# Northern NY Agricultural Development Program
## 2016 Project Report

## Feeding Strategies & Behavior of Heat-Stressed Calves in NNY

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**Background:**

With losses due to heat stress of approximately $253,000 annually for heifers 0 to 1 year of age in New York alone, ways to implement heat abatement and/or alleviate the adverse impact of heat stress is of economic importance to dairy producers in the Northern New York (NNY) region (St-Pierre et al., 2003).

Calves are homeotherms and maintain a constant physiological core temperature independent of ambient temperature (Bligh, 1998) by generating metabolic heat and exchanging heat with their environment (Da Silva, 2012). Thermic stress results when calves are unable to maintain a constant core temperature by thermoregulatory mechanisms under extreme environmental conditions, causing negative impacts on body weight gain and performance (Virtala et al., 1996; Donovan et al., 1998; Snowder et al., 2006) along with negatively impacting animal welfare (Silanikove, 2000).

The suggested thermoneutral zone for calves varies based on physiological and environmental factors such as age, size, breed, nutrition, hair coat, behavior, bedding, and weather (Webster, 1974; Holmes et al., 1978; Schrama et al., 1993), making it difficult to set a standard range of temperatures at which calves do not need to expend additional energy to heat or cool themselves. Penn State Extension (2012) and Cullens (2013) suggest a thermoneutral zone of 50-78˚F (10-26˚C) for newborn Holstein calves. Outside this temperature range, the calves must use additional energy above their normal maintenance requirements to thermoregulate, therefore decreasing the amount of energy available for growth.

The temperature-humidity index (THI) measures the combined effects of ambient temperature and relative humidity to determine heat load intensity. Although minimal research has been done to determine the optimal THI range for calves, lactating cows have an upper critical THI of 68, above which the risk of negative production impacts increase, such as decreased feed intake, decreased milk production, increased respiratory rate, and increased disease incidence (Zimbelman et al., 2009).

While the southern United States is usually the region that comes to mind when thinking about heat stress, other areas of the United States experience times of heat stress as well. For instance, Northern NY had an average maximum THI for the last five years (2011-2015) greater than 68 for the months of May through September with July having an average maximum THI between 79 and 83 (Weather Underground, 2015), which Huhnke et al. (2001) classified as a dangerous situation.

While Northern NY (NNY) may not stay above a THI of 68 for long periods of time, the large swing in temperatures in NNY can potentially cause more of a detriment because animals do not have time to adapt (Hansen, 2009) as acclimatization to heat events can take days or weeks to achieve (Nienaber et al., 1999). During the acclimatization period, calves are under increased stress and have higher cortisol levels.

Christison and Johnson (1972) found sharp increases in plasma cortisol levels 20 minutes after the onset of thermal stress, which continued to increase until they reached a plateau 2 to 4 hours after the onset of thermal stress. Under continuous heat stress, cortisol levels returned to normal 1 to 2 days later and decreased over several weeks.

We observed in a previous Northern New York Agricultural Development Program-funded study that calves decreased intake of milk replacer and starter during times of heat stress, thus we identified the need to investigate strategies to minimize intake suppression during heat stress in calves in the NNY region.

Minimal research has been conducted regarding nutrition of heat-stressed calves. During heat stress, calves must use more energy to regulate their body temperature, leaving less energy available for growth, and in cases where the calf is disease challenged, less energy to generate an immune response (Quigley, 2001).

Research has indicated that as calves become heat-stressed, intakes decline therefore reducing average daily gain (ADG) (Hill et al., 2012). Hill et al. (2012) found that during the winter months calves will make up for the additional energy requirement to thermoregulate by consuming more starter, but in the summer months calves won't consume more starter, even though their maintenance energy requirements have increased due to heat stress. Producers need to find new ways to increase caloric intake in calves during heat stress to minimize declines in ADG.

Supplementing fat is one way to increase the energy density of the diet and also produces less metabolic heat per unit of energy fed compared to carbohydrates (Baldwin et al., 1980). Feeding supplemental fat to mature cows has shown benefits during heat stress. When lactating cows were fed supplemental fat during heat stress body temperature was decreased by 1ºF (0.56°C) and solids corrected milk was increased by 8.10 pounds/d (3.67 kg/d) (Wang et al., 2010).

Little research has been done to determine the implications of supplementing fat to calves in the summer but research has been conducted in the winter and has shown that supplementing fat when calves require more energy due to temperatures outside their thermoneutral zone increases ADG (Jaster et al., 1992; Litherland et al., 2014).

The main objective of this study was to evaluate feeding strategies during the NNY summer months to optimize caloric intake, improve ADG, and promote animal health in dairy calves in NNY. A secondary objective was to evaluate the impact of THI on intake, core body temperature, and behavior in order to help establish critical THI limits of calves.

## Methods:

Research was conducted at the William H. Miner Agricultural Research Institute in Chazy, NY, from June 7, 2016 to Oct. 7, 2016 and was approved by Miner Institute's Animal Care and Use Committee prior to the beginning of the study. Sixty calves (27 heifers and 33 bulls) were enrolled with 58 calves included in the final dataset because 2 bull calves died between 1 to 2 weeks of age. Calves were only enrolled in the study if they had adequate passive transfer of ≥ 5.2 g/dL serum total protein concentration (Tyler et al., 1996) and weighed between 78 and 114 pounds (35 and 52 kg). Calves were fed colostrum or colostrum replacer at birth and remained in the calf nursery until they were moved to individual hutches at 2 days of age.

Twenty blocks of 3 calves (n=60) were assigned to one of three dietary treatments (20 calves/treatment). Treatments were fed twice daily at 6:30 am and 6:30 pm using a pail feeder from 2 to 57 days of age.

1) Milk replacer with no added fat (**CON**)
2) Milk replacer with added fat only when temperatures exceeded the upper critical temperature for calves of 78 ˚F (26˚C) (Penn State Extension, 2012; Cullens, 2013) anytime during the previous 24 hours before the 6:30 pm feeding, which determined if fat was added to both that night's feeding at 6:30 pm and the following morning at 6:30 am (**FTEMP**).
3) Milk replacer with added fat for all study days (**FALL**)

### Feeding

Milk replacer (Poulin Grain, Newport, VT) was 26% CP (crude protein) and 18% fat on an as-fed basis fed at 13% solids. The fat source used for FTEMP and FALL was Milk Energizer (7% CP and 60% fat on an as-fed basis; Milk Specialties Global, Eden Prairie, MN), a high-energy, instant-mixing dry fat source.

Milk Energizer was added to the milk replacer at 1.2% of total reconstituted milk replacer at the time of mixing to keep final volume the same, which increased the solids content to 14.2%. When Milk Energizer was added to the milk replacer the calculated as-fed protein:fat ratio became 24:21.
The primary fat source for both the milk replacer and Milk Energizer was animal fat preserved with butylated hydroxyanisole and butylated hydroxytoluene.

Milk replacer was fed at the following volumes based on age:

- 2 to 8 days fed 4 quarts twice daily,
- 9 to 43 days fed 5 quarts twice daily,
- 44 to 50 days fed 3 quarts twice daily,

- 51 to 54 days fed 2 quarts twice daily, and
- 55 to 57 days fed 2 quarts once daily at 6:30 am.

While calves were receiving full amounts of milk from 2 to 43 days of age, the period was referred to as preweaning. All calves had *ad libitum* access to water and pelleted calf starter (22% CP on an as-fed basis, medicated, Poulin Grain, Newport, VT), which was replaced daily.

**Housing**
Calves were housed in individual hutches with sawdust and tethered to the hutch with a collar and lead. Two types of hutches were used due to limitations in hutch numbers on the farm (Polysquare Calf Nursery, Polydome, Litchfield, MN; and SSL Calf Hutch, Agri-Plastics Mfg., Grassie ON, Canada), but calves were blocked based on hutch type to account for any variation hutch type may have on the results.

**Sampling and Data Collection**
- Milk replacer, starter, and water intakes were measured daily. Samples of milk replacer, starter, and Milk Energizer were collected weekly, composited every 4 weeks and analyzed for nutrient content and dry matter.
- Calves were evaluated on a weekly basis for body weight, hip height, and hip width.
- A jugular artery blood sample using a BD Vacutainer Serum Separation Tube (Becton, Dickinson and Company, Franklin Lakes, NJ) was collected weekly and analyzed for serum glucose and nonesterified fatty acids (Cornell University Animal Health Diagnostic Center, Ithaca, NY).
- Calves were evaluated daily at 3:00 pm for rectal temperature and respiration rate.
- Dehydration was assessed by evaluating skin tenting ($<$ 2 mm = normal; $\geq$ 2 mm = dehydrated) and sunken eyes ($<$ 2 mm = normal; $\geq$ 2 mm = dehydrated).
- Additionally, health status was assessed following the calf health-scoring chart developed by the University of Wisconsin (McGuirk, 2008), and based on the scores, the following normal and abnormal designations were made (Pena et al., 2016): nasal score (0, 1 = normal; 2, 3 = nasal discharge), cough score (0, 1 = normal; 2, 3 = abnormal, pneumonia), and fecal score (0, 1 = normal; 2, 3 = diarrhea).
- Calf lying behavior was determined with loggers (HOBO Pendant G; Onset Computer Corp., Bourne, MA) attached to the metatarsus bone on the hind leg. Loggers were attached at 1 day of age and changed weekly thereafter. Loggers were attached using Co-Flex cohesive flexible bandage and reattached to the opposite hind leg each week.

**Environmental Conditions**
Temperature and relative humidity inside of the hutches was recorded continuously using THI loggers (HOBO Pro v2; Onset Computer Corp., Bourne, MA) with one placed inside of each type of calf hutch. Temperature and relative humidity outside of the hutches was measured using Cornell University's Network for Environment and Weather Applications (Ithaca, NY). The equation used to calculate THI was: $THI = (1.8 \times T_{db} + 32) - [(0.55 - 0.0055 \times RH)(1.8 \times T_{db} - 26)]$, where $\mathbf{T_{db}}$ is the dry bulb temperature in ºC and **RH** is the percent relative humidity (NRC, 1971). The THI measurements were

recorded inside and outside of the hutches and were averaged or recorded hourly over the course of the study. The outside hutch temperature was used to determine when fat was added to the FTEMP treatment.

**Health Status**
Calf health was monitored daily and health events and treatments were recorded. Treatments were given to calves based on normal farm protocol. Unfortunately, 3 calves between 1 and 2 weeks old passed due to health issues during the first month of this study. A necropsy was performed by a veterinarian on each calf at the time of death andit was determined that none of the deaths could be specifically linked to dietary treatments. Farm management decided to give a First Defense (Immucell Corporation, Portland, ME) bolus to all calves at birth and biosecurity was also heightened to prevent the spread of disease. No serious health issues were reported after the first two months of the study.

**Statistical Analysis**
Intake, growth and feed efficiency data were averaged by week and analyzed using the GLIMMIX procedure of SAS. Health data were analyzed using logistic regression. The effect of feeding treatments were assessed using preplanned contrasts, comparing Control (CON) vs Fat Supplementation (FTEMP + FALL) and FTEMP vs FALL. Statistical significance was set at values of $P < 0.05$.

## Results:

Fifty-eight calves completed the study. Fat was supplemented in the FTEMP treatment 73 out of 122 days. Figure 1 illustrates the average temperature and THI by month over the course of the study. Since calves were enrolled on the study as they were born, the largest number of calves (58) on the study at a given time was during July and August, which were the months with the highest average temperature (70 ºF) and THI (68).

Initial body weights and serum total protein (a measure of passive transfer) did not differ among treatments (Table 1).

Analyzed chemical composition of milk replacer, starter grain and supplemented fat product are presented in Table 2. Intake and performance of calves fed the three feeding treatments are presented by preweaning period (weeks 0-6) and overall (weeks 0-8) in Table 3 and Figures 2 and 3.

Average daily gain was greater for the calves supplemented with fat during the preweaning period ($P < 0.01$), however, changes in hip height and hip width during the same period did not differ among treatments. This indicates that gains in body weight did not result in increased stature of the calves and most likely resulted in fat deposition. Unfortunately, we are unable to confirm this assumption since calves were not body condition scored during this study.

Dry matter intake was highest for calves fed the fat supplement since the solids content of the milk replacer was increased with the addition of the fat ($P < 0.01$). Starter grain and water intake did not differ among treatments ($P > 0.05$). **The overall feed efficiency (gain/feed from 0-8 weeks of age) was greatest for the CON calves (milk replacer**

**with no added fat), indicating that fat supplementation in milk replacer during the summer months decreases feed efficiency.**

Measures of calf health including body temperature, respiration rate and frequency of health events are presented in Table 4. No treatment differences for body temperature were observed. However, fat supplemented calves, particularly those receiving it daily (FALL), had higher respiration rates ($P \leq 0.05$).

Feeding treatment did not have an effect on health events or number of days calves were treated for illness.

Blood glucose and non-esterified fatty acids (NEFA) levels were impacted by feeding treatment (Figs. 4 and 5). Most notably, calves fed fat supplement had significantly higher NEFA throughout the preweaning period. Elevated NEFA were unexpected since it usually indicates mobilization of fat and it is apparent that calves were gaining weight and were depositing body fat similar to calves fed the CON diet. Other researchers have reported similar findings when feeding high fat milk replacers (Bascom et al., 2007).

The relationships between THI and calf body temperature and respiration rate are presented in Figures 6 and 7 for calves at 1, 4 and 8 weeks of life. Interestingly, body temperature did not appear to be strongly influenced by THI. It is evident that some calves had high body temperatures, most likely influenced by illness and not THI, over the course of the study.

Respiration rate tended to increase as THI increased particularly with the youngest calves (Weeks 1 and 4). Calves at 8 weeks of age did not appear to be as affected by THI. The amount of time calves spent lying down tended to decrease slightly and the number of times the calves got up and down (lying bouts) increased as THI increased (Figures 8 and 9). This is similar to behavior reported in dairy cows with animals preferring to stand when it is hot to allow more of their surface area to disperse heat to the air.

The average THI over the course of the day did not affect the dry matter intake of calves at 1 and 4 weeks of age (Figure 10). Since most of the dry matter they consumed was from milk replacer, it is understandable that their intakes did not change when THI increased. Older calves (8 weeks) tended to decrease intake as THI increased, most likely because of reduced starter intake. At this age, starter intake is important to minimize the slump in ADG during the weaning process.

Water intake increased for older calves (8 weeks) when THI increased (Figure 11). **Providing sufficient ad lib water to calves is important during the weaning process as calves increase their intake of starter grain, but may be particularly important during the summer months.**

## Conclusions/Outcomes/Impacts:

The results of this study indicate that calves did not benefit from being fed supplemental fat during the summer months. It is common for many producers in Northern New York to feed a 23% CP/22% fat milk replacer during the winter months and many continue to feed it during the summer. **Based on the results of this study, producers should**

**consider feeding a lower fat milk replacer to maximize feed efficiency and lean growth in their calves during the summer months.**

Average daily gains during the first 6 weeks of age were greater for calves receiving fat supplementation compared to the group not receiving fat-supplemented milk replacer at the same age, however, there was no difference between treatments when calf height or stature was compared. This indicates that weight gained by fat supplemented calves was not because they grew taller, they just got heavier which is not desirable.

In addition, the impact of heat stress on calves at all stages of development should be considered. Northern NY farmers should evaluate their calf management program to determine the impact summer heat stress may have on animal performance and well-being.

## Outreach:

A press release sent out by the Northern New York Agricultural Development Program during the summer when the project was being conducted made the project very visible to the farming community in Northern New York. The results of this study will be shared through the Miner Institute Farm Report and made available on Miner Institute's website. An abstract will also be submitted and presented at the national meeting of the American Dairy Science Association in Pittsburgh, PA in June 2017.

**Next Steps:** Current calf feeding practices in Northern New York have been shifting toward feeding high fat milk replacers year-round, not only during the winter months. This study clearly shows that high levels of fat in milk replacer may be detrimental to lean calf growth and feed efficiency during the summer months. While heat stress can negatively impact calves, future research may focus on heat abatement for dairy calves such as shade cloth, hutch covers, etc.

## Acknowledgments:

Thank you to the farm and research staff at Miner Institute for their hard work and dedication throughout this study. Also, thank you to the farmers of the Northern New York Agricultural Development Program for financial grant support of this study, Milk Specialties for their generous donation of Milk Energizer, and to Dr. Chris Rossiter for her guidance in choosing a milk replacer for this study.

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