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Dynamic Response Indicators of Heat Stress in Shaded and Non-shaded Feedlot Cattle, Part 1: Analyses of Indicators

T.M. Brown-Brandl; R.A. Eigenberg; J.A. Nienaber; G.L. Hahn

USDA-ARS US Meat Animal Research Center, P.O. Box 166, Clay Center, Nebraska USA; e-mail of corresponding author: brandl@email.marc.usda.gov

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Heat stress in feedlot cattle can cause decreases in feed intake and growth, and in extreme cases may result in death. Providing shade during hot weather has shown inconsistent results, reducing direct and indirect losses in some areas of the United States, but not in others. The objectives of this study were to evaluate the dynamic responses of feedlot cattle to environmental conditions with and without access to shade, and to determine the most appropriate physiological measurement for monitoring feedlot cattle during hot weather as a guide for improved management. Eight crossbred steers (initially weighing $294{\cdot}7 \pm 10{\cdot}8$ kg) were randomly assigned to one of eight individual pens, where one of two treatments were applied: shade access, or no-shade access. Respiration rate, daily feed intake, and core body temperature were collected, using automated systems during eight periods, for a total of 37 days. The data were analysed using four categories of daily maximum temperature humidity index (maximum I_{TH}) values (Normal for maximum $I_{TH} < 74$; alert for $74 \leqslant$ maximum $I_{TH} < 78$; Danger for $78 \leqslant$ maximum $I_{TH} < 84$; Emergency for maximum $I_{TH} \geqslant 84$). Shade was found to impact the physiological responses in all I_{TH} categories, with the largest impacts in the Danger and Emergency categories. Shade lowered respiration rate and core body temperature during the peak temperature hours of the day. It was concluded that respiration rate is the most appropriate indicator of thermal stress to monitor because it was consistently affected in all I_{TH} categories, it is easy to monitor without the need for costly equipment, and there is little or no lag associated with it.
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1. Introduction

Hot weather affects animal bioenergetics, and has negative impact on animal performance and well-being. Reductions in feed intake, growth, and efficiency are commonly reported in heat-stressed cattle (Hahn, 1999). The impacts of heat load on these production parameters are quite varied, ranging from little to no effect in a brief exposure, to death of vulnerable animals during an extreme heat event (Hahn & Mader, 1997). An extreme event in July, 1995, caused the loss of approximately 3750 head of cattle in western Iowa; direct losses were estimated at US \$2·8 million, and production losses at US \$28 million (Busby & Loy, 1996). *Bos taurus* feedlot cattle are particularly vulnerable to heat stress as a result of the high-energy diet they are fed, and their inability to move into a more suitable environment (Blackshaw & Blackshaw, 1994). With the increased concern for global warming and animal welfare, along with the high number of cattle in feedlots, researchers and producers have increased their interest in methods to reduce thermal stress.

As absorbed solar radiation may exceed metabolic heat production by several times (Riemerschmid, 1943), the use of shade during hot weather has been of interest for many years. A simple shade can reduce the animals' radiant heat load by 30% or more (Bond *et al.*, 1967). Results from performance trials with shaded and unshaded feedlot cattle have shown inconsistent results. Garrett (1963) summarised results from several shade studies and concluded that feedlot cattle in areas with more than 750 h/yr of temperatures above 29·5 °C generally show a performance improvement, while gains of cattle in areas that receive 500–750 h/yr of temperatures above 29·5 °C are less conclusive. This lack of performance improvement from shade can be explained by the ability of cattle to acclimate and compensate for a short-term suppression in feed intake and growth resulting from a heat stress event (Hahn, 1982; Mader *et al.*, 1999).

While shades have not consistently shown a performance improvement, cattle with access to shade have consistently shown a reduction in core body temperature and respiration rate (Mitlöehner *et al.*, 2001; Valtorta *et al.*, 1997; Paul *et al.*, 1999). During times of high solar radiation, high temperature, and high humidity, a reduction of solar radiation may be a method of reducing heat stress (Blackshaw & Blackshaw, 1994), improving animal well-being, and preventing death in extreme cases.

2. Objectives

The objectives of this study were to evaluate the dynamic physiological responses of feedlot cattle (respiration rate, daily feed intake, feeding behaviour, and core body temperature) to different environmental conditions with and without access to shade, and to determine which physiological measurement was the most appropriate to monitor feedlot cattle under heat stress conditions.

3. Materials and methods

Eight crossbred steers (1/4 Angus, 1/4 Hereford, 1/4 Pinzgauer, 1/4 Red Poll) initially weighing 294·7 ± 10·8 kg were randomly assigned to one of eight individual concrete-surfaced pens where one of two treatments was applied (Shade or No-shade). The pens were located at the US Meat Animal Research Center near Clay Center, Nebraska; they had a north/south orientation and were connected to the south side of a 122 m long building (*Fig. 1*). Animal access to the building was prevented. The pens were 3·6 m by 12 m, with a 3·6 m space between pens. Shade treatment pens were equipped with free-standing shade structures made of 0·3 mm thick polyvinyl 100% shade cloth, and were 3·6 m by 6 m by 3 m high at the peak, 2·4 m high on the east side, and 1·8 m high on the west side. These shade structures were designed such that steers had access to shade from mid-morning (10:00 h Central Daylight Time [CDT)]) to early evening (19:00 h CDT). The shade structures covered approximately 50% of the pen area. Data were collected during eight periods during the summer of 2001. The collection periods were a combination of pre-selected periods and periods selected based on weather predictions. The steers were moved to a new pen and changed treatments at the end of each period.

Respiration rate, core body temperature, and feeder weights were continuously recorded during each of the eight treatment periods. Respiration rate was obtained using respiration rate monitors, which consisted of a respiration rate sensor, and a data logger/microcomputer. The output signal from the respiration rate sensor was recorded on the data logger/micro-computer for 1 min every 15 min at 10 Hz (Eigenberg *et al.*, 2000). These data were then post-processed using software developed in-house (Eigenberg *et al.*, 2000).

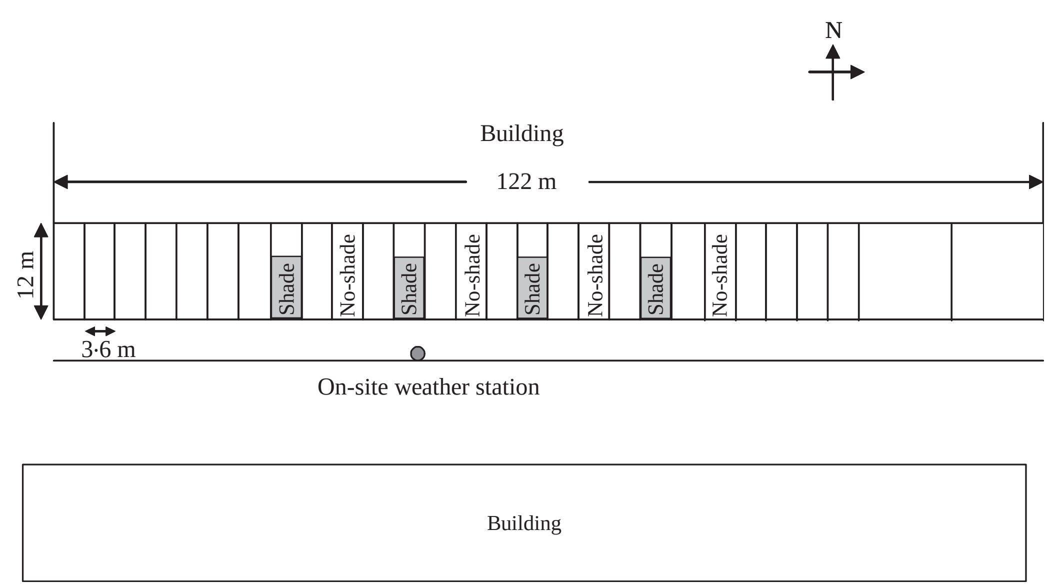

Fig. 1. Detail of experimental site; eight, 12 by 3·6 m pens were used, four equipped with a 3·6 m by 6 m by 3 m high shade structure; both the feed and the waterer were placed under the shade