EFFECT OF SHADE ON RESPIRATION RATE AND RECTAL TEMPERATURE OF ANGUS HEIFERS

J.B. GAUGHAN[A], L.A. TAIT[A], R. EIGENBERG[B] and W.L. BRYDEN[A]

[A] School of Animal Science, The University of Queensland, Gatton, Qld 4343
[B] USDA-ARS Meat Animal Research Center, Clay Center, Nebraska, USA 68933

SUMMARY
The effect of shade on respiration rate and rectal temperature of grain-fed Angus heifers was examined in a 21-day study. Six heifers were housed in individual outside yards (15 m^2). Three of the yards had shade, and 3 did not. Each pen had an individual water bowl and feed bunk. Three data collection periods were used during which time the cattle were exposed to hot conditions (mean heat load index > 83). Overall the heifers with access to shade had lower rectal temperatures and respiration rates than those without access to shade. The largest difference was seen in the afternoon (1201-1700 h), with little or no differences seen at other times of the day. Dry matter intake was not affected by treatment, however, there were changes in eating dynamics, with un-shaded cattle eating more at night. Provision of shade resulted in lower rectal temperature and respiration rate during periods of peak heat load.

Keywords: shade, respiration rate, rectal temperature, feedlot cattle, heat stress

INTRODUCTION
Physical protection from direct solar radiation with shade offers 1 of the most immediate and cost-effective approaches for enhancing performance and well-being of cattle in hot environments (Blackshaw and Blackshaw 1994; Gaughan *et al*. 1998). Shade changes the radiation balance, but does not affect air temperature or humidity. Beneficial aspects of shade may be offset by a lack of air movement under the shade structure. This may be due to crowding by cattle that reduces air movement (Mader *et al*. 1997), or when there is little natural air movement. Provision of shade has been shown to improve milk yield of dairy cows (Davison *et al*. 1988). However, little advantage has been reported for feedlot cattle (Clarke 1993). However, during severe heat waves, death loss among shaded cattle was lower than for un-shaded cattle (Busby and Loy 1996; Entwistle *et al*. 2000). This suggests that provision of shade will reduce the death loss in feedlot cattle and may improve overall welfare. This study was undertaken to evaluate the effect of shade on respiration rate and rectal temperature in grain fed cattle.

MATERIALS AND METHODS
Location and treatment
The study was undertaken at The University of Queensland, Gatton Campus feedlot (27^{o}34 S, 152^{o}20 E, altitude 91 m) between mid January and mid February 2003. Six Bos taurus heifers, 15 months of age (Black Angus; mean liveweight 280 ± 20 kg) were used in the study. The cattle were individually identified and were vaccinated against clostridial diseases, tick fever, and treated for internal and external parasites using a pour-on drench prior to the start of the study. During the treatment period, 3 of the heifers were housed in individual half-shaded pens and 3 were housed in individual pens without shade. The pens each had an area of 15 m^2 (5 m x 3 m). Each pen was fitted with an individual water trough and feed bin. The shade structure was aligned east-west and had a solid galvanized iron roof approximately 2 m in height and provided 7.5 m^2 of shade.

Experimental design
A 21-day study involving 3 periods was undertaken. At the beginning of each period, cattle were sequentially rotated through the pens. This allowed 4 heifers to be exposed to both treatments, while 1 only had access to shade and 1 only to no shade. Due to the study being conducted under natural climatic conditions, the periods were not balanced in terms of days. The periods were selected on the basis of the predicted Heat Load Index (HLI) of a day being greater than 83, above which cattle are under some degree of heat stress (Gaughan and Goopy 2002). The HLI is defined by the following equation, which has been modified from Gaughan and Goopy (2002):

$$HLI = 33.2 + (0.2 \times RH) + (1.2 \times BGT) - (0.82 \times WS)^{0.1} - Log(0.4 \times (0.0001 + WS^2))$$

where RH = relative humidity (decimal form), BGT = black globe temperature (^oC) and WS = wind speed (m/s).

Climatic data, respiration rate and rectal temperature

Climate data (ambient temperature (ºC), relative humidity (%), wind speed (km/h), wind direction, rainfall (mm), and solar radiation (nm)) were recorded at 10 min intervals using a portable weather station (Davis Advantage Pro, Model No. 6310, Davis Instruments, Harvard, California). Black globe temperature was calculated by a predictive equation, using ambient temperature and solar radiation, developed by EA Systems (2002). The climatic data were then used to calculate the HLI.

Respiration rate (RR) was measured at 15 min intervals using a respiration rate belt (Eigenberg *et al.* 2000) consisting of 2 pressure sensor pads (0.05 m^2) held in position (approximately 0.2 m down from the top of the wither) by an elastic cord (4 mm in diameter). The pressure sensor pads were then connected to a data logger on a girth harness.

Rectal temperature (RT) was recorded using a 210 mm rectal probe with a sensor mounted in the tip. The rectal probes (2 per treatment per period) were held in place by an elastic cord (4 mm in diameter) that was secured to a girth harness. Rectal temperature was recorded every 5 min to a data logger (YSI 400, Mini-Mitter, Sunriver, OR, USA).

Feeding

The heifers were fed a standard feedlot ration (10.8 MJ metabolisable energy, 12% crude protein) throughout the study. Daily feed allocation was initially based on 2.5% of liveweight. The heifers were fed half of their allocation at 0800 and 1600 h. Cattle that did not eat during the day were given their afternoon allocation in addition to residue feed left from the morning allocation. All orts were removed and weighed at 0800 h.

Statistical analysis

Statistical analysis was done using the GLM procedures of SAS (1993), with treatment and heifer as independent variables in the model. The statistical model included pen, period, time of day (morning (0601-1200 h), afternoon (1201-1700 h), and night (1701-0600 h)), climatic conditions, period x climate conditions, and time of day x climatic conditions. Treatment means were compared using least significant differences ($P \leq 0.05$).

RESULTS

Climatic data

There were 3 periods that met the required climatic criteria. Period 1 was of 6 days duration, period 2 of 2 days duration and period 3 of 6 days duration. There were only small differences for HLI between each period. The mean climatic data for each period are presented in Table 1.

Feed intake

There were no differences in total daily DM intake between treatments. The only difference was that the shaded cattle tended to eat their morning allocation within 1 hour whereas the un-shaded group tended not to eat until late afternoon or early evening. This meant they may have consumed over 12 kg of feed at night. Over the 21 day period, the heifers gained an average of 29.6 ± 6.7 kg, but there were no differences between treatments.

Respiration rate and rectal temperature

There were no pen effects for either RR or RT. In general, the mean daily RR was greater in the un-shaded heifers (Table 2). During period 3, which had highest mean heat load, the RR of the un-shaded heifers was greater than the RR of the shaded heifers. Due to equipment failure, it was not possible to collect rectal temperature (RT) of the shaded heifers during period 1. In both periods 2 and 3, the RT of the un-shaded heifers was greater than that of the shaded heifers.

The effect of time of day on RR and RT are presented in Table 3. The HLI was highest in the afternoon, which is reflected in the higher RT of the shaded heifers, and in the higher RR of both the shaded and un-shaded cattle during this time compared with morning and night. Access to shade did not always result in a reduction in RT. During the 1201-1700 h time during periods 2 and 3, and during the 0601-1200 h time of period 3, the RT of the shaded heifers was higher than that of the un-shaded heifers. At night (1701-0600 h), the RT of the shaded cattle was over 1°C lower than during the afternoon. In contrast, the RT of the un-shaded group varied little over a 24 h period. The largest difference between the shaded and un-shaded cattle in respect to RR occurred in the afternoon. There was a 32 bpm difference in period 1, a 10 bpm difference in period 2 and a 28 bpm difference in period 3.

Table 1. Mean (± s.d.) climatic data (BGT = Black globe temperature; [2] WS = windspeed; [3]HLI = heat load index (24 h mean)) for 3 data collection periods.

	Dry Bulb (°C)	Relative Humidity (%)	BGT (°C)	WS (km/h)	HLI
Period 1					
0601 – 1200 h	26.9 ± 3.2	60.2 ± 14.7	33.6 ± 4.5	3.1 ± 1.6	84.4 ± 2.5
1201 – 1700 h	32.2 ± 4.1	41.5 ± 18.3	39.6 ± 5.3	4.4 ± 2.2	87.3 ± 3.3
1701 – 0600 h	24.3 ± 3.4	68.7 ± 12.8	23.6 ± 4.4	4.8 ± 1.7	76.2 ± 3.9
Period 2					
0601 – 1200 h	25.6 ± 2.9	64.1 ± 14.2	32.3 ± 4.3	2.0 ± 1.9	85.3 ± 1.6
1201 – 1700 h	29.8 ± 1.3	44.0 ± 6.4	37.2 ± 0.6	4.8 ± 1.0	84.6 ± 1.7
1701 – 0600 h	22.5 ± 2.1	77.6 ± 9.7	21.8 ± 3.7	1.3 ± 1.9	76.7 ± 3.0
Period 3					
0601 – 1200 h	27.1 ± 3.4	63.9 ± 13.5	34.2 ± 4.8	2.4 ± 1.7	86.7 ± 2.4
1201 – 1700 h	32.3 ± 1.8	41.4 ± 6.1	40.1 ± 2.6	4.8 ± 1.7	87.5 ± 2.6
1701 – 0600 h	23.5 ± 3.2	76.9 ± 14.0	22.7 ± 4.6	0.8 ± 1.8	78.6 ± 3.4

Table 2. Means (± s.d.) for periods of day of rectal temperature (RT) and respiration rate (RR; breaths per min) for shaded and un-shaded heifers.

Period	RT (°C)	RR (bpm)	Heat load index
Shaded			
1	n.d	$57.2^a \pm 13.2$	80.6 ± 5.9
2	$38.8^a \pm 0.8$	$66.1^a \pm 18.8$	80.3 ± 4.8
3	$39.4^b \pm 0.8$	$68.1^a \pm 20.3$	82.6 ± 5.2
Un-Shaded			
1	$39.1^b \pm 0.8$	$68.6^a \pm 33.7$	80.6 ± 5.9
2	$39.2^c \pm 0.3$	$65.6^a \pm 21.6$	80.3 ± 4.8
3	$39.7^c \pm 1.8$	$74.4^b \pm 31.6$	82.6 ± 5.2

Means in a column with different superscripts are significantly different (P<0.05)

Table 3. Effect of time of day on rectal temperature (RT) and respiration rate (RR) of shaded and un-shaded heifers (HLI; heat load index).

	Shade RT (°C)	Un-Shaded RT (°C)	Shade RR (bpm)[1]	Un-Shaded RR (bpm)	HLI
Period 1					
0601 – 1200 h	n.d.	39.0 ± 0.8	$61.3^x \pm 10.9$	$71.9^y \pm 29.2$	84.4 ± 2.5
1201 – 1700 h	n.d.	39.4 ± 1.1	$64.8^x \pm 12.9$	$97.5^y \pm 46.0$	87.3 ± 3.3
1701 – 0600 h	n.d.	38.9 ± 0.7	$52.3^x \pm 12.3$	$55.8^x \pm 19.6$	76.2 ± 3.9
Period 2					
0601 – 1200 h	$38.7^a \pm 0.9$	$39.3^b \pm 0.2$	$58.3^x \pm 16.2$	$70.4^y \pm 19.5$	85.3 ± 1.7
1201 – 1700 h	$39.7^a \pm 0.6$	$39.3^b \pm 0.3$	$75.9^x \pm 18.2$	$85.9^y \pm 21.2$	84.6 ± 1.6
1701 – 0600 h	$38.5^a \pm 0.4$	$39.3^b \pm 0.3$	$60.5^x \pm 11.3$	$60.1^x \pm 18.2$	76.7 ± 3.0
Period 3					
0601 – 1200 h	$39.4^a \pm 0.7$	$39.1^a \pm 2.3$	$68.9^x \pm 15.1$	$69.6^x \pm 26.5$	86.7 ± 2.4
1201 – 1700 h	$40.6^a \pm 0.4$	$39.9^b \pm 2.4$	$85.9^x \pm 22.1$	$112.6^y \pm 18.2$	87.5 ± 2.6
1701 – 0600 h	$38.9^a \pm 0.4$	$39.9^b \pm 1.0$	$60.5^x \pm 16.8$	$61.0^x \pm 21.8$	78.6 ± 3.4

Means in a row with different superscripts are significantly different (P<0.05)

DISCUSSION

Generally the heifers preferred to be in the shade when the HLI was high (> 83). On most days, the shaded cattle would move from the shade in late afternoon. However, at times, cattle were observed standing or lying in the sun even when the HLI was high. The reasons for this were not clear, however, similar observations have been seen under commercial conditions (Gaughan and Goopy 2002).

The lower RT of the un-shaded heifers during the afternoon is a function of the relationship between RR and body temperature. The higher RR of the un-shaded group resulted in a lower RT during the hottest part of the day. The higher RT of this group at night was a result of feeding activity and the lack of adequate night time cooling. Heat load index did not fall below 72 for more than 2 hours during any period. Therefore, it is unlikely that the un-shaded cattle had sufficient opportunity to lose the heat gained during the day (Gaughan and Goopy 2002). The shaded cattle did not have the extra burden from the heat of digestion and were able to return to normal body temperatures over night.

It is likely that cattle well-being was improved by provision of shade. If shade structures are not adequate, then cattle welfare may be compromised and any positive benefits of the shade will be lost (Mader *et al*. 1997). The shade structure used in this study should not be taken as an industry norm, nor is it being recommended as a suitable structure. Work is being undertaken under commercial conditions to determine ideal shade structures, and the effects of group dynamics on shade usage.

REFERENCES

BLACKSHAW, J.K. and BLACKSHAW, A.W. (1994). *Aust. J. Exp. Agric.* **34**, 285-295.
BUSBY, D. and LOY, D. (1996). 'Beef Research Report. Heat Stress in Feedlot Cattle: Producer Survey Results.' (Iowa State University: Iowa, USA.)
CLARKE, M.R. (1993). *In* 'Aust. Assoc. Cattle Vet. Conf.' (Upjohn Animal Health: Rydalmere.)
DAVISON, T.M., SILVER, B.A., LISLE, A.T. and ORR, W.N. (1988). *Aust. J. Exp. Agric*. **28**, 149-154.
EA SYSTEMS (2001). 'Final Report – FLOT.317 Measuring Microclimate of Eastern Australian Feedlots.' (Meat and Livestock Australia: Sydney.)
EIGENBERG, R.A., BROWN-BRANDLE, T. and NIENABER, J.A. (2000). *Trans. ASAE* **43**, 723-728.
ENTWISTLE, K.E., ROSE, M and MCKIERNAN, B. (2000). 'Mortalities in Feedlot Cattle at Prime City Feedlot, Tabbita, NSW.' (NSW Agriculture: NSW.)
GAUGHAN, J.B., GOODWIN, P.J., SCHOORL, T.A., YOUNG, B.A., IMBEAH, M., MADER, T.L. and HALL. A. (1998). *Aus. J. Exp. Agric.* **38**, 17-21.
GAUGHAN, J.B. and GOOPY, J.P. (2002). 'Final Report – FLOT.316 Excessive Heat Load Index for Feedlot Cattle.' (Meat and Livestock Australia: Sydney.)
MADER, T.L., DAHLQUIST, J.M. and GAUGHAN, J.B. (1997). *J. Anim. Sci.* **75**, 26-36.
SAS (1993). 'SAS/STAT Users Guide.' Second Edn. (SAS Institute Inc.: Cary, NC, USA.)

Email: j.gaughan@uq.edu.au