

Final Project Report

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Project title

Straw as "environmental enrichment": identifying the properties which help to reduce pen-mate manipulation in pigs

MAFF project code

AW0122

Contractor organisation and location

ADAS Consulting Limited, Woodthorne, Wergs Road, Wolverhampton, WV6 8TG.

Total MAFF project costs

£ 129,728

Project start date

01/04/98

Project end date

31/03/00

Executive summary (maximum 2 sides A4)

Background

The presence of straw in pig housing systems has been shown to reduce the incidence of behavioural vices (particularly pen mate directed behaviours). However, a substantial proportion of commercial systems at present use fully- or part-slatted flooring, and the use of (long) straw in such systems is highly impractical. The Welfare of Livestock Regulations (1994) dictates that, in these circumstances, alternatives need to be used, to satisfy the pig's behavioural needs. The present study aimed to investigate how pigs use straw, by pursuing four experimental objectives.

Objective 1: to qualitatively assess the behavioural components used by finishing pigs manipulating straw, in order to develop a detailed ethogram.

This experiment was designed to describe the behavioural components which pigs use to manipulate straw and propose a list of behaviours (ethogram) which could be used to study straw-directed behaviour in subsequent experimentation. To achieve this objective pigs of either 6, 12 or 19 weeks of age were observed when straw was presented either in a rack, chopped on the floor, or in a deep bed. The pigs were housed in groups of four animals, which were balanced with respect to gender. Two animals in each group (one male and one female) were randomly selected to serve as focal animals, and these animals were observed for one hour between 0800h and 0930h on two occasions, each by a different observer. The observers described in the greatest detail possible; i) the behaviour itself, ii) the part of the pig's body which was being used to express the behaviour, iii) whether other pigs were involved, iv) the duration of the behaviour and v) the location the behaviour was performed. A consensus panel met after all the data had been collected to devise an ethogram. In a subsequent experiment, the ethogram was validated by 'experienced' and 'novice' observers and assessments made of the reliability of behavioural observations made on two identical sections

of video-taped behaviour. The intra-observer reliability was higher for the ‘experienced’ observers compared with the ‘novice’ observers (69.6 vs. 42.6% agreement). Observers who had the same levels of experience demonstrated higher levels of inter-observer reliability than observers who had different levels of experience. It is concluded that observers can differ markedly in their use of a complex ethogram, and wherever possible, experiments should ensure that the same observer is used throughout. Where multiple observers are used, potential bias should be compensated for in the design.

Objective 2: to investigate the (interactive) effects of previous experience of straw and the level of straw bedding on quality and quantity of substrate and pen mate manipulation.

This experiment was designed to investigate whether prior experience of straw and the level of straw bedding could affect the quantity and/or quality of straw- and pen-mate-directed behaviour. Groups of pigs which had, or had not, had prior experience of straw were exposed to one of four levels of straw bed depth (barren, minimal, substantial or deep). It was found that groups of pigs with prior experience of straw bit other pigs more in barren environments than groups of pigs with no such prior experience. When pigs had no prior experience of straw, the expression of tail-biting and nosing of other pigs was elevated for three weeks after being moved into growing/finishing accommodation. The quantity of straw-directed behaviour was found to be proportional to the amount of straw provided, and an increasing depth of straw bed was found to result in an increase of rooting, ploughing, sweeping and flicking straw, with a concomitant decrease in aggression, belly-nosing, tail-biting, ear-chewing, and licking, biting and nosing other pigs. These results suggest that moving pigs from previously strawed accommodation to unstrawed accommodation increases the occurrence of adverse pen-mate directed behaviour, and that when pigs have had prior experience of straw, even a small quantity of straw in the growing/finishing accommodation may serve to ameliorate the negative effects of the environmental challenge. Increasing the quantity of straw provided reduces the occurrence of potentially damaging behaviours, but may not affect the diversity of straw-directed behaviour.

Objective 3: to investigate the effect of straw length on quality and quantity of substrate manipulation, and on levels of pen mate manipulation.

This experiment was designed to investigate whether different lengths of chopped straw would achieve differential enhancements in pig welfare, with the objective of exploring the possibility that small quantities of chopped straw, in preference to unchopped straw, could be provided in part- and fully-slatted systems thus avoiding the blockage of liquid slurry handling facilities. Twenty-four groups of growing pigs were exposed to one of four treatments (no straw bedding, full length straw, half chopped straw, and chopped straw). Both pen-mate- and straw-directed behaviours were recorded using time and *ad libitum* sampling on weeks one, four, 7 and 10 of the trial. It was found that the provision of straw, irrespective of its length, reduced the expression of adverse pen-mate directed behaviours, and increasing lengths of straw increased both the quantity and quality of straw-directed behaviours. However, tail-biting was found to increase as the length of chopped straw decreased. It is concluded that the use of chopped straw in growing/finishing housing systems may be beneficial in reducing the occurrence of certain adverse behaviours, however, its use in part- or fully-slatted housing systems is inadvisable whilst there is a possibility that levels of tail-biting may be increased. Furthermore, straw which has been finely chopped is not able to accommodate many of the behaviours which pigs direct towards longer lengths of straw, and the degree to which this reduces the efficacy of the substrate in improving welfare remains to be determined.

Objective 4: to test the hypothesis that, in finishing pigs, straw satisfies an exploratory need, independent of foraging motivation.

This experiment determined how relative shifts in the level of exploratory and feeding motivation influenced straw-directed behaviour. Groups of pigs were given access to either fresh straw (F) or one day old straw (O), exposed to either restricted (R) or *ad libitum* (A) feeding and their straw-directed and pen-mate directed behaviour recorded. It was found that the rooting, dropping and licking of straw was significantly lower, and the licking and nosing of other pigs was significantly higher in O groups than in F groups. Sniffing straw and nosing other pigs was significantly higher in A groups than in R groups. These results suggest that straw-directed behaviour arises as a result of both exploratory and feeding motivations. When pigs are feeding motivated, the expression of adverse behaviours is diminished when ample straw is provided, and under these circumstances, motivated activity is directed towards straw bedding rather than pen-mates. Therefore, when

environmental enrichment devices are being designed to replace straw, they must be suitable to accommodate both exploratory and feeding motivated behaviours.

Conclusions

- a) The consensus panel approach to ethogram development is useful as it allows a number of different opinions to be expressed prior to the full-scale use of the ethogram in an experiment. However, inter- and intra-observer reliability can vary markedly between observers when using a complex ethogram. Ethogram simplification is a useful strategy to improve reliability scores but, wherever possible, experiments should ensure that the same observer is used throughout, and that potential observer effects are compensated for in the design (e.g. balancing observers across treatments).
- b) Moving pigs from previously strawed accommodation to unstrawed accommodation increases the occurrence of adverse pen-mate directed behaviour. It is possible that such a reduction in welfare may result from a difference in behavioural needs caused by prior experience. When pigs have had prior experience of straw, even a small quantity of straw in the growing/finishing accommodation may serve to ameliorate the negative effects of the environmental challenge. Increasing the quantity of straw provided, reduces the occurrence of potentially damaging behaviours, but may not affect the diversity of straw-directed behaviour.
- c) The use of chopped straw is beneficial in reducing the occurrence of certain adverse behaviours such as aggression and the nosing of other pigs, however, tail-biting appears to increase in frequency as the length of chopped straw decreases. The use of chopped straw in part- or fully-slatted systems is inadvisable until further research has been conducted to ascertain the nature and robustness of this effect. Straw which has been finely chopped is not able to accommodate many of the behaviours which pig's direct towards longer lengths of straw and the degree to which this reduces the efficacy of the substrate in improving welfare remains to be determined.
- d) Straw-directed behaviour arises as a result of both exploratory and feeding motivation. When ample straw is provided, adverse behaviours appear to be diminished as a result of elevations in feeding motivation, and it is suggested that, in these circumstances, motivated activity is directed towards straw bedding rather than pen-mates. When environmental enrichment devices are being designed to replace straw, they must be suitable to accommodate both exploratory and feeding motivated behaviours.
- e) The results of these experiments are relevant to MAFF policy objectives as they provide a better understanding of what properties of an alternative to straw should have in order to be equally successful in reducing adverse behaviours. The results provide an immediate answer as to whether the provision of minimal straw in fully- and part-slatted systems confers welfare advantages. Ultimately, the results will assist in the improvement of the public perception of intensive pig housing.

Scientific report (maximum 20 sides A4)

1. Introduction

The Welfare of Livestock Regulations 1994, state that “In addition to the measures normally taken to prevent tail biting and other vices and in order to enable them to satisfy their behavioural needs, all pigs, taking into account environment and stocking density, must have access to straw or other material or object suitable to satisfy those needs”. The legislation refers to straw specifically for welfare reasons, because research has shown that straw possesses properties which help to reduce behavioural vices. However, approximately 76% of all finishing pigs are currently housed in environments which are incompatible with the use of straw as bedding, or as a foraging and / or exploratory substrate. In these circumstances, the legislation requires producers to provide a suitable alternative, without further specification of what properties this alternative should have.

This project was set-up to study the behavioural responses of pigs to straw, because identification of the key routes by which straw reduces behavioural vices in pigs will help legislators to formulate welfare requirements more specifically. It will also identify the fundamental principles for further research into the alternatives to straw, ultimately providing suitable environmental enrichment in commercial systems where the use of straw is not practical.

2. Objective 1: *to qualitatively assess the behavioural components used by finishing pigs manipulating straw, in order to develop a detailed ethogram.*

2.1 Background

The measurement of behaviour is a fundamental prerequisite to the study of ethology and applied ethology. There are a number of techniques available to facilitate such measurement (Martin and Bateson, 1986), however, all generally rely on the use of an ethogram and a human observer to collect data. Whilst the aim of all behavioural observation is to produce data which are both valid (accurate) and reliable (repeatable), such objectivity could be compromised in some circumstances.

An ethogram is a list of behavioural categories which describe the behavioural elements which an animal may express. The categories included in the ethogram are generally chosen on the basis of the experimental aim and, as such, can range from the rather simple to the extremely complex. Whilst the ethogram is an essential part of behaviour observation, there is relatively little published information on how such ethograms may be devised. The properties which are common to all ethograms are that the categories are mutually exclusive (Cane, 1961), and must also be described in such a way that it is clear to the observer which behavioural element is being expressed. Beyond these properties, there is very little information concerning the point at which an ethogram becomes over-complex and may adversely affect the quality of data being collected.

The second prerequisite for most studies of behaviour is the human observer. With any type of data collection, there is a danger of observations being biased by the person who is collecting the data; one person does not always see things the same way as their colleague. If the aim of behavioural observation is to measure objectively the activity of an individual, the agreement between observers (inter-observer reliability), and within observers (intra-observer reliability) should be demonstrated to be high. Very few studies indicate whether such assessments of reliability have been made, despite the knowledge that factors such as individual variation and experience may affect the quality of data collected. Therefore, the aim of this study was to develop a complex ethogram to describe the behaviour of pigs given access to straw, and investigate the effect of individual variation between observers and their level of experience on both inter- and intra-observer reliability. The ultimate objective was to develop an appropriate ethogram to use in subsequent studies of the straw-directed behaviour of domestic pigs.

2.2 Methodology

A ‘consensus panel’ approach was used to develop an ethogram to describe the behaviour of growing pigs given access to straw. To ensure that the ethogram was sensitive to both age dependent variation, and variation due to the method of straw presentation, groups of pigs were observed at either 6, 12 or 19 weeks of age, when straw was presented either in a rack, chopped on the floor or as a deep bed. The experimental subjects were nine groups of four pigs (two male and two female), and each group of pigs was observed under each of the conditions. Each group was given seven days to acclimatise to the experimental conditions

prior to the initiation of observations. Two animals in each group were randomly chosen to serve as focal animals, and were clearly marked with stock marker-spray. These focal pigs were observed for one hour between 0800 and 0930h on two occasions, each with a different observer. During these observations, all the behavioural elements in which the animals were manipulating straw were described in the greatest detail possible. Special attention was given to describing: i) the behaviour itself, ii) the part of the body which the pig was using to perform the behaviour, iii) whether another pig was involved, iv) the bout duration and v) the location in which the behaviour was being performed. The consensus panel met (once all observations had been collected) and an ethogram was designed which contained an exhaustive list of mutually exclusive categories to describe the straw-directed and pen-mate-directed behaviour of growing pigs.

To validate the ethogram, a three hour sample of pig behaviour was recorded using a video camera which had the capability of recording high quality, real time, colour images with sound. Two representative, 10 minute, periods of behaviour were selected by an independent person to be used in the reliability assessment. These periods of behaviour were edited onto a new tape and a visual cue added which indicated when observations should start. This was important as all observers were required to watch exactly the same section of behaviour. To determine the reliability of data recording between observers, four personnel from the ADAS Terrington staff were recruited to take part in the study. Two observers were ‘experienced’ in the observation of pig behaviour and had routinely used similar ethograms for at least two years, and two observers were ‘novice’ and had never formally observed pig behaviour using an ethogram. The ‘experienced’ and ‘novice’ observers each attended two observation sessions where they were required to observe and record the behaviour of the pigs in the two clips of video. Behaviour was recorded using a hand-held computer running the Noldus Observer software which facilitated the *ad libitum* sampling of behaviour. The software required the observer to press the key on the keyboard which corresponded to the behaviour which they believed the pig was expressing. Observers were given a briefing and allowed five minutes to study the ethogram prior to testing. The order in which the clips were presented was fully randomised. After the final session, each observer was requested to complete an exit questionnaire which asked them to indicate the behavioural categories which they found difficult to distinguish. This information was subsequently used to investigate whether simplifying the ethogram in these areas resulted in a significant improvement in intra- and inter-observer reliability. At the end of each session, the resulting data were downloaded into a desktop personal computer and analysed using the reliability function of the Noldus Observer Suite, which enabled the *percentage agreement* (equation 1) between pairs of observation files to be calculated.

$$\% \text{ agreement} = (\text{number of matches} / (\text{number of matches} + \text{number of errors})) * 100 \quad (\text{Eq. 1})$$

To derive this index, the number of matching events was compared with the number of errors, however, a tolerance of two seconds was set to determine a ‘window’ in which events were coded as a match; thereby permitting a small degree of time-slippage between observers.

Where the observers had indicated in their exit questionnaire a degree of ambiguity between two or more behavioural categories these were combined into a new composite measure and new data-sets formed. The effect of such ethogram simplification was investigated by re-running the reliability analysis on the new data-sets. The resulting data were analysed by ANOVA in Genstat V (Lawes Agricultural Trust, 1987) using observer or comparison as a blocking factor.

2.3 Results

The consensus panel designed the ethogram given in Table 1 to describe the straw-directed and pen-mate-directed behaviour of growing pigs. The exit questionnaire indicated that all observers had difficulty distinguishing between ‘sniffing’ and ‘licking’, and ‘aggression’ and ‘play-fighting’. On the basis of these results, three levels of ethogram simplification were devised, the behavioural data-files modified in line with these levels, and the statistical analysis repeated at each level. The level of simplification was subsequently used as a factor in the analysis to investigate its effect on intra- and inter-observer reliability.

Table 1: *The ethogram devised by the consensus group.*

Behaviour	Description
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Behaviour	Description
<u>Straw directed elements</u>	
Mouthful	Picks up a mouthful of straw, jaws open
Pick	Picks up a piece of straw using the front of the mouth
Sniff	Sniffs at straw, moving the flat of the nasal disc across the surface of the straw
Chew	Chewing straw at the back of the mouth
Nibble	Slight chewing of straw at the front of the mouth
Push	Moves straw forward using the flat of the snout
Root	Pushes snout into straw, moving it forward and lifting it slightly with the rim of its disc
Plough	Moves forward in a straight line, pushing the straw along and parting it
Sweep	Moves the head to one side (arc-shaped movement) using the side of the snout to sweep straw along
Flick	Lifts straw up on top of the snout throwing it into the air
Paw	Pulls trotter along the floor, through the straw, whilst standing
Scrape	Pulls trotter along or through the straw towards the body whilst lying on its side
Carry	Walks with straw in mouth
Steal	Takes straw from another pig's mouth
Tug	Pulling at straw, with the mouth, which is held by an object, e.g.: straw rack
Drag	Pulls underside of snout back along straw/floor to bring the straw back towards the body
Lick	Takes pieces of straw into the mouth using the tongue
Hold	Holds straw down using a front leg so that it can manipulate it, e.g.; push or chew
Shove	Pushes straw towards another pig
Spit	Rapidly ejects straw from mouth
Fall	Passively allows straw to drop to floor from mouth
Drop	Opens mouth and actively drops straw on floor
Place	Places a mouthful of straw onto the floor
Present	Displays a mouthful of straw to another pig
Dive	Rapidly pushes snout deep into straw
Shake	Rapidly moves head from side-to-side with straw in the mouth
Other	Undefined straw manipulatory behaviours
<u>Pen-mate directed elements</u>	
Aggression	All aggressive interactions
Mounting	Mounting another pig
Belly nosing	Using the snout to massage the belly of another pig
Tail biting	Biting or chewing the tail of another pig
Ear chewing	Chewing the ear of another pig
Play fighting	Non-aggressive interactions
Sucking	Sucking any part of another pigs anatomy as though suckling milk
Licking	Licking any part of another pig
Nose	Nosing any part of another pig except the belly
Bite	Biting any part of another pig except the tail

The intra-observer reliability was significantly greater for the ‘experienced’ observers compared with the ‘novice’ observers (42.6 vs. 69.6% agreement for ‘novice’ and ‘experienced’ observers respectively; $F_{(1,18)}=30.70$; $sed=4.87$; $P<0.001$). The procedure of ethogram simplification did not have a significant effect on intra-observer reliability nor was there an interactive effect with the level of observer experience.

There was a statistically significant effect of the level of experience on inter-observer reliability (21.94, 28.53 and 28.34% agreement for ‘novice’ vs. ‘experienced’, ‘experienced’ vs. ‘experienced’ and ‘novice’ vs. ‘novice’ respectively; $sed=3.419$; $P<0.05$). There was a significant interaction between the level of experience and the session number (Figure 1; $F_{(2,54)}=6.72$; $P<0.01$), with the ‘novice’ observers performing better during the first session than the second session. On average, the procedure of ethogram simplification improved inter-observer reliability, although the absolute levels of agreement remained low and the effects of simplification were not significant (Figure 2; $F_{(2,54)}=1.65$; $P=0.202$). This effect was common to both ‘experienced’ and ‘novice’ observers and there were no significant interactions between level of simplification and experience.

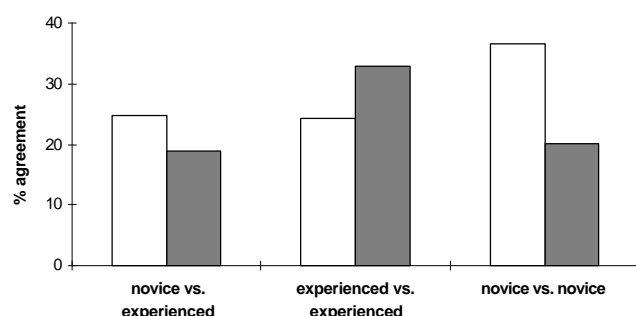


Figure 1: The interaction between level of experience and the session number (\square = session 1 and \blacksquare = session 2) and its effect on inter-observer reliability. Values represent means ($sed=4.836$).

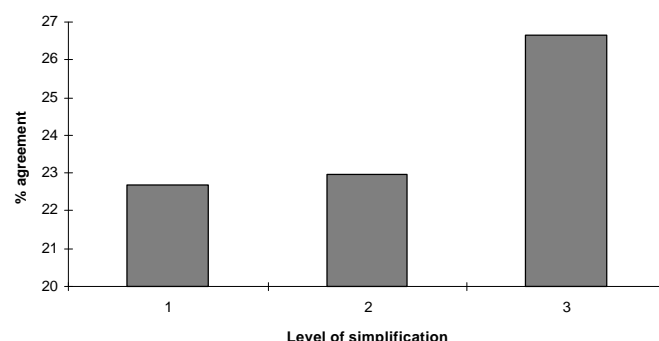


Figure 2: The effect of ethogram simplification on the level of inter-observer reliability. Values represent means ($sed=2.418$).

2.4 Discussion

The consensus panel approach was valuable as it allowed a number of different opinions to be expressed before the final ethogram was produced. This addressed areas of ambiguity prior to the initiation of data collection. Such an approach should be advocated as it helps to avoid ethograms being designed by one person and used by one or more different people, thereby creating the potential for errors in data collection.

The levels of intra-observer agreement were low, although the mean value for ‘experienced’ observers was rather higher than that for the ‘novice’ observers. It was clear that if an observer had more experience in collection of behavioural data, they were able to demonstrate higher levels of intra-observer agreement. The less reliable data recorded by the ‘novice’ observers may have resulted from the relatively higher cognitive demand of the task. Other authors have investigated experience effects and found that novice observers are less likely to make intuitive judgements about animal behaviour (Renner and Renner, 1993). They state that whilst both novices and experts use similar cognitive processes in solving problems, the expert’s knowledge is “well organised and richly interconnected, which allows for rapid problem assessment, identification of critical features, and causal analysis of problems”.

A surprising finding of the present study was the very low level of inter-observer agreement. This has important ramifications because it is possible that the reliability of data collection was reduced by the complexity of the ethogram employed. It was found that by simplifying the ethogram (e.g. merging the categories which the observers found difficult to distinguish), the mean levels of agreement tended to increase. Authors have commented previously that the formation of, so called, composite measures can sometimes yield a single more reliable measure (Kraemer, 1981; Martin and Bateson, 1986). Additional simplification may have further improved the levels of reliability. However, this was not attempted in the present study as the observers’ exit questionnaires provided no justification for the formation of further composite measures. In addition, the final ethogram would have lacked the detail necessary for the purpose for which it was designed.

The main implication of these findings is that, wherever possible, only one observer should be used when the experimental ethogram is complex, and that the personnel in question should be highly competent in the use of the experimental ethogram and data-collection method.

3. Objective 2: to investigate the (interactive) effects of previous experience of straw and the level of straw bedding on quality and quantity of substrate and pen mate manipulation.

3.1 Background

Pig welfare codes in the United Kingdom are based upon the philosophy that “animals should be free to express most normal patterns of behaviour” (MAFF, 1983). This approach has a firm scientific basis as the thwarting or channelling of motivated behaviour in barren housing environments is known to be implicated in the development of adverse behaviours (Fraser, 1987a,b; Terlouw *et al.*, 1991; Lawrence *et al.*, 1993; Rushen *et al.*, 1993; Day *et al.*, 1996a,b & 1997).

In order to combat the negative effects of barren environments on pig welfare, legislation in the UK states that “...all pigs, taking into account environment and stocking density, shall have access to straw or other

material or object suitable to satisfy those [behavioural] needs” (Statutory Instrument No. 2126: The Welfare of Livestock Regulations, 1994). Despite this, 91% of pig producers in the EU are still using fully- or part-slatted finishing pig housing systems which are barren and often preclude the expression of motivated behaviour. In the UK, 38% of finishing pigs are reared in fully-slatted systems and 38% in part-slatted systems (Hendriks *et al.*, 1998).

It is known that straw can improve the welfare of pigs housed in barren environments as it can act as a recreational and/or nutritional stimulus as well as for use as bedding (Fraser *et al.*, 1991; Arey & Bruce, 1993; Arey & Franklin, 1995; Lyons *et al.*, 1995). However, the use of straw bedding is not universally adopted as it is not compatible with fully- or part-slatted slurry systems, is not readily available in some areas, and can be quite costly. There is, therefore, a requirement to develop systems or types of environmental enrichment which improve pig welfare to the same (or larger) degree as straw bedding. However, it is first necessary to investigate which properties of straw bedding are behaviourally advantageous, before these can be incorporated into environmental modification or enrichment programmes. Whilst it is believed that straw improves pig welfare, because it allows pigs to express foraging/exploratory behaviours, it is currently not known how this improvement is achieved. Information is required on which behavioural elements pigs need to be able to perform, for example, is the quality of behaviour which pigs can direct towards the substrate important and does a small quantity of straw achieve the same welfare improvement as a deep straw bed?

A secondary, and again currently unknown issue, is whether the provision of straw bedding at different stages of the pigs’ development will affect their subsequent behaviour. This may have implications for producers who use chopped straw in the farrowing house, but subsequently house the pigs in fully- or part-slatted systems until slaughter. It could be argued that pigs exposed to straw in early life may develop different behavioural needs to pigs which do not have a similar early experience.

To attempt to address some of these issues, it was hypothesised in this study that; i) prior experience of straw affects the subsequent behaviour of growing pigs and that ii) straw bed depth affects the quality and quantity of straw-directed behaviour. The aim of this experiment was to test these hypotheses by exposing pigs which had, or had not, had prior experience of straw to four levels of straw bed depth (barren, minimal, substantial or deep). It was predicted that pigs which had prior experience of straw would develop more adverse behaviours when moved into barren accommodation, than would pigs which had no prior experience of straw. Furthermore, both the quantity and quality of straw-directed behaviour would increase with increasing depth of straw bed.

3.2 Methodology

The experimental subjects were 32 groups of 10 growing/finishing pigs. These groups were selected with a mean initial live weight of 27.2 kg (standard deviation (SD)=2.49 kg), and were balanced with respect to gender. Either two males and one female animal, or two females and one male animal were randomly selected from each group to serve as focal animals such that, across the entire experiment, there were six focal animals of each gender represented within each of the experimental treatments. Prior to selection, the pigs had either experienced continual access to straw bedding, or had never experienced straw bedding from birth.

The experimental building was an automatically controlled naturally ventilated (ACNV) unit which contained 12 pens measuring 6.5 x 2.0 m. Six pens were located on either side of a central access passageway. The pens had an insulated, solid concrete floor which sloped at an angle of 15 degrees to a dunging passage. The sides of the pens were constructed from solid panels so that the sight of, and tactile contact with, other pigs was impossible. The thermostat in the building was set to 17°C, and achieved a daily mean temperature of 17.5°C (SD=1.88). Throughout the experiment, the animals were exposed to a 12h:12h light regime (with lights on at 0700h, however, it should be noted that ambient day-light would have illuminated the building if sun-rise occurred prior to the lights being switched on). Each group had unrestricted, *ad libitum*, access to both food and water. The pigs were offered a growing pig diet (Optima 15/50, Dalgety Agriculture Ltd., UK) until the mean body weight of the group was judged to be approximately 50 kg, after which a finishing pig diet (Optima 50, Dalgety Agriculture Ltd., UK) was offered until slaughter. The pens in the experimental unit were cleaned between 0800h and 0900h on Monday and Wednesday and Friday when all soiled straw was removed and the dunging passage cleared.

A 2 x 4 factorial design was used to investigate the separate and interactive effects of prior experience of straw and straw bed depth on growing pig behaviour; with two levels of prior experience N: no prior

experience of straw, and S: prior experience of straw, and four levels of straw bed depth (N: none, M: minimal, S: substantial, and D: deep). Each of the eight treatments was replicated four times.

Pigs exposed to the NN and SN treatments were housed in a pen in which no straw bedding was provided. Each day, NM and SM groups were provided with one bucket of straw (mean weight=0.92kg; SD=0.16), NS and SS groups were provided with one section of a straw bale (mean weight=10.92kg; SD=0.52), and ND and SD groups were provided with two sections of a straw bale (mean weight=21.84kg; SD=1.04).

The behaviour of the focal animals in each group was sampled using two methodologies; i) direct *ad libitum* sampling, and ii) time sampling from 24h video-tapes. Details of each type of sampling methodology can be found in Martin and Bateson (1986), and the experimental ethogram is given in Table 1.

The *ad libitum* sampling of behaviour involved an observer watching each of the focal pig's behaviour each week for 10 minutes. The observer was required to record every occurrence of each behavioural element in the ethogram. This gave an indication of overall activity and the relative proportions of that activity which each behavioural element comprised. To facilitate this process the Noldus Observer program was used running on a hand-held computer, and, to increase the accuracy of these data, each focal animal was observed by two observers each week.

The time sampling of behaviour involved observing previously recorded video-tapes. During weeks one, five and 9 the behaviour of each group was video-taped for one full 24 hour period. The day of the week on which the video was recorded was randomised. To facilitate the capture of video images during the night, infra-red floodlights and cameras with infra-red capability were used to ensure that behaviour could be observed once the lights had been switched off. The behaviour from these video tapes was captured using time sampling with a 10 minute interval (such that 144 observations of behaviour were made in the 24h period). A dedicated computer package was used to take records of; i) the numbers of pigs active, ii) the numbers of pigs engaged in straw-directed behaviour and iii) the numbers of pigs engaged in pen-mate-directed behaviour.

Pigs were observed for a period of 10 weeks. Pigs were weighed on entry to the experimental building and moved into their pen which had already been bedded with the appropriate quantity of straw. Fresh straw was added daily, and the amount of straw provided was under constant review to ensure that variations in straw usage were responded to appropriately to maintain the target bed depth. At the end of the trial each group was weighed.

The *ad libitum* sampled behavioural observations were collated to yield a data-set containing the total number of times each behavioural element was observed within each session. An index of total activity was derived by calculating the sum of observations within each session. This index was used to express each behavioural element as the proportion of total activity. These data were transformed to meet the requirements of parametric statistics, and each element subjected to a one-tailed t-test to determine whether its overall distribution differed significantly from zero. Bonferroni correction was used to compensate for the likelihood of encountering a type I error which could have resulted from the large number of tests conducted. Behavioural elements which failed this test were excluded from the analysis or combined to form a composite category of behaviour. The time sampled behavioural observations were collated to yield a data-set containing; i) the total number of pigs active per scan, ii) the total number of pigs observed interacting with straw per scan, and iii) the total number of pigs interacting with other pigs per scan. Each of these variates was expressed as the proportion of total scans and the proportion of total active scans. These data were normally distributed and met the requirements of parametric statistics without transformation. The experimental data were analysed using repeated measures ANOVA in GENSTAT V (Lawes Agricultural Trust, 1987).

3.3 Results

The frequency at which the different behavioural elements in the ethogram occurred during the *ad libitum* sampling of behaviour was found to be variable, and low in many cases. Analyses of these data indicated that the frequency at which the categories; carry, hold, drag, shake, scrape, other, steal, shove, spit, dive, present and place occurred did not differ significantly from zero. As these behavioural elements did not, intuitively, have any functional similarities, they were not combined to form composite categories and were excluded from the analysis. It should be noted, however, that the use of t-tests in this manner did permit certain behavioural elements which possessed a low frequency and low variance (e.g. flick and tug) to be included in the final analyses. In the *ad libitum* sampled data-set, overall levels of activity were not significantly affected by either prior experience of straw, straw bed depth, time, or any interactions thereof.

The *ad libitum* sampling of behaviour revealed no significant main effects of prior experience on any of the behavioural elements analysed (Tables 2 and 3).

Table 2: The effect of straw bed depth and prior experience on straw-directed behaviour. Values represent the mean proportion of active behaviour observed during *ad libitum* sampling. + = $P < 0.1$

Behaviour	Straw (S)				Experience (E)			Effects		
	Minimal	Substantial	Deep	SED	Yes	No	SED	S	E	S x E
<u>Straw-directed behaviours</u>										
Mouthful	0.0002	0.0006	0.0007	0.00027	0.0006	0.0004	0.00022			
Pick	0.0017	0.0017	0.0020	0.00049	0.0018	0.0018	0.00040			
Sniff	0.0253	0.0303	0.0320	0.00432	0.0293	0.0291	0.00353			
Chew	0.0282	0.0252	0.0244	0.00242	0.0248	0.0271	0.00198			
Nibble	0.0086	0.0108	0.0118	0.00196	0.0091	0.0117	0.00160			
Push	0.0143	0.0132	0.0126	0.00251	0.0139	0.0128	0.00205			
Root	0.0003	0.0034	0.0076	0.00088	0.0040	0.0035	0.00072	***		
Plough	0.0001	0.0011	0.0004	0.00023	0.0007	0.0004	0.00019	***		
Sweep	0.0004	0.0009	0.0009	0.00024	0.0008	0.0006	0.00020	+		
Flick	0.0001	0.0001	0.0003	0.00009	0.0002	0.0001	0.00007	+		
Paw	0.0006	0.0005	0.0007	0.00026	0.0008	0.0004	0.00021			
Tug	0.0001	0.0001	0.0000	0.00003	0.0001	0.0000	0.00002			
Lick	0.0230	0.0191	0.0162	0.00321	0.0214	0.0175	0.00262			
Fall	0.0001	0.0000	0.0002	0.00005	0.0001	0.0001	0.00004			
Drop	0.0006	0.0006	0.0008	0.00015	0.0007	0.0006	0.00012			

Table 3: The effect of straw bed depth and prior experience on pen-mate-directed behaviour. Values represent the mean proportion of active behaviour observed during *ad libitum* sampling.

Behaviour	Straw (S)					Experience (E)			Effects		
	None	Minim	Subst	Deep	SED	Yes	No	SED	S	E	S X E
<u>Pen-mate-directed behaviours</u>											
Aggression	0.01832	0.0075	0.0090	0.0080	0.00241	0.0109	0.0105	0.00171	***		
Mounting	0.00171	0.0004	0.0016	0.0013	0.00064	0.0014	0.0012	0.00045			
Belly nosing	0.00578	0.0022	0.0027	0.0020	0.00076	0.0030	0.0034	0.00054	***		
Tail biting	0.00295	0.0004	0.0005	0.0002	0.00042	0.0012	0.0008	0.00030	***		
Ear chewing	0.00928	0.0022	0.0021	0.0022	0.00110	0.0035	0.0043	0.00078	***		
Play fighting	0.01367	0.0066	0.0053	0.0076	0.00267	0.0067	0.0099	0.00189	*		
Sucking	0.00550	0.0043	0.0012	0.0023	0.00236	0.0032	0.0035	0.00167			
Licking	0.00768	0.0018	0.0013	0.0016	0.00100	0.0033	0.0029	0.00070	***		
Nosing	0.06532	0.0208	0.0198	0.0156	0.00317	0.0315	0.0293	0.00224	***		
Biting	0.00609	0.0017	0.0012	0.0008	0.00074	0.0018	0.0031	0.00053	***		**

The time sampling of behaviour indicated that the proportion of active observations in which pigs were observed interacting with straw was significantly affected by their prior experience of straw (Figure 3: $F_{(1,18)}=4.89$; $P < 0.05$).

From Table 2, it can be seen that straw bed depth significantly affected the proportion of total observations in which pigs were observed to be rooting ($F_{(2,18)}=34.38$; $P < 0.001$) and ploughing ($F_{(2,18)}=10.65$; $P < 0.001$), and there was a tendency for straw bed depth to affect the proportion of total observations in which pigs were observed to be sweeping ($F_{(2,18)}=3.16$; $P=0.067$) and flicking ($F_{(2,18)}=3.16$; $P=0.067$). In addition to the effects on straw directed behaviour, Table 3 shows that straw bed depth significantly affected the proportion of total observations in which pigs were observed to be engaged in aggression ($F_{(3,24)}=9.00$; $P < 0.001$), belly nosing ($F_{(3,24)}=10.81$; $P < 0.001$), tail-biting ($F_{(3,24)}=19.32$; $P < 0.001$), ear chewing ($F_{(3,24)}=21.07$; $P < 0.001$), play fighting ($F_{(3,24)}=3.83$; $P < 0.05$), licking other pigs ($F_{(3,24)}=19.05$; $P < 0.001$), nosing other pigs ($F_{(3,24)}=108.69$; $P < 0.001$), and biting other pigs ($F_{(3,24)}=21.68$; $P < 0.001$); effects which stemmed mainly from the difference between the treatments where straw was and was not provided.

The proportion of the total number of observations in which pigs were active was significantly affected by straw bed depth ($F_{(3,24)}=9.63$; $P < 0.001$). The mean values were (0.0020, 0.0023, 0.0023 and 0.0026 for N, M, S and D respectively; SED=0.00012). Furthermore, Figure 4 indicates that the proportion of active

observations in which pigs were manipulating pen-mates was also significantly affected by straw bed depth ($F_{(3,24)}=19.58$; $P<0.001$).

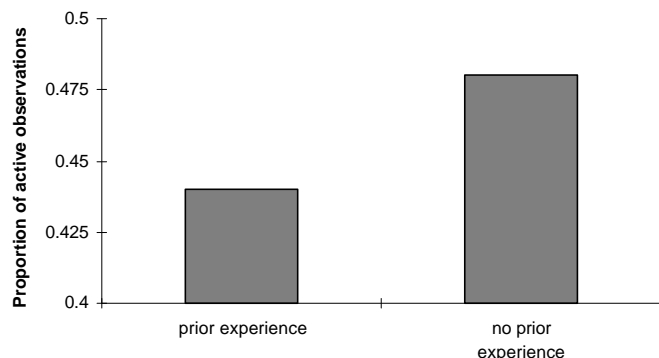


Figure 3: The effect of prior experience of straw on the proportion of active observations in which pigs were observed interacting with straw ($sed=0.02$).

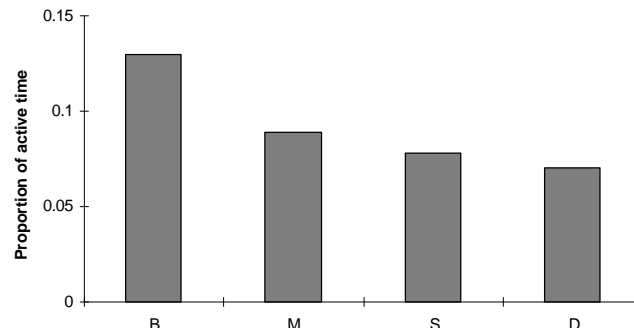


Figure 4: The effect of straw bed depth on the proportion of active time spent interacting with pen-mates ($sed=0.086$).

The proportion of active observations in which pigs were observed in straw-directed behaviour was also significantly affected by straw bed depth ($F_{(2,18)}=8.64$; $P<0.01$; mean values: 0.42, 0.45 and 0.52 for M, S and D respectively; $SED=0.024$).

There were significant effects of week on the proportion of total observations in which pigs were observed to be engaged in the straw directed categories pick ($F_{(9,983)}=3.33$; $P<0.001$), sniff ($F_{(9,983)}=2.38$; $P<0.05$), chew ($F_{(9,983)}=1.93$; $P<0.05$), nibble ($F_{(9,983)}=$; $P<0.05$), root ($F_{(9,983)}=2.13$; $P<0.05$), or fall ($F_{(9,983)}=2.16$; $P<0.05$). However, for all of these effects, there was a significant interaction with one of the other experimental factors. In addition, there were significant effects of week on the proportion of total observations in which pigs were observed to be engaged in the pen-mate-directed categories aggression ($F_{(9,1245)}=2.75$; $P<0.01$), mount ($F_{(9,1245)}=1.89$; $P<0.05$), tail-bite ($F_{(9,1245)}=2.98$; $P<0.01$), ear-chew ($F_{(9,1245)}=4.35$; $P<0.001$), play-fight ($F_{(9,1245)}=9.98$; $P<0.001$), lick ($F_{(9,1245)}=4.13$; $P<0.001$), nose ($F_{(9,1245)}=3.46$; $P<0.001$), and bite ($F_{(9,1245)}=2.61$; $P<0.01$). For all of these effects, except aggression, there was a significant interaction with one of the other experimental factors.

There were a number of two-way and three-way interactions detected in the analysis, and many of these were not instantly informative. However, from Figure 5 it can be seen that the pen-mate directed biting was subject to a significant interaction between prior experience x straw bed depth ($F_{(3,24)}=6.14$; $P<0.01$). The straw-directed behavioural elements pick, sniff, chew, and fall were subject to a significant straw bed depth x time interaction. The behavioural elements chew and nibble were subject to a significant prior experience x time interaction, and sniff was subject to a significant prior experience x straw bed depth x time interaction. The pen-mate-directed behavioural elements tail-bite, ear chew, play fight, lick, and nose were subject to a straw bed depth x time interaction. The behavioural elements tail-bite (see Figure 6), play fight, and lick were subject to a significant prior experience x time interaction, and mount, ear chew, play fight, lick, nose, and bite were subject to a significant straw bed depth x prior experience x time interaction.

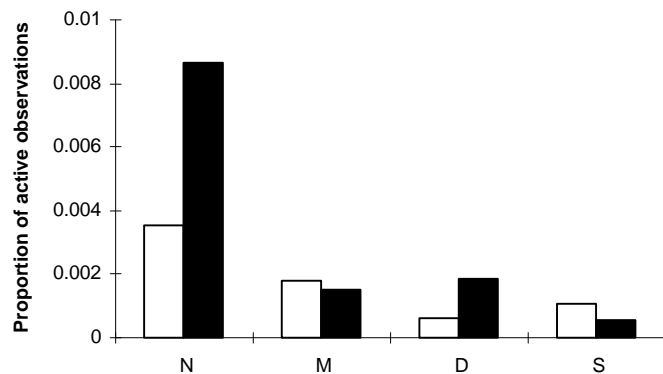


Figure 5: The interactive effects of prior experience and straw bed depth on the proportion of active observations in which groups were biting their pen-mates ($sed=0.001$). Values represent means for groups which have had prior experience of straw (), or have had no prior experience of straw ().

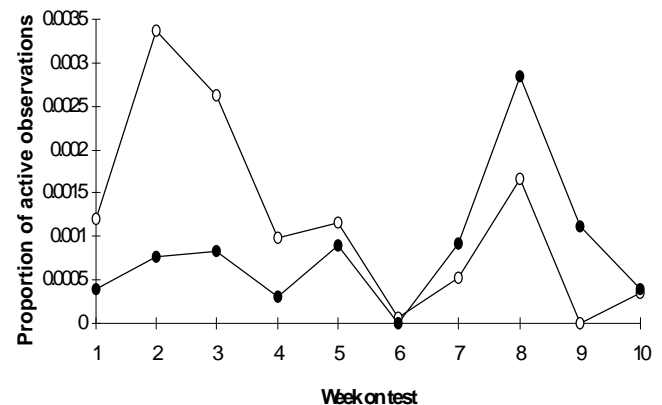


Figure 6: The interactive effect of prior experience and time on the occurrence of tail-biting. Values represent mean values ($sed=0.0009$) of groups which have had prior experience of straw (•) or have had no prior experience of straw (o).

3.4 Discussion

Groups of pigs with prior experience of straw bit other pigs more in barren environments than groups of pigs with no such prior experience. There were no other detectable statistically significant interactions on the other pig-directed behaviours, however, in contrast to biting behaviour, it was found that the expression of tail-biting and nosing of other pigs was elevated in the first three weeks of the experiment when pigs had not had prior experience of straw. The effect of prior experience on tail-biting was interesting as the differences between levels of prior experience were most noticeable in the initial phases of the experiment, and also coincided with changes to the diets which the pigs were offered. This may indicate that the pigs from barren environments reacted to the straw as a novel stimulus and were generally more active, or had previously learned tail-biting as a feeding strategy to redress specific nutrient deficiencies (Fraser, 1987a,b; Day *et al.*, 1996a,b; Day *et al.*, 1998).

Theories of behavioural development have suggested that an animal's early life environment is important as it may determine its behavioural needs later in life (Beattie *et al.*, 1995; Simonsen, 1995). The results of the present experiment are consistent with these theories in that it was likely to be the change in straw availability between environments, and not the straw *per se*, which exerted an influence on pig behaviour.

Other theories suggest that straw bedding enhances pig welfare as it acts as an outlet for nosing, rooting and chewing behaviours which, in barren environments, would be 'channelled' towards inappropriate stimuli such as pen-mates (Fraser *et al.*, 1987a,b; Terlouw *et al.*, 1991; Lawrence *et al.*, 1993; Rushen *et al.*, 1993; Day *et al.*, 1996a,b & 1997). It is particularly striking that it was the provision of straw *per se*, rather than an increasing depth of straw, that reduced the occurrence of many adverse behaviours. Decreases in the rooting and chewing pen-mates has been observed elsewhere as a result of straw provision (Fraser *et al.*, 1991) and the present results further confirm the benefits of straw bedding to pig welfare. However, the results of the current experiment confirm that an increasing depth of straw bed results in an increase in the expression of rooting, ploughing, sweeping and flicking behaviours. Whilst an increase in the occurrence of such behaviours could be argued to be an artefact of the animals' increasing ability to perform them, there was a concomitant decrease in behaviours such as the biting and nosing of other pigs.

The total number of observations in which pigs were interacting with straw increased with increasing straw depth. This suggested that, within the constraints of the present experimental design, the quantity of straw-directed behaviour was proportional to the amount of straw provided. The depth of straw bed did not exert a large effect on the relative occurrence of the different behavioural elements in the ethogram. However, the types of behavioural elements which were enhanced when pigs had access to more straw were rooting, ploughing, sweeping and flicking. The expression of such behaviours would have been constrained in the minimal straw treatment and these effects may have merely reflected an inability for an individual to root or plough a small quantity of straw.

There was a significant interaction between time and prior experience for the behavioural elements chew and nibble straw. Groups of pigs which had not had prior experience of straw expressed these behaviours at a higher level than groups which had prior experience of straw. It was also found that pigs with no prior experience of straw were more likely to be engaged in straw-directed activity than pigs with prior experience of straw. This suggests that the value of straw as an enrichment substrate may be influenced by an individual's prior experience of straw.

4. Objective 3: to investigate the effect of straw length on quality and quantity of substrate manipulation, and on levels of pen mate manipulation.

4.1 Background

Despite the knowledge that the provision of straw can enhance pig welfare, and the increase in consumer demand for higher standards of welfare, the use of straw bedding has not been universally adopted. This may be due largely to its incompatibility with housing systems containing perforated flooring, and 91% of pig producers in the EU, and 76% of pig producers in the UK currently use fully- or part-slatted finishing housing systems (Hendriks *et al.*, 1998). Furthermore, straw is not readily available in some geographic areas, and its provision in substantial quantities may be costly. To address this problem, and to assist producers in better meeting legislative requirements, previous research has investigated the properties of straw bedding which are behaviourally rewarding to pigs. The acquisition of such knowledge is necessary to facilitate the construction of environmental enrichment devices which meet the behavioural needs of pigs, whilst also being compatible with part- and fully-slatted housing systems. The aim of this study, however, was to investigate whether different lengths of chopped straw would achieve equal enhancements in pig welfare. The rationale behind this aim was to explore the possibility of providing pigs with small quantities of chopped straw, as opposed to unchopped straw, in part- and fully-slatted systems, thereby avoiding blockage of the liquid slurry handling facilities.

To achieve this aim, groups of growing pigs were exposed to one of four treatments where the length of chopped straw varied (no straw, unchopped straw, half chopped straw, and fully chopped straw). The experimental hypotheses predicted that the provision of straw, irrespective of its length, would reduce the expression of adverse pen-mate directed behaviours, and that an increasing length of straw would increase both the quantity and quality of straw-directed behaviours.

4.2 Methodology

The experimental animals were 24 groups of 10 growing pigs. These groups were balanced with respect to gender, and had a mean initial live weight of 28.3 kg (SD=3.15). The animals had gained prior experience of straw bedding in the farrowing crate, but had been housed in unstrawed flat-deck accommodation from weaning until they were selected for use on the trial. This type of prior experience has been shown previously to affect a pig's behaviour (Day *et al.*, 2000b) and is now becoming an important consideration in this type of study (Beattie *et al.*, 1995; Simonsen, 1995). Two male and two female pigs in each group were randomly selected to serve as focal animals for behavioural measurements.

The experimental building was the same as used for objectives 1 and 2, and soiled straw was removed from the experimental pens between 0800h and 0900h on Mondays, Wednesdays and Fridays. The environmental temperature was set to 20°C, prior to pigs entering the building, and this was maintained for two weeks after which it was reduced to 17°C for the following eight weeks of the trial. Pigs were offered a medicated grower diet (Optima 15/50, Dalgety Agriculture Ltd., UK) until the average weight of the pen was approximately 55kg, when a finisher diet (Optima 50, Dalgety Agriculture Ltd., UK) was offered until the end of the trial.

The experiment used a between-subjects, randomised complete block design to investigate the effect of four different straw lengths (N: none, F: full unchopped, H: half chopped, C: fully chopped) on the quality and quantity of both straw-directed and pen-mate-directed manipulation. There were six replicates of each of the four treatments. For statistical purposes the group was regarded as the experimental unit.

On the first day of testing, each group requiring the provision of straw was given 8kg of either unchopped, half chopped or fully chopped straw. Subsequently, these groups received 4kg per day of the same straw treatment until the end of the trial period. For all groups, straw was added to the top of the pen at 0900h.

Pigs on treatment F received good quality long straw. Pigs on treatment H received half chopped straw produced by passing sections of straw through the low grade filter on a portable straw chopper. Pigs on

treatment C received chopped straw produced by passing sections of straw through the high grade filter of a static straw chopper.

Each week, six grab samples were randomly collected from each of the straw treatments. Each sample was sorted into length categories of either 1-10mm, 11-40mm, 41-70mm or 71+mm. The sorted samples were then weighed and the data expressed as the proportion of the total sample weight. The mean values are given in Table 4.

Table 4: *The distribution of straw chop lengths used in the experiment.*

Treatment	Percentage of total sample			
	1-10mm	11-40mm	41-70mm	71+ mm
F	0.79 ±0.150	3.67 ±0.520	10.16 ±1.101	85.37 ±1.590
H	8.18 ±1.016	40.07 ±1.268	32.13 ±1.270	19.61 ±1.101
C	27.36 ±1.969	53.58 ±1.509	16.47 ±1.436	2.59 ±0.393

The pigs were housed in the experimental building for a period of 10 weeks. Upon selection, each group of pigs was randomly assigned to one of the four treatments and to a pen within the experimental building.

Behaviour was recorded on weeks one, four, 7 and 10 using both time and *ad libitum* sampling methods (Martin and Bateson, 1986). An experimental ethogram which detailed an animal's behaviour towards straw and its pen-mates was used for both sampling methodologies (Table 1).

The time sampling of behaviour involved observing the four focal animals within each group concurrently for 60 minutes. Within this observation period, and at exactly five minute intervals, the behavioural element which each focal animal was expressing was noted such that 12 samples were collected per animal. These observations were conducted either between 1000-1100h, or 1400-1500h, and the overall distribution of observation times was balanced within each treatment.

The *ad libitum* sampling of behaviour involved watching one focal animal within a group for a six minute period and noting whenever it expressed one of the behavioural elements within the ethogram. Observations were conducted on weeks one, four, 7 and 10 weeks between 1300h and 1540h. The order in which focal animals were observed was randomised. The Noldus Observer program running on a hand-held computer was used to facilitate behavioural data capture. The same observer carried out all of the behavioural observations to ensure that inter-observer variation was eliminated (see Day *et al.*, 2000a).

Both the time and *ad libitum* sampled behavioural observations were collated to yield data-sets containing the total number of times each behavioural element was observed within each session. An index of total activity was derived by calculating the sum of active observations within each session. This index was used to express each behavioural element as the proportion of total activity. These data were transformed to meet the requirements of parametric statistics, and each element subjected to a one-tailed t-test to determine whether its overall distribution differed significantly from zero. Bonferroni correction was used to compensate for the likelihood of encountering a type I error which could have resulted from the large number of tests conducted. Behavioural elements which failed this test were excluded from the analysis or combined to form a composite category of behaviour. The experimental data were analysed using repeated measures ANOVA in GENSTAT V (Lawes Agricultural Trust, 1987).

4.3 Results

The frequency at which the different behavioural elements in the ethogram occurred during the time and *ad libitum* sampling of behaviour was found to be variable, and low in many cases. Analyses of the time sampled data indicated that the frequency at which the categories flick, paw, scrape, carry, steal, tug, drag, lick, hold, shove, spit, fall, drop, place, present, dive, shake, other, mount, tail-bite, ear-chew suck, lick and bite occurred did not differ significantly from zero. Similarly, analyses of the *ad libitum* sampled data indicated that the frequency at which the categories root, plough, paw, scrape, carry, steal, tug, drag, hold, shove, spit, fall, place, present, dive, shake, other, mount, suck and bite occurred did not differ significantly from zero. As such, these behavioural elements were excluded from further analysis. General levels of activity were found to be significantly affected by straw treatments in the *ad libitum* sampled data-sets ($F_{(2,15)}=12.87$; $P<0.001$). The mean levels of activity were 90.2, 80.7 and 19.3 behavioural observations per 6 minute period for F, H and C groups respectively (sed=15.18). In addition, activity levels also decreased over time ($F_{(3,197)}=10.19$;

$P < 0.001$). The mean values were 92.9, 73.8, 43.8 and 43.2 behavioural observations per 6 minute period for weeks one, four, 7 and 10 respectively ($sed = 10.76$).

The time sampling of behaviour (Table 5) revealed that belly-nosing ($F_{(3,20)} = 3.88$; $P < 0.05$), pick ($F_{(2,15)} = 4.46$; $P < 0.05$) and rooting ($F_{(2,15)} = 12.79$; $P < 0.001$) were significantly affected by the experimental treatments. The *ad libitum* sampling of behaviour (Table 6) revealed that aggression ($F_{(3,20)} = 6.46$; $P < 0.01$), tail-biting ($F_{(3,20)} = 4.11$; $P < 0.05$), nosing other pigs ($F_{(3,20)} = 72.74$; $P < 0.001$), chew ($F_{(2,15)} = 14.12$; $P < 0.001$) and drop straw ($F_{(2,15)} = 18.90$; $P < 0.001$) were significantly affected by the experimental treatments.

Table 5: A summary of the results and main effects from the time sampled dataset. The mean values represent the proportion of active scans in which an individual was observed performing the separate behavioural elements in the ethogram.

Behaviour	Treatment (T)					Week (W)					Significance		
	N	F	H	C	SED	1	4	7	10	SED	T	W	T x W
<u>Pen-mate</u>													
Aggression	0.0195	0.0059	0.0086	0.0062	0.00389	0.0100	0.0109	0.0145	0.0048	0.00207	**	***	***
Belly-nose	0.0060	0.0017	0.0015	0.0023	0.00153	0.0020	0.0022	0.0041	0.0032	0.00125	*		
Play-fight	0.0026	0.0020	0.0024	0.0038	0.00152	0.0056	0.0027	0.0011	0.0015	0.00100		***	*
Nose	0.0077	0.0167	0.0202	0.0187	0.00586	0.0279	0.0318	0.0278	0.0453	0.00305	***	***	***
<u>Straw</u>													
Mouthful	-	0.0009	0.0014	0.0006	0.00072	0.0014	0.0002	0.0011	0.0012	0.00084			
Pick	-	0.0007	0.0042	0.0011	0.00184	0.0058	0.0053	0.0024	0.0024	0.00137	*	*	
Sniff	-	0.0312	0.0342	0.0324	0.00507	0.0438	0.0334	0.0271	0.0261	0.00371		***	
Chew	-	0.0382	0.0334	0.0367	0.00502	0.0312	0.0321	0.0399	0.0411	0.00376		*	*
Nibble	-	0.0076	0.0073	0.0070	0.00267	0.0132	0.0057	0.0062	0.0040	0.00180		***	
Push	-	0.0163	0.0162	0.0187	0.00353	0.0149	0.0202	0.0176	0.0156	0.00266			
Root	-	0.0057	0.0004	0.0014	0.00111	0.0034	0.0023	0.0028	0.0017	0.00118	***		
Plough	-	0.0014	0.0003	0.0019	0.00097	0.0026	0.0007	0.0014	0.0000	0.00088		*	
Sweep	-	0.0010	0.0013	0.0006	0.00071	0.0002	0.0024	0.0008	0.0006	0.00078		*	

Table 6: A summary of the results and main effects from the *ad libitum* sampled dataset. The mean values represent the proportion of active observations in which an individual was observed performing the separate behavioural elements in the ethogram.

Behaviour	Treatment (T)					Week (W)					Significance		
	N	F	H	C	SED	1	4	7	10	SED	T	W	T x W
<u>Pen-mate</u>													
Aggression	0.0115	0.0117	0.0167	0.0358	0.00641	0.0107	0.0235	0.0286	0.0128	0.00441	**	***	
Belly-nose	0.0013	0.0017	0.0030	0.0021	0.00182	0.0006	0.0020	0.0006	0.0047	0.00130		**	*
Tail-bite	0.0000	0.0001	0.0007	0.0013	0.00043	0.0004	0.0003	0.0009	0.0006	0.00035	*		
Ear-chew	0.0014	0.0014	0.0004	0.0033	0.00118	0.0020	0.0004	0.0010	0.0032	0.00088		**	*
Play-fight	0.0011	0.0039	0.0024	0.0079	0.00249	0.0098	0.0023	0.0015	0.0016	0.00194		***	***
Lick	0.0010	0.0010	0.0023	0.0034	0.00136	0.0025	0.0003	0.0003	0.0045	0.00107		***	***
Nose	0.0181	0.0198	0.0202	0.0745	0.00457	0.0294	0.0334	0.0292	0.0406	0.00402	***	*	
<u>Straw</u>													
Mouthful	-	0.0005	0.0003	0.0000	0.00018	0.0006	0.0003	0.0000	0.0001	0.00013		***	*
Pick	-	0.0017	0.0003	0.0000	0.00017	0.0016	0.0005	0.0004	0.0002	0.00022	***	***	***
Sniff	-	0.0316	0.0352	0.0000	0.00545	0.0302	0.0236	0.0188	0.0166	0.00333	***	***	***
Chew	-	0.0333	0.0245	0.0000	0.00649	0.0196	0.0254	0.0127	0.0195	0.00426	***	*	
Nibble	-	0.0066	0.0035	0.0000	0.00194	0.0101	0.0014	0.0024	0.0000	0.00154	*	***	***
Push	-	0.0153	0.0141	0.0000	0.00376	0.0039	0.0066	0.0192	0.0096	0.00247	**	***	***
Sweep	-	0.0007	0.0005	0.0000	0.00032	0.0008	0.0005	0.0004	0.0001	0.00028			
Flick	-	0.0002	0.0002	0.0000	0.00015	0.0000	0.0001	0.0001	0.0003	0.00016			
Lick	-	0.0122	0.0217	0.0000	0.00408	0.0093	0.0083	0.0157	0.0012	0.00304	***		**
Drop	-	0.0003	0.0000	0.0000	0.00006	0.0002	0.0001	0.0001	0.0000	0.00008	***		

The mean values indicated that aggression increased as the length of the straw provided decreased. In the time sampled data-set, belly-nosing was much higher in N groups than F, H and C groups. Tail-biting, however, was higher in F, H and C groups than N groups, and increased as the length of chopped straw decreased. The rooting, chewing and dropping of straw decreased as the length of chopped straw decreased.

The only time and *ad libitum* sampled pen-mate directed behaviour which was subject to an effect of week was nosing (Table 5: $F_{(3,207)} = 3.50$; $P < 0.05$), although this effect was not instantly informative. In addition to

the pen-mate directed behaviours, it was found that pick ($F_{(3,498)}=3.63$; $P<0.05$), sniff ($F_{(3,498)}=9.57$; $P<0.001$), nibble ($F_{(3,498)}=10.07$; $P<0.001$), plough ($F_{(3,498)}=2.98$; $P<0.05$) and sweep ($F_{(3,498)}=3.13$; $P<0.05$) straw were significantly affected by week in the time sampled data-set (Table 5). The mean values for these effects indicated that, in general, the behaviours decreased in prevalence across weeks.

Interactions between treatment and week are useful indicators as to when the effects of time (such as those associated with behavioural development) differ significantly between treatments. In the time sampled data it was found that levels of aggression ($F_{(9,584)}=7.76$; $P<0.001$), play fighting ($F_{(9,584)}=1.97$; $P<0.05$), and nosing ($F_{(9,584)}=7.73$; $P<0.001$) were subject to such an interaction. The two most notable effects were aggression, where it was found that N groups were most aggressive during week one (Figure 7a), and nosing, where N groups interacted with other pigs at a consistently higher level than their H, F and C counterparts (Figure 7b).

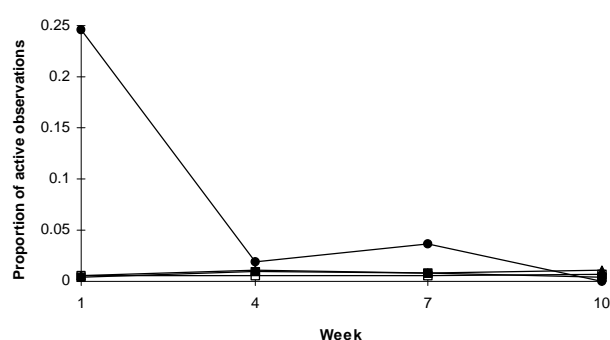


Figure 7a: The interaction between treatment and week on the level of aggression ($sed=0.0053$). Values represent means for N (---), F (- - -), H (- · -) and C (- ■ -) respectively.

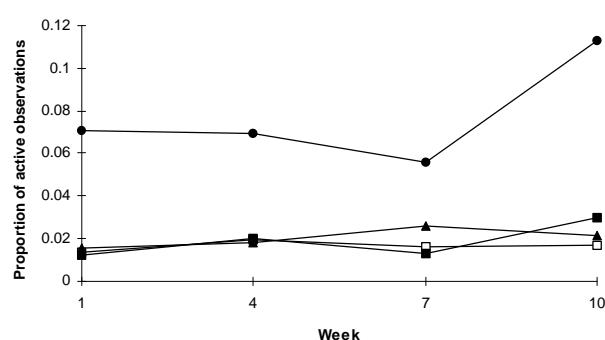


Figure 7b: The interaction between treatment and week on the level of nosing observed during time sampling ($sed= 0.0079$). Values represent means for N (---), F (- - -), H (- · -) and C (- ■ -) respectively.

In addition to the pen-mate directed behaviours, it was found that chewing straw was subject to a significant treatment x week interaction ($F_{(3,498)}=$; $P<0.05$). The mean values indicated that the interaction arose due to an increase in chewing between weeks one and four in the F groups, and a decrease during the same period for the H and C groups.

In the *ad libitum* sampled data-set significant interactions were found for the pen-mate directed behavioural elements belly-nosing ($F_{(3,207)}=2.08$; $P<0.05$), ear-chewing ($F_{(3,207)}=2.31$; $P<0.05$), play-fighting ($F_{(3,207)}=5.84$; $P<0.001$), and licking ($F_{(3,207)}=5.84$; $P<0.001$). The most notable of these effects was that of play fighting where C groups exhibited the behaviour at an elevated rate during week one (Figure 8). The other interactions were, again, not instantly informative.

In addition to the pen-mate directed behaviours found in the *ad libitum* sampled data-set, mouthful ($F_{(6,154)}=2.55$; $P<0.05$), pick ($F_{(6,154)}=8.52$; $P<0.001$), sniff ($F_{(6,154)}=4.18$; $P<0.001$), nibble ($F_{(6,154)}=7.86$; $P<0.01$), push ($F_{(6,154)}=6.77$; $P<0.001$), and lick ($F_{(6,154)}=3.13$; $P<0.01$) were subject to a significant treatment x week interaction. The mean values for mouthful (Figure 9a), pick (Figure 9b) and nibble (Figure 9c) indicate that the rate of decrease of these behaviours over time is a function of the length of the chopped straw.

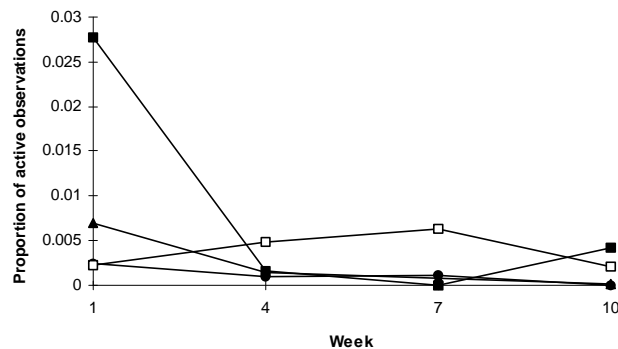


Figure 8: The interaction between treatment and week on the level of play-fighting ($sed=0.0042$). Values represent means for N (---), F (-.-), H (-D-) and C (-■-) respectively.

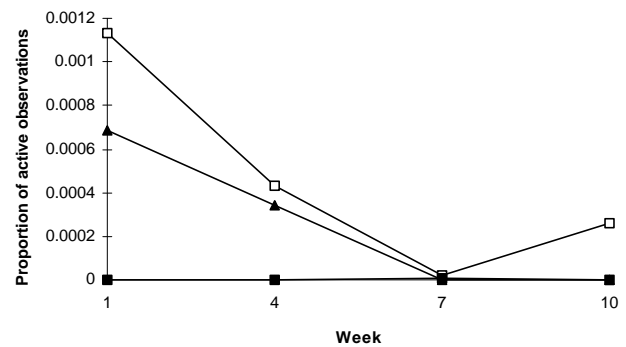


Figure 9a: The interaction between treatment and week on the prevalence of mouthful ($sed=0.0003$). Values represent means for F (-.-), H (-D-) and C (-■-) respectively.

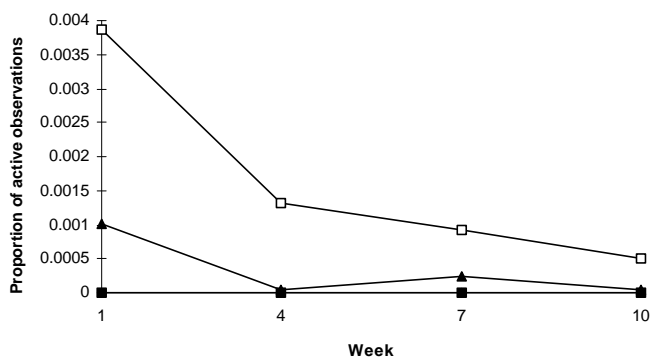


Figure 9b: The interaction between treatment and week on the prevalence of pick ($sed=0.0004$). Values represent means for F (-.-), H (-D-) and C (-■-) respectively.

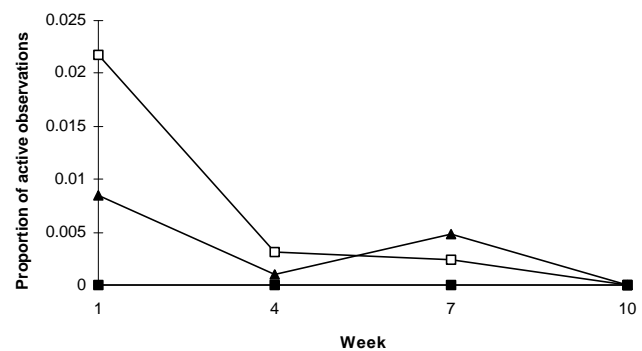


Figure 9c: The interaction between treatment and week on the prevalence of nibble ($sed=0.0030$). Values represent means for F (-.-), H (-D-) and C (-■-) respectively.

4.4 Discussion

Belly-nosing was most prevalent in N groups of pigs, and the provision of straw resulted in an approximately three-fold decrease in its occurrence. Levels of aggression and play fighting were elevated during week one of the growing/finishing period, and there was a significantly elevated and sustained level of nosing other pigs in N groups. Such results reinforce the existing evidence that barren housing environments can be implicated in the development of adverse behaviours which can impact upon animal welfare (Terlouw *et al.*, 1991; Lawrence *et al.*, 1993; Rushen *et al.*, 1993; Day *et al.*, 1997). Furthermore, the findings reinforce evidence from previous studies which have found that pigs with prior experience of straw react adversely to barren, unstrawed, growing/finishing housing systems (Day *et al.*, 2000b).

Perhaps the most significant and important finding was that levels of tail-biting increased as the length of chopped straw decreased. This makes the commercial use of small quantities of chopped straw a less attractive proposition. It also raises an important theoretical issue. It may be possible that chopped straw acts as an exogenous cue (environmental stimulus) which increases the level of exploratory or foraging motivation, and, consequently, an individual's propensity to express nosing, rooting and chewing behaviours. As chopped straw does not easily accommodate chewing behaviours, such activity may be redirected towards pen-mates. Further work is required to validate this hypothesis, and research should be targeted in this area as chopped straw is widely used in farrowing systems.

As predicted, variation in the length of chopped straw affected both the quantity and quality of straw-directed behaviour. It was found that the quantity of behaviour sustained by straw decreased as the chop length decreased, and that the overall level of straw-directed activity decreased over the growing/finishing period. This indicated that straw which is distributed predominantly in the 1-10mm and 11-40mm length bands is less able to sustain behaviour than straw which is distributed predominantly in the 11-40mm and 41-70mm length bands. In addition, straw which is distributed predominantly in the 11-40mm and 41-70mm

length bands is less able to sustain behaviour than straw which is distributed predominantly in the 41-70mm and 71+ mm length bands. Further clarification concerning the nature of this effect was found in the quality of straw-directed behaviour observed. In many cases it was seen that the initial level of behaviours such as mouthful, pick and nibble was higher in the treatments where the longer lengths of straw were provided, and decreased more rapidly to a baseline level over time. It was found that the C groups were unable to express certain behaviours. This indicates that the physical properties of finely chopped straw are not compatible with some of the behavioural elements in the pig's behavioural repertoire.

5. Objective 4: to test the hypothesis that in finishing pigs, straw satisfies an exploratory need, independent of foraging motivation.

5.1 Background

In the United Kingdom, legislation states that “all pigs, taking into account environment and stocking density shall have access to straw or other material or object suitable to satisfy those (behavioural) needs. (Statutory Instrument No. 2126: The Welfare of Livestock Regulations 1994), because it is known that straw can improve the welfare of pigs housed in barren environments as it acts as a recreational and/or a nutritional stimulus as well as improving levels of thermal comfort as bedding (Arey & Bruce, 1993; Arey & Franklin, 1995; Lyons *et al.*, 1995). However, it is currently unclear what ‘other materials’ or ‘objects’ producers should offer to groups of pigs when the use of straw is not possible (i.e. in a fully-slatted housing system which is the dominant form of system both in the UK and other EU Member States, Hendriks *et al.*, 1998). To answer this question, environmental enrichment devices should be designed with a knowledge of the properties of straw which pigs find behaviourally rewarding (e.g. Young *et al.*, 1994; Beattie *et al.*, 1996). The benefits of straw as a ‘recreational stimulus’ (Fraser *et al.*, 1991) are believed to stem from its ability to accommodate the behavioural elements associated with exploratory and feeding (foraging) motivation and, as such, it is important to understand the relative contributions of these motivations in controlling straw-directed behaviour.

To discover the motivational basis of straw-directed behaviour, it is essential to be able to experimentally distinguish between exploratory and feeding motivated behaviour (Day *et al.*, 1995). Historically, this has been viewed as problematic because these motivations are expressed using similar behavioural elements. However, by careful manipulation of feeding motivation through feed restriction, and exploratory motivation through the provision of novel stimuli, it is possible to observe the relative changes in an individual's behaviour (Day *et al.*, 1995).

In this experiment, it is assumed that i) providing fresh straw will elevate an individual's level of exploratory motivation, and ii) feed restriction will elevate an individual's level of feeding motivation (for an explanation of theory see Day *et al.*, 1996b, 1997 and 1998). After making these assumptions, the aim of the present experiment was to determine how relative shifts in the level of exploratory and feeding motivation would influence straw-directed behaviour. It was predicted that: i) pigs given fresh straw would be more active than pigs with one day old bedding, and ii) feed restricted pigs would be more active and express more straw-directed behaviour than pigs offered feed *ad libitum*.

5.2 Methodology

The experimental animals were 8 groups of 8 growing pigs (Camborough, PIC, UK). These groups were balanced with respect to gender, and had a mean initial body weight of 30.1kg (SD=4.03). Pigs had prior experience of straw bedding in the farrowing crate, but were housed in unstrawed flat-deck accommodation from weaning until their selection onto the trial. This type of prior experience has been shown previously to influence pig's subsequent behaviour (Day *et al.*, 2000b), and is now becoming an important consideration in studies of this type (Beattie *et al.*, 1995; Simonsen, 1995). One male and one female within each group were randomly selected to serve as focal animals for behavioural measurements.

The experimental building was the same as that used for objectives 1, 2 and 3 and soiled straw was removed between 0800h and 0900h on Monday, Wednesday and Friday. The environmental temperature was set to 20°C, and groups were fed a standard grower diet (Grower Care Elite 451, BOCM Pauls, Bury St Edmunds, UK) throughout the trial.

The experiment used a within-subjects 2x2 factorial design with two levels of feeding motivation (R: restricted, and A: *ad libitum*), and two levels of straw freshness (F: fresh straw, and O: one day old straw). The treatments were arranged in a Graeco-Latin square design which was replicated twice. Within each replicate of each Latin square design, four groups of pigs were exposed to each of the four treatments over

four consecutive weeks. At selection, prior to the first week of experimentation, the pigs had a five day acclimatisation period in the experimental building to allow the group dominance hierarchy and food intake to stabilise. Treatments were imposed from Monday to Friday with Saturday and Sunday acting as ‘wash-out’ days to reduce the possibility of deleterious carry-over effects of the treatments.

All groups of pigs received four sections of straw from a large bale on Monday and Thursday at 0900h. The groups on the treatment F received a further section of fresh straw on Tuesday and Friday morning, five minutes prior to behavioural observations were begun. At this time, the groups on OA and OR treatments were aroused as if to get fresh straw as it was important to ensure that any behavioural effects seen resulted from the straw itself rather than general arousal. During the wash-out period, all groups received one section of straw at 0900h.

From Monday to Thursday, the feed hoppers of the R groups were removed over-night and for the rest of the following morning. The feed hoppers remained in the pens on the Friday evening as the start of the between treatment wash-out period where all groups received food ad libitum.

Observations of the behaviour of each group were made on Tuesday and Friday mornings between 0930h and 1200h using ad libitum sampling (Martin and Bateson, 1986). This methodology involved two observers simultaneously recording the behaviour of the focal animals in each group for a 30 minute period and noting when the animal expressed one of the behavioural elements within the experimental ethogram (Table 1). This ethogram was chosen on the basis of previous work where it had been used to good effect (Day et al., 2000a). The Noldus Observer program running on a hand-held computer was used to facilitate behavioural data capture. The four observation periods began at i) 0930h, ii) 1010h, iii) 1050h and iv) 1130h and were assigned to the four groups of pigs in accordance with the Graeco-Latin square design. The feed hoppers were removed at i) 1000h, ii) 1040h, iii) 1120h and iv) 1200h giving a total of 19h of feed restriction per day.

The behavioural observations were collated to yield data-sets containing the total number of times each behavioural element was observed within each session. An index of total activity was derived by calculating the sum of observations within each session. This index was used to express each behavioural element as the proportion of total activity. These data were transformed to meet the requirements of parametric statistics, and each element subjected to a one-tailed t-test to determine whether its overall distribution differed significantly from zero. Bonferroni correction was used to compensate for the likelihood of encountering a type I error which could have resulted from the large number of tests conducted. Behavioural elements which failed this test were excluded from the analysis or combined to form a composite category of behaviour. The experimental data were analysed using repeated measures ANOVA in GENSTAT V (Lawes Agricultural Trust, 1987).

5.3 Results

All of the behavioural elements occurred at a frequency which differed significantly from zero and were subjected to further analyses. The straw-directed behavioural elements root ($F_{(1,25)}=51.18$; $P<0.001$), drop ($F_{(1,25)}=6.02$; $P<0.05$) and lick ($F_{(1,25)}=13.03$; $P<0.001$) were found to be significantly affected by straw freshness. The rooting and dropping of straw were found to be diminished in OA and OR groups when compared with FA and FR groups, whereas the licking of straw was found to be enhanced in OA and OR groups when compared to FA and FR groups (Table 7).

Table 7: The effect of straw freshness and feed level on the expression of straw-directed behaviour.

Behaviour	Straw freshness (S)			Feed level (F)			Significance		
	F	O	SED	A	R	SED	S	F	SxF
Mouthful	0.0010	0.0009	0.00077	0.0005	0.0014	0.00077			
Pick	0.0026	0.0024	0.00083	0.0023	0.0027	0.00083			
Sniff	0.0296	0.0273	0.00292	0.0333	0.0236	0.00292		**	
Chew	0.0014	0.0037	0.00562	0.0403	0.0483	0.00562			
Nibble	0.0014	0.0037	0.00133	0.0026	0.0025	0.00133			
Push	0.0146	0.0186	0.00303	0.0152	0.0180	0.00303			
Root	0.0341	0.0064	0.00388	0.0188	0.0217	0.00388	***		
Plough	0.0007	0.0007	0.00052	0.0007	0.0006	0.00052			
Sweep	0.0005	0.0001	0.00031	0.0003	0.0004	0.00031			
Flick	0.0008	0.0002	0.00030	0.0004	0.0005	0.00030			
Paw	0.0009	0.0001	0.00075	0.0009	0.0001	0.00075			
Scrape	0.0000	0.0002	0.00012	0.0002	0.0000	0.00012			
Carry	0.0003	0.0000	0.00020	0.0002	0.0001	0.00020			
Steal	0.0000	0.0000	0.00005	0.0000	0.0000	0.00005			
Tug	0.0000	0.0000	0.00000	0.0000	0.0000	0.00000			
Drop	0.0001	0.0000	0.00004	0.0001	0.0001	0.00004	*		
Lick	0.0114	0.0260	0.00405	0.0170	0.0205	0.00405	***		
Hold	0.0000	0.0002	0.00013	0.0001	0.0001	0.00013			
Shove	0.0000	0.0000	0.00001	0.0000	0.0000	0.00001			
Spit	0.0000	0.0000	0.00001	0.0000	0.0000	0.00001			
Fall	0.0000	0.0000	0.00003	0.0000	0.0000	0.00003			
Drop	0.0004	0.0002	0.00015	0.0003	0.0003	0.00015			
Place	0.0001	0.0001	0.00005	0.0001	0.0001	0.00005			
Present	0.0000	0.0000	0.00001	0.0000	0.0000	0.00001			
Dig	0.0001	0.0000	0.00003	0.0001	0.0000	0.00003	*	*	*
Scrape	0.0001	0.0000	0.00004	0.0001	0.0000	0.00004			
Other	0.0000	0.0000	0.00000	0.0000	0.0000	0.00000			

Significant effects of straw freshness were found for the pen-mate directed behavioural elements lick ($F_{(1,25)}=6.96$; $P<0.05$) and nose ($F_{(1,25)}=12.83$; $P<0.01$) other pigs. Mean values indicated that both of these behaviours were increased in OA and OR groups when compared with FA and FR groups (Table 8).

Table 8: The effect of straw freshness and feed level on the expression of straw-directed behaviour.

Behaviour	Straw freshness (S)			Feed level (F)			Significance		
	F	O	SED	A	R	SED	S	F	SxF
Aggression	0.0027	0.0042	0.00123	0.0035	0.0034	0.00123			
Mount	0.0004	0.0002	0.00042	0.0005	0.0001	0.00042			
Belly-nose	0.0011	0.0014	0.00070	0.0009	0.0002	0.00070			
Tail-bite	0.0001	0.0004	0.00027	0.0003	0.0002	0.00027			
Ear-chew	0.0005	0.0019	0.00081	0.0012	0.0012	0.00081			
Play-fight	0.0013	0.0005	0.00047	0.0009	0.0009	0.00047			
Suck	0.0013	0.0009	0.00150	0.0002	0.0020	0.00150			
Lick	0.0003	0.0016	0.00050	0.0008	0.0011	0.00050	*		
Nose	0.0081	0.0200	0.00324	0.0183	0.0096	0.00324	**	*	

Sniffing straw was significantly affected by feed restriction ($F_{(1,25)}=11.04$; $P<0.01$), with mean values indicating that the behaviour was more prevalent in FA and OA groups than in FR and OR groups. The pen-mate directed behaviour nose other pigs was found to be significantly affected by feed restriction ($F_{(1,25)}=7.28$; $P<0.05$) with more nosing occurring in FA and OA groups than in FR and FA groups.

None of the effects described above was also affected by a interaction between straw freshness and feed restriction. However, a significant interaction was found for shove straw ($F_{(1,25)}=3.07$; $P<0.05$), where feed restriction increased the occurrence of the behaviour when straw was fresh and decreased the occurrence of the behaviour when the straw was one day old.

5.4 Discussion

Groups housed with one day old straw bedding licked and nosed other pigs at a higher frequency than pigs which had recently been given fresh straw. One of the assumptions of the present experiment was that fresh straw would act as a novel stimulus which the pigs would find rewarding to directed exploratory behaviour towards. This assumption is based upon motivational theory (Toates, 1990) which dictates that behaviours are expressed as a result of an underlying level of motivation, which in turn, is controlled by both external (exogenous) and internal (endogenous) factors (Day *et al.*, 1997 and 1998). Other theories have suggested that motivational systems (e.g. feeding motivation, exploratory motivation etc.) compete for their ultimate expression as behaviour (McFarland and Houston, 1981). Therefore, the behaviour which an individual expresses reflects the strongest motivation at a given time. The application of such theories to the present results would suggest that the novelty of the straw resulted in an increase in the level of exploratory motivation and caused the pigs to express exploratory behaviour in preference to other behaviour patterns. This may, in part, explain why there was a relative reduction in the nosing and licking of other pigs as the FA and FR groups investigated the fresh straw.

In addition to the effects of straw freshness, it was found that feed restriction decreased the level of nosing other pigs. Applying motivational theory once more, the feed restricted pigs would have experienced an elevation in their level of feeding motivation, and as a consequence, were more likely to express foraging behaviour. As straw was available to all groups this may have acted as an outlet for such activity in preference to pen-mates. It should be noted, however, that there is considerable evidence to indicate that where straw is not provided such feeding motivated activity is ‘channelled’ towards pen-mates (Fraser, 1987a,b; Terlouw *et al.*, 1991; Lawrence *et al.*, 1993; Rushen *et al.*, 1993; Day *et al.*, 1996a and 1997).

The provision of fresh straw was found to increase the expression of rooting, flicking and dropping of straw. Once again, if motivation theory is invoked, such effects can be explained to arise as a result of an elevated level of exploratory motivation, and this make intuitive sense. A pig which is attempting to learn about the properties of straw would root and flick through the substrate to investigate what was contained within the matrix and then proceed to pick up straw in its mouth and eventually drop it. The only result which initially appears counter-intuitive is that for the licking of straw. This behaviour was found to be higher when the straw was one day old. It is possible that, through the action of the pigs’ behaviour over one day, the nature of the straw bed changed qualitatively; maybe with long blades of straw comprising a smaller proportion of the overall substrate. This would increase the relative prevalence of shorter blades of straw which would require more licking behaviour to chew or ingest.

The sniffing of straw was decreased when groups were feed restricted, however, the mean values for behavioural elements such as mouthful and chew increased as a result of feed restriction (although not significantly). It is likely that this result may have been spurious, or may have arisen due to pigs spending more time engaged in activities related to the ingestion of straw.

6. Relevance of research to MAFF policy objectives

The project has provided a better understanding of what properties of straw pigs find behaviourally rewarding, and has begun to address which of these properties an alternative to straw should have in order to be equally successful in reducing pen-mate manipulation. Immediate beneficiaries of this research are those within the Ministry who have to specify which alternatives to straw meet the behavioural requirements of pigs. The results provide an immediate answer as to whether the provision of minimal straw in unstrawed systems confers welfare advantages. In the longer term, the results of this project will contribute to the body of data needed for the improvement of the welfare of intensively housed pigs. The results will assist in developing enrichment techniques which can be applied by producers in commercial situations, and ultimately, through all these means, the benefits will assist in improving the public perception of intensive pig housing.

7. Recommendations/conclusions (Objective 5)

On the basis of the results obtained from this project, the following recommendations have been formulated:

- a) In behavioural studies, the consensus panel approach to ethogram development should be advocated as it allows a number of different opinions to be expressed prior to the full scale use of the ethogram in an experiment. Studies of inter- and intra-observer reliability indicate that observers can vary markedly in their use of a complex ethogram. Therefore, **where possible only one observer should be used in an experiment, and where this is not possible, observer bias should be quantified and compensated for in the experimental design.**
- b) Moving pigs from previously strawed housing accommodation to unstrawed accommodation increases the occurrence of adverse pen-mate directed behaviours. This should be avoided wherever possible. **When pigs have had prior experience of straw in their developmental history, the provision of a small quantity of straw in the growing/finishing accommodation may serve to ameliorate the negative effects of the environmental challenge.**
- c) **In growing/finishing systems where the use of straw is possible, increasing the quantity of straw provided reduces the occurrence of potentially damaging behaviours,** but may not necessarily affect the diversity of straw-directed behaviour.
- d) The use of chopped straw is beneficial in reducing the occurrence of certain adverse behaviours such as aggression and nosing other pigs, however, tail-biting may increase in frequency as the length of chopped straw decreases. This would make **the use of chopped straw in fully- or part-slatted systems inadvisable until further research has been conducted to ascertain the nature and robustness of the effect of chopped straw on adverse behaviour.**
- e) Straw directed behaviour arises as a result of both exploratory and feeding motivation. When pigs are feeding motivated, adverse behaviours appear to be diminished when straw is provided, and it is suggested that in these circumstances, motivated activity is directed towards straw bedding rather than pen-mates. **When environmental enrichment devices are being designed to replace straw, they must be suitable to accommodate both exploratory and feeding motivated behaviours.**

8. Future research requirements

Whilst this project has advanced our understanding of how different modes of straw presentation affect the expression of straw-directed and pen-mate-directed behaviour, it has also raised two very important issues.

First, it is necessary to further clarify the nature and robustness of the effect of chopped straw on adverse behaviour. Whilst the provision of chopped straw appeared to reduce the expression of aggression and nosing of other pigs, it also appear to increase the expression of tail-biting. As such, the use of small quantities of chopped straw on fully- or part-slatted system cannot currently be advocated. Further research is necessary to facilitate an objective recommendation.

Second, the design and testing of environmental enrichment devices to act as replacements for straw (where the use of straw is not possible) is required. The pig industry in the UK requires a clear indication of which types of environmental enrichment devices they should provide when the straw is not possible. A recent MAFF funded project (AW0124) has just begun to address this issue and the information generated will further advance our understanding of how to meet the behavioural needs of pigs at the different stages of their behavioural development.

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10. Publications arising from project (to date)

- DAY, J. E. L., WHITTAKER, X. & EDWARDS, S. A. (2000). A note on the development of a complex ethogram and the reliability of behavioural measurement using multiple observers. *Behaviour* (submitted).
- DAY, J. E. L., BURFOOT, A., DOCKING, C. M., WHITTAKER, X., SPOOLDER, H. A. M. & EDWARDS, S. A. (2000). The effects of prior experience of straw and depth of straw bedding on the behaviour of growing pigs. *Animal Science* (submitted).
- DAY, J. E. L., CHAMBERLAIN, H. & EDWARDS, S. A. (2000). The effect of varying lengths of chopped straw bedding on the behaviour of growing pigs. *Applied Animal Behaviour Science* (submitted).
- DAY, J. E. L., CHAMBERLAIN, H. & EDWARDS, S. A. (2000). The effect of feed restriction and freshness of straw bedding on the behaviour of growing pigs. *Applied Animal Behaviour Science* (submitted).

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