January 2004

Thermal Conditions Within Pens Fitted With Differing Zone-Heating Options and Resulting Performance of Newly Weaned Pigs in a Wean-to-Finish Facility

Richard R. Stowell
University of Nebraska - Lincoln, rstowell2@unl.edu

Sherri Colgan
University of Nebraska - Lincoln

Mike Brumm
University of Nebraska, mbrumm1@unl.edu

Thermal Conditions Within Pens Fitted With Differing Zone-Heating Options and Resulting Performance of Newly Weaned Pigs in a Wean-to-Finish Facility

Rick Stowell
Sherri Colgan
Mike Brumm[1]

Summary and Implications

Research was conducted to assess the effects of the type of zone heater and floor mat used in a wean-to-finish building on the thermal environment created for newly weaned pigs and resulting pig performance. Gas-fired brooder heaters were compared to electric heat lamps and farm-cut wood sheathing was compared to commercial [unheated] rubber floor mats. No consistent differences in air temperature near the heating zone were found between either of the treatments. However, black-globe temperatures in pens having gas-fired heaters and/or wood mats were consistently warmer than in their comparison pens. Temperature deviations during the 26-day study period were similar statistically for both air and black-globe temperatures (about ±2.5°F) for all treatments, as were the temperature deviations from pen to pen for all treatment combinations (±1.7°F or less). Pig health was affected by an outbreak of porcine reproductive and respiratory syndrome (PRRSV). Performance of the disease-challenged pigs was similar for the two heating systems. However, pigs in pens having wood sheathing on the floor below the zone heater consumed more feed on a daily basis than those resting on rubber mats. This evidence supports statistically significant ($P<0.05$) advantages for the wood mats in pig weight (+3%) and average daily gain (+6%) over the 26-day study period. Feed-to-gain ratios over this same time period were similar for all treatments. The fact that there was greater radiant heating (as indicated by warmer black-globe temperatures) with gas-fired heaters in this study suggests that extra adjustments in heater height and gas pressure may have been needed to obtain equivalent heating effects, and that additional information on placement and adjustment of zone heaters also would be useful to producers. The data collected in this study and associated experience of farm management imply that producers can develop an similarly stable thermal environment for nursery pigs using either electric heat lamps or gas-fired brooder heaters. The improved heating effect and pig performance observed in this study with floor mats made from wood sheathing have positive practical implications. Sheets of wood sheathing are readily available from many local lumber suppliers and hardware stores and can be purchased at a fraction of the price of commercial rubber mats. A small amount of labor is required to quarter the sheets, and we don't recommend re-using the wood mats. But, the results of this study suggest that wood sheathing should be investigated further as a floor-mat option.

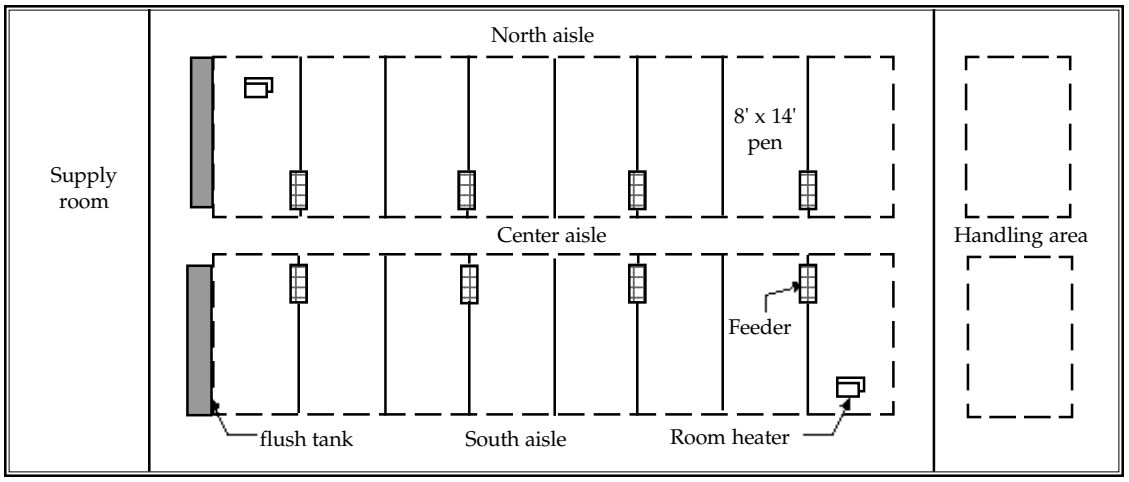

Figure 1. Layout of the wean-to-finish facility used in this study.

Introduction

While wean-to-finish systems are rapidly gaining in use, the development of useful information on the appropriate selection of zone-heating components has not kept pace. The advantages of wean-to-finish production systems rest mainly in moving pigs one less time during production, which results in less stress on the pigs and reduced labor associated with moving pigs from a nursery unit to the grow-finish facility. Improved profit potential depends largely on performance soon after pigs are placed in the wean-to-finish facility — when the newly weaned pigs are placed in a facility designed to accommodate much larger market-weight hogs. This research project addressed the issue of providing a comfortable thermal environment in a cost-effective manner, which, along with overcoming inefficient space utilization and limiting the incidence of gastro-intestinal disease when pigs are small, is a major determinant of profitable production.

Materials and Methods

The research project was conducted in a wean-to-finish facility (see Figure 1 for facility layout) at the Haskell Agricultural Laboratory in Concord, Neb., during early spring, 2003. The performance of two heat sources (brooder heater vs. heat lamp) and two floor mats (wood sheathing vs. rubber) was compared in a 2x2 factorial arrangement of treatments. The 16 available pens at the wean-to-finish facility allowed replication of each treatment combination in four pens.

Gas-burning brooder heaters (Gasolec2 M3 LP 20-310 Infrared Heater, Gasolec America, Inc., Tulsa, Okla.) with a maximum rated output of 5,425 Btu/hr (1,590 W) were installed in September 2002 along with necessary gas distribution lines and fixtures. Room temperature was maintained using two unvented propane heaters in the northwest and southeast quadrants of the room (Figure 1). A gas meter was installed to record propane usage of the gas-fired zone heaters. These heaters were operated with newly weaned pigs during a pre-trial fall finishing phase to ensure that the equipment was operable and functioned as desired with the modulating controller. This test period also allowed the herdsman and farm management to become as comfortable using the new heat sources as they were using electric (250 W) heat lamps.

After this group of hogs was removed (sent to market), the facility was cleaned according to standard procedures on the research farm. Then, commercial rubber floor mats and mats made of 3/8 inch OSB (oriented-strand board) sheathing were placed in randomly assigned treatment pens for the new batch of weaned pigs. The wood mats were cut to the same dimensions (42 x 42 inches) as the commercial rubber mats. Correspondingly, gas-fired heaters were removed from eight randomly assigned pens and were replaced with electric heat lamps, so each heater/mat combination was replicated within four pens (Figures 2-3).

Newly weaned 17-day-old pigs were placed within pens at a stocking rate of 15 pigs per pen (7.5 sq ft/pig). Each pen had one two-hole FarmWeld wean-to-finish feeder and one wean-to-finish cup waterer. Pigs were weighed weekly for the first four weeks post-weaning. The original intention was to weigh pigs biweekly thereafter to slaughter weight, but when PRRSV (Porcine Reproductive and Respiratory Syndrome) was diagnosed in the pigs during the second week after placement in the facility, these plans were altered. The pigs were uniformly medicated and monitored. About two weeks later, the pigs reached a size where zone heat was no longer required (based upon farm management criteria). At this point, 26 days after the newly weaned pigs entered the facility, zone heat-

(Continued on next page)

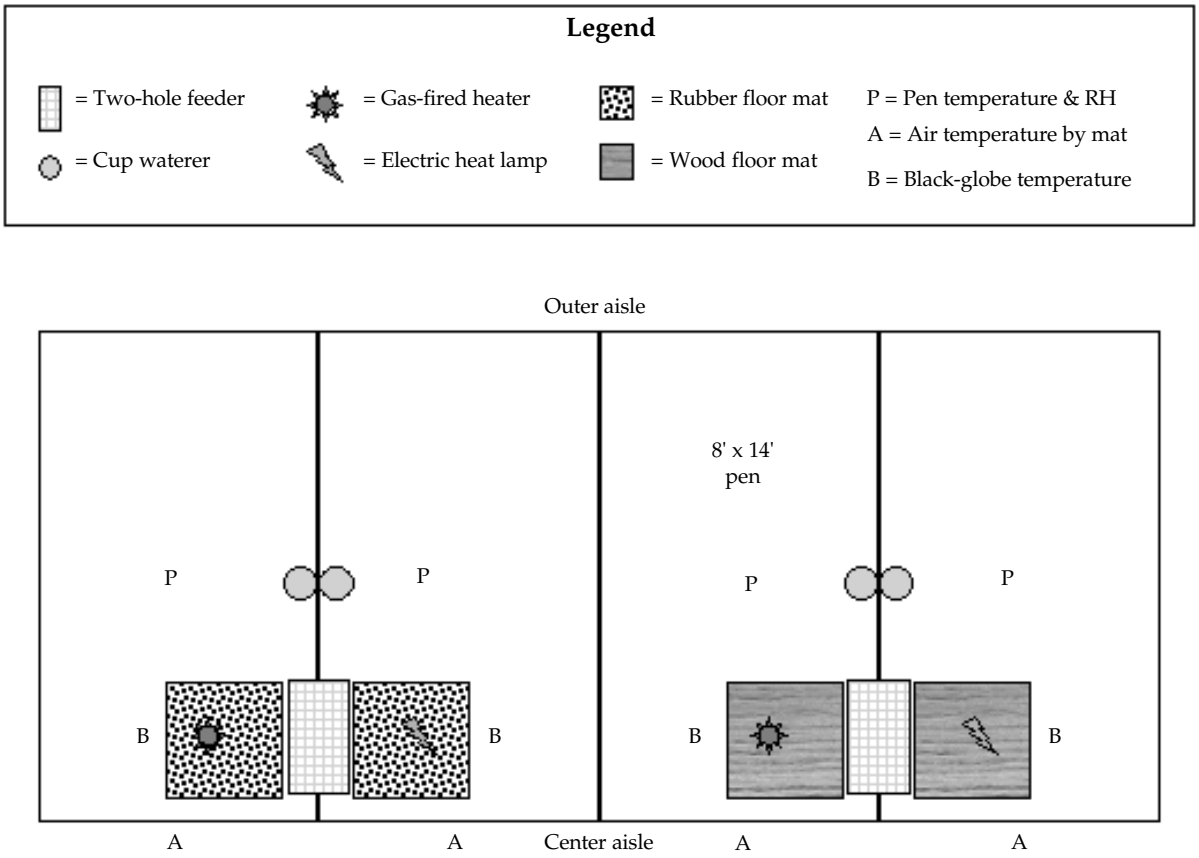

Figure 2. Pen layout showing key pen features, the four combinations of heaters and mats used in this study, and locations of sensors within pens.

ing was discontinued simultaneously in all of the treatment pens and the experiment was terminated.

Thermocouples were placed in each pen to measure air temperature and black-globe temperature near the floor mat (resting area with zone heat). Air temperature in each pen was measured just outside of the aisle pen gate, near the middle of the pen floor mat and about 1 foot above the floor. Black globes were situated inside the pens, consistently placed along the side of the mat opposite the feeder and a little less than two feet off the pen floor. Measurement of 'black-globe temperature' directly incorporates the effect of radiant heating — the type of heating performed by both zone-heating systems. These temperatures were measured at 1-minute intervals and data loggers recorded average temperatures every 10 minutes. Additionally, miniature recorders were placed centrally within each pen and 5-6 feet off the floor to record air temperature and humidity — again at 10-minute intervals. Weather data for the research station during the study period was collected and retrieved to help qualify observed heating needs. Data on pig performance and environmental temperatures were analyzed as a complete random design with pen as the experimental unit.

Figure 3. Photo of two of the four treatment combinations used - an electric heat lamp and wood mat (left-hand pen), and a gas-fired heater and rubber mat (right-hand pen).

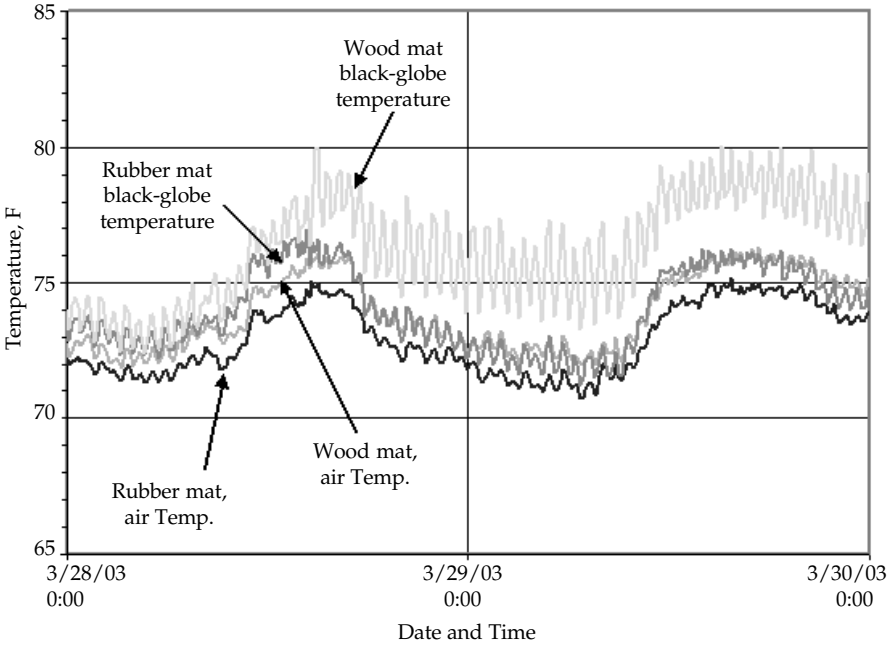

Figure 4. Air and black-globe temperatures near the zone-heating area over a two-day period, illustrating average temperatures for pens having rubber vs. wood floor mats.

Results and Discussion

The data obtained for this study were derived over the first 26 days of the wean-to-finish growth period [March 15 to April 9, 2003], rather than over the full time from weaning to market weight, due to PRRSV being diagnosed during week 2. The newly weaned pigs entered the facility weighing 11.4 lb and were removed weighing about 25 pounds. Zone heat was available throughout this 26-day period, with pigs taking advantage of it extensively during the first two weeks.

Temperature

Air temperatures inside the facility fluctuated over the 26 days, as would normally occur in production facilities, but not nearly as much as the temperature outdoors. In the ideal environment, the temperature is always the same as the set-point temperature. In practice, producers want to develop a stable environment with minimal fluctuation. The average heating zone air temperature (at the aisle sides of the pens next to the floor mats) was about 74.5°F, with the coolest pen (southeast quadrant, electric lamp, rubber mat) averaging 72.8°F and the warmest (northwest, gas, wood) 76.9°F. The standard deviation about the mean, representing the fluctuation in zone air temperatures over time, was about ±2.8°F overall, with the fluctuation within the most consistent pen (northeast, gas, wood) being ±2.12°F compared to ±3.22°F in the most variable pen (northwest, gas, wood). One of the room heaters was located next to the most variable pen, which may have influenced the amount of fluctuation observed in that pen. There were no statistical differences between treatments or treatment combinations in terms of level of temperature fluctuation, with roughly ±2.4°F fluctuations observed over time for the treatments. For comparison, the average outdoor air temperature during the same period was 44.2°F with a standard deviation of ±14.14°F.

Black-globe temperatures inside of the pens (next to the floor mats) were maintained around 76°F with the coolest pen (northwest, gas, rubber) averaging 74.1°F and the warmest (northwest, gas, wood) 80.7°F. The standard deviation about the mean globe temperature over time was about ±3.0°F with the fluctuation in the most consistent pen (southwest, electric, wood) being ±1.75°F compared to ±2.97°F in the most variable pen (northwest, gas, wood). There were no statistical differences between treatments or treatment combinations in terms of level of fluctuation in black-globe temperature, with roughly ±2.4°F fluctuations again observed over time for the treatments. The temperature variations observed in this study highlight the challenge that producers face when trying to develop stable zone-heating environments for small pigs.

Temperature differences between treatments and between sides of the facility are shown in Table 1 alongside the average standard deviation in temperatures across pens within the respective treatments/sides. The latter number represents how much variation there was between the replications of similar treatments and treatment combinations. A difference in temperature between treatments is noteworthy if it is large relative to the variation within treatments.

Overall, air temperatures were slightly warmer in pens with gas-fired heaters and in pens with wood mats. However, no temperature difference exceeded the corresponding temperature deviation within treatments, and in only one case was a difference in air temperature between treatments greater than 1°F. Consequently, there were no statistically significant differences in air temperature between treatments or treatment combinations.

Larger differences and a wider range of standard deviations were evident for black-globe temperature. The black-globe temperatures within pens having gas-fired heaters and wood mats were notably higher (about 3°F warmer) on average than within their counterpart pens with electric heat lamps and/or rubber mats (Figure 4). These differences were at least twice that

(Continued on next page)

of the corresponding variation within treatments. Consequently, statistically significant differences in black-globe temperatures existed between both treatments and amongst the treatment combinations. Interestingly, the largest differences in black-globe temperatures corresponded with the smallest differences in air temperature, illustrating that the two sensors measured different thermal effects. Black-globe temperature directly incorporates the effect of radiant heating, whereas air temperature does not. Since zone heaters rely heavily on radiant heating, it makes sense that any temperature differences between treatments would show up more prominently in the black-globe temperatures. The higher black-globe temperatures with gas-fired heaters may suggest an actual difference in heating effect or it may imply that extra adjustments in heater height and gas pressure were needed to obtain equivalent heating effects. The higher black-globe temperatures with wood floor mats most likely are due to wood having different surface characteristics (e.g. reflectivity) than rubber. A soon-to-be-completed analysis of manual mat and pig surface temperature readings may allow a more complete assessment of heating effects.

The zone heaters were managed with the intent of maintaining consistently comfortable thermal conditions in each pen (based upon operator observations and experience). The fact that standard deviations in air and black-globe temperatures within treatments were relatively low suggests that farm management was able to produce similar thermal environments within similar zone-heating treatments.

Differences in temperatures between the north and south sides and the east and west halves of the facility were noticeably small, which suggests that location effects were minimal in the research facility. Since the air temperature sensors were all located in the 5-foot-wide central aisle, those on the north side were only about 5 feet away from those on the south side, and very little temperature difference was expected. Air temperatures tended to be coolest in the northwest pens, which makes sense given the prevalence of cold-season winds from the north and northwest in northeast Nebraska and the resulting increase in heat loss from exposed building surfaces.

Table 1. Temperature differences (zone-heating areas) for the treatments and average temperature deviations within the compared treatments.

Treatment comparison	Air temperature		Black-globe temperature	
	Temperature difference (^{O}F)	Temperature deviation, StD. (^{O}F)	Temperature difference (^{O}F)	Temperature deviation, StD. (^{O}F)
Gas-fired vs. electric heater	0.91	1.46	*2.07	1.53
- in pens w/wood mats	0.81	1.46	**3.35	1.28
- in pens w/rubber mats	1.06	1.44	**0.70	1.01
Wood vs. rubber mat	0.69	1.51	*1.76	1.69
- in pens w/gas heaters	0.59	1.65	**2.94	1.46
- in pens w/electric heaters	0.83	1.25	**0.29	0.83
North vs. south pens	-0.16	1.54	-0.01	1.85
East vs. west pens	0.10	1.53	-0.24	1.97

*Indicates that the treatment difference was statistically significant at P<0.05.
**Indicates that a statistically significant (P<0.05) interaction effect existed overall between type of heat source and floor mat used.

Table 2. Pig performance over 26-day trial period for experimental treatments.

Treatment	Final weight (lb)	CV within pen (%)	ADF (lb)	ADG (lb)	Feed:Gain
Heat source					
Gas-fired heater	25.2	20.6	0.73	0.53	1.37
Electric heat lamp	24.9	18.6	0.75	0.52	1.44
Floor mat					
Wood mat	*25.4	20.1	0.76	*0.54	1.40
Rubber mat	24.7	19.0	0.72	0.51	1.41

*Indicates that the treatment advantage was statistically significant at P<0.05.

Pig Performance

Results for pig performance at the end of the trial - 26 days after placement in the facility when zone heating was discontinued — are shown in Table 2. The pig-performance results describe effects on nursery-age, disease-challenged pigs raised in a wean-to-finish facility. Since the PRRSV outbreak and symptoms existed in all pens, and treatment was uniformly applied, the results were considered statistically valid with health status being a confounding factor.

No statistically significant differences in pig performance were found between pigs raised in pens with gas-fired heaters vs. electric heat lamps. However, pigs raised in pens with wood floor mats outperformed (P<0.05) those on rubber mats in terms of final (26-day) weight and average daily gain (ADG). These differences amounted to 3% and 6% improvements, respectively, over the rubber mats. There was some evidence that average daily feed intake was higher for pigs on wood mats also (P=0.14), which lends additional credence to the findings for pig weight and ADG. There was some evidence that the coefficient of variation in 26-day pig weight may have been higher for pigs in pens with gas-fired heaters (P=0.19); however, there also may have been an interaction between heat source and mat (P=0.08). No other treatment or treatment interaction (heat source x mat) effects on performance were

observed. Time-lapse video recordings will be analyzed to determine whether behavior differences can help explain the performance differences found between the mat types.

Conclusions

The electric heat lamps and gas-fired heaters functioned well and were readily managed during this trial. Analyses of temperature fluctuations revealed that temperatures were generally maintained within $\pm 3^{o}$F of the mean temperature, and that there were no differences in temperature fluctuations between the two heating systems, the mat types, or combinations of the treatments. No significant differences in air temperatures were evident between treatments or treatment combinations. Black-globe temperatures within pens with gas-fired heaters and/or wood floor mats were warmer (2-3^{o}F) than in comparison pens having electric heat lamps and/or rubber floor mats. The higher black-globe temperatures with gas-fired heaters may imply that extra adjustments in heater height and gas pressure were needed to obtain equivalent heating effects. Since producers often struggle to find the right setting for their zone heaters, this issue may deserve additional study. Given the variety of farm situations and management practices that exist, information that would help producers calibrate their zone-heating equipment once it is installed would be helpful. Higher black-globe temperatures with wood floor mats most likely were due to wood being more reflective than rubber.

This study showed an advantage to using wood floor mats in terms of pig growth rate (end weight and ADG), at least for nursery-age, disease-challenged pigs. This advantage combined with the ready availability and low cost of wood sheathing (relative to commercially distributed rubber mats) suggests that producers may have another option to cut costs while enhancing production. This study did not reveal any other significant treatment or interaction effects on performance. A subsequent economic assessment of the heaters and mat types should shed more light on which zone-heating systems should be considered most seriously by producers and under what circumstances.

This research was financially supported by a grant from the National Pork Board per the recommendations of the Nebraska Pork Producers Association.

[1]Rick Stowell is an assistant professor in biological systems engineering; Sherri Colgan is a research technologist; and Mike Brumm is a professor and Extension swine specialist at the Northeast Research and Extension Center.