EFFECT OF ACCESS TO ROUGHAGE AND SHELTER ON SELECTED BEHAVIOURAL INDICATORS OF WELFARE IN PIGS HOUSED IN A COMPLEX ENVIRONMENT

A W Olsen[1]*, H B Simonsen[2] and L Dybkjær[1]

[1] Danish Institute of Agricultural Sciences, Department of Animal Health and Welfare, Research Centre Foulum, P O Box 50, DK-8830 Tjele, Denmark

[2] The Royal Veterinary and Agricultural University, Department of Animal Science and Health, Grønnegårdsvej 8, DK-1870 Frederiksberg C, Denmark

* Contact for correspondence and requests for reprints: Anne.Olsen@agrsci.dk

Abstract *Animal Welfare 2002, 11*: 75-87

The aim of this study was to examine the effects of roughage and shelter on certain welfare indicators in growing pigs that have access to ample straw and space. The effects of the two treatments were evaluated both by recording the pigs' use of the various areas of the pen and by measuring the frequency of two specific behaviours, 'aggression' and 'play', that are considered to be significant indicators of welfare in pigs. Seven replicates were used, each involving 96 pigs. The pigs were randomly allocated to eight experimental pens at 10 weeks of age, and were observed from 13 to 22 weeks of age. The two treatments, roughage and shelter, were distributed according to a 2 x 2 design in the pigs' outdoor runs, four of which were located on each side of the barn (north side versus south side). The pigs spent most of their time in the straw-provided areas, and the frequency of their aggressive behaviour was also the highest in these areas, suggesting that these locations were the most attractive to the pigs. The pigs with access to roughage showed a lower frequency of aggression ($P < 0.05$) and spent more time in the outdoor area where the roughage was placed than those pigs with no access to roughage ($P < 0.05$). No other effects of treatment were found on the length of time spent in the different pen locations. Play frequency decreased with age ($P < 0.05$) and with increasing temperature ($P < 0.01$). Moreover, when housed on the south side of the building, the pigs with access to shelter played more than those without (2.0 versus 1.0 events per hour [SE = 0.3]; $P < 0.05$); this suggests that the opportunity to regulate the body temperature by use of shade results in improved welfare. In conclusion, the pigs' behaviour indicated that their welfare was improved by free access to roughage and shelter.

Keywords: *animal welfare, behaviour, housing, pigs, roughage, temperature*

Introduction

One of the aims of organic farming in Denmark is to improve the animals' welfare (BØJ 1994). In organic systems, sows and their piglets must be kept outside; after weaning, however, the growing pigs may be kept indoors if they are provided with a straw-bedded area and allowed free access to roughage and an outdoor run (BØJ 1994). Thus, the Danish legislations on organic farming take into consideration pigs' need for rooting activities, but not pigs' sensitivity to heat (Ingram 1965). When considering the animals' welfare, facilities for evaporative cooling, such as wallows or sprinklers, and outdoor shelters to provide

protection from the sun, clearly should also be taken into consideration. However, until now, no investigations have been made into the welfare consequences of providing pigs with an outdoor shelter and access to roughage.

The Danish organic farmers committee anticipates that roughage may improve the welfare of pigs when provided as an extra rooting substrate in addition to straw. This is a reasonable assumption, as substrates for oral manipulation positively influence behavioural indicators of welfare in pigs (Fraser *et al* 1991; Beattie *et al* 1993; Böhmer & Hoy 1993). The availability of roughage is expected to increase play, to decrease aggression, and to decrease redirected oral behaviour against penmates and pen hardware. In this paper, only two behavioural indicators of welfare — play and aggression — are investigated. Results concerning oral behaviour against penmates and pen hardware are reported in Olsen (2001).

Access to shelter is not stipulated by law. However, provision of cooling facilities may improve the welfare of pigs. Because pigs are highly sensitive to heat (Ingram 1965), access to shelter may decrease aggression associated with fights for cool spots and shady places. We also expect shelter to increase the frequency of play, as play is a significant indicator of welfare (Newberry *et al* 1988).

To reveal whether environmental factors used to enrich the animals' environment result in welfare improvements, behavioural indicators of well-being may be used (Cornell & Beattie 1999). When the behaviour of pigs kept in a rich environment is compared to that of pigs kept in more barren surroundings, rooting, playing and exploring behaviours are shown to increase in frequency, whereas manipulations of penmates and of objects decrease (Buchenauer 1981; Pearce 1993; Spoolder *et al* 1995). Play is a significant indicator of welfare (Newberry *et al* 1988): it is an explicit indicator of enjoyment, and it occurs only when the animals' basic needs are satisfied (Buchenauer 1981). On the other hand, aggression and non-nutritive oral manipulation can be both symptoms and causes of reduced well-being in pigs.

Play can be defined as the exhibition of scampering and/or jumping (eg van Putten 1980; Newberry & Wood-Gush 1988; Dybkjær 1992) and, in some cases, fighting elements (eg pushing, butting and biting) have also been included in the definition (Dobao *et al* 1985; Blackshaw *et al* 1997). In the present study, head-knocks and bites have been included in the definition of play when observed in connection with scampering and/or jumping.

Increased aggression in pigs can be caused by different stressors. Worsaae and Schmidt (1980) found aggression in early weaned piglets to be negatively correlated with play, whereas non-nutritive oral activities and plasma cortisol concentration correlated positively with aggression. Limited resources (Hansen *et al* 1982), increased stocking density and crowding (Simonsen 1990), and mixing of unfamiliar pigs (McGlone 1985; Stookey & Gonyou 1994) also increase aggression, whereas the provision of appropriate rooting substrates or chewing objects decreases aggression (Schaefer *et al* 1990; Cornell & Beattie 1999). Aggression may negatively influence the health and welfare of pigs in at least two ways. First, as aggression is positively correlated with plasma cortisol concentration (Worsaae & Schmidt 1980), it may depress the immune response and consequently increase the risk of viral infection (McGlone *et al* 1993). Second, fights can cause injuries that increase the risk of infection, and may result in pain from the injuries and from any subsequent infection.

The aim of this study was to examine the effects of access to roughage and shelter on selected behavioural welfare indicators (play and aggression) in growing pigs housed in a straw-bedded barn with ample space and access to outdoor runs.

Materials and methods

In each of seven replicates, 96 pigs at 10 weeks of age were randomly allocated to eight experimental pens (2.7 × 4.75 m, ie 12.8 m^2) with outdoor runs (2.7 × 4.75 m, ie 12.8 m^2). Four of the pens were on the south side of the barn, and four were on the north side. The indoor area of each pen contained a deeply bedded straw area (6.2 m^2) closest to the aisle running longitudinally through the middle of the barn, a straw-flow area (3.9 m^2) where the floor slopes by six per cent (Bruce 1990) towards the slats in the middle of the pen, and a slatted area (2.7 m^2) closest to the building wall. The outdoor runs were provided with wallows (2.0 m long, 1.0 m wide, and 0.1 m deep). In addition, half of the runs were provided with shelters (2.7 × 2.0 m) along the building wall, and half of the runs were provided with roughage *ad libitum* in a trough (2.7 m long, 0.4 m wide, and 0.2 m deep) furthest away from the building. The pigs were fed *ad libitum* with cereal feed from self-feeders indoors. More details about the animals used for the investigation and their housing and management are described in Olsen (2001).

Treatments and design

The two experimental treatments were: (i) free access to roughage (wholecrop silage of barley and peas [*Hordeum vulgare* and *Pisum sativum* ssp. *Arvense*]) in the outdoor run; and (ii) shelter (partial coverage) in the outdoor run. These two treatments were distributed according to a 2 x 2 design on each side of the building (north versus south).

The shelters (2.7 x 2.0 m), each covering 30 per cent of each outdoor run, were made from sheets of plywood placed at the pen-fixtures 1.1 m above floor level at the end of the run closest to the building wall. Because of the orientation of the building, the shelters on the north side of the building were overshadowed by the building itself in the morning, and so the shelters themselves did not provide shade until the afternoon. In contrast, on the south side of the building, the shelters provided shade during the entire day.

The roughage troughs (2.7 m long, 0.4 m wide, and 0.2 m deep) were placed at ground level in the outdoor run furthest away from the building. The pigs on the roughage treatment had free access to roughage provided every morning and afternoon (on average, 5.8 kg per pen daily). To prevent rain and snow from falling into the troughs, they were each covered by a length of plywood at about 1 m above floor-level.

Behavioural measurements

The pigs were moved into the experimental pens at about 10 weeks of age (mean = 68.6 days, SD = 5.0). After an adaptation period of two weeks, the observations began at 13 weeks of age (week 13), and were repeated at weeks 15, 17, 19, 21 and 22. In each of these weeks, the observations were carried out on two successive days between 0800h and 1600h.

Focal animal sampling and scans were made. Two different people observed the same animal simultaneously: one person observed the current focal pig when it was outdoors, and the other person observed the current focal pig when it was indoors. The start positions (outdoor versus indoor) of the two observers were determined randomly in advance. The observers changed positions each day at noon after 24 pigs had been observed (on day 1), and again after 72 pigs had been observed (on day 2). Thus, by the end of each two-day observation period, all 96 pigs had been observed and the observations had been distributed equally between indoor and outdoor observers on mornings and afternoons.

The observation order for pigs and pens was determined randomly in advance. In each randomly chosen pen, each of three randomly chosen pigs was observed for 5 min by use of all-occurrence sampling. However, if the pig to be observed was not active, the next randomly listed pig was chosen for the observation (Dybkjær 1992). Between each 5 min observation period, a scan was made to determine the pigs' locations in the different areas of the pen and outdoor run. Simultaneously, the outdoors observer recorded the weather conditions — rain, snow, wind, overcast, or sunshine. This procedure continued until all pigs had been observed by the end of the second observation day. Handheld computers (Psion Organizer II and Psion Work About from Psion PLC) were used for data collection.

The following behaviours were recorded:

Aggression: Head-knocks with or without bites. A head-knock is defined as a rapid thrust upwards or sidewards with the head or snout towards another pig's head or body (Jensen 1980, 1982) with or without the mouth open. Head-knocks with or without bites were not recorded as aggression if performed in connection with play (see next paragraph).

Play: Scampering and jumping alone or together with one or more penmates. If head-knocks or bites were performed in this context, they were included as elements of play ('play-fighting').

As both aggression and play are relatively short-lasting, the number of events was recorded (Martin & Bateson 1986). Because aggression may increase as a result of limited resources (Hansen *et al* 1982), aggression was analysed for each part of the pen separately. Also, the length of time the pigs spent in each part of the pen was recorded separately in order to determine which parts of the pens the pigs preferred. If the pig's body was located concurrently in more than one area, the pig was recorded to be in the area that its head was oriented toward. The different locations of the pen and outdoor run were defined as follows: indoor — deep straw, straw-flow, slats; outdoor — wallow, shelter, roughage trough and remaining outdoor area. The different pen areas can be seen in the illustration of the barn in Olsen (2001).

Statistical analyses

Because the pen was the experimental unit, pen-means were calculated on the basis of the 12 pig-means per pen for each behavioural measure. All continuous variables were analysed by mixed linear models using PROC MIXED with RANDOM statement in SAS (SAS Institute Inc. 1995). Class variables were: replicate (1–7); weeks of age (1–6: repeated measures in weeks 13, 15, 17, 19, 21 and 22); pen (1–8); side of building (north/south); roughage (+/–); and shelter (+/–). The model statement included roughage ($df = 1$), shelter ($df = 1$), side of the building ($df = 1$) and week ($df = 5$) as general fixed effects, and interactions between these variables if $P < 0.05$. Random variables included pen, replicate, and all interactions in which they took part. Temperature (min: –4.4°C, max: +23.7°C), humidity (min: 56.8%, max: 99.3%), number of sun recordings (min: 0, max: 12), number of rain recordings (min: 0, max: 12) and number of wind recordings (min: 0, max: 12) were included as covariables if $P < 0.05$. The method of measurement of the climatic conditions, and the criteria for including them in the mixed linear analysis and correlation analysis, are described in Olsen *et al* (2001). To meet the requirements of variance stability, some of the dependent variables were ARCSIN transformed (inverse squared sine transformation).

Results are given in least square means (LS-means) and standard errors (SE) printed in PROC MIXED when using the LSMEAN statement. If transformed, LS-means and their SE were back-transformed using approximations presented in Jørgensen and Pedersen (1998).

Results

The pigs' use of the different pen sections

The pigs spent about 75 per cent of the observation time indoors and about 25 per cent outdoors. The pigs without roughage tended to spend more time indoors than those with roughage (2863 versus 2787 s h^{-1} [SE = 46]; $P = 0.11$). Table 1 shows the time the pigs spent in the different locations of the pen and outdoor run. The roughage treatment affected only the time spent at the roughage trough. The pigs with roughage spent more time in this location than those without ($P < 0.05$). In general, the pigs spent the majority of time in the deep-straw area. However, pigs without access to shelter spent less time in the deep straw compared to pigs with access to shelter ($P < 0.05$), and the pigs with access to shelter spent less time in the straw-flow area compared to those without ($P < 0.05$). Pigs with access to shelter spent significantly more time in the deep straw than those pigs without access to shelter, which spent significantly more time in the straw-flow area than pigs with access to shelter.

Table 1 **Duration of the pigs' stay in the different locations of the pen (seconds per hour). Data are LS-means (SE).**

Indoor						Outdoor							
Deep-straw		*Straw-flow*		*Slats*		*Wallow*		*Shelter*		*Roughage*		*Remaining*[1]	
NR	R	NR	R	NR	R	NR	R	NR	R	NR	R	NR	R
1789	1774	963	140	109	130	140	121	124	112	69	230	377	316
(77)	(77)	(40)	(20)	$(15)^{(a)}$	$(15)^{(b)}$	(20)	(20)	(11)	(11)	$(22)^{a}$	$(22)^{b}$	(38)	(38)
NS	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S
1723	1840	985	861	126	114	132	129	108	128	148	150	341	350
$(74)^{a}$	$(74)^{b}$	$(38)^{b}$	$(38)^{b}$	(15)	(15)	(20)	(20)	(10)	(10)	(20)	(20)	(35)	(35)

[1] Remaining outdoor area

R: Pigs with access to roughage

NR: Pigs without access to roughage

S: Pigs with access to shelter

NS: Pigs without access to shelter

Within each pen location, numbers with different superscripts are different at $P < 0.05$; numbers with different superscripts in brackets are different at $P < 0.07$.

During week 13, the length of time for which the pigs used most of the different pen sections was different from weeks 15–22 (Figure 1). During week 13, the pigs were located indoors and in the deep-straw area for longer than in weeks 15–22 ($P < 0.001$ [indoor] and $P < 0.05$ [deep-straw], respectively). Also, the pigs spent less time in the wallow, in the shelter area, and in the remaining outdoor area in week 13 than in weeks 15–22 ($P < 0.05$), and the pigs were occupied for longer at the roughage trough in weeks 17 and 21 than in weeks 13 and 15 ($P < 0.05$). The length of time spent in the straw-flow area was not affected by the pigs' age.

Aggression

The total frequency of aggression was lower in pigs with access to roughage than in those without (0.5 versus 0.6 events per hour [SE = 0.004]; $P < 0.05$). The effects of roughage on the frequency of aggression in the different pen areas are shown in Figure 2: in three of the seven areas there was a significant effect on aggression, and in two of the seven areas the results showed a tendency toward an effect of aggression. Pigs without roughage had a lower frequency of aggression at the roughage trough, but a higher frequency in the deep-straw area and in the remaining outdoor area ($P < 0.05$ for all), and they also tended to be more aggressive at the indoor slats and in the wallow ($P < 0.10$).

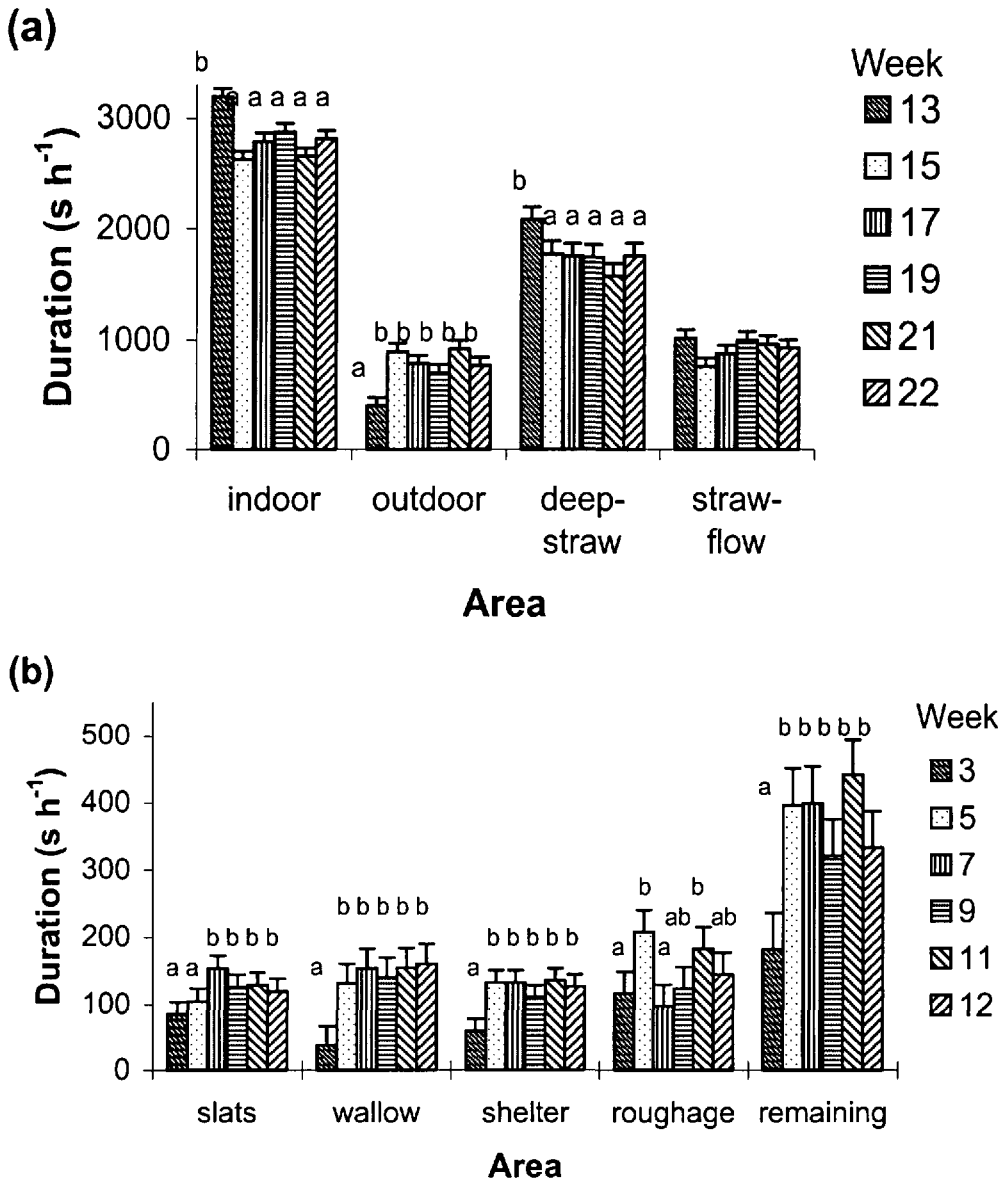

Figure 1 **The length of time (seconds per hour) spent by pigs in the different pen locations at different ages (weeks 13, 15, 17, 19, 21, 12). The areas are (a) indoors, outdoors, the deep-straw area, the straw-flow, and (b) the indoor slats, the wallow, the shelter area, the roughage trough and the remaining outdoor area. Data are LS-means and SE. Within each pen location, different superscripts are different at $P < 0.05$.**

No single effects of shelter were found ($P < 0.05$). However, for pigs located in the deep-straw area, an interaction between shelter and roughage was evident. Pigs that had access to roughage, with or without shelter, had a lower frequency of aggression than pigs that had access to shelter but not to roughage (0.15 and 0.18, respectively, versus 0.26 events per hour

https://doi.org/10.1017/S0962728600024325 Published online by Cambridge University Press

[SE = 0.03]; $P < 0.05$), whereas the aggression frequency in pigs with access neither to shelter nor to roughage did not differ from the three other treatment combinations (0.20 events per hour [SE = 0.03]). In the straw-flow area, the pigs with access neither to shelter nor to roughage tended to have a higher frequency of aggression than the pigs with access to roughage but not to shelter (0.02 versus 0.007 events per hour [SE = 0.005]; $P < 0.10$). The total frequency of aggression tended to be lower when pigs had access to both roughage and shelter compared to when they had access to either roughage or shelter (0.4 versus 0.6 and 0.5 events per hour [SE = 0.05]; $P < 0.10$).

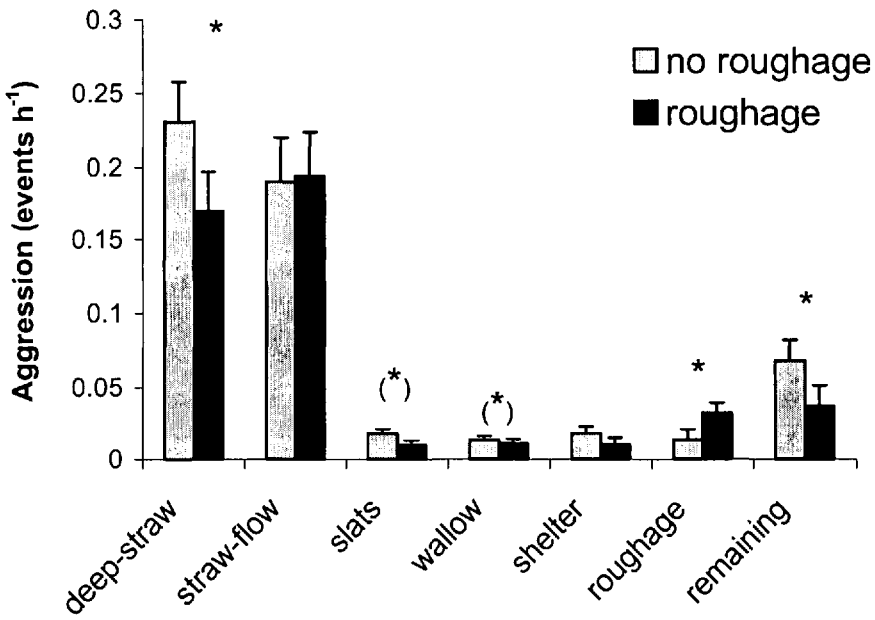

Figure 2 **Frequency of aggression (events per hour) in the different locations of the pens and outdoor runs. Data are LS-means and SE. *$P < 0.05$; (*)$P < 0.10$.**

There was no interaction between treatments and the age of the pigs, but single effects of age were evident (Figure 3). The majority of the aggressive interactions took place indoors (on average, 0.39 events per hour [SD = 0.56]), where the level of aggressive interactions was higher during weeks 13–17 than during weeks 19–22 ($P < 0.0001$). Detailed analysis showed that this was attributable to a higher level of aggression in the straw-flow area during weeks 13–17 than during weeks 19–22 ($P < 0.05$), and in the deep-straw area during weeks 13–15 compared to weeks 19–22. The frequency of aggressive interactions on the slats was higher during week 17 compared to weeks 15, 21 and 22 (0.33 [SE = 0.07] versus 0.06 [SE = 0.07], 0.14 [SE = 0.07] and 0.12 [SE = 0.07], respectively; $P < 0.05$); however, all of these values are very low. Outdoors, the aggression frequency was, on average, 0.1 events per hour (SD = 0.3), and no effect of age was found in any of the outdoor sections ($P > 0.05$).

https://doi.org/10.1017/S0962728600024325 Published online by Cambridge University Press

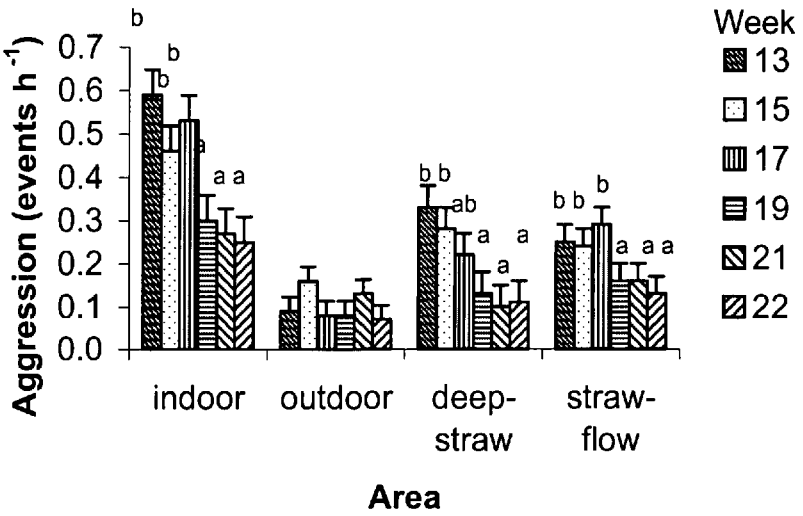

Figure 3 **The effect of age on frequency of aggression (events per hour) in the different locations of the pens and outdoor runs. Data are LS-means and SE. Bars with different superscripts are different at $P < 0.05$.**

Play

Play frequency decreased with increasing age ($P < 0.01$; Figure 4). The play frequency at week 13 was higher than at weeks 17–22 ($P < 0.05$), the frequency at week 15 was higher than at weeks 17–22 ($P < 0.05$), and the frequency at week 17 was higher than at week 22 ($P < 0.05$).

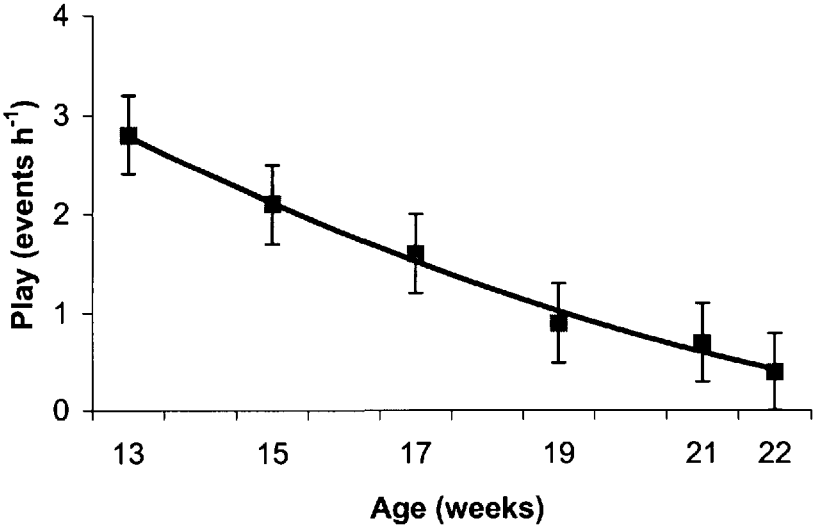

Figure 4 **Age significantly affects play frequency (events per hour) ($P < 0.01$). Data are LS-means and SE. The slightly curved line is the regression line for the relationship between weeks of age and play frequency. $[week]^2 = 0.01$ (SE = 0.05), [week] = –0.61 (SE = 0.08), Intercept = 9.01 (SE = 1.59); $P < 0.01$.**

https://doi.org/10.1017/S0962728600024325 Published online by Cambridge University Press

Play frequency was affected by an interaction between shelter and side of building (north/south): on the south side of the building, the pigs played more often when they had access to shelter than when they had not (2.0 versus 1.0 events per hour [SE = 0.3]; $P < 0.01$). No other treatments were found to affect play.

Influence of climatic conditions

Temperature affected the length of time that the pigs spent in the straw-flow area, in the remaining outdoor area and in the outdoor area in total ($P < 0.05$ for all), and positive correlations were evident for these pen locations ($R_P = 0.20$, $R_P = 0.30$ and $R_P = 0.41$, respectively; $P < 0.01$ for all). Temperature also affected the following variables ($P < 0.05$), for which negative correlations were found: the length of time spent indoors and in the deep-straw area ($R_P = -0.32$, $R_P = -0.48$, respectively; $P < 0.01$ for both); the frequency of aggression in these two areas ($R_P = -0.29$, $R_P = -0.28$, respectively; $P < 0.01$ for both); and the frequency of play ($R_P = -0.23$; $P < 0.01$). Temperature and age did not correlate ($R_P = 0.04$, $P = 0.47$). The mixed model analysis showed that the number of times that the weather was recorded as 'sunny' had an effect on the length of time that the pigs spent in the indoor area ($P < 0.05$), and correlation analysis revealed this correlation to be negative ($R_P = -0.32$; $P < 0.01$). Mixed model analysis showed that the number of 'sunny' recordings had an effect on the time spent in the outdoor run, the time spent in the shelter area, and the time spent at the roughage trough ($P < 0.05$). In all three cases, correlation analysis gave positive correlations ($R_P = 0.32$, $R_P = 0.0.27$, $R_P = 0.20$, respectively; $P < 0.01$ for all). The number of wind recordings and the number of rain recordings did not affect behaviour ($P > 0.05$).

Discussion

The results show that roughage reduced the total frequency of aggression as well as reducing aggression in the deep-straw area and in the remaining outdoor area. Furthermore, roughage tended to reduce the frequency of aggression in the wallow and on the slats. This is notable, as there was no difference between the pigs with and without roughage in the time spent in these locations. However, pigs with access to roughage had a higher frequency of aggression at the roughage trough than those without, but this was the only location where the pigs with roughage spent more time than those without. Moreover, the frequency of aggression in that location was low (less than 0.05 events per hour) and we find it negligible in comparison with the total aggression level (0.51 events per hour). Shelter in combination with roughage also reduced aggression. However, access to roughage was the main factor causing this reduction and, on the basis of the behaviour variables recorded in the present study, it is considered to be the most enriching stimulus of the two treatments.

As all pigs in the present study had access to ample straw, we find the effect of roughage remarkable. Others have found that enrichment with straw or other kinds of equipment for oral manipulation reduces the level of aggression in pigs (Simonsen 1990; Beattie *et al* 1993; Böhmer & Hoy 1993; Cornell & Beattie 1999); however, the pigs in their studies were compared with pigs that had no substrate for oral manipulation. In contrast, in the present study, all pigs were housed in a complex environment, and the pigs with roughage were compared with pigs that had access to ample straw and space. Thus, even though the pigs were housed in a relatively rich environment, the additional supply of roughage may have contributed positively to their welfare. The straw served as bedding material as well as rooting material, and the pigs' nutritional requirements were met from the *ad libitum* feeding

with cereal food. The roughage, therefore, served primarily as a 'recreational' material that met the pigs' need for oral activities.

Shelters were expected to enrich the pigs' environment in terms of providing protection from the sun, and so it was anticipated that shelter would contribute to the reduction of aggression because there would be fewer fights for cool areas and shady places. However, we did not find any effects of shelter on aggression levels, presumably because the pigs were not subjected to extreme temperatures.

The pigs spent the majority (about 75%) of the daytime indoors, of which about half was spent in the deep-straw area. This indicates that the deep straw was the main enriching factor in the complex environment. Shelter did not influence the duration spent outdoors, but access to roughage tended to increase this duration. Although this increase was not significant, it supports our assumption that roughage was attractive to the pigs and was the most enriching stimulus of the two treatments.

The pigs spent more time in the deep-straw area at younger ages. This may be because of the preference of smaller pigs for a warmer environment (Bonn 1981), and may also reflect the increase in environmental exploration with increasing age that has been demonstrated in confined (Olsen 2001) as well as in semi-natural conditions (Petersen 1994; Newberry & Wood-Gush 1988). Although the pigs spent the majority of the daytime indoors, at younger ages we found more competition (ie more aggression) in the indoor deep-straw and straw-flow areas. This supports the notion that young pigs prefer straw-bedded areas (Botermans & Andersson 1993).

As 'play-fighting' can be difficult to distinguish from aggression (van Putten 1980), the elevated aggression level early in the growing period may include elements of 'play-fighting'. However, in accordance with Schaefer *et al* (1990) and Cornell and Beattie (1999), we found that the lowest level of aggression was expressed in the richest environment (access to roughage), indicating that our definition of aggression is adequate.

The pigs usually used the entire pen for play. Typically, one or more pigs began playing in the deep-straw area, but suddenly they would start running and scampering throughout the indoor pen and outdoor run, entering and exiting the pen several times at high speed. We expected roughage and shelter to enrich the pigs' environment, and thus we expected the two treatments to increase the play frequency; however, we did not find such an effect. This might be because of the rich environment of the basic experimental pen, which included ample space in which to run, deep straw, *ad libitum* feeding and relatively small group sizes. In the present study, we found a decrease in play throughout the growing period, which is also found in pigs kept in a semi-natural environment (Newberry & Wood-Gush 1988). The regression line of play frequency relative to age in the present study (Figure 4) matches the findings of Dobao *et al* (1985), who found more play in pigs at younger ages in a confined environment. Therefore, the pigs' age must be taken into consideration when using play as a behavioural indicator of welfare.

The decrease in play frequency with age was not because of the systematic concurrent increase in temperature; however, the increase in temperature, as well as being housed on the south side of the building without access to shelter, decreased play frequency. Consequently, as play is an unquestionable indicator of welfare in young animals (Newberry *et al* 1988), we suggest that limited opportunity to find shade when temperatures increase may compromise the welfare of outdoor pigs. Von Haske-Cornelius *et al* (1979) found that temperature-related indicators of reduced welfare in pigs, such as increased restlessness and tail- and ear-biting, were exhibited in response to the increasing temperature when growing pigs were housed on

the south side of a pig unit compared to the north side. Consequently, we suggest that heat exposure and building orientation are important considerations when designing 'welfare housing systems' for pigs.

In Olsen (2001), we found that shelter in combination with roughage reduced the manipulation of penmates. Furthermore, roughage also reduced the number of skin injuries and the level of oral activities towards objects in the pigs' environment (Olsen 2001). The present results show that access to roughage in particular reduced the aggression level. Therefore, under the current circumstances and on the basis of the recorded measurements, roughage appears to be an important enriching stimulus. However, shelter also contributes to the enrichment of the pigs' environment and, as mentioned earlier, further effects of shelter could have been expected if the pigs were subjected to more extreme temperatures than those encountered in this investigation.

Conclusion

Access to roughage tended to increase the time spent in the outdoor run, and was found to decrease the frequency of aggression. Aggression levels were highest in straw-provided areas where the pigs spent most of their time, suggesting that these locations were the most attractive to the pigs. The play frequency was found to decrease with age and with increasing temperature, and pigs housed at the south side of the building played more if they had access to shelter in the outdoor run. No single effects of roughage or shelter were found on play, suggesting that the pigs' need to play may be fulfilled though the high quality of the basic pen environment. In conclusion, the behavioural welfare indicators recorded in the present study were positively affected by roughage and, to a lesser extent, shelter, suggesting that roughage may be the most enriching factor under the given circumstances.

Animal welfare implications

The study shows that providing growing pigs with roughage in addition to ample straw, space and a complex environment might improve their well-being. Therefore, the provision of additional roughage products, besides ample straw, for growing pigs should be considered. Furthermore, according to the results of the present study, more attention should be given to pigs' requirement for behavioural temperature regulation when designing pig barns — for example, the orientation of the barn should be taken into consideration.

Acknowledgements

We thank Dr David Fraser, Animal Welfare Program, University of British Columbia, and Dr E-M Vestergaard, Department of Animal Health and Welfare, Danish Institute of Agricultural Sciences, for their advice. The technical assistance of P M Hagelskjær, M Levring, L Jensen, and E L Decker, Danish Institute of Agricultural Sciences, is gratefully acknowledged, and we also thank Hans Kier's Fund, The Danish Society of Animal Production, for contributing to the financing of this study.

References

Beattie V E, Sneddon I A and Walker N 1993 Behaviour and productivity of the domestic pig in barren and enriched environments. *Proceedings of Livestock Environment IV Conference, Coventry UK, 6–9 July* pp 43-50. American Society of Agricultural Engineers: St Joseph, Michigan, USA

Blackshaw J K, Swain A J, Blackshaw A W, Thomas F J M and Gillies K J 1997 The development of playful behaviour in piglets from birth to weaning in three farrowing environments. *Applied Animal Behaviour Science 55*: 37-49

Böhmer M and Hoy S 1993 The influence of the housing system (deep litter system with additives of slatted metallic floor) on the behaviour of fattening pigs. *Proceedings of Livestock Environment IV Conference, Coventry UK, 6–9 July* pp 483-488. American Society of Agricultural Engineers: St Joseph, Michigan, USA

BØJ 1994 Bekendtgørelse om økologisk jordbrugsproduktion. *Plantedirektoratets Bekendtgørelse nr. 892 af 27 oktober*: Ministry of Food, Agriculture and Fisheries [Title translation: Regulations for organic farming in Denmark, Executive Order No 982, 27 October]

Bonn C R 1981 The effect of departures from lower critical temperature on the group postural behaviour of pigs. *Animal Production 33*: 71-79

Botermans J A M and Andersson M 1993 Pen function and thermal comfort in an unisolated stable for growing-finishing pigs. *Proceedings of Livestock Environment IV Conference, Coventry UK, 6–9 July* pp 851-858. American Society of Agricultural Engineers: St Joseph, Michigan, USA

Bruce J M 1990 Straw-flow: a high welfare system for pigs. *Farm Building Progress 102*: 9-13

Buchenauer D 1981 Parameters for assessing welfare: ethological criteria. In: Sybesma W (ed) *The Welfare of the Pig* pp 75-89. A seminar in the EEC programme of coordination for research on animal welfare, 25–26 November, Brussels. Martinus Nijhoff: The Hague, Netherlands

Cornell N E O and Beattie V E 1999 Influence of environmental enrichment on aggressive behaviour and dominance relationships in growing pigs. *Animal Welfare 8*: 269-279

Dobao M T, Rodrigañez J and Silio L 1985 Choice of companions in social play in piglets. *Applied Animal Ethology 13*: 259-266

Dybkjær L 1992 The identification of behavioural indicators of 'stress' in early weaned piglets. *Applied Animal Behaviour Science 35*: 135-147

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 10*: 307-318

Hansen L L, Hagelsø A M and Madsen A 1982 Behavioural results and performance of bacon pigs fed "ad libitum" from one or several self feeders. *Applied Animal Ethology 8*: 307-333

von Haske-Cornelius H, Bogner H and Beschke W 1979 Untersuchen zum Verhalten von Mastschweinen in vershiedenen Stallsystem unter besonderer Berücksichtigung des Schwanz- und Ohrenbeissens. *Bayerisches Lantwirtschaftliches Jahrbuch 56*: 162-200 [Title translation: Investigations on the behaviour of fattening pigs in different housing systems in relation to tail and ear biting]

Ingram D L 1965 Evaporative cooling in the pig. *Nature 207*: 415-416

Jensen P 1980 An ethogram of social interaction patterns in group-housed dry sows. *Applied Animal Ethology 6*: 341-350

Jensen P 1982 An analysis of agonistic interaction patterns in group-housed dry sows — aggression regulation through an "avoidance order". *Applied Animal Ethology 9*: 47-61

Jørgensen E and Pedersen A R 1998 *How to obtain those nasty standard errors from transformed data — and why they should not be used.* International Report 7 (20 pp). Biometry Research Unit, Danish Institute of Agricultural Sciences.

Martin P and Bateson P 1986 *Measuring Behaviour. An Introductory Guide.* Cambridge University Press: Cambridge, UK

McGlone J J 1985 A quantitative ethogram of aggressive and submissive behaviours in recently regrouped pigs. *Journal of Animal Science 61*: 559-565

McGlone J J, Salak J L, Lumpkin E A, Nicholson R I, Gibson M and Norman R L 1993 Shipping stress and social status effects on pig performance, plasma cortisol, natural killer cell activity, and leukocyte numbers. *Journal of Animal Science 71*: 888-896

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

Newberry R C, Wood-Gush D G M and Hall J W 1988 Playful behaviour of piglets. *Behavioural Processes 17*: 205-216

Olsen A W 2001 Behaviour of growing pigs kept in pens with outdoor runs. I. Effect of access to roughage and shelter on oral activities. *Livestock Production Science 69*: 255-264

Olsen A W, Dybkjær L and Simonsen H B 2001 Behaviour of growing pigs kept in pens with outdoor runs. II. Temperature regulatory behaviour, comfort behaviour, and dunging preferences. *Livestock Production Science 69*: 265-278

Pearce C A 1993 *Behaviour and other indices of welfare in growing/finishing pigs kept on straw-flow, bare-concrete, slats and deep straw*. PhD thesis, University of Aberdeen, UK

Petersen V 1994 The development of feeding and investigatory behaviour in free-ranging domestic pigs during their first 18 weeks of life. *Applied Animal Behaviour Science 42*: 87-98

van Putten G 1980 Objective observations on the behaviour of fattening pigs. *Animal Regulation Studies 3*: 105-118

SAS Institute Inc 1995 *SAS Users Guide, Version 6.11*. Cary NC, USA

Schaefer A L, Salomons M O, Tong A K W, Sather A P and Lepage P 1990 The effect of environmental enrichment on aggression in newly weaned pigs. *Applied Animal Behaviour Science 27*: 41-52

Simonsen H B 1990 Behaviour and distribution of fattening pigs in the multi-activity pen. *Applied Animal Behaviour Science 27*: 311-324

Spoolder H A M, Burbidge J A, Edwards A A, Simmins P H and Lawrence A B 1995 Provision of straw as foraging substrate reduces the development of excessive chain and bar manipulation in food restricted sows. *Applied Animal Behaviour Science 43*: 249-262

Stookey J M and Gonyou H W 1994 The effects of regrouping on behavioural and production parameters in finishing swine. *Journal of Animal Science 72*: 2804-2811

Worsaae H and Schmidt A 1980 Plasma cortical and behaviour in early weaned piglets. *Acta Veterinaria Scandinavica 21*: 640-657