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AUSTRALIAN Pork

Heating conventional indoor weaner sheds with reduced nocturnal temperatures in winter

Final Report
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Executive Summary

Heating weaner sheds in winter represents a significant energy cost in the pig industry. Reducing the heating cost in weaner sheds may be a way to control the cost of production, provided that animal welfare and performance are not compromised. Piglets may not require the same levels of artificial heating during night as the daytime, because of the reduced activity and increased huddling behaviour during the night. An overseas study showed that a heating regime with 6°C reduction in nocturnal temperature saved 30% energy cost without negative impacts on growth performance in winter (Johnston *et al.* 2013). However, such a protocol has not been evaluated in Australian production systems. Therefore, we proposed an experiment to evaluate such a heating protocol for weaner pigs housed in indoor conventional sheds in winter. An experiment was conducted to compare the two heating protocols [STD (standard heating regime): set room temperature of a constant 28°Cat entry then decreased by 2°C each week thereafter; NTR (Nocturnal Temperature Reduction): similar daytime temperature setting as STD but set to 22°C from 15:00 h to 07:00 h daily] on the growth performance of weaners housed in a conventional shed (metal slatted floor with the concrete lying area; 18 pigs/pen) in winter. Results showed:

1. Growth performance and mortality rate of weaners were not different between STD and NTR heating regimes.
2. The occurrence of piling was similar between STD and NTR heating regimes. The NTR heating regimes tended to increase the proportion of pigs huddled during the early weaner phase.
3. Rectal temperature of piglets in the NTR group was slightly lower than STD group during the early weaner phase but still within the normal range.
4. The NTR heating regime used 20% less gas compared with STD heating regimes. The total cost of feed and energy usage was $84 lower for 1000 weaners during 35 d during winter.

In conclusion, the NTR heating regime reduced the cost of production without affecting weaner growth performance in winter. Before implementation, pig producers are encouraged to evaluate the NTR heating regime in their production systems and climate conditions. The NTR heating regime may contribute to the reduction of greenhouse gas emissions if solar energy could be used for daytime heating in the future.

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1. Background to Research

The thermoneutral zone for 5-15 kg weaner pigs housed in an insulated shed with concrete floors is 31-19°C (Brent 1986). Maximum energy retention for growth happens when pigs are housed in their thermoneutral zone. To maintain the room temperature within the weaners thermoneutral zone, heaters are usually used in conventional weaner sheds during winter. Heating weaner sheds in winter represents a significant energy cost for the pig industry. For example, a heavy-duty gas heater (SuperSaver™) used for heating a conventional weaner shed (e.g.: 500 weaners per shed) costs approximately $1000-$2000 for 35 days. Reducing the heating cost in weaner sheds may be a way to control the cost of production, provided that animal welfare and performance are not compromised. A US study showed that a heating protocol with a 6°C nocturnal temperature reduction (NTR) saved 30% energy cost without negative impacts on growth performance in winter (Johnston *et al.* 2013). However, such protocol has not been evaluated in an Australian production system. Therefore, we proposed an experiment to compare the NTR heating protocol with a standard heating protocol for weaner pigs housed in indoor conventional sheds in winter.

2. Objectives of the Research Project

This project set out to compare the growth performance, mortality rate, and cost of production of weaners housed indoors with standard heating (STD) or nocturnal temperature reduction (NTR) heating regimes.

3. Introductory Technical Information

The common standard heating regime (STD) for weaner sheds in winter is to set the shed temperature to a constant 28°C in the first week post-weaning and then decrease by 2°C every week thereafter. The nocturnal temperature reduction heating regime maintains a similar daytime temperature as the STD heating regime, but the night temperature is set as 22°C from Day 4 post-weaning. The settings of the two heating regimes are demonstrated in Figure 1.

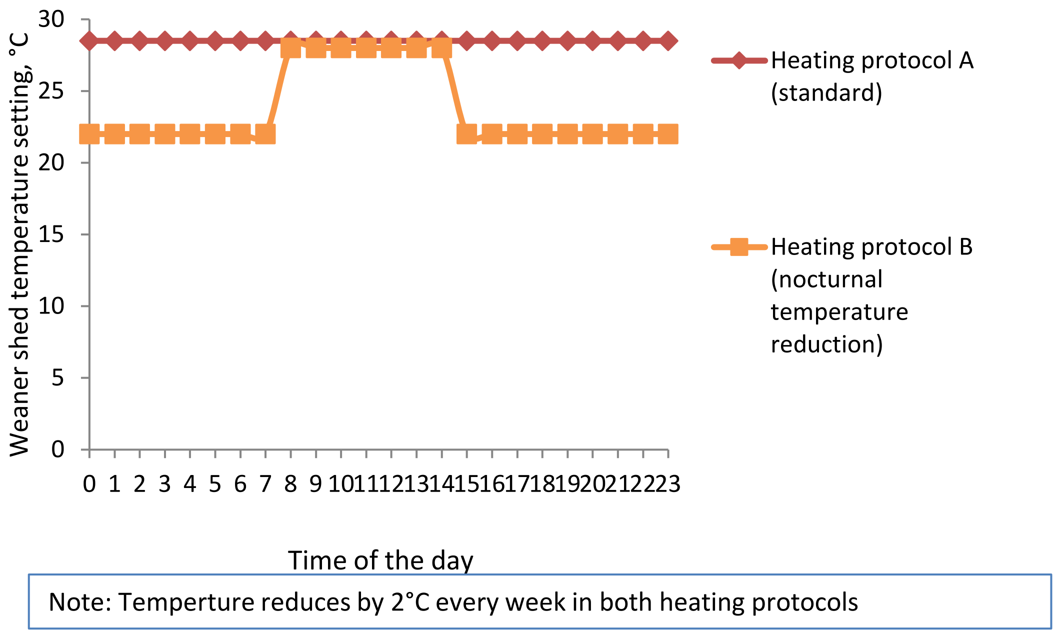

Figure 1 Temperature settings for standard heating regime vs nocturnal temperature reduction heating regime.

4. Research Methodology

4.1 Animals and experimental design

All animal procedures had prior institutional ethical approval from the Rivalea Animal Ethics Committee (protocol ID:18P051 and 20P026) under the requirement of the New South Wales Prevention of Cruelty to Animals Act (1979) in accordance with the National Health and Medical Research Council/Commonwealth Scientific and Industrial Research Organisation/Australian Animal Commission Australian Code of Practice for the Care and Use of Animals for Scientific Purposes (NHMRC, 2013).

The experiment compared the growth performance of weaners housed in conventional indoor weaner sheds with standard heating regime (STD) or a nocturnal temperature reduction (NTR) heating regime during winter. A total of 120 pens of weaner pigs (av. 26 d age; equal male and female pens) were allocated to four weaner sheds (30 pens per shed) with STD and NTR heating regimes applied over two winter seasons in Corowa, Australia (August - September 2018 and July - August 2020). Pigs were housed in group pens (18 weaners per pen; 0.29 m^2 space per pig) with the pen used as the experimental unit for measuring growth performance. Each pen consisted of 2/3 partially metal-slatted area and 1/3 concrete area. The feeder was located in the concrete area. The diets were formulated to meet or exceed the NRC requirement (National Research Council 2012) (not shown). A gas heater (SuperSaver™) was used in each weaner shed for heating. The ambient temperature of the weaner sheds with STD was set to 28°C when the weaners arrived in the shed and was then decreased by 2°C weekly until d 35 post-weaning. The NTR heating regime was set to a similar room temperature as the STD regime during 7:00 h-15:00 h, but the temperature was dropped to 22°C from 15:00 h until 7:00 h the following day. Indoor temperature was recorded using digital temperature loggers during the experiment. The average daily temperature is shown in Figure 2. Pigs were fed *ad libitum* and had *ad libitum* access to water via nipple drinkers. Deaths of pigs were recorded daily. Two gas meters were installed and used to monitor the gas usage throughout the weaner shed.

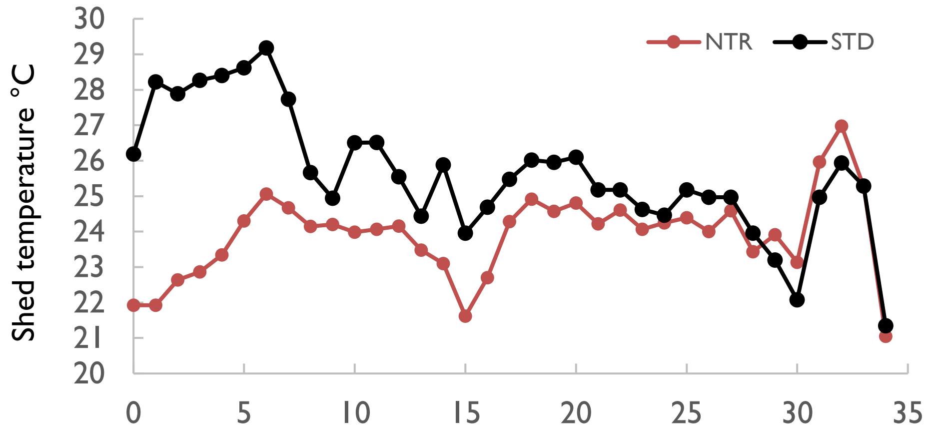

Figure 2 Daily temperature in the weaner sheds with standard heating (STD) or nocturnal temperature reduction (NTR) heating regime during winter

4.2 Growth performance

Pigs were weighed at weaning (0 d; the same day as entry to the weaner shed) and at 35 d post-weaning, and average daily gain (ADG) was calculated. Feed delivery and refusals were weighed once or twice per week to calculate average daily feed intake (ADFI). Feed conversion ratio (FCR) was calculated as the ratio between ADFI and ADG.

4.3 Huddling behaviour and rectal temperature measurements

The occurrence of piling was defined as there being at least two pigs that had 50% of their body overlapped whilst huddling within the pen. The occurrence of piling (recorded as yes or no) and the number of pigs huddling in each pen was observed quietly by an animal technician at 07:00 and 15:00 h on d 2, 8, 15, 22 post-weaning. The percentage of pigs huddling was calculated by normalising the number of pigs huddling to the total number of pigs in the pen. Rectal temperature was measured on one random pig per pen at 07:00 and 15:00 h on d 2, 8, 15, 22 post-weaning using a digital thermometer.

4.4 Statistical analysis

Growth performance data were analysed using the Univariate procedure for the main effects of the heating regime (STD vs NTR), year of the trial, and sex. Mortality rate was analysed using Pearson's Chi-squared analysis. Rectal temperature and percentage of pigs huddling were analysed using the Univariate procedure for the effects of the heating regime, year of the trial, day of observation, time of the observation, heating regime*day, heating regime*time; heating regime*day*time. The occurrence of piling (yes or no) in each pen was analysed using binary logistic regression for the effects of the heating regime, year of the trial, day of observation, time of the observation, heating regime*day, heating regime*time; heating regime*day*time. All the analysis was conducted in SPSS (version 24; IBM, Chicago, IL, USA). Means were considered to differ significantly when $P \leq 0.05$, and a trend was identified when $P \leq 0.10$.

5. Results

4.1 Growth performance

Pigs were allocated to the experiment with a similar body weight between STD and NTR heating regimes (Table 1). ADI, FCR, or ADG was not affected by heating regimes during 0-35 d post-weaning period (Table 1). The interaction between sex and heating regimes was not significant on any of the measurements (not reported).

The mortality rate was not affected (P=0.15) by heating regimes (data not shown).

4.2 Rectal temperature

Rectal temperature was not affected by NTR heating regimes (Heating regime, P=0.64) (Figure 3). The rectal temperature increased d 2 until d 15 post-weaning (Day, P<0.001). The rectal temperature measured at 7:00 h was lower than at 13:00 h. There was a trend for the interaction between heating regimes and time of day (Heating regime*Time, P=0.074), such that rectal temperature tended to increase at a greater magnitude from 7:00 to 13:00 in the NTR group (from 38.97 to 39.14°C) than in the STD group (39.06 to 39.09°C).

4.3 Behavioural measurements

The occurrence of piling in pens was not affected by the heating regimes or its interaction with day or time (All P>0.1; data not shown). A greater proportion of pigs huddled at 07:00 h than at 13:00 h (Time, P<0.01) (Figure 4). The proportion of pigs huddled increased from 0.6 to 0.7 from day 2 to day 8, then gradually reduced thereafter (Day, P<0.01). The main effect of heating regime was not significant (P=0.21). The interaction between day and heating regime tended to be significant (P=0.055), such that the NTR group tended to have a greater proportion of pigs huddled than the STD group on day 2 and 8 post-weaning but not at other time points (Figure 4).

4.4 Comparison of cost of feed and energy usage between STD and NTR heating regime

Feed costs were calculated using the average diet cost ($0.42/kg) times ADFI over 35 d. Pigs with the NTR heating regime had a 2% higher feed cost ($7027 vs $6894 for 1000 weaners over 35 days), but 20% lower energy usage ($906 vs $1121 for 1000 weaners over 35 days) than the STD group. The combined feed cost and energy cost savings for 1000 weaners over 35 days was $84 for the NTR heating regime compared the STD heating regime (Table 2).

Table 1 Growth performance of weaners housed in the sheds with standard heating (STD) or nocturnal temperature reduction (NTR) heating regime during winter

Variables	Conventional heating (n=60 pens)	Nocturnal temperature reduction (n=59 pens)	SE	P-value
Body weight (d 0), kg	7.3	7.4	0.19	0.80
Body weight (d 35), kg	19.9	20.1	0.19	0.62
ADFI, g	469	478	7.0	0.38
ADG, g	365	369	5.4	0.60
FCR	1.28	1.29	0.009	0.45

Table 2 Comparison of feed and energy cost between STD (standard) and NTR (nocturnal temperature reduction) heating regime during 35-d weaner phase in winter.

	STD	NTR
Feed cost, $/1000 weaners	$ 6,894	$ 7,027
Energy (gas) cost, $/1000 weaners	$ 1,121	$ 906
Feed + energy cost, $/1000 weaners	$ 8,016	$ 7,932

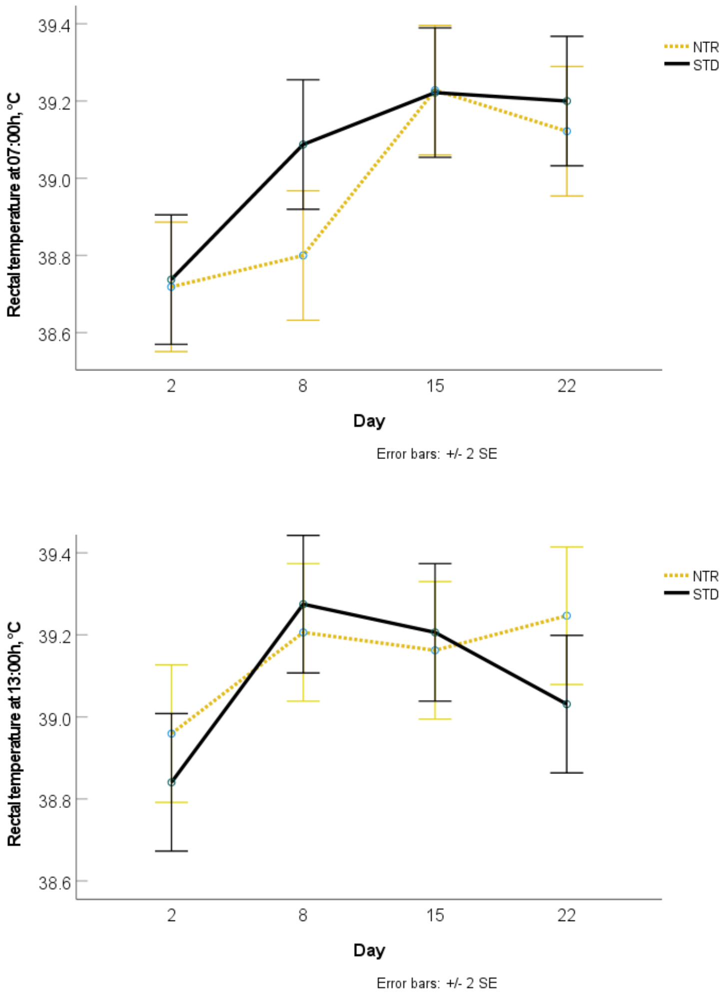

Figure 3 Rectal temperature of weaners housed in the sheds with standard heating (STD) or nocturnal temperature reduction (NTR) heating regime

Rectal temperature was measured in one random pig per pen (n=30 pigs per heating regime) at 07:00 h and 13:00 h on d 2, 8, 15, 22 post-weaning. P-values are 0.64 (Heating regime), <0.001 (Day), <0.001 (Time), 0.011 (Day*Time), 0.074 (Time*Heating regime), 0.15 (Day*Heating regime), 0.51 (Day*Time*Heating regime).

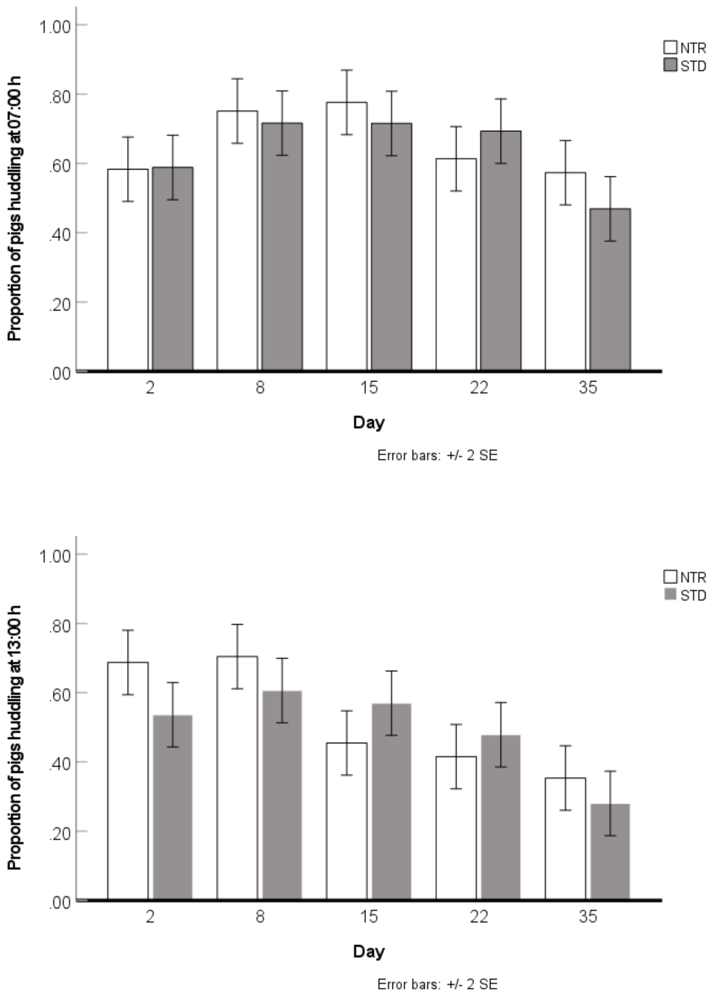

Figure 4 Proportion of huddling weaners housed in the sheds with standard heating (STD) or nocturnal temperature reduction (NTR) heating regime

The proportion of weaners huddling in a pen (n=120 pens per heating regime) at 07:00 h and 13:00 h on d 2, 8, 15, 22 post-weaning. P-values are 0.21 (Heating regime), <0.001 (Day), <0.001 (Time), <0.001 (Day*Time), 0.89 (Time*Heating regime), 0.055 (Day*Heating regime), 0.14 (Day*Time*Heating regime).

6. Discussion

The main finding was that the using NTR heating regime achieved a similar weaner growth performance as that of the conventional heating protocol in winter, and importantly, with 20% reduced energy consumption. This finding is similar to the publication by Johnston et al. (2013) in which a 6°C reduction in nocturnal temperature applied to weaner sheds had no impact on the growth performance of weaners. There tended to be an increased percentage of huddling pigs under the NTR heating regime during the early weaning phase (i.e.: d 2 and d 8 post-weaning), suggesting that the young piglets tried to reduce their surface area for heat dissipation in a colder environment (Hicks *et al.* 1998). The increased proportion of huddling piglets coincided with the tendency of slightly lowered rectal temperature observed on d 8 post-weaning. However, all rectal temperatures measured were still in the normal physiological range. From d 15, the huddling behaviour and rectal temperature both become similar between NTR and STD heating regimes. The occurrence of piling was similar between NTR and STD heating regimes.

In the current experiment, feed intake was numerically 2% greater in the NTR group compared to the STD group, although this was not statistically different. Feed intake was not affected by NTR heating regimes in the US study (Johnston *et al.* 2013). It remains unknown whether NTR with a greater reduction in nocturnal temperature can trigger a significant increase in feed intake. The cost associated with increased feed intake may outweigh the energy-saving, thus cautions should be taken. Future experiments should evaluate the NTR heating regime in winter under different housing systems and climate conditions.

The NTR heating regime not only saves on cost of production but also has positive implications for the environment. Reducing the pace of global warming is a priority across all industries, and the mitigation of greenhouse gas emissions is the key. The diurnal nature of the generation of solar energy makes it suitable for the NTR heating regimes, which facilitate the adoption of solar energy in heating weaner sheds thus subsequently reduce the greenhouse emissions from fossil fuels.

The overall growth rate in this trial was 360 g/d, which was lower than the growth rate expected. The low growth rate may be due to the relatively low health status of the weaners over the two replicate batches, as evidenced by a higher than usual mortality rate.

In conclusion, the NTR heating regime has the potential to save energy usage used for heating conventional weaner sheds (concrete floor with metal slats) during winter without compromising weaner growth performance.

7. Implications & Recommendations

- The NTR heating regime can be used in winter as an energy-saving strategy in conventional weaner sheds (concrete floor with metal slats).

- The reduced energy usage may contribute to reduced emissions of greenhouse gases.

- Pig producers are encouraged to evaluate the NTR heating regime in their production systems and climate conditions, particularly on energy and feed usage and pig behaviour and welfare before implementation.

8. Intellectual Property

There is no intellectual property arising from the research. The findings from the project will be publishable with the permission from APL.

9. Technical Summary

The experiment followed a classical design, and conventional measurements were used.

10. Literature cited

Brent G. (1986) 'Housing the pig.' (Farming Press Ltd: Ipswich, UK)

Hicks T.A., McGlone J.J., Whisnant C.S., Kattesh H.G., Norman R.L. (1998). Behavioral, endocrine, immune, and performance measures for pigs exposed to acute stress1. *Journal of Animal Science* 76, p. 474-483.

Johnston L.J., Brumm M.C., Moeller S.J., Pohl S., Shannon M.C., Thaler R.C. (2013). Effects of reduced nocturnal temperature on pig performance and energy consumption in swine nursery rooms1,2,3. *Journal of Animal Science* 91, p. 3429-3435.

National Research Council (2012) 'Nutrient Requirements of Swine.' (Natl Acad Press: Washington, DC)

11. Publications Arising

NA