Anim. Prod. Aust. 2002 Vol. 24: 77-80

REVIEW OF CURRENT ASSESSMENT OF CATTLE AND MICROCLIMATE DURING PERIODS OF HIGH HEAT LOAD

J. B. GAUGHAN [A], T.L. MADER [B], S. M. HOLT [C], G. L. HAHN [D] and B.A. YOUNG [A]

[A] School of Animal Studies, The University of Queensland, Gatton, Qld. 4345
[B] Dept of Animal Science, University of Nebraska, Lincoln, NE, USA 68583
[C] Dept of Animal & Range Sciences, South Dakota State University, Brookings, SD, USA 57007
[D] USDA-ARS Meat Animal Research Center (MARC), Clay Center, NE, USA 68933

SUMMARY
The implications of high heat load (HHL) on feedlot cattle can be costly. Its impact is felt economically and consumer perceptions of the beef industry can be tainted. Animal assessments such as dry matter intake, body temperature, respiration rate and behaviour can be useful in providing information on how well cattle are coping. However, used in conjunction with microclimatic factors such as ambient temperature and humidity it has the potential to be a useful management tool from which informed decisions can be made to alleviate the effects of HHL.

Keywords: cattle, feedlot, heat load, assessment, climate, welfare

INTRODUCTION

High Heat Load (HHL) occurs when a combination of local environmental conditions and animal factors leads to an increase in body heat content beyond the animals normal physiological range, thus decreasing its ability to cope.

Feedlot cattle deaths have occurred when adverse weather conditions have reached critical levels. While these incidences are not common, they are, when they do occur, often severe. There have been sizable losses of feedlot cattle associated with heat waves in the USA (Nebraska and Iowa, 1995 ~ 4,000 head; Nebraska, 1999 ~ 5,000+ head) and Australia (Qld., 1991 ~ 3,000 head; NSW, 2000 ~ 1300 head). Death events of these magnitudes are accompanied by performance losses in surviving animals, which result in large economic losses and have serious animal welfare implications. Importantly, and possibly more damaging to the beef industry, is that public perceptions are negatively affected. The feedlot industry must project a positive proactive image to issues regarding animal welfare such as summer time heat stress.

This paper reviews methods of assessing cattle exposed to high heat load conditions, and methods of monitoring the climatic factors, which predispose these animals to heat stress.

ASSESSING THE ANIMAL

Before tactics to minimize heat load on cattle can be implemented an assessment of the current status of the cattle is required. A number of factors can be used to assess the impact of HHL on feedlot cattle. These factors include DMI, internal body temperature, respiration rate and animal behaviour. Ideally all cattle in the feedlot should be assessed. Where this is not possible the most vulnerable cattle should be monitored. Vulnerable cattle include the following: Non-adapted cattle of predominately *Bos taurus* breeding, dark coloured cattle (black coated are most vulnerable, followed by red), cattle that are close to finish (especially long fed cattle), newly arrived cattle (these animals may still be suffering from the effects of transport, induction, mixing, etc) and sick cattle or cattle recovering from illness. Assessment should commence prior to any anticipated periods of adverse weather conditions.

Dry matter intake (DMI)

In general, DMI decreases when cattle are exposed to hot conditions. This is exacerbated when high-energy diets are used (Hahn 1996). The reduction in DMI is an attempt by the animal to bring metabolic heat production in line with its heat dissipation capabilities (NRC 1981). However, DMI may not always decline, especially when night time temperatures are low permitting recovery from daytime temperatures, or if exposure to hot conditions is of short duration e.g. one or two days.

Changes in DMI are further complicated by the energy density of the diet, animal condition, previous exposure to hot conditions and days on feed.

Internal body temperature

Internal body temperature is probably the most useful method of assessing the thermal balance of cattle (Shearer and Beede 1990). The normal rectal temperature (RT) for cattle is usually given as 38.3 ± 0.5 ºC (Anon 1991). However, RT is not constant and will rise and fall over a 24-hour period (Hahn 1999; Gaughan 2002). Knowledge of the relationship between the circadian change in RT and environmental thermal conditions is necessary if sound management decisions are to be made. The diurnal rhythm for RT is often a reflection of the pattern of change in ambient temperature. Under thermoneutral conditions RT lags ambient temperature by 8 to 10 hours (Hahn 1995; Holt *et al*. 1998), while under hot conditions lags of 2 to 5 hours are expected. This means that RT may peak at 2000 h, well after the hottest part of the day. Breed differences also need to be considered. Under hot conditions the RT of Brahman, Hereford and crossbred steers peak at different levels and at different times (Gaughan 2002). In addition to the circadian change, daily mean and amplitude values (i.e. the differences between maximum and minimum RT) are greater when cattle are exposed to hot conditions (Hahn 1995).

Rectal temperature is difficult to measure under field conditions. However, recent advances in telemetry technology may allow real time reading of internal body temperature via radio transmission from small devices placed in the rumen. This technology has considerable merit and may allow real time assessment of cattle in the near future.

Respiration Rate

Respiration rate (RR) is a useful indicator of heat load in cattle because it is the first visual response. RR is primarily influenced by ambient temperature. However, other factors such as solar radiation, relative humidity and wind velocity also contribute to heat load and subsequently RR. Respiration rate is easy to observe under field conditions, and is a useful assessment tool. When RR is used a number of factors need to be considered. (i) RR should be used in conjunction with a panting score (Mader *et al*. 2001) (Table 1); (ii) While RR increases with ambient temperature above 21 ºC, it does not respond directly. RR tends to lag ambient temperature by 1 to 4 hours (Hahn *et al*. 1997). Therefore, it is necessary to observe RR at least 4 hours before and 4 hours after the hottest part of the day if possible; (iii) RR will reach a peak, and may then decrease. This does not necessarily indicate that an animal is coping with HHL. On the contrary, it may indicate failure. Regular assessment of RR is required (every 2 hours) in conjunction with other behavioural factors (discussed below); (iv) RR may fall suddenly for a short period of time. This may indicate an attempt to balance CO_2/O_2 levels in the blood; (v) Cattle with previous exposure tend to have higher RR at lower temperatures; (vi) Body condition score, and (vii) time of day will also influence RR.

Table 1. Breathing Condition, Respiration Rate and Panting Score.

Breathing Condition	Respiration Rate ^{A} (bpm)	Panting Score
No panting (normal)	Less than 40	0
Slight panting, mouth closed	40 – 70	1
Fast panting, occasional open mouth	70 – 120	2
Open mouth + some drooling	120 – 160	3
Open mouth, tongue out + drooling	< 160^{B}	4

^{A} Count respiration rate for at least 2 minutes. ^{B} At this stage, RR may decrease due to change to deep phase breathing.

Respiration rate is an effective management tool to assist in the decision making process in relation to the heat load effects on feedlot cattle, and should be used as part of summer management. During periods of hot weather RR of vulnerable cattle should be assessed before 0800 h, and then at 2-hour intervals at least until 1800 h. Cattle with a panting score of 4 would be considered to be in danger. Without some form of relief from HHL, death is a distinct possibility.

Behaviour

Changes in behaviour are important considerations when assessing the effects of heat load. Behavioural change is primarily an attempt to maintain acceptable comfort levels. Changes in behaviour due to environmental stressors are variable (Ingram 1978). Behavioural changes include:

(i) **body alignment with solar radiation** – cattle will face the sun in an effort to reduce exposure to solar radiation; (ii) **shade seeking** – non adapted *Bos taurus* cattle will seek shade from 20 ºC, while adapted cattle will seek shade from about 28 ºC (Bennett *et al.* 1985; Gaughan *et al*. 1998); (iii) **time spent standing** – does not appear to be influenced greatly by HHL (Hoffman and Self 1973; Bennett *et al*. 1985); (iv) **crowding over water trough** – there is field evidence that shows cattle exposed to HHL crowding around water troughs; (v) **agitation/restlessness** – cattle moving as a 'herd' from one end of the pen to the other, or just generally mill about; (vi) **bunching** – is a phenomena seen in both cattle and sheep. During periods of hot weather, especially where there is little shade, cattle may bunch together. This may occur as cattle attempt to gain shade from another animal, or due to the basic herding instinct of cattle when exposed to stressors; (vii) **changes in respiration rate** – see above.

ASSESSING THE MICROCLIMATE

The standard meteorological procedures to measure the physical environment are: ambient temperature (T_a), relative humidity, solar radiation, wind speed and rainfall. Ammonia levels within a feedlot pen may also be an important factor (MLA 2001). Whilst these are reasonable assessments of climatic conditions in a region or at a site, they are not always directly equivalent to the microclimate of a feedlot pen.

Climatic conditions

There are a number of climatic conditions that may predispose feedlot cattle to heat stress. Managers need to monitor weather conditions, especially 3 and 5 day weather predictions. While these have not always been reliable they do form a basis from which management decisions can be made. These predictions need to be considered with other climatic factors. For example when mean T_a increases by approximately 7 ºC over a 2-week period, were there is little or no air movement, where there has been 2 or more days with little nighttime relief, and where high temperatures (30 ºC+) follow within 1 to 3 days of a significant rainfall event (Mader *et al*. 2001; MLA 2001). Each of these may contribute significantly to the heat load. Wind speed, or a lack thereof appears to be a significant factor contributing to heat load. Observations of feedlot cattle confirm that the heat load effects can be exacerbated by low wind speed, even when T_a decreasing (S. Lott, pers. comm.).

Temperature Humidity Index (THI)

When assessing the impact of the climatic environment on cattle, there is a need to estimate the combined thermal effects of the components of the physical environment. Combining all or some of the meteorological measures into a single index is standard. A number of indices have been developed, generally for use with humans. However, a few have been used in conjunction with livestock. Of these, the THI has been extensively used.

THI = $(0.8 \times T_a) + [RH \times (T_a - 14.3) + 46.3$, where T_a = dry bulb temperature (ºC), and RH is expressed an decimal form (Thom 1959).

The index was developed in the late 1950s as a measure of human discomfort (Thom 1959). In the 1960s the index was adapted for use by the dairy industry as a tool to evaluate the combined effects of T_a and humidity on DMI and milk yield (Kibler 1964). Although THI is simplistic it is currently the best 'heat stress' indicator for feedlot cattle, and can account for up to 78% of an animals response to the climatic environment (Gaughan 2002). The risk of loss due to excessive heat and humidity have been determined by Hubbard et al. (1999) as (i) the total number of days with THI ≥ 84; (ii) the duration of the event; (iii) the magnitude of the event; and (iv) the degree of recovery during an expected hot period (number of hours with THI ≤ 74). Four assessment phases of heat load can be used in feedlots.

Alert Phase – THI less than 79. Mild heat load effects on vulnerable cattle, especially where air speed is > 5 km/h. It is time to think about implementation of heat load reduction tactics.

Danger Phase – THI 79 to 83. Strong to severe heat load effects on cattle. Death not likely but is possible, especially where there is little air movement (i.e. < 5km/h), and/or within 1 to 3 days of a significant rainfall event. Sick animals may be at risk.

Emergency Phase – THI 84 to 89. Severe to extreme heat load effects on cattle. Death possible in vulnerable cattle without access to shade and/or sprinklers, especially where there is little air movement, within 1 to 3 days of a significant rainfall event, has been little nighttime relief, cattle are at a condition score (CS) of 4+, have dark coloured coat, sick or recently arrived.

Crisis Phase – THI 90 or above. Death possible in all cattle even with access to shade and/or sprinklers, especially where there is little air movement, within 1 to 3 days of a significant rainfall event, has been little nighttime relief, and cattle are at a CS of 3+, have dark coloured coat, sick or recently arrived.

The assessment criteria should be used in conjunction with cattle behaviour, especially RR rate. The animal can be used to further gauge the severity of the heat load. If RR is above 80 breaths per minute (bpm) even under the alert phase there could be a pending problem, and management action may be necessary. Conversely there may be times when THI is high, but due to high winds the heat load effects may be reduced.

THI-Hour

THI-hour is an adaptation of THI incorporating a time dimension to improve assessment. This is achieved by recording the amount of time (h) that THI is above a threshold index (Hahn *et al.* 1999). The threshold index is based on the vulnerability to HHL. THI-hours are calculated by the equation: THI-hours = Σ (hourly THI – THI threshold) to obtain the accumulated heat load each day. The accumulated THI-hours indicates the severity of the thermal load on the animal. An accumulated 15 to 20 THI-hours or more per day above a threshold of 84 for two or three days is likely to cause death in vulnerable cattle. THI-hours can also be used to calculate recovery time. The best recovery from heat load is where THI is below 70 for at least six hours. Recovery time is calculated by the following equation. THI-hours = Σ (70 - THI threshold). The amount of recovery time, essentially needed to bring body temperature back to 'normal', is dependent upon the number of THI-hours above a given threshold, and other factors such as wind speed and condition of cattle.

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Email: jbg@sas.uq.edu.au