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Summary

Four heifers were used in two trials comparing the effect of high energy and high roughage diets on three body temperature measurements. Body temperatures were measured in the vagina, in the ear canal near the tympanic membrane, and in the rumen. The high roughage diet lowered all three measures of body temperatures as compared with the high energy diet. Vaginal, tympanic, and ruminal temperature all appeared to effectively measure body temperature as they followed the same diurnal cycle; however, ruminal temperatures were, on average, 0.5 to 1.4°F higher than other body temperature measures.

Introduction

Contradictory opinions have evolved on temporarily increasing roughage levels in the diet to help manage short periods of cold stress. Roughages are assumed to have a higher heat increment than concentrates, and often are recommended to improve cold stress tolerance of cattle. However, this practice may not be beneficial, as higher roughage levels reduce metabolizable energy (ME) intake and increase the rate of passage through the rumen, thus potentially reducing fermentative heat production in the rumen.

Body temperature measurements are traditionally used in diagnosing sick animals, but they also may be used as an indication of heat or cold stress. A healthy, unstressed animal will have a core body temperature in the range of 100.4 to 103.1°F, that generally follows a diurnal pattern. Acceptable measures of core body temperature can be taken in the rectum, vagina, or ear canal near the tympanic membrane. Technologies are being developed for continuously monitoring body temperatures via radiotelemetry, which would allow earlier detection of sick cattle for treatment and could even be used to identify time of ovulation in cows and heifers.

The objectives of this trial were to determine the effect of feeding high roughage and high energy diets on body temperature, and to compare body temperature measurement taken in the rumen with the traditionally used vaginal, rectal, and tympanic temperature measures.

Procedure

Trial 1

Tympanic, vaginal, and ruminal temperatures were obtained from four crossbred heifers (mean weight = 911 lb) over four-day periods while being fed the high energy or high roughage diet (Table 1). The heifers were initially fed the high energy diet, then switched to the high roughage diet and allowed a 10-day acclimation period before temperatures were monitored.

Table 1. Diet composition (% dry matter basis).

Ingredients	High Energy	High Roughage
Alfalfa hay	5.0	26.0
Brome hay	—	10.0
Corn silage	5.0	60.0
Dry rolled corn	80.0	—
Rumensin/Tylan	2.2	1.0
Soybean meal	3.5	—
Liquid supplement	4.3	3.0
Dry matter, %	80.86	40.06
Metabolizable energy, Mcal/lb	1.42	1.13

Tympanic temperatures (TT) were recorded using a Stowaway XTI® data logger (Onset Corporation, Pocasset, MA) and thermistor. The thermistor was inserted approximately four to five inches into the ear canal until the tip was near the tympanic membrane. The loggers recorded temperatures at 15-minute intervals.

Vaginal (VT) and ruminal (RT) temperatures were recorded using the ETD Bolus™ (CowTek, Inc., Santa Clarita, CA). The ruminal boluses were inserted using a balling gun and remained in place until removal at slaughter. Vaginal temperatures were recorded using the same type of bolus. The bolus was hand-placed inside the vagina, immediately behind the cervix, during periods when temperatures

(Continued on next page)

were recorded. All boluses were activated via wireless signal to record temperatures at one-hour increments.

Due to problems receiving data from the boluses, primarily caused by bolus orientation and distance of the bolus to the signal receiver, approximately two-thirds of the VT and RT observations were missing from the first set of data during the high energy feeding period. Therefore, the receiver was moved and the heifers were observed for a second four-day period while being fed the high energy diet. (Approximately 60% of VT and RT observations were missing from the second period.) Data from both four-day high energy diet collections were pooled. The heifers were switched to the high roughage diet and the receiver was moved again to improve reception, resulting in only 8% of VT and RT observations missing from the high roughage feeding period.

Before analyzing the data, VT and RT observations were matched with TT occurring at the nearest hour. The remaining TT measurements were not used in the analysis. Because there was not a complete set with all three temperature observations for every hour, time of day was divided into six-hour (h) quarters as follows: Quarter 1 = 0000h to 0559 h; Quarter 2 = 0600 h to 1159 h; Quarter 3 = 1200 h to 1759 h; and Quarter 4 = 1800 h to 2359 h, with results reported accordingly. Also, any time that more than one observation occurred on the same date in the same quarter on the same heifer, a mean was taken for that quarter and heifer. This aided in balancing the data set for quarter and diet. For the entire study, 178 and 167 data points were obtained for heifers on high energy and high roughage diets, respectively, with approximately one-third of the points occurring for each temperature location. Additionally, 90-105 data

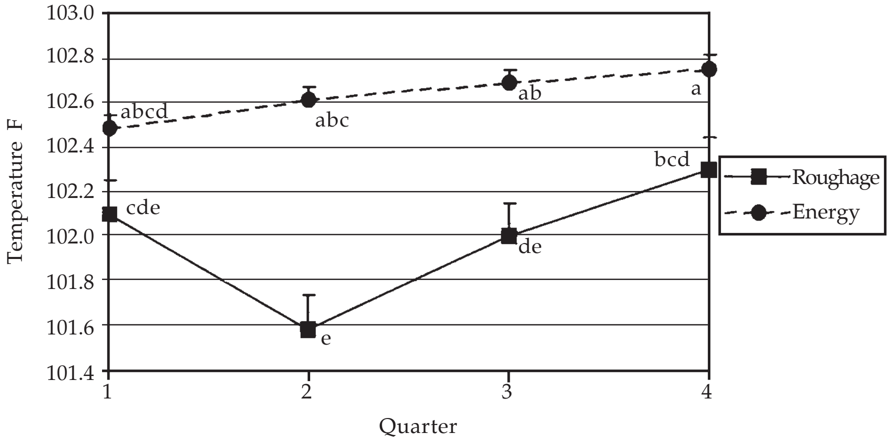

Figure 1. Mean temperature (pooled across vaginal, ruminal, and tympanic temperatures) by quarter for heifers fed high roughage and high energy diets.

Quarter: 1 = 0000 h to 0559 h; 2 = 0600 h to 1159 h; 3 = 1200 h to 1759 h; 4 = 1800 h to 2359 h. Diet by quarter interaction (*P* = 0.082); significant diet effect (*P* < 0.0001).
[abcde]Temperature means differ by *P* < 0.05.

Table 2. Weather conditions during periods and trials.[a]

Diet	Mean (SD)	Mean Min (SD)	Mean Max (SD)
Trial 1			
Energy Feeding Period			
Temperature (ºF)	18.0 (6.3)	9.8 (5.2)	27.1 (9.7)
Relative humidity(%)	78.9 (9.4)	59.8 (20.2)	91.3 (2.9)
Wind speed (mph)	9.2 (1.8)	4.8 (2.8)	14.8 (2.8)
Solar radiation (langleys)	162 (58)	——	——
Roughage Feeding Period			
Temperature (ºF)	35.3 (5.5)	26.8 (5.5)	45.7 (4.8)
Relative humidity(%)	61.6 (3.2)	38.9 (7.9)	82.2 (4.5)
Wind speed (mph)	14.6 (2.8)	7.8 (4.0)	22.4 (3.4)
Solar radiation (langleys)	265 (48)	——	——
Trial 2[b]			
Energy diet			
Temperature (ºF)	43.2 (9.7)	——	——
Relative humidity (%)	56.6 (17.1)	——	——
Wind speed (mph)	14.4 (5.2)	——	——
Solar radiation (langleys)	384 (157)	——	——

[a]As reported by High Plains Research and Climate Center for site near Concord, Nebraska, approximately 1 mile north and 1/2 mile west of the feedlot.
[b]Means for April 1 - 10.

Table 3. Mean temperatures by recording location.

	Tympanic	Rectal	Vaginal	Ruminal	SEM
Trial 1	101.8[a]	——	101.9[a]	103.2[b]	0.16
Trial 2[c]	103.0[a]	103.7[ab]	103.8[ab]	104.3[b]	0.51

[ab]Means within a row differ (P<0.10).
[c]Temperatures were taken in order, left to right.

points were obtained in every quarter, except quarter 1 (0000h to 0559 h), when only 49 measures were recorded. Observations were analyzed using Proc Mixed analysis of variance procedures (SAS; SAS Institute, Inc. Cary, NC). The model included diet, temperature location, quarter, and all interactions as fixed effects with animal nested in the quarter by temperature location interaction (since vaginal and ruminal temperatures were only recorded at times when the animal was within receiver range) as random effects.

Trial 2

On a separate date, the same four heifers were moved into the working facilities. Tympanic, rectal, vaginal, and ruminal temperatures were taken in that order within a two-minute time frame while each animal was in the chute. The ruminal temperature was recorded using the ETD Bolus™ that was already in place, while the other three were recorded with a digital thermometer (Deltatrak, Pleasanton, CA). All heifers were on the high energy diet (Table 1) during this trial.

These observations were analyzed using the Proc Mixed analysis of variance procedures (SAS; SAS Institute, Inc., Cary, NC). The model included temperature location as fixed effect with animal as a random effect.

Results

Overall, feeding the high roughage diet reduced body temperature when compared with feeding the high energy diet. Figure 1 shows the effect of diet and quarter on temperature, as pooled across temperature location. Diet by quarter interaction is significant (P = 0.082), which indicates that diet may have a tendency to alter the diurnal temperature rhythm. For all quarters except the first one, temperature means were significantly higher ($P<0.05$) for high energy than high roughage diets, even though weather conditions were slightly warmer during the roughage feeding period. Average weather conditions during both trials are shown in Table 2. Cattle were near or within the thermoneutral zone for the duration of the trial.

Temperatures recorded at each location are presented in Table 3. In Trial 1, ruminal temperature was significantly higher than both tympanic and vaginal temperatures ($P<0.05$); however, in Trial 2, tympanic temperature was the only temperature significantly different from ruminal temperature ($P<0.10$) with rectal and vaginal temperature intermediate. Temperature location by diet interaction is not significant (P = 0.1824).There are several reasons that Trial 2 temperatures may have had a tendency to run higher than Trial 1. All of the Trial 1 data was used (both diet treatments) while Trial 2 observations only occurred while heifers were on the high energy diet. Additionally, Trial 2 involved moving the animals into working facilities, utilized different devices, and occurred two months after Trial 1.

There was no quarter interaction between temperature recording and location (P = 0.998). This indicates that all three temperature locations followed the same trends and may be effective measurements of body temperature. Further research needs to be done to enhance and maintain constant receiver/signal communication, so that temperatures can be statistically analyzed as measured on an hourly basis to ascertain the similarity of RT to VT and TT.

Feeding a high roughage diet lowered all measures of core body temperature when compared to feeding a high energy diet. Ruminal temperature may be an effective way to measure body temperature, as it follows a similar diurnal rhythm as vaginal and tympanic temperature measurements, although water and feed intake effects need to be evaluated. In addition the nature of the ruminal diurnal pattern should be evaluated hourly.

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