Legislative methods for specifying stocking density and consequences for the welfare of finishing pigs

H.A.M. Spoolder\textsuperscript{a,*}, S.A. Edwards\textsuperscript{b,1}, S. Corning\textsuperscript{a,2}

\textsuperscript{a}ADAS Terrington, Terrington St. Clement, King’s Lynn PE34 4PW, UK
\textsuperscript{b}SAC Aberdeen, The Ferguson Building, Craibstone, Bucksburn, Aberdeen AB1 9YA, UK

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Abstract

EU Council Directive 91/630/EEC specifies a banded system of increasing space allowance for finishing pigs, which imposes a degree of inflexibility on housing management. The study presented in this paper investigated whether there are measurable differences in welfare when pigs are kept at the minimum stocking densities described by the bands of the regulations (B), compared to those calculated using an equation (E) relating space allowance and live weight; Area (m\textsuperscript{2}) = 0.030 \times \text{Live weight}\textsuperscript{0.67} (kg). Furthermore, the study compared different floor types [fully slatted (F), solid without straw (N) or solid with straw bedding (S)] at these stocking densities. Eighteen groups of 12 pigs were allocated to this 2 \times 3 factorial experiment, between 29 and 110 kg live weight. Data were collected on a range of welfare parameters. No effects of the space allowance treatments or interactive effects between space allowance and floor type were found. S pigs showed higher levels of manipulative behaviours than N pigs (47 vs. 57\% of time spent active, N vs. S; \(P < 0.01\)), with S pigs manipulating straw approximately 45\% of active time. Observed skin damage was less in N pigs compared to S pigs, but this may have been confounded by their pens being more soiled (59 vs. 77\% clean floor area, N vs. S; \(P < 0.001\)). Post slaughter assessments did not show differences between treatments. It was concluded that straw provision may provide welfare benefits in terms of pen cleanliness and its properties as a foraging substrate. The results indicated that the equation method of specifying minimum space requirements, which offers practical advantages compared with the banded method, provides a similar degree of welfare. This conclusion may help to form the basis for future European welfare legislation. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: Finishers; Housing system; Space allowance; Legislation

1. Introduction

EU Council Directive 91/630/EEC specifies a system of increasing space allowance for finishing pigs based on a series of weight bands (Fig. 1). However, the width of the bands in the Regulations imposes a greater degree of inflexibility on the management of finishing pig accommodation, com-
pared with previous methods of expressing recommendations such as the UK Pig Welfare Codes (MAFF, 1983). By law, a producer with fully slatted flatdeck facilities designed to house second stage weaners from 17 to 35 kg live weight, would have to house pigs at $0.4 \text{ m}^2$ per pig. A pen of $2 \times 4 \text{ m}$ would therefore house 20 animals.

An alternative approach to specifying space allowance is to use an allometric equation which continuously relates total space requirements ($A$) to average pig live weight $W$ by some appropriate factor $a$: $A (\text{m}^2) = a \times W^{0.67} (\text{kg})$ (Petherick, 1983). The equation suggested by Edwards et al. (1988), based on a study with growing-finishing pigs, used a factor of 0.30 (see Fig. 1). Using this equation in the above example, a producer would need to allow $0.32 \text{ m}^2$ per 35 kg pig, and be able to house 24 pigs in the same pen. However, before the use of this equation can be considered, its welfare advantages and disadvantages relative to existing legislation need to be investigated in a worst-case scenario; a hypothetical situation in which a producer would offer the minimum level of space per pig based on either the equation or the banded system.

The type of flooring (solid or slatted) and the presence of bedding may well affect the outcome of any stocking density experiment, since pigs show preferential use of different pen areas for different behaviours (Petherick, 1983), different levels of activity in different circumstances (Petherick, 1983) and different possibilities to maintain pen hygiene at limited space allowance with different floor types. Both the methods of specifying space requirements described above, ignore the quality of the floor and only relate pig weight to “total unobstructed floor area”. Previous recommendations in the 1983 UK Welfare Codes (MAFF, 1983) specified a precise lying area requirement, but did not indicate the amount of extra space needed for other functions.

The present study therefore sought to resolve some of the issues by investigating the effects on pig welfare of providing space at the minimum stocking densities described by the bands of the Regulations, compared with those calculated using the equation by Edwards et al. (1988), in fully slatted accommodation as well as on solid floors with and without straw.

2. Materials and methods

2.1. Animals and treatments

Eighteen groups of 12 pigs (weight 29.1 kg, SD = 4.2 kg) were allocated to a $2 \times 3$ factorial experiment. The first factor was method of defining space allowance, which was increased over time according to the equation (E): $A (\text{m}^2) = 0.030 \times W^{0.67} (\text{kg})$ or to the banded system (B) described in the EU Directive (see Fig. 1). The second factor compared floor type: fully slatted (F), solid sloping floor (1:16 slope) without straw (N) or solid sloping floor with straw bedding (S). Each of the six treatment combinations had three replicate pens, giving a total of 18 pens (216 animals). Groups remained on treatment until an average weight of 110 kg was reached.
Concentrate feed and water were provided ad libitum. Straw was available to animals on the S treatments from a straw hopper, which was topped up daily (approximately 2 kg straw per pig per week). The experiment was conducted between 25 July 1995 and 9 November 1995 at the ADAS Terrington experimental farm, Norfolk, UK. Ambient temperatures ranged from 25°C (beginning of August) to 7.7°C (end of October).

All pigs were weighed every fortnight. E pens were adjusted to a size determined by the anticipated average weight of the pigs a week from the date of weighing, using the equation. B pens were adjusted on the day the predicted average weight of the pigs reached the next band (i.e., at 50 kg or at 85 kg). Floor area of the pen was increased whilst maintaining the same ratio between length and width of the pen, through the use of adjustable pen divisions within each pen. Data were collected on a wide range of potential welfare indicators throughout the experimental period.

### 2.2. Performance

All pigs on the experiment were weighed at least every other week. A record was kept of all food added to the single space hoppers in the sloping bed building (Straw and No-straw treatments) to give total food consumption of the group. In the slatted building (Fully slatted treatment) individual food intakes could be recorded, as all pens were fitted with an electronic feed recording system (Collinsons Ltd.). From these data the Voluntary Food Intake (VFI), Daily Live Weight Gain (DLWG) and Food Conversion Ratio (FCR) could be calculated, either on a group level (S and N treatments) or on an individual level (F treatment). The total number of days from 30 to 110 kg were also recorded.

### 2.3. Behaviour

Behavioural time budgets were estimated using a scan sampling technique (Martin and Bateson, 1994). In each group two male and two female pigs were randomly chosen to serve as “focal animals” throughout the study. They were observed every week for 1 h in the morning and 1 h in the afternoon. During each hour the posture, behaviour and any substrate used were recorded six times for each pig.

To indirectly assess the level of aggression between pigs, the level of skin damage was assessed every fortnight for the four focal animals in each group. The technique used was derived from Burfoot et al. (1995). It scored the total number of skin lesions (bruises, scratches and wounds) per area: front (from snout to middle of back), rear (from middle of back to tail) and tail. The total of these lesions was called the damage score.

### 2.4. Cleanliness

Three times per week (Mondays, Wednesdays and Fridays) an assessment was made of the proportion of pen area which was not soiled in the Sloping Floor building (S and N treatments).

### 2.5. Health records

A health record was kept and included any administration of drugs or other health related treatments, and any reasons for animals which were taken off trial.

### 2.6. Post-slaughter observations

At the abattoir, measurements were taken of the pigs back fat thickness (at the P2 position) and their hot and cold carcass weights. Furthermore, the stomach of each animal was collected and the gross appearance of the pars oesophagus was scored for any development of parakeratosis or ulceration (following the scoring system described by Potkins and Lawrence, 1989), as there are indications that ulceration may be related to stress (e.g., Hessing et al., 1992; Dybkjaer et al., 1994). Adrenal glands were removed and weighed. Hearts were removed and scored for signs of haemorrhaging and other abnormalities.

### 2.7. Statistical analyses

For the performance data, the group was used as the experimental unit, with data being recorded from
all animals. For the behavioural data, the four randomly chosen focal pigs were the experimental units, with a correction for group effects in the analyses of variance. The analyses of variance tests were only used if the data met the assumptions of the analyses. There were no blocking factors. The two treatment factors were stocking density method and pen type. Additional effects which were tested to further analyse the “pen type” factor were: solid vs. slatted floors, and strawed vs. unstrawed pens. An extra factor was created when testing for effects over time (or weight). This was only tested for together with the main effects: stocking density method, pen type and weight category. The definition of the weight categories can be found in Table 1.

Tukey’s HSD was used for pair-wise comparison of the means of the treatments. Transformations were used where appropriate, and in the following order: angular, square root and e-logarithm. Data which could not be normalised, were analysed using non-parametric techniques, such as the Kruskal–Wallis one-way analysis of variance (ANOVA) (Siegel and Castellan, 1988). Incidence of health problems was analysed using the Chi-square test.

### 3. Results

#### 3.1. Performance

No effect of main treatments was found on performance parameters (Table 2). Detailed analysis of pen type factors only revealed a significant effect of stocking density treatment on the hot carcass weight at slaughter (78.4 vs. 81.1 kg for B vs. E, respectively; $P < 0.05$), although related variables (such as sale weight and killing out) were not significantly different. There was a tendency for back fat levels to be lower at slaughter in F pigs compared to N pigs (9.5 vs. 10.2 mm, for F vs. N, respectively; $P < 0.1$).

#### 3.2. Behaviour

A total of 10 250 lines of data were collected with information on the behaviour, substrate used and posture of 72 focal pigs (two males and two females in each of the 18 pens). No effects at all of the stocking density treatment were found on any of the behavioural parameters measured (Table 3). Manipulation of pen components (straw, floor, walls, etc.) was lowest in N pigs; 52, 47 and 57% of active time for F, N and S, respectively ($P < 0.05$), of which in S pigs about 45% of active time was spent manipulating straw. Drinking and feeding behaviour increased over time [feeding: 5.8, 5.3, 7.1, 8.8, 6.2, 8.1 and 9.6% of observations for weight categories 1 to 7, respectively, Kruskal–Wallis one-way ANOVA (for large samples): $KW = 13.3; \ df = 5; \ P < 0.05$] (for weight categories see Table 1). There was an indication that oral behaviours (such as sham chewing and tongue sucking) occurred more frequently in

### Table 1

Description of the seven weight ranges used in the analysis

<table>
<thead>
<tr>
<th>Category</th>
<th>Weight range (kg)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1–40</td>
<td>Lightest half of first band</td>
</tr>
<tr>
<td>2</td>
<td>40–50</td>
<td>Heaviest half of first band</td>
</tr>
<tr>
<td>3</td>
<td>50–62</td>
<td>Lightest third of second band</td>
</tr>
<tr>
<td>4</td>
<td>62–73</td>
<td>Middle third of second band</td>
</tr>
<tr>
<td>5</td>
<td>73–85</td>
<td>Heaviest third of second band</td>
</tr>
<tr>
<td>6</td>
<td>85–100</td>
<td>Lightest half of third band</td>
</tr>
<tr>
<td>7</td>
<td>100</td>
<td>Heaviest half of third band</td>
</tr>
</tbody>
</table>

### Table 2

The effects of treatment on Daily Live Weight Gain, Food Conversion Ratio, weight at slaughter and backfat (at P2)*

<table>
<thead>
<tr>
<th></th>
<th>BF</th>
<th>BN</th>
<th>BS</th>
<th>EF</th>
<th>EN</th>
<th>ES</th>
<th>SED</th>
<th>P-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>DLWG (kg)</td>
<td>0.873</td>
<td>0.914</td>
<td>0.927</td>
<td>0.863</td>
<td>0.902</td>
<td>0.887</td>
<td>0.035</td>
<td>0.226</td>
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<tr>
<td>FCR</td>
<td>2.55</td>
<td>2.51</td>
<td>2.63</td>
<td>2.63</td>
<td>2.53</td>
<td>2.61</td>
<td>0.120</td>
<td>0.622</td>
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<tr>
<td>End weight (kg)</td>
<td>106.9</td>
<td>108.4</td>
<td>109.0</td>
<td>107.3</td>
<td>110.3</td>
<td>110.6</td>
<td>2.572</td>
<td>0.320</td>
</tr>
<tr>
<td>P2 (mm)</td>
<td>9.4</td>
<td>9.9</td>
<td>9.7</td>
<td>10.4</td>
<td>10.3</td>
<td>0.438</td>
<td>0.121</td>
<td>0.242</td>
</tr>
</tbody>
</table>

* Treatments are: B: banded system according to the EU directive; E: equation system; F: fully slatted floor; N: solid floor without straw; S: solid floor with straw.
The effects of treatment on behaviour

<table>
<thead>
<tr>
<th>Means per treatment</th>
<th>SED</th>
<th>P-values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Floor</td>
<td>Stock</td>
</tr>
<tr>
<td>BF</td>
<td>35.49</td>
<td>36.46</td>
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<tr>
<td>BN</td>
<td>40.17</td>
<td>41.39</td>
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<tr>
<td>EN</td>
<td>5.092</td>
<td>0.798</td>
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<tr>
<td>ES</td>
<td>55.6</td>
<td>45.0</td>
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<tr>
<td>EF</td>
<td>49.1</td>
<td>49.1</td>
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<tr>
<td>BN</td>
<td>4.98</td>
<td>0.042</td>
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<tr>
<td>BS</td>
<td>2.95</td>
<td>5.90</td>
</tr>
<tr>
<td>Pen mate</td>
<td>57.1</td>
<td>4.62</td>
</tr>
<tr>
<td>EF</td>
<td>3.49</td>
<td>4.17</td>
</tr>
<tr>
<td>EN</td>
<td>4.71</td>
<td>0.47</td>
</tr>
<tr>
<td>BS</td>
<td>57.3</td>
<td>57.1</td>
</tr>
<tr>
<td>Oral</td>
<td>1.54</td>
<td>0.33</td>
</tr>
</tbody>
</table>

Treatments are: B: banded system according to the EU directive; E: equation system; F: fully slatted floor; N: solid floor without straw; S: solid floor with straw.

Behaviours are: Active: percentage of total observations active; Manipulation: percentage of active time spent chewing, nosing, rooting, biting and licking substrates, pen components and or pen mates; Pen mate: percentage of active time spent manipulating pen mates; Oral: percentage of active time spent tongue sucking and sham chewing.

Data could not be normalised. Analysis was done by Kruskal–Wallis one-way ANOVA (using the Chi-square distribution to test the critical value KW), KW = 7.68; df = 5; P > 0.10.

F than in N and S pens [Kruskal–Wallis one-way ANOVA (for small samples): KW = 5.36; df = 6, 6, 6; 0.1 > P > 0.05], but pen mate manipulation did not differ.

The average skin lesions scores were not different between the stocking density treatments, but a smaller number of lesions were found on pigs of the non-straw treatment, 8.5, 4.8 and 8.3 lesions on average for F, N and S, respectively (P < 0.05). However, this may have been confounded by pen cleanliness (see below).

### 3.3. Cleanliness

Strawed pens had a smaller proportion of the floor area soiled than pens with bare floors, 58.8 vs. 76.5% clean floor area for No-straw and Straw, respectively ($F_{1,8} = 40.7; P < 0.001$). There was no relationship between the proportion of pen area soiled and the stocking density treatment: 68.7 vs. 66.6% clean floor area, for E vs. B, respectively ($F_{1,8} = 0.56; P > 0.05$). Post-hoc comparisons of pen cleanliness during time categories 1, 3 and 6 (when the difference in space allowance between E and B is greatest) did not show an effect of stocking density treatments: 70.8 vs. 68.6% clean floor area, for E vs. B respectively ($F_{1,24} = 0.41; P > 0.05$).

### 3.4. Health records

Health records showed that 11 pigs were removed from the experiment (5.1%), 10 of which came from unstrawed pens (either N or F). Rectal prolapses were the main reason for removal (seven animals, 3.3%). Overall incidences were too low to differentiate between treatments.

#### 3.5. Post-slaughter observations

Slight subepicardial and/or subendocardial haemorrhaging was observed in 24 hearts (13.5% of all animals), and moderate haemorrhaging in eight (4.5%). One heart showed extensive bruising and this pig was suspected of having experienced a heart attack. There were a small number of hearts with mild and/or severe pericarditis (3.4%). The stomach lining of the pars oesophagus was examined for incidences of parakeratosis. A small number of shallow lesions and reddening was found in 30 cases (16.9%). More severe ulceration was observed in three pigs (1.8%). The recovery rate of intact adrenal glands was low (38.7%). About two thirds of the recovered glands came from the left and one third from the right side of the pig’s carcass. The weights averaged 2.85 g. There was no effect of treatments on the incidence of heart abnormalities, parakeratosis of the pars oesophagus of the stomach or the adrenal weight.

### 4. Discussion

Despite studying a wide range of possible welfare indicators, no differences in any of the parameters...
associated with the well-being of pigs were found between the two methods used to increase space allowance during the finishing period. The greatest difference in allowance occurred at the early weights within each band [category 1 (up to 40 kg), 3 (50–62 kg) and 6 (85–100 kg)]. Particularly the heavier of these weight categories (3 and 6) were expected to result in greater differences between stocking density treatments: pigs over approximately 50 kg live weight are more reluctant to lie on top of each other (Boon, 1981), and heavier pigs are at a greater risk of thermal stress than lighter pigs if overcrowded (Nichols et al., 1981). However, no effects were found.

Kornegay and Notter (1984) predicted that performance would have been better at space allowances greater than described by 0.030 × \( m^{0.67} \) (kg): they continued to obtain responses up to a final space allowance equivalent to a factor 0.048. The absence of an effect in the present study might have been the result of the adverse effects of space restriction being mitigated by good pen design and management. Warnier and Zayan (1985) for example indicate that crowding in combination with poorly designed pens may increase cortisol levels. This can not only have an effect on performance (Spencer, 1985), but elevated cortisol levels are also commonly associated with reduced welfare (Broom, 1988).

The results of the present study confirm suggestions that floor type and provision of straw as bedding material may have an effect on welfare parameters. Straw provision resulted in higher levels of manipulation in the Sloping Bed building: straw enriched the environment, stimulating exploratory and foraging behaviour and resulting in significantly altered time budgets: S pigs spent less time manipulating substrates other than straw (such as walls, dung or pen mates), compared with N pigs. Straw also helped to keep the pens and the pigs cleaner, with potential benefits for the general health of the pigs. However, the lower levels of skin lesions in the unbedded treatment appear to indicate that pigs in strawed pens are more involved in aggressive interactions. It is possible that this was caused by the N pigs soiling a significantly greater area of their pen. This resulted in less clean pigs, and it is therefore likely that scratches and wounds were more difficult to count on N pigs, and that skin damage in these pigs was underestimated.

Behavioural vices such as abnormal oral behaviours and manipulation of pen mates have often been associated with barren environments (e.g., Beattie et al., 1993; Spoolder et al., 1995). The present study found an indication that oral behaviours were more prevalent in the slatted treatments, but could not show significant effects. The incidence of pen mate manipulation, which includes behaviours such as tail biting and belly nosing, was not different between pigs on different housing treatments and considerably less (1.7% of all observations) than incidences quoted by others [e.g., Beattie et al. (1993): approximately 6% nosing penmates for finishers in “barren” environments; Pearce and Paterson (1993): approximately 5% “non-aggressive interactions” in their “uncrowded unenriched” pens]. Other housing aspects, feed type or differences in observational techniques could be responsible for this.

No interactive effects were found between the type of flooring and the stocking density treatments. Such effects could have been expected due to thermoregulatory or hygiene reasons: it can be hypothesised that the effects of temporary reductions in space allowance are more pronounced in solid floor systems, because there is a greater need to keep lying and dunging areas separate. Good control of the building environment (average daily temperatures in the ACNV building ranged from 26.3°C during the warm summer days to 14.5°C in late autumn) and the regular cleaning of pens prevented this. However, to be able to prove or disprove any difference in the responses to various stocking densities when comparing pigs housed in fully slatted systems with those in other accommodation, further research will still be required.

5. Conclusion

Applying the method described in EU Council Directive 91/630/EEC does not improve the welfare status of the animals in a measurable way, compared to applying a level of space as described in the equation: \( a \, (m^2) = 0.030 \times m^{0.67} \) (kg).

We suggest therefore that future revisions of the
current legislation on stocking densities in pigs should consider: (i) formulating the minimum space allowance in terms of an equation, or (ii) formulating the minimum space requirements in bands which each cover a smaller weight increment.

This should maintain the welfare of the animals at a level comparable with that under current legislation, but will considerably increase the producer’s flexibility in terms of managing their finishing pig accommodation.

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