Effects of insulation on the temperature within farrowing huts and the weaning weights of piglets reared on a commercial outdoor pig unit


The air temperatures inside uninsulated and insulated huts were recorded on an outdoor pig unit in the south of England between September 1997 and September 1998, and the herd’s production parameters were also recorded. During the summer the temperatures inside some of the uninsulated huts exceeded 45°C, but the temperatures inside the insulated huts were lower and fluctuated less. Despite the high temperatures, the weaning weight of piglets reared in the uninsulated huts were often higher than those of the piglets reared in the insulated huts, possibly as a result of the higher mortality of small piglets in the uninsulated huts, especially during the winter. The weaning weights of the piglets were higher during the summer.

MATERIALS AND METHODS

Experimental design

The study was carried out on a commercial, outdoor pig unit in the south of England, which kept approximately 564 sows, 142 maiden gilts and 34 boars. All the sows were PIC NPD line 250. The sows, 142 maiden gilts and 34 boars. All the sows were PIC in the south of England, which kept approximately 564

The experiment was repeated six times between September 1997 and September 1998, three trials being conducted during the winter and three trials during the summer (Table 2).

Temperature recording

The environmental temperatures and the temperatures within the huts were measured throughout the preweaning period of three to four weeks with miniature temperature dataloggers (‘Tinytalk’; Gemini Dataloggers). The environmental temperature was measured by a datalogger attached to a fence post outside the two paddocks; it was housed in a wooden box to protect it from rain and direct sunlight, but a good airflow was provided around the probe by a series of holes drilled in the sides of the box. Dataloggers were also placed inside five uninsulated and five insulated huts. The probes were protected from the sows using galvanised metal boxes, which were insulated from the sides of the huts to minimise direct heat transfer, and had holes in the sides to allow good airflow around them. The dataloggers were placed 24 cm from the edge of the door at approximately the shoulder height of a sow. The recorded temperatures were considered to indicate the temperatures experienced by the sows on entering the huts.

Where possible, the dataloggers were programmed to start recording approximately five days before the start of farrowing and to continue until several days after the expected weaning date, ensuring that temperature data were available for the period from birth to weaning in most cases. During the monitoring period from birth to weaning in most cases. During the mon-
itoring period, the temperature was recorded every 30 minutes. After weaning, the dataloggers were removed from the huts and the data were downloaded and imported into a spreadsheet (Excel; Microsoft), where functions were written to calculate the mean daily temperatures, maximum daytime and minimum night-time temperatures and the time per day spent above the sow’s evaporative critical temperature (ECT), defined as the temperature at which pigs start to pant in order to maintain body temperature; for lactating sows the ECT has been estimated to be approximately 25°C (Black and others 1993, Pollock 2000).

Production
The sows were introduced into the paddocks approximately five days before their expected farrowing date and were allowed to farrow under normal management conditions. They had access to fresh water. No additional shade was available within the paddocks but each sow had access to a wallow; no problems had been encountered with piglets accessing the wallow and drowning. The farrowing huts faced approximately south throughout the duration of the study. Each hut was checked by the stockman at least once a day and dead piglets were removed and recorded. For each sow, the stockman also completed a questionnaire, recording its identification number, parity, size, farrowing date, litter size, litter mortality, fostering records and weaning dates.

Weaning weights were analysed by using a mixed effect (model III) analysis of variance with hut type (uninsulated v insulated) and season (winter v summer) as fixed variables and trial number as a random variable nested within season. Weaning weights were also analysed by using a one-way analysis of variance with treatment and season (P=0·0034), and the data for each season were therefore analysed separately. During the winter there was a marginally significant interaction between treatment and season (P=0·0491), although during trials 1, 2 and 3, the mean hut temperatures were significantly lower in the uninsulated huts than in the insulated huts (P=0·0056, 0·0572 and 0·0216, respectively). In contrast, dur-
ing the summer, there was no significant interaction between treatment and trial number, and the analysis indicated a significant effect of treatment ($P=0.0246$) with the temperatures in the uninsulated huts being higher than in the insulated huts.

The maximum daytime and minimum night-time temperatures for each day during the preweaning period were calculated for each hut (Fig 4). Throughout the year, the minimum temperatures in both types of hut were essentially similar, but the maximum temperatures were very different. During the autumn and winter, the maximum temperatures in the uninsulated and insulated huts were similar, although the highest peaks tended to occur in the uninsulated huts; however, during the summer, the maximum temperatures in the uninsulated huts were much higher than in the insulated huts, in some cases exceeding 45°C.

The mean time per day that the ambient temperature of each hut was above the sows' ECT (25°C) is shown in Fig 5. During the autumn and winter, the temperature in the insulated huts exceeded 25°C for only short periods and there were only moderate increases during the summer. In contrast, in each trial, the temperature in the uninsulated huts exceeded 25°C for longer than the insulated huts. Moreover, during the summer, the temperature in the uninsulated huts exceeded 25°C for an average of over five hours per day.

**Mortality**

Total mortalities, early mortalities (occurring within 24 hours of birth) and late mortalities (occurring between 24 hours and weaning) were calculated for each litter from data provided by the farmer in a questionnaire (Table 3). Previous studies using postmortem examinations have shown that the external appearance of a dead piglet cannot be used to distinguish stillborn piglets reliably from those dying within a few hours of birth (Edwards and others 1995). The number of early mortalities therefore included stillborn piglets.

Litter size had a highly significant effect on total piglet mortality during the preweaning period, with increased mortalities occurring in larger litters ($P<0.001$). Hut type had a marginally significant effect ($P=0.057$), with a tendency for higher mortalities occurring in the uninsulated huts. During the summer, however, neither litter size nor hut type had significant effects. In the uninsulated huts, there was a significant effect of litter size ($P<0.001$) and early mortalities were significantly higher during the winter. In contrast, in the insulated huts there was no effect of litter size or season.

When considering late mortalities, the inclusion of an interaction between season and hut type did not significantly improve the fit of the model and the model containing only main effects was considered. Litter size had a marginally significant effect ($P=0.041$) but hut type had no significant effect. In contrast, however, season had a highly significant effect ($P<0.001$), with higher mortalities occurring in the summer.

**Production**

The mean weaning weights for piglets in each type of hut are shown in Fig 6. There was a highly significant interaction between the type of hut and the trial number ($P<0.001$). The mean weaning weight of the piglets reared in the uninsulated huts was significantly higher than the mean weaning weight of the piglets reared in the insulated huts for trials 2, 3, 4 and 6; the pattern in trial 1 was similar, although the difference was not statistically significant. In trial 5, however, the mean weaning weight of the piglets reared in the insulated huts was significantly lower than that of the piglets reared in the insulated huts. Other differences are shown in detail in Fig 6.

The weaning weights of piglets weaned during the summer months were significantly higher than those of the piglets weaned during the autumn and winter ($P<0.001$). However, when the treatment groups were considered separately, the effect was significant for the litters born in the insulated huts ($P<0.001$) but not for those born in the uninsulated huts ($P=0.177$). Nevertheless, there appeared to be an effect of sea-
son, and it was hypothesised that weaning weights could be affected by a season-specific variable such as day length or mean daily temperature.

To investigate the possible role of day length on weaning weights, the times of sunrise and sunset for the experimental period were obtained for the nearest major town using the website of the Astronomical Applications Department of the US Naval Observatory (http://mach.usno.navy.mil/), and day length was calculated for each day from birth to weaning for each litter. The mean preweaning day length was calculated for each treatment group. The effect of day length on the mean weaning weights is shown in Fig 7. An analysis of covariance identified a significant interaction between day length and hut type (P<0.001). Analysing the effect of day length on the weaning weights in each hut type revealed a highly significant positive association in the insulated huts (P<0.001) but a marginally non-significant association in the uninsulated huts (P=0.056).

Similar results were found for the effect on weaning weights of mean daily temperatures during the preweaning period. The mean daily environmental temperatures were calculated for each litter from birth to weaning and the mean preweaning environmental temperatures were calculated for each treatment group. Once again, there was a highly significant interaction between mean daily temperature and hut type (P<0.001). Analysing the results for each hut type identified a highly significant positive association between environmental temperature and weaning weights in the insulated huts (P<0.001) but a non-significant association in the uninsulated huts (P=0.675).

The FAWC (1996) report on the welfare of pigs kept outdoors suggested that insulating farrowing huts may help to reduce condensation and heat loss when pigs make contact with the sides of the hut but has little effect on the air temperature in the hut or on the performance of the pigs (paragraph 51). Nevertheless, it also recognised that farrowing huts can become very hot in the summer and that the most beneficial effects of insulation may occur during this period (paragraph 55). The results of this study clearly support the latter suggestion. The air temperature within the uninsulated huts became very high during the middle of the day, especially during the summer, whereas the temperature fluctuations within the insulated huts were much smaller (Fig 4). In Scotland, similar effects have been reported in insulated outdoor farrowing huts (Edwards and others 1995), but in Texas, USA, insulation affected neither the mean temperature nor the relative humidity in outdoor farrowing huts (Johnson and McGlone 2003). In the present study, there were only slight differences between the mean daily temperatures recorded in the insulated and uninsulated huts (Fig 3); if the insulation serves to reduce extreme temperature fluctuations, it is not surprising that the average temperatures in the two types of huts were similar. However, when the data were expressed as the maximum daytime temperatures or the numbers of hours spent above the sows’ ECT, there were more marked differences between the groups (Figs 4, 5).

The very high temperatures reached in the uninsulated huts, especially during the summer trials, might have resulted in considerable periods of time during which the sows would have avoided entering them. In these circumstances, it is likely that the sows’ behaviour would have changed to pre-
vent overheating, and this may have had effects on their suckling behaviour. The possible effects of such excessive temperatures on the welfare of the sows and piglets need to be investigated.

The total mortalities during the preweaning period were slightly lower in the insulated huts but tended to be higher during the summer months. However, there were larger differences between the distributions of early and late mortalities. There were significantly more early mortalities in the uninsulated huts during the winter than in either the insulated huts during the winter or the uninsulated huts during the summer. In contrast, the number of late mortalities was unaffected by the type of hut but increased markedly during the summer. It is possible that the large numbers of early mortalities in the uninsulated huts during the winter were due to small, non-viable piglets dying within a few hours of birth as a result of the low temperatures. Similar piglets born during the summer might have survived longer owing to the warmer temperatures and would have been classified as late mortalities. Despite this effect, the results suggest that the higher summer temperatures did not significantly reduce total preweaning mortalities.

The MLC reported that the average annual mortality of piglets born on outdoor breeding units is approximately 10 per cent (Table 1). In the present study, the overall mortality rate of the piglets born alive was 10·0 per cent, although the values for the individual trials ranged from 0 per cent in trial 2 to 17·8 per cent in trial 4. The close agreement between these mortality figures suggests that the farm used in the study was probably representative of outdoor units in the UK. The variations between the trials agree with anecdotal claims that preweaning mortality rates in outdoor units tend to be highly variable.

The mean weaning weights of the piglets were higher in the uninsulated huts than in the insulated huts, except in trial 5. The data collected in trial 5 were approximately normally distributed and had a similar standard deviation to the data collected in other trials, there were no obvious outliers and no compelling reasons to exclude the data from the analysis. It was initially hypothesised that the lower weaning weights in the uninsulated huts in trial 5 were due to the high temperatures within the huts inhibiting the sows from entering to suckle their piglets. Indeed, the mean (±SE) period during which the temperatures inside the uninsulated huts were above the ECT of the sow (25°C) was 5·88 (0·25) hours per day, compared with 1·91 (0·20) hours per day for the insulated huts (Fig 3). However, if this hypothesis were correct, similar results would have been expected in trial 6, in which the mean time spent above the ECT in the uninsulated huts was 5·44 (0·31) hours per day compared with 2·89 (0·30) hours per day in the insulated huts. In trial 6, however, the pattern of weaning weights in the uninsulated and insulated huts was similar to that in the other trials. Although the unusual pattern of weaning weights in trial 5 could not be explained in terms of the data, it is possible that the lower weaning weights in the uninsulated huts were due to some additional variables, such as the health of the pigs. The data were recorded under commercial conditions and could have been influenced by events affecting a single batch of piglets. The highly significant interaction terms identified between treatment group and day length or mean environmental temperature were undoubtedly caused by the unusual data recorded in trial 5.

This resulted in a highly significant association between weaning weights and day length or mean environmental temperature in the insulated huts but an apparent lack of effect in the uninsulated huts.

The weaning weights of the piglets reared in the uninsulated huts were significantly higher than the weaning weights of the piglets reared in the insulated huts in trials 2, 3, 4 and 6; a similar pattern was observed in trial 1, although the difference was not significant (Fig 6). No similar differences between the weaning weights of piglets reared in uninsulated and insulated huts have been reported in other studies. Edwards and others (1995) found no significant effect of hut type on the weaning weight of piglets born to sows farrowed outdoors in Scotland. Similarly, Johnson and McGlone (2003) reported no overall effect of insulation on litter weight for piglets reared outdoors in Texas, although in one experiment, the weaning weights were lower in uninsulated huts with short wooden fenders than in insulated huts with a similar fender design.

The reasons for the different effects on production parameters reported in different studies remains unknown. However, it is possible that other, uncontrollable variables may have played important roles. For example, there were highly significant, positive associations between the weaning weights and season-specific variables such as day length and average daily temperature. Such statistical associations should not be considered as evidence for causal relationships, although both variables have plausible biological effects that could explain the observed data. Mabry and others (1983) showed that sows rearing litters in an environment with a 16-hour photoperiod weaned more piglets per litter and reared piglets with heavier 21-day weights than the sows exposed to an eight-hour photoperiod. The sows in the 16-hour photoperiod suckled their piglets more often, an effect that has been shown to increase total milk output (Spinka and others 1997), and produced milk containing more total solids. It is therefore possible that the longer photoperiod during the summer months directly influenced the nursing behaviour of the sows and resulted in the increased weaning weights of the piglets. Nevertheless, such positive effects of extended photoperiod on piglet weaning weights have not been observed in all studies (McGlone and others 1988).

The higher environmental temperatures during the summer months could also have affected the performance of the piglets. Piglets maintained in a warm environment would be likely to have higher feed conversion ratios, resulting in increased weaning weights. To counter this effect, however, it has been shown that sows maintained in an environment above their ECT have a lower milk yield (Black and others 1993). Such an effect could be minimised by dietary manipulation and, especially, by increasing the evaporative heat losses from the sow by wetting its skin. The results of Black and others (1993) were obtained from sows maintained in warm environments. In the present study, the higher temperature may have had only a minimal effect on milk yield because the sows were able to control their own evaporative losses by wallowing in the pits provided in each paddock. Hence, it is possible that the net effect of the higher environmental temperature was to increase the weaning weights of the piglets.

The longer day length and higher environmental temperatures during the summer months, together with other confounding variables, such as possible improved management practices during the summer, could each have had direct effects on the weaning weights of the piglets. Further experiments are required to define the mechanisms by which season affects the weaning weights of piglets reared on outdoor pig units.

Even though the results support the hypothesis that there are marked temperature fluctuations within uninsulated huts and that these fluctuations are reduced by insulation, there is little evidence to suggest that the use of insulated farrowing huts had a significant effect on the productivity of the sows. Presumably, the sows spend considerable periods of time outside the huts when the internal temperature is above their ECT, but without a net detrimental effect upon their ability to feed their piglets.
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