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Extreme Heat Leads to Yield Losses for Midwestern Dairy Producers

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Livestock production is vulnerable to extreme weather. For dairy cattle, one of the main points of vulnerability is heat stress. High heat and humidity decrease appetites, increase thirst, increase agitation, and increase vulnerable to illness among dairy cattle (West et al., 2003; Bohmanova et al., 2007; Bagath et al., 2019; Bishop-Williams et al., 2015). These changes, in turn, can cause significant losses for dairy producers, especially in herds on farms without the infrastructure to manage heat. Small herds, which are a cornerstone of Midwestern agriculture, are the most vulnerable. This article covers the new research on the cost of extreme heat in terms of milk yield for Midwest dairy producers (Hutchins, Skidmore, and Nolan, 2025).

Methods

For our study, we analyzed 56 million records of daily cow-level milk yield provided by members of Dairy Herd Improvement Associations. Our sample includes 18,000 herds in the period 2012 – 2016. Once a month, DHIA members measure milk yield and test milk for butterfat content, protein content, and somatic cell count. The additional tests allow milk yields to be adjusted for protein and fat (aka quality adjusted).

We paired each adjusted yield record, measured at the cow-level, with data on the temperature and humidity in the previous week and constructed weather categories based on the maximum and minimum temperature humidity index (THI) reached each day. While the maximum THI is relevant, it is also critical that cows have time to recover (typically overnight) between daily peaks. Thus, high *minimum* THI values indicate that the animal has been consistently under heat stress with no recovery time.

Following Hutchins and Hueth (2022), we modeled milk yield using the standard Wood lactation curve and allowed shifts in milk yield if the cow was exposed to low, medium, or high heat stress (defined based on previous work by Key et al., 2014). We distinguished if the heat stress was zero through seven days preceding the milk testing. Our study produced three significant results.

Herds in the Midwest Lose an Average of 1% of Milk Yield per Year Due to Heat Stress

We find that cows lose up to 8.2% of a day's milk in total over the week following a day of stress. This ranges from 1.6 – 2.2% following a day of low stress, 3.2% following a day of moderate stress, and 8.2% following a day of extreme stress (figure 1b).

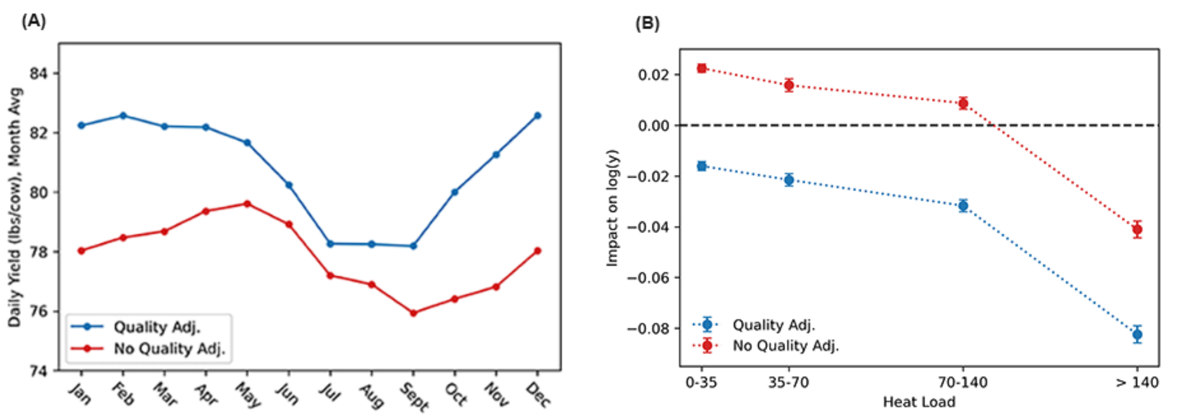
We use this to estimate the average loss for a cow in our sample based on the weather and production over the five years in our data. On average, herds in our sample lost 1% of annual yield each year due to heat stress, though the exact loss varies year over year. For example, losses were higher during a particularly warm summer in 2012. Over the five-year period, the total lost revenue in the herds in our sample was $245 million. Particularly when margins are thin, these revenue losses diminish a farmer's bottom line.

Neglecting Quality Adjustment Underestimates Heat and Overestimates Cold Stress Losses

Under the milk marketing system, payments are based on components rather than simply fluid ounces. Our analysis is the first to measure the effect of heat stress on quality-adjusted milk yield at scale. Adjusting for the effects of heat impacts our results significantly. On average, the gap between quality-adjusted and non-quality-adjusted milk yield is highest in the winter months, when cows produce energy-dense milk (i.e., more fat and protein per fluid ounce; figure 1a). This quality adjustment is critical to understand whether a calf's nutrient demands are being met and the impact on a farmer's revenue.

Ignoring the quality adjustment would lead us to several errors: underestimating the impact of heat stress by half under extreme stress conditions, estimating a small *increase* in yield under low and moderate heat stress conditions, and even detecting yield *losses* due to cold (figure 1b). Cold stress findings have been reported in the past, but based on our analysis we caution against these conclusions. Holstein cows, which make up most of the Midwestern dairy herd, are resilient to cold stress, but our results demonstrate their vulnerability to heat stress.

Figure 1. Monthly Milk Yield and Effect of Heat Stress on Milk Yield With and Without Quality Adjustment



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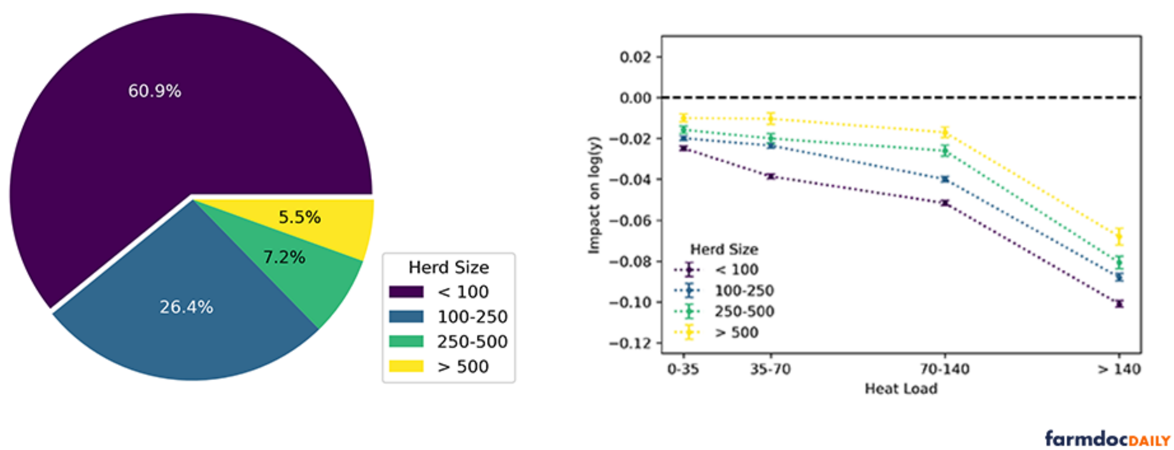
Small Herds Are Most Vulnerable

Small and family-owned dairy herds are an integral part of Midwestern agriculture. The average dairy herd in the Midwest is well under 500 head, yet they compete with Western states where the average herd size is well over 1,000 (Hutchins and Janzen, 2023).

We find that cows in smaller herds are also more vulnerable to heat stress. In our sample, herds under 100 head lose 1.61% of annual yield to heat stress and lose 2.5 – 3.9% of a day's yield in the week following one low stress. In contrast, herds over 500 head lose less than 1% following a day of low stress. Following extreme events, small herds lose 50% more (10% vs. 6.8%) than large herds.

These results lead us to two conclusions. First, small herds have not been able to implement the mitigation and management practices that larger Midwestern herds have already adopted. The infrastructure needed includes fan and sprinkler systems that often have high capital costs. Thus, small herds continue to lose yield on low- and medium-stress days that have only minimal effects on large herds. Second, even the current mitigation and management practices are not sufficient to completely mitigate against extreme stress days.

Figure 2. Share of Herds and Effect of Heat Stress by Herd Size



Conclusion and Policy Discussion

Dairy producers currently face risk and yield losses due to extreme heat, and small farms are the most vulnerable. In an era of consolidation and farm exits, managing extreme heat adds to the challenges that farmers with small herds face. However, no farms are completely insulated from extreme heat.

Additional research and innovation on how to manage extreme heat in a cost-effective way can benefit Midwestern dairy herds, particularly as they compete with massive operations in the Western United States. Small farms will also benefit from technical or financial support to incorporate new and existing management strategies in their systems. Research, technical, and financial support for dairy farms to cope with heat stress is one potential tool to help keep family-owned dairy farms present and competitive in the Midwest.

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