Impact of Ohio Weather on Managing Dairy Facilities

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Cold and heat stress influence dairy cow performance. Figure 1 show the percent annual hours within 5 °F degree temperature ranges for Dayton, Ohio. During the energy crisis of the 1970's each military base complied weather data to enable resources to be focused towards appropriate energy conservation practices. The data in Figure 1 was plotted using the 5 years of hourly weather data compiled for the Wright-Patterson Air Force base. The thermal neutral zone of a dairy cows is in the range of 20 to 70 °F. The data shows for Dayton, Ohio annually less than 6 % of hours are below 20 °F. However, cow's experience heat stress when temperatures exceed 70 °F nearly 18 % of the time during a year. Outdoor temperatures are in the thermal neutral zone about 75 % of the time during the year. Therefore, Ohio dairy producers should focus on minimizing heat stress prior to focusing on cold stress.

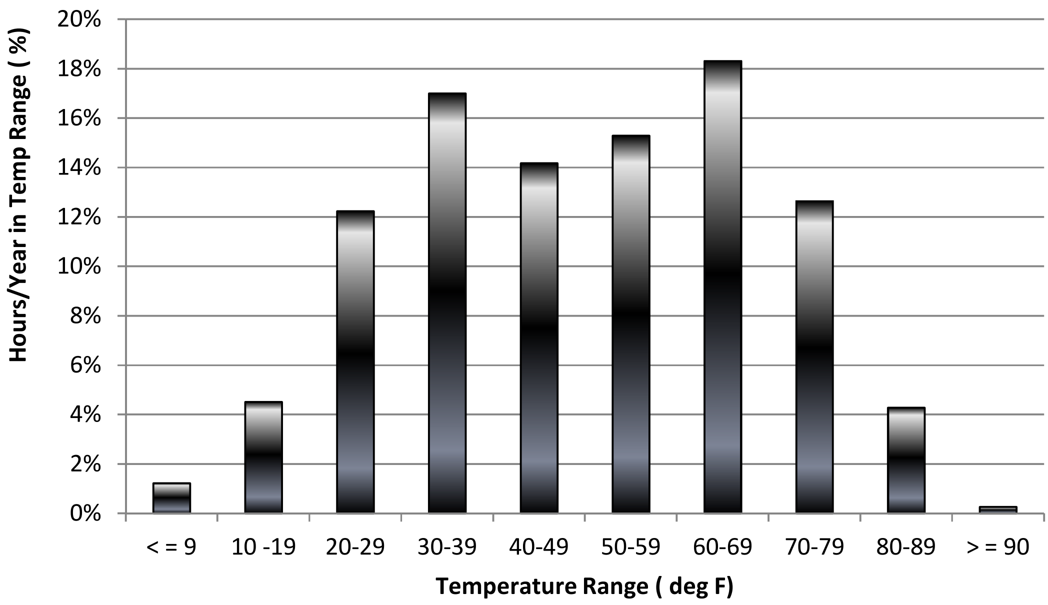

Figure 1 Annual hours (percent) of weather data in 5 °F temperature ranges for Dayton, Ohio

Weather data may be used to estimate water requirements for low pressure sprinkler systems used in heat abatement. The annual hours at Akron between 70 and 79 °F equaled 73.5 %, between 80 and 89 °F equaled 24.9 % and only 1.6 % hours above 90 °F. Temperature controllers allow water to be applied 1 minute on and 14 minutes off (15 minute cycle) between 70 and 79°F, 1 minute on and 9 minute off (10 minute cycle) between 80 and 89 °F and above 90°F, 1 minute on and 4 minute off (5 minute cycle). With a 1 gpm low pressure nozzle and spacing of 8 ft above the feedline, annual water usage for heat abatement would equal approximately 1,750 gallons for cooling cows. Water usage with low pressure systems is not 100 % efficient since the systems operates based on temperature rather than cows present at the feedline. This results in some water entering the storage pond requiring land disposal. Based on $0.02 per gallon of water for disposal, cost estimate for application of the extra water is estimated at $20 per cow per summer. Basically, 1 ½ cwt of extra milk is required to pay for the cost of excess water disposal.

Figure 2 shows weather data from three military bases in Ohio including Dayton, Cincinnati and Akron. The data suggest cows experience temperatures below 20 °F less than 6 percent of the time during a year. Temperatures above 70 °F occur nearly 20 percent of the year in Ohio based on these 3 locations.

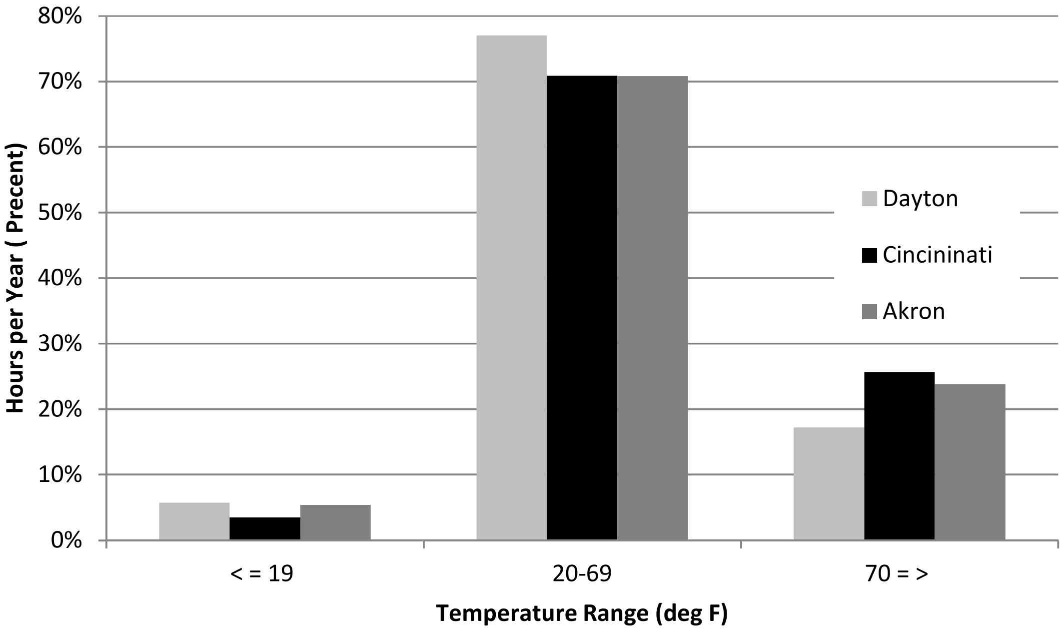

Figure 2 Annual hours (percent) at three locations in Ohio within various temperatures

Figure 3 shows the hourly weather data from August 1-14, 2011 for Columbus, Ohio. The temperature ranged from 58 °F to 91 °F with an average of 77 °F. The relative humidity averaged 70 % (31 to 94 %) and the temperature humidity index averaged 73.5 (58 to 82.2) during this two week period. Nearly 50 percent of the time the temperatures exceed 75 °F.

Figure 4 plots the range of relative humidity and THI values for a given temperature during this period. For example at 75 °F, the relative humidity ranged from 40 to 90 %, while the THI ranged from 70 to 75. The THI value is influenced more by temperature than relative humidity resulting in a close correlation between temperature and THI (R^2 = 0.93) as shown in Figure 4. However, the correlation between temperature and relative humidity is poor (R^2= 0.42). Evaporative cooling is more effective at lower relative humidity. The variability of the relationship between temperature and relative humidity as shown in Figure 4 indicates there will be periods when cows may still experience some heat stress in spite of low pressure systems or evaporative cooling systems. In dairy regions where there is poor correlation between temperature and relative humidity, the recommendations is to install a low pressure sprinkler systems over the feedline even if there is an evaporative cooling systems is the primary cooling system. This is based on the assumption there is adequate airflow in the stall or resting area.   At higher humidity, low pressure systems will be more effective.

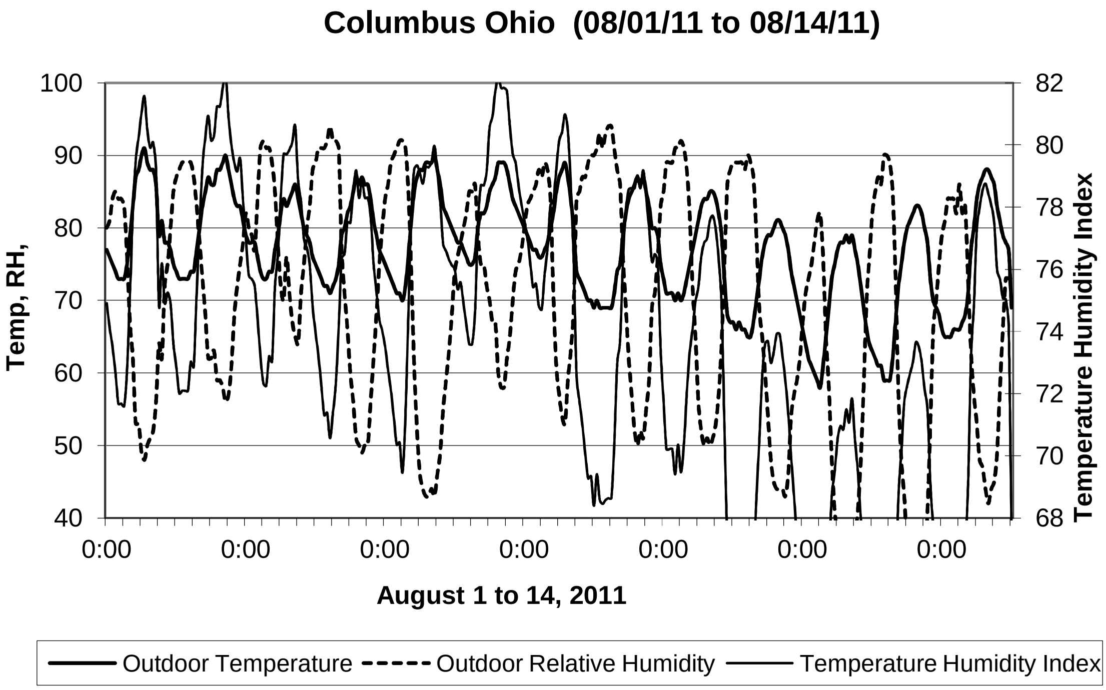

Figure 3 Hourly temperature, relative humidity and temperature humidity index between August 1-14, 2011 for Columbus, Ohio

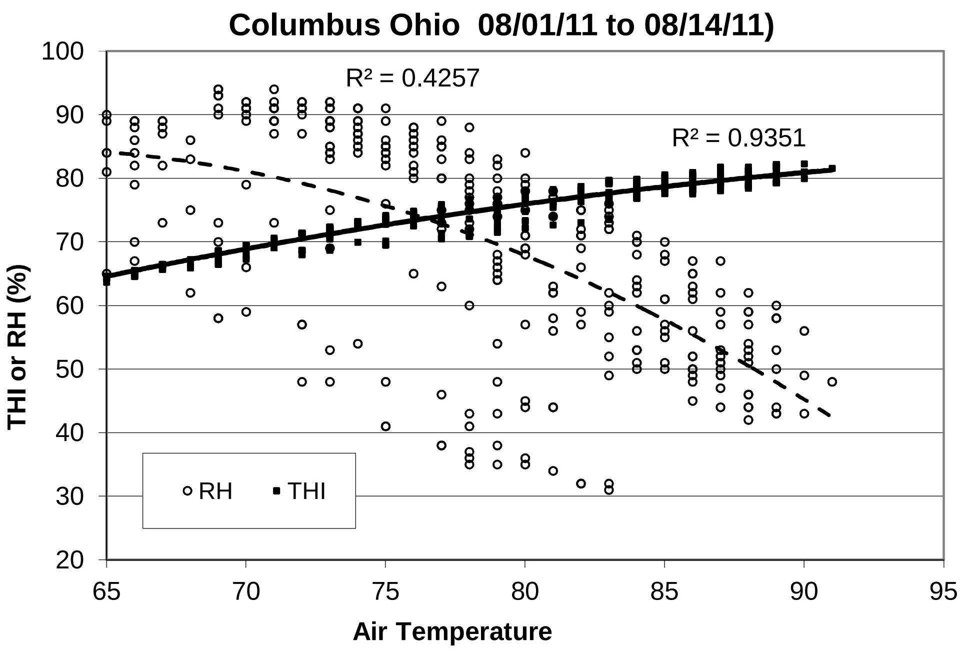

Figure 4 Range of relative humidity and temperature humidity indices for a given temperature between August 1-14, 2011 for Columbus, Ohio

Weather data may be used to evaluate the effectiveness of evaporative cooling systems. Figure 5 compares the ambient THI index to the THI index assuming an evaporative cooling system was 100 percent efficient during the August 1 to 14, 2011 in Columbia, OH. The poor correlation between the temperature and 100 percent efficient values is a due to the variability of relative humidity (Figure 3 or 4). However, the plot indicates the potential to lower the THI values via evaporative cooling. The THI indices may be reduced to less than 75 even when temperatures are above 85 °F using an evaporative cooling system. In spite of the variability of the relative humidity, evaporative cooling has the potential to have significant effect on reducing heat stress or lower the THI value.

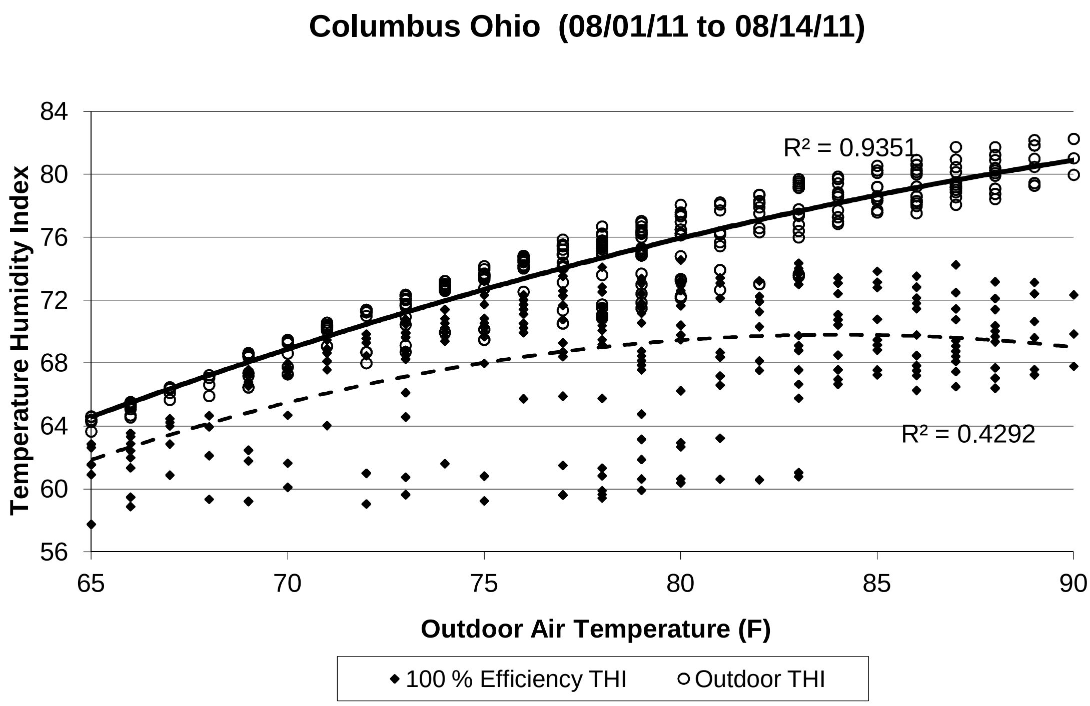

Figure 5 Impact of evaporative cooling on the THI assuming 100 percent efficiency during August 1-14, 2011 in Columbus, Ohio

Figure 6 plots the temperature drop assuming the evaporative cooling system is 100 percent efficient during August 1-14, 2011 in Columbus, Ohio. For given temperature such as 75 °F, temperature drops of 2 to 16 °F are possible depending on the relative humidity. As previously noted, the variability in relative humidity influences the potential temperature drop. For a given temperature, the temperature drop will be greater as the relative humidity decreases. The average temperature drop is 6 °F at 75 °F outdoor air temperatures.

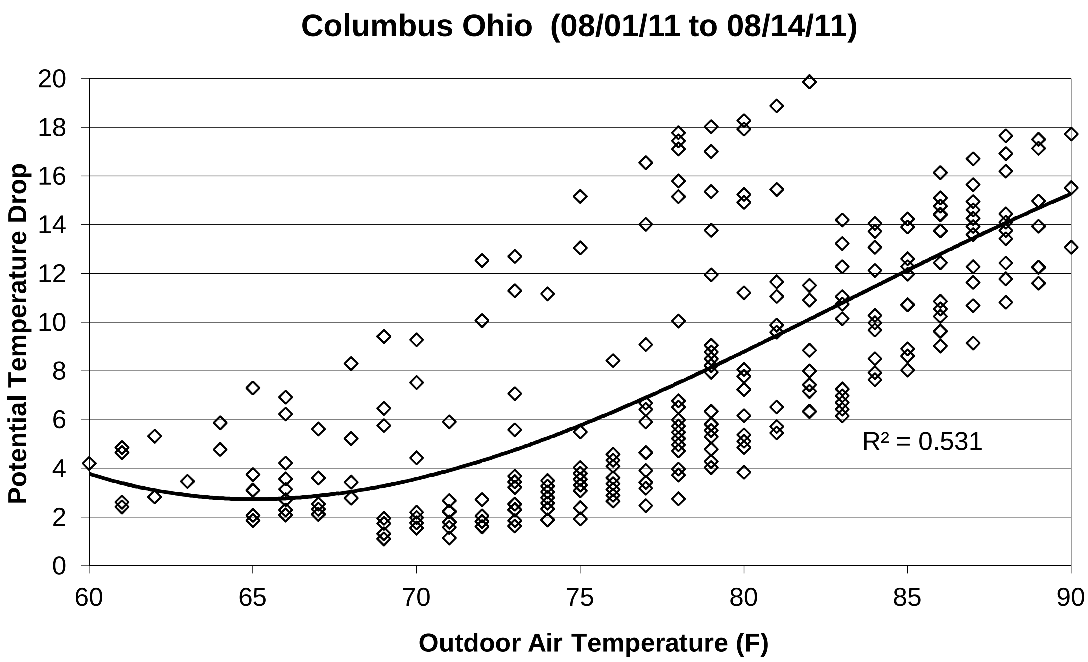

Figure 6 Potential temperature drop of the air due to an evaporative cooling system during August 1-14, 2011 in Columbus, Ohio

Weather data analyzed from three locations in Ohio indicate dairy producers in the state should initial focus on heat stress rather than cold stress. Annually, about 20 percent of the time the environmental conditions are such cows will experience heat stress as compared to only 6 percent with cold stress. Evaporative cooling systems will work in spite of the variability of the relative humidity at a given temperatures during the summer months. A low pressure sprinkler system along with adequate airflow will be critical to minimize the impact of the variability of relative humidity even if evaporative cooling systems are installed.