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Influence of social status on the welfare of growing pigs housed in barren and enriched environments

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Abstract

One hundred and twenty-eight pigs were reared in barren or enriched environments from birth to slaughter at 21 weeks of age. Pigs remained as litter-mate groups until 8 weeks of age when they were mixed into groups of eight animals. These groups were balanced for gender and weight and contained two pigs from each of four different litters. Each pig was assigned high or low social status on the basis of relative success in aggressive interactions at mixing. Injury levels were assessed on a weekly basis from 8 to 21 weeks of age. Pigs were exposed to two group food competition tests after a period of food restriction at 10 weeks of age, and to an individual novel pen test at 11 weeks of age. Behavioural and plasma cortisol responses to both types of test were recorded. Low social status was associated with increased injuries to the head, neck and ears, and therefore reduced welfare. Pigs with low social status showed reduced resource-holding ability in the food competition test, and greater avoidance of a novel object during the novel pen test. It is suggested that avoidance of the novel object reflected 'learned' fearfulness in these individuals. Environmental enrichment did not negate the effect of low social status on injury levels, but did appear to reduce the negative influence of low social status on stress during food restriction, and led to a reduction in fearfulness in response to the novel pen test. These results suggest that environmental enrichment may improve the welfare of growing pigs with low social status.

Keywords: *animal welfare, behaviour, physiology, pigs, rearing environment, social status*

Introduction

Pigs are a gregarious species that form social hierarchies through aggressive behaviour at mixing (Meese & Ewbank 1973). Evidence suggests that social status within these hierarchies has a marked effect on welfare. For example, previous research with sows shows that individuals with low social status suffer greater levels of aggression and have greater difficulty gaining access to resources than those with high social status (O'Connell *et al* 2003). These factors may contribute to the increased physiological stress (Ruis *et al* 2002) and reduced immune capacity (McGlone *et al* 1993) observed in growing pigs with low social status. Pigs with low social status also show increased responsiveness to acute stress (Hicks *et al* 1998; de Jong *et al* 2000), and research with poultry suggests that this may be related to greater fearfulness (Cunningham *et al* 1988).

Previous studies have suggested that the negative effects of low social status on the welfare of pigs are reduced by rearing them in enriched environments (de Jonge *et al* 1996; Olsson *et al* 1999). However, the enrichment treatment used in these studies involved allowing pigs to socialise with animals from different litters in a free-ranging environment prior to weaning. This practice of early socialisation may have specifically improved social skill development (Newberry & Wood-Gush 1986). The aim of the present study was to assess whether environmental enrichment, in the form of a more complex pen design, also leads to improvements in the welfare of pigs with low social status. Welfare was assessed using categorical measures such as injury level (Signoret 1983), and also by assessing behavioural and physiological responses to acute stress.

Materials and methods

Experimental design

The effects of social status (high or low) and rearing environment (barren or enriched) were assessed in a factorial design experiment with two replicates. Pigs were reared in groups of eight in either barren or enriched housing from birth to slaughter at 21 weeks of age. Within each group, each pig was assigned high or low social status on the basis of relative success in aggressive interactions. The influence of social status and rearing environment on welfare-related behavioural, physiological and injury parameters was assessed.

Animals

One hundred and twenty-eight pigs were used in this study, equal numbers being allocated to barren and enriched rearing environments. Each of the two replicates was composed of the litters of eight Large White × Landrace sows (not always mated to the same boar), which farrowed in crates at approximately the same time. The piglets were weaned from the sow at 4 weeks of age but remained as litter-mate groups until 8 weeks of age. At this stage, four boars and four gilts were chosen from each litter according to least variation from the average weight of the litter group. The selected boars and gilts from each of the four litters in enriched housing (in each replicate) were completely mixed and regrouped into groups of eight. These groups were made up of one boar and one gilt from each of the four litters. A similar process was performed on pigs in barren accommodation. These groups of eight pigs remained together for the duration of the study. All procedures used in this experiment were carried out under a Home Office licence granted under the Animals (Scientific Procedures) Act 1986.

Housing

Stage 1 (0 to 6 weeks)

In the first stage of life, all piglets were housed in a farrowing pen measuring 2.6 × 1.6 m and with a floor made of plastic slats. In the enriched treatment the sow and piglets were provided with straw in the farrowing pen, whereas in the barren treatment no substrate was provided.

Stage 2 (7 to 12 weeks)

The barren environment during Stage 2 consisted of flat deck cages that measured 2.4 × 1.2 m and had expanded metal floors. The enriched environment measured 3.1 × 4.5 m and had solid floors. In the enriched treatment the pen was divided into five areas: rooting area, straw area, sleeping area, feeding area, and defecating area. The pigs were provided with spent mushroom compost in the rooting area. The space allowance was 0.36 m^2 per pig in the barren environment and 1.75 m^2 per pig in the enriched environment.

Stage 3 (13 to 21 weeks)

The barren environment during Stage 3 consisted of pens measuring 1.9 × 3.2 m with fully slatted floors. The enriched pen was similar in design to that used during Stage 2 but with twice the floor area in each of the five sections. The space allowance was 0.76 m^2 per pig in the barren environment and 3.5 m^2 per pig in the enriched environment. A detailed description of the housing used during Stages 2 and 3 is given in Beattie *et al* (1995).

Mixing procedure

Each group of eight pigs was mixed together at 8 weeks of age. The pigs were mixed between 0800h and 0900h in specialised pens (3.3 × 1.8 m) with solid floors and no enriching substrate. The pigs remained in these pens for 24 h post mixing after which they were returned in their new groups to their respective Stage 2 housing.

Husbandry schedules

At all stages, pigs in both environments experienced a day/night cycle, with full lighting between 0800h and 1700h, and dimmed lighting for the remainder of the time. In the farrowing accommodation the environmental temperature was maintained at approximately 18°C and localised supplementary heating was supplied by heat lamps over the creep areas. Ambient temperature outside the sleeping kennels in Stages 2 and 3 of the enriched environment ranged from 10 to 22°C. Temperature was controlled in the barren environments at 21°C in Stage 2 and at 17°C in Stage 3.

Lactating sows were fed to appetite and starter feed was provided for the piglets in the farrowing pens from 10 days of age. Water was available from birth for the piglets, via water nipples, in the farrowing pens. In Stages 2 and 3, in both environments, feed was offered *ad libitum* in single space wet and dry feeders (Verba wet feeder, L Verbakel BV, The Netherlands). Spent mushroom compost and straw were replenished as necessary in enriched accommodation during Stages 2 and 3.

Diet

During lactation sows in both environments were offered on average 6.5 kg per day of a cereal/soya-based diet, which supplied 14 MJ digestible energy (DE) per kg air-dry diet. Piglets up to 6 weeks old were offered commercial starter feeds. From 7 weeks of age to slaughter, pigs were offered cereal/soya-based diets *ad libitum*. The diets offered from 7 to 12 weeks and from 13 to 21 weeks contained 14.2 and 13.8 MJ DE per kg, and 220 g and 180 g crude protein per kg respectively. Diets used at all stages were pelleted.

Slaughter procedures

Prior to slaughter the pigs were transported a distance of 80 km to a commercial abattoir where they spent approximately 2 h in lairage. Different groups of pigs were mixed together during transport and in lairage. Pigs were asphyxiated using carbon dioxide gas and slaughtered according to normal commercial practice.

Behavioural measures

Aggression at mixing

Each group was video-taped continuously in real time for the first 8 h following mixing. Aggressive and submissive behaviours (ethogram listed in Table 1) were recorded during this period along with the identity of the perpetrator and recipient of these behaviours. Social status was calculated for each pig according to the following equation:

(number of pigs dominated by focal pig / number of pigs dominated by focal pig + number of pigs that dominated focal pig) × 100

In each dyad of behaviour a pig was deemed dominant to another pig if it performed at least two aggressive behaviours and its opponent performed no aggressive behaviours. In cases where both pigs performed aggressive behaviours, a pig was deemed dominant if it performed four times more aggressive behaviours and also less submissive behaviours than its opponent, or if it performed twice as many aggressive behaviours and less than half the number of submissive behaviours performed by its opponent. Pigs with a social

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Table 1 Ethogram of the aggressive and submissive behaviours recorded during mixing at 8 weeks of age.

Behaviour	Description
Aggressive	
Win fight	Biting, pushing and ramming the opponent with the head at the end of a fight without retaliation from the opponent
Threaten	Being in head to head contact with an opponent which then actively withdraws
Headthrust	Ramming or pushing another pig with the head, with or without biting, in an event that is not recorded as part of a fight
Bite	Aggressively biting any part of another pig without headthrusting
Chase	Actively pursuing another pig
Displace from feeder	Actively displacing another pig from the feeder either aggressively or non-aggressively
Displace from lying area	Actively displacing another pig from its lying area either aggressively or non-aggressively
Submissive	
Lose fight	Receiving bites, pushes and headthrusts from another pig at the end of a fight without retaliating
Flee	Actively moving away from another pig following an aggressive interaction (except displacement)
Withdraw	Actively moving away from another pig without any obvious interaction having taken place
Body turn	Turning the body 180° to protect head and ears from attack

status value greater than or equal to 50% were assigned high social status and pigs with a social status value less than 50% were assigned low social status. In both barren and enriched environments, 50% of pigs in each pen were assigned high social status and 50% low social status, on average.

Food competition test

Each group of pigs was subjected to two food competition tests at 10 weeks of age. The tests were performed in the resident pen on non-consecutive days. In each test the feeder was turned off for 18 h prior to testing. When the feeder was turned back on, the pigs were observed by direct observation for 15 min. It was only possible for one pig to feed at a time and each pig was identifiable by a number sprayed on its back. An observer recorded which pig was using the feeder, the duration it remained at the feeder, and the pig that displaced it. Each pig was assigned a dominance index based on its relative ability to displace its pen-mates from the feeder. The dominance index was based on the following equation:

(number of pigs displaced by focal pig / number of pigs displaced by focal pig + number of pigs which displaced focal pig) × 100

Displacement involved actively moving the pig that was feeding away from the feeder and taking its place at the feeder.

Novel pen test

At 11 weeks of age each pig was introduced individually into a novel pen measuring 7.2 × 4.5 m. The pen had a solid concrete floor and was enclosed by solid black partitions. The pen floor was divided into twelve equal rectangles, each measuring 1.8 × 1.5 m. Each pig was left in the novel pen for a total of 7 min. Two minutes after the pig entered the pen a novel object in the form of a bucket was lowered rapidly from the roof until it hit the floor of the pen. The bucket was immediately raised to 0.5 m above the ground and was left there for the remainder of the test. The number of vocalisations (grunts and squeals) made by the pig was recorded by direct observation throughout the test. Video observations were used to determine the frequency of contact with the novel object, the floor, and the partitions of the test pen. Contact was defined as sniffing, licking, chewing, or touching with the head. The number of squares entered by the pig during the test was assessed from video observations and the number of novel squares entered (ie the number of squares entered by the pig that had not previously been entered during the test) was calculated. A pig was recorded as entering a square if its head and front feet were in that square.

The test pen was not cleaned out between tests; therefore, to preclude any treatment bias created by olfactory cues, the order of testing was randomised. All tests were carried out between 0900h and 1300h.

Plasma cortisol

Blood samples were taken from each animal 18 h prior to the food competition tests (baseline value), immediately prior to the test (post-food restriction) and immediately after the test (post-food competition). Three parameters were calculated: (1) response to food restriction (post-food restriction minus baseline value); (2) response to the food competition test (post-food competition minus pre-food competition value); and (3) response to the food competition test plus food restriction (post-food competition minus baseline value).

Blood samples were also taken immediately before and after the novel pen test, and plasma cortisol responses calculated (post-test minus pre-test levels). Blood was collected by jugular venipuncture, using plastic, heparinised vacutainer tubes (Vacutainer Systems, Becton Dickinson Vacutainer Systems Europe, France). Samples were centrifuged within 2 h of collection. The plasma was extracted and stored at –20°C awaiting analysis. Plasma

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Table 2 Interactive effects between social status and rearing environment on plasma cortisol responses (nmol l^{-1}) to food restriction, the food competition test, and the food competition test plus food restriction.

	Barren environment		Enriched environment		SEM
	High social status	Low social status	High social status	Low social status	
Food competition test 1					
Food restriction	27.8	74.8	23.2	23.6	15.31
Food competition test	–6.5	–21.2	6.9	–11.0	13.22
Food competition + restriction	21.2*	55.8*	26.1	9.5	11.66
Food competition test 2					
Food restriction	35.1	33.2	42.3	38.1	15.18
Food competition test	20.5	13.4	5.2	24.2	9.31
Food competition + restriction	55.7	45.9	69.6	65.6	10.87

Means within the same row and the same environmental treatment denoted by an asterisk are significantly different (* $P < 0.05$).

cortisol concentration was determined using a commercial radioimmunoassay kit (Corti-cote, ICN Pharmaceuticals Ltd, UK).

Injuries

Injuries were recorded from all pigs on a weekly basis from 8 until 21 weeks of age. Injuries were recorded on two separate areas of the body: (1) the head and neck; and (2) the ears. In both areas, injuries were recorded on a scale of 0 to 2 where 0 = no lesions, 1 = lesions apparent on less than 50% of area, and 2 = lesions apparent on greater than 50% of area. Both ears of the pig were counted as one area. Injuries were defined as raised skin with redness, or broken skin with or without redness, and must have been ≥1 cm in length.

Body weight

Individual body weights were recorded from all pigs at 8, 10 and 15 weeks of age.

Statistical analysis

The data were analysed using GENSTAT (Version 5, Lawes Agricultural Trust 1989). The influence of rearing environment on aggressive behaviour at mixing was assessed using one-way analysis of variance (ANOVA). In this analysis, group mean values were used as experimental units, and were normalised following square root transformation. A two-way ANOVA was used to examine the effects of social status and rearing environment on body weight and injuries, and on behavioural and/or plasma cortisol responses to the food competition tests and the novel pen test. In this analysis the main effects of the two factors as well as interactive effects were assessed. Group mean values for each social class (high and low social status) were used as experimental units. All variation in ANOVA is expressed as the standard error of the mean (SEM). Pearson's product moment correlations (*Rp*) (Swinscow 1996) were calculated between the first and second food competition test in order to test consistency in dominance index values and in plasma cortisol responses. The level of statistical significance for all tests was set at $P < 0.05$.

Results

Aggression at mixing

Rearing environment did not have a significant effect ($P > 0.05$) on the average frequency of aggressive behaviours during the first 8 h after mixing (square root values are as follows: fights = 11.7; threats = 5.8; headthrusts = 13.3; bites = 24.7; chases = 6.9; displacements from feeder = 6.2; displacements from lying area = 3.4; total aggressive behaviours = 33.4).

Social status scores calculated from aggressive behaviour at mixing ranged from 0 to 42% (mean = 13.8%) for pigs with low social status across all groups. Social status scores for pigs with high social status ranged from 50 to 100% (mean = 80.1%) across all groups.

Food competition test

Behaviour

There was a significant correlation between the first and second food competition test in the dominance index score ($R_p = 0.239$; $P < 0.01$). Therefore, the average dominance index value from the two food competition tests was used to assess the effects of social status and rearing environment.

Pigs with high social status had a significantly higher dominance index value than those with low social status (high social status = 37.9, low social status = 25.4, SEM = 2.62%, $P < 0.01$). There was no significant interactive effect between social status and rearing environment on the dominance index value.

Plasma cortisol

There were no significant correlations between the first and second food competition tests in plasma cortisol responses to food restriction ($R_p = 0.059$; $P > 0.05$), to the food competition test ($R_p = 0.015$; $P > 0.05$) or to the food competition test plus food restriction ($R_p = 0.096$; $P > 0.05$). Therefore, the effects of social status and rearing environment on these parameters were assessed separately for the first and second food competition tests.

There was a significant interactive effect between social status and rearing environment on plasma cortisol response

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Table 3 Main effects of social status and rearing environment on behavioural and plasma cortisol responses to the novel pen test.

	Social status		SEM	Rearing environment		SEM
	High	Low		Barren	Enriched	
Contact with novel object (frequency/min)	0.21*	0.13*	0.027	0.11*	0.23*	0.029
Contact with ground (frequency/min)	3.39	3.37	0.121	2.85**	3.92**	0.200
Contact with partitions (frequency/min)	0.26	0.30	0.026	0.16**	0.40**	0.043
Locomotion (frequency/min)	2.58	2.48	0.169	1.71***	3.35***	0.270
Total no. novel squares entered	11.26	10.67	0.251	10.29***	11.65***	0.226
Total no. vocalisations	78.8	69.2	7.31	52.7*	95.4*	13.12
Plasma cortisol response (nmol l^{-1})	88.0	97.9	5.38	80.3*	105.6*	7.67

Means within the same row and treatment category denoted by asterisks are significantly different (* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$).

to the food competition test plus food restriction in the first food competition test ($P < 0.05$) (Table 2). In barren environments, pigs with low social status showed greater plasma cortisol responses than did pigs with high social status ($P < 0.05$), whereas in enriched environments there were no significant differences in responses between pigs with high and low social status. This interactive effect was observed only on the first occasion that the pigs experienced feed restriction and became significant only when the responses to food restriction and the food competition test were combined. There were no significant interactive effects between social status and rearing environment on any other plasma cortisol parameters in either the first or the second food competition test.

Neither social status nor rearing environment had a significant main effect on plasma cortisol response to food restriction, to the food competition test, or to the food competition test plus food restriction in either the first or the second food competition test.

Novel pen test

The main effects of social status and rearing environment on behavioural and plasma cortisol responses to the novel pen test are listed in Table 3. There were no significant interactive effects between social status and rearing environment on these parameters.

Behaviour

Pigs with high social status contacted the novel object more frequently than did pigs with low social status during the novel pen test ($P < 0.05$). There were no other significant main effects of social status on behaviour in the novel pen test.

Pigs from enriched environments performed more exploratory behaviour in the form of nosing the novel object, nosing the ground, and nosing the partitions of the test pen during the novel pen test than did pigs from barren environments ($P < 0.05$). Pigs from enriched environments also walked more frequently ($P < 0.001$), visited a greater number of novel squares ($P < 0.001$) and vocalised more frequently than did their counterparts from barren environments ($P < 0.05$).

Plasma cortisol

Social status did not have a significant main effect on plasma cortisol responses to the novel pen test. Pigs from enriched environments showed higher plasma cortisol responses (post-test minus pre-test levels) to the novel pen test than did pigs from barren environments ($P < 0.05$).

Injuries

Pigs with low social status showed greater injury scores to the head and neck area and to the ears than did pigs with high social status (head and neck: high social status = 0.054, low social status = 0.102, SEM = 0.0113, $P < 0.01$; ears: high social status = 0.122, low social status = 0.178, SEM = 0.0127, $P < 0.01$). There were no significant main effects of rearing environment on injury levels (head and neck: barren = 0.083, enriched = 0.073, SEM = 0.0144, $P > 0.05$; ears: barren = 0.146, enriched = 0.154, SEM = 0.0181, $P > 0.05$). There were no significant interactive effects between social status and rearing environment on injury parameters.

Body weight

The main effects of social status and rearing environment on body weight at 8, 10 and 15 weeks of age are shown in Table 4. Pigs with high social status had a significantly greater body weight than pigs with low social status at all ages ($P < 0.001$). Pigs reared in enriched environments had significantly greater body weights than those reared in barren environments at 10 weeks of age ($P < 0.05$) and at 15 weeks of age ($P < 0.001$). There were no significant interactive effects between social status and rearing environment on body weight parameters.

Discussion

Body weight and injury

The relationship shown in the present study between body weight and social status agrees with previous research with pigs (Scheel *et al* 1977; O'Connell *et al* 2003). Increased body weight may enable pigs to dominate pen-mates more

Table 4 Main effects of social status and rearing environment on body weight (kg) of pigs at 8, 10 and 15 weeks of age.

	Social status		SEM	Rearing environment		SEM
	High	Low		Barren	Enriched	
8 weeks	12.73***	11.36***	0.239	11.47	12.62	0.476
10 weeks	27.26***	24.00***	0.393	24.31*	26.95*	0.689
15 weeks	63.51***	58.37***	0.689	56.80***	65.07***	0.852

Means within the same row and treatment category denoted by asterisks are significantly different (* $P < 0.05$; *** $P < 0.001$).

easily in aggressive encounters (Jensen & Yngvesson, 1998). In addition, subordinate animals may be less inclined to retaliate when the opponent is larger and therefore perceived as having greater fighting ability (Rushen 1987). Low social status was associated with increased levels of injuries to the head, neck and ears during the treatment period, and therefore with reduced welfare (Signoret 1983). Injuries were probably sustained during the first few weeks after mixing, when low-ranking animals appear to suffer greatest levels of aggression (Gonyou *et al* 1988). These findings agree with previous research which showed greater levels of aggression-related injury in sows with low rather than high social status (O'Connell *et al* 2003).

The lack of an interactive effect between social status and rearing environment on injury levels suggests that environmental enrichment during rearing did not negate the effect of low social status on this parameter. In addition, environmental enrichment during rearing did not have a significant main effect on injury level or aggressive behaviour at mixing. This is in contrast to previous research which found that pigs reared in enriched environments were less aggressive than those reared in barren environments (O'Connell & Beattie 1999). However, in the study by O'Connell and Beattie (1999), pigs were mixed with unfamiliar animals at an earlier age than in the present study, and therefore may have shown more aggression (O'Connell *et al* 2002). It is possible that the relatively late age at which pigs were mixed in the present study led to a reduction in aggression, which meant that the effect of enrichment on aggressive behaviour was not as marked as in previous studies.

Food competition test

The reduced resource-holding ability shown by pigs with low social status in the food competition tests supports previous research in this area (Hunter *et al* 1988; O'Connell *et al* 2003). This reduced resource-holding ability, in addition to a period of food restriction, was associated with a greater stress response in pigs with low rather than high social status in barren environments. This effect was shown in the first food competition test but not in the second test, where overall stress responses were higher. Previous research has also demonstrated a link between low social status and increased physiological responses to stress (Ruis *et al* 2002). In the present study, the greater stress response among low-ranking pigs in barren environments appeared to be primarily related to the food restriction part of the test. It is possible that food restriction led to greater levels of aggression (Buré 1991) and that this aggression was directed primarily towards lower-ranking pigs in the group. In addition, food restriction may have been particularly stressful for low-ranking animals as they may already have had difficulty gaining access to the feeder (O'Connell *et al* 2003). The presence of environmental enrichment may have reduced the negative effects of low social status by increasing exploratory behaviour and thereby reducing aggression and stress (Schaefer *et al* 1990).

Novel pen test

Pigs with low social status made less contact with the novel object than did pigs with high social status, which suggests greater levels of fear in pigs with low social status (Jones & Waddington 1992; Boissy & Bouissou 1995). Previous research with poultry suggests that this fearfulness among low-ranking animals may be learned as a result of receiving greater levels of aggression in the resident pen (Cunningham *et al* 1988). The lack of an interactive effect between social status and rearing environment on this parameter suggests that environmental enrichment did not negate the effect of low social status. However, environmental enrichment led to an overall increase in contact with the novel object, and in vocal and locomotory behaviour, which agrees with previous research (Beattie *et al* 2000). Evidence suggests that this increased responsiveness to the novel pen test was due to a reduction in fearfulness as a result of an enhanced ability to adapt to novelty (Jones & Waddington 1992).

The fact that pigs from enriched environments showed less fear-related behaviour in the novel pen test, but greater plasma cortisol responses to it, suggests that these responses did not reflect greater emotional stress (Beattie *et al* 2000). Previous research suggests that plasma cortisol levels are influenced by factors such as physical activity (Broom & Johnson 1993). Therefore, it is possible that the increased plasma cortisol responses to the novel pen test shown by pigs from enriched environments may simply have reflected the greater levels of locomotory behaviour shown by these pigs during the test. The suggestion that plasma cortisol responses were influenced by physical activity rather than by emotional response is supported by the fact that pigs with low social status showed more fear-related behaviour during the novel pen test, in terms of avoidance of the novel object, but did not show any difference in locomotory behaviour or in plasma cortisol response.

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Conclusions and animal welfare implications

Growing pigs with low social status suffered poorer welfare than their counterparts with high social status in terms of sustaining greater levels of injury and showing greater fear in response to novelty. In addition, pigs with low social status had reduced resource-holding ability in a food competition test. Environmental enrichment did not negate the effect of low social status on injury levels; however, it did appear to improve the welfare of pigs with low social status by reducing stress associated with food restriction. Behavioural observations suggested that environmental enrichment also led to welfare benefits in terms of reducing fearfulness in response to novelty.

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