Environmental stress in confined beef cattle[1]

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ABSTRACT: The performance, health, and well being of cattle are strongly affected by climate. Almost annually, heat waves and/or periods of severe winter weather cause significant losses in one or more regions of the United States. In the past 10 yr, economic losses in the feedlot industry alone averaged between $10 million to $20 million/year as a result of adverse climatic conditions. For each animal that dies from climatic stress, corresponding economic losses approach $5,000 due to mortality and associated live animal performance losses. Management systems are needed that incorporate information and guidelines regarding cattle responses to weather challenges. Altering the microclimate by providing protection from the environment is one of the most useful tools to help animals cope with climatic conditions. For most cattle, facilities and management programs do not need to eliminate environmental stress completely, but rather minimize the severity of the environmental challenge and aid the animal in adapting to it. Inexpensive management alternatives, such as the use of bedding in winter or sprinklers in summer, need to be considered. When designing or modifying facilities, it is important that changes made to minimize impact of the environment in one season do not result in adverse effects on animals in another season. For instance, using permanent wind barriers to minimize cold stress in the winter for feedlot cattle may require that shade or sprinklers be provided in the summer to minimize heat stress. In addition to facility changes, dietary manipulation may be beneficial for cattle challenged by environmental conditions.

Key Words: Beef Cattle, Environment, Feed Intake, Management Alternatives, Stress

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Introduction

Whereas new knowledge about animal responses to the environment continues to be developed, managing cattle to reduce the impact of climate remains a challenge (Hahn, 1995, 1999; Sprott et al., 2001). In particular, additional environmental management strategies are needed to guide managers when making decisions prior to and during periods of adverse weather (Mader, 1986; Mader et al., 1997a; Mader and Davis, 2002). In 1992, 1995, 1997, and 1999, individual feedlots lost in excess of 100 animals during severe heat episodes. The heat waves of 1995 and 1999 were particularly severe, with cattle losses in individual Midwestern states approaching 5,000 animals each year (Busby and Loy, 1996; Hahn and Mader, 1997; Hahn et al., 2001). Early snowstorms in 1992 and 1997 resulted in the loss of over 30,000 head of feedlot cattle each year in the Southern Plains of the United States. The winter of 1996/1997 also caused hardship for cattle producers because of greater than normal snowfall and wind with up to 50% of the newborn calves being lost in many areas, and over 100,000 head of cattle lost in the Northern Plains states. In addition to losses in the 1990s, in the winter of 2000/2001 (Hoelscher, 2001a,b,c), feedlot cattle efficiencies of gain and daily gain decreased approximately 5 and 10%, respectively, from previous years as a result of late-autumn and early-winter moisture combined with prolonged cold stress conditions. These recent examples suggest that rational, cost-effective management systems are needed to reduce climate-related losses in feedlot cattle. Hahn (1999) has previously provided a detailed review of how the animal responds to thermal heat loads. This report summarizes results that support improvements in environmental management of cattle cared for in feedlots during both hot and cold weather. Application of these strategies can be extended to the cow-calf and stocker cattle segments of the industry when they are managed in confined areas.

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Table 1. Effect of adding bedding (wheat straw) to feedlot pen surfaces during winter and spring[a]

	None	Bedding	SE
Initial weight, kg	293	293	2.7
Final weight, kg	653	655	4.5
Daily DMI, kg			
d 0 to 67	6.73	6.63	0.09
d 68 to 172	9.35	9.55	0.11
d 0 to 172	8.33	8.41	0.11
ADG, kg			
d 0 to 67	1.36	1.41	0.03
d 68 to 172[b]	1.36	1.49	0.01
d 0 to 172[b]	1.36	1.46	0.02
Feed:gain[c]			
d 0 to 67	4.95 (0.202)	4.70 (0.213)	0.14
d 68 to 172[b]	6.90 (0.145)	6.44 (0.155)	0.06
d 0 to 172[b]	6.14 (0.163)	5.77 (0.173)	0.09

[a] Pooled analysis of studies, weighted by the number of pens per treatment, per trial, conducted by Birkelo and Lounsbery (1992) and Stanton and Schultz (1996). Approximate harvest dates for cattle were middle to late May.

[b] Means differ ($P < 0.05$).

[c] Parenthetical numbers are gain:feed.

Management Strategies

Cold Mitigation Strategies. One of the quickest methods of minimizing cold stress is to provide insulation or shelter for the animal. If bedding is used, the added residue contributes to added waste in the pens. In addition, if the bedding constitutes a fibrous feed source, cattle will sometimes consume the bedding instead of their normal high-energy diet, thereby reducing ME intake and performance. Nevertheless, a summary of two trials conducted in South Dakota (Birkelo and Lounsbery, 1992) and Colorado (Stanton and Schultz, 1996) found that providing approximately 1 kg of straw/animal daily as bedding during the feeding period improved gains approximately 7% and efficiency of gains more than 6% (Table 1). The benefits of bedding were not observed in the early part of these studies, but rather in the last 90 to 100 d of each study, which corresponds to the late-winter and early-spring feeding period. It is during this time that cattle in these studies were heavier, and the adverse effects of wetter conditions and mud would likely be most prevalent and difficult for cattle to cope with. In these studies, the economic benefit of providing bedding averaged $11/animal after taking into account bedding cost.

Additional feedlot studies (Mader et al., 1997a), involving both heat and cold challenges, have been conducted to evaluate year-round effects of shelterbelts or tree wind breaks provided for winter wind protection. A series of feeding trials were conducted during each season of a 3-yr period in which cattle were fed in outside lots with access to shelter or shelterbelts (tree windbreak north and northwest of pens) or outside lots with no access to shelter or a windbreak. Performance of yearling animals was not improved during the winter by providing wind protection, possibly because normal to slightly better than normal winter feeding conditions existed during the years that trials were conducted (Table 2). Also, providing wind protection or shelter resulted in decreased cattle gains in the summer. However, cattle fed in the unprotected area did have greater fat thickness in the winter and greater intramuscular fat in the winter and autumn than cattle fed in protected areas. In a follow-up study, performance of heavier steers fed during a 2- to 3-mo feeding period was severely impaired when protection was not provided in the winter (Table 3). Data from these studies indicate that benefits of feeding cattle in sheltered or protected areas in the winter can be offset by lower performance experienced by cattle fed in those same areas in the summer. However, as cattle approach slaughter weights, the benefits of providing protection from cold challenge are greatly increased. In addition, fat deposition was enhanced in cattle exposed to moderate cold stress and maintained by cattle exposed to more severe cold stress even though performance was reduced.

Other studies (Mader et al., 2001) were conducted at the University of Nebraska to evaluate the effect of diet energy level and/or energy level adjustments on finishing steer performance. In winter trials, two levels of alfalfa hay (7.5%, Low and 15%, High) along with two diet switch feeding regimens (7.5 to 15%, Low-High and 15 to 7.5% alfalfa hay, High-Low), with the switch occurring under cold stress conditions, were fed in two facilities (with and without wind protection). The common feedlot practice of switching from low- to high-roughage diets was not found to be beneficial. For cattle exposed to the greatest cold stress (fed in facilities without wind protection provided), the opposite was found in that switching from high to low roughage diets appeared to be the most beneficial. The extra ME from starch would appear to be more beneficial than the extra heat increment derived from fiber.

Proper feedlot pen layout and design are also crucial for minimizing effects of adverse climates. Mounds need to be built into feedlot pens, especially in the Northern Plains and Western Cornbelt of the United States, to minimize mud problems during wet periods and enhance airflow during hot periods. Proper design and strategic use of windbreaks is also warranted. Mader et al. (1997a) found that feedlot cattle do not necessarily need wind protection in moderate winters; however, if wind protection is provided, it is best to place it outside the pen to prevent excessive drifting of snow into the pens. Windbreaks will provide protection downwind to a distance of 5 to 10 times their height. Tree shelterbelts should be a minimum of 25 m from fence lines, whereas other forms of protection, mainly temporary, can be set closer. If a windbreak is located very near pens, it should have 10 to 20% open space to allow some air movement through the windbreak to prevent excessive drifting in front of the shelter, which adds to snow buildup and moisture in pens. If possible, having any wind protection near cattle in the summer should be avoided.

Table 2. Effect of facility and season on feedlot steers (3-yr summary)

	Facility^{a}				
Variable	OS	SP	NP	SEM	Season mean
ADG, kg					
Winter	1.40	1.44	1.47	0.03	1.42 ± 0.02^{b}
Spring	1.51	1.50	1.47	0.02	1.50 ± 0.02^{c}
Summer	1.37^{f}	1.34^{f}	1.48^{g}	0.04	1.40 ± 0.02^{b}
Autumn	1.40	1.42	1.42	0.04	1.44 ± 0.02^{bc}
Facility mean	1.43	1.43	1.46	0.02	
Daily DMI, kg					
Winter	9.68	9.50	9.77	0.10	9.68 ± 0.11^{c}
Spring	9.02	8.88	8.94	0.10	8.97 ± 0.09^{b}
Summer	10.16	10.00	10.38	0.15	10.15 ± 0.10^{d}
Autumn	10.53	10.60	10.48	0.18	10.65 ± 0.11^{e}
Facility mean	9.88	9.78	9.93	0.09	
DMI, percentage of BW					
Winter	2.22	2.17	2.22	0.02	2.21 ± 0.02^{b}
Spring	2.21	2.18	2.20	0.02	2.19 ± 0.02^{b}
Summer	2.20	2.14	2.21	0.03	2.18 ± 0.02^{b}
Autumn	2.33	2.33	2.33	0.04	2.35 ± 0.02^{c}
Facility mean	2.24	2.21	2.24	0.02	
Feed:gain					
Winter	6.97	6.66	6.77	0.13	6.90 ± 0.12^{c}
Spring	5.99	5.93	6.10	0.09	6.01 ± 0.10^{b}
Summer	7.43	7.52	7.04	0.19	7.32 ± 0.10^{d}
Autumn	7.58	7.52	7.39	0.24	7.45 ± 0.12^{d}
Facility mean	6.99	6.92	6.85	0.10	
Fat thickness, cm					
Winter	1.38^{h}	1.37^{h}	1.62^{i}	0.06	1.43 ± 0.04^{d}
Spring	1.40	1.44	1.50	0.04	1.45 ± 0.03^{d}
Summer	1.09	1.03	1.09	0.05	1.07 ± 0.03^{b}
Autumn	1.29	1.15	1.24	0.06	1.23 ± 0.04^{c}
Facility mean	1.29^{hi}	1.24^{h}	1.35^{i}	0.03	
Marbling score^{j}					
Winter	5.54^{h}	5.45^{h}	5.82^{i}	0.08	5.59 ± 0.07^{d}
Spring	5.41	5.37	5.38	0.07	5.36 ± 0.05^{b}
Summer	5.35	5.30	5.55	0.09	5.39 ± 0.06^{bc}
Autumn	5.41^{f}	5.41^{f}	5.67^{g}	0.09	5.54 ± 0.07^{cd}
Facility mean	5.42^{h}	5.38^{h}	5.60^{i}	0.05	
Quality grade^{k}					
Winter	7.20^{hi}	7.13^{h}	7.30^{i}	0.04	7.20 ± 0.03^{c}
Spring	7.13	7.12	7.11	0.03	7.11 ± 0.02^{b}
Summer	7.10^{fg}	7.06^{f}	7.18^{g}	0.04	7.11 ± 0.02^{b}
Autumn	7.08^{h}	7.06^{h}	7.24^{i}	0.04	7.16 ± 0.03^{bc}
Facility mean	7.13^{h}	7.09^{h}	7.21^{i}	0.02	

[a] OP = overhead shelter enclosed on the north side; SP = shelterbelt to north and northwest; NP = no wind protection.

[b,c,d,e] Seasonal means within a column bearing different superscripts differ ($P < 0.05$).

[f,g] Facility means within a row bearing different superscripts differ ($P < 0.10$).

[h,i] Facility means within a row bearing different superscripts differ ($P < 0.05$).

[j] 4.5 = average slight; 5.5 = average small.

[k] 6.5 = average select; 7.5 = average choice.

Heat Mitigation Strategies. In restricted-feeding studies, Mader, et al. (1999b) housed feedlot steers under thermoneutral or hot environmental conditions. Steers were offered a 6% roughage finishing diet ad libitum (**HE)**, offered the same diet restricted to 85 to 90% of ad libitum DMI levels (**RE**), or offered a 28% roughage diet ad libitum (**HR**). Steers fed the HR diet tended to have lower respiratory rates and significantly lower body temperatures under hot conditions than HE- and RE-fed steers, whereas RE-fed steers had significantly lower body temperature than HE-fed steers (Figure 1). The lower body temperature of the HR- and RE-fed steers would indicate that ME intake prior to exposure to excessive heat load influences the ability of cattle to cope with the challenge of hot environments and that lowering ME intake can lower body temperature.

In regard to the use of restricted or managed feeding programs, Galyean (1999) provided an excellent review of concepts and research. Benefits of using restricted-feeding programs under hot conditions have been re-

Table 3. Effect of winter weather stress and harvest date on short-fed feedlot steers[a]

	Windbreak (WB)			No wind protection (NWB)			
Item	Heavy	Light	Mean	Heavy	Light	Mean	SE
Initial weight, kg[b]	475	432	454	480	441	460	2
Final weight, kg[cd]	533	542	537	515	528	521	5
Days on feed	51	86	69	51	86	69	
ADG, kg[cd]	1.12	1.28	1.20	0.69	1.01	0.85	0.07
Daily DMI, kg[b]	10.39	9.54	9.97	9.98	9.45	9.72	0.14
Feed:gain[cde]	9.30 (0.108)	7.44 (0.134)	8.37 (0.120)	14.76 (0.68)	9.41 (0.106)	12.09 (0.085)	0.73
Fat thickness, cm	0.97	0.97	0.97	0.94	0.99	0.97	0.04
Quality grade[bf]	7.02	7.31	7.16	7.08	7.25	7.17	0.03
Yield grade	2.3	2.2	2.3	2.3	2.3	2.3	0.1

[a] Harvest dates were January 28 and March 3 for the heavy and light groups, respectively. Windbreak and no wind protection = feedlot location; heavy, light, mean = weight group.

[b] Heavy vs. light group ($P < 0.10$).

[c] WB vs. NWB ($P < 0.10$).

[d] Determined from hot carcass weight divided by 0.62.

[e] Parenthetical numbers represent gain:feed.

[f] 6.5 = average select; 7.5 = average choice.

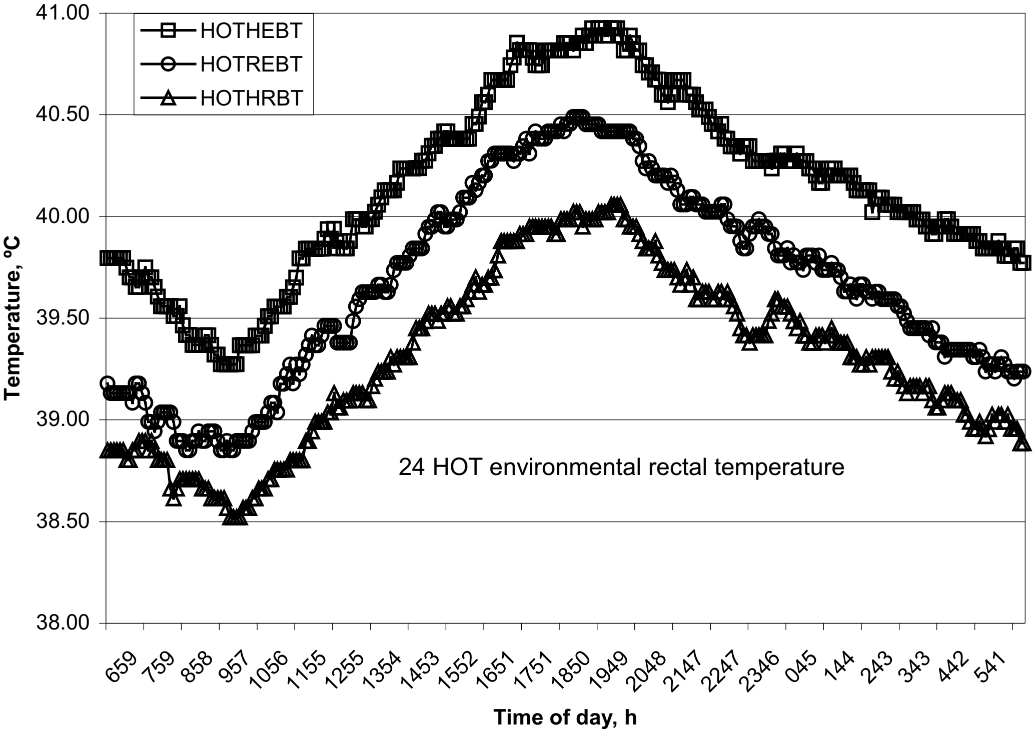
ported by Mader et al. (2002). In addition, Reinhardt and Brandt (1994) found the use of restricted feeding programs to be particularly effective when cattle were fed in the late afternoon or evening vs. morning. Implementing a bunk management regimen, whereby bunks are kept empty for 4 to 6 h during the daytime hours could be used to minimize peak metabolic heat load occurring simultaneously to peak climatic heat load. Even though this forces the cattle to eat in the evening, it does not appear to increase night-time body temperature (Davis et al., 2002) provided bunks are kept empty a few hours prior to feeding. Although slight feed intake reductions can occur with bunk management programs, particularly when they are first implemented, benefits of both bunk management and restricted-feeding programs are observed for several days after cattle are moved to a normal feeding program (Figure 2).

In addition to altering feeding regimen, sprinkling can be effective in minimizing heat stress. Benefits of sprinkling tend to be enhanced if sprinkling is started in the morning, prior to cattle getting hot (Figure 3; Davis et al., 2002). These data also show significant benefits to sprinkling or wetting pen surfaces. Sprinkling of pen surfaces may be as much or more beneficial than sprinkling the cattle. Kelly et al. (1950) reported feedlot ground surface temperatures in excess of 65°C by 1400 in Southern California. Cooling the surface would appear to provide a heat sink for cattle to dissipate body heat, thus allowing cattle to better adapt to environmental conditions vs. adapting to being wetted. Wetting or sprinkling can have adverse effects, particularly when the cattle get acclimated to being wet and failed or incomplete sprinkling occurs during subsequent hot days (Davis, 2001).

Shade also has been found to be beneficial for feedlot cattle exposed to hot climatic conditions; however, in research conducted in northeast Nebraska (Mader et al., 1999a), positive benefits occurred only in the early portion of the feeding period and only in cattle with wind barriers provided. In this study, three summertime trials were conducted over consecutive years. Shaded and unshaded cattle were fed in pens with or without wind protection provided. Performance was similar for shaded and unshaded cattle fed in the facility without wind barriers provided; some benefit to shade was found in facilities that had wind barriers provided. In general, the response to shade occurred within the first 56 d of the feeding period, even though shade use tended to increase with time cattle were on feed. This suggests that cattle must adapt to shade or social order around and under shade before optimal shade use occurs. Although no heat-related cattle deaths occurred in this study (Mader et al., 1999a), these results suggest that shade improves performance in the summer when cattle are fed in facilities that restrict airflow and for cattle that have not become acclimated to hot conditions. Once cattle are acclimated or hot conditions subside, compensation by unshaded cattle offsets much of the benefits of providing shade.

Benefits of using shade would most likely be found in areas with greater temperature and/or solar radiation (Figure 4; Hahn et al., 2001). More consistent benefits of using shade would likely occur the further south cattle are in the United States. Mitlöhner et al. (2001) found excellent results to providing shade for cattle fed near Lubbock, TX. The overall economic benefit of using shade depends not only on location, but also on cost of structures and maintenance. Also, heat stress is dependent not only on temperature and solar radiation, but also on humidity and wind speed. Adjustments for humidity can be made by using the temperature-humidity index (NOAA, 1976; Hubbard et al., 1999), which has been adapted for use in the livestock safety index (Livestock Conservation Institute, 1970). Adjustments for solar radiation and wind speed have also been developed and need to be considered for when predicting heat stress (Davis, 2001).

In contrast to hot environment results, when cattle were exposed to cold conditions at or below thermoneutral levels, feeding higher-energy diets tended to enhance cattle performance when compared with feeding higher-roughage (lower energy) diets (Mader et al., 2001). An elevated metabolic rate is indicative of metabolic adaptation to cold stress. Thus, a need exists for greater ME intake in the winter to minimize cold stress, whereas in a hot environment, animals must dissipate metabolic heat when there is a reduced thermal gradi-



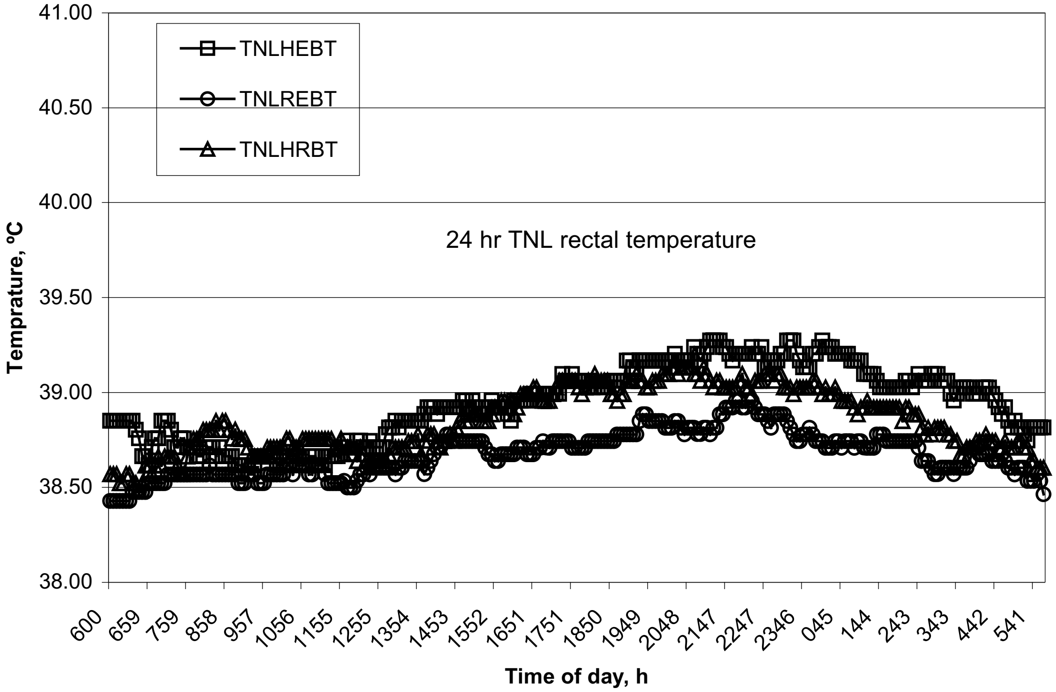


Figure 1. Body temperature (BT) of cattle exposed to thermoneutral (TNL) or hot (HOT) environments and fed a 6% roughage, high-energy diet ad libitum (HE) or restricted to 90% of ad libitum (RE) or fed ad libitum a 28% roughage diet (HR). Standard error = 0.1. Figure was derived from Mader et al. (1999b).

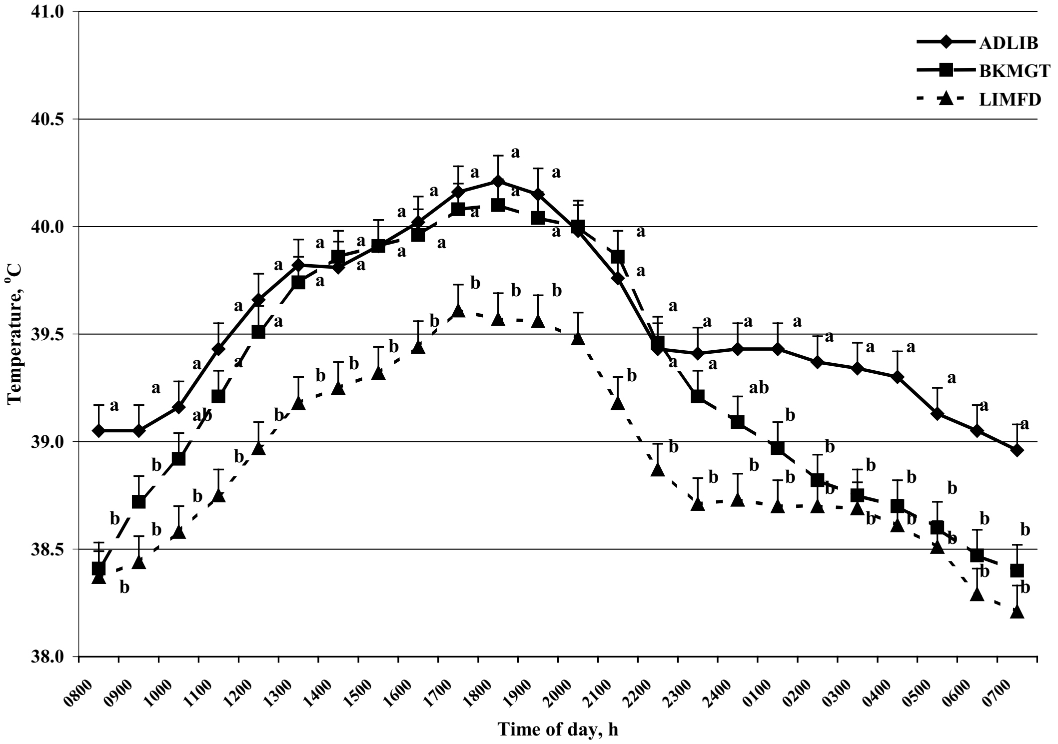


Figure 2. Carryover of previous nutritional regimen on tympanic temperature (TT) of steers during severe heat stress conditions (mean daily temperature-humidity index > 77). At the time these TT were obtained, all steers had been fed ad libitum. Treatments had been imposed for a 23-d period, which had ended approximately one week prior to taking TT. The treatments were as follows: ADLIB steers had been fed ad libitum at 0800; bunk management (BKMGT) steers had been fed at 1600 with bunks empty at 0800; and limit-fed (LIMFD) steers had been fed 85% of predicted ad libitum intake at 1600. ^{a,b}Means within a time with unlike superscripts differ ($P < 0.05$).

ent between the body core and the environment. The higher-producing animals, which consume more feed, thereby creating more metabolic heat, would appear to be more susceptible to heat stress. In addition, evaporation of moisture from the skin surface (sweating) or respiratory tract (panting) is the primary mechanism used by the animals to lose excess body heat in a hot environment. Under these conditions, waterer space available and water intake per animal becomes very important. During heat episodes, Mader et al. (1997b) found that as much as three times the normal waterer space (7.5 vs. 2.5 cm of linear space per animal) may be needed to allow for sufficient room for all animals to access and benefit from available water.

Intake and Net Energy for Maintenance Requirement Considerations

Although management strategies can be implemented to buffer the animal against adverse environmental conditions, the primary factors limiting the precision of predicting performance is our ability to predict DMI (Hicks, et al., 1990). Additionally, a key component of performance is our ability to predict NE_m requirements of cattle, particularly when they are exposed to adverse climatic conditions.

The effects of ambient temperature (**T**) on DMI, as described in the NRC (1996), are based on incremental change in T with adjustments ranging from a 16% increase for T between –15°C and –5°C to –35% for T > 35°C and no night cooling taking place. Although large variation exists among cattle relative to the effect of T on DMI, the general relationships can be determined. Separate hot- and cold-condition DMI curves can be defined from existing databases (Table 4). In addition, a polynomial equation can be determined that fits a full range of T (Table 4, Figure 5). However, the influence of no nighttime cooling on DMI is not completely accounted for in this equation. Frank et al. (2001) derived an algorithm that assumes the average effects of T on DMI at T > 24°C were in between those observed with and without night cooling. The percentage change in DMI was equal to

$$(1 - \{(T - 24) \times [0.01 + 0.0015 \times (T - 24)]\}) \times 100$$

At an average T of 40°C, this equation would predict DMI to be approximately 50% of normal in feedlot cattle, which is a very likely scenario; however, it may not be the case for all cattle in general.

To better account for effects of no nighttime cooling mentioned in NRC (1996), the negative effects of rela-

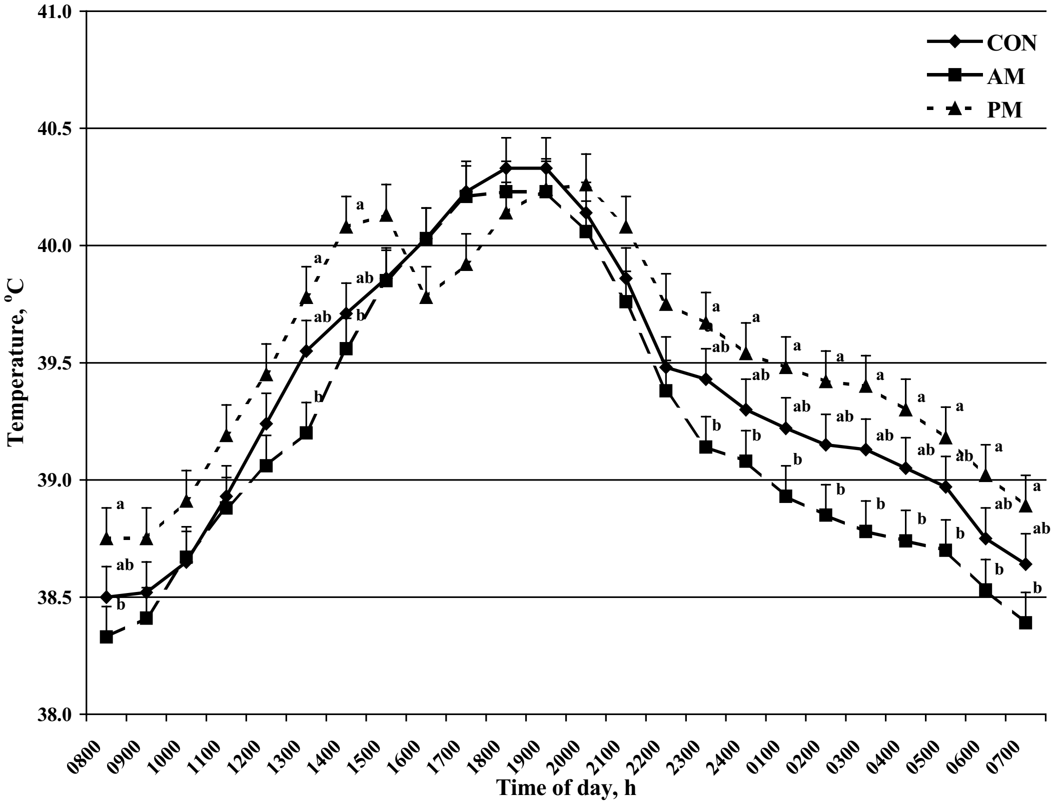


Figure 3. Tympanic temperatures of steers during severe heat stress (mean daily temperature-humidity index > 77). No water was applied to control (CON) mounds, versus mounds were sprinkled between 1000 and 1200 (AM) and 1400 and 1600 (PM), respectively. ^{a,b}Means within a time with unlike superscripts differ ($P < 0.05$).

tive humidity (**RH**) on the evaporative cooling process need to be considered. The ability of cattle to lose body heat (cool down) at night is dependent not only on T, but also on atmospheric moisture levels, or more specifically, RH, at night. Generally, RH is lower during daytime hours, but reach maxima when nighttime temperatures are typically the lowest, between 0400 and 0800 (Davis, 2001). Cattle feeding areas in the Southern Plains (AZ, NM, Western TX) often have high T during the day, but can cool more and quicker at night due to the low RH, whereas cattle fed in the Western Cornbelt can be subjected to more heat stress as a result of high RH even though actual average temperatures may be less than those found in the southern Plains.

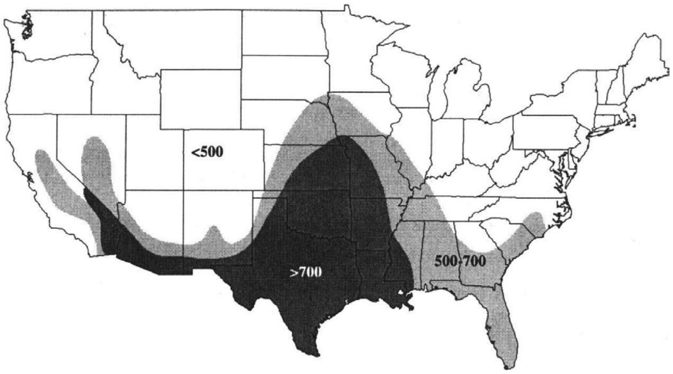


Figure 4. Areas of the mainland United States having selected categories of yearly hours above 85°F (Hahn et al., 2001). Areas >700 h would likely benefit the most from shade.

The temperature-humidity index (**THI**) was developed to adjust effects of T for RH. Under hot conditions, assuming thermoneutral conditions range between 15 and 25°C (NRC, 1996), a separate equation (Table 4) can be used to describe effects of THI on DMI. Using the THI equation more effectively accounts for the nighttime cooling effects on DMI. In addition, an increase in NE_m requirements is found in cattle exposed to hot conditions. The NE_m increase is largely dependent on the level and intensity of panting (NRC, 1981; 1996). However, NE_m requirements under hot conditions are also dependent on body condition. Cattle with greater body condition begin displaying signs of heat stress sooner than those with less body condition. By combining data reported in NRC (1981) and Davis (2001), an adjustment for body condition score can be incorporated into a NE_m requirement (Table 4), based on THI. In this analysis, it is assumed that the BCS of cattle in previously reported studies (NRC, 1981) averaged 5 (scale of 1 to 9).

In contrast to developed algorithms shown in Table 4 and Figure 5, DMI data shown in Table 2 indicates

Table 4. Regression of temperature (T), temperature humidity index (THI), and body condition score (BCS) on percentage change in feedlot cattle DMI and NE_m requirement[a]

Response variable and independent variable	Regression coefficient (SE)	R^2
DMI (T < 16°C)		
Intercept	5.1 (0.127)**	0.999
T	–0.15 (0.016)*	
T × T	–0.0019 (0.00077)	
T × T × T	–0.00054 (0.000048)*	
DMI (T > 24°C)		
Intercept	–33.0 (27.38)	0.997
T	3.65 (1.759)	
T × T	–0.0948 (0.0276)	
DMI (Full T Range)		0.998
Intercept	4.65 (0.233)**	
T	–0.080 (0.0187)**	
T × T	0.00551 (0.000835)**	
T × T × T	–0.00047 (0.000035)**	
T × T × T × T	–0.0000043 (0.0000006)**	
T × T × T × T × T	–0.000000059 (0.00000002)**	
DMI (THI > 70)		
Intercept	–229.74 (105.472)	0.997
THI	7.2125 (2.63341)	
THI × THI	–0.0561 (0.016341)	
NEm (THI > 65 and BCS > 5)		
Intercept	–64.94 (3.673)**	0.994
THI	0.905 (0.034)**	
BCS	1.21 (0.41)**	

[a] THI = (0.8 × T) + [(% relative humidity/100) × (T – 14.3)] + 46.4.

*$P < 0.10$.

**$P < 0.05$.

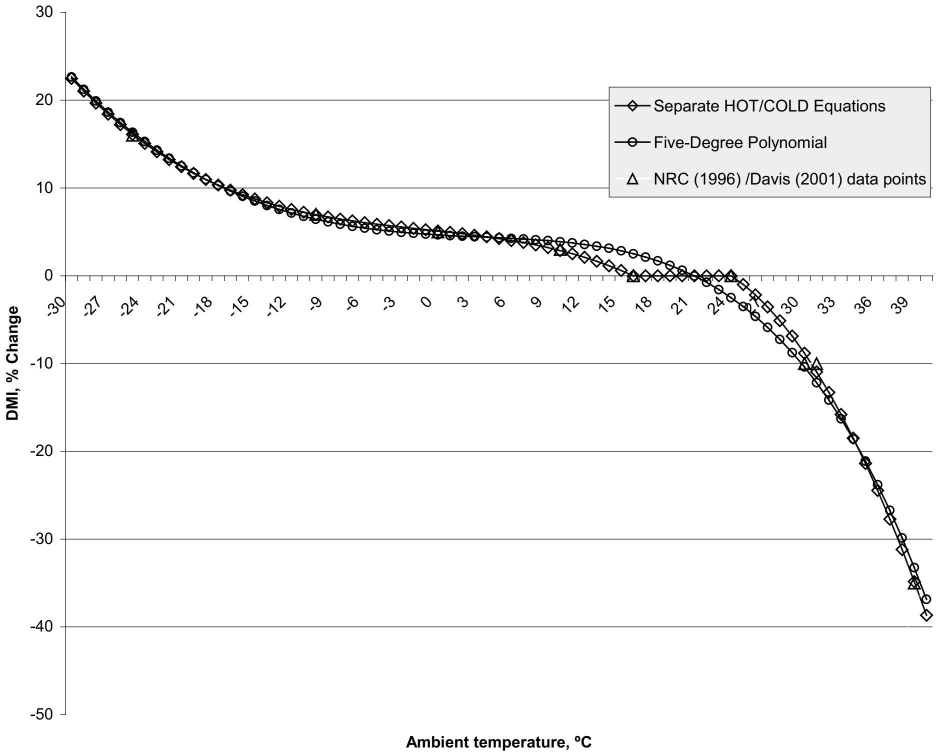


Figure 5. Graphical representation of the effects of temperature (T) on DMI, based on equations defining separate curves for 16°C > T > 24°C (HOT/COLD), a best fit 5° polynomial curve, and base value data points.

nonexistent differential intakes between summer- vs. winter-fed cattle. However, Kreikemeier and Mader (2002) reported over 20% greater DMI in winter vs. summer feedlot feeding studies. As indicated previously, large variation in DMI can exist in feedlot cattle. Seasonal patterns are likely dependent on normal vs. abnormal environmental conditions, as well as variations in these conditions. Short-term, sharp declines in DMI may be observed more often in the winter than in the summer due to the effects of winter storms that often accompany changing ambient temperatures (NRC, 1987). Lower DMI in the winter could be attributed to decreases in effective pen or bunk space due to pen conditions and/or negative social interactions among cattle. In addition, energy-dense diets provided to feedlot cattle and associated acidic end-products of fermentation are also factors limiting DMI (NRC, 1987). Increases in DMI brought on by cold stress, for instance, may be limited unless diet soluble starch content is reduced.

Implications

Beef cattle are traditionally managed outdoors with exposure to natural and variable environmental conditions. Cattle are particularly vulnerable not only to extreme environmental conditions, but also to rapid changes in these conditions. Management alternatives, such as the strategic use of wind protection and bedding in the winter or sprinklers and shade in the summer, need to be considered to help cattle cope with adverse conditions. In addition to these changes, manipulation of diet energy density and intake may also be beneficial for cattle challenged by environmental conditions. Algorithms designed to predict effects of environmental conditions on dry matter intake and maintenance energy requirements can be used with currently accepted prediction equations to better define and predict impact of the environment on beef cattle.

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