, FL, USA).

The compartment with the minimum illuminance had no overhead lighting, and had an additional layer of black card between the light bulbs and the compartment lid, while the bulbs remained lit in order to maintain a radiant load on the compartment. Infrared LED panels (IR2 Infra Red Illuminator, Anchor Supplies Ltd., Derbyshire, UK) were used to enable video recording in the dimmest compartment. Pigs cannot perceive infrared light (Klopfer, 1966; Wheelhouse and Hacker, 1981; Taylor et al., 2005), so the spectral contribution of the infrared LED panel could not contribute to their preference.

2.3. Experimental procedure

The pigs occupied the chamber for five consecutive periods, each of 2 days. The first period was for acclimatisation, followed by four experimental periods. Each period comprised 44 h of continuous occupation of the chamber with no human intervention, then a period of 4 h in which the pigs were removed from the chamber whilst it was cleaned, the food troughs were emptied and refilled with fresh food, and illuminances were re-set. The arrangement of the illuminances followed a balanced-randomised pattern such that each group received each illuminance in each compartment over the course of each experimental run. The groups alternated between the two halves (left and right) of the complete chamber in order to reduce any positional preference for compartments. All occupation of the chamber was recorded using time lapse video. Scan samples of each pig’s location and behaviour were taken every sixth minute from the video footage throughout the central 24 h (midnight to midnight) of each experimental period (giving a total of 964 observations per group of pigs for each arrangement of illuminances). Six-minute scans
were found to contain >95% of the information recorded in 3 min intervals, whereas 9 min intervals contained less than 90% and were inaccurate for short duration activities. Similar scan sample intervals have also been verified by Guy et al. (2002), Beattie et al. (1998) and Archer et al. (2003) for recording behaviour of similar groupings of young pigs. An ethogram was used to divide the observed activity into four postures and six behaviours, as well as two activities that could only occur as a specific combination of both posture and behaviour (Table 1).

The experiment used four groups of four gilts at 7 weeks of age, repeated with the same groups at 11 weeks, to give four replicates at each age, resulting in a total of 32 days of video footage for analysis across the whole experiment. The younger age gave the pigs 3 weeks to overcome weaning stressors and become accustomed to the environment of the home pen and the other pigs; this period could also enable them to become detached from earlier associations they may have made between light and other environmental factors whilst housed outdoors. The maximum age and size at which eight gilts could comfortably occupy the chamber was 12–13 weeks, thus limiting the upper age to 11 weeks.

2.4. Data analysis

Each pig’s choice of compartment and its behaviour at each sixth-minute scan was recorded as a “count”, i.e. 964 counts were recorded for a group of four pigs over each 24 h observation period. For analysis of the pigs’ preferences for occupation and their behaviours during occupation of the different illuminances, the compartment was treated as the statistical unit; hence all analyses were performed on the combined counts of the four

<p>| Table 1 |
| Ethogram of behavioural categories used in scan samples |</p>
<table>
<thead>
<tr>
<th>General category</th>
<th>Specific category</th>
<th>Definition</th>
</tr>
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<tbody>
<tr>
<td>Posture only</td>
<td>Lying recumbent</td>
<td>Lying on side, legs not tucked under the body</td>
</tr>
<tr>
<td></td>
<td>Lying ventral</td>
<td>Lying on front, legs tucked underneath body, ventral surface in contact with the floor for maximum length</td>
</tr>
<tr>
<td></td>
<td>Sitting</td>
<td>Front legs weight-bearing, rump in contact with floor</td>
</tr>
<tr>
<td></td>
<td>Standing</td>
<td>Weight borne on all legs</td>
</tr>
<tr>
<td>Behaviour</td>
<td>Chain-playing</td>
<td>Using snout or head to manipulate the hanging chains</td>
</tr>
<tr>
<td></td>
<td>Drinking</td>
<td>Head/snout lowered over water bowl</td>
</tr>
<tr>
<td></td>
<td>Eating</td>
<td>Head/snout lowered over food trough</td>
</tr>
<tr>
<td></td>
<td>Interacting</td>
<td>Head/snout moving in contact with another pig</td>
</tr>
<tr>
<td></td>
<td>Investigating</td>
<td>Snout in contact with objects in the chamber other than substrate, chains or other pigs e.g. walls, side of food trough</td>
</tr>
<tr>
<td></td>
<td>Rooting</td>
<td>Manipulation of shavings using snout</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>Behaviours not falling into any above category e.g. scratching, moving between postures</td>
</tr>
<tr>
<td>Behaviour–posture combination</td>
<td>Defecation/urination</td>
<td>Elimination behaviours, only performed in typical squatting posture</td>
</tr>
<tr>
<td></td>
<td>Locomoting</td>
<td>Walking or running with head/snout not in contact with floor or substrate</td>
</tr>
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</table>
pigs in each group. The data were analysed in three ways; counts of occupancy as a whole, two categories of behavioural state, and the 12 separate recorded behavioural categories.

The counts of occupancy were transformed using a logit transformation \[ \log_e(p/(1-p)), \]
where \( p \) is the proportion of total counts, which stabilised the variance, allowing an ANOVA to be performed. Effects of two factors, age (two levels) and group (four levels), as well as their interaction with illuminance were investigated, but none of these were significantly associated with occupancy, so the treatment used in the ANOVA model was illuminance (four levels; 2.4, 4, 40 and 400 lx). The data were blocked using the Genstat notation side/(occasion/compartment). The “occasion” term refers to the period of occupancy per age, i.e. four levels (day 1–2, 3–4, 5–6, 7–8 following acclimatisation). “Compartment” refers to the four physically distinct compartments of the preference chamber, and this is nested within “occasion”. Both these terms were nested within “side” (two levels; left and right) to fully identify the position of the compartments.

For the second analysis, the data were divided into two behavioural states of “inactive” and “active”. “Inactive” behaviours were indicative of resting or sleeping, i.e. the pig was laterally or ventrally recumbent and was not moving its mouth or snout in contact with any other pig, object or substrate within the chamber. It was not possible to differentiate these two behaviours further in the majority of scans. All other behaviours were defined as “active”. The counts for each of the two states were logit transformed separately, i.e. “active” behaviours per compartment were compared against the total counts of active or inactive behaviours performed. These data were then analysed using the same ANOVA model described above.

Counts of the 12 separate behaviours varied considerably, with the 10 active behaviours subdividing the 21.3% of time not occupied by inactive behaviours. An ANOVA of counts of the behaviours according to illuminance could not be informative because of the high variability of counts of the different behaviours, so a separate ANOVA (using the above model) was performed for each separate behaviour. In this way, the concatenating influence of mutually exclusive behaviours on each other was removed and the probability of finding significant differences increased, so the results should be interpreted with discretion.

Bout lengths of behaviour were analysed only on completed bouts of behaviour within the same compartment, i.e. behaviours which potentially extended over either the start or end of the 24 h period of footage were discarded from the analysis. As data were calculated from scans, they are not true bout lengths as gaps of <6 min could occur but were not recorded. Bout lengths were calculated for each individual, and analysis, i.e. comparisons of means and standard deviations, was performed on the combined results for the group.

3. Results

3.1. Overall preference for illuminance

Overall preference for illuminance was calculated from counts of occupation of the different illuminances over 24 h; illuminance significantly affected how long the pigs occupied each compartment (Table 2; ANOVA \( F_{3,127} = 8.93, P < 0.001 \)): in general, as illuminance increased, occupancy decreased. The pigs significantly preferred to occupy the
dimmest compartment (7 h 20 min per 24 h, backtransformed data) over the two highest illuminances (5 h 25 min and 4 h 49 min per 24 h for 40 and 400 lx, respectively), and also showed a significant preference for 4 lx (6 h 25 min) over 400 lx. This preference did not change significantly between 7 and 11 weeks of age (ANOVA; $F_{1,89} = 0.85; P = 0.470$).

3.2. Main influence on preference

The pigs spent 78.7% of their time inactive (18 h 53/38 min per 24 h from backtransformed data) and significantly preferred being inactive in the dimmer illuminances (Table 3; ANOVA $F_{3,186} = 6.00, P < 0.001$); the only non-significant difference was between 40 and 400 lx; in all other comparisons the dimmer illuminance was significantly preferred to the next-highest when inactive. However, the pigs showed no significant association between illuminance and amount of active behaviours shown (backtransformed mean of 1 h 16/3.5 min per 24 h per illuminance, $P > 0.05$).

3.3. Illuminance and behaviours

Being inactive whilst lying either ventrally or recumbently accounted for over 78% of observations, thus the 10 active behaviour categories subdivided the remaining 22% of observations. The results of the separate ANOVAs for each behaviour are shown in Table 4. Only three behaviours were significantly affected by illuminance; more time was spent lying inactive both ventrally and recumbently in dimmer illuminances ($P < 0.001$). The

<table>
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<th>Table 2</th>
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<tr>
<td>Time spent in each illuminance per 24 h observation period</td>
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<td>Illuminance (lx)</td>
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<tr>
<td>Minimum</td>
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<td>4</td>
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<td>40</td>
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<td>400</td>
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Data shown are logit transformed counts of occupancy per day unless otherwise indicated. ANOVA $F_{3,127} = 8.93, P \leq 0.001$.

<table>
<thead>
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<th>Table 3</th>
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<tr>
<td>Distribution of “active” and “inactive” behaviour between illuminances</td>
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<tr>
<td>Illuminance (lx)</td>
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<td>40</td>
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<td>400</td>
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Data shown are logit transformed counts per day unless otherwise indicated. ANOVA $F_{3,186} = 6.00, P < 0.001$. Different proportions ($p$) were used to obtain the logit transformed data in “active” and “inactive” columns (logit transformation ($\log_e(p/(1 − p))$) hence the apparent discrepancy between the values when backtransformed from the different columns.
only active behaviour which changed with illuminance was defecation, which showed the opposite pattern; significantly more defecation was observed in brighter illuminances.

3.4. Duration of bouts

The duration of bouts of occupancy was compared between the different illuminances. Interpretation of bout-length analysis is limited because the inter-observation period of 6 min was sufficient for pigs to briefly visit other compartments or perform other behaviours without this being recorded; the probability of this happening increases with the length of bout recorded. There were non-significant trends ($P < 0.1$) for both the number of bouts of occupancy per day and their average duration to increase with lower illuminances, which combined to give the significant difference in overall time spent in each illuminance. Single-observation bouts (i.e. a behaviour which occurred for $< 12$ min) accounted for 46% of observed bouts, and 36% of total observations were for bouts of between 6 min and 1 h. Bout lengths of more than 8 h were recorded in three of the illuminances; five occasions in minimum lux, two in 4 lx and one in 400 lx, however, these bouts may have been divided by excursions of $<6$ min into other compartments.

3.5. Photoperiod

There was no clear pattern of illuminance use over 24 h, i.e. the pigs showed no migration from dark to light and back. As shown in Table 3, the pigs spent similar times active in all four illuminances provided; because no clear time and illuminance association was shown, the pigs’ preferred routine for 24 h is instead inferred from their pattern of activity.

3.6. Activity pattern per day

To investigate diel patterns of activity, counts of active behaviours were summed for each group of pigs for each hour of observation and compared against time of day, as shown
in Fig. 2. There was a low level of activity throughout the day (average of less than two pigs active for 23 h of the day per group of four), with consistently less activity between 01:00 and 07:00 h compared with the rest of the day. The period from 09:00 to 10:00 h was the only hour in which an average of two or more pigs were active per group of four per scan, however this coincided with high levels of human activity in the building surrounding the preference chamber and so may be an artefact.

4. Discussion and conclusions

The pigs in this experiment preferred to rest and/or sleep in the darkest compartment, despite having equal familiarity with all illuminances whilst in their home pen. Their initial acclimatisation period was intended to overcome any behavioural associations they may have made as piglets by providing a free choice environment for 3 weeks. In pigs, behaviours such as feeding, drinking and suckling are not strongly influenced by rearing conditions (Schouten, 1986), however experiments by Christison et al. (2000), Phillips et al. (1988) and Tanida et al. (1996) indirectly suggest that pigs and piglets may be biased towards the lighting of their home environment. Prior to weaning, the test animals had access to dark, sheltered arks, so it is possible that despite the acclimatisation period, they may have been displaying a learned preference for a dim illuminance which persisted until 12 weeks of age. Furthermore these results cannot indicate whether the pigs chose to enter the dark compartment in order to rest, or whether the minimum illuminance induced rest and/or sleep once encountered.

The overall preference for dim illuminances is the result of trends for both the number of bouts and their duration to increase with lower illuminances. The pigs rested in the dimmest available illuminance for an average of over 6 h per day (6 h 19 min from back-transformed data, 9 h from observed data). This suggests that pigs should have access to a darkened area (~2.4 lx or less) for at least 6 h per day in order to cater for their preferred illuminance; in a piggery, this could be provided either temporally or spatially. This finding supports the Freedom Food standard which requires that pigs should have access to a dark area for a minimum of 6 h (Freedom Food, 2003).

Current EU and DEFRA regulations recommend that pigs receive a minimum of 8 h of light of 40 lx per day (see DEFRA, 2003). An illuminance of 40 lx or above is specified
because it enables better observation by stockpersons and can therefore contribute to better welfare, but its benefits for pigs are not stated. The pigs in this experiment however, rarely remained in any one illuminance for 8 h at a time, with bouts of less than 1 h accounting for 82% of observations. This implies that the pigs either preferred to encounter a range of illuminances throughout each day, or that they were strongly motivated to explore, perhaps foraging or monitoring their environment, and did not choose to restrict themselves to only one compartment. Equally, the pigs may have chosen to distribute themselves according to their proximity to other pigs, with preference changing depending on activity. The pigs showed the same level of active behaviours in all four illuminances; thus the pattern and type of activity expressed by commercial pigs is unlikely to alter by changing the illuminance (up to 400 lx as tested).

The only active behaviour associated significantly with illuminance was defecation, with more defecation in higher illuminances. It is likely that this finding is influenced by the pigs’ preference to defecate away from their resting/sleeping area (Olsen et al., 2001), hence in this experiment as they preferred to rest in the lower illuminances, they consequently moved to the higher illuminances to defecate. An alternate explanation would be that the animals showed a preference to defecate in the brighter illuminances and consequently slept in the darker compartments to avoid these fouled areas. The pigs’ prioritisation of allocating rest and dunging compartments could not be determined from this experiment.

This experiment examined the animals’ preference for illuminance as a first step towards specifying optimal illuminance for welfare. There may also be benefits from exposure to higher illuminances that have not been covered in this experiment such as ocular health and cyclical hormonal responses (Mutton, 1987). One key issue is that motivation was not measured: brief exposures to higher illuminances may be as important to pigs as a longer time spent in dimmer illuminances. A series of motivation studies by Baldwin and Meese (1977) showed that when pigs were able to switch lights on for brief periods (up to 10 and 20 s per interruption), the light was kept on for less than 1% of the time (illuminance 350 lx), indicating that motivation was weak and/or the animals preferred to be doing activities other than controlling light onset. When the animals could switch their pen lights on and off by a single action, the lights were kept on for approximately 72% of the time, with some proportion of each hour unlit but no long periods without light. Baldwin and Meese concluded that pigs showed a strong preference for light over darkness despite light onset itself being only weakly reinforcing to the animals. Several factors may account for the differences between this work and the current study. The pigs used by Baldwin and Meese were older at the start of the trials, and were housed in a lighted farrowing house until 8 weeks of age when they were moved to a dimly illuminated fattening house; as noted above, pigs may show an affinity for their home lighting environment. Baldwin and Meese also used bulbectomised pigs to compare the effect of anosmia on motivation for visual information (and therefore illumination) but there was no significant effect on the amount of light obtained. Furthermore, the animals were isolated in a sound-proof room throughout the experiment and thus may have found illuminance more reinforcing (due to a lack of auditory information and isolation). Animals in our experiment were group-housed throughout and may therefore have felt less isolated, and more comfortable in a dim/dark environment.
Several authors have discussed the limitations of preference experiments; e.g. only a limited number of options can be tested, while domesticated animals may or may not choose wisely in terms of their health and welfare (Bateson, 2004). In some instances, preference experiments may be studying inappropriate questions, e.g. asking animals to choose between conditions which are similarly aversive or preferred, while experimental design needs to take into account prior experience of the animals under the different environments (Grandin et al., 1994).

These results contradict common beliefs about the optimal illuminance for pigs. To humans, a bright environment is more appealing, and darker environments in animal housing are considered indicative of poorer welfare (Spoolder et al., 2003). However, our results concur with those of Hacker et al. (1973), and should not be surprising given that the progenitor species of domestic pigs can be nocturnal and are often forest dwellers (Oliver et al., 1993), suggesting sensory adaptations for dim light. Pigs have a similar peak density of rod cells to humans, e.g. $1.52 \times 10^5$ cells/mm$^2$ (Chandler et al., 1999) and $1.5$–$1.7 \times 10^5$ cells/mm$^2$, respectively (Jonas et al., 1992; Ahnelt, 1998, respectively). Both species have similar eyeball size and retinal area suggesting similar light gathering capability and thus good scotopic vision, but pigs have far fewer cone cells than humans, implying that their vision is poorer than humans’ at high illuminances (Gelatt, 1998). Rod cell density and retinal size alone are, however, only two factors in scotopic vision; the effects of summation, optical aberrations and neural processing will also affect the quality of image perceived.

Light/dark preferences in pigs have been tested previously with conflicting results. Tanida et al. (1996) found that young piglets entered illuminated compartments more readily than dark ones, whereas Christison et al. (2000) found no overall preference for lit over unlit creeps and Andersen et al. (2000) found that young pigs preferred darkness over light. This variation suggests that further research should be done to reveal the extent to which the preferences of juvenile pigs, as in this experiment, may differ from those of both younger and older animals. Effects of breed, sex, spectrum of light source, familiarity with the test environment and space allowance per group or individual could also affect both the direction and strength of preference for illuminance.

Our pigs chose to have access to light for several hours per day and rested under all illuminances provided, although dimmer ones were preferred. One interesting finding is the differentiation between minimum ($\sim 2.4$ lx) and 4 lx illuminances, with a significant preference shown for the dimmest compartment. This could indicate that the pigs were choosing the darkest compartment available and may still prefer complete darkness over the dimmest provided in this experiment, perhaps suggesting a need to define a maximum illuminance for the “dark” period provided under artificial lighting regimes. The dimmest compartment was the only one in which the overhead light sources were not visible, thus it is possible that the pigs perceived the black “ceiling” as more sheltered or protective, although no behaviour was observed suggestive of fear or anxiety. The pigs had not experienced any low ceilings within the home pen to avoid influencing their subsequent preference, however it is possible that they associated a low ceiling with the arks in which they were raised prior to weaning.

The peak in daily activity at 9–10 a.m. coincided with human activity within the building and with the husbandry routine of the pigs whilst in their home pen, thus external
cues are likely to have been a strong influence on the daily pattern of behaviour. Lay et al. (1999) noted that pigs kept in a sensory-restricted environment became more responsive to subtle cues regarding routine. Our findings are in accordance with those of Baldwin and Meese (1977) in that the pigs showed no predictable pattern of light usage and no tendency to prefer darkness during the night.

One way of incorporating these findings into commercial systems, such as group-housing, would be to provide a night period of 6 h of darkness as well as a spatial region of dim illuminance throughout the day, with zones of temporally higher illuminance. This would provide pigs with their preferred light environment for their preferred occupation, which could be assumed to be a less stressful environment than an aversive illuminance. Provision of a distinguishable resting area should further enable the pigs to distance themselves from their dunging area, with consequent benefits for hygiene.

In summary, growing pigs show a strong preference to be inactive whilst in dim light. Further work is needed to determine how this may affect their welfare, how important this resource is to the pigs, and how this finding may be applied in the pig industry.

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References


