EFFECTS OF ENVIRONMENTAL ENRICHMENT ON BEHAVIOUR AND PRODUCTIVITY OF GROWING PIGS

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Abstract *Animal Welfare 1995, 4:* 207-220

This study examined the effects of enriching the environment on the behaviour and productivity of pigs, in an attempt to assess changes in welfare. A total of 102 pigs were housed in either barren or enriched housing from birth to slaughter. The barren environments were defined as intensive housing and the enriched environments incorporated extra space, an area which contained peat and straw in a rack. Enriching the environment reduced both the amount of time pigs spent inactive and the time involved in harmful social and aggressive behaviour. Tail biting was absent from the enriched environment but four pigs were removed from barren pens with severe tail damage. Pigs housed in enriched environments spent longer durations in exploratory behaviour than those in barren housing, and young pigs in enriched environments performed locomotory behaviour more frequently than their counterparts in barren environments. Overall growth rates were similar in both treatments. These results indicate that welfare is improved by enrichment with substrates and suggest that barren pens should be modified to provide these facilities.

Keywords: *animal welfare, behaviour, environmental enrichment, pigs*

Introduction

'The evaluation of animal comfort and well-being is one of the greatest challenges facing animal scientists and we might never get satisfactory answers to some of the questions related to animal welfare issues' (Hartsock & Curtis 1983). The problem arises because the concept of welfare is not a unitary one, there is no universally accepted single measurement of welfare and different measures of welfare do not always co-vary. In addition the significance of some measures are difficult to interpret as it is often inappropriate to impose specific cut-off values (Mason & Mendl 1993). Indeed there is no easy way of knowing how much weight to give each of the various measures, nor at what level a measure indicates poor welfare. Reduced welfare is indicated by pathological measures such as broken bones, wounds, stomach ulcers and disease. These measures Signoret (1983) argued are not ambiguous. High production levels have traditionally been used to claim that welfare in intensive pig units is adequate. However, high production measured at the level of the whole production unit does not guarantee that each individual is producing to its full potential. Measuring production on an individual basis is a better indicator of welfare. An inability to grow or reproduce given a suitable partner indicates that welfare is poor, however, the reverse

does not apply. An animal can grow and reproduce but only by extensive use of behavioural and physiological coping procedures (Broom 1988).

Behaviour is one component of both regulatory and emergency responses. When behaviour is used as a measure of welfare two different responses of the animal are observed. Firstly the behaviour observed may be the animal's actions to help it cope with a difficult situation or secondly it may be behaviour pathologies that have no beneficial effect and which can harm the perpetrator or others (Broom 1991).

A widely held assumption is that creating a naturalistic environment for animals will allow them to display their normal range of behaviour. However, such an environment is anthropomorphically defined, and it may have little relevance to the animal's actual need. Markowitz (1982) claimed that we, as human animals, retain our freedoms by making our environment responsive. He proposed that enrichment of an environment does not have to replicate nature but that the aim of enrichment should be to create an environment sophisticated enough to provide feedback. Studies with pigs have shown that enrichment of the environment can stimulate behaviour patterns similar to that of pigs in semi-natural conditions (Beattie 1994; Simonsen 1990). Simonsen (1990) designed a pen which contained toys, straw and discrete areas. It is evident from such enrichment work that it is pen design rather than merely the addition of toys that stimulates more natural behaviour. Work using toys as a form of enrichment has shown that toys only stimulate a behavioural response when 'novel' (Millar *et al* 1988). Adding simple toys (Apple & Craig 1992; Pearce & Paterson 1993), unlike enrichment incorporated into the design of the pen, cannot meet the three elements of complexity, unpredictability and responsiveness.

In this study enrichment was incorporated into the present housing system by using substrates. These were arranged to form an integral part of the overall design, which attempted to give the pigs control over their environment. The pigs in this investigation were observed from birth to slaughter and the effects of different environments on behaviour and production parameters were examined.

Method

Design

The effect of rearing in different environments (barren and enriched) was examined in a two treatment design with nine replicates. This study took place over a 20 week period which was divided into three stages:

Stage 1 (S1): 1–6 weeks of age
Stage 2 (S2): 7–13 weeks of age
Stage 3 (S3): 14–20 weeks of age

Animals

One hundred and two pigs were used in this study, 54 (nine replicates) were allocated to the barren treatment and 48 (eight replicates) to the enriched. Each replicate was composed of the litters of two Large White x Landrace sows not always mated to the same boar which farrowed in crates at approximately the same time. The average parity of dams in the barren and enriched treatments were 4.5 and 5.0 respectively with a range from 1 to 13 for individual animals. Previous farrowing and lactation periods were spent in farrowing crates.

On the day of parturition the piglets had approximately 2cm docked off their tails. One sow and litter was allocated at random to the barren treatment and the other sow and litter to the enriched treatment. In the barren treatment the sow with her litter remained in the farrowing crate throughout stage 1, while in the enriched treatment the sow and litter were moved to a straw-bedded pen three days post-partum. At week four the excess of each litter was weaned to leave three boars and three gilts. The remaining offspring stayed with their dam until weaning at six weeks of age. Each group of six littermates remained together for the duration of the study. The enriched treatment litter in one replicate was discarded because the litter size was too small.

For brevity, pigs kept in barren housing are referred to as barren pigs and pigs housed in enriched environments as enriched pigs.

Housing

Stage 1 (1–6 wks)

In the first stage of life (S1), piglets were housed either in a farrowing pen (barren environment), or in a straw-bedded pen (enriched environment) with their dams.

The farrowing pen was 2.6x1.6m and had a floor made of plastic slats. Part of the pen was enclosed with a kennel and had a solid floor (creep area). The sow was restrained in a farrowing crate for the entire stage.

The enriched pen measured 3.6x2.2m and had a solid floor which was bedded with unchopped straw. The sow had unrestrained access to all the pen except an area of 1.6m^2 partitioned off to form a creep.

The creep areas in both environments were heated using infrared heat lamps for the first three weeks after farrowing.

Stage 2 (7–13 weeks)

The barren environment at stage 2 (S2) consisted of flat-deck cages, 2.4x1.2m with expanded metal floors.

The enriched environment was 14m^2 in total, divided into five areas (Figure 1) all with solid floors except area 4:

1 The peat area was 2.8m^2 with a 12cm surround, covered with peat at a depth of approximately 6cm which was replenished as necessary.
2 The straw area was 6.8m^2 and contained the straw hopper which allowed the pigs to control the amount of straw used.
3 An enclosed kennel of 1.8m^2 with access through a curtain of polythene strips and bedded with shredded paper was the sleep area.
4 The drinking area (0.6m^2) had two water nipples which were situated 0.5m above the fully slatted floor.
5 The immediate area around the feeder was defined as the feeding area. This occupied approximately 2m^2 including the feeder.

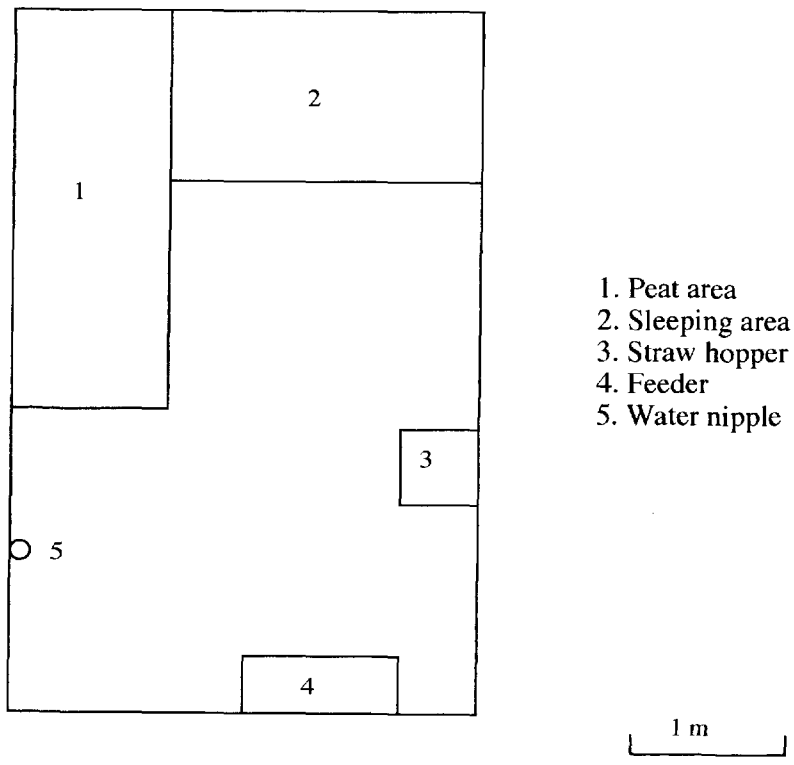

Figure 1 **Spatial representation of the enriched pen.**

Stage 3 (14–20 weeks)
The barren environment for stage 3 (S3) was a pen measuring 1.9x3.2m with a fully slatted floor. The enriched pens were of similar design to the stage 2 enriched pens but with twice the floor area in each of the five sections.

Husbandry schedules
Both environments at all stages had a day/night cycle, with full lighting between 800 and 1800 hours, and dimmed lighting for the remainder of the time. In the barren, farrowing housing the environmental temperature was maintained at approximately 18°C while the average temperature of the enriched farrowing environment was 15°C. Localized supplementary heating was supplied by heat lamps over the creep areas in both environments. Ambient temperature outside the sleeping kennels in stages 2 and 3 of the enriched environments ranged between 10°C and 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 from ten days of age, creep feed was provided for the piglets in both environments. Water was available from birth for the piglets via one water nipple, in both environments. In stages 2 and 3 in both environments, feed was offered *ad libitum* in a four space dry feeder

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and water was continuously available from two water nipples. In enriched stage 2 and 3 housing peat and straw were replenished as necessary, the straw was weighed before being placed in the straw rack.

Diet

Sows in both environments during lactation were offered on average 6.5kg d^{-1} of a cereal/soya based diet supplying 13.4MJ digestible energy (DE) per kilogram air-dry diet. Piglets up to six weeks old were offered a commercial creep feed. Before weaning the excess of the litter at four-weeks of age, each litter consumed approximately 8kg of creep feed. Weaned pigs from seven weeks to slaughter were fed *ad libitum* on cereal/soya based diets. The diets offered from 7 to 13 weeks of age and from 13 weeks to slaughter contained 14.2 and 13.4MJ DE kg^{-1} respectively. Diets at all stages were pelleted.

Behavioural observations

In each treatment group of six littermates, one boar and one gilt in each litter were chosen as focal animals. These animals were selected on the basis of being the nearest to the average weight of the litter. Each focal animal was observed directly twice per week between 1330 and 1800h. This part of the day had previously been identified as the most active period for pigs of all ages (Beattie 1994). Observational periods for all treatments were matched in time, pen order and gender of the focal animal, and were carried out by one observer. Individual observation periods lasted ten minutes, during which the behaviour of the focal animal was recorded continuously. Both the frequency of occurrence and duration of the 29 behaviours listed in Table 1 were recorded.

Recordings were made by direct observation using the 'Observer 2000' (Noldus) program downloaded on to a Psion organizer, this allowed frequency and durations of individual behaviours to be recorded.

Growth recordings

Weight gain was measured for each stage. In addition growth rate and feed intake were recorded for each group of pigs in stages 2 and 3 and feed conversion ratio was calculated from these measures.

Statistical analysis

Behavioural analysis was carried out for the frequency and duration of behaviour of individual focal animals. For production data each group of six littermate pigs was analysed as one experimental unit, and for behavioural data the pen mean was used, that is the mean of behaviour of the focal boar and focal gilt. Missing plot values were calculated as necessary.

The relationship between environment and stage was examined by a split plot factorial analysis (Genstat V, Lawes Agricultural Trust 1989). Students's *t* test was used to determine whether two particular means with equal variance were significantly different.

For brevity, only significant interactions between environment and stage and the main effects of these two variables are presented in the text.

Table 1 Ethogram showing the behavioural measures.

Behaviour	Definition
Inactive	
Lying with eyes open	Lying inactive with eyes open
Lying with eyes closed	Resting with eyes closed
Doing nothing	Sitting or standing inactive
Exploratory	
Nosing fixtures	Sniffing, touching, sucking or chewing any object which is part of the pen
Nosing ground	Sniffing or rooting in substrate
Chewing	Chewing particles other than feed, eg straw, peat or faeces
Manipulating straw	Pulling or nibbling straw from the hopper
Social	
Mounting	Placing both front hoofs on the partner's back, with or without pelvic thrusts
Mounted	Being the recipient of the above behaviour
Rub heads	Nose to nose contact by two animals without intensity of nosing behaviour
Nose sow	Manipulating the sow's udder. Being active at the udder when the sow is not in the nursing posture or when less than half of the litter is present at the udder
Harmful Social*	
Nosing another pig	Sniffing, touching with nose or chewing any part of a penmate
Nosed by another pig	When the animal being observed is the recipient of the above behaviour
Tail biting	Nosing or chewing a penmate's tail
Tail bitten	Being the recipient of the above behaviour
Agonistic	
Headthrusting without bites	Ramming or pushing penmates with the head (each occurrence recorded separately)
Headthrusted without bites	Being the recipient of the above behaviour
Headthrusting with bites (biting)	When the headthrusts are accompanied by bites
Headthrusted with bites (bitten)	Being the recipient of the above behaviour
Fighting	Mutual pushing parallel or perpendicular, ramming or pushing of the opponent with the head, with or without biting in rapid succession. Lifting the opponent by pushing the snout under its body
Locomotory	
Scraping ground	Scraping the ground with one of the fore legs
Scampering	Running across the pen
Frisking	Short, rapid movement which orients the body 90°
Rolling in substrate	Lying on back and moving from side to side
Tossing head	Rapid horizontal shaking movement of the head
Ingestive	
Feeding	Time spent with head in the feeder and chewing feed
Drinking	Use of the water nipple to obtain water which was subsequently ingested. Not merely playing with the water nipple
Sucking	At least half of the litter being active at the udder while the sow is in the nursing posture (lying on the side with the udder fully exposed)
Eliminative	Defecating or urinating

* These behaviours are listed under harmful social behaviour as they can lead to injury of conspecifics.

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Results

Behaviour

Means for the duration of behaviour were expressed as a percentage of observation time, while frequency of behaviour means were expressed as the number of occurrences per minute. Means of interactions between environment and stage are given in the text (means with different superscripts are significantly different) and means of the effect of environment are presented in Tables 2 and 3.

Table 2 Percentages of observation time spent performing each behaviour by pigs in barren and enriched environments between 1330 and 1800 hours

Behaviour	Barren	Enriched	SEM	*P*
Inactive				
lying eyes open	21.32	8.38	2.173	<0.01
lying eyes closed	12.83	31.83	3.933	<0.05
doing nothing	18.03	5.62	1.640	<0.01
Exploratory				
nosing fixtures	10.20	3.97	1.062	<0.01
nosing ground	7.13	28.53	2.217	<0.001
chewing	0.70	4.38	0.242	<0.001
manipulating straw	0.00	3.05	0.783	<0.05
Social				
mounting	0.05	0.00	0.018	ns
mounted	0.01	0.01	0.002	ns
rub heads	0.09	0.11	0.031	ns
nose sow	2.88	1.37	0.467	ns
Harmful social				
nosing	8.83	1.13	0.953	<0.001
nosed	5.42	0.67	0.473	<0.001
tail biting	0.32	0.02	0.074	<0.05
tail bitten	0.31	0.02	0.123	ns
Agonistic				
headthrusting	0.30	0.10	0.037	<0.01
headthrusted	0.29	0.08	0.032	<0.01
biting	0.02	0.00	0.008	ns
bitten	0.02	0.00	0.007	ns
fighting	0.06	0.00	0.024	ns
Locomotory				
scraping	0.00	0.04	0.016	ns
scampering	0.01	0.10	0.039	ns
frisking	0.05	0.17	0.027	<0.05
rolling	0.00	0.00	0.001	ns
tossing head	0.12	0.11	0.016	ns
Ingestive				
feeding	7.38	5.98	0.930	ns
drinking	1.08	0.91	0.144	ns
sucking	1.97	2.97	1.057	ns
eliminative	0.37	0.20	0.103	ns

ns – not significant

Table 3 **Number of occurrences per minute of each behaviour by pigs in barren and enriched environments between 1330 and 1800 hours.**

Behaviour	Barren	Enriched	SEM	*P*
Inactive				
lying eyes open	0.59	0.36	0.045	<0.05
lying eyes closed	0.09	0.13	0.021	ns
doing nothing	2.05	0.82	0.171	<0.01
Exploratory				
nosing fixtures	0.88	0.56	0.096	ns
nosing ground	0.92	1.55	0.129	<0.05
chewing	0.17	0.52	0.037	<0.01
manipulating straw	0.00	0.09	0.017	<0.01
Social				
mounting	0.01	0.00	0.002	<0.01
mounted	0.00	0.00	0.001	ns
rub heads	0.02	0.04	0.007	ns
nose sow	0.08	0.04	0.009	<0.05
Harmful social				
nosing	1.10	0.25	0.100	<0.01
nosed	0.71	0.18	0.072	<0.01
tail biting	0.06	0.05	0.008	<0.05
tail bitten	0.05	0.04	0.011	ns
Agonistic				
headthrusting	0.30	0.08	0.037	<0.01
headthrusted	0.27	0.08	0.034	<0.01
biting	0.02	0.00	0.007	ns
bitten	0.01	0.01	0.006	ns
fighting	0.00	0.00	0.002	ns
Locomotory				
scraping	0.00	0.03	0.012	ns
scampering	0.00	0.05	0.018	ns
frisking	0.06	0.09	0.016	ns
rolling	0.00	0.00	0.000	-
tossing head	0.09	0.08	0.011	ns
Ingestive				
feeding	0.16	0.10	0.012	<0.05
drinking	0.08	0.06	0.018	ns
sucking	0.01	0.01	0.003	ns
eliminative	0.01	0.01	0.003	ns

ns – not significant

Inactive behaviour

The time spent ($P<0.01$) and the frequency of ($P<0.05$) the behaviours lying with eyes open and doing nothing were greater for pigs housed in barren environments compared with those housed in enriched environments. Pigs in enriched environments spent longer periods lying with their eyes closed than pigs in barren environments ($P<0.05$).

Exploratory behaviour

Time spent performing the behaviour nosing ground, was greater for enriched pigs at stage 2 than for enriched (E) pigs at stage 1 or barren (B) pigs at any of the stages but not significantly greater than enriched pigs at stage 3. In addition pigs in enriched environments at stages 1 and 3 spent more time in this behaviour than pigs in barren environments at all three stages (B: S1 7.92^{a}, S2 6.68^{a}, S3 6.92^{a} E: S1 20.83^{b}, S2 35.90^{c}, S3 27.77^{bc} SEM 2.892 $P<0.01$). The frequency of nosing the ground was highest for pigs in enriched environments at stage 2 and significantly greater than enriched pigs at stages 1 and 3 and barren pigs at all stages of development. In addition, stage 3 enriched pigs nosed the ground significantly more frequently than barren pigs at stages 1, 2 and 3 (B: S1 0.91^{a}, S2 0.96^{a}, S3 0.90^{a} E: S1 1.05^{ab}, S2 2.03^{c}, S3 1.49^{b} SEM 0.176 $P<0.05$). Enriched pigs at stage 3 spent more time manipulating straw than enriched pigs at stages 1 and 2 ($P<0.05$). However, the frequency at which this behaviour was performed was greater in both stage 2 and 3 pigs kept in enriched environments than stage 1 enriched pigs (E: S1 0.00^{a}, S2 0.11^{b}, S3 0.15^{b} SEM 0.024 $P<0.01$). Time spent performing the behaviour chewing, was greater by enriched pigs at stages 2 and 3 than by enriched pigs at stage 1 which in turn spent more time chewing than barren pigs at all three stages (B: S1 0.32^{a}, S2 0.90^{a}, S3 0.85^{a} E: S1 2.32^{b}, S2 5.08^{c}, S3 5.47^{c} SEM 0.485 $P<0.05$). The frequency of performance of this behaviour was greater for pigs housed in enriched environments than by barren pigs ($P<0.01$).

Pigs in barren environments at all stages spent more time nosing fixtures than enriched pigs at stages 1 and 3 (B: S1 11.62^{b}, S2 8.73^{b}, S3 10.43^{b} E: S1 2.43^{a}, S2 6.00^{ab}, S3 3.22^{a} SEM 1.722 $P<0.05$). The behaviour nosing fixtures was performed significantly more frequently by barren pigs at stage 1 than by enriched pigs at stages 1 and 3 (B: S1 0.95^{b}, S2 0.88^{ab}, S3 0.83^{ab} E: S1 0.22^{a}, S2 0.88^{ab}, S3 0.52^{a} SEM 0.142 $P<0.05$).

Social behaviour

Time spent and frequency of the occurrence of the behaviour mounted, was greater for barren pigs at stage 2 than for barren pigs at stages 1 and 3 or enriched pigs at any of the three stages (Duration B: S1 0.00^{a}, S2 0.03^{b}, S3 0.00^{a} E: S1 0.00^{a}, S2 0.01^{a}, S3 0.01^{a} SEM 0.006 $P<0.05$; Frequency B: S1 0.00^{a}, S2 0.01^{b}, S3 0.00^{a} E: S1 0.00^{a}, S2 0.00^{a}, S3 0.00^{a} SEM 0.002 $P<0.05$). Enriched pigs at stage 1 spent less time (B: S1 9.60^{b} E: S1 4.57^{a} SEM 1.030 $P<0.05$) and manipulated their dam's udder (nose sow) less frequently (B: S1 0.27^{b} E: S1 0.12^{a} SEM 0.018 $P<0.001$) than barren pigs at stage 1. Pigs at stage 1 spent more time involved in the behaviour rub heads, (S1 0.24^{b}, S2 0.07^{a}, S3 0.02^{a} SEM 0.041 $P<0.05$) and rubbed heads more frequently (S1 0.06^{a}, S2 0.03^{b}, S3 0.01^{c} SEM 0.008 $P<0.001$) than pigs at stages 2 and 3.

Harmful social behaviour

The time spent nosed by another pig increased progressively from a low level for enriched pigs at all stages through to barren pigs at stage 1 to barren pigs at stage 3, which in turn spent less time in this behaviour than barren pigs at stage 2 (B: S1 2.73^{b}, S2 7.68^{d}, S3 5.47^{c} E: S1 0.63^{a}, S2 1.10^{a}, S3 0.27^{a} SEM 0.732 $P<0.05$). Pigs at stage 2 were also found to be nosed by another pig more frequently than pigs at stage 1 ($P<0.01$) and pigs at stage 3 but the frequency at which the latter pigs performed this behaviour was not significantly lower. Barren pigs spent more time nosing another pig than enriched pigs ($P<0.01$) and in

conjunction with this barren pigs were also nosed by another pig more frequently than enriched pigs ($P<0.01$). Both the time spent ($P<0.05$) and the frequency ($P<0.05$) of tail biting were greater among barren pigs than enriched pigs.

Agonistic behaviour

Barren pigs spent more time ($P<0.01$) and performed headthrusting behaviour more frequently ($P<0.01$) than enriched pigs. Similarly, for the behaviour headthrusted, barren pigs spent more time involved in this behaviour ($P<0.01$) and performed it more frequently ($P<0.01$) than enriched pigs.

Locomotory behaviour

Enriched pigs at stage 2 spent significantly more time scraping ground, than barren pigs at all three stages (B: S1 0.00^{a}, S2 0.00^{a}, S3 0.01^{a} E: S1 0.04^{ab}, S2 0.07^{b}, S3 0.02^{ab} SEM 0.019 $P<0.05$), however, the differences between the enriched stage 2 pigs and the enriched pigs at stages 1 and 3 were not significant. Time spent frisking was greater for pigs in stage 1 enriched environments than for enriched pigs at stages 2 and 3 or barren pigs at any of the three stages (B: S1 0.08^{a}, S2 0.06^{a}, S3 0.02^{a} E: S1 0.41^{b}, S2 0.10^{a}, S3 0.03^{a} SEM 0.052 $P<0.01$).

Pigs in stage 1 spent more time scampering (S1 0.18^{a}, S2 0.00^{b}, S3 0.00^{b} SEM 0.053 $P<0.05$) and scampered more frequently (S1 0.09^{a}, S2 0.00^{b}, S3 0.00^{b} SEM 0.024 $P<0.05$) than pigs in stages 2 and 3.

Ingestive behaviour

Barren pigs were involved in feeding behaviour more frequently than enriched pigs ($P<0.05$).

Production

There was no significant treatment effect on any of the production parameters used at any of the stages of development (Table 4). In the enriched environments at stages 2 and 3, each group of six pigs used approximately 5kg of straw.

Table 4 Performance of pigs in barren and enriched environments from birth to slaughter at 20 weeks of age.

	Barren	Enriched	SEM
birth weight (kg)	1.61	1.68	0.077
liveweight at 6 weeks (kg)	15.28	16.21	0.710
0–6 week performance			
liveweight gain (g d^{-1})	328	339	13.3
liveweight at 13 weeks (kg)	52.8	50.3	1.60
7–13 week performance			
feed intake (g d^{-1})	1349	1284	56.3
liveweight gain (g d^{-1})	748	704	25.0
feed conversion ratio (g g^{-1})	1.8	1.8	0.05
liveweight at 20 weeks (kg)	91.3	88.8	2.84
14–20 week performance			
feed intake (g d^{-1})	2034	2000	7.94
liveweight gain (g d^{-1})	811	812	54.6
feed conversion ratio (g g^{-1})	2.5	2.5	0.14

Pathology

Four pigs had to be removed from the barren treatment, all during stage 3, because they had severely bitten tails. No pigs were removed from the enriched treatment for this reason (B: 1.9% E: 0.0% SEM 0.07 $P<0.05$).

Discussion

Behaviour

Inactive behaviour

Pigs kept in barren environments spent greater durations inactive than pigs kept in enriched environments in agreement with the findings of Bøe (1992) . This inactivity in barren environments was dominated by the behaviours standing and/or sitting motionless and lying with eyes open. Wood-Gush & Beilharz (1983) suggested that such inactivity may protect the animal from the lack of stimulation. Alternatively Schouten (1986) proposed that pigs in barren environments were constantly the recipients of harmful social behaviour by their penmates. He proposed that barren pigs unlike enriched pigs did not rest with their eyes closed but instead lay with their eyes open so that they could see any approaching penmate. This proposal, that inactivity combined with alertness is a response to harmful social behaviour, is supported by the finding in this study that pigs from barren environments performed more harmful social behaviour than their counterparts from enriched environments.

Exploratory behaviour

Van Putten (1981) stated that the pig is naturally an exploratory animal. Exploratory behaviour was predominant when pigs were active in both treatments. Pigs given substrates spent nearly one third of the observation time employing them while those pigs in barren environments explored the pen fixtures. This observation that pigs in barren pens nosed the walls and feeding equipment is in agreement with the findings of Horrell (1992). He proposed that because pigs perform exploratory behaviour in the absence of a strong eliciting stimulus then it must be a 'behavioural need'.

Social behaviour

The behaviour rubbing heads which involved nose to nose contact was greater in stage 1 than in stages 2 and 3. This is in agreement with Schouten (1986) and Edwards (1987) who suggested that this behaviour was involved in recognition and the increase of olfactory and visual cues with age is responsible for the decline of this behaviour.

Harmful social behaviour

The shorter periods of time spent in exploratory behaviour by pigs in the barren environment were complimented by higher durations of harmful social behaviour, supporting the argument that pigs in the absence of substrates use penmates as substitutes (Van Putten 1979). This harmful social behaviour was composed largely of persistent nosing and chewing of penmates which led in some cases to cannibalism. Therefore this form of social behaviour can be classified as negative in terms of welfare (Signoret 1983). A similar scenario was observed at stage 1. Making the assumption that enriched pigs were not receiving any more milk than barren pigs as their weaning weights were similar and there were no significant differences in the frequency or time spent sucking, then the higher levels of manipulating the sow's

udder in the barren pens may have been due to redirected exploratory behaviour rather than appetitive behaviour.

Pigs in enriched environments had more than four times the floor space of pigs in barren environments. The fact that pigs in barren environments had higher stocking densities could explain the higher incidence of harmful social behaviours. However, a study examining the effect of various floor space allowances with or without enrichment showed that enrichment plays a greater role in determining pig behaviour than floor space allowance (Beattie *et al* 1992).

Agonistic behaviour

It has been widely argued that aggression in pigs is due to the formation of a dominance hierarchy (Beilharz & Cox 1967). However, in this study the pigs remained in litter groups throughout the duration of the experiment, therefore any aggressive interactions were not due to the establishment of dominance relationships as these are formed early in life (Scheel *et al* 1977). The higher levels of agonistic behaviour in the barren environment may have been a result of the high incidence of social behaviour. Evidence for this proposal comes from the observation that a pig being nosed by a penmate would often retaliate by headthrusting the performer. Such chronic aggression is evidence of poor welfare (Schaefer *et al* 1990).

Locomotory behaviour

The category locomotory behaviour was predominated by the behaviours frisking and scampering. Such behaviours have been described as play behaviour (Newberry *et al* 1988); this suggestion is in agreement with the finding in the present study that locomotory behaviour decreased with age. Play behaviour has been described as a luxury activity (Lawrence 1987) which is only performed when all other needs are met, hence it is usually observed in young animals. Therefore it has been claimed that animals that play are in a good state of welfare (Lawrence 1987). The inference is that pigs in barren environments especially in stage 1 were in poor welfare, measured by the lack of play behaviour and suggesting that all the needs of the young pig were not being met.

Ingestive behaviour

The frequency of feeding behaviour revealed that pigs in barren environments fed more frequently than pigs in enriched environments, however, overall they did not spend more time feeding. Continual displacement at the feeder by other penmates would be revealed by an increase in the recorded frequency, while such disturbance of behaviour would not be exposed by the time measurement alone. If the frequency of feeding behaviour is considered in conjunction with the higher levels of headthrusting behaviour in barren environments then this supports the hypothesis that there was much competition at the feeder. As both environments had the same feeder and the feeding space per pig was equal in both environments, theoretically the level of competition should have been equal. However, barren pigs had only two main outlets for any behaviour. These outlets are the manipulation of their feed or water nipple and the manipulation of their penmates. The increase in the persistent nosing behaviour in barren environments previously outlined lends support to the latter proposal that manipulation of penmates is one outlet for behaviour in barren environments, and work by Morrow (1993) has shown that pigs in barren environments given another outlet for behaviour did reduce the frequency of feeding.

Production

The various measures of production performance at the different stages did not reveal any differences between pigs housed in the two environments. This is not unexpected as barren environments have been developed to ensure efficient production performance. If production was used on its own as a measure of welfare then the inference that could be drawn from this study is that the welfare of pigs in the barren housing systems was adequate.

Animal welfare implications

Pigs irrespective of their housing environment demonstrated a preference to explore, hence it may be claimed that barren housing reduced welfare by limiting stimuli for the performance of this behaviour. The resultant redirection of exploratory behaviour created high levels of harmful social behaviour in barren environments which ultimately led to cannibalism. Young animals with all their needs met are expected to spend time in playful activities. Enriched piglets demonstrated approximately a ten fold increase in playful behaviour compared to barren piglets. This suggests that all the needs of young pigs were not met in the barren environment. Overall production performance was similar in both environments, however, the behavioural analysis revealed that welfare was not. This illustrates the fallacy of the belief that meeting production requirements automatically ensures high standards of welfare.

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