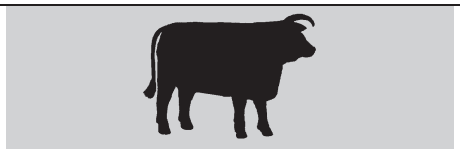
The Professional Animal Scientist 31 (2015):387–393; http://dx.doi.org/10.15232/pas.2014-01336



Case Study: Ruminal temperature as a measure of body temperature of beef cows and relationship with ambient temperature[1]

B. H. Boehmer, PAS, T. A. Pye, and R. P. Wettemann,[2] PAS
Department of Animal Science, Oklahoma Agricultural Experiment Station, Stillwater 74078-0425

ABSTRACT

Angus cows (4–7 yr of age) were used to evaluate the effectiveness of ruminal temperature (RuT) as a measure of body temperature (rectal temperature; RT) of beef cows and the influence of elevated ambient temperature on RuT. In Exp. 1, RT, RuT, and respiration rate were evaluated in cows (n = 24) during 2 consecutive days when daily maximal ambient temperature was 36.8 or 28°C. Ruminal temperature was evaluated in 12 cows during 7 d in the summer (June and August) and 1 d in the winter (January) in Exp. 2. Cows were administered RuT transmitting boluses (SmartStock LLC) that were programmed to transmit RuT every hour. Ambient temperature was recorded each hour (www.mesonet.org) and ranged from 2 to 20°C in January and 12 to 37°C in June and August. In Exp. 1, RuT, RT, and respiration rate were greater ($P < 0.05$; 40.2 ± 0.1°C, 40.8 ± 0.1°C, 114 ± 3 breaths/min, respectively) on the day when maximal ambient temperature was 36.8°C compared with 28°C (37.5 ± 0.1°C, 38.1 ± 0.1°C, 36 ± 3 breaths/min, respectively). Ruminal temperatures for both days were correlated ($P < 0.001$) with RT ($r = 0.97$) and respiration rate ($r = 0.95$) and were adequate to assess body temperature in mature beef cows. When hourly maximal ambient temperature was between 34 and 36°C, RuT was greater ($P < 0.001$) compared with when hourly maximal ambient temperature was <34°C in Exp. 2. These results indicate RuT is an effective measure of body temperature. Elevated ambient temperature may influence the usefulness of RuT as a predictor of physiological events in beef cows.

Key words: ruminal temperature, beef cattle, ambient temperature

INTRODUCTION

Cows maintain normal body temperatures or normothermia by exchanging heat with the external environment. Cows produce heat through metabolism and fermentation of feed, ensuring body temperatures are adequate for biological processes. Energy required for sustaining vital body activities accounts for approximately 70% of ME that is consumed (Ferrell and Jenkins, 1987). Regulation of core body temperature is a primary maintenance function (NRC, 2000). The thermoneutral zone is the range of ambient temperatures (**Tamb**) in which heat production of cows is offset by heat loss to the environment, without an increase in metabolic heat production (NRC, 1981). Rectal, tympanic (Mader et al., 1999), vaginal (Vickers et al., 2010), and surface (Kotrba et al., 2007) temperatures have been established as effective measures of body temperature in beef cattle in varying environmental conditions. Daily variation in body temperature of cows occurs, with maximum body temperature in the late afternoon to early morning and the nadir at midday (Hahn et al., 1990; Beatty et al., 2006). Cows become heat stressed when Tamb exceeds the thermoneutral zone of the animal. Respiration rate increases during thermal stress in

[1] Approved by the director of the Oklahoma Agricultural Experiment Station. This research was supported under project H-2331 and the Oklahoma Center for the Advancement of Science and Technology (AR09-058).
[2] Corresponding author: bob.wettemann@okstate.edu

cattle (Robertshaw, 1985; Al-Haidary et al., 2001). Sweating increases in cattle exposed to elevated Tamb (Berman, 1971; Gebremedhin et al., 2008). Humidity, wind velocity, and animal insulation influence heat dissipation efficiency (Gebremedhin et al., 2008). Body temperature increases (Mader et al., 2010) with increasing Tamb (Berman, 1971) when cows are unable to dissipate the heat load.

Body temperature has been used to describe physiological changes in beef cattle. Temperature boluses (SmartStock LLC, Pawnee, OK) have been developed for frequent, noninvasive measurement of ruminal temperature (**RuT**; Cooper-Prado et al., 2011; Rose-Dye et al., 2011). Ruminal temperature is an indicator of estrus, parturition, and health of beef cows. Ruminal temperature increases 0.6 to 1.0°C at estrus in beef cows (Bailey et al., 2009; Cooper-Prado et al., 2011). Ruminal temperature decreased 2 d before parturition in beef cows (Cooper-Prado et al., 2011). Following a pathogenic challenge, RuT of steers increased between 0.3 to 0.8°C (Rose-Dye et al., 2011). The effect of elevated Tamb on RuT is not clearly defined. We hypothesize that ruminal temperature is an effective measure of body temperature in beef cows, that diurnal variation occurs in RuT, and RuT increases in response to elevated ambient temperatures and increased temperature–humidity index (**THI**). To evaluate these hypotheses we evaluated RuT as a measure of body temperature in beef cows and the effects of exposure of beef cows to elevated Tamb and THI on RuT.

MATERIALS AND METHODS

The Oklahoma State University Animal Care and Use Committee (AG061) approved experimental procedures used in this study.

Exp. 1

Ruminal temperature, rectal temperature (**RT**), and respiration rate (**RR**) were evaluated in mature, lactating, Angus cows (n = 24) in early gestation to determine relationships between RuT, RT, and RR during thermoneutral and elevated ambient temperatures. Cows weighed 544 ± 10 kg with a BCS of 4.4 ± 0.1 (Wagner et al., 1988). Cows were managed in a drylot (0.25 ha) with access to shades (3 m^2 per head). Cows were allowed ad libitum prairie grass hay (6% CP; *Andropogon scoparius*, *Andropogon gerardii*) and water, and they received 1.8 kg/d of a 38% CP (DM basis) soybean meal–based supplement. Cows were administered active RuT boluses (8.25 cm × 3.17 cm; 114 g) with a balling gun. When the same type of bolus was placed into steers, it was recovered from the rumen at exsanguination (Rose-Dye et al., 2011). Bolus records (ID, RuT, date, and hour) were transmitted each hour by 3 receiver–repeater antennas to a base station receiver and PC data-recovery system (SmartStock LLC). Ambient temperature and relative humidity were recorded every 5 min during the experimental period (www.mesonet.org) from a weather station 8 km from the experimental site. Ruminal temperature, RT, and RR of cows were recorded at 1400 h on each of 2 sequential days when maximal ambient temperature was 36.8°C (d 1; **HT**) and 28°C (d 2; **WM**). Consumption of water can decrease reticular temperature in dairy cows (Bewley et al., 2008b). As a result, RuT associated with drinking events (RuT ≤2 × SD of the mean for a cow; Cooper-Prado et al., 2011) were excluded from analyses. Respiration rate was determined by counting chest movement of cows for 60 s. Within 10 min of RR determination, cows were secured in an alley and RT was measured with a digital thermometer (Agricultural Electronics, Montclair, CA; model # M216) at a depth of 10 to 15 cm. Respiration rates and RT were measured twice by each of 2 researchers within 2 min, and values were averaged.

Statistical Analyses

Effects of maximum temperature (**Tmax**; HT or WM) on RT, RR, and RuT were determined with PROC GLM (SAS Institute Inc., Cary, NC). Simple correlations between RT, RR, and RuT were determined with PROC CORR. Four cows were eliminated from the analyses because RuT boluses failed to function.

Exp. 2

Mature, spring-calving, Angus cows (n = 12, 4 to 7 yr of age) were used to evaluate the effect of Tamb on RuT. Cows weighed 537 ± 7 kg and had a BCS of 4.4 ± 0.1. Cows were managed in a drylot (0.25 ha) with access to shades (3 m^2 per head). Cows were fed as described for Exp. 1. Cows were administered RuT boluses with a balling gun. Bolus records (ID, RuT, date, and hour) were transmitted by 3 receiver–repeater antennas to a base station receiver and PC data-recovery system (SmartStock LLC). Ruminal temperatures were recorded every hour during 1 d in January (late gestation), 3 d in June (breeding), and 4 d in August (early gestation). Ruminal temperatures associated with drinking events (RuT ≤2 × SD of the mean for a cow) were excluded. Ambient temperature and relative humidity were recorded every 5 min during the experimental period (www.mesonet.org) from a weather station 8 km from the experimental site. The Tmax, minimum temperature (Tmin), mean Tamb, and THI (Thom, 1959) were calculated for each hour.

Statistical Analyses

The effects of diurnal variation in RuT were analyzed with PROC MIXED (SAS Inst. Inc.) with hour and environment (days when Tmax was ≤20°C, >20°C and <32°C, and ≥32°C) as fixed effects and environment × hour within cow as the experimental unit. Covariance structures were evaluated (compound symmetry, variance components, autoregressive, Toeplitz, unstructured, and Huynh-Feldt) for best model-fit criteria. Denominator degrees of freedom were calculated using Kenward-Roger ap-