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Comparison of the severity of esophagogastric, lung and limb lesions at slaughter in pigs reared under standard and enriched conditions

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Abstract

Two hundred and ten pigs were reared in three groups (according to genotype) under enriched conditions of large open-front sawdust-bedded barns. Eight hundred and twenty pigs were reared under standard conditions of small 15-animal pens in a conventional barn with partially slatted floors and natural ventilation. Production parameters including percentage mortality, feed conversion rate and average daily weight gain were calculated at the end of the fattening period. Stomachs, limbs and lungs were examined at slaughter in order to compare the number and severity of lesions between the enriched environment groups and the standard environment group. There was a significantly greater number of esophagogastric lesions in the standard environment group than in the enriched environment groups. No esophagogastric ulcers were observed in any pigs from the enriched groups, while 17.5% of stomachs from pigs in the standard environment group displayed this condition. There were no significant differences in the number of lung lesions associated with enzootic pneumonia between pigs from the standard and enriched environment groups. The limbs of animals reared in the standard environment had more lesions, especially in floor-contact areas, than those reared in the enriched environment (23.84% versus 1.08%). The production parameters measured were improved in the pigs from the enriched environment. These results suggest that the welfare of fattening pigs may be improved by the provision of enrichment in their housing environment. Evaluation of esophagogastric ulceration could be a useful indicator of welfare in pigs.

Keywords: *animal welfare, esophagogastric ulcer, fattening, limb lesions, lung lesions, pig*

Introduction

During the past few years, the welfare of pigs (*Sus scrofa scrofa*) has become one of the most important issues concerning consumers, governments, veterinarians, animal technicians and pig producers. At present, legislation regarding welfare has been implemented in some member countries of the European Union; the remainder must comply by 2013. Generally, the 'Five Freedoms' proposed by the UK Farm Animal Welfare Council in 1992 (FAWC 1993) have been accepted as guidelines for improving the welfare of all species of farm animal: they must be free from (i) hunger and thirst, (ii) thermal and physical discomfort, (iii) pain, injury and disease, (iv) fear and stress, and (v) they must be free to express normal behaviour.

There has been much debate regarding the tools used to measure welfare. The perception of producers and animal technicians is that good performance indicates an adequate level of welfare. In some cases, however, animals express their response to an unsatisfactory environment through behavioural modification rather than through changes in physiology or production (Edwards 2000). Another way to assess welfare is by assessing the animals' state of health.

The development of porcine esophagogastric ulcers is influenced by factors related to all of the Five Freedoms. Their development is influenced by the availability of feeders and drinkers (Straw *et al* 1992): Melnichouk *et al* (1999) demonstrated that animals subjected to food restriction quickly develop esophagogastric lesions. Henry (1996) and Taylor (1999) showed that discomfort, pain and injury can influence the occurrence of extragastric pathologies, whilst the development of gastric ulcers has also been classically considered to be strongly influenced by stress (related to the fourth and fifth Freedoms) in a number of species including humans (Saggioro & Chiozzini 1994). Similarly, limb lesions related to the type of floor, and lung lesions related to swine enzootic pneumonia (SEP), are linked to the second and third Freedoms.

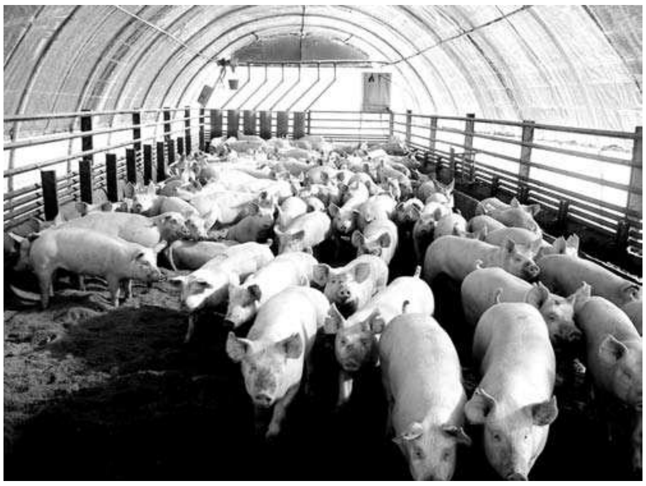
The aim of this study was to compare, at slaughter, esophagogastric, lung and limbs lesions of fattening pigs reared under two different conditions: open-front sawdust-bedded buildings as an improved welfare model (enriched environment) versus conventional fattening buildings (standard environment).

Materials and methods

Animals and facilities

The enriched environment group comprised three groups of seventy nine-week-old pigs, brought directly from their origin farm to the fattening unit, which was situated in a high porcine density area. The groups were established

Figure 1



Inner view of one of the large barns (enriched environment). The barns measured 5 × 20 m, providing 1.42 m² per animal, and were bedded with an 80 cm thick sawdust layer.

Figure 2

View of a conventional barn (standard environment). The pens measured 3 × 3.5 m and contained 15 animals each, providing 0.7 m² per animal. The floor was partially slatted.

along genetic lines (A: male [Pi × LW] × female [Pi × LW × LR]; B: male [Pi × Du] × female [LR × LW]; C: male [Pi × (Pi × LW)] × female [LP × LW]). Each group comprised equal numbers of males and females. The groups were housed in open-front barns measuring 5 × 20 m (1.42 m² per animal), containing a sawdust layer 80 cm deep (Figure 1). Feed and water were supplied *ad libitum* by tubular PVC feeders (Tecnologías Aplicadas Efeeme SL, Spain) and nipple drinkers. The average initial weights were 21, 15 and 15 kg for each group, respectively.

The standard environment group contained 820 pigs, with proportional numbers from the three genetic lines used in the enriched groups, weaned at a common nursery from origin farms. These pigs were reared in a conventional building on a farm in a low porcine density area. The building had a partially slatted floor (5 cm of solid and 2 cm of recess) and natural ventilation (ie no mechanical systems for air exchange). Pens measured 3 × 3.5 m and each housed 15 animals, grouped by sex, providing 0.7 m² per animal (Figure 2). Feed was supplied by a conventional concrete feeder with two places for eating simultaneously, and water was supplied by nipple drinkers placed beside the feeder. All buildings in this farm were managed under an all-in all-out policy, with cleaning and disinfection between batches and at least one week of sanitary withdrawal. The average initial weight of this group was 20 kg.

Animals in both groups were obtained from porcine reproductive and respiratory syndrome (PRRS), atrophic rhinitis (AR), *Actinobacillus pleuropneumoniae* and *Mycoplasma hyopneumoniae* carrier farms. During the fattening period they were vaccinated against Aujeszky's disease with a gE-deleted attenuated live vaccine (Auskipra GN, Hipra, Spain). The trial was conducted during spring (March, April and May) with mean temperatures around 15–21°C and rainfall of 2.5–10 l m^{-2}.

Feed

Pigs from standard and enriched environments were fed with pelleted feed using two different diets depending on the age of the animals: a growing feed (20–50 kg live weight) and a finishing feed (50–100 kg live weight). The digestible energy values (kcal kg^{-1}) of the growing and finishing diets, respectively, were 3.544 and 3.500, and the metabolisable energy values, respectively, were 3.260 and 3.225.

Production parameters

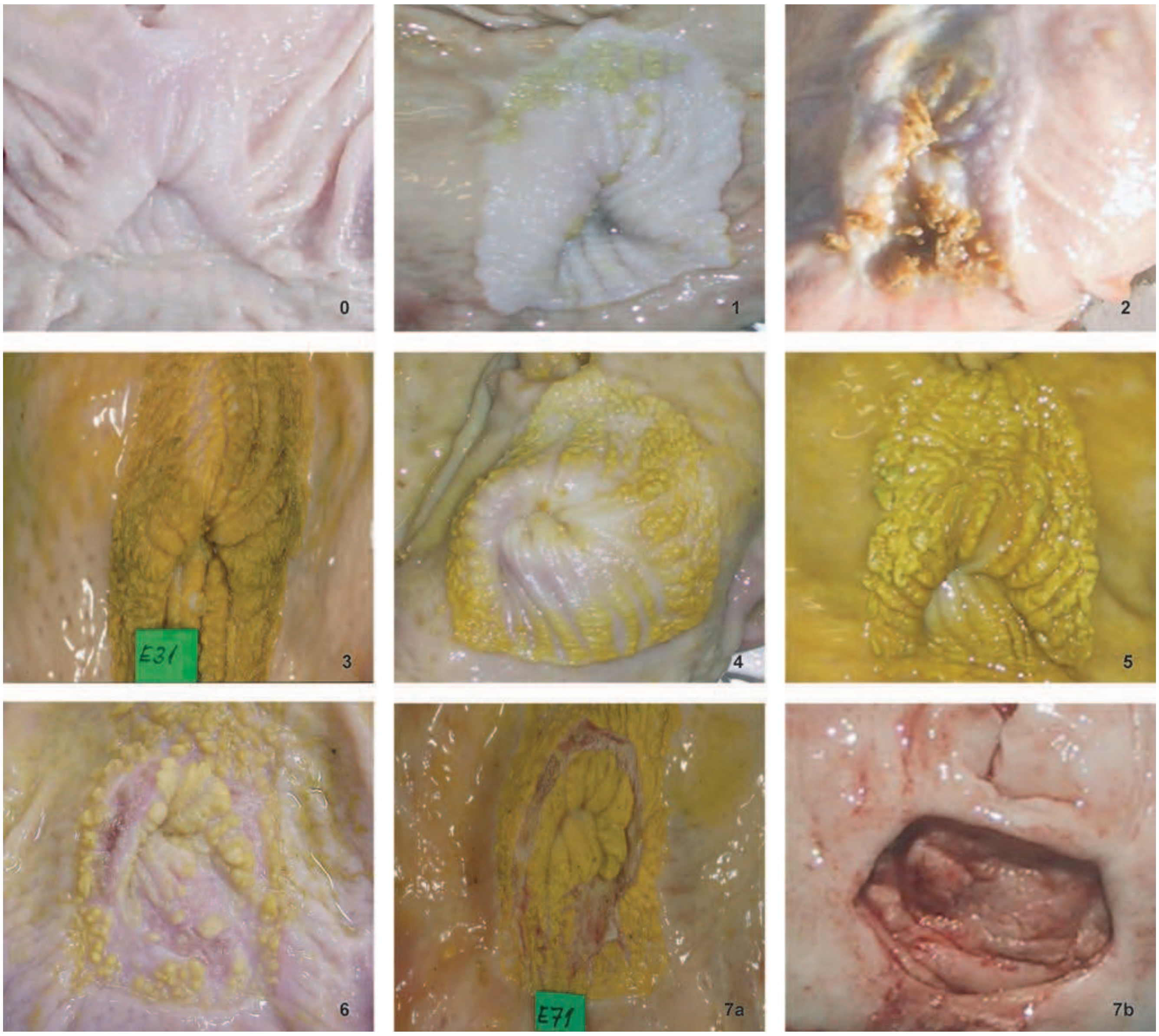
Percentage mortality was calculated for each group, in addition to the feed conversion rate ([FCR]: kg of feed/kg of meat made during fattening) and the average daily weight gain (ADG) (kg of meat made during fattening/average days of fattening).

Lesions

All animals that died during fattening were necropsied in order to establish the cause of death. A diagnosis of 'ulcer' was determined in all carcasses showing an intragastric clot and in carcasses showing no lesions other than gastric lesions.

Following the fattening period, the pigs were slaughtered. At slaughter, any lesions present in the pigs were recorded. Food was withdrawn 12 h prior to transportation to the abattoir, and upon arrival pigs were rested for at least 4 h prior to slaughter. Enriched and standard farms were 10 km and 30 km away from the abattoir, respectively. Animals were slaughtered by neck cutting after stunning in a CO_2 chamber, and were bled using a Rotastick® vacuum pump (Anitec, Sweden). Average weights at slaughter were 94.36 kg, 94.35 kg and 89.02 kg for the enriched environment groups and 102.79 kg for the standard environment group. Stomachs were removed from the carcasses 20 min after slaughter and moved to the sanitary facilities in the abattoir where they were opened and washed in water. The stomachs were observed immediately after their collection

Figure 3



Examples of each stomach lesional classification. 0, normal nonglandular mucosa; 1, mild parakeratosis; 2, moderate parakeratosis; 3, severe parakeratosis; 4, mild erosion; 5, moderate erosion; 6, severe erosion; 7a, acute ulcer; 7b, chronic ulcer.

because after death the epithelium of the nonglandular gastric mucosa suffers desquamation very quickly (O'Brien 1969) and may therefore show erosions or ulcers as a result. The macroscopic classification proposed by Straw *et al* (1992) was used for lesion scoring, giving a numeric value to each lesional stage as described in Table 1 and illustrated in Figure 3.

Lung and limb lesional stages were scored as the carcasses passed through the slaughter chain. To score the lung lesions associated with SEP, which are characterised by well-defined, greyish-red depressed areas of consolidation (Kobisch *et al* 1993), the point system described by Pallarés *et al* (2000) was used. This scale ranges from 0 (total absence of lesions) to 11 (lungs totally affected), based on the lung surface affected with the following distribution: right apical lobe, maximum 1 point; left apical lobe, maximum 1 point; right cardiac lobe, maximum 1 point; left cardiac lobe, maximum 1 point; right diaphragmatic lobe, maximum 3 points; left diaphragmatic lobe, maximum 3 points; intermediate lobe, maximum 1 point (Figure 4).

The presence or absence of bursitis (identified as a movable well-demarcated mass), skin erosions, ulceration, and exostosis (identified as a non-movable firm and hardened soft tissue linked to the bone) was recorded in the limbs. The hock, tarsus, plantar face and foot of hindlimbs, and the elbows, carpus, palmar face, and foot of forelimbs were all assessed for lesions.

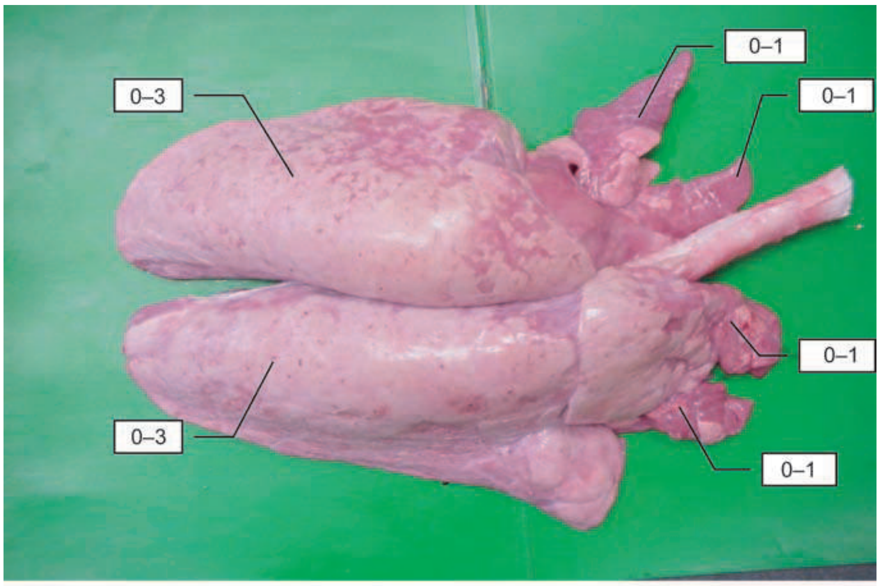
Statistical analysis

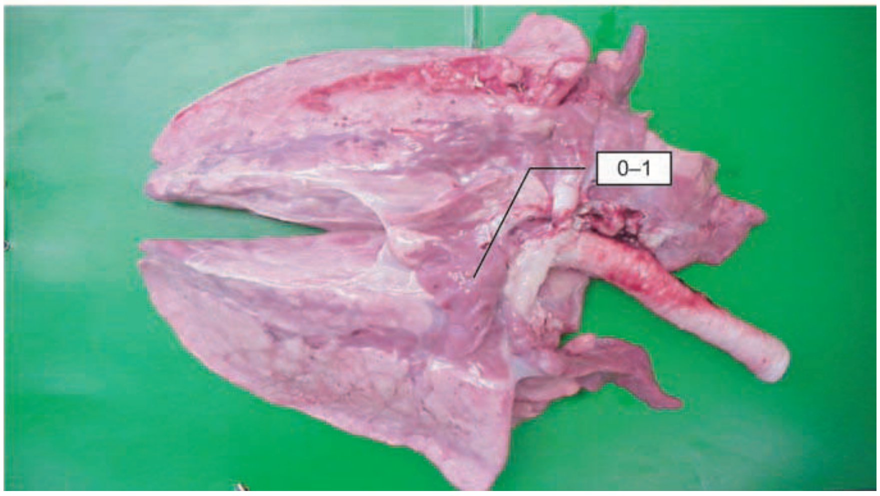
Lesion data obtained from stomachs and lungs were analysed using a General Linear Model (Systat® v 5.0 software for Windows®). The mean lesion score was

Table 1 Criteria for esophagogastric lesion scoring at slaughter, based on macroscopic lesion description from Straw *et al* (1992).

Lesional stage	Lesion score	Description
Normal	0	Nonglandular mucosa soft, white, smooth and glistening.
Keratinisation		
mild	1	Light yellow discolouration and keratinisation of the superficial first or second cell layers, with a mild epithelial thickening involving <25% of nonglandular gastric mucosa surface.
moderate	2	Dark yellow discolouration and keratinisation of the superficial epithelial layers, and development of wrinkling of the surface. Changes involving 25–50% of nonglandular mucosa surface.
severe	3	Dark yellow discolouration and keratinisation of the entire epithelial layer with a 2-fold increase in epithelial thickness, and rugged formation of the surface. Changes involving >50% of the surface area.
Erosion		
mild	4	Filament-like erosions <2 cm in length with occasional areas of pin-point haemorrhage.
moderate	5	Linear erosions with areas of haemorrhage along the eroded area.
severe	6	Broad (>3 mm) erosions with haemorrhage along the entire length of the affected area.
Ulcer	7	Complete epithelial loss with exposure of the underlying muscularis. Also healed ulcers.

Figure 4





Dorsal and ventral lungs, showing the maximum scores for each lobe, depending on the affected surface. In this case the lungs would have a score of 7 (right apical lobe, 1 point; left apical lobe, 1 point; right cardiac lobe, 1 point; left cardiac lobe, 1 point; right diaphragmatic lobe, 1 point; left diaphragmatic lobe, 1 point; intermediate lobe, 1 point). The lesions are well-defined, depressed, hardened, greyish-red areas.

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Table 2 Production parameters from each group.

	Genotype	n	Percentage mortality	ADG	FCR
Enriched environment	A	70	0	853	2.55
	B	70	1.42	818	2.45
	C	70	0	771	2.34
Standard environment	A+B+C	820	2.44	739	2.50

ADG = Average daily gain in weight (g per day)
FCR = Feed conversion rate (kg of feed/kg of meat)

Table 3 Percentage of observed pigs from each group showing different severities of esophagogastric lesions.

	Enriched environment group			Standard environment group
Lesional score	Genotype A (n = 68)	Genotype B (n = 69)	Genotype C (n = 66)	(n = 200)
0	1.5	10.1	3	3.5
1	0	0	13.6	2.5
2	1.5	0	3	6
3	94.1	76.8	51.5	41.5
4	2.9	10.1	28.9	9
5	0	3	0	3.5
6	0	0	0	16.5
7	0	0	0	17.5
Total	100	100	100	100
Mean lesional score ± standard deviation	3.06 ± 0.21[a]	2.86 ± 1.05[a]	2.92 ± 1.04[a]	4.14 ± 1.93[b]

Different superscripts in the same row indicate statistically significant differences ($P < 0.001$).

expressed as the least squared mean, and a Tukey test was used to assess the difference between groups in mean lung lesion score. The phenotypic standard deviation (σ_p) for each production parameter was also calculated using the slaughter company's historic records of more than 500 slaughtered batches of pigs.

Results

Production parameters

The results for the production parameters are shown in Table 2. Mortality during fattening was higher in the standard environment group than in the enriched environment groups; total mortality for the entire enriched environment group was only 0.47% (1/210). The cause of death of the only animal in this group (from genotype B) to die during fattening was diagnosed as extragastric; there were no losses attributable to gastric ulcers in the enriched environment groups. In comparison, mortality in the standard environment group was 2.44% (20/820), of which 40% (8/20) was attributable to gastric ulcers. In all enriched groups, ADG was higher than in the standard group, although there were differences between genotypes. Although there appear to be differences between the enriched and standard environment groups, the reduced number of data did not allow us to calculate the significance of these differences, but we can assess the trend of the differences using the phenotypic standard deviations (σ_p ADG = 70 g day^{-1} and σ_p FCR = 0.041 kg feed kg^{-1} meat, respectively) to compare data. In any case, all production data were better in the enriched environment groups than in the standard environment group.

Lesion study

The frequencies of gastric lesions and the mean gastric lesional scores are shown in Table 3. There was no difference in mean lesional scores between genotypes in the enriched environment, but the difference between the standard environment group and the three enriched environment groups is statistically significant ($P < 0.001$). In fact, no ulcerated stomachs were found in any of the enriched environment groups, whereas in the standard environment group 17.5% of the stomachs contained these lesions. The most prevalent lesion in all groups was parakeratosis of the entire nonglandular mucosa surface.

With regard to lung lesional scores (Table 4), in the enriched environment groups 60.9%, 42.03% and 24.24% of lungs showed lesions (genotypes A, B and C, respectively), and in the standard environment group 20.5% of lungs showed lesions. The difference between the mean lesional scores for genotypes A and B was not significant, but both significantly differed from the score of genotype C ($P < 0.001$ and $P = 0.048$, respectively) and from the score of the standard environment group ($P < 0.001$ and $P = 0.006$, respectively). There was no significant difference between the lesional scores from genotype C and the standard environment group.

Animals from the enriched environment had fewer limb lesions (Table 5) than those from the standard environment

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Table 4 Lung lesional scores for animals in the different groups.

Lesional score	Enriched environment group			Standard environment group
	Genotype A (n = 68)	Genotype B (n = 69)	Genotype C (n = 66)	(n = 200)
0	39.70	57.97	75.75	79.5
1	33.82	20.29	21.21	11
2	11.23	15.94	0	7.5
3	8.82	2.90	1.51	0.5
4	4.41	2.90	0	0
5	0	0	1.51	1
6	0	0	0	0.5
7	0	0	0	0
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0
11	0	0	0	0
% total lesioned	60.29	42.03	24.24	20.5
Mean lesional score ± standard error	1.044 ± 0.108[a]	0.729 ± 0.107[a]	0.333 ± 0.110[b]	0.322 ± 0.063[b]

Different superscripts in the same row indicate statistically significant differences.

Table 5 Limb lesional scores for animals in the different groups.

Standard environment									
	Hindlimb (n = 400)				**Forelimb (n = 400)**				
Lesion (%)	Hock	Tarsus	Plantar face	Foot	Elbow	Carpus	Palmar face	Foot	Total (%)
Absent	23.5	86	50.5	99.5	98.5	5.165	100	100	76.18
Skin erosion	0	13	0	0	0	36	0	0	6.125
Bursitis	76.5	0.5	0	0.5	1.5	8	0	0	10.87
Skin ulceration	0	0.5	0	0	0	4.5	0	0	0.62
Exostosis	0	0	49.5	0	0	0	0	0	6.19
Total lesioned (%)	76.5	14	49.5	0.5	1.5	48.5	0	0	
Enriched environment									
	Hindlimb (n = 406)				**Forelimb (n = 406)**				
Lesion (%)	Hock	Tarsus	Plantar face	Foot	Elbow	Carpus	Palmar face	Foot	Total (%)
Absent	88.17	100	100	99.51	100	97.04	100	99.51	98.02
Skin erosion	0.74	0	0	0	0	2.71	0	0.49	0.48
Bursitis	11.58	0	0	0.49	0	0.25	0	0	1.54
Skin ulceration	0	0	0	0	0	0	0	0	0
Exostosis	0	0	0	0	0	0	0	0	0
Total lesioned (%)	12.31	0	0	0.49	0	3.20	0	0.49	

(1.08% and 23.84% of observation points displayed lesions, respectively). In the standard environment group, the most frequent lesions were bursitis of the hock (76.5%), exostosis of the plantar face (49.5%), skin erosions of the tarsus (13%) and skin erosions of the carpus (36%). The location of these lesions is typical of floor-contacted areas. The prevalence of limb lesions in sawdust-bedded barns (enriched environment groups) was insignificant.

Discussion

With regard to the production parameters obtained, it seems clear that the system which theoretically provides the higher level of welfare did indeed produce better results, as indicated by the phenotypic standard deviations for the population. So, although poor welfare is more often associated with behavioural alterations than with reduced production levels (Edwards 2000), the higher-welfare system used here resulted in higher production levels, supporting the suitability of production records as guidelines for assessing welfare. The major differences between the two systems were in total mortality rate and mortality rate resulting from esophagogastric ulcers.

In the past 50 years there has been a shift in the management of fattening pigs, from extensive outdoor systems to intensive industrial systems, as farmers seek to improve production performance. This intensification has resulted in the housing of pigs in barns, which imposes territorial restrictions, alters social interactions, and affects the nutrition of the animals. These changes have resulted in the onset of chronic stress, producing new pathologies or the increased prevalence of others such as esophagogastric ulcers (Lagreca *et al* 1998a).

Rearing pigs in large sawdust-bedded barns has certain advantages compared with rearing in conventional buildings, and may decrease or abolish a number of stressors. For example, sawdust-bedded barns provide increased available space, more opportunities for movement, an increase in comfort and, theoretically, an improvement of air quality through a decrease in the concentration of injurious gases. However, there are also certain disadvantages associated with these systems, such as larger group sizes and a possible increase in the volume of suspended dust particles.

Space availability for pigs has been suggested to be an underlying factor in rates of gastric ulceration, although not a determinant factor (Reese *et al* 1966; Pickett *et al* 1969). In a comparison of space availability of 1.50 m^2 per animal versus 0.54 m^2, using the same facilities for both groups, no differences were recorded in lesional stage of the gastric nonglandular mucosa (Eissemann & Argenzio 1999).

Another factor to take into account is group size. In the large sawdust-bedded barns, the large number of animals meant that well-defined hierarchic groups were not able to form. This can result in more agonistic interactions (Lagreca *et al* 1998c), which may cause a higher level of stress and an increase in the prevalence and severity of esophagogastric lesions. These problems may be particularly likely to occur in standard housing conditions where space allowance is only 0.7 m^2 per animal. Increased space availability (1.42 m^2 per animal in this case), although linked to an increase in group size, allows agonistic interactions to be avoided and may actually result in a decrease in stress.

The use of sawdust as bedding material has many advantages: it provides comfort, which the pigs reared in conventional barns lack, it absorbs ejections and prevents a build-up of moisture, and it provides a soft and uniform walking surface, which helps to keep the animals' limbs healthy. Indeed, in the present study, pigs reared in barns with concrete-slatted floors showed a higher prevalence of limb lesions, especially in the areas contacting the floor during rest or those being used to stand up (hocks, plantar face and carpus). The floor surface of the conventional building has solid parts where faeces and urine accumulate, which, in addition to being unsanitary, increases the risk of animals slipping and falling. The use of sawdust or straw as bedding material not only provides thermal and physical comfort, but also supplies manipulable material, providing a substrate for foraging, exploration and nesting (Edwards 2000). Foraging can relieve hunger or help to regulate *ad libitum* food consumption (Lagreca *et al* 1998b), as well as helping to avoid prolonged fasting periods in those animals awaiting access to the feeder. Previous experiments using sawdust as a bedding material did not reveal any differences in the prevalence or severity of esophagogastric lesions (Pocock *et al* 1969). Only when it was used as an addition to feedstuff was a difference observed. This was probably because the consumption of sawdust when it was used as bedding was irregular, whereas when it was added to the feed the resulting fibre consumption was continuous. It has been suggested that any disease that produces a prolonged period of anorexia can increase the prevalence or severity of esophagogastric lesions (Straw *et al* 1992).

Large single barns, being open buildings, provide a major improvement in air quality, which in turn is likely to bring about improvements in the respiratory heath status of the animals, in terms of both respiratory stress and stress in general. Curiously, the lung lesional score related to SEP was higher in two of the groups reared in open-fronted buildings. This may have been due to other influencing factors such as dust suspension and density of pigs in the surrounding area (Stark *et al* 1992).

A theoretical disadvantage of large sawdust-bedded barns compared to conventional buildings is feeder availability. Whereas in the sawdust-bedded barns there were 11.6 animals per feeder, in the conventional buildings there were 7.5 animals per feeder. Straw *et al* (1992) suggest that inadequate feeder space availability is a determining factor of esophagogastric lesions, whilst Amory and Pearce (2000) found that the higher prevalence of esophagogastric lesions in larger groups was due to a higher probability of feed intake interruptions as a consequence of competition for feeders. It is important to note that when concrete feeders are placed in the corner of the pen, as in the standard buildings in our study, we observed that not enough space was available for two 80 kg animals to access the feeder simultaneously; therefore, when animals reach this weight (during the last month of the fattening period, at least), the availability of feeder space in the standard environment is reduced to 15 animals per feeder. Moreover, the animals in the enriched environment could avoid long periods of fasting by eating sawdust.

It is important to take into account that the most frequent type of lesion was parakeratosis of the entire nonglandular mucosa area. This is the first change to occur in the squamous epithelium (O'Brien 1992; Barker & Van Dreumel 1995) and could be produced by pre-mortem management as suggested by Guise *et al* (1992).

Conclusions

The difference in the prevalence and severity of lesions in pigs from two very different production systems, which provide different welfare levels, suggests that evaluation of gastric and limb lesions could be a suitable tool with which to assess animal welfare. Gastric ulceration may be a particularly useful indicator, as it is a condition influenced by a wide range of factors including stress, adequate nutrition, extragastric disease, management, and behaviour, all of which could be used as indicators of welfare. In contrast, the prevalence of lung lesions associated with SEP differed between groups that were reared under the same environmental conditions; therefore, these types of lesion may not be such a reliable indicator of welfare.

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