Body Temperature in Feedlot Cattle

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Abstract

Body temperature is often used as an indicator of animal health status. In addition, body temperature can be used as a measure of heat stress, which occurs during the summer months and significantly impacts cattle performance and well-being. In a series of heat stress management and handling studies, tympanic temperatures (TT), an indicator of body temperature, were obtained in unrestrained feedlot cattle. In management studies, restricting feed intake to 85% of *ad libitum* lowered TT approximately 0.9 °F (0.5 °C), even after the period of feed restriction ended. Sprinkling feedlot surfaces was more effective in cooling cattle if sprinkling was done in the morning versus in the afternoon. Also, during hot days, TT of black-hided cattle can be over 0.9 °F (0.5 °C) greater than TT of white-hided cattle. In handling studies, moving cattle through working facilities requires an expenditure of energy causing an elevation of average body temperature between 0.5 and 1.4 °F (0.3 and 0.8 °C), depending on the ambient conditions. Effects of cattle movement and handling on body temperature needs to be taken into account when evaluating animal health studies. In addition, strategies designed to reduce the detrimental effects of heat stress while maintaining animal productivity need to be implemented. Furthermore, minimal handling of cattle during hot days is recommended for promoting animal well-being and comfort.

Introduction

Heat stress during the summer months severely impacts feedlot cattle and under severe circumstances can result in death. In the 1990s, four heat events in the high plains and western cornbelt resulted in the confirmed deaths of over 10,000 head of feedlot cattle[1,2,3]. These heat episodes were similar in that their duration was less than 5 d, with immense monetary impact. Smiley[5] estimated the losses as a result of a 1995 heat wave to be $31 million in Iowa alone, with additional losses throughout the Northern Plains and Cornbelt. Mader *et al*[4] estimated direct and indirect losses (cattle death and loss of performance) as a result of adverse weather averaged between $4,000 and $5,000 for each animal that dies.

Management strategies involving restricting or altering feed intake pattern may be helpful in reducing the effects of heat stress. By lowering feed intake, maintenance energy requirements are reduced as is overall metabolic heat production. In early studies[3], feedlot steers housed under thermoneutral or hot environmental conditions while being fed a high-energy diet (6% roughage) restricted to 85 to 90 % of ad libitum or fed a 28% roughage diet ad libitum, had significantly lower body temperature (BT) under hot conditions than steers fed the high-energy finishing diet ad libitum (Figure 1). The lower BT of the steers fed higher roughage diets or restricted in intake would indicate that ME intake prior to exposure to excessive heat load allows cattle to better cope with the challenge of hot environments.

In addition to heat stress, processing cattle may also elevate body temperature. In the United States, nearly 10 million head of cattle are being fed in feedlots

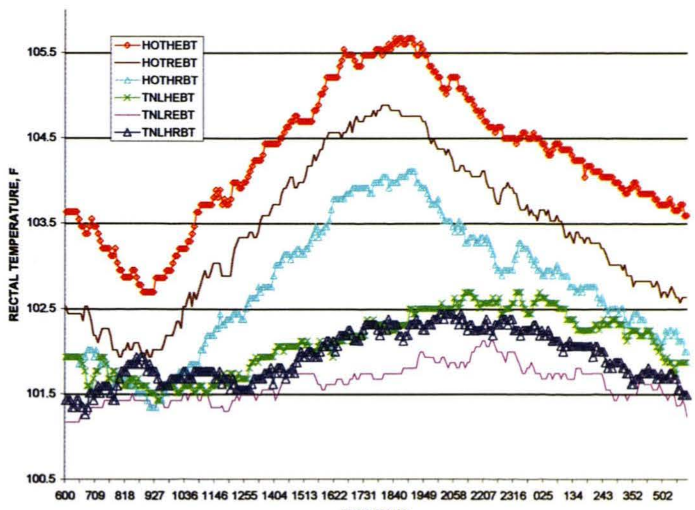

Figure 1. Rectal temperature (BT) of cattle exposed to thermoneutral (TNL) or hot (HOT) environments and fed a 6% roughage, high energy diet *ad libitum* (HE) or restricted to 90% of *ad libitum* (RE) or fed *ad libitum* a 28% roughage diet (HR).

at any one time. Generally, cattle are processed (vaccinated, treated for parasites, receive a growth implant and provided an eartag for identification) within a few days of coming into the feedlot. In addition, a significant number of cattle are returned to the processing facilities to receive health care or to be re-implanted with a growth promotant. The effect of activity on body temperature is important if temperature is used as an indicator of health status. The objective of these studies was to evaluate effects of cattle movement in the feedyard and quantitate body temperature of animals moved various distances and at different times during the year. In addition, effects of strategies to mitigate heat stress were evaluated.

Research Methods

Heat stress studies

In Experiment 1 (Exp. 1), 144 yearling steers were used in a completely randomized design to evaluate the effects of altered feeding time and(or) amount of feed on performance, tympanic temperature and eating behavior of feedlot steers. Steers were weighed and randomly assigned to pens. Treatments were imposed for 22 d during the projected hottest portion of the summer, and consisted of: 1) steers provided *ad libitum* access to a high energy finishing diet fed at 0800 h (ADLIB); 2) steers fed at 1600 h with feed amount adjusted so that no feed was available at 0800 (BKMGT); or 3) steers fed at 1600 h at 85% of predicted *ad libitum* levels (LIMFD). At the end of a 23-d period (managed feeding period), all steers were fed *ad libitum* at 0800 h (AL). Feed and water intake were recorded daily. Body weights were obtained on days 0, 23 and 82 (termination of the trial). On day 10, 24 steers (8 hd/treatment) were fitted with a datalogger attached to a thermistor to record tympanic temperature on an hourly basis. These devices were removed on day 23. The process was repeated on day 36 to 41.

In Experiment 2 (Exp. 2), 96 Angus crossbred yearling steers were used to evaluate the effects of cooling pen surfaces (dirt mounds) as a means to minimize heat stress. Treatments consisted of: 1) control, no water application; 2) water applied to the mounds between 1000 and 1200 h (AM); and 3) water applied to the mounds between 1400 and 1600 h (PM). Water was applied using ground level water sprinklers on days when the maximum temperature-humidity index (THI) was predicted to exceed 77. Tympanic temperatures were obtained for four consecutive days (28 to 31) in which sprinklers were operational. Feed and water intakes were recorded daily, while BW was obtained on days 0, 35 and 82 (termination of the trial).

Handling Studies

Two winter and two summer experiments were conducted utilizing yearling feedlot cattle being fed a high-energy finishing diet. Studies were conducted in the following order; January, February, August and June, respectively. In the first winter study, five animals from one pen were moved from the pen through the working facilities and back into the pen. Cattle were moved at 0800 and 1500 h. Total distance moved each time was approximately 500 feet (150m or 75m one-way). Animals were moved two days and allowed a day of rest before and in-between the days moved. In the second winter study, six animals from one pen were moved from the pen through the working facilities and back into the pen. Cattle were moved only once at approximately 0945 h. Total distance moved was approximately 1,000 feet (300 m). Animals were moved two days in a row and allowed a rest day before and after the days that they were moved. In both of these studies, cattle were allowed to move at a constant pace. They were moved to the facilities, briefly delayed in the working facilities, and returned to the pens. Total moving time was approximately 15 minutes, but varied between 5 and 25 minutes.

In the first summer study eight animals were placed in two pens (four head/pen). On day one and two, one pen of cattle was moved through the working facilities a short distance of approximately 500 feet (150m) and the other pen was moved a longer distance, approximately 2,000 feet (600m), through the working facilities and back to their pens. Cattle were allowed two days of rest and moved again over the next two days. Moving distance (short vs long) assignments were reversed for each pen of cattle on the second set of moving days. Mean starting time for moving the cattle was at 0906 h. In the second summer study, 18 animals were placed in three pens (six head/pen). On days one and two, cattle from respective pens were moved through the working facilities a total distance of approximately 1000, 2000 and 3000 feet (300, 600 and 900m), respectively. Cattle were moved only once/day at approximately 0900 h. Cattle were allowed a day of rest after the second day of moving. In both of these studies, cattle were allowed to move at a constant pace, similar to cattle in the winter studies. In all handling studies, tympanic temperatures were obtained throughout the study period using procedures described below. In these studies, average animal weight was approximately 1,050 lb (480 kg).

Temperature Measurements

In all studies, individual animals were randomly selected within each pen to assess the effect of the imposed treatment on tympanic temperature (TT). In the heat stress studies, TT were obtained from eight steers per treatment. In the two winter handling studies, TT were obtained from three animals in the pen. In the summer handling studies, two and four animals/pen were selected in the first and second study, respectively. Tympanic temperature loggers were placed in the left ear of the selected animal. Placement of the logger into the ear consisted of attachment of a thermistor to the data logger and inserting the thermistor approximately 13 cm down the ear canal until the tip was located near the tympanic membrane of the animal. The datalogger was wrapped in gauze and secured to the ear using self-adhesive bandages (Vet-Wrap®[b]) and athletic tape. Tympanic temperature was obtained once every 15 minutes in the heat stress winter studies, and every two and 1.5 minutes in the first and second summer studies, respectively. Once loggers were secured to the ear, all steers were returned to their respective pens. The handling studies were initiated the day following placement of the data loggers; data loggers were removed the day following the last day cattle were moved or rested, depending on study design.

Ambient temperature for each study was obtained from the High Plains Climate Center automated weather station located approximately 1 mile (1.6 km) northwest of the feedlot facilities.

Statistical Analysis

Tympanic temperature data were analyzed using analysis of variance procedures for repeated measures (SAS; SAS Inst. Inc., Cary, NC). The model included treatment, animal, day and time. In the handling experiments, data from days cattle were rested were used for determining moving treatment TT changes, which occur over time relative to cattle that are not moved, with pre-study TT used as a covariant. Differences among treatments were determined using Fisher's Protected LSD and the PDIFF option. Behavior data were analyzed using chi-square. Significance was determined based on the Mantel-Haenszel Chi-square test.

Results and Discussion

In Exp. 1 of the heat stress studies, treatment did not affect ($P > 0.10$) final body weight or daily gain. Overall water intake was reduced approximately 2.4 gallon/hd/day for LIMFD vs BKMGT and ADLIB steers. Data support the positive relationship between feed intake and water intake and that water requirements are increased for cattle full-fed high-energy finishing diets. During the 22-d managed feeding period, LIMFD had lower ($P < 0.05$) TT than ADLIB and tended ($P < 0.10$) to be lower than BKMGT. A carryover effect of limit-feeding was evident during severe heat stress (d 35 to 37) with LIMFD steers having lower ($P < 0.05$) TT than ADLIB (Figure 2). This was during the *ad libitum* feeding period and indicates that lowering metabolic rate through limiting feed intake is beneficial in lowering BT even after cattle resume *ad libitum* feeding. In a previous study conducted with treatments and designs similar to Exp. 1, TT was averaged across treatments for black vs white-hided feedlot cattle. During hot environmental conditions, TT of black-hided cattle were more than 0.9 °F (0.5 °C) greater than white-hided cattle from mid to late afternoon (Figure 3). Cattle that are most

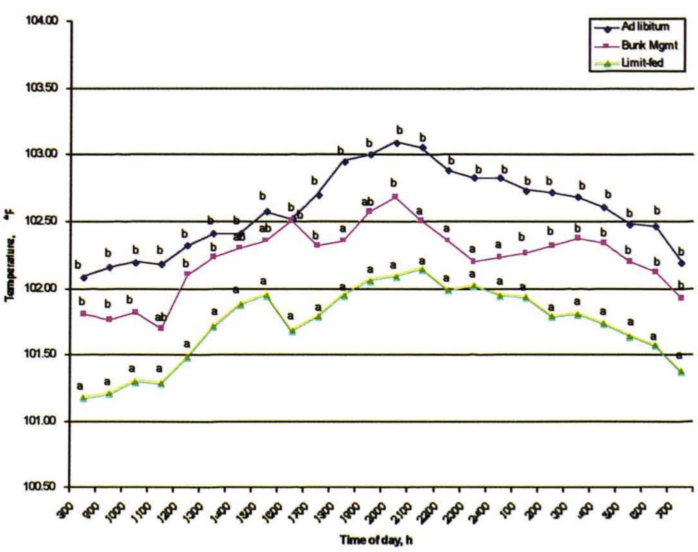

Figure 2. Tympanic temperature of steers during severe heat stress conditions (mean daily temperature-humidity index > 77) on d 35 to 37 of Exp. 1 with all steers fed *ad libitum* at 0800 h during the time temperatures were being obtained. Previously, bunk management (BKMGT) and LIMFD steers had been on managed feeding from d 0 to 22. During managed feeding, BKMGT steers were fed at 1600 h with bunks empty at 0800 h, while LIMFD steers were fed 85% of predicted *ad libitum* intake at 1600 h.

[ab]Means within a time with unlike superscripts differ ($P < 0.05$).

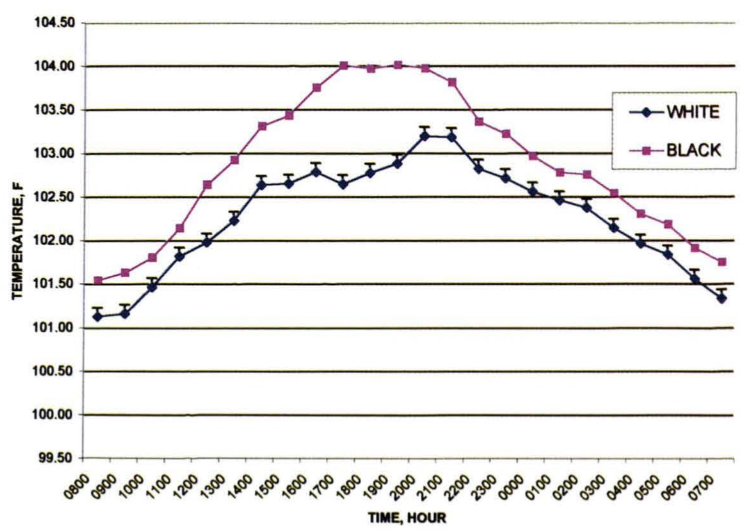

Figure 3. Tympanic temperatures for white vs black coat colored cattle when fed under hot environmental conditions. Vertical lines indicate SE. Means differ for 1200 through 2100 hours.

susceptible to heat stress would therefore be black-hided and cattle being full-fed a high-energy diet. Cattle nearly finished or carrying above average body condition would also be subject to heat stress.

In Exp. 2, ADG and feed intake did not differ among treatments, however, feed efficiency of AM sprinkled steers was superior (P = 0.06) to PM steers. Although treatment x time of day interaction (P < 0.001) existed, AM steers had lower (P < 0.05) TT than PM steers between 2200 to 0900 h and for 1300 and 1400 h (Figure 4). Collectively, the heat stress studies suggest manipulation of feeding time and(or) amount of feed consumed

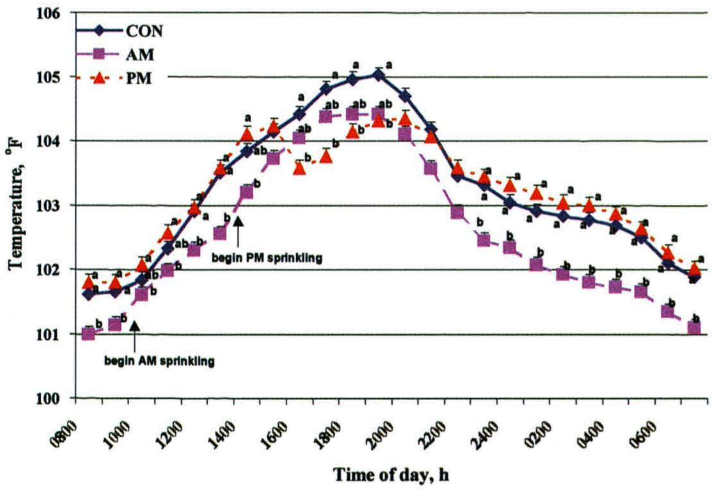

Figure 4. Tympanic temperatures of steers from Exp. 2 on d 30 to 32 during severe heat stress (mean daily temperature-humidity index > 77). No water was applied to control mounds, while AM and PM mounds were sprinkled between the hours of 1000 and 1200 and 1400 and 1600 h, respectively.
[ab]Means within a time with unlike superscripts differ (P < 0.05).

can effectively improve an animal's heat balance under periods of heat stress resulting in enhanced animal comfort.

Altering the time of feed is consumed can alter the timing of peak metabolic heat load. Typically, peak metabolic heat occurs 4 to 8 hours after a meal. For animals fed in the morning, this would mean peak metabolic and environmental heat loads would coincide and severely limit the ability of the animal to cope with the heat load. Furthermore, these changes in dietary management will maintain high levels of productivity. Provision of external cooling in the form of sprinklers to cool pen surfaces to reduce heat stress in feedlot cattle is also effective in improving heat balance. This improvement is due not only to the ability of the water to remove heat from the animal surface via the latent heat of vaporization, but also by cooling the feedlot surface and reversing the heat gradient to allow for heat to flow away from the animal. It is imperative that if sprinklers are used as a cooling strategy for feedlot cattle, that their use remain consistent and persist until the threat of heat stress has subsided, especially if the animal is wetted rather than the pen surface. Animals accustomed to sprinkling during heat stress periods may be more at risk for heat related losses if sprinkling is terminated prematurely versus animals that have never been sprinkled.

In the handling experiments, TT were increased by moving cattle in the winter both in the morning and afternoon (Figure 5, Figure 6 and Table 1). The process of moving cattle obviously elevates TT and body temperature immediately, most likely due to muscle activity. The rate of decline in TT can be very rapid as found in the first winter study, but may remain constant as shown in the second winter study. In the first study,

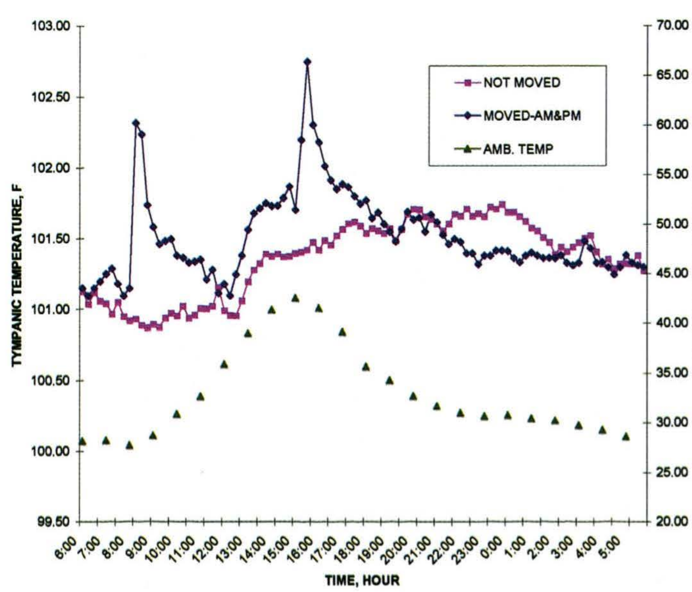

Figure 5. Tympanic temperatures of cattle moved through working facility in first winter handling experiment.

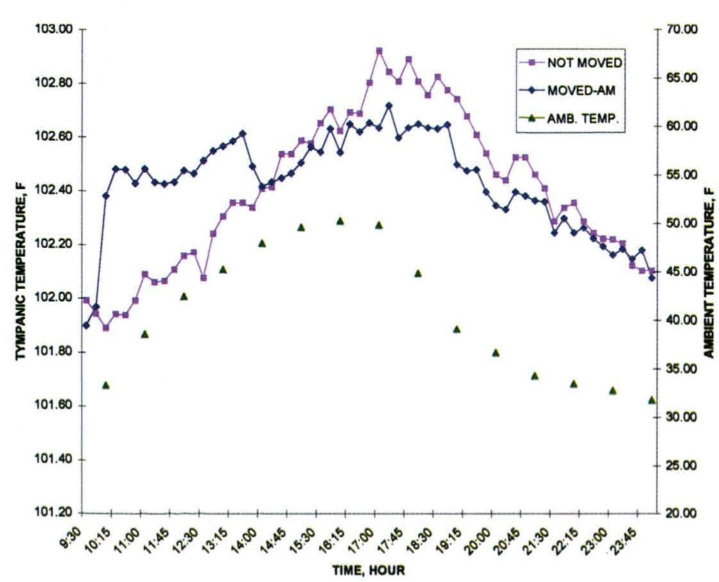

Figure 6. Tympanic temperatures of cattle moved through working facility in second winter handling experiment.

Table 1. Effects of moving cattle through working facilities on tympanic temperature.

	Tympanic temperature (TT), °F			
	Baseline	Initial peak	Post-peak low[a]	Post-low high
		Winter		
Trial 1				
First move				
Distance, feet				
0[b]	100.9	100.9	101.2	101.4
500	101.1	102.3	101.1	101.9
SE	0.1	0.1*	0.1	0.1*
Time, h[b]	0800	0815	1145	1445
Second move				
Distance, feet				
0[b]	101.4	101.4	101.6	101.7
500	101.7	102.7	101.6	101.7
SE	0.1	0.1*	0.1	0.1
Time, hb	1500	1530	1900	1945
Trial 2				
Distance, feet				
0[b]	102.0	102.0	102.4	102.9
1,000	102.0	102.5	102.4	102.7
SE	0.3	0.3	0.2	0.2
Time, h[b]	0945	1015	1400	1715
		Summer		
Trial 1				
Distance, feet				
0 (for 500 foot move)[b]	101.4	101.4	101.5	102.5
0 (for 2,000 foot move)[b]	101.4	101.4	101.8	102.5
500	101.4	102.0	101.5	102.6
2,000	101.4	102.7	101.8	102.5
Pooled SE	0.1	0.1*	0.2	0.3
Time, h (for 500 foot move)[c]	0906	0922	1002	1814
Time, h (for 2,000 foot move)[c]	0906	0928	1136	1812

*Means between moved and non-moved cattle, within a column for respective trial or moving time, differ ($P < .05$).

[a]Low point and/or point at which moved cattle TT becomes # to that of cattle not moved (see figures).

[b]Corresponds to time moved cattle TT were recorded.

[c]Time TT was recorded for characteristic associated with moved cattle.

non-moved cattle TT remained very low, while in the second study, non-moved cattle TT was rising during the day-time hours. Feeding pattern and in-pen activity, as well as ambient climatic conditions, would most likely influence the rate of TT decline.

In summer studies, the rise in TT was similar to that found in the winter for cattle moved a short distance (Figure 7 and Table 1). For cattle moved longer distances, rise in TT was nearly doubled (Figure 7) when compared with cattle moved shorter distances. In the second summer study, TT rises were similar regardless of distance moved. The rise was significant in all cases (Figure 8 and Table 2). In every study, TT of cattle that were moved returns (declines) to points below or equal that of the TT of non-moved cattle before their TT begins to rise again. Cattle apparently need to reach some lower TT level comparable to what would be normal under prevailing conditions, before they resume normal eating and other behavior patterns. Also, during short moves, peak TT occurred after cattle were returned to the pen. During longer moves peak TT occurs while the cattle are being moved or possibly in the working facilities (Table 2). Also, moving affects other post-move activities, which is dependent on distance cattle were previously moved. Particularly the percentage of cattle lying, standing, or at water varied with time of day and previous distance moved. Eating activity (head in bunk) tended to be reduced at 1000 and 1100 h, particularly if cattle were moved but increased by noon for cattle moved the farthest distance (Table 2). Interestingly, non-moved cattle were all resting (lying) by 1400 hr while only 33 to 36% of the moved cattle were resting.

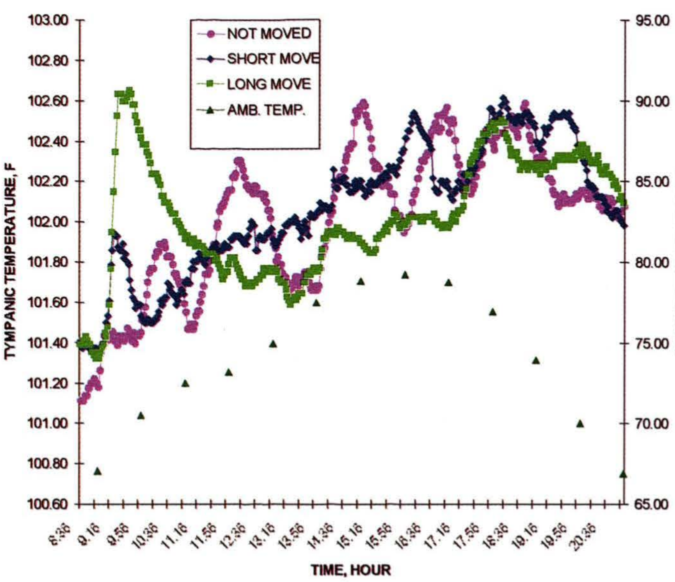

Figure 7. Tympanic temperatures of cattle moved through working facility in first summer handling experiment.

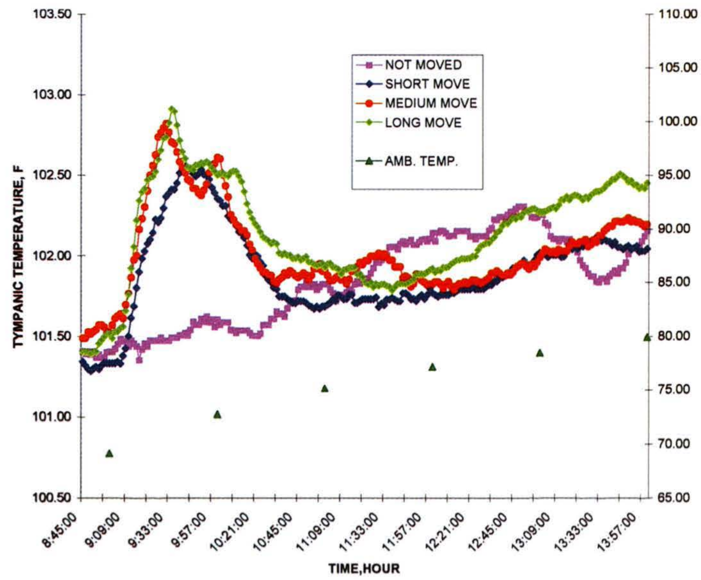

Figure 8. Tympanic temperatures of cattle moved through working facility in second summer handling experiment.

Conclusion

Strategies designed to reduce the detrimental effects of heat stress while maintaining animal productivity do exist. In order to derive maximum benefit, livestock producers must be proactive in their decision-making and must be able to accurately assess the level of stress their animals are subjected to. Furthermore, minimal handling of cattle during hot days and adoption of heat stress relief strategies is a justifiable means to promote animal well-being and comfort.

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Table 2. Effects of moving cattle through working facilities (summer – trial 2).

	Distance moved, feet				
			Chi-square		
	0	1,000	2,000	3,000	P-value
Tympanic temperature, °F					
Baseline, 0900 h	101.4	101.3	101.5	101.5	
Initial peak[ab]	—	102.6 (.2)	102.8 (.2)	102.9 (.1)	
Time initial peak occurred, h	—	0942	0931	0934	
Post-peak low[b]	—	101.7(.1)	101.8(.1)	101.8(.1)	
Time post-peak low recorded, h	—	1052	1112	1137	
Time cattle were returned to pens	—	0934	0937	0945	
Behavior, % of observations					
Time					
1000					
Standing	19.4	83.3	75.0	83.3	0.01
Lying	36.1	5.6	0.0	0.0	0.02
Head in or over waterer	2.8	5.6	8.3	2.8	0.87
Head in bunk	41.7	5.6	16.7	13.9	0.20
1100					
Standing	55.6	38.9	44.4	55.6	0.91
Lying	2.8	47.2	41.7	38.9	0.13
Head in or over waterer	16.7	11.1	5.6	0.0	0.06
Head in bunk	25.0	2.8	8.3	5.6	0.10
1200					
Standing	80.5	61.1	41.7	58.3	0.13
Lying	2.8	16.7	30.6	22.2	0.20
Head in or over waterer	13.9	13.9	13.9	0.0	0.15
Head in bunk	2.8	8.3	13.9	19.4	0.23
1300					
Standing	77.8	38.9	66.7	72.2	0.85
Lying	11.1	47.2	22.2	22.2	0.89
Head in or over waterer	11.1	13.9	11.1	5.6	0.89
Head in bunk	0.0	0.0	0.0	0.0	—
1400					
Standing	0.0	38.9	44.4	52.8	0.01
Lying	100.0	33.3	44.4	36.1	0.02
Head in or over waterer	0.0	2.8	8.3	8.3	0.11
Head in bunk	0.0	25.0	2.8	2.8	0.72

aMeans differ from control (0 m moved) at respective times TT were recorded ($P < .05$).
bParenthetical numbers represent standard error of the mean.