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Applied Animal Behaviour Science 99 (2006) 230–247
APPLIED ANIMAL BEHAVIOUR SCIENCE
www.elsevier.com/locate/applanim

Effects of species-relevant environmental enrichment on the behaviour and productivity of finishing pigs

Heleen A. Van de Weerd [a,*], Caroline M. Docking [b], Jon E.L. Day [b], Kate Breuer [b], Sandra A. Edwards [a]

[a] *University of Newcastle, School of Agriculture, Food and Rural Development, King George VI Building, Newcastle upon Tyne, NE1 7RU, UK*
[b] *ADAS Pig Research Unit, Terrington St. Clement, King's Lynn, Norfolk, PE34 4PW, UK*

Accepted 28 October 2005
Available online 5 December 2005

Abstract

Three different enrichment objects, which were designed according to pig-specific requirements, were provided to groups of growing pigs with undocked tails. The enrichment treatments were a substrate dispenser providing straw, a rootable feed dispenser providing flavoured feed and a liquid dispenser that provided flavoured water when chewable rods were manipulated. These objects were compared with a pen with a full bed of straw (positive control) and a commercial enrichment object, a Bite Rite (Ikadan System, Denmark, minimal enrichment). Video tape recordings from weeks 1, 3 and 7 were scanned using time-sampling to investigate general behaviour and enrichment use. Production parameters were measured, as well as occasions where tail biting (with fresh damage to a tail) occurred. The behavioural observations revealed that all of the enrichment provided was used by the pigs, but there were differences in the level and type of enrichment use by the pigs. The extent to which the straw and straw rack were used was significantly greater than for the other treatments (11.5 and 3.6% of the observations). Enrichment that was located on the floor could be manipulated from different postures, including whilst lying down; for example in 6.6% of the observations in which pigs on straw were lying down, they were manipulating the straw. This also applied, but to a lesser extent, to the straw rack and rootable feed dispenser. Groups provided with the liquid dispenser (which experienced technical problems) and Bite Rite had the highest prevalence of tail biting incidents

* Corresponding author at: Pig and Poultry Research Group, ADAS Gleadthorpe, Meden Vale, Mansfield, Nottinghamshire, NG20 9PF, UK. Tel.: +44 1623 844331.

0168-1591/$ – see front matter
doi:10.1016/j.applanim.2005.10.014

(100 and 83% of pens, respectively). This study shows that a full bed of straw was the most successful way of occupying the pigs and, in addition, it prevented severe tail biting. Where it is not possible to supply a full bed of straw, point source enrichment objects such as substrate or feed dispensers appear to offer a good substitute. Such objects were well-used and did not affect production negatively; furthermore, severe outbreaks of tail biting were prevented.

Keywords: Enrichment; Behaviour; Production; Welfare; Pigs

1. Introduction

There is a large body of literature supporting the hypothesis that environmental enrichment improves animal welfare (see Young, 2003 for an overview). One of the main mechanisms by which enrichment improves animal welfare is the creation of behavioural opportunities to allow an animal to express control over its environment. It may well be that enrichment is also intrinsically rewarding. Environments with low levels of predictability and controllability will limit the regulatory capacity of organisms, which can lead to decreased welfare (Wiepkema and Koolhaas, 1993). Successful enrichment strategies for pigs have been associated with modifications to barren environments that allow individuals to express key elements of their behavioural repertoire, such as foraging and exploratory behaviour (Van de Weerd et al., 2003; Young, 2003).

Straw is generally regarded as a functional form of enrichment for pigs (Arey, 1993), as it occupies pigs for up to 25% of their active time (McKinnon et al., 1989; Beattie et al., 2000). It provides thermal and physical comfort, it can be ingested to provide gutfill, and it provides a substrate for chewing and rooting activities (Fraser, 1975). Mainly because of these last characteristics, straw reduces the risk of the development of harmful social behaviour (Ruiterkamp, 1987; Fraser et al., 1991; Lyons et al., 1995; De Jong et al., 1998; Van de Weerd et al., 2005). Among the harmful social behaviours of pigs, tail biting is one of the most serious due to its damaging nature and the associated risks of infection. In situations where a substrate cannot be provided enrichment objects should be offered instead (Defra Code of Recommendations for the Welfare of Livestock: Pigs, 2003). These types of enrichment objects will be referred to as point source enrichment objects as they are often restricted to a single location in a pen and they are limited in size, in that they generally do not allow all animals in a group simultaneous access. If an enrichment object is offered as an alternative to straw it should occupy animals to the same extent and divert them from performing adverse behaviour.

In a previous study, Van de Weerd et al. (2003) investigated which characteristics of enrichment objects played a major role in determining the extent of object directed exploratory behaviour in pigs. The characteristics of objects, which were found to maintain a pig's attention were ingestible, destructible, deformable, chewable and odorous, and these were in many cases associated with rootable substrates (Van de Weerd et al., 2003). However, other characteristics suggested by the analysis as important were 'not rootable' and 'not particulate', which although initially counterintuitive, related to hanging, ingestible objects, which proved very effective in maintaining a pig's interest. In the

present study, a combination of these important characteristics was incorporated in the design of environmental enrichment objects, thus, taking into consideration species-relevant requirements. The objects were designed to stimulate foraging and exploratory behaviour and, also, to maintain responsiveness to the pigs' manipulation activities after reinforcement of these behaviours beyond an initial novelty value.

The enrichment objects were tested for their effects on pig behaviour and compared with a positive control treatment, which was a pen with a full bed of straw and a treatment with a minimal level of enrichment (Van de Weerd et al., 2005). This treatment consisted of a commercially available hanging object. The behaviour of the pigs was filmed to assess the effectiveness of the treatments and observe any form of harmful social behaviour, especially, tail biting. Another important aspect to consider when introducing enrichment is whether it affects the performance of pigs, because potential detrimental effects on production might hamper adoption of enrichment on a larger commercial scale. Most studies looking at the effects on production of single enrichment objects (e.g. chains, tyres, balls, metal bars, rubber objects or cloth strips) have found no effects (e.g. Pearce et al., 1989; Pearce and Paterson, 1993; Blackshaw et al., 1997; Day et al., 2002a).

The expectations in the current study were that an enrichment object, which was designed according to pig-specific requirements, would not affect performance negatively and would have a positive effect on use and behaviour. Consequently, harmful social behaviour such as tail biting would be reduced, thereby contributing to pig welfare.

2. Animals, materials and methods

The study was performed under the auspices of the Animals (Scientific Procedures) Act 1986, following approval from the ADAS ethical review committee.

2.1. Animals

Three hundred and sixty Large White/Landrace crossbred growing/finishing pigs (average liveweight ± S.D. = 55 ± 5 kg) with undocked tails were exposed to experimental treatments in groups under near-to-commercial housing conditions. Prior to the experiment, the pigs were housed in grower accommodation with straw.

At the start of the experiment, the animals were selected and mixed into groups of 12 animals, with 5 treatment groups per cohort and 6 cohorts in total. Within a cohort, groups were balanced with respect to liveweight and gender. Animals were individually ear-tagged and each group moved to a part-slatted pen that had one of the five enrichment treatments randomly allocated to it for the finishing period (lasting 7–8 weeks). The animals remained on test until slaughter.

2.2. Housing conditions

The finishing accommodation was a fan-ventilated part-slatted system with showers over the slatted area of each pen. The pens had solid concrete floors of 4.4 m × 2.0 m, with

an adjacent area of concrete slats measuring 1.2 m × 2.0 m. The sides of the pen were solid and so high that pigs in adjacent pens did not have visual contact. Five pens adjacent to one another were used within a cohort and the treatments were randomised over these five pens. The pens on the opposite side of the building were used for the next cohort. Cohorts partly overlapped in time and they were separated by 1–4 weeks. Lighting in the building was regulated with a time clock and fluorescent lights were on from 08:30 to 20:30 h.

2.3. Treatments

Three different enrichment treatments were applied during this trial and compared with a fully bedded straw pen (positive control) and a commercial enrichment object (minimal enrichment).

2.3.1. Substrate dispenser providing straw

The substrate dispenser consisted of a metal tube (height: 77.0 cm, diameter: 29.0 cm) with a chain mail basket underneath (height: 17.0 cm). The dispenser was attached to the pen side over the solid floor area approximately 3.0 m away from the front of the pen, so that the chain mail basket was at pig head level. The dispenser was filled with long straw that the pigs could root and pull through the chain mail. A metal tray (57.5 cm × 56.0 cm, edge of 4 cm) was attached to the pen side on the floor underneath the dispenser to catch straw that fell down.

2.3.2. Rootable feed dispenser, providing flavoured feed

The rootable feed dispenser consisted of a heavy metal tube (10.0 cm × 15.0 cm × 76.0 cm) attached to a frame via a pivoting point (at 47.0 cm height). The frame was attached to the pen side in the solid floor area approximately 3.0 m away from the front of the pen. The tube could swing backwards and forwards on the pivot point (swing approximately 5.0 cm). The bottom of the tube was closed, except for a hole (diameter: 2.0 cm) through which flavoured feed from within the tube could emerge. Underneath the tube was a dish attached to the frame (diameter: 36.0 cm, edge 2.0 cm). Pigs could root the dispenser and, by doing so, release the flavoured feed which, then, fell into the dish. To flavour the feed, three different Maxarome liquid flavours (Braes Feed Ingredients, Merseyside, UK) were used and changed on a weekly basis. The flavours were diluted into vegetable oil (10 ml/l) and sprayed onto feed pellets (from the normal diet of the pigs), until all pellets were covered (approximately 200 ml per 10 kg of feed). These pellets were, then, mixed with equal parts of unflavoured feed so that one in two pellets were flavoured in the tube.

2.3.3. Chewable liquid dispenser, providing flavoured water

The liquid dispenser consisted of a metal container (31.5 cm × 12.0 cm × 20.0 cm) attached to the pen side in the solid floor area approximately 3.0 m away from the front of the pen. The container could hold up to 5 l of flavoured water. Two rods (approximately 20.0 cm) made of silicone (diameter 2.0 cm) protruded from the container at pig head level and when the pigs manipulated the rods, some liquid from the container was released.

Three different flavours, strawberry, vanilla and almond (Supercook, Leeds, UK), were used and changed on a weekly basis. One ml of the concentrated flavour was added to 1 l of tap water. The flavours used were chosen on the basis of previous work to ensure that the ones chosen were not aversive to pigs (McLaughlin et al., 1983; Hutson et al., 2000; Jones et al., 2000; Croney et al., 2003).

2.3.4. Commercially available enrichment object

The Bite Rite Tail Chew enrichment device (Ikadan System, Denmark) consisted of a red plastic cone with four protruding plastic sticks (length: 21.0 cm, diameter: approximately 1.0 cm). The Bite Rite was suspended (at pig head level) on a chain from the side of the pen over the solid floor area approximately 3.0 m away from the front of the pen.

2.3.5. Straw bedded pen

In order to provide a fully bedded straw pen, the slatted area was covered and the showers blocked off. At the start of the study, a straw bed of approximately 5.0 cm was provided in the pen.

2.3.6. Maintenance

Three times daily, checks were performed to observe the health status of the animals (e.g. signs of ill health, lameness or tail biting). In addition, during the morning checks, drinkers were checked, food hoppers and enrichment topped up (straw, flavoured liquid and flavoured food). The amount of enrichment provided was recorded. In the straw pens, soiled straw was removed and replenished with fresh straw. When excessive soiling in any of the other pens occurred, manure was scraped from the solid area onto the slats.

2.4. Skin lesion scores

Skin lesions after mixing were recorded, as an environment might influence aggression in newly mixed, unacquainted, pigs. The number of skin lesions, for each individual animal, was recorded at the start of the experiment and 48 h after mixing. Lesions were counted on different body areas: head and shoulders, flanks, rear and tail.

2.5. Production data

Animals were offered a standard, pelleted, commercial diet (Growlean LG: oil 4.5%, protein 18.5%, fibre 4.0%, ash 5.0%, lysine 1.25%, moisture 13.8%, BOCM PAULS Ltd.) ad libitum from multi-space feeders. Water was available ad libitum from two single-bite drinkers in each pen. Food intake on a group level was recorded. All the animals were weighed at the start of the experiment and again 5 days later to determine if there had been a retardation of growth as a result of mixing with unfamiliar animals and to assess whether the treatments had any effects on this. Animals were, also, weighed prior to going to slaughter at approximately 90 kg. Individual carcass data (cold weight and back fat thickness at the P2 position, 6.5 cm from the edge of the dorsal mid-line at the level of the last rib) were collected from the slaughterhouse.

2.6. Environmental measures

2.6.1. Pen cleanliness

Placing enrichment in pens might influence hygiene as it changes how animals use available facilities and this may have knock-on effects on dunging patterns (Simonsen, 1990; Zonderland and Spoolder, 2001). Therefore, once a week throughout the experimental period, a score was given for the cleanliness of the floor of each pen. For this purpose, the pen floor was divided into three virtual areas. Area *A* was the area of solid floor at the front of the pen where the food hopper was placed, area *B* was the adjacent area with solid floor, area *C* was the slatted floor area at the rear of the pen. The cleanliness scores used were: 1 = <1/4 of the area soiled (wet/dirty), 2 = 1/4 − 1/2 of area soiled, 3 = 1/2 − 3/4 of area soiled and 4 = >3/4 of area soiled.

2.6.2. Ammonia concentration and temperature measurements

Environmental conditions in pens can influence pig behaviour, therefore, temperature and ammonia levels in the pens were monitored. On the same days that pen cleanliness was scored, ammonia measures were taken with a hand held ammonia meter (Gasman II, Crowcon Detection Instruments Ltd., Abingdon, UK). Measures were taken at pig head level in the middle of the three pen areas. Each day throughout the experimental period the temperature of the building was measured at a central point between all the pens.

2.7. Behavioural observations

Continuous 24-h time-lapse video tape recordings were made of each pen from the start of the experiment. The tapes from 1 day in week 1 (first day after the start of the experiment), 1 day in week 3 (2 weeks later) and 1 day in week 7 (in the last week before slaughter) were subsequently analysed between 09:30 and 20:30 h, using scan time-sampling. Every 6 min, all the pigs in a group were scanned (observed) to determine whether they were engaged in any of the 17 different classes of behaviour (see Table 1, ethogram). This gave 110 scan samples for each observation day in an observation week.

2.8. Tail biting

Tail biting '*incidents*' were defined as each occasion where some level of fresh damage (where blood was present) on the tail of at least one pig in a group was diagnosed. Repeated observations within 1 week (7 days) were not recorded as a new incident. If the level of damage to the tail of a pig was so severe that recovery within the group seemed unlikely, the animal was removed from the study. When this happened body weight and gender of the removed pig were recorded.

2.9. Data handling and statistical analysis

All analyses were performed using SPSS version 11.0 (SPSS Inc.).

Table 1
Ethogram of behaviour

Behaviour	Description
Enrichment use	Nose or mouth in contact with (or very close to) an enrichment device or straw
Pen manipulation	Nose or mouth in contact with penning: sides, floors (except in straw pens). Includes scratching or rubbing penside/feeder/object
Social contact	Intentional contact with other pig – includes rubbing, circling or chasing, sniffing or nosing (but excludes nosing of tail, ear or hock)
Pig manipulation	Nosing, chewing or biting tail, ear or hock of another pig
For each of the previous behaviours, it was also noted whether the pigs were lying down or active (standing or moving) while performing the behaviour	
Feeding	Head in feeder or very close to feeder (includes nosing feeder)
Drinking	Mouth at drinker
Active	Active (=not lying down) doing none of the other behaviours, includes elimination
Inactive	Lying down and doing none of the other behaviours
Other	None of the above categories or impossible to assess what a pig is doing

2.10. Skin lesion scores

The total number of fresh skin lesions was counted before mixing as well as after mixing. The difference between these two scores was calculated (=total skin lesion score change) and a mean calculated for each group of pigs, this mean was analysed by ANOVA with treatment and cohort as factors.

2.11. Production

Body weight change after mixing was calculated as the difference between weight at mixing and weight 5 days later. Daily weight gain per pig, daily food intake per pig, and food conversion ratios (FCRs) were calculated. The mean group values of these variables as well as carcass data (cold weight and back fat P2) were analysed by ANOVA with treatment and cohort as factors.

2.12. Environmental measures

For each treatment, the weekly pen cleanliness scores and ammonia concentration measures were averaged for the separate areas in the pen and these were subsequently analysed by ANOVA for treatment effects with treatment and cohort as factors. Spearmans' correlations were calculated between cleanliness scores and ammonia concentrations for

the different pen areas. From the daily records, a mean temperature was calculated for each cohort.

2.13. Behavioural observations

For each observation day (within a week), the number of pigs performing a behaviour were totalled and divided by the number of pigs present during that observation day, because during the experimental period some pigs were removed from the trial (see Section 3.5). These frequencies were, then, converted to a percentage of the total number of observations. For the analysis, the position of the animals (lying down or being active) was ignored and only overall categories analysed, since some of the sub-categories (performing a behaviour while lying or while active) had low occurrences. An exception was made for the category 'enrichment use', which was analysed for both sub-categories, excluding the enrichment objects that were not usable in a lying position (liquid dispenser and Bite Rite). The proportion of observations performing a behaviour when lying down or being active was also related to the total number of observations lying down (including inactive) or being active (standing/moving), but excluding the category 'other behaviour'.

A repeated measures analysis (Pillai's Trace) was performed to detect changes in behaviour over time, treatment effects and interactions between these. Cohort was included as a factor. Corrections with the Greenhouse-Geisser epsilon were applied whenever sphericity assumptions were violated. As no interactions between time and treatment were found, the means of all three observations sessions were calculated and analysed with ANOVA with treatment and cohort as factors, to detect differences in pig behaviour between the treatments. When a significant effect of treatment was found, post hoc comparisons were made with a Tukey's HSD test to find the significant contrasts.

3. Results

3.1. Skin lesions

No significant differences between the treatments were found in the change in skin lesion scores incurred in the 2-day period after mixing (means = liquid dispenser 4.7, Bite Rite 4.8, straw rack 5.3, feed dispenser 7.7, straw 7.8, S.E.D. 3.22).

3.2. Production

Daily food intake, weight gain and feed conversion efficiency differed significantly between the five treatments (see Table 2). Pigs housed in straw pens had higher daily feed intakes than pigs exposed to the liquid dispenser and Bite Rite treatments. Pigs housed in straw pens had higher daily weight gain than pigs exposed to the liquid dispenser, Bite Rite and straw rack treatments. Pigs housed in straw pens and those exposed to the feed dispenser treatment had a better feed conversion efficiency (FCR) than pigs exposed to the liquid dispenser treatment.

Table 2
Production data

	Straw	Straw rack	Feed disp.[a]	Liq. disp.	Bite Rite	S.E.D.
Food intake (kg/day)	2.27 b	2.20 ab	2.15 ab	2.12 a	2.10 a	0.030
Weight gain (kg/day)	0.91 b	0.85 a	0.86 ab	0.81 a	0.83 a	0.013
FCR	2.49 a	2.59 ab	2.50 a	2.62 b	2.55 ab	0.027
Weight gain post mixing (kg)	3.08	2.95	3.08	2.55	2.77	0.313
Cold weight carcass (kg)	73.32	72.13	72.05	70.90	72.02	0.545
Back fat at P2 (mm)	10.83	11.28	11.15	10.67	11.05	0.193

Within rows, means with different letters differ significantly at $P < 0.05$.
[a] Does not include feed taken from the dispenser, which was on average 40 g/pig/day.

3.3. Environmental measures

Mean temperatures varied from 16.2 to 19.9 ± 0.5 °C during the experiment. There were some significant differences between the strawed pens and other treatments in the level of soiling at the front and middle of the pen. As the slatted area in the strawed pens was covered, the pigs did not always use the rear of the pen for dunging and this resulted in soiling in the front or middle area more often than in other pens. These dunging patterns, in conjunction with the flooring lay-out, may have resulted in the higher ammonia concentrations recorded for the straw pens (Table 3).

3.4. Behaviour

3.4.1. Behavioural changes over time

The behavioural categories 'inactive', 'pen manipulation' and 'social contact' showed significant changes over time (see Fig. 1), which were similar for all the treatments.

Table 3
Summary of mean weekly pen cleanliness and ammonia measurements for the whole experimental period

	Straw	Straw rack	Feed disp.	Liq. disp.	Bite Rite	S.E.D.
Cleanliness[a]						
Area *A* (front of pen)	2.0 b	1.2 ab	1.3 ab	1.0 a	1.2 ab	0.20
Area *B* (middle)	1.2 b	1.9 a	1.4 ab	1.3 ab	1.2 ab	0.15
Area *C* (slatted area)	3.2	2.9	2.5	2.5	2.4	0.21
Ammonia (ppm)						
Area *A*	19.4 b	7.0 a	7.3 a	3.9 a	7.8 a	1.82
Area *B*	16.2 b	6.2 a	6.6 a	3.7 a	7.5 a	1.53
Area *C*	13.3 b	5.5 a	5.2 a	3.6 a	6.0 a	1.53

Within rows, means with different letters differ significantly at $P < 0.05$.
[a] Cleanliness scores: 1 = <1/4 of the area soiled (wet/dirty); 2 = 1/4 − 1/2 of area soiled; 3 = 1/2 − 3/4 of area soiled; 4 = >3/4 of area soiled.

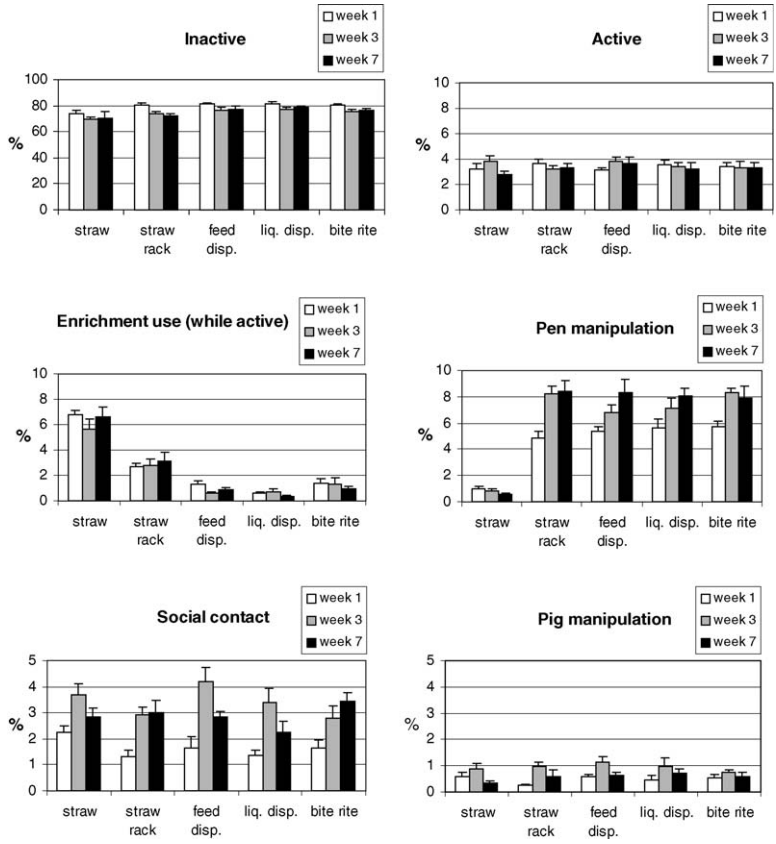

Fig. 1. Behaviour of undocked finishing pigs in pens with different forms of enrichment at three time points (mean proportions and S.E.M.). For statistical differences, see Section 3.

'Inactivity' decreased slightly but significantly over the weeks (time effect, $P < 0.001$), whereas 'pen manipulation' and 'social contact' showed an increase over the weeks (time effect, $P < 0.001$). The other behavioural categories did not show any significant changes over time.

3.4.2. Behaviour over the 3 weeks

Table 4 displays the means over 3 weeks for the different behavioural categories. The daytime use of the enrichment objects when the pigs were active (i.e. not lying down) was highest for the straw pen in comparison with the other treatments ($P < 0.001$). The straw rack had second highest use ($P < 0.001$). Levels of Bite Rite manipulation were comparable to those of the feed dispenser. The levels of liquid dispenser use were fairly low; this was, however, associated with technical problems with the design of the object so that it did not function as intended. The use of the enrichment when the pigs where lying down was only analysed for substrates/objects, which could be used from a lying position.

Table 4
Behaviour as a percentage of the total number of daytime observations, means over the three observation periods

Behaviour	Straw	Straw rack	Feed disp.	Liq. disp.	Bite Rite	S.E.D.
Inactive	72.1 b	75.6 ab	78.3 a	79.2 a	77.6 a	1.23
Active	3.3	3.4	3.5	3.4	3.4	0.20
Enrichment use (active)	6.4 b	2.9 c	0.9 a	0.5 a	1.2 a	0.23
Enrichment use (lying)	5.1 b	0.7 a	0.6 a	–	–	0.43
Pen manipulation	0.8 b	7.2 a	6.9 a	6.9 a	7.2 a	0.35
Social contact	2.9	2.4	2.9	2.3	2.7	0.21
Pig manipulation	0.6	0.6	0.8	0.7	0.6	0.12
Feeding	5.3	4.5	4.6	4.7	4.9	0.22
Drinking	2.1	1.4	1.5	1.6	1.8	0.15

Within rows, means with different letters differ significantly at $P < 0.001$, except for inactive, $P < 0.01$.

Manipulation levels were highest in the straw pen in comparison with the straw rack and feed dispenser treatments ($P < 0.001$).

Pig manipulation, defined as all pig directed chewing or biting behaviour, was highest in the liquid dispenser and feed dispenser pens but these differences were not significant. Levels of pen manipulation were lowest in the straw pen in comparison with the other treatments ($P < 0.001$). Inactivity levels were lowest for the pigs in the straw pen in comparison with the other treatments, except for the straw rack treatment ($P < 0.01$).

The results of a more detailed investigation of the posture in which animals performed some of the behaviours are presented in Table 5. The percentages of social contact, pig manipulation and tail manipulation are very similar between the treatments, but enrichment use and pen manipulation show interesting differences. In 6.6% of the observations in which pigs on straw were lying down, they were manipulating the straw, whereas enrichment use while lying down was less than 1% for the pigs in other treatments. In comparison, in 29–32% of the observations in which pigs were seen to be active, they were performing pen manipulation (mainly directed at the floor), for pigs in straw pens this 30% was directed towards straw on the floor.

Table 5
Behaviour expressed as a percentage of the total number of observations lying down (including inactive) or being active (standing/moving)

Behaviour	While	Straw	Straw rack	Feed disp.	Liq. disp.	Bite Rite
Enrichment use	Active	31.5	14.5	4.8	2.9	6.2
	Lying	6.6	0.9	0.8	0.0	0.0
Pen manipulation	Active	3.5	28.7	29.9	32.7	31.7
	Lying	0.1	1.9	1.5	1.2	1.3
Social contact	Active	11.0	8.7	11.8	9.2	9.8
	Lying	0.9	0.9	0.8	0.8	0.9
Pig manipulation	Active	1.7	1.4	2.6	2.1	1.9
	Lying	0.3	0.4	0.4	0.4	0.3

Table 6
Tail biting incidents

	Straw	Straw rack	Feed disp.	Liq. disp.	Bite Rite	Overall
Total no. of incidents	1	6	2	8	6	23
Affected pens (%)	17	50	33	100	83	57
No. of pigs removed	0	1	1	1	8[a]	11 (3%)

[a] One of the outbreaks involved the removal of six pigs.

3.5. Tail biting

During daily health checks, tails of the pigs were inspected for signs of biting. A total of 23 tail biting incidents were recorded, involving 57% of all the pens. The number of affected pens was significantly lower for the straw treatment than for the Bite Rite or Liquid dispenser treatments ($P < 0.05$, Fisher test). Table 6 summarises the tail biting incidents. In total, 3% of the pigs (both bitten pigs and biters) had to be removed from the study as a consequence of tail biting.

4. Discussion

In the present study, enrichment objects incorporating characteristics previously indicated by pigs to be important (Van de Weerd et al., 2003) were provided to pigs and compared with a straw-bedded pen and a commercially available enrichment object. The behavioural observations showed that all enrichment provided was used by the pigs while active or lying down (ranging from a total of 0.5% of the observations for the liquid dispenser to 11.5% for the straw). Other studies report interaction levels for the most popular objects (from a set of 74 different objects) of up to 10% of daytime (Van de Weerd et al., 2003) and interactions with straw in a straw-bedded pen of 12–20% of daytime (Jensen et al., 1993; De Jong et al., 1998).

Pig manipulation, such as tail-, hock- or ear-manipulation levels were low (observed in less than 1% of the observations). When pigs are housed under barren conditions, levels of tail biting can be very high, such that tail bitten pigs and tail biters have to be removed from their groups to prevent escalation of tail biting into cannibalism (Beattie et al., 2001; Van de Weerd et al., 2005). These results suggest that providing pigs with enrichment may prevent high levels of undesirable pig manipulation, however, the results do indicate differences in the level and type of enrichment use by the pigs.

The liquid dispenser and Bite Rite incorporated chewable and deformable plastic sticks. Chewing and gnawing behaviour in pigs appears to have a strong element of spontaneous motivation (Fraser, 1983/1984) and this has emerged in experiments where pigs showed a preference for chewable objects (e.g. dog toys) in comparison with non-chewable objects (e.g. chains, Apple and Craig, 1992; Hill et al., 1998). Chewable also emerged as an important characteristic of objects, which maintained interest from pigs (Van de Weerd et al., 2003). However, the functionality of the liquid dispenser and Bite Rite objects as enrichment was questioned as the treatments had the highest prevalence of tail biting outbreaks (100 and 83% of the pens were affected for the liquid dispenser

and Bite Rite, respectively). It seemed that the chewing stimulation most likely did not yield feedback corresponding to the expectations of the pigs (Ruiterkamp, 1987; Van de Weerd et al., 2005). The liquid dispenser was designed to provide flavoured water in response to manipulation of the rods, but problems with executing this design caused a premature leaking of the liquid so that, for the majority of time, the container was empty (and behaviour not reinforced). The Bite Rite only provides chewing without reinforcement. Day et al. (1996) showed that pigs performed more chewing on a rubber tube that provided a nutritional substrate in comparison with a tube without any substrate.

The occurrence of tail biting outbreaks in the pens provided with the liquid dispenser and Bite Rite indicates that caution should be exercised when providing animals with enrichment, which may increase their motivation to perform a behaviour but subsequently frustrate the behavioural expression of this motivation (Wemelsfelder and Birke, 1997; Mench, 1998; Day et al., 2001). Failure to provide an appropriate outlet for species-specific behaviour can mean that the animal is unable to obtain the reinforcement on offer due to the incompatibility between the reward and the behaviour required to obtain it (Young, 2003). In previous work, manipulation levels of the Bite Rite were three times lower than straw manipulation and it did not prevent high levels of tail biting, whereas tail biting levels in straw-bedded pens remained very low (Van de Weerd et al., 2005). This raises the question whether the sticks on the Bite Rite show too much of a resemblance to tails of pen mates and, thus, potentially stimulate tail biting behaviour. Further research to investigate this possibility is required.

The overall use of the rootable feed dispenser was higher than use of the liquid dispenser and the Bite Rite. This will partly be caused by the fact that the pigs could use it from a lying position giving additional access (see further on in this section). In contrast to the liquid dispenser and Bite Rite, manipulation of the dispenser did reward the pigs' rooting behaviour with a release of flavoured food. Wood-Gush and Beilharz (1983) found temporal relationships between rooting and feeding or other consummatory acts. The feed dispenser incorporated important characteristics such as deformable, chewable, ingestible and odorous, thus, satisfying both exploratory and feeding motivation, which are essential characteristics of effective pig enrichment devices (Day et al., 2002a; Van de Weerd et al., 2003).

The level of use of the straw and straw rack was highest compared to the other treatments in this study. Although the pigs in this study had previous experience with straw, it was not likely that this influenced the level of straw-directed behaviour, as was shown in a study by Day et al. (2002b). One of the main differences between straw bedding and a point source enrichment object is the surface area that straw bedding occupies, providing easy access for every animal from different postures, including lying down (Zonderland et al., 2003). This also applies, but to a lesser extent, to the straw rack and feed dispenser. The manipulation of straw from a lying position increased the total time engaged in straw manipulation. This resulted in more activity and, thus, lower levels of inactivity, as also seen in other studies (McKinnon et al., 1989; Guy et al., 2002).

The pigs maintained an interest throughout the experiment in the straw and straw rack and, to a lesser extent, in the dispenser (70% of all the feed used through the dispenser was

used in the first-half of the trial). A decline in interest in the enrichment provided is undesirable, as unstimulated animals may channel manipulatory behaviour to less desirable objects (Fraser, 1983/1984; Rushen et al., 1993). Habituation to unstimulating objects may occur after only a few days of object presentation (Van de Weerd et al., 2003). This illustrates the importance of studies into the mechanisms by which enrichment modifies the immediate and long-term expression of behaviour.

The present study showed that with a full bed of straw, pigs manipulated the straw for a much larger proportion of their active time, compared with the objects comprising the other treatments. This was partly caused by exploratory behaviour directed towards the straw on the floor. The animals in the other treatments directed their exploratory behaviour to the (barren) pen floor, illustrated by the proportion of active time spent on pen manipulation (which consisted mainly of floor directed behaviour). Similar findings have been reported by Ruiterkamp (1987), Lyons et al. (1995) and De Jong et al. (1998). These high levels of rooting at a very unsuitable substrate, the concrete floor, illustrated how important rooting is to pigs (Van Putten, 1980). In barren pens without any additional enrichment features, unsatisfying floor directed exploration might be redirected at pen mates leading to tail biting.

Although the treatments differed in number of tail biting outbreaks these differences were not reflected in pig manipulation levels as scored during the observation scans. This could be due to the frequency of observations, but it has been reported previously that the relationship between pig manipulation levels and tail biting outbreaks is not necessarily linear (Van de Weerd et al., 2005) and outbreaks may be caused by several cumulative internal and external factors such as deficiencies in the environment. Ruiterkamp (1985) found that tail-in-mouth behaviour frequencies were sometimes higher in pens without tail biting than in pens that had actual outbreaks of tail biting.

The production data showed that pigs housed on straw had an increased food intake and daily weight gain, in line with previous studies (Lyons et al., 1995; Morgan et al., 1998; Van de Weerd et al., 2005) and feed conversion ratios were improved. The pigs provided with the liquid dispenser were least productive; feed intake and weight gains were lower than those of pigs on straw and their FCRs significantly poorer than those of pigs housed on straw or with the feed dispenser. However, this pen was comparable to a non-enriched pen because for the majority of time the liquid dispenser was not functioning as enrichment and this may have contributed to the high occurrence of tail biting incidents in this treatment. Ruiterkamp (1987) also found a reduced feed intake in pigs in pens with high levels of pen-mate directed behaviour and Wallgren and Lindalh (1996) found depressed weight gain. However, Zonderland et al. (2003) found no effect of mild or severe tail damage on production data. In the current study, the presence of the straw rack or feed dispenser did not affect production negatively.

There are limitations to the extent to which point source enrichment objects can substitute for an environment that allows animals to express a more complete behavioural repertoire. The limited size of point source enrichment may restrict access to enrichment causing competition, aggression or restlessness in groups of animals. Schaefer et al. (1990) observed competition when access to point source enrichment was restricted. Limited size and, thus, availability is also inherently related to the location of point source enrichment in the pen (e.g. Krötzl et al., 1994). For example, enrichment objects present in the lying area might cause disruption of resting during use. This topic has not yet been thoroughly studied.

The availability of substrates from enrichment objects such as straw racks may be limited, depending on their design. It is important that a substrate (either for a dispenser or a full bed) is topped up regularly with fresh material, as renewing with small amounts may present more novelty than a deep bed, which is not replenished (Moinard et al., 2003). Replenishment will keep the substrate in an optimal condition for its multiple functions. A benefit of supplying small amounts is that the risk of negative effects of substrates such as straw is lower (e.g. respiratory disease due to the level of airborne contaminants, Smith, 1994).

When substrates are combined with slatted floors, potential problems with blockage of slurry systems can be prevented by controlling the flow of substrates from a dispenser. In the present study, straw use by the pigs was approximately 86 g/pig/day with an ad libitum straw supply from the straw rack (topped up daily), small quantities of approximately 90 g/pig/day reduced the occurrence of adverse behaviours such as tail biting in the study by Day et al. (2002b), and even as little as 5–20 g/pig/day has beneficial effects (Stubbe et al., 1999; Zonderland et al., 2003). A simple threshold between the lying and dunging area can be enough to keep the straw away from the slats (Van Putten, 1980). However, it is important to remember that the quantity of straw-directed behaviour is proportional to the amount of straw provided (Kelly et al., 2000; Day et al., 2002b).

Neither the straw rack nor feed dispenser were able to totally prevent tail biting, but less than 50% of the pens with these treatments were affected and severe outbreaks of tail biting were not seen (only two animals had to be removed). Zonderland et al. (2003) found similar results for a straw dispenser, which did not stop mild levels of tail biting but did significantly reduce severe biting where animals had bleeding wounds on their tails. Other types of substrate dispensers such as a mushroom compost rack, hanging metal baskets with straw or compost provided on a tray have also been successful in significantly reducing tail biting (Buré et al., 1983; Fraser et al., 1991; Beattie et al., 2001). Stubbe et al. (1999) did not observe tail biting in pigs with intact tails in pens with the straw dispenser. Their design incorporated a piece of wood attached on chains, which the pigs could manipulate to release straw from a container into a rooting dish. This indicates that it is crucial to get the design of enrichment objects right to get the best effects.

5. Conclusion

The present results show that the presence of a full bed of straw was the most successful way of occupying the pigs. In addition, it prevented high levels of tail biting, even though conditions in the straw pen were not always optimal as indicated by the cleanliness scores and ammonia concentration levels. When it is not possible to supply a full bed of straw, point source enrichment objects such as substrate or feed dispensers are a good substitute, because these are well-used and allow pigs to root and forage. Taking into account the availability limitations (due to object size or location in the pen) as outlined above, they are a promising form of enrichment for pigs in intensive housing conditions.

Acknowledgements

We gratefully acknowledge the financial support for this project from Defra, BOCM PAULS, GE Baker UK Ltd. (Quality Equipment), PIC, Quality Meat Scotland, Tesco, assistance from J. Edwards with the video observations and farm staff for practical assistance at the ADAS pig research unit.

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