Northern NY Agricultural Development Program
2019 Project Report

The Effect of Increasing Total Amount of Nutrients Supplied through Milk or Milk Replacer on Calf Growth and Health in Multiple Housing Systems during Winter Months in NNY

Project Leaders:
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Project Collaborators:
2 NNY dairy farms

Background:
Young dairy calves have limited body fat reserves and only modest insulation from their hair coat (Alexander et al., 1975). As a result, the thermoneutral zone (temperature range where extra energy is not needed to maintain body temperature) of a calf under 3 weeks of age is between 59°F and 77°F. Below the lower end of the thermoneutral zone, additional energy is needed to maintain body temperature, and the calf will experience cold stress (Rowan, 1992; NRC, 2001). Therefore, to maintain body temperature, the calf must either consume more energy or use what limited body reserves it has to meet this requirement (NRC, 1981). This prioritization of nutrients will always go first to maintenance (thermal regulation, immune, and stress responses) and then any additional nutrients available will go toward the growth of the calf.

The requirement for maintenance (thermal regulation, immune, and stress responses) in a calf is quite substantial and increases as temperatures drop below the thermoneutral zone of the calf. As an example, Table 1 estimates the amount (in quarts) of whole milk or milk replacer (20% protein; 20% fat) required to meet the maintenance requirement of an 88-pound calf under different environmental temperatures.

As an example, for calves being fed whole milk, if the environmental temperature reaches 23°F or below, the majority of a 4-quart allotment is mostly going toward maintenance, leaving little to no nutrients for growth. Due to differences in nutrient content, calves fed a conventional milk replacer rather than whole milk, will need to consume more to meet their maintenance requirements. Below 41°F much of 4 quart allotment of a 20:20 milk replacer would be used for maintenance. As the temperature drops below 14°F, almost 5 quarts or more are required for maintenance alone.

Table 1. Estimated amount (quarts) of whole milk or milk replacer required for 88-pound calf maintenance under varying environmental temperatures

	Temperature, °F						
Nutrient source	**59**	**50**	**41**	**32**	**23**	**14**	**5**
Whole milk	2.23 qts.	2.74 qts.	3.04 qts.	3.33 qts.	3.62 qts.	3.91 qts.	4.17 qts.
Milk replacer (20% CP; 20% Fat)	2.78 qts.	3.42 qts.	3.78 qts.	4.14 qts.	4.50 qts.	4.87 qts.	5.19 qts.

Meeting the maintenance requirement becomes more challenging when temperatures fall below 59°F, which it often does in the Northern New York. Although there are different ranges of feeding levels and milk replacer formulations across farms, there are several methods to increase consumption of nutrients to meet maintenance requirements and allow for growth (Drackley, 2008).

Methods to increase milk or milk replacer intake in cold weather include:

1. Increase the volume of milk or milk replacer fed per day. This can be achieved by increasing the amount offered during normal feedings or by incorporating an extra feeding.
2. Increase milk solids by increasing the concentration of milk replacer powder.
3. Switch to a more energy-dense milk replacer that is formulated with higher fat concentrations (Jaster et al., 1992).

Other factors that influence maintenance requirements include bedding and housing type, which have been shown to influence requirements of young calves experiencing cold stress (Hill et al., 2007). Understanding the interactions of nutrient intake under different housing managements is important to have successful growth and health of dairy calves in Northern New York herds under Northern New York climatic conditions.

Objective:

To assess the impact of increasing the amount of nutrients fed during winter months by increasing the amount of milk or milk replacer fed in different housing systems on growth and health of dairy calves in Northern New York State.

Methods:

This study was approved by the Miner Institute Animal Care and Use Committee. Research was conducted on two farms with different calf housing and feeding strategies in Northern New York between January and April of 2019. Farm A housed calves in a non-heated barn in group pens equipped with natural ventilation and supplemented with positive pressure tube ventilation. Calves were bedded with a pack of sawdust topped with straw for the duration of the study. Farm B housed calves in hutches outside bedded with sawdust and straw. Calf jackets were used on both farms and use of calf jackets was noted at each farm visit.

Calves born on each farm were assigned to one of two feeding levels specific to each farm with feeding rates chosen by the farms. The lower feeding rate was the current feeding program used by the farm and the higher feeding rate was an increase chosen by farm that was feasible within the bounds of each farm's feeding program and management.

Farm A fed a commercial milk replacer (23% Protein, 22% Fat; Opti-Milk Artic BOV, Poulin Grain Inc., Newport, VT) at a maximum feeding level of either 11.6 or 13.7 quarts per day reconstituted to 15% solids (Figure 1).

Farm B fed calves either 4.8 or 8.9 quarts of whole saleable milk, supplemented with a commercial milk balancer (25% Protein, 10% fat; Alphaline® MilkBuilder, Poulin Grain Inc.) included at a rate of 0.06 pounds per quart (Figure 1).

Actual intake of milk or milk replacer on each farm was not measured. Water was offered for ad libitum intake but actual intake was not measured during the study. Both farms fed a commercial starter (Alphaline Start Calf Starter, Poulin Grain Inc.) however, intake was not recorded on either farm so nutrient intake provided from the starter cannot be determined or estimated in how it might contribute to energy and protein requirements of the calves. Based on previous research, it can be expected that there would be differences in starter intake based on milk or milk replacer feeding level (Drackley, 2008) and overall would contribute to meeting the requirements of the calf and supporting growth.

Measurements:
Environmental Conditions and Housing**:** Environmental temperature was recorded continuously using a temperature logger (Onset HOBO Pendant light/temperature loggers; Onset Computer Corporation, Bourne, MA) every 10 minutes for the duration of the study. Additionally, weather data from weather stations in close proximity to each farm was collected from the Network for Environment and Weather Applications website (newa.cornell.edu).

Bedding score was evaluated weekly for all calves during the study using the University of Wisconsin Madison scoring system. Scores were assigned on a scale of 1 to 3:
1 = legs entirely visible; 2 = legs partially visible when laying; 3 = legs not visible when lying.

Growth**:** Body weight, hip height, and body condition scores of calves were measured within the first week of life, and 4 and 8 weeks after first observation (4 and 8 weeks of age). Body weight was measured on a digital scale and body condition score was assigned in 0.25-unit increments on a 1 to 5 scale (Ferguson et al., 1994).

Health**:** Any health events or medications were recorded. Calves were scored once weekly to evaluate signs of diarrhea and respiratory disease. Fecal scores were assigned on a 1 to 4 scale: 1 = normal and well formed; 2 = soft but still holds form; 3 = loose without form; and 4 = consistency of water (Osorio et al., 2012). Nose, eye, and ear scores were assigned to calves based on the School of Veterinary Medicine University of Wisconsin-Madison (2011) calf health scoring chart. Nose scores were assigned on a scale of 1 to 4: 1 = normal serous discharge; 2 = small amount of unilateral cloudy discharge; 3 = bilateral cloudy or excessive mucus discharge; 4 = copious bilateral mucopurulent discharge. Eye scores were assigned on a scale of 1 to 4: 1 = normal, no discharge; 2 = small amount of ocular discharge; 3 = moderate amount of bilateral discharge; 4 = heavy ocular discharge. Ear scores were assigned on a scale of 1 to 4: 1 = normal; 2 = ear flick or head shake; 3 = slight unilateral droop; 4 = head tilt or bilateral droop.

Blood: Blood samples were collected by jugular venipuncture during the first week of life, and 4 and 8 weeks after the first collection using a 10-mL evacuated serum separation tube (Becton Dickinson, Franklin Lakes, NJ). Blood was allowed to clot before centrifugation at 1,300 × *g* for 20 minutes to decant serum. Initial serum protein was determined from the sample collected during the first week of life by refractometry using a hand-held refractometer (Vet 360; Leica Microsystems Inc., Buffalo, NY).

Feed analysis**:** Samples of milk replacer, milk balancer, and starter were collected weekly and composited by month for further analysis for the respective farms. Milk replacer and milk balancer were analyzed for dry matter (DM), crude protein (CP), fat, and ash by standard wet chemistry methods (Dairy One, Ithaca, NY). Starter was analyzed using wet chemistry techniques for DM, CP, lignin, fat, ash, starch, and metabolizable energy (ME) (Dairy One). The milk samples collected on Farm B were analyzed for fat, true protein, and solids by mid-infrared procedures (CombiScope FTIR 300 Hp; Delta Instruments, Drachten, The Netherlands).

Economics: Each treatment was evaluated for average cost per pound of gain per day to evaluate the economic feasibility of increasing the amount of nutrients fed during winter months. There are some limitations because starter intake consumption and cost were not accounted for. The economics presented are based only on offered milk replacer, milk, or balancer through the preweaning period.

Statistical Analysis: Farms were not compared to each other, only feeding rates within each farm were compared. Data was analyzed as a randomized block design using the Statistical Analysis System (SAS; SAS Institute Inc., Cary, NC). Data for growth and blood variables were analyzed using mixed linear models using the MIXED procedure of SAS with the effect of treatment as a fixed effect. Calf within treatment was the subject for repeated measurements. Models for occurrence of health events were evaluated by logistic regression using a binomial distribution in SAS using the GLIMMIX procedure.

Results and Discussion:

The environmental temperature on each farm is shown in Figure 2. During the time in which this study was conducted calves on both farms experienced temperatures below the lower critical temperature (59°F) for young dairy calves. The temperatures between farms were very similar with the minor difference being that Farm A, which housed calves inside a barn, had less extremes in temperatures.

Nutrient composition and intake offered:
Milk replacer on Farm A and milk balancer on Farm B, and starter on both farms were similar to the expected nutrient composition provided by each feedstuff.

Interestingly, we were able to take twice daily samples of whole milk fed to calves on Farm B to more closely represent the milk composition fed to calves at each feeding throughout the study (Figure 3):

- The range in protein was 2.66-3.55% with an average of 3.14% overall.
- The range in fat was 1.54-7.71% with an average of 4.73%.
- The range in solids was 10.52-16.29% with an overall average of 13.55%.

While the average composition provided by feeding whole milk is a good source of fat and protein to meet maintenance and growth requirements, the variability of those nutrients day-to-day, and even within day, is a concern. Previous research has demonstrated that variability in solids content can reduce average daily gain of calves compared to calves that received the same total nutrients, but at a consistent rate (Hill et al., 2009).

In winter, calves have a specific requirement of energy to meet their requirements for maintenance. Variability in composition might lead to underfeeding for calf requirements when a fixed volume is provided without consideration for nutrient density.

The actual pounds of solids offered based off analyzed milk composition is shown in Figure 4 for Farm B. The variable solids content provided from the whole milk led to daily deviations in the amount of solids fed to calves on Farm B regardless of feeding rate.

Body weight, daily gain, hip height, and body condition score:
Average body weight, daily gain, hip height, and body condition scores of calves fed different feeding rates on Farm A and Farm B are shown in Figure 5.

Body weight, growth, and efficiency on Farm A were not different between feeding rates.

On Farm B there was significant effect ($P < 0.01$) of feeding rate over time for body weight, growth, and efficiency between feeding rates (Figure 5). During the first four weeks of age calves on the higher feeding rate had an average daily gain of 2.5 lb per day compared with the lower feeding rate which averaged 1.8 lb per day on Farm B (Figure 5). Hip height, as an indication of frame growth, was significantly increased for calves fed the higher feeding rate on Farm B.

Body condition score was increased in the calves fed the higher feeding rate on both farms. There was a significant ($P = 0.05$) effect of feeding rate on body condition score with calves fed the higher feeding rate having an increased body condition compared with the lower feeding rate for Farm A.

Industry standard for calf body weight gain in the first 56 days of life is to double the birth weight of the calf while also gaining 4-5 inches of hip height (Dairy Calf and Heifer Gold Standards). On Farm A at eight weeks of age calves on both feeding rates achieved this goal of doubling birth weight. Overall hip height gain was not different between feeding rates for Farm A, but did meet the goal, with gains of 4.0 inches compared to 4.4 inches on the higher feeding rate.

On Farm B, calves fed the lower feeding rate did not meet the goal of doubling their birth weight, gaining only 84.8 lbs by 8 weeks of age. However, calves fed the higher feeding rate did, gaining 102.8 lbs. Calves on both feeding rates on Farm B also met the goal for height gain with an average of 4.7 and 5.7 in. for the low and high feeding rate, respectively.

Estimated body weight based on nutrients offered through milk replacer on Farm A and milk plus milk balancer on Farm B were compared to actual observed body weight as shown in Figure 6. The estimated body weight used the initial body weight measure from each calf and estimated growth based on intake and environmental temperature. The environmental temperature was used to estimate the maintenance requirement of the calf, and the amount of metabolizable energy offered, through milk or milk replacer, was used to estimate how much the calf would grow after maintenance requirements were met. The amount of metabolizable energy was estimated based on analyzed nutrient composition and the amount of feed offered.

On Farm A, the predicted body weight for both feeding rates was above the observed body weights of the calves. Overall, calves on both feeding rates were offered a high plane of nutrition but we were not able to quantify actual consumed nutrients, so calves may not have consumed all of the milk replacer that was offered to them. At week 8 on Farm A, the estimate of body weight was closer to what was observed.

On Farm B the estimates of body weight on both feeding rates were below what was observed. This could be due to the amount of starter and the timing in which these calves first consumed starter to help meet their maintenance and growth requirements. At the lower level of milk offered on Farm B, it would be expected that calves would consume starter in the first three to four weeks of life, supporting the greater body weights of the calves compared with what was predicted.

Average initial total protein for both farms was above the recommended cutoff of 5.5 g/dL as an indication of successful passive transfer with an average of 5.8 g/dL for Farm A and 5.6 g/dL for Farm B.

Health Scores:

Health scores on Farm A were similar between feeding rates, with a large proportion of calves having elevated health scores in the preweaning period (Figure 7). On Farm B however, the proportion of calves with elevated health scores was impacted by feeding rate. Calves fed the lower feeding rate tended ($P = 0.07$) to be 2.7 times more likely to have an elevated nasal score and 1.9 times more likely to have an elevated eye score.

Elevated fecal scores were minimal on both Farm A and B and did not differ between feeding rates.

The cumulative number of days that each calf was medicated (not including electrolytes) is shown in Figure 8. There were no differences in days treated between feeding rates on either farm, however, Farm A had a larger number of calves that were medicated. The number of calves with elevated health scores, independent of feeding rate, and medication on Farm A could be associated with the type of housing provided. Housing calves in group pens in a barn can be challenging from a pathogen exposure and ventilation standpoint. The added immune and environmental challenges associated with this housing system may have increased maintenance requirements for these calves leading to greater health challenges.

Bedding:
Bedding scores are shown in Figure 9. A large number of calves had a bedding score of 1 or 2. Ideally, a higher score is better for calf housing in winter, however, both farms used calf jackets which has been equated to adding a single bedding score thus limiting calf exposure to the environment and minimizing the amount of body heat lost in young calves.

Economics:
A simple economic comparison was done based on milk replacer, and milk and milk balancer, offered to calves. Cost per pound of gain was calculated for both feeding rates on each farm based on overall gain during the study. On Farm A it was estimated that the cost of milk replacer was $1.30/lb. Overall, it cost $224.19 for the lower feeding rate and $256.87 for the higher feeding rate. The cost per pound of gain was therefore $2.34 and $2.59 for the lower and higher feeding rates on Farm A.

On Farm B, milk was estimated to cost $0.18 per fluid pound of milk and $1.50/lb for milk balancer. Overall, it cost $86.65 for the lower feeding rate and $134.97 for the higher feeding rate. The cost per pound of gain was therefore $1.02 and $1.31 for the lower and higher feeding rates on Farm B.

Cost for starter intake was not accounted for and should be considered in the future.

Conclusions/Outcomes/Impacts:
Results from this study indicate that there are important considerations from a milk feeding standpoint for calves during cold weather under the climatic conditions in Northern New York. As temperatures decrease, across housing types, the requirements of the calf increase. It is important to compare within farms how the impact of increasing nutrients supplied will improve the growth and health of the calves. Certain housing systems have different challenges that need to be managed in the winter that will impact the maintenance requirements of the calf, including health challenges. This study has provided useful feedback for the farmers who participated and could be evaluated on other farms within Northern New York.

Education and Outreach:

Farms enrolled in this study have full access to the information collected. There has been great interest in the results and at least one of the farms adjusted its winter calf nutrition program after this study was conducted. Outcomes of this study will be shared with farmers in the 6 counties in NNY by summarizing and reporting data in the Miner Farm Report along with presenting outcomes at the national annual meeting of the American Dairy Science Association. Information will be made available on the Miner Institute website and presented at producer meetings in the area, and this report will be posted on the NNYADP website at www.nnyagdev.org.

Acknowledgements:

We thank the two farms that collaborated on this study to help evaluate different feeding rates and housing systems on farms in Northern New York. We would also like to thank the Northern New York Agricultural Development Program for funding this research.

For More Information:

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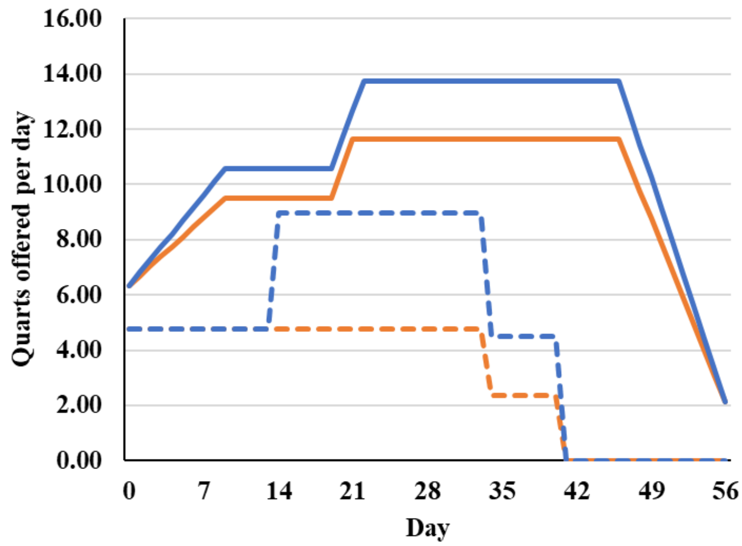
Northern New York Agricultural Development Program
2019-2020 Project Report APPENDIX

The Effect of Increasing Total Amount of Nutrients Supplied through Milk or Milk Replacer on Calf Growth and Health in Multiple Housing Systems during Winter Months in NNY



a. above, b. below

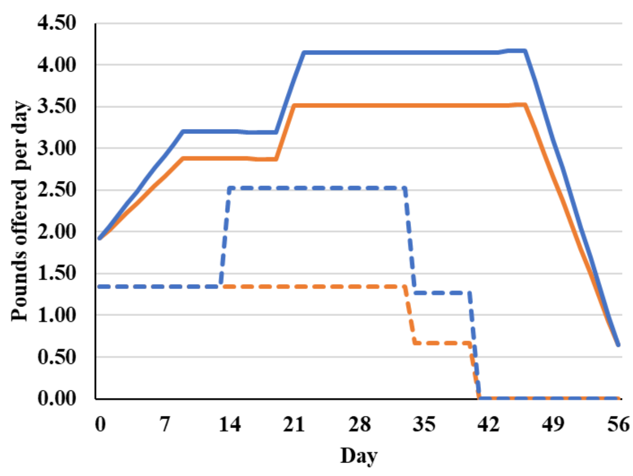
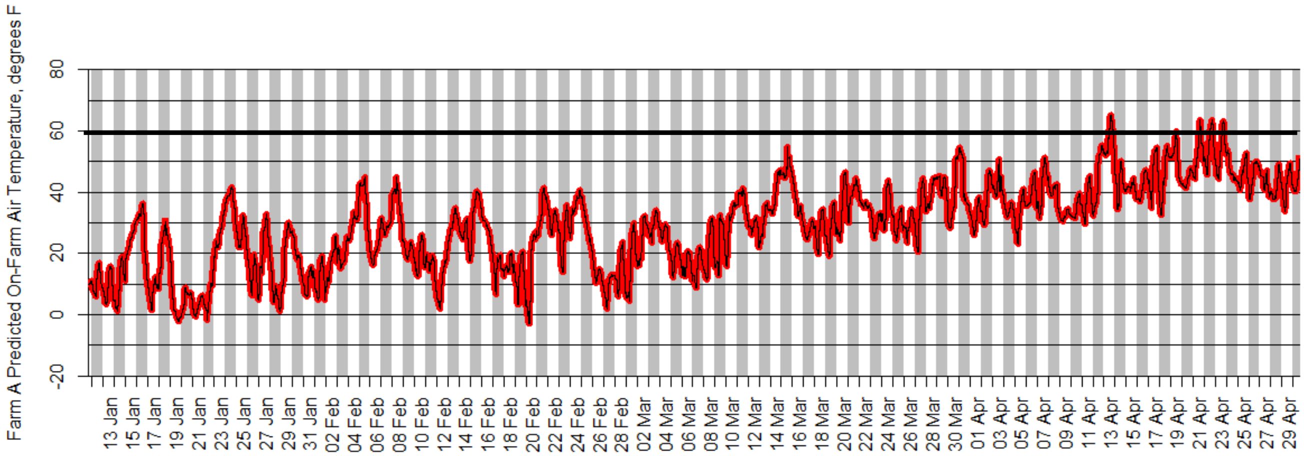


Figure 1. Volume in quarts (a) or pounds of solids (b) offered of reconstituted milk replacer (Farm A; solid lines) or whole milk (Farm B; dashed lines) at two feeding rates of either a low (orange) or high (blue) amount. The feeding rate was specific to each farm.



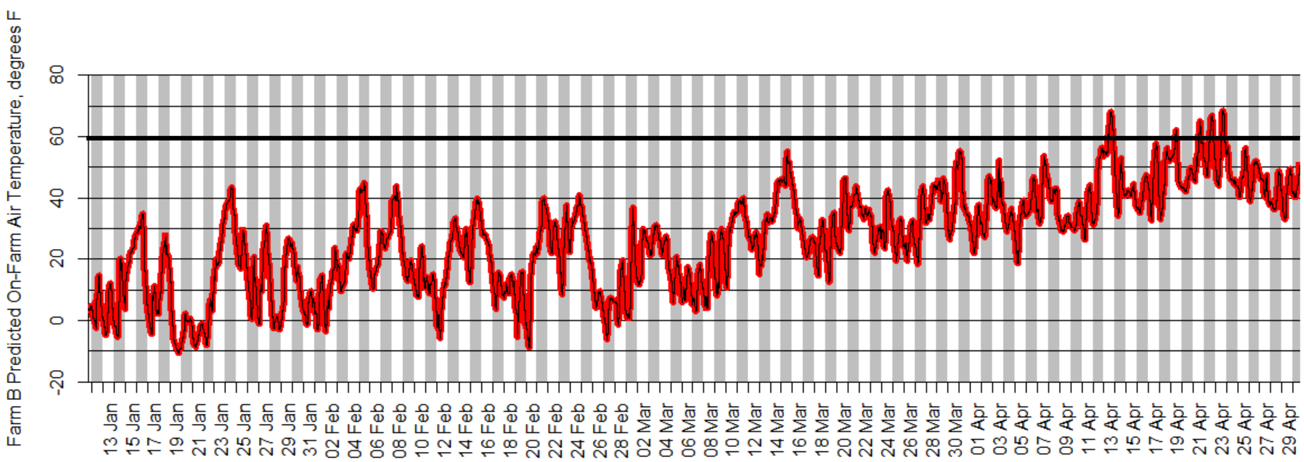


Figure 2. Environmental temperature recorded on Northern New York farms that fed different feeding rates to preweaned calves in winter.

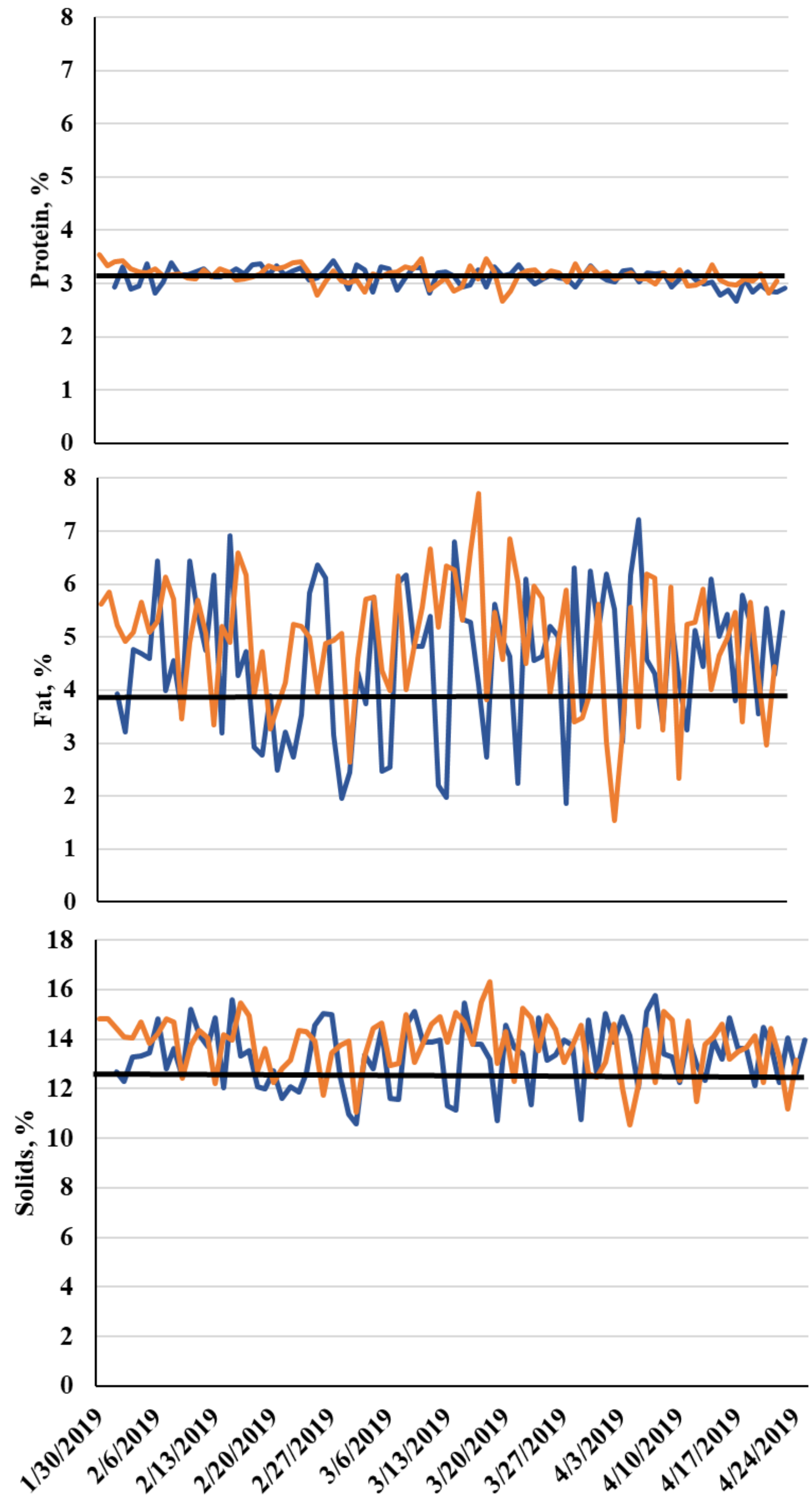


Figure 3. Composition of whole milk fed twice daily to calves on Farm B. Samples were collected at both the morning (Blue line) and evening feeding (Orange line).

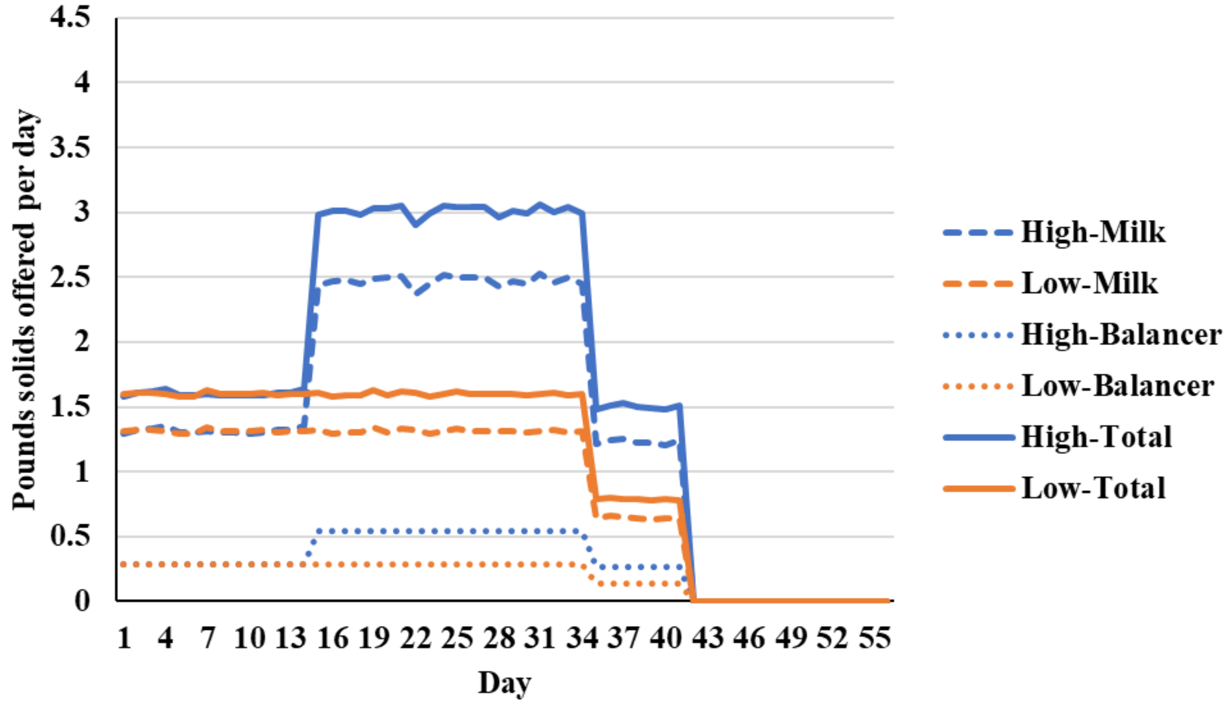


Figure 4. **Actual amount (lbs) of solids offered on Farm B from whole milk (dashed lines), milk balancer (dotted lines), and total solid intake from both sources (solid lines) at two feeding rates of either a low (orange) or high (blue) amount. The amount of each feedstuff offered is based on analyzed composition over the course of the study.**

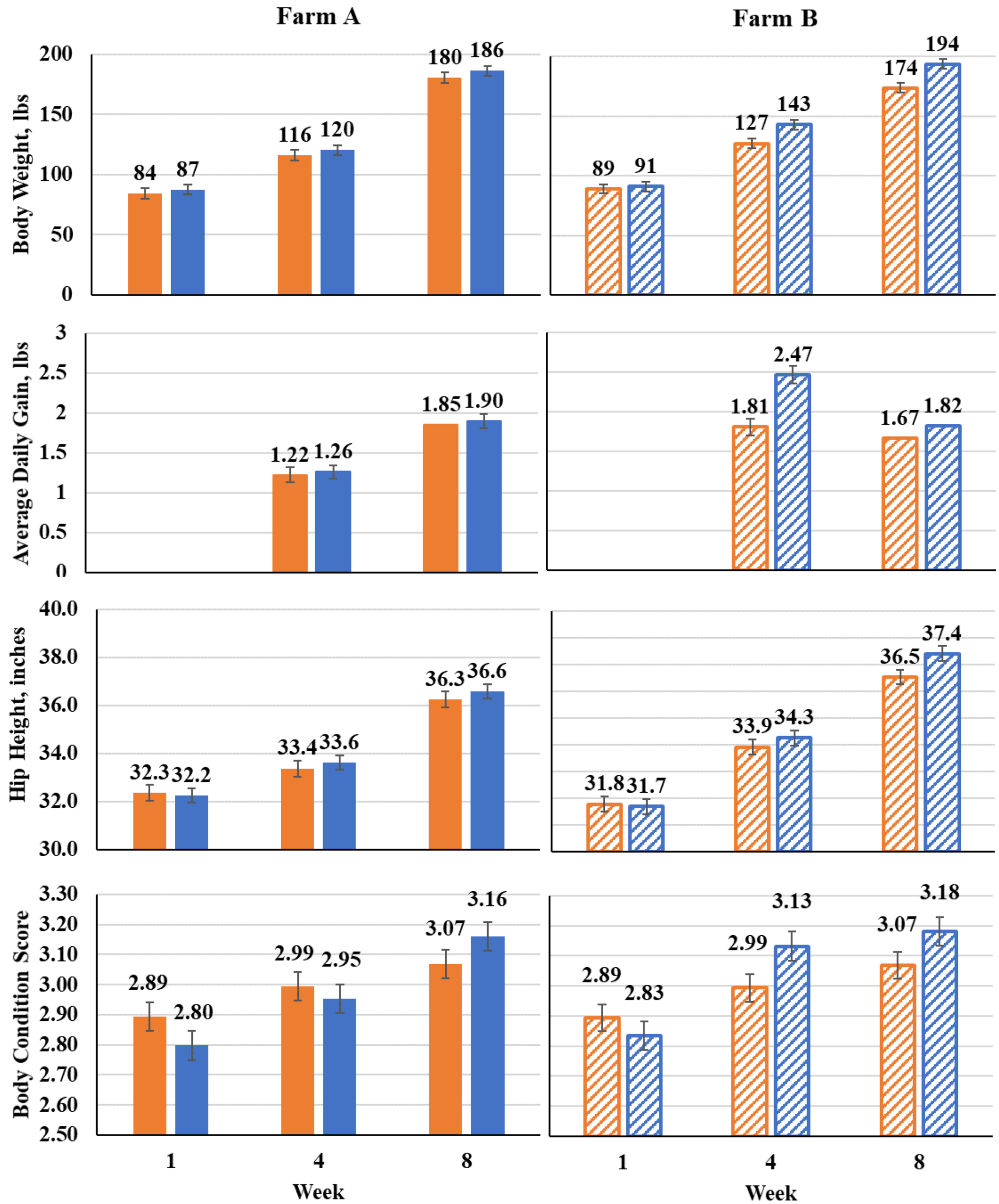
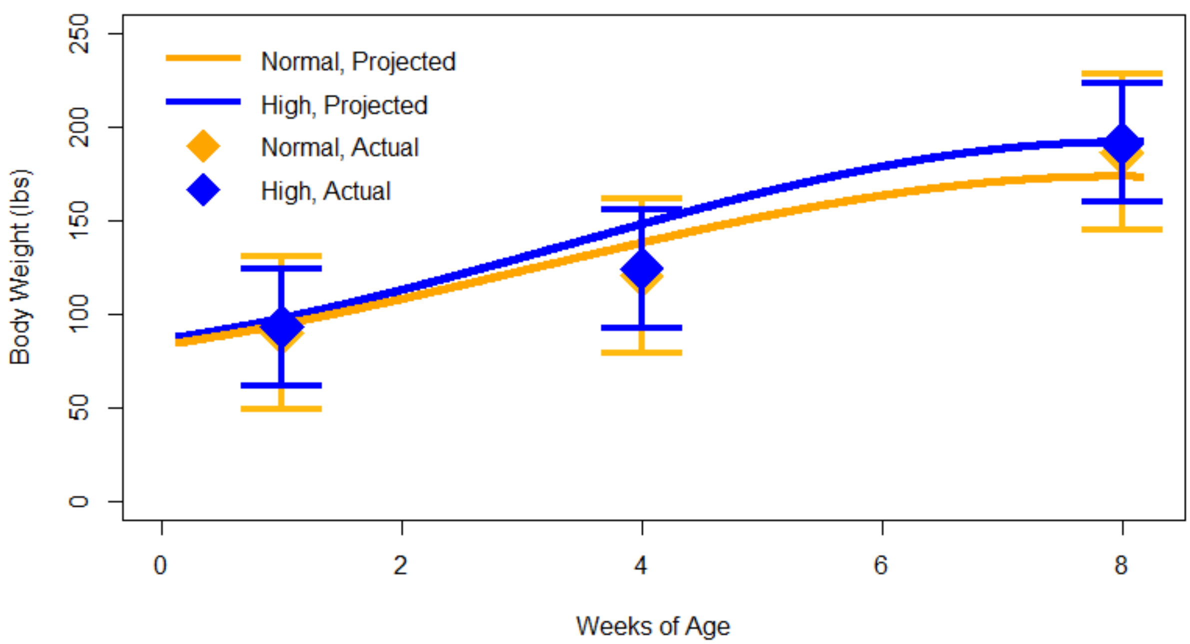


Figure 5. **Body weight (lbs), average daily gain (lb/d), hip height (in), and body condition score of calves in the preweaning period on two farms that fed two feeding rates of either a low (orange) or high (blue) amount. The feeding rate was specific to each farm. Body weight, hip height, and body condition score was recorded within the first week of age, at 4 weeks of age, and 8 weeks of age. Average daily gain was calculated after four weeks of age and eight weeks of age.**

Farm A



Farm B

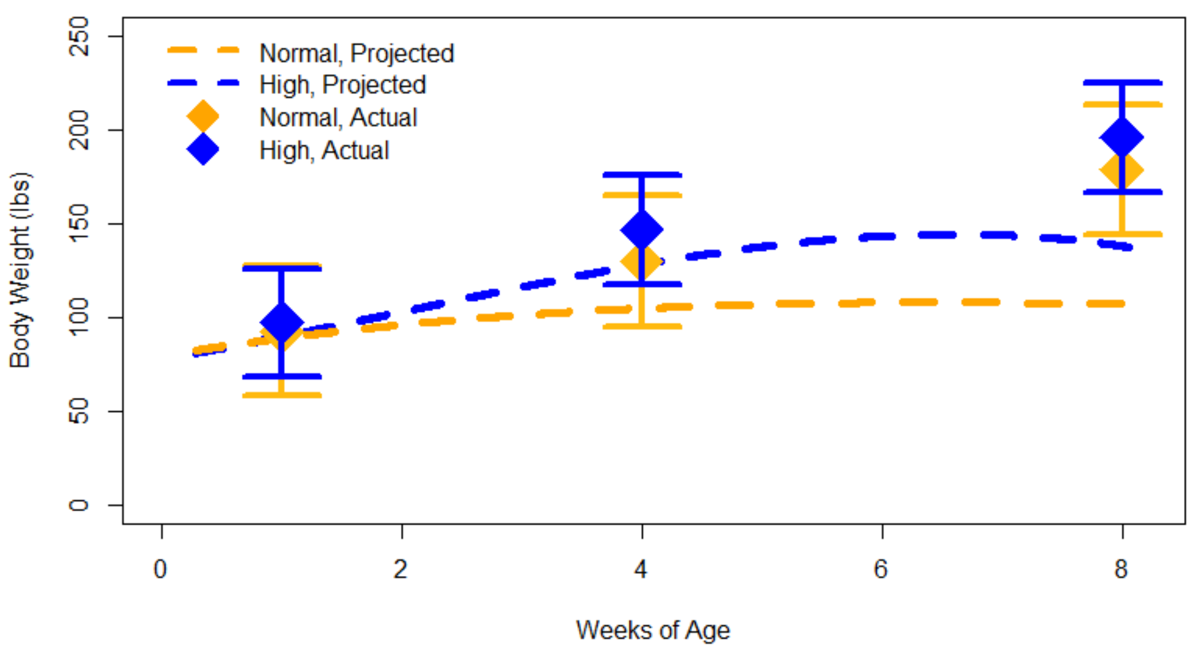


Figure 6. Estimated body weight (lbs) of calves on two farms in Northern New York during winter based off of environmental temperature and estimated consumed nutrients provided from milk or milk replacer. The first figure shows estimated body weight.

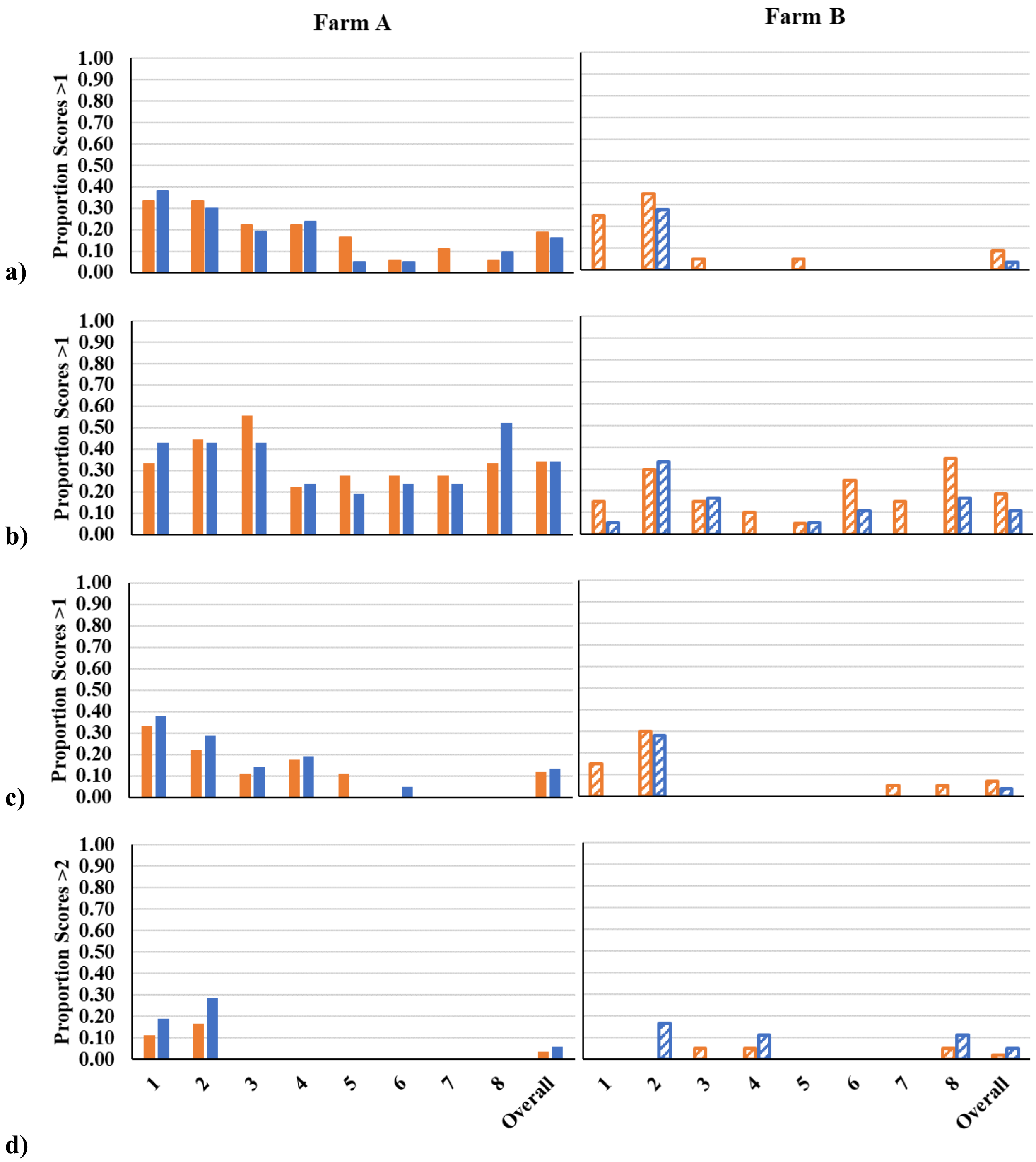


Figure 7. Proportion of nasal discharge (a), eye (b), and ear (c) scores that were greater than 1 (normal), and fecal (d) scores that were greater than 2 (1 and 2 normal) on a 1 to 4 scale for calves in the preweaning period on two farms that fed two feeding rates of either a low (orange) or high (blue) amount. The feeding rate was specific to each farm. Nasal discharge scores were assigned once weekly for all calves enrolled in the study.

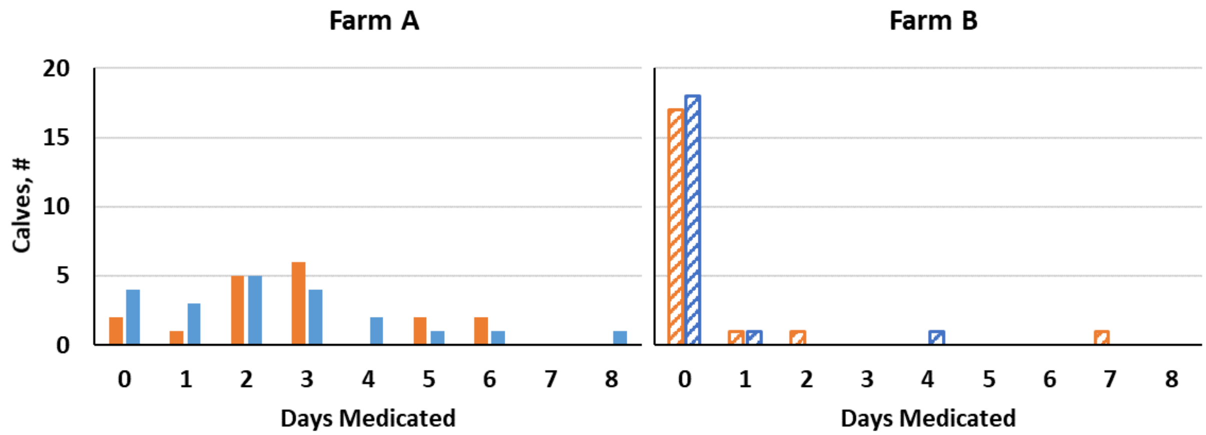


Figure 8. The number of calves that were medicated for cumulative days through the preweaning period on two farms that fed two feeding rates of either a low (orange) or high (blue) amount. The feeding rate was specific to each farm. Medications include any antibiotic or anti-inflammatory medications and did not include administration of electrolytes.

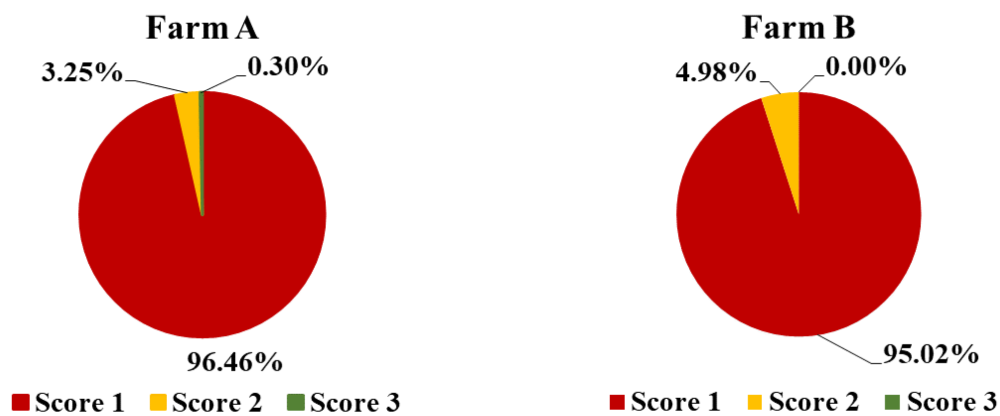


Figure 9. Bedding Scores for calves in the first eight weeks of life on two farms that fed two feeding rates specific to each farm in the winter. Bedding scores were evaluated using the University of Wisconsin scoring system where 1: is the legs of the calf are entirely visible; 2: is the legs of the calf are partially visible; and 3: is the legs of the calf are generally not visible.