Title: Comparing Heat Lamp vs. Heat Mat for Farrowing Crate Heating – NPB #12-191

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Industry Summary

From 2007 to 2012, the average number of piglets born and piglets born alive for the US swine operation increased by 1.1 and 1.2 piglets per sow per farrowing event, respectively. However, increase in average number of piglets weaned during the same time period was 0.8 piglets per sow per farrowing event; and the pre-weaning mortality increased from 14.2% to 15.5% (Stalder, 2013). The preweaning mortality rate, coupled with the increased birth rate, means that 1.9 piglets per litter born alive are lost before weaning. These mortality figures stem from the challenges in meeting the different thermal, space, and behavioral needs of the sow and piglets in a production system that requires specialized herd management. Swine farrowing operations face the unique challenge of maintaining two distinct thermal environments in the same facility. Piglets require a dry, draft-free environment at 32.2-35°C (90-95°F), while sows prefer a comfortable temperature of 15.5-18.3°C (60-65°F) (MWPS, 1983). To meet these two needs, the room temperature is often maintained at 18.3-23.9°C (65-75°F) range and localized heating is provided to the piglets. There are two main methods of localized heating in the U.S. swine industry, heat lamps and heat mats. The goal of the localized heating is to draw the piglets away from the sow when not nursing to avoid mortalities due to being laid or stepped on. Because the cost of maintaining a sow through breeding, gestation and farrowing is generally fixed and independent of litter size, a change in preweaning mortality rate resulting in an extra pig per litter weaned approximately equates to an 11% reduction in fixed cost. Reducing prewean mortality by a small amount will have a significant economic impact on the swine industry. Improving energy efficiency in localized heating is another important factor that will affect the production bottom line as farrowing is the most energy intensive phase of the production cycle.

The objective of the study reported here was to quantify and compare the effects of localized heating type – mat *vs.* lamp with regards to piglet mortality, rate of gain, heat source utilization and electric energy use in swine farrowing rooms.

A 4,300-sow capacity breeding/gestation/farrowing facility (PIC genetics) in central Iowa was used in this study. The farrowing portion of the facility consisted of two buildings with nine farrowing rooms each. Three farrowing rooms, designated as Room F1, Room F2, and Room F3, were selected. Each room had four rows of ten farrowing crates. The rooms were filled and weaned within 3 to 4 days of each other. Two rows of crates in each room used a 125 W heat lamp suspended over a 2 ft × 4 ft black rubber mat. The rubber mat was shared between two crates, giving each crate 4 ft^2 of mat area. The remaining twenty crates in each room used 2 ft × 5 ft Stanfield heat mats (290W, Osborne Industries, Osborne,

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KS, USA). The heat mats were shared between two crates which provided each crate with 145W over a 5 ft^2 area. The lamps were controlled (on/off) with the room's environmental controller. The mats were controlled with a separate control system that varied the power to the mats based on room temperature. Power usage of each heat source for each room was monitored with an electric meter.

All litters were weighed on day 1 or 2 post parturition. Randomly selected litters were weighed at intervals of 4 to 6 days to develop growth curves. All litters for each heat source type were weighed together at weaning using a drive-on truck scale. Other production data, such as mortality numbers and causes, number of piglets born alive, and number of piglets weaned, were recorded by the farm personnel. Piglet utilization of heat sources was monitored with infrared thermography for 24-hr periods at 4 to 5 d intervals during lactation. The thermographs were analyzed to determine heat source usage by the piglets.

Sixteen farrowing cycles (August 2012 to September 2013) were monitored and the results summarized in Table I. The mats had a mean (±SE) electric energy use of 0.3 (±0.03) kWh per lb weaned piglet while the lamps had 0.48 (±0.02) kWh per lb weaned piglet, i.e., 36% reduction by the mats ($p<0.001$). At an assumed electricity rate of $0.07 per kWh, this represents a $0.012 per lb of weaned piglet or $0.14 per weaned piglet in energy savings by the mats. The pay-back period for the heat mats from electric savings based on production values of this facility is 3.4 years or 57 farrowing cycles. The average weight gain (AWG) of piglets (mean ±SE) was 0.49 lb/d (±0.01) and 0.48 lb/d (±0.01) for the mat and lamps, respectively, and was not significantly different ($p=0.64$). Overall, the prewean mortality (mean ±SE) for piglets was 7.8% (±0.4%) with heat mats and 7.4% (±0.5%) with heat lamps ($p=0.41$).

Table I. Summary of piglet average weight gain (AWG) and energy use associated with heat mat and heat lamp as the localized heating source. Values are mean (SE).

Heat Type	AWG, lb d^{-1}	Mortality Rate, %	Electricity Use, kWh lb^{-1}
Mat	0.49 (*0.01*)	7.8% (*0.4%*)	0.3 (*0.03*)
Lamp	0.48 (*0.01*)	7.4% (*0.5%*)	0.48 (*0.02*)

The pattern of daily heat source use vs. piglet age is shown in Figure I. No significant difference was observed in the piglet use of the mat or lamp. The use of the heat source from birth to day 3 (mat) or 5 (lamp) was higher than during days 4 (mat) or 6 (lamp) to 9 post parturition; and interestingly bounced back up thereafter. Further research in the piglet-sow interaction is needed to improve heat source design to enhance the microenvironment for the piglets.

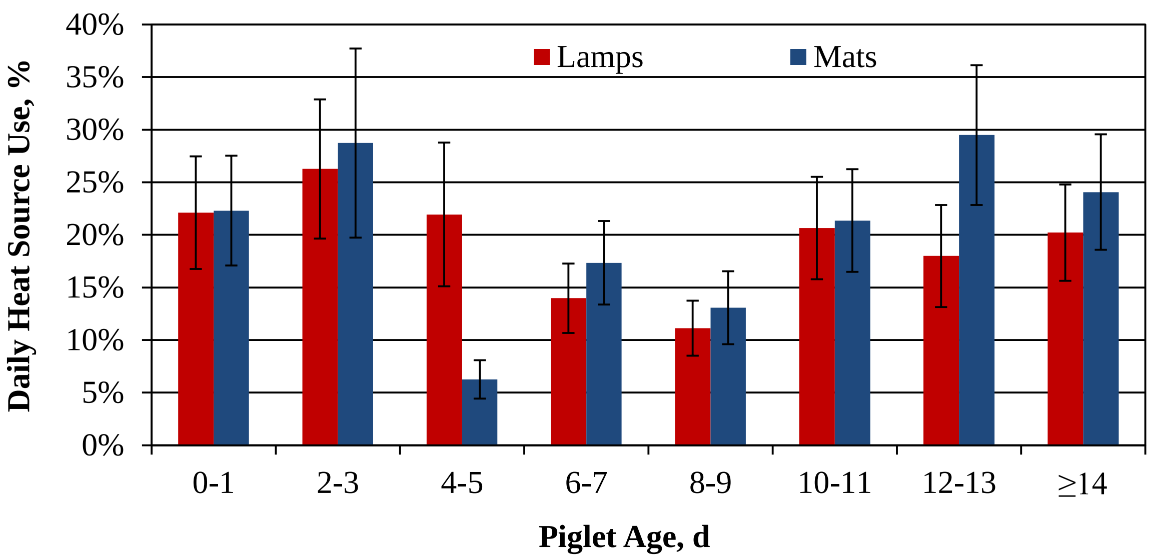

Figure I. Daily heat source use (±SE) by the piglets of heat mat or heat lamp from birth to weaning.

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Keywords

Swine farrowing, localized heating, piglet thermal comfort, energy efficiency, thermography

Scientific Abstract

Heat lamps and heat mats are the two main types of supplemental heat sources used to provide localized heating to pre-wean piglets in modern swine farrowing systems. Both localized heat sources aim to provide a warmer microenvironment for the piglets while allowing the room conditions to suite the sow's thermal needs. Previous work has shown that localized heating in farrowing operation is the most non-feed energy intensive phase in swine production; and new systems offer the possibility of reducing electricity consumption. However, the new heating system's effects on piglet performance (rate of gain, mortality) must be quantified. For this study, three 40-crate farrowing rooms were equipped with 125W heat lamps in half of the crates and 290W 0.6m x 1.5m (2ft x 5ft) double heat mats shared between two crates in the other half of the crates. A temperature dependent, variable output controller regulates the power supply to the mats. The lamps were controlled on/off by the room ventilation system controller and turned off when the room temperature exceeded the set point by 5.5°C. Electricity use of each half of the rooms was measured separately with electric meters. Piglet performance was recorded by farm personnel and our research group. Additionally, infrared thermography cameras were deployed for a 24-hr period several times during the lactation period to capture the piglet behaviors. Average body weight gain (AWG, mean ±SE) of piglets in the mat and lamp regimens was, respectively, 224 (±5.7) g/d and 220 (±5.9) g/d. Prewean mortality (mean ±SE) for the mat and lamp regimens were, respectively, 7.8% (±0.4%) and 7.4% (±0.5%). Electricity use (mean ±SE) for the mat and lamp regimens was respectively, 0.66 (±0.06) kWh and 1.05 (±0.04) kWh per kg weaned pig. Overall, the heat sources were occupied for 58% and 56% of the time for mats and lamps, respectively. When the heat source was utilized, at least two piglets were present 76% and 87% of the time for mats and lamps, respectively. Overall, the mats and lamps performed similarly except for power use.

Introduction

From 2007 to 2012, the U.S. swine industry average number of piglets born and piglets born alive increased by 1.1 and 1.2 piglets per sow per farrowing event, respectively. However, increase in average number of piglets weaned during the same time period was 0.8 piglets per sow per farrowing event; and the pre-weaning mortality increased from 14.2% to 15.5% (Stalder, 2013). The preweaning mortality rate, coupled with the increased birth rate, means that 1.9 piglets per litter that are born alive are lost before weaning. Since the cost of maintaining a sow through breeding, gestation and farrowing is generally fixed and independent of litter size, a change in preweaning mortality rate resulting in an extra pig per litter weaned approximately equates to an 11% reduction in fixed cost. Reducing prewean mortality by a small amount would have a significant impact on the swine industry.

The vast majority of preweaning mortality (60-70%) occurs within 3 days of birth, when infectious agents play a minor role (Herpin et al. 2002). One study found that 79% of preweaning mortalities were due to crushing of the piglets by the sow (Weary et al., 1998). While crushing by the sow may be the ultimate determination of death, multiple underlying causes increase the risk of crushing events (e.g. sow behavior, litter size, cold stress, starvation, disease). Following crushing, the primary cause of death after 3 days is related to weak piglets (e.g., enteric or respiratory diseases, or lack of nutrients) (McGlone and Johnson, 2003). These mortality figures are due to the challenges in meeting the different thermal, space, and behavioral needs of the sow and piglets in a production system that requires specialized herd management.

Swine farrowing operations face the unique challenge of maintaining two distinct thermal environments in the same facility. Piglets require a dry, draft-free space at 32.2-35°C (90-95°F), while sows prefer a comfortable temperature of 15.5-18.3°C (60-65°F) (MWPS, 1983). To meet these two distinct needs, the room temperature is often maintained at 18.3-23.9°C (65-75°F) range and localized heating is provided to the piglets. Within the last two decades, advancements in genetics and nutrition have provided significant increases in sow size, piglet numbers, and weaning weights. However, farrowing stalls in use today are typically based on design standards like the Midwest Plan Service Swine Housing and Equipment Handbook (MWPS, 1983) developed with data corresponding to significantly smaller sows and litters.

There are two main methods of localized heating in the U.S. swine industry, heat lamps and heat mats. The goal of the localized heating is to draw the piglets away from the sow when not nursing to avoid mortalities due to being laid or stepped on. There has been some work in the past examining the two heating systems. Zhou and Xin (1999) found that heat lamp usage by piglets was independent of light color (white or red) and that piglets used a varied output heat lamp more as they grew than a constant output lamp. This advantage of varied output carries over to heat mats. Some of the designs of heat mats in the past were inadequate in terms of even heat distribution. Depending on the design, some mats when on full power or if not controlled by a variable controller can be too hot for the piglets and reduce the usable heated area available (Zhang and Xin, 2000). When given a choice between both heat sources, heat lamps were chosen more than the heat mats during the first two days after parturition (Zhang and Xin, 2001). Previous study also suggested that the typical 0.3 by 1.2 m (1ft by 4ft) heat mat might not provide enough area, especially with the current size of litters at weaning (10.3 per litter; Stalder, 2013). Hence, larger heat mats (e.g. 0.3 by 1.5 m or 1ft by 5ft) were investigated in this study. However, all methods attempt to entice the piglet away from the sow with warmth only, when piglets are drawn to be near the sow by both the warmth and smell (Lay et al., 1999).

Data from the mid 90's indicate that the Iowa swine industry spends more than $70 million on fuel and electric energy in producing market-size pigs (Xin et al., 1997). The annual energy costs could be partitioned into $9.7 million in lighting, $22.2 million in ventilation, and $38.2 million in supplemental heating. It was further estimated that 70% of the supplemental heating cost ($26.7 million) occurs in localized heating, mostly with heat lamps, in the farrowing operations. Clearly, farrowing was/is the most (non-feed) energy intensive phase in swine production cycle. The combined potential energy savings and improved surface temperature control led to the use of a room temperature dependent variable power output controller for the heat mats.

The objective of this study was to quantify the effects of localized heating type – mat *vs.* lamp on piglet mortality, rate of gain, heat source utilization and electric power use in swine farrowing rooms.

Objectives

The goal of this project is to compare heat mat vs. lamp for piglet heating in a commercial swine farrowing operation for one year. To achieve this goal, the following objectives were developed:

- Compare heat mat vs. heat lamp in a commercial farrowing operation regarding
    - electricity use;
    - piglet performance (preweaning mortality, average daily gain); and
    - behaviors of piglets in using the localized heat source

Materials & Methods

A 4,300-sow capacity breeding/gestation/farrowing facility (PIC genetics) in central Iowa was used in this study. The farrowing portion of the facility consisted of two buildings with nine farrowing rooms each. Three farrowing rooms, designated as Room F1, Room F2, and Room F3, were selected. The farrowing rooms were each 15.5m × 13.9m (51ft × 45.5ft) with a shallow-manure pit system (0.61m or 2ft deep) that was emptied after every turn (approx. 21 days). Each room had four rows of ten farrowing crates. The farrowing rooms shared a common hallway that was cooled by evaporative cooling pads during warm/hot weather. The rooms were filled and weaned within 3 to 4 days of each other. Room conditions at the piglet level were measured with temperature/relative humidity (RH) loggers (HOBO Pro V2, Onset Computer Corporation, Bourne, MA, USA).

The layout for heat mats and lamps in one of the farrowing rooms is shown in Figure 1. Twenty crates in each room used a 125 W heat lamp suspended over a 0.6 m × 1.2 m (2 ft × 4 ft) black rubber mat. The rubber mat was shared between two crates, giving each crate 0.37 m^2 (4 ft^2) of mat area. The remaining twenty crates in each room used 0.6 m by 1.5 m (2 ft by 5 ft) Stanfield heat mats (290W, Osborne Industries, Osborne, KS, USA[1]). The heat mats were shared between two crates which provided each crate with 145W over a 0.46 m^2 (5 ft^2) area. Figure 2 shows the installed heat lamps and heat mats in the farrowing rooms.

[1] Mention of company or product names is for presentation completeness, and does not represent endorsement by the authors or Iowa State University, nor does it imply exclusion of other suitable products.

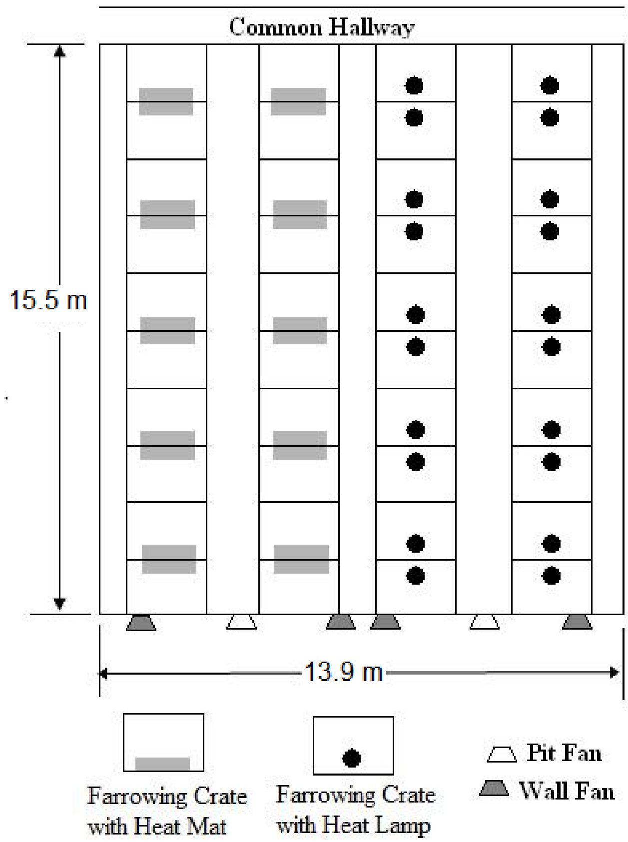

Figure 1. Farrowing room schematic for 20 crates utilizing heat mats and 20 crates utilizing heat lamps.

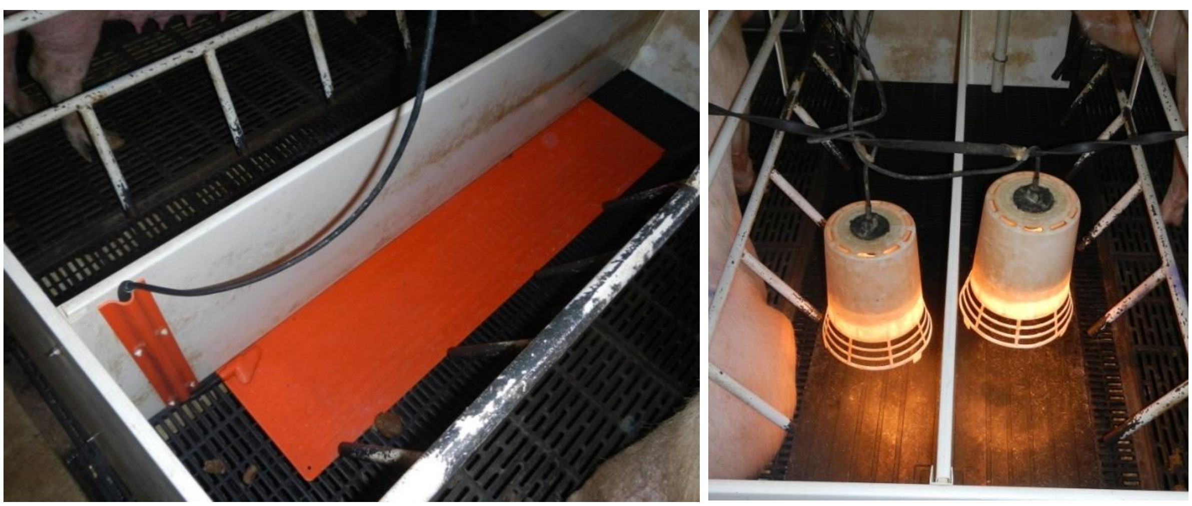

Figure 2. Installed localized heating sources in this study: Stanfield double heat mat (0.6 m × 1.5 m) 290W (145 W each side) heat mat (left) and 125 W heat lamps over a 0.6 m × 1.2 m rubber mat (right).

The lamps were controlled with the room's environmental controller (Model TC5-2V8SA, Automated Production Systems, Assumption, IL, USA). The lamps were on except when the room temperature reached 5.5°C above the room set point. The mats were controlled with a separate control system (Osborne Heat Pad Controller, Osborne Industries, Osborne, KS, USA) that varied the power to the mats based on room temperature. Power usage of each heat source for each room was monitored with an electric meter (Model E10-320825-JKIT, E-Mon, Langhorne, PA, USA). Cumulative power use at the end of each farrowing cycle was recorded for each treatment. Instantaneous power use was collected by the data acquisition system of a Mobile Air Emission Monitoring Unit (MAEMU) installed at the facility for a separate project (Stinn and Xin, 2014).

Piglet weights were measured with a portable litter scale (WayPig Litter Scale, Raytec Manufacturing, Ephrata, PA, USA). All litters were weighed by farm workers after processing (tail clipping, castration) on day 1 or 2 post parturition. Randomly selected litters were weighed at intervals of four to six days for the development of growth curves. All litters for each heat source type were weighed together at weaning using a drive-on truck scale. Other production data, such as mortality numbers and causes, number of piglets born alive, and number of piglets weaned, were recorded by the farm personnel.

Piglet utilization of heat sources was monitored with infrared thermography cameras (Model T440, FLIR Systems Inc., Boston, MA, USA). The cameras were deployed for 24 hr periods over both heat sources at 4 to 5 d intervals during lactation and captured thermographs at 1-min intervals for each 24-hr period. The thermographs (fig. 3) were analyzed to determine heat source usage by the piglets through manual counting of the piglets utilizing the heat source in each image. These data were then analyzed to calculate the number of and duration of occupied and unoccupied events for each heat source. The time of occupation of different piglet numbers (1 to the litter size) were determined. The data were grouped by production stage (piglet age) into four groups: Birth to Day 3, Day 4 to 8, Day 9 to 13, and Day 14 to 18. The values were analyzed with Tukey's Studentized Range tests within each production stage for differences between the occupation times for different piglet numbers (1 to the litter size). The daily heat source use was determined for each observation period using the equation:

$$DSHU = \frac{\sum (PN \times Tn)}{LS \times PL} \times 100\ \% \qquad (1)$$

Where DHSU = daily heat source use, %

PN = piglet number, 0 to litter size

Tn = time utilized by each piglet number, minutes

LS = litter size

PL = length of monitoring period, minutes

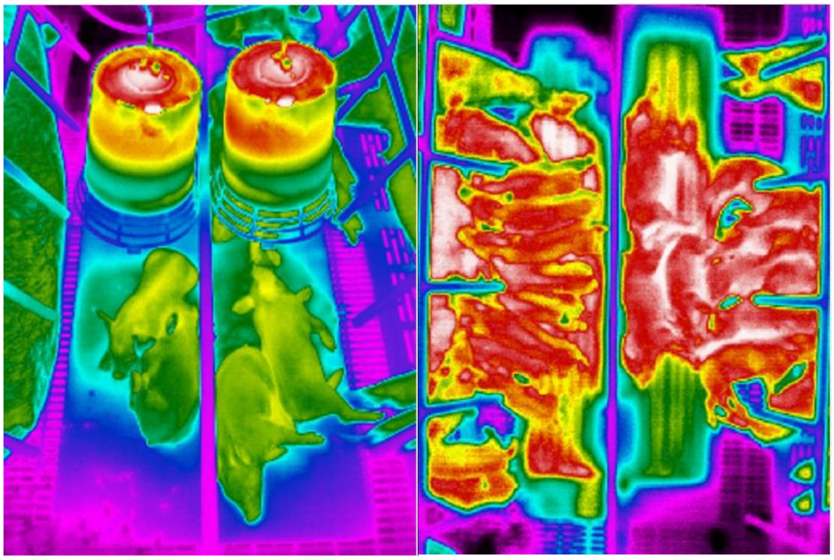

Figure 3. Thermographical images of heat lamps at pre-parturition height (left) and heat mat at full power (right).

Results

For the duration of the project (August 2012 to September 2013) sixteen farrowing cycles were monitored (Table 3).

Table 3. Summary of turn dates (2012 – 2013) and duration monitored for the study.

Turn Number	Room F1		Room F2		Room F3	
	Dates	Duration of Turn, days	Dates	Duration of Turn, days	Dates	Duration of Turn, days
1	8/31-9/21	22	9/3-9/24	22	9/4-9/25	22
2	9/26-10/16	21	9/27-10/18	22	9/28-10/18	21
3	10/19-11/7	20	10/19-11/8	21	10/23-11/9	18
4	11/11-11/29	19	11/11-11/29	19	11/11-11/29	19
5	12/3-12/20	18	12/4-12/21	18	12/5-12/24	20
6	12/26-1/15	21	12/27-1/16	21	12/28-1/17	21
7	2/12-3/1	18	2/14-3/4	19	2/15-3/5	19
8	3/6-3/25	20	3/6-3/26	21	3/8-3/29	22
9	3/28-4/16	20	3/28-4/17	21	3/30-4/18	20
10	4/18-5/8	21	4/21-5/9	19	4/22-5/10	19
11	5/10-5/30	21	5/13-5/31	19	5/13-6/1	20
12	6/3-6/24	22	6/5-6/24	20	6/6-6/26	21
13	6/26-7/16	21	6/27-7/17	21	6/27-7/18	22
14	7/19-8/7	20	7/20-8/8	20	7/21-8/8	19
15	8/12-8/30	19	8/12-9/2	21	8/13-9/3	21
16	9/2-9/23	22	9/3-9/24	22	9/4-9/25	22

Electric energy use by the heat sources

A sample of the instantaneous power use data is shown in Figure 4 from day 17 of a farrowing turn where the ambient temperature exceeded 25°C from 13:34 to 17:21 h. During this time the room temperature was higher 5.5°C above the room set point and the lamps were turned off by the controller. The mats were operating at less than 500W to maintain the desired surface temperature due to being near the end of the temperature curve on the mat controller. The mats also turned off in the afternoon due to the elevated temperature. Figure 5 shows the daily power consumption and cumulative power use over two farrowing cycles. Due to the higher full power output of the mats compared to the lamps (145W *vs.* 125W), the mats will consume more electricity until the temperature curve on the variable output controller begins to reduce the mat temperature and output with increased piglet age.

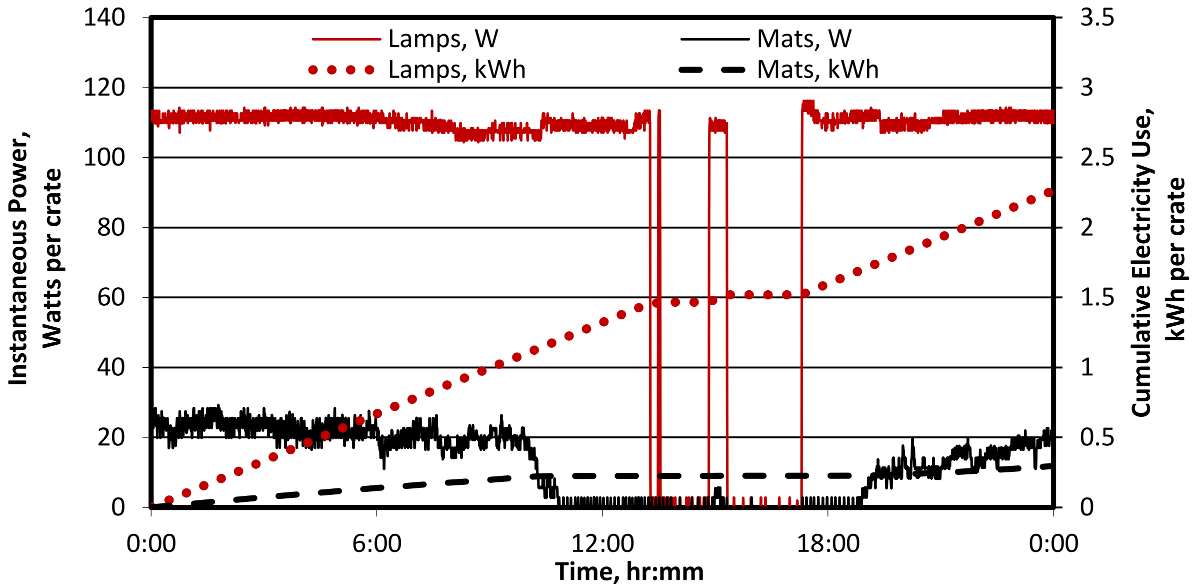

Figure 4. Diurnal heat mat and heat lamp instantaneous power and cumulative electricity use patterns on day 17 of farrowing cycle with ambient temperature exceeding 25°C from 13:34 to 17:21 h.

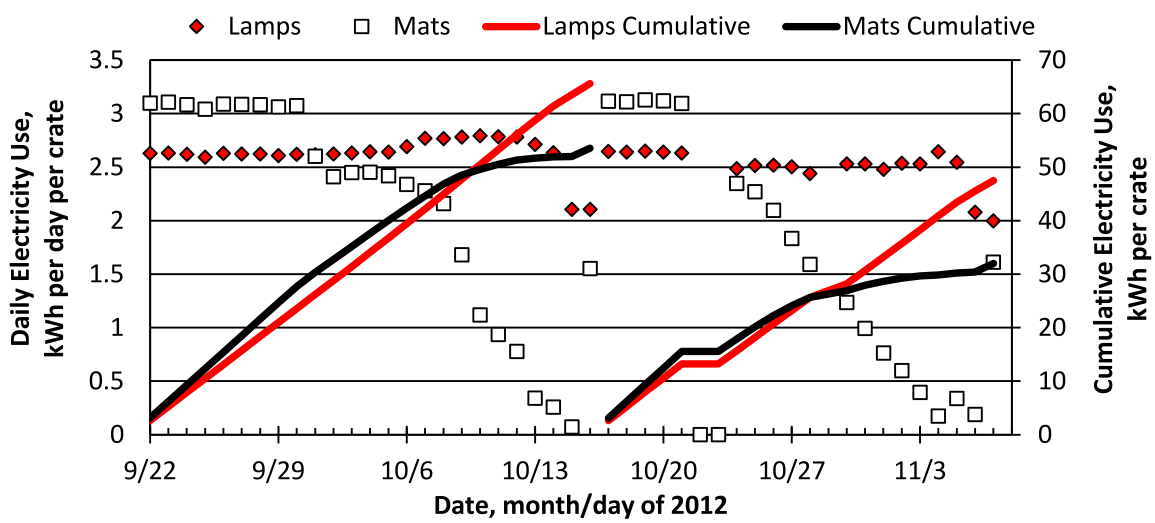

Figure 5. Daily and cumulative electricity use by the heat mats and heat lamps over two farrowing cycles.

The turn-by-turn electricity use values are shown in Figure 6. The cumulative electricity use per turn was normalized to the specific mass of weaned piglets. The mats consumed an average (±SE) of 0.66 (±0.06) kWh per kg weaned piglet while the lamps consumed 1.05 (±0.04) kWh per kg weaned piglet, a 36% reduction by the mats ($p<0.001$). At an assumed electricity rate of \$0.07 per kWh, this represents a \$0.026 per kg of weaned piglet or \$0.14 per weaned piglet energy savings by the mats. The pay-back period based on production values of this facility for mats due to the electricity savings is 3.4 years or 57 farrowing cycles.

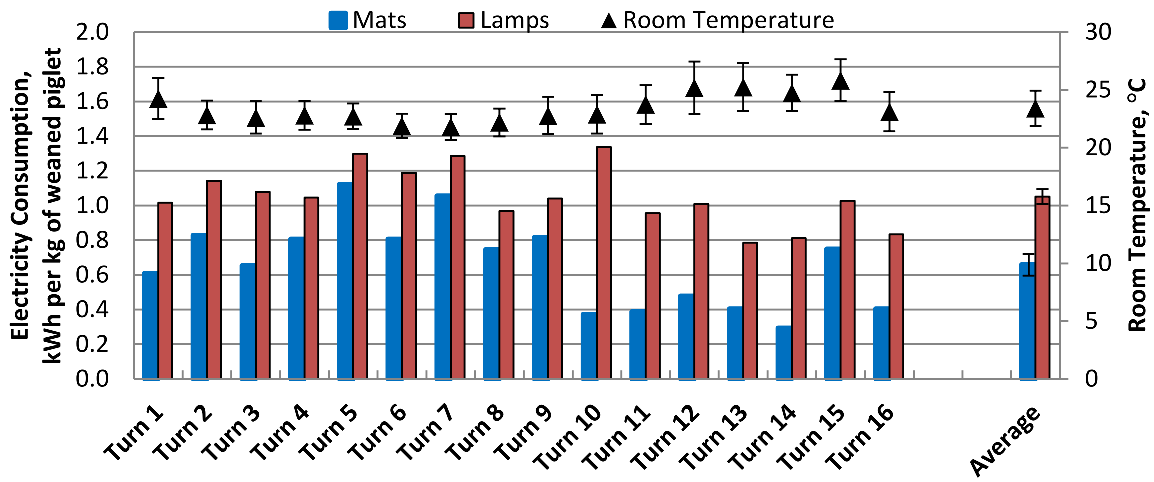

Figure 6. Electricity use per kg of weaned pig for heat mat or heat lamp as the heat source by individual turns and the overall mean (±SE), and the corresponding room temperatures (±SD).

Piglet performance

The average weight gain (AWG) of piglets in crates with heat mats *vs.* heat lamps is shown in Figure 7. AWG (mean ±SE) was 224 g/d (±5.7) and 220 g/d (±5.9) for the mat and lamps, respectively and were not significantly different (p =0.64). These values were comparable to those reported by Zhou and Xin (1999) and Beshada et al. (2006), ranging from 225 to 294 g/d and 221 to 268 g/d, respectively.

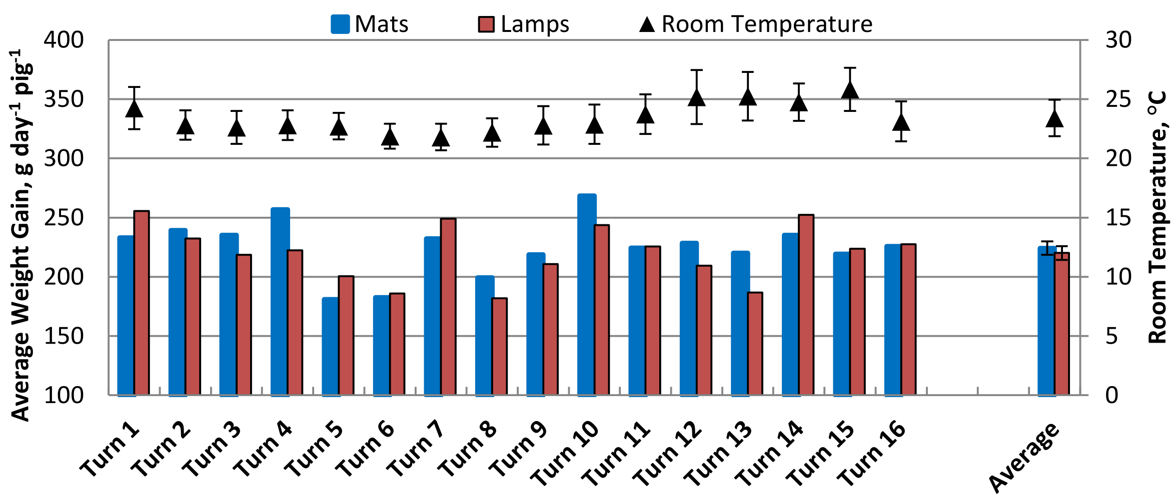

Figure 7. Piglet average weight gain (AWG) in farrowing crates with heat mat or heat lamp as the localized heat source by turn and the overall AWG (±SE), and the corresponding average room temperature (±SD).

Figure 8 shows the comparison of mortality rates between the mats and lamps. Overall, the prewean mortality (mean ±SE) for piglets was 7.8% (±0.4%) with heat mats and 7.4% (±0.5%) with heat lamps (p=0.41). Beshada et al. (2006) found mortality rates ranging from 7.3% to 14.5% over five farrowing turns for piglets raised with mats and lamps. Stalder (2013) reported an average prewean mortality rate of 15.5% for the swine industry in 2012, with the average prewean mortality rate of 8.4% for the top 25% sow farms.

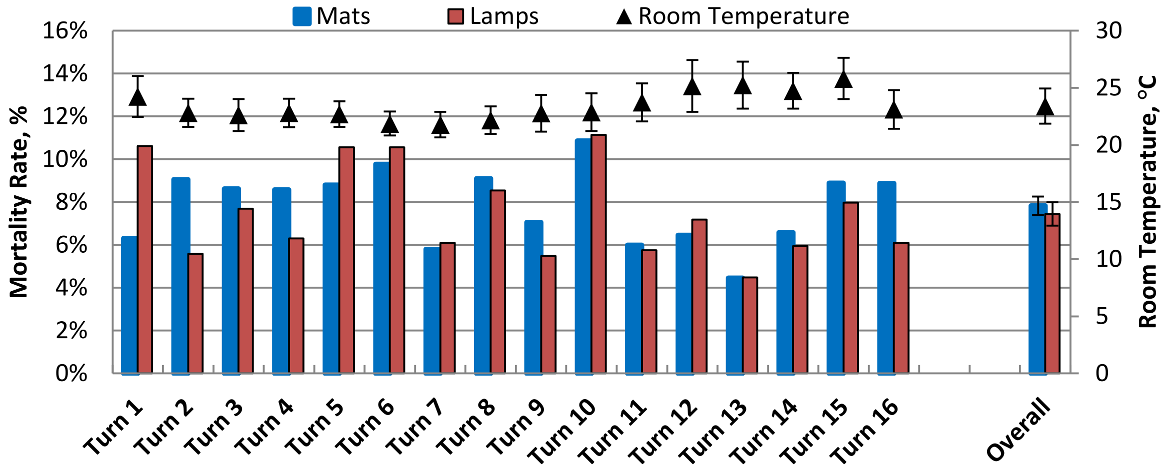

Figure 8. Piglet prewean mortality) by farrowing crate localized heat source (heat mat or heat lamp) and by farrowing turn, the overall mortality rate (±SE), and the average room temperature (±SD) for each turn.

Behaviors of piglets in using the localized heat source

For each day of heat source utilization data, one thermograph per hour was selected that had no piglets utilizing the heat source. The average daily surface temperature of the heat mat or the black rubber mat for heat lamp was determined. The results are summarized in Table 4. The heat mat surface temperature drops from 40.5°C at the beginning of the cycle to 27.0°C at the end. The heat lamp surface temperature remains constant except for the effect of decreasing room temperature.

Table 4. Room and surface temperature (SD) of heat mats or heat lamps for each production stage.

	Heat Mat			Heat Lamp		
Production Stage	Number of Days	Room Temperature, °C	Surface Temperature, °C	Number of Days	Room Temperature, °C	Surface Temperature, °C
Birth-Day 3	4	24.7 (0.06)	40.5 (7.5)	4	25 (0.81)	30.3 (2.1)
Day 4-8	4	24.9 (1.0)	34.7 (2.4)	4	25.9 (0.69)	32.5 (1.8)
Day 9-13	5	25.2 (2.6)	25.3 (1.1)	4	24.1 (1.7)	27.7 (4.4)
Day 14-18	3	24.6 (1.0)	27.0 (1.1)	3	23.7 (2.0)	27.1 (5.1)

The heat source use is shown in Figures 9, 10, 11, and 12 for production stages Birth to Day 3, Day 4 to 8, Day 9 to 13, and Day 14 to 18, respectively. The figures show the average percentage of the day each heat source is un-occupied (0 piglets) or occupied by 1, 2, 3, 4, 5, 6, or > 6 piglets. The utilization of each heat source and the number of piglets were analyzed for significant differences within each production stage. Values with different letters are significantly different ($p<0.05$). The time of non-occupancy is significantly higher than most of the rest of the utilization groupings. The time of non-occupancy is not significantly different across production stage or heat source. Vasdal et al. (2009) found that piglets used a heated creep area for 50% of the time from parturition to 4 days post parturition and that piglets rarely rested alone. For a similar production stage, this study found that piglets used a heat source 63% (mats) and 55% (lamps) of the time. When the piglets were utilizing the heat source, more than one piglet was present 76% and 87% of the time for mats and lamps, respectively. The daily heat source use vs. piglet age is shown in Figure 13. The mat and lamp behave similarly. The heat source use is lowest for 6 to 9 days of age.

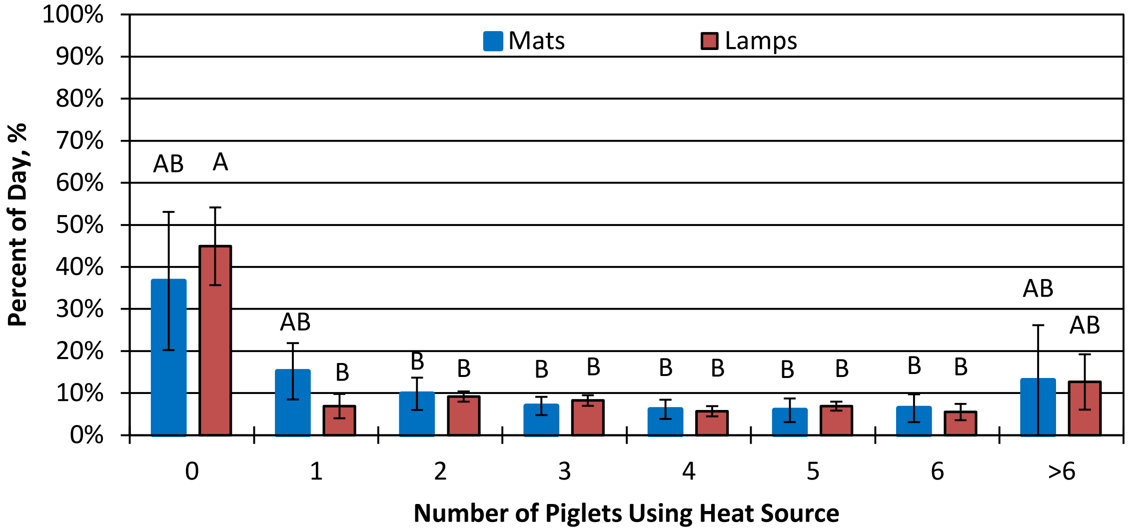

Figure 9. Heat mat and lamp utilization (percent of day ±SE) by piglets from birth to 3d of age. Means with different letters are significantly different (p<0.05).

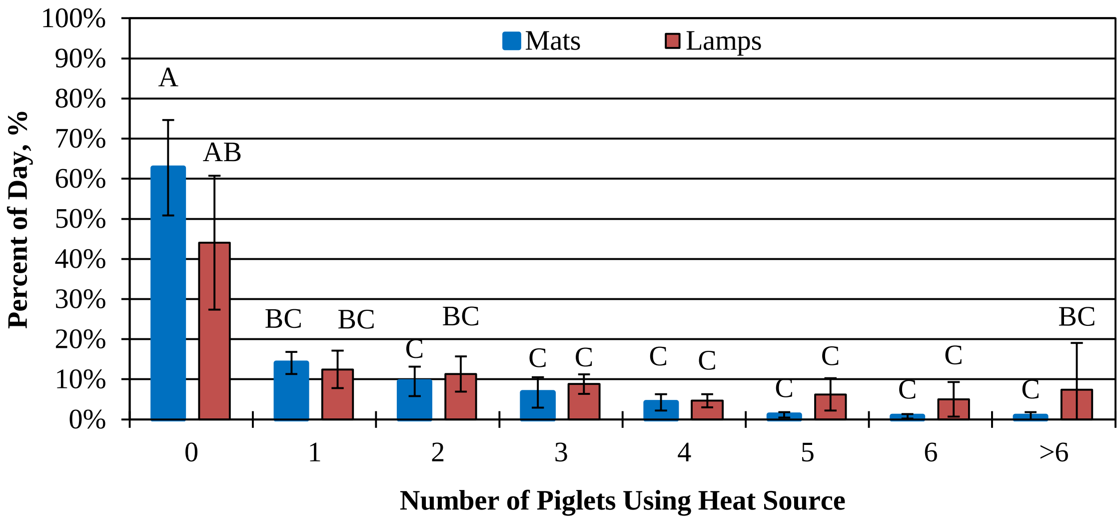

Figure 10. Heat mat and lamp utilization (percent of day ±SE) by piglets from 4 to 8 days of age. Means with different letters are significantly different (p<0.05).

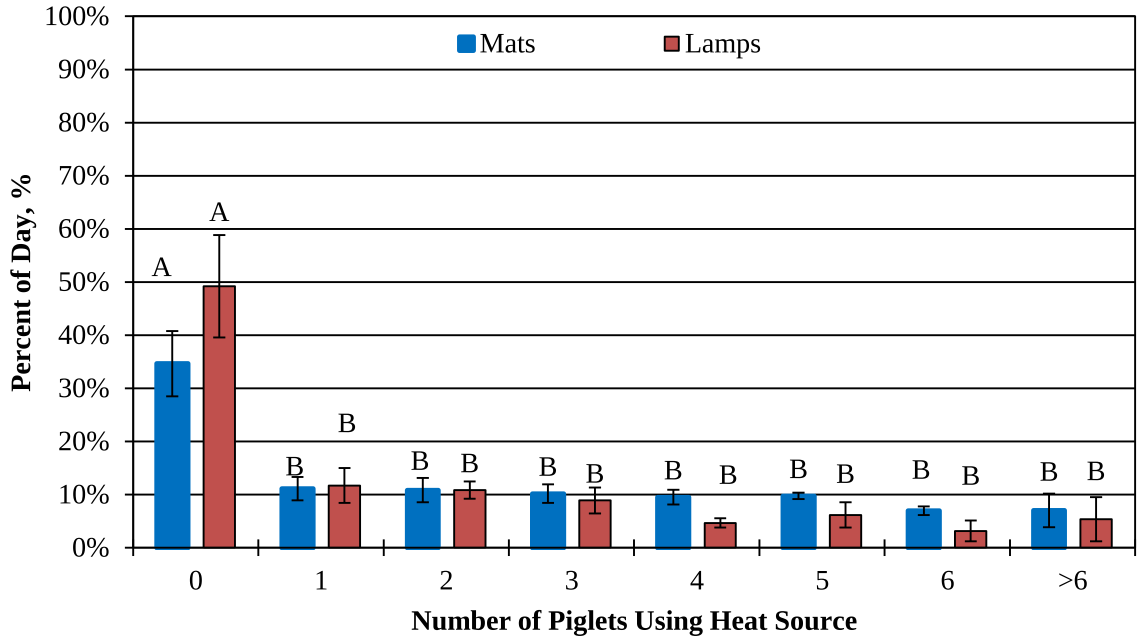

Figure 11. Heat mat and lamp utilization (percent of day ±SE) by piglets from 9 to 13 days of age. Means with different letters are significantly different (p<0.05).

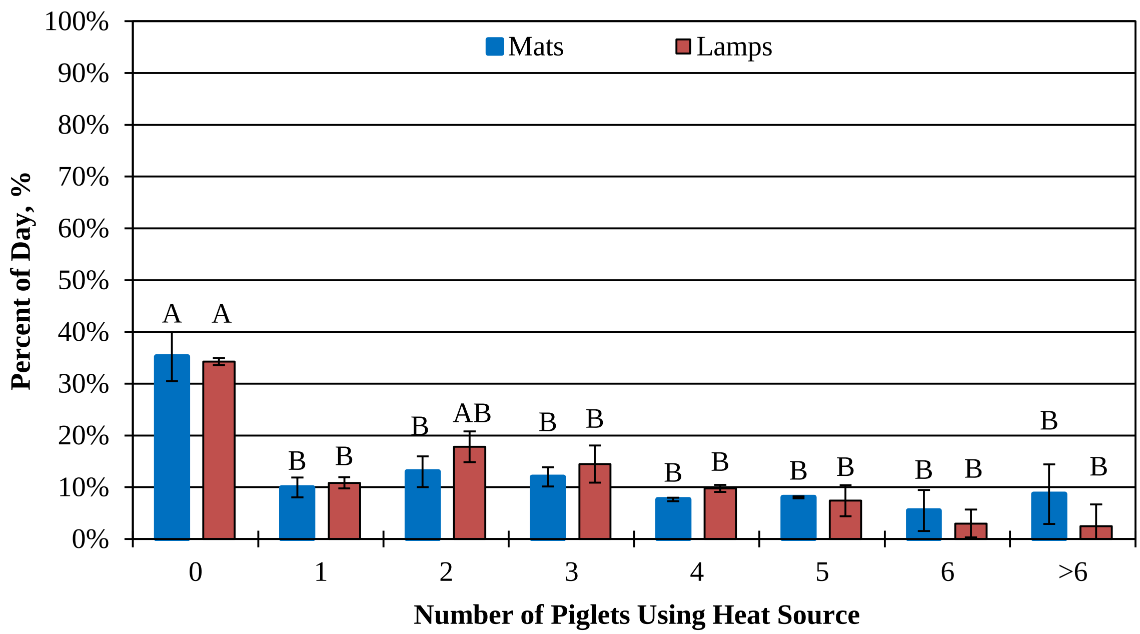

Figure 12. Heat mat and lamp utilization (percent of day (±SE)) by piglets from 14 to 18 days of age. Means with different letters are significantly different (p<0.05).

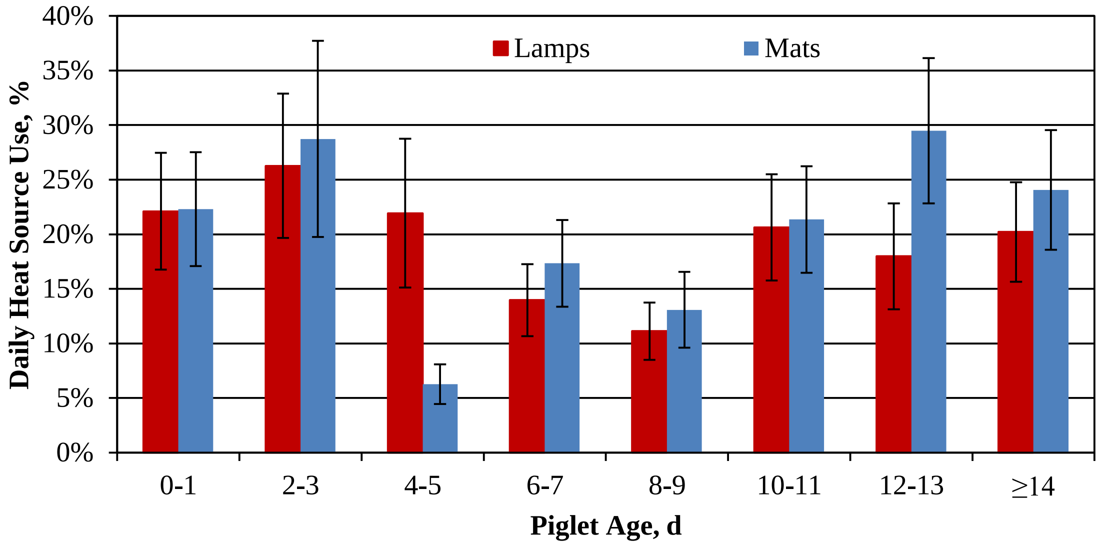

Figure 13. Average daily heat source use (±SE) by piglets by piglet age.

The number and duration of unoccupied and occupied events were determined (Table 5). Unoccupied events were not significantly different by treatment (mats vs. lamps) ($p>0.92$) or by production stage within treatment ($p>0.29$). The event durations are also comparable across heat source type and production stage.

Table 5. Summary of heat source use by piglets in lamp or mat regimen, including number and duration of occupied and unoccupied events and average number of piglets using heat source when occupied.

Piglet Age	Heat Source		Unoccupied Events	Unoccupied Duration, min	Occupied Events	Occupied Duration, min	Number of Piglets per Occupied Event
Birth-Day 3	Mats	Mean	46.5	11.3	47.3	19.3	4.0
		SE	11.8	1.7	11.6	7.7	1.1
	Lamps	Mean	32.3	20.1	32.5	24.4	4.4
		SE	4.8	6.3	5.1	6.6	0.5
Day 4-8	Mats	Mean	68.5	13.2	68.5	7.8	2.3
		SE	10.3	2.2	10.3	3.1	0.4
	Lamps	Mean	42.3	15.0	42.5	19.0	3.6
		SE	13.0	34.4	12.8	29.0	0.8
Day 9-13	Mats	Mean	41.9	11.9	42.3	22.2	3.8
		SE	3.6	2.7	3.5	2.5	0.2
	Lamps	Mean	30.0	23.6	30.3	24.2	3.3
		SE	4.1	7.0	4.2	8.5	0.5
Day 14-18	Mats	Mean	39.7	12.8	40.7	22.9	3.7
		SE	3.2	1.4	3.2	2.9	0.6
	Lamps	Mean	42.7	11.6	43.0	22.0	3.1
		SE	8.7	1.7	9.0	4.6	0.4

The lack of differences between the two heat sources is possibly due to farrowing crate design and the sow. Piglet location in the crate is likely heavily influenced by sow posture. Piglets have a strong desire to feed and thus the direction of sow lie (i.e., teats toward or away from heat source) will have a large effect on piglet location. Further research in the piglet-sow interaction and how it affects the heat source use is needed to improve heat source design to enhance the microenvironment for the piglets.

Discussion and Summary

Three, 40-crate farrowing rooms were selected for this comparison study. Half of each room used heat lamps for localized piglet heating while the other half of each room used heat mats. Sixteen farrowing cycles were monitored for power use, piglet performance, and piglet usage of localized heat source. The only significant impact of either localized heating system was on the power use, where the mats were 36% lower than the lamps. Specific observations are as follows.

- The average weight gain (±SE) of the piglets in the mat and lamp regimens was 224 (±5.7) g/d and 220 (±5.9) g/d, respectively.
- The prewean mortality (±SE) for the mat and lamp regimens was 7.8% (±0.4%) and 7.4% (±0.5%), respectively.
- Piglets in both lamp and mat regimens showed similar behavior in heat source usage.
- Electricity use (±SE) for the mats and lamps was 0.66 (±0.06) kWh and 1.05 (±0.04) kWh per kg weaned pig, respectively. Based on an electricity rate of $0.07 per kWh, the payback period for the heat mats was estimated to be 3.4 years or 57 farrowing cycles.

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