Temperature Changes in a Low-Profile, Cross-Ventilated Building in the High Plains

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Summary
Performance of an evaporative cooling system was evaluated in the High Plains in a low-profile, cross-ventilated dairy facility housing 4,200 lactating cows. The temperature decrease across the 6-inch cellulose evaporative pad during the afternoon hours from July 15 to August 14, 2008, was 12.6°F. The temperature-humidity index was below 72 for 14 and 19 hours/day in pens near the outlet (exhaust fans) and inlet (near evaporative cooling pad), respectively, compared with 12 hours under ambient conditions. Throughout the study period, the evaporative cooling system decreased the number of hours that cows were housed in a heat stress environment irrespective of pen location in the building.

Introduction
Optimizing the environment where cows are housed increases milk production, improves feed efficiency, raises income over feed cost, strengthens reproductive performance, allows for controlled lighting, reduces lameness, and lessens fly-control costs. Dairy cows housed in an environment outside their thermoneutral zone alter their behavior and physiology to adapt. Adaptations help maintain a stable core body temperature, but nutrient utilization and profitability are negatively affected. Previous studies of the performance of LPCV buildings were based on data collected in the north central part of the United States. The objective of this study was to evaluate the performance of an LPCV building located in the High Plains, a more arid climate.

Experimental Procedures
A 4,200-cow LPCV building located in the Texas Panhandle was monitored in summer 2008 to evaluate the performance of an evaporative cooling system in the High Plains. The building was oriented north to south with a center transfer lane to the milk center. The building was 320 ft wide by 1,400 ft long. The building had a 10-ft evaporative cellulose pad along the west side. The pad was 6 inches thick. Three temperature-humidity recording devices were placed on 6 baffles located in the northern half of the building. Each half of the building had 6 groups of lactating dairy cows with a baffle located between the head-to-head stalls in each pen. Devices recorded temperature and humidity every 15 minutes throughout the study period. Data were analyzed from July 15 to August 14, 2008. Devices were hung approximately 7 ft above the concrete alleys. Two temperature-humidity devices were placed in sun shields and installed outside the building to record ambient conditions. Three hundred sixty data points were averaged to obtain the average hourly temperature and humidity value at each baffle during the study period. Temperature-humidity data were used to calculate the ambient and interior temperature-humidity indices (**THI**).

Results and Discussion
Figures 1 and 2 show the average hourly temperature and relative humidity, respectively, during the 30-day study period.

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Baffle 1 was located approximately 23 ft from the evaporative pad at the inlet side of the building. Baffle 6 was located approximately 23 ft from the exhaust fans at the outlet side of the building. The average temperature drop observed between noon and 2000 hours was 12.6°F. During these afternoon hours, the relative humidity was less than 40% (Figure 2). The relative humidity decreased 5 to 10% as the air moved across the building and was warmed by the heat being transferred from the lactating cows to the air. The average hourly air temperature increase across the building was 0.0094°F/ft of building width.

Figure 3 shows the hourly ambient and interior THI. From 1000 to 2000 hours, the ambient THI was above 76. The THI remained at or below 72 during the 24-hour period in pen 1 near the inlet. The THI remained below 75 in the pen near the exhaust side of the building.

Figure 4 compares ambient temperature with the temperature at baffle 1 for the entire data collection period. The temperature difference between these 2 points reflects the ability of the evaporative pad to cool the incoming air. The lack of accuracy, as indicated by the low R^2 value, in predicting the temperature at baffle 1 on the basis of ambient temperature is due to the variability of the ambient relative humidity. Relative humidity in the High Plains is variable at a given temperature. Figure 2 shows that humidity varied from 40% during the afternoon hours to nearly 80% during the early morning hours.

Figure 5 compares the ambient THI to the THI at baffle 1. When humidity is included, the correlation increases and the ambient THI value could be used to predict the THI at baffle 1, indicating the potential for heat stress. Figure 6 shows the average hours per day during the study period when the THI was less than 72. The ambient THI was less than 72 for only 12 hours/day. At baffle 1 near the inlet, the THI was less than 72 for nearly 19 hours/day. This resulted in 58% less time each day when the cows were experiencing heat stress. The THI was less than 72 for only 14 hours/day at baffle 6 near the exhaust fan, which provided 16% fewer heat stress hours per day. Figure 6 shows the impact of the air absorbing heat generated by the lactating cows as the air moves from baffle 1 (inlet) to baffle 6 (exhaust).

Temperature drop across the 6-inch evaporative pad during the afternoon hours from July 15 to August 14, 2008, was 12.6°F. The THI was below 72 for 14 and 19 hours/day in pens near the outlet and inlet, respectively, compared with 12 hours under ambient conditions. Throughout the study period, the evaporative cooling system decreased the number of hours that cows were housed in a heat stress environment irrespective of pen location in the building.

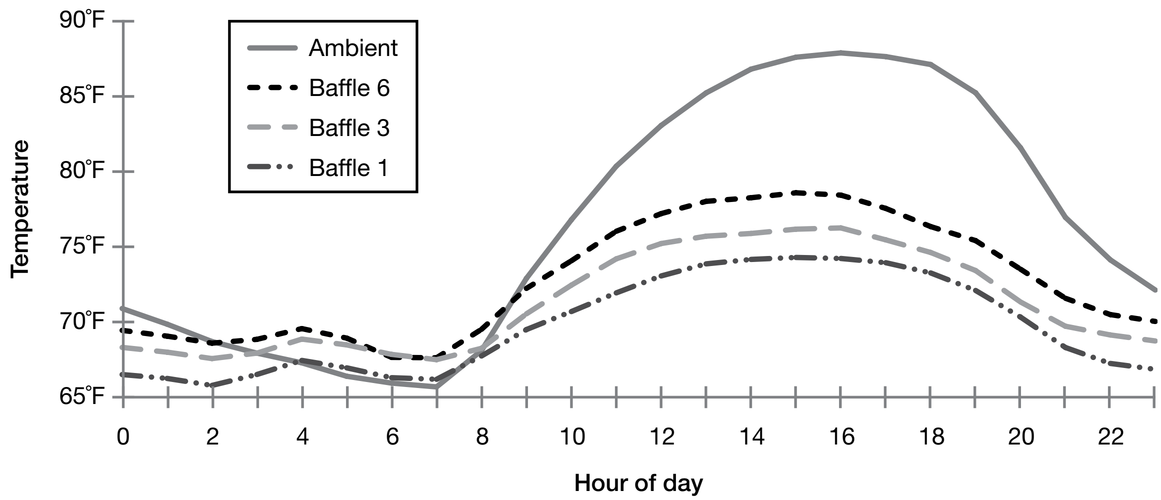

Figure 1. Hourly average ambient temperature and temperature at different locations inside a low-profile, cross-ventilated dairy facility in the High Plains from July 15 to August 14, 2008.

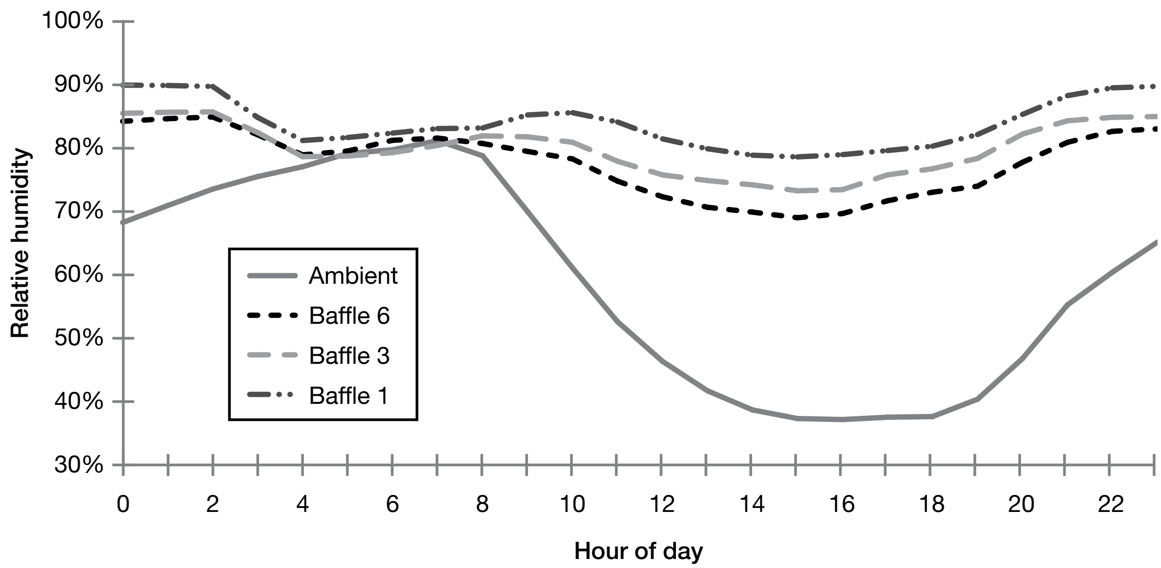

Figure 2. Hourly average ambient relative humidity and relative humidity at different locations inside a low-profile, cross-ventilated dairy facility in the High Plains from July 15 to August 14, 2008.

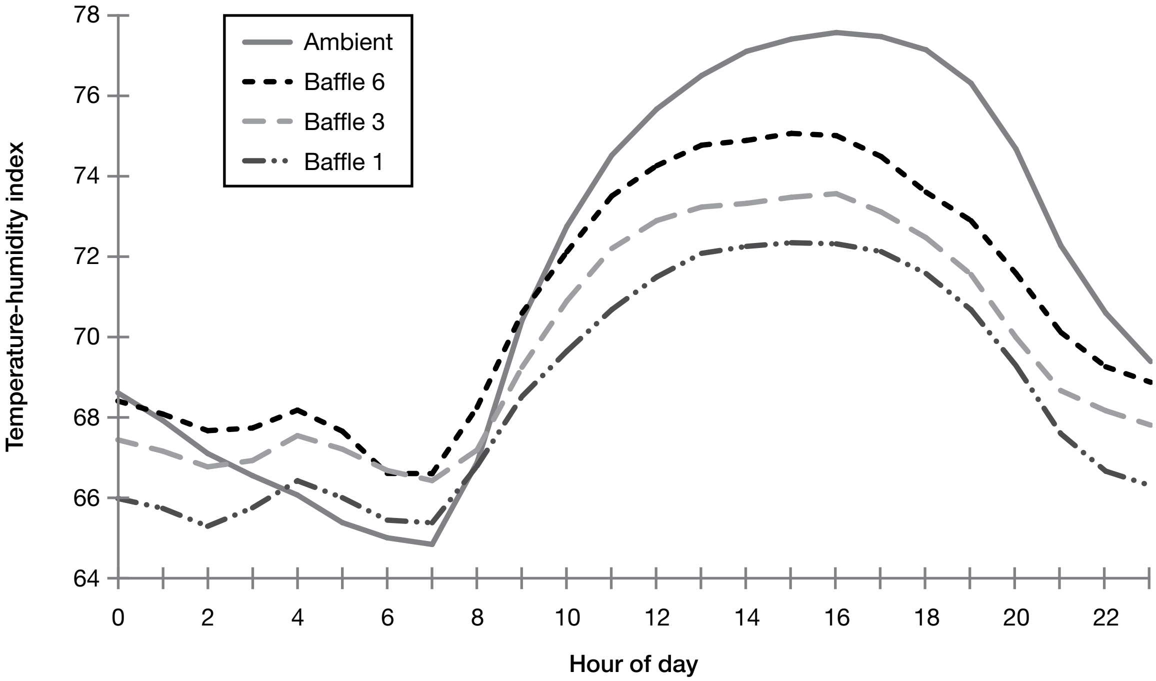

Figure 3. Hourly average ambient temperature-humidity index and temperature-humidity index at different locations inside a low-profile, cross-ventilated dairy facility in the High Plains from July 15 to August 14, 2008.

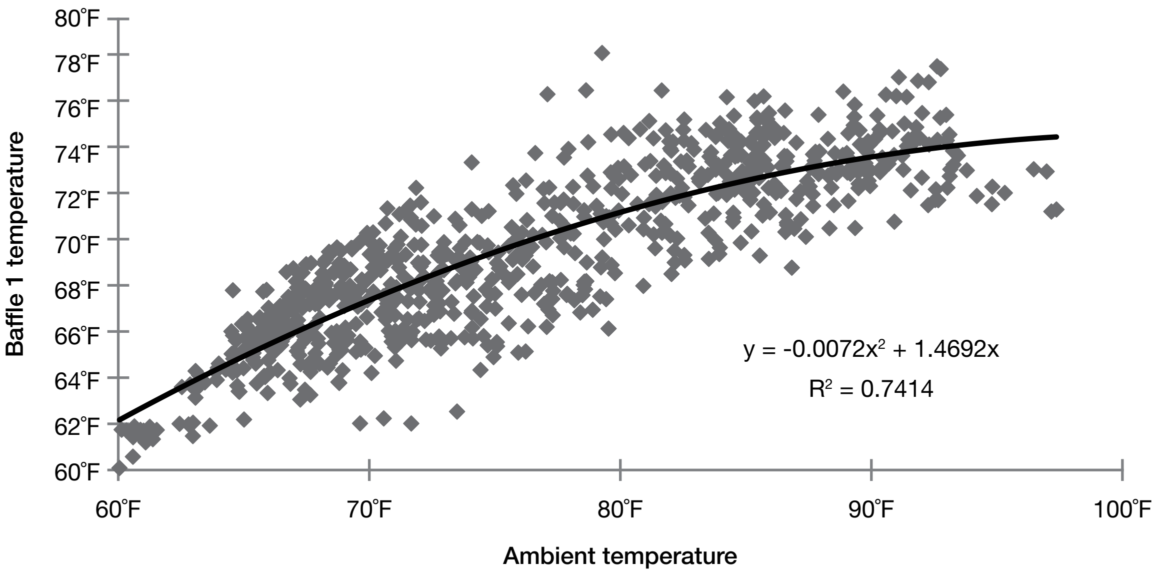

Figure 4. Comparison of ambient and baffle 1 temperature in a low-profile, cross-ventilated dairy facility in the High Plains from July 15 to August 14, 2008.

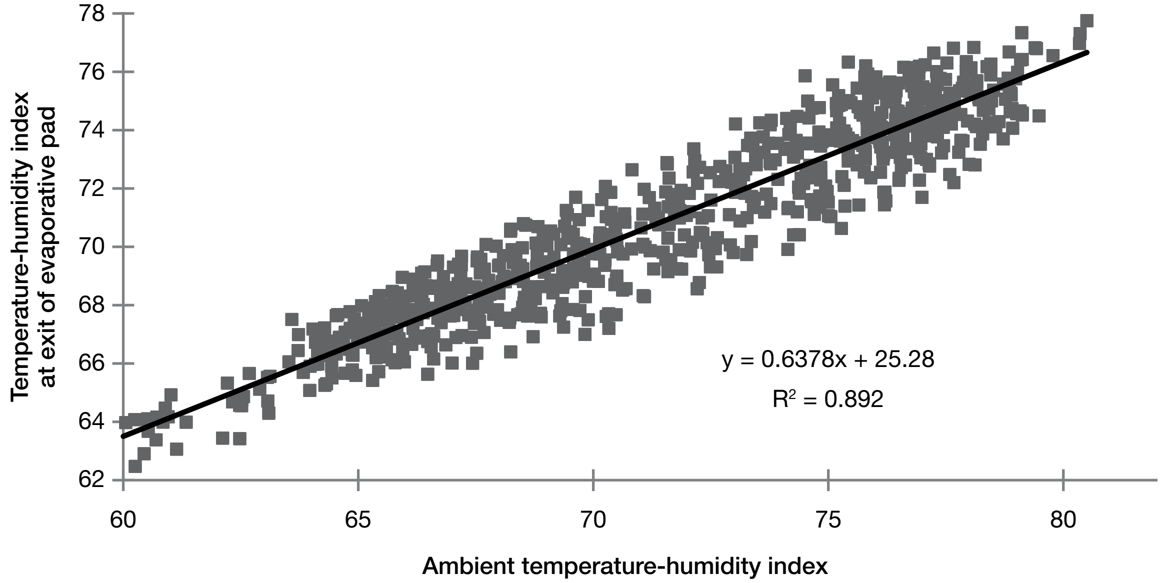

Figure 5. Comparison of ambient and baffle 1 temperature-humidity indices in a low-profile, cross-ventilated dairy facility in the High Plains from July 15 to August 14, 2008.

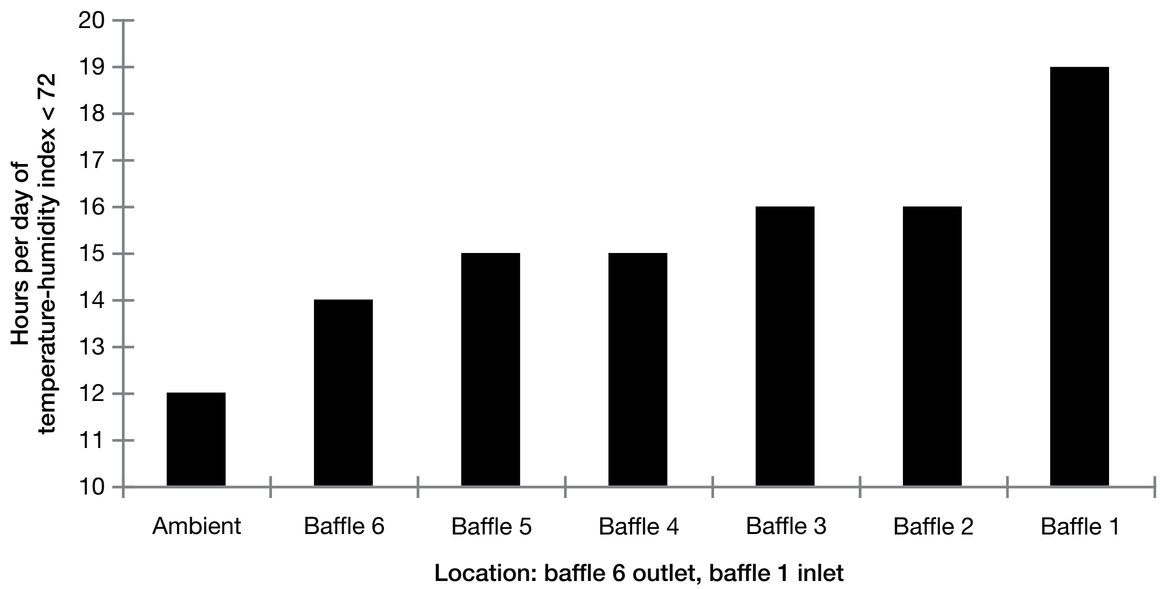

Figure 6. Comparison of hours per day at different locations when the temperature-humidity index was less than 72 in a low-profile, cross-ventilated dairy facility in the High Plains from July 15 to August 14, 2008.