Northern New York Agricultural Development Program
2018 Project Report (Preliminary)

The Effectiveness of Heat Stress Abatement Systems on Performance, Behavior and Lameness of Lactating Dairy Cows in Northern New York – Year 2

Project Leaders:
William H. Miner Agricultural Research Institute, 1034 Miner Farm Rd., P.O. Box 90, Chazy, NY 12921

- Ashley Cate, Agricultural Research Intern
- Dominique D'Huyvetter. Summer Research Intern
- Emily Fread, Summer Research Intern
- Katie Ballard, MS, Director of Research, 518-846-7121 ext. 112, ballard@whminer.com
- Rick Grant, PhD, President

Collaborators:

- Four NNY dairy farms

Background:
Dairy cattle respond to heat stress in several ways including greater standing time, reduced eating activity, greater water consumption, less rumination, lower dry matter intake, and reduced milk production and reproductive performance (*West, 2003; Tapki and Sahin, 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. Anecdotally, dairy farmers in this region often state that bouts of heat stress that occur early in the summer (June), or late in the summer (September), have the most dramatic negative effects.

The economic consequences of heat stress on dairy herds has been documented and discussed by several researchers (*DeVries, 2012*). DeVries (2012) presented data showing that the economic loss for heat-stressed cows with minimal abatement ranged from greater than $600/cow/yr for Florida and Texas to $72/cow per year for Wisconsin. The annual hours of heat stress for Florida and Texas, as assessed by a Temperature Humidity Index (THI) >70, were 49% and 36%, respectively, whereas Wisconsin was only 9%. There are dramatic differences by region of the

US in severity of heat stress, but St-Pierre (2001) still estimated a greater than 2:1 return on investment for heat stress abatement in New York.

The short- and longer-term consequences of heat stress on behavior and production are under-appreciated, especially in more moderate heat stress typical of northern states (*Cook et al., 2007*). In a study conducted at Miner Institute in 2016, THI ranged from 48 to 75 between early May and September. All cows, regardless of heat abatement system used, spent more time standing when THI was >72. Cows provided fans only over stalls tended to stand more in the stalls as THI increased. Milk production and milk fat percentage was less affected by heat stress when maximal heat abatement (fans and sprinklers over stalls and feed alley) was provided.

During the summer of 2017, the Northern New York Agricultural Development Program (NNYADP) supported a study conducted on four farms with different housing systems with varying degrees of heat abatement. This study clearly demonstrated that dairy cows in Northern New York are adversely impacted by episodic bouts of heat stress with all farms being impacted to varying degrees regardless of type of heat abatement system employed. Standing time increased the most (2.5 hours/day) for the farm with no heat abatement on days when THI was ≥ 68 for the majority of the day (21.3 ± 2.6 hours/day). For farms using box fans in the housing area, standing time increased by 1.2 – 1.7 hours/day.

Lameness increased significantly from beginning to end of summer on farm with no heat abatement in the housing area. Additionally, the farm with no heat stress abatement system in the housing area demonstrated that 32% of the variability in bulk tank milk protein could be explained by THI while other farms with varying degrees of heat abatement showed little to no relationship (<10%) between milk protein and THI. Unexpectedly, there was no relationship between bulk tank milk fat production and THI for any of the farms participating on the study. Perhaps, the mild weather during the summer of 2017 contributed to this finding.

On many farms, dairy cattle exhibit bunching behavior during the summer months which can increase heat stress experienced by cattle, decrease lying and eating time, and increase the risk of injury as cattle fight for center position within the bunch. Mitigating this behavior during the summer months would improve cow comfort, animal productivity, and ultimately farm profits (*Cook, 2014*). Air flow, light intensity, and fly pressure have all been identified as potential causes of bunching, however, no definitive recommendations have been provided to mitigate this behavior.

Since the summer of 2017 did not have normal weather patterns, NNYADP supported a continuation of this research to evaluate the impact of heat stress on animal behavior, performance, and lameness on commercial dairy farms in Northern New York using different heat abatement systems.

Objectives:

- To assess the impact of episodic heat stress within farm management systems with different degrees of heat abatement on lameness, and behavioral and productive responses of dairy cattle from July through October in Northern New York State.

- To evaluate the degree of change in milk fatty acid profile on farms using different heat abatement systems in Northern New York State.
- To assess factors that influence bunching behavior of dairy cattle.

Methods:

This study was approved by the Miner Institute Animal Care and Use Committee. Research was conducted on four farms in Clinton County with varying degrees of heat abatement systems. 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 for each farm (Appendix: Table 1).

Farms. The four farms in the NNY Effectiveness of Heat Stress Abatement Systems project had the following designs and heat abatement systems:

Farm	Barn	Ventilation System	Milking Freq	Feeding Freq
A	6-row freestall/sand bedded	Natural	2x	1x
B	6-row freestall/sand bedded	Fans - stalls	2x	1x
C	4-row freestall/mattress-shavings	Fans/sprinklers – feedbunk Fans - stalls	3x	1x
D	6-row freestall and converted tiestall/mattress-shavings	Fans - stalls	2x	1x

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 the beginning of July through the end of September 2018. 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: $(1.8 * Tdb + 32) – [(.55 - .0055 * RH) * (1.8 * Tdb – 26)]$.

Lameness

All cows were scored at the beginning and end of the study for locomotion on a flat and level surface. Cows housed in a free stall pen 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 of focal cows (time spent lying and standing, bouts, and distribution of bouts during 24 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 1 through the end of September 2018.

Bunching Behavior

This part of the study was conducted at the William H. Miner Agricultural Research Institute in Chazy, NY from July 5-30, 2018. Three pens of lactating Holstein dairy cattle at the Miner

Institute were used where bunching behavior had been observed in the past: Pens 1, 2 and 31. Pens 1 and 31 are oriented on the west side of the barn and pen 2 is located on the east side. Cows were milked three times daily, beginning at 04:30, 13:30 and 20:30 and were fed between 05:00 and 06:30 daily. Bunching behavior was determined by assessing stocking density at each end of the pen using Moultrie Panoramic 150 digital game cameras.

A pen was determined to exhibit bunching behavior if more than 2/3 of the cows (66.7%) were in one half of the pen. A pen was considered to have a "Bunching Day" if they had a least two consecutive hours of bunching behavior. Light intensity was measured every 10 minutes using Onset HOBO Pendant light/temperature loggers attached to stall dividers throughout each pen and secured with Velcro wrap. Fly pressure was assessed by mounting white notecards in each pen and counting the number of fly specks on each card weekly (*Axtell, 1970 and Lysky, 1985*).

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.

Statistical Analysis
All data were analyzed within farm; no across farm comparisons were made. 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. Significance was declared at $P < 0.05$. Linear relationships between THI and bulk tank milk composition were evaluated using regression coefficients. The influence of light intensity on bunching behavior was evaluated by comparing the difference between light intensity at the north and south end of each pen during bunching and non-bunching events using the Proc Mixed procedure of SAS.

Results and Discussion:
Overall, the summer of 2018 was warmer than 2017 in Northern New York, with average THI two units higher and 6 more days when average THI was greater than 68 from July 1 through September 30 (Appendix: Figure 1). Periods of heat stress when the average THI was greater than 68 were broken up by a few days when the THI was less than or equal to 68.

All farms showed similar patterns of heat stress. 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 four different dairy farms with varying management and heat abatement systems (Appendix: Table 1).

Episodic Heat Stress and Lameness
All farms exhibited a significant increase in lameness from the beginning of the study in July to early October when the focal cows last lameness score was assessed (Figure 2). In 2017, only two farms realized an increase in lameness over the course of the summer with one of those farms having little to no heat abatement. The warmer temperatures with fewer periods of relief may have been a contributing factor on all farms in 2018 regardless of heat abatement employed.

When cows exceed a lameness score of 2, both dry matter intake and milk yield decreases, negatively impacting farm profitability (*Juarez and Robinson, 2002*).

Episodic Heat Stress and Bulk Tank Milk Fat and Protein
Little to no relationship was observed on all farms between bulk tank milk fat and maximum daily THI (Figure 3). However, over 40% of the variability in milk protein could be attributed to the maximum daily THI on Farms A and D, with milk protein decreasing as THI increased (Figure 4). Farms B and C also showed a moderate relationship between milk protein and THI (R^2=0.23 and 0.21, respectively). The fact that milk protein is depressed with no change in milk fat could be a reflection of lower dry matter intake (DMI) and, therefore, reduced microbial protein production and less metabolizable protein (MP) supply for milk protein synthesis (*Robinson, 1998*).

Bunching Behavior
As expected, bunching behavior occurred in all pens with pen 1, 2 and 31 having 9, 3 and 1 bunching day(s), respectively.

In pens 1 and 2, cows bunched toward the south end of the pens as illustrated in Figure 5 (Appendix) which shows that, at times, over 80% of the cows in the pen were bunched toward the south ends of the pen. On the day that cows bunched in pen 31, they bunched in the south end in the morning and in the north end in the late afternoon.

Because of the north/south orientation of the barn, it is speculated that light intensity during the morning in pen 2 and in the afternoon for pen 1 and 31, may bring about the bunching behavior. Figure 6 (Appendix) illustrates that light intensity in both the north and south ends of pen 2 and 31 were highest on days when cows were bunching. While the difference in pen 1 does npt appear to be as defined, it should be noted that the light intensity in pen 1 was extremely high in both the north and south end of the pen during the late afternoon, as the sun was setting. In pen 31, we observed that cows bunched in the north end of the pen in the early afternoon when light intensity was highest in the south end, then bunched in the south end of the pen when light intensity was greatest in the north end during the early evening.

There was little fly pressure observed in any of the pens during this observation period and, therefore, was unlikely a contributing factor to the bunching behavior observed.

Conclusions/Outcomes/Impacts:

- Since all farms, regardless of heat abatement systems, experienced increase in herd lameness over the course of the summer, additional research is needed to determine contributing factors and whether additional heat abatement will decrease incidence of lameness during the summer months.
- Cows on farms with minimal heat abatement are more susceptible to heat stress with decreased milk protein content, which results in a negative impact on farm profitability.
- Efforts should be made to improve heat abatement systems on Northern New York dairy herds with inclusion of fans over stalls/feedbunk and sprinkler systems to decrease the negative impact of heat stress on milk composition.

- When dairy cows exhibit bunching behavior, they tend to bunch where light intensity is lowest in their pen. **Since this is the first research reporting this relationship**, additional studies should be conducted before recommendations to reduce light intensity in pens is made. It is clear that dairy cows in Northern New York are adversely impacted by episodic bouts of heat stress with all farms being impacted to varying degrees regardless of type of heat abatement system employed. While farms may provide similar heat abatement such as fans over freestalls, it is apparent that not all fan systems within different barn designs provide the same relief from heat stress. Impact of heat stress on individual farms should be assessed and actions taken to minimize its influence on animal well-being.

Outreach:

Outcomes of this study will be shared with farmers in the 6 NNY counties 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 will also be made available on the Miner Institute website. This report will be posted on the NNYADP website at www.nnyagdev.org.

Next Steps:

Summarization of resting/lying data will be completed when a modification to the Excel macro and data screening is completed. This important information will be presented in future presentations and publications of this study. The inclusion of this data will provide additional insight on the impact of episodic heat stress on dairy cattle in Northern New York. A third year of this study will be conducted in 2019 evaluating similar and additional parameters focused on animal health (body temperature) and rumen health.

Acknowledgments:

We would like to thank the four farms that collaborated "anonymously" for consecutive years as we evaluate the impact of heat stress on our dairy farms in northern New York. We would also like to thank the Northern New York Agricultural Development Program for continued funding for this research.

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For More Information:

- Katie Ballard, Miner Institute, Director of Research, 518-846-7121 ext. 112, ballard@whminer.com

APPENDIX

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Table 1. Herd descriptions of four farms with average days in milk and milk production of focal animals at start of study on each farm: Effectiveness of Heat Stress Abatement Systems on Lactating Dairy Cows in NNY project, NNYADP, 2018.

	Herd Description			Focal Animal Description	
	Herd Size	**Breed**	**Pen Setup**	**Days in Milk (±SD)**	**Milk Production (lbs±SD)**
Farm A	300	Holstein	Free Stall	69 ± 29	112 ± 15
Farm B	700	Holstein	Free Stall	87 ± 18	123 ± 24
Farm C	410	Holstein	Free Stall	64 ± 20	130 ± 19
Farm D	475	Holstein	Free Stall	53 ± 24	111 ± 11

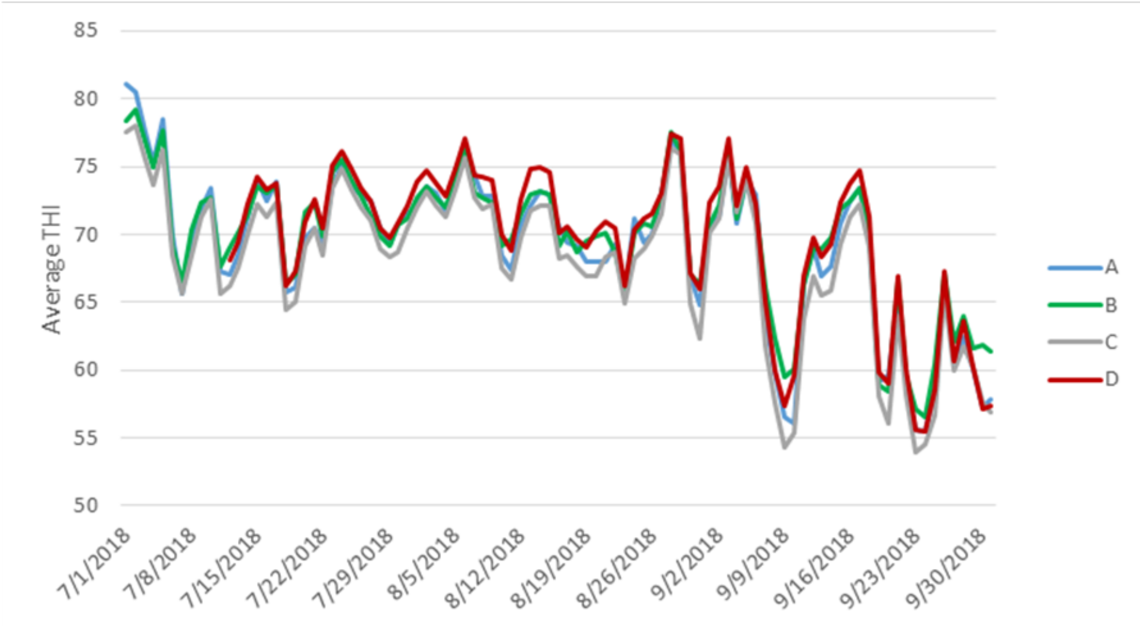

Figure 1. Average temperature humidity index (THI) by farm from July 1 through October 1, 2018: Effectiveness of Heat Stress Abatement Systems on Lactating Dairy Cows in NNY project, NNYADP, 2018.

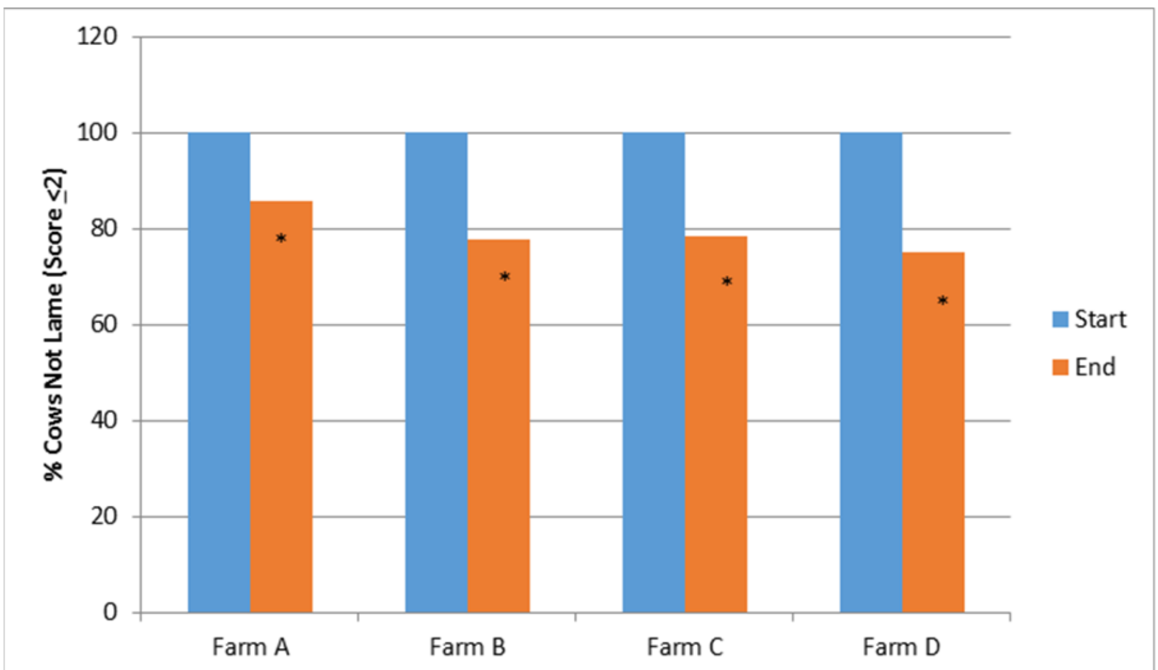

Figure 2. Percentage of focal animals that were not lame at the start and end of the study on the four farms. (Significant difference (P<0.05) in percent of cows not lame within farm from the start to the end of the study denoted by asterisk (*): Effectiveness of Heat Stress Abatement Systems on Lactating Dairy Cows in NNY project, NNYADP, 2018.

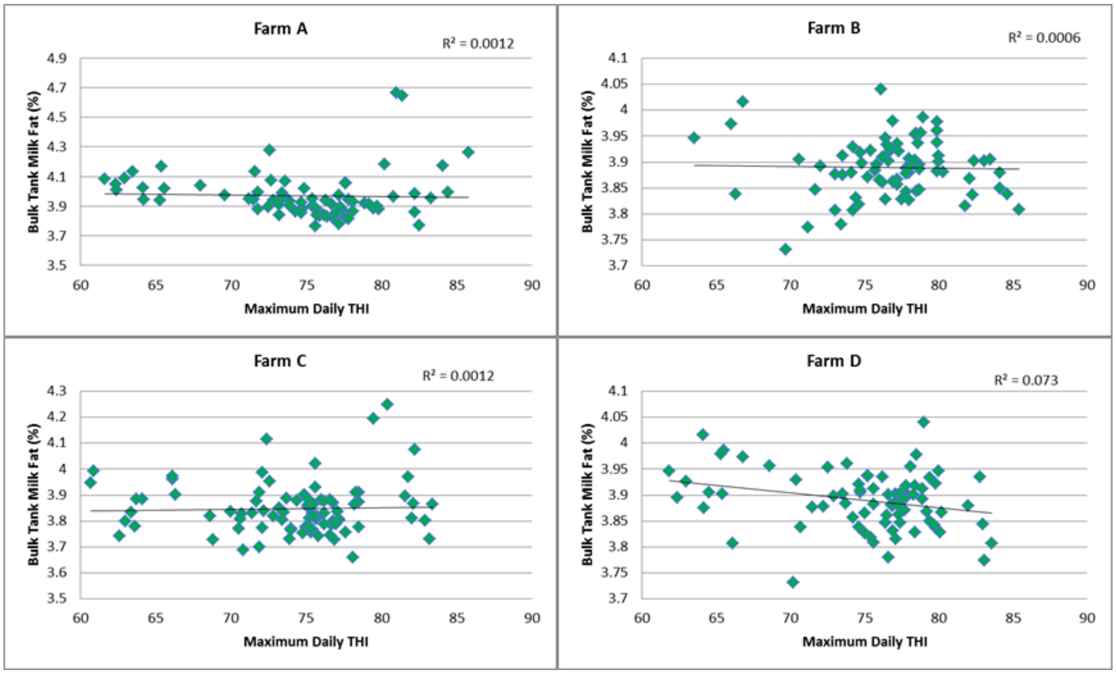

Figure 3. Relationship between maximum daily THI and bulk tank milk fat (%) from July 1 – September 30, 2018: Effectiveness of Heat Stress Abatement Systems on Lactating Dairy Cows in NNY project, NNYADP, 2018.

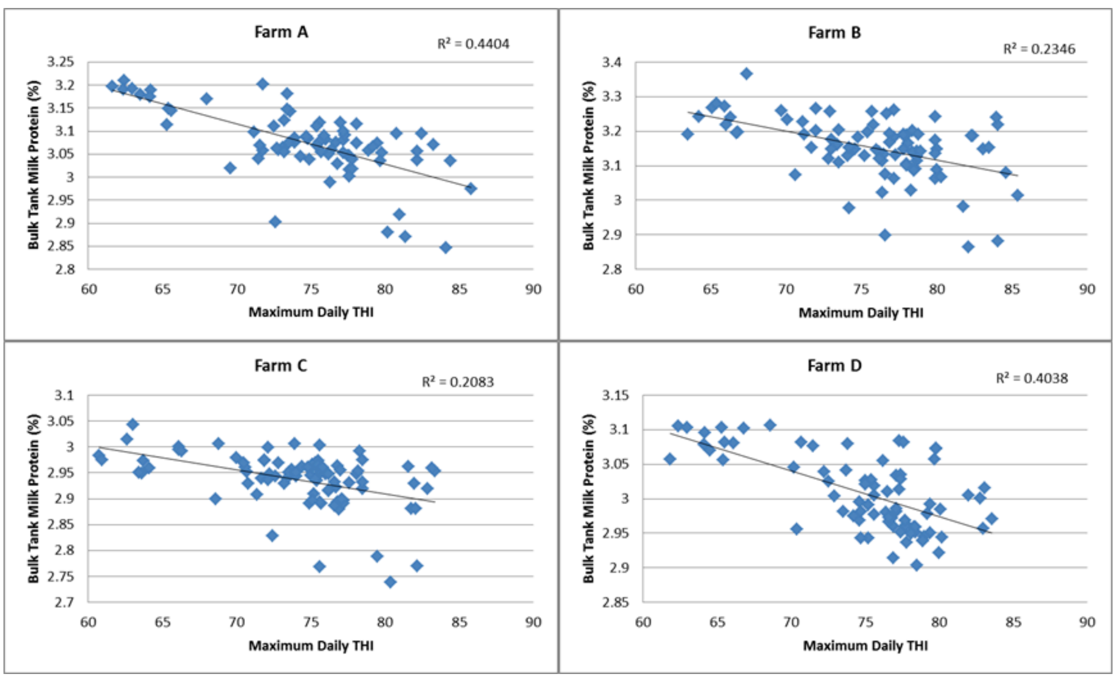

Figure 4. Relationship between maximum daily THI and bulk tank milk protein (%) from July 1 – September 30, 2018: Effectiveness of Heat Stress Abatement Systems on Lactating Dairy Cows in NNY project, NNYADP, 2018.

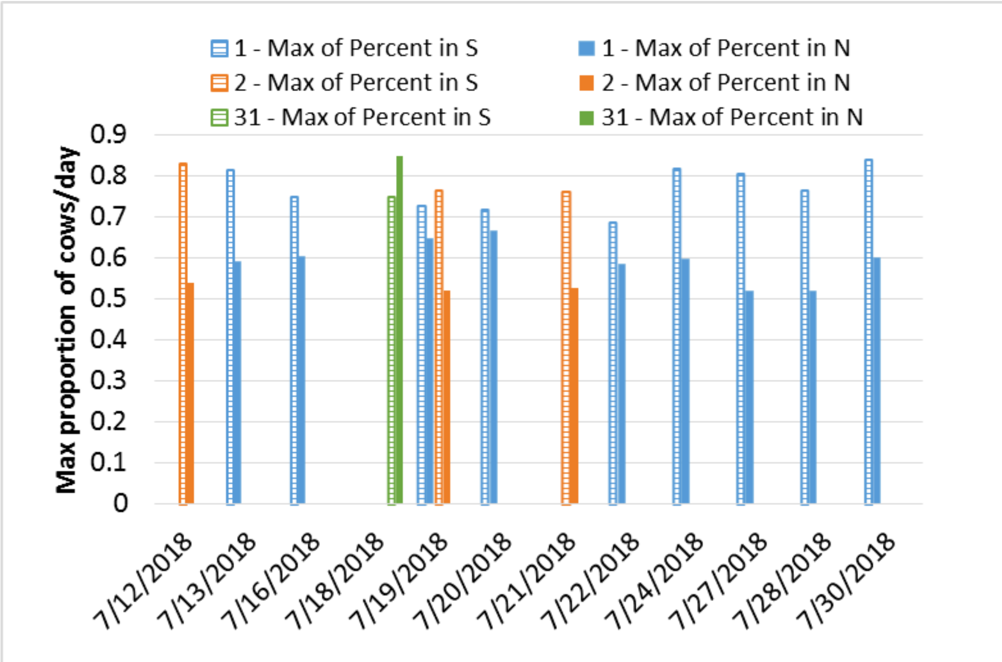

Figure 5. The maximum proportion of cows in north (N) and south (S) end of pen on bunching days: Effectiveness of Heat Stress Abatement Systems on Lactating Dairy Cows in NNY project, NNYADP, 2018.

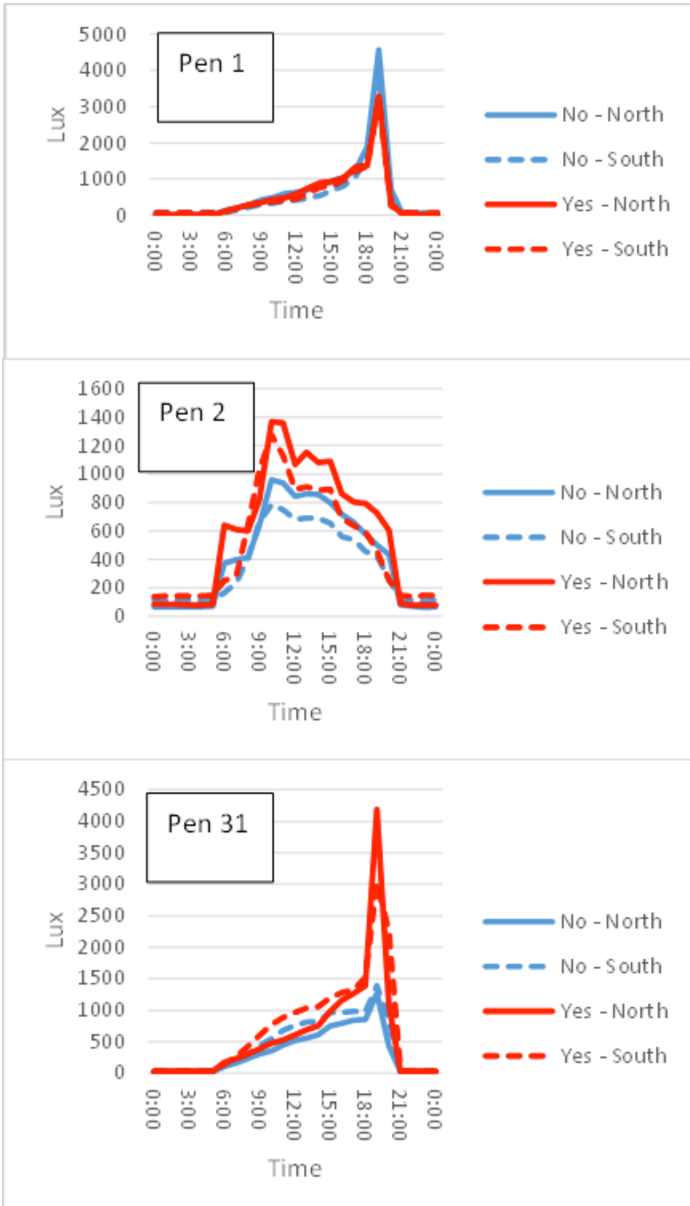

Figure 6. Average light intensity in north and south ends of pen for days when cows did (Yes) and did not (No) bunch: Effectiveness of Heat Stress Abatement Systems on Lactating Dairy Cows in NNY project, NNYADP, 2018.