Northern NY Agricultural Development Program
2023 Project Report

The Effectiveness of Fans for Heat Stress Abatement in Lactating Dairy Cows in Northern New York

The value of improving wind speed in dairy freestall housing during summer: a comparison of animal well-being and economic impact before and after fan installation on a dairy in Northern New York

Project Leaders:
Director of Research Katie Ballard, MS; Jasmine Guerrero; Alex Pape, MS; Morgan Terry; Landon Privette; Miner Institute, 1034 Miner Farm Rd., P.O. Box 90, Chazy, NY 12921; 518-846-7121, ballard@whminer.com

Collaborators: NNY dairy farms

Background:

Heat stress is a major concern for dairy cattle producers as it impacts the health and well-being of their animals. A considerable challenge to 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; making dairy cattle now even more susceptible to heat stress. In addition, it is estimated that heat stress accounts for roughly $900 million of annual economic losses for the US 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 well-being 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 may have deleterious effects on animal health.

The short- and longer-term consequences of heat stress on behavior and production are underappreciated, especially in more moderate heat stress typical of northern states (Cook et al., 2007). In NNYADP-supported studies conducted by Miner Institute in 2016-2019, the impact of heat stress was evaluated on commercial dairy farms with varying degrees of heat abatement. The collective results of these studies indicated that increased air movement, creating a "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. Improved air movement on one farm in 2019 resulted in an hour greater lying time and reduced lameness when compared to 2018. One hour of increased lying time can result in 2-3.5 pounds more milk per cow per day. The reduced incidence of lameness may be attributed to moderate body temperature increases and little fluctuation over the course of the day during heat events. Over all the years studied, the farm impacted the most by heat events had minimal heat abatement and no mechanical ventilation in the freestall.

In 2022, fans were installed on the farm with minimal heat abatement which provided a unique opportunity to evaluate the same herd under similar management conditions to assess the impact of the fan installation on animal well-being and farm profitability. Previous data collected on-farm in 2019 served as a baseline of minimal heat abatement for comparison of animal performance and health in 2023 after fans were installed in 2022.

Objectives:

To assess the impact of installaing fans in freestall housing on:

- lameness and resting time of lactating dairy cattle from July through September in Northern New York;
- body temperature of lactating dairy cattle from July through September in Northern New York;
- bulk tank milk volume and composition from July through September in Northern New York; and
- reproductive performance from July through September in Northern New York.

Methods:

This study was approved by the William H. Miner Agricultural Research Institute Animal Care and Use Committee (2023AUR04). Research was conducted on a farm enrolled for the NNYADP-supported studies in 2018 and 2019 with minimal heat abatement (no fans). In 2022, six 51-inch variable speed auto control fans (55°F startup temperature and maximum speed at 70°F) were installed over the center two rows of stalls. Thirty multiparous cows with lameness score ≤ 2 served as focal groups and averaged more than 100 lbs milk/day and were housed at the same stall stocking density of 117% in 2019 and 2023 (Table 1).

Environmental conditions: Temperature and relative humidity were recorded in ten minute intervals from June through the end of September using a Kestrel® DROP D2AG data logger (Nielsen-Kellerman Company, Boothwyn, PA) 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: $(1.8 * Tdb + 32) – [(.55 - .0055 * RH) * (1.8 * Tdb – 26)]$. Windspeed was measured at standing (55 inches) and lying (32 inches) heights in stalls and at standing height in the feed alley once weekly using a Kestrel 5200 Anemometer (Nielsen-Kellerman Company, Boothwyn, PA) mounted on a tripod.

Reticular temperature: SmaXtec boluses (SmaXtec; Graz, Austria) were administered to the 30 focal animals and used to measure body temperature from the reticulum. SmaXtec boluses allowed for real-time collection of data at 10-minute intervals through wirelessly transmitted data from bolus and internet storage of data.

Behavioral assessment: Lying and standing behavior of focal cows (time spent lying and standing, bouts, and duration of bouts during 24 hours (h)) 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 July through the end of September.

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.

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.

Reproductive assessment: The impact of added heat abatement on reproductive performance was assessed by comparing pregnancy rates in 2019, before added fans and during 2023, after fans were added.

Statistical Analysis:
Data were analyzed within year 2019 (no fans) and 2023 (after fan installation). 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 year 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 year using Proc Mixed to evaluate differences in daily lying time (h/day) and reticular temperature (°F) for COOL and HOT days. Significance was declared at $P \leq 0.05$.

Results and Discussion:

Environmental conditions
Overall, the barn environment from June through September during 2023 was cooler than 2019 with average THI of 67.2 vs 68.4, respectively. In 2023, there were only 12 days when the average THI was greater than 72, compared to 2019 when there were 27 days greater than 72. In both 2019 and 2023, there were periods of heat events (THI>68) broken up by a few days when the THI was ≤ 68 (Fig. 1). 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 a farm with no mechanical heat abatement in the housing environment (2019) and after installation of fans (2023).

With the fan installation, windspeeds (mph) over the center rows of stalls at standing and lying positions increased from 0.7 and 0.4 to 5.5 and 3.6 mph, respectively. Windspeeds over feed alleys and stall beds with no fans directly over them (outside wall) had a modest 0.5 mph increase in windspeed from 2019 to 2023, averaging 1.5 mph in 2023. While air velocity throughout the pen was not at recommended levels of 4-6 mph (Bailey et al., 2016), the stall beds with fans over them did achieve the recommended windspeed levels.

Reticular temperature and lying time
As illustrated in Figure 2, prior to fan installation, body temperature of focal cows reflected the magnitude of heat events. After installation of fans, body temperature of the cows still appeared reactive to heat events, indicating that sufficient cooling may not have been achieved during heat events with longer durations.

The diurnal pattern of hourly body temperature of cows during cool weather (average THI<68), moderate heat events (average THI 68-72), and heat events (average THI >72) in 2019 and 2023 are presented in Figure 3. Diurnal patterns of body temperature were similar before and after fan installation. The presence of fans seemed to mitigate body temperature compared to 2019 when COOL (THI <65) vs HOT (THI ≥72) days were compared with 1.1°F average increase in 2023 compared to 1.6°F average increase in 2019 (Table 3).

Lying time and duration of lying bouts was significantly reduced during heat events before and after installation of fans indicating that cows were standing more to dissipate body heat. The impact of the heat events was slightly less (1/2 h) in 2023 compared to the impact in 2019.

Lameness

Prior to fan installation, there was a significant increase in lameness in the focal cows from beginning to end of study (27%, $P < 0.05$). After fan installation, the incidence of lameness was 7% and not a significant change from the beginning of the study ($P = 0.15$; Figure 4).

Lactation performance

The bulk tank average milk production per cow per day shipped from the farm from April through October in 2019 and 2023 is presented in Figure 5.

- From June to July, there was an 8% decrease in milk shipped in 2019, compared to less than 1% decrease in 2023.
- Overall, milk production was sustained through the summer months in 2023 which may be attributable to the installation of fans.
- Bulk tank milk composition of milk fat and milk protein was more reactive to heat events in 2019 than in 2023 (Figure 6). This also carried through to the milk fatty acid profiles of de novo, mixed and performed (Figure 7). Overall, de novo fatty acids were higher and preformed fatty acid levels were lower during the summer of 2023 which supported the overall higher milk fat (%) produced by the herd. While nutritional factors also influence these preferred levels of fatty acid production, it is clear from the figures that the presence of fans mitigated fluctuations in fatty acid profile of milk during heat events.

Reproductive performance

Pregnancy rates for the herd before (2019) and after (2023) installation of fans are shown in Figure 8.

- Prior to installation of fans, pregnancy rates decreased dramatically during July and August, which may be attributed to the combined impact of heat stress on estrus and conception rates.
- After fan installation, pregnancy rates did not decline and surprisingly increased during the summer months.

Admittedly, after 2019, the farm implemented a new heat detection system in 2022; however, this wouldn't fully explain the sustained reproductive performance through the summer months. The installation of fans appears to have contributed to better reproductive performance during the summer months.

Conclusions/Outcomes/Impacts:

From previous NNYADP-supported research, it is clear that dairy cows in Northern New York are adversely impacted by episodic bouts of heat stress regardless of type of heat abatement system employed. This study provided a unique opportunity to evaluate the impact of installation of fans on animal well-being and performance. While the physiological impact of the fans on cows was marginally evident with body temperatures and lying time being slightly less impacted by heat events, the animal performance measures of incidence of lameness, milk production/composition, and reproductive performance clearly indicate the economic value of the installation of fans for the farm.

The impact of fan installation on the marginal physiological responses may be attributed to the fans being installed over only 2/3 of available stalls and the angle at which they were installed (Figure 9). Perhaps additional value of the current fan installation may be captured if air movement is increased with changing the angle of the fans. The farm with Fans Only during the study conducted in 2019 exceeded recommended values of 4-6 mph and achieved values up to 12 mph with fans installed with a higher angle (Figure 10). On that farm in 2019, heat events had minimal impact on body temperature throughout the day and lying time. A follow-up study with increased fan angle increasing windspeed and potential "wind chill" effect on cows may be helpful. The recommended windspeeds may need to be increased to mitigate the physiological impact of heat stress on cows in Northern New York.

Education and Outreach:

Preliminary data from this study was shared at the 2023 Dairy Day at Miner Institute and will be presented at the national meeting of the American Dairy Science Association in 2024.

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For More Info:

- Katie Ballard, MS; Miner Institute, 518-846-7121, ballard@whminer.com

Northern New York Agricultural Development Program
2023 Project Report APPENDIX

The Effectiveness of Fans for Heat Stress Abatement in Lactating Dairy Cows in Northern New York

The value of improving wind speed in dairy freestall housing during summer: a comparison of animal well-being and economic impact before and after fan installation on a dairy in Northern New York

Table 1. Herd/facility description in 2019 and 2023 with average days in milk and milk production of focal animals at start of study each year: Effectiveness of Fans for Heat Stress Abatement on Lactating Dairy Cows in NNY project, NNYADP, 2023.

Herd Description					Focal Animal Description		
Year	**Herd Size**	**Breed**	**Pen Setup**	**Heat Abatement**	**Days in Milk (±SD)**	**Milk Production (lbs±SD)**	**Average Stocking Density for Stalls**
2019	305	Holstein	6-row freestall sand-bedded	No mechanical ventilation in pen Fans and sprinklers in holding area	80 ± 28	121 ± 15	117%
2023	325	Holstein	6-row freestall sand-bedded	Fans over center stalls Fans and sprinklers in holding area	84 ± 40	105 ± 9	117%

Table 2. Weekly wind speed (mph) in feed alley and stall beds in 2019 and 2023 (mean ± SD): Effectiveness of Fans for Heat Stress Abatement on Lactating Dairy Cows in NNY project, NNYADP, 2023.

Location	Feed Alley	Center Stall Beds		Outside Stall Beds	
	Standing	Standing	Lying	Standing	Lying
2019 - No Fans	0.9 ± 1.0	0.7 ± 0.9	0.4 ± 0.5	0.7 ± 0.9	0.4 ± 0.5
2023 - Fans	1.3 ± 1.4	5.5 ± 1.8	3.6 ± 1.6	1.4 ± 1.3	1.7 ± 1.2

Table 3. The impact of heat events on reticular body temperature (°F) and lying behavior of dairy cattle on a farm before and after installation of fans: Effectiveness of Fans for Heat Stress Abatement on Lactating Dairy Cows in NNY project, NNYADP, 2023.

	COOL	HOT	SE	*P*-value
THI	**< 65**	**≥ 72**		
Reticular Body Temperature (°F)				
No Fans (2019)	101.7	103.3	0.15	**<0.01**
With Fans (2023)	102.4	103.5	0.07	**<0.01**
Lying Time (Hours/day)				
No Fans (2019)	11.2	8.9	0.33	**<0.01**
With Fans (2023)	12.2	10.4	0.28	**<0.01**
Lying Bouts (#/day)				
No Fans (2019)	8.7	9.3	0.64	**0.02**
With Fans (2023)	9.1	10.7	0.35	**<0.01**
Lying Bout Duration (min/day)				
No Fans (2019)	86.4	65.5	4.8	**<0.01**
With Fans (2023)	81.3	63.3	4.2	**<0.01**

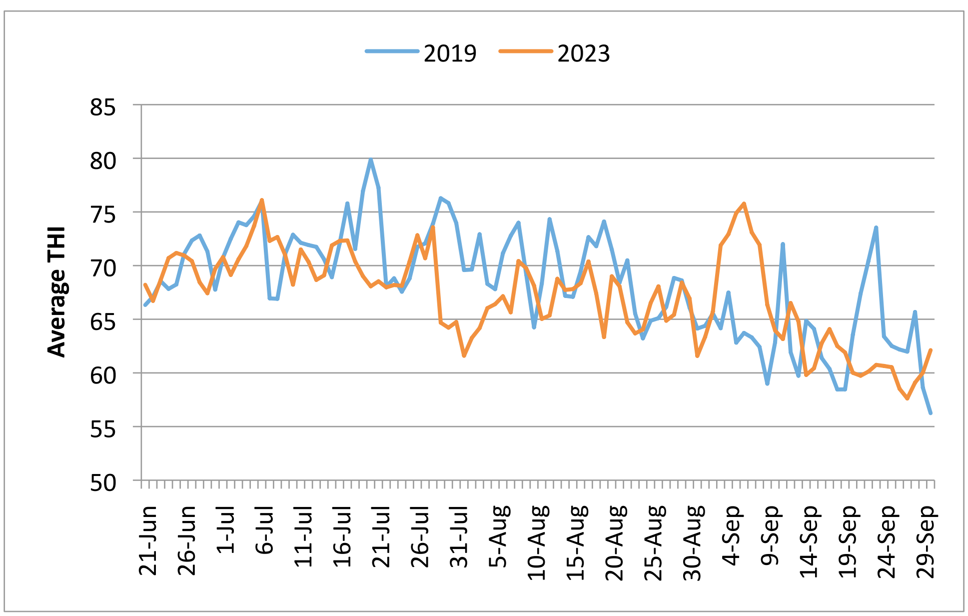


Figure 1. Average temperature humidity index (THI) by year from June 21 through September 30: Effectiveness of Fans for Heat Stress Abatement on Lactating Dairy Cows in NNY project, NNYADP, 2023.

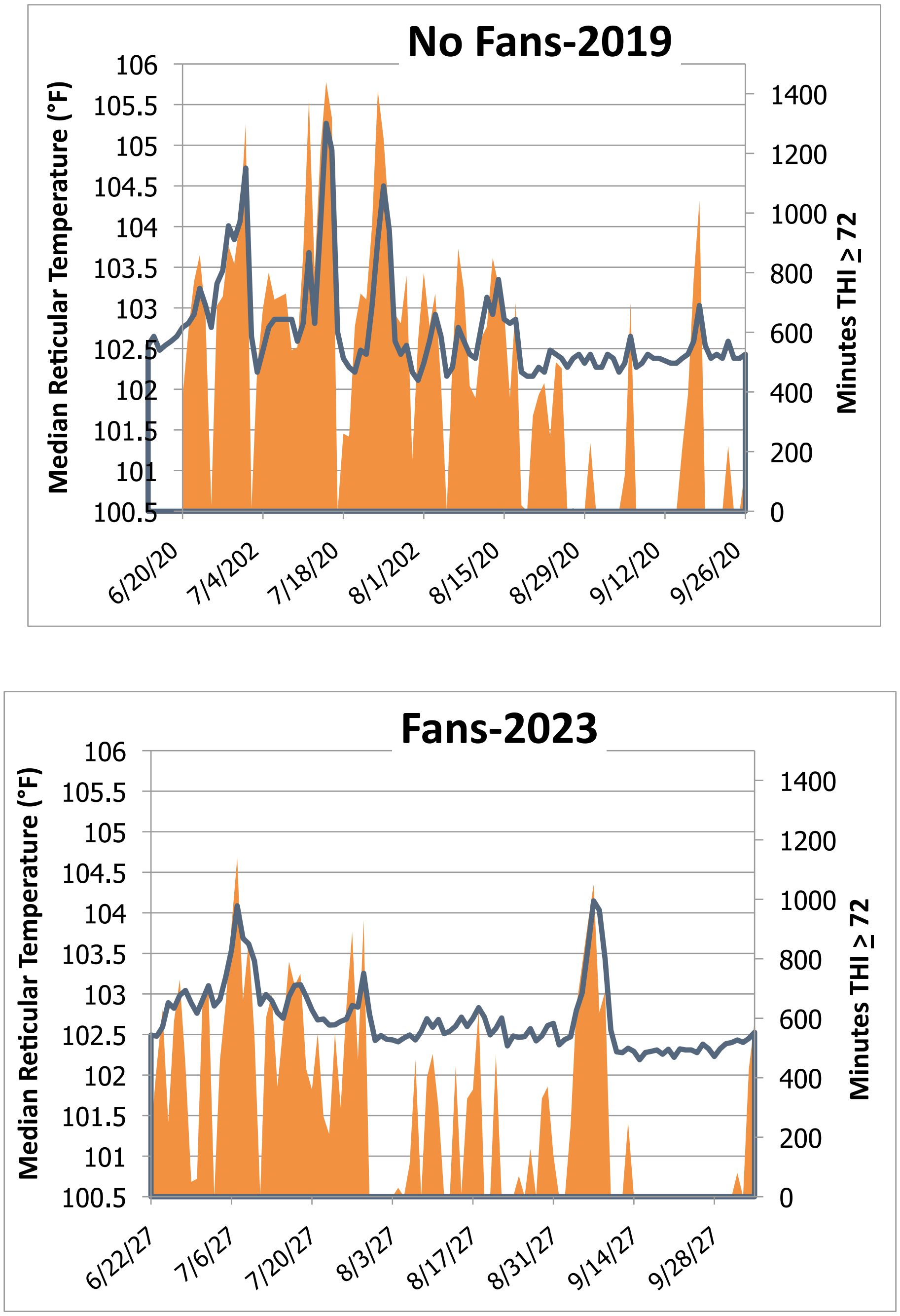


Figure 2. Relationship between median reticular temperature of dairy cattle and heat events (minutes THI >72) before (2019) and after (2023) fan installation: Effectiveness of Heat Stress Abatement Systems on Lactating Dairy Cows in NNY project, NNYADP, 2023.

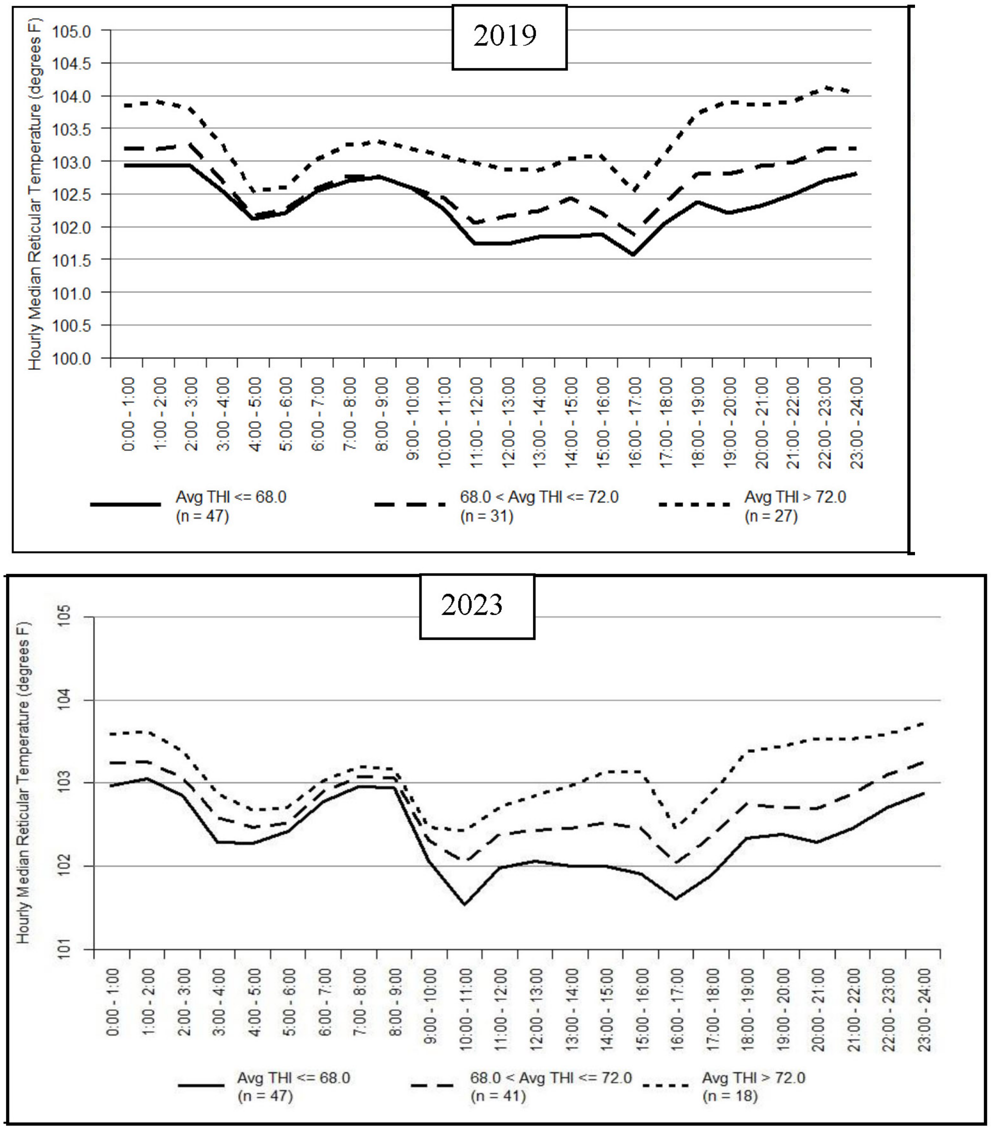


Figure 3. Diurnal pattern of hourly median reticular temperature of focal cows relative to daily mean temperature-humidity index (THI) class before (2019) and after fan installation (2023). Effectiveness of Fans for Heat Stress Abatement on Lactating Dairy Cows in NNY project, NNYADP, 2023.

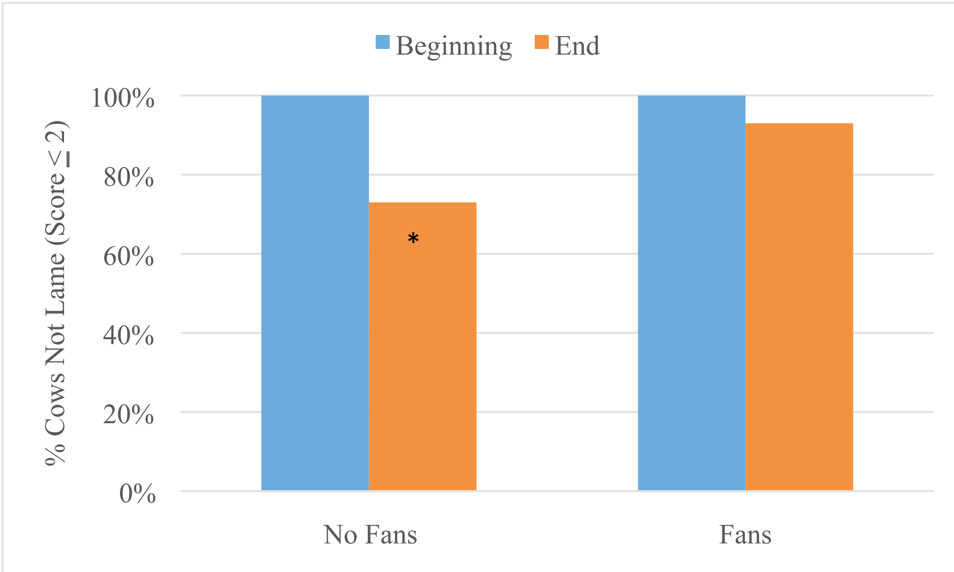


Figure 4. Percentage of focal animals that were not lame at the start and end of the studies before and after fan installation (No Fans and Fans, respectively). (Significant difference (P<0.05) in percent of cows not lame within study year from the start to the end of the study denoted by asterisk (*): Effectiveness of Fans for Heat Stress Abatement on Lactating Dairy Cows in NNY project, NNYADP, 2023.

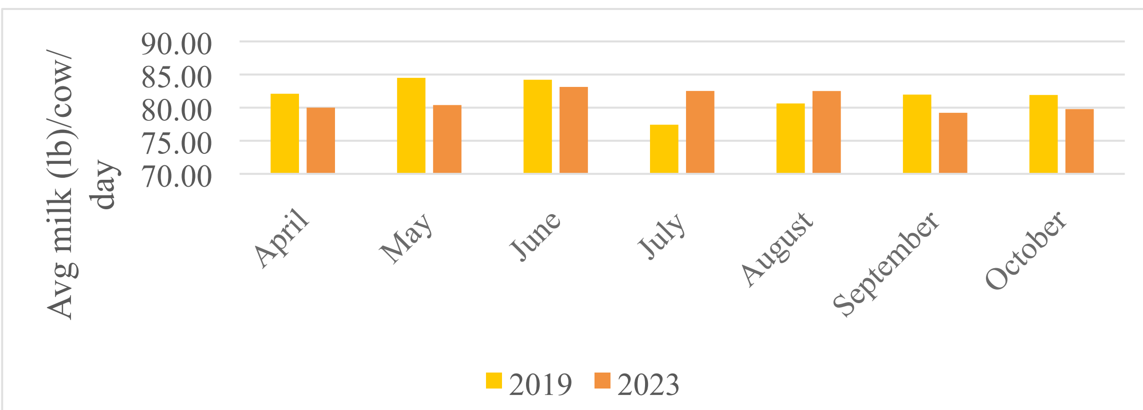
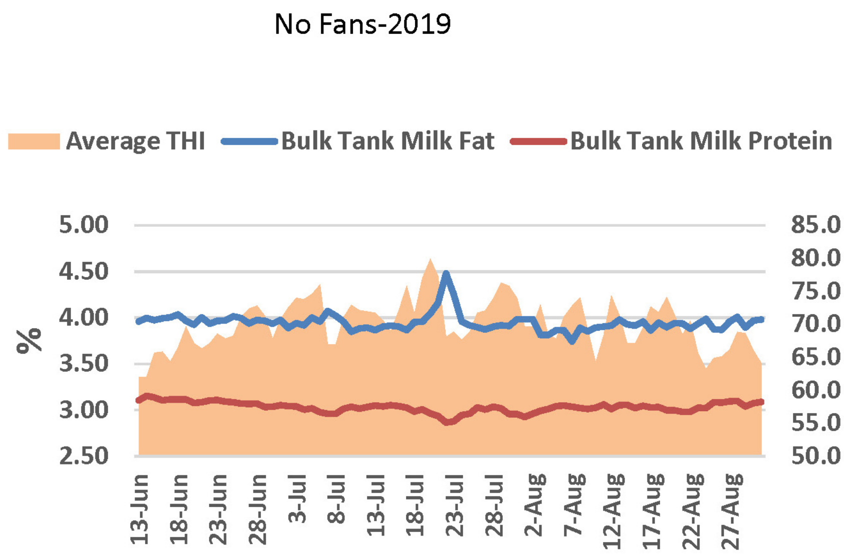


Figure 5. Average milk production per cow per day shipped from the farm before (2019) and after (2023) installation of fans. Effectiveness of Fans for Heat Stress Abatement on Lactating Dairy Cows in NNY project, NNYADP, 2023.



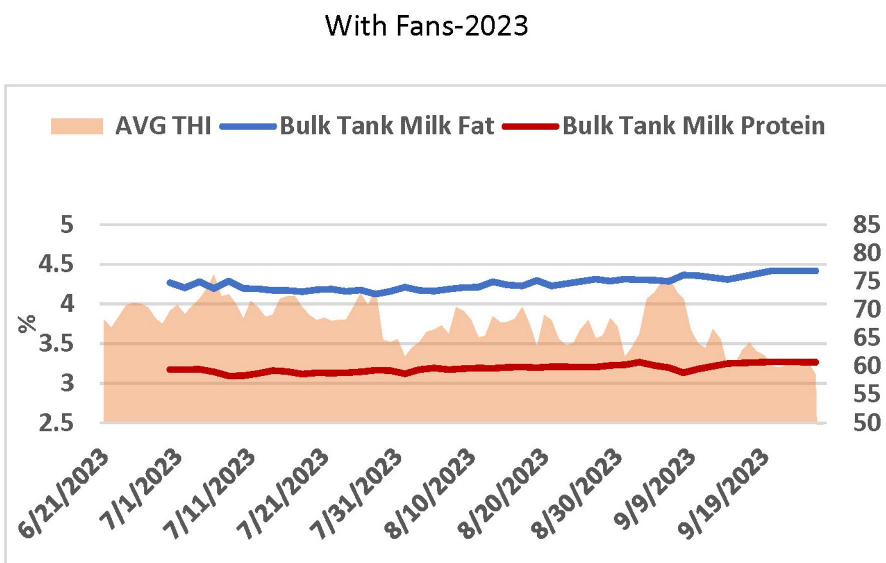


Figure 6. Visual relationship between bulk tank milk fat and protein (%) and Average THI before (2019) and after (2023) installation of fans. Effectiveness of Fans for Heat Stress Abatement on Lactating Dairy Cows in NNY project, NNYADP, 2023.

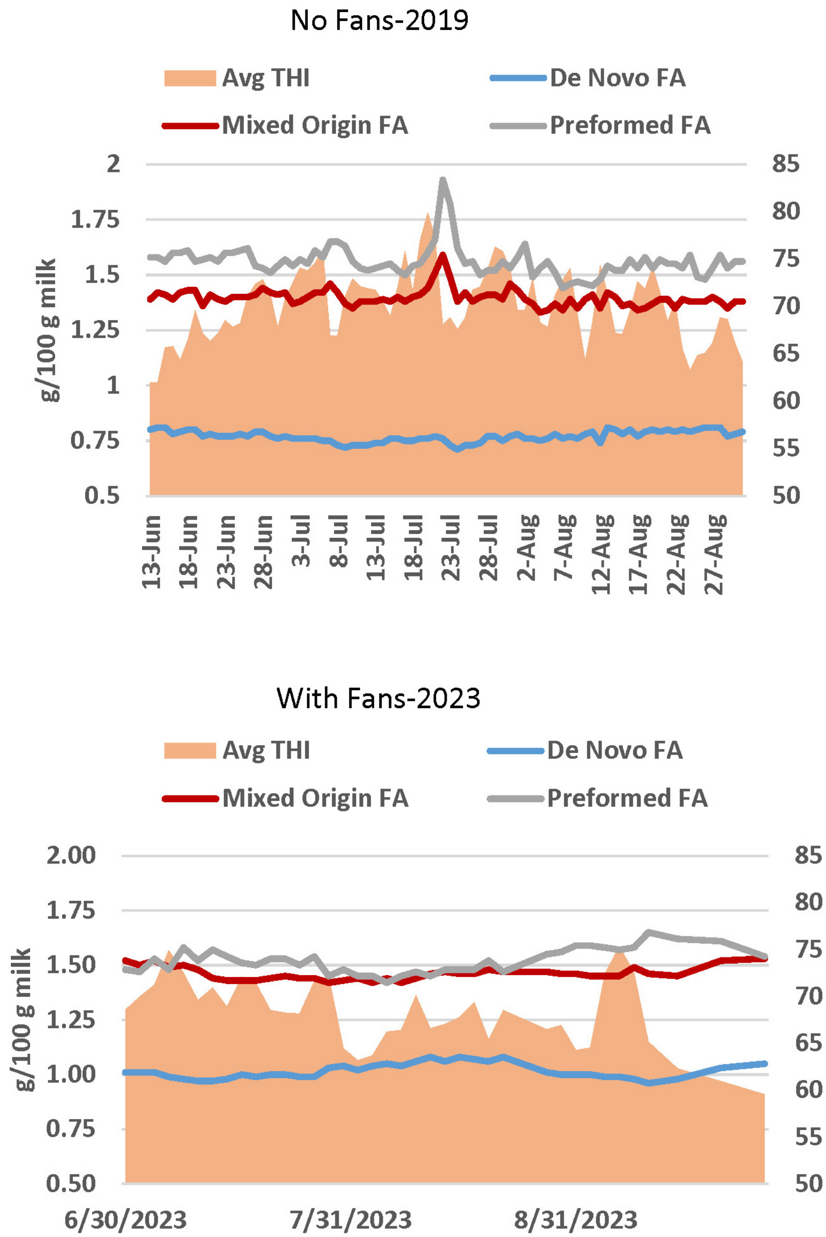


Figure 7. Visual relationship between bulk tank de novo, mixed origin and preformed fatty acids (g/100 g milk) and average THI before (2019) and after (2023) installation of fans. Effectiveness of Fans for Heat Stress Abatement on Lactating Dairy Cows in NNY project, NNYADP, 2023.

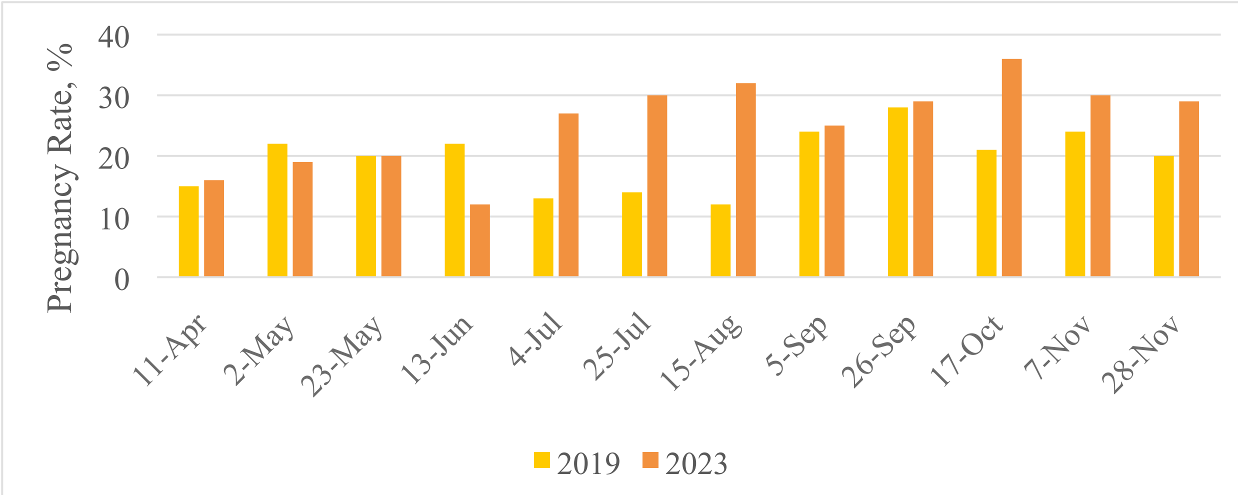


Figure 8. Pregnancy rates for herd before (2019) and after (2023) installation of fans. Effectiveness of Fans for Heat Stress Abatement on Lactating Dairy Cows in NNY project, NNYADP, 2023.

Figure 9. Fan showing current installed angle. Effectiveness of Fans for Heat Stress Abatement on Lactating Dairy Cows in NNY project, NNYADP, 2023.

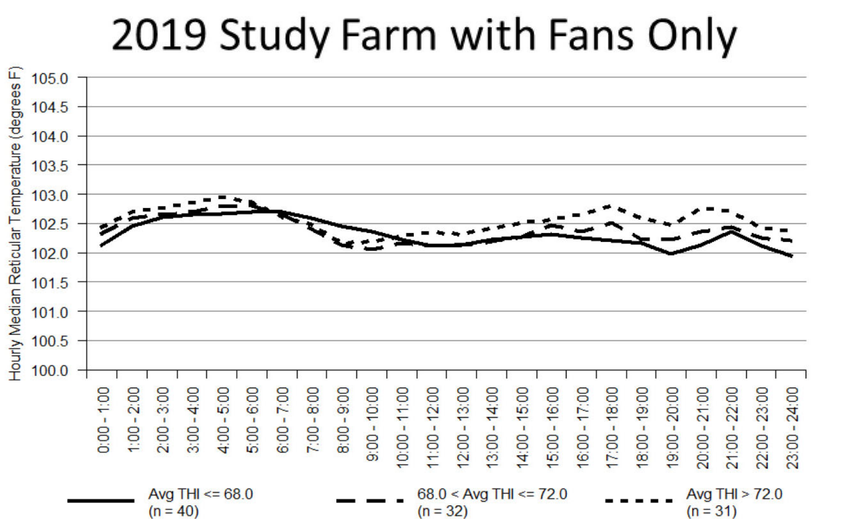


Figure 10. Diurnal pattern of hourly median reticular temperature of focal cows relative to daily mean temperature-humidity index (THI, above graph) class and picture of fan angle on 2019 study farm with fans only. Effectiveness of Fans for Heat Stress Abatement on Lactating Dairy Cows in NNY project, NNYADP, 2023.