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Growing-Finishing Pigs in an Uninsulated House

2. Pen function and thermal comfort

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Abstract. Pen function and thermal comfort in an uninsulated housing system for pigs from 10 weeks of age to slaughter were studied. Comparison with reference housing in an insulated pig housing system showed that the functioning of both systems was rather similar, although there were more problems with pen hygiene in the uninsulated housing system which may partly have been due to the solid floor. The pigs in the uninsulated housing system were more active and spent less time in the lying area. Age and air temperature had a considerable impact on pig behaviour: young pigs were more active in general. In both housing systems, pigs spent more time in the excretory area and less in the lying area with increasing temperatures.

The provision of a kennel in the uninsulated housing system improved the close environment for the pigs. Nevertheless, during cold periods, young animals (10–25 kg) in both systems had to cope with cold stress by huddling.

INTRODUCTION

Housing growing-finishing pigs in uninsulated houses can be an interesting alternative to reducing building costs (Rowinski & Johnsson, 1990). More variation in air temperature may be expected in an uninsulated house as compared to conventional housing. Since there are large differences in requirements for a 20 kg pig compared to a 110 kg pig with regard to space (Baxter, 1990) and climate (Bruce, 1981; Close, 1981), it is a challenge to develop a well-functioning pen design suitable for pigs from 20 to 110 kg live weight during both very warm and cold periods.

Normally, housing pigs in uninsulated buildings implies the use of simple techniques, large groups of animals and ad libitum feeding with feed hoppers. Deep litter systems are very common in uninsulated pig houses and much experience exists with regard to these housing systems. In deep litter systems, the pen is not divided into different areas for resting, feeding and dunging, which implies that large amounts of straw have to be used in order to prevent the deep litter from turning into a dunghill. The high straw expenditure (Møller, 1992) and lowered carcass meat percentage at slaughter (Koomans, 1978), make these systems economically unfeasible.

By means of a pen lay-out with separate lying, feeding/activity and excretory areas, the straw expenditure can be decreased substantially. The excretory area can be free from straw, while the lying area can contain a great deal. The climate in the lying area should be comfortable during both extreme warm and cold periods. The pigs also have to be able to keep the lying and feeding/activity area clean under these extreme circumstances, to avoid additional labour.

Behaviour studies are often used to obtain a better understanding of pen function and pig welfare. Pig behaviour may vary greatly with age and with the climate (Geers et al., 1990). Thus, it is important to take these factors into account when evaluating pen function using behaviour studies.

Little is known about the thermal comfort of pigs in extensive housing systems. Pigs maintained on straw can tolerate lower air temperatures better than pigs maintained on concrete floors (Bruce & Clark, 1979), but actual data from practical systems are not available. The thermal comfort of a pig is influenced by its heat production and the heat loss due to conduction, radiation, convection and evaporation (Sørensen, 1961). Since the measurement of these factors is too complicated and expensive, behaviour is often used as an indicator of thermal comfort (Geers et al., 1986).

Boon (1982), Geers et al. (1986) and Riskowski et al. (1990) observed that pigs huddled more at lower temperatures and high air velocities. Activity did not appear to be influenced by air temperature (Riskowski et al., 1990), but Scheepens et al. (1991) found that the total activity of pigs was significantly higher during periods with draughts. The pigs showed more explorative behaviour, redirected explorative behaviour on penmates and exhibited agonistic behaviour during the draughty periods.

At increasing temperatures, lying on the side increases and animal contact when lying decreases (Götz & Rist, 1984; Riskowski et al. 1990). The animals also are less active and lie more in the excretory area (Heitman & Hughes, 1949; Sällvik & Walberg, 1984).

Pigs huddling or lying on their sides may still be in the thermally neutral zone, but this behaviour indicates that the pigs are using behaviour to cope with their thermal environment. Thus lying behaviour will be a good indicator of pig thermal comfort.

The purpose of this paper was to describe pen function and thermal comfort in an uninsulated housing system for growing-finishing pigs using behaviour as the criterion, and to compare it with observations for growing-finishing pigs in an insulated reference housing system. This study was a part of a larger investigation studying performance and health (Botermans et al., 1995) of growing-finishing pigs and climate, labour and straw expenditure (Andersson et al., 1994) in an uninsulated pig housing system.

MATERIAL AND METHODS

Experimental design

Eight batches (trials) of pigs were used for this investigation (see Botermans et al., 1995), introduced at different seasons of the year. These batches were divided into two groups, housed in the reference housing system and uninsulated housing system, respectively.

Animals

The experiment was performed at the JBT research farm, Odarslöv, with 40 purebred Swedish Landrace sows in production. Piglets were weaned at 4.5 weeks of age, and at 10 weeks and weighing approximately 17 kg (range 10–25 kg), the pigs were introduced into the reference and uninsulated housing systems, respectively. They were slaughtered at about 110 kg live weight. For more details about rearing, feeding and husbandry routines see Botermans et al. (1995).

Housing systems and pen design

Technical details of the housing systems and pen design are fully described by Andersson et al. (1994). Eight pigs per pen (Danish design) were housed in the insulated reference housing system. The pens had a bedded lying- and feeding area (2.6 ∗ 2.25 m) giving room to one single-space feeder. Two drinking nipples were present on the excretory area (2.6 ∗ 1.5 m), which had slatted flooring. The pens in the uninsulated building housed 16 pigs and had the same basic lay-out as the pens in the reference housing system. The well-bedded lying area (2.5 ∗ 3.0 m) was covered with an insulated roof during cold periods (daytime temperatures lower than 18°C) and for the first 4–5 weeks after introduction, plastic flaps in the entrance were used to keep the warm air inside the lying area. The kennel had a movable wall, which made it possible to increase the lying area according to pig size, thus reducing eliminative behaviour in the kennel when the animals were small. Two single space feeders were placed on the feeding area (1.0 ∗ 3.0 m). The excretory area (3.5 ∗ 2.25 m) had a solid concrete floor with an urine channel and 3 water nipples. The space distribution and the total space per pig (1.2 m^2/pig) was the same for both treatments.

Climate studies

The reference house temperature was set at a minimum of 18°C for pigs up to 50 kg and at a minimum of 16°C for pigs of more than 50 kg. The climate in the uninsulated house was influenced by natural ventilation.

During trial 3, air temperatures in both houses and outside the buildings were continuously recorded using a thermocouple (type T). The air temperature in the reference house was measured 1.0 m above floor level. In the uninsulated house, the air temperature was measured in one pen at 1.0 m above floor level in the lying, feeding and excretory areas, respectively.

During the behaviour studies (trials 1–8), the air temperatures in the three areas of the pen were recorded manually in the two pig housing systems.

Cleanliness studies

During trials 1–8, the cleanliness of all pens was studied one day a week to help evaluation of the pen function. The pen was divided into lying-, feeding/activity- and excretory areas, respectively. A score was given to each area using the following scale; 1 = clean, 2 = dirty, 3 = very dirty.

Behaviour studies

During the 8 trials, interval studies by direct observation were carried out at 11 (19 kg), 17 (45 kg) and 23 (85 kg) weeks of age (age groups), respectively. The pigs in both pig housing systems were simultaneously observed by two observers who alternated in registering behaviour at 9.00–10.00, 11.00–12.00, 13.00–14.00 and 15.00–16.00 h. Every 5 minutes, the location and posture (standing, sitting or lying) of the pigs were recorded. The way they were lying (huddling, normal or on the side) was also noted. Pigs were considered to be 'huddling' when they lay on each other. Pigs were noted as 'lying on the side' when all 4 legs were visible.

Pen function

One goal of the behaviour studies was to describe how the pigs utilized their pen. For the day the behaviour studies were carried out, a score for pen function was determined per pen and age group for each location/posture combination. The percentage of this score with respect to the total number of observations and the average of these percentages were calculated for each housing system.

To describe the impact of temperature on pen function, the effect of the air temperature in the excretory area on the location of the pigs was studied.

Thermal comfort

For describing the impact of air temperature on thermal comfort, the relationship between air temperature in the lying area and lying position (huddling, normal or on the side) was studied. In addition, the relation between the air temperature in the excretory area and the location of the pigs when lying was determined. For each age group and housing system combination, the best fitting models were calculated.

Statistical analyses

During the 8 trials, a total 44 pens were observed on three different occasions (age groups 11, 17 and 23 weeks). The observations for each pen and age group (a total of 119 observations) were considered to be independent, because it was assumed that the effect of pen was zero in comparison to the effect of air temperature and age. This assumption made it possible to correct for age and temperature.

The data were statistically analyzed using analysis of variance to determine differences in pen function between age groups and the two housing systems, using the following model:

$$Y_{ijk} = u + h_i + a_j + t_{ijk} + e_{ijk}$$

where:

y_{ijk} = the ijkth observation
u = general mean
h_i = effect of the ith housing system ($i = 1, 2$)
a_j = effect of the jth age group ($j = 1, 2, 3$)
t_{ijk} = effect of the temperature in the excretory area for each ijkth observation
e_{ijk} = residual random term.

RESULTS

Climate

The climate changes in the two housing systems were followed in trial 3. Figure 1 shows the average 24-hour period air temperatures in the uninsulated house kennel, outside the building and in the reference house. These pigs entered the housing systems on the 19th of February and were slaughtered during May and June. There was little difference (5°C) between the kennel and the outside temperatures at introduction of the animals, because the young animals had difficulties in heating the kennel. The average 24-hour period air temper-

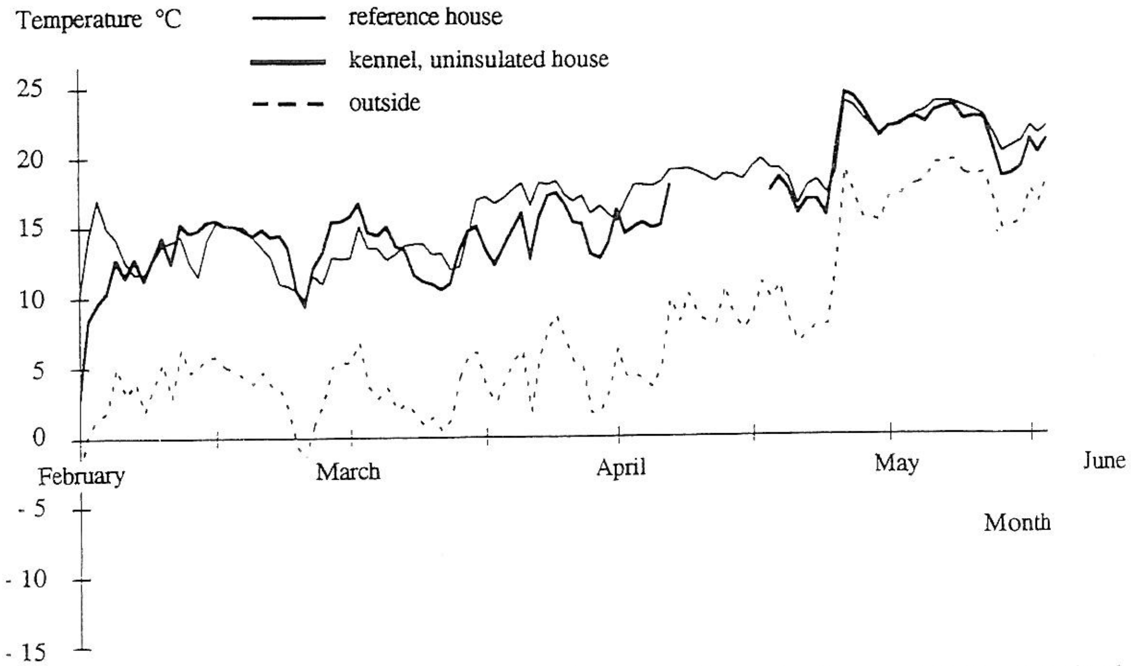

Fig. 1. Average 24-hour period air temperatures in the reference house, in the kennel in the uninsulated house and outside the buildings. Trial 3.

ature in the kennel was just 3–5°C during the first days. The difference in air temperature between the kennel and outside increased as the animals grew older and produced more body heat. Towards the end of the trial, it decreased again because the plastic flaps in the entrance were removed at the end of March and the kennel roof was removed at the beginning of May. In general, the air temperature in the kennel followed the fluctuations in the outside temperature and was always 5–10°C above. The air temperature in the reference house also followed the outside temperature fluctuations to a certain extent, because there was no supplemental heating system in this pig house.

Figure 2 shows the average 24-hour period air temperatures in the different areas of the uninsulated house during the same trial. The animals could always choose different thermal environments.

The air temperatures in the excretory area during the behaviour studies (trials 1–8) varied between 11.5 and 28.0°C in the reference house, and between 2.9 and 28.0°C in the uninsulated house, depending upon the season. This large variation in air temperature during the studies made it necessary to take air temperature into account when evaluating pig behaviour.

Pen function

In general, pen function appeared to be rather similar between the two housing systems, at the same pig age, however, differences occurred. The young pigs used the pen as it was designed to function. The older pigs lay more often in the excretory area (1.5%, 8.4%, and 18.2% at 11, 17 and 23 weeks of age, respectively, $p = 0.0001$). Age had a significant effect on pen function: young animals were more active in comparison to the older animals (56.8%, 44.1%, and 31.0% at 11, 17 and 23 weeks of age, respectively, $p = 0.0001$) (Table 1). Temperature also had a large impact on pen function. After adjusting for the effect of age group and housing system, pigs spent significantly more time in the excretory area ($p = 0.0001$) and less in the lying area ($p = 0.0001$) with increasing air temperatures in the excretory area (Table 1 and Fig. 3). The time spent lying

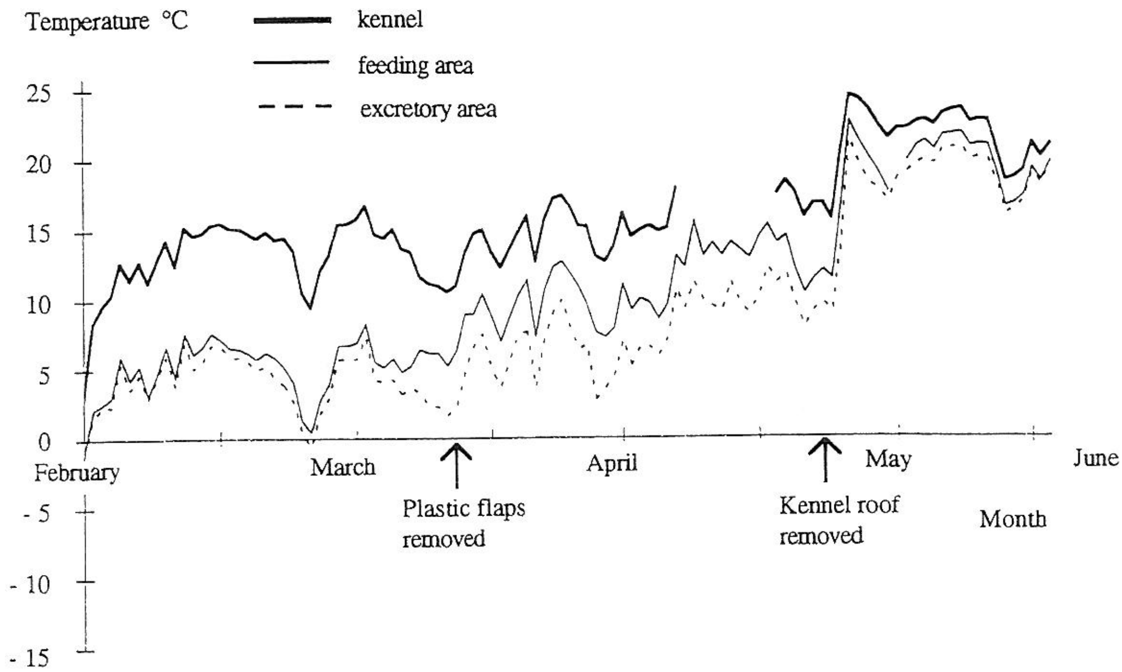

Fig. 2. Average 24-hour period air temperature in the kennel/lying area, feeding/activity area and the excretory area, for the uninsulated housing system. Trial 3.

($p = 0.0002$) and standing ($p = 0.0006$) was also significantly affected by the temperature in the excretory area (Table 1); especially older pigs (23 weeks) were less active at high air temperatures (see also Andersson et al., 1994).

After correction for age group and temperature, there were still differences in pen function present between the two housing systems. Pigs in the uninsulated housing system were more active ($p = 0.0153$) and spent more time in the excretory area ($p = 0.0001$) and less in the lying area ($p = 0.0001$) (Table 1).

Cleanliness

The cleanliness in the feeding- and excretory areas was poorer in the uninsulated housing system in comparison to the reference housing system (mean score 1.4 vs. 1.1, and 2.4 vs. 2.0, respectively), especially during warm periods. This might have been due to the excretory area of the uninsulated housing system having solid flooring.

Thermal comfort

For all age groups in both housing systems, there was a significant effect of air temperature in the lying area on the position of the pigs when lying: with increasing air temperature, pigs lay more on their sides ($p = 0.0001$) and huddled less ($p = 0.0001$). The relation between the air temperature in the lying area and the lying position of pigs 11 weeks of age is shown in Figure 4. The results for the other age groups have been presented in Andersson et al. (1994). Although, young animals (11 weeks of age), were observed to huddle in both housing systems, this behaviour was especially frequent in the uninsulated housing system. At a kennel air temperature of 7°C, approximately 38% of the young pigs were huddling. In the reference house it was never colder than 13°C during the behaviour studies, but approximately 12% of the young animals 11 weeks of age were huddling. The pigs in the uninsulated housing system lay significantly less (10.0% vs. 12.5%, $p = 0.03$) on their sides at same age and air temperature than those in the reference housing system. Instead, they coped with a hot environment by changing their location in the pen; 12.4% of the pigs in the uninsulated housing

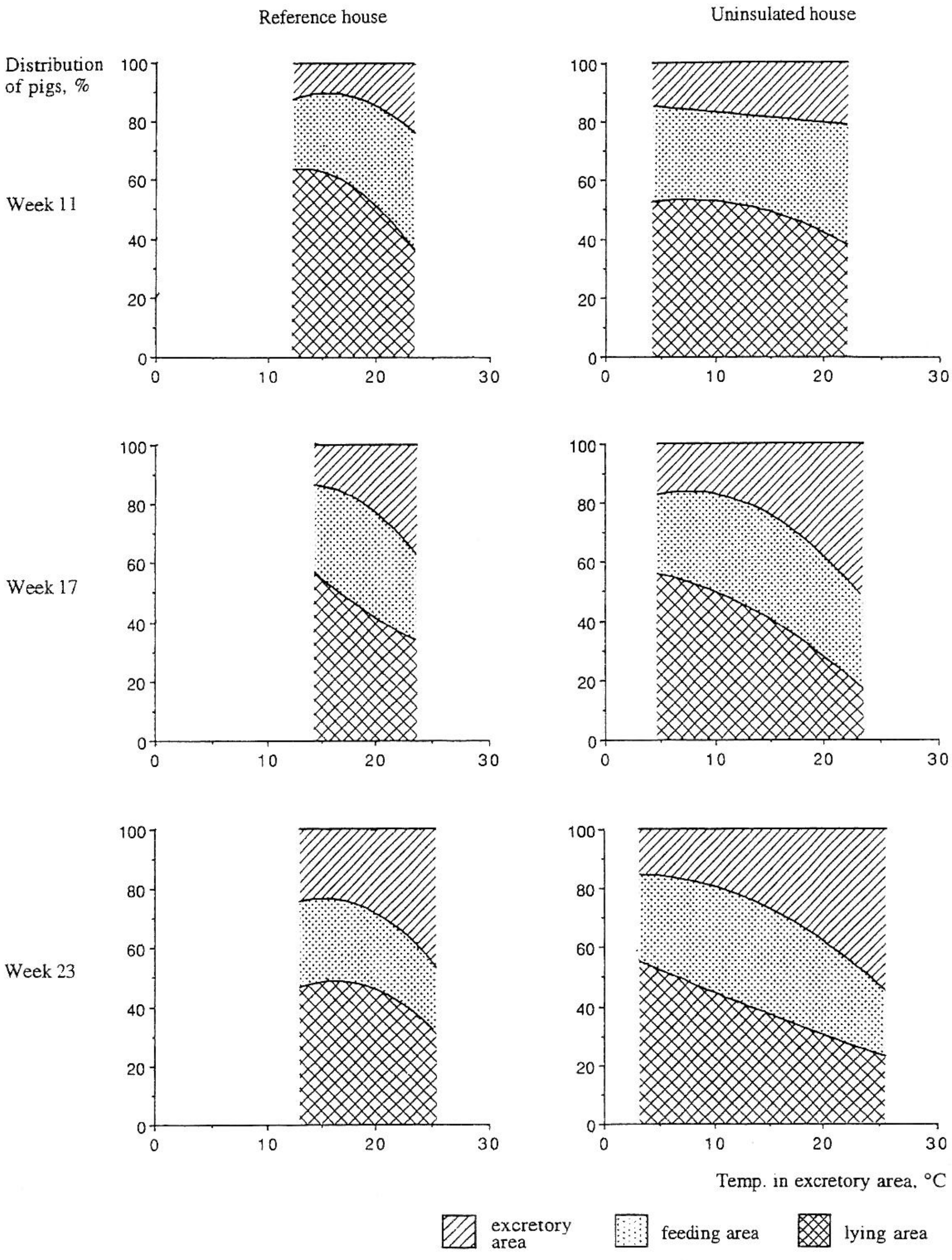

Fig. 3. The relationship between the temperature in the excretory area and the location of the pigs for the 3 age groups, in the reference and uninsulated housing systems, respectively.

Table 1. *Least square means for the location and posture of the pigs. Percentage distribution. Corrected data for effects of age and temperature*

	Reference housing	Uninsulated housing	S.E.D.	Level of significance: Age group	Temp. in excretory area	Housing system
No. observations	73	46				
No. pigs/pen	8	16				
Location and posture						
Lying area						
Lying	38.8	29.0	1.67	n.s.	***	***
Sitting	2.9	1.7	0.28	**	***	***
Standing	10.9	9.0	0.81	***	***	*
Total	52.6	39.7	1.55	***	***	***
Feeding area						
Lying	8.1	9.0	1.00	***	**	n.s.
Sitting	1.2	1.0	0.22	***	n.s.	n.s.
Standing	20.4	22.2	0.75	***	**	*
Total	29.8	32.2	1.24	**	n.s.	*
Excretory area						
Lying	6.4	12.4	1.34	***	***	***
Sitting	0.7	0.8	0.11	***	***	n.s.
Standing	10.5	14.9	0.81	***	n.s.	***
Total	17.6	28.1	1.44	***	***	***
Total pen						
Lying	53.3	50.4	1.76	***	***	n.s.
Sitting	4.9	3.5	0.43	***	n.s.	**
Standing	41.8	46.1	1.73	***	***	*
Total	100.0	100.0				

n.s. = not significant. * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$.

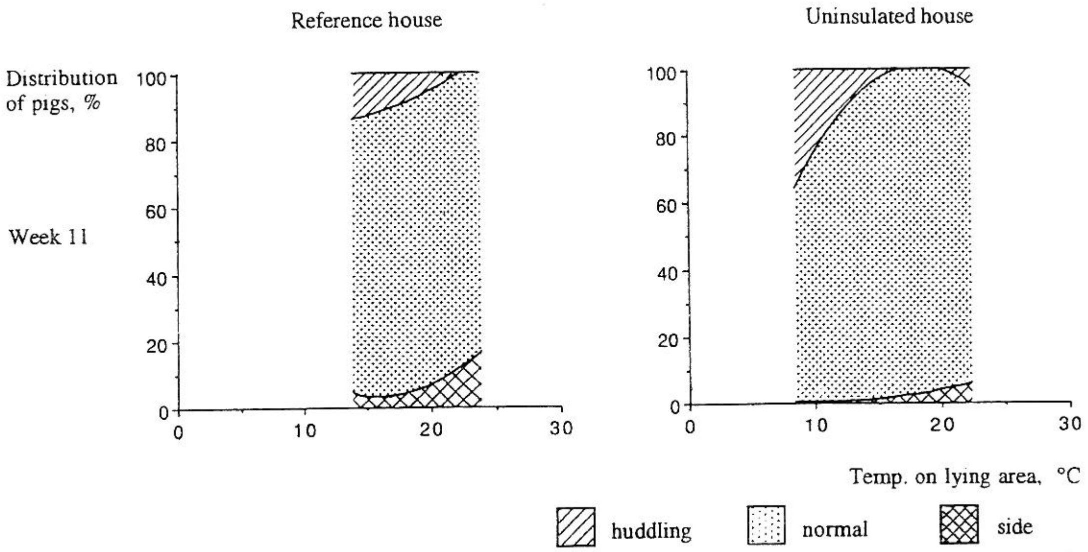

Fig. 4. The relationship between the temperature in the lying area and the lying behaviour for pigs 11 weeks of age, in the reference and uninsulated housing systems, respectively.

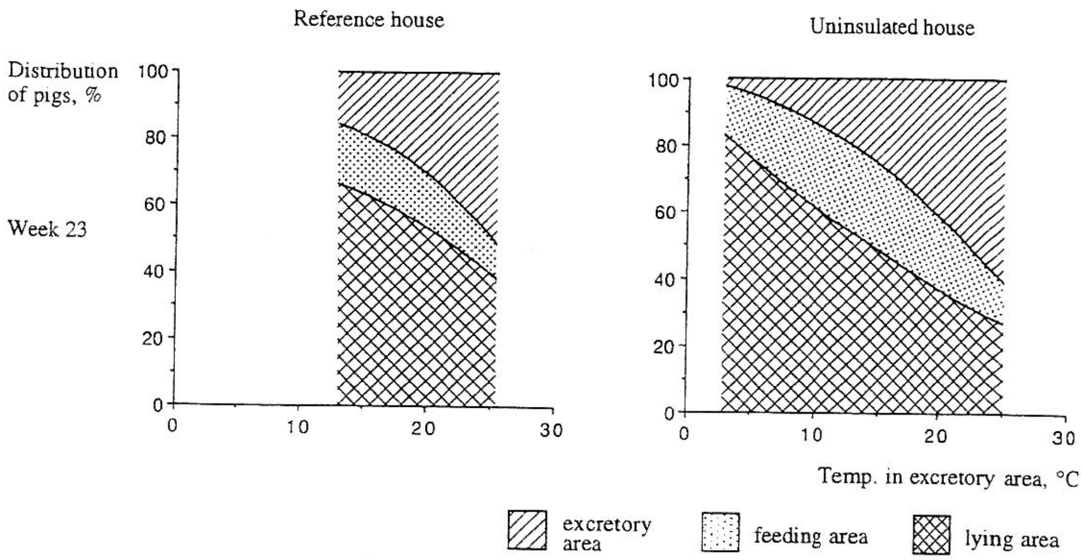

Fig. 5. The relationship between the temperature in the excretory area and the location of the pigs when lying for animals 23 weeks of age, in the reference and uninsulated housing systems, respectively.

system lay in the excretory area vs. 6.4% in the reference housing system ($p = 0.0001$). The relation between the air temperature in the excretory area and the location of the animals when lying is shown for pigs 23 weeks of age in Figure 5. For all age groups, the animals lay significantly less in the lying area ($p = 0.0001$) and significantly more in the excretory area ($p = 0.0001$) with increasing air temperatures in the excretory area.

DISCUSSION

Behaviour studies are often used to obtain a better understanding of pen function and pig welfare. The results of these studies showed that it is very important to keep age (or live weight) constant when comparing pig behaviour in different housing systems. In addition, air temperature has to be taken into consideration when comparing behaviour between treatments. A change in behaviour may primarily not be due to the treatment per se, but the underlying cause may be a difference in air temperature between the two treatments. In addition, using air temperature as a covariate in the model facilitates the detection of statistical differences in behaviour between treatments. On the other hand, in some cases, the air temperature may be considered to be a part of the treatment. Thus, an insulated housing system will not be expected to have very low temperatures, whereas these would be expected to occur in an uninsulated housing system during the wintertime.

For practical reasons, only air temperature was chosen as a parameter for the climate. The effects of air velocity, radiation, convection, etc., were not studied, although they are also important (Sørensen, 1961). Under draughty conditions, pigs might huddle at moderate temperatures, and during a warm summer day feel comfortable when there is some fresh wind.

In the uninsulated housing system, the air temperature in the excretory area followed the outside temperature fluctuations whereas the reference housing air temperature was more stable. The variation in air temperature in the uninsulated housing system made it difficult to create a well functioning pen, but using a kennel greatly helped to create a better close environment for the pigs by aiding the retention of body heat. With the exception of the first days after introduction during the winter, when the pigs had problems in heating the kennel, the kennel air temperature was very similar to the reference house air temperature. This was achieved by placing plastic flaps in the entrance during the first weeks after introduction.

Generally, the pens functioned as intended in both housing systems. Young animals used the system as it was designed, but older animals tended to lie more outside the lying area. Comparison of behaviour showed that the pigs in the uninsulated housing system were more active, spending more time in the excretory area and less time in the lying area. This may have been due to the pigs considering the solid excretory area to be more interesting for explorative behaviour and more comfortable than the pigs in the reference housing system found a slatted floor to be. In addition, larger groups of pigs may also be more active.

Even though a heavily strewed kennel improved the close environment for the pigs, pigs 11 weeks of age still huddled during cold periods in the uninsulated housing system. At a kennel air temperature of 7°C, up to 38% of the pigs huddled, showing that pigs maintained at low temperatures will change their behaviour to keep themselves warm. It is difficult to determine what exactly is a high level of huddling, but it has been shown that cold stress reduces the immune response (Rafai & Tuboly, 1986) and makes the animals more susceptible to disease (Nielsen, 1980). Pigs 11 weeks of age varied greatly in live weight (range 10–25 kg), and the small pigs which huddle most may also be those which become ill and vice versa. Introducing pigs of 25–30 kg of live weight into the uninsulated housing system would probably have avoided these problems.

At increasing temperatures and for all age groups, a great proportion of the pigs in the reference housing system preferred to regulate their heat loss by lying on their sides, while pigs in the uninsulated housing system relatively more changed their location in the pen. This may have been due to the greater difference in temperature between the excretory and lying areas and the greater air velocity in the excretory area in the uninsulated housing system, in comparison to conditions in the reference housing system. Another reason could be that the pigs could cool themselves better on the wet/dungy solid excretory area in the uninsulated housing system than on the slatted flooring used in the reference housing system. This reverse lying behaviour resulted in more dirty animals and more problems with pen hygiene than those in the reference housing system. The animals were never heat stressed, as found in an investigation studying climate conditions and production characteristics in a greenhouse (Gustafsson et al., 1990).

The possibility of choosing different areas with a great variation in stimuli and air temperatures in the uninsulated housing system could be an advantage for the animals, and enabling them to cope with the more extreme thermal environment. On the other hand, data which is not presented in this paper showed that the division of the pen into different thermal environments was a problem during the immediate post-introduction period; subordinate animals could be forced by dominant animals to stay in the excretory area.

It can be concluded that there was more variation in climate in the uninsulated house compared to the reference house, but it was possible to create a better close environment by providing a kennel in the uninsulated house. Nevertheless, this kennel was too cold for pigs of 11 weeks of age during the winter time. Introducing heavier animals (25–30 kg) might eliminate this problem. In general, the pen function was similar in both pig housing systems, although pigs in the uninsulated housing system were more active and spent more time in the excretory area. During warm periods, pigs in the uninsulated housing system lay more in the excretory area and reversed their eliminative behaviour, resulting in dirty lying- and feeding areas and extra labour.

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