

## **Cooling Caged Laying Hens in High-rise House by Fogging Inlet Air**

**H. Xin, M.C. Puma**

### **ABSTRACT**

*Cost effective and easy-to-retrofit cooling systems are needed for heat stress relief of laying hens in the Midwest of the United States. This field study evaluates the efficacy of cooling ventilation air by high-pressure (6,893 kPa or 1,000 psi) foggers installed along the eave air inlets of a commercial high-rise layer house (100,000 Hy-Line W-98 hens). Fogging was controlled to operate when the house temperature exceeded 30°C with a concomitant relative humidity (RH) of <76%. The system was able to lower the inside air temperature by up to 7°C as compared to the outside temperature, depending on outside RH. The one-year (1999) test results showed that the system has good potential to be a viable alternative cooling system for the region. Further testing of the system, particularly its longevity and maintenance requirements, is warranted.*

**Keywords:** *Heat stress relief, Poultry housing, High-pressure fogging*

### **INTRODUCTION**

As of December 2000, Iowa ranks first nationally in egg production, with about 30 million laying hens. The weeklong heat wave sweeping across the Midwestern United States in July 1995 took a death toll of more than 1.8 million laying hens (about 10% of the hens in stock) in Iowa alone. The disastrous economic loss was compounded by disposal of the mortality and reduced egg quantity and quality for the hens that managed to survive the heat spell. Commercial layer houses in the Midwest are traditionally not equipped with supplemental cooling systems, as typically used in the Southeast. Summer cooling is limited to increasing ventilation rate through the houses. Ventilation systems are designed such that without evaporative cooling, air inside a poultry house will be at least 1.5 to 3°C warmer than the outside air as a result of the sensible heat generation by the birds. Thus, when the outside is 40 to 43°C, as it occurred in 1995, the inside would be 42 to 46°C. Under such adverse environmental conditions, birds with a normal body temperature of 41~41.5°C will actually gain heat from the ambient air. And the rate of heat gain will accelerate with increasing ventilation rates or air velocity, causing heat prostration to occur faster. The increasing frequency of occasional but devastating heat waves prompts the need to investigate alternative, cost-effective cooling method(s) for typical Midwestern laying hen facilities. A cooling system that can be retrofitted into existing houses as well as installed in new facilities would be particularly beneficial.

In a controlled environment laboratory study, Chepete and Xin (2000) evaluated the efficacy of cooling caged layer by intermittently sprinkling water onto the head and appendages of the hens. The authors revealed significant reduction of mortality and body temperature rise for the cooled hens as compared with the control counterparts. In a subsequent verification study involving a commercial layer house in Iowa, Ikeguchi and Xin (2001) found that hens receiving low pressure (276 kPa or 40 psi), intermittent sprinkle cooling (when inside temperature > 32°C) had up to

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5.6% increase in hen-day egg production. The same study showed no adverse effects of the sprinkling on feed and eggshell integrity. The low-pressure sprinkling system cost about \$5,000 for a house of 90,000 to 100,000 hens. These findings were consistent with the thermoregulatory characteristics of the birds, as documented in the literature. For example, Van Kampen (1971) reported that the total surface area of the comb and the wattles accounts for about 10% of the total body surface, and consequently the head and appendages play an important role in heat dissipation. During heat stress the unfeathered extremities such as comb and wattles of fowl are normally vasodilated (Richards, 1971; Van Kampen 1971; Nolan et al. 1978). Naked-neck chickens were reported to have increased heat tolerance than their normally feathered counterparts (Cahaner et al., 1993; Eberhart and Washburn, 1993; Yalcin et al. 1997).

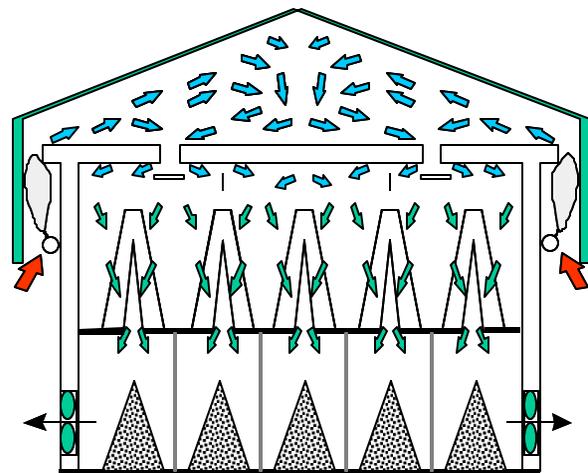
While the relatively low-cost, partial surface sprinkling method proves reasonably effective in alleviating heat stress in hen houses with certain (i.e. A-frame) type cage layout, it would be difficult to get the water droplets onto the birds in houses with battery-type cage layout. For the latter case, evaporative cooling of the ventilation air would be a more viable approach. Cooling of entire ventilation air is typically done via an evaporative pad system. In comparison, information is meager regarding the applicability of cooling the ventilation air by high-pressure fogging, particularly under the Midwest summer weather conditions. Such a system can be easily retrofitted to existing houses at a cost of about \$0.20 per bird.

The objective of this field study was to evaluate the efficacy of cooling ventilation air by high-pressure (6,893 kPa or 1,000 psi) foggers installed along the eave inlets of a commercial high-rise layer house.

## METHODOLOGY

The experimental, high-rise layer house was located in northwest Iowa. The term “high-rise” means that the hens are housed in the upper level whereas manure is stored in the lower level (fig. 1). The house measured  $146.3 \times 15.8$  m ( $480 \times 52$  ft), had a north-south orientation, and held 100,000 Hy-Line W98 hens at the start of the test on June 26, 1999. It had two continuous ceiling inlets, each being 4 m away from its respective sidewall. Thirty 1.2-m (36-inch) exhaust fans were located in the sidewalls (16 fans in one sidewall and 14 in the other) to provide the maximum summer ventilation rate, averaging about  $10.2 \text{ m}^3/\text{hr}$  (6 CFM) per hen. Two rows of air deflectors were installed above the second and fourth cage rows in the longitudinal direction of the house.

The fog cooling system consisted of 242 stainless steel (SS) nozzles (rated at 7.5 l/hr per nozzle) and SS supply pipe at each of the eave air inlets (fig. 1 & 2), a booster pump, and a controller (Val Environmental Systems, Bird-In-Hand, PA). Selection of the number of nozzles was based on a projected temperature reduction of  $8.3^\circ\text{C}$  ( $15^\circ\text{F}$ ) under the maximum ventilation rate, 95% evaporation efficiency of the fogged water, and a safety factor of 1.2 to account for plugged nozzles (which proved to be the case during the initial operation). Fogging was controlled to start when the house temperature exceeded  $30^\circ\text{C}$  ( $86^\circ\text{F}$ ) with a concomitant RH of less than 76%. To protect the fogging from strong wind



**Figure 1.** A schematic of cross-sectional view of the experimental high-rise layer house with fogger lines installed along the inlet airways.



**Figure 2.** A photographic view of the high-pressure fogger lines installed along the inlet airways of the experimental layer house.

effects, the original eave inlet chambers were extended. The extended distance between the fogger line and the attic was to ensure complete evaporation of the fog before entering the attic/insulation area. The following environmental and production variables were monitored and recorded: outside and inside air temperature and relative humidity (RH) using electronic data loggers (Hobo Pro Series, Onset Computer Corporation, Pocasset, MA), daily egg production, and daily bird mortality. The monitoring period was from June 26 to September 4, 1999.

## RESULTS AND DISCUSSION

The daily mean and maximum temperature and RH values inside and outside the layer house during the period of July 1 and September 4, 1999 are shown in Figure 3. As shown, the maximum inside temperature rarely exceeded the controlled target of 30°C (86°F) when the outside temperature was above 30°C (86°F). This result indicates that the fogging system functioned reasonably well in maintaining the set-point temperature. The magnitude of house temperature reduction by the cooling system is illustrated in Figure 4. Note that the differences between the outside  $T_{\max}$  and inside  $T_{\max}$  were theoretically not the temperature reductions by the cooling system. This is because the inside temperature was also affected by the bird sensible heat which elevated the temperature and evaporation of certain moisture from the feces which lowered the temperature. However, for practical purposes the error caused by assuming the two effects of increment and decrement offsetting each other would be quite marginal.

Table 1 summarizes the weekly mortality and hen-day egg production of the layer barn. Weekly hen-day egg production is also plotted for comparison with the industry standard values in Figure 5. Mortality spiked on July 29, 1999, the hottest day of the summer with the daily high of 39.4°C (103°F) outside and 33.9°C (93°F) inside. The RH was rather high as well, ranging from 42 to 89% with a mean of 64% outside and 78 to 94% with a mean of 85% inside. Because inside RH exceeded the preset cut-off point of 76%, the system remained off most of the hot part of the day. It remains to be further investigated if the mortality could have been alleviated had the RH cutoff value been set higher than 76%, which would have allowed the fogging system to run longer. The result demonstrated the expected limitation of the fogging system in relieving bird heat stress under hot and *humid* conditions.

**Table 1. Weekly mortality and hen-day egg production during summer 1999.**

Week	No.	Death	%Death	%Egg
1-Jul	98,135	61	0.062%	84.7%
8-Jul	98,050	106	0.108%	86.2%
15-Jul	97,972	45	0.046%	88.3%
22-Jul	97,823	66	0.067%	84.2%
29-Jul	97,431	763	0.783%	84.5%
5-Aug	97,112	84	0.086%	82.4%
12-Aug	97,011	94	0.097%	81.9%
19-Aug	96,925	90	0.093%	82.0%
26-Aug	96,835	95	0.098%	84.3%

There were no side-by-side comparative data to quantify the efficacy of the fogging system. Nevertheless, the cooperative producer was pleased with the performance of the system based on his previous years of experience with heat losses. Without the cooling system, daily mortality of 3,000 to 5,000 hens would have occurred for the hot conditions as encountered during the summer. As can be seen in Figure 5, the hen-day egg production for the experimental house followed quite closely the industry performance standard that is based on thermoneutral conditions.

Maintaining the foggers to be free of clogging by impurities in the water proved to be the biggest challenge in the system operation. More chemical treatment and filtration of the well water will be implemented to eliminate or reduce this problem. More data collection is warranted.

## CONCLUSION

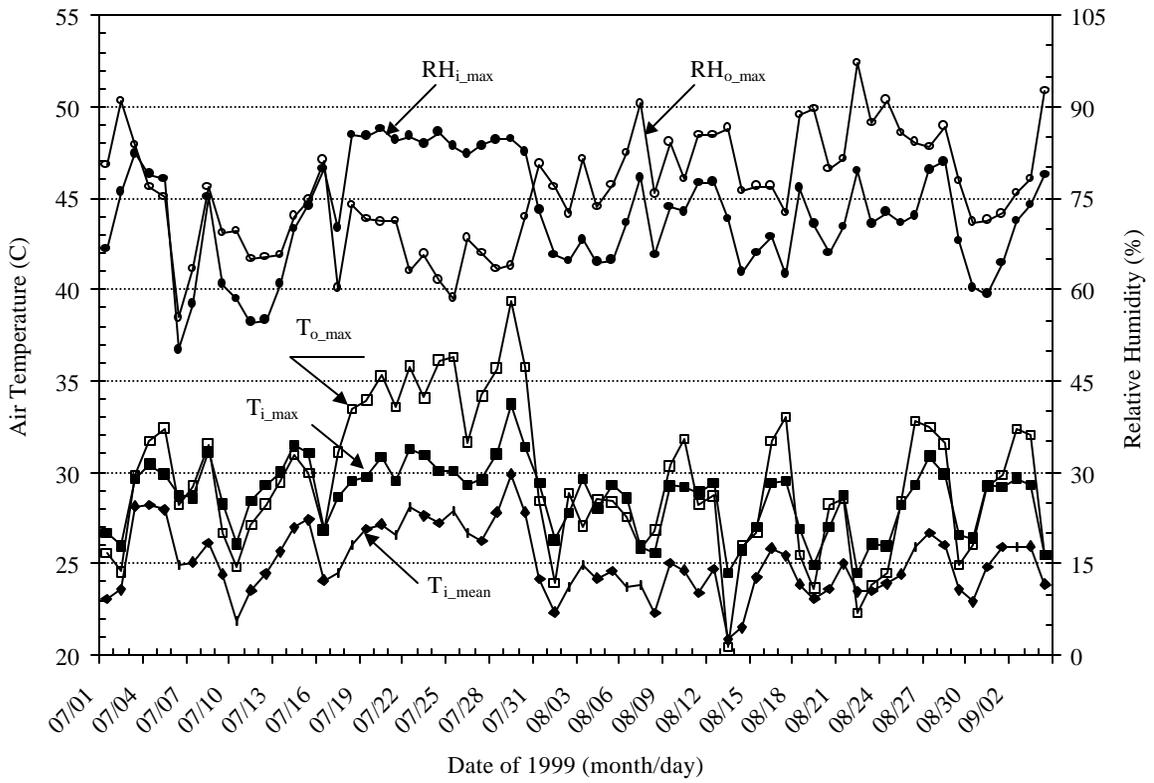
High-pressure fogging of inlet air shows good promise as an alternative, retrofitting system for cooling laying hens in high-rise houses under the Midwestern US summer climatic conditions. Limitation exists with the system's ability to reduce air temperatures under humid conditions. Better control or treatment of the water quality to prevent nozzle clogging is needed. More testing and evaluation of the system performance, including maintenance requirements, is warranted.

## ACKNOWLEDGEMENTS

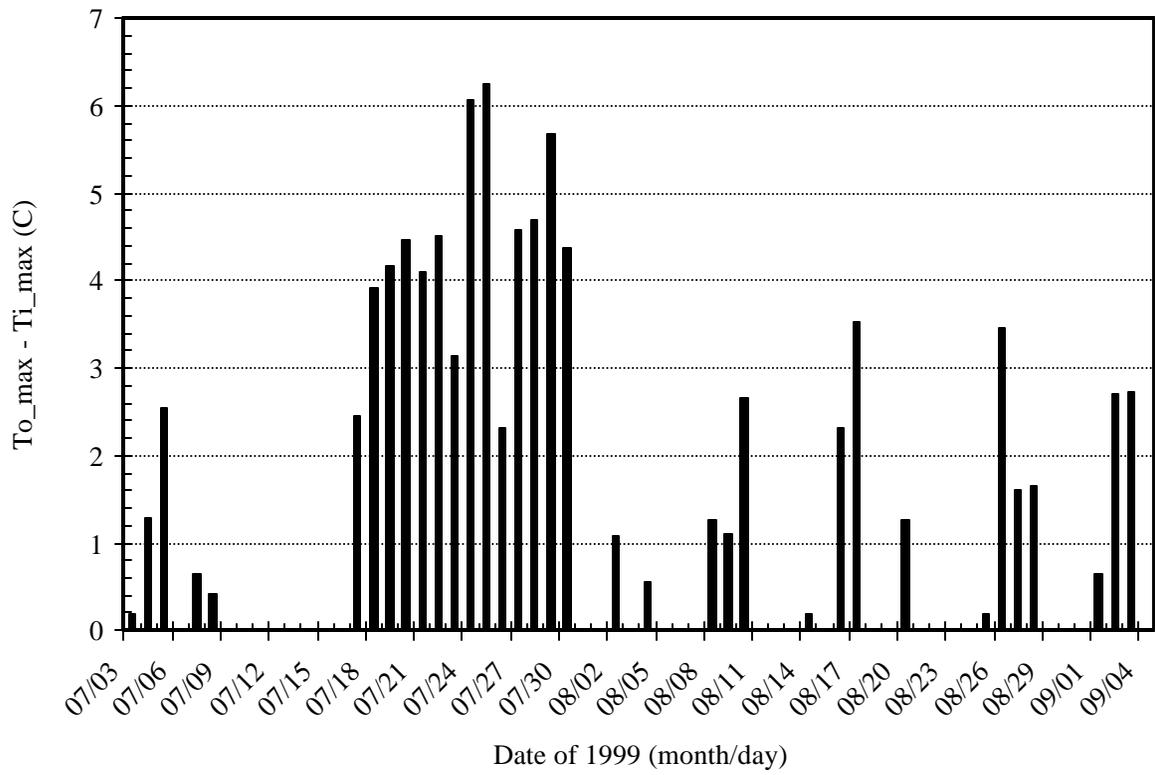
The authors wish to thank Val Environmental Systems for providing the high-pressure fogging system to the study, Mr. Mark Olson of Bode, IA for his cooperation in meticulously collecting the egg production and mortality data.

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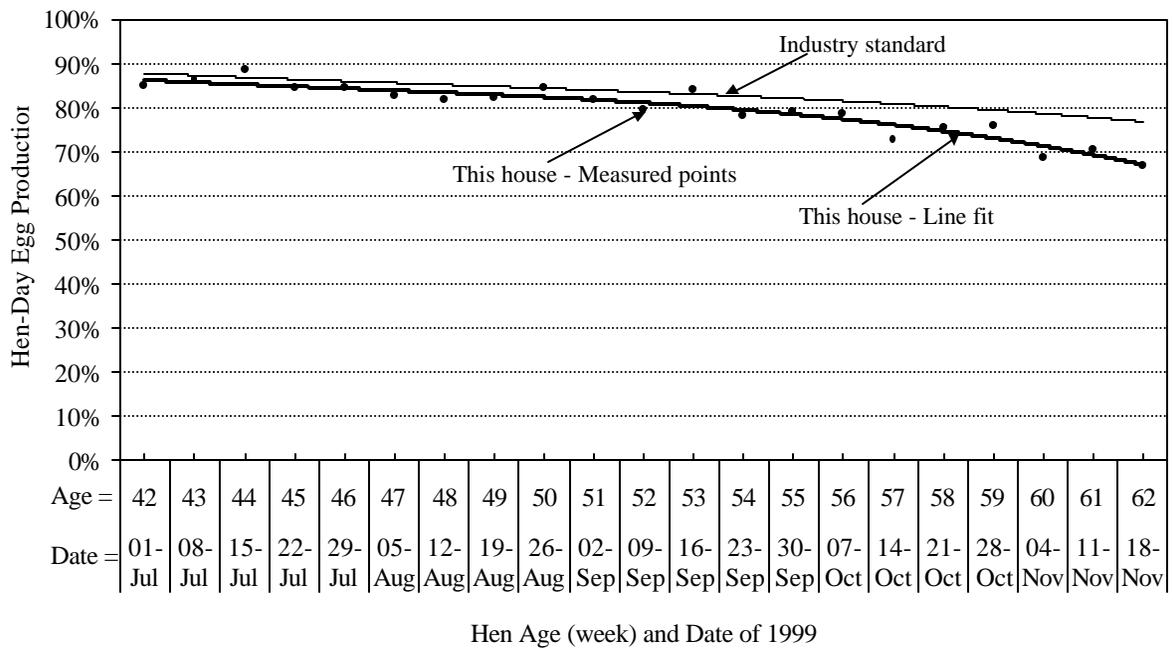
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**Figure 3.** Daily temperature and RH conditions inside and outside the experimental layer house equipped with high-pressure foggers along the eave inlets.



**Figure 4.** Reduction of inside air temperature ( $T_{i\_max}$ ) with regard to the outside temperature ( $T_{o\_max}$ ) on days when the high-pressure fogging system was in operation.



**Figure 5. Weekly average hen-day egg production of W-98 laying hens in the experimental house equipped with the high-pressure fogging system as compared with the industry performance standard.**