Northern NY Agricultural Development Program
2019 Project Report

The Effectiveness of Heat Stress Abatement on Lactating Dairy Cows' Performance, Behavior & Health in NNY: Year 3

Project Leaders:

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Collaborators:

4 NNY dairy farms with different heat abatements systems

Background:

Heat stress is a major concern for dairy cattle producers and the health and well-being of their animals. A considerable challenge for dairy producers is maintaining cow comfort during summer heat events (Hillman et al., 2005).

When temperatures and the temperature humidity index (THI) rise to certain levels, dairy cattle may respond to heat stress in a variety of ways. These may include less lying time, lower dry matter intake (DMI) and rumination, as well as a decline in milk production and reproductive performance (West, 2003; Tapki and Sahin, 2006).

According to Collier et al. (2006), the average production per cow has doubled in the past few decades. Therefore, there is an increased metabolic heat output as a result of an increase in production. Dairy cattle are now even more susceptible to heat stress because of this. In addition, it is estimated that heat stress accounts for roughly $900 million of annual economic losses for the U.S. dairy industry (Collier et al., 2006).

Although numerous studies have been conducted that evaluate cow response to heat stress, few studies have been conducted in the northeastern United States where episodic heat-stress periods are typical. Through the months of June to late September, cows in northern New York experience periods of heat stress that negatively impact their health and wellbeing because the animal's body never becomes acclimated to the heat. According to Collier et al. (2006), heat acclimation is a biphasic pattern that can be divided into two periods. The first is known as acute or short-term heat acclimation in which heat stress causes changes in cellular signaling pathways, thus, disrupting cellular homeostasis. In effect, cells become adapted to the effects of heat stress.

The second phase is known as chronic, or long-term, heat acclimation in which the heat-acclimated phenotype of the cellular changes is now expressed after chronic exposure to heat stress. In order for heat acclimation to occur, alterations in various hormonal secretions and signals must take place in addition to changes in the response of target tissues to specific hormones, meaning an increase in receptor populations.

It takes weeks as opposed to days in order to complete both acclimation phases (Collier et al., 2006). Because northern New York does not typically have heat events lasting weeks, animals' bodies may not become acclimated to the heat, and therefore heat events in the region may have deleterious effects on animal health.

The short- and longer-term consequences of heat stress on dairy cow behavior and production are under-appreciated, especially in more moderate heat stress typical of northern states (Cook et al., 2007). In Northern New York Agricultural Development Program (NNYADP)-supported research studies conducted by Miner Institute in 2016-2018, the impact of heat stress was evaluated on commercial dairy farms with varying degrees of heat abatement systems in place. During these studies, daily average THI ranged from 48 to 80 between June and September. All cows, regardless of the heat abatement system used, spent more time standing when THI was ≥ 68. However, standing time increased the most (~2.7 hours/day) in 2018 for the farm with no heat abatement on days when THI was ≥ 68 for the majority of the day. For farms using box fans in the housing area, standing time increased by 2.3-2.5 hours, while the farm with a feedline soaker and fans increased standing time by 2 hours. Lameness increased significantly from beginning to end of summer on all farms in 2018.

Bulk tank milk protein was decreased during the heat events 2016-2018, particularly on the NNY farms where the cows appeared to be the most vulnerable to heat stress. Greater than 40% of the variability in bulk tank milk protein on these farms could be explained by THI. Unexpectedly, in 2017 and 2018, there was no relationship between bulk tank milk fat production and THI for any of the farms participating in the study.

Additional technologies (SmaXtec; Graz, Austria) have recently become available that enable body temperature, animal activity, drinking behavior and rumen pH to be evaluated continuously and provide additional information on the impacts of heat stress on animal health and rumen function.

Combining this new information with milk composition and behavior data will be a valuable tool to help producers understand and evaluate the economic impact of heat stress on farms in Northern NY with varying heat abatement systems. This research is developing a science-based understanding of heat stress in dairy animals that will empower dairy farmers to initiate, add or enhance their heat abatements systems to increase cow comfort and maintain strong milk production year'round.

2019 Project Objectives:

- To assess the impact of different heat abatement systems on lameness and resting time of dairy cattle from June through September in Northern New York.
- To assess the impact of different heat abatement systems on rumen pH (function), drinking behavior, activity, and body temperature of dairy cattle from June through September in Northern New York.
- To evaluate the degree of change in bulk tank milk composition on farms using different heat abatement systems in Northern New York.
- To evaluate the impact of heat stress on reproductive performance in herds with different heat abatement systems.

Methods:

This study was approved by the Miner Institute Animal Care and Use Committee. Research was conducted on the same four farms in Clinton County with varying degrees of heat abatement systems that participated in the study conducted in 2019 (Appendix, Table 1). In 2019:

- Farm A made no changes to its heat abatement system from 2018. Pen setup was a 6-row freestall with sand bedding, no mechanical ventilation in pen, fans and sprinklers in holding area
- Farm B increased the downward angle of fans over stall beds and closed doors at the north end of the pen to create more air movement within pens. There were fans in the holding area and milkers would manually spray cows in the holding area during hot periods. There were no fans over the feed alley.
- Farm C used a mister system attached to box fans over the feed alley and stall beds instead of a soaker line at the feedbunk.
- Farm D made no changes to its heat abatement system from 2018: fans over stalls and in holding area and parlor.

On each farm, early to mid-lactation Holstein cows (n=30) were identified at the beginning of the study based upon the expectation that they would remain in the same lactating group for the duration of the study and were not lame (lameness score ≤ 2). This group of cows served as a focal group averaging over 100 lbs/day on each farm (Table 1).

Measurements:

Environmental conditions. Temperature and relative humidity were recorded in ten-minute intervals using a Kestrel® DROP D2AG data logger (Nielsen-Kellerman Company, Boothwyn, PA) from June through the end of September. Each device was located centrally within the pen and mounted at cow height, inside a PVC pipe with holes drilled to allow air flow to most accurately capture the cow's environment.

THI was calculated by the Kestrel device using the following NRC (1971) THI equation: $(1.8 * Tdb + 32) – [(.55 - .0055 * RH) * (1.8 * Tdb – 26)]$. A Kestrel® 3000 device was used to determine wind speeds on each farm throughout the pen housing focal cows. A map of each pen was drawn out and wind speeds (mph) were measured weekly at specific points within the free stall to assess the air flow the animals experienced when eating, standing, or lying down in stall beds.

Lameness. All cows were scored at the beginning and end of the study for locomotion on a flat and level surface. Cows were scored using a 5-point scoring system where 1 = normal, 2 = mildly lame, 3 = moderately lame, 4 = lame, and 5= severely lame (Sprecher et al., 1997). Only cows scoring ≤ 2 were enrolled as focal cows.

Behavioral assessment. Lying and standing behavior (time spent lying and standing, bouts, and distribution of bouts during 24 hours) of focal cows were measured continuously using leg-mounted HOBO Pendant G data loggers (Onset Computer Corporation, Bourne, MA) that were changed out on a weekly basis from June through the end of September.

Lactation performance. Bulk tank yield and milk composition were monitored throughout the study period. Daily bulk tank samples were analyzed for milk composition (fat, true protein, urea nitrogen, somatic cell count, and fatty acid profiles) by the Miner Institute Milk Laboratory.

Reticular temperature, activity and reticular pH. SmaXtec boluses (SmaXtec; Graz, Austria) were used to measure body temperature, activity and pH from the reticulum. Two types of boluses were administered: Basic to 25 focal animals to measure reticular temperature and activity, and Premium to 5 focal animals to measure reticular pH in addition to the Basic bolus features. SmaXtec boluses allowed for real-time collection of data at 10-minute intervals through wirelessly transmitted data from thebolus and internet storage of data. Prior to administering with a balling gun, Premium boluses were calibrated in buffer solution for 5 minutes.

Statistical analysis. All data were analyzed within farm; no across-farm comparisons were made. Descriptive statistics were used to summarize environmental parameters and reticular temperature. Differences in lameness (not lame vs lame) from beginning to end of study period within farms were analyzed using Proc Freq and significance was determined using Chi-square. Retrospectively, six days of cool weather (mean THI < 68, COOL) and six days of hot weather (mean THI > 72, HOT) were selected and lying behavior and average reticular temperature was summarized and analyzed by farm using Proc Mixed to evaluate differences in daily lying time (h/d) and reticular temperature (°F) for COOL and HOT days. Significance was declared at $P \leq 0.05$.

Results and Discussion:

Overall, the summer of 2019 was warmer than 2017 in Northern New York, but not as warm as 2018 with average THI about one unit lower. The average THI across farms was similar from June through October (Fig. 1). As in past summers, periods of heat stress when the average THI was greater than 68 were broken up by a few days when the THI was ≤ 68. This allowed for the evaluation of the impact of episodic heat stress events on the lying behavior, lameness, and production performance of dairy cows on farms with varying management and heat abatement systems (Table 1) and did not provide an opportunity for cows to acclimate to the heat.

Episodic Heat Stress and Lameness. All farms exhibited a significant increase in lameness from the beginning of the study in June to early October when the focal cows' last lameness score was assessed (Fig. 2). In 2018, all farms exhibited a significant increase in lameness from beginning to end of the study regardless of heat abatement employed. In 2019, all farms, with the exception of Farm B, had a significant increase in lameness from beginning to end of the study.

Episodic Heat Stress and Lying Time. The impact of heat events on average lying time (hours/day) is presented in Table 2. As demonstrated in past summers, cows on all farms stood 1.2 to 2.4 hours longer on hot days in an attempt to dissipate their body heat.

Episodic Heat Stress and Body Temperature. Figure 3 illustrates the influence heat events (as measured by minutes per day THI > 72) have on median reticular temperature.

Cow body temperature increased in direct response to heat events on all farms regardless of heat abatement, particularly on Farm A. The body temperature of cows on Farm A was the highest during the early morning and late night hours, particularly during heat events (Fig. 4).

The process of milking and/or movement to the holding area with fans and sprinklers, appeared to reduce body temperatures on Farms A, C and D.

The body temperature of cows showed the least diurnal pattern on Farm B with slightly elevated median reticular temperature on the hottest days (average THI > 72).

The heat abatement systems on Farms C and D seemed to effectively mitigate mild heat events ($68 < \text{THI} \leq 72$) but were not as effective when average THI > 72. Farm A cows were vulnerable to mild and moderate heat events.

Wind speed. Measures of wind speed in pens are presented in Table 3. Although wind speed was not able to be measured on a daily basis, the weekly averages on Farm B showed the greatest amount of air movement in the stall beds for cows in a standing and lying position. Air movement over cows when they are standing and lying will remove heat produced by the cow (see next section).

Conclusions/Outcomes/Impacts:

It is clear that dairy cows in Northern New York are adversely impacted by episodic bouts of heat stress regardless of the type of heat abatement system employed. Increased air movement, creating a cooling "wind chill" effect, at both standing and lying positions in stalls may have minimized increases in body temperature which enabled cows to spend more time lying during hot days on the farms where wind speed was greatest.

The changes Farm B made to improve air movement throughout the pen resulted in an hour greater lying time when compared to 2018. One hour of increased lying time can result in 2-3.5 pounds more milk per cow per day.

Increased lameness is most likely associated with greater standing time and increased body temperature during heat stress. The reduced incidence of lameness on Farm B may be attributed to moderate body temperature increases and little fluctuation over the course of the day during heat events.

In addition to air movement, water availability also plays a critical role in helping cows maintain their core body temperature. Using the information gathered from the boluses, additional work will be done to evaluate drinking behavior of the dairy cows during heat events.

Overall, this research continues to show that farmers should consider even modest investments to maximize air movement to improve animal comfort and productivity on dairy farms during summers.

Outreach:

Outcomes of this study will be shared with the 6-counties in this region by summarizing and reporting data in the Miner Farm Report along with presenting outcomes at the national meeting of the American Dairy Science Association. Information was shared at the 2019 Dairy Day held at Miner Institute. Information will also be made available on the Miner Institute website.

Next Steps:

Summarization of drinking bouts, reticular pH, bulk tank data, and reproductive performance data combined with the economic impact of heat stress on farms with varying degrees of heat abatement will be completed and provided in future presentations and publications of this research study. A summary of three years of heat stress research will provide valuable insight on the impact of episodic heat stress on dairy cattle well-being and farm profitability in northern New York. The economic consequences of increased lameness, reduced milk protein and compromised lying time will be important components of the summary report.

Acknowledgments: We thank the four farms that collaborated "anonymously" for consecutive years as we evaluated the impact of heat stress on our dairy farms in northern New York, and the Northern New York Agricultural Development Program for continued funding for this important animal health and dairy production research.

For More Information:

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Northern New York Agricultural Development Program
2019 Project Report APPENDIX

The Effectiveness of Heat Stress Abatement Systems on Lactating Dairy Cows' Performance, Behavior and Health in NNY: Year 3

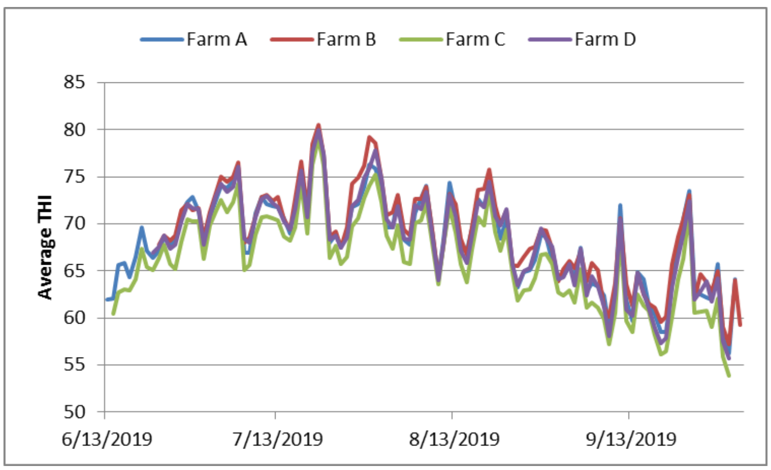

Figure 1. Average temperature humidity index (THI) by farm from June 13 through October 1, 2019: Effectiveness of Heat Stress Abatement Systems on Lactating Dairy Cows in NNY project, NNYADP, 2019. **See Table 1 for each farm's heat abatement system.**

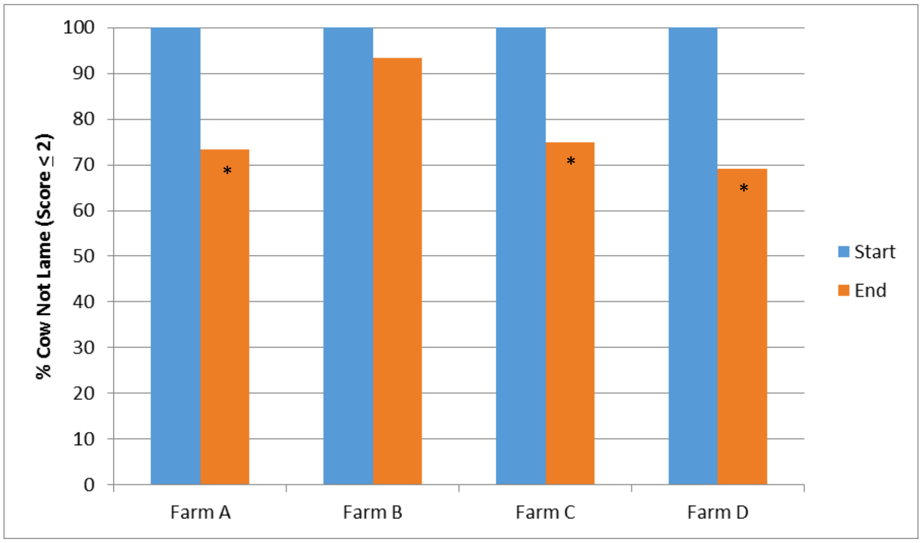

Figure 2. Percentage of focal animals that were not lame at the start and end of the study on the four farms. Significant difference (P<0.05) in percent of cows not lame within farm from the start to the end of the study denoted by asterisk (*). Effectiveness of Heat Stress Abatement Systems on Lactating Dairy Cows in NNY project, NNYADP, 2019.

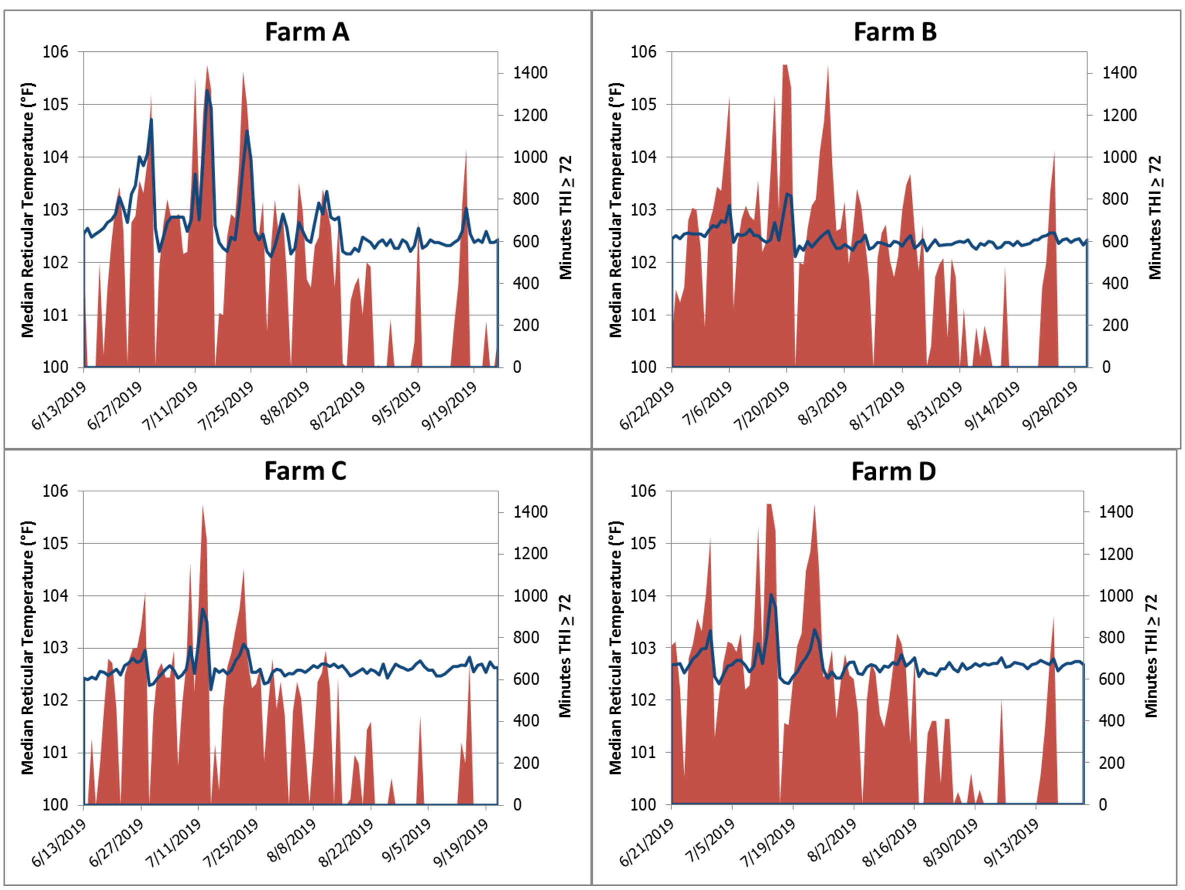

Figure 3. Relationship between median reticular temperature of dairy cattle and heat events (minutes THI ≥ 72) on farms with different heat abatement systems in Northern New York: Effectiveness of Heat Stress Abatement Systems on Lactating Dairy Cows in NNY project, NNYADP, 2019.

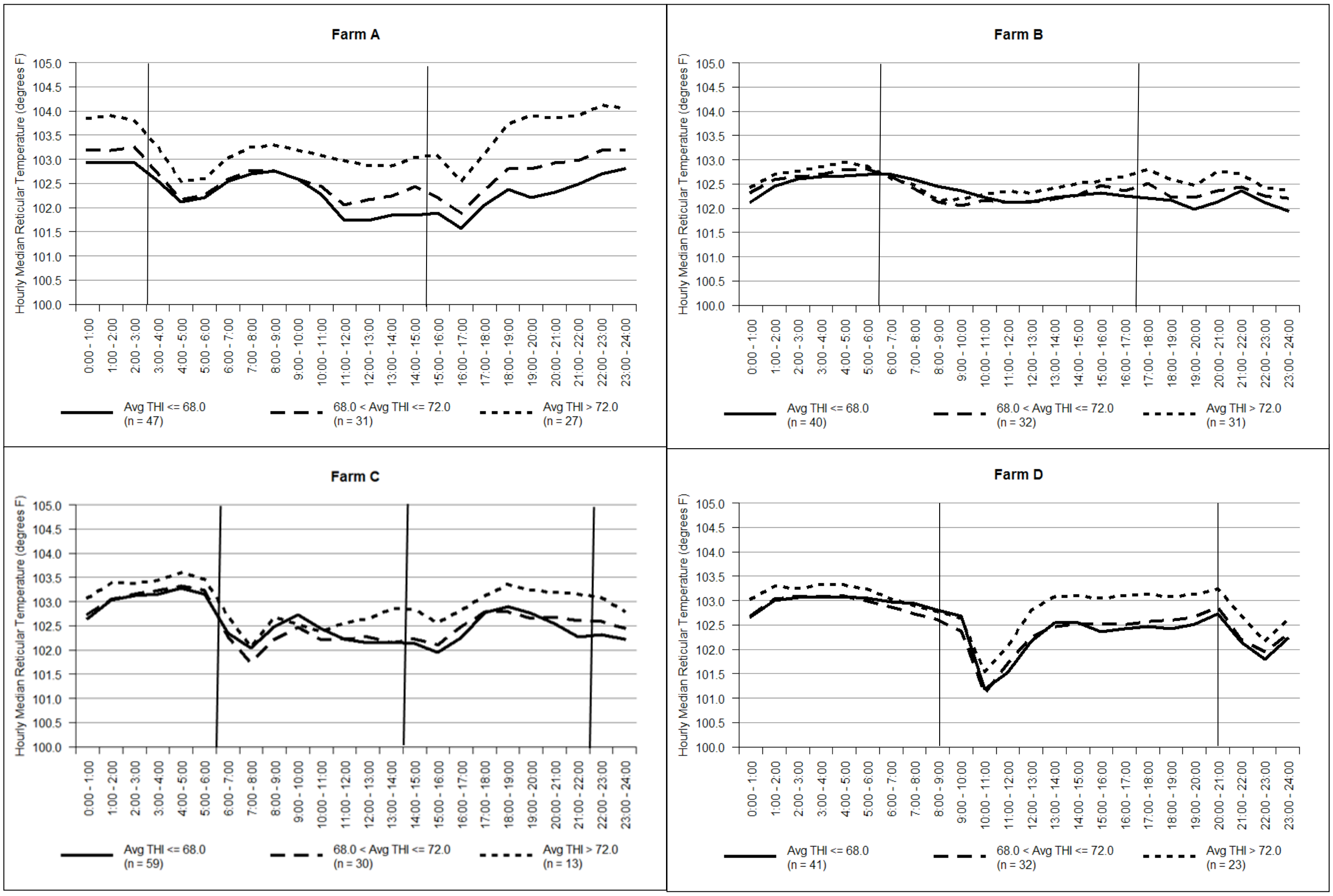

Figure 4. Diurnal pattern of hourly median reticular temperature of focal cows relative to daily mean temperature-humidity index (THI) class. Vertical lines represent milking times: Effectiveness of Heat Stress Abatement Systems on Lactating Dairy Cows in NNY project, NNYADP, 2019.

Table 1. Herd descriptions of four NNY farms with average days in milk and milk production of focal animals at start in YEAR? of research study on each farm: Effectiveness of Heat Stress Abatement Systems on Lactating Dairy Cows in NNY project, NNYADP, 2019.

Herd Description					Focal Animal Description		
Farm	**Herd Size**	**Breed**	**Pen Setup**	**Heat Abatement**	**Days in Milk (±SD)**	**Milk Production (lbs±SD)**	**Average Stocking Density for Stalls**
A	305	Holstein	6-row freestall sand bedded	No mechanical ventilation in pen Fans and sprinklers in holding area	80 ± 28	121 ± 15	117%
B	635	Holstein	6-row freestall sand bedded	Fans over stalls Fans in holding area with hose spraying when hot	58 ± 17	101 ± 17	131%
C	395	Holstein	4-row freestall mattress/shavings	Fans/misters – feedbunk and stalls Fans and soakers in holding area	106 ± 30	124 ± 30	123%
D	395	Holstein	6-row freestall and converted tiestall mattress/shavings	Fans over stalls Fans in holding area and parlor	87 ± 32	111 ± 12	103%

Table 2. The impact of heat events on average lying time (hours/day) and average reticular body temperature (°F) of dairy cattle on 4 NNY farms with varying degrees of heat abatement: Effectiveness of Heat Stress Abatement Systems on Lactating Dairy Cows in NNY project, NNYADP, 2019.

	COOL	HOT	SE	*P*-value
THI (mean ± SD)	64.1 ± 3.2	75.0 ± 2.9		
Minutes THI ≥ 68 (mean ± SD)	278 ± 276	1366 ± 116		
Lying Time (Hours/day)			SE	***P*-value**
Farm A	11.2	8.8	0.33	**<0.01**
Farm B	11.1	9.9	0.30	**<0.01**
Farm C	11.2	9.8	0.35	**<0.01**
Farm D	11.0	8.9	0.30	**<0.01**
Reticular Body Temperature (°F)				
Farm A	101.7	103.3	0.15	**<0.01**
Farm B	101.7	102.1	0.04	**<0.01**
Farm C	101.8	102.5	0.07	**<0.01**
Farm D	101.8	102.6	0.06	**<0.01**

Table 3. Weekly wind speed (mph) in feed alley and stall beds on farms with varying degrees of heat abatement (mean ± SD): Effectiveness of Heat Stress Abatement Systems on Lactating Dairy Cows in NNY project, NNYADP, 2019.

Location	Feed Alley	Stall Beds	
	Standing	Standing	Lying
Farm A	0.9 ± 1.0	0.7 ± 0.9	0.4 ± 0.5
Farm B	2.1 ± 1.3	3.0 ± 3.0	2.2 ± 2.2
Farm C	3.7 ± 1.8	2.6 ± 1.4	2.0 ± 1.1
Farm D	1.6 ± 1.3	2.1 ± 1.5	1.5 ± 1.1