2009

Effects of Surface Soil Temperature on Daily Water Intake in Feedlot Cattle

Rodrigo Arias
University of Nebraska-Lincoln

Terry L. Mader
University of Nebraska-Lincoln, tmader1@unl.edu

Effects of Surface Soil Temperature on Daily Water Intake in Feedlot Cattle

Rodrigo A. Arias
Terry L. Mader[1]

Summary

The relationships among soil surface temperature (SST), soil temperature (ST) (4 inches depth) and daily water intake (DWI) were studied using data collected between 2004 and 2006. The equations obtained through simple and polynomial linear regression were evaluated using data collected during the summer 2007. An overall model (May-October) and a summer model (June-August) were developed. The best fit was reached with the overall model using SST in a quadratic model ($r^2 = 0.86$), whereas the summer model fit linearly with SST ($r^2 = 0.70$). Both models tended to slightly over-predict DWI (13.5% and 12.5%, respectively).

Introduction

In order to adequately quantify environmental effects on thermal balance it is critical that environmental measures be obtained at appropriate locations. Ambient temperature (AT) is usually recorded at an 80 in height, whereas the typical steer height is approximately 55 in, with the middle of the animal estimated at around 35 in height. Likewise, AT decreases with height above ground surface (*2002, Nebraska Beef Report*, pp. 61-65). As a result of animal activity and precipitation, the physical properties of pen surfaces and soil change. There is a reduction in soil porosity due to compacting, which could alter the soil heat conductivity. Thus, we hypothesize that the surface soil temperature could be an important predictor of cattle thermal balance and daily water intake (DWI). Hence, our objective was to assess the use of surface soil temperature (SST) as a predictor of daily water intake in feedlot finished cattle.

Procedure

The relationships among DWI, SST, ST and tympanic temperature (TT) were established using information from a set of experiments conducted from 2002 to 2006. The SST and ST were collected from two weather stations located in the feedlot pens. The DWI was recorded daily for each set of two pens, which shared a common waterer. The data set was divided into two groups: the overall model representing the period May to October and the summer model representing the period June to August. Subsequently, a repeated measures analysis was conducted in order to compare the hourly differences among AT, ST and SST throughout the day. Data were analyzed graphically using Microsoft Office Excel 2007®, and statistically using JMP® and SAS®. Scatterplots and ANOVA were used to assess the relationship and differences among AT, SST and ST. Finally, simple linear and polynomial regression analyses were conducted to obtain DWI equations based on ST and/or SST. A finishing trial conducted during the summer 2007 at the Haskell Ag. Lab in Concord, Neb., was used to evaluate the predictive equations previously obtained. In this trial, 112 crossbred steers were finished (7 head/pen). The DWI, SST and ST were collected for a 51-day period, from June 26 to August 15. In addition, hourly TT was collected for a period of 7 days (July 5 to 12) as an indicator of cattle body temperature. The models were assessed using graphical representation of actual DWI, predicted DWI, and the analysis of the residuals of each model.

Results

Relationships among Air Temperature, Soil Temperature and Tympanic Temperature

The TT of animals follows a circadian rhythm, which is highly influenced by the surrounding environment. Figure 1 displays average hourly ST, SST, AT and TT for July 5-12, 2007. ST had the lowest variation through the day, showing greater values than AT late in the evening and during the night, but lower values than SST during the day. SST was the only variable that exhibited a pattern similar to TT. The ambient and soil temperatures changed with time of day as well as TT ($P < 0.0001$). ST was greater than AT between 2000 and 0900 hours, whereas no differences were found between 1000 and 1900 hours ($P > 0.05$). Likewise, SST showed similar values to AT between 2100 and

(Continued on next page)

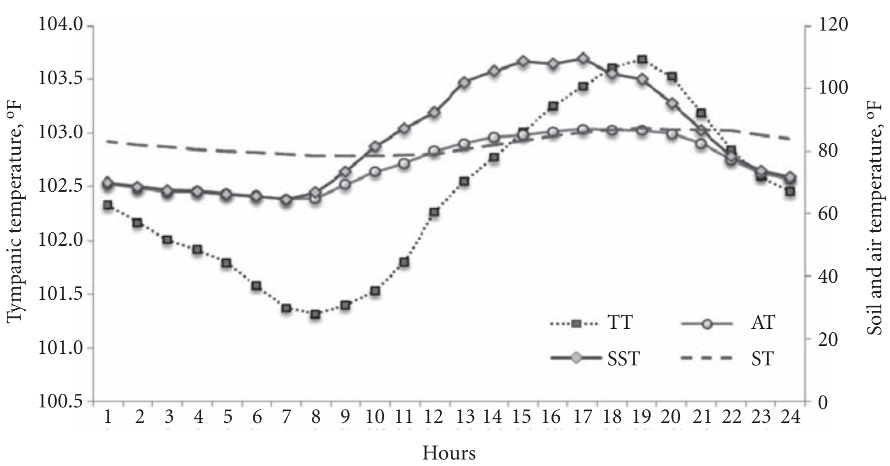

Figure 1. Relationship between surface soil temperature (SST), soil temperature (ST), air temperature (AT), and tympanic temperature (TT) from July 2007.

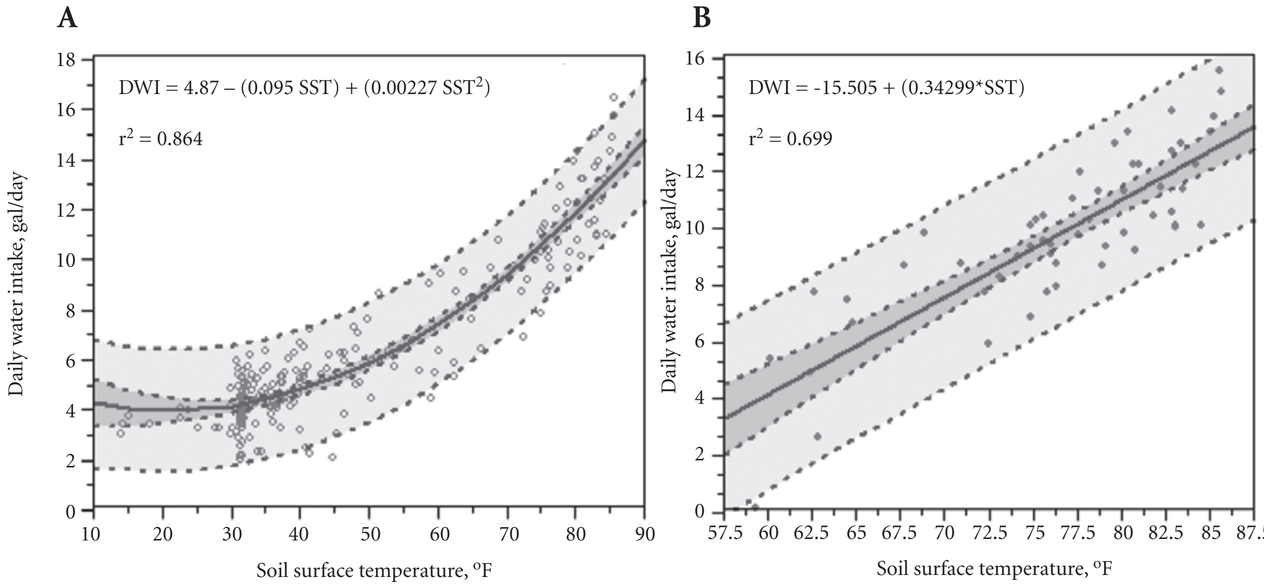

Figure 2. Linear and polynomial regression for daily water intake with surface soil temperature as predictor (A = May-Oct; B = June-August).

Table 1. Statistical summary for the period of evaluation (gallons per day).

Item	Actual free DWI	Summer Model	Overall Model
Mean	10.97	12.57	12.35
SE	(0.298)	(0.222)	(0.179)
Maximum	15.8	16.2	15.5
Minimum	3.8	9.4	9.9
Range	12.1	6.9	5.6

0700 hours ($P > 0.05$). SST seems to be influenced by solar radiation, since values increased quickly after sunrise, reaching their peak between 1300 and 1800 hours (solar radiation data not shown). For the period of study, SST was 8.3 and 1.7ºF greater than ST and AT, respectively (84.2 ± 0.8, 82.5 ± 0.8, and 75.9 ± 0.8, $P < 0.0001$), whereas the daily mean TT reached 102.46 ± 0.81ºF. Finally, during the day, AT and ST were similar.

Obtaining DWI Equations

The relationships among DWI, ST and SST were studied by simple linear regression analyses. The analyses were conducted for the overall data representing the period May to October (n = 211 and 362 for SST and ST, respectively, with n = number of days), and the summer data representing the period June to August (n = 97 and 115 for SST and ST, respectively). These analyses indicate SST was a better predictor of DWI than ST for the summer period ($r^2 = 0.70$ vs. 0.64 for SST and ST, respectively), as well as for the overall data ($r^2 = 0.82$ vs. 0.65 for SST and ST, respectively). Figure 2 displays the best fit of DWI using SST as a predictor. The best fit for the overall model was a quadratic relationship ($r^2 = 0.86$, Figure 2A), whereas in the summer model, the best fit was reached with a simple linear regression ($r^2 = 0.70$, Figure 2B).

Model Evaluation

The DWI and SST were collected for a period of 51 days, from June 26 to August 15. The SST records were used to predict the daily water consumption of cattle using equations presented in Figure 2. Table 1 summarizes the average values for actual and predicted DWI. In general, both equations tended to slightly overpredict DWI for each period of study (13.5% and 12.5% for the summer and overall models, respectively). Models properly calculated maximum DWI, but they failed in calculating minimum DWI. This greater variability in actual DWI indicates other factors may influence water consumption. For example, cloudy days may reduce the incidence of the incoming solar radiation and decrease water consumption (data not shown).

Limited information about the effects of soil temperature or soil surface temperature on cattle behavior is available. Previous studies conducted at the University of Nebraska–Lincoln have shown that sprinkling a feedlot pen modifies its microclimate. Water applications to the pen reduce the soil temperature as well as the temperature at 3 feet above the pen surface, and cattle move to and occupy these areas. This demonstrates that soil temperature conditions have a direct effect on the microclimate impacting cattle behavior. Likewise, soil is the main source of long-wave radiation that affects cattle thermal balance. When data from previous research studies were pooled (summer and winter), AT and temperature humidity index (THI) each explained approximately 55% of DWI variability. For data presented herein, r^2 values of 0.86 and 0.70 were obtained for the overall and the summer models, respectively. Therefore, SST seems to be a good predictor of DWI. However, feed yards across the United States present different types of soil textures, degree of soil compaction and organic matter content. All of these, plus other environmental factors, could affect heat conductivity properties, as well as the SST. In conclusion, ST has a significant effect on DWI, whereas SST appears to be a better predictor for DWI compared with other weather variables such as THI and AT.

---

[1]Rodrigo A. Arias, graduate student; Terry L. Mader, professor, Animal Science, Northeast Research and Extension Center, Concord, Neb.

