Management changes when using indwelling rumen temperature monitoring technology in dairy calves

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Abstract

Precision Dairy Farming technology for dairy has mostly focused on tools to improve cow care, but new tools are available to improve the care of pre-wean calves and heifers. These technologies apply real-time monitoring to measure individual animal data and detect deviations from normal. On-farm validation of new technologies remains important for the successful deployment of new technologies within commercial farms to understand how the technology can improve dairy calf welfare, performance, and health. Multiple factors exist that are critical in determining if a technology is valuable to farm management. One assessment is determining if the technology can be validated against a gold standard which for calf temperature monitoring, is rectal temperature. This was done by comparing the rectal temperature of calves less than 3 weeks to the rumen-reticular temperature over a 5-hour period using the Farmfit™ system. The first step in the validation of this research was to look at the correlation between sensor temperature and rectal temperature. Lin's concordance correlation coefficient was strongest at 0.36 when the ruminal temperature reading was used closest to rectal temperature assessment time using the average rumen-reticular temperature of 18:00 and 19:00. The bias correlation to the 1:1 line was 0.988 with an average difference of 0.001°C showing a strong average connection of the Farmfit™ average temperature to the gold standard calves rectal temperature.

Keywords: automation, temperature, dairy calves, bolus

Introduction

Precision livestock farming tools such as remote temperature monitoring have the potential to improve dairy calf care through earlier detection of disease. USDA APHIS, (2018) Health and management practices on U.S. dairy operations indicated that 18% of pre-weaned dairy calves experience respiratory distress and 25% have diarrhea that requires treatment. This study used an indwelling rumen temperature monitoring device with a herd management user interface from ST Farmfit™.

Rumen-reticular temperature monitor tools are commercially available for adult cattle. Body temperature monitoring is commonly used by calf managers as a method to detect disease and assist in determining treatment recommendations. Body temperature has been described as the most easily measurable parameter that is a very sensitive indicator of the reaction an animal will have to the disease process, physico-environmental factors, and physico-environmental factors (Nakamure et al., 1983). The rectal temperature has been found to be lower than the rumen-reticular temperature in dairy cows by 0.45 ± 0.33 °C but is strongly correlated at (r=0.645) (Bewley et al., 2008). One challenge with rumen-reticular temperature is that it is affected by the temperature of what the animal eats and drinks, with the greatest effect caused by the consumption of cold water. However pre-weaned dairy calves only drink small amounts of water at a time. When milk meals are fed at temperatures close to the normal body temperature of 38.5°C these meals are not associated with a rumen-reticular change in temperature during the hour right after feeding (Knauer et al., 2016). Voss et al. (2016) found that all calves diagnosed with Bovine Respiratory Disease had pyrexia at least once in a 30-minute period within 5 days of clinical diagnosis. Therefore, the objective of this study was to look at the correlation between indwelling rumen-reticular temperature monitoring systems in pre-weaned dairy calves and the gold standard rectal temperature taken after feeding. This correlation was examined over a 5-hour period, centered around the time of feeding, and measuring of rectal temperature.

Materials and methods

For this project, the indwelling rumen-reticular temperature monitoring bolus from ST Farmfit™ was used to monitor the temperature along with the ST Farmfit™ user interface management app. The system consists of an indwelling rumen-reticular temperature monitoring device, a radio frequency collector, an internet gateway, and ST Farmfit™ user interface. All parts of this system are developed and produced by ST Farmfit™ and are currently available for commercial use. The herd management interface not only provided the interface for users to visually monitor the temperature recorded by the rumen-reticular bolus, but it also provided health alerts from 4 consecutive high-temperature recordings, and the ability to record animal health events and treatments. Each animal establishes its own normal baseline and pyrexia is triggered when a one-hour average temperature is 1.11°C above that animal's baseline for four hours in a row. Utilizing the farm management interface provides one-hour temperature averages while the bolus took temperature readings every 15 minutes. By using the ST Farmfit™ interface, we were utilizing the same tools producers would commercially utilize.

This project was conducted on a commercial dairy farm with purebred Holsteins in Crawford County Ohio from January 2022 through December 2022. Only female calves that would be kept for replacements were enrolled in the study. Once per week all enrolled calves had their rectal temperature taken between 18:30 and 19:30 in the evening. Calves were feed milk at approximately 18:15 each night at a temperature of 38.9°C. A total of 102 usable temperatures were recorded. Measurements were not utilized if the calf defecated during rectal temperature readings. Readings were also not utilized for a week after equipment updates.

Boluses were administered orally to calves at least two days of age that were not bloused the previous week. Boluses were allowed at least two days between the administration of the bolus and the first comparison of rectal temperature. All calves in the study were under 3 weeks of age and drinking milk from a bottle. For rectal temperature monitoring a GLA M900 Thermometer was used with an M207R 10.0 cm probe. The probe was inserted 10 cm into calves for 90 seconds with the thermometer set to record the peak temperature over that time. All temperatures were then recorded in the Farmfit™ app. While rectal temperature is the gold standard, it can be affected by multiple factors. One of those factors is probe length or insertion depth which is highly correlated at different depths but has a difference of 0.4±0.02°C when inserted at 6 cm versus 11.5cm (Burfeind et al., 2010).

For statistical analysis, Lin's concordance correlation was used in the analysis. Watson and Petrie (2010) reported that Lin's concordance correlation coefficient provided a superior comparison since it not only compares the closeness of the data around the best-fit line but also how well that line follows a 45 degree, 1:1 line representing perfect agreement. Data analysis was conducted using Rstudio, R Core Team (2021). The packages EpiR for analyzing Lin's concordance correlation coefficient (Stevenson et al., 2013) and ggplots2 package v3.3.3. for making graphs (Wickham, 2016).

The strength of the correlation was compared over a 5-hour time period just in case, feeding caused an effect on ruminal temperature monitoring. Both one-hour times and averages of the 2 hours around rectal temperature readings were collected. This collection timing allowed the dairy manager to better understand how a single-hour and multi-hour average temperature related to the actual rectal temperature of an animal since they have used these temperatures to historically determine pyrexia and illness.

Results and discussion

Comparing rectal temperature to the temperatures measured by the rumen-reticular bolus resulted in a positive Lin's concordance correlation coefficient with a range of 0.18-0.36 depending on the time comparison. Calves' rectal temperatures averaged 39.16°C with a standard deviation between these calves' temperatures of 0.619°C. The range of calves' temperatures was 38-40.44°C.

As expected, the strongest correlation was between the rumen-reticular temperature reading closest to the time when the rectal temperature reading was taken. Lin's concordance correlation coefficients were all positive but were weak. Concordance correlation coefficients less than 0.2 are considered poor and greater than 0.8 are excellent. In relation to a 1:1 line showing a perfect correlation between the rectal temperature and rumen-reticular temperature, Bias correlations were much tighter with only the usage of high or low temperatures being less than 0.94 bias correlation. The closer the Bias correlation is to 1 the more accurate the best-fit line is. Table 1 summarizes the correlations between calves' rectal temperature taken between 16:30and 17:30) and the temperature reported by the Farmfit technology over a 5 hour time span. The strongest correlation is from using the 2-hour average of 18:00-19:00 (Figure 1) which best corresponds to when the rectal temperature was taken with a Lin's concordance correlation coefficient of 0.36 and a bias correlation of 0.988. A between-calf standard deviation of 0.7197°C with an average difference between the rectal temperature and rumen-reticular temperature of 0.001°C but a range in the difference between the two of 4.93°C (-2.665-2.265°C). The average difference is very similar, but the range is wider than expected. Similar to other studies the single-hour variation is greater in rumen-reticular temperature than rectal temperature due to influences of digestion and water consumption (Knauer et al., 2016).

Table 1: Lin's Concordance Correlation Coefficient for all hourly comparisons made to the rectal temperature that was taken between 18:30-19:30 after milk was fed for the evening feeding

Time used for Comparison	Lin's Correlation Coefficient	Bias Correlation	Standard Deviation	Ave. Diff.
17:00 hour temperature average	0.21	0.942	0.875	0.050
18:00 hour temperature average	0.33	0.941	0.875	0.050
19:00 hour temperature average	0.26	0.979	0.743	-0.048
20:00 hour temperature average	0.30	0.941	0.858	-0.090
21:00 hour temperature average	0.19	0.965	0.791	-0.070
Temperature average from 17:00-21:00	0.35	0.997	0.651	-0.022
Temperature average from hours 18:00 and 19:00	0.36	0.988	0.719	0.001
Average outside of milk feeding hours 17:00,20:00,21:00	0.30	0.992	0.651	-0.030
Highest hourly temperature between 17:00-21:00	0.28	0.750	0.551	-0.046
Lowest hourly temperature from 17:00-21:00	0.18	0.729	1.098	0.532

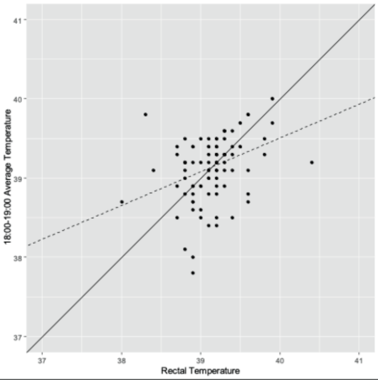

Figure 1: Average Farmfit™ temperature from 18:00 and 19:00 compared to Rectal temperature

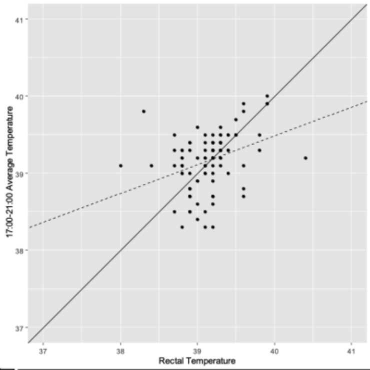

Figure 2: Average Farmfit™ temperature from 17:00 to 21:00 (5-hour average) compared to rectal temperature

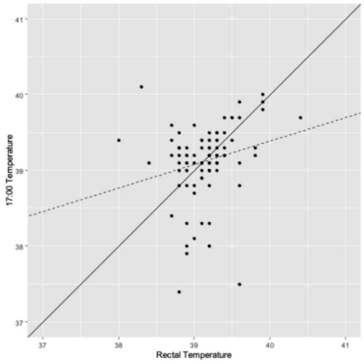

Figure 3: Average Farmfit™ temperature at 17:00 compared to average rectal temperature

One of the challenges our producers noted and can be seen from this study was that temperature is not consistent and must be compared as close as possible between when a rectal temperature is taken and the ruminal temperature from the same time. Although looking at a larger time period besides hourly can have similar results with Lin's concordance correlation coefficient of 0.35 and a bias correlation of 0.997 when averaging the 5 hours period (Figure 2). On the other hand, if an hourly temperature from Farmfit™ is just an hour prior to the rectal temperature assessment it only has Lin's correlation coefficient of 0.21 (Figure 3) with an average temperature difference of 0.05°C and a bias correlation of 0.942.

The user interface of Farmfit™ is often several hours behind meaning when a producer looks up a calf that acts lethargic the latest temperature reading may not be accurate to a rectal temperature they take. Once the ruminal bolus has synced with the collector and Farmfit™ app, temperature accuracy would improve. Temperatures trend the same way as in Farmfit™ as it does rectally. Producers can have confidence that a high rumen-reticular temperature from Farmfit™ would also have a higher-than-normal rectal temperature at the time of that measurement. Unfortunately, due to natural hourly variations in calf temperature, it may not always be at pyrexia levels when checked by calf managers. Piccione et al., (2003) found that calves had minimal rhythmicity of body temperature through one week of age and developed a strong dusk-to-dawn rhythm of 1.4°C over the next 8 weeks.

Since the release of the bolus and software we used in this study, the boluses have been updated to include a quicker temperature relay to the Farmfit™ app and an additional activity monitoring component has been added. One of the shortcomings our cooperating farm identified was that in pre-weaned calves, they often noticed the calves acting slow prior to a fever detection. This may not be the case on other farms that spent less time with each calf than this farm. Our cooperating farm looks at each calf prior to feeding, at feeding, and then after feeding to check for health concerns.

Conclusions

The results of this study show that rumen-reticular temperature can be a useful tool for detecting pyrexia in dairy calves. The Bias correlation of 0.988 for the 18:00-19:00 average time frame, which is the time frame rectal temperatures were taken shows that on average the rectal temperature and the Farmfit™ rumen-reticular temperature fall close to the 1:1 comparison between the two. Lin's concordance correlation coefficient is strongest at 0.36 using the 2-hour average temperature around rectal temperature check showing a positive relationship between the rumen-reticular temperature and the gold standard rectal temperature that would allow farmers to use this system to be aware of when a calf has pyrexia. Multi-hour averages of either the 2 hours around the time rectal temperature were taken or a longer average of 5 hours from Farmfit™ was more reliable to the gold standard rectal temperature than single-hour temperature.

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