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Abstract

A one-year field study compared the conventional 250W IR heat lamp with an energy-efficient 175W radiant heat lamp for swine farrowing operations. The energy-efficient heat lamp showed a $36 annual cash savings per unit (assuming $0.10/kWh electricity); a 1.2% absolute reduction in piglet mortality from birth to weaning (5.0±0.28% vs. 6.2±0.44%) ($P<0.01$); a 45% lower lamp failure rate (18±4% vs. 32±3%) ($P<0.05$); and a slightly higher rate of weight gain for the piglets (217±4 g/day vs. 211±4 g/day) ($P>0.05$). The possible benefits of using the energy-efficient heat lamp include an annual energy savings of $5,400 and 284 more weaned pigs for a 1,000-sow farrowing operation. The study also revealed circadian patterns of thermoregulatory behavior of the piglets, i.e., higher heat lamp usage during the day and lower at night. Both the frequency and the magnitude of heat lamp usage seemed to depend on heat lamp size and piglet age. Particularly, piglets spent more time under the 175W heat lamp than under the 250W heat lamp, although visits to the heat lamps decreased with piglet age in both instances. The results suggest that to accommodate the progressively decreasing thermal needs of the piglets, a variable-output heat lamp would be more suitable than a constant-output heat lamp. Further research is warranted to quantify the dynamic thermal needs of the piglets during this critical phase of their life cycle.

Keywords

Behavior, Energy, Farrowing, Heat lamp, Localized heating

Disciplines

Agriculture | Bioresource and Agricultural Engineering

Comments

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Comparison of Energy Use and Piglet Performance Between Conventional and Energy-efficient Heat Lamps

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Abstract. *A one-year field study compared the conventional 250W IR heat lamp with an energy-efficient 175W radiant heat lamp for swine farrowing operations. The energy-efficient heat lamp showed a $36 annual cash savings per unit (assuming $0.10/kWh electricity); a 1.2% absolute reduction in piglet mortality from birth to weaning (5.0±0.28% vs. 6.2±0.44%) (P<0.01); a 45% lower lamp failure rate (18±4% vs. 32±3%) (P<0.05); and a slightly higher rate of weight gain for the piglets (217±4 g/day vs. 211±4 g/day) (P>0.05). The possible benefits of using the energy-efficient heat lamp include an annual energy savings of $5,400 and 284 more weaned pigs for a 1,000-sow farrowing operation. The study also revealed circadian patterns of thermoregulatory behavior of the piglets, i.e., higher heat lamp usage during the day and lower at night. Both the frequency and the magnitude of heat lamp usage seemed to depend on heat lamp size and piglet age. Particularly, piglets spent more time under the 175W heat lamp than under the 250W heat lamp, although visits to the heat lamps decreased with piglet age in both instances. The results suggest that to accommodate the progressively decreasing thermal needs of the piglets, a variable-output heat lamp would be more suitable than a constant-output heat lamp. Further research is warranted to quantify the dynamic thermal needs of the piglets during this critical phase of their life cycle.* ***Keywords.*** *Behavior, Energy, Farrowing, Heat lamp, Localized heating.*

The fuel and electricity cost for farrow-to-finish swine production in Iowa averages 3¢/kg body weight ($1.37/Cwt) (ISU Swine Enterprise Summary, 1994). This energy cost translates to an annual expenditure of $69.3 million for the 23 million hogs marketed per year in Iowa. Barber et al. (1989) reported that the total energy cost in swine farrow-to-finish operations for the northern climates could be divided as 14% in lighting; 32% in ventilation; and 50% in heating of which 70% was provided by heat lamps during the farrow-to-wean period. Applying these relative proportions of energy cost to Iowa swine production, the annual energy costs can be partitioned as $9.7 million on lighting, $22.2 million on ventilation, and $24.3 million on supplemental heating with heat lamps.

Traditionally, 250W infrared lamps have provided localized heating for baby pigs to satisfy the different thermal needs of piglets (30~32°C) (Mount, 1963) and sows (18~21°C). The 1992 federal energy bill brought about new energy-efficient products for application in agribusiness. One such product being promoted for application in swine production is the energy efficient (Philips PAR) 175W radiant heat lamp, which saves up to 30% of energy compared with its conventional counterpart (McDonald, 1994). Moreover, the new heat lamp was claimed to have narrower radiant beam spread than its conventional counterpart, thereby keeping the sows cooler. But concerns arose about whether the new heat lamp provides enough radiant heat spread for a litter of 10 to 11 piglets and how it would affect piglet performance. We found no field data to address such concerns.

The objective of this study was thus to evaluate the performance of the energy efficient 175W heat lamp versus the conventional 250W heat lamp with regard to energy use, piglet performance, and economic impacts on swine farrowing operations.

Materials and Methods

An 1,100-sow farm located near Ogden, Iowa, was used for this field study. Two identical, environmentally controlled rooms with 14 farrowing crates each were selected; 250W infrared heat lamps were used in one room and Phillips PAR 175W radiant heat lamps were used in the other (fig. 1). The heat lamps generally were turned on the day before farrowing began and were located in the back of the crates. They were relocated to the front of the crates within two days after farrowing. The heat lamps were suspended 40 to 60 cm (16 to 24 in.) from the floor, depending on the age of the piglets.

Electricity use by the heat lamps, ventilation fans, and total operation was recorded daily with kWh meters. Room temperature and relative humidity (RH) were continuously measured with a commercial temperature/RH sensor (model HMP35C, Campbell Scientific, Inc., Logan, Utah) that was connected to a battery-powered datalogger (model CR10, Campbell Scientific, Inc.). Surface temperature distribution

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Figure 1–The energy efficient 175W (left) and the conventional 250W (right) heat lamps used in this study.

of the creep floor area (concrete) was measured with an infrared thermometer at a resolution of 0.1°C (0.18°F) (model OS3702, Omega Engineering, Inc., Stamford, Conn.). Average body weight of the piglets at birth and weaning and piglet mortality from birth to weaning were also recorded for each trial. In addition, the thermoregulatory behavior of the piglets in randomly selected farrowing crates, expressed as the percentage of litter mates lying in the heat-lamp heated area (50 × 50 cm or 20 × 20 in. under the heat lamp), was recorded by using time-lapse photographic technique. Specifically, programmable photographic cameras (Canon model T70 with command back) were mounted 1.5 m (5 ft) above the floor and took pictures of the creep area at 20-min intervals for a 24-h period at one week and two weeks of age, respectively. The 20-min sampling interval proved to be adequate for measurement of the piglet dynamic behavior (Zhou et al., 1996). No flashlight was used for the photographic cameras because of sufficient illumination produced by the heat lamps, which eliminated the potential disturbance of flashing light to the piglets. The behavioral photographs were visually examined to determine the number and the percentage of the litter mates using the heat lamp.

During the one-year trial period (September 1994 to August 1995), 13 farrowing cycles were monitored for each type of heat lamp. Complete randomized block design was used and analysis of variance was performed on the response variables.

Table 1. Comparison of energy use and piglet performance by trials between the conventional 250W IR heat lamp and the energy-efficient 175W heat lamp

Lamp Size (W)	Farrow Date mm/dd/yy	Wean Age (day)	Body-Weight Birth (kg/pig)	Body-Weight Wean (kg/pig)	Weight Gain (g/day)	Litter-Size Birth (pigs/litter)	Litter-Size Wean (pigs/litter)	Death Rate (%)	Lamp Failure (%)	Electricity-Use Lamp (kWh/day/crate)	Electricity-Use Fan (kWh/day/crate)	Electricity-Use L+F (kWh/day/crate)
250	09/10/94	20	1.5	5.5	210	11.1	10.6	4.5%	21%	—	—	—
	10/06/94	21	1.5	6.1	231	10.9	10.3	5.3%	14%	4.75	0.67	5.42
	10/31/94	22	1.5	5.5	190	10.8	9.7	9.9%	36%	5.62	0.47	6.09
	11/26/94	19	1.5	5.2	207	10.7	10.0	6.7%	14%	5.43	0.41	5.84
	12/19/94	22	1.5	5.5	190	10.1	9.2	8.5%	32%	5.19	0.32	5.51
	01/13/95	22	1.5	6.4	231	10.6	10.1	4.7%	29%	5.17	0.24	5.42
	02/08/95	24	1.5	6.4	213	10.5	9.8	6.8%	36%	5.06	0.23	5.29
	03/10/95	20	1.5	5.7	222	10.9	10.4	4.6%	43%	4.64	0.43	5.07
	04/04/95	19	1.5	5.8	239	10.9	10.4	5.2%	36%	4.26	0.29	4.55
	04/28/95	22	1.5	5.9	207	11.2	10.5	6.2%	31%	4.90	0.79	5.69
	05/26/95	21	1.5	5.8	213	11.0	10.5	4.9%	46%	4.89	1.24	6.13
	06/21/95	21	1.5	5.5	197	11.1	10.4	5.8%	36%	4.38	1.30	5.68
	07/19/95	19	1.5	5.0	197	11.5	10.6	7.4%	46%	3.06	1.37	4.44
	Mean	21	1.5	5.7a	211a	10.9	10.2	6.2a	32%a	4.78a	0.65a	5.43a
	SE	0.4		0.1	4	0.1	0.1	0.5%	3%	0.19	0.12	0.15
175	09/07/94	17	1.5	5.5	247	11.1	10.5	5.2%	7%	—	—	—
	10/04/94	21	1.5	5.9	220	10.6	10.1	4.7%	0%	3.74	0.76	4.50
	10/29/94	21	1.5	5.5	197	10.8	10.0	7.8%	0%	3.93	0.35	4.27
	11/24/94	4	1.5	5.2	207	10.7	10.1	5.8%	0%	3.82	0.23	4.05
	12/15/94	23	1.5	5.7	192	10.4	10.0	3.7%	0%	3.85	0.20	4.06
	01/10/95	23	1.5	6.3	216	10.6	10.1	4.1%	14%	3.78	0.38	4.16
	02/06/95	24	1.5	6.3	207	10.5	10.0	4.8%	43%	3.95	0.25	4.21
	03/08/95	20	1.5	5.8	227	10.6	10.0	5.4%	29%	4.03	0.38	4.42
	04/02/95	18	1.5	5.5	235	10.4	9.9	4.8%	14%	3.95	0.34	4.29
	04/26/95	22	1.5	6.6	244	10.9	10.5	3.9%	21%	3.83	0.64	4.47
	05/23/95	20	1.5	5.7	220	10.7	10.1	5.3%	36%	3.88	0.82	4.70
	06/19/95	21	1.5	5.5	200	10.7	10.3	4.0%	21%	4.02	0.67	4.69
	07/18/95	20	1.5	5.4	205	11.2	10.6	5.5%	46%	2.22	1.32	3.55
	Mean	21	1.5	5.8a	217a	10.7	10.2	5.0%b	18%b	3.75b	0.53b	4.28b
	SE	1.5		0.1	5	0.1	0.1	0.3%	5%	0.14	0.09	0.09

Note: SE = standard error of the mean.
L + F = sum of lamp and ventilation fans.
Column means with different letters are significantly different ($P<0.05$).

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Figure 2–Resting behavior of 7-day-old piglets subjected to 250W and 175W heat lamps.

Results and Discussion

Energy use, longevity of the heat lamps, and piglet performance for the 13 trials are listed in table 1. Electricity savings by the 175W heat lamp averaged 1.15 kWh/lamp·day (4.28 *vs.* 5.43 kWh). The energy savings consisted of direct savings from the reduced energy use of the heat lamp and indirect savings from the ventilation fans which had less excess heat to remove from the heat lamps during the warm season. Assuming a heat lamp usage of 320 days per year and an electricity rate of $0.10/kWh, one 175W heat lamp would save $36.80 a year in kWh usage. The same heat lamp also reduced the load demand by 75W to 82W. The greater load demand reduction (82W) resulted from the difference in energy use by ventilation fans during warm weather.

The annual heat lamp failure rate averaged 32% for the 250W lamp and 18% for the 175W lamp. At the retail prices of $2.35/250W lamp and $4.70/175W lamp, the difference in annual heat lamp cost per farrowing crate was calculated to be $1.22 in favor of the 250W lamp; however, the minimal extra lamp cost for the 175W heat lamp could easily be offset by the additional labor time required to replace the more frequently failed 250W lamps. Taking into account this extra heat lamp cost, the annual net energy savings of the 175W heat lamp would be $35.58. For a 1,000-sow farrowing operation (152 crates), the 175W heat lamps would yield approximately $5,400 cash savings, plus savings from reduced load demand and less labor time spent on changing burnt-out heat lamps.

No adverse effects on the piglets were observed from the energy-efficient heat lamp. In fact, as shown in table 1, piglets subjected to the new heat lamp had somewhat improved rates of weight gain (217 g/day) than piglets subjected to the conventional heat lamp (211 g/day). Furthermore, the 175W heat lamp piglets had significantly lower birth-to-weaning mortality (5.0%) than the 250W heat lamp piglets (6.2%) ($P<0.01$). Assuming a sow farrows 24 pigs a year, the reduced mortality by the 175W heat lamp would translate to 284 more weaned pigs annually for a 1,000-sow operation.

Figure 3–Radial distribution of concrete floor surface temperature for the 250W and 175W heat lamps at various lamp heights (ambient temperature = 21°C or 70°F; 1 in. = 2.54 cm).

The exact cause of the reduced mortality for the 175W heat lamp was not quite clear. The speculation was that piglets subjected to the 250W heat lamp might have spent more time around the sow and, consequently, have become more susceptible to crushing. Figure 2 shows the typical resting patterns of piglets subjected to 250W and 175W heat lamps. Piglets of the 250W heat lamp avoided staying directly under the heat lamp; whereas, piglets of the 175 W heat lamp spread more uniformly. This discrepancy in resting behavior could be attributed to the excessive heat and/or brightness of the 250W heat lamp. Figures 3 and 4 show the surface temperature profiles of the heat lamp/creep area for the conditions of concrete floor and black rubber mat on wire mesh, respectively. Specifically, when the floor is concrete, the surface temperature underneath the heat lamp is 2 to 7.5°C (4 to 14°F) higher for the 250W heat lamp (fig. 3). When the floor is a rubber mat, the temperature difference increases to 7 to 25°C (13 to 45°F) for the rubber mat (fig. 4), which would resemble the presence of piglets. Naturally, the dangerously hot temperatures of the 250W heat lamp would prohibit the piglets from staying underneath it.

Piglets under both heat lamp treatments also exhibited circadian variations in heat lamp usage (figs. 5 and 6), although more variations were associated with the 250W heat lamp. These diurnal variations in thermal needs observed in the present study were consistent with the previous report on piglets by Morrison et al. (1987). In

Figure 4–Radial distribution of rubber mat floor surface temperature for the 250W and 175W heat lamps at various lamp heights (ambient temperature = 20°C or 68°F; 1 in. = 2.54 cm).

Figure 5–Diurnal heat lamp use patterns of 7- and 14-day old piglets subjected to 250W heat lamp.

Figure 6–Diurnal heat lamp use patterns of 7- and 14-day old piglets subjected to 175W heat lamp.

addition, the results of the present study show that heat lamp usage by the piglets decreases progressively with age, especially for the 250W heat lamp. This outcome has two implications. First, the microenvironment provided by the 250W heat lamp was less adequate for the piglets, which in turn led to a modified thermoregulatory behavior of the piglets. Secondly, providing a constant heat source for the piglets would be counterproductive because their needs for heat progressively decreases with age. More research seems to be warranted to define and meet the *variable* thermal needs of the piglets during this critical period of their life cycle.

Conclusions

Results from a one-year field comparison of energy-efficient 175W radiant heat lamps versus conventional 250W IR heat lamps for swine farrowing operations indicate that the energy-efficient heat lamp has the possible advantages of:

- A $36 annual cash savings per heat lamp (assuming an electricity rate of $0.10/kWh) or $5,400 annual cash savings for a 1,000-sow farm.
- A 1.2% absolute reduction in birth-to-wean piglet mortality (5.0% *vs*. 6.2%) or 284 more piglets weaned annually for a 1,000-sow farm.
- A 45% lower lamp failure rate (18% *vs.* 32%) and associated labor in lamp replacement.
- A slightly higher piglet rate of gain (217 g/day *vs.* 211g/day).

The results also revealed circadian patterns of the piglet thermoregulatory behavior which were influenced by heat lamp type and piglet age. Further investigation of the variable thermal needs of the piglets and means to meet such needs is warranted.

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