RELATIONSHIP BETWEEN ROOTING BEHAVIOUR AND FORAGING IN GROWING PIGS

V E Beattie* and N E O'Connell†

*† Agricultural Research Institute of Northern Ireland, Large Park, Hillsborough, County Down BT26 6DR, Northern Ireland

* Present address: Devenish Nutrition, 96 Duncrue Street, Belfast, County Antrim BT3 9AR, Northern Ireland

† Contact for correspondence and requests for reprints: niamh.o'connell@dardni.gov.uk

Abstract *Animal Welfare 2002, **11***: 295-303

The objective of the present study was to investigate the relationship between rooting behaviour and foraging in growing pigs. In study 1, forty-eight 11-week-old pigs were housed in eight groups of six with access to a rooting substrate in the form of spent mushroom compost. In half of the groups the rooting substrate contained food rewards, and in the other half of the groups it did not. All pigs had ad libitum *access to feed. In study 2, one hundred and ninety-two 11-week-old pigs were housed in thirty-two groups of six, all with access to spent mushroom compost, and eight groups were each fed to 70, 80, 90 or 100% appetite. Treatments were applied over a two-week period in both studies. The number of pigs involved in active rooting (rooting in substrate while standing), inactive rooting (rooting in substrate while sitting or lying) or non-rooting activity (standing in substrate area and involved in any activity except rooting) was recorded by scan sampling. These behaviours tended to reach a peak in the morning and again in the afternoon. Inactive rooting was not significantly affected by treatments in study 1 or study 2. Food rewards in the rooting substrate led to a significant reduction in active rooting behaviour and in non-rooting activity during peak periods of the day ($P < 0.05$). It is suggested that learned associations between rooting behaviour and acquisition of food caused the pigs to stop rooting when all the food rewards had been consumed. The fact that rooting was performed in the absence of nutritive feedback suggests that this behaviour is performed independently of its appetitive foraging function. Restricting feed levels to 70 or 80% of appetite led to a significant increase in active rooting and in non-rooting activity during peak periods ($P < 0.05$). The relationship between feed restriction and active rooting behaviour tended to be linear ($P < 0.08$). This suggests that levels of rooting behaviour are flexible in response to nutritional needs.*

Keywords: *animal welfare, feed restriction, food rewards, pigs, rooting behaviour*

Introduction

Pigs have evolved as opportunistic omnivores who use rooting behaviour as a tool for finding food (Newberry & Wood-Gush 1988; Stolba & Wood-Gush 1989). Rooting behaviour is also performed in intensive production systems, however, in the absence of obvious nutritive feedback from the behaviour (Beattie *et al* 2001). This may suggest that the performance of rooting behaviour has become dissociated from its appetitive foraging function (Beattie 1994). In addition, the fact that rooting behaviour is performed in production systems where feed is freely available (Beattie *et al* 2001) may suggest that this behaviour is inflexible or unresponsive to nutritional needs.

The aim of the present study is to investigate the relationship between rooting behaviour and foraging in growing pigs. An initial study will investigate if rooting behaviour is influenced by the presence of food rewards. A second study will investigate the flexibility of rooting behaviour by assessing responses to different levels of feeding.

Methods

The relationship between rooting behaviour and foraging in growing pigs was investigated in two studies. Study 1 assessed the effect of food rewards in the rooting substrate, and study 2 assessed the effect of feed restriction on rooting behaviour and non-rooting activity levels.

Animals and treatments

In study 1, forty-eight Landrace × Large White 11-week-old pigs were divided into eight groups of six animals to provide four replicates of two treatments. Treatment 1 comprised access to a rooting substrate into which food pellets had been mixed at a ratio of 1:8 (pellets:substrate), measured on a mass per mass basis. Treatment 2 comprised access to the same rooting substrate as treatment 1, but without feed pellets mixed into it.

In study 2, one hundred and ninety-two Landrace × Large White 11-week-old pigs were divided into thirty-two groups of six animals to provide eight replicates of four treatments. The treatments corresponded to the following feeding regimes:

1. 100% appetite (1.50 kg feed pig^{-1} day^{-1})
2. 90% appetite (1.35 kg feed pig^{-1} day^{-1})
3. 80% appetite (1.20 kg feed pig^{-1} day^{-1})
4. 70% appetite (1.05 kg feed pig^{-1} day^{-1})

These feed-restriction levels were calculated from *ad libitum* levels of feed intake. All pigs in study 2 had access to a rooting substrate. In both studies 1 and 2 the treatments were applied over a two-week period and animals were randomly assigned to groups which were balanced for weight and gender.

Housing

Each group of pigs in studies 1 and 2 was housed in a pen (3.3 × 1.8 m) with solid floor and walls and a single-space feeder supplying feed and water ('Verba wet feeder', Verbakel BV, The Netherlands). Four kilograms of a rooting substrate was placed in the pen on a daily basis at approximately 0900h. Any wet or soiled substrate was removed at this time, and the feeder was replenished with feed. The rooting substrate used was spent mushroom compost that had had the top casing removed. The substrate was dried to approximately 54% dry matter before it was used. It was placed in one half of the pen and was kept in place by a small wooden partition on the ground. The feeder was located in the other half of the pen. Temperature was maintained at 20°C and artificial lighting was supplied continuously throughout the experimental period. The pigs were moved to these pens from slatted accommodation at the start of the experimental period.

Diet

The pigs in studies 1 and 2 were fed pelleted cereal/soya-based diets (manufactured at the Agricultural Research Institute of Northern Ireland) containing 14.2 MJ digestible energy

(DE) per kg and 22% crude protein. The pigs were fed this diet for several weeks prior to the experimental period.

Measures

Each group of pigs in studies 1 and 2 was recorded for a continuous 72 h period at the end of each week using time-lapse video recorders (2 frames per second). Instantaneous sampling at 10 min intervals was used to record the number of pigs in the substrate area that were involved in active rooting behaviour, inactive rooting behaviour or non-rooting activity. Active rooting behaviour was defined as when the pig was rooting in the substrate while standing, and inactive rooting behaviour was defined as when the pig was rooting in the substrate while lying or sitting. Non-rooting activity was defined as when the pig was performing any activity except rooting behaviour while standing. Rooting behaviour was defined as when the pig was making back-and-forth movements in the rooting substrate with the snout disc.

The average number of pigs involved in the different behaviours was calculated over a 24 h period. In addition, the average number of pigs involved in the different behaviours during each 2 h period was calculated and used to assess diurnal patterns of behaviour. The number of pigs involved in the different behaviours was expressed as a percentage of the number of pigs in the group.

Statistical analysis

The data were analysed using Genstat, version 5 (Lawes Agricultural Trust 1989). An analysis of variance (blocked for replicate) was used to determine the effect of treatment on behavioural parameters. Interactive effects between treatment and period of day were also assessed by analysis of variance, using a nested model (period within day within week within replicate). The influence of feed restriction on behavioural parameters was tested for linearity using analysis of variance (blocked for replicate). All parameters were analysed using the group as the experimental unit and all variations are given as the standard error of the mean (SEM).

Results

Study 1

The addition of food rewards to the rooting substrate did not have a significant effect on the average number of pigs over a 24 h period that were involved in active rooting behaviour (food rewards: 3.6% of group; no food rewards: 4.4% of group; SEM 0.63), inactive rooting behaviour (food rewards: 6.9%; no food rewards: 5.6%; SEM 1.10) or non-rooting activity (food rewards: 1.4%; no food rewards: 2.0%; SEM 0.56).

There was a significant interactive effect between treatment and period of day on active rooting behaviour ($P < 0.05$; see Figure 1). Food rewards in the rooting substrate led to a significant reduction in active rooting behaviour between 0800h and 1000h (food rewards: 8.4%; no food rewards: 13.0%; SEM 1.04; $P < 0.05$) and also between 1200h and 1400h (food rewards: 5.5%; no food rewards: 10.2%; SEM 1.04; $P < 0.05$).

Treatment and period of day also had a significant interactive effect on non-rooting activity ($P < 0.05$; see Figure 2). Food rewards in the rooting substrate led to a significant reduction in non-rooting activity between 0800h and 1000h (food rewards: 1.4%; no food rewards: 3.7%; SEM 0.72; $P < 0.05$), between 1000h and 1200h (food rewards: 1.9%; no food rewards: 4.1%; SEM 0.72; $P < 0.05$) and also between 1400h and 1600h (food rewards: 2.3%; no food rewards: 4.6%; SEM 0.72; $P < 0.05$).

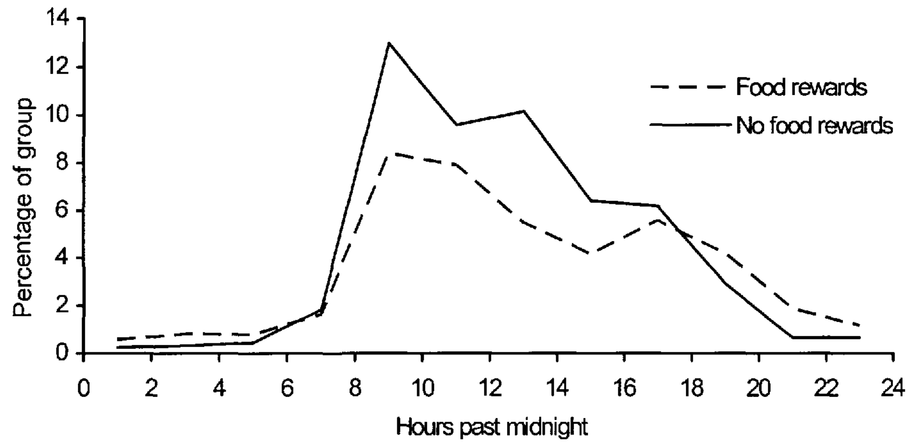

Figure 1 **Influence of food rewards on the percentage of pigs in a group involved in active rooting behaviour.**

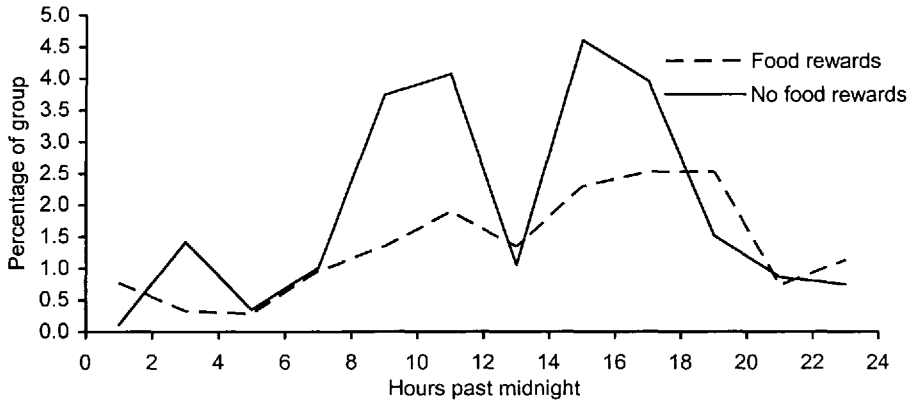

Figure 2 **Influence of food rewards on the percentage of pigs in a group involved in non-rooting activity.**

There was no significant interactive effect between treatment and period of day on inactive rooting behaviour ($P > 0.05$; see Figure 3).

Study 2

Restricting feed to different levels of appetite did not have a significant effect on the average number of pigs over a 24 h period that were involved in active rooting behaviour (70% appetite: 3.9%; 80% appetite: 3.4%; 90% appetite: 2.3%; 100% appetite: 2.7%; SEM 0.57), inactive rooting behaviour (70% appetite: 4.5%; 80% appetite: 4.2%; 90% appetite: 4.5%; 100% appetite: 3.6%; SEM 1.77) or non-rooting activity (70% appetite: 3.9%; 80% appetite: 3.5%; 90% appetite: 3.1%; 100% appetite: 3.1%; SEM 0.41).

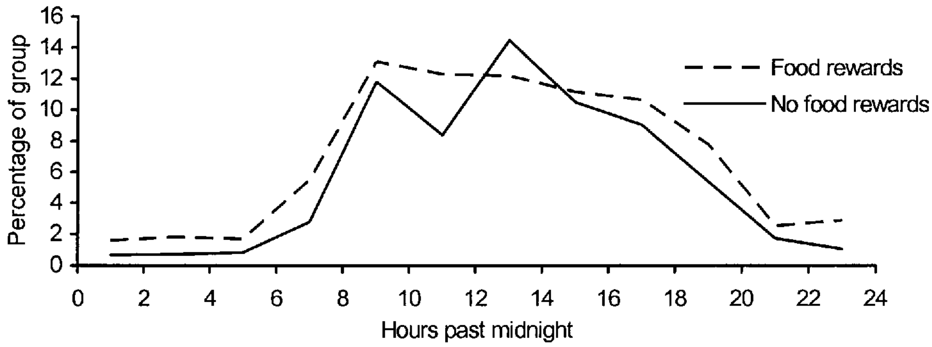

Figure 3 **Influence of food rewards on the percentage of pigs in a group involved in inactive rooting behaviour.**

There was a significant interactive effect between treatment and period of day on active rooting behaviour ($P < 0.001$; see Figure 4). Between 0800h and 1000h, there were significantly more pigs performing active rooting behaviour when they were fed at 70 or 80% appetite than when they were fed at 90 or 100% appetite (70% appetite: 10.7%; 80% appetite: 11.4%; 90% appetite: 6.6%; 100% appetite: 8.3%; SEM 0.81; $P < 0.05$). This same effect was also shown between 1000h and 1200h (70% appetite: 7.1%; 80% appetite: 6.9%; 90% appetite: 4.1%; 100% appetite: 3.1%; SEM 0.81; $P < 0.05$). The relationship between level of feed restriction and active rooting behaviour tended to be linear; however, this tendency was not significant ($P < 0.08$).

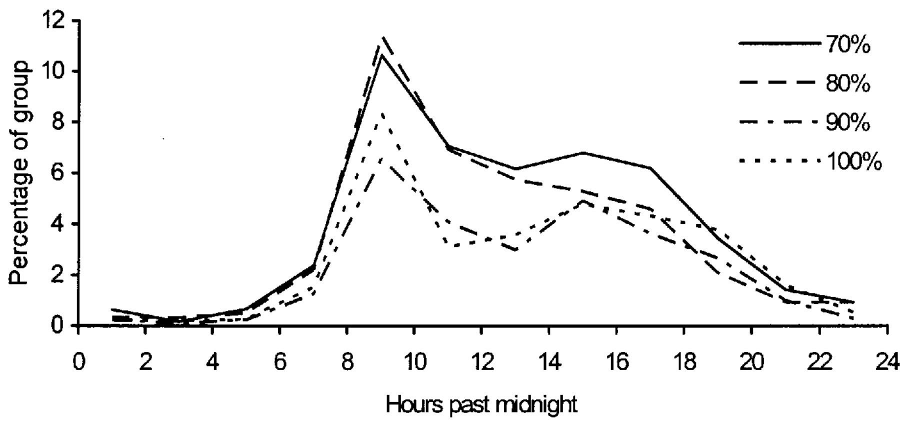

Figure 4 **Influence of feed restriction on the percentage of pigs in a group involved in active rooting behaviour.**

Treatment and period of day also had a significant interactive effect on non-rooting activity ($P < 0.01$; see Figure 5). Restricting feed to 70% of appetite led to a significant increase in non-rooting activity compared with pigs fed to 90 or 100% of appetite between 0800h and 1000h (70% appetite: 9.6%; 80% appetite: 8.3%; 90% appetite: 6.6%; 100% appetite: 6.4%; SEM 0.67; $P < 0.05$), 1000h and 1200h (70% appetite: 5.8%; 80% appetite:

3.5%; 90% appetite: 3.4%; 100% appetite: 3.6%; SEM 0.67; $P < 0.05$) and also between 1200h and 1400h (70% appetite: 6.3%; 80% appetite: 5.0%; 90% appetite: 4.1%; 100% appetite: 3.4%; SEM 0.67; $P < 0.05$). Restricting feed to 80% of appetite led to a significant increase in non-rooting activity compared with animals fed to 100% of appetite between 0800h and 1000h ($P < 0.05$).

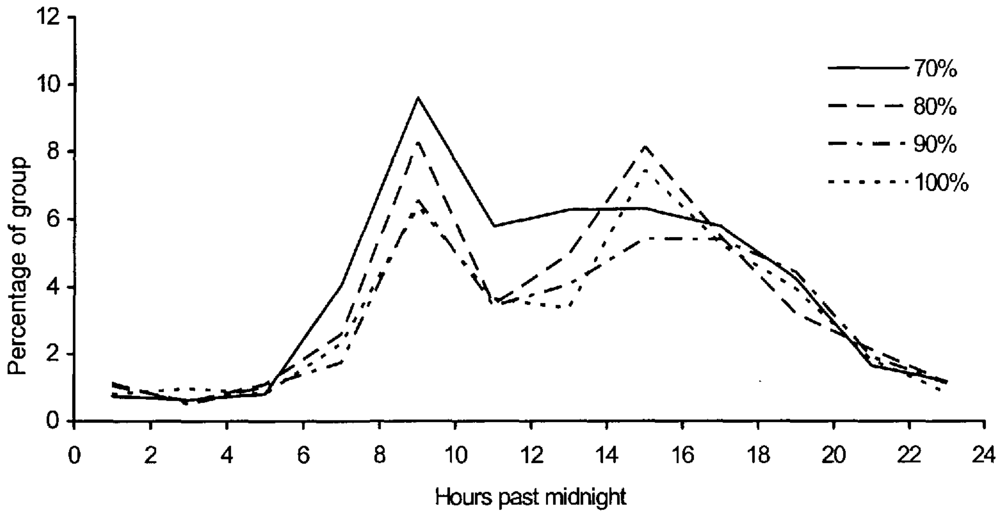

Figure 5 **Influence of feed restriction on the percentage of pigs in a group involved in non-rooting activity.**

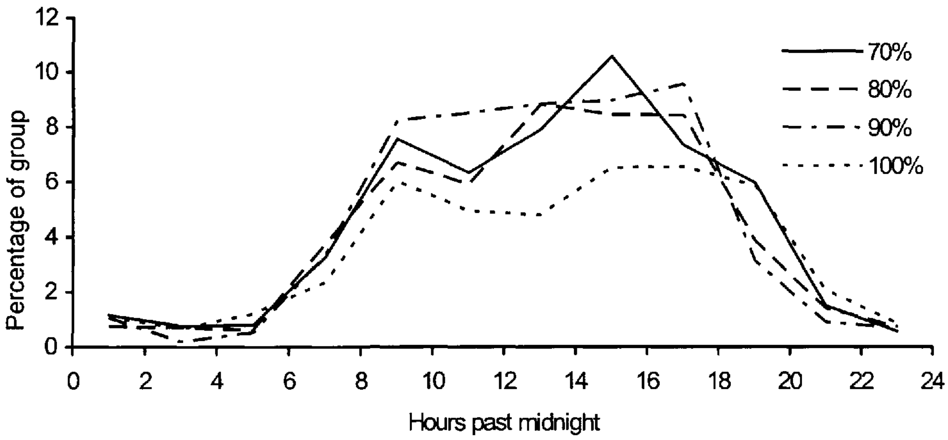

Figure 6 **Influence of feed restriction on the percentage of pigs in a group involved in inactive rooting behaviour.**

There was no significant interactive effect between treatment and period of day on inactive rooting behaviour ($P > 0.05$). In addition, there was no evidence of a linear relationship between level of feed restriction and either inactive rooting behaviour or non-rooting activity ($P > 0.05$).

Discussion

The peak in active rooting behaviour shown in the morning in both studies may have been related to the fact that fresh substrate was provided at this time (Fraser *et al* 1991). This is supported by research with growing pigs which shows that the motivation to root is increased by the novelty of the rooting substrate (Hutson 1989). It is also possible that the entrance of stockmen and replenishment of feed hoppers in the mornings led to an increase in general activity and consequently to an increase in active rooting behaviour. The fact that active rooting behaviour tended to reach a peak in the morning and again in the afternoon suggests that it was influenced by diurnal activity rhythms, as suggested by previous research (Olsen *et al* 2000). Inactive rooting behaviour occurred at similar levels to active rooting behaviour, but tended to show less distinct diurnal patterns. This may be due to the fact that it was measured when animals were lying or sitting, and suggests that rooting behaviour is not merely a function of general activity but also occurs when animals are resting.

Evidence suggests that the primary function of rooting behaviour in natural environments is the acquisition of food (Newberry & Wood-Gush 1988; Stolba & Wood-Gush 1989). However, in both studies 1 and 2 in the present experiment, and in previous studies (Jensen *et al* 1993; Day *et al* 1995), pigs performed rooting behaviour in the absence of obvious nutritive feedback. This may suggest that the rooting behaviour shown in these studies represented another function, such as exploration (Fraser *et al* 1991). However, it is also possible that pigs are genetically pre-programmed to perform rooting behaviour irrespective of the functional consequences of the behaviour. This agrees with suggestions that pigs which continue to root when food rewards are scarce in natural environments are more likely to survive, and therefore be selected for, than their counterparts which stop rooting in the absence of extrinsic reward (Beattie 1994). It is also possible that mechanisms within the pig were selected for which intrinsically reinforced rooting behaviour to ensure its performance in the absence of reward (McFarland 1989). This agrees with suggestions that the performance of appetitive behaviours in pigs is self-reinforcing (Day *et al* 1995; Haskell *et al* 1996).

The presence of food rewards in the rooting substrate did not have a significant effect on the average number of pigs performing rooting behaviour over a 24 h period. During peak rooting periods, however, the number of pigs rooting in the substrate was significantly lower when the substrate contained food rewards than when it did not. This reduction in rooting behaviour may represent a negative feedback effect of food consumption on appetitive behaviour (Rushen *et al* 1993). However, as animals in both treatments had *ad libitum* access to food from feeders, it is assumed that food consumption was similar between treatments. It is also possible that pigs in the food reward treatment learnt to associate rooting behaviour with the acquisition of food and, as a consequence, ceased performing rooting behaviour when the food rewards had been consumed. This agrees with previous findings which show that animals can learn to associate a behaviour with a reward and that when the reward is removed the animal undergoes a process called extinction (Pavlov 1927). These results suggest that external stimuli — namely food rewards — overrode the loop between rooting behaviour and internal factors such as pre-programming and self-reinforcement (McFarland 1989; Beattie 1994).

Although feed restriction did not significantly affect rooting behaviour over a 24 h period, the number of pigs performing active rooting behaviour during peak rooting periods increased significantly when feed was restricted to 70 or 80% of appetite. This agrees with previous research that showed increased levels of rooting and chewing when pigs were fed a restricted diet (Jensen *et al* 1993; Day *et al* 1995). This increase in rooting behaviour is thought to represent appetitive foraging resulting from increased feeding motivation (Day *et al* 1995). The increase in non-rooting activity that was also shown when feed was restricted corresponds with previous observations that locomotion is an integral part of appetitive foraging strategies (Stolba & Wood-Gush 1989). These strategies may not incorporate inactive rooting behaviour, as this was not significantly affected by feed restriction in the present study.

These results suggest that although rooting behaviour may be performed independently of its appetitive foraging function, it is responsive to nutritional needs. Further evidence for this is provided by the fact that the relationship between food restriction and rooting behaviour tended to be linear. This suggests that rooting behaviour is relatively flexible or 'elastic' between feeding levels of 70 and 100% appetite (Hughes & Duncan 1988; McFarland 1989). This elasticity may have welfare benefits in natural environments as it means that behaviours other than rooting can be performed when food availability is high (McFarland 1989). These findings may be explained by classical learning theory, which suggests that the more an animal is motivated (eg hungry), the greater will be the behavioural response when appropriate stimuli are presented (Sheffield & Campbell 1954). However, the fact that pigs which were fed *ad libitum* in studies 1 and 2 still performed rooting behaviour suggests that there is a second mechanism underlying rooting behaviour that is intrinsically rather than extrinsically reinforced (Gross 1996).

Animal welfare implications

Rooting behaviour appears to be a behavioural need that is performed irrespective of feeding level or nutritive feedback. This suggests that a suitable rooting substrate should be provided even for pigs which are fed *ad libitum*. The provision of a rooting substrate may be even more important for animals on restrictive feeding regimes, which are likely to show increased levels of rooting behaviour.

Acknowledgements

We wish to thank Dr D J Kilpatrick and Mr A Gordon for statistical analysis. Thanks are also due to the technicians and stockmen at the Agricultural Research Institute of Northern Ireland's pig unit for technical assistance and care of the animals.

References

Beattie V E 1994 *The effects of environmental enrichment on the domestic pig.* PhD Thesis, Queen's University Belfast, Northern Ireland

Beattie V E, Sneddon I A, Walker N and Weatherup R N 2001 Environmental enrichment of intensive pig housing using spent mushroom compost. *Animal Science 72*: 35-42

Day J E L, Kyriazakis I and Lawrence A B 1995 The effect of food deprivation on the expression of foraging and exploratory behaviour in the growing pig. *Applied Animal Behaviour Science 42*: 193-206

Fraser D, Phillips P A, Thompson B K and Tennessen T 1991 Effect of straw on the behaviour of growing pigs. *Applied Animal Behaviour Science 30*: 307-318

Gross R 1996 *Psychology: The Science of Mind and Behaviour.* Hodder & Stoughton: Oxon, UK

Haskell M J, Terlouw E M C, Lawrence A B and Erhard H W 1996 The relationship between food consumption and persistence of post-feeding foraging behaviour in sows. *Applied Animal Behaviour Science 48*: 249-262

Hughes B O and Duncan I J H 1988 The notion of ethological 'need', models of motivation and animal welfare. *Animal Behaviour 36*: 1696-1707

Hutson G D 1989 Operant tests of access to earth as a reinforcement for weaner piglets. *Animal Production 48*: 561-569

Jensen M B, Kyriazakis I and Lawrence A B 1993 The activity and straw directed behaviour of pigs offered foods with different crude protein content. *Applied Animal Behaviour Science 37*: 211-221

Lawes Agricultural Trust 1989 *Genstat 5 Reference Manual*. Clarendon: Oxford, UK

McFarland D 1989 *Problems of Animal Behaviour*. Longman Scientific & Technical/John Wiley & Sons Inc: New York, USA

Newberry R C and Wood-Gush D G M 1988 Development of some behaviour patterns in piglets under semi-natural conditions. *Animal Production 46*: 103-109

Olsen A W, Vestergaard E-M and Dybkjær L 2000 Roughage as additional rooting substrates for pigs. *Animal Science 70*: 451-456

Pavlov I P 1927 *Conditioned Reflexes*. Oxford University Press: Oxford, UK

Rushen J, Lawrence A B and Terlouw E M C 1993 The motivational basis of stereotypies. In: Lawrence A B and Rushen J (eds) *Stereotypic Animal Behaviour: Fundamentals and Applications to Welfare*. CAB International: Wallingford, Oxon UK

Sheffield F D and Campbell B A 1954 The role of experience in the "spontaneous" activity of hungry rats. *Journal of Comparative and Physiological Psychology 43*: 471-481

Stolba A and Wood-Gush D G M 1989 The behaviour of pigs in a semi-natural environment. *Animal Production 48*: 419-425