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Effects of shade on heat-stressed heifers housed under feedlot conditions

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Introduction

Chronic heat stress can substantially affect beef cattle productivity (Hahn, 1999). One coping strategy of cattle during heat stress is to decrease metabolic heat production by lowering feed intake, which adversely affects productivity. In West Texas, shade is generally not used in commercial feedlots because it is not thought to be cost effective. However, research using shade to decrease heat stress in feedlot cattle has not been conducted in this region. The objective of our study was to compare the effects of shade vs no shade on performance, carcass traits, physiology, and behavior of feedlot cattle under conditions similar to those in commercial feedlots.

Experimental Procedures

General. The experiment was conducted at the Texas Tech University Burnett Center in New Deal, TX, using dirt-floored pens with a stocking rate typical for commercial feedlots (142 ft²/animal). The study was conducted from 6/13/2000 until 10/20/2000. Animals were housed and used in accordance with the Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching (FASS, 1999), and the Texas Tech University Animal Care and Use Committee approved the project.



Figure 1: Shade seeking by feedlot heifers at the Burnett Center.

Twelve dirt-floored pens, each with a pen area of 2,000 ft² (20 x 100 ft), were used. Fences were metal pipe and t-posts connected with steel cables. The concrete feed bunk was 20 ft long and located on the north end of the pen allowing for approximately 17 in of bunk space/animal. A water trough, with float activated water supply, was located on the south end of the pen.

Treatments were: (1) no shading (CONT) and, (2) shading (SHADE). A total of six pens were shaded. The roof was Galvalum tin sheets (Bethlehem Steel, Jackson, MI) resting on 8 in x 2.5 in purlin construction. The roof was mounted on 2.875-in steel pipes. Shade height was 13 ft on the north and 12 ft on the south side, which provided a slope for precipitation runoff. The orientation of the shade was east to west with a length of 120 ft (20ft/pen) and a width of 16 ft.

A total of 168 heifers was used, of which 132 were Angus-crossbred and 36 were Charolais-crossbred heifers. Heifers were blocked by body weight (BW) and assigned randomly to pens with three Charolais-crossbred and 11 Angus-crossbred heifers per pen. The diet was 90% concentrate (see Table 1 in Mitlöhner et al, 2001) fed once daily (approximately 1000), and water was available at all times.

Before transport to the Burnett Center, cattle were implanted with Synovex H (Fort Dodge, Websa, FL), and received injections of Vision 7 (Bayer Animal Health, Kansas City, MO), IBR Lepto (Pfizer Animal Health, Exton, PA), and Ivomec Plus (Merial, Iselin, NJ).

On d 0, cattle were assigned randomly to the treatments and to one of the six BW blocks. On d 56, heifers were reimplanted with Revalor H (Intervet Animal Health, Millsboro, DE).

Macro- and Microclimate. The same weather data (ambient temperature, relative humidity, and wind speed) and methods for data collection described in Mitlöhner et al. (2001) were used in the present study. In addition, ground surface temperature (°F) and ground moisture (%) were measured on

three randomly selected days during the study. Ground temperature was measured using an infrared thermometer (Model 39650, Cole Parmer, Chicago, IL) in each pen either in the middle of the shaded area or at the same spot within the unshaded pen, respectively. Ground moisture (%) also was measured in each pen, by taking substrate samples at the same spot where the temperature was measured previously. Fresh samples were first weighed and then dried in an oven for 24 h. Samples were weighed again to determine the DM content.

Performance and Weather Data. The same performance data (BW, DMI, ADG, and F:G) and methods described in Mitlöhner et al. (2001) were obtained in the present study. The weather data reported for Exp. 2 of Mitlöhner et al. (2001) would be those that apply to the present study.

Carcass Traits. Carcass measurements were obtained by personnel of West Texas A&M University Beef Carcass Research Center. Procedures were identical to those described for the carcass measurements in Exp. 2 of Mitlöhner et al. (2001). Of the initial 168 heifers, three were removed from the study prematurely for reasons unrelated to the treatments.

Behavior. Behavioral measurements and data analyses were identical to those described for Exp. 1 of Mitlöhner et al. (2001).

Respiration Rate. Respiratory rates were measured in four heifers per pen once weekly (at approximately 1500) by counting the animal's flank movements per minute. Three Angus-crossbred and one Charolais-crossbred heifer per pen were

chosen randomly, and their respiration rate was measured once per week.

Experimental Design and Statistical Analyses. The experiment was arranged as a randomized complete block design, blocked by BW, with six replications (pens) per treatment. The GLM procedure of SAS (SAS Inst. Inc., Cary, NC) was used for the analyses. All data were analyzed as a randomized complete block. The pen was the experimental unit. For some carcass traits (dark cutters, liver scores, quality grade, and yield grade) CATMOD and the Chi-Square procedures of SAS were used.

Results

Performance. Performance results are presented in Table 1. After stratification and random assignment of the heifers at d 0, their initial BW averaged 783 lb (SE = 1.29). The final BW on d 121 was 25 lb/heifer (1,247 vs 1,222 lb, respectively) greater ($P < 0.05$) for the shaded vs unshaded heifers. Daily DMI was 2.9% greater (21.6 vs 21.0 lb/d, $P < 0.01$) by shaded vs unshaded heifers. As would be expected from differences in BW, ADG was 7.5% higher ($P < 0.05$) in shaded vs unshaded heifers (3.86 vs 3.59 lb/d), and F:G was 5.64 vs 5.81 kg (unshaded vs shaded heifers, $P = 0.29$). Calculated NEM and NEg for the diets did not differ between treatments.

Carcass Traits. The hot carcass weight of shaded heifers was 17 lb greater than that of unshaded heifers (777 vs 760 lb; $P = 0.095$; Table 2). Fat thickness, marbling score, longissimus muscle area, kidney, pelvic, and heart fat, and USDA yield grade did not differ between treatments. The quality grades for shaded vs unshaded heifer carcasses showed differences ($P <$

0.05) with 44% vs 64% for Select and 56% vs 36% for Choice. Differences ($P < 0.05$) also were found for dark cutters with 8.3% in the shaded and 19.8% in the unshaded heifer carcasses.

Behavior. The shaded heifers used the shade extensively from 0900 until 1730. Cattle followed the shade line and avoided standing in the direct sunlight (Figure 1). The 12-h means of the behaviors standing, lying, walking, feeding, drinking, and bulling (Table 3) did not differ between the treatments. Agonistic (aggressive) behavior was more than four times higher (0.34 vs 1.40%, $P < 0.05$) in the CONT vs the SHADE heifers. Several behaviors like feeding, drinking, bulling, and agonistic behavior differed over time. Especially in the early evening hours (around sunset), cattle in CONT showed higher ($P < 0.05$) bulling and agonistic behavior, whereas heifers in SHADE performed more drinking and walking behavior during this time.

Respiration Rate. The average respiration rate (Figure 2) was 30% less ($P < 0.05$) in SHADE than in CONT heifers (74 vs 105 breaths/min). Over the 12-wk period of experiment, respiration rates showed fluctuations (Figure 3), but were consistently higher in CONT vs SHADE. At the end of the study in October, 2000 (wk 11 and 12), respiration rates in both treatments dropped from their high summer values, but remained different between treatments.

Macro- and Microclimate. Temperatures during the study reached upper 80 to lower 90° F almost every day throughout the study. Relative humidity was low throughout the study. Ground moisture (%) is shown in Figure 4. Moisture was higher ($P < 0.05$) in the

shaded vs the unshaded pens (approximately 20% vs 10 to 17%, respectively). However, even in the shaded pens, no wet spots were found. Ground surface temperature under the shade (Figure 5) was decreased ($P < 0.01$) in the shaded pens compared with the same area of the pen in the unshaded pens (SHADE = 60 to 90° F vs CONT = 110 to 130° F).

Discussion

Heat stress is known for its potential to affect mortality and performance by cattle. During a heat wave in the Midwestern United States in 1995, over 4,000 cattle died because of direct effects of the heat wave (Hahn and Mader, 1997). Economically, these animal deaths caused direct losses of \$ 2.8 million, but indirect costs were an additional \$ 25.2 million from decreased performance. Performance effects are mainly a result of a decrease in DMI, which generally occurs when ambient temperatures exceed 77° F (Morrison, 1983; Hahn et al., 1992). Those performance losses as a result of heat stress also were confirmed in our experiment. When provided with shade, high performance levels can be maintained. In contrast, unshaded heifers showed a drop in performance during the summer heat. Shaded cattle also showed better quality carcasses. Most dramatic was the difference between the treatments in the numbers of dark cutters and in quality grade. Shaded cattle showed only half as many dark cutters and twice as many Choice carcasses compared with their unshaded peers.

Frequently, a concern is raised in the industry that shades create "wet spots" underneath. Moisture levels in our study were moderate (20%) under the shade but

high enough to potentially decrease aerial dust. During hot, dry periods, commercial feedlots can experience problems with respect to dust generation after sunset. We found that especially in the evening hours shade decreased dust-generating behaviors of cattle, namely bulling and agonistic behavior. Further research in commercial feedlots is needed to determine whether, and to what degree, shade might affect dust concentrations by changing behavior of the cattle and by increasing pen moisture to a more desirable level.

Considering the improvement of cattle performance alone (\$18/animal) noted in this experiment and the one-time cost of building the shades (\$18 to 20/animal), shade was cost effective under our conditions. Nonetheless, commercial application and usefulness of shade would require consideration of year-round performance effects and costs associated with maintenance of shades, pen cleaning, and other management factors that were not considered in our study.

Implications

Heat stress negatively impacted production by beef heifers in a West Texas experimental feedlot. Under the observed conditions of summertime heat, shade of 22 ft²/animal affected performance, physiology, and behavior of feedlot cattle. Shaded cattle showed greater ADG and hot carcass weights than their unshaded peers. This effect of shade on feed intake and average daily gain led to a financial advantage of approximately \$18 per heifer during the summer. This dollar figure does not account for the decrease in dark cutters and increase in quality grade noted in shaded cattle. The total cost (material and labor) for the shade construction was

approximately \$20/heifer. Under our conditions, shade improved animal performance and profitability; however research on shade is needed at commercial feedlots to determine the applicability of these results to the cattle feeding industry.

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Literature Cited

- Hahn, G. L. 1999. Dynamic responses of cattle to thermal heat loads. *J. Anim. Sci.* 77:10-20.
- Hahn, G. L., Y. R. Chen, J. A. Nienaber, R. A. Eigenberg, and A. M. Parkhurst. 1992. Characterizing animal stress through fractal analysis of thermoregulatory responses. *J. Therm. Biol.* 17:115-120.
- Hahn, G. L., and T. L. Mader. 1997. Heat waves in relation to thermoregulation, feeding behavior and mortality of feedlot cattle. *Trans. Am. Soc. Agric. Eng. Proc. of the 5th International Symposium, Bloomington, MN.*
- Morrison, S. R. 1983. Ruminant heat stress: effect on production and means of alleviation. *J. Anim. Sci.* 57:1594-1601.
- Mitlöhner, F. M., M. L. Galyean, J. B. Patterson, G. A. Nunnery, G. B. Salyer, J. L. Morrow-Tesch, J. W. Dailey, and J. J. McGlone. 2001. Shade and water application to decrease heat stress of heifers in an experimental feedlot. Burnett Center Internet Progress Report 10. http://www.asft.ttu.edu/burnett_center/progress_reports.
- FASS, 1999. Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching. 1st rev. ed. Federation of Animal Science Societies, Savoy, IL.

Table 1. Performance by heifers exposed to hot weather

Trait	Treatment		SE	P-value
	Shade	Control		
Number of heifers	84	81	-	-
Number of pens	6	6	-	-
Initial BW, lb	783	784	2.85	0.69
BW at d 121, lb	1,247	1,222	6.55	0.04
ADG, lb ^a	3.86	3.59	0.06	0.05
DMI, lb/d	21.60	21.00	0.11	0.01
Feed:gain	5.64	5.81	0.10	0.29
NEm ^b	0.96	0.95	-	-
NEg ^c	0.66	0.65	-	-

^aADG = Average daily gain.

^bNEm = Net energy for maintenance, calculated from performance data according to NRC (1996).

^cNEg = Net energy for gain, calculated from performance data according to NRC (1996).

Table 2. Carcass traits of heifers exposed to hot weather

Trait	Shade	Control	SEM	P value
Number of heifers	84	81	-	-
Number of pens	6	6	-	-
Hot carcass wt, lb	776.7	760.1	5.54	0.09
Dressing percent	62.29	62.19	0.22	0.34
Fat thickness, in	0.54	0.51	0.03	0.45
Marbling score ^a	383.7	386.7	8.57	0.81
LMA, in ² , ^b	14.57	14.65	0.25	0.82
KPH, % ^c	1.94	1.89	0.05	0.42
USDA yield grade	2.4	2.22	0.04	0.024
Dark cutters, %	8.33	19.05	-	0.033
<i>Quality Grade</i>				
Select, %	44.16	63.77	-	0.012
Choice, %	55.84	36.23	-	0.012

^a300 = Slight; 400 = Small.

^bLongissimus muscle area.

^cKidney, pelvic, and heart fat.

Table 3. Behaviors (% of observations) by heifers exposed to hot weather

Measure	Treatment		SE	P-value
	Shade	Control		
Number of replicates (pens)	6	6	-	-
Number of animals	84	81	-	-
Standing	38.48	41.00	1.47	0.25
Lying	49.69	47.84	1.61	0.56
Walking	1.85	1.46	0.40	0.63
Feeding	7.10	5.69	0.44	0.10
Drinking	2.02	1.63	0.12	0.20
Bulling	0.52	0.98	0.21	0.19
Agonistic	0.34	1.40	0.33	0.05

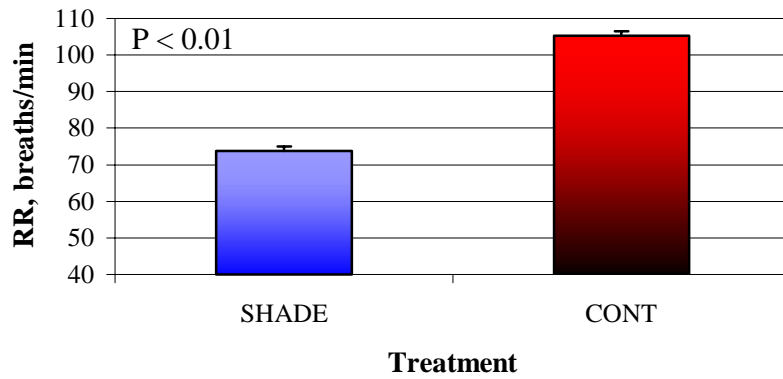


Figure 2. Respiration rates (RR, breaths/min) for heifers during the summer.

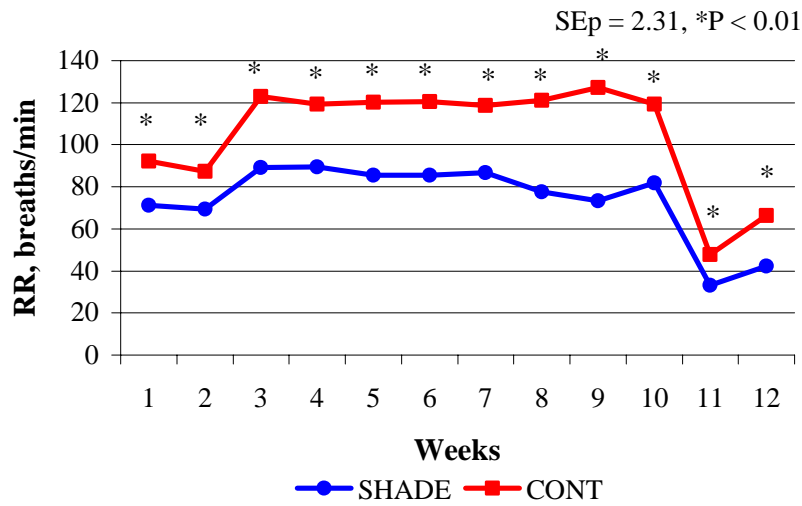


Figure 3. Respiration rates (RR, breaths/min) over time for heifers during the summer.

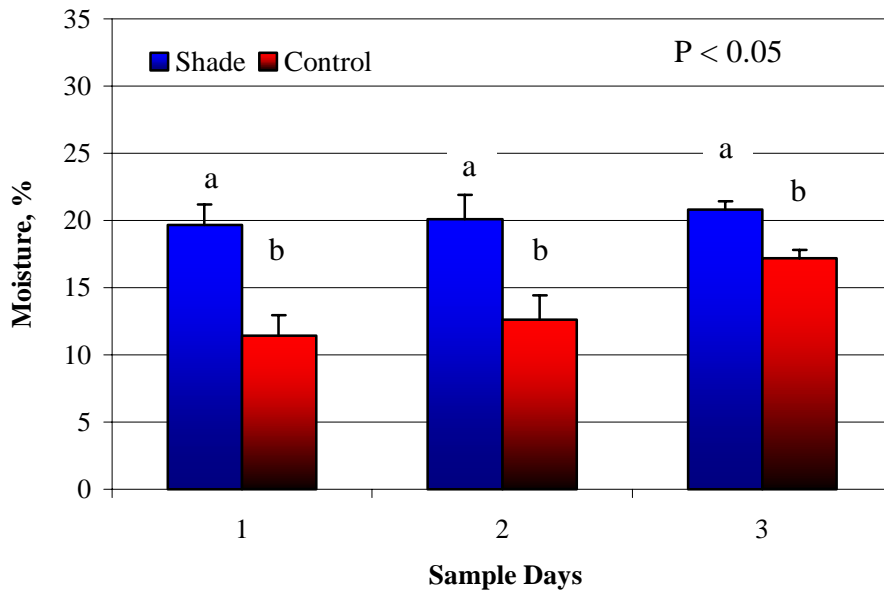


Figure 4. Ground moisture percent in SHADE vs CONT pens.

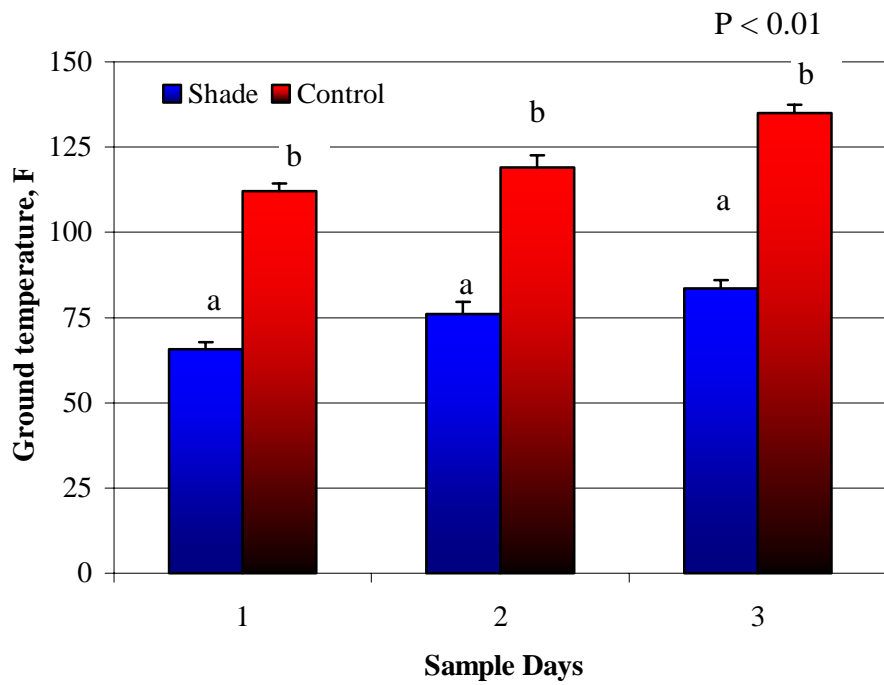


Figure 5. Ground surface temperature (°F) in SHADE vs CONT pens.